Sadhan Kumar Ghosh *Editor*

Circular Economy: Global Perspective

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Preface

The way our societies and businesses are organized, massive changes are essential to have a transition to sustainable development. The circular economy (CE) model offers a new chance of innovation and integration among natural ecosystems, businesses reengineering, our daily lives and society and waste management. The circular model of resources should be defined in a holistic manner that is internationally accepted. The rise in consumerism and disposable products is choking our planet and exhausting it simultaneously. Actions must be taken seriously well before we reach the day where more plastics in the sea exist than fish. According to the World Economic Forum, moving toward a circular economy is the key, and a "trillion-dollar opportunity, with huge potential for innovation, job creation, resource conservation and economic growth". Without urgent action, global waste will increase by 70% on current levels by 2050, according to the World Bank's "What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050" report. Driven by rapid urbanization and growing populations, global annual waste generation is expected to jump to 3.4 billion tons over the next 30 years, up from 2.01 billion tons in 2016, the report finds. In 2016, the world generated 242 million tons of plastic waste or 12% of all solid waste.

It is good to note that a new ISO technical committee has been formed very recently in May 2019 intending to connect the dots in a circular economy and address the above issues and something more. ISO/TC 323, *Circular economy*, is currently made up of experts from over 65 different countries and growing. The idea for the committee began with a seminar held by AFNOR, ISO's member for France, where business leaders from many sectors expressed the need to move from a linear to a circular economy model. What followed was a French standard, XP X30-901, *Circular economy—Circular economy project management system—Requirements and guidelines* that was published in 2018. The response was so positive that an international committee ISO/TC 323 was born in France for all.

Mankind has been following a linear model of production and consumption since the industrial evolution. Researchers report that global material use has tripled over the past four decades, with annual global extraction of materials growing from 22 billion tons (1970) to 70 billion tons (2010). This latest report from the

International Resource Panel, Global Material Flows and Resource Productivity, provides a comprehensive, scientific overview of this important issue. It shows a great disparity of material consumption per capita between developing and developed countries. This has tremendous implications for achieving the SDGs in the next 11 years. Global material use has been accelerating. Material extraction per capita increased from 7 to 10 tons from 1970 to 2010, indicating improvements in the material standard of living in many parts of the world. Raw materials have been transformed into goods that are afterward sold, used and turned into waste that has been many times unconsciously discarded and managed. On the opposite, the circular economy is an industrial model that is regenerative by intention. One of the goals of the circular economy is to have a positive effect on the planet's ecosystems and to stop the excessive exploitation of natural resources. The circular economy has the potential to reduce greenhouse gas emissions (GHGs) and the use of raw materials, optimize agricultural productivity, decrease the negative externalities brought by the linear model and enhance resource efficiency and productivity. When it comes to reducing greenhouse gases, a circular economy can be helpful. The report *Global Material Flows and Resource Productivity* identified the large gaps in material standards of living that exist between North America and Europe and all other world regions. Annual per capita material footprint for the Asia Pacific, Latin America, the Caribbean and West Asia is between 9 and 10 tons, or half that of Europe and North America, which is about 20 to 25 tons per person. In contrast, Africa has an average material footprint of below 3 tons per capita.

The uses of renewable energy in the long run are less polluting than fossil fuels. Thanks to reusing and dematerializing a fewer materials and production processes. Residues are seen as valuable in the circular model and are absorbed to the maximum possibilities in order to be reused in the process and subsequent processes in turn. A study reported that a circular economy development path could halve carbon dioxide emissions by 2030, relative to today's levels. Waste management is a major problem across the world; its effective disposal is one of the most plaguing issues faced by the municipalities in different countries. The waste can act as a major source of energy rather than a disposable material. Given the high volatility of resource prices and the still heavy pollution of primary production, recycling becomes mandatory.

Considering the importance of the circular economy, a research project entitled "Global status of implementation of circular economy" was formulated and established in which more than 50 experts from 34 countries have been participating from November 2017 to continue till December 2021 with an Indian expert as the project lead. The project was launched in the meeting of the International Scientific Committee at the International Conference on Sustainable Waste Management platform in November 2017 at Hyderabad during 7th IconSWM in India. The chapter in this book are the first-phase outcome of the research project of International Society of Waste Management, Air and Water (ISWMAW).

Twenty countries from Asia (Australia, Afghanistan, Bhutan, China, Lao PDR, India, Malaysia, Republic of Korea, Thailand, Asian Island country—Mauritius), Western Asia (Israel), Europe (Germany, Italy, Norway, Serbia and the EU), Africa

(Kenya, Nigeria), the USA and Canada have participated and contributed their articles in this volume of this book, *Circular Economy: Global Perspective* that has been agreed by Springer Nature to publish. The main focus of this book has been given on existence and implementation status of national and regional legislation on resource efficiency, management of all types of wastes and circular economy, resource recovery practices adopted, case studies of implementation circular economy and 3Rs or any other innovative concepts. One chapter has been devoted to the introduction of circular economy for easy understanding of the backdrop, the sustainable development goals (SDG) and the relationship between the circular economy and the SGDs. The chapters in this book have been thoroughly peer reviewed, and required revisions were made by the authors before inclusion in this book.

This book, including CE case studies from 20 countries for the first time, will be helpful for the educational and research institutes, policy makers, government, implementers, ULBs and NGOs. I request the readers to send feedback on any of the related issues.

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Prof. Sadhan Kumar Ghosh
Editor and CE Project Leader

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Pranati Ghosh, My Wife
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Contents

About the Editor

Prof. Dr. Sadhan Kumar Ghosh, Ph.D. (Engg.) is the Dean of faculty of engineering and technology and Professor & Former Head of the Mechanical Engineering Department and Founder Coordinator of the Centre for QMS at Jadavpur University, India. A prominent figure in the fields of waste management, circular economy, SME sustainability, green manufacturing, green factories, and TQM, he served as the Director, CBWE, Ministry of Labour and Employment, Government of India, and L&T Ltd. Prof Ghosh is also the founder and Chairman of the IconSWM and President of the International Society of Waste Management, Air and Water, as well as the Chairman of the Indian Congress on Quality, Environment, Energy and Safety Management Systems (ICQESMS). He was awarded a Distinguished Visiting Fellowship by the Royal Academy of Engineering, UK, to work on “Energy Recovery from Municipal Solid Waste” in 2012. He received the Boston Pledge and NABC 2006 award for the most eco-friendly innovation “Conversion of plastics & jute waste to wealth” in the ESP/50K Business Plan Competition at Houston, Texas, USA. He holds patents on waste plastics processing technology and high-speed jute ribboning technology preventing water wastage and occupational hazards. He is member of ISO Working Groups concerning waste management (ISO/TC 297). His projects have been funded by European Union Horizon 2020 (2018-2022) on waste water, Royal Academy of Engineering (2018-2020 & 2012) on Circular economy in SMEs, Shota Rustaveli National Science Foundation (SRNSF) of Georgia

(2019-2021) on resource circulation from landfill, GCRF 2019/2020 Pump Priming - Aston Project UK on impact of wellbeing & mental health on productivity & sustainability in Industries, UNCRD/DESA as Expert (2016-2018) on SWM, Asian Productivity Organisation (APO) (2016-2019) on green manufacturing, British Council & DST (2012-2014), Royal Society (2015), Erasmus Plus (2016-17), ISWMAW (2018-21), Indian Statistical Institute (2019-2021), Institute of Global Environmental Strategies (IGES, Japan) (2019), South Asian Cooperation Environmental Programme (SACEP, Sri Lanka)(2018-2020) for preparing SWM roadmap for South Asian Countries, Jute Technology Mission (2008-2011), Central Pollution Control Board (1999-2002), Govt. of India on plastics waste management and a few others. www.sadhankghosh.com

Introduction to Circular Economy and Summary Analysis of Chapters

Sadhan Kumar Ghosh

1 Introduction

One-way model of production and consumption has been dominating over the past one and a half century in the globe. In the supply chain in this one-way model, the goods are manufactured from raw materials in production processes, sold, used, and subsequently at the end of its lifetime as the specific product is discarded as waste to landfill or incinerated. The raw materials are once extracted from the nature, usually discarded at the end of the use of a particular product. This model simply runs on a linear path and hence some times termed as linear model. Linear model does not support environmental sustainability and resource efficiency.

With the ever-increasing global population growth, faster urbanization and industrialization, growing demands of resource consumption, and negative impacts on environment, it is becoming increasingly apparent that business in a usual linear model cannot be continued for a sustainable future and development. Concept of recirculation of resources has been discussed in the Stockholm Conference. Based on that concept, recently the policy makers, researchers, major global companies and implementers are attracted and increased their attention towards transition from the existing linear model of economy to a circular one. World Economic Forum 2012 in Davos, the Ellen MacArthur Foundation (EMF) and McKinsey Company published a report which evaluates the potential benefits of the transition to a circular economy (CE): It could create an opportunity of US$630 billion a year for only a subset of the EU manufacturing sectors (Ellen MacArthur Foundation 2012, p. 5). Next to the huge economic benefits, the EMF pointed out the significant environmental and social benefits derived from a circular economy. These figures have created a huge

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awareness for the topic as many companies were willing to seize their chance to get a part of this potential revenue opportunity. Circular economy approach will be able to decouple economic growth from resource use that can be achieved based on sharing, leasing, reusing, repairing, refurbishing, and recycling, in an (almost) closed loop, to limit the leakage of resources to the maximum extent possible. The implementation of circular economy for any products or process starts from the conceptual and design stage. There are many theoretical interpretations of circular economy. Let us first discuss the available definitions of circular economy.

2 Understand the Circular Economy

The design of a product should be such that it extends the useful life; however faced with market saturation for their devices, companies are designing products for single use and shorter life spans, thereby accelerating their replacement cycle. A longer life span not only saves on the material resources but allows the carbon footprint of the product to be spread out over a long period of time. There is a greater need to design electrical equipment that is easier to upgrade and repair. The diagrammatic representation of a circular economy is demonstrated in Fig. 1.

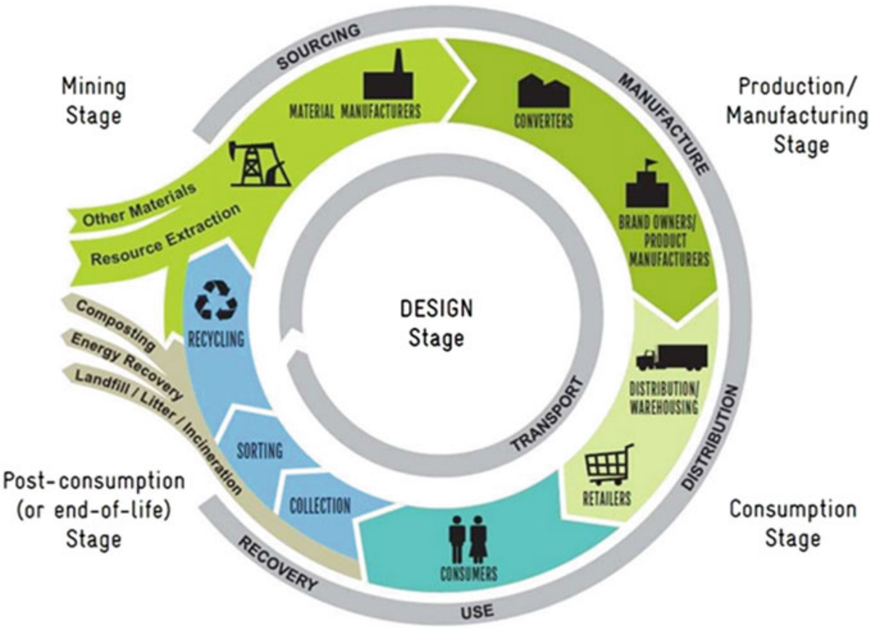

Fig. 1 Diagrammatic representation of a circular economy based on 6R approach. *Source* www.spcadvance.com In RP, 2017

Circular economy goes beyond recycling and is based around a restorative industrial system focused to treat waste as a resource. Whenever a product reaches the end of its useful life, the attempt is made to keep the materials within the production boundary and use them productively enough to create further value out of it (Ellen McArthur 2015). Figure 2 (Denmark without waste II. 2015) demonstrates a typical value chain of the electronic and electrical equipment (EEE) sector including designing, raw material supply, sub-components and subassembly production and manufacturing, storing, distribution and retail, use phase, waste treatment, and recycling.

Large quantities of easily accessible resources and energy are the key requirements in linear "take-make-dispose" model and are increasingly unfit for the reality in which it operates. Resource efficiency and eco-efficiency are also key incentives that will strengthen efforts to improve the sustainability of economic growth in a risky development context (Hicks and Dietmar 2007). In developing economies, the

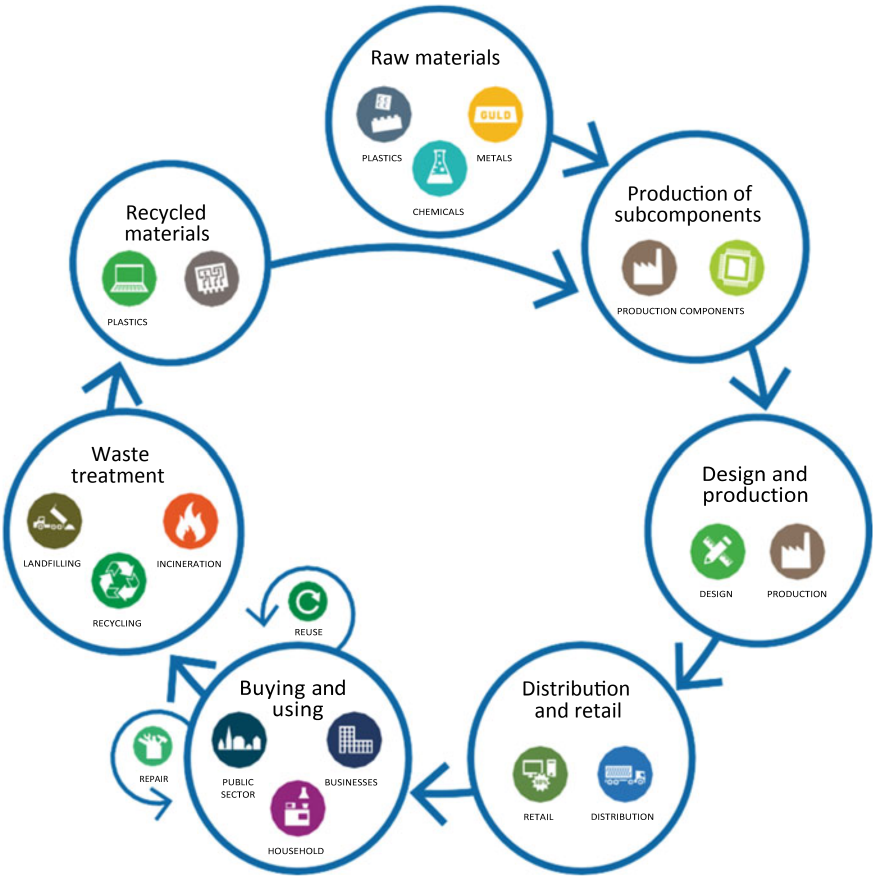

Fig. 2 Circular economy value chain of electronic and electric equipment

waste is being treated in the reduce, reuse and recycle (3R) concept under a broader concept of circular economy. The circular economy refers to an industrial economy that is *restorative* by intention; aims to rely on renewable energy; minimizes, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design. In circular economy model, durable goods would be designed so that they could be repaired rather than replaced and biological materials would be managed so that they could be returned to the biosphere without contamination. Coincidentally, the implementation of a circular economy is specifically based on both resource efficiency and eco-efficiency, and its purpose is to acquire a set of key measures to move toward a more circular, green, and sustainable economy (Yuan et al. 2006; Geng et al. 2009). The literature review has shown that there are many initiatives which support the circular economy either in the same name or in some other, but it is evident that circular economy is an inevitable proposition in the present-day world.

Circular consumption is a significant part of a circular economic system for sustainable economic growth and combating environmental degradation and resource depletion. Circular consumption into practice can be addressed by reduce, recycle and reuse (3R) principle. Circular consumption supports for converting wastes into valuable products leading a zero-waste society. Circular economy covers entire scopes of resource circulation and closed loop system in the areas of solid and liquid waste management, pollution reduction in water, air and land, resource conservation, greening of manufacturing sectors and many others activities.

Circular economy approach can deliver several benefits having untapped business potential. Globally, replacing only 20% of single-use plastic packaging with reusable alternatives offers an opportunity worth at least USD 10 billion (Ellen MacArthur Foundation 2017, 2019). Reuse models can bring superior user experiences, user insights, brand loyalty, and cost savings in some of the following ways:

1. Global alignment to act on plastic pollution: More than 350 organizations have signed up to the vision of building a circular economy for plastics through the New Plastics Economy Global Commitment. The Global Commitment has also seen more than 100 business signatories of the Global Commitment who have committed to move from single use to reusable packaging by 2025.
2. Shifting user preferences (Kantar World Panel 2017: Innovative reuse models can significantly shift the preferences delivering better-looking, more functional packaging which may contribute to gathering valuable user intelligence and allow the user to customizing the product.
3. Climate and other environmental benefits (Ellen MacArthur Foundation 2014): Moving from single use to reuse will help eliminate plastic waste and pollution and also offer significant reductions in greenhouse gas (GHG) emissions with other negative externalities.

3 CE Definitions

The concept of circular economy has deep-rooted origins. The practical applications have gained momentum from the late 1970s or early 1980s to modern economic systems and industrial processes. Cradle-to-cradle (https://www.ellenmacarthurfoundation.org/circular-economy/concept/schools-of-thought) concept and certification process were initiated in Germany long back. The design philosophy behind the concept is to consider all materials involved in industrial and commercial processes to be nutrients, in which two main categories are the actors: (a) technical and (b) biological. The cradle-to-cradle framework focuses on design for effectiveness in terms of products with positive impact and reducing the negative impacts of commerce through efficiency. The safe and productive processes of nature's "biological metabolism" have been received in the cradle-to-cradle design leading to a model for developing a "technical metabolism" flow of industrial materials. It requires the product/components that can be designed for recovery and reutilization on a continual basis as biological and technical nutrients within these metabolisms.

Products, processes, and materials must be designed with life cycles that are safe for the environment and human health. The system should be developed to mobilize and recover the value of the materials subsequent to their use as a specific product. The circular economy concept evolved from the cradle-to-cradle framework. There are a number of researchers who defined the circular economy in various ways. As the concept is being matured, the inputs to the subject and experience of implementation raise many questions and clarity. The author evolved the definition of circular economy as follows and finds it as one of the appropriate definitions covering all related aspects.

> Circular economy is a systems-level approach to economic development and a paradigm shift from the traditional concept of linear economy model of extract-produce-consume-dispose-deplete (epcd[2]) to an elevated echelon of achieving zero waste by resource conservation through changed concept of design of production processes and materials selection for higher life cycle, conservation of all kinds of resources, material and/or energy recovery all through the processes, and at the end of the life cycle for a specific use of the product will be still fit to be utilised as the input materials to a new production process in the value chain with a close loop materials cycles that improves resource efficiency, resource productivity, benefit businesses and the society, creates employment opportunities and provides environmental sustainability.

Circular economy may be defined in the following ways those shared by several researchers, though there are several others. Table 1 gives the collection of a number of definitions cited by a few researchers in different times. It is not easy to specify one perfect definition, but most of them are very much appropriate in one way or other.

Over the years, the concept of the circular economy has also attracted much criticism on several grounds including the reasons for having different definitions of the concept. The circular economy has achieved a broad appeal among the academic, policy, and business audiences (Vanner et al. 2014; Ghisellini et al. 2016), but its

Table 1 Circular economy definitions and interpretations

Source	Definition/interpretation of circular economy	Remarks
Ghosh (2019) (in this chapter)	Circular economy is a systems-level approach to economic development and a paradigm shift from the traditional concept of linear economy model of extract-produce-consume-dispose-deplete (epcd^2) to an elevated echelon of achieving zero waste by resource conservation through changed concept of design of production processes and materials selection for higher life cycle, conservation of all kinds of resources, material and/or energy recovery all through the processes, and at the end of the life cycle for a specific use of the product will be still fit to be utilised as the input materials to a new production process in the value chain with a close loop materials cycles that improves resource efficiency, resource productivity, benefit businesses and the society, creates employment opportunities and provides environmental sustainability	It talks about paradigm shift, innovative resource conservation, all kinds of resources, redesign of process, material selection, recovery of energy and materials, utilization of waste of first process as input to second process, closed-loop material cycle, employment generation, business model, resource efficiency, and environmental sustainability
EEA (2016)	It provides opportunities to create well-being, growth, and jobs, while reducing environmental pressures. The concept can, in principle, be applied to all kinds of natural resources, including biotic and abiotic materials, water, and land"	It talks about well-being, growth, and environmental pressure, all kinds of natural resources, e.g., biotic and abiotic materials, water, and land"
Ghisellini et al. (2016)	The radical reshaping of all processes across the life cycle of products conducted by innovative actors has the potential to not only achieve material or energy recovery but also to improve the entire living and economic model	It talks about reshaping of all processes, innovation, material or energy recovery, improvement of living and economic model
Sauvé et al. (2016)	"Production and consumption of goods through closed-loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)"	It talks about closed-loop material flows, environmental externalities, virgin resource extraction, linking to wastes/pollution

(continued)

Table 1 (continued)

Source	Definition/interpretation of circular economy	Remarks
Mitchell (2015)	A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extracting the maximum value from them while in use, then recovering and reusing products and materials	It talks about, alternative to linear economy, longer life cycle of resources, maximum value extraction of resources, recovery, and reuse
European Commission (2015)	The circular economy is an economy "where the value of products, materials, and resources is maintained in the economy for as long as possible, and the generation of waste minimized." The transition to a more circular economy would make "an essential contribution to the EU's efforts to develop a sustainable, low-carbon, resource-efficient, and competitive economy"	It talks about the value of products, materials and resources to maintain for long time, and minimized waste
Ellen MacArthur Foundation (2013, p. 7)	The circular economy as "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts toward the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." The overall objective is to "enable effective flows of materials, energy, labor, and information so that natural and social capital can be rebuilt"	It talks about a restorative or regenerative industrial system that is by intention and design, regenerating natural systems, redefine growth, focus on positive society-wide benefits, decoupling economic activity from the consumption of finite resources
Su et al. (2013)	The focus of the circular economy gradually extends beyond issues related to material management and covers other aspects, such as energy efficiency and conservation, land management, soil protection, and water	It talks about the issues beyond material management covering energy efficiency and conservation, land management, soil protection, and water

(continued)

Table 1 (continued)

Source	Definition/interpretation of circular economy	Remarks
Bastein et al. (2013)	The circular economy transition "is an essential condition for a resilient industrial system that facilitates new kinds of economic activity, strengthens competitiveness, and generates employment"	It talks about transition to a resilient industrial system, new kinds of economic activity, competitiveness, and employment generation
Preston (2012)	"Circular economy is an approach that would transform the function of resources in the economy. Waste from factories would become a valuable input to another process—and products could be repaired, reused, or upgraded instead of thrown away"	It talks about transformation of function of resources, waste as valuable input to another process, repair, reuse, or upgraded instead of thrown away
Heck (2006)	The utilization of sustainable energy is crucial in a circular economy. The transition to a circular economy would require addressing the challenge of establishing a sustainable energy supply as well as decisive action in several other areas such as agriculture, water, soil, and biodiversity	It talks about sustainable energy supply and utilization, decisive action in agriculture, water, soil, and biodiversity

Source Vasileios Rizos et al. (2017)

interpretation and application have been very diverse. This in turn generated confusion and hence reduced opportunities for international cooperation (Preston 2012). One of the concerns of the interpretation issue is the challenge of assessing the impact of the transition to circular economy. However, several studies by researchers have emerged that the circular economy has the potential to deliver economic, environmental, and social benefits though their focus and the aspects they measure are often varied. Furthermore, according to EASAC (2015), this research field is still in its early phase, and therefore the applied quantitative models are sometimes based on simplifications and assumptions that could be challenged.

4 SDGs and Circular Economy

Circular economy and the Sustainable Development Goals have a close relationship in many aspects. Circular economy will definitely help in implementation of SDG 2030 in the world. CE practices and related business models can help achieve several of the SDGs' targets. CE practices directly contribute to achieve twenty-one targets of SDGs and indirectly to an additional 28 targets. Targets in SDG6, SDG7, SDG8, SDG12, and SDG15 have the strongest relationships with the CE practices. CE practices also offer potential to create synergies between several SDGs, such as those promoting economic growth and jobs, eliminating poverty, ending hunger and sustainable food production, and those SDGs aiming for biodiversity protection in the oceans and on land. CE practices will not solve all the issues to be addressed by the SDGs as at least 35 of the targets have no or little influence to the CE practices while the CE offers potential as an implementation approach for specific SDG targets (Schroeder et al. 2018a, b). Table 2 gives a ready reference to the SDGs 2030.

5 Summary of the Chapters of Different Countries

Tables 3 and 4 demonstrate the summary of the chapters written on twenty countries around the world. These twenty countries can fall in distinct four categories with regard to the implementation of CE. Countries like Germany, Norway, the UK, and South Korea have matured CE-driven society and achieved significantly higher echelon of CE implementation status, whereas Australia, Canada, China, India, Malaysia, Serbia, Thailand, and USA have progressive CE-driven society. They have either started the CE process long back with limited results or started the CE process recently with significant results of implementation. A few more countries like Bhutan and Vietnam have initiated CE-driven society with a number of actions and strategies. They started minimization and utilization of resource consumption in many fields of the economy and gaining results. Afghanistan, Lao PDR, Israel, Kenya, Mauritius and Nigeria are at the primitive stage of implementation of CE concepts though in isolation there are a few cases where resource recycling take place on individual initiatives. All these twenty countries have been classified into four major categories in this chapter, while it may be noted that the categorization has been made based only on the information available in the chapters of this book and the experience of the author which do not claim that the categorization as a whole for respective countries. This information is not claiming the actual results of each of the countries as a whole. This is the limitation of this study. It has also been observed that each of the countries has an intention to go forward toward a CE-driven society. It is expected that there will be a sea change in the resource circulation system in these countries in a couple of years in the future. Table 4 summarizes salient points from the chapters on countries.

Table 2 Ready reference to the SDGs 2030

SDG	Contribution from sustainable waste management and circular economy	
1	No poverty	Provides livelihoods for millions of people globally, ranging from street cleaning and waste collection (including numerous informal sector workers) to waste treatment and material reprocessing. Right to access to basic services such as waste collection is included here
2	Zero hunger	Reducing food waste is a priority for reducing hunger amongst the world's poorest people. Reduce food waste and create value from unavoidable food waste, through composting and anaerobic digestion, creating useful fertilizers and energy
3	Good health and well-being	Poor waste management practices, such as open burning of waste and uncontrolled dumping, cause serious health impacts, particularly amongst those living close to waste sites Improving waste and resource management will reduce these health impacts
4	Quality education	Many informal waste sector workers are children. Working with the informal sector will help get out of this sector and into education
5	Gender equality	The majority of informal waste sector workers are women. Working with the informal sector to improve their working conditions will have a strong benefit to women working in waste and resource management
6	Clean water and sanitation	Effective solid waste management is a fundamental element of providing clean water and sanitary conditions for all
7	Affordable and clean energy	Waste has excellent potential as a source of energy
8	Decent work and economic growth	The waste and resource management sector is a key employer and is essential for economic growth. Clean cities attract business and investment
9	Industry, innovation, and infrastructure	Waste and resource management is at the center of innovation in the way that we use materials and consume services

(continued)

Table 2 (continued)

SDG	Contribution from sustainable waste management and circular economy	
10	Reduced inequities	The poorest are harmed the most by poor waste management. Improving waste management will create benefits for those most in need
11	Sustainable cities and communities	Sustainable waste management is key to making sure cities are inclusive, safe, resilient, and sustainable, where everyone has access to all the basic services
12	Sustainable consumption and production	Developing sustainable models of consumption and production requires that we reduce waste and develop models of production based on the principles of circularity
13	Climate action	Uncontrolled emissions from landfills and dumpsites are one of the main sources of global methane emissions, a powerful greenhouse gas. Effective waste and resource management will reduce these emissions and offset emissions from other sectors, including industrial production (by encouraging the use of secondary materials) and energy
14	Life below water	Effective waste and resource management is essential to prevent the leakage of waste materials, particularly plastics, into the world's oceans
15	Life on land	Poor waste management leads to pollution of soils, rivers, and water bodies. Providing waste management services for all will eliminate these impacts
16	Peace, justice, and strong institution	Waste management is a critical issue at municipal level and can be used as an indicator of good governance. Municipal officials rank it amongst the most important issues
17	Partnership for the goals	The waste and resource sector is an excellent example of a sector that, when working effectively, involves stakeholders, from government, the private sector and the informal sector, all working together

Table 3 Status of CE implementation in the countries

Country	Matured CE-driven society	Progressive CE-driven society	Initiated CE-driven society	Not yet started	Legislation supporting CE
Australia		X			Yes
Afghanistan				X	No specific legislation
Bhutan			X		No specific legislation
Canada		X			Yes
China		X			Yes
Germany	X				Yes
Lao PDR				X	No specific legislation
India		X			Yes
Israel				X	No specific legislation
Kenya				X	No specific legislation
Malaysia		X			Yes
Mauritius				X	No specific legislation
Nigeria				X	No specific legislation
Norway	X				Yes
South Korea	X				Yes
Serbia		X			Yes
Thailand		X			Yes
UK	X				Yes
USA		X			Yes
Vietnam			X		No specific legislation

Table 4 Summary of the country chapters

Country	Summary
Australia	Most Australia states and territories have waste strategies and recently implemented container deposit systems. All states and territories are considering circular economy policies or actions and are at different stages of development and implementation. In addition, more recently in response to China's decision to restrict the importing of mixed plastics and fiber (China's National Sword Policy), Australia has been made more aware of the opportunities a circular economy may provide, and a number of new initiatives at a national level and at state level have been implemented as a response. Recycling and waste industry associations have also been calling on the Commonwealth and state governments for more integrated policy development, stronger leadership, and action to develop circular economy policies and actions. Emphasis has been given on material recovery in the recycling and compost industries. The country sought for resource efficient business in the water, waste water, solid waste and energy sectors. Reductions in waste to landfill and increasing recycling rates are also in the mandate in Australia
Afghanistan	In Afghanistan, there is no individual policy/strategy/plan/program about the circular economy and did not work on system of resource utilization where reduction, reuse, and recycling of elements prevail. Individual activities in isolation take place to reduce, reuse, and recycling of wastes in Afghanistan, rather as a whole. South Dakota Army National Guard Soldiers and other service members initiated waste recycling pilot program, designed to provide a renewable heat source for Afghans living in the capital of Kabul. In this invention, members of the 196th Maneuver Enhancement Brigade are volunteering their time to develop a "fuel donut" made from recycled materials, which burns like a briquette and provides an alternative heat source for Afghan families who live in homes without modern heating conveniences. Countrywide legislation is not available focusing CE
Bhutan	Bhutan is widely renowned for its carbon negative status in the environmental arena. Different streams of wastes are emerging, and in particular, MSW is serious issue in Bhutan with shift in consumption patterns and increasing population rate. Apart from the National Environment Commission (NEC) acting as an apex body for regulating and monitoring waste management, similar initiatives have been taken by local governments, other government agencies, private enterprises, and NGOs to create litter-free and healthy environment by implementing 3Es and 4Rs toward circular economy The concept of circular economy in Bhutan got introduced with the Waste and Climate Change Project (WCC) of NEC and WWF Bhutan. The circular economy concept is the main philosophy of the National Waste Management Strategy (NWMS) which aims to establish waste management as a national priority and provide information, logical steps, and strategies required for its successful implementation. The NWMS aims to resolve data gaps, challenges, and issues between agencies regarding waste management. It would also ensure that waste management programs are trickling down to the gross root systems fostering a national waste reduction, reuse, and recycling concept

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Country	Summary
Canada	Canada, specifically Ontario, has become the first jurisdiction in the Americas to enact a comprehensive circular economy law, the Resource Recovery and Circular Economy Act, 2016 ("RRCEA"). Legislation [that] will tackle the problem of waste generation by increasing resource recovery and moving toward a circular economy. Inside of Ontario and across the many other jurisdictions of North America, the transfer of obligation under the RRCEA from the government designated IFOs directly to the Producers themselves is a shift of responsibility for diversion/resource recovery to a near fully private model is often termed "individual producer responsibility" (or IPR). A number of environmental policy changes are proposed under the RRCEA. Circular economy is more than simply another iteration of the IFO waste diversion programs The RRCEA sets 6 IPR obligations for resource recovery directly upon the Producer. Provincial regulations under the Environmental Protection Act (Ontario), dating from more than 20 years ago, mandated the IC&I sector to take positive steps in the reduction of waste. In Canada, of the 12% of plastics that are collected for recycling processes, a large proportion is "downcycled", meaning those plastics are no longer usable for their original purpose due to a change in their chemical/physical properties. Closed-loop waste management in improved status exists focusing CE
China	In 2002, China promulgated the Cleaner Production Promotion Law, which emphasizes the scientific and technological innovations and upgrading. In China, circular economy along the supply chain generally involves two aspects such as cleaner production and waste recycling. Cleaner production is achieved primarily in ecological industrial park (IP), and waste recycling is performed mostly in urban mining demonstration base. These two actions are the core practical approaches of circular economy toward a sustainable society. In April 2017, fourteen ministries and commissions jointly promulgated the Action Plan for Circular Economy Development, which would achieve an improvement of the resource productivity of 15% than in 2015 and the recycling rate of 54.6% for main types of solid wastes. Creating a new strategic guarantee system on resources is one of the main objectives in this action plan. In the industrial level, circular transformation of IPs was one of the major circular economy construction pilot programs, issued in the 12th Five-Year Plan by the China State Council. It comprised of seven prime tasks to transform previously large resource- and energy-intensive production into high efficiency and low pollutant processing. By 2017, 129 IPs had been approved for circular transformation by NDRC. In order to improve the performance of circular economy in industrial parks (IPs), in March 2012 National Development and Reform Commission (NDRC) and the Ministry of Finance released the opinions on the promotion of circular transformation of IPs

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Country	Summary
Germany	In 1972, the first German waste regulation, the Waste Disposal Act (Abfallbeseitigungsgesetz, AbfG), was created. Today, the Act to Promote Closed Substance Cycle and to Ensure Environmentally Compatible Waste Management (Kreislaufwirtschaftsgesetz, KrWG) is the core regulation of waste legislation. As a successor regulation, the KrWG retains the essential structural elements of the old Closed Substance Cycle and Waste Management Act (KrW-/AbfG). Since 1978, the German government uses an eco-label called the "Blue Angel" [8]. For over 40 years, this label has been a reliable guide on sustainable consumption by setting high standards for an environmentally friendly product design. Waste legislation in Germany is based on the Closed Substance Cycle Act (KrWG), which came into force on June 1, 2012, and implements the requirements of European waste legislation The law aims at promoting closed-loop recycling for the conversation of natural resources and the protection of people as well as the environment regarding the generation and management of waste. Since January 2015, Germany has had separate collection obligations for biowaste, paper, metal, plastic, and glass waste. For decades, it has been collected separately. However, the obligation has now also been laid down in law. The Closed Substance Cycle Act (KrWG), the German Packaging Act, and the EU Packaging Directive lay down new minimum requirements for recycling quotas. With its own 10-point action plan "Marine protection and sustainable fisheries," the BMZ aims to help eliminate the causes of marine pollution. In the field of energy generation from waste ("waste to energy"), the German Federal Ministry for Economic Cooperation and Development supports the introduction of appropriate technologies. Closed-loop waste management in improved status exists focusing CE in Germany as per EU Directives
Lao PDR	National policy frameworks need to be strengthened to ensure that waste management practice shifts from an end-of-pipe approach to an integrated resource management approach. In addition, at the local level, the 3Rs need to be integrated into waste management strategies and action plans for municipalities. These need to be developed and implemented especially in Vientiane and other big cities. A sound solid waste management system is to be established in harmony with city government and development by 2030 In Lao PDR, several government agencies involve in drafting and enacting laws and regulations relating to waste management. Recently in Vientiane Capital, the trade of recyclable waste material (RWM) has been promoted to reduce amount of solid waste by VCOMS. The players involving in managing RWMs comprise waste pickers, waste banks, junk shops, waste exporters, and recycling factories. Currently, waste collection services can be found in many districts and towns throughout the country, but they simply collect and dispose solid wastes in the landfill directly. Official waste segregation scheme does not exist, while some valuable wastes are collected and traded among informal waste pickers, scrap traders, community waste banks, and plastic recycling companies. Countrywide legislation is not available focusing CE

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Country	Summary
India	A National Committee on Environmental Planning and Coordination was set up by the Government of India, and Article 48A was added by the Constitution (42nd Amendment) Act, 1976, which stated that, "State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country." The implementation of sustainable development and promotion of cleaner production concepts started from 1972 in India. Various schemes and rules focusing on circular economy and 5R encourage the implementation of CE. Very recent release of draft policy on National Resource Efficiency in 2019 will open a new horizon for the CE implementation. National Resource Efficiency Authority (NREA) is proposed to be created as a dedicated institution for fostering resource efficiency in the NREA, 2019, that draws its power from Environment (Protection) Act, 1986, to provide for the regulatory provisions of this policy. More than 4237 cities are now implementing resource circulation in waste management. Swachh Bharat Mission (SBM), revision and introduction of seven waste management rules, namely solid waste, e-wastes, plastic waste, hazardous wastes, biomedical waste, and battery recycling have given boost to the CE and 5R initiative in the country. India has also pushed the action-driven plastic economy and plastic waste management through "Beat the Plastic Pollution" by hosting the World Environment Day 2018. It has taken initiatives for waste minimization and recirculation through ZED and ELV recycling initiatives
Israel	A national program for streamlining resources and a circular economy in the industry was developed (IMoE&I, 2018) and was approved by the government (Decision No. 3768). The goal of the program is to motivate the industry toward more efficient use of resources and the handling of environmental problems by new technological means, from the early design, design, and production stages, thereby turning environmental requirements into opportunities rather than burdens on the industry. At the beginning of 2019, the IMoE&I started running a pilot project in which four companies will compete for the recycling of industrial materials. A legislative framework related to circular economy is still lacking in Israel. The main legislation with regard to circular economy principles, which relates to resource and material management, mainly deals with waste management and recycling. The introduction of an extended producer responsibility (EPR) system in 2011 was an important component of the IMoEP recycling revolution, as the EPR system states that producers are legally responsible for the entire life cycle of the products they manufacture, as well as the product's packaging. Closing the MSW loop is a significant key factor in achieving a circular economy. In 2017, the IMoEP presented a new waste management strategy for Israel, named the MSW 2030 strategic plan. The top target of this plan is to minimize landfilling and promote recycling and recovery. The policy document outlines the ministry's plan for an integrated waste management strategy, based on striking the right balance between material recycling and energy recovery. Countrywide legislation is not available focusing CE

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Country	Summary
Kenya	In Kenya, there are several legislations and legal frameworks to enhance sustainable implementation of circular economy strategies. CE legislations in Kenya include parliament acts, bills, bylaws, and legal publications in most governmental parastatals and lead agencies. The new Kenyan Constitution 2010 mainly Chapter five Part 2 on Land and Environment mainly states all the obligations of its citizens to ensure sustainable exploitation of natural resources and sustainable management and protection of the environment. Circular economy concepts in Kenya started to gain recognition since the development and implementation of Environmental Management and Coordination Act (EMCA) of 1999. EMCA 1999 is a legal framework law on environmental management and conservation in Kenya. EMCA 1999 has led to the establishment of the following institutions to help the country achieve environmental sustainability: National Environment Management Authority (NEMA), Public Complaints Committee (PCC), National Environment Tribunal (NET), National Environment Action Plan (NEAP) Committees, and County Environment Committee Despite existence of regulations and policies that guide on waste management, weak implementation and unsustainable individual practices have led to accumulation of waste in most urban centers in Kenya. Poor waste management has led to outbreak of waterborne disease and dengue fever, especially in Mombasa and parts of northeastern counties. The plates below show examples of poor waste management in Kenya. In Kenya, the number of industrial plants engaging themselves in Resource-Efficient Cleaner Production (RECP), the 3Rs programs—reduce, reuse and recycle—and Industrial Ecology (IE) is on the rise. Some technologies in RECP, 3Rs, and IE are very expensive to adopt, especially among the small-scale manufacturing industries; thus, the government should offer monetary support. The process of "greening" the Special Economic Zones (SEZs) has greatly helped Kenya attract green foreign direct investments (FDIs). Countrywide implementation of legislation is not reflected focusing CE
Malaysia	In 1996, under the Danish Cooperation for Environment and Development (DANCED), several projects introduced the implementation of circular economy at firm level or cleaner production in Malaysia for the first time. Malaysia does not have a legal framework on the implementation of circular economy like other nations, i.e., China, Japan, Germany, etc. However, there are certain sections in Environmental Quality Act 1974, Solid Waste and Public Cleansing Management Act 2007, and Regulation 7 in Environmental Quality (Scheduled Waste) Regulation 2005 that promote the practice of resource circulation. Malaysia incorporated sustainable production and consumption in 11th Malaysian Plan and aims to take holistic approach toward national waste management. Under the umbrella of 11th Malaysian Plan, Malaysia targets to reduce 40% of GHGs emission intensity from GDP compared to 2005 level and reach 22% of recycling of MSW with a long-term goal of becoming zero-waste nation. Additionally, SWCorp launched SWCorp Strategic Plan from 2014 to 2020 to promote sustainable solid waste management services, and CIDB initiated CITP that has a target of incorporating 20% of recycled construction and demolition waste (tonnage) by the year 2020 from the baseline of 2016. Malaysia launched its latest national plan, 11th Malaysian Plan, from year 2016 to 2020. In this national plan, a great emphasis has been given on the adaptation of sustainable consumption and production. The national target of MSW recycling is 22% by the end of 11th Malaysian Plan As circular economy is not implemented at national or municipal level in Malaysia, the benefits of circular economy are only confined to the enterprises that are practicing circular economy at enterprises. Due to the implementation of circular economy at firm level, the impact on GDP is not significant but the benefits of implementation of circular economy at enterprise level are reduction in resource consumption, reduction in generation of waste, protection of environment and human health, reduction in energy consumption, cost savings by reusing or recycling the waste, and additional profit gain by selling waste to potential industries

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Country	Summary
Mauritius	While some recycling is practiced on the island, circular economy is still in its infancy stage due to several obstacles faced by the local recyclers. Nevertheless, it is expected that with the implementation of the forthcoming projects such as scrapyard facility, C&D waste storage sites, material recovery facility, and e-waste management system, recycling will receive a major boost in Mauritius. In 2001, government promulgated the Environment Protection (Polyethylene Terephthalate (PET) Bottle Permit) Regulations 2001 to ensure the environmentally sound management of PET bottles. These regulations were based on the concept of extended producer responsibility, implying that the producers of PET bottles had to pay for the waste and pollution they create. The Local Government (Registration of Recycler and Exporter) Regulations were promulgated in 2013 in view to regulate the recyclers and exporters involved in the recycling industry. One of the best practices of circular economy in Mauritius is the implementation of the project “Enhancement of resource productivity and environmental performance of Micro, Small and Medium Enterprise in six African countries through the concept of Industrial Symbiosis” under the SWITCH Africa Green (SAG) Program. Under this project, waste is considered as a resource which can be valorized; for instance, waste from one firm can be an input/raw material for another firm
Nigeria	The problems militating against municipal waste management in Nigeria are numerous and diverse; these problems are related to economical, technological, psychological, and political aspects. Nigeria, like many African countries, does not have large-scale recyclable collection from source, and less than 12% of waste is formally recycled from dumpsites in an unsafe and hazardous condition. The poor waste disposal methods lead to clogged drains, flooding, and other environmental problems. The Federal Ministry of Environment (FMEnv) with support from the United Nations Industrial Development Organization (UNIDO), other technical partners, and critical stakeholders in the public and private sectors developed the National Solid Waste Management Policy as a statement of intent to be implemented as a procedure or protocol in the management of solid waste in Nigeria

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Country	Summary
Norway	The legislative framework for circular economy in Norway is based on the European Directives that need to be implemented through the European Economic Area Agreement between EU and Norway. The European Waste Framework Directive (WFD, 2008) issued by the European Commission lays out common recycling targets and strategies for the EU Member States. The objective is to achieve a level playing field and improved resource efficiency in waste management. Six Member States landfilled less than 3% of their municipal waste in 2011, while 18 states landfilled over 50%, with some exceeding 90% (EC, 2015). Circular economy has a significant growth potential in Europe and in Norway. On average, recycled materials only meet less than 12% of the EU demand for materials (EC, 2019). EU alone may save 600 billion US dollars annually after 2025 if industrial companies are able to turn their business around a circular economy (MacArthur and McKinsey 2015). In addition, such a transformation can create more than two million jobs by 2030, according to the EU Commission. In Norway, the total material recycling level in 2017 was around 45%, which indicates a huge potential for circular economy initiatives The Norwegian government presented a White Paper to Parliament on waste policies in a circular economy with an emphasis on increasing reuse and recycling on June 21, 2017. The White Paper also outlines Norway's strategy to strengthen international commitment to combat marine litter through cooperation in the Nordic region, the EU, other regional fora and through the UN. The fundamental idea behind EPR is to place a responsibility for the postconsumer phase of certain goods on the producers. According to OECD, EPR is a policy approach under which producers are given a significant responsibility—financial and/or physical—for the treatment or disposal of postconsumer products. Around 651 000 tons of waste were processed at biogas and composting plants in 2017, and 56% was used for biogas production (SSB, 2019). This is a significant increase the last 5 years. Some of the reason may be the prohibition to dispose biodegradable waste in landfill from 2009 Stronger CE implementation. Closed-loop waste management in improved status exists focusing CE as per EU Directives
South Korea	There is a paradigm shift of waste policy for circular economy in Korea that builds the means to promoting the recycling for circular economy. Circular economy also flows in EPR system. The current waste policy is aimed at minimizing landfill and incineration of waste, and maximizing recycling by refraining from a single use and disposal of wastes to create a resource circulation society in which wastes and an emitted energy are recirculated within the economic activity areas for as much as possible. In accordance with the changes in the waste management paradigm, the Resources Circulation Basic Act was enacted from 2018 E-wastes and waste vehicles are not managed by EPR system but are managed by Eco-Assurance System (Eco-AS) in Korea. For the implementation of resource circulation, the management of e-waste in Eco-AS is implemented in two means depending on the role of the subjects related discharging e-waste: prevention and post-management. As a privative means, manufacturers and importers must comply with the standards for hazardous materials in products and improve materials and structure of the products to facilitate recycling. The post-management is a means to promote the recycling of e-wastes and waste vehicles similar to the EPR system. This is a system that encompasses EU RoHS, WEEE, and ELV Directive. In Eco-AS, the circular economy flows for e-waste are similar to that of EPR, with additional privative means. S. Korea made significant achievement of ambitious targets of recycling and reduction in landfill (from 14% at present to 3% by 2020) Stronger CE implementation. The current waste policy is aimed at minimizing landfill and incineration of waste, and maximizing recycling by refraining from a single use and disposal of wastes to create a resource circulation society in which wastes and an emitted energy are recirculated within the economic activity areas for as much as possible

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Country	Summary
Serbia	The Republic of Serbia has been following the processes of adopting and introducing a circular economy in the European Union (EU) and has responded swiftly by adopting EC recommendations on circular economy. One of the important development documents for the realization of a new vision of development is the National Sustainable Development Strategy for the Republic of Serbia, which was adopted in 2008 and covers the period until 2017. The Ministry of Environmental Protection has signed a cooperation agreement with the National Alliance for Local Economic Development (NALED) regarding sustainable development of the CE in Serbia. Reduction of adverse environmental effects, conservation of natural resources (including minerals, metals, other materials, water and air) and biodiversity are the focus in the Republic of Serbia
Thailand	Several practices and initiatives relevant to postconsumer packaging recovery and utilization are already in place, which are mainly driven by value and demand of PCP materials by retailers and business operator/production sectors The existing policies and programs on CE are focused more toward 3R concepts and less on other subsectors of CE, e.g., products-as-services, next life sales, product transformation, and collaborative consumption. CE indicators are primarily based on 3R concepts, whereas it is recommended that the other sub-sects of CE should also be taken into consideration to measure the actual CE progress. Producers have started initiatives as part of CE practices that are carried out on a voluntary basis
UK and EU	The approach to bans is through Green Public Procurement—this does not ban a particular product on the market, but due to the purchasing power of public institutions this can have a significant impact on use of plastics and can drive investment by producers in alternatives. An example is the commitment that the UK central government offices are to be made single-use plastic free (HM Government, 2018). More reuse of plastics: A UK scheme which incentivizes consumers to bring back their used appliances for recycling. Several actions to promote a circular economy concern issues such as product quality, and through this, there are consequences for international trade. The EU is a single internal market for trade, and trade policy with non-EU countries is the competence of the EU, rather than its Member States. The size of the EU economy means that decisions affecting what is allowed within its internal market have consequences for manufacturers of products in non-EU countries wishing to export to the EU market. UK has been implementing the CE as per EU Directives and achieved significant benefits. Stronger CE implementation in the UK and EU. Short-term and highly wasteful consumption patterns can be addressed In UK, municipal wastes are being treated in waste to energy plants very effectively. The WtE plant in different parts of the UK generate power in the range of 10–25 MW per plants and provides heat as well to the city council. There are a number of e-waste recycling plants operating effectively in the UK

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Table 4 (continued)

Country	Summary
USA	Nationwide US waste management laws began in 1965 with the "Solid Waste Disposal Act" (Fig. 2). This was followed by the Resource Conservation and Recovery Act (RCRA) of 1976. The RCRA program implemented by the US EPA and its partner states, tribes, and local governments protects communities and the environment from the improper management of solid and hazardous waste, cleans land and water, conserves resources, and empowers citizens by delivering information and opportunities that enable communities to participate in decision-making processes. RCRA also serves as a legislative basis for EPA's Sustainable Materials Management (SMM) program, which is a systemic approach for promoting using and reusing materials over their life cycle. The program has four primary goals: to decrease the disposal rate; reduce environmental impacts; increase socioeconomic benefits; and increase the capacity of communities to adopt SMM practices. RCRA also serves as a legislative basis for EPA's Sustainable Materials Management (SMM) program, which is a systemic approach for promoting using and reusing materials over their life cycle. The program has four primary goals: to decrease the disposal rate; reduce environmental impacts; increase socioeconomic benefits; and increase the capacity of communities to adopt SMM practices In USA, municipal wastes are being treated in waste to energy plants very effectively. The WtE plant in Philadelphia generated 84 MW of power where the MSW is being transported by railway wagons from different cities/states. There are a number of e-waste recycling plants
Vietnam	Up to present, even the circular economy term is not referred in any legislation; nevertheless, the Vietnamese government has made the great effort for the minimization and utilization of resource consumption in many fields of the economy The National Plan on Environment and Development for the period 1991–2000 (issued by the Decision No. 187-CT dated June 12, 1991) is considered as first strategic foundation for sustainable development in Vietnam, though it did not refer directly to the minimization of resource consumption and utilization of natural resources. Nevertheless, under the deployment of this plan, the first Environmental Protection Law (No. 29-L/CTN dated December 27, 1993, of the National Assembly Chairman), in the Article 1, has declared that: "Environmental protection stipulated in this Law are activities to keep the environment clean, clean, improve the environment, ensure ecological balance, prevent and overcome bad consequences of people and natural disasters to the environment, exploitation and use reasonably economically the natural resources." Landfill is still a dominated treatment method in Vietnam despite many efforts of the government to promote 3R initiative. Although it is known as the most useful and cost-effective treatment, composting is taken a very small proportion Vietnam has been conducted 3R model for a long time, especially in agriculture field. Starting from the utilization of cultivation and breeding wastes, it was extended into different types of closed farm that now have been developed all over the countries. In the case of industry, the recycling of metals, paper, and plastic have been conducted from the 1960s, mostly for providing the materials for production industry, which was still limited even in terms of scale, capacity, and sources In paper industry, nearly 70% production is from scrap, while 60% steel facilities are used scrap as major input source The issues of natural resource depletion, pollution, and climate change risk have raised the need for a change in the development model of Vietnam, where a transition from linear economy to circular economy could be sensible. Therefore, some legislative framework to support the transition has been forming gradually in the country From resource utilization perspective, in a material circulation society (or closed economy), 3R, in general, and recycle, in particular, not only aim to treat or reduce the amount of waste generated, but also aim to create new industries that are corresponding to the type of wastes and development needs, thereby bringing waste back into the production process

6 Conclusion

Circular economy model is becoming a very popular concept throughout the world. Using economic modeling and the information collected through 150 interviews with experts, Ellen MacArthur Foundation and McKinsey Center for Business and Environment (2015a, b, c) estimate that in the mobility, food systems and built environment sector technological advancements combined with organizational innovations would allow Europe's resource productivity to grow by 3% by 2030, translating to total annual benefits of €1.8 trillion. This includes the primary resource benefit of €0.6 trillion as well as the non-resource and externality benefits (e.g., non-cash health impacts of accidents, pollution, and noise) of €1.2 trillion. On the other hand, there are concerns of the interpretation issue that becomes challenge for assessing the impact of the transition from linear economy to circular economy. There are several studies in the available literature that provide mappings of different circular processes at company level. Different chapters of this book bring the status of implementation of CE in twenty countries around the world that may be a real-life assessment of the acceptability and implementation of CE. It will take a few more years to conclude the future of circular economy.

References

Bastein, T., Roelofs, E., Rietveld, E., & Hoogendoorn, A. (2013). Opportunities for a circular economy in the Netherlands. TNO, Report Commissioned by the Netherlands Ministry of Infrastructure and Environment.

Circular economy for productivity and sustainability, Productivity Week 2019, Productivity E-Newsletter bulletin, National Productivity Council, New Delhi.

Denmark Without Waste II. (2015). The Danish Government.

EASAC (The European Academies Science Advisory Council). (2015). Circular economy: A commentary from the perspectives of the natural and social sciences. Preston.

EEA (European Environment Agency). (2016). Circular Economy in Europe—Developing the knowledge base. EEA Report No. 2/2016.

Ellen MacArthur Foundation. (2012). Towards the circular economy: Economic business rationale for an accelerated transition.

Ellen MacArthur Foundation. (2014). Towards a circular economy: Accelerating the scale-up across global supply chains (Vol. 3).

Ellen MacArthur Foundation. (2015a). Towards a circular economy: Business rationale for an accelerated transition. https://tinyurl.com/zt8fhxw.

Ellen MacArthur Foundation. (2015b). Potential for Denmark as a circular economy. A case study from: Delivering the circular economy. https://tinyurl.com/zv8exrl.

Ellen MacArthur Foundation. (2015c). Delivering the circular economy—A toolkit for policymakers. https://tinyurl.com/ztd4f2u.

Ellen MacArthur Foundation. (2017). The new plastics economy: Catalysing action.

Ellen Macarthur Foundation. (2019). Completing the picture how the circular economy tackles climate change. https://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy-_Tackles_Climate_Change_V3_26_September.pdf.

European Commission. (2015). Closing the loop—An EU action plan for the Circular Economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM (2015) 614 final.

Geng, Y., Zhu, Q. H., Doberstein, B., & Fujita, T. (2009). Implementing China's circular economy concept at the regional level: A review of progress in Dalian, China. *Waste Mangement, 29,* 996–1002.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114,* 11–32.

Heck, P. (2006). Circular economy related international practices and policy trends: Current situation and practices on sustainable production and consumption and international circular economy development policy summary and analysis. Institut für angewandtes Stoffstrommanagement (IfaS).

Hicks, C., & Dietmar, R. (2007). Improving cleaner production through the application of environmental management tool in China. *Journal of Cleaner Production, 15,* 395–408.

https://economictimes.indiatimes.com/articleshow/70228635.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst.

https://www.ellenmacarthurfoundation.org/circular-economy/concept/schools-of-thought.

Kantar World Panel. (2017). The future of e-commerce in FMCG.

Mitchell, P. (2015). Employment and the circular economy—Job creation through resource efficiency in London. Report produced by WRAP for the London Sustainable Development Commission, the London Waste and Recycling Board and the Greater London Authority.

Preston, F. (2012). *A global redesign? Shaping the circular economy*. Briefing Paper, London: Chatham House.

Rizos, V., Tuokko, K., Behrens, A. (2017). The circular economy: A review of definitions, processes and impacts. Centre for European Policy Studies, European Union's Horizon 2020 research and innovation Programme under Grant Agreement No. 730316.

Sauvé, S., Bernard, S., & Sloan, P. (2016). Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. *Environmental Development, 17,* 48–56.

Schroeder, P., Anggraeni, K., & Weber, U. (2018a). The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology*. https://doi.org/10.1111/jiec.12732.

Schroeder, P., Anggraeni, K., & Weber, U. (2018b). The relevance of circular economy practices to the sustainable development goals: Circular economy and SDGs. *Journal of Industrial Ecology*. https://doi.org/10.1111/jiec.12732.

spcadavance.com. (2015).

Su, B., Heshmati, A., Geng, Y. & Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production, 42*, 215–227.

Towards the Circular Economy. (2013). Economic and business rationale for an accelerated transition. Ellen MacArthur Foundation.

Vanner, R., Bicket, M., Withana, S., ten Brink, P., Razzini, P., van Dijl, E., et al. (2014). Scoping study to identify potential circular economy actions, priority sectors, material flows & value chains. Study prepared for the European Commission, DG Environment.

Yuan, Z. W., et al. (2006). The circular ecology: A new development strategy in China. *Journal of Industrial Ecology, 10,* 4–8.

The Development of a Circular Economy in Australia

P. S. M. Vaughan Levitzke

1 Background

Elements of the circular economy have been in play for many years in Australia. These elements have included cleaner production programmes, waste to landfill levies (tax on landfill disposal), collection and recycling of household packaging and paper, metals recycling, regional waste strategies, infrastructure planning and investment, waste and recycling legislation and other regulatory interventions under state-based environment protection acts.

However, unlike Europe, where measures to transition towards a more circular economy have gained considerable momentum and mandated through EU directives, Australia has been more cautious and limited by much smaller dispersed population centres and dependence on materials extraction through mining. Although it has a well-developed advanced manufacturing sector, the economy has a greater reliance on agriculture, forestry and mining activities, which are largely export-oriented. Australia's consumer market is also highly dependent on imported goods.

In addition, the Australian Constitution vests in the states' responsibilities for environmental issues. Therefore, state-based policies and governance models have become more important, and these are linked to the environment and economic activity in regions. This results in various approaches in different states, with some common elements and some quite different or novel approaches. Some states are arguably more advanced than others in these aspects.

Most Australia states and territories have waste strategies and quite recently implemented container deposit systems. Notably, South Australia was first to do so in 1977, followed by the Northern territory in 2012. New South Wales introduced a scheme in 2017, Queensland in 2018, the Australian Capital Territory also in 2018, Western Australia will have a scheme operational in 2020 and Tasmania has announced

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https://doi.org/10.1007/978-981-15-1052-6_2

its intention to have a scheme in 2021. Victoria is the only Australian state to not yet commit to a scheme. Most states also have waste levies, where a tax on landfill disposal is imposed (exceptions are Tasmania, the Australian Capital Territory and Northern Territory, and however, some of these are as of 2019 reviewing that position). These levies, through hypothecation, are often used to fund investment with the private sector and local government in infrastructure to enable collection and sorting of recyclable materials and to enable post-processing materials into secondary products.

It is fair to say that all states and territories are also considering circular economy policies or actions and are at different stages of development and implementation. In addition, more recently in response to China's decision to restrict the importing of mixed plastics and fibre (China's National Sword Policy), Australia has been made more aware of the opportunities a circular economy may provide, and a number of new initiatives at a national level and at state level have been implemented as a response.

The significant reduction in certain recycled exports to China and the downturn for prices paid for recycled materials globally has sent a clear message to the Australian waste and recycling industry and governments. It is recognised that to overcome the problem, more emphasis has to be placed on the following:

- Creation and diversification of markets locally through product development and testing and recycled content procurement.
- Education of consumers to reinforce the need for increased and better recycling (i.e. less contamination) and their engagement to enable better outcomes.
- Contamination reduction in recycled material to enable it to be used both locally and internationally in new products.
- Investment in new state-of-the-art technology to better sort and process recyclables.

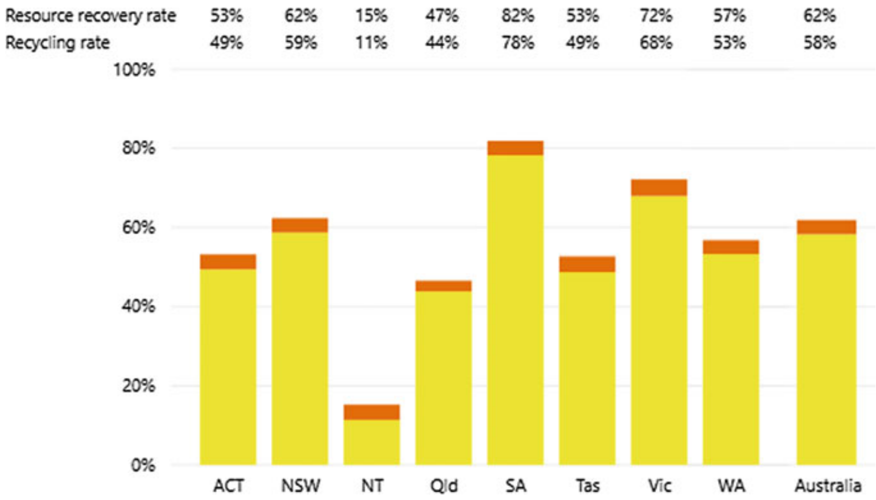
Recycling and waste industry associations have also been calling on the Commonwealth and state governments for more integrated policy development, stronger leadership and action to develop circular economy policies and actions.

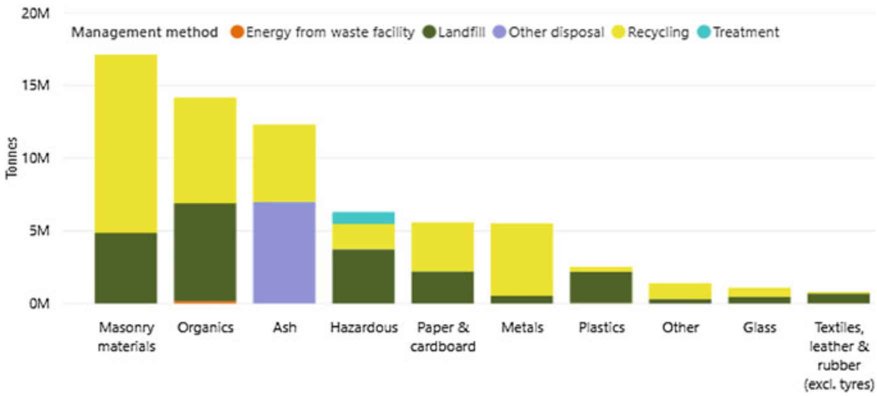
This chapter does not attempt to summarise all of the activity in Australia, but to highlight some of the key actions and initiatives which are shaping the current landscape for circular economy activities.

[1]

[1]National Waste Policy 2019 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=2ahUKEwiPtfbdiOjiAhVRJHIKHQZPB3sQFjAJegQIBhAC&url=https%3A%2F%2Fwww.environment.gov.au%2Fsystem%2Ffiles%2Fresources%2Fd523f4e9-d958-466b-9fd1-3b7d6283f006%2Ffiles%2Fnational-waste-policy-2018.docx&usg=AOvVaw1-kfKNtN07Zj7ACd3PBDYE.

2 Recycling and Waste Management in Australia 2016–2017[2]





3 Australia's Waste 2016–17

The 2018 report, reproduced Table 1 is a summary of each Australian jurisdiction's policy settings in relation to waste management.

[2]https://www.environment.gov.au/system/files/resources/7381c1de-31d0-429b-912c-91a6dbc83af7/files/national-waste-report-2018.pdf.

Table 1 Summary of Australian state and territory circular economy and waste policy initiatives

	Landfill levy (2016–17)—In $ Australian	Strategy document(s)	Targets to increase recovery rate	Other (incl. landfill bans)
ACT	MSW C&I Mixed C&I with >50% recyclable material $90.55/t Municipal Solid Waste $146.20/t Construction and Demolition waste $199.20/t Mixed C&I waste Not a landfill levy as ACT owns the landfill and sets fees	*ACT Waste Management Strategy: Towards a sustainable Canberra 2011–2025*	Waste generation grows less than population. Expand reuse of goods. Waste sector is carbon neutral by 2020. Double energy generated from waste. Recover waste resources for carbon sequestration Recovery rate increases to over: • 85% by 2020 • 90% by 2025	Landfill ban on computers and televisions. Container deposit system for beverage containers introduced in 2018

(continued)

Table 1 (continued)

	Landfill levy (2016–17)—In $ Australian	Strategy document(s)	Targets to increase recovery rate	Other (incl. landfill bans)
NSW	Metropolitan area $144/tonne Regional area 79.60/tonne Virgin excavated natural material, Shredder floc and Coal washery rejects have a range of levies	*NSW Waste Avoidance and Resource Recovery Strategy 2014–21* A new 20-year waste strategy is being developed (2019–2020) A Circular Economy Policy document has been developed and released (2019) A Circular Economy Innovation Network has been launched through the Office of the Chief Scientist to bring together stakeholders from academia, government, industry and not for profit sector (2019)	By 2016–17, reduce litter items by 40% compared with 2011–12 then continue to reduce to 2021–22. Also by 2021–22: • reduce waste per capita • reduce illegal dumping in Sydney and the Illawarra, Hunter and Central Coast regions by 30% • establish baseline data to develop additional targets By 2021–22, increase recycling rates for: • Municipal Solid Waste (MSW) from 52% (in 2010–11) to 70% • Commercial and Industrial (C&I) waste from 57% to 70% • Construction and Demolition (C&D) waste from 75 to 80%	Hazardous waste tracking system in place Container deposit scheme on beverage containers introduced in December 2017
NT	No landfill levy	*Waste Management Strategy for the Northern Territory 2015–2022*	No specific targets are included in the strategy	Container deposit scheme for beverage containers in place since 2016

(continued)

Table 1 (continued)

	Landfill levy (2016–17)—In $ Australian	Strategy document(s)	Targets to increase recovery rate	Other (incl. landfill bans)
Qld	Landfill levy introduced in March 2018 of $70/tonne, effective July 2019	*Waste—Everyone's responsibility: Queensland Waste Avoidance and Resource Productivity Strategy (2014–2024)* A Circular Economy platform is being developed by the Queensland government and consultants with major companies participating[a]	By 2024: • reduce waste per capita by 5% • reduce waste to landfill by 15% • improve management of problem wastes (specific targets to be developed) By 2024, increase: • state average MSW recycling rate to 50% (from 33% in 2012–13) • C&I recycling rate to 55% (from 42%) • C&D recycling rate to 80% (from 61%)	Hazardous waste tracking system in place
SA	Metropolitan Adelaide $110/tonne Non-metropolitan Adelaide (50%) $51.50/tonne (100% discount currently in place for asbestos; smaller discount for shredder floc from metal recyclers and charities from July 2019) $110/t for Adelaide metropolitan area and $55/t for regional areas	*South Australia's Waste Strategy 2015–2020* A new 5 year strategy is being developed for 2020–2025	35% reduction in landfill from 2002–03 level by 2020 (30% by 2017–18-achieved). 5% reduction in waste generation per capita by 2020 (from 2015 baseline) For metropolitan Adelaide: • MSW landfill diversion of 70% by 2020 • C&I diversion of 80% by 2020 (Achieved 2018) • C&D diversion of 90% by 2020 (Achieved 2017) Non-metropolitan waste—maximise diversion for MSW, C&I and C&D	Landfill bans on a wide range of hazardous, problematic and recyclable materials, including most e-waste, whole tyres, separately collected recyclables etc. Container deposit scheme for beverage containers in place (since 1977). Currently being reviewed to improve and expand scheme Hazardous waste tracking system in place

(continued)

Table 1 (continued)

	Landfill levy (2016–17)—In $ Australian	Strategy document(s)	Targets to increase recovery rate	Other (incl. landfill bans)
Tas	Voluntary levy adopted at levels of $0 to $5/t at the time of writing	*The Tasmanian Waste and Resource Management Strategy*	No quantified targets are included in the strategy	Container deposit scheme announced to be implemented by 2022
Vic	Metro and regional: • MSW $65.90/t • C&I and C&D $65.90/t • Rural: MSW $33.03/t • C&I and C&D Prescribed industrial waste: • Cat B $250/t • Cat C $70/t • Asbestos $30/t $53.35/t $250/t $70/t $30/t	*Statewide Waste and Resource Recovery Infrastructure Plan 2015–44* A new Waste Strategy is under development and links to Circular Economy	No numerical targets are included in the plan	Landfill bans on paint, industrial transformers, grease trap, used oil filters, whole tyres and large containers Landfill ban on e-waste from July 2019 Hazardous waste tracking system in place
WA	All solid waste $70/t	*Western Australian Waste Strategy: Creating the Right Environment* (March 2019)	Landfill diversion: • 10% waste reduction per capita by 2025 and 20% by 2030 • Material recovery 70% by 2025 and 75% by 2030 Only 15% of waste to be landfilled by 2030 Only residual waste to Waste to Energy by 2020	Hazardous waste tracking system in place

Source Australian National Waste Report 2016
[a]http://statements.qld.gov.au/Statement/2019/2/25/australian-first-circular-economy-lab-opens

4 A National Waste Policy

The Commonwealth Government with all states and territories is currently (2019) working on a new National Waste Policy document (the last one dates from 2009) and various other initiatives that will support change, including agreeing to targets for packaging recycling. The first part of the policy has been developed and publicly available in late 2018 and is available online;[3] however, the targets for specific waste streams and implementation components remain a work in progress and could be expected to be released later in 2019. The policy strongly references circular 73 economy principles. It states '*New products and new technologies are changing the way we create and manage materials. Changing international markets are affecting the final destinations for recycled materials. Together, this means that improving Australia's domestic resource recovery capacity and sustainable consumption is critical. A hypothetical five per cent improvement in efficient use of materials across the Australian economy could benefit Australia's GDP by as much as $24 billion.*[4]

The 2018 National Waste Policy embodies a circular economy, shifting away from "take, make, use and dispose" to a more circular approach where we maintain the value of resources for as long as possible.

Australia is moving towards a circular economy, with businesses and governments recognising the opportunities waste materials provide and the economic value they retain. This move is also happening across the globe, including in the European Union, Canada, and Australia's major trading partners, including China.

By working together to improve waste management, we can create opportunities for jobs, protect the environment and better manage valuable and finite resources'.[5]

The document goes on to spell out the five principles of a circular economy as:

1. *Avoid waste*:
   - *Prioritise waste avoidance, encourage efficient use, reuse and repair*
   - *Design products so waste is minimised, they are made to last and we can more easily recover materials.*
2. *Improve resource recovery*:
   - *Improve material collection systems and processes for recycling*
   - *Improve the quality of recycled material we produce.*
3. *Increase use of recycled material and build demand and markets for recycled products.*
4. *Better manage material flows to benefit human health, the environment and the economy.*

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[3] https://www.environment.gov.au/protection/waste-resource-recovery/publications/national-waste-policy-2018.

[4] Centre for International Economics, Final report: Headline economic value for waste and materials efficiency in Australia, 27 October 2017.

[5] https://www.environment.gov.au/protection/waste-resource-recovery/publications/national-waste-policy-2018.

5. *Improve information to support innovation, guide investment and enable informed consumer decisions.'*[6]

5 Other National Activity

5.1 A National Food Waste Strategy

Australia's National Food Waste Strategy was launched on 20 November 2017.[7] The national strategy aims to halve Australia's food waste by 2030 and establishes a framework to support actions that achieve this outcome. It was developed through consultation with food charities, the food industry, universities, local government and state governments.

The strategy contributes towards global action on reducing food waste by aligning with Sustainable Development Goal 12—ensures sustainable consumption and production patterns[8] and helps give effect to Australia's obligations under the United Nations Framework Convention on Climate Change[9] to reduce greenhouse gas emissions, primarily through the diversion of food waste from landfill.

The strategy states that '*Food waste is estimated to cost the Australian economy $20 billion each year, as well as significant impacts on the environment through the wasted use of resources such as land, water, labour, energy and fuel to produce and distribute food. When disposed of in landfill, food waste has other environmental impacts e.g. the production of greenhouse gas emissions*'.[10]

The strategy goes on to state that '*the volume and value of wasted food presents a number of opportunities to identify where the greatest benefits can be achieved in avoiding food waste or where it can be repurposed. This approach is consistent with the idea of a circular economy where resources are kept in use for as long as possible while also minimising negative impacts*'.[11]

In Australia, there is already a significant amount of work underway to target food waste that is making a difference locally, regionally and nationally. The Love Food Hate Waste campaign which has been implemented in NSW and Vic has improved food waste diversion by 23% away from landfill. Household food waste is also collected in organics bins with garden waste and composted across many councils in Australia. Organics collection from food manufacturing, restaurants, office buildings

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[6] ibid.

[7] http://www.environment.gov.au/protection/waste-resource-recovery/publications/national-food-waste-strategy.

[8] https://sustainabledevelopment.un.org.

[9] https://unfccc.int.

[10] http://www.environment.gov.au/protection/waste-resource-recovery/publications/national-food-waste-strategy.

[11] ibid.

and food courts is increasing in some jurisdictions such as SA, Vic and NSW. The national strategy seeks to leverage these efforts and identifies four priority areas where improvements can be made—policy support, business improvements, market development and behaviour change.

6 Product Stewardship

Australia has three pieces of national legislation establishing product stewardship schemes, including the:

- *Product Stewardship (Oil) Act 2000*
- *Product Stewardship Act 2011*
- National Environment Protection (Used Packaging Materials) Measure 2011.

7 Product Stewardship for Oil[12]

The product stewardship for oil scheme was established in 2001 and has supported the establishment of an oil recycling industry in Australia. A levy of 8.5 cents per litre of new oil imported or manufactured in Australia is collected through the tax and customs systems. Benefits of up to 50 cents per litre are payable through the tax system for recycling of oil, with the highest rate of benefit payable for re-refining of oil such that it is suitable for reuse as lubricating oil.

More than 275 million litres of recycled oil are now being produced under the scheme.

8 Product Stewardship Act 2011[13]

The *Australian Product Stewardship Act 2011* recognises that each product, material and industry, is unique. Products and materials are addressed as the need arises, for example, to keep step with Australia's international obligations on managing certain types of waste, or by virtue of common agreement that certain products need attention because of such things as strong public interest, high pollution potential or lack of recycling options.

Industry sectors and products can be regulated in several ways, while also making provision for voluntary activities, these are explained further below.

[12] http://www.environment.gov.au/protection/used-oil-recycling/product-stewardship-oil-program.

[13] https://www.legislation.gov.au/Details/C2012A00197/Html/Text.

The Act sets out governance arrangements, including reporting and audit requirements for organisations delivering product stewardship schemes and powers of the Australian Government, comprising compliance, enforcement and penalties.

Voluntary accreditation encourages product stewardship without regulation. Accredited arrangements do, however, need to manage their activities in a transparent and accountable manner and, so doing, provide confidence to the community that the arrangements are achieving what they claim to be.

Two voluntary schemes have been accredited so far:

- *Mobile Muster*, through which the mobile telecommunications industry funds the recycling of mobile telephones; and
- *FluoroCycle*, under which commercial users of mercury-containing lamps commit to recycling lamps at end of life and reporting on recycling rates.

The Act also provides for products to be identified as priorities for work by industry and government. Voluntary schemes dealing with tyres and paint have been established in this way. Paintback, a national scheme to collect and treat used paint, and is funded by a 15c per litre levy on new paint was launched in 2016. Tyre Stewardship Australia collects fa levy on new tyres and provides funding to research and market development for rubber crumb and associated products.

Other products which have gained attention for future schemes include batteries and photovoltaic panels.

Co-regulatory schemes are delivered by the industry sector and regulated by the Australian Government. The regulations specify outcomes to be achieved and identify the liable responsible parties. All identified liable parties acquit their responsibility by joining a co-regulatory arrangement, which delivers the outcomes on their behalf.

The National Television and Computer Recycling Scheme of 2011 is the only co-regulatory product stewardship scheme regulated under the Act and specifies outcomes relating to collection and recycling of waste televisions and computers and identifies importers and manufacturers as the liable parties. Co-regulatory arrangements are also required to manage occupational work health and safety requirements, environmental performance and other related issues.

Mandatory product stewardship places a legal obligation on liable parties to take certain actions in relation to a product, possibly including labelling, arrangements for recycling products, or requiring a deposit and refund to be applied to a product or even banning certain substances or materials from use in products.

There are currently no mandatory product stewardship schemes in Australia.

9 The Australian Packaging Covenant[14]

Beginning in 1999, the Australian Packaging Covenant has been the national producer responsibility measure to manage impacts of post-consumer packaging. It attempts

[14]https://www.packagingcovenant.org.au.

to optimise the resource recovery of Consumer Packaging through the supply chain and prevent impacts of litter on the environment.

It is an industry-led of a co-regulatory arrangement underpinned by the National Environment Protection (Used Packaging Materials) Measure 2011 (NEPM).

The Covenant currently applies to businesses in a supply chain that are consumers of packaging or packaged products with an annual turnover of $5 million or more. Liable businesses are required to choose between becoming a signatory to the Covenant, or meet their obligations under the NEPM through laws of states and territories.

Newly developed targets for the packaging industry have been committed to by the industry and governments. These are as follows:

1. 100% of all Australia's packaging will be reusable, recyclable or compostable by 2025 or earlier
2. 70% of Australia's plastic packaging will be recycled or composted by 2025
3. 30% average recycled content will be included across all packaging by 2025
4. Problematic and unnecessary single-use plastic packaging will be phased out through design, innovation or introduction of alternatives.[15]

In addition to the targets, a new Australasian Recycling Label scheme is being adopted voluntarily by brand owners. Developed in 2018 by Planet Ark and APCO, and known as ARL, it tells customers what to do with the used packaging, i.e. into which bin it should be placed. The label is based on the PREP software tool which informs brand owners of the recyclability (or otherwise of their packaging. Finally, Australia has a tool that influences design and a label that informs consumers.

10 Academic and National Research Agendas on Circular Economy

Many Australian universities have been placing greater emphasis on sustainable practices and researching ways to produce materials and products more efficiently or to recover materials from waste streams. Much of this research remains largely untapped, i.e. not yet commercialised. The Australian Commonwealth Science and Research Organisation (CSIRO) has recently begun working in partnership with universities to begin developing materials flow analysis and modelling that would give greater understanding of what is currently happening with materials flows in the Australian economy, juxtaposed to what perhaps should be happening or could be happening if we were to be more circular.

OneSteel, a major steel producer in Australia, takes carbon from waste tyres with coke to use in electric arc furnaces and was invented by Laureate Professor

[15]ibid.

Veena Sahajwalla and her team at the Centre for Sustainable Materials Research and Technology (SMaRT) at the University of New South Wales.[16]

Commercialisation of innovation is gaining greater attention in the tertiary education sector, and circular economy is gaining more interest as part of this.

11 A Case Study for the Circular Economy—South Australia

A circular economy[17] builds upon the 'reduce, reuse, recycle' waste hierarchy that has been largely adopted in South Australia and other states and territories in Australia for the past decade.

In 2017, Green Industries South Australia commissioned Lifecycles in a joint venture with EconSearch, Colby Industries and the University of Queensland to investigate the potential benefits of a circular economy in South Australia. The report, *Creating Value, the Potential Benefits of a Circular Economy in South Australia*[18], measures the possible impacts of a more circular economy in South Australia. The report affirms South Australia's achievements in recycling and recovery of solid waste and its current focus on the development of a low carbon economy.

Employment opportunities associated with developing aspects of a more circular economy are highlighted. It estimates the environmental and social impacts of a more circular economy by assessing 2030 greenhouse gas emissions and employment outcomes in South Australia. The report uses well-recognised macro-economic modelling using an environmentally extended input-output model of the South Australian economy.

The model depicts the interdependencies between 78 sectors, showing how input from one sector may become an input to another. Assumptions and modelling techniques were reviewed by an international panel of circular economy experts. To assess material flows and energy use in South Australia, the circular economy is regarded as consisting of two elements—'material efficiency' and 'renewable and energy efficiency'.

To quantify the greenhouse gas emissions and employment impacts of moving to a more circular economy, assumptions are made relating to 'material efficiency' and 'renewable and energy efficiency' aspects.

These assumptions involve how long materials stay in use in South Australia, energy efficiency levels and the replacement of fossil fuel by renewable energy. For interpretation, results are referenced to a 'Business as Usual' scenario which assumes current state growth projections to 2030.

[16] https://www.csiro.au/en/Research/MRF/Areas/Resourceful-magazine/Issue-08/What-goes-around-comes-around---towards-a-circular-economy.

[17] *Creating Value, the Potential Benefits of a Circular Economy in South Australia*, www.greenindustries.sa.gov.au/circular-economy.

[18] www.greenindustries.sa.gov.au/circular-economy.

While the report's release appears to be well received by business, government and the community, the opportunities of a more circular economy for South Australia do need to be more specifically understood if interventions are to be championed and delivered. The report has stimulated other similar investigations in Australia, including New South Wales "Advantage NSW—Creating value in the Circular Economy"; and "Too Good to Waste"—a discussion paper on circular economy approach for NSW (October 2018).

Meanwhile, South Australia has further developed its circular economy credentials by drawing upon local examples of businesses and policies which form the nucleus of its Global Leadership Program on Circular Economy.[19] These case studies/ examples include:

- construction and demolition waste recovery and recycling (more than 90% of C&D waste is recycled in SA)
- refuse derived fuel used to replace natural gas for cement kilns (approx. 110,000 tonnes per annum are used in this manner)
- container deposit legislation, where a refundable 10c deposit is placed on certain beverage containers
- recycling of water resources from sewage treatment plants to use in horticulture
- rain water harvesting and aquifer recharge for use in manufacturing
- renewable energy developments—this includes the world's largest virtual power plant, the world's largest lithium-ion battery installation and will likely reach 75% by 2025
- identification and commercialisation of innovation pathways, and
- evidence-based public education and engagement activities.

Supported by the United Nations Centre for Regional Development, it is a unique initiative which presents practical case studies for experimental learning, knowledge sharing and adoption.

There are many businesses in South Australia actively working in the circular economy area, from composting operations to water utilities, electronics and the construction and demolition industry. It also has highly developed intellectual property across these industry sectors and a base of consultants that assist in actioning circular economy training as well as implementation at the business level. There is a growing willingness for SMEs to consider circular improvements, ranging from food and beverage sector to larger, more iconic companies. Some have seen the business case for circularity and are quietly implementing the changes.

A national conference on the circular economy held in Adelaide annually has attracted participants from across the globe. Organised by Powering the Change, businesses, policy makers and researchers compare approaches and case studies for the development of a circular economy.[20]

[19] See https://www.greenindustries.sa.gov.au/leadership-program.

[20] https://www.poweringthechange.org.au.

12 Waste Management in South Australia

The circular economy is enshrined in the *Green Industries Act 2004*. The Act also establishes a fund, governance arrangements for the statutory authority Green Industries SA.[21]

The governance arrangements for Green Industries include the establishment of a skill-based board, the powers and functions of Green Industries SA and a requirement to prepare an annual business plan. It also establishes the South Australian Waste Strategy (nominally every five years) which must be regarded in establishing policy and regulation, for example, the Environment Protection Authority. The Green industries Fund is used to fund the agency as well as invest in infrastructure, community education, data collection and other activities with local government and industry.

Each year, a Recycling Activity Survey is undertaken by Green Industries SA. This has recorded data from industry going back to 2003.[22] The results of the Survey undertaken in 2016–17 show that South Australia diverted 83.4% of all waste generated, equating to 4.401 million tonnes of material diverted from landfill (see Table 2). The long-term trend for resource recovery in South Australia remains upwards. In the period since 2003–04 (baseline), the total reported resource recovery has increased from 2 million to just over 4.4 million tonnes a year; and the diversion rate has increased by nearly 22 percentage points over this period.

Table 2 Summary of 2016–17 Recycling Activity results for resource recovery, landfill disposal, total waste generated and total diversion (waste to resource recovery) achieved in SA

	2016–17 Recycling Activity Data Account Summary		
	Standard reporting materials[a]	Separately reported materials and clean fill[b]	Total (all materials)
Resource recovery, tonnes	2.880 million	1.521 million	4.401 million
Landfill disposal, tonnes	0.739 million	0.134 million	0.873 million
Waste generated, tonnes	3.619 million	1.655 million	5.274 million
Diversion, % to resource recovery	79.6%	91.9%	83.4%

[a]Standard reporting materials and separately reported materials and clean fill, as specified in Dept of Env and Energy (2015)
[b]Total waste generated = Resource recovery + landfill disposal

[21]https://www.legislation.sa.gov.au/LZ/C/A/GREEN%20INDUSTRIES%20SA%20ACT%202004/CURRENT/2004.1.AUTH.PDF.

[22]https://www.greenindustries.sa.gov.au/SArecycling.

With reported recycling rates among the best in the world, South Australia is a leading example of turning policy into action. It was internationally recognised in 2010 in the UN-Habitat report on *Solid Waste Management in the World's Cities*. In addition to container deposits, it banned plastic bags in 2009 (other Australian jurisdictions are following) and banned a number of problematic wastes from landfill, including e-waste.

13 The Important of a Plastics Circular Economy

Recent policy announcements by the South Australian government include the following:

Single-use plastics are attracting considerable local, national and international interest, and the South Australian community has increasingly been calling for action on items such as plastic bags, coffee cups and polystyrene. In January and February 2019, Green Industries SA undertook consultation and engagement to understand the attitudes and opinions of South Australians on this topic.

The '*Turning the tide on single-use plastic products*' discussion paper sought to further the public conversation around a range of single-use plastic products that are impacting our environment. Community feedback was overwhelmingly positive and the government has announced its intentions to phase out plastic straws, cutlery, and stirrers, with take-away expanded polystyrene cups and trays after 12 months. A multi-stake holder task force has also been appointed.[23]

Significant effort has also been placed in improving the fate for waste plastics in South Australia. A major investment of $3m has played a significant role in establishing a new state of the art 40,000 tonnes per annum mixed plastics recycling centre in Adelaide. Nearby industries that manufacture plastic lumber have also been supported, and use the pelletised material in their products. Work is underway to improve market acceptance of recycled plastic lumber in engineering projects. This demonstrates a circular economy in action for the plastics industry. Further investments are planned for this sector, which will provide improved capacity for more recycled plastic polymer material to find its way to engineered and fit for purpose products.

14 Conclusion

As stated in the introduction, elements of the circular economy have been in play in Australia for many years. This is seen in the emphasis on material recovery in the recycling and compost industries, resource efficiency for business in water, waste and energy and reductions in waste to landfill and increasing recycling rates. These

[23] https://www.greenindustries.sa.gov.au/priorities/plastics.

are the initial elements of a more circular economy, but without necessarily being described as 'circular economy' action.

To build momentum there is much more work required—from the development of case studies to establish an evidence base to establishing partnerships with business to pilot a circular economy approaches, and undertaking sector-by-sector analyses to identify the opportunities involved in transitioning towards a circular economy: … *effective Circular Economy policymaking requires the combination of many policy interventions, and does not rely on a 'silver bullet' or blanket solutions*.[24]

[24] https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_PolicymakerToolkit.pdf.

Solid Waste Management in Kabul

Hamidullah Nikzad

1 Introduction

Many developed countries have made great strides in addressing waste management, particularly since the environment came onto the international agenda in the 1960s, and there are many good practice examples available for the international community to learn from.

However, the initial focus was on waste after it had been discarded, whereas now attention has moved upstream, addressing the problem at its source through, for example, designing out waste, preventing its generation, reducing both the quantities and the uses of hazardous substances, minimizing and reusing, and, where residuals do occur, keeping them concentrated and separate to preserve their intrinsic value for recycling and recovery, and preventing them from contaminating other waste that still has economic value for recovery.

Low- and middle-income countries still face major challenges in ensuring universal access to waste collection services, eliminating uncontrolled disposal, and burning and moving towards environmentally sound management for all waste. Addressing these challenges is made even more difficult by forecasts that major cities in the lowest income countries are likely to double in population over the next 20 or so years, which is also likely to increase the local political priority given to waste issues. Afghanistan, as one of the low- and middle-income country, is facing major challenges in ensuring universal access to waste collection services, eliminating uncontrolled disposal, and burning and moving towards environmentally sound management for all wastes. Kabul City, as the capital city of Afghanistan, has more than 4.5 million populations in it, and it makes difficulties on the waste management activities in this city. In this chapter, tried to discover the situation of all kinds of solid waste management in the Kabul capital city of Afghanistan.

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S. K. Ghosh (ed.), *Circular Economy: Global Perspective*,
https://doi.org/10.1007/978-981-15-1052-6_3

2 Recycling Mapping

2.1 Introduction

The first activity undertaken was the recycling mapping. The survey conducted by Strong Hubs for Afghan Hope and Resilience (SHAHAR) by interviewing the informal recyclable collectors in different areas across Kabul collecting both recyclables and food waste. During the SHAHAR Survey, advisors visited with multiple different informal recyclers in different locations.

After data collection with multiple informal recyclers, the researcher went to the location where the recyclers were selling the material. The material first went to middle buyers who purchase many types of waste (Nawid Royaee 2014/2016).

After meeting with the middle buyers, the researchers went to the final destination of the different material, mostly located in Districts. Many companies were visited; they are outlined in the section entitled recycling companies.

2.2 Informal Recyclers

The informal recyclers are individuals collecting recyclable material throughout the city, at the transfer station and at the landfill. The main materials they are after are plastic bottles, paper, aluminum cans, metal, leather, bones, and food waste. Some members collect a little bit of each, others focus on just food waste. These collectors work both in groups and individually.

> The average informal recycler in Kabul makes $2.60 USD per day if collecting recyclables and food waste and not working at the transfer station. Informal recyclers working at the transfer station make $3.98 per day. Food waste collectors make around $1.32 per day.

Based on an extensive survey done by SHAHAR, an informal recycler collects on average 57.87 kg per day of material which is mostly sold to middle buyers earning on average 238 Afghani per person/per day. The amount an informal recycler is able to collect depends on the location and type of material they are collecting. Those collecting just food waste earned much less than those collecting a wide variety of recyclable material.

While some of the informal recyclers collect recyclable material and food waste, there are also individuals that focus on just food waste. Food waste can either be sold per kilogram or collected for personal use in feeding a collector's own livestock. Food waste is eaten mostly by cows, sheep, goats, and chickens and consists of wet bread, rice, potatoes, fruit, and vegetables. Out of the informal collectors of food waste,

Fig. 1 Informal recyclers, SHAHAR

most of them made around half as much as recyclers who collected both recyclables and food waste (Hameedullah 2017).

The informal recyclers deliver the material mostly by bicycles to the middle buyers, as it is a low cost and effective delivery mechanism due to heavy traffic in the city. These middle buyers buy the products, congregate them and then resell them to industries at slightly higher fees (Fig. 1).

2.3 Recycling Companies

After the informal recyclers take the waste to the middle buyer, the middle buyers organize with the final users/recycling companies to collect the material. Every company that was visited could recycle significantly more material than they were currently collecting. Table 1 shows the breakdown of the different collectors of material and their uses.

While many different materials are recyclable in Kabul, the buyers mentioned that they do not accept especially dirty material. Plastic, paper, and food waste that is very mixed or dirty are not collected. This shows that further material would be recycled if at-source separation was more prevalent.

As Table 1 shows, most of the recycling is done in Kabul, which creates additional jobs and has added environmental benefits. A wide variety of material has a market throughout the city. We will be breaking down the percentage of waste in Kabul that has a market in another part of this document that deals with the waste audit at the transfer station and throughout different secondary collection points in Kabul.

Table 1 Recycler companies, SHAHAR

Item	Companies	Product
Paper	There are over six different paper companies in Kabul, Nastrin Toilet Paper was visited	Toilet paper
Plastic bottles (PET)	Haji Azizullah Plastic Woolen Company is a plastic bottle	Wool, mattresses, and blankets
Plastic bags (soft plastic)	While we heard about companies buying plastic bags, we could not find one to visit	Plastic bags
Hard plastic (HDPE)	Two companies were visited that recycle hard plastic: Mya Abdul Karim Company, Hewad Plastic Industry, and Bradran Barjgi Pipe company	Made into pellets, pipes, buckets, and other plastic items
Metal cans/scrap metal	There are multiple scrap metal and can buyers. The company visited was named Steel Bar Company	They make the items into steel bars
Aluminium cans	Hayatullah Mohsin Zada Manufacturers buys aluminium cans and other scrap metal	These are made into pressure cookers, cooker pots, and irons
Bones	Chicken feed companies are purchasing the bones	These are crushed and used for chicken feed
Food waste	There are many individuals collecting food waste either for their own animals or to sell to other people keeping livestock	Used to feed livestock
Dry bread	There are many individuals collecting food waste either for their own animals or to sell to other people keeping livestock	Used to feed livestock
Leather	This is purchased both by people who export it and by local shoemakers	Reused or exported

2.4 Companies Visited

The following seven companies were visited:

1. **Mya Abdul Karim Company**: This company is recycling hard plastic into small pellets which are sold to plastic bucket and pipe-making companies located in the same subdistrict. The owner said that they purchase one ton of hard plastic for 15,000 AFN, and after they are turned into pellets, sell it for 20,000 AFN per ton (Fig. 2).

Fig. 2 Recycler hard plastic's company, SHAHAR

2. **Hewad Plastic Industry**: This company is recycling only one type of hard plastic into plastic buckets. They are producing 350 kg of plastic buckets per day. They buy one ton of hard plastic for 30,000 AFN and sell the buckets for 100,000 AFN per ton (Fig. 3).
3. **Steel Bar Company**: This company recycles all types of metal cans and other scrap metal into steel bars. The scrap metal is purchased between 10 and 15 AFNs per kilogram. They also purchase aluminum for 80 AFNs per kilogram. They press the material into bales before making them into steel bars (Fig. 4).

Fig. 3 Recycler hard plastic's company, SHAHAR

Fig. 4 Illustrates the baled scrap metal in the company

4. **Nastrin Toilet Paper**: This company is recycling all types of paper into toilet paper. They said that they can recycle 10 tons of paper per day. They purchase one ton of waste paper for 3,500 AFG. They make the coloured toilet paper from coloured paper and white toilet paper from white paper. They are just one of over nine toilet paper companies in Kabul (Fig. 5).
5. **Bradran Barjgi Pipe Company**: This company is recycling 5 tons of hard plastic per day; they buy a ton of plastic for 35,000 AFN. This is made into pipes (Fig. 6).
6. **Hayatullah Mohsin Zada Manufactures**: This company recycles 150 kg of scrap metal per day; they make pressure cookers, cooker pots, and irons. They buy aluminum for 80,000 AFN per ton. Most products are being sold locally.
7. **Haji Azizullah Plastic Woolen Company**: This company is one of two companies that is recycling plastic bottles—PET. They have a capacity of over 7,000 kg per day but are nowhere close to meeting that capacity. They can not get enough plastic bottles. They make the recycled bottles into wool, mattresses, and blankets. This is quite advanced; many countries do not have this capability.

Fig. 5 Illustrates the collected waste paper from the city for recycling into toilet paper

Fig. 6 Illustrates the process of recycled pellets into pipes

3 Waste Audit at Six Collection Points

The second activity undertaken was the waste audit of six secondary collection points across the city. One of the more difficult tasks that is needed for this waste audit is to assess the actual amount of waste before the intervention of the informal recyclers. If we weigh the waste at the landfill or at the transfer station, chances are some of the most valuable material (plastic bottles, cans, tins, etc.) is already taken out. This gives us inaccurate data of what is actually produced.

Therefore, we need to intervene and weigh the waste going to a collection point in six locations before informal collectors take out material in order to assess how much material is reduced by informal recyclers.

Moreover, it is also important to assess what sector the waste is coming from (residential, industrial, commercial, construction/demolition, institutional, agricultural, or medical). This will help us target different areas for income generation (Fig. 7).

The SHAHAR team went to the following locations on September 10–12 2018:

1. Saloy Markazi—District #4 **(Nahya 4)**, Kabul city
2. Kheweshal Mena—District #5 **(Nahya 5)**, Kabul city
3. Qwaye Markaz—District #2 **(Nahya 2)**, Kabul city
4. Sarak e Antin—District #3 **(Nahya 3)**, Kabul city
5. Sarak e Awal Sarsabzi—District #4 **(Nahya 4)**, Kabul city
6. Sarak e Do Sarsabzi—District #4 **(Nahya 4)**, Kabul city.

Fig. 7 Illustrates the separating of waste at the secondary collection point in Kabul

3.1 Waste Composition

The analyzed data by NEPA auditors in Gazak2 Dumping Site in Kabul on April 2019 shows that more than 32% of waste combined from organic waste. For more information, go to Table 2.

Based on the audit data, the largest items of waste are food waste—31.97%, soil/dirt—18.45%, plastic (plastic bags and other plastic) at 17.26% (Table 3).

Initiatives should be aimed at these four items as they make up 77.36%

You can see the full breakdown in Table 4.

Table 2 Percentage of waste, NEPA

Material	Percentage (%)
Organic waste	32.192
Construction waste	25.32
Plastic	21.964
Textile	12.186
Glass	4.345
Paper	3.300
Metal	0.278

Table 3 Percentage of waste, SHAHAR

Material	Percentage (%)
Food waste	31.97
Soil/dirt	18.45
Plastic (bags and other plastics)	17.26
Paper (cardboard, paper, tetrapak)	9.68

Table 4 Volume and percentage of wastes by areas, SHAHAR

Location	Nahya 4	Nahya 5	Nahya 2	Nahya 3	Nahya 4	Nahya 4		
Type	Kilograms	Kilograms	Kilograms	Kilograms	Kilograms	Kilograms	Total	Percentage (%)
Paper	7	2	1.5	8	4.12	5.22	27.84	4.29
Cardboard	8.5	10	8	2.5	0	0	29	4.47
Tetrapak	2	2	0.5	1.5	0	0	6	0.92
Glass	4	10	1	0	0	0	15	2.31
Plastic bags	18.5	8	I8.5	6	9.17	7.27	67.44	10.39
Other plastic	14	8.5	5.5	7.12	3.41	6.02	44.58	6.87
Aluminium, can/tins	0.8	0.3	0.8	0.3	0.18	2	4.38	0.63
Other metal	1	0.6	1.5	0.8	0	0	3.9	0.60
Food waste	56	18	45	32	28.5	27.9	207.4	31.97
Green waste	6.7	2	0	4.4	0	0	13.1	2.02
Building waste	0	15.5	0	12.5	0	0	28	4.32
Timber/lumber	1	1.5	10	8.5	0	0	21	3.24
Soil and dirt	33	30.5		13.5	16.6	26.1	119.7	18.45
Hazardous waste	0	0	0.2	0	0	0	0.2	0.03
Leather and fabric	3.8	0	0.5	0.5	2.8	7.2	14.8	2.23
Other	16.5	0	16	14	0	0	46.5	7.17
Total	172.8	108.9	109	111.62	64.78	81.71	643.31	

Table 5 Average of wastes by areas, SHAHAR

Type	Nahya 4 (%)	Nahya 5 (%)	Nahya 2 (%)	Nahya 3 (%)	Nahya 4 (%)	Nahya 4 (%)	Average (%)
Residential	20	48	45	61	67	72	52
Commercial	50	47	40	24	33	28	37
Industrial	23	0	0	0	0	0	4
Medical	0	5	9	0	0	0	2
Agriculture	4	0	0	0	0	0	1
Institutional	3	0	0	0	0	0	1

3.2 Waste Producers

The SHAHAR team went further and broke up the waste into different streams. A noted researcher biased for this study was that different locations were chosen that would have a more diverse mix of waste from multiple sectors. There is a lot of variance between Nahyas (districts) and thus this data is difficult to extrapolate. From the collection points chosen, there is one area where more than 72% of the waste comes from residents and another one where only 20% of the waste comes from residents. It is also important to note that this data was collected on Monday, Tuesday, and Wednesday. The percentage coming from residents will likely be much higher during Friday since many businesses and institutions are closed.

This is still able to give us a general idea. As the data states, the majority of waste come from residents, with commercial and then industrial following. There is very little agricultural or medical waste (Table 5).

The first sample from Nahya 4 is a very clear outlier with the location known for its commercial and industrial footprint. Due to this fact, it is important to exclude this when extrapolating across the entire city. A more accurate average for amount of waste coming from residential areas is 58.6%.

During a weekday, around 59% of the total waste in Kabul comes from residents. Since many institutions and businesses are closed on Friday, this rate is likely even higher then.

3.3 Recycling Rates

Lastly, as part of this audit, after the material was separated, the SHAHAR team allowed the informal recyclers to take out the material they would normally remove.

Table 6 General recycling rate of wastes, SHAHAR

Material	Recycling rate (%)
Paper	100
Cardboard	93
Tetrapak	100
Glass	5
Plastic bags	71
Other plastics	97
Aluminum, can/tins	100
Other metal	100
Food waste	13
Green/garden waste	0
Building/demolition waste	0
Timber/lumber	0
Soil and dirt	0
Hazardous and electronic wastes	0
Leather and fabric	0
Other (describe in comments)	0
Total	26

With the intervention from informal recyclers, around 26% of the material was recycled. Paper, aluminum, and metal are almost always recycled. Tetrapak is often taken out as well, but it is used for burning in the house (which is bad for the environment and health of the citizens). Food waste, plastic bags, and cardboard would be recycled at a much higher rate if they were not mixed, as the informal recyclers cannot collect them if they are dirty. Table 6 shows the rate of recycling of each material.

4 Transfer Station

As part of the waste audit, the SHAHAR researchers segregated and weighed a representative quantity of the mixed waste stream at the transfer station to determine the percentage of various waste components, and which items would be taken out for recycling. This also helps identify a percentage recycled rate for the transfer station by breaking down the waste components at the transfer station and in the previous section at the different secondary collection points (Fig. 8).

Fig. 8 Illustrates the separating of waste at the transfer station in Kabul

4.1 Waste Composition

The waste composition at the transfer station is quite comparable to the composition done at the different secondary collection points. It is clear that some of the material is taken out before arriving at the transfer station, but still the top three types of waste remain the same: namely—food waste, soil/dirt, and plastic. Table 7 shows the breakdown of the top six items.

Initiatives that seek to reduce waste to landfill in Kabul should focus on food waste, soil/dirt, and plastic reduction—as these items make up 72% of all waste in the city. The waste composition at the transfer station broke down over 1 ton of waste. Table 8 shows the complete breakdown per kilogram (Fig. 9).

Table 7 Composition of wastes at the secondary collection points, SHAHAR

Material	Percentage (%)
Food waste	41
Soil/dirt	11
Plastic (bags and other plastics)	20
Leather and fabric	8
Paper (cardboard, paper, tetrapak)	7
Other	7

Table 8 Composition of wastes at the transfer station per kilogram, SHAHAR

Type (location)	Kilograms (transfer station)	Percentage of waste (%)
Paper	46.2	4
Cardboard	24.6	2
Tetrapak	9.15	1
Glass	10	1
Plastic bags	195.4	18
Other plastics	17.6	2
Aluminum, can/tins	1.6	0
Other metal	6	1
Food waste	441.1	41
Green/garden waste	33.5	3
Building/demolition waste	0	0
Timber/lumber	0	0
Soil and dirt	119.9	11
Hazardous and electronic wastes	4.2	0
Leather and fabric	89.74	8
Other (describe in comments)	75.5	7
Total	1,074.49	

Fig. 9 Composition of wastes at the transfer station per kilogram

4.2 Recycling Rate at Transfer Station

Just like the audit that took place at the secondary collection locations, the audit team segregated the waste and then allowed the informal recyclers to collect the material for recycling, and the remaining portion was weighed. The transfer station rate of recycling was about half of the rate of recycling in the secondary collection locations

Table 9 Recycling rate of waste components, SHAHAR

Material	Recycling rate (%)
Paper	100
Cardboard	100
Tetrapak	0
Glass	0
Plastic bags	7
Other plastics	100
Aluminum, can/tins	100
Other metal	100
Food waste	4
Green/garden waste	0
Building/demolition waste	0
Timber/lumber	0
Soil and dirt	0
Hazardous and electronic wastes	100
Leather and fabric	0
Other (describe in comments)	0
Total	12

(12% vs. 26%). This had a lot to do with the fact that some of the waste is already taken out before reaching the transfer station.

The other issue is that the food waste and the plastic bags have been mixed during the journey to the transfer station and are more difficult to recover. The audit team also mentioned that the informal recyclers would have taken more material out at the transfer station, but there was more waste than people could handle, so they primarily focused on the higher value material (paper, hard plastic, and aluminum). It is suggested to allow for more informal recyclers at the transfer station (Table 9).

It is difficult to determine a total recycling rate for the city since occasionally the waste may go through both the informal recyclers at a secondary location and the transfer station, and other times it may go straight to the transfer station without any intervention from informal recyclers, so there could be some double counting. To further complicate things, there are also further scavengers at the landfill. This paper will assume that around 38% is recycled regularly, combining the two rates, though this will likely not happen all the time.

Table 10 Per capita waste generation and composition of waste in Kabul, SHAHAR

Strata type	No. of people in household	Weight of waste (kg) (2 days)	Weight of waste (kg) (1 day)	Solid waste (kg/capita/day)
High-income households	1634	2622.6	1311.3	0.81
Middle-income households	1760	2118.2	1059.1	0.61
Low-income households	1911	1549.15	774.58	0.41
Average				0.61
Weighted average				0.45

5 Household Data

Good data has been collected by PhD candidate Ahmad Khoshbeen on per capita waste generation and composition of waste in Kabul with a sample of 600 households in June and July of 2018. Based on the comprehensive research data of Mr. Khoshbeen, high-income households produce nearly twice as much waste per person than low-income households (Table 10).

Most estimates of Kabul residents state that 80% of households are living in informal areas and are thus low-income households. For the weighted average, we estimated that 5% of residents in Kabul are high-income households, 10% are middle income, and 85% are low income. These are estimates based on available data, but should be further explored.

Mr. Khoshbeen also did a detailed waste composition. The data he found is similar to the composition of the waste from the SHAHAR audits—both the secondary collection and the transfer station audit. The only material that is missing is soil/dirt, which is not categorized in his study. This is probably due to the fact that the large quantity of soil/dirt is coming from sweeping the streets and/or construction sites (Table 11).

6 Landfill

Fortunately, the Ghazak 2 landfill in Kabul has a weighbridge making it easy to find the amount of waste going to the landfill on a daily/monthly basis.

Based on data from the Sanitation Division of Kabul Municipality, the landfill receives on average 1,415.79 tons of waste per day from 208 trucks. This is 43,889.68 tons per month or 516,765.54 tons per year. This is around 0.31 kg per person per day if Kabul has an estimated population of 4.5 million (Fig. 10) (Kabul Municipality).

This will now be compared to the other data in order to establish an estimate of total waste collection in Kabul (Fig. 11).

Table 11 Household waste composition in Kabul, SHAHAR

Material	Percentage (%)
Food waste	49
Plastic (bags and other plastics)	17
Paper (cardboard, paper, tetrapak)	20
Aluminum cans	4
Glass	3
Green waste	2
Textile	1
Hazardous	2
Inert	1

Date	Number of Vehicles	Total Waste transferred (tonnes)
15-09-18	222	1,531.04
16-09-18	326	2,227.94
17-09-18	321	1,605.46
18-09-18	283	1,733.78
19-09-18	270	1,678.88
20-09-18	95	571.68
21-09-18	50	307.61
22-09-18	189	1,307.68
23-09-18	252	1,630.76
24-09-18	283	1,594.84
25-09-18	210	1,658.71
26-09-18	267	1,767.06
27-09-18	234	1,627.60
28-09-18	89	602.06
29-09-18	247	1,623.05
30-09-18	186	1,402.31
01-10-18	230	1,583.64
02-10-18	239	1,679.16
03-10-18	224	1,607.05
04-10-18	243	1,670.40
05-10-18	83	606.00
06-10-18	199	1,497.24
07-10-18	228	1,659.40
08-10-18	209	1,517.33
09-10-18	216	1,512.66
10-10-18	218	1,558.17
11-10-18	232	1,722.58
12-10-18	62	371.98
13-10-18	109	837.54
14-10-18	222	1,520.95
15-10-18	208	1,675.15
Total	6,446	43,889.68
Average	207.9355	1,415.79

Fig. 10 Number of vehicle for waste transfer in Kabul

Fig. 11 Gazak landfill site, Kabul

Based on the household data, the average person creates 0.45 kg of waste per person per day. This is assuming that a weighted average of 5% of residents in Kabul are high-income households, 10% are middle income, and 85% are low income.

However, on the above waste audit on six collection points, we note that only 58.6% of waste is coming from residential areas during weekdays, meaning a full 41.4% is coming from commercial, industry, agriculture, medical, or institutional. To make this more complicated, while residents continue to produce waste during the weekend (Friday is the main day off in Kabul), most institutions, businesses, and industries do not. Therefore, we can assume that waste per person on Friday will drop by an estimated 41.4%. This is generally accurate with accepted literature on waste in developing countries.

Therefore, household data represents only 58.6% of the total waste created six days per week and 100% one day per week. When the waste from all other sectors is added and weighed based on this, the total waste per person is around 0.71 kg per person per day.

Since there are an estimated 4.5 million people in Kabul, this would mean that around 3,195 tons are created per day. Out of that as much as 38% is recycled, leaving 1,980.9 tons. If the landfill is collecting on average 1,415.79 tons per day, that means the 71% of the waste in the city that is being produced and not recycled/reused is being collected and taken to the landfill.

As much as 29% of the total waste in Kabul is not being collected and taken to the landfill. Instead, it is being burned, buried, or illegally dumped.

7 Medical and Medicinal Waste

The collected information before year 2012 shows that only low volumes of pharmaceutical wastes are being managed and it is maybe about 75 tons in total. This operation does not normally include all waste of medicines, so this is incomplete information all over the country.

In general, it is believed that the amount of waste products currently collected is not from the official supply chain of private sector and governmental organizations and is primarily a poor quality and counterfeit that has been recorded by the Ministry of Public Health is wiped off the market and the country's entry points. For example, in 2008, about 300 tons have been reported that this amount of waste will require four times the current storage for central storage of medicines; if these figures are true, it only shows the amount of garbage collected one day of the cable.

The World Health Organization (WHO) suggests that if the medicinal wastes are to be wasted, should burned in heat above 1200 °C, the commercial combustion price for every 4.1 kg of materials is about 2.2 USD. Therefore, this is a very high price process in Afghanistan (3R Country Report, 2016–2021).

About healthcare waste management, major government and large private hospitals are sorting their waste and handling it by incineration and proper safe disposal. Common practice for disposal of healthcare wastes is open dumping, ordinary landfilling, and highly controlled air incineration (3R Country Report, 2016–2021).

8 Electronic Waste

About environmentally sound management of e-waste, there is no specific legislative stage, including collection, storage, transportation, recovery, recycling, treatment, and disposal in Afghanistan; therefore, people usually sell their e-waste (waste electrical and electronic equipment) to the retailer and to the second-hand shops for reuse (3R Country Report, 2016).

Unfortunately, there are no specific policies and regulations in place to ensure health and safety aspects of those involved in e-waste management. In addition, there is no specific data for amount of e-waste generation and recycle per specific timing (3R Country Report, 2016).

9 Chemicals and Hazardous Waste

Afghanistan published its national action plan for the Stockholm Convention on Persistent Organic Pollutants (POPs) in 2017, four years after accession to the convention highlights a number of sources of concern. These include the presence of ageing stocks of banned pesticides, oils containing PCBs in old and damaged electrical distribution equipment, and emission of dioxins and furans from combustion processes. As with many other environmental issues facing the country, the plan suffered from a lack of quantitative environmental data, in part due to NEPA's limited resources but also the access problems caused by the security situation. Resolving some of these issues—such as the threat from oils containing PCBs—will require significant international financial and technical assistance. The cost of PCB management alone is estimated at US$20 million, while the installation of incinerators at hospitals to dispose of clinical waste without producing dioxins would cost US$50 million (Ministry of Public health of AFG).

NEPA has established mechanisms under the Basel Convention for preventing illegal and inappropriate export and import of waste, including transit trade, especially of hazardous waste and e-waste. Recently, NEPA has prepared a procedure for transferring old batteries and waste of NATO forces abroad of the country by private companies (NEPA).

Large quantities of hazardous waste material have accumulated in Afghanistan during more than eleven years of NATO presence and operations in the country. Gearing up retrograde activities now that combat operation "Enduring Freedom" has drawn to a close; NATO must now comply with international standards to dispose of this hazardous ecowaste appropriately.

The huge scale and diversity of the waste include fuels, oils, oil filter waste and lubricants, paints and solvents, and chemical products such as pesticides and detergents. There are also compressed gas cylinders and all types of bulbs and batteries, including lead-acid, nickel-metal hydride, dry cells, gel, nickel-cadmium, and lithium. Trickier troubles include waste containing asbestos and contaminated soils. All of this ecowaste requires an exceptional range of equipment and technical skills to comply with European Commission directives and regulations for disposal.

In spite of an $80-million investment in building incinerators for hazardous waste disposal in Afghanistan, the U.S. military left many of them unused, resulting in increased use of open-air burn pits whose dangerous fumes put thousands of soldiers and civilians at risk.

The repeated use by the U.S. military of burn pits to dispose of solid and hazardous wastes—from batteries, plastics, and aerosol cans to tires and entire vehicles—was one of the foulest stories to come out of the Afghanistan war. The practice produced acrid smoke and exposed tens of thousands of soldiers and civilian personnel to toxic fumes that have been linked to serious health problems, including cancer, cardiopulmonary diseases, and reduced lung function.

To address the problem and reduce exposure to military personnel, the Department of Defense (DOD) invested $81 million on 23 solid waste incineration systems for nine installations in Afghanistan.

10 Plastic Waste

Plastic wastes are another environmental issue in Afghanistan. Based on the interview of an official of NEPA on 2018 by the BBC Persian, daily four tons of plastic bags are consumed in Kabul city, where the life of its use is "from shop to Home" and then become waste. The official added that on a daily basis 3 tons of other types of plastic materials also enter the Kabul environment, which is disturbing.

In Afghanistan, about 800 factories are producing and supplying hundreds of plastic products to markets daily. Entering this amount of plastic into the environment, the ring of plastic use brought to sound. In Kabul and other major cities of Afghanistan, most citizens use plastic bags to move goods from stores and even bread from bakeries to home. This plastic bag will be converted into effortless waste after a short period of time, which will last for about 100 years, (10).

To solve the problems caused by the plastic waste mentioned above, the National Environmental Protection Agency (NEPA) provided the Action Plan to reduce and remove the use of plastic bags and represented to the Government of the Islamic Republic of Afghanistan for approval. The plan is under the process of approval by the Government for implementing in Kabul and other big cities (NEPA).

11 Circular Economy

In Afghanistan, there is no individual policy, strategy, plan, and program about the circular economy and did not work on system of resources utilization where reduction, reuse, and recycling of elements prevails. It does not mean that there are no activities on reduction, reuse, and recycling of wastes in Afghanistan, rather is some individual activities. For example, South Dakota Army National Guard Soldiers and other service members stationed here are getting environmentally conscious by initiating a waste recycling pilot program, designed to provide a renewable heat source for Afghans living in the capital of Kabul. In this invention, members of the 196th Maneuver Enhancement Brigade are volunteering their time to develop a "fuel donut" made from recycled materials, which burns like a briquette and provides an alternative heat source for Afghan families who live in homes without modern heating conveniences. Using shredded paper and sawdust from the camp, the material is combined with water and ash and pressed into shape of a doughnut or roll. The doughnut can burn for about an hour, providing heat for warmth or cooking and gives off few emissions.

Another example is the Community-based Plastic Waste Management for Wetland Conservation project implemented by Afghanistan Young Greens (AYG) at Kol-e Hashmat Khan protected area in Kabul on March 2017 to March 2019. The result of this project is raising the awareness of families and school students and being existence a number of volunteers to monitor and prevent waste disposal at the lake, and the area is now being kept free from plastics, positively affecting health and welfare of the community members, (8).

In addition, there are some informal activities done by different persons, NGOs, Organizations to aim their specific goals, but the side effects are resulting in the circular economy. These activities can include the activities of informal waste pickers to second-hand shops and informal recyclers, (Author).

12 Current Policies/Strategies/Plans

Government of Islamic Republic of Afghanistan has added the waste management issue in the 2030 Agenda of UN (SDGs Agenda). The SDGs Agenda is aligned with Afghanistan National Priority Programs (NPPs). Therefore, Afghanistan sets its basis toward the sustainable management of wastes.

In addition, the National Environmental Protection Agency (NEPA) is currently working on revising the Solid Waste Management National Policy to be included in the 3R and circular economic policies in this national policy.

About the plastic waste, also NEPA is working on making the National Action Plan on Management of Plastic Waste in Afghanistan. In this phase, NEPA has done the survey on effects of plastic pollution on health and environment. The earliest period the data will analyze to finalizing the National Action Plan on Management of Plastic Waste.

Fortunately, Afghanistan has Medical Waste Management Regulation, beside that NEPA and Kabul Municipality jointly are working on finalizing the Urban Solid Waste Management Regulation. In addition, Kabul Municipality designed the Integrated Solid Waste Management (ISWM) Program in Kabul city with collaboration of ADB in Kabul city (ISWM 2018).

Solid Waste Management Manual, Guideline, and Landfill Design Guideline prepared and Incineration plan, composting plan and recycling plan have been planned by government subjected to the donor funds availability for years 2016–2021 (AFG, 3R).

13 Conclusions

The extensive waste audit in Kabul has provided a lot of detail on the composition, weight, and recycling potential of the waste in Kabul. The city produces on average 3,195 tons per day. More than half of this waste is categorized as residential (58.6%) with a third categorized as commercial, and the rest coming from agriculture, industrial, institutional, or medical sectors.

From a household level, we have noted that wealthier residents produce nearly double the amount of waste per person as less affluent residents (0.81 vs. 0.41) with the median amount being around 0.61 kg per person per day from households.

However, this average needs to be weighted since the majority of residents in Kabul are low income. Based on our weighted average, the average person produces 0.45 kg per day. Since on average only 58.6% of waste comes from residents, it is safe to assume that including commercial, agricultural, institutional, industrial, and medical activities, the amount of waste per day per person produced in Kabul is around 0.71 kg. If the population of Kabul is 4.5 million, the waste produced per day in Kabul is around 3,195 tons per day. Of that, the majority is food waste between 32 and 41%. The next is plastic, soil/dirt, and paper.

Fortunately, large portions of waste can be recycled, with paper and scrap metal reaching high recycling rates both at the secondary collection point and the transfer station. From secondary collection locations, as much as 26% of material is recycled regularly. From the transfer station (or even at the landfill), additional material can also be collected, as much as 12%. This paper assumes that around 38% of the material in Kabul is regularly recycled. Based on that, 1,980.9 tons of waste should be going to the landfill per day, or burned/buried somewhere else in the city. The landfill is currently receiving 1,415.79 tons per day on average. Therefore, 29% of the total waste produced in the city that is not being recycled or reused is either burned, dumped illegally, or buried somewhere other than the legal landfill.

More interventions should be done to help more food waste and plastic be collected. This should include at-source separation schemes for food waste, recyclables, and general waste. If more of these two items are recycled, it could reduce waste by another 40%.

Additional transfer stations should be allocated across the city; this can help reduce the waste to landfill by a minimum of 11%. This also creates jobs that pay around $3.98 per day—one-third more than those collecting at secondary locations. The current transfer station should allow more informal recyclers to collect there, as the current recyclers cannot collect all of the recyclable material.

Materials like plastic bags could be banned or reduced. While paper bags can be worse for the environment if they end up in the landfill (because they release methane as they decompose), this audit has seen that paper bags have a much higher chance of being recycled. Nearly, 100% of paper is recycled in Kabul. This could also support the local pulping industries in and around Kabul in providing them with both market and supply. Any efforts should be coordinated with private paper companies to ensure success.

If food waste was separated, there is a market for it as fodder for livestock. Though much more food waste available than currently being collected (food waste recycling rates are around 4–13%), there seems to still be a market for additional material if it is separated. Other important initiatives such as biogas could be interesting alternatives if fodder for livestock reaches peak supply.

Informal recyclers are doing the heavy lifting throughout Kabul when it comes to recycling and waste reduction, along with the local companies processing the material. Both informal recyclers and local recycling companies should be supported through equipment and regulation to help them increase the material they are collecting which will create jobs, reduce waste to landfill, reduce pollution, and save the municipality money.

Information and data about other types of wastes, such as e-waste, chemicals and hazardous wastes, plastic wastes, and medical wastes do not exist, if there is very little and informal published data.

Lastly, any revenue collection initiative should make sure to target both residential areas and commercial areas as these make up around 89% of the waste.

References

Afghanistan 3R Country Report. (2016).

Afghanistan Ministry of Public Health. (2015). *Technical report of pharmaceutical waste fading in Afghanistan* (pp. 10–11).

Afghanistan Ministry of Public Health. (2016). *Waste disposal of pharmaceutical national policy*.

Chen, S., De Bruyne, C., Manasa, B. (2019). *Plastics and circular economy community solutions*. United Nations Development Programme. www.sgp.undp.org.

Hameedullah, N. (2017). *Solid waste management in Kabul city*. Thesis presented in partial fulfillment of the requirements for the Degree of Master in International Cooperation and Policy Ritsumeikan Asia Pacific University (pp. 31–34).

https://ceobs.org/the-slow-violence-of-pollution-in-afghanistan/.

http://www.bbc.com/persian/afghanistan-44370421.

Integrated Solid Waste Management (ISWM). (2018). Presentation, presented in *Integrated Solid Waste Management Workshop* (p. 6).

Kabul Municipality. http://km.gov.af/.

Nawid Royaee—Urban Management Masters Program. (2014/2016). *Solid waste management*. Berlin: University of Technology.

Strong Hubs for Afghan Hope and Resilience (SHAHAR). (2018). *Solid Waste Audit in Kabul* (pp. 1–23). AID-306-C-14-00016.

Waste Database of Afghanistan National Environmental Protection Agency. (2019). http://www.nepa.gov.af/.

Integrated Waste Management in Bhutan

Ugyen Tshomo, Chhimi Dorji and Yogeeta Dahal

Abstract Bhutan is widely renowned for its carbon negative status in the environmental arena. However, owing to its geographical location as a Himalayan country sandwiched between China and India, the influence of globalization from the north and south has drastically increased the rate of urbanization and economic activities in Bhutan over the years. This paper provides an account on waste management, policy, and initiatives taken by government, NGOs, and enterprises in Bhutan. Different streams of wastes are emerging and in particular, municipal solid wastes are serious waste management issues in Bhutan with a shift in consumption patterns and increasing population rate. Apart from the National Environment Commission (NEC) acting as an apex body for regulating and monitoring waste management, similar initiatives have been taken by local governments, other government agencies, private enterprises, and non-governmental organizations (NGO) to create litter-free and healthy environment by implementing 3Es and 4Rs towards circular economy. The concept of circular economy in Bhutan got introduced with the Waste and Climate Change Project (WWC) of NEC and WWF Bhutan. The circular economy concept is the main philosophy of the National Waste Management Strategy (NWMS) which aims to establish waste management as a national priority and provide information, logical steps and strategies required for its successful implementation. The NWMS aims to resolve data gaps, challenges, and issues between agencies regarding waste management. It would also ensure that waste management programmes are trickling down to the gross root systems fostering a national waste reduction, reuse, and recycling concept.

Keywords Circular economy · Waste management · 3R · 4R · Bhutan

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1 Introduction

The constitution of the Kingdom of Bhutan is under the Article 5: Environment mandates a minimum of sixty percent of Bhutan's total land of forest cover for all time. Concurrently, environmental conservation plays an important role be it in the four pillars of the Gross National Happiness. With visionary policies in place, Bhutan is widely renowned for its carbon negative status in environmental arena around the world. However, owing to its geographical location as a small Himalayan country sandwiched between developed countries, China and India, the influence of globalization from the north and south has drastically increased the rate of urbanization and economic activities in Bhutan over the past years. In the late 1980s and early 1990s, more than 90% of Bhutan's total population of 600,000 were estimated to have lived in rural areas within a total country area of 38,394 km (Planning Commission 1989). During that time, the percentage of urban settlement was negligible and most of the population resided in rural areas was practising subsistence agriculture. However, in 2005, population has increased to 634,982 with the rise of 30.9% of total population residing in urban areas and the remaining 69.1% of total population living in rural areas (PHCB 2005). The pattern of consumption of goods in urban area has shifted from domestic organic agro goods to commercial goods that are imported from the neighbouring countries. These industrial manufactured goods generate enormous amount of waste and need systematic method of disposal to avoid any sort of pollution in the soil, water, air, and its environmental vicinities. Different streams of wastes are emerging and in particular solid wastes are serious waste management issues in Bhutan (NEC 2019).

The emerging waste issues in the country have been recognized at the highest level. His Majesty the Fifth DrukGyalpo of Bhutan during the Royal Bhutan Flower Exhibition on 1 April 2015, addressed the significance of having a clean and safe environment for everyone to live: '*Where we live must be clean, safe, organized, and beautiful, for national integrity, national pride, and for our bright future. This too is nation building'*. In addition, His Majesty reiterated the waste concern of his beloved father the Fourth Kind of Bhutan, always watchful, His Majesty the Fourth King would observe litter that blights our pristine environment, and express concerns on the growth of waste and their proper disposal on 11 November 2015, Changlimithang, Thimphu. His Majesty the King always emphasized on shared responsibilities to manage our own waste at individual and community level. During the 109th National Day celebration on 17 December 2016, His Majesty underscored the role of every Bhutanese towards waste management, 'It is our collective responsibility to ensure that where we live remain clean, safe, well organized, and beautiful, for all times to come'. Similarly, Her Majesty the Queen is as equally concern towards waste management as a royal ambassador to the environment. During the World Environment Day in 2018, Her Majesty in her speech addressed, 'for any initiative to be successful, dedication and consistency is essential. We must all remind ourselves that our actions on the World Environment Day should not remain symbolic, standalone activities but instead must be practiced every day'. In this context, Bhutan is opportune to have royal support and visionary guidance in addressing waste management concerns and environmental conservation. Similarly, Her Majesty on 2 June 2019 also launched the National Waste Management Strategy for Bhutan and the Flagship Project on waste management.

In recent times, numbers of good initiatives in Bhutan pertaining to waste management have been recognized with good partnerships and supported by the United Nations Development Programme (UNDP) in terms of promoting recycling businesses at small and micro-enterprises through public advocacy and engagement of the private sectors. However, public health has become another concern due to open dumping of solid waste and contamination of the natural environment by the choked drains and polluted waterways. Proper waste collection and segregation at source are limited to only few urban towns of Bhutan either with safe disposal or recycling of waste materials as the end processes of waste management. Currently, in Bhutan, a systematic approach of an integrated solid waste management which addresses all processes of solid waste management (SWM) cycle and sustainability aspects is not in place owing to the scarce institutional set-up, trained human capacity and financial resources.

In a circular economy, all materials are utilized in loops at each phase of its production, utilization or disposal. This ensures that there is minimum input of virgin natural resources, maximum use of goods and services, minimum waste generation followed by utmost reuse and recycling as shown in Fig. 1.

In Bhutan's case, the concept of circular economy got introduced with the Waste and Climate Change Project (WWC) of National Environment Commission and WWF Bhutan. The concept of a circular economy, which is a paradigm shift in the way we look at designing, producing, transporting, consuming and managing waste, has been adopted as the most suitable model in planning for waste management in Bhutan (NEC 2019). National Waste Management Strategy and Thimphu Waste Management in Bhutan include waste management activities designed to enable recovery and recycling as much as possible. Both the reports put strong emphasis in the reduction of waste, reuse, refuse and recycling from the cradle to grave of all associated activities.

While there have been earlier initiatives on 3Rs on waste management, the model of circular economy is implemented in planning of waste management activities. In line with this, enhanced education/awareness and capacity building are being provided to reduce waste generation, while also looking at various initiatives of recycling and reuse of materials. Use of waste PET bottles for decoration, plastics for cushions, tetra packs for shopping baskets, paper waste for egg trays, plastics for road construction and also HDPE for fencing poles are recent initiatives by various individuals and firms. The government on its part is making the environment conducive for such measures and also providing loans, subsidies and policy support.

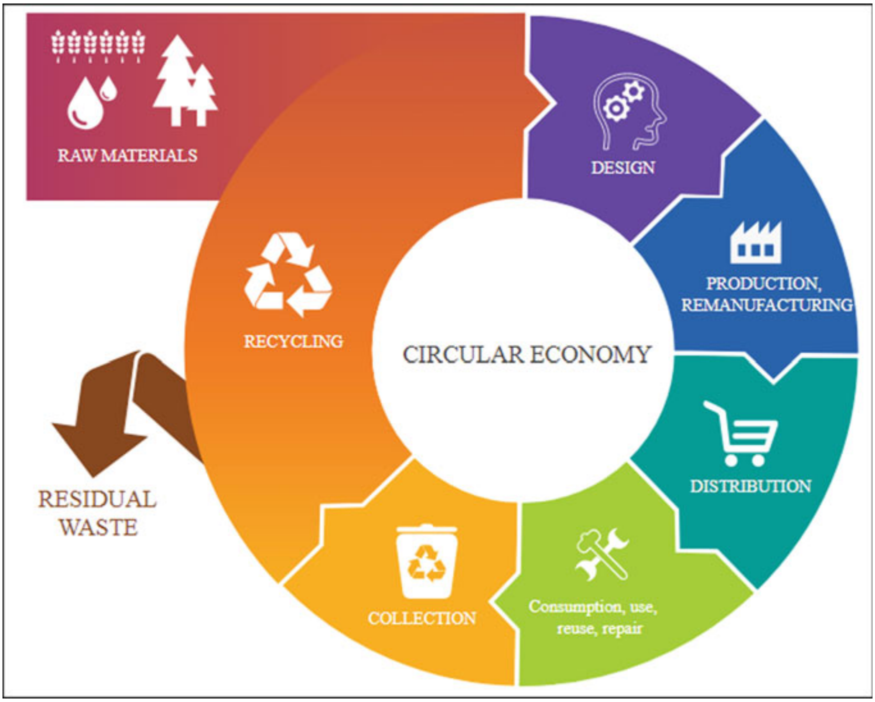


Fig. 1 Outline of the circular economy (Paquot 2017)

2 Policy Framework on Waste in Bhutan

2.1 NEPA

The National Environment Commission (NEC) periodically produces Bhutan State of the Environment Report (BSER) in accordance with the mandate under the National Environment Protection Act of Bhutan, 2007 (NEPA). The BSER analyses the current environment issues, provides scientific information, raises awareness on current state of environment for informed decision-making, helps in effective management of the environmentand makes recommendation for strengthening of environmental policies, plans and programmes (NEC 2016).

2.2 EA Act

The Environment Assessment Act of Bhutan establishes assessment procedures of potential effect from policy, programmes and projects on the environment. The Environment Assessment Act considers sustainable development and *middle path* by recognizing the country's development without compromising country's cultural integrity, heritage, environment and quality of life of the future generation. The royal government of Bhutan ensures that environmental concerns are taken into account as per the rules and regulations when implementing any policy, programme or projects (NEC 2000).

2.3 Water Act

Water is one of the most important natural resources in Bhutan. Although Bhutan has abundant of water resources, local scarcity of water for drinking and agricultural purpose exists. The existing policy is determined to protect the environment and its resources through integrated water resource management. The government, stakeholders and communities participate for sustainable use of water resources by planning for conservation, development and management of water resources. Prevention and control of water pollution from sources such as release of effluent and hazardous waste must comply with effluent discharge standards before being released into the water bodies. The National Environment Commission is responsible for developing, implementing and monitoring the water quality standards and effluent discharge standards of Bhutan (NEC 2014a, b).

2.4 Waste Act, Waste Regulation

The Waste Prevention and Management Act and Regulation of Bhutan aims to establish a sound waste management system that includes monitoring procedures at every organization level including efficient collection, segregation, treatment, storage, transportation, reduction, reuse, recycling and safe disposal of solid, liquid and gaseous wastes. Additionally, being mindful of adverse impact of waste to the environment, ecology of the country, human health though sound waste management in pursuit of Gross National Happiness and living in harmony with nature(NEC 2009, 2012).

The Waste Prevention and Management Regulation has categorized the waste into following:

(1) Medical waste
(2) Municipal waste
(3) Industrial waste
(4) E-waste
(5) Other waste.

To make the waste management system effective, education and awareness are provided to public. The implementing agency, National Environment Commission, along with Road Safety and Transport Authority, Ministry of Health, Ministry of

Work and Human Settlement, Ministry of Economic affairs (Department of Industries) are responsible for management of waste generated from each sector. Additionally, education and training institutes include waste management in their curriculum and co-curricular activities and the Non-Government Organization and Civil Society Organizations are also involved in management to waste and initiating research works. Policies to stop illegal dumping of solid wastes and release of effluent include levy fee charges for waste collection, treatment and transpiration and impose fine incurred for recover costs including polluters pay principle for non-compliance with rules (NEC 2019).

2.5 *Integrated Solid Waste Management 2014*

Bhutan is beginning to experience the challenges of changing lifestyle while also transforming from subsistence farming to consumerist economy where waste generation is increasing with increase in population. The policies and practices of waste management require new strategies to resolve the new set of environmental challenges especially with excessive waste generation and improper disposal. The waste management system in Bhutan is in its initial stage and the country requires initializing integrated solid waste management (ISWM) with engagement of not only the policy makers and relevant agency but also including broad stakeholders including legislators, private sectors, local communities and civil society groups at the central and local levels. The ISWM initiated by NEC in 2011 aims to move towards zero waste Bhutan through maximizing resource recovery, creating sustainable waste management systems, protecting the natural ecology of Bhutan, promoting and practicing of 4Rs and developing ISWM at par with international standards by 2022.

2.5.1 Summary of IWMS

Awareness and education are chosen as a key for successful implementation of waste management plans. Inclusion of people especially by providing them with understanding of the importance of waste management will bring about maximum change. Therefore, the strategies to create awareness in ISWM for successful implementation includes dissemination of information, demonstrations of 4R programmes, waste management programmes, clean up campaigns, volunteerism and use of media to reach information to various stakeholders such as educational institutions, urban communities, rural communities and commercial entities.

2.5.2 Summary of National Waste Management Strategy Document

The National Waste Management Strategy (NWMS) of Bhutan has been launched by Her Majesty the Gyaltsuen on 2 June 2019 in Thimphu. The NWMS' goal is to continuously move/promote towards 'Zero Waste Bhutan by 2030' in partnership with the public, industry, civil society organizations, government authorities at local and sectoral levels, municipalities and potential development partners. This strategy highlights waste as an evolving environmental issue in the Bhutan and aims to accomplish a better understanding and awareness on waste; incorporation of the concept of principles of 4Rs; stakeholder participation, timely and appropriate waste collection and disposal, and proper waste monitoring and evaluation.

There are sets of goals for the short terms to which within 2019–2023 and long-term activities to achieve waste prevention and reduction further, through medium and long-term targets which are as below:

The strategic objectives is planned to be attained by implementing right strategic tools. The tools are as follows;

(a) Sustainable Financing

Set up a sustainable waste management fund through government funding and innovative financing systems.

(b) Technology Development

The key concept of circular economy is planned to be truly implemented by exploring technology and methods that are less wasteful and sustainable. Technologies that are both cost-effective and green are to be explored, piloted and implemented.

(c) Establish Communities and School Waste Banks

It is also proposed that waste segregation is implemented at the community levels through establishment of waste banks and drop-off centres. Under the waste bank programme, households and schools who participate in waste bank activities will receive benefits, both in the form of money and improvement in environmental quality. Certain amount of capital injection might be necessary in the initial years of bank operation. This could be funded by the National Waste Management Fund and direct subsidies by the government.

(d) Capacity Development

A nationally coordinated capacity building programme will need to be developed that will address those capacity building barriers. Trainings would be provided for waste handlers to engineers and managers to private entities.

(e) Voluntary Agreement

The NEC could enter into voluntary agreement with companies to pilot Extended Producer Responsibility (EPR) Scheme for waste products generated by them beyond point of sale with inclusion of corporate social responsibility (CSR). This arrangement should be based on the understanding that those companies have potential to contribute towards effective waste management.

(f) Behavioural Change Through Education and Awareness Programme

Behaviour change is the most important aspect in ensuring cooperation from the public and waste management. Targeted programmes that can be continuous overall for longer period of time will be crucial to ensure that required behavioural changes are brought about to all sections of the society from manufactures to consumers. Education of children and adults from all walks of life through all medium such as television, Internet, social media, etc. are necessary as part of regular waste programs.

(g) Mandatory Budget Head Creation for All LGs (Link to Annual Performance Agreement (APA)/Annual Work Plans (AWP) and Five-Year Plan (FYP).

In many cases, it has been found that there is no budget for waste management activities at local level and designated institutions. Therefore, it is proposed that all responsible offices plan, secure and disburse budget for waste management programmes in their respective sectors or jurisdiction. NECS shall work with these agencies to plan out budgeting for the initial years.

(h) Data and Information Collection

For the process policy development and the choice and implementation of the strategy, the central key players depend on data and information exchange, and collection. Information on implementation of programmes and monitoring and evaluation shall be maintained and assessed from time to time.

Cross-cutting issues on waste management during public gatherings and also involvement of women in the sector are also looked into in the NWMS. Measuring the progress of the strategy is through periodic performance auditing of the implementation of the strategy by an oversight agency. The NEC will need to review the strategy as and when necessary to ensure effectiveness and adequacy of this strategy in addressing waste management issues, if such needs arise in future (Fig. 2).

As part of Strategic Tools for Sound Waste Management, Table 1 shows the various activities that will be carried out under each tool. The implementation plan of each activity is given in Table 1.

3 Waste Management in Bhutan

Until 2001, Bhutan does not have waste management system. Firstly, there was no information on waste quality or generation in terms of quantity in Bhutan. Secondly, Bhutan did not have specialists or experts in waste management area. And thirdly, subsistence agriculture played a huge role in the livelihood dependency of rural area that was densely populated. Agricultural products were usually biodegradable and eco-friendly. Developmental activities have created employment opportunities in urban areas and easy access to facilities like health, education and technology. To upgrade daily earning income and standard of living, people have migrated to Thimphu. Thimphu alone has a total of 98,676 population of which 79,185 person

Fig. 2 Strategic interventions for NSWM (NEC 2019)

account for its urban population that is almost 80.3% of its population contributing it as one of the largest urban population among all other 20 Dzongkhags. Thimphu had 98,676 population compared to 3,116 in Gasa district, which is located in the north of Thimphu. Therefore, accumulation of municipal solid waste generation has become a concerned issue in a prominent city like Thimphu with high density of population at a rapid pace of urbanization with poor waste management (Phuntsho et al. 2010).

i. *Municipal Solid Waste*

According to the waste Composition and Quantity Survey carried out by the National Environment Commission in 2018, it was indicated that total organic waste constituted the largest fraction of the Municipal Solid Waste (58.05%), and subsequently by plastics (13%), paper/paperboards (9.2%) (Fig. 3).

In Bhutan, the pressure of urbanization is observed only in few cities as they are densely populated compared to other remote districts. The capital city Thimphu alone

Table 1 Activities under strategic tool (NEC 2019)

Strategic tool	Activities
Sustainable financing	Creation of National Waste Management Fund (WMF)
	Initiate economic instruments
Technology Development	Assess feasible environmentally sound technologies for waste collection and treatment
	Set up waste collection and treatment facilities as needed
Capacity development	Develop a nationally coordinated capacity building programme
	Implement training programmes for all relevant stakeholders
Voluntary agreement	Work on corporate social responsibility (CSR) initiatives with Bhutanese companies to pilot Extended Producer Responsibility Scheme for waste products generated by them
Waste banks	Set up waste separation and waste banks at schools and communities[a]
	Establish functional recycling programs for the waste banks with proper modus operandi
Behaviour change	Education programme on waste for schools
	Waste management education through integration in the curriculum
	Curriculum development and programs in the tertiary education system
	Assessment of the awareness programmes at periodic interval
	Improved delivery of public waste management awareness
	Use of mass media, websites and social media for education on waste
Link with APA and IWP	Ensure that waste management activities are included in all respective agency's APA/AWP and reflected in individual IWPs as part of FYPs
	Seek financial support for the activities as per plans
Data and information collection	Set up a pollutant release and transfer registers programs
	Develop a waste management network
	Set up a database on waste
	Periodic monitoring of waste management activities, targets and achievements

[a]This is similar to the waste drop-Off Centre initiated in Thimphu Thromde in September 2018

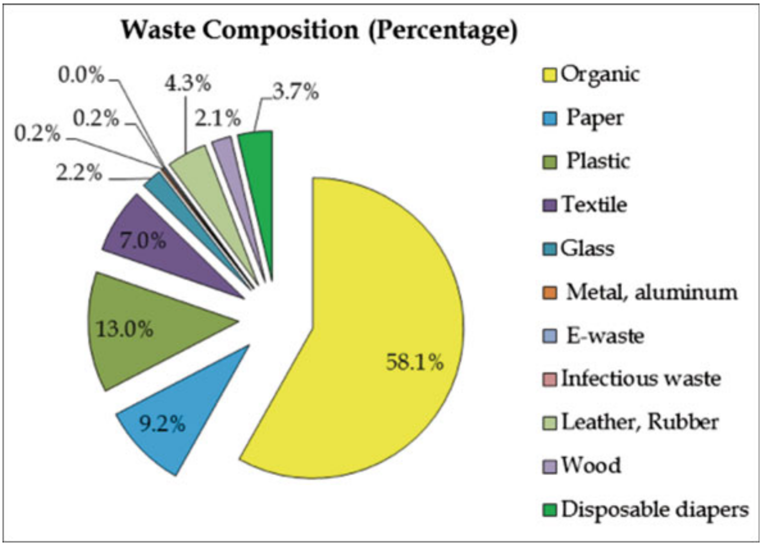


Fig. 3 Average composition of MSW for Thimphu (NEC 2018)

exceeds 40% of the total urban population in Bhutan followed by Phuentsholing in the southern part which is the closest city to Indian border (PHCB 2005). In 2005, The Royal Society for Protection of Nature's survey in 2005 reported that daily wastes collection from Thimphu City was 36.7 tons (RSPN 2006). This amount of waste generation has increased to 64.5 tons per day by 2007. If we go back to 1992, waste generation was assumed to 17.5 tonnes on a daily basis by the Thimphu City Corportation project document though it is difficult to get an accurate data on waste management since inventory prior to 2001 did not exist and some were poorly documented into paper. A clear-cut amount of waste generation can be drawn from 2007 and 1992's data: it has increased by four folds. The waste composition and analysis survey carried out in 2018 as a part of developing the National Waste Management Strategy confirmed that the total waste generated in Thimphu Thromde was 40.3 tons per day accounting to 0.35 kg/capita/day (NEC 2018). By 2020, waste generation from Thimphu Municipality is projected to increase up to 110 tons per day if continued with similar existing trends and urban population growth.

Waste Prevention and Management Act 2009 defined waste as 'any material or substance in whatever form, whether solid, liquid, or gaseous, hazardous or non-hazardous, organic or inorganic that has lost its primary value and is disposed of, intended to be disposed of or recycled' (NEC 2009). NEC has refrained from referring waste as merely useless material and added more values with inclusion of 'recycle' to turn it into a useful material in its definition. To add value to the circular economy and to reduce the organic waste, Thimphu City Corporation has started *Takakura* waste composting at household levels in Bhutan. This initiative started in March

2018. Thimphu City Corporation has reached to more than 15 community composting centres mostly run by Self-Help Group (SHG) women including Jigme Dorji Wangchuck National Referral Hospital, Royal Bhutan Army to mention few.

ii. *Medical Waste*

As per the Waste Inventory and Baseline Study for Developing National and City Level Waste Management Strategies and Action Plans (2018), about 70% constitutes of general waste from hospitals. General wastes like papers and plastics have the potential to recycle and contribute to the circular economy of the hospital communities and similarly, reduce the amount of hazardous waste which includes infectious waste, sharps, pathological waste, chemicals, pharmaceuticals, radioactive waste and genotoxic waste.

Currently, Bhutan has 24 hospitals, 1 National Referral Hospital, 2 Regional Referral Hospital, 24 Basic Health Unit-I, 184 Basic Health Unit-II, Sub post 28 and 494 Outreach Centres (MoH 2016). The medical waste generated from these health facilities is increasing each year at the rate of about 15–20%. For instance, in 2017, the total medical waste generated increased from 378 tonnes to 428 tonnes with increase of 13.2% (MoH 2018).

For medical wastes, source segregation practices are being implemented using colour-coded bins and plastics. Red for infectious and pathological wastes, green for general waste like papers and plastics, blue for food waste like leftover food, fruits and vegetable piles, yellow/white for sharps: needle, blades, chemotherapy waste with red bucket labelled 'Biohazard', pharmaceutical waste-cartoon boxes and chemicals—bottles/containers. Ministry of Health has emphasized on deep pit burial where the biomedical wastes like sharps are eventually disposed after autoclaving and pathological wastes, too. Even though hospitals throughout the country have well-sealed pits but BHU's have open pits that require attention because it will become easy for chemicals and other liquid wastes to leach out and mix with other non-hazardous wastes in the soil and water.

Ministry of Health has successfully carried out a pilot project on Model Health Care Waste Management at Phuentsholing General Hospital on 21 June 2016. Concurrently, the waste treatment and storage house under this pilot project will serve as a training centre for support staff on waste management in the coming days. Staff would enhance their skills and generate revenue from these sellable waste items to support health facilities. This pilot project models will be replicated to other four hospitals like Gelephu, Samtse, Wangdue and Damphu and eight more other districts through Asian Development Bank during the 12th Five-Year Plan.

iii. Industrial Waste

Industrial wastes are disposed at Pasakha Industrial Landfill which is under the purview of Ministry of Economic Affairs and at Association of Bhutan Industries landfill. A total of 520 tons of industrial wastes are disposed each year. There is no other landfill at other five industrial estates (NEC 2019). A tipping fee for waste collection and disposal of Nu. 1240 per ton is collected from the Industries. A total

Table 2 Current situation of waste management (NEC 2019)

S. No	Waste stream	Quantity	Year
1	Municipal solid waste	861.4 Mt/week	2017
2	Industrial waste	520 tons/year	2017
3	Medical waste	428 tons/year	2017
4	E-Waste	912 items	2017

sum of Nu. 2.5 million has been collected as waste tipping fee from DoI as of now, which is directly deposited to the government revenue account at Ministry of Finance (NEC 2019).

3Rs Initiative

3Rs' initiative is widely practiced in industrial estate areas. For instance, industrial wastes like dusts produced from metal industries are reused within the metal industries, and some sold to the other industries as raw material or to the local markets. It helps in reduction of generation of waste from source. Sludge waste is reused in land filling within the industrial premises. And similarly, oil and lubricant waste from the automobile workshops are either reused or sold. Metal scraps are sold to the local vendors and recycled into other products from the neighbouring country's recycling facilities.

iv. E-Waste

As per the Waste Inventory and Baseline Study for Developing National and City Level Waste Management Strategies and Action Plans (2018), approximately 912 e-waste items were generated in 2017 (NEC 2019). The Department of Information Technology and Telecom (DITT) is responsible for e-waste management. The DITT hands over to the Department of National Properties (DNP) the e-waste items recorded from the government offices and DNP auctions to the private scrap dealers (Table 2).

3.1 Other Practices: Youth Action for 4Rs in Schools

Youth Action for 4Rs was launched on 4th June 2015 by Her Majesty the Gyaltsuen Jetsun Pema Wangchuck led by the National Environment Commission in 15 schools with primary objectives:

i. To build sustainable waste management partnership between the NEC and the schools;
ii. To build a conducive environmentally friendly civic responsibilities among our youths; and
iii. To have youth goodwill ambassadors for waste management in schools, families and society.

The schools carry out the following activities:

i. A focal person in the school dealing with waste management activities;
ii. Ensure an active membership for at least 10 members for effectively carrying out activities/programs;
iii. Carry out at least three waste management programmes annually of which, one will involve a programme with a community/town;
iv. Adopt a stream or river and maintain its hygiene and protection at all times to come;
v. Promote segregation, reuse and recycling of wastes in the school practicing waste bank model. Schools sell their recyclable waste items to the private entities and the generated money is used for other activities in the schools;
vi. After segregation, maintain a periodic (pre-determined time) record of the amount of waste generated in weight;
vii. Incorporate at least, a week-long morning assembly speech program on waste issues/initiatives in the school by the club and/or others.

3.2 Clean Bhutan

Clean Bhutan is a registered Civil Society Organization and was established on 5 February 2014. Through Advocating Behavioural Change programmes and practice of the 3Rs, the main aims of Clean Bhutan is to change the mindset of every Bhutanese to be responsible citizens and practice sustainable consumption by using available resources most efficiently (Clean Bhutan 2017). Clean Bhutan has worked with more than 6,819 volunteers and has successfully carried out *Empowering Women and Youth through Waste Entrepreneurship* project in *2017–2018.* With the financial support received from EU-Helvetas Bhutan of total Nu. 1,227,000, Clean Bhutan conducted hands-on training for self-help groups (SHGs) comprised of women and youth to develop skill and generate additional income to boost up the circular economy. Women and youths learned how to weave basket out of plastic waste to develop products and to use plastic as secondary resource. More than 245 participants from the Royal Bhutan Army, Royal Bhutan Police, Royal Body Guard and youth group attended the hands-on training. Concurrently, Clean Bhutan could successfully minimize waste disposal at landfill with reduction of 465 kgs of plastic waste. Through this project, participants could venture out into small home-made business such as selling of baskets made of waste plastic. One of the good practices is Aum Dechen Pelzom of Royal Bhutan Army, who has earned around Nu. 37,000. Similarly, several other trainees have ventured out into small business and are making these baskets available in Thimphu City fulfilling the objective of the project to help the community in developing small production unit at household level for housewives to generate additional income. The profit will be shared and utilized as community welfare fund to support during the adverse situation and other emerging new entrepreneurs within their community to avail soft loans. The goal is to make these self-help groups function independently. Through such initiatives, the communities are well informed about waste management, its scope in circular economy and to reduce the amount of plastic waste into the landfill.

3.3 Greener Way

Greener way is Bhutan's first private waste management and recycling firm which was established on 8 March 2010 in Thimphu by Mr. Karma Yonten under Small and Medium Size Enterprises (SMEs).

Its main missions (3Es) are:

(a) E1: To save Environment
(b) E2: To create Employment
(c) E3: To boost Bhutan's Economy.

Services:

(a) They collect and dispose municipal solid waste in central and southern zones of Thimphu through rag pickers and trucks.
(b) They provide service on demand of customers even out central and southern zones of Thimphu
(c) They offer their evening service even for office-goers
(d) They segregate waste from the source into dry (inorganic waste) and wet (organic waste). They transport wet waste to waste drop-off centre and transfer station, some dry waste to plastic recycling units and some are sold to the local scrap dealers at different rates. Currently, the drop-off centre is run by the Thimphu City Corporation. There are five different disposal bins, one each for pet bottles, plastics, papers, metals, and food and other wastes. The caretakers have to segregate wastes before dumping into the landfill. In return, the caretakers could keep whatever income is generated from sellable wastes. The National Environment Commission Secretariat also intends to install more waste drop-off centres at strategic location and promotes in different districts across the country as reflected in the National Waste Management Strategy. Similarly, Greener Way has its own transfer station at Olakha, Thimphu. Greener Way segregates waste and earns money from the sellable wastes (Images 1 and 2).

Segregation of waste from the source has helped Memelakha landfill from mixing up of waste.

In 2015, Greener Way has collected 1,731 tons of dry waste and 957 tons of wet waste. The amount of collection has drastically increased in 2016: 2,748 tons of dry waste and 1,321 tons of wet waste.

Image 1 Waste drop-off centre below Kelki Higher Secondary School, Thimphu in 2018

Image 2 Transfer station at Olakha, Thimphu in 2018

3.4 Challenges for Waste Management in Bhutan

Despite the above-mentioned programmes, Waste Management in Bhutan is still at nascent stage due to:

Municipal Wastes

1. Improper segregation of wastes at source;
2. Lack of public participation and cooperation;
3. Illegal waste dumping;
4. Unsuitable waste collection timing;
5. Overflowing landfill sites and improper management;
6. No proper disposal sites for segregated wastes;
7. Strict advocacy and implementation of Acts, rules and regulations;
8. No proper management of rural wastes; and
9. Lack of fund and resources for implementing agencies.

Medical Wastes

1. No storage for medical wastes;
2. Disposal of infectious and general waste at BHUs are in the same pit;
3. Segregated waste is dumped together into the municipal trucks; and
4. Lack of compliance and/or awareness among new staff or interns and students or patients.

Wastewater

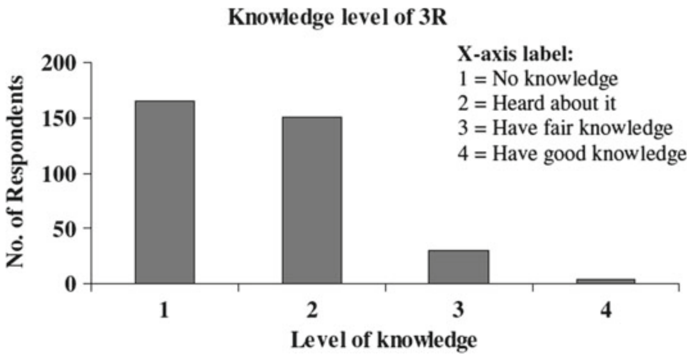
1. Septic tanks with soak pits are not as per standards;
2. Sludge from the septic tanks are not treated;
3. Network lines and treatment plants are always over loaded as the sludge from the septic tank areas are pumped into the sewer line; and
4. No treatment/management of grey water.

Industrial Wastes

1. Lack of fund to build treatment plant for industrial estates;
2. Hazardous waste assessment and sound management;
3. Operational budget is centralized and districts are usually short of budget for proper segregation and awareness; and
4. The tipping fee collected and submitted to the government is not utilized directly for waste related activities.

E-Wastes

1. No treatment (recovery and recycling) facilities;
2. Lack of expertise;
3. Storage facilities is not adequate to store all the wastes;
4. No proper system of monitoring e-waste disposal by the winning bidders;



Graph 1 Level of 3R knowledge by residents in Thimphu (Penjor 2007)

5. No proper rules on segregation of waste;
6. Technical limitations and manpower shortage to really evaluate and assess the actual valuation of the surrendered assets; and
7. Costly affairs to transport all surrendered equipment, vehicle and scraps all the way to Thimphu.

The National Waste Management Strategy, 2019 has also identified barriers for sound management of waste specifically institutional barrier, policy barrier, technical barrier, financial barrier, capacity barrier, informational barrier and public support barrier. Similarly, lack of public awareness and advocacy is still a pressing issue. Waste management concept, implementations of 3R and safe disposal of e-waste awareness campaigns and programmes will also help in reduction of waste. Waste management education as a part of school teaching curriculum is felt pertinent for behavioural change and inculcate civic sense towards proper waste management from early ages in the schools and for wider outreach of general public. To cite an example, Penjor (2007) carried out a survey among the residents of Thimphu to understand people's knowledge on 3R for his study entitled 'Enhancing Municipal Solid Waste Management System with 3R Options in Thimphu'. It was astonishing to see that most of people have no idea about 3R as indicated below (Graph 1).

4 Conclusion

The increased demand for resources and its competing use has enabled the focus of waste management strategy to be on efficient use of resources. The municipal authorities, to a large extent, have established waste collection systems in the urban areas either directly or through private waste management entities. Waste segregation has been initiated in some of the Dzongkhags and most urban centres in the country. Over the years, waste management practices in the country have also progressed with involvement of the private sector and volunteers, especially for solid waste management. Initiatives such as polyethylene terephthalate (PET) bottle collection by the schools and their linkages with recycling industries have started to make its mark on the waste scenario in the country. There have been visible private sector interest and involvement in waste management, including an establishment of a plant for recycling plastic waste as road surfacing material, PET bottles for arts and decoration, tetra packs for shopping baskets, HDPE for fencing poles, used school uniforms for school bags, etc. initiatives to reduce, refuse, reuse and recycle goods at all stages set Bhutan's economy towards the trajectory of a circular economy. The concept is introduced and gaining popularity and acceptance.

The benefits of circular economy are that it would necessitate only minimum goods and services in the first place. With the improvement in their life span and utility, one good can be used for multiple use and longer duration. These would not require lesser waste collection services, but also reduce the need to handle and treat/dispose them. Thus, the benefit of circular economy concept is multiple folds. Inclusion of circular economy concept in the National Waste Management Strategy is timely and brilliant. The main aim of the strategy will be to establish waste as a national priority and providing the information, logical steps and strategies required for implementation. The NWMS will also help resolve any data gaps, challenges and issues that are there between agencies. It would also ensure that waste management programs are trickling down to the gross root systems fostering a national waste reduction, reuse and recycling concept.

On the same note, the government of Bhutan also launched the Flagship project on Waste Management through the Prime Minister's Office. It is proposed to address the immediate needs for waste management through establishment of a special unit at the Prime Minister's Office (PMO). The unit shall formulate programs for waste reduction, awareness, segregation, recycling, transport, treatment, disposal and enforcement across the country in coordination with central government agencies, local governments, Non-Governmental Organizations (NGOs), educational centres and the public.

References

Clean Bhutan. (2017). *2017 annual report*. Bhutan: Thimphu.

MoH. (2016). *Annual health bulletin 2016*. Ministry of Health, Royal Government of Bhutan.

MoH. (2018). *Annual waste report for 2018*. Ministry of Health, Royal Government of Bhutan.

NEC. (2000). *Environment assessment act of Bhutan*. National Environment Commission, Royal Government of Bhutan.

NEC. (2009). *Waste prevention and management act*. National Environment Commission, Royal Government of Bhutan.

NEC. (2012). *Waste prevention and management regulation*. National Environment Commission, Royal Government of Bhutan.

NEC. (2014). *National solid waste management strategy*. National Environment Commission, Royal Government of Bhutan.

NEC. (2014).*The water regulation of Bhutan*. National Environment Commission, Royal Government of Bhutan.

NEC. (2016). *Bhutan state of environment report*. National Environment Commission, Royal Government of Bhutan.

NEC. (2018). Waste inventory and baseline study for developing national and city level waste management strategies and action plans. *Baseline Report*. National Environment Commission, Royal Government of Bhutan.

NEC. (2019). *National waste management strategy 2019*. National Environment Commission, Royal Government of Bhutan. Retrieved from http://www.nec.gov.bt/nec1/wp-content/uploads/2019/07/National-Waste-Management-Strategy-2019.pdf.

Paquot, L. (Ed.). (2017). *Moving towards a circular economy with EMAS. Best practices to implement circular economy strategies (with case study examples)*. European Union: Luxembourg Publications. https://doi.org/10.2779/463312.

Penjor, Y. (2007). *Enhancing municipal solid waste management system with 3R options in Thimphu, Bhutan*. Retrieved from http://faculty.ait.ac.th/visu/public/uploads/Data/AITThesis/Master%20Thesis%20final/yp.pdf.

PHCB. (2005). *Population and housing census of Bhutan 2005*. Office of the Census Commissioner. Royal Government of Bhutan. Retrieved from http://www.nsb.gov.bt/publication/files/pub6ri44cs.pdf.

Phuntsho, S., Dulal, I., Yangden, D., Ugyen, T. M., Herat, S., Shon, H., & Vigneshwaran, S. (2010). Studying municipal solid waste generation and composition in the urban areas of Bhutan. *Waste Management and Research*. Sage Publications. https://doi.org/10.1177/0734242x09343118.

Planning Commission. (1989). *Human settlements: 6th Five Year plan.* Planning Commission, Royal Government of Bhutan.

RSPN. (2006). *Public private partnership for urban environment (PPPUE). Policy framework for solid waste management.* Royal Society for Protection ofNature, Bhutan.

Circular Economy in Canada

Jonathan Cocker and Kimberley Graham

Abstract Canada, specifically Ontario, has become the first jurisdiction in the Americas to enact a comprehensive circular economy law, the *Resource Recovery and Circular Economy Act*, 2016 ("RRCEA") (SO 2016 c. 12). Previously, waste diversion existed in Ontario under the *Waste Diversion Act* ("WDA") (SO 2002, c 6), a government-managed scheme that was meant to oversee the diversion of target waste streams away from landfills. The WDA tasked Waste Diversion Ontario ("WDO") to be the industry regulator, and the province designated industry-funded organizations ("IFOs") as service providers to coordinate waste management activities for their respective industries. The fatal systemic flaw of this framework, however, was that these two bodies were placed between the "Producers" (namely the manufacturers, first importers, and brand owners) and the end-of-life supply chain. The RRCEA will allow the province to more effectively preserve and recover resources, divert materials from landfills, and reduce greenhouse gas emissions from waste, with the overall aim of implementing a "circular economy." Under the RRCEA, the Producers will be the primary resource recovery party, solely responsible for complying with the Ministry's mandated obligations for resource recovery, with non-transferable liabilities. By naming the Producer as the operator of the product's end-of-life (or "reverse") supply chain, their decisions as to a product's composition, content, and deconstruction attributes are now relevant to the waste management process—giving rise to an integrated circular economy market. Canada's treatment of plastics gives interesting insight into how a circular economy might be implemented. Additionally, to address these requirements and liability issues, Producers are looking to Producer Responsibility Organizations ("PROs") as waste management third parties to help address the new and often daunting obligations, as examined in this paper's case study on the used tire industry in Ontario. To help implement RRCEA, Ontario has identified no less than 15 actions to help facilitate the smooth transition to a circular economy, with the express interest of creating scalable solutions which can then be mass-produced across North America.

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1 Introduction

In 2016, Canada became the first country in the Americas to enact a comprehensive circular economy law, which Glen Murray, Former Minister of the Environment and Climate Change for the Government of Ontario, describes as "legislation [that] will tackle the problem of waste generation by increasing resource recovery and moving toward a circular economy. At the heart of the legislation is the idea that Producers should be responsible for the end-of-life management of their products and packaging."[1] Specifically, the landmark RRCEA was enacted in Canada's largest province, Ontario, with the complementary goals of preserving/recovering more resources, diverting more materials from landfills, and reducing greenhouse gas emissions from waste, all with the express overall aim of implementing a "circular economy" in Ontario.[2]

The RRCEA does not, however, arise in a regulatory vacuum. Instead, the Province of Ontario (along with all of the other provinces and territories of Canada) has legislated waste diversion programs for a number of different products/waste streams, generally consistent in purpose, if somewhat more limited, than those of the European Union and elsewhere.[3] Many of the activities now captured under the RRCEA were previously cast as "waste diversion" and regulated under conventional recycling laws,[4] with a more prescribed and less ambitious set of environmental and product life cycle goals.

What is also new and potentially profound in its effects upon waste management both inside of Ontario and across the many other jurisdictions of North America is the transfer of obligation under the RRCEA from the government designated IFOs directly to the Producers themselves.[5] This shift of responsibility for diversion/resource recovery to a near fully private model is often termed "individual Producer responsibility" (or **IPR**), and it is this shift, along with a number of environmental policy changes, which are proposed as the means under which to make the RRCEA, and the circular economy, more than simply another iteration of the IFO waste diversion programs.

[1] https://www.ontario.ca/page/strategy-waste-free-ontario-building-circular-economy.

[2] The RRCEA defines "circular economy" as an economy in which participants strive, (a) to minimize the use of raw materials, (b) to maximize the useful life of materials and other resources through resource recovery, and (c) to minimize waste generated at the end-of-life of products and packaging.

[3] This paper has focused its analysis upon the RRCEA as the only comprehensive circular economy law, but a somewhat lesser commitment to resource recovery and "circularity" can be seen in a number of provincial programs across Canada.

[4] Waste Diversion Act, 2002, S.O. 2002, c. 6 (https://www.ontario.ca/laws/statute/02w06).

[5] As described in more detail below, the RRCEA and the Tire Regulation place the "Producer" at the epicenter of the obligations for resource recovery and this party can be the manufacturer, brand owner, importer, distributor, dealer, or retailer.

This paper will consider (i) the experience of the waste management parties under the IFO model and its relevance in the transition to a circular economy; (ii) the centrality played by IPR—where Producers are directly tasked with operating an end-of-life supply chain with non-transferable liabilities; (iii) the policy goals and mechanisms of the RRCEA; (iv) a case study of how the used tire waste management industry participants have responded and positioned themselves to meet the first circular economy product law, the Tire Regulation[6]; and (v) the supporting government infrastructure measures deemed necessary to IPR's success.

2 Part I: The Transition from Diversion to Circular Economy

2.1 Ontario Waste Market Necessitated Diversion

The Province of Ontario is Canada's largest by population and has a waste generation profile all-too typical in North America. In 2014, for example, approximately 11.5 million tonnes of waste were generated in the province—nearly a tonne of waste per person per year.[7] Forty percent of this waste is generated by households with the other 60% coming from industry, commercial businesses, and institutions. Ontario municipalities are responsible for the waste generated from households and collect, process, market, and dispose of 4.9 million tonnes of material each year, at a cost of $1.2 billion Canadian dollars.

Municipalities in Ontario have some of the most sophisticated diversion programs in North America, with 95% of Ontario households having access to curbside recycling (Blue Box) and curbside compost programs made available to 71% of households in the province. Ontario's Blue Box Program for printed paper and packaging has achieved a recycling performance of 65%.

While municipalities have been driven to increase recycling through programs and regulatory provisions, such progress has not happened elsewhere in the economy and, unfortunately, 3/4 of Ontario's waste has been sent to landfill for the past 10 years.[8]

[6]O. Reg. 225/18: TIRES (April 9, 2018) filed under the *Resource Recovery and Circular Economy Act,* 2016, S.O. 2016, c. 12, Sched. 1.

[7]Ontario Ministry of the Environment and Climate Change (2016a) at p. 4 ("Strategy for a Waste-Free Ontario").

[8]Ibid.

The Ontario government has recently recognized its diminishing waste capacity, the need for resource conservation, and the missed economic and environmental opportunities. In fact, waste diversion has been made a critical piece of the province's *Climate Change Action Plan.*[9] The larger benefit, however, as the province has identified, is replacing virgin resources in the economy with recovered resources available in Ontario.

2.2 What Did Ontario Previously Create?

The predecessor to the RRCEA is the WDA which created the WDO as the regulator tasked with indirectly overseeing the diversion from landfill of a number of waste streams. Included within this group were:

– **waste electrical and electronic equipmen**t including computers, screens, peripherals, and audio/visual equipment;
– **municipal solid waste streams including glass**, metals, printed paper and packaging, and plastics;
– **municipal hazardous and special wastes**, including batteries, pressurized and aerosol containers, fertilizers, herbicides, insecticides and pesticides, paints and coatings, oil bottles and filters, and antifreeze and solvents; and
– **used tires**, including on-road passenger and truck tires and off-the-road tires.

2.3 Industry-Funded Organizations

Through the WDA, the province designated IFOs for each of the target waste streams.[10] IFOs enlisted service providers and coordinated the waste management activities of all of waste diversion participants for each waste stream, including the Producers, haulers, collectors, processors, and remanufacturers (depending upon the waste stream). These IFOs allocated volumes, set fee structures, rated performance, and conducted auditing and performance assessments of all the regulated parties.

[9] Ontario Ministry of the Environment and Climate Change (2016b). At the time of writing, a new Ontario government has expressed an intention to discontinue the Climate Change Action Plan and to reorient the Province's sustainability strategy elsewhere.

[10] There were, in addition, certain more narrowly focused Industry Stewardship Plans, which acted very similarly to IFOs.

With the WDO and the IFOs, two intermediary bodies were, however, placed between the Producers[11] (namely manufacturers, first importers, and brand owners) and the end-of-life supply chain. This was arguably a fatal design flaw that prevented a harmonized approach between regulator and industry.

WDO was to effectively represent the provincial environmental interests regarding waste diversion targets, education, and promotion. The IFOs, in turn, were notionally a coordinating body of industry interests, staffed by industry personnel, making specific allocations of waste resources to the various waste diversion participants in order to coordinate the overall waste diversion enterprise (the "**Command Diversion Framework**"). From inception, IFOs had an unclear enforcement mandate under the Command Diversion Framework in spite of their centrality within it.

An equivalent of the Command Diversion Framework had not been tried on a broad province or statewide scale previously in North America, and there was clearly going to be an element of trial and error in its execution with one or more of the regulated waste streams. The problems, unfortunately, were systemic.

2.4 What Went Wrong with the Command Diversion Framework?

Participants in Ontario's waste diversion programs have a long list of complaints with both the structure and the administration of the Command Diversion Framework, including:

- the failure to make waste reduction and reuse preferable to recycling—it did not incentivize these activities distinctly from recycling, making it the near default diversion strategy;
- Producers were permitted to externalize their responsibility (both financial and liability), making them disinterested parties with no inducements to innovate;
- as IFOs effectively controlled sector monopolies, service providers and Producers were locked into protocols that left little room for needed deviation;
- the Producers' waste diversion fees were, too often, disconnected from the actual costs of diverting the waste;
- poor enforcement and sanction mechanisms permitted a complacent compliance culture in some areas which resulted in an unaccounted for Producer segment operating outside of the Command Diversion Framework;

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[11] S. 59 of the RRCEA uses the term "brand holder," defined as a person who owns or licenses a brand or who otherwise has rights to market a product under a brand. The Tire Regulation reverts to "Producer" to expressly delineate the obligated party formula.

– below optimal diversion rates for organics;
– no effective incentives to reduce waste;
– exclusion of important streams, such as Industrial Commercial and Institutional ("**IC&I**") waste; and
– (perceptions of) lack of fairness, transparency, and certainty in the manner in which the waste resources were allocated among participants, creating uncertainty in the market.

With these attendant problems visible within the first years of inception, calls for a fundamental overhaul have been made repeatedly in the past decade from all stakeholders, with the provincial government finally acceding that the Command Diversion Framework simply did not achieve its goals[12] for most, if not all, of the regulated waste streams.[13]

2.5 Dismantling the Command Diversion Framework

On November 30, 2016, the Province of Ontario finally passed the RRCEA which enabled the passage of transitional legislation, the *Waste Diversion Transition Act, 2016*,[14] thereby permitting the province to move away from the Command Diversion Framework. The transition from a government-managed scheme to the RRCEA *without the disruption or diminution of waste diversion services and activities* is not going to be easy, and the government's planning for the changeover includes:

– moving the government oversight of Ontario waste diversion from the WDO to the resource productivity and recovery authority (the "**Authority**"), with the Authority assuming more of a night watchman role;
– enabling the Ministry of the Environment, Conservation and Parks ("**MOECP**" or the "**Ministry**")[15] to directly change current diversion programs; and
– permitting the MOECP to request the windup of the IFOs, which is anticipated to be a staged and gradual process in light of the need for continuity.

[12]Strategy for a Waste-Free Ontario, *supra* at p.4.

[13]Notably, IFO Ontario Tire Stewardship had the highest diversion rates for reasons which are only partially attributable to its relatively manageable and specialized set of waste diversion participants.

[14]SO 2016, c 12, Sch. 2.

[15]At the time of passage of the RRCEA, the provincial environmental regulator was the Ministry of the Environment and Climate Change.

In short, the WDA and its mixed legacy are near an end, while the waste industry stakeholders (both from within Ontario and elsewhere) scramble to respond to the new regime and its challenges and opportunities.

3 Part II: RRCEA and IPR

3.1 Circular Economy Under the RRCEA

Viewed from the vantage point of waste diversion programs across North America and elsewhere, the RRCEA combines ambitious waste diversion goals with the dynamism of a mandated but relatively unfettered diversion market. Shades of the European Union's innovation with waste diversion[16] can be seen in the outcomes sought:

– a registry of all introduced products and their primary, convenience packaging[17] and transportation packaging[18] (giving rise to regulated wastes) will be established;
– "cradle-to-cradle" stewardship obligations imposed upon brand holders;
– design-for-environment; and
– expanded scope of obligated parties to include those with a "commercial connection."[19]

3.2 Resource Recovery Extends Beyond Recycling

One of the features of the RRCEA which makes it a circular economy law and not merely a privatized waste diversion law is the broader recognition of activities which constitute "resource recovery." Specifically, the RRCEA deems all of the following as "resource recovery":

> the extraction of useful materials or other resources from things that might otherwise be waste, including through reuse, recycling, reintegration, regeneration or other activities[20]

[16]European Commission, *Closing the loop—An EU action plan for the Circular Economy* (EUR-Lex: European Commission, Brussels, 2.12.2015).

[17]Defined under RRCEA as "material used in addition to primary packaging to facilitate consumer's handling or transportation of one or more products, such as boxes and bags."

[18]Defined under the RRCEA as "material used in addition to primary packaging to facilitate the handling or transportation of one or more products by persons other than consumers, such as pallets, bail wrap, and boxes, but does not include shipping containers designed for transporting things by road, ship, rail, or air."

[19]Under s.61(3) of RRCEA, a person who imports, wholesales, leases, or retails product or is otherwise involved in the regulated product's distribution.

[20]S.O. 2016, c, 12—Part I—General, Definitions.

This is significant in that it creates a dynamism within the existing and new waste management industry to find new, less costly and maybe more product-specific recovery activities. Under the Tire Regulation, used tire reuse and recapping have expanded the recovery options available to Producers potentially creating new secondary markets. It also *finally* makes the Producers' decisions as to its product composition, content, deconstruction attributes, etc., relevant to the waste management process—giving rise to a true, integrated circular economy market.

3.3 Producer as Primary Resource Recovery Party

The RRCEA expressly sets six IPR obligations for resource recovery directly upon the Producers:

1. Designate Materials—Producers must self define and designate its products and related packaging for resource recovery.
2. Define Responsible Parties—brand owners, distributors, importers, and retailers must confirm which party is the Producer for every product and related packaging based on regulatory priority rules.
3. Set up a Collection and Management System for the End-of-Life Products and Related Packaging—either individually or through private collectives, Producers must operate a resource recovery supply chain for their products and related packaging.
4. Provide Promotion and Education—Producers must create and/or implement a promotion and education program to increase product and related packaging collection, reuse, recycling, and recovery.
5. Register, Report, Auditing, and Recordkeeping—a central database will be created by the enforcement body resource recovery and productivity authority (the "**Authority**") which will track product and related packaging resource recovery activities.
6. Reduce Waste—Producers will be obligated to engage in design-for-environment in both reducing waste and better-capturing resources at end-of-life.

These six obligations effectively place Producers in a new and unfamiliar role as operators of product end-of-life (or "reverse") supply chains.

3.4 Authority as "Night Watchman" Under IPR?

There is also a clear divide between market participants and the Authority, which shall, under the IPR model, only:

- operate as a data registry for waste diversion participants (namely Producers and service providers);

- engage in compliance and enforcement independent from the industry itself (which will include inspections, compliance orders, and administrative penalties); and
- provide *limited* direct oversight of obligated parties, which may well include Producers, municipalities, service providers, and privately formed collectives of obligated and related service parties.

Notable in its absence is an Authority mandate over policy or waste diversion program development, which shall be assumed directly by the MOECP.[21] Instead, the Authority has signaled and, as of the date of writing, continues to maintain a willingness to enforce the RRCEA mandated outcomes, but the means used in achieving them will principally remain with the market participants.

Of the approaches highlighting this more circumspect regulatory position, the Authority (and, indirectly the MOECP) has, to date:

- permitted various waste management parties to act as PROs for obligated Producers under the RRCEA;
- assumed no coordinating or "clearinghouse" role in the collection, movement, or distribution of resources subjected to recovery activities;
- allowed for the transfer of recovered resources, and perhaps even verification credits, among and between Producers and PROs; and
- not sought to mandate commercial contract terms, including prices, for any parties in the reverse supply chain.

This "night watchman" role for the Authority may, however, be reflective of the current transition to a circular economy and the need to allow for the waste diversion-era parties to first implement a form of IPR before restraints on market activities, including aberrant practices, are introduced over time. The content of those restraints will, in all likelihood, emanate from its broad "provincial interests" mandate (discussed below).

3.5 Balancing Market Certainty and "Provincial Interests"

The RRCEA is notable both its commitment to IPR and the governmental oversight and program direction powers which are retained by the Ministry. Specifically, the RRCEA specifies the "provincial interest" retained by the government as follows:

Provincial interest

2 It is in the provincial interest that Ontario has a system of resource recovery and waste reduction that aims to,

(a) protect the natural environment and human health;
(b) foster the continued growth and development of the circular economy;

[21] It could be argued that WDO also omitted any policy development work, but their central position and obfuscated mandate crowded out the MOECP from much policy initiative.

(c) minimize greenhouse gas emissions resulting from resource recovery activities and waste reduction activities;
(d) minimize the generation of waste, including waste from products and packaging;
(e) increase the durability, reusability, and recyclability of products and packaging;
(f) hold persons who are most responsible for the design of products and packaging responsible for the products and packaging at the end-of-life;
(g) decrease hazardous and toxic substances in products and packaging;
(h) minimize the need for waste disposal;
(i) minimize the environmental impacts that result from resource recovery activities and waste reduction activities, including from waste disposal;
(j) provide efficient, effective, convenient, and reliable services related to resource recovery and waste reduction, including waste management services;
(k) increase the reuse and recycling of waste across all sectors of the economy;
(l) increase opportunities and markets for recovered resources;
(m) promote public education and awareness with respect to resource recovery and waste reduction;
(n) promote cooperation and coordination among various persons and entities involved in resource recovery activities and waste reduction activities;
(o) promote competition in the provision of resource recovery services and waste reduction services;
(p) foster fairness for consumers; and
(q) do any other related thing that may be prescribed.

Notable among this list are those which purport to reinsert the Ministry into the middle of waste sector commercial relationships, such as:

(l) Increase opportunities and markets for recovered resources.
(n) Promote cooperation and coordination among various persons and entities involved in resource recovery activities and waste reduction activities.
(o) Promote competition in the provision of resource recovery services and waste reduction services.

Many of these provincial interests have the ability to profoundly make and remake any or all of the specific circular economy product programs.

3.6 Extent of Provincial Interest Policy-Making?

What is unclear is the extent to which the Ministry will evoke any of these powers and how, in doing so, they will balance existing interests (and investments) with these goals.

As participants under the IPR model, every evocation of a provincial interest will create concerns as the predictability and stability of the circular economy model. Conversely, a resource recovery model predicated simply upon cost reductions and meeting disposal restrictions and bans will not achieve all of the environmental policy aspirations of a circular economy.

This concern over the intrusive role which may be played by the MOECP is not merely hypothetical. Section 11 of the RRCEA expressly anticipates that the Ministry will issue policy statements evoking provincial interests rights:

Policy statements

11 (1) For the purpose of furthering the provincial interest described in Section 2, the Minister, with the approval of the Lieutenant Governor in Council, may issue resource recovery and waste reduction policy statements.

Development of policy statements

(2) In developing a policy statement, the Minister shall consult, in the manner the Minister considers appropriate, with,
   (a) representatives of municipalities;
   (b) representatives of persons engaging in resource recovery activities and waste reduction activities;
   (c) representatives of environmental organizations;
   (d) the public; and
   (e) such other persons as the Minister considers advisable.

While IPR is embedded in the structure of the RRCEA (and Tire Regulation), there is no legislated right for a party to claim non-interference from the Authority or MOECP in the form of IPR freedom from regulatory oversight and management.

In other words, IPR is not a provincial interest and waste management parties will want to understand the significance of this in considering long-term commitments such as capital investments. Further, the limited law which emerged during the diversion era appeared to confirm that legislated environmental promotion powers may be license for all types of policy changes without regard for market impacts.[22]

4 Part III: Canada's Approach to Circular Economy in Plastics

4.1 Canada's Approach to Circular Economy in Plastics

The linear economy that previously existed in Canada created a problem in plastics, and the current take-make-waste model for manufacture, use, and disposal of plastics, is environmentally unsustainable. Had recovery and recycling been more effectively utilized, energy and emissions necessary for each production cycle in plastics would have been alleviated. A move toward a closed loop is necessary, and what is needed is for Canada's chemical industry to innovate how plastics and chemical compounds

[22] Sims Group Recycling v. Minister of the Environment and Waste Diversion Ontario, 2013 ONSC 209.

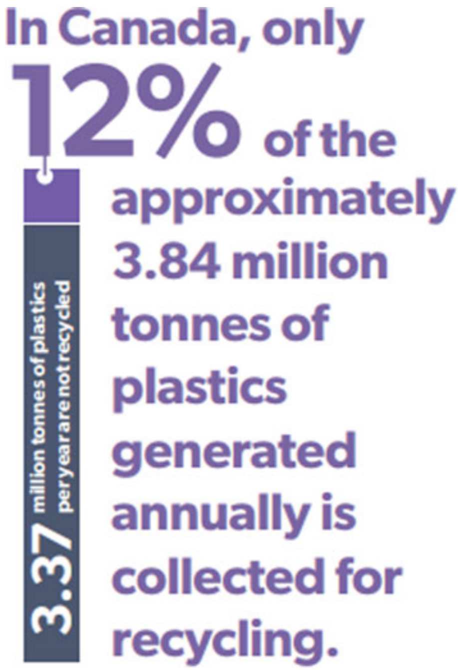

Fig. 1 Usman Valiante; Report: a vision for a circular economy for plastics in Canada, february 2019: pg. 5. https://institute.smartprosperity.ca/sites/default/files/report-circulareconomy-february14-final.pdf; infographic

used in the production of plastics to be reused or more effectively recovered and recycled. However, Canada faces several deterrents for a circular economy for plastics in Canada, cost being the primary one, with technological and informational barriers following closely behind due to the jurisdictional nature of waste management.

4.2 *Current, Linear Approach to Plastics*

Canada's current approach to plastics is referred to as a "take-make-waste model," whereby raw materials are extracted and used to manufacture polymers in plastics and then disposed of into a landfill at their end-of-life. As per the Smart Prosperity Institute's report, dated February 2019, "In Canada, only about 11–12% of approximately 3.84 million tonnes of plastic generated annually is collected for recycling."[23] Most of the waste plastics are disposed of via landfill, incineration, or export. Some plastic waste finds its way directly into the environment through litter, illegal dumping, ineffective waste management, and even through untreated sewage (Fig. 1).[24]

[23] Valiante (2019).

[24] Tevegini Matveev, "The Biggest Source of Ocean Plastic may not be What you Think." Canadian Broadcasting Corporation News. July 2, 2018.

Canada's use of linear, end-of-life models still remains the cheapest form of manufacturing. This reality is only made more difficult with the fluctuating prices of oil and gas, leading to a drop in domestic demand for recycled plastics.[25] This directly impacts how much stakeholders can invest in recycled plastics. The cheaper the virgin resources, the less demand there is to recycle plastics due to an additional and economically prohibitive affiliated cost. Canada does not appear to be an outlier in this regard, however. According to the Ellen MacArthur Foundation, globally only about 2% of plastics are recycled for manufacturing to replace virgin resources in a closed-loop system.[26]

4.3 Intergovernmental Collaboration Toward Circular Economy for Plastics

Within Canada, waste management is handled primarily at the provincial/territorial level, and waste collection activities often fall to municipalities. Jurisdictionally, Canada has inconsistent policies and definitions creating a patchwork of incongruent regulatory requirements and standards.[27] Intergovernmental collaboration between these jurisdictions is needed to harmonize an effective circular economy model on plastics. The federal government has received, via the *Canadian Environmental Protection Act* (CEPA), a blueprint for establishing a regulatory framework for plastics. For example, under the CEPA's Schedule 1 (Toxic Substances List),[28] any substance that is identified as a toxic under this legislature is subjected to regulation no matter the stage of a product's life cycle. This framework is also useful for developing environmental objectives, national standards, and pollution protection plans.[29]

4.4 Support for a Circular Economy

One of the challenges is the division among plastic industry stakeholders as to what the circular economy outcome should be. Canada has a large chemical industry which produces plastics (natural gas), and there are three ways to replace fossil fuel-derived resins with renewable ones[30]:

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[25] Valiante. "A Vision for a Circular Economy for Plastics in Canada," 8.

[26] https://www.ellenmacarthurfoundation.org/news/the-new-plastics-economy-rethinking-the-future-of-plastics-infographics.

[27] Valiante. "A Vision for a Circular Economy for Plastics in Canada," 25.

[28] https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/canadian-environmental-protection-act-1999/schedules.html#sch1.

[29] Valiante. "A Vision for a Circular Economy for Plastics in Canada," 25.

[30] Ibid., 12.

1. Combining hydrogen and CO_2 monomers (ethylene, styrene, or polypropylene). Carbon Engineering, a company based in Squamish, BC has developed a way to extract carbon directly from the air.
2. Gasification of biomass (woody biomass from forestry slash) to convert particles into monomers.
3. Manufacture renewable resins from the production of bio-plastics, such as poly-lactic acid (PLA) which is derived from cultivated biomass (corn).

However, the development of these initiatives will depend largely on economic cost and commercialization of the above-noted processes. Despite their pioneer status, these are promising future developments for the chemical processing and recover polymers for plastic resins. This type of innovation is necessary for long-term renewable plastics; however, the more pressing concern is the reuse of plastics in the current Canadian economy (Fig. 2).

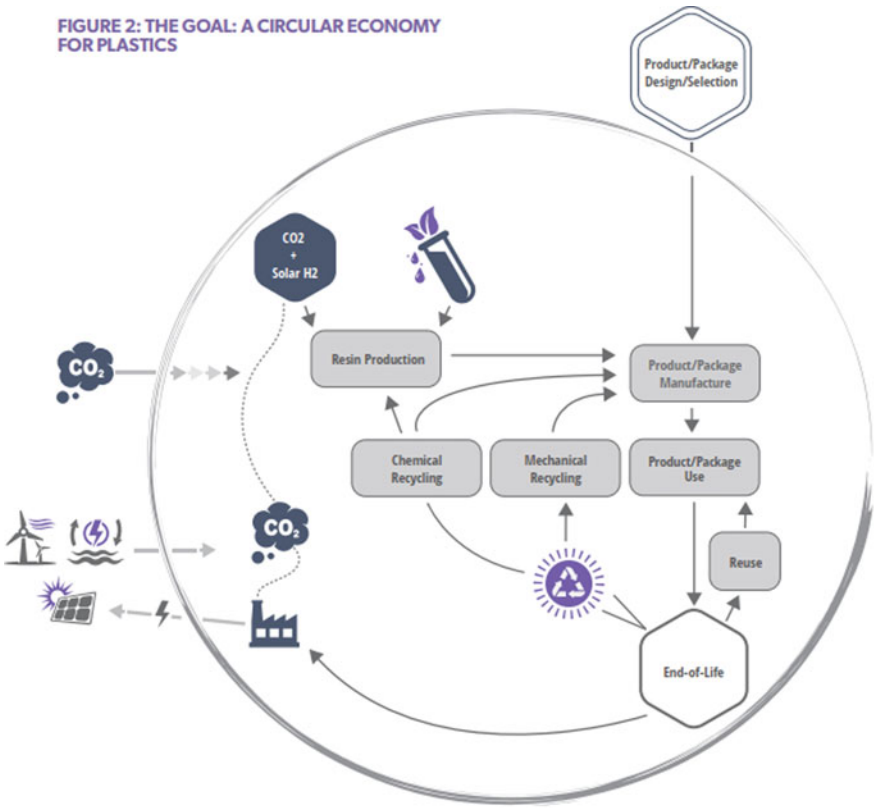

Fig. 2 Usman Valiante; The goal: a circular economy for plastics; Report: a vision for a circular economy for plastics in Canada, february 2019: pg. 11. https://institute.smartprosperity.ca/sites/default/files/report-circulareconomy-february14-final.pdf; diagram

4.5 Recovery Activities to Be Adopted

A. **Recirculation**

In Canada, of the 12% of plastics that are collected for recycling processes, a large proportion is "downcycled," meaning those plastics are no longer usable for their original purpose due to a change in their chemical/physical properties.[31] Recycling, therefore, cannot be the only reliable method for waste recovery and action plan for end-of-life products. Instead, the Smart Prosperity Institute has identified four complimentary pathways to recover plastic waste and reintegrate plastics into the next product life cycle[32]:

1. reuse;
2. mechanically processed and recycled (to be used over virgin resources);
3. chemically processed and recycled (chemolysis and pyrolysis processes, catalytic cracking, gasification, etc.).

   Examples of commercialization

   a. Quebec-based Loop Industries;
   b. Ontario-based Pyrowave Inc.;
   c. Quebec-based Enerkem facility in Edmonton.

4. CO2 recirculation and energy recovery.

B. **Extended Producer Responsibility (EPR) Model**

One of the most effective policies for implementing a circular economy in Canada is to adopt a policy that will incentivize reverse supply chains to evolve into a plastic circular economy. There must be policy in place that will determine and assign Producers responsibility, regulatory requirements, and recycling targets for end-of-life plastics. Or in other words, EPR is regulation that "specifies required outcomes or objectives, rather than the means by which they must be achieved."[33] Such models will inject competition into the market, for Producers to find ways to meet their non-transferable obligations and liabilities respect the end-of-life products they manufacture.

Producer Responsibility Organizations (PROs) are the likely answer for the plastic industry. British Columbia has successfully implemented EPR regulatory structures using this model. Encorp Pacific (a PRO for beverage Producers) recovered 73.9% of plastic beverage containers supplied into BC in 2017.[34] Similarly, and also in 2017, the BC Used Oil Management Association (BCUOMA), recovered 82.5% of plastic used oil and antifreeze containers supplied into the province.[35]

[31] Valiante. "A Vision for a Circular Economy for Plastics in Canada," 8.

[32] Ibid., 12–13.

[33] Coglianese et al. (2002)

[34] Valiante. "A Vision for a Circular Economy for Plastics in Canada," 20.

[35] Ibid., 20.

These high recovery percentages are the result of collaboration and consideration of all stages of a product life cycle. With Producers being directly tied to the product's end-of-life with financial and legal non-transferable liabilities, there is now a vested interest in the management of recycling systems. This will also help by verifying the outcomes of performance standards while providing Producers with the freedom to meet their regulatory obligations. This will likely result in commercial collaboration and among industry associations and address incongruity between Producers and plastic recyclers.

C. **Recycled Content Performance Standards**

This is more on the demand side of the economic policy, whereby materials that would have been otherwise recycled are now sought after materials which will reinforce commercial investment in recycling. A market is created for recovered materials that will ensure demand despite costs from other sources of feedstock. This can also protect against the global market fluctuation of virgin raw material pricing.

4.6 Other Options for Reducing the Amount of Virgin Plastics

In their February 2019 Report, the Smart Prosperity Institute notes two compelling strategies for reducing the amounts of virgin plastics for use in Canada:

(1) Bans on the Sale of Plastic Products and Packaging

Following the EU's example, there has been an international surge in the number of laws that prohibit the use of certain kinds of single-use plastics (straws, drink containers, cutlery, etc.). Bans on such single-use plastic products represent a small fraction of plastic waste, but if implemented at national level could maximize their impact.[36] Although impactful at the consumer level for individual awareness surrounding the issue of plastic waste, it may not be the most effective method.

(2) Single-use Plastic Taxes

Taxes that are implemented on single-use plastics, such as shopping bags, have a similar result to bans, as observed in EU countries such as England, Ireland, Portugal, and Denmark.[37] A tax on the production of single-use plastics discourages both wasteful use and the considerations for manufacturing a product that would put additional stresses on recycling systems. Norway provides a compelling case study regarding their single-use bottle tax. Collectively, once Producers achieve a 95% recycling target, the aforementioned tax is lifted.[38] With such an incentive, Producers created a strategy that refunded deposits which resulted in the recycling

[36] Walker and Xanthos (2018).

[37] Valiante. "A Vision for a Circular Economy for Plastics in Canada," 27.

[38] Ibid., 27.

of 97% of all beverage containers sold to consumers, with 92% being remade into other beverage containers.[39] These taxes serve to help consumers both make environmentally conscious choices when purchasing products and also provide revenue for governments to offset recycling costs.

5 Part IV: Case Study—Used Tires in Ontario

In drafting the new Tire Regulation under RRCEA, the Government of Ontario posted a notice on the Environmental Registry to seek feedback from industry association groups and the general public. The consultation was open from December 1, 2017 to January 22, 2018.[40] Since then, the Tire Regulation[41] has come into full force. Used tires in Ontario, and the processes that currently exist to divert, recover, and recycle them, provide a compelling case study in how the tire industry previously met compliance obligations under the Command Division Framework and how the industry will need to adjust to comply with the Tire Regulation.

Previously, as discussed earlier in this paper, the government-managed scheme under the WDA was meant to oversee the diversion of waste from landfills, with Waste Diversion Ontario functioning as the industry regulator. Under this systemic structure, provinces further designated industry-funded organizations to act as service providers to coordinate all waste management activities. Within the tire industry, Ontario Tire Stewardship ("OTS") emerged as a prominent IFO that managed its own stewardship program, to which members paid fees, to coordinate the end-of-life supply chain for tires.

[39] https://www.theguardian.com/environment/2018/jul/12/can-norway-help-us-solve-the-plastic-crisis-one-bottle-at-a-time, The Guardian, July 12, 2018.

[40] Environmental Registry. Government of Ontario. (2016). https://ero.ontario.ca/notice/013-1716 .

[41] Tires, O. Reg. 225/18.

The tonnes supplied and collected for passenger and light truck ("PLT") tires, medium truck ("MT") tires, and off-the-road ("OTR") tires in Ontario have been as follows under the OTS plan:

Amounts Supplied in Tonnes by the OTS[42]

Tire type	2017	2016	2015
PLT (supplied)	118,740	116,230	113,524
MT (supplied)	46,080	45,448	44,858
OTR (supplied)	20,937	18,225	18,422
Total supplied	185,757	179,903	176,804

Amounts Collected in Tonnes by the OTS

Tire type	2017	2016	2015
PLT (collected)	88,399	90,036	88,835
MT (collected)	35,457	34,155	32,122
OTR (collected)	17,827	18,412	16,472
Total collected	141,683	142,603	137,429

The used tire supply and collection can be further segregated by tire type[43]:

Amounts Supplied in Units by the OTS

Tire type	2017	2016	2015
PLT (supplied)	11,874,000	11,623,000	11,352,400
MT (supplied)	921,600	908,960	897,160
OTR (supplied)	209,370	182,250	184,220

Amounts Collected in Units by the OTS

Tire type	2017	2016	2015
PLT (collected)	8,839,900	9,003,600	8,883,500
MT (collected)	709,140	683,100	642,440
OTR (collected)	178,270	184,120	164,720

[42] Annual Reports, *Ontario Tire Stewardship*, 2018, online: https://rethinktires.ca/about-us/annual-report/#sthash.IwYRpwNq.dpbs.

[43] The following ratios can be used to calculate the number of individual tires:
1 PLT = 10 kg
1 MT = 50 kg
1 OTR = 100 kg.

The statistics reaffirm that there remains a delta between tires supplied and collected. Under the IFO regime, OTS managed its stewardship program with no less than 18 different tire classifications (Fig. 3).

OTS Tire Classification[44]

Under OTS, the following other tire types were expressly excluded[45]:

- push lawn mowers;
- tires on toys;
- bicycle tires
- inner tubes;

Tire Class	Criteria 1	Criteria 2
1	On-Road Passenger, Light Truck Tires	Includes tires designed for use on: • passenger cars, light trucks, small Recreational Vehicles and multipurpose passenger vehicles (MPVs), including sport utility vehicles (SUVs) and crossover utility vehicles (CUV's). • consumer or commercial light trucks, under 10,000 lbs/4500 kg Gross Vehicle Weight. Passenger and Light Truck tires must comply with Motor Vehicle Tire Safety Regulation (MVTSR), Technical Safety Bulletins (TSBs) 109 or 139. • motorcycles, motorcycle sidecars, motor bikes, mopeds, mini-cycles, and golf carts, whether on or off highway.
2	On-Road Medium Truck Tires	Also commonly known as Commercial Truck Tires – Truck and Bus tires including Wide Base or Heavy Truck tires designed for truck/bus applications and Larger RV tires not marked "P or LT". All of which comply with Motor Vehicle Tire Safety Regulation (MVTSR), Technical Safety Bulletin (TSB) 119.
3	Off-Road Pneumatic Tires and wheels not included in classes 1 or 2 and within the weight range in column 3.	1 to ≤ 15 kg
4		> 15 to ≤ 30 kg
5		> 30 to ≤ 70 kg
6		> 70 to ≤ 120 kg and Agricultural Tires* > 70 to ≤ 250 kg
7		> 120 to ≤ 250 kg
8		> 250 to ≤ 375 kg and Agricultural Tires* > 250 kg
9		> 375 to ≤ 700 kg
10		> 700 to ≤ 1200 kg
11		> 1200 kg
12	Solid & Resilient Tires and wheels not included in classes 1 or 2 and within the weight range in column 3.	1 to ≤ 30 kg
13		> 30 to ≤ 60 kg
14		> 60 to ≤ 250 kg
15		> 250 to ≤ 375 kg
16		> 375 to ≤ 700 kg
17		> 700 to ≤ 1200 kg
18		> 1200 kg

***Agricultural Tires are defined as those tires listed as such in The Tire and Rim Association, Inc. Annual Year Book Section 5 and which are used on Agricultural equipment and excluding Industrial and Log-Skidder tires.**

Fig. 3 OTS Tire Classification; Ontario Tire Stewardship; 2013; http://rethinktires.ca/wp-content/uploads/OTS-Tire-Classification-April-2013-Final.pdf; chart

[44]"OTS Tire Classification," Ontario Tire Stewardship (2013), online: http://rethinktires.ca/wp-content/uploads/OTS-Tire-Classification-April-2013-Final.pdf.

[45]General Program Information, *Ontario Tire Stewardship*, online: http://rethinktires.ca/program-participants/faq/#sthash.I0ZSUEx6.dpbs.

- polyurethane tires;
- wheel barrel;
- manual dollies;
- manual hand trucks;
- laminate tires—comprised of used tire components;
- personal mobility device tires;
- commercial aircraft tires.

5.1 *Incentives for Processors*[46]

The OTS plan provided an incentive ranking system for certain secondary tire products.[47] Specifically, an incentive ranking system was used for the following product categories, with crumb rubber receiving the highest incentive level:

- crumb rubber;
- shred;
- fabricated products;
- manufactured products.

5.2 *Tire Stewardship Fee (TSF) Chart*[48]

In respect of the eco fees charted Producers, they range widely from $3.50 to over $500 per tire depending upon size and related processing costs:

[46] Incentives, *Ontario Tire Stewardship*, online: http://rethinktires.ca/program-participants/processor/incentives/#sthash.hd4gSgeZ.dpbs.

[47] Tire processors process tires and create multiple sizes of tire-derived product ("TDP"), which is sold to recycled product manufacturers, who then use that TDP to create various products made from recycled rubber (calendared, molded, and extruded products). Some consumer products that are manufacturer include rubber landscape tiles, rubber mulch, playground surfacing, roofing shakes, athletic flooring, acoustic underlay and carpet pads, rubber paving, and rubber bricks. See: “Why Tire-Derived, Recycled Rubber Products?" Ontario Tire Stewardship, online: http://rethinktires.ca/around-the-home/recycled-rubber-products/#sthash.100vm5Qo.vSrr2jbx.dpbs.

[48] Tire Stewardship Fee (TSF) Chart, Ontario Tire Stewardship, online: http://rethinktires.ca/program-participants/stewards/tsf-fee-chart/#sthash.0yH5OJOA.dpbs .

Tire category	Tire description	Tire class	Tires supplied on or after May 1, 2017	Tires supplied on or after May 1, 2016	Tires supplied May 1, 2014, to April 30, 2015	Tires supplied April 1, 2013, to April 30, 2014
			TSF	TSF	TSF	TSF
On-road tires	Passenger and light truck (PLT) tires	1	\$3.30	\$3.55	\$5.43	\$5.69
	Medium truck (MT)	2	\$12.95	\$12.95	\$14.65	\$14.65
Off-road pneumatic tires	1 to ≤ 15 kg	3	\$5.55	\$5.55	\$5.88	\$5.88
	>15 to ≤30 kg	4	\$11.10	\$11.10	\$11.76	\$11.76
	> 30 to ≤70 kg	5	\$27.76	\$27.76	\$29.40	\$29.40
	> 70 to ≤120 kg and agricultural tires[a] >70 to ≤250 kg	6	\$44.41	\$44.41	\$47.04	\$47.04
	>120 to ≤250 kg	7	\$111.03	\$111.03	\$117.60	\$117.60
	> 250 to ≤375 kg and agricultural tires[a] >250 kg	8	\$172.10	\$172.10	\$182.28	\$182.28
	> 375 to ≤700 kg	9	\$333.09	\$333.09	\$352.80	\$352.28
	> 700 to ≤1200 kg	10	\$516.29	\$516.29	\$546.84	\$546.84
	>1200 kg	11	\$1,237.98	\$1,237.98	\$1,311.24	\$1,311.24
Solid and resilient tires	1 to ≤30 kg	12	\$11.10	\$11.10	\$11.76	\$11.76
	>30 to ≤60 kg	13	\$22.21	\$22.21	\$23.52	\$23.52
	> 60 to ≤250 kg	14	\$55.51	\$55.51	\$58.80	\$58.80

(continued)

(continued)

Tire category	Tire description	Tire class	Tires supplied on or after May 1, 2017	Tires supplied on or after May 1, 2016	Tires supplied May 1, 2014, to April 30, 2015	Tires supplied April 1, 2013, to April 30, 2014
			TSF	TSF	TSF	TSF
	> 250 kg to ≤375 kg	15	$172.10	$172.10	$182.28	$182.28
	>375 to ≤700 kg	16	$333.09	$333.09	$352.80	$352.80
	>700 to ≤1200 kg	17	$516.29	$516.29	$546.84	$546.84
	>1200 kg	18	$1,237.98	$1,237.98	$1,311.24	$1,311.24

[a] Agricultural tires are defined as those tires listed as such in The Tire and Rim Association, Inc. Annual Year Book Section 5, which are used on agricultural equipment and excluding industrial and log skidder tires

5.3 Who Is the Producer?

The first and likely most central determination to be made under the Tire Regulation is an assessment as to which party in a tire supply chain is the "Producer." As with many consumer sectors, there is an ever-changing mix of parties, including manufacturers, importers, distributors, dealers, and unaffiliated retailers, many of which can fall into multiple categories depending upon the movement of tires.

The Tire Regulation seeks to define the Producer using a "waterfall" definition predicated upon residency within the province:

3. (1) For the purposes of the definition of "producer" in subsection 1 (1), the producer is

(a) subjected to subsections (2) and (3), with respect to new vehicles marketed to consumers in Ontario, on which new tires are provided,

- (i) if the manufacturer of the vehicle is resident in Ontario, the manufacturer;
- (ii) if there is no person described in subclause (i) and the vehicle is imported into Ontario by a person resident in Ontario, the importer;
- (iii) if there is no person described in subclause (i) or (ii) and the vehicle is marketed by a person resident in Ontario, the first person who marketed the vehicle; or
- (iv) if there is no person described in subclause (i), (ii), or (iii) and the vehicle is marketed by a person not resident in Ontario, the person who marketed the vehicle.

(b) with respect to new tires marketed to consumers in Ontario separately from a vehicle,

- (i) if the brand holder of the tires is resident in Ontario, the brand holder;
- (ii) if there is no person described in subclause (i) and the tires are imported into Ontario by a person resident in Ontario, the importer;
- (iii) if there is no person described in subclause (i) or (ii) and the tires are marketed by a person resident in Ontario, the first person who marketed the tires; or
- (iv) if there is no person described in subclause (i), (ii), or (iii) and the tires are marketed by a person not resident in Ontario, the person who marketed the tires.

As can be seen, the primary party is the resident manufacturer, failing which it is the resident importer, and then the resident "marketer," and, lastly, the nonresident marketer. This formula has created some interesting dynamics among Producers, where a company can be the Producer for some, but not necessarily all, of the tires sold in the province. Under the Command Diversion model, these issues were easily (and exhaustively) dealt with through a commercial agreement as to which party would pay the stewardship fee.

With direct Producer liability for such tires, and competing tire PROs with different reverse supply chains and cost structures, the question becomes much more significant. Further, there appears to be reluctance among Producers and certainly among PROs to transfer obligations for tire brands where there are multiple Producers responsible. Instead, precise accounting will be needed to make sure all of the tires, but none more are subjected to the RRCEA recovery obligations as imposed on individual Producers.

This convoluted formula, made worse by the web of intricacies within the tire industry in the province, is a vestige of the Command Diversion model, under which the priority was to locate a fee payer resident in the province. This model ceases to make sense once the full extent of the circular economy obligations is understood.

5.4 The Test of Residency

The corporate presence within a sub-national jurisdiction, such as a province or state, is typically used as the qualifying test for which party is obligated to assume stewardship obligations for a waste-diverted product. This was true under the Command Diversion model, and it is now been maintained under the Tire Regulation:

> "resident in Ontario" means a person having a permanent establishment in Ontario within the meaning of the *Corporations Tax Act*;

In the Ontario tire market, this has meant that some, but not all, of the largest manufacturers are directly deemed Producers under this test, potentially creating asymmetrical obligations among direct competitors within a PRO.

5.5 Tire Regulation Defines Key Producer Obligations

Among the six key obligations imposed upon Producers under the RRCEA, two of those obligations will impose the most obligation and related liability among Producers:

- establishing and operating a used tire collection network and
- managing the resource recovery activities in respect of the collected tires.

Each is discussed in turn below.

Tire Collection

(a) Tire Collection Amounts

The Tire Regulation proposes a formula for collection of used tires at 85% of the Producer's supply of new tires "into the market," with a "rolling" three-year period, set two years retrospectively. The 85% is notionally the loss of tire mass during the useful life of a new tire supplied into Ontario. It is not clear if this type of discount would be used in other product/waste streams to discount other obligations, perhaps due to shrinkage of the resource. As also noted above, the supply of tires (setting the Producer's recovery obligation) has traditionally been substantially higher than the collection in Ontario. The formula is set out as follows:

4. (1) Subject to subsection (7), every calendar year, every producer shall collect a minimum amount of tires in accordance with this section.

(2) The minimum amount of tires that must be collected each calendar year shall be determined using the formula

$$(Y3 + Y4 + Y5)/3 \times 0.85$$

in which,

"Y3" is the calculated weight of tires supplied or provided on vehicles supplied in Ontario by the producer in the calendar year three years prior to the collection year.
"Y4" is the calculated weight of tires supplied or provided on vehicles supplied in Ontario by the producer in the calendar year four years prior to the collection year.
"Y5" is the calculated weight of tires supplied or provided on vehicles supplied in Ontario by the producer in the calendar year five years prior to the collection year.

The collection obligation also makes it clear that only used tires originating in the province will qualify for meeting Producer recovery obligations and that the reverse supply chain parties must also be registered with the Authority.

(3) No producer shall collect tires from outside of Ontario for the purpose of satisfying the minimum amount of tires required under subsection (2).
(4) The following conditions apply for the purposes of satisfying the minimum amount of tires required under subsection (2):

1. Tires counted toward the minimum requirement must be
   i. picked up by a tire hauler registered under Section 17 and provided to a tire processor or tire retreader registered under Section 17 or
   ii. provided to a person for reuse.
2. Tires must only be counted once and must not be counted by more than one producer.

In addition to collection amounts, Producers are obligated to extend their collection network to essentially anywhere that their tires are sold in the province *by anyone, not only the Producers themselves.* For large Producers, this formula is as follows:

Tire collection, large Producer

6. (1) Every producer, other than a producer who only supplies large tires or vehicles on which large tires are provided, who is required under Section 4 to collect 10,000 kg or more of calculated weight in a calendar year shall.

(a) satisfy the following four requirements:

- (i) In local municipalities with one or more retail locations that supplied the producer's tires or vehicles on which their tires were provided to consumers in the previous calendar year, the producer shall establish and operate as many tire collection sites in the subsequent calendar year as are equal to or greater than 75% of the number of retail locations in the municipality that were operating in the previous calendar year and had supplied more than 1,000 kg of calculated weight in that year.
- (ii) In local municipalities with a population of 5,000 or more, as reported by Statistics Canada in the most recent official census, but without a retail location that supplies the producer's tires or vehicles on which their tires are provided to consumers, the producer shall establish and operate at least one tire collection site.
- (iii) In territorial districts, the producer shall establish and operate a tire collection site within 30 km of each retail location that supplies the producer's tires or vehicles on which the tires are provided.
- (iv) In territorial districts with a population of 1,000 or more, as reported by Statistics Canada in the most recent official census, but without a retail location that supplies the producer's tires or vehicles on which their tires are provided to consumers, the producer shall establish and operate at least one tire collection site or hold at least one public tire collection event each calendar year.

(b) satisfy the following two requirements:

- (i) In local municipalities with a population of 1,000 or more, as reported by Statistics Canada in the most recent official census, the producer shall establish and operate.
  - (A) at least one tire collection site if the population is less than 3,000 or
  - (B) if the population is 3,000 or more, at least one tire collection site for every 3,000 people or portion thereof
- (ii) In territorial districts with a population of 1,000 or more, as reported by Statistics Canada in the most recent official census, the producer shall establish and operate at least one tire collection site.

This requirement is easily the most onerous logistically for any one Producer to handle themselves, effectively pushing them into some form of collective action to manage the obligation. The Tire Regulation expressly mandates that PROs, discussed below, will serve this collective need.

(b) Tire Resource Recovery
The other notable feature of the Tire Regulation is the obligation to manage an effective reverse supply chain for used tires generated in the province. The obligations are, on their face, profound in placing Producers into a waste management role without any clear ability to transfer liabilities for such liabilities to their waste management third-party providers, including PROs.
Among the interesting features of these obligations are the qualifying resource recovery activities, some of which are included as legacy approved activities under the OTS plan. These rules, as observed from outside of the provincial tire recycling industry, can appear arbitrary and the subject of special interests.

Management of tires

11. (1) Every producer shall, in addition to establishing and operating a collection system for tires, establish and operate a system for managing the collected tires in accordance with the requirements set out in this section.

(2) The producer shall ensure that, with respect to tires collected in a calendar year for the purpose of satisfying the minimum amount requirement under Section 4 for that calendar year,

(a) one or more of the reuse, retreading, or processing activities referred to in subsection (3) are undertaken with respect to the collected tires by March 31 in the following calendar year and
(b) the calculated weight of the tires that were reused or retreaded or the weight of the processed materials used in place of raw materials, or a combination thereof, amounts in total to at least 85% of the calculated weight of the collected tires.

(3) The activities referred to in subsection (2) are the following:

1. The tires are reused without modification for their original purpose.
2. The tires are reused without modification for a new purpose, including for the purpose of being reused as a bumper or similar apparatus for absorbing shock or preventing damage, but not including for the purpose of being deposited on land.
3. The tires are retreaded by a tire retreader registered under Section 17.
4. The tires are processed by a tire processor registered under Section 17, and the processed materials are used in place of raw materials in the making of new products or packaging, including the following:
   i. blasting mats;
   ii. paving products used in pavement, including products used to maintain or repair pavement;
   iii. rubber products used for indoor or outdoor surfaces, including poured-in-place rubber products, mats, curbs, carpeting, or athletic or recreational surfacing;
   iv. rubber products used for bases to support signage;

v. subject to subsection (5), mulch and landscaping material;
vi. subject to subsection (5), tire-derived aggregate used in roadbed construction or repair.

(4) The producer shall not include the following in the 85% minimum requirement referred to in clause (2) (b):

1. the calculated weight of tires or the weight of processed materials that are land disposed;
2. the calculated weight of tires, the weight of processed materials, or the weight of any products or packaging derived from tires or processed materials that are incinerated or used as a fuel or a fuel supplement;
3. the calculated weight of tires or the weight of processed materials that are stored, stockpiled, or otherwise deposited on land, unless they are deposited on land in a manner set out under paragraph 4 of subsection (3).

(5) Mulch and landscaping material and tire-derived aggregate used in roadbed construction or repair must not, separately or combined, account for more than 20 per cent of the 85% minimum requirement referred to in clause (2) (b).
(6) Any producer who collects tires in a calendar year despite being exempt from the requirement to collect tires in that calendar year pursuant to subsection 4 (7) shall ensure that the activities referred to in subsection (3) of this section are undertaken with respect to those tires.

Contained within these rules are perhaps exercises of the "provincial interest." What is not clear is the origin and policy justification for these particular rules.

5.6 The Central Role of PROs

Finally, the accumulated obligations of Producers are the RRCEA and Tire Regulation will, in practice, be primarily discharged by PROs, at least in the early years of a circular economy regime. A PRO is defined in the Tire Regulation as:

"Producer Responsibility Organization" means a person retained by a Producer for the purposes of carrying out one or more of the following Producer responsibilities relating to tires:

1. arranging for the establishment or operation of a collection or management system;
2. establishing or operating a collection or management system;
3. preparing and submitting reports.

The Tire Regulation is novel in fostering what are rightly be the first PROs in North America. At the time of writing, the PROs have come from diverse origins:

– tire manufacturers' industry association;
– large single tire retailer; and

– existing tire processors.

What will likely prove difficult over time will be the management of the various interests and priorities of the PRO members in light of the divergent paths and interests of Producers.

6 Part V: Ontario's Strategy to Support the RRCEA

In implementing the RRCEA, the province has recognized that it must actively create the conditions necessary for the regime to succeed. Simply supplanting the WDO with a market-based RRCEA is understood as insufficient for a true circular economy to germinate. No fewer than 15 actions[49] have been identified in the strategy:

Action #1: Empower the Resource Productivity and Recovery Authority

This is responsive to the widely held view that the WDO was lacking a sufficiently robust enforcement mandate to compel compliance. The Authority is expressly tasked with "ensuring producer compliance with regulated requirements and a fair system that discourages non-compliance and prevents free riders."[50]

Action #2: Issue Policy Statements to Provide Clear Direction on the Provincial Interest

The province has a laundry list of lofty goals for the reorientation of the Ontario economy away from its current disposal practices. Policy statements are intended to be issued by the Minister and serve as directives to the Authority, updating and supplementing the content of the RRCEA and regulations. They could directly impact municipal decision-making and others that hold environmental approvals.

Action #3: Establish a Registry and Build Data Capacity to Provide for Evidence-Based Decisions

The Authority is to "collect import data from producers and other parties that conduct activities related to waste reduction and resource recovery. These efforts will help the province effectively set targets and develop policies while the Authority monitors and assesses producer performance."[51] If the province fully succeeds in electronically tracking the introduction and removal of waste volumes (which admittedly is easier in some regulated waste streams than others), compliance levels will no doubt improve, though there may be unintended consequences and resulting industry concern associated with this level of monitoring.

[49] Strategy for a Waste-Free Ontario, supra at 14–35.

[50] Ibid., at 14.

[51] Ibid., at 17.

Action #4: Transition Existing Waste Diversion Programs Smoothly to New Producer Responsibility Framework Without Disruption of Services

The province is highly sensitive to any disruptions in waste diversion services occasioned by the transition. The most difficult waste diversion program to transition to an IPR is Blue Box, a municipally run waste diversion program for printed paper and packaging and based on 50–50 shared responsibility.[52] This program is mandated under Ontario Regulation 101/94[53] and requires every Ontario municipality with at least 5000 residents to operate a Blue Box program.

Action #5: Amend the 3Rs Regulations to Increase Resource Recovery Across all Sectors

Provincial regulations under the *Environmental Protection Act* (Ontario), dating from more than 20 years ago, mandated the IC&I sector to take positive steps in the reduction of waste:

- Ont. Reg. 102/94 Waste Audits and Waste Reduction Work Plans[54];
- Ont. Reg. 103/94 Industrial, Commercial and Institutional Source Separation Programs[55]; and
- Ont. Reg. 104/94 Packaging Audits and Packaging Reduction Work Plans.[56]

Together, these process-focused obligations (largely without concrete performance targets) were the original foundational support for IC&I waste reduction goals, frequently referred to as the "3Rs Regulations."[57] The province no longer views the current 3Rs Regulations as forming part of the future IC&I waste strategy, describing them as:

> no longer adequately drive waste diversion. Their requirements are limited to large establishments and only select waste materials, and require only "reasonable efforts" to send source-separated wastes for recycling or reuse.[58]

Proposed changes to IC&I waste diversion will mean the substantial revision, if not wholesale replacement, of the 3Rs Regulations and are likely to include:

- concrete diversion thresholds;
- use of "new technologies" to measure performance;
- third-party monitoring, certification, and audits; and
- possible imposition of IPR obligations, along with selective disposal bans.

It is the disposal bans which will be viewed as the most onus of these requirements, if, for no other reason, than the sheer volume of material to be diverted.

[52] Many of these concerns are highlighted in Valiante (2016)

[53] Recycling and Composting of Municipal Waste, O Reg 101/94.

[54] Waste Audits and Waste Reduction Work Plans, O Reg 102/94.

[55] Industrial, Commercial and Institutional Source Separation Programs, O Reg 103/94.

[56] Packaging Audits and Packaging Reduction Work Plans, O Reg 104/94.

[57] Draft Strategy for a Waste-Free Ontario, supra at 22.

[58] Ibid., at 22.

Action #6: Establish Service Provider Requirements to Protect the Environment While Promoting Resource Recovery

The province takes the view that IPR and the RRCEA cannot succeed without a modernization of the support services, including hauling, processing, recycling, diversion, and disposal. As part of this process, the government is seeking to adopt:

- new national, international, and industry standards for diversion and disposal;
- new technical recycling standards; and
- third-party monitoring, auditing, and public reporting.

Ontario's recent end-of-life vehicle environmental standards for disposal sites,[59] which covers depollution, waste storage, training, and recordkeeping, are held up as the model for diversion standards for other regulated waste streams, including diverted waste. There may well be some difficult transitions to come in the event that comparable onerous diversion processing requirements are applied more broadly to all current and impending regulated waste streams.

Action #7: Ensure Landfills are Well Planned and Managed to Minimize the Need for Them and Reduce Greenhouse Gas Emissions

The province estimates that more than 70% of products within the Ontario marketplace are ultimately sent to landfill.[60] While the *Strategy* acknowledges that there will still be a need for some additional landfills in the province, these will be subjected to stringent new approval and operating standards to protect against environmental harms, including to drinking water sources.

More notably, the province plans to develop a landfill gas recapture protocol, focused on methane, which will permit the generation of offset credits under Ontario's new greenhouse gas reduction cap-and-trade scheme, which were made operational in January 2017.[61] This serves as another example of the interdependence of the circular economy and climate change regulation.

Action #8: Establish Promotion and Education Requirements to Support Public Participation in Resource Recovery

The RRCEA places promotion and education requirements for waste diversion upon the industry participants themselves instead of the Authority, who are now obligated under the RRCEA to "ensure consumers are getting the information they need to properly participate in resource recovery efforts."[62]

It is unclear whether those requirements will be tied to waste diversion performance and exactly how such efforts will be overseen by the Authority. Clearly, there will be a role for Producers and their Producer Responsibility Organizations (PROs) to coordinate on promotion and training.

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[59] Registrations Under Part II.2 of the Act—End-of-Life Vehicles, O Reg 85/16.

[60] Strategy for a Waste-Free Ontario, supra at. 24.

[61] Climate Change Mitigation and Low-carbon Economy Act, SO 2016, c 7.

[62] Strategy for a Waste-Free Ontario, supra at 26.

Action #9: Designate New Materials to Ensure Producers are Fully Responsible for Recovering More Materials from Products and Packaging

The 2009 Canadian Council of Ministers of the Environment Extended Producer Responsibility Plan[63] included a phased plan for the long-term expansion of waste diversion programs to a number of other products and packaging sources. The RRCEA focuses on three of these sources:

– printed paper and packaging;
– food and organic wastes; and
– construction and demolition materials.

Other waste streams will be resource recovered based on a host of considerations including:

– viability of end-of-life markets for the diverted waste;
– infrastructure capacity;
– effectiveness of existing non-regulated efforts;
– experience of diversion of such waste streams outside of Ontario; and
– harmonization with existing international efforts.

It is anticipated that the first phase of additional materials to be subjected to circular economy obligations, under the RRCEA, will include:

– appliances;
– electrical tools;
– batteries;
– fluorescent bulbs and tubes;
– mattresses;
– carpets;
– clothing and other textiles; and
– furniture and other “bulky” items.

It is hoped that the diversion of existing regulated materials, along with others identified through this review and assessment process, will harmonize Ontario’s efforts with those of the international community, thereby further opening the door to the collective wisdom of the broader waste diversion industry, including the European Union’s Action Plan for the Circular Economy.[64]

Action # 10: Implement an Action Plan to Reduce the Volume of Food and Organic Waste Going to Landfill

Organics bans have yet to be broadly implemented across Canada. Ontario is considering an ambitious province-wide ban on organics which will clearly need to involve municipalities (as the current collector and disposer of household organics) in any such phased-in plan. Commercial organic waste generators will need to seek market solutions to their impending diversion obligations.

[63] Ibid., at 27.
[64] Ibid., at 23.

Action #11: Implement an Excess Soil Management Policy Framework to Increase the Reuse of Excess Soil, While Protecting Human Health and the Environment

The goal of excess soil management is to redeploy excavated soils wherever possible in place of the traditional practices of landfilling such soils as wastes regardless of their current or treatable quality. This can only be done through ensuring that generators of excess soil are implementing proper testing standards which will mitigate environmental risk and managing those soils consistent with any environmental restrictions.

Action # 12: Adopt and Implement Modern Regulatory Approaches to Build on And Promote Innovative Best Practices

A critical element in Ontario's plan will be a fundamental reconsideration of what constitutes a "waste" so that industry in Ontario can fulfill the fourth RRCEA goal—namely exportable innovation for the use of recovered resources for secondary and tertiary purposes. Notably, the Minister is to develop a:

Risk-based approach for compliance and enforcement will also simplify legal requirements and business processes for activities which are lower risk and less complex or have standard requirements, while continuing to protect the environment and human health.[65]

In short, Ontario is seeking to revisit traditional waste sector presumptions that material no longer fit for its original use is necessarily a waste to be destined for landfilling. The impediments to innovation posed by the current MOECP waste regulation and practice cannot be overestimated.

Action #13: Improve and Establish Environmental Standards to Provide for a Level Playing Field and a Strong Foundation for Markets

The province is considering the adoption of a series of environmental standards for recovered materials to ensure the consistency of feedstock for nascent secondary markets for diverted materials. Standards may include regulatory requirements, guidelines, best practices, and certification programs. The need for robust markets for the diverted materials, fostered by clear standards, is also central to the *Strategy.*

Action #14: Use Green Procurement Practices to Build Market Demand for Recovered Materials

Government procurement is to support the circular economy with its preference (in some circumstances) for recovered resources and recycled content, as well as more environmentally responsible service providers.

Action #15: Implement Disposal Bans to Direct Materials to End-Markets

Perhaps the most challenging of all circular economy measures coincident with the RRCEA are the proposed disposal bans set for:

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[65] Ibid., at 32.

– organics;
– existing diverted wastes;
– beverage containers;
– corrugated cardboard and some paper materials; and
– fluorescent bulbs and tubes.

Producers may well have allied interests in seeing that disposal bans can be used to facilitate the diversion markets.

7 Part VI: Conclusion

7.1 Will the RRCEA Succeed?

In a vacuum, the introduction of the RRCEA into a "greenfield" municipal-based waste disposal regime would be challenging, given the lack of industry experience, including processing capacity. Given the (sometimes bitter) experience of the past decade under the Command Diversion Framework, however, there is substantial working knowledge of diversion of the existing regulated waste streams which, when supplemented by technology and resource recovery expertise from outside the province, may well be enough to make it viable in Ontario and then beyond. There is certainly a view that some Producers will move slowly away from current IFO-based historical groupings, perhaps keeping some of the IFO era practices instead of adopting more "circular" initiatives.

7.2 Used Tires as IPR Test Case

As a first regulated waste stream under the RRCEA, used tires are viewed by many inside Canada and elsewhere as the test case for IPR. The Tire Regulation clearly reaffirms the intention by the MOECP to let private industry decide how to establish and operate an end-of-life supply chain for used tires. Further, the Tire Regulation does not propose specific quotas and scoring for the end recovery uses of such tires other than a few restrictions discussed above. This may well engender the type of innovation and industry which can be exported for used tire recovery operations elsewhere, but will likely be years in germination.

Many uncertainties remain, however, including the most fundamental quandary facing Producers such as how they can comply in diverting a waste stream that they do not control and their PROs cannot command.

Further, like all resources, there will be more and less preferred sources, with differential costing based on location, resource collection efficiencies, certainties of supply, etc. There is already concern among Producers of various regulated waste streams that the prime diversion sources need to be secured far in advance of the anticipated RRCEA compliance date and that they over collection by some may lead to non-commercial practices.

Finally, the *Strategy*, in some sectors, seems to require an economy of scale that effectively pushes segments of Producers into PROs, but this may create unintended complications under Canada's *Competition Act,*[66] which contains prohibitions on oligopolies and other restraints of trade. In other words, if some Producers act jointly with due diligence and seek to secure the diversion supply they need to offset their product waste, their actions may be punishable by Industry Canada where the resulting PROs are viewed as engaging in anticompetitive activities.

7.3 Could Ontario Become the Circular Economy Model for North America?

Every other province and territory in Canada operates waste diversion programs, along with many US states and municipal entities. The products subjected to diversion under Ontario's RRCEA will be predominantly the same supply "imported" into the other provinces, states, and territories in North America. As such, a workable solution in Ontario has the real benefit of being replicable at scale elsewhere in North America.

In fact, the Province of Ontario is effectively betting that, as a first mover in North America in the circular economy, it develops the innovation with Ontario's scheme to then reproduce the know-how and industry elsewhere—a cottage industry with aspirations as a North American leader.

In short, the ability to replicate the RRCEA elsewhere in North America is arguably a fundamental premise upon which it has been legislated in Ontario so its expansionist goals should come as no surprise. It remains to be seen just how successful and amenable to replication these efforts may be.

References

Coglianese, C., Nash, J., & Olmstead, T. (2002). *Performance based regulation: prospects and limitations in health, safety and environmental protection*. *Regulatory Policy Program, Center for Business and Government*. Cambridge, MA, USA: John F. Kennedy School of Government, Harvard University

Environmental Registry. Government of Ontario. (2016). *Draft tire regulation under the Resource Recover and Circular Economy Act, 2016*. http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTMzODM2&statusId=MjAzNTY1&language=en.

Ontario Ministry of the Environment and Climate Change. (2016). *Strategy for a waste-free Ontario: Building the circular economy*. Queen's Printer for Ontario.

Ontario Ministry of the Environment and Climate Change. (2016). *Climate change Action Plan 2016–2020*. Ontario Ministry of the Environment and Climate Change. Accessed online: http://www.applications.ene.gov.on.ca/ccap/products/CCAP_ENGLISH.pdf.

[66]RSC 1985, c C-34.

Valiante, U. (2016). *A practical pathway to producer responsibility for paper products and packaging in Ontario*, December 6th, 2016, Corporate Policy Group LLP.

Valiante, U. (2019) *Report: A vision for a circular economy for plastics in Canada—The benefits of plastics without the waste and how we get it right*. Smart Prosperity Institute. February, 2019. https://institute.smartprosperity.ca/sites/default/files/report-circulareconomy-february14-final.pdf.

Walker, T. R., & Xanthos, D. (2018). A call for Canada to move toward zero plastic waste by reducing and recycling single-use plastics. *Resources, Conservation & Recycling*.

Circular Economy in China

Xianlai Zeng and Jinhui Li

Abstract Circular economy is devoted to improving resource efficiency and recycling rate. Its actions are being motivated by four major drivers: (i) regulatory control led by a mix of US states, European Union legislation, and China's environmental law; (ii) competitive incentives for both cost decrease and technology innovation; (iii) stakeholder promotion related to brand reputation and greater transparency; and (iv) risks from supply chain broken caused by regional resource shortage and vis major event (Dauvergne and LeBaron in New Polit Econ 18(3):410–430, 2013). In China, these drivers and pressures have imposed evolution of circular economy.

1 China's Adventure Process

Since the policy of reform and open was initiated in 1978, China has transferred from a centrally planned to a market-based economy, which enables the rapid economic and social progress in the recent four decades. Gross domestic product (GDP) growth has averaged nearly 10% per year, which is the rarely sustained expansion by a major economy in history. Thus, over 800 million peoples have got rid of poverty. China not only realized all the Millennium Development Goals (MDGs) by 2015 but also created a prime contribution to the global achievement of the MDGs. Although China's GDP growing rate has gradually descended since 2012, it is still impressive on current global standards. In 2018, China's GDP surpassed 90 trillion CNY (Fig. 1). With a population of nearly 1.4 billion, China is the second largest economy and has become the largest contributor to international growth since the global financial crisis of 2008. These achievements are majorly performed by more than 40 million companies around China.

In China, circular economy along the supply chain generally involves two aspects as cleaner production and waste recycling. Cleaner production is achieved primarily

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https://doi.org/10.1007/978-981-15-1052-6_6

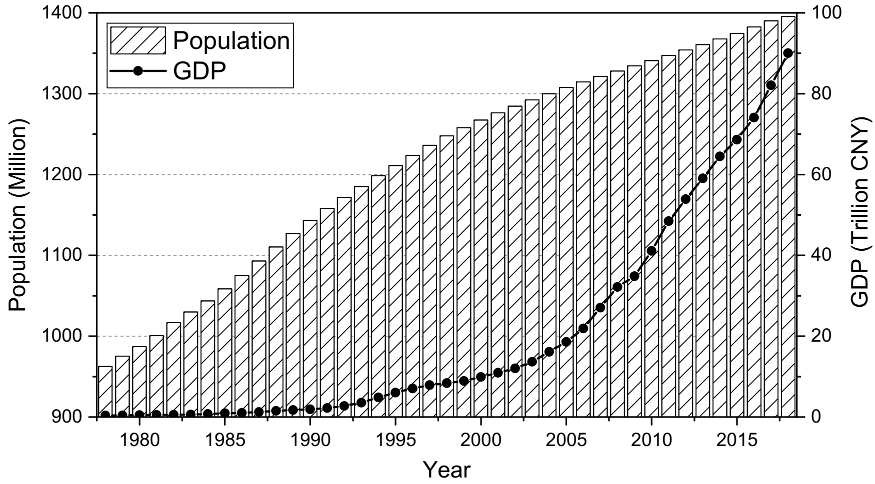

Fig. 1 China's population and GDP from 1978 to 2018. *Note* Data source from China Statistics, http://www.stats.gov.cn/tjsj/

in ecological industrial park (IP), and waste recycling is performed mostly in urban mining demonstrate base. These two actions are the core practical approaches of circular economy towards a sustainable society. In this chapter, we will address them to outline the policy and technology along the adventure.

(1) Before 1970

In order to improve circular economy subject to resource efficiency and waste recycling, some small enterprises were gathered and scaled up, known for IP. The traditional IP can be tracked back to 1950s. But the IP was characterized with the led by the national enterprise in remote place. They had no relevant facilities and single industry type so that they were the mixed industry with labour and intensified land between pollution and non-pollution. There was no legislation system on environmental protection and waste recycling. Almost all the industrial waste and municipal solid waste were disposed with open dump without environmental consideration. Additionally, there was lack of technical process for waste recycling and circular economy (Fig. 2).

(2) 1970–1995

In this period, especially after 1980, China's economy was rapidly lifted. In 1979, Environmental Protection Law (trial run) was implemented so that the legislation system of environmental protection started to establish, and environmental protection was regulated as one national policy. But the philosophy of 'pollute first, then clean up' dominated. As a result, waste disposal with simple landfilling was popular without some efficient recycling (Fig. 2). Five economic special economic zones and 14 open cities emerged with a couple of economic development zones. Modern IPs

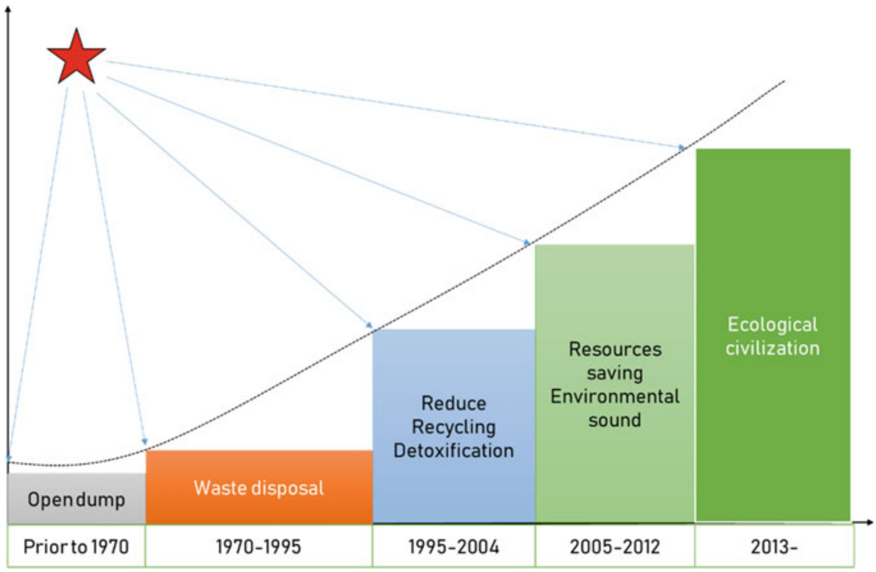

Fig. 2 China's adventure of industry and pollution controlling

were established with feasible land plan and environmental plan. More and more environmental pollution occurred in the cities.

(3) 1996–2004

As a 'world factory', China exported functional products, but consumed natural resources and left the majority pollutants behind for domestic land (Liu and Diamond 2005). Accordingly, China became the largest contributor of sulphur oxides and chlorofluorocarbons to the atmosphere. On April 1, 1996, Solid Waste Pollution Prevention Law was enforced so that waste recycling and safety disposal were regulated. In August, 1996, the environmental policy of 'one controlling and two meets' was released by State Council: all the industrial source should meet the emission standard, and the fifteen types small enterprises should be closed, covering about 84,000 small electroplating, small papermaking, and small chemical plant. Until 31 December 2000, 97.7% of industrial sources met the emission standard, and 93.6% of priority pollution enterprises realized the requirement of emission standard.

In 2002, China promulgated the Cleaner Production Promotion Law, which emphasizes the scientific and technological innovations and upgrading. Two years later, China amended the regulation to grant a legal status for nongovernment-owned enterprises. Since most cleaner productions occurred in these enterprises, such a legislative system indicates China's broad acknowledgement of the significance of the private sector, which in turn was conducive to accelerate cleaner production.

Regarding the IPs, they had established stronger link with the city and served more functions like housing, entertainment, and trade. In 2002, 49 national economic development zones obtained the GDP of 311 billion CNY, and their total industrial output value reached 78.7 billion CNY. With the updating of global industry structure, IP was transformed into high-tech development zone. In 2000, 53 high-tech zones had gained 794.2 billion CNY with the annual increasing rate of 60% in the year of 1990–2000.

(4) 2005–2012

The government initially imposed a great deal input on environmental protection. China's economy, given by high polluting and low efficiency industry, is gradually being updated by a circular economy philosophy that employs the principles of 'reduce, reuse, and recycle' (or called '3R') or adopts one process's waste as another process's resource. In 2005, China State Council initially proposed the need of circular economy propelling and enacted *Outline of the National Program for Long- and Medium-term Scientific and Technological Development (2006–2020)*. Later, China released Circular Economy Promotion Law in August 2008. Thus, it is almost consensus that fulfilling circular economy can solve the problem of economic growth and resource shortage.

By the end of 2010, there was 83 national high-tech development zones and 107 national economic development zones. All the provinces, almost all the cities and countries, have established industrial parks. With respect to the IP, in order to further improve the performance of circular economy, in March 2012, National Development and Reform Commission (NDRC) and the Ministry of Finance released the opinions on the promotion of circular transformation of IPs.

(5) 2013–

To screw the ecological civilization construction, a new environmental protection law was implemented in 2015. It is the nation's first attempt to merge economic and social consideration to fit for environmental maintenance. The new law was recognized as the most progressive and stringent regulation in the history of environmental concern in China. It in detail addressed the harsher penalties for environmental offences—for instance, for acts of tampering and falsifying information, discharging contaminants surreptitiously, and evading governmental supervision. It involved many provisions for tackling pollution, raising public awareness, and preserving whistle-blowers. This law not only put more responsibility and accountability on local governments and law-enforcement agencies, but also set higher standards for enterprises from producer to recycler. To date, more than 100 environmental regulations and policies have been enacted to cover all the supply chain.

In the industrial level, circular transformation of IPs was one of the major circular economy constructions pilot programs, issued in the 12th Five-Year Plan by the China State Council. It comprised of seven prime tasks to transform previously large resource- and energy-intensive production into high efficiency and low pollutant processing. By 2017, 129 IPs had been approved for circular transformation by NDRC.

2 Regulation and Policy of Circular Economy

Historically, the attitudes as regulation and policy of government to SMEs have varied considerably: at the initial phase, SMEs were motivated to promote the economic progress. When the environmental problems came out from SMEs, the government sets regulation or law to control their manners. Regulation and policy serve as the lever to adjust and green SMEs in recent decades. Main regulations and policies can be seen at Table 1.

Table 1 Examples of policies, guidance, and regulation for circular economy published during 2005–2016

No.	Title	Year	Government
1	Opinions on Accelerating Growth of Circular Economy	2005	State Council
2	Recovery and Management Measures on Renewable Resources	2007	State Council
3	The Regulation for the Administration of Collection and Treatment of Waste Electrical and Electronic Equipment	2008	State Council
4	Notice on Demonstration Base Construction of Urban Mining	2010	NDRC
5	12th Five-Year Plan of Mineral resources saving and comprehensive utilization	2011	Ministry of Land and Resources
6	12th Five-Year Plan of Major industrial solid waste comprehensive utilization	2011	Ministry of Industry and Information Technology
7	Implementation Plan of Comprehensive Utilization of Crop and Straw during 12th Five-Year Plan	2011	NDRC, Ministry of Finance, Ministry of Agriculture
8	The Opinions on the Promotion of Circular transformation of Industrial Parks	2012	NDRC, Ministry of Finance
9	Comprehensive Utilization of Resources Guidance during 12th Five-Year Plan	2012	NDRC
10	Circular Economy Development Strategy and the Recent Action Plan	2013	State Council
11	Action Plan of Energy development strategy(2014–2020)	2014	State Council
12	Opinions about Pushing the Construction of Ecological Civilization	2015	State Council
13	Guide Plan for Circular development (Draft open to public advice)	2016	NDRC

Before China making a clear definition of urban mining in 2010, policies are established for renewable resources and circular economy. The Chinese government initiated the establishing of venous industrial parks in 2006, and the development of renewable resources industry was seen as an important part of circular economy in the 11th Five-Year Plans. The subsequently proposed major measures to create a resource-saving and environment-friendly society further reveal the determination of the country on sustainable development and renewable industry. Based on pilot cities on recycling renewable resources and venous industry parks, industry chain was gradually formed, involving collection, transport, sorting, and treatment in many areas. It shows a potential for the building of a national urban mining and industrial development pattern.

To promote the scale up and industrial development of urban mining industry, to elevate the utilization level of urban mining, the NDRC and Ministry of Finance issued the notice for establishing national pilot bases for urban mining in 2010 to cover the shortage of lacking natural resources and to alleviate the tense on resources and environment for socio-economic development. This notice defines the concept of urban mining and means the government formally acknowledge and accept urban mining, and direct plan the layout of pilot bases, which is a major shift of national view and strategy on resources. By July 2017, 43 national pilot bases had been established shown in Fig. 3 (Hu and Poustie 2018). The present regional distribution of national pilot bases shows a pattern of more locating in southeast and less in northwest, which is closely related to regional economic development level. A dense distribution of pilot bases around coastal areas can be attributed to easy importation of renewable resources. Regional centres aggregating a large amount of resources are formed

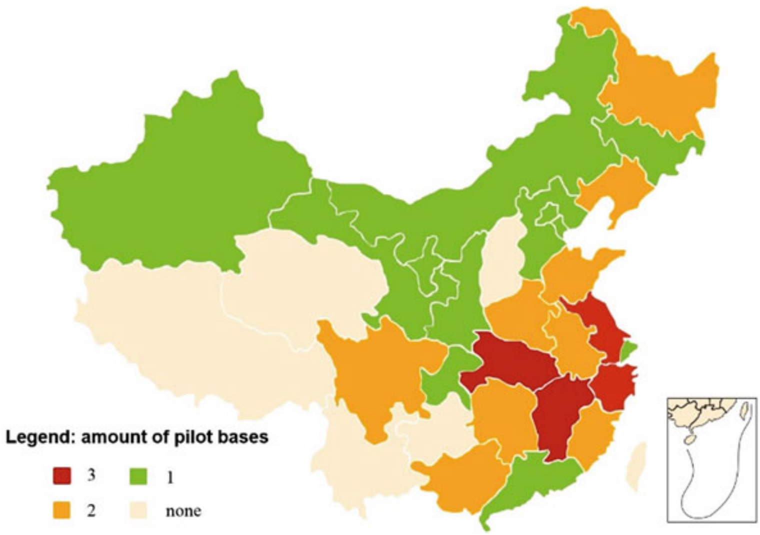

Fig. 3 Distribution of urban mining demonstration bases in China

around the existing waste materials exchange market. These bases mainly located in three regions, including those in Circum-Bohai Sea region to utilize renewable resources home and abroad, the ones in Yangtze River Delta region to produce high-value-added products relying on technology advantages, and the ones in Central Region to comprehensive develop urban mines under the background of the regional economy.

Urban mining industry is considered as an important strategic emerging industry in the national development plan of strategic emerging industries during the 13th Five-Year Period issued by the State Council in Nov. 2016. It is required to promote urban mining and the utilization on wastes with low recycling value. In April 2017, fourteen ministries and commissions jointly promulgated the Action Plan for Circular Economy Development, which would achieve an improvement of the resource productivity of 15% than in 2015 and the recycling rate of 54.6% for main types of solid wastes. Creating a new strategic guarantee system on resources is one of the main objectives in this action plan.

References

Dauvergne, P., & LeBaron, G. (2013). The social cost of environmental solutions. *New Political Economy, 18*(3), 410–430.

Hu, Y., & Poustie, M. (2018). Urban mining demonstration bases in China: A new approach to the reclamation of resources. *Waste Management, 79,* 689–699.

Liu, J., & Diamond, J. (2005). China's environment in a globalizing world. *Nature, 435*(7046), 1179–1186.

Status and Development of the Circular Economy in Germany

Michael Nelles, Abdallah Nassour and Gert Morscheck

1 Introduction in the Context of Implementation of Circular Economy

What is circular economy? Wikipedia says:

> Circular economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing energy and material loops; this can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, recycling, and upcycling.

Circular economy is actually very old. People have always reused or recycled materials after use. Of course, that was not due to ecological thinking. Economic constraints and the absence of raw materials were the reasons. Only the constant and inexpensive availability of raw materials led to their disrespect and waste. This environment-destroying economy and way of living have spread worldwide.

The European Union produces more than 2.5 billion tonnes of waste a year. It is currently updating its waste legislation to promote the transition from a linear to a circular economy.

In Germany, the relationship to the circular economy was also shaped by the political division of the country into two states. In the socialist East, the circular economy played a major role due to economic hardship. In the 1970s, the idea of the circular economy began to take root everywhere.

It quickly became clear that only binding legal requirements and financial incentives can drive the circular economy and therefore the conservation of resources. Every year around 360 million tonnes of waste are collected, transported, sorted, processed, recycled or disposed of in Germany. Each German citizen thus accounts

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for more than 4 tonnes of waste per year. The largest part of the waste consists of construction and demolition waste or arises in the extraction and treatment of natural resources. The focus of the circular economy and public interest, however, is primarily on the 56 million tonnes of waste, mainly from industry and commerce, and 52 million tonnes of municipal solid waste, of which around 37 million tonnes are produced in private households.

Recycling rates in Germany are high by international comparison. However, the amount of waste increases especially in the private sector! The avoidance of waste is very difficult for the Germans. Recycling often includes the thermal recycling (incineration) of waste. From a scientific point of view, however, only material recycling makes sense!

New regulations will force more material recycling (especially of plastic waste) in the future.

It is about more recycling, higher recycling rates and more recycling and reuse. Consistent recycling dampens demand for primary raw materials. The life and useful life of consumer goods and capital goods must be extended.

Waste prevention has to be much more promoted! The European Union has set itself ambitious recycling targets this year under new waste and recycling legislation. Improving waste management can not only benefit the environment, the climate and human health. The four legal acts of the new “recycling package” are part of a shift in the EU policy towards a circular economy. The idea is to create a system that preserves the value of products, materials and resources in the economy for as long as possible.

Many raw materials are finite. Therefore, it is necessary to manage the resources (Fig. 1).

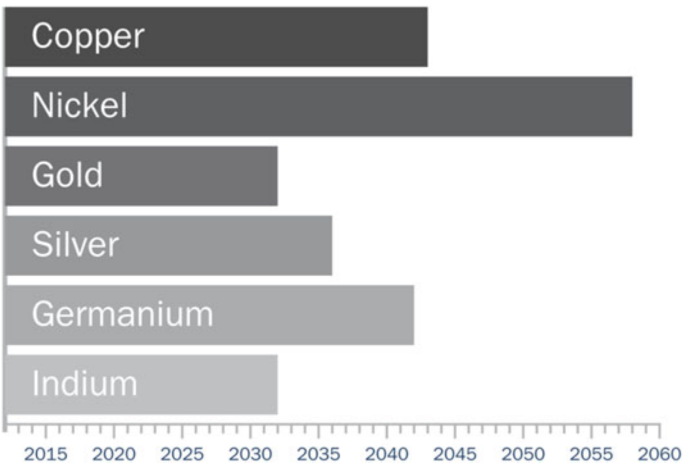

Fig. 1 Range of coverage of reserves in years (Oberösterreichische Zukunftsakademie 2013)

The improvement of the recycling economy could bring advantages:

– Less pressure on the environment,
– Increased security of raw material supply,
– Increasing competitiveness,
– Innovation, growth and employment (creating 580,000 jobs in the EU).

In a closed-loop economy, consumers benefit from more durable and innovative products that lead to cost savings and a better quality of life (Fig. 2).

The new rules require that from 2025, at least 55% of municipal waste must be recycled; from 2030, this applies to 60% and from 2035 to 65%. Recycling targets for packaging are 65% from 2025 and 70% from 2030 with specific targets for paper and cardboard, plastics, glass, metal and wood. Germany currently has a recycling quota of municipal waste of about 66% (European Commission (EC) 2019).

According to the new regulations, the maximum landfill quota for municipal waste from 2035 may only be 10%. Some EU countries (Austria, Belgium, Denmark, Germany, The Netherlands, Sweden) dump no household waste in landfills. Other EU countries (Cyprus, Croatia, Greece, Latvia and Malta) still landfill more than three-quarters of their municipal waste.

It was also agreed that biowaste must be collected separately from 2024 across the EU. The same applies to textiles and household waste classified as hazardous

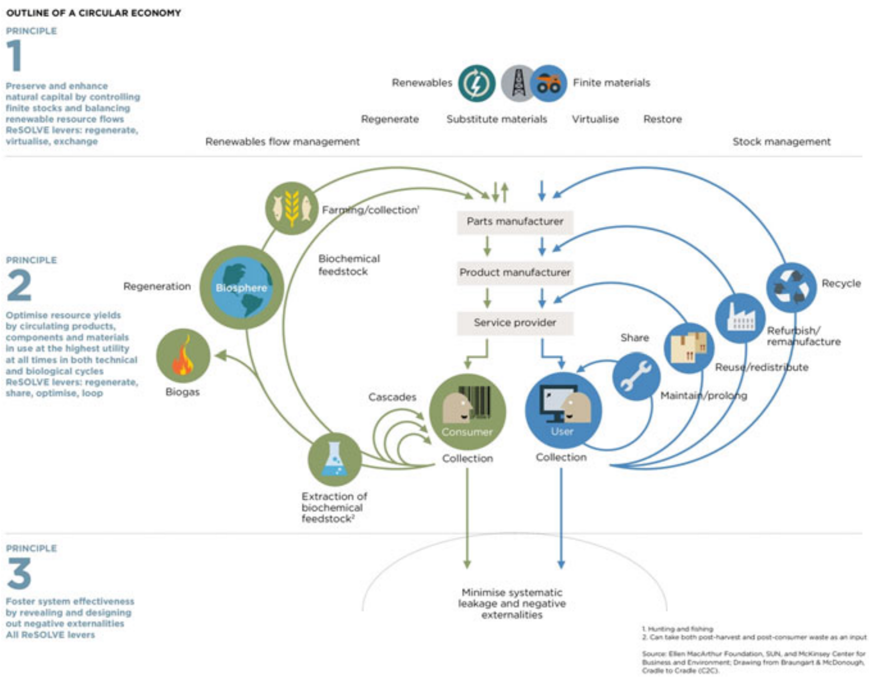

Fig. 2 Circular economy system diagram (Circular Economy System Diagram 2018)

from 2025. In line with the United Nations Sustainable Development Goals, Member States should aim to reduce food waste by 30% by 2025 and 50% by 2030. In order to avoid food waste, Member States should encourage the collection of unsold food and its safe redistribution. Consumer awareness of the importance of shelf life data on labels should also be improved (European Commission (EC) 2019).

2 Legislation in the European Union and Germany

2.1 Legislation in the European Union

A sustainable policy of conserving natural resources attaches great importance to the creation of closed material cycles. Modern waste policy is a very important part of it. It ensures that wastes generated are reused or recycled as high as possible.

The goal of material flow management is to use the materials taken from nature as intensively as possible in order to save resources and avoid waste. The aim is to decouple economic growth and the impact on human health and the environment associated with waste generation.

In order to harmonise the requirements for the prevention, recycling, recovery and disposal of waste in all EU Member States, the EU has adopted numerous regulations since 1974. The key European requirement in this policy area is the 2008 updated EU Waste Framework Directive (EU Directive 2008/98/EC on waste).

Waste legislation is characterised by a large number of European legal acts. While regulations have direct effect in the Member States, directives must be transposed into national law. The Waste Framework Directive defines essential waste-related terminology and specifies, among other things, a five-level waste hierarchy. The guideline contains important requirements for German waste legislation.

The EU has made major changes to the EU waste prevention, recovery and disposal policies. Many things in the right direction: more recycling, more re-use, but there are also weak points.

Four key European waste legislations will be amended:

- the Waste Framework Directive,
- the Packaging and Packaging Waste Directive,
- the Landfill Directive as well as
- the directives on end-of-life vehicles, batteries and accumulators, old batteries and accumulators, and waste electrical and electronic equipment.

The proposed amendments to the Waste Framework Directive (European Commission (EC) 2018) essentially include expanded requirements for promoting waste prevention, setting targets for recycling and preparing for the reuse of municipal waste. An output-based calculation method is used. There are now minimum requirements for extended producer responsibility (EPR) systems, extended criteria for end-of-waste assessment and new requirements for separate collection.

The requirements for the separate collection are significantly expanded. From now on, Member States will have to collect paper, metal, plastics, glass and, from 2025, used textiles separately. Construction waste is also regulated to a greater extent: for selective removal, for example, welcome that gypsum is recorded as a separate material fraction. This creates an important prerequisite for high-quality recycling and the discharge of impurities.

The requirements for the prevention of waste are significantly expanded.

The core elements of the amendment to the Packaging Directive are the new minimum recycling rates for packaging waste. The Packaging Directive also includes approaches to strengthen the reuse of packaging. The EC counts the composting of biodegradable packaging for recycling. That is not the case in Germany.

2.2 Federal Law in Germany

In Germany, the first nationwide regulation of waste law was created in 1972 with the Waste Disposal Act (Abfallbeseitigungsgesetz, AbfG). Today, the Act to promote closed substance cycle and to ensure environmentally compatible waste management (Kreislaufwirtschaftsgesetz, KrWG) is the core regulation of waste legislation. As a successor regulation, the KrWG retains the essential structural elements of the old Closed Substance Cycle and Waste Management Act (KrW-/AbfG).

Regulations for specific product waste can also be found in the End-of-Life Vehicles Ordinance (AltfahrzeugV), the Battery Act (BatterieG) and the Electrical and Electronic Equipment Act (ElektroG).

Waste legislation in Germany is based on the Closed Substance Cycle Act (KrWG), which came into force on 1 June 2012 and implements the requirements of European waste legislation. The aim of this law is to promote closed-loop recycling in order to conserve natural resources and to ensure the protection of people and the environment in the generation and management of waste.

A central principle of the law is the five-level waste hierarchy:

1. avoid or reduce waste
2. preparation for re-use of waste
3. waste recycling
4. other recovery of waste (energy recovery, backfilling of excavation or mining sites, etc.)
5. disposal of waste.

On the basis of these principles, the waste management measure best suited to the protection of man and the environment shall be selected. Technical, economic and social aspects must be taken into account.

With a few exceptions, there is a ban on mixing hazardous waste. The mixing of waste in order to reduce contents and thereby comply with limit values is prohibited.

Since January 2015, Germany has had separate collection obligations for biowaste, paper, metal, plastic and glass waste. For decades, it has been collected separately. However, the obligation has now also been laid down in law.

The Closed Substance Cycle Act (KrWG), the German Packaging Act and the EU Packaging Directive lay down new minimum requirements for recycling quotas (Table 1).

More recycling generates raw materials that no longer have to be taken from the environment. Between 1995 and 2010, the share of secondary raw material on all raw materials is showed a clear overall increase, excluding mineral oil, uranium, coal and gas (Institut der deutschen Wirtschaft Köln 2010), (Fig. 3).

In some industrial sectors, the share of secondary raw materials (recycled waste) is already very high. Especially for very rare or very expensive or environmentally damaging raw materials, the proportion of secondary raw materials has to be increased (Fig. 4).

2.3 Federal Waste Prevention Programme

On 31 July 2013, the Federal Government ratified the federal waste prevention programme. It systematically and comprehensively records targeted public approaches to waste prevention in the form of concrete recommendations, instruments and measures. It analyses various waste avoidance measures in production, product design, trade, industry and the use of products, also taking into account economic, social and legal criteria.

Thus, for the first time, systematic and comprehensive targeted public approaches to waste avoidance were recorded in the form of recommendations for concrete instruments and measures. At the same time, the cabinet decision marks the start of a dialogue between the Federal Government, the Federal States, local authorities and other stakeholders on waste prevention. The programme was drawn up with the participation of the Federal States.

The waste prevention programme analyses various waste prevention measures that affect the various life cycle stages of products, including approaches that take into account production, product design, trade, commerce and the use of products. In addition to the key criteria of waste prevention potential and environmental impacts, the analysis also looks at economic, social and legal criteria. The waste prevention programme only recommends measures that can be expected to have a positive impact if all these criteria are taken into account.

In addition to information and sensitisation as well as research and development, the following approaches, among others, are pursued in the waste prevention programme:

- Active monitoring of European research on waste-saving criteria within the framework of the EU Eco-design Directive

Table 1 Recycling quotas of the EU packaging directive (applies to all packaging waste) and the packaging act in Germany (applies only to packaging waste from private end consumers) as well as the rate of recycling of all materials in Germany in 2017 (European Commission (EC) 2019; Statistisches Bundesamt (Destatis), Abfallwirtschaft 2017; and own estimations)

	Current EU Packaging Directive	Future EU Packaging Directive		Packaging Act Germany		Material recycling
	2008	By 31.12.2025	By 31.12.2030	From 01.01.2019	From 01.01.2022	Germany in 2017
Plastics	22.5	50	55	58.5	63	34
Wood	15	25	30	–	–	26
Ferrous metals	50	70	80	80	90	92
Aluminium		50	60	80	90	88
Glass	60	70	75	80	90	85
Paper, cardboard	60	75	85	85	90	86
Beverage carton packaging	–	–		75	80	–
Another composite packaging	–	–		55	70	–

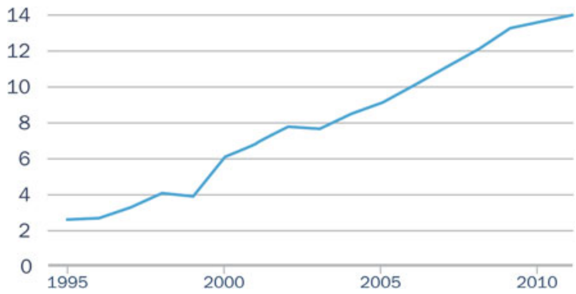

Fig. 3 Growing shares of secondary raw materials in Germany in raw materials in total (without mineral oil, uranium, coal and gas), in percent (Institut der deutschen Wirtschaft Köln 2010)

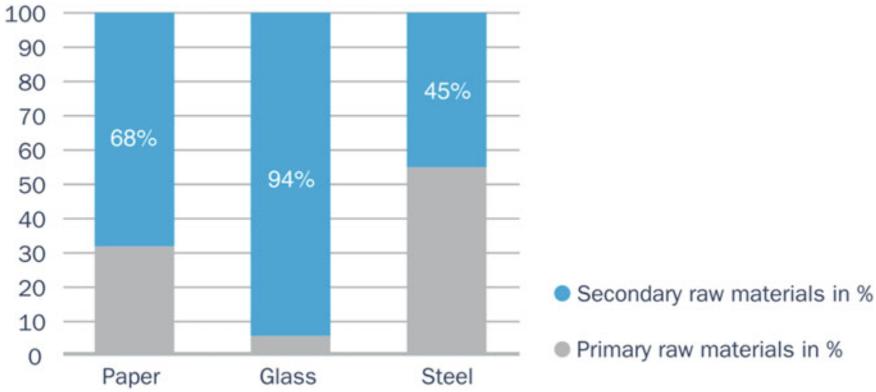

Fig. 4 Use of secondary raw materials for production in Germany (BMWI 2016)

- Organizational or financial promotion of structures for the reuse or multiple use of products and repair centres
- Promotion of the concept of "use instead of own" with the aim that consumer goods are used more intensively and by a larger circle of users (e.g. car sharing).
- Concerted actions and agreements between public sector and industry or commerce to reduce food waste generated along the production and supply chain.
- Inclusion of further product groups in the Blue Angel's portfolio; creation of practical working aids for contracting authorities for increased consideration of resource efficiency and waste avoidance aspects.

The Blue Angel is the German eco-label (https://www.blauer-engel.de/en). The Blue Angel has been the German government's eco-label since 1978. The Blue Angel sets high standards for environmentally friendly product design and has proven itself over the past 40 years as a reliable guide to more sustainable consumption.

2.4 Waste Law of the Federal States

Politically, the Federal Republic of Germany is divided into 16 Federal States. Due to their constitutions, these states form a federal republic, not a loose confederation of states.

The Federal Closed Substance Cycle Waste Management Act is supplemented and substantiated by the waste laws of the 16 Federal States. Due to the competing legislative competence of the federation for waste management (Art. 74 Para. 1 No. 24 GG), however, federal state legislation is only possible in areas that are not already covered by federal law. The states waste laws therefore essentially concern questions of enforcement; for example, the determination of the bodies responsible for waste management and the competent authorities in the waste sector.

2.5 Municipal Waste Law

The collection and processing of household waste are laid down at municipal level in the form of statutes. For example, waste statutes contain regulations on compulsory connection and use. Charges for the use of waste disposal are levied on the basis of municipal waste charge statutes.

3 Nuclear Waste Management

In Germany, radioactive waste is not subject to waste management regulations.

Radioactive waste is disposed of under special conditions. Radioactive wastes are subject to nuclear law.

The basic law of the Federal Republic of Germany (for historical reasons the term constitution is not used in Germany) contains provisions on the competences of the Federal Government and the Länder with regard to the use of nuclear energy (Articles 73(14), 87c and 85). Accordingly, the Federal Government has exclusive legislative competence in this area. As the competent licensing and supervisory authorities, the Länder implement nuclear law on behalf of the federation (Federal Mandate Administration). In doing so, the federation exercises legal and expediency supervision and can, if it deems it necessary, draw on the expertise.

The state is obliged to make every effort to identify potential hazards at an early stage and to counter them with the necessary constitutional means. The legislature has therefore enacted provisions of nuclear protection law and radiation protection law. They are directed towards a comprehensive and interlocking structure of standards that ensure the complete sovereign control and monitoring of all behaviour patterns and facilities for the peaceful use of nuclear energy.

The Atomic Energy Act (AtG) was promulgated on 23 December 1959 after the Federal Republic of Germany declared its renunciation of nuclear weapons and has since been amended several times. The purpose of the Atomic Energy Act is, among other things, to protect life, health and property against the dangers of nuclear energy and the harmful effects of ionising radiation.

Against the background of the accident at the Japanese nuclear power plant Fukushima in March 2011, the Federal Government decided to accelerate the energy system transformation and to gradually abandon completely the generation of electricity in German nuclear power plants until the end of 2022.

The Atomic Energy Act contains the basic national regulations for protection and precautionary measures, radiation protection and the disposal of radioactive waste and irradiated fuel elements in Germany and is the basis for the associated ordinances.

Since 1962, a total of 37 nuclear power plants (NPPs) have been constructed in Germany and have started commercial operation. Some of them were only briefly connected to the grid.

At present, there are still seven nuclear power plants on the grid, all of which will be shut down by the end of 2022 at the latest.

In addition to the commercial generation of electricity from nuclear energy, nuclear technology is used in Germany in a variety of processes in medicine, industry and research. This use as high technology will be needed in Germany beyond 2022. The precautionary measures required for this—such as nuclear safety and radiation protection—must therefore continue to be guaranteed.

A number of different companies in the nuclear industry are located in Germany: Uranium supply companies, companies in the field of uranium enrichment and fuel element production, planners and constructors of nuclear facilities as well as companies involved in the transport of nuclear fuels, the treatment and storage of radioactive waste and the decommissioning and rehabilitation of nuclear power plants, including their suppliers and service companies. Many of these companies also export.

Intermediate Storage

The irradiated fuel elements and the waste from reprocessing are stored in transport container storage facilities. In addition to the on-site interim storage facilities at the nuclear power plant sites, there are the transport container storage facilities in Gorleben, Ahaus and the interim storage facility North.

It is expected that by 2027, all fuel elements used in the power reactors will have been placed in transport and storage casks in transport cask storage facilities. The radioactive waste resulting from reprocessing is also contained in transport and storage casks.

Sufficient interim storage capacities for the storage of all irradiated fuel elements and radioactive waste from reprocessing are available in Germany.

According to the licences issued, the storage period for transport and storage casks is limited to 40 years.

Final Disposal

In Germany, the Konrad shaft has been approved as a repository for low- and intermediate-level radioactive waste. The former mine has been converted into a repository since 2007 and is expected to go into operation in 2027, receiving up to 303,000 m^3 of radioactive waste with negligible heat generation.

Germany is currently looking for a site for a repository for heat-generating radioactive waste:

- The waste is to be disposed of in Germany, in a repository in deep geological formations.
- The aim is to finally close the repository mine—with the possibility of retrieval for the duration of the operating phase and recovery for 500 years after closure.
- The safe containment of the waste must be guaranteed for a period of one million years.

4 Benefits

In practice, the concept of closed-loop waste management involves keeping waste to a minimum. Once a product has reached the end of its service life, the materials it contains remain in the economic cycle as far as possible. In this way, they can be used again and again in the manufacture of products and contribute further to added value. Measures leading to a circular economy include the reuse, repair, overhaul and recycling of existing materials and the products made from them. What used to be considered "waste" can now be transformed into a valuable resource.

The transition to a closed-loop economy will reduce the pressure on the environment, increase the security of raw material supply, increase competitiveness, innovation and growth and create jobs.

5 Learning from Other Countries and Collaboration with Other Countries

Waste is a potential source of raw materials that are becoming increasingly important in view of the global scarcity of resources. If, however, waste is incorrectly disposed of, it endangers the environment and health. Germany supports its partner countries in avoiding, collecting, recycling and disposing of waste in an ecological, social and economic way.

Waste volumes are rising rapidly worldwide, but around two billion people still do not have access to regulated waste collection. Waste often ends up on the roadside, in rivers and uncontrolled landfills, or is improperly incinerated in backyards. Poor air, polluted water and contaminated soil are the consequences—and thus health risks, climate-damaging greenhouse gas emissions and threats to biological diversity.

With Agenda 2030 for Sustainable Development, the United Nations and German Development Cooperation are striving to achieve environmentally sound management of all waste. Waste volumes are to be reduced as far as possible through avoidance, reuse and recycling. In particular, cities are called upon to reduce their environmental impact through improved waste management. Pollution of the seas by waste from the mainland must also be significantly reduced.

The German Federal Ministry for Economic Cooperation and Development (BMZ) supports partner institutions in developing strategies and legal regulations and in setting up corresponding structures (https://www.bmz.de/de/themen/abfall/index.html). It also promotes the initial and further training of technical and managerial staff. It provides financing instruments for the construction of recycling and disposal facilities.

In order to exploit the opportunities offered by improved waste management and environmental services, the BMZ promotes partnerships with the private sector, non-governmental organisations and international initiatives. The ministry ensures that waste collectors in the partner countries are also involved and that their working and living conditions are improved.

Current development cooperation focuses on waste and recycling management, urban waste management, marine waste, electronic waste, climate change and Agenda 2030.

5.1 Development of an Integrated Urban Waste Management System

The population of large cities in developing and emerging countries is rising rapidly, consumer behaviour is changing and waste problems are also growing as a result. Worldwide around two billion tons of municipal waste are produced each year. In the cities alone, the amount of waste is expected to double from 1.3 to 2.6 billion tons per year by 2025.

Waste management is the least developed urban service in many countries. There is often a lack of know-how, clear responsibilities and adequate financing. Municipal administrations are faced with the challenge of further developing their waste and recycling management systems in order to ensure a healthy living environment for their citizens and to better exploit the economic potential of waste recycling.

The “New Urban Agenda” adopted by the United Nations in October 2016 calls for universal access to environmentally sound waste management in cities. This requires comprehensive investment in sustainable infrastructure and support for urban decision-makers.

In order to develop an integrated urban waste management system, technical, legal and institutional issues must be tackled jointly. This is the only way to exploit the potential for environmental and climate protection and for the creation of jobs and training places.

Care must be taken to ensure that the many waste collectors who have hitherto been active outside formal employment relationships are included in the value chains. Only then can their working and living conditions improve.

Germany supports its partner countries in developing waste management concepts, training specialists and monitoring the collection, recycling and disposal of waste. Awareness-raising among the population is also promoted.

In order to increase the recycling rate, adapted solutions for the sorted collection of recyclable materials and organic waste are being developed. In addition, the German Federal Ministry for Economic Cooperation and Development supports the partners in financing waste management on a cost-covering basis, for example by further developing fee models or introducing take-back and deposit systems.

Appropriate financing instruments are being promoted to establish suitable infrastructure for the collection, recycling and disposal of waste. Interactions with other sectors, such as the protection of groundwater when planning landfills, are taken into account.

5.2 Marine Waste—A Danger for Humans and Animals

Marine waste poses a global threat to marine ecosystems, fisheries, tourism and, possibly, human health through the food chain. It is estimated that every year between 4.8 and 12.7 million tonnes of plastic waste are transported from land to sea worldwide. Much of this comes from developing and emerging countries, including Southeast Asia and the Mediterranean. In addition, there are fishing nets lost at sea and microplastics from cosmetics, textiles and other products contained in wastewater.

Negative effects of marine waste on around 800 animal species are currently known. Seabirds and marine mammals in particular, as well as marine reptiles and fish, absorb or trap plastic in their food.

Reduce Marine Litter

With Agenda 2030, the United Nations aims to significantly reduce marine pollution, especially from marine waste and land nutrients, by 2025. Decisions within the framework of the UN Environment Assembly and the Biodiversity Convention as well as regional marine waste action plans call for the development of environmentally sound waste management and the adoption of further measures.

The Federal Ministry for Economic Cooperation and Development supports the G7 Action Plan and the G20 activities to combat marine waste.

With its own 10-point action plan “Marine protection and sustainable fisheries”, the BMZ aims to help eliminate the causes of marine pollution. To this end, it is expanding environmental policy cooperation with its partner countries and working with them to develop model approaches to integrated waste management. In addition, the BMZ is committed to the exchange of knowledge between developing and emerging countries and to partnerships with the private sector.

5.3 Electronic Scrap—Recycling Valuable Raw Materials

In 2018, around 50 million tons of electronic scrap is expected to be generated worldwide; for example, refrigerators, televisions, computers, mobile phones and batteries. In 2014, the figure was around 42 million tons. In many developing and emerging countries, the volume of waste electrical and electronic equipment is growing particularly rapidly. The reasons for this are rising prosperity, digitalisation, changing consumer habits and population growth. In addition, there are often illegal imports of scrap from industrialised countries.

According to the International Basel Convention (1989), e-waste must not be exported to countries that do not have an adequate recycling infrastructure. However, used equipment may be exported and is more affordable for the local population than new equipment. However, they too will sooner or later end up on the mountain of waste. An estimated 1.5 million tonnes of used electrical appliances were exported from the European Union in 2012. Of these, around 400,000 tonnes were electrical scrap.

Very Few Official Collection and Recycling Systems

In most developing and emerging countries, there are neither official collection systems for old appliances nor legal regulations and corresponding facilities for recycling and disposal. In these countries, the collection and recycling of electrical and electronic waste are predominantly carried out in the informal sector by workers, for whom, for example, copper and gold from electrical and electronic waste represent an important source of income.

However, the recovery of precious metals is often carried out using the most primitive techniques—such as incineration in the open air using cyanide and mercury—and poses considerable risks to people and the environment. The aim here is to promote the expansion of local structures and the introduction of simple, but efficient and environmentally compatible techniques for the recovery of metals.

In its partner countries, the German Federal Ministry for Economic Cooperation and Development (BMZ) is working to reduce the negative consequences of uncontrolled management of electronic waste while at the same time exploiting the employment and income potential of the recycling of electronic waste.

By further developing recycling systems, resources can be used more efficiently and secondary raw materials can be tapped. In order to organise and finance the proper collection and recycling of WEEE, producers and importers must be involved and technology cooperation must be expanded. At the same time, more must be done in the industrialised countries to combat the illegal export of electronic waste. The BMZ promotes international exchange on solutions for electronic waste management.

German Development Cooperation supports the partner countries in setting up socially and environmentally compatible recycling systems. It advises on the drafting of laws and regulations on waste and electrical scrap management and supports authorities in their implementation.

It also promotes dialogue between government and private sector actors (e.g. manufacturers and importers, collectors and recyclers) in order to establish effective financing and management systems. Informally, active workers in particular are actively involved in this process. The aim is to secure their livelihood while at the same time improving their working conditions. In addition, the BMZ supports the international exchange of solutions for electric scrap management.

5.4 Waste and Climate Change

Waste that is not disposed of in an environmentally sound manner contributes significantly to global climate change. The climate-damaging methane gas escapes in large quantities from open landfills or illegal waste disposal sites. The irregular incineration of waste produces exhaust gases that are not only bad for the climate but also very harmful to health. According to estimates by the Intergovernmental Panel on Climate Change (IPCC), landfills and wastewater treatment plants are responsible for around three percent of global greenhouse gas emissions.

However, the potential contribution of waste management and recycling to climate protection is much greater: according to estimates, global greenhouse gas emissions can be reduced by around 10 to 15% through improved waste management. This includes, for example, the possibility of producing more energy from waste instead of fossil fuels. Even though industry is increasingly using recycled materials, large amounts of energy are saved, and fewer raw materials are consumed. Improvements in waste transport are also taken into account in the calculations.

Paris Climate Agreement

With the Paris Climate Agreement of December 2015, the global community aims to limit global warming to a maximum of 2 °C, but if possible below 1.5 °C, compared to the pre-industrial era. As part of their nationally determined contributions (NDC), the parties also formulate targets and measures in the field of waste management and recycling.

German Commitment

German Development Cooperation supports partner countries in making their waste management more climate-friendly. It provides instruments for calculating greenhouse gas emissions in the waste sector and advises on the restructuring of waste management. In addition, the partner countries are supported in expanding the recycling of recyclable materials and in recycling biowaste. By means of appropriate financial instruments, Germany promotes the construction of landfills with control systems to record the climate-damaging landfill gas.

In the field of energy generation from waste ("waste-to-energy"), the German Federal Ministry for Economic Cooperation and Development supports the introduction of appropriate technologies. It also offers advice on environmental and safety standards as well as on the necessary institutional and financial requirements. These include the energetic use of landfill gas, the construction of biogas plants and the processing of waste into alternative fuels for cement works and waste incineration plants.

5.5 Waste as a Topic of Agenda 2030

Waste management and environmental services play an important role in Agenda 2030, especially in the Sustainable Development Goals (SDGs) on "Sustainable Cities and Municipalities" (SDG 11), "Responsible Consumption" (SDG 12) and "Life under Water" (SDG 14):

- SDG 11.6: "Reduce per capita pollution from cities by 2030, including special attention to air quality and municipal and other waste treatment" (SDG 11.4).
- SDG 12.4: "By 2020, achieve environmentally sound management of chemicals and all wastes throughout their life cycle in accordance with agreed international frameworks and significantly reduce their release into air, water and soil to minimise their adverse effects on human health and the environment".
- SDG 12.5: "Significantly reduce waste generation by 2030 through prevention, reduction, recycling and reuse".
- SDG 14.1: "Prevent and significantly reduce by 2025 all types of marine pollution, in particular from land-based activities and in particular marine waste and nutrient pollution".

In addition, the development of a functioning waste and recycling management system makes a positive contribution to other objectives, such as health (SDG 3), decent work (SDG 8) and climate protection (SDG 13).

Agenda 2030

On 25 September 2015, the "Agenda 2030 for Sustainable Development" was adopted at a UN summit in New York. It takes the form of a World Future Treaty and contains 17 Sustainable Development Goals (SDGs). Agenda 2030 is the first international agreement in which the principle of sustainability is linked with poverty reduction and economic, ecological and social development. The Agenda is intended to help all people worldwide to live in dignity. It is intended to promote peace and to help all people to live in freedom and an intact environment. The Agenda is addressed to all states of the world community. They are equally called upon to stand up for the development goals *formulated in it—there is no division into "donors" and "recipients" or into "first", "second" and "third world" in the Agenda.*

Important Steps for Implementation

The Habitat III Conference on Sustainable Urban Development, held in October 2016 in the Ecuadorian capital Quito, was the first important milestone in the implementation of these goals in cities. It reaffirmed the goal of sustainable waste management and recycling.

In June 2017, the UN conference was held in New York on the implementation of SDG 14 on marine conservation, including the prevention of marine waste. In July 2018, the United Nations High-Level Policy Forum on Sustainable Development reviewed progress in urban development (SDG 11) and sustainable consumption and production patterns (SDG 12).

References

Blue Angel—The German Ecolabel. https://www.blauer-engel.de/en.

BMWI (German Federal Ministry of Economics and Technology). (2016). Sector Focus Mining and Raw Materials.

Circular Economy System Diagram. (2018). The Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram.

European Commission (EC). (2018). Directive (Eu) 2018/851 of the European Parliament and of the Council. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0851&from=EN.

European Commission (EC). (2019). The European Commission Circular economy package. https://ec.europa.eu/environment/circular-economy/.

Institut der deutschen Wirtschaft Köln (Cologne Institute for Economic Research). (2010). Study conducted on behalf of BDE [Federation of the German Waste, Water and Raw Materials Management Industry].

Ministry for Economic Cooperation and Development (BMZ). https://www.bmz.de/de/themen/abfall/index.html.

Oberösterreichische Zukunftsakademie (Upper Austrian Future Academy). (2013). "Endlichkeit der Rohstoffe" ("Finiteness of fossil raw materials").

Statistisches Bundesamt (Destatis), Abfallwirtschaft 2017. http://www.destatis.de/, 2019.

Solid Waste Management in Lao PDR: A Pathway Toward the Circular Economy

Vatthanamixay Chansomphou

1 Introduction

Lao People's Democratic Republic (Lao PDR) is a land-locked developing country in Southeast Asia. The total area of the country is 236,800 km^2. The total population as of 2017 was 6.8 million (World Bank 2019). Since the last two decades, the economy of Lao PDR has been growing significantly. Economic growth, population increase, rapid urbanization, and changing lifestyle are major contributions to growing environmental problems, especially solid wastes. In Vientiane Capital, wastes are generated approximately 650 tons per day, and only half of them are collected and disposed of properly in the landfill (VCOMS 2018).[1] The same situation can be seen in secondary provinces, such as Luang Prabang, Savannakhet, Champassak, and other provinces across the country.

The problems relating to solid waste management found in Lao PDR are that majority of people do not separate wastes at source and still get rid of wastes in old fashion, by burning and dumping inappropriately, as they lack awareness on proper waste disposal. As such, people have been confronting health risks and environmental impacts caused by inappropriate waste handling. Currently, although half of generated wastes are collected and disposed of in the landfill, the rests are disposed of improperly without recycling and composting schemes. Main reason for not using waste collection service is that the service fee is considered expensive by low-income families, and the provision of the service does not reach all communities.

[1] VCOMS stands for Vientiane City Office for Management and Service.

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Currently, waste collection services can be found in many districts and towns throughout the country, but they simply collect and dispose of solid wastes in the landfill directly. Official waste segregation scheme does not exist, while some valuable wastes are collected and traded among informal waste pickers, scrap traders, community waste banks, and plastic recycling companies. In order to introduce proper solid waste management measures, the Lao government has recently cooperated with some international organizations and private sectors that have experiences with integrated waste management.

2 Situation of Solid Waste Management in Lao PDR

The amount of wastes has been generated at different rates. In Vientiane Capital, the generation of solid wastes is 0.7 kg/person/day; while in secondary provinces (such as Luang Prabang, Savannakhet, and Champassak) and smaller provinces, the generation of wastes is 0.6 kg/person/day and 0.5 kg/person/day, respectively (VCOMS 2018). Figure 1 reports the significantly increasing trend of solid waste in Vientiane Capital. It can be seen that the amount of wastes has increased from 40,471 tons in 2007 to 113,746 tons in 2017, or almost three folds in the last decade.

Wastes in Lao PDR can be classified into hazardous and non-hazardous wastes. *Hazardous wastes* include infectious wastes, e-wastes, chemical wastes, and so on; they are mostly from hospital, commercial, and industrial sector. For Vientiane Capital, infectious wastes are burned in a small incinerator installed in the landfill and managed by Vientiane City Office for Management and Service (VCOMS). In many other provinces, they are mostly transferred and disposed of in the landfill. Hazardous wastes are simply collected and disposed of in the landfill by waste collecting companies. Some wastes are even disposed of by a specific landfill constructed by waste generators themselves. *Non-hazardous wastes* include municipal solid wastes generated by households, commercial sector, and agricultural sector. The municipal solid waste in Lao PDR is broadly classified into nine different types, including

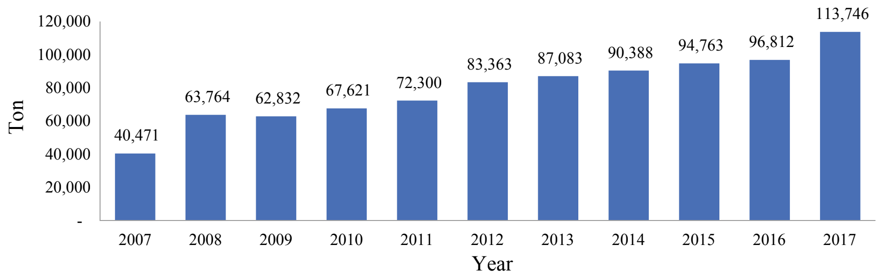

Fig. 1 The trend of solid waste in Vientiane Capital. *Source* VCOMS (2018)

Table 1 Composition of solid waste in some provinces in Lao PDR

Waste fraction	Vientiane Capital (%)	Luang Prabang (%)	Savannakhet (%)	Champassak (%)
Food, vegetables	30	51	54	62
Wood, grass, trees, leaf	19	23	16	21
Paper	6	8	9	4
Plastic	13	9	15	6
Glass	6	6	2	2
Metal	3	1	1	1
Textile	2	1	1	1
Others	21	1	2	3
Total	100	100	100	100

Source GIES (2012)

garbage, paper, textile, plastics, wood, metal, glass, and other. Table 1, shows the percentage of waste composition in four provinces in Lao PDR.

Recently in Vientiane Capital, the trade of recyclable waste materials (RWM) has been promoted to reduce amount of solid waste by VCOMS. The players involving in managing RWMs comprise waste pickers, waste banks, junk shops, waste exporters, and recycling factories (Fig. 2).

Waste banks can be seen sparsely in some villages and schools. Junk shops and waste dealers purchase recyclable waste materials from waste pickers, waste banks, and other sources. They usually sell some recyclable wastes to waste exporters and sell plastics to plastic recycling factories (Climate and Clean Air Coalition 2016). This similar pattern of municipal waste management can also be seen in the cities of major provinces. At the moment, waste banks and mobile traders are not registered formally with the authorities. In fact, there is no registration system for them. Therefore, the exact number of waste banks and mobile traders is not known. This

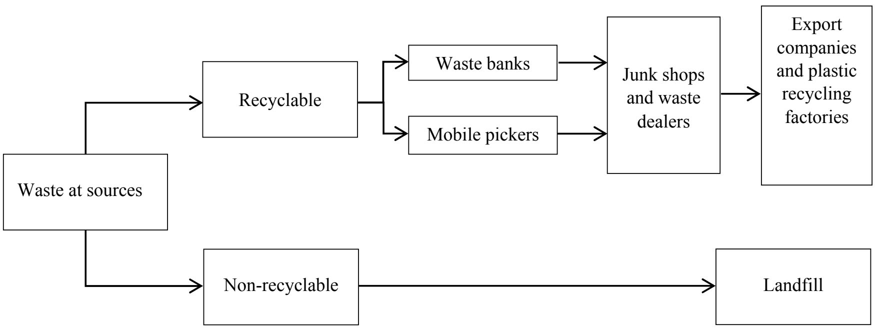

Fig. 2 Waste Management in Lao PDR. *Source* Author adapted from various sources

informal sector makes up a large part of the micro-level solid waste management, while the public sector plays an important role in macro management of municipal solid wastes.

At micro level, households are motivated by waste banks and mobile traders to classify wastes, such as papers, glasses, plastics, and metals, for selling and donating. However, this sector is not well incorporated into the macro management. The main actors in the informal sector's waste collection are mobile traders. These include poor Lao citizen from rural areas and migrants from China and Vietnam. Most of them have the lowest (drop-out from primary school) or no education. The wastes they collect are mostly those that are required by export companies and recycling factories, including PET bottles, papers, cardboard, aluminum, copper, metals as well as electric and electronic items. Waste collection generates income for them around 40,000–60,000 Kip per day (or approximately \$5–\$7 per day). Although they can make a living with this amount of income, it does not ensure their access to education for their children, proper health care, nor social welfare (Update Lao Magazine 2018). Especially on health care, the informal waste collectors are exposed to different types of diseases such as diarrhea, infectious diseases, tuberculosis, lung cancer, and so on.

3 Legislative Framework Supporting 3Rs and Circular Economy Initiatives

Although the initiative of waste management was established during 1990s, the integrated solid waste management has been recently developed in Lao PDR. The National Assembly approved a draft law regarding national hygiene, health care, and protection on May 6, 2001. This law defines the main responsibilities for waste management and provides a framework for more detailed regulations.

In Lao PDR, several government agencies involve in drafting and enacting laws and regulations relating to waste management. These include Ministry of Public Works and Transport (MPWT), Ministry of Natural Resources and Environment (MONRE), Ministry of Industry and Commerce, and Ministry of Health. While ministries provide legislations as general guides, legislation at provincial level allocates the responsible agency or committee, defines the specific scope of work, and sets the fees to be collected from private households, offices, and commercial enterprises and industries.

Several ministerial guidelines, ministerial decisions, laws, and other legislations have been enacted are as follows:

- Industrial Waste Discharge Regulation. No. 180/MOIC, 1994.
- Law on Hygiene, Disease Prevention, and Health Promotion, 2001.
- Regulation of Hygiene of Public Places, 2004.
- Decision on Waste Management in Health Care Service, No. 1706/MOH, 2004.
- Decision on Landfill Management. No. 521/MCTPC, 2007.

- Regulation on Landfill Site Management, 2007.
- Final Draft Regulation on Waste Management in Urban, 2010.
- Draft Guideline on Waste Management in Vientiane Capital, 2010.
- The Environment Protection Law, 2013.
- National Environment Standard amended in 2017.

4 Examples of Best Practice of 3Rs

This section introduces two examples of best practice relating to integrated solid waste management in Vientiane Capital. They are JICA Grass Root Waste Management Project and FES Waste Management Project of National University of Laos.[2]

Case1: *JICA Grass Root Waste Management Project.* This project was undertaken between 2015 and 2018, under the cooperation of Kyoto City of Japan, VCOMS, and MONRE of Lao PDR.[3] The project has four components, including (1) providing training to authority working in waste management of Vientiane Capital; (2) studying and improving waste collection system in Vientiane Capital; (3) raising awareness about waste management for schools and communities; and (4) introducing a community waste separation and collection scheme for targeted villages in Vientiane Capital. While other components are commonly seen in many places, the fourth component is unprecedented. The main objective of the fourth component is to encourage the participation of the community on waste separation and collection. This component is an incentive-based waste collection scheme. Four Villages from four districts were selected as targeted villages. They were selected by taking into account the population density and the diverse of economic activities (such as high concentration of households, restaurants, hotels, and so on). Under this scheme, the households in the targeted villages have to separate valuable wastes such as plastics, papers, metals, aluminum, and glass from other wastes. Later, every three months, the Waste Collection Service Unit of VCOMS goes and buys these materials in an open space of the villages (usually at school's yard) (Fig. 3).

The fourth component of JICA Grass Root Waste Management Project is considered as a very successful case for community participation on waste separation at source. Hence, currently, even though the project ended, the activities have still been promoted to many other villages in Vientiane Capital (Xayapheng and Xaephan 2018).

Case2: *FES Waste Management Project of National University of Laos.* The FES Waste Management Project was established by the Faculty of Environmental Sciences (FES), National University of Laos, in 2017. Although the faculty was established since 2004, solid waste management had been an on-and-off activity in the past. It was not until 2017 when the National University of Laos announced its stand

[2]JICA stands for Japan International Cooperation Agency, while FES stands for Faculty of Environmental Sciences under National University of Laos.

[3]MONRE stands for Ministry of Natural Resource and Environment.

Fig. 3 Waste separation of JICA Grass Root Waste Management Project. *Source* Xayapheng and Xaephan (2018)

to become the leading university of environmental management that integrated waste management has become a focus in many faculties, especially in FES and Faculty of Forestry. FES Waste Management Project has objective to reduce, reuse, and recycle wastes as much as possible. It has three components, including waste separation at source, 3Rs, and waste bank. Volunteers, mostly students, are recruited to work for the project. They have to ensure the efficiency and effectiveness of all the three components. (1) *Waste separation at source* is an activity which faculty staff and students have to comply. Four types of waste bin are provided, including waste bin for plastics and papers, hazardous waste, food and organic waste, and the bin for other wastes. (2) 3R practices are advertised at the faculty by waste volunteers. Currently, the reduction of waste generation can be seen throughout the faculty. Many students are promoting the use of stainless straw or bamboo straw instead of plastic straw, the use of stainless bottle for containing drinking water, instead of buying bottled water, and the use of cotton bag instead of plastic bags for shopping. For generated wastes, some reusable materials are re-used directly or else are transformed before usage. Some valuable wastes, such as plastics and papers, are sold to the waste bank, while food wastes are composted to produce fertilizer, and other organic wastes are turned into bio-charcoal. Hazardous waste and other types of waste are separated and transferred to the landfill. (3) *Waste bank* is a component initially established to support waste separation at source in the Faculty of Environmental Sciences alone, but it became popular in a short period of time, and then was expanded to serve customers outside the faculty. Customers using the service have to register with the bank at site, get a bank book, and deposit wastes to the bank. Different types of wastes have different prices. When depositing, wastes are valuated, and their values are recorded into the bank account. Customers can withdraw money from the bank when the amount is large enough, but they have to keep the minimum deposit of ten US dollar in the account. Collected plastics are sold to a plastic recycling company, while other valuable wastes are sold to waste dealers. This system ensures the sustainability of waste-to-resource practice.

5 Future Plan for Solid Waste Management in Lao PDR

Lao PDR still lacks clear policy and legislation for 3Rs promotion and implementation. In addition, there is no framework to support the adoption of waste-to-resource scheme. The policy and regulatory framework do not cover the penalties for littering and open dumping, and they lack mechanisms to promote the segregation of waste at the source (GGGI 2018). In addition, people's awareness on solid wastes is still low. Therefore, implementing 3Rs as a pathway toward circular economy is very important.

Therefore, national policy frameworks need to be strengthened to ensure that waste management practice will shift from an end-of-pipe approach to an integrated resource management approach. In addition, at the local level, the 3Rs need to be integrated into waste management strategies and action plans for municipalities. These need to be developed and implemented, especially in Vientiane and other big cities. A sound solid waste management system is to be established in harmony with city government and development by 2030 (UNCRD 2016).

To tackle the above issues, the Pollution Control Department, Ministry of Natural Resource and Environment of Lao PDR set up the vision, strategy, and plan as follows:

(1) Vision and strategy

- Goal in 2030: A sound solid waste management system is established in harmony with the city's environment and development.
- Strategies until 2025: 3Rs are promoted throughout the country.

(2) Plan

- Collecting data relating to types of wastes, amount of wastes, in all province in Lao PDR.
- Developing strategy on integrated waste management.
- Developing regulations on waste management in industrial sector, commercial sector, and another related sectors.
- Increasing public awareness regarding 3Rs and other solid waste management practice.
- Promoting and enforcing 3Rs principle in all provinces.

References

Climate and Clean Air Coalition. (2016). *Solide waste management city profile: Vientiane capital*. Lao PDR: Climate and Clean Air Coalition.

GIES. (2012). *A guide for improving municipal solid waste management and promoting urban organic waste utilization in Lao PDR*. GIES Working Paper No. SCP-2012-01. Institute for Global Environmental Strategies (IGES), Kanagawa, Japan.

GGGI. (2018). *Solid waste management in Vientiance, Lao PDR: Situation assessment and opportunities for waste-to-resource*. Seoul: Global Green Growth Institute.

UNCRD. (2016). Seventh Regional 3R Forum in Asia and the Pacific: Advancing 3R and Resource Efficiency for the 2030 Agenda for Sustainable Development. *UNCRD* (p. 46). Adelaide: United Nation Center for Regional Development.

Update Lao Magazine. (2018). *Update Lao Magazine.* Vientiane Capital.

VCOMS. (2018). *Report of waste management in Vientiane Capital 2017*. Vientiane Capital: VCOMS.

World Bank. (2019). *Lao PDR*. Retrieved 05 30, 2019, from data.worldbank.org: https://data.worldbank.org/country/lao-pdr.

Xayapheng, C., & Xaephan, V. (2018). *The effectiveness of household waste management of JICA grass root project in Thatluangkang Village Saysettha District and Anou Village Chanthabouly District, Vientiane Capital*. Vientiane Capital: Faculty of Environmental Sciences, NUoL.

Circular Economy in India

Sadhan Kumar Ghosh

1 Introduction

India is a fastest growing economy with unity in many diversities comprising of 28 states and nine union territories. The population in India as estimated in 2019 is at 1.37 billion based on the most recent UN data and 2011 census data. India is the second-most populous country. It is the seventh-largest country in the world, having total area of 3,287,263 km^2 (1,269,219 sq mi) measuring 3214 km (1997 mi) from north to south and 2933 km (1822 mi) from east to west. A land frontier of 15,200 km (9445 mi) and a coastline of 7516.6 km (4671 mi) exist in India (Annual Report 2016–17). With USD 2.6 trillion GDP, India has increased the material consumption from 1.18 billion tons in 1970 to 7 billion tons in 2015, a six times growth. India can become a 5 trillion dollar economy in the next five years as has been said by the hon'ble Prime Minister on the 73rd independence day of India, 15 August 2019. The resource requirements in India are projected to be nearly 15 billion tons by 2030 and around 25 billion tons by 2050. The material consumption is expected to be two times in 2030 than the present level, because of increasing population, growing demands and aspirations, rapid industrialization and urbanization. Economic growth and industrialization are always coupled with inherent cost on natural environment. In recent past, India has observed a sharp decline in poverty rate and increased urbanization simultaneously an enhanced demand for goods and services. All these factors of increasing consumption lead to pressurized resource reserve and hence mostly indiscriminate exploitation of natural resources. The results are the threat to environment sustainability. India is committed to provide for sustained economic

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growth with sustainable consumption of natural resources safeguarding the environment as a signatory to UN Sustainable Development Goals. Waste generation is a subset of material consumption, which when suitably processed could deliver valuable secondary resources and when it is reduced deliver resource efficiency. Resource efficiency has a vital role towards mitigation of land degradation, bio-diversity loss and top of it is the climate change. India needs to take the path of economic development with efficient use of resources and minimum negative impacts on environment that leads to sustainable development. Here comes the importance of the implementation of concept of circular economy in India. Circular economy helps in redesign the products and processes, waste reduction leading to green productivity and resource productivity reducing associated environmental impacts and process cost, delivering a more competitive economy, addresses emerging resource security/scarcity issues, and employment generation. Circular economy drives the ongoing resources utilization for as long as possible extracting the maximum value, recover and regenerate products and materials at the end of each service life; circular economy helps limiting the extraction of natural resources to maximum possible extent. The conventional, "take, make and dispose" economic model, popularly known as linear economic model, is very much exists in India's manufacturing sector, one of the significant growth areas. Linear economic model does not support replenishing finite resources. With finite resources of material, an urgent need evolved for decoupling economic growth from resources, which can be achieved through the concept of circular economy.

2 Demography

According to the Census of India of 2001, having the eighth schedule of the Indian Constitution lists 22 languages, India has 122 major languages and 1599 other languages. In South Asia, India is bordered by the Bay of Bengal, the Arabian Sea and the Indian Ocean, and surrounded by the neighbouring countries, namely Bangladesh, Bhutan, China, Nepal, Myanmar (formerly Burma) and Pakistan. India is the world's third-largest economy on PPP basis (~USD 8.7 Trillion) and seventh-largest country by area with 3,287,590 km^2 with 23 official languages, business language predominantly being the English. One in every six people on the planet live in India, and between the 2001 and 2011 censuses, the country grew by 17.7%, adding 181.5 million people. There are 28 states and nine union territories in India. India's current yearly growth rate is 1.02%. Nearly 416 people per square kilometre (population density) live in India, which ranks 31st in the world. The population density in Mumbai is 21,000 people per square kilometre (54,000/square mile). Towns/cities with populations of 1 lakh (100,000) are categorized as Class-I towns or Cities. The 46 cities with populations of 1 million and above are known as million-plus urban agglomerations (UAs) or cities. The three cities with populations of 10 million and above are known as megacities, the census defined the three as Greater Mumbai UA (18.4 million), Delhi UA (16.3 million) and Kolkata UA (14.1 million). 65.8% of Indian population in the working age group is of 27.6 years, a large potentially productive workforce. India has second-highest GDP and highest GDP growth rate among BRICS (Source: Reserve Bank of India, Ministry of Finance, Govt. of India). There are a few demographic advantages in India, like, emergence of middle class: rising household income, growing consumer market: booming retail sector, large younger workforce: highly skilled and educated and large English-speaking population with an urbanization rate of 31% in 2010 to an estimated value of 35% in 2020. All these demographic conditions are considered to be the advantages towards making India proceeding to the circular economy model.

3 Materials Consumption

The Indian economic model has been and still today is largely a linear one where the activities run around "take-make-consume-dispose (t-m-c-d)" economic model, rather than a circular model. While in many areas, the concepts of circular economy and 5R have been introducing and in the state of transition from the "take-make-consume-dispose" situation to a "Closed loop processes" of circular economy. The linear economic model, t-m-c-d, of materials use in India is not sustainable and, for many materials, the consumption in the country far exceeds the contents in the geographical boundaries of the country with 17% of the global population, on 2% of world's landmass with 4% of total freshwater resources. On the other hand, a circular economy model provides opportunities to create growth, well-being, resource circulation, jobs and local economy while reducing environmental pressures. With the growth of global economy, integrated collaborative efforts are significant for ensuring availability and conservation of resources to reconcile increasing demand with finite supply. India has traditionally been a frugal society eschewing wastefulness, reusing and recycling products, making these last beyond its intended purposes (TERI 2018). However, it is a challenge to sustain with the advent of consumerism, growing purchasing power and higher standard of living.

With the continuing current dynamics (8% growth in GDP p.a. until 2030, thereafter 5%), the material consumption in total in 2030 is projected to be 14.2 BT (billion Tons). This amount consists of biomass amounting to 2.7 BT, fossil fuels 4.2 and 0.8 BT of metals (Fig. 1). This means tripling of demand for primary materials compared to 2010. India has achieved the self-sufficiency in mineral raw materials for thermal power generation, iron and steel, different kinds of refractories, ferroalloys, aluminium and cement. India has high import dependence for certain critical materials as Molybdenum (100%), Nickel (100%), Cobalt (100%), Copper (95%), Oil (70%), etc. The current status of materials extraction and recycling activities are as follows (National Resource Efficiency Policy 2019),

- Resource extraction of 1580 tons/acre in the country at present is higher than the world average of 450 tons/acre with the third-largest material demand (year 2010).
- Low material productivity in comparison with the global average.

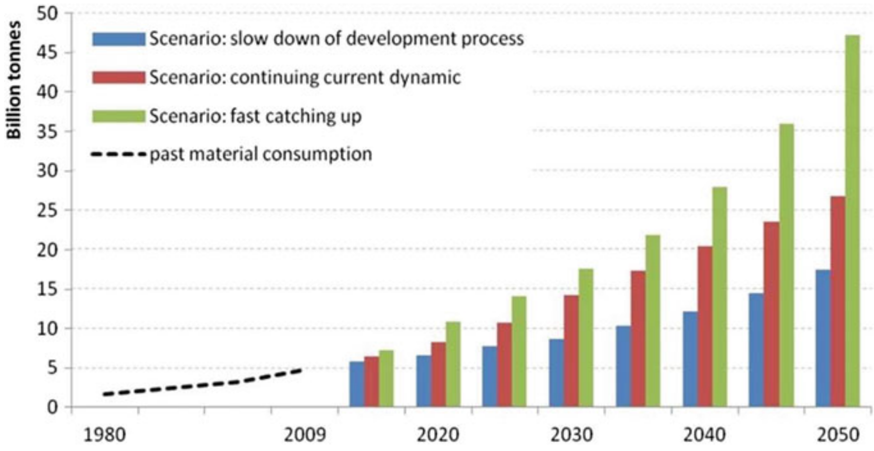

Fig. 1 India's past material demand and future projections until 2050 (IGEP 2013 and NITI Aayog 2017)

- 30% of land undergoing degradation.
- Low recycling rate at 20–25% which is similar to many of the countries in the Asia Pacific (much higher in Australia, S. Korea, and Japan) and significantly lower than the recycling rates in any developed countries (nearly 70% Europe).
- Responsible for 6.9% of global CO_2 emissions.
- Highest water withdrawal globally for agriculture, third-highest CO_2 emitter.
- High import dependency of many critical raw materials.

4 National Resource Efficiency Policy (NREP) Considers the Resources and Materials Used

National Resource Efficiency Authority (NREA) has been proposed as a dedicated institution in the country for fostering resource efficiency in the NREP, 2019, that draws its power from Environment (Protection) Act, 1986, to provide for the regulatory provisions of this policy. NREP will encircle the biotic and abiotic resources as well as ecosystem services. These include air, water, forest, land, metals, minerals, fossil fuels and biomass. The NREP will cover biotic and abiotic resources across entire lifecycle stages those includes raw material extraction, material processing, production, use, disposal and end-of-life management of any system or product. The policy aims to cover all resources both biotic and abiotic, environmental aspects and all sectors across lifecycle stages, required to achieve sustainable development. The policy will include biotic and abiotic resources and materials, specific dependent sectors and generated waste (or secondary resources) from these sectors, These include resources and materials, namely metals and metal industry (steel, aluminium, copper, etc.), non-metallic minerals, water, land, air, biomass and fossil fuels; different sectors, namely plastic, packaging, construction, transportation, electrical and electronic equipment, agriculture, textile, renewable energy (solar, wind, WtE, etc.) and food and wastes, namely municipal solid waste, plastic packaging, e-wastes, industrial waste, etc. A set of indicators will track the progress of the resource efficiency. A few types of indicators, namely established indicators, sector-specific indicators, recovery and recycling indicators will track the progress with resource efficiency targets developed by the concerned ministries (and state governments) in consultation with stakeholders.

5 Basic Acts: Waste Management Legislation and Resources Circulation

In India, the circular economy has been supported by the legislation and regulations for quite a long time. Information in Fig. 2 demonstrate the linkage of framework and key policies across lifecycle stages and different rules, regulations and guidelines pertaining to resource conservation in different areas of concerns. India does not have any law directly for circular economy but the concept and its implementation requirements are embedded in many rules and regulations. Very recently, in the later part of 2019, the national resource efficiency policy draft has been released. The concept of sustainable development and environmental protection was embedded to some extent evolved in India since long back in 1881 through the Factories Act 1881 followed by Factories Act 1934 and the Factories Act 1948 in independent India with subsequent amendments. The basic environmental plan in Indian legislation was evolved as the forward action plans after the 1972 Stockholm Conference and the 42nd amendment in Article 48 part IV & Article 51A(g) in the Constitution of India. The Constitution of India was amended within five years after the Stockholm Declaration, for the Protection and Improvement of Environment as constitutional mandate.

A National Committee on Environmental Planning and Coordination was set up by the Government of India. Article 48A was added by the Constitution (42nd Amendment) Act, 1976 which stated that "*State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country*." Article 51 ensures that the state shall strive for the promotion and maintenance of just and honourable relations between nations respect for international law and treaty obligations, as well as settlement of international disputes by arbitration. Article 51 in the constitution of India 1949 included 51A (g) "*to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures*"; Article 51-A (g) deals with fundamental duties of the citizens states and stated, "It shall be the duty of every citizen of India to protect and improve the

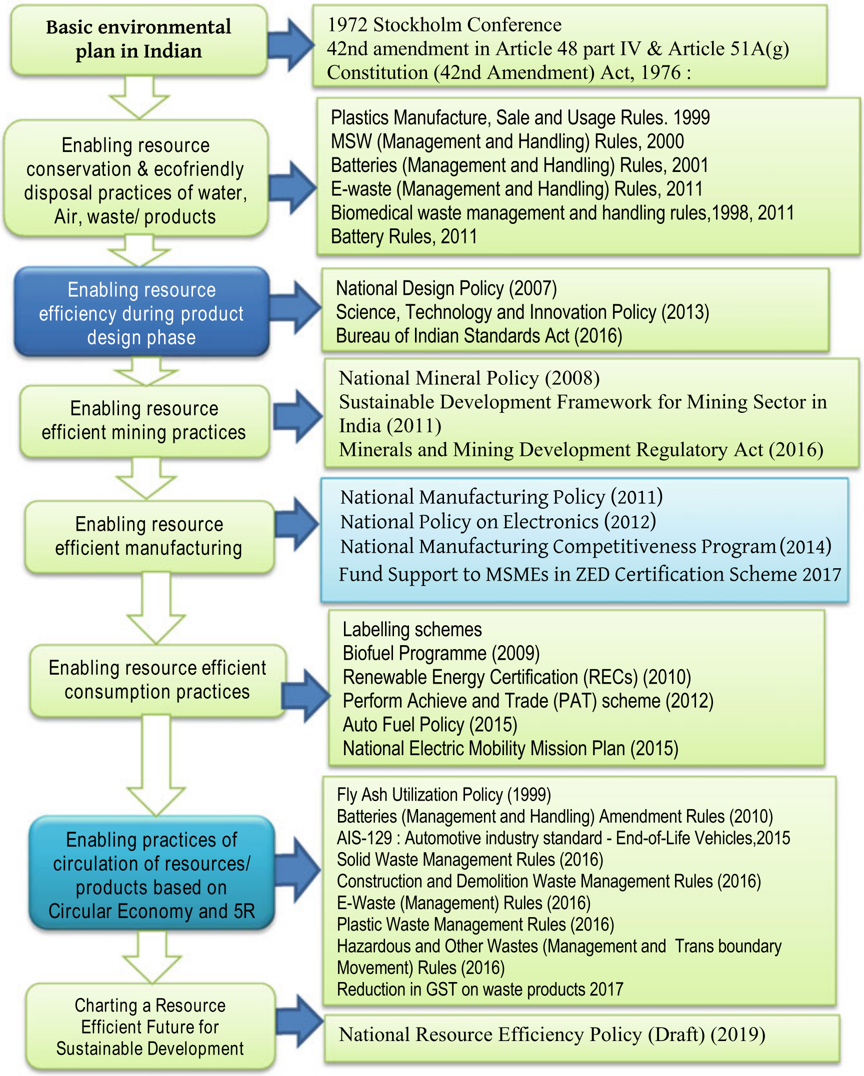

Fig. 2 Framework and key policies across lifecycle stages in India focusing SDGs, Resource conservation Circular Economy and 5R. (*Source* Developed by Prof. S. K. Ghosh, the author)

natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures." The protection and improvement of natural environment is the fundamental duty of the State (Article 48-A) and every citizen (Article 51-A (g)) (Constitution of India) under the Constitution Act of 1976.

Wildlife Act, 1972, Water Act, 1974, Air Act, 1981 and a few other acts were introduced in India soon after the Stockholm Conference. The right to clean, healthy and pollution-free environment was included as the fundamental right of life enshrined in Article 21 of the Indian constitution. "Polluters Pay" under the doctrine of sustainable development and the precautionary principles were explicitly embedded in the recent environmental legislations including in the National Green Tribunal Act 2010. Figure 1 demonstrates the framework of Indian rules and regulations focusing Circular Economy, 5R and Resource conservation.

There were many initiatives in India towards resource circulation by the way of several policies, legislations and schemes which support the circular economy and 5Rs concepts. The very recent initiative in India concerning resource circulation and circular economy is the release of a draft National Resource Efficiency Policy (NREP), 2019, on 23.07.2019, by the ministry of Environment, Forest and Climate Change, Govt. of India charting a Resource Efficient Future for Sustainable Development (National Resource Efficiency Policy 2019).

The policy will help in creating facilitative and regulatory environment to mainstream resource efficiency across all sectors through cross-sectoral collaborations, development of policy instruments, action plans and efficient implementation and monitoring frameworks. These rules are the first step for mainstreaming resource efficiency in India and provide for review after ten years, if needed. The guided principles of NREP, 2019, are:

(i) reduced primary resource consumption to "sustainable" levels, to achieve the sustainable development goals and staying within the planetary boundaries,
(ii) higher value creation with less material through resource-efficient and circular approaches,
(iii) minimization of waste and material security, and
(iv) creation of employment opportunities and business models beneficial to the cause of environmental protection and restoration.

Scope of the National Resource Efficiency Policy encompasses resources and materials used across all lifecycle stages of any sector. Resources include both biotic and abiotic resources as well as ecosystem services that include air, water, forest, land, metals, minerals, fossil fuels and biomass. The NRE policy covers these resources (biotic and abiotic) across all the lifecycle stages including raw material extraction, production and material processing, use and disposal and end-of-life management of any product or system.

In India, there are specific documents and legislations those give clear pathway for the transition of the economy to a more circular model, based on the principle of 5Rs—Reduce, Reuse, Recycle, Remanufacturing and Refurbish. The focused and integrated approach to circular economy is visible in India in a few of the policies, namely National Resource Efficiency Policy (Draft) (2019), National Electricity

Mobility Mission Plan in consumption stage, *the ZED (Zero* Effect, Zero Defect) in manufacturing stage, the various Waste Management Rules of 2016 in disposal stage and Swachh Bharat Mission. Across various sectors of the economy, these are further supported for effective technology and finance mechanisms by development of specific policies.

5.1 Enabling Practices of Circulation of Resources/Products Based on Circular Economy and 5R—Resource Conservation and Eco-friendly Disposal Practices

After the notification of the Fly Ash Utilization Policy in 1999, the fly ash utilization has increased to nearly 60% in India. The notification on fly ash utilization was first issued in the year 1999 and since then, the fly ash utilization in the country has increased to almost 60%. Power-generating companies have been given mandate by the government to provide fly ash at free of cost to the consumers within 300 kms, on the other hand, the ministry of forest, environment and climate change (MoEF&CC) revised some of the norms to diversify the application of fly ash across other sectors. The cement industries operating within a radius of 300 kms of a coal-based thermal power plant have to use fly ash for cement manufacturing as per Bureau of Indian Standards (BIS).

The amended Batteries (Management and Handling) Amendment Rules (2010) include provision for sale of batteries through registered dealers. Rules ensure the collection, recycling, transportation and sale of batteries will be the responsibility of the manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, bulk consumer and consumer (MoEF & CC 2010). The Government of India in 2016 notified the new Solid Waste Management Rules (SWM), 2016, replacing the earlier rules 16 years ago in 2000. The new rule explicitly mandates source segregation of waste for creating opportunities of value addition and promotes recovery, reuse and recycle reducing the landfill to the minimum extent possible encouraging resource circulation.

Construction and Demolition Waste Management Rules (2016) is the inclusion of set of new rules given the responsibility to the waste generators for their storage and transportation to collection centre as provided by local bodies (ULB) or to be handed over to authorized processing facilities. E-Waste (Management) Rules (2016) was introduced by revising the previous rules for properly channelizing e-waste for formal treatment and resource recovery. The rule introduced extended producer responsibility (EPR). Plastic Waste Management Rules (2016) will bring responsibilities in system of collecting back plastic wastes, use of plastic waste for specific applications for gainful utilization of waste. Hazardous and Other Wastes (Management and Transboundary Movement) Rules (2016) emphasize the recovery and reuse of materials from hazardous and other waste materials generated from a process and ensure sound management of all hazardous and other waste material.

5.2 *Enabling Resource Efficiency During Product Design Phase*

The sustainable development involves three pillars, namely operational including environmental aspects, social aspects and economical aspects. Designing and manufacturing environmentally benign products is a key to achieving sustainable consumption and production goal of SDGs. There are some key parameters that act as determinants in ensuring sustainability of products under the three sustainable development pillars (Table 1).

National Design Policy (NDP) has been introduced by the Department of Industrial Policy and Promotion (DIPP), India in 2007. NDP promotes a design enabled Indian industry, brand image for Indian designs and award *India Design Mark* on designs based on key criteria, e.g. innovation, originality, aesthetic appeal, ergonomic features, user-friendliness, safety and eco-friendliness. Science, Technology and Innovation Policy (2013) were introduced with an objective to enhance sustainable and inclusive growth fostering resource-optimized, cost-effective innovations, across size and technology domains and popularizing innovation through R&D focusing green manufacturing. Bureau of Indian Standards Act (2016) was introduced in 2017 revising the previous act of 1986. The BIS develops standards and certification covering a wide range of products, processes, systems across different sectors of industries for manufacturing and services. BIS recognizes environment-friendly products through its labelling scheme eco-mark. BIS forms the Indian mirror body of

Table 1 Aspects of sustainable development

Operational and environmental aspects	Social aspects	Economic aspects
Green productivity	Legislation and enforcement	Green supply chain management
Energy conservation	Social capital	Innovativeness
Bio-degradable material	Job opportunity	Product life cycle
Circular economy and 5R concept	Housing and service infrastructure	Carbon trading
Waste minimization	Health and education	Profitability
Carbon footprint	Community participation and benefits	Return on investment
Clean development mechanism		GDP growth

International Organization for Standardization (ISO) and participates in formulation of standards in different technical committees of ISO.

5.3 Enabling Resource-Efficient Mining Practices

Significant portion of material requirement, nearly 95%, is met from domestic sources in India. A small improvement in resource efficiency at the mining stage can lead to substantial savings in the sector as well for the country's economy. The National mineral policy of 2008 focuses the significance of resource conservation, prevention and mitigation of adverse environmental effects, making zero waste mining as the national goal using modern machinery and equipment to improve efficiency, productivity and economic viability of mining and strengthening research. *Sustainable Development Framework for Mining Sector in India* (2011) released by the Ministry of Mines envisions mining to be "financially viable; socially responsible; environmentally, technically and scientifically sound; with a long-term view of development; uses mineral resources optimally; and ensures sustainable post-closure land uses". *Minerals and Mining Development Regulatory Act (MMDR)* (2016) sets guidelines, recommends evaluation and implementation of sustainable development frameworks for the mining sector empowering the central government to issue directions to reduce wastes, adoption of waste management practices and promotion of recycling of materials, mitigation of adverse environmental impacts on groundwater, air, noise and land, minimize impacts on bio-diversity, flora, fauna and habitat and to formulate strategies for restoration and reclamation activities for rational use of land resource. Enhancement of resource efficiency in this mining sector would mean improved mining practices leading to minimal wastage, beneficiation, better transportation, as well as fewer environmental and social conflicts.

5.4 Enabling Resource-Efficient Manufacturing

India's manufacturing sector has emerged as a key economic sector for decades. To address the renewed commitments of the Government on "Make in India", "Digital India" and "Skill India", the earlier National Manufacturing Policy has been modified in 2011. Apart from increasing income and employment, the policy aimed at enhancing global competitiveness of India's manufacturing sector, increasing domestic value addition and strengthening technological depth that supports environmental sustainability. National Manufacturing Policy helps in identifying importance of green manufacturing and provides incentives for acquiring technologies that are eco-friendly and control consumption resources, namely water, energy, etc. To meet the growing demand for domestic and export markets, the National Policy on Electronics was introduced in 2012 aiming at making India a globally competitive electronics manufacturing hub by ministry of electronics and information technology, government of India. Its other objective was to streamline the implementation of e-waste rules as well as the extended producer responsibility. National Manufacturing Competitiveness Programme was launched in 2014 to enhance the competitiveness of Micro-, Small and Medium Enterprise (MSME) sector which is the backbone of India's manufacturing industries (Source: Ministry of Micro-, Small and Medium Enterprises, 2017). Government of India introduced "Financial Support to MSMEs in ZED Certification Scheme, 2017" to promote Zero Defect Zero Effect (ZED) across all manufacturing and service sector industries with a specific emphasis on the MSMEs.

5.5 *Enabling Resource-Efficient Consumption Practices*

Resource efficiency in the consumption phase has a lot to offer in terms of material savings. In recent years, the Government has introduced new policies and as well modified earlier policies with a larger objective to promote sustainable consumption and production.

Eco-mark 1991: Eco-mark is one of the labelling schemes in the country introduced by the ten ministries of environment and forest and Bureau of Indian Standards (BIS), which helps in voluntary participation to identify eco-friendly products involving significantly reduced environmental impacts all through the supply chain of extraction, manufacturing, use and disposal considering cradle-to-grave approach. Bureau of Energy Efficiency (BEE) introduced Star Labelling Program in 2006 to provide consumers informed choice about purchase decisions thereby saving their electricity bills. The Star Labelling Program bought substantial energy savings in the residential and commercial buildings covering room air conditioners (Fixed Speed), ceiling fans, colour TV, computer, refrigerators, distribution transformers, domestic gas stoves, frost-free refrigerators, general-purpose industrial motor, pumps, stationary-type water heater, submersible pump set, washing machine, ballast, solid-state inverter, office automation products, diesel engine driven, diesel generator set, led lamps, room air conditioners (variable speed), chiller, variable refrigerant flow, agricultural pump sets, microwave oven, etc., and many others. Biofuel Programme (2009) was introduced in December 2009 to meet the increasing energy needs of the country, reduce open burning as well as utilization of biomass, to provide energy security, National Policy on Biofuels was announced in December 2009. It gave thrust on research and development on cultivation, processing and production of biofuels and a blending mandate of 20% ethanol and bio-diesel by 2017.

Specific targets have been assigned for energy consumption in designated industries that can trade energy-efficient certificates in energy-intensive sectors based on the efficiency gained by the designated consumers. The Central Electricity Regulatory Commission (CERC) introduced Renewable Energy Certification (REC) 2010 program to meet Renewable Purchase Obligation targets by the electricity distribution companies while incentivizing green energy generation. Electricity Act, 2003, and the National Action Plan on Climate Change (NAPCC) have given roadmap to increase the per cent of renewable energy generation in the total generation capacity. Energy efficiency in energy-intensive industries has been encouraged through the Perform Achieve Trade (PAT) 2012, a market-based trading scheme that was introduced under the National Mission on Enhanced Energy Efficiency (NMEEE) administered by the Bureau of Energy Efficiency (BEE).

The ministry of petroleum and natural gas, government of India, has been promoting the improvement in fuel quality and enforcing stricter emission norms for the automobile sector by introducing Auto Fuel Policy 2015 and Vision for 2025. This has brought a significant change in the auto fuel efficiency and as a whole the competence in automobile sectors. Adoption of electric vehicles and their manufacturing have become one of the flagship programmes in India to enhance national fuel security, providing affordable and environmentally friendly transportation and enabling the Indian automotive industry to achieve global manufacturing leadership. The National Electric Mobility Mission Plan (NEMMP) 2020, providing the vision and the roadmap for the implementation at faster rate setting an ambitious sales target to achieve 6–7 millions of hybrid and electric vehicles by 2020. Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) India scheme aims to promote multimodal public electric mobility through an incentive scheme in cities for the promotion of adoption of electric vehicles.

6 Action Plans for Waste Management in ZED

Adopting circular economy in industries is not just about improving environmental performance. It improves the resource efficiency thereby conserving materials in micro-economic and macro-economic considerations. By the implementation of circular economy model significant savings in resources can be realized. These savings offer possibility investments elsewhere and give a globally competitive status for Indian SMEs. ZED (Zero Effect, Zero Defect) in manufacturing facilities is a tool that helps in implementation of CE in industries. Followings are some of the action plans the government of India has taken up. These should go beyond the traditional 3Rs concept and integrate more aspects related to redesigning the products and re-engineering the processes, e.g. Product Stewardship or extended producer responsibility (EPR) is crucial in achieving many CE goals.

1. Create awareness by training all employees on value and waste concept of lean manufacturing.
2. Development of a system and training of people to reduce waste using lean and six-sigma tools.
3. Detection of waste through value stream mapping and elimination of waste through structured application.
4. Identify the environment impact of materials used in the products, when they are disposed of.

5. Safe disposal instructions provided on packaging in local languages.
6. Develop instructions for environmentally safe use, storage and disposal after use and educate the customer about proper disposal.
7. Substitution of negative impact materials with environmentally safe materials.
8. Develop companywide scrap reduction system.
9. Evaluate cost for poor quality due to scrap and try to minimize in the every sector of the production unit.
10. Identify the root cause of the scrap and make countermeasure.
11. Training of people on prevention of pollution.
12. Mapping of environmental pollutants from processes.
13. Identify opportunities to take measure to conserve natural resources in various areas of company.
14. Implement techniques for optimal use of natural resources and measure natural resource usage in all areas of organization by developing natural resource monitoring system.

7 Swachh Bharat Mission (SBM)—Swachh Survekshan: Resource Circulation in ULB

World's biggest ever survey, the Servekshan 2019, impacting nearly 0.43 billion citizens in 4237 cities in India was conducted early 2019 that started in 2016. Swachh Bharat Mission (SBM), a flagship scheme of the government of India has brought a significant shift in waste management and sanitation in the country both for urban and rural areas. Every year, cities and towns across India are awarded with the title of "Swachh Cities" (Clean Cities) on the basis of their status of open defecation (to achieve ODF), cleanliness, sanitation and waste management drives as a part of the Swachh Bharat Abhiyan that was launched in October 2014. The Swachh Survekshan–2016 was conducted by the Ministry of Housing and Urban Affairs in January 2016 assessing 73 Urban Local Bodies (ULBs) when Mysuru city received the tag of the cleanest city of India. The 2017 edition was conducted in January–February 2017 covering 434 ULBs. Indore emerged as the cleanest city in 2017 survey. Indore city received and continued the tag of the cleanest city in 2018 and 2019 consecutively for three years. Four thousand forty-one (4041) cities were involved in Swachh Servekshan 2018 ranking first 500 cities on national level which have more than 0.1 million population, among which three thousand five hundred forty-one (3541) cities were included with less than 0.1 million population. Swachh Survekshan has given a big push in the implementation of new sets of rules on waste management effectively.

8 Solid Waste: Minimizing Resource Consumption Enhancement of Resource Circulation Based on Circular Economy and 5Rs

The Government of India has revised five rules pertaining to municipal wastes, plastics wastes, e-wastes, hazardous waste and bio-medical wastes and introduced construction and demolition wastes in the year 2016 and thereafter subsequent amendments based on the concepts of 5Rs and circular economy. All the requirements on these sets of new rules focused on resource circulation and reduction to the final sink.

The salient features of the Solid Waste Management Rules 2016 released on 8 April 2016 are as follows,

(a) Every household, Event organizers, Street Vendors, RWAs and Market Associations, Gated Community having more than area 5000 m^2, hotels and restaurants, etc., are among the waste generators, and bulk waste generators.
(b) The responsibilities of specific officers in state as well as the central level have been defined.
(c) Extended producer responsibility (EPR) is introduced among the manufacturers/brand owners to facilitate collect back wastes of their products. Manufacturers of products like sanitary wastes, etc., shall have to provide pouch for packaging and disposal for treatment, Industry (cement, power plant, etc.) shall use RDF within 100 km and the operator of facilities shall follow guidelines and standards.
(d) EPR has also been introduced in case of plastic products and electrical and electronic equipment (EEE) for management of plastics waste and e-wastes.
(e) The Construction and Demolition waste (C&DW) management Rules have been launched in the year 2016 to segregate the generated C&DW at source and transported separately to the C&DW recycling facility. This will help in enhancing the calorific value of municipal wastes because of the source separation. India has installed two C&DW recycling plants at Delhi (1000 tpd) and Gandhinagar, Ahmedabad (500 tpd) and several such plants are in the commissioning or approval stage by the government.
(f) There are four bigger Waste to Energy (WtE) plants (ranging from 700 to 2000 tpd) running at Delhi and Jabalpur. More than 40 WtE plants are at the commissioning or approval stage by the government. There are many biomethation plants ranging from 1 to 100 tpd in the operational or commissioning or approval stage by the government and private agencies.
(g) Though there are a few landfill sites, the new rules do not encourage landfill sites of bigger sizes.
(h) Waste Storage: The Solid Waste Management Rules 2016 requires that the household wastes are segregated in three streams: The wet bio-degradable wastes in green bin, dry non-bio-degradable wastes in white or blue bins and the domestic hazardous wastes in black bins.
(i) Waste Transport and Treatment (Fig. 3): The wet bio-degradable wastes are

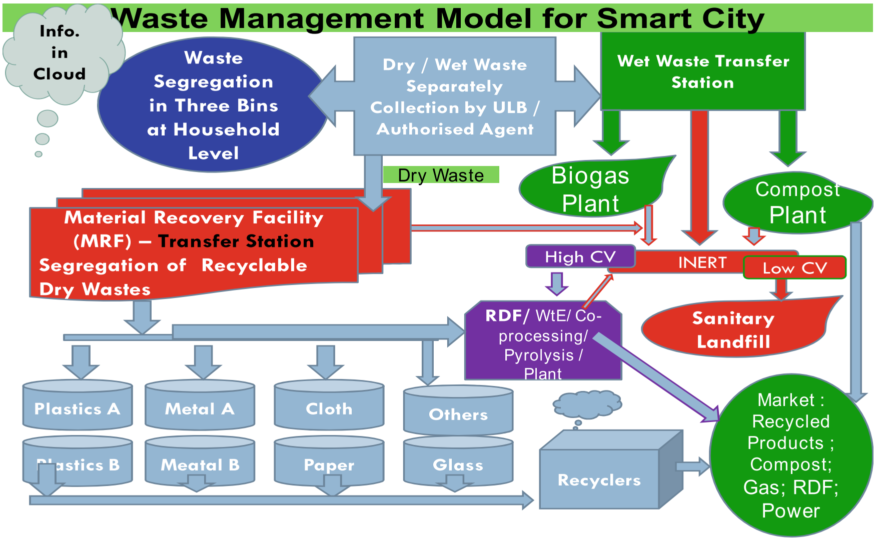

Fig. 3 Sustainable waste management model developed by the author

transported and, if necessary, temporary stores may be carried out at transfer station on the way to the treatment facilities for further segregation or pre-processing. The treatment facility needs to have the provision of composting and/or biomethanation processes of the wet wastes as is possible. The government will give a subsidy of nearly 7 USD (INR 1500/-) per ton of compost produced. The dry non-bio-degradable recyclable wastes have to be separated in as maximum as possible streams in the material recovery facility (MRF) and will arrange for recycling. The incinerable wastes out of these dry wastes which have more than 1500 kcal/kg may be used for waste-to-energy plants and/or RDF plants to be used for co-processing in cement plants to be used as alternative fuel and raw materials (AFR) or any other uses, etc., be white or blue bins and the domestic hazardous wastes in black bins.

(j) Plastics may be treated for mechanical recycling for making recycled granules, pyrolysis, road making, etc. Bio-medical wastes and hazardous waste management have their own system of storing, transport, treatment and disposal systems. The transboundary movement of wastes is controlled by rules in India.

(k) The responsibilities of all the related stakeholder have been defined with authorities and power to take penal actions.

9 Plastics Economy in India

In India, the design, manufacturing, use, recycling and waste disposal of plastic are the most challenging areas of concern for the circular economy. Plastics, due to its various advantageous aspects, have become one of the most ubiquitous materials used throughout the world. The global production on an average has increased by about 9% per year since 1950. The plastic industry has become a major economic actor with revenue of about 1722 billion Euros in 2015. Since the 1970s, the issue of plastics ending up in the oceans harming the marine life forms and ecosystem has been known and becoming concern for the mankind and the environment. The impacts associated with exposure of organisms to marine micro- and macro-plastics have been increasing day by day. Research focus on these issues is also taking significant shape. However, studies linking the processes in the plastic value chain to plastics being released to the oceans are only starting to emerge. The GDP growth in India has been shown in Table 2 which has a strong relation to petrochemical growth in the country. Among Indian plastics industries, more than 2000 exporters, 30,000 processing units employing more than 4 million people and nearly 85–90% of the processing units are small- and medium-sized enterprises (SMEs) employing. India's plastic exports experienced a growth of 31.6% at $4.59 billion during the period April–September 2018 as against $3.48 billion in same period during 2017–18. It registered a faster growth than the overall merchandise export growth from India (Plexconcil). During H1 2018–19, India reported merchandise exports worth $164.04 billion, up 12.5% from $145.75 billion in H1 2017–18. In the first half of 2019, trend in plastic exports from India has been very positive with a strong year-on-year growth vis-a-vis 2017–18 with August 2018 topping $800 million. Average per capita consumption of plastic in India is 11 kg, whereas the average per capita global consumption is 28 kg. The estimated annual per capita consumption in India would be 20 kg by 2022.

India is a major producer and importer of plastics and generator of plastic waste. The Chinese waste ban recently poses a new challenge for the management of plastic waste in Asia, but even if the waste that is collected is managed correctly, a large amount still leaks into the environment as litter. As a result, action on plastics needs to address not only the effective management of the material once produced but measures to reduce plastic use as this is needed to reduce waste production and leakage.

Table 2 GDP growth in India with polymer consumption growth and import duty

Year	GDP growth (%)	Polymer consumption growth (%)	Import duty
1990–1995	5.0	12.9	50%+
1995–2000	6.5	14.6	40%
2000–2004	5.9	5.8	45–15%
2005–2012	8.7	10.9	12.5–5%
2012–2017, 12th plan	7.2	10.6	7.5–5%
2017–2022, 13th plan	8	10.4	5–0%

Source Plastindia Foundation (2018)

There are a number of initiatives for addressing the issues related to pollution evolved from use of particular types of products of plastics and disposal of plastics waste generated. The number of organized recycling units in India is nearly 3500 and the number of unorganized recycling units is more than 4000 involving nearly 600,000 manpower directly and more than 10,00,000 manpower in indirect way that includes waste pickers. The quantity of plastics wastes recycled in India is nearly 5.5 million tons per annum. Plastic waste generated in India in 2017–18 was 660,787.85 tons, whereas plastic waste generation in 60 major cities was 4059 TPD. Plastic waste generation in Delhi only is nearly 689 TPD. The total quantum of plastic waste treated is not necessarily equal to the amount of plastic produced in the same year in the country. There is always difference exists in the quantity of plastic product, in-use plastic stocks, product lifetimes and annual variations in plastics production and demand. Hence, the mapping of plastic waste treatment was developed independently of the production and consumption mapping. Generally in India, the plastic waste composition is nearly 94% recyclable and 06% non-recyclable (CPCB Report 2018). Figure 4 demonstrates the percentage of classified plastics waste in the plastics waste streams. Figure 5 shows the location of plastics recycling centres in 27 cities across the country. Co-processing of plastic waste (PW) in cement kilns as per CPCB's guidelines is being carried out at nearly 180 cement plants. Nearly 38 cement plants located in several states are presently using plastic waste as alternative fuel and raw materials (AFR). Automatic feeding mechanism for feeding PW to cement kilns flows in the path as, (a) PW preprocessed, (b) is burnt destroyed at a higher temperature of around 1400 °C, (c) PW's inorganic content gets fixed with the clinker, (d) setting-up of laboratory for plastics waste analysis and (e) monitoring of emission by cement industry/SPCBs to get energy and cement as output.

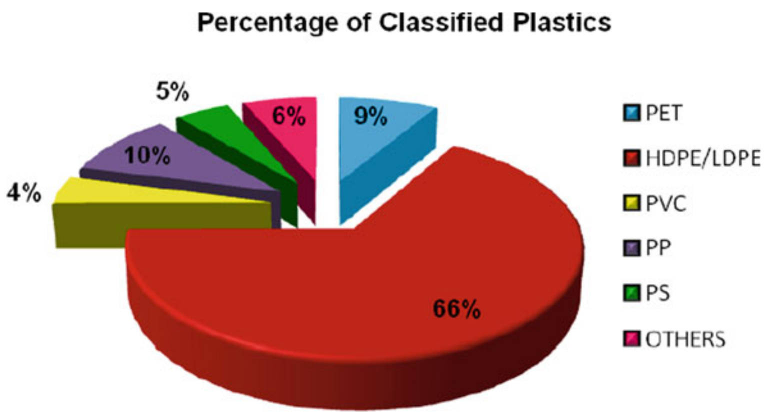

Fig. 4 Percentage of classified plastics waste in the plastic waste streams

Fig. 5 Major plastic recycling clusters spread across India (Source: CPCB Report 2018)

9.1 Issues and Challenges in Plastics Waste Management

Plastic waste littering is a major environmental concern. It makes land infertile, choke the drains, ingestion by cattle causing death, plastics resource depletion and give ugly look of a city or town. Followings are some of the concerns of plastic waste littering and management.

- Absence of proper system of collection and segregation of plastic waste in cities/towns.
- Accumulation of non-recyclable plastic waste such as multilayered laminated packaging, thermoset plastic like SMC and FRP.
- Open burning, especially thermoset plastic waste is a major health and environmental issue, as it emits toxic gases.

- Impact of leaching on soil, underground water, etc., due to improper dumping of plastic waste (contain metals and phthalates).
- Running of unregistered plastic manufacturing and recycling units/industries in residential areas.

9.2 Actions Taken in India Addressing Recirculation and Reduction of Plastics Wastes

The Circular Economy Action Plan in India developed multipronged strategies for plastics. Considering the number of problems and their impact on the environment and the society, a lot more actions have been taken up in India. The report shows that almost 100% rigid plastics waste and nearly 95% PET bottle waste are recycled, recycling of imported plastics scrap is continued. In-house plastic scraps are being utilized in production process and feedstock recycling (mechanical recycling and Pyrolysis). Energy recovery through co-processing in cement kiln gained popularity and acceptance in India. Around 1.0 million tons of wastes in 2016–17 co-processed in cement kiln which is projected to reach up to 1.5 million tons in 2019–20. Use of plastic waste in bitumen road construction is also practiced in India.

The Plastic Waste Management Rules (2016) enforced a few implementation strategies as follows for the import, manufacture, stock, distribution, sale and use of plastic carry bags, sheets, etc.

- India has 7500 km of coastline. A national marine litter action campaign programme has been taken up to measure the amount of plastic enters India's coastal waters. The nation will pledge to make 100 national monuments litter-free, including the Taj Mahal.
- India will eliminate all single-use plastic in the country by 2022. The new initiative for the same will be started from 2 October 2019.
- Applicable to every waste generator; local body, Gram Panchayat, manufacturer, importers and producer.
- Minimum thickness of (virgin or recycled) of plastic carry bags, sheets, etc., not < 50 μm).
- Minimum thickness criteria not applicable for compostable carry bags (conforming IS/ISO: 17088 & having CPCB Certificate for marketing/selling).
- Manufacturers of plastic carry bags shall register with state and central pollution control board (CPCB) and pollution control committee (PCC).
- Manufacturer and seller of compostable carry bags shall obtain a certificate from CPCB.
- Packing Gutkha, pan masala and tobacco, plastic sachets/pouches are not permitted.
- Recycled carry bags not to be used for packing/storing/dispensing of food items, etc.
- Carry bag must print the name, registration number of manufacturer, thickness, "recycled" mark, etc., as applicable.

- Pricing of carry bags and registration.
- Bought rural areas and plastic importers under its purview.
- Introduced Plastic Waste Management (PWM) fee through pre-registration of the producers, importers of plastic carry bags/multi-layered plastics (MLPs) and vendors selling the same for establishing the waste management system.
- Retailers/Vendors to provide labelled carry bags, sheet or MLP.
- EPR: All producers work out modalities for waste collection system based on EPR. The manufacturers are supposed to establish a system for collecting back the plastic waste generated due to their products.
- Local body shall utilize the amount for development of waste management system.

9.3 Actions Taken in India on Curbing Plastics Use

India was the host country of the World Environment Day 2018. The WED 2018 theme was, "Beat the Plastics Pollution" and announcement on abolish *Single-Use-Pla*stics by 2022 stopping manufacture, storage, sale and use was made on 5 June 2018. There are many more actions that India taking place, a few of which are noted below.

- Ban on six single-use plastics products from 2 October 2019: Plastics bags, small plastics bottles, plastics plates, plastic straws, certain types of sachets of MLP and plastics cups.
- Value chain for PET recycling already exists and country has enough capacity for recycling PET.
- Certification by CPCB to compostable carry bag manufacturers and sellers.
- Ban on plastics carry bags less than 50 μm thickness.
- Introduction of campaign against marine litter.
- Pledge to make 100 national monuments litter-free.
- Formation of local eco-groups to curb use of plastics and develop alternative business propositions.
- Enhanced research projects.
- Stop using single-use plastics in higher educational institutes.

9.4 Plastic Waste Management Technologies Practised in India

- Eco-friendly recycling of Plastics waste to produce granule (Fig. 6; [Source: https://www.youtube.com/watch?v=Pyz33PEitD0]
- Utilization of Plastic Waste in Road Construction (As per IRC: SP:98-2013)
- Co-processing of Plastic Waste in Cement Kilns
- Plasma Pyrolysis Technology (PPT)
- Conversion of plastic waste into liquid RDF (Oil)

Fig. 6 Eco-friendly waste plastics process and machine developed and patented for producing recycled granules by Prof. S.K. Ghosh, at Jadavpur University, Kolkata

10 E-Waste Management and Policies of Extended Producer Responsibility (EPR)

Electronic waste (e-waste) mainly includes discarded mobile phones, computer monitors, motherboards, PCB, chargers, compact discs, television sets, headphones, washing machines, air conditioners, refrigerators and other electrical and electronic equipment. According to the Global E-Waste Monitor 2017, nearly 2 million tons of e-waste is generated in India that ranks fifth among e-waste-producing countries, after the USA, China, Japan and Germany. Around 0.036 tons of e-waste has been treated in India in the year 2016–17. India's informal recycling system is very strong and nearly 95% of the e-waste generated is recycled in the informal sector in very crude manner impacting the health and environment. United Nations (UN) in World Economic Forum on 24 January 2019 on e-waste reported that the waste stream reached 48.5 tons in India in 2018 and is expected to double the amount if nothing changes. It needs immediate attention. The e-waste management rules 2016 and subsequent amendments in 2018 are in the implementation stage in a very close monitoring system with a number of targets in EPR plans. India has introduced the EPR for e-wastes in 2018 in true sense. In case the producer has started sale, the EPR target shall be applicable as per e-waste management (amended) rules 2018 Schedule-III (A) and these targets applicable from financial year 2018–2019. Once the product achieves its average life as fixed by the Central Pollution Control Board (CPCB), the targets of collection shall be revised as per Schedule III (Table 3). Extended Producer

Table 3 EPR target schedule as per e-waste management (amended) rules 2018

Sl.	Year	E-Waste collection target (by weight)	E-waste collection target (by weight)
(i)	2017–2018	10% of quantity of e-waste generation as per EPR Plan of organization	
(ii)	2018–2019	20% of quantity of e-waste generation as per EPR Plan of organization	5% of sales figure of FY 2016–17
(iii)	2019–2020	30% of quantity of e-waste generation as per EPR Plan of organization	5% of sales figure of FY 2017–18
(iv)	2020–2021	40% of quantity of e-waste generation as per EPR Plan of organization	10% of sales figure of FY 2018–19
(v)	2021–2022	50% of quantity of e-waste generation as per EPR Plan of organization	10% of sales figure of FY 2019–20
(vi)	2022–2023	60% of quantity of e-waste generation as per EPR Plan of organization	15% of sales figure of FY 2020–21
(vii)	2023–2014 and onwards	70% of quantity of e-waste generation as per EPR Plan of organization	15% of sales figure of FY 2021–22
(viii)	2024–2025		20% of sales figure of FY 2022–23
(ix)	2025 onwards		20% of sales figure of the year preceding the previous year

Responsibility targets have been revised that is applicable from 1 October 2017 as per Schedule III.

11 End-of-Life Vehicles (ELV)

It was realized that the impact of end-of-life vehicles (ELV) has to be minimized on the environment, which will contribute to the protection, preservation and improvement of the environmental quality and energy conservation. Considering the situation, it has been realized that the ELV regulation in India cannot be the only solution towards making automobile recycling an organized sector at this stage. There are a few more very significant measures to be taken for making auto recycling an environment-friendly process (AIS-129: Automotive industry standard—ELV, 2015). The significant concerns are, big unorganized group involved in inefficient

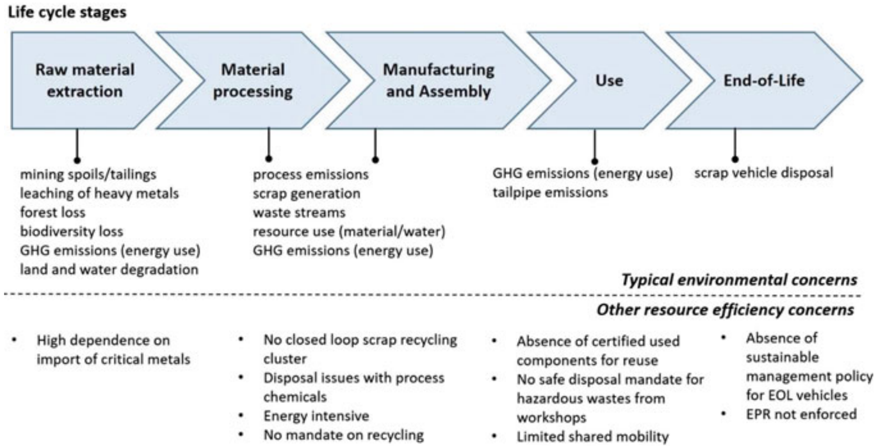

Fig. 7 Lifecycle stages across value chain and related resource efficiency concerns

dismantling of vehicles, very low efficiency of material recovery, etc. These vehicles usually end up reaching the unorganized dismantling centres where auto components are either refurbished or sent for recycling. Efficiency of material recovery is very low due to inefficient dismantling. Guidelines were issued by the CPCB to regulate the sector in an environmentally friendly manner, recommending a system of "shared responsibility". All the stakeholders, including the government, manufacturers and recyclers, dealers, insurers, consumers must be involved in the supply chain of the ELV management. The lifecycle stages (Fig. 7) show across value chain and related resource efficiency concerns (Source: NREP 2019).

While analysing the pectoral aspects, it has been observed that the respective value chain highlights enormous potential in augmenting recycling, resource efficiency and innovative applications. SMEs are the most potential for achieving the resource efficiency across the value chain of ELV in automotive sector. Nearly 21 million vehicles are estimated to reach the end-of-life stages by 2030 which is a challenge to manage the end-of-life vehicles (ELV) in the country.

12 Case Studies

There is a huge number of initiatives of decentralized waste management in the country all through which help supporting circular economy model. A few of the initiatives are discussed in brief in this section.

12.1 Initiative in Housing Society in Kolkata, a Metro City

The bulk waste generators have to install its own waste management system as per the SWM Rules 2016. Bangalore, another big city, is the pioneer in this aspect. The Diamond City South housing complex in south Kolkata has initiated the project, "*ISWMAW-DCSRA Waste Management Project*" (Figs. 8 and 9) to segregate the wastes in dry and wet wastes at the source by incorporating bin cultures among the residents (model in Fig. 3).

Fig. 8 ISWMAW-DCSRA waste management project team in training

Fig. 9 3R initiative to implement SWM Rules 2016 at DCS housing complex in Kolkata

Customized composter has been installed for composting (WtC Facility) used flower, garden wastes, green vegetable and fruit wastes, eggshells, etc. The compost produced from its own plant substituted the chemical fertilizer. The dry wastes are also segregated in nearly 12 streams to sell the same to the recyclers reducing the burden of waste disposal to landfill site, generating revenues by recycling and effectively utilizing the resources, an example of circular economy (Fig. 8). The project is self-sustainable and reduced the burden of nearly 90 tons of waste not going to landfill but circulating to generate resources reducing the primary resource consumption.

12.2 Municipal Waste Management at Indore—The Cleanest City in India

The City generates nearly 1100 tons of municipal solid waste a day. The city administration took three pronged approaches: Bin-free, litter-free and dust-free city. The city installed nearly 3053 litter bins in all commercial areas, parks and gardens and in all high footfall areas. For improving the standards of public health and environmental quality, efficient mechanism for collection and transportation of municipal solid waste has been established. Domestic hazardous waste is stored in separate bin and taken weekly to TSDFs.

Treatment facilities like compost, biomethanation and bioremediation have been established and operated regularly (Fig. 10). Composts are sold to the farmers and other users, whereas the gas generated from biomethanation plants are used for running public vehicles, namely state-operated buses. The dry waste collected is separately in three-binned vehicle (Figs. 11 and 12). Plastics are recycled to make granules and in one small plant to convert into liquid fuel. Dry wastes are separated in several streams and each of those, e.g. textiles, metals, papers, plastics, glass, etc., go to the respective recycling plant.

Fig. 10 Compost plant at Indore

Fig. 11 Author and the waste handlers at dry waste collection centre (MRF-material recovery facility)

Fig. 12 Dry and wet waste collection vehicle with two compartment and additional third container at rear end

Indore Municipal Corporation encourages home composting providing 50% subsidy. In Indore, nearly 28,000 households are doing home composting and pot composting of household waste has been carried out in all 85 wards with the help of volunteers. The city has a target of reduction of 150 ton solid waste per day. A 100 tons per day capacity C&D waste plant runs in the city. All the rag pickers taken into the mainstream formal sectors. Grievance redressing, complaint and feedback systems have been established through "Mayor Helpline Indore 311" App. The App also monitors the collection and transportation system of waste in the whole city. Indore wins the first position in the all India competition called Swachh Survekshan 2017, 2018 and 2019.

13 Sectoral Resource Efficiency Strategies in India

The National Resource Efficiency Policy in India aims to implement resource efficiency across all relevant resources, namely fossil fuels, metals, minerals, air, water, land, biomass, forests, etc., and across all lifecycle stages including extraction of raw material, material processing, production, use, end-of-life management. Target sets for achieving resource efficiency in different fields of applications in the draft National Resource Efficiency Policy 2019 have been collated in Table 4.

Table 4 Target sets for achieving resource efficiency in different fields of applications as per the National Resource Efficiency Policy 2019

Sl.	Proposed Resource Efficiency objectives	Targets
1	Recycling rate for vehicles manufactured before 1990	75%
2	Recycling rate for vehicles manufactured between 1990 and 2000	85%
3	Recycling rate for vehicles produced after 2000	90%
4	Number of official ELV dismantlers and equal number of PRO across major urban centres to be established	20 number by 2020
5	Use of recycled materials in commercial and passenger vehicles	25% of the kerb weight by 2030
6	Recycling and reuse rate PET plastic	100% by 2025
7	Recycling and reuse rate of other plastic packaging materials	75% by 2030
8	Ban on disposal of recyclable waste (plastics, metals, glass, paper, cardboard and bio-degradable waste) to landfills	by 2025
9	Municipalities in Tier 1 and Tier 2 cities to start inventorizing of construction and demolition waste data	by 2022
10	Recycling rate for C&D waste to reach	50% by 2025 and 75% by 2030
11	Public procurement of materials for civil construction from recycled materials	by 2025, 30% of total procured mat
12	Implementation of targets stated in the existing e-waste management rules.	Targets as per rules
13	Introduce deterrent penalty mechanism for violation of e-waste management rules	By 2020
14	Establishing major authorized E-waste dismantling facilities	4 by 2025 and 8 by 2030
15	Recovery rate of materials from discarded PVs	85%
16	Import of steel scrap for recycled steel production	Zero impost by 2030
17	Percentage of recycled steel be produced from domestic scrap	100%
18	Establish steel manufacturing capacity from the Electric Arc Furnace (EAF) route	50% by 2030
19	Increase steel recycling rate	to 90%
20	Overall utilization of slag	Ensure 50% by 2025 and 85% by 2030

(continued)

Table 4 (continued)

Sl.	Proposed Resource Efficiency objectives	Targets
21	By 2022, introduce quality index-based pricing mechanism to facilitate continuous and smooth scrap supply to recyclers	
22	Domestic scrap to fulfil 50% of the total aluminium scrap requirement	By 2030
23	Increase domestic scrap recycling rate	to 50% by 2025 and 90% by 2030
24	Increase rate of utilization of dross	40% by 2025 and 80% by 2030

14 Conclusion

India has a great potential for the implementation of circular economy. It has taken lots of initiatives specifically the policy decisions as well as implementation strategies for creating a resource circulation society with the evidence of hundreds best practices. Very recent release of draft policy on national resource efficiency in 2019 will open a new horizon for the CE implementation. In next ten years, India will have a new dimension in the worlds of circular economy.

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References

AIS-129: ELV. (2015). Guidelines for environmentally sound management of end-of-life vehicles (ELVs).

Annual Report. (2016–17). *Ministry of Home Affairs* (PDF). Retrieved 7 March 2018. https://en.wikipedia.org/wiki/Geography_of_India.

Asase, M., Yanful, E. K., Mensah, M., Stanford, J., & Amponsah, S. (2015). Comparison of municipal solid waste management systems in Canada and Ghana: a case study of the cities of London, Ontario, and Kumasi, Ghana. *Waste Management, 29,*(10), 2779–2786. 2009. https://doi.org/10.1016/j.wasman.2009.06.019

Baldé, C. P., Forti V., Gray, V., Kuehr, R., Stegmann, P. (2017). The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. Electronic Version: 978-92-808-9054-9.

Binafeigha, T. R., & Enwin, A. (2017). The state of solid waste management in Port Harcourt City, Nigeria. *American Journal of Civil Engineering and Architecture*, *5*(4), 160–166. Science and Education Publishing. Available online at https://doi.org/10.12691/ajcea-5-4-4. http://pubs.sciepub.com/ajcea/5/4/4

Burntley, S. J. (2007). A review of municipal solid waste composition in the United Kingdom. *Journal of Waste Management, 27*, 1274–1285. http://dx.doi.org/10.1016/j.wasman.2006.06.018

Constitution (Forty-second Amendment) Act, 1976, s. 2, for "Sovereign Democratic Republic" (w.e.f. 3-1-1977). https://www.india.gov.in/sites/upload_files/npi/files/coi_part_full.pdf.
Construction and Demolition Waste Management. (2016). http://www.indiaenvironmentportal.org.in/content/426955/construction-and-demolition-waste-management-rules-2016/.
CPCB Report. (2018). Annual Report 2017-18. Central pollution control board ministry of environment, forest & climate change. http://www.cpcb.nic.in.
E-Waste Management Rules. (2016). http://www.indiaenvironmentportal.org.in/content/426933/e-waste-management-rules-2016/.
IGEP (Indo-German Environment Programme). (2013). India's future needs for resources: dimensions, challenges and possible solutions. New Delhi: GIZ. http://www.igep.in/live/hrdpmp/hrdpmaster/igep/content/e48745/e50194/e58089/ResourceEfficiency_Report_Final.pdf.
Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review. *Cogent Environmental Science*, 2, 1139434. http://dx.doi.org/10.1080/23311843.2016.1139434
Mitlin, D., & Satterthwaite, D. (1996). Sustainable development and cities. in: C. PUGH (Ed.) *Sustainability: The environment and urbanization, 23±61*. London: Earth scan Publications.
National Resource Efficiency Policy. (2019) (Draft). Ministry of Environment, Forest and Climate Change Government of India.
NITI Aayog Report. (2017-18). https://niti.gov.in/sites/default/files/2019-04/Annual-Report-English.pdf.
Plastics Waste Management Rules (2016), http://www.indiaenvironmentportal.org.in/content/426634/plastic-waste-management-rules-2016/
Plastindia Foundation. (2018). https://www.speindia.org/pam2016/SPE%20PAM%202016%20PRESENTATIONS%20UPLOAD/Rajeev%20Chitalia%20-%20Plastindia%202018%20Next%20is%20Here%20-%20Plastindia%20Foundation.pdf.
Plexconcil. (2018). *64th Annual Report of Plastic Export Promotion Council, 2018-19*. https://plexconcil.co.in/images/pdf/64TH_ANNUAL_REPORTS-Plexconcil.pdf
(2006, April) Quality and Reliability Engineering International. *22*(3),335–367.
Solid Waste Management Rules. (2016). http://www.indiaenvironmentportal.org.in/content/427824/solid-waste-management-rules-2016/.

Circular Economy—Situation in Israel

Shira Daskal and Ofira Ayalon

Abstract Circular economy (CE) is still in its infancy in Israel. In the past years, the Israeli Ministry of Environmental Protection (IMoEP) and the Israeli Ministry of Economy and Industry (IMoE&I) have started consolidating numerous plans toward achieving CE. Yet the main activities in this field in the past three decades were related to waste management and recycling, in an effort for closing the municipal solid waste (MSW) loop as a significant key factor in achieving a CE. The measures that were taken have been mainly reflected in regulation and legislation conducted by the IMoEP for increasing the overall recycling rates in Israel. The case of Israel, however, illustrates that even when there is an extensive regulation including laws, economic penalties, and financial incentives such as landfill levy, this does not guarantee achievements or improvements in MSW treatment and promote CE. The development of suitable infrastructure to enable achievement of the desired results is necessary. This chapter presents the main steps taken to promote recycling and additional plans consolidated for achieving CE in Israel.

Keywords Circular economy · Regulation · Legislation · Waste management · Recycling · Green growth

List of Acronyms

BAT	Best Available Technology/Technique
CBS	Central Bureau of Statistics
CE	Circular Economy
EPR	Extended Producer Responsibility
IMoE&I	Israeli Ministry of Economy and Industry
IMoEP	Israeli Ministry of Environmental Protection
MBT	Mechanical Biological Treatment

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MSW	Municipal Solid Waste
NIMBY	Not In My Back Yard
OECD	Organization for Economic Cooperation and Development
RDF	Refuse Derived Fuel
SCP	Sustainable Consumption and Production
WTE	Waste to Energy

1 Introduction

According to the Israeli Central Bureau of Statistics (CBS), Israel's population is expected to grow from 8.7 million in 2017 (CBS 2017) to 11 million by 2030, whereas the global population will reach 8.5 billion people (UN 2015). This growth will create unprecedented pressure on natural resources—by 2030, the need for food, energy, and water will increase between 35 and 50% (OECD 2014) and thus communities that consume natural resources and do not allow nature to renew are unsustainable in the long term. The population growth rate in Israel is one of the highest and the State of Israel is one of the more dense countries among OECD countries (Tal 2002), which imposes even greater challenges.

Being the residual end-of-life component of consumption products, MSW is a key factor in achieving a sustainable industry that lays the foundation for the circular economy; thus, MSW is a matter of great concern and recycling is considered a key solution in the circular economy for a reusable cycle to maintain the value of materials (Daskal et al. 2019; Haas et al. 2015; Lieder and Rashid 2016). At the beginning of the 90s, the Israeli Ministry of Environmental Protection (IMoEP) started progressing a national plan for the prevention of MSW dumping in unregulated dumps (Nissim et al. 2005). In the past two decades, the IMoEP has declared a "recycling revolution" that includes a comprehensive program for transitioning from landfilling to turning MSW into a resource via recycling. The initial goal set by the MoPE in 1998 was to increase MSW recycling and recovery rates to 25% by 2007 (IMoEP 1998). Beginning in 2006, further steps were taken, as detailed in the following sections.

2 Management of Resource Consumption and Utilization

The IMoEP is responsible, *inter alia*, for the prevention of overexploitation of ecosystems and natural resources. This includes treatment of solid waste and raising awareness for recycling (IMoEP 2019). However, in the past decades, in the context of resources and materials management, the IMoEP has focused mainly on waste management and recycling rather than consolidating a broader strategic approach of CE. In this respect, the main goal set by the IMoEP was and still is to reduce waste landfilling to preserve land reserves and reduce the negative effects of waste on the environment and increase recycling (to reduce the usage of raw materials). However, very little has been done in the field of reduction at source for example (IMoEP 2018), and only recently, the IMoEP has started preparing such a plan.

Another Israeli Governmental Ministry that has been operating in recent years to achieve CE in Israel is the IMoE&I. The IMoE&I took part in consolidating a number of plans seeking to achieve a CE, and in June 2018, it stated that the Industrial Administration (formerly Environment and Sustainable Development Administration) is formulating a national program for streamlining resources and a circular economy in the industry (IMoE&I 2018). The following subsections present the main activities of the IMoEP and the IMoE&I in this field.

2.1 Green Growth for Israel

In 2011, the IMoE&I and the IMoEP published a joint paper presenting "Indices of Green Growth" in Israel (IMoE&I 2011). In 2013, an additional joint paper called "Green Growth for Israel" was published, presenting key insights and six major levers of change (IMoEP 2013). The levers of change are detailed in Table 1.

2.2 Sustainable Consumption and Production Roadmap for Israel 2015–2020

The IMoEP acknowledged the challenge of achieving economic growth and development in the face of the limited carrying capacity and the need to develop Sustainable Consumption and Production (SCP) strategies. In 2015, the IMoEP consolidated an SCP roadmap that was divided into three chapters, according to their relative consumption versus production emphasis. The structure of the SCP roadmap is presented in Table 2 (IMoEP 2015a, b).

At the time of writing this paper, we do not have information regarding the status of the actual implementation of the road map and the plans that it included.

2.3 Formulating a National Program for Streamlining Resources and a Circular Economy in Industry

A national program for streamlining resources and a circular economy in the industry was developed (IMoE&I 2018) and was approved by the government (Decision No. 3768). The goal of the program is to motivate the industry toward more efficient use of resources and the handling of environmental problems by new technological means, from the early design, design and production stages, and thereby turning

Table 1 Toward green growth-major levers of change

Lever No.	Description
Lever 1—Integrated pollution, prevention and control	In order to move toward improvements in environmental performance while at the same time increasing economic growth, the many different environmental licensing processes which exist today should be unified into a single framework of integrated green licensing. The integrated licensing process will motivate an integrated vision, source reduction, and green innovation so as to gradually implement advanced environmental standards and techniques in industrial plants and businesses. The licenses and permits will provide businesses with both a longer planning horizon and stability by providing them with certainty concerning timetables and criteria. In addition, a hierarchy of operation will be established between central government and local government, and each facility will deal with only one licensing entity. These processes will be carried out providing the appropriate regulatory capabilities for central and local government, and while implementing the principle of public transparency throughout the environmental licensing procedures. In order to support these processes, the possibility of establishing a system for the review of techniques and technologies developed in Israel but not included in the European Union's reference documents (BREFs) will be examined in order to recognize them as best available techniques (BAT) which can be implemented in industrial plants and businesses for the purpose of compliance with the law
Lever 2—Green growth and production center	To help industry and the private sector comply with regulatory requirements and incorporate environmental efficiency and clean production processes, numerous gaps in knowledge in these fields must be bridged. Therefore, the establishment of a knowledge center on green growth and green production is a central component of the National Green Growth Plan. Such a center will serve industrial plants and businesses, for which environmental licensing is obligatory, or those interested in promoting sustainable conduct. It will concentrate the existing knowledge on environmental efficiency, green growth tools, and the support measures for their implementation and will make such information accessible to plants and businesses. The center will promote cooperative projects on sustainable conduct and will encourage industrial plants and businesses to invest in innovative green techniques and technologies, to transition to environmental-friendly production, and to reduce expenses
Lever 3—Green consumption	The consumption of products and services has major environmental impact. This impact is a function of the scope and characteristics of the products we buy, the manner in which we use them, and their post-use treatment. To spearhead a change in the consumption patterns of all consumers in the market so as to reduce their negative impact on the environment, a variety of policy tools which influence the purchasing decisions and the patterns of use of products and services should be adopted, including: developing a knowledge infrastructure to analyze the life cycle of products and services, promoting the green label, promoting energy-efficient products (ex. taxing energy-inefficient products, granting tax breaks on green label products, and establishing clear guidelines for advertising environmental claims on products)

(continued)

Table 1 (continued)

Lever No.	Description
Lever 4—Green procurement	As a complementary step to incentivizing green consumers, the government should serve as an example in integrating green public procurement in its agencies. By transforming the process of public procurement into a greener process, major improvements in the environmental-economic performance of central and local government can be achieved—leading to direct savings of about a billion shekels to taxpayers. Such a change requires an assessment of the cost of a product throughout its life cycle (purchase, use, and disposal) and not only at the time of purchase. In a significant number of cases, green procurement is economically worthwhile in the long range but requires financial incentives in the short term. Such assistance should be granted to government ministries and local authorities in order to incentivize the initial investment. At the same time, the government should take steps to increase awareness of the subject
Lever 5—Green track to innovation	Israeli environmental innovation in the field of clean tech will contribute to the environmental performance of companies in Israel and worldwide and to the growth of the economy. To encourage environmental innovation in Israel, obstacles to the establishment of beta sites should be removed by such means as enabling regulations for these facilities, development of an accreditation system for local best available techniques (BATs), and provision of economic incentives for their implementation. A dedicated academic research center on resource and waste management should be established to advance basic academic research in this field while decreasing the "brain drain" in Israel and contributing to the return of experts to Israel and to the establishment of a scientific community in this field
Lever 6—Green employment	The transition to a green economy will impact many employees in the economy and will require the development of new skills. Therefore, the new knowledge should be incorporated in both the academic and the professional training systems on the basis of forecasted future demands in the labor market. To do this, the creation of new study tracks in the required fields should be promoted. At the same time, adaptations of existing study and training tracks should be encouraged, along with the establishment of a system of professional retraining and support for workers at risk of dismissal due to the anticipated occupational changes

Source IMoEP (2013)

Table 2 Structure of the SCP roadmap for Israel 2015–2020

Sustainable production	Sustainable consumption
• Sustainable development strategies in government companies • Promoting best practices for small and medium • Enterprises (SMEs) • Supporting social-environmental businesses • Resource efficiency Knowledge Center • Promoting green investments	• Green public procurement – Servicizing and innovation in procurement – Green public procurement in housing – Green public procurement in transport – Green public procurement in local authorities • Lifestyle labs • Behavioral economics
Connecting the Dots: Between Sustainable Production and Sustainable Consumption	
• Sustainable materials management strategy • Circular economy: The case of household food waste • Sustainable urbanism • Environmental standards and labeling • Prevention of greenwash and promotion of reliable environmental claims	

Source IMoPE (2015a)

environmental requirements into opportunities rather than burdens on the industry. As part of the formulation of the plan, the most effective tools that have been tested worldwide will be mapped and evaluated and will draw up a detailed plan of the relevant targets, budgets, timetables, and partners (IMoE&I 2018).

The program objectives:

- Promoting the efficient use of resources, reducing the use of natural resources, and reducing the environmental impacts of the industry by changing business models and methods of production.
- Making the Israeli industry a global pioneer in the development, implementation, and export of solutions and technologies for optimizing resources.
- Removing regulatory barriers to a circular and efficient economy.

2.4 Industrial Symbiosis Program

At the beginning of 2019, the IMoE&I started running a pilot project in which four companies will compete for the recycling of industrial materials. The plan will save companies the costs of transporting and disposing of industrial waste. In the framework of the program, the same waste will start production machines in other plants or will serve as a raw material in the various production processes. The IMoE&I declared that at the end of the pilot period, the program will be operated as a national project for a period of five years (IMoE&I 2018).

3 Legislation

A legislative framework related to circular economy is still lacking in Israel. The main legislation with regards to circular economy principles, which relates to resource and material management, mainly deals with waste management and recycling. Therefore, in this chapter, we review the legislation in this field.

3.1 The Landfill Levy

The landfill levy was first approved in 2007 as a mean of internalizing the external costs of land filling, such as land consumption, air pollution, water pollution, and other environmental ills that result from the landfilling of waste. The IMoEP imposed this levy out of the perception that the low cost of landfilling was the main obstacle to increasing the recycling and recovery rates of MSW, and that an increase in the landfill levy would help achieve the goal of decreasing MSW land filling. The funds collected in a cleaning fund were intended for the construction of MSW treatment facilities, which would serve as an alternative to land filling. The levy was gradually increased during the first five years of implementation in order to allow the local authorities time to adjust to the rising costs. The current levy is 126 NIS (31€) including 17% VAT (IMoEP 2017). However, this infrastructure was never constructed and recycling rates have not increased. (State Comptroller 2016).

3.2 Separation of Waste at Source

In 2010, the IMoEP launched a financial support program for local authorities, aimed at the establishment of infrastructure for the separation of waste at source into at least two streams: clean biodegradable (organic/wet), and all the remainder (dry). Separating the biodegradable organic waste, which makes up about 34% of Israel's MSW (Shachaf Environmental Planning 2014), allows for maximum use of the waste and reduces the environmental degradation caused by land filling. Broitman et al. (2012) have contradicted this approach of separation of the biodegradable organic waste at households, mainly because the demand for compost in Israel is very low, and, in addition, the infrastructure required to handle two waste streams separated at the source is lacking (State Comptroller 2016). In 2011, separation at source of packages took effect in the framework of the Packaging Law as detailed in Sect. 2.3.

3.3 Extended Producer Responsibility

The introduction of an extended producer responsibility (EPR) system in 2011 was an important component of the IMoEP recycling revolution, as the EPR system states that producers are legally responsible for the entire life cycle of the products they manufacture, as well as the product's packaging. The Packaging Law, enacted in 2011 (IMoEP 2011) as part of this new system, was intended to urge local authorities, which were previously responsible for the treatment of packaging waste, to sign contracts with the producers' association, transferring the responsibility to them. In addition, another goal of the law was to incentivize producers to reduce the environmental impact of their packaging in the first place.

Table 3 summarizes the waste recycling legislation in Israel between 1984 and 2016.

4 Example of Best Practices—a Breakthrough in Closing the MSW Loop

A major breakthrough was achieved with the establishment of two advanced MSW treatment facilities, a mechanical biological treatment (MBT) plant located near the city of Jerusalem and a refuse-derived fuel (RDF) plant located near the city of Tel Aviv. Both plants, the MBT plant and the RDF plant, together receive about 3000 tons of MSW per day, which is about one-sixth of the MSW generated in Israel. With an average recovery rate of 50% each, the two plants are expected to contribute to the reduction of landfilling in Israel by approximately 8%.

5 Future Plans and Targets

In 2017, the IMoEP presented a new waste management strategy for Israel, named the MSW 2030 strategic plan. The top target of this plan is to minimize landfilling and promote recycling and recovery. The policy document outlines the ministry's plan for an integrated waste management strategy, based on striking the right balance between materials recycling and energy recovery, in addition to the only form of energy recovery in Israel, RDF that is used in the Nesher cement factory and produced in the Hiriya recycling park since 2016. The IMoEP's Waste-to-Energy (WTE) policy guidelines was adopted by the National Planning and Building Board, Israel's top planning body, in January 2018 (IMoEP 2018). The implementation of this plan involves various challenges including the "Not In My Back Yard" (NIMBY) phenomena (Daskal et al. 2019).

Table 3 Waste and recycling legislation in Israel, 1984–2016

Purpose	Legislation	Year
Prohibits littering or the disposal of waste, building debris, and vehicle scrap in the public domain	Maintenance of Cleanliness Law	1984
Provides the principles and the legal framework for recycling in Israel. It authorizes local authorities and obliges them, when required by the Minister of Environmental Protection, to allocate sites for recycling centers and to install recycling facilities and containers	Collection and Disposal of Waste for Recycling	1993
These regulations require local authorities to reduce their waste for disposal by means of recycling, in accordance with graduated recycling targets as per the following timetable: at least 10% by December 1998; 15% by December 2000; 25% by December 2007	The obligation of Waste Disposal for Recycling-Regulations	1998
Required manufacturers, importers, and retailers to collect a deposit on beverage containers larger than 0.1 L and smaller than 1.5 L, with the exception of bags or paper containers. A recycling corporation was established under the law to institute a refund, bottle collection, and recycling system, which was required to comply with graduated targets for collecting empty beverage containers	Deposit on Beverage Containers	1999
In effect since July 1, 2007; requires landfill operators to pay a levy for every ton of waste landfilled. The aim is to internalize the full and real costs of waste treatment and disposal	Amendment to Maintenance of Cleanliness Law, 2007: Landfill Levy	2007
Aims to reduce the environmental nuisance caused by improper tire disposal in Israel, while promoting tire recycling. The law makes tire producers and importers responsible for the disposal and recycling of used tires at graduated rates each year, with recycling totally replacing disposal after July 2013	Tire Disposal and Recycling	2007
This law imposes direct responsibility on manufacturers and importers in Israel to collect and recycle the packaging waste of their products	Packaging Law	2011

(continued)

Table 3 (continued)

Purpose	Legislation	Year
Environmental treatment of electrical and electronic equipment and of batteries and accumulators, in order to encourage the reuse of electrical and electronic equipment, reduce the quantity of waste created from electrical and electronic equipment and from batteries and accumulators, prevent the burial of such waste, and mitigate the negative environmental and health effects of electrical and electronic equipment, of batteries and accumulators, and of the waste from these products	Electrical and Electronic Equipment and Batteries Law	2012
Reducing the use of carrying bags to reduce the amount of waste generated by their use and the negative environmental effects of this waste, inter alia by restricting the distribution of disposable bags by dealers without payment and by imposing a duty to sell them	The Law for the Reduction of the Use of Disposable Carrying Bags	2016

6 Summary and Discussion

Table 4 below summarizes the legislation supporting CE as presented and discussed in this chapter.

Between the years 2005 and 2016 about 80% of the MSW in Israel has been landfilled and recycling rates have not increased, despite the regulation. The challenging complexity of recycling even applies much more strongly since China announced it would no longer absorb plastic and paper from outside its country. Nowadays, the IMoEP is changing its approach toward the treatment of MSW, including new consideration of WTE for the generation of energy from MSW, which IMoEP had totally rejected within the frame of its regulation in the past (Knesset 2017). WTE technologies have been in use for decades and the use of these technologies is increasing in the world. In Europe, many waste treatment systems combine recycling and energy production from MSW as a solution to reduce the volume of MSW sent to landfills. A common method for MSW treatment in many countries is the burning of waste and the production of the energy inherent in it in dedicated combustion facilities, which are often located in industrial areas close to energy-consuming plants. The waste brought to the fire includes, inter alia, paper and plastic products, glass and metal that are burned in many cases without further sorting. The heat emitted during the combustion process is used to produce steam that is transferred to industrial plants for use in energy production processes. The availability of advanced technologies

Table 4 Status of implementation of circular economy (CE) concept

Legislation supporting CE	Significant area where CE implemented	Reduction in consumption	Reduction in Landfill	Increase in recycling
• Collection and Disposal of Waste for Recycling, 1993 • The obligation of Waste Disposal for Recycling-Regulations, 1998 • Deposit on Beverage Containers, 1999 • Amendment to Maintenance of Cleanliness Law, Landfill Levy, 2007 • Tire Disposal and Recycling, 2007 • Packaging Law, 2011 • Electrical and Electronic Equipment and Batteries Law, 2012 • The Law for the Reduction of the Use of Disposable Carrying Bags, 2016	Recycling	NA	97–80% between the beginning of the 90s–2003 Nissim et al. (2005) No change in recycling rate 2005–2015 Daskal et al. (2018)	3–20% between the beginning of the 90s–2003 Nissim et al. (2005) No change in recycling rate 2005–2015 Daskal et al. (2018)

enables the minimization of emissions from these facilities (Sabbas et al. 2003) and the remnants of the fire can be used in various industries such as the cement industry, so that in practice this process leads to zero or close to zero landfilling (Lin 2005). The efficiency of energy production from waste depends, among other things, on the size of the population serving the facility (the amount of waste collected in the facility), the regular supply of waste to it, and the quality of the waste (Consonni et al. 2005).

The conventional concept of circular economy does not recognize WTE as an implementation of circular economy (Winans et al. 2017); however, in WTE processes, most waste is converted to energy, thus saving environmental costs (due to transportation, pollution, land use, etc.) and preserving natural resources such as coal, oil, and gas.

Despite significant and developing legislation in the waste management sector, the State of Israel has not managed to reduce, at the source, the amount of waste being produced nor to reduce the rate of waste being landfilled. In recent years, Israel started formulating plans for achieving CE; however, it is still far from being implemented in its broad holistic sense.

7 Conclusions

Closing the MSW loop is a significant key factor in achieving a circular economy. The case of Israel illustrates that even when there is an extensive regulation including laws, economic penalties, and financial incentives such as landfill levy, this does not guarantee achievements or improvements in MSW treatment. The key to success is first and foremost developing a suitable infrastructure that will enable achievement of the desired results. The description of the situation in Israel is also relevant to other countries, particularly, countries that face strict regulations on the one hand but lack of appropriate infrastructure on the other hand. In recent years, Israel started formulating plans for achieving CE; however, CE is still far from being implemented in Israel in its broad holistic sense.

References

Broitman, D., Ayalon, O., & Kan, I. (2012). One size fits all? An assessment tool for solid waste management at local and national levels. *Waste Management, 32*(10), 1979–1988.

CBS. (2017). *Population & Demography* (in Hebrew). Available at: http://www.cbs.gov.il/reader/?MIval=cw_usr_view_SHTML&ID=705.

Consonni, S., Giugliano, M., & Grosso, M. (2005). Alternative strategies for energy recovery from municipal solid waste: Part A: Mass and energy balances. *Waste Management, 25*(2), 123–135.

Daskal, S., Ayalon, O., & Shechter, M. (2018). The state of municipal solid waste management in Israel. *Waste Management and Research, 36*(6), 527–534.

Daskal, S., Ayalon, O., & Shechter, M. (2019). Closing the loop: The challenges of regulation in municipal solid waste management. *Detritus, 05,* 3–10.

Haas, W., Krausmann, F., Wiedenhofer, D., & Heinz, M. (2015). How circular is the global economy?: An assessment of material flows, waste production, and recycling in the European Union and the world in 2005. *Journal of Industrial Ecology, 19*(5), 765–777.

IMoE&I. (2011). *Indices of Green Growth in Israel* (in Hebrew). Available at: http://www.sviva.gov.il/InfoServices/ReservoirInfo/DocLib2/Publications/P0601-P0700/p0620.pdf. Accessed June 16, 2019.

IMoE&I. (2018). *Formulation of a national program for streamlining resources and a circular economy in the industry* (in Hebrew). Available at: https://www.gov.il/he/Departments/news/resources-streamlining. Accessed June 16, 2019.

IMoEP. (1998). *Regulations for Collection and Removal of Waste for Recycling* (in Hebrew). Available at: http://www.sviva.gov.il/InfoServices/ReservoirInfo/DocLib/%D7%A4%D7%A1%D7%95%D7%9C%D7%AA/psolet10.pdf. Accessed June 16, 2019.

IMoEP. (2011). *Packaging treatment law-2011* (in Hebrew). Available at: http://www.sviva.gov.il/subjectsenv/waste/beverage/documents/containers%20law.pdf. Accessed June 16, 2019.

IMoEP. (2013). *Green Growth for Israel* (in Hebrew and English). Available at: http://www.sviva.gov.il/InfoServices/ReservoirInfo/DocLib2/Publications/P0701-P0800/P0720.pdf. Accessed June 16, 2019.

IMoEP. (2015a). *Sustainable Consumption and Production Roadmap for Israel*. Available at: https://www.oneplanetnetwork.org/sites/default/files/sustainable_consumption_and_production_roadmap_for_israel_2015_-_2020.pdf. Accessed June 16, 2019.

IMoEP. (2015b). *Circular Economy, Material and Resource Management.* Available at: http://www.sviva.gov.il/English/env_topics/InternationalCooperation/OnTheIntlFront/Documents/CircularEconomy,MaterialandResourceManagement-PresentationtoEU-IsraelEnvironmentSubcmte-June2015.pdf. Accessed June 16, 2019.

IMoEP. (2017). *The waste disposal price list is updated to January 2017*, (in Hebrew). Available at: http://www.sviva.gov.il/subjectsEnv/Waste/Laws/Pages/Landfill-Levy.aspx. Accessed June 16, 2019.

IMoEP. (2018). *Israel Environment Bulletin*. Available at: http://www.sviva.gov.il/english/resourcesandservices/publications/bulletin/documents/bulletin-vol44-march2018.pdf. Accessed June 16, 2019.

IMoEP. (2019). *Ministry of Environmental Protection*. Available at: https://www.gov.il/en/departments/ministry_of_environmental_protection. Accessed June 16, 2019.

Knesset. (2017). *Minutes of the meeting of the Interior and Environmental Protection Committee*, 15 February, 2017 (in Hebrew). Available at: http://main.knesset.gov.il/Activity/committees/InternalAffairs/Pages/CommitteeAgenda.aspx?tab=3&ItemID=2012288. Accessed June 16, 2019.

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of Cleaner Production, 115,* 36–51.

Lin, K. L. (2005). The influence of municipal solid waste incinerator fly ash slag blended in cement pastes. *Cement and Concrete Research, 35*(5), 979–986.

Nissim, I., Shohat, T., & Inbar, Y. (2005). From dumping to sanitary landfills: Solid waste management in Israel. *Waste Management, 25,* 323–327.

OECD. (2014). *Towards a circular economy: A zero waste programme for Europe*. Europen Commission. Available at: http://ec.europa.eu/environment/circular-economy/pdf/circular-economy-communication.pdf. Accessed June 16, 2019.

Sabbas, T., Polettini, A., Pomi, R., Astrup, T., Hjelmar, O., Mostbauer, P., … & Heuss-Assbichler, S. (2003). Management of municipal solid waste incineration residues. *Waste management, 23*(1), 61–88.

Shachaf Environmental Planning. (2014). *The national survey of the composition of waste, final report for the IMoEP* (in Hebrew). Available at: http://www.sviva.gov.il/InfoServices/ReservoirInfo/DocLib2/Publications/P0701-P0800/P0749.pdf. Accessed June 16, 2019.

State Comptroller. (2016). *Separation at source of household waste in local authorities* (in Hebrew). Available at: http://www.mevaker.gov.il/he/Reports/Report_554/08a04796-1b27-43d7-ba1d-d891ddf71c97/108-project.pdf. Accessed June 16, 2019.

Tal, A. (2002). *Pollution in a promised land: An environmental history of Israel*. University of California Press.

UN. (2015). *Population 2030—Demographic challenges and opportunities for sustainable development planning*. Available at: http://www.un.org/en/development/desa/population/publications/pdf/trends/Population2030.pdf. Accessed June 16, 2019.

Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews, 68,* 825–833.

Circular Economy in Italy

Francesco Di Maria

Abstract Italy is located in the south-west part of Europe with a population of about 60.6 million of inhabitants and a gross domestic product of about 1,934,798 M US$ in 2017. Italy operates in the wider legal framework of the European Union (EU) legislation that is internationally recognized as one of the most advanced approaches in the sectors of environmental protection, sustainable development and waste management. The broad concept of sustainability entails, among the others, also the preservation of the environment quality and of the resources of the earth for the future generations. In this context takes places the concept of circular economy (CE) based on the circular use of resources. An important sector in which circular use of resource was successfully implemented since 1991 was the waste management. The directive 91/156/EEC (CD 1991) formally introduced in the legal framework of waste management the concept of the waste management hierarchy establishing the priority goals to be pursued with a hierarchic order in waste management (Fig. 1): Prevention, Reuse, Recycling, Recovery and Disposal. From the hierarchy was also extrapolated the 3R concept based on Reuse, Recycle and Recover. The same directive introduced also the concept of extended producer responsibility (EPR) that is another fundamental pillar for enhancing the recycling of waste. These basic concepts during the years were updated and improved but never replaced or repealed by the successive directives. Legal and economic support resulted key factors for a successful implementation of CE even if it is necessary to size these activities in each specific market. Large differences were detected in the sector of the municipal solid waste compared to the ones generated by industrial and commercial sectors. Long-term efforts which aimed to the implementation of the legal framework in the sector lead in about 8 years to a reduction of the amount of waste disposed of about 33%. Furthermore, latest data available shows that this positive trend is still increasing. Socio-economic indicators showed that there is a general decrease of waste generated and that the paradigm between the increase of GDP and families' expenditures and waste generation is starting to be capsized. Different results were detected for the waste generated in industrial and commerce sectors. Even if the high level of

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recycling that in the 2014 was of about 85%, their effective prevention seems not to be successfully pursued yet.

1 Introduction

Italy is located in the south-west part of Europe with a population of about 60.6 million of inhabitants and a gross domestic product of about 1,934,798 M US$ in 2017.

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The broad concept of sustainability entails, among the others, also the preservation of the environment quality and of the resources of the earth for the future generations. In this context takes places the concept of circular economy (CE) based on the circular use of resources. An important sector in which circular use of resource was successfully implemented since 1991 was the waste management. The directive 91/156/EEC (CD 1991) formally introduced in the legal framework of waste management the concept of the waste management hierarchy establishing the priority goals to be pursued with a hierarchic order in waste management (Fig. 1): Prevention, Reuse, Recycling, Recovery and Disposal. From the hierarchy was also extrapolated the 3R concept based on Reuse, Recycle and Recover. The same directive introduced also the concept of extended producer responsibility (EPR) that is another fundamental pillar for enhancing the recycling of waste. These basic concepts during the years were updated and improved but never replaced or repealed by the successive directives. Figures 2 and 3 reported the municipal solid waste (MSW) management for the EU member states for the years 2006 and 2014, respectively (ISRPA 2009, 2017a). These figures indicated clearly the successful implementation

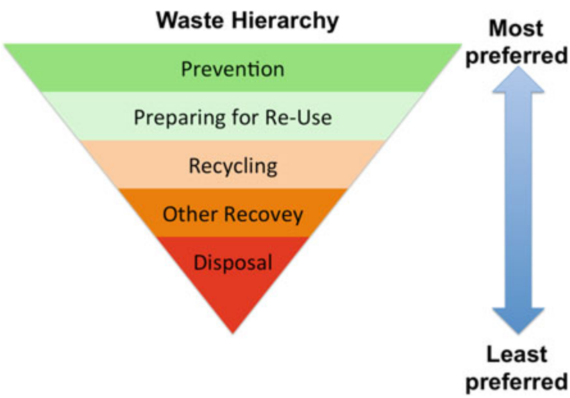

Fig. 1 Waste hierarchy

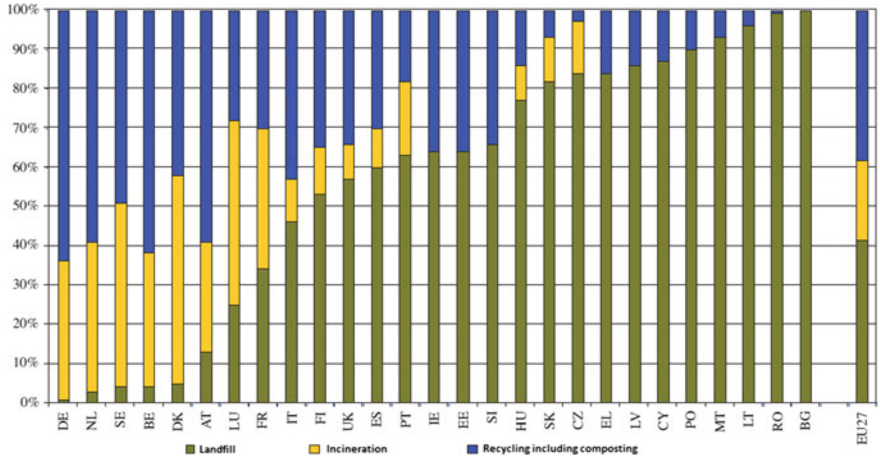

Fig. 2 Municipal solid waste management in the member states of the European Union for the year 2006

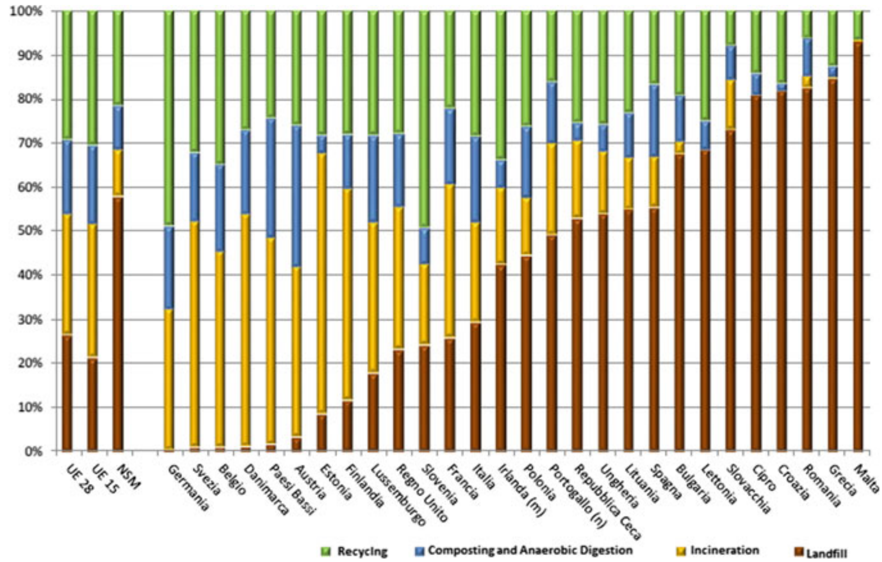

Fig. 3 Municipal solid waste management in the member states of the European Union 28 for the year 2014 (NSM = New State Members)

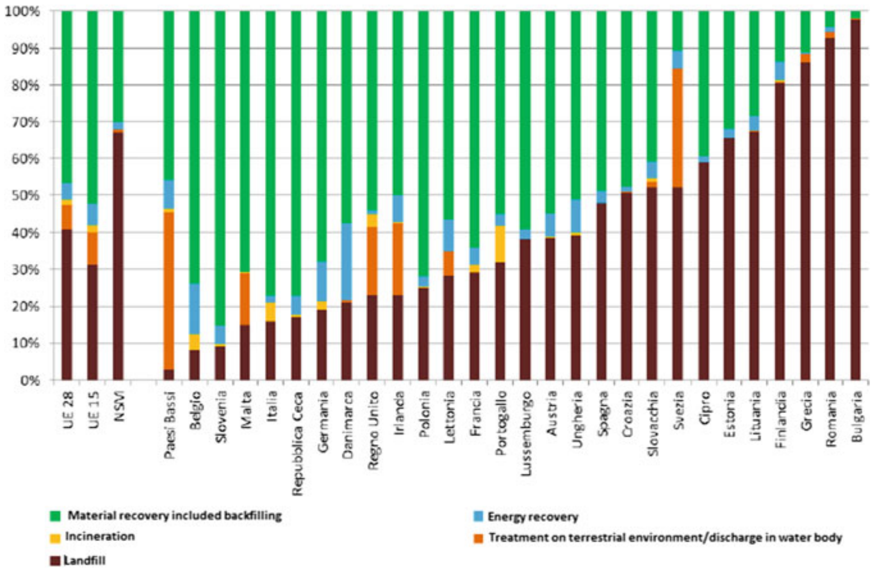

Fig. 4 Special waste management in the member states of the European Union 28 for the year 2014 (NSM = New State Members)

of the legal goals with a significant decrease of the MSW disposed of and a corresponded increase of those recycled including the composting and the anaerobic digestion of the organic fraction. By the way, according to legal definition, MSW are those generated strictly by households and similar activities and represent only a limited amount (i.e. 250 Mtonne for EU and about 29 Mtonnes for Italy) of the whole waste generated (i.e. about 15%). In fact, waste generated by other activities (e.g. industry, agriculture and commerce) legally defined as special waste by the EU legislation (ISRPA, 2017b) in the EU were about 2,502 Mtonnes (2014), whereas in Italy, this figure was of about 160 Mtonnes (2014). Figure 4 reports the management of these special wastes in the different member states of the EU.

Of course the waste management sector is relevant in the implementation of circular economy as it determines the put in practice of the waste hierarchy (Fig. 1). By the way, other actions need to be taken for a full implementation of CE involving different actors and activities necessary and strategic for the achievement of this goal.

Key drivers for CE are represented by economic actors as business and consumers, local, regional and national authorities and also over national authorities as EU. All these actors have to operate for the implementation of the right regulatory framework related to each single market and indicate to all the actor which is the way forward. Above these, other relevant activities are necessary to be pursued as the implementation and promotion of the United Nations Agenda for Sustainable Development (UNRIC 2018) and the G7 alliance for resource efficiency (EC 2015b). International cooperation is also another key factor for CE implementation.

2 Legislation

Currently, in EU and Italy, it is possible to find several legislations related to the implementation of CE concept in specific sectors since more than 20 years. By the way, the first coordinated and specifically dedicated document for the implementation of CE in the EU is represented by the communication of the EC COM(2015) 614 final (EC 2015a). By this communication, the EC launches an EU action plan for the implementation of CE.

This action plan is an integrated approach involving legislative, economic and research aspects supporting the CE implementation in each step of the value chain starting from production to consumption, repair, remanufacturing, waste management and secondary raw materials feed back into the economy. Action will be also taken on fertilizers and water reuse.

Implementation of CE starts from the first phase of the value chain that is the design and production of goods. Design is the first step for promoting repair, reuse, upgrade and recycling of products. Increasing the lifespan of goods is another important aspect of CE. More incentives for eco-design will be hence implemented. By the way, even if efficient eco-design is performed, no adequately efficient production systems can lead to the generation of a high amount of waste. Production system and waste generated differ a lot by industrial sectors. The European Commission will elaborate specific best reference documents (BREFs) for supporting legal authorities in releasing permission for industrial installation for promoting innovative and best practice which able to increase the production efficiency including the remanufacturing of secondary raw materials and recycling. Concept based on industrial symbiosis will be also promoted. Reject of materials and energy from one production process can be used as inputs from another production process minimizing the waste of materials and energy. For the implementation of this concept, an improvement of the extended producer responsibility will be also pursued.

Consumers play a crucial role in successful implementation of CE, but there is a need of correct information, affordable prices and regulatory framework. Information about the eco-friendly level of products is fundamental for driving the consumers in the choice of more sustainable products. Eco-label, energy performances and similar labelling systems are already put in practice but not always so clear or useful for the goal. National and local authorities will also promote economic supporting schemes for more eco-friendly products by different supporting scheme as tax reduction or similar. Guidance for product repair and availability of spare parts is also another important aspect to be promoted for increasing the lifespan of products. Green public procurements represent also another important aspect for driving purchase towards CE implementation.

As already stated, waste management plays a central role in the implementation of CE since it determines how the hierarchy is put into or practice. All wastes have to be considered from household to industrial, including mining and construction and demolition. The European Commission is committed to establish long-term recycling targets and to reduce landfilling. Particular care will be also focused on how the wastes are managed that is an essential point for returning high valuable and recyclable materials.

Waste management is also crucial for secondary raw materials' reuse. Secondary raw materials replace raw materials pursuing two objectives—prevention of resource depletion and security of supply. Two main obstacles, nowadays, hamper the secondary raw materials' exploitation—uncertainty about their quality and market demand. About the first aspect, the European Commission will elaborate common quality standards in particular for organic fertilizer generable from organic waste. In the second case, appositely legislation will be implemented together with adequate economic support. Another import issue is also represented by wastewater reuse. About this aspect, the European Commission will implement legislation together with minimum quality standards. Furthermore, the COM(2015) also targeted five priority areas characterized by specificities of their products or value chain, their environmental footprint or dependency of material from outside. These areas are represented by:

(1) **Plastics**. Plastic materials are widely used in different products from packaging to vehicles. Currently in the EU, about 25% is recycled and about 50% is landfilled. Improper plastic management causes also ocean pollution with very high environmental burden. The European Commission will implement more ambitious targets for plastic recycling, reduce marine litter and avoid hazardous substances in plastics production.
(2) **Food waste**. Food production, distribution storage and use generate high impact. This resulted in increase of edible food disposal. Furthermore, food waste takes place at all the level of the value chain from production, to final users (e.g. restaurants, canteen, home) making very difficult its quantification. The European Commission will elaborate uniform calculation methodologies for addressing these amounts. Data marking is also another issue to be addressed as the 'best before' that usually did not indicated the expiry date. Wrong interpretation of this also causes a large generation of food waste.
(3) **Critical raw materials**. These are represented by high value and vulnerable supply distribution materials. These are often present in electronic waste. Recycling rate will be hence improved, and the commission will promote this activity.
(4) **Construction and demolition waste**. This represents one of the largest amounts of waste generated in the EU. A lot of recyclables in such waste still continue to be disposed. Quality standard and selective demolition procedures are among main criticisms for their recycling. Green public procurement is also another important aspect to implement for increasing construction and demolition waste.
(5) **Biomass and bio-based products**. Biomass can play an important role in replacing fossil and mineral resources for the production of fuels, energy and chemicals. It is in any case mandatory to analyse with attention the sustainability of the supply chain with particular attention to the environmental impact. Wood packaging recycling will be also increased. Research funding for supporting EU bio-based economy is also a fundamental factor for a full implementation of CE.

Finally, the COM(2015) 614 (EC 2015a) indicates also a timetable for the planning of the actions to be taken forward per each main from 2015 to 2018.

Furthermore, the European Commission proposed other two documents related also to emending the 2020 targets reported in the WFD (2008). They consist in an overall recycling of waste within 2030 of 65% (EC 2015c) and in an increase of recycling rates of specific waste materials (EC 2015d): plastics up to 65%; metals up to 85%; wood up to 75%; glass up to 85%; paper and cardboard up to 85% EC (2018) (Table 1).

3 Research Models

In the following are reported some of the most meaningful recent research projects involving different aspects related to the implementation of circular economy.

Of particular interest are those concerning the production and the consumption aspects.

For the production aspect:

LIFE M3P—Material Match Making Platform for promoting the use of industrial waste in local networks

The Life M3P project will study and implement an online platform to promote exchanging of industrial waste among the companies of manufacturing districts. The Life M3P project will last three years (October 2016–September 2019), and it runs in Italy—Lombardy, Belgium—Flanders, Greece—Western Macedonia, Spain—Asturias.

The final objective is to demonstrate and apply experimentally a model of territorial management of industrial waste in order to promote the Industrial Symbiosis. Through the proposed model, the project wants to boost the overall efficiency of industrial processes in the target areas by increasing the use of industrial waste and reducing landfill, storage and transport.

Implementing and using the online platform will allow to address the lack of information about the industrial waste produced in a local area, through a systematic approach oriented to the life cycle of products and to the material chain needed to make them.

In particular, the partnership—coming from Italy, Belgium, Spain and Greece—aims to strengthen local networks for the improvement of the industrial waste, fostering their use in other local businesses and reducing the needs for treatment, storage, transport and the consequent environmental impact.

The M3P project wants to support industrial companies in their continuous improvement in order to reduce processing waste and to replace raw materials with others resources less critical for environment and supply.

In fact, the study of a model of local collaboration on materials will allow companies to act consciously as ‘geographical area’, and it will provide to small- and medium-sized companies useful operational tools for the materials efficiency. The

Table 1 List of regulation in the sector of waste management in the EU and in Italy

Year	Number	Title	Main targets
European			
1975	75/442/EEC	Council directive on waste	Definition of waste and of disposal Promotion of recycling, reuse and energy recovery
1991	91/153/EEC	Council Directive 18 March 1991 amending Directive 75/442/EEC on waste	Introduction of the waste hierarchy
1994	94/62/EC	European Parliament and Council Directive of 20 December 1994 on packaging and packaging waste	Recycling target from 50–65%
2008	2008/98/EC	Directive of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives	Recycling target 2020: 50% of waste and 70% of construction and demolition waste
2015	COM(2015) 614 final	Closing the loop—An EU action plan for the Circular Economy	Priority areas for CE implementation. Timetable of action to be taken
2015	COM(2015) 595 final	Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste	Waste recycling target 2030 65%
2015	COM(2015) 596 final	Proposal for a Directive of the European Parliament and of the Council amending Directive 94/62/EC on packaging and packaging waste	Specific waste materials recycling targets 2030: plastics 65%; metals 85%; wood 75%; glass, paper and cardboard 85%
2018	COM(2018) 28 final	Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions A European Strategy for Plastics in a Circular Economy	List of EU action for implementing the strategy

(continued)

Table 1 (continued)

Year	Number	Title	Main targets
Italian			
1982	DPR n.915	Implementation of EU directives 75/442/EEC, 76/403/EEC, 78/3149/EEC on different waste	Waste classification
1997	D.Lgs. n. 22	Implementation of EU directives 91/156/EEC, 91/689/EEC, 94/62/EC on different waste	Target on separated collection; 15% 1999; 25% 2001; 35% 2003
2004	L. n. 308/2004	Delega al Governo per il riordino, il coordinamento e l'integrazione della legislazione in materia ambientale e misure di diretta applicazione	Ferrous by-products from steel industry not a waste
2006	D.Lgs. n. 152/2006	Norme in materia ambientale	Target on separated collection: 35% 2006; 45% 2008; 65% 2012
2010	D.Lgs. n.205/2010	Disposizioni di attuazione della Direttiva 2008/98/CE del Parlamento europeo e del Consiglio del 19 novembre 2008 relativa ai rifiuti e che abroga alcune direttive—Implementation of Directive 2008/98/EC	Target on reuse and recycling: MSW and packaging 50% 2020; C&D 70% 2020
2015	L. n.221/2015	Disposizioni in materia ambientale per promuovere misure di green economy e per il contenimento dell'uso eccessivo di risorse naturali.—Green economy and prevetnion of natural resource depletion	Economic support for separated collection
2016	L. n.166/2016	Disposizioni concernenti la donazione e la distribuzione di prodotti alimentari e farmaceutici a fini di solidarieta' sociale e per la limitazione degli sprechi.—Food waste prevention	Economic incentives for retailers; Social cooperation

Life M3P project will also allow to search for new applications of waste, based on creative features and useful to product managers, process engineers, designers, looking for innovative solutions or replacements for their products.

The expected result is twofold:

- Create awareness of locally available resources (waste or by-products), in order to reduce the need for handling, as well as the treatment and final disposal;
- Strengthen the synergies with the other European industrial areas in order to get a better overall waste recovery.

LIFE ECO-PULPLAST—Local circular ECOnomy by an innovative approach for recycling paper industry PULper waste into new PLASTic pallets

The overall objective of the LIFE ECO-PULPLAST project is to progressively reduce to zero the amount of paper mills' pulper waste sent to landfill and incinerators. In order to reach this goal, the technical and economic feasibility of an innovative technology to recycle pulper waste into new plastic compounds and products will be demonstrated during the project lifetime, with the realization and testing of a demonstration production line especially designed for the characteristics and peculiarities of pulper waste. The main idea behind this project is to realize plastic euro-pallets to be reused by the same paper district that generates the material waste in the first place and creating local circular economy, which is one main goals of the European environmental strategy for the next decades. Thanks to the local products manufacturing and reuse, the project also aims at reducing the environmental impact due to the current transportation of pulper waste to incinerators and landfills and the related disposal's impacts.

In addition, by replacing common wooden euro-pallets, that require a high consumption of raw natural materials, with reusable plastic pallets from recovered waste materials, the project addresses the European strategy towards an efficient use of resources. More specifically, the project aims at demonstrating that pulper waste can be used as main input material in the new compounds, by using a simple and low energy consuming mechanical process that does not require a washing phase or the removal of the residual fibres from the plastic materials and not even a selection phase of the different polymers composing the pulper waste-mixed plastics. A further objective of the LIFE ECO-PULPLAST project concerns the working method. The project, in fact, is promoted in synergy by different entities: industrial and technological partners working side by side with environmental organizations, all aiming at a common goal (Fig. 5).

For the consumption aspects:

LIFE PROMISE Product Main Impacts Sustainability through Eco-communication

The main objective of the PROMISE project was to reduce the negative environmental impact of products in Italy, particularly household products and agri-food products. A communication strategy would be designed and implemented covering information campaigns that target producers, retailers, consumers and public authorities. Communication actions would be tested to assess their effectiveness in achieving lifestyle or behaviour changes that help create environmental benefits. Different

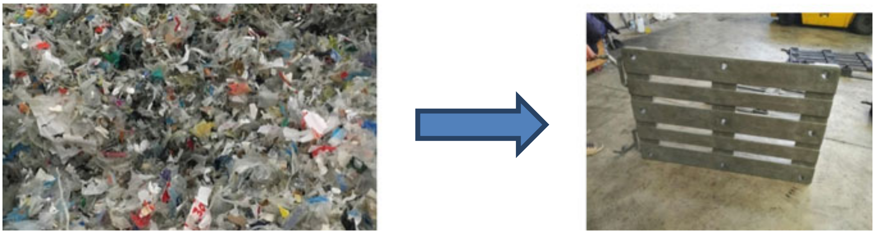

Fig. 5 Pallet produced from pulp waste plastic by the LIFE ECO-PULPLAST project

approaches to disseminating information would be piloted and evaluated in terms of the reduction of environmental impact throughout product lifecycles. Results from local level actions would help develop a communication model at national level that supports the EU's SCP/SIP Action Plan. The communication strategy represents a 'means' to achieve a variety of tangible results, including green public procurement in public authorities and wider uptake of initiatives such as eco-branding and EMAS.

The PROMISE project targeted the environmental impacts of products (EIPRO) that represent a problem across all EU member states and are strictly related to the lifestyles of EU citizens. The project implemented four communication campaigns to increase the awareness of the different actors that can reduce the environmental impacts associated with the products, their production, distribution, use and end of life.

The objective of increasing awareness on sustainability was met by disseminating good practice in sustainable production and consumption. The project involved all those who have a strategic role to play in this process: consumers, retailers, companies and public sector.

In line with the European and national policies, PROMISE carried out a measure to improve the understanding of all policy-makers on consumer choices and sustainability.

Specifically, it increased awareness of green choices among:

- Producers that can use clean technologies and introduce certification of process and products;
- Local authorities, which have a didactic role to play, and are themselves final consumers;
- Citizens, particularly those multipliers of information and knowledge, such as young people, educators and representatives' cultural and environmental associations;
- Retailers, who are able to influence consumers' choices through the provision of products and the distribution of information.

The project also helped locate information gaps on green products by producers, distributors, consumers and local authorities, as well as identify and recognize a 'green product' without ambiguity, through the dissemination of knowledge of the EU labels. Through the use of different media, it promoted the professional growth of manufacturers, retailers and local authorities. Moreover, it applied plans of communication aimed at promoting changes of behaviours of all actors of the lifecycle of the product manufacturers, distributors, consumers and local authorities. This foresaw the overcoming of information barriers, the need to incentivize dialogue and understanding among the various actors in the market and the promotion of clear and easy to understand information for all the subjects involved.

At a low estimate, the project involved:

- 600,000 consumers through the dedicate awareness campaign (conferences, forum, web site, brochures, boards, media news/reportage, video). The beneficiary estimates that some 2,500,000 of consumers have been reached;
- 300 local bodies through the awareness campaign (seminars, brochures, conferences and web site). At the end of the project, all the local bodies (provinces, municipalities, national and regional parks) of the three regions had been involved;
- 200 companies through the awareness campaign; and
- 300 dealers through the awareness campaign. Some 8,000 Coop retailers nationwide have been reached by the campaign.

A report on the efficiency of the communication showed that:

- GPP increased by 15.8% in those public authorities involved in the awareness campaign;
- Green products increased by 19.5% in Coop stores;
- Sales figures of green products increased by 21.1% in the Coop stores;
- Four eco-design initiatives were adopted by producers; and
- Three companies adopted cleaner techniques, including the installation of photovoltaic panels in their production sites.

Finally, the project provided the Commission's consultation 'Stakeholders Consultation on Delivering more Sustainable Consumption and Production' of March 2012 with a position paper. It was presented by the Liguria region and included the guiding principles on how communication on SCP should be implemented in an effective way. It featured the requisites and rules based on ISO 14020 standards, to be provided to the national authority for the drawing up of the Italian National Communication Plan on SCP.

LIFE12 ENV/IT/000393 PREFER PRoduct Environmental Footprint Enhanced by Regions

The LIFE PREFER project aims to demonstrate the effectiveness of the European methodology for environmental footprint in different sectors using the cluster approach, in order to overcome the typical drawbacks affecting SMEs (lack of human and financial resources). It will develop and strengthen this approach based on shared resources. The project will provide an opportunity for innovative environmental governance on the possibility to facilitate knowledge-sharing and experience exchange among participants and encourage the application of the PEF methodology. At the cluster level, a set of instruments, tools and resources will be shared with local SMEs in order to support them in the application of the PEF methodology and to achieve improvements in environmental performance. The effectiveness and uniqueness of the project lie in using the clustering methodology in an innovative way—i.e. to define and implement a policy and governance approach aimed at increasing the uptake PEF among SMEs.

PRoduct Environmental Footprint Enhanced by Regions is a project co-financed by the European Commission's LIFE Plus Programme. PREFER (LIFE12 ENV/IT/000393) started in October 2013 and finished in December 2016. The project coordinator was the Institute of Management of Sant'Anna School cooperating with five partners: CENTROCOT, Consorzio dell'Asti, ERVET, Patto dell'Agro and Lombardy Region. PREFER project aimed at fully implementing the European Product Environmental Footprint (PEF) methodology on eight different products. The European Commission adopted the PEF by the Recommendations 2013/179/EU. The project involved eight Italian clusters placed in Campania, Emilia Romagna, Lombardy, Piedmont and Tuscany. The project budget is 1.541.845 € with a Life Plus contribution of 50%. The project results concern the PEF implementation. The partners tested the methodology on 13 products representing 8 Italian clusters (Paper district of Lucca, Tuscany fashion district, Lombardy textile district, Wine district of Asti, Agricultural and Food District of Nocera Gragnano, Northern Italy industrial tomato cluster, Shoes district of San Mauro Pascoli, Lombardy wood district). The pilot companies attending the project were 38, 32 SMEs and 6 large enterprises. Eight PEFCRs were developed and shared with three European cluster organizations in Spain and Romania. A project survey (94 respondents) identified the main needs and barriers to PEF adoption. Based on survey results, partners designed five technical tools to support SMEs in the PEF implementation. The PREFER training initiatives involved 350 organizations.

LIFE PRISCA Pilot project for scale reuse starting from bulky waste stream

The main objective of the PRISCA project was to reduce the flow of bulky waste sent to landfill. The project also aimed to increase the recovery and reuse of bulky waste. Its specific aims were to contribute to the effective implementation of the EU Thematic Strategy on waste and natural resources, focusing its efforts on the national priorities; to set up two demonstration reuse centres, in Vicenza (northern Italy) and San Benedetto del Tronto (central Italy); and to reduce the flow of bulky waste going to landfill, with a target of reusing 60% of that waste.

PRISCA—Pilot project for scale reuse starting from bulky waste stream—is a project financed by the European Commission through the Life Plus Environment 2011 programme, that aims to demonstrate the feasibility of two reuse centres, one in Vicenza and one in San Benedetto del Tronto, where reusable goods from solid urban waste flows are sent for preparation for reuse operations to enter a second life, instead of being disposed to landfill.

The PRISCA project contributed to improvements in waste management generally and, in particular, to the implementation of the waste prevention objectives of the EU Waste Framework Directive (2008/98/EC). The project established two waste reuse centres, in Vicenza and San Benedetto del Tronto, which reduced the flow of waste and goods going to landfill by reusing more than 60% of the incoming material at both sites.

In both the demonstration sites, performance monitoring systems were implemented. These consisted of traceability tools that provide useful information and verified the project's target in terms of intercepted waste flows and management efficiency of the overall process from interception to marketing. Dedicated software was used for the optical reading of characters on labels, to replace the manual input of codes, which made the process of traceability for intercepted goods both easier and faster. The project team created a testing and repair laboratory and published a technical manual.

The project's dissemination activities, aiming to replicate the model in other areas, included 20 regional seminars, targeted at local operators and public administrations, 2 national workshops, 3 national conferences and a final International event. Intensive networking activities were also organized with other LIFE projects. Awareness-raising activities were aimed at citizens living near the two waste reuse sites, focusing on citizen involvement in waste management and sustainable consumption behaviour.

The environmental impacts of the PRISCA model were evaluated with Life Cycle Assessment (LCA) tools. Environmental benefits were generated by the reduction of quantities of waste and goods destined for disposal by landfill or incineration, through their diversion into reuse activities that extended their life cycle as second-hand goods. This life cycle extension brings relative saving in resources, and subsequent savings in greenhouse gas (GHG) emissions. During the start-up phase in Vicenza, a total of 244 tonnes (2014), and in San Benedetto del Tronto a total of 5 tonnes (during 5 months in 2015), were diverted from the waste flows. LCA evaluations of the global GHG savings connected to the activity of the reuse centres during this start-up phase were for 236 tonnes CO_2 eq. in Vicenza and 36 tonnes CO_2 eq. in San Benedetto del Tronto.

In addition to helping implement the Waste Framework Directive, the PRISCA project also contributes to the implementation of the Thematic Strategy on the sustainable use of natural resources COM (2005) 670 final (EC 2005a); COM(2003) 302 (EC 2003) on Integrated Product Policy; the Sustainable Consumption and Production (SCP) and Sustainable Industrial Policy (SIP) Action Plan COM(2008) 397 final (EC 2008); and the Thematic Strategy on the Prevention and Recycling of Waste COM(2005) 666 final (EC 2005b) and its follow-up Report on the Strategy COM(2011) 13 final (EC 2011), which stressed that waste prevention was a priority to be urgently implemented. Waste production prevention is also an important objective in the Communication Towards a circular economy: a zero waste programme for Europe COM (2014) 398 final (EC 2014).

The PRISCA model developed an economically sustainable supply chain that supports waste prevention activities in the long term. The project integrated the second-hand product sector and the reuse supply chain through its solid urban waste management system, to increase the interception of reusable items. PRISCA introduced an 'industrial approach', to promote standardization of manufacturing processes, in a field not always well-organized as far as supply, workflow management and final retail are concerned.

Management tools that enable optimal traceability and the logistic organization of the reuse centres allow reuse operators to increase and widen their market and to better cope with market demand. The demonstration activities in the two project areas, involving a multi-disciplinary team of coordinating and five associate beneficiaries, showed the importance of cooperation among stakeholders at waste reuse centres.

In terms of social benefits, the PRISCA model helped create new jobs at the two reuse centres and, as the activity is likely to become a structural support to local waste management systems, this result can be acknowledged as a long-term benefit. During the project, all the job positions created in Vicenza for implementing the Prisca model were made permanent, increasing the staff of Cooperativa Insieme. Furthermore, in San Benedetto del Tronto, which was a greenfield, implementation generated four permanent part-time positions and the opportunity to hire four disadvantaged people via the municipal administration. In addition, the introduction of standardized procedures and equipment, along with workers' training activities, enabled improvements to be noted in conditions, as well as in health and safety, in the workplace.

4 Case Studies

In Italy, the implementation of circular use of resource is monitored also by a public web site www.economiacircolare.com CDCA, ECODOM (2018). In this web site, there is reported an atlas (Fig. 6) indicating the geographical position of the companies and the short description of the circular use of resources implemented in their production cycle. The industrial sectors involved are very broad ranging from the

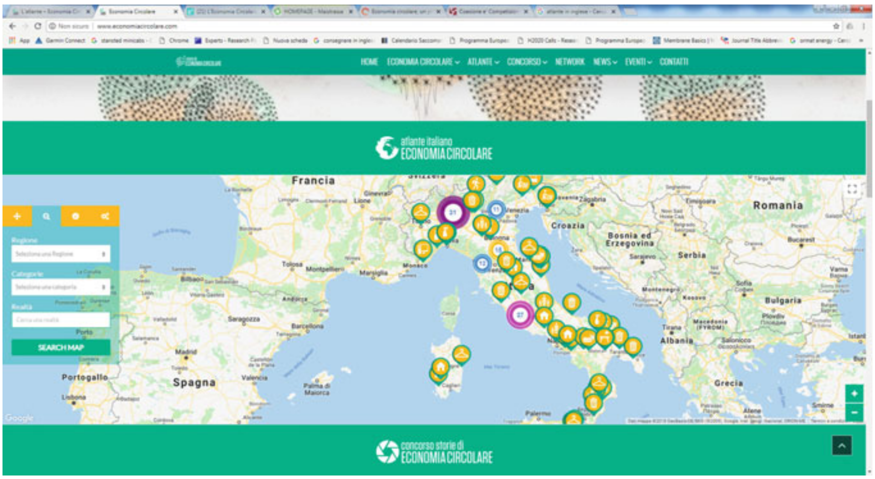

Fig. 6 Atlas of circular economy implementation

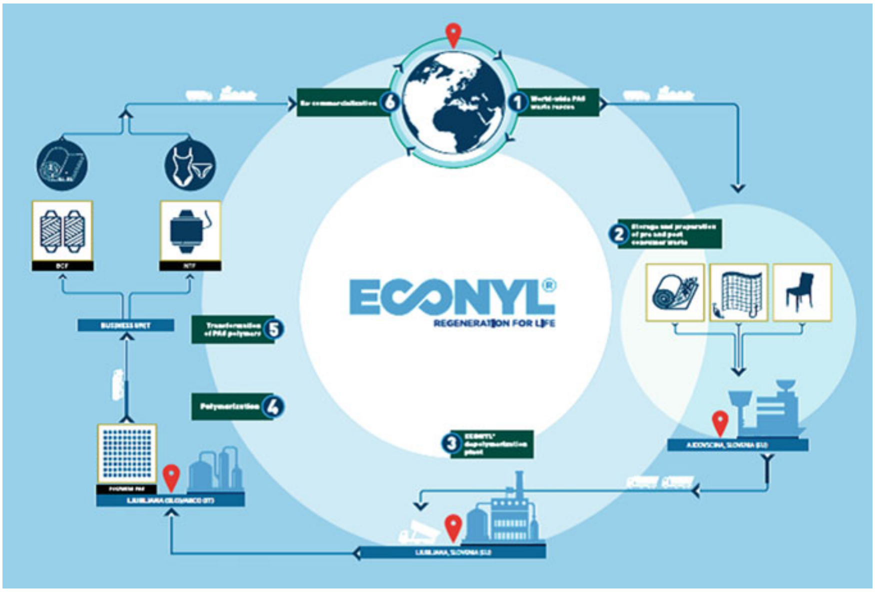

Fig. 7 Econyl project scheme

agriculture, the textile, the building, the ICT, the waste management, furniture and others.

Among these of interest are the best practices introduced by the following two companies.

Acquafil

Acquafil is a company operating in the textile sector producing a wire for carpet and for dresses. Starting from this business, they implemented the Econyl project (Fig. 7) aimed to generate an high-quality nylon wire from waste containing nylon.

This activity consists of three main steps:

(1) Nylon waste collection including residues from production, industrial plastics components, moquette, carpet and fish nets;
(2) Waste pre-treatment for removing impurities;
(3) Waste depolymerization for producing high-quality nylon;
(4) Polymerization;
(5) Transformation in new nylon wire;
(6) Back to market.

Lucart

Lucart is a company producing hygienic paper that in 2013 started the natural project for a total recycling of the multilayer beverage packaging. This project was implemented in collaboration with Tetra Pak and recovery all the component of these kinds of packaging. From the paper of the external part of the multilayer container, Lucart produces the Fiberpack tissue. From the polyethylene and aluminium components produce AL. Pe is a homogeneous material used for producing different components as pallet, urban furniture and other products completely recyclable.

5 Discussion and Analysis

In a successful implementation of circular use of the resource, the generation of waste will be significantly decreased and at least eliminated. This requires a complex action involving economic systems, technologies, product design, consumers' attitude and also legal and economic supports. One of the main drivers for waste generation is represented by the increase in GDP and families' expenditure. In general, the higher is the GDP, the higher is the amount of product and services delivered by a given economy; higher is the families' expenditures, higher is the amount of product purchased. This, in a traditional approach leaded to a direct proportionality between these two socio-economic indicators and the waste generation (Fig. 8). For Italy, starting from the year 2015, macro-data concerning socio-economic and waste generation indicators showed that this paradigm is starting to be capsized. It is hence possible to have an economic grow at which do not correspond a directly proportional increase of the MSW generated (Figs. 8 and 9).

This is an important result concerning the pursuing of waste prevention according to the implementation of the hierarchy (Fig. 1).

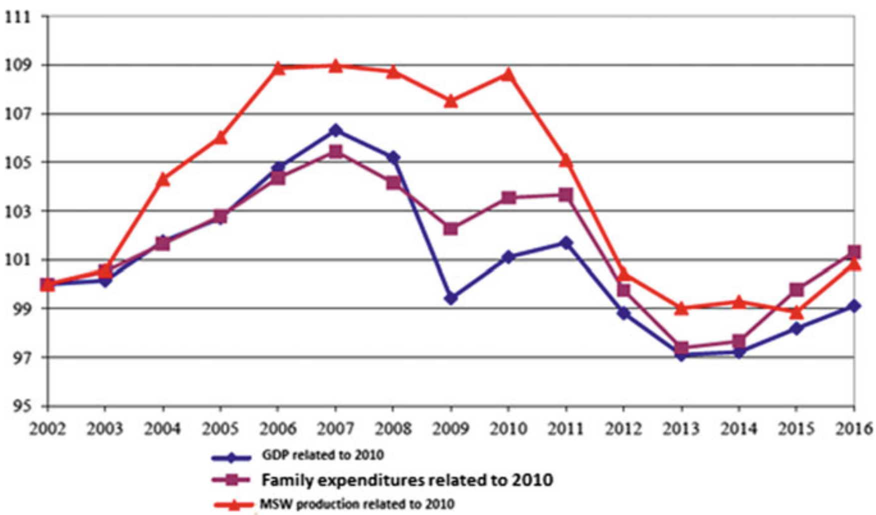

Fig. 8 GDP, families' expenditures and MSW generation normalized to the levels of 2010

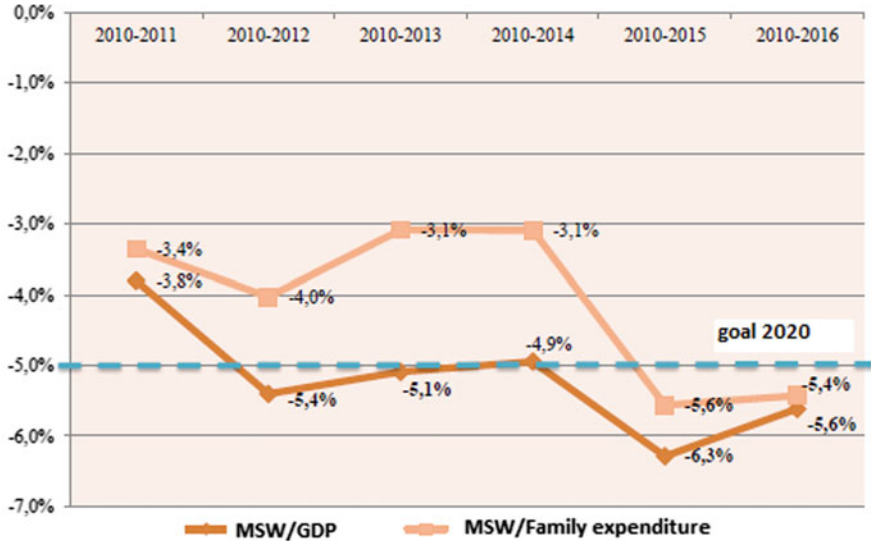

Fig. 9 MSW/GDP and MSW/families' expenditure ratios with respect to 2010 from 2011 to 2016

Concerning the implementation of the other levels of the hierarchy, preparation for reuse and recycling, a fundamental instrument for its increase was represented by the separated collection. Based on the results reported in Fig. 10, it is possible to detect a quite parallel increase of the amount of waste collected separately and

Fig. 10 Percentages of separated collection and recycling for the period 2010–2016

the amount of waste recycled, indicating the relevance of the collection phase. But starting from the 2015, it was observed that for continuing to pursue the same trend in the increase of previous periods for the waste recycling rates, the efforts in the separated collection of waste have to increase to a higher extent compared to the previous years. In fact, the two curves that were practically parallel since the 2010 from the 2015 started to be divergent with the one indicating the waste separation percentage increasing more than the one of the recycling.

This fact opens the floor to a critical discussion about the causes of this tend and on the convenience of pursuing to higher values the separated collection based on the current status of the art (e.g. waste quality, collection systems, recycling markets, legal support). In fact, there are two main opposite effects concerning the separated collection and the recycling. On the one hand, the extended producer responsibility imposes to the producers of packaging to provide their collection. But on the other hand, not all the materials collected separately have an effective recycling pathway. This last aspect is a consequence of different causes among which the absence of adequate recycling markets for such materials; the absence of specific regulation able to provide the necessary support for the recycling; the absence of adequate economic support for promoting specific recycling pathways; the decreased quality of materials collected separately. All this indicates the complexity of the action to be pursued for a successful implementation of the circular use of resources.

Meanwhile for the MSW, there are a lot of signals indicating that the efforts concerning the implementation of the hierarchy (Fig. 1) and consequently of the circular use of resources are starting to give positive results, the signals arising from the management of special waste indicate that there is no evidence of similar trend (Fig. 11). The linkage between GDP and special waste production still remain characterized by a direct proportionality. This is of course partially due to the quality of these wastes but also to the difficulty in the implementation of efficient approaches in specific sectors as the one of construction and demolition waste representing more than 41% of the whole special waste produced. Another 27% of these wastes are represented by those arising from remediation and reclamation of contaminated soils, and finally, about 20% are those generated by the manufacture sector. All this indicates that further efforts have to be pursued in this sector for an effective implementation of CE.

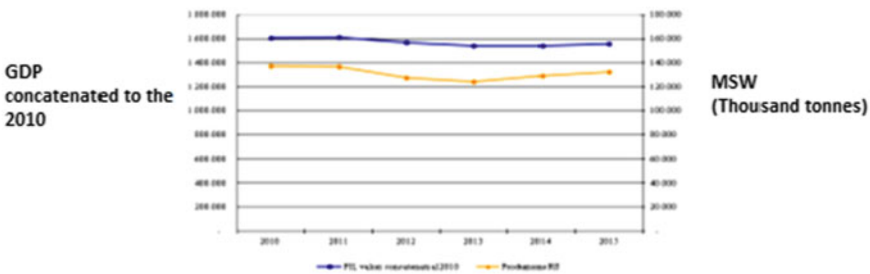

Fig. 11 Percentages of separated collection and recycling for the period 2010–2016

6 Conclusion

Implementation of circular use of resources is a complex activity involving different aspects among which the most relevant are represented by adequate legislation and economic support for promoting specific activities in each specific market.

Industrial sectors as the plastic, the paper, the metals and the glass have, nowadays, achieved high levels of recycling of waste materials even if more ambitious target are going to be implemented. But the final goal of a circular use of resources is related to avoid the production of waste. Waste represents a symptom of a 'hilliness' that is located somewhere else in the economic systems and along the values chain of products.

It is important to identify and remove these obstacles hampering the avoidance of the waste generation phase and implement an effective circular use of resources. By the current state of the art, represented by the quality of the products generated, the materials used for their production, the industrial processes, the economic convenience and the legal support some positive signals concerning waste prevention have been detected for the household wastes. For those generated by the industrial and commercial sectors, there is no evidence of the avoidance of waste generation, indicating that more efforts resulted necessary.

References

CD. (1991). Council Directive 91/156/EEC. 1991. Council Directive of 18 March 1991 amending Directive 75/442/EEC on waste. Official Journal of the European Communities 26.3.91 N. L78/32.

CDCA, ECODOM. (2018). L'atlante dell'economia circolare. Available at: http://www.economiacircolare.com/latlante/. Accessed 15.07.2018.

EC. (2003). COM(2003) 302 final. Communication from the commission to the council and the European Parliament Integrated product policy. Brussels 18.06.2003. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52003DC0302&from=it. Accessed 07.09.2018.

EC. (2005a). COM(2005) 670 final. communication from the commission to the council, the European Parliament, The European Economic and Social Committee and The Committee of the Regions thematic strategy on the sustainable use of natural resources. Brussels 21.12.2005. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0670:FIN:EN:PDF. Accessed 07.09.2018.

EC. (2005b). COM(2005) 666 final. Communication from the commission to the council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions taking sustainable use of resources forward: A thematic strategy on the prevention and recycling of waste. Brussels 21.12.2005. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52005DC0666&from=EN. Accessed 07.09.2018.

EC. (2008). COM(2008) 397 final. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the sustainable consumption and production and sustainable industrial policy action plan. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0397:FIN:EN:PDF. Accessed 07.09.2018.

EC. (2011). COM(2011) 13 final. Report from the Commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the Regions on the thematic strategy on the prevention and recycling of waste. Brussels 19.1.2011. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0013:FIN:EN:PDF. Accessed 07.09.2018.

EC. (2014). COM (2014) 398 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Towards a circular economy: A zero waste programme for Europe. Brussels 2.7.2014. Available at: http://ec.europa.eu/transparency/regdoc/rep/1/2014/EN/1-2014-398-EN-F1-1.Pdf. Accessed 07.09.2018.

EC. (2015a). COM(2015) 614 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Closing the loop—An EU action plan for the Circular Economy. Brussels 2.12.2015. Available at https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF. Accessed 27.08.2018.

EC. (2015b). G7 Alliance for Resource Efficiency. European Commission, Environment, Eco-Innovation. Available at: https://ec.europa.eu/environment/ecoap/events/g7-alliance-resource-efficiency_en. Accessed 28.08.2018.

EC. (2015c). COM(2015) 595 final. Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste. Brussels 2.12.2015. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:c2b5929d-999e-11e5-b3b7-01aa75ed71a1.0018.02/DOC_1&format=PDF. Accessed 30.08.2018.

EC. (2015d). COM(2015) 596 final. Proposal for a Directive of the European Parliament and of the Council amending Directive 94/62/EC on packaging and packaging waste. Brussel 2.12.2015. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:b68494d2-999f-11e5-b3b7-01aa75ed71a1.0019.02/DOC_1&format=PDF. Accessed 30.08.2018.

EC. (2018). COM(2018) 28 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions a European Strategy for Plastics in a Circular Economy. Brussels 16.1.2018. Available at https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF. Accessed 27.08.2018.

ISPRA. (2009). Rapporto Rifiuti Urbani. Edizione 2009. ISPRA, Rapporti 108/2010. ISBN 978-88-448-0430-5.

ISPRA. (2017a). Rapporto Rifiuti Urbani. Edizione 2017. ISPRA, Rapporti 272/2017. ISBN 978-88-448-0852-5.

ISPRA. (2017b). Rapporto Rifiuti Speciali. Edizione 2017. ISPRA, Rapporti 264/2017. ISBN 978-88-448-0828-0.

UNRIC. (2018). Sustainable development goals. United Nations. Available at: https://www.unric.org/en/unric-library/30089-unric-library-backgrounder-sustainable-development-goals-in-local-languages?format=pdf. Accessed 28.08.2018.

Circular Economy in Kenya

Michael K. Koech and Kaburu J. Munene

1 Introduction

A circular economy is a system based on economic and industrial concepts that advocates reusing of products and raw materials so as to maximize the restorative capacity of natural resources. The circular economy attempts to minimize value destruction in the overall system and to maximize value creation in each link in the system. The main benefit of this kind of economy is the reduction of environmental pressure through minimizing emissions of harmful products such as carbon dioxide, nitrogen oxides, and methane among others thus resulting into a cleaner world without rising temperatures and other corresponding negative consequences. The earth is currently facing severe environmental challenges as vital ecosystems such as forests, woodlands, grasslands, and wetlands are facing extreme depletion due to unsustainable human activities. It is estimated that almost half of the world's rivers have been depleted thus accelerating the impacts of global warming. Environmental degradation has led to migration of more than 50 million people from their homes to urban areas where majority reside in urban informal settlements. The planet will continue to face the ever-increasing challenges unless countries shift to more sustainable ways of living and development. Countries and global community must adopt and implement circular economy strategies that seek to reduce environmental damages while maximizing on sustainable development.

In Kenya, many people especially those residing in urban informal settlements and rural areas have started to practice circular economy activities such as the establishment of biogas digesters and reusing of plastic bottles. The country has also banned the use of plastic bags thus creating opportunities for its citizens to reuse and recycle materials such as sisal woolen bags. The establishment of biogas digesters

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in Kenyan rural areas and slums has led to generation of power to light up homesteads and also made cooking easier and safer. Biogas establishment in many parts of Kenya has led to sustainable management of solid waste and municipal wastewater. Recycling and reusing of solid waste from households and municipal wastewater in Kenya has helped the country improve sanitation conditions of most slums. In 2017, the Kenyan government in collaboration with Africa Development Bank (AFDB) under Sustainable Energy Fund for Africa (SEFA) came into an agreement to establish 100 megawatts (MW) waste to energy electricity plant in Dandora dumpsite. Dandora dumpsite is the largest dumpsite in the country that receives waste from most part of Nairobi City County. Asticom Kenya Limited has already been granted permits by the Kenyan government to undertake the task of building this 100 MW municipal waste to energy (WTE) plant. The WTE project in Kenya will have significant benefits to the health, socio-economic, and environmental dimensions of the country. According to AFDB, the project will be receiving an approximate of 1,000 tonnes of municipal solid waste from Kibera slums.

In 2018, Kenyan Association of Manufacturers introduced a plastic bottle recycling initiative to mark the celebrations of World Environment Day. The plastic bottle initiative by KAM led to the establishment of polyethylene terephthalate (PET) recycling company known as PETCO Kenya that will ensure sustainable management of plastic materials through recycling and reusing in the country. All private manufactures in the country will be represented in PETCO thus ensuring that the initiative gains popularity across the country. PETCO Kenya aims to achieve recovery and recycling of PET materials at a rate of 25 pc in 2018 and 70 pc by 2030, (Rutten 2018). Recycling and reusing of plastic bottles in Kenya has led to emergence of business initiatives. Urban dwellers in Kenya especially those living in informal settlements are reusing plastic bottles to set up small kitchen gardens. Crops such as onions, broccoli, cabbage, kales, bullet chilies, garlic, and ginger are planted in large plastic bottles filled with soil and manure from domestic animals mostly cows and donkeys. According to Kumar, a Nairobi resident in Parklands, they buy 10 L plastic bottles from companies within the city at Kshs 50 each in order to set up a kitchen garden of about 1,000 plastic bottles (Kilonzo 2014).

Kenya has also implemented the use of renewable energy as a means of promoting circular economy concepts. Kenya Electricity Generating Company (KENGEN) has already set up three plants to generate geothermal resource in the country. These geothermal plants include Olkaria I which generates 195 MW, Olkaria II generating 105 MW, and Olkaria IV which generates 140. Geothermal electricity will help to reduce the country relying on Hydroelectric Power (HEP), (Ochieng 2017). Private investors across the country have also invested in small-scale solar and wind electricity generation plants. World Bank-funded rural electrification program commonly referred to as Last Mile Main Grid Connectivity in Kenya seeks to establish the largest solar power in East and Central Africa in Garissa on 85 ha piece of land. Kenya investment in renewable energy is one of the strategies to reduce its carbon emissions by 64,190 tonnes per year. In order to ensure success in promotion of circular economy concepts, the country has set up organizations like Kenya National Cleaner Production Center (KNCPC), Kenya Nuclear Electricity Board (KNEB), and National Environment Management Authority (NEMA).

2 Legislative framework supporting Circular Economy in Kenya

In Kenya, there are several legislation and legal frameworks to enhance sustainable implementation of circular economy strategies. CE legislations in Kenya include parliament Acts, bills, by-laws, and legal publications in most governmental parastatals and lead agencies. The new Kenyan constitution 2010 mainly Chapter 5 Part 2 on land and environment mainly states all the obligations of its citizens to ensure sustainable exploitation of natural resources and sustainable management and protection of the environment. Chapter 5 Part 2 of the constitution environment and natural resources is helping the country achieve green growth and sustainable development which is a key step toward implementation of a circular economy. The circular economy concepts in Kenya started to gain recognition since the development and implementation of Environmental Management and Coordination Act (EMCA) of 1999. EMCA 1999 is a legal framework law on environmental management and conservation in Kenya. EMCA 1999 has led to the establishment of the following institutions to help the country achieve environmental sustainability; National Environment Management Authority (NEMA), Public Complaints Committee (PCC), National Environment Tribunal (NET), National Environment Action Plan Committees (NEAP), and County Environment Committees.

The National Environment Management Authority (NEMA) was established as the principal instrument of government charged with the implementation of all policies relating to the environment and to exercise general supervision and coordination over all matters relating to the environment. In consultation with the lead agencies, NEMA is empowered to develop regulations, prescribe measures and standards, and issue guidelines for the management and conservation of natural resources and the environment. EMCA 1999 also led to the formulation and adoption of Environmental Impact Assessment (EIA), Environmental Audit (EA) and monitoring, environmental restoration orders, conservation orders, and easements. The incorporation of EIA and EA in development concerns in the country has helped to promote cleaner production and sustainable development which is a major step toward realizing achievement of circular economy. All development projects in the country are required by law to undertake EIA to ensure all the potential impacts are identified and sustainable mitigation measures are developed. Regular monitoring of ongoing development projects in the country is also carried out to ensure that all developers and projects comply with the set of environmental regulations.

In June 10 2008, the then President Mwai Kibaki launched Vision 2030, a long-term blueprint toward the achievement of sustainable development in the country by

2030. Vision 2030 has also played a key role toward the promotion of CE in the country. The blueprint advocates for adoption of industrial ecology, cleaner production principles, and other sustainable practices to ensure that the country achieves a green growth that reduces environmental harm while at the same time maximizing on the economic gains. The country is also a signatory to several regional conventions such as the Africa Vision 2063, Bamako Convention, Convention of the African Energy Commission, and the Revised African Convention on the Conservation of Nature and Natural Resources. The country has also adopted international sustainable development goals (SDG) to guide sustainable implementation of developmental issues that promote circular economy.

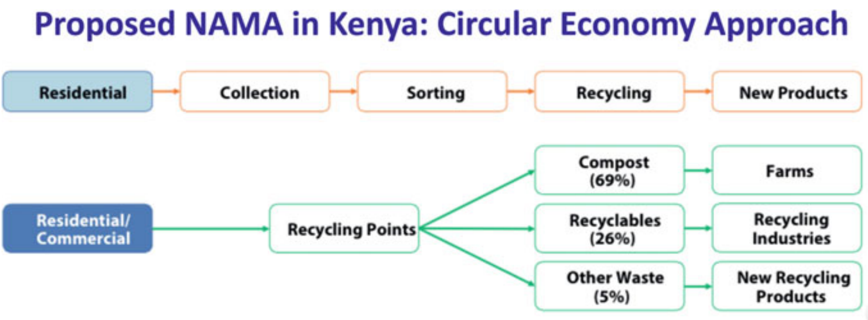
3 Research Models

In 2016, the Ministry of Environment and Natural Resources in collaboration with UNDP developed a circular economy research model on solid waste management in urban areas. The Research model adopted is known as Low Emission Capacity Building (LECB) Program under funding from the European Commission (EC), the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), and the Australian Government. LECB's main aim is to ensure partnership among the public sector, private sector, industries, and relevant national and international organizations in order to ensure development of low emission approaches. National counterparts are supported to strengthen technical and institutional capacities to identify and formulate Nationally Appropriate Mitigation Actions (NAMAs) and Low Emission Development Strategies (LEDS) in the public and private sectors, and to strengthen the underlying greenhouse gas inventory management and Measurement, Reporting and Verification (MRV) systems. The LECB Program runs through 2016 and is active in 25 countries: Argentina, Bhutan, Chile, China, Colombia, Costa Rica, the Democratic Republic of Congo (DRC), Ecuador, Egypt, Ghana, Indonesia, Kenya, Lebanon, Malaysia, Mexico, Moldova, Morocco, Peru, Philippines, Tanzania, Thailand, Trinidad and Tobago, Uganda, Vietnam, and Zambia. LECB program is being implemented in the country through NAMAs. The NAMAs circular Economy Municipal Solid Waste Management Approach for urban areas aims to transform Nairobi's waste sector from a disposal-driven one to one of recycling and composting.

NAMAs circular Economy Municipal Solid Waste Management Approach will have the following benefits to the country; affordable waste collection services to all income areas, increase in the amount of waste collected and recycle, improved health at household levels, reduction in GHG emissions, direct and indirect job creation, and increase in the application of compost to improve agricultural soil fertility. The NAMA circular economy model seeks to propose that 90% of all the waste collected in Kenya must be recycled thus making the country among the highest ranking globally in terms of recycling. In comparison, developed nations like Italy and USA have recycling rates of 36 and 34.5%, respectively. NAMA model states that waste from households and companies in Kenya will be collected by waste collection companies. Waste collection companies will then transport the waste into a central waste recycling point instead of disposing it at Dandora dumpsite. At the central waste recycling point, sorting out of the waste into different fractions will be carried out. 30% of the recyclable materials recovered at the central recycling point will be sold to recycling industries while 60% of the total waste that is mainly organic will be transported to composting plants for manure manufacturing. The remaining percent of the waste will be disposed with a small research pilot activity undertaken to generate energy through cement kiln method.

The figure below shows the operational flow of the circular economy approach of the NAMA. Revenues come from three sources:

- Waste collection fees (earned by collectors)
- Sales of recyclable materials and tipping fees (earned by recycling points)
- Sales of compost (by composting businesses)
- Sales of new products (by recycling industries).



Source Nema (2016)

4 Case Studies of CE Implementation

4.1 Safi Organics

Safi Organics is a rice processing company based in Mwea Kenya. The company was founded in 2015 and boosts of annual turnover of 42,000 USD. The company is an eco-inclusive enterprise that aims at reversing the declining agricultural production while creating job opportunities for the youth in Kenya. Rice farmers in Mwea face the challenges of disposing off rice husk which they burn thus polluting the air around the area. Safi Organics has developed technologies to collect the rice husk and transform it into organic fertilizer. Waste rice husk is collected from farmers and processed into biochar, the biochar is then stored, processed, and a local enzyme is added to enable microbial growth. The fertiliser and soil treatments are sold back to the farmers directly or through agents. Safi Organics has created a local circular economy that enables farmers to exploit the value of their waste in an environmentally friendly manner, as well as gain access to cheaper fertilisers and soils treatments. Safi Organics also employs a number of local youths, providing them with an income stream and access to valuable training and experience. Safi Organics is collaborating with Kenya Agricultural and Livestock Research Organization (KALRO) to increase opportunities in organic farming among rice farmers in Mwea. Safi Organics' main environmental objective is to reverse declining soil fertility and reduce the burden of chemical fertiliser on the local environment. Safi Organics contributes to enhanced soil conditions by encouraging local farmers to use rice husks for soil maintenance. Prior to their involvement with Safi Organics, local farmers were unaware of this sustainable, local alternative to chemical fertilisers.

4.2 EcoPost Limited

EcoPost is a social enterprise that addresses the challenges of urban waste management especially plastic pollution, youth unemployment, deforestation, and impacts of climate change in Kenya. EcoPost is involved in recycling plastic waste in order to manufacture eco-friendly plastic products such as outdoor furniture and fencing materials. The enterprise is making huge contributions toward minimizing plastic pollution in informal settlements. The enterprise aims to recycle 20.9 million kgs in the next 10 years. EcoPost Limited is working closely with Safaricom Foundation, Ministry of Youth Affairs, Enablis East Africa, and BiD Network from Netherlands to ensure it achieves and its objectives.

4.3 Sanergy Kenya

Sanergy Kenya is an organization that aims at improving the sanitation condition of most urban slums such as Mukuru in Nairobi. Urban slums in Kenya are faced by challenges such as high population that exacerbates the poor sanitation conditions in these informal settlements. An approximate of 8 million slum dwellers in Kenya are forced to use unsanitary options such as "flying toilets" that involves mainly defecating in available plastic bags that are later disposed on the streets. The ban of plastic bags is likely to make the conditions worse as most slum dwellers may start to defecate in the open. Sanergy Kenya is now providing Fresh Life Toilets that are designed to be used 80–100 per day. The waste from the toilets is collected regularly in sealed cartridges and taken to a central processing facility. In the central processing facility, the waste is stored in special bio-digesters where it breaks down and releases methane that is used as a fuel in biogas generating plants in the slum. The bio-digesters also help in removing disease-causing pathogens thus making the leftover matter safe to use as fertilizer. According to Sanergy Kenya, one tonne of human waste produces about 0.6 m^3 of biogas. Sanergy has already collected 2,700 metric tonnes of waste from Mukuru slums. Once the Sanergy's biogas plant is completed, it will generate 250 kW of electricity that will help to light up the slums and also sell to the national grid. Poo-to-power initiatives are already at work in some Kenyan slums as well as several schools, but projects such as Sanergy's with bigger funding and wider aspirations hope to bring the benefits to more of the population.

4.4 Coca-Cola Kenya

Coca-Cola Company has launched a global plan "World Without Waste" that will help in recycling of plastic waste. The company aims to reshape its packaging and a new global goal that aims at recycling almost 100% of its packaging by 2030. The companies "World Without waste" initiative will be guided mainly by the three R's scheme: Reduce, Reuse, and Recycle. The company has reduced its dependence on fossil fuels by introducing the Plant Bottle Packaging, which is the first fully recyclable polyethylene terephthalate (PET) plastic bottle made with up to 30% plant-based material. Together with partners, the company has invested in two bottle-to-bottle recycling facilities at Extrupet and MPact, to create recycled PET for use in the beverage industry. 45,000 tonnes of PET bottles are diverted from landfills each year to be reused in the beverage industry. Coca-Cola, together also with its bottling partners and other members of the PET value chain, has helped to set up a recycling company, PETCO, which in 2016, achieved a recovery and recycling rate of 58% of post-consumer PET bottles—one of the highest rates in the world.

4.5 TakaTaka Solutions

TakaTaka Solutions is a small-scale waste recycling enterprise that mainly operates with Nairobi City County. The enterprise claims that it is capable of recycling up to 95% of the waste it collects. Waste collected by TakaTaka Solutions is separated into two fractions mainly organic and inorganic at the initial stage. Organic waste which accounts for a high amount of an approximate 60% is then transported to the enterprise's central facility for production of compost. The compost produced is popularly known as the TakaTaka Solution Biobooster. Recyclable materials from the waste collected such as plastic containers, cardboards, and metals are then sold to recycling industries across Nairobi. TakaTaka Solutions is also involved in manufacturing of wine glasses and tumblers from recycled glass bottles.

5 Discussion and Analysis

There is a strong relationship between CE and environmental sustainability as they both aim at improvement of the social, economic, health, and environmental dimensions in a society. Humanity must learn to sustainable utilize the available resources to improve their well-being while at the same time learn how to modify waste generated to create more products. In Kenya, the number of industrial plants engaging themselves in Resource Efficient Cleaner Production (RECP), the 3Rs programs—reduce, reuse, and recycle, and Industrial Ecology (IE) is on the rise. Some technologies in RECP, 3Rs, and IE, are very expensive to adopt especially among the small-scale manufacturing industries thus the government should offer monetary support. The process of "greening" the Special Economic Zones (SEZs) has greatly helped Kenya attract green Foreign Direct Investments (FDIs). In Kenya, over the years, there has been an emerging international consensus that the country is exploiting its natural resources in an unsustainable manner. This has led to implementation of interventions such as Industrial Ecology, EIA, EA, and cleaner production strategies in order to reduce pressure on the existing ecological resources. In the past, manufacturing industries in Athi River SEZ have been operating in a linear approach where they extract raw materials from the environment to produce products and then dumping the waste in landfills. The adoption of a circular economy in the country coupled with Resource Efficient Cleaner Production (RECP) and industrial symbiosis will improve resource security of the SEZs, reduce associated ecological impacts associated with waste disposal, and offer new opportunities for economic growth and wealth creation. The adoption of CE in Kenya is likely to encounter barriers such as inadequate awareness of the benefits of adopting CE concepts and strategies. The policy makers in the country also are likely to encounter challenges inaccurate production and manufacturing data that can be relied upon to make informed decisions.

The over reliance on out-dated production regulations that do not prioritize CE concepts and efficient harnessing of ecological resources, limited research in CE should serve as learning points for policy makers in Kenya to improve the country's production and manufacturing sector. Adoption of a circular economy requires an incentive approach as demonstrated in European and Asian countries. An incentive approach will allow manufacturing industries to seal loopholes in use of raw materials and energy use so as to minimize disposing large amounts of wastes in landfills. Kenya aims to achieve a Gross Domestic Product (GDP) growth rate of 10% by 2030. The country aims to promote Foreign Direct Investment (FDIs) through implementation of several flagship projects over the Vision 2030 period. In the first Medium Term Plan (MTP) of Vision 2030 (2008–2012), the countries implemented the following flagship projects: creation of Small Scale Enterprise (SMEs) parks, development of SEZs, creation of industrial parks, industrial and manufacturing zoning, inputs cost reduction, value addition and market access development, and development of livestock Disease Free Zones (LDFZ) for production of premium quality beef and other livestock products. The implementation of these flagship projects during the first Medium Term Plan was slow as some of the projects were never realized. During the first MTP (2008–2012), five SMEs industrial parks were to be developed in Eldoret, Kisumu, Nakuru, Mombasa, and Nairobi, but they have not been established since.

5.1 Current Status of Waste Management in Kenya

In Kenya, there is increased urbanization coupled with rapid growth of human population mostly in the urban areas. Increased trends of urbanization and rapid population growth have led to increased rate of waste generation and challenges in waste flow. Despite existence of regulations and policies that guides on waste management, weak implementation, and unsustainable individual practices have led to accumulation of waste in most urban centers in Kenya. Poor waste management has led to outbreak of waterborne disease and dengue fever especially in Mombasa and parts of North Eastern counties. The plates below show examples of poor waste management in Kenya.

Illegal waste dumping on the streets

Uncontrolled open dumpsite

In Kenya, most urban centers have inefficient waste collection and disposal systems. The table below shows a summary of waste generation, collection, and recovery status in major towns.

Name of town	Estimated waste generated (tons/day)	Waste collected	waste recovery	Uncollected waste
Nairobi	2400	80%	45%	20%
Nakuru	250	45%	18%	37%
Kisumu	400	20%	Unknown	Unknown
Thika	140	60%	30%	40%
Mombasa	2200	65%	40%	35%
Eldoret	600	55%	15%	45%

Source Ministry of Environment and Natural Resources (2010)

Waste is mainly transported in Kenya using open trucks, donkey carts, handcarts, and buckets that lead to massive pollution and contamination of the environmental resources.

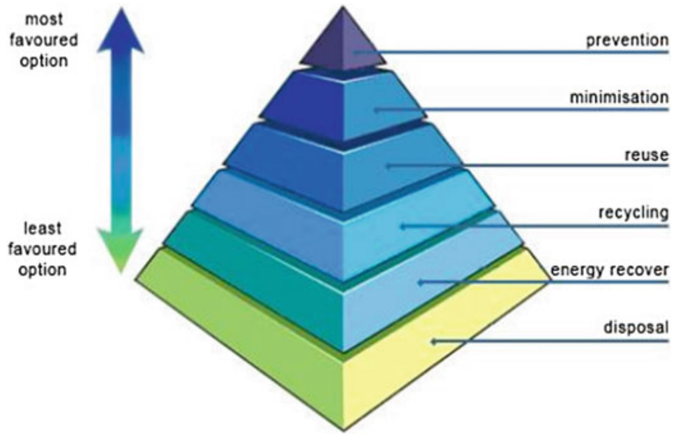
5.2 Type of Waste and Management Method in Kenya

Type of waste	Disposal method
Organic (vegetable and fruit remains)	Fed to animals, disposed to landfills or dumpsite
Food remains	Fed to animals, taken to dumpsite
Debris from construction	Deposited in open dumpsite, recycled
Plastics	Reused, recycled, dropped on the environment, taken to dumpsite
Sludge	Discharged to water bodies–rivers, streams
Bio-medical	Burying, burning
Sawdust	Reused in toilets, fuel
Old fabrics	Recycled

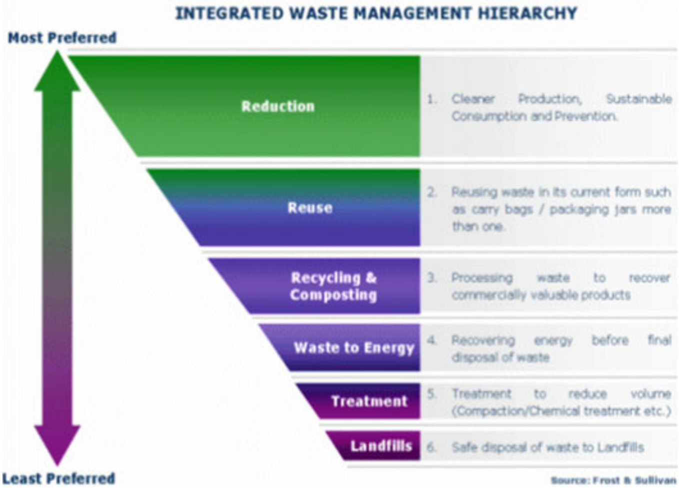
Source Kilonzo (2014)

5.3 The Preferred State of Waste Management in Kenya: Integrated Solid Waste Management

Integrated Solid Waste Management (ISWM) hierarchy is an integrated approach that aims at protection and conservation of the environment through implementation of various approaches of sustainable waste management. ISWM establishes the preferred order of solid waste management alternatives as follows: waste reduction, reuse, recycling, resource recovery, incineration, and landfilling. The figures below represent ISWM Hierarchy.

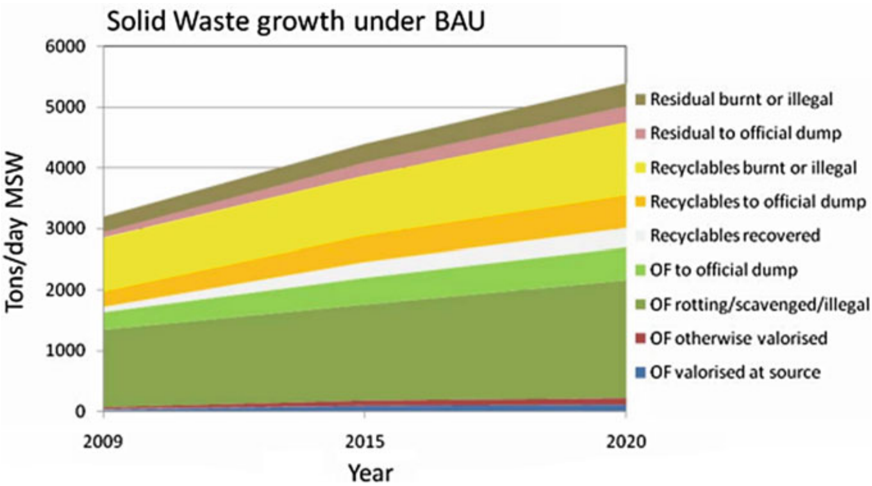


Source KIPPRA (2013)

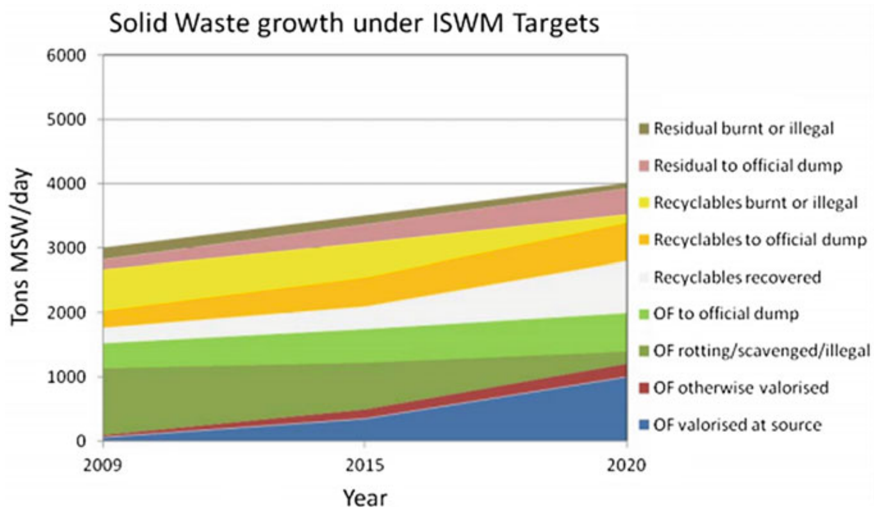


Source KIPPRA (2013)

ISWM plan targets to transform waste collected into different fractions. The possible future scenarios for solid waste management in Nairobi city are illustrated in the figures below for business as usual under ISWM targets.



Source Muthoni (2014)



Source Muthoni (2014)

The following table summarizes an estimate of waste volumes in 2009 and predictions with and without the ISWM plan for 2015 and 2020 (Table 1).

Table 1 Status quo and possible futures for solid waste volumes in Nairobi

	Quantities in tons/day					
Year	2009		2015		2020	
	Best	Worst	ISWM	BAU	ISWM	BAU
Total generated	3000	3200	3500	4400	4000	5400
Organic Fraction valorised at source	2%	1%	10%	2%	25%	2%
Organic Fraction otherwise valorised	1%	1%	4%	2%	5%	2%
Of rottirg/scavenged/illegal	35%	40%	21%	36%	5%	36%
Organic Fraction to official dump	13%	9%	15%	10%	15%	10%
Recyclables recovered	8%	3%	10%	6%	20%	6%
Recyclables to official dump	9%	8%	13%	10%	15%	10%
Recyclables burnt or illegally dumped	21%	27%	15%	22%	3%	22%
Residual waste to official dump	5%	3%	8%	5%	10%	5%
Residual burnt of illegally dumped	6%	8%	4%	7%	2%	7%
Total	100%	100%	100%	100%	100%	100%
Total to dump	*30%*	*18%*	*36%*	*25%*	*40%*	*25%*
Total valorised	*8%*	*5%*	*24%*	*10%*	*50%*	*10%*
Total illegal	*62%*	*77%*	*40%*	*65%*	*10%*	*65%*

OF—Organic Fraction; *BAU*—Business As Usual

It is estimated that Nairobi City County receives at least 50% of waste collection services while half of Nairobi residents do not completely receive waste collection services. This equates to an approximate of about 1560 tonnes that remain uncollected per day. Based on April 2009 CCN records, average CCN collection levels at present are approximately 430 tons/day out of an average of 567 tons/day received at Dandora in 2009. Weighbridge records at the Dandora dumpsite over the period 2006—end 2008 indicated an average 830 tons/day were disposed there prior to 2009. In Nairobi, there is an active and well-documented material recovery and recycling sectors operating thus creating employment opportunities, especially among the youth. Material recovery and recycling sector accounts for a large amount of the generated but remains limited to about 300 tonnes per day that can be broken down as follows: 100 t/day of paper (~18% of paper waste), 100 t/day of plastic (~20% of plastic waste), 62 tonnes per day of metal (Most Valuable Metal is recovered), and 2.4 tonnes of organics are composted (<1% of organic waste). It is unknown how much organic waste is recovered for livestock feeding. Recycled glass volumes appear to be on the decline at approximately 50 tonnes per day.

6 Impact of CE on GDP

In any given economy, an emergence of a business opportunity is greatly considered as a chance to accelerate the economic growth. Circular economy is presenting numerous opportunities to the Kenyan economy through improvement of its production and consumption patterns, cost savings, and creation of employment and room for technological advancement through innovation. Economic growth is the ability of economy to produce products and services for society and measured in terms of Gross Domestic Product (GDP) and Gross National Product (GNP) indicators. According to …, it is estimated that the Kenyan economy will achieve a double digit growth by shifting from linear economy to circular economy. The country's transition to GE will bring about huge benefits such as industrial innovation, changes in production and manufacturing processes, and other industrial technological advancement. Industrial technological advancement may ring up to 3% of economic productivity per year in the country. The circular economy will lead to less exploitation of natural resources and increase opportunities in waste recycling and reusing. Recycling and reusing waste will increase household savings and minimize the expense due to availability to transform waste into more desirable products thus boosting the GDP.

In the near future, it is estimated that unemployment in developing nations will significantly decrease. Studies reveal that the implementation of circular economy strategies by developing nations will result in creation of several job opportunities. Implementation of circular economy concepts by developing nations will also change the production and consumption patterns of both small- and large-scale enterprise through the adoption of new technologies of production and resource conservation. Adoption of sustainable production and consumption patterns by manufacturing industries will lead to creation of high-quality products thus also raising their consumption levels through creation of new markets. Foreign investors and international financial lending institutions will be attracted to invest in developing countries that have adopted circular economy concepts thus boosting their economic growth. According to Ellen MacArthur Foundation, industries with fast-moving consumer goods, the net material cost savings might be about 700 billion dollars globally. Innovations by replacing usual, one-way goods with those, that are "circular by design" and creating the logistical facilities for circular network systems can give extra possibilities for economies and companies to use new ideas at their businesses and, thus, generate new channels of revenues. The advantages may include such aspects as higher labor and energy effectiveness, better technological development, redesigned materials, and bigger profits opportunities. Besides economical and business opportunities, the circular economy gives the possibility to improve the environment. The circular economy promises to reduce carbon dioxide emissions by 48% by 2030 and by 83% by 2050 in Europe and also reduces 7.4 million tonnes of greenhouse gas emissions by not letting organic waste permeate into landfills.

A circular economy development path could result in a reduction of primary material consumption (measured by car and construction materials, real estate land, synthetic fertiliser, pesticides, agricultural water use, fuels, and non-renewable electricity) by 32% by 2030 and 53% by 2050, compared with today (SUN Institute 2015). In addition, primary material consumption could be reduced by 32% by 2030 and by 53% by 2050 compared with today's indexes. Primary materials may include construction materials, pesticides, fuel, real estate land, and others. Moreover, we have to take into consideration the land degradation and that it costs billions of dollars annually. By moving more biological materials with composting, the circular economy will make the necessity for replenishment with additional nutrients much more less. Organic waste, which is used systematically, can help regenerate the soil and reduce the use of chemical fertilizers to 2–7 times comparing with today. The households could reduce the costs by 16% by 2030, as circular economy is controlling the externalities, which involve pollution of water and air, climate change, land use, and the release of toxic substances, (Ellen MacArthur Foundation 2015). Circular Economy Opportunities in Business Profitability is one of the main goals of the companies.

The circular economy could help individual businesses achieve the lower rates of input costs in their production and open the new profit streams. There are some ways on how to do it: Beer production demands input costs as water, grains, yeast, and energy. Usually, the used materials are thrown away, but what if the company starts to sell the used brewer's grains. It can help to gain USD 1.90 per hectoliter of beer which was produced, which leads to capturing the millions as a profit. Another example could be the reduction of costs of mobile phones remanufacturing. Remanufacturing expenses can be less in 50%. In this case, the mobile industry needs to offer the motivation to return the phones and to improve the reverse cycle. The high-end washing machines could be leased to consumers instead of selling it. Then washing machines will be affordable for most households; customers would save about third per wash cycle, and the producers would earn a third more in profits, but gaining money for leasing. The circular economy concept is also applicable to clothes industry. Clothes manufacturers can collect worn pieces of clothes to produce new items, which reduce the costs of input. Such concept is already used by many companies. The circular economy can give companies the opportunity to be independent of changeable raw material prices, as the transition to circular path involves the usage of more remanufactured materials and less virgin, which eliminates the raw material price dependency and makes the enterprise more stable. Besides this, producers will be less dependent from natural disasters or geopolitical situations, as decentralized providers offer alternative sources of materials. Consequently, manufacturers are confident in their supplies, and there is a lower risk of bankruptcy, (Timmermans 2015).

The green economy will also create the demand for new business services. With the new system of doing economy, there would be needed such services as collection and reverse logistics organizations, that would support products to enter the new system, sales platforms, that will improve the utilization of the goods, remanufacturing, and repairing companies, and that would give the new life to products. Customers will be engaged in new ways. The circular economy gives the solutions to firms how to interact with clients on the longer terms. As the life-time of the products is increased, there will be more touch points with the customers, which will bring the better satisfaction both to clients and companies, (Ellen MacArthur Foundation 2015). Further, the circular business models will be studied and discussed, which will help to get the full understanding of circular economy adoption for the company level.

7 Conclusions

Currently, across the globe, the concept of circular economy is gaining recognition and several countries have developed policies to ensure its successful implementation. Many countries are aiming to replace the “end-of-life” concept with circular economy which is a more sustainable means of development. The circular economy aims at encouraging reusing, recycling, and recovering of materials in the production process assumed to be waste and then use them as raw materials to create new products, by-products, and services. The circular economy will help to reduce environmental pollution and damage by ensuring sustainable management of waste. The circular economy operates at micro-levels of raw materials extraction and production with the objective of enhancing the accomplishment sustainable development. The circular economy will help to improve environmental quality while simultaneously enhancing economic prosperity and social equity to the current and future generations. Government, policy makers, business leaders, and consumers must realize that in order to ensure there is continued wealth creation and economic growth, new industrial models that depend less on primary energy and inputs must be adopted. The circular economy concepts must act as drivers of the twenty-first century industrial revolution by promoting innovations and industrial technological advancements.

References

C. (2018, June 06). *Kenyan manufacturers launch plastic bottle recycling initiative—Capital Business*. Retrieved from https://www.capitalfm.co.ke/business/2018/06/kenyan-manufacturers-launch-plastic-bottle-recycling-initiative/.

Ellen MacArthur Foundation. (2015). Towards the Circular Economy: Accelerating the scale-up. Retrieved from http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf.

Kilonzo, E. (2014, June 14). *Our small kitchen garden where we harvest in plenty*. Retrieved from https://www.nation.co.ke/business/seedsofgold/small-kitchen-garden-harvest-plenty–/2301238-2348570-7odm07/index.html.

Kenya Institute for Public Policy Research and Analysis (KIPPRA). (2013). *Kenya Economic Report 2013*. Available from www.kippra.org/downloads/KenyaEconomicReport2013.pdf.

Matienzo, M. (n.d.). *Thinking beyond coffee—A research essay on circular economy*. Retrieved from http://www.academia.edu/31010612/Thinking_Beyond_Coffee_-_A_Research_Essay_on_Circular_Economy.

Ministry of Environment and Natural Resources. (2010). *National Sustainable Waste Management Policy: Waste Generation, Collection and Recovery in Kenya. National Sustainable Waste Management Policy: Waste Generation, Collection and Recovery in Kenya* (pp. 1–41).

Muthoni, P. (2014). *Stakeholder's involvement in municipal solid waste management: A case study for Nairobi City County–Kenya*. Master's Thesis, University of Jyväskylä, Finland. Available from https://jyx.jyu.fi/dspace/handle/123456789/44288.

NEMA. (2016). A Circular Economy Solid Waste Management Approach for Urban Areas in Kenya.

Ochieng, A. (2017, May 16). *Kenya to build East & Central Africa's largest solar-power plant in Garissa*. Retrieved from http://cleanleap.com/kenya-build-east-central-africa's-largest-solar-power-plant-garissa.

Plastic bags and the circular economy in Kenya. (n.d.). Retrieved from https://kenyacic.org/news/plastic-bags-and-circular-economy-kenya

Roy, D. (n.d.). *Kenya to build 10 MW waste-to-energy electricity plant*. Retrieved from http://www.africanreview.com/energy-a-power/power-generation/kenya-to-build-10mw-waste-to-energy-electricity-plant.

Rutten, G. (2018, March 12). *In Kenya, the circular economy modernizes small-scale farming*. Retrieved from https://www.greenbiz.com/article/kenya-circular-economy-modernizes-small-scale-farming.

Timmermans, F. 2015. First Vice-President Timmermans' and Vice-President Katainen's opening remarks at the presentation of the Circular Economy package. 2 December 2015. Transcript published by the European Commission, Brussels https://europa.eu/rapid/press-release_SPEECH-15-5614_en.htm. Accessed 17 April 2017.

Circular Economy in Malaysia

P. Agamuthu and S. B. Mehran

Abstract Circular economy is a concept that aims to improve resource efficiency by minimizing resource consumption and waste generation. The implementation of circular economy can be conducted at three levels: in single enterprise or group of enterprises, in a group of collocated firms and at the city or municipal level. Currently, implementation of circular economy in Malaysia is at firm level. There is a lack of legal framework on the implementation of circular economy in Malaysia. However, there are certain sections and regulations in Environmental Quality Act 1974, Solid Waste and Public Cleansing Management Act 2007 and in Environmental Quality (Scheduled Waste) Regulation 2005, respectively, that promote resource circulation. Nationwide initiatives taken to promote circular economy are inclusion of integration of sustainable production and consumption, reduction of 40% of greenhouse gas emissions intensity from GDP compared to 2005 level and 22% of recycling of MSW, in Eleventh Malaysian Plan. Additionally, SWCorp has launched SWCorp Strategic Plan to promote sustainable solid waste management services, and CIDB has initiated CITP that has a target of incorporating 20% of recycled construction and demolition waste (tonnage) by year 2020 from baseline of 2016. Also, there are guidelines on coprocessing and proposals on establishment of industrial ecology by DOE. A few case studies show implementation of circular economy in manufacturing industries. The benefits of these implementations were reduction in energy and resource consumption, reduction in waste generation, protection of environment and human health, cost savings by reusing or recycling waste and additional profit gains by selling waste to potential buyers. Several opportunities of sustainable waste management and resource circulation have been highlighted in this chapter such as manufacturing of bioproducts and butanol from biomass to coprocessing between ELVs and construction industry. To successfully implement circular economy, top-down and bottom-up approach is required, and currently, Malaysia does not have explicit top-down and bottom-up approaches.

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1 Introduction

Circular economy (CE) or the closed-loop economy is a concept that aims to improve resource efficiency by slowing, closing and narrowing material and energy loops to minimize overall resource and energy input and as well as waste generation (Ghisellini et al. 2016). It is suggested that circular economy can be implemented at three levels: in single enterprise or a group of enterprises, in a group of collocated firms and at city or municipal level. At the first level, resource and energy efficiency are achieved by implementation of cleaner production in a single enterprise or in a group of enterprises. To implement CE at the second level, the establishment of eco-industrial parks or industrial symbiosis is required by collocating a group of firms, e.g. Kalundborg, Denmark. The outcome is the enhancement of collective energy and resource efficiency by sharing a certain stream of energy and resources. Third level, so far mainly found in China, requires whole municipal area or city that engages in recycling and interconnected processes with the help of economic and administrative incentives (Mathews and Tan 2011).

Conceptually, circular economy is currently being promoted by European Union and other nations such as Germany, France, Canada, China and Japan (Korhonen et al. 2018). In Asia, China and Japan are the two countries that have institutionalized circular economy. In 2008, China enacted the legislation on circular economy which came into effect the following year, 2009. Unlike most countries in the world, circular economy is not incorporated in environmental policy in China, but it is rather in the national development and economic policy. In the world, China is the first country to incorporate circular economy in the national strategy of economic and social development; whereas, Japan, USA and Germany, have incorporated circular economy in environmental and waste management policies (Ghisellini et al. 2016). China is the only country at present, where the top-down approach (through institutionalization) is being complimented by a bottom-up approach (private initiatives taken at firm levels) to implement circular economy.

Circular economy in Malaysia is still an unofficial long-term goal as the legal framework is lacking. But there have been sporadic practices of cleaner production at firm levels in Malaysia. Legal framework for waste management, in the light of circular economy, is still in its early stages as only in 2007, and Solid Waste Management (SWM) Act was introduced in Malaysia (Fauziah and Agamuthu 2012). In this SWM Act, main emphasis has been given on segregation at source and recycling in municipal solid waste. On the contrary, the practice of 3R and/or decoupling of resource consumption from economic development is not part of the legislation on hazardous waste in Malaysia. However, there are proposals and programs for initiation of industrial ecology and eco-waste parks in government agencies like Department of Environment (DOE) Malaysia and Malaysian Investment Development Authority (MIDA), respectively. There have also been practices of waste exchange and reuse of hazardous waste in Malaysia, but it is not widely practised among industries. DOE Malaysia has also been promoting coprocessing, especially in cement manufacturing plants since May 2015. All nine cement plants in Malaysia are practicing coprocessing at present. Yet, no clear pattern of reduction in the generation of hazardous waste from industries was observed in the last seven years.

The terminology used for waste exchange by DOE is coprocessing. Coprocessing is defined as waste utilization as raw material or as energy source or both in a manufacturing process. Therefore, the practice of waste exchange in this chapter will be mentioned as coprocessing. Lastly, hazardous waste is referred as scheduled waste in Malaysia. Hence, the hazardous waste will also be described as scheduled waste from here on.

In this chapter, environmental legislations and national plan are explained that may promote circular economy indirectly. Then, research models proposed by DOE and Ministry of Automotive Association are discussed, followed by case studies of implementation of circular economy at enterprise level. Afterwards, the practice of coprocessing and factors promoting and inhibiting the successful implementation of circular economy are discussed. At the end, the benefits of implementation of circular economy are listed, followed by international collaborations for implementation of circular economy.

2 Legislations

The environmental protection law in Malaysia was introduced in 1974 as Environmental Quality Act (EQA) 1974 (Department of Environment 2018a). Until now, a total of 31 regulations and orders on environmental protection have been ratified since 1974. The initial environmental legislations were focused on protecting environment from pollution originating from palm oil and rubber industry. Then, scheduled waste started to become a major problem, and in 1989 regulation on scheduled waste was enacted. However, after full amendment on 1989 scheduled waste regulation, updated regulations on scheduled waste were passed as legislation in 2005 (Isa 2012). Then in 2007, a second act was introduced on solid waste management pertaining to municipal solid waste. Interestingly, even though Malaysia has several legislations on protecting the environment from pollution, one can contravene it after acquiring a licence. A list of legislations on environmental protection and resource circulation is shown in Fig. 1.

Unlike other Asian countries, i.e. China, Japan and Malaysia do not have any legislation specifically on circular economy. Nevertheless, there are some sections in two environmental acts and in Scheduled Waste Regulation that promote 3R (reduce/reuse, recycle, recover) and can establish the foundation for implementation of circular economy (Table 1). The regulation 7 in Environmental Quality (Scheduled Waste) Regulation 2005 is especially being administered by DOE to promote reuse and recycling of scheduled waste generated from industries. Kualiti Alam is the only licenced scheduled waste management company in peninsula Malaysia that treats and disposes off hazardous waste. But the special management of scheduled waste in this regulation refers to waste management by the unlicenced facilities,

Legislations Related to Environmental Protection and Resource Circulation

- Environmental Quality Act, 1974
- Environmental Quality (Scheduled Waste) Regulation, 2005
- Solid Waste and Public Cleansing Management Act, 2007

Legislations Related to Environmental Protection

- Environmental Quality (Prescribed Premises) (Crude Palm-Oil), 1977
- Environmental Quality (Prescribed Premises) (Raw Natural Rubber), 1978
- Environmental Quality Clean Air Regulations, 1978
- Environmental Quality (Sewage and Industrial Effluents) Regulation, 1979
- Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulation, 1985
- Environmental Quality (Refrigerant Management) Regulation, 1999
- Environmental Quality (Halon Management) Regulation, 1999
- Environmental Quality (Dioxin and Furan) Regulation, 2004
- Environmental Quality (Industrial Effluent) Regulation, 2009
- Environmental Quality (Control of Pollution From Solid Waste Transfer Station and Landfill) Regulation, 2009
- Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 2015

Fig. 1 Malaysian legislations related to environmental protection and resource circulation

Table 1 Regulations and sections of Malaysian environmental law that promote resource circulation

Legislations	Regulation/section/subsection	Description
Environmental Quality Act 1974	**Section 21** (Power to specify conditions of emission, discharge, etc.)	Minister may set the limits on the emission, discharge or deposit of pollution, hazardous material or waste
	Section 30A (Power to control use of substance and product and to state environmental labelling)	Minister may prescribe a substance to be reduced, recycled, reused or a product to contain a minimum percentage of recycled substance
	Section 51 (Regulations)	Minister may make regulations that are in accordance to Environmental Quality Act 1974
Environmental Quality (Scheduled Waste) Regulation 2005	**Regulation 7** (Application for special management of scheduled wastes)	Waste generator can apply for their scheduled waste treated, disposed of or recovered in premises or facilities other than prescribed premises or facilities
Solid Waste and Public Cleansing Management Act 2007	**Section 101** (Reduction, reuse and recycling of controlled solid waste)	Minister may require reduction, reuse and recycling of controlled solid waste
	Section 102 (Take back system and deposit refund system)	Minister may introduce extended producer responsibility

Source Department of Environment (2018a, b) including the industry itself. Under this regulation, industries have more control over the management of their waste as they can opt for reuse and recycling of scheduled waste, instead of sending it to prescribed facility for final disposal. A detailed discussion on the special management of scheduled waste is elucidated in the discussion and analysis section. Solid Waste and Public Cleansing Management Act, 2007 is directed towards the management of municipal solid waste, construction and demolition waste, agricultural waste, etc. There are sections in the Solid Waste Act that promote resource circulation by implementation of 3R and promote extended producer responsibility. Lastly, Environmental Quality Act 1974 also presents the legal binding of protecting environment from the release or generation of pollutants and waste, respectively. Moreover, section 30A in EQA 1974 also gives the power to the Minister to prescribe the practice of 3R (reduce, reuse and recycle) and/or reduce the consumption of raw material by using the recycled material. Nevertheless, section 30A cannot be enforced until the Minister, after consultation, approves such practices. Hence, no binding legislations related to circular economy have been introduced into the Malaysian environmental law.

Malaysia launched its latest national plan, Eleventh Malaysian Plan, from year 2016 to 2020. In this national plan, a great emphasis has been given on the adaptation of sustainable consumption and production. The national target of MSW recycling is 22% by the end of Eleventh Malaysian Plan. To completely implement sustainable consumption and production, dependency on unrenewable energy sources must decrease while at the same time dependency on renewable energy sources must increase. Malaysia regards wind, geothermal and ocean energy sources as the potential sources. Hence, current national plan aims at research and development on renewable energy sources. The national target of installation of renewable energy capacity is 2080 MW, and consequently, aims at 40% reduction in GHGs emission intensity from gross domestic product (GDP) in comparison with 2005 level. Under the umbrella of Eleventh Malaysian Plan, sustainable consumption and production will be achieved by following the strategies that focus on renewable energy and holistic waste management. Before the introduction of current national plan, waste management had been implemented independently by several agencies such as Department of Environment for scheduled waste, Solid Waste Management and Cleansing Corporation (SWCorp) for municipal solid waste, construction and demolition waste and others. Since the target is to formulate a holistic approach towards waste management including all types of wastes: agriculture, solid, sewage, construction, mining, radioactive and scheduled waste; it is suggested that these agencies would be working together on a shared platform for the successful enforcement of holistic waste management. Moreover, investments on "waste as resource" are planned to increase so that waste could be recycled, reused, reclaimed instead of current method of disposal at landfills (Eleventh Malaysian Plan 2018). It is worth noting that Malaysia has recycling target for MSW only. There are no targets or goals for other types of waste, especially related to hazardous or non-hazardous waste generated from industries. However, the consensus among government agencies is that the larger goal of waste management is to move towards zero waste nation. So, the recycling target for MSW is only the beginning.

In 2009, at the 15th Conference of Parties in Copenhagen, Denmark, Malaysia, voluntarily agreed upon reduction in the emission intensity of GDP by up to 40% by 2020 from 2005 level, and this has been added in the Eleventh Malaysian Plan. Furthermore, the goal of sustainable production and consumption is also aligned with 12th Sustainable Development Goal "Responsible Consumption and Production" as it was incorporated in the national plan. Another international treaty that Malaysia enacted is Basel Convention. There are three main objectives of Basel Convention. Firstly, it aims to reduce hazardous waste generation, in terms of quantity and quality of the hazardousness. Secondly, Basel Convention intends to reduce the movement of hazardous waste internationally, which thus leads to its third objective which is to dispose the hazardous wastes in proximity to the source of the generation of hazardous wastes. Malaysia incorporated Basel Convention in their Scheduled Waste Regulation 2005 to stop the transboundary movement (Isa 2012).

Solid Waste Cooperation (SWCorp) launched the SWCorp Strategic Plan 2014–2020 for the promotion of sustainable solid waste management services in accordance with government's effort for it. This plan is part of the planning of SWCorp to strengthen the solid waste management services and aims towards a clean nation by 2020 through implementation of several strategies. These strategies cover a broad range of aspects relating to public awareness (including awareness on waste to wealth and waste to energy), change in behaviour, sustainability, improving solid waste management facilities and technologies, enforcement of existing legislations and policies, research and development (Mohr and Manaf 2017). This plan also realizes the fact that sustainable solid waste management will only be possible by implementation of circular economy; therefore, all the strategies must work towards the long-term goal of zero waste nation.

When it comes to construction and demolition waste in Malaysia, although there are no legal requirements in practicing resource circulation, a program titled "Construction Industry Transformation Program (CITP)" was initiated by Construction Industry Development Board (CIDB). Under CITP, sustainable development is aimed through several initiatives. The initiative related to resource circulation is "Reduce irresponsible waste during construction", and the target is to utilize 20% of recycled construction and demolition waste (tonnage) by year 2020 from the baseline of 2016 (CITP 2018).

In conclusion, Malaysia is currently lacking an official top-down approach to implement circular economy or resource circulation, unlike China and Japan. Despite the absence of direct legislations on circular economy, the need for resource circulation and sustainable waste management has been realized among the government agencies. Therefore, several initiatives have been taken, and targets have been set until year 2020. Nevertheless, in the absence of explicit regulatory framework on circular economy, becoming a zero waste nation would be nearly impossible for Malaysia.

3 Research Models

The research models described in this section are based on the proposal of the Department of Environment (DOE) on industrial ecology and the proposal of the Malaysian Automotive Association on processing of End-of-Life Vehicles (ELVs). These research models do not represent the basis of CE implementation for all sectors. But, they do provide the realization among Malaysian authorities on potential opportunities in waste to wealth and waste to energy alternatives.

DOE released guidelines on coprocessing of scheduled waste in cement industry on 25 May 2015. A list of scheduled wastes that can be used as raw material or additive is given in the guidelines. Due to Malaysia's heavy reliance on coal-fired power plants, the fly ash and bottom ash are seen as potential raw material. Based on the category of scheduled waste, fly ash and bottom ash, in addition to dross, slag and clinker, are generally the highest amount of waste generated in Malaysia annually. In 2016, 44.2% of total scheduled waste generated was ash/dross/slag/clinker. Moreover, the second highest amount of scheduled waste generated in Malaysia is gypsum (20.2%), followed by heavy metal sludge (13.61%). Therefore, there is a huge potential for coprocessing in cement industry. The list of scheduled wastes required as alternative raw material or additive is given in Table 2. In the guidelines, a criterion is given for selecting the scheduled waste as raw material alternative, additive or fuel source. Depending on the demand, scheduled wastes can be added to different stages of cement manufacturing process (Fig. 2).

Furthermore, DOE is also promoting industrial ecology and a proposal of establishment of industrial ecology of two types of waste, namely abandoned vehicle and bleached earth are discussed here. In bleached earth management, bleaching earth factory, palm oil mill and acetylene manufacturing plant are proposed to exchange the waste (Fig. 3). Bleached earth from bleaching earth factory will be utilized by palm oil mill, and spent bleached earth will be transferred to soil conditioner; whereas, residue gypsum waste will be available for coprocessing as well for soil conditioner. Calcium hydroxide from acetylene manufacturing plant will be utilized by bleaching earth factory in neutralization process.

Table 2 List of scheduled waste generated in Malaysia and its potential use in cement industry

Type of scheduled waste	Potential usage
Castoff copper slag Spent pot linings Castoff garnets	Alternative raw material
Sludges containing one or more metals: lead, chromium, nickel, copper, zinc, aluminium, tin, cadmium, vanadium and beryllium	
Fluoride containing sludges	
Fly ash from coal-based power plant	Cement additive
Gypsum from power plant Gypsum from chemical plant	

Fig. 2 Processes where scheduled waste can be utilized in cement manufacturing process

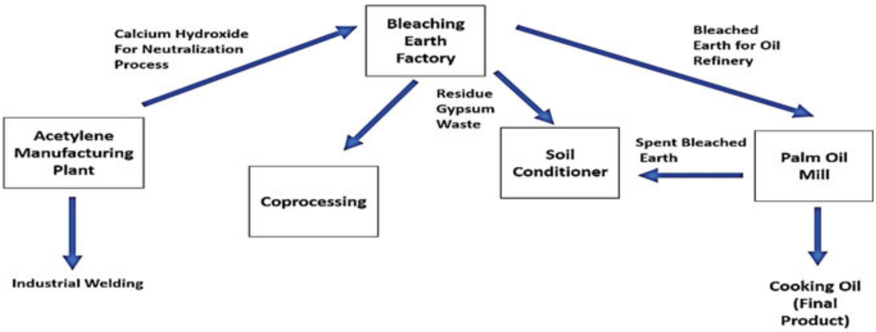

Fig. 3 DOE proposal of industrial ecology for bleached earth plant

In the proposal for abandoned car management, steel manufacturing industry and energy recovery facility are the main facilities that will utilize potential resources from metal recovery and energy recovery from shredded automotive residue (Fig. 4). First abandoned cars will undergo shredding, then plastic and metal will be separated. At this stage, iron will be utilized by steel manufacturing plant, and plastic will be transferred to plastic recovery recycle facility. Shredded automotive residue

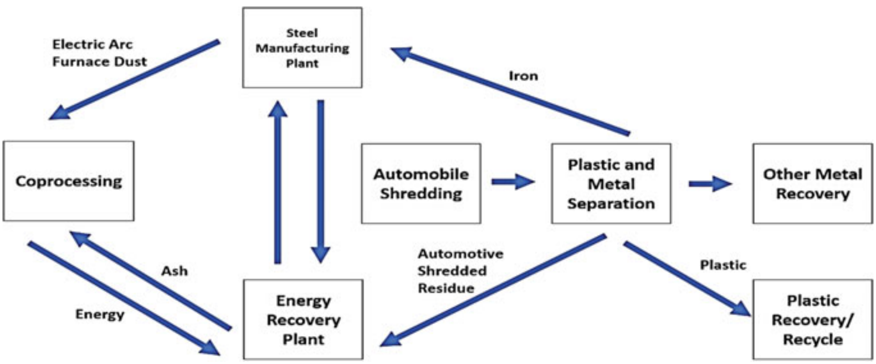

Fig. 4 DOE proposal of industrial ecology for abandoned vehicles

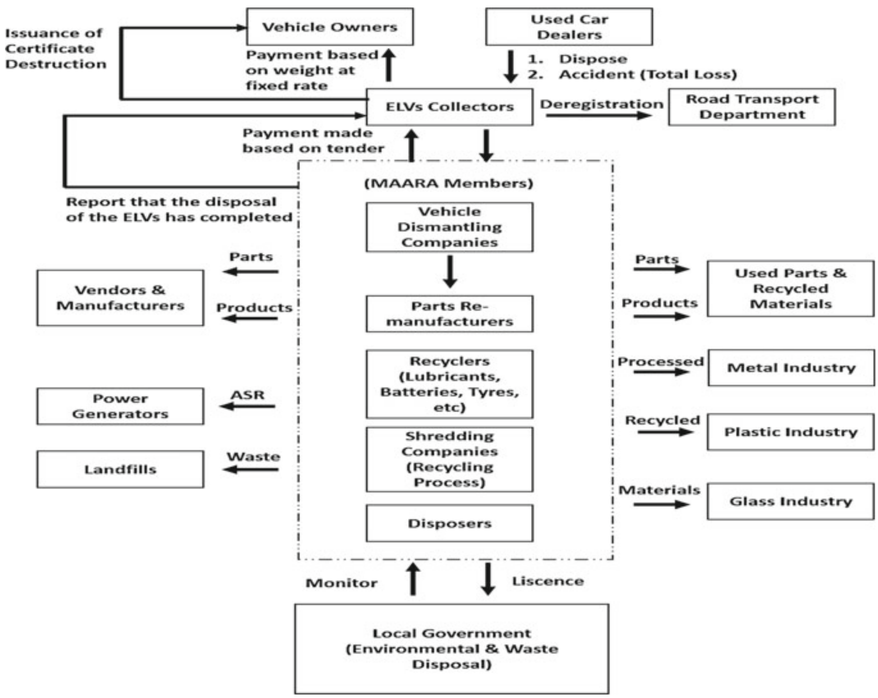

Fig. 5 Proposal of ELVs management (Wong et al. 2018)

will be used for energy recovery. On the other hand, electric arc furnace dust from steel manufacturing plant and ash from energy recovery plant will be available for coprocessing to the requisite industry.

Lastly, a more in-depth proposal was presented by the Malaysian Automotive Association for processing End-of-Life Vehicles (ELV) that is also in line with the proposal of industrial ecology by DOE (Fig. 5). In the proposal of Malaysian Automotive Association, deregistration of vehicles ought to be performed before the dismantling of ELVs. The next step is to acquire the Certificate of Destruction (COD) and to pay depending on the value of fixed scrap imposed by ELV collectors. After the necessary paperwork, under the monitoring of local government (Environmental and Waste Disposals), the procedures starting from disassembling to discarding will be performed by involving parties, such as corporations of vehicle dismantling, parts remanufacturing companies, recycling firms, shredding companies and waste disposing organizations. This is where the implementation of industrial ecology will take place by the participation of several parties, and waste will be incorporated as resource and/or energy resource in several processes depending on the relevant industries. The components of ELVs after dismantling will be reused (that are usable) by vendors and remanufacturers, and ELVs after shredding will be processed and recycled in form of new products (Wong et al. 2018).

The industrial eco park of ELVs management also has the potential of creating industrial symbiosis with construction industries. The proposed concept outlining the ELV processing from automotive to the construction industry revealed the following opportunities of waste exchange. Since ELV processes involve dismantling and shredding, the following materials can be utilized by construction industry after dismantling stage; seats, carpet, plastics and tyres, all of which can be recycled. Whereas, the second stage of ELV processes is shredding. There are two types of shredding processes that are employed, i.e. light and heavy shredding. Depending on the type of shredding carried out, coprocessing can be achieved by following activities: production of raw materials from smelting and refining, creating smelted products from aluminium scraps and recycling (non-metallic residue treatment). The end products of coprocessing will be insulation materials, flooring materials, concrete blocks, foundation, roof tiles, aluminium cladding, composite panels, structural glazing, container buildings, partition walls, windows and interior furniture (Wong et al. 2018).

4 Case Studies

The case studies demonstrated here are based on the implementation of closed-loop initiatives or cleaner production at the enterprise level. However, the implementation of closed-loop initiatives at each enterprise level has resulted in industrial cascade of waste transfer. Hence, instead of sending waste to landfill for final disposal, the waste was sent to respective companies for utilization of waste as resource.

4.1 Oleochemical Processing Plant

As evident in the Eleventh Malaysian Plan, there is a growing realization of sustainable development by balancing the economic and industrial growth in conjunction with environmental preservation and protection, as well as efficient utilization of energy sources. The expansion of oleochemical industries in Malaysia has been contributed by several factors such as the availability of raw materials (palm oil), the fluctuations in petroleum prices, regular animal diseases (which made tallow-based fats unreliable) and the high demand for downstream products such as fatty acids, fatty alcohols and glycerine. Therefore, the expansion of industry has resulted in manufacturing of additional products, i.e. soap noodles, esters, fatty alcohols, oleic acid, etc. Consequently, the expansion of oleochemical industry and the production of downstream products have led to complex waste generation. Wastes generated from oleochemical industry are filter cake, biological sludge, steam condensate, spent nickel catalyst, glycerine pitch, fatty acids residue, wastewater and flue gas.

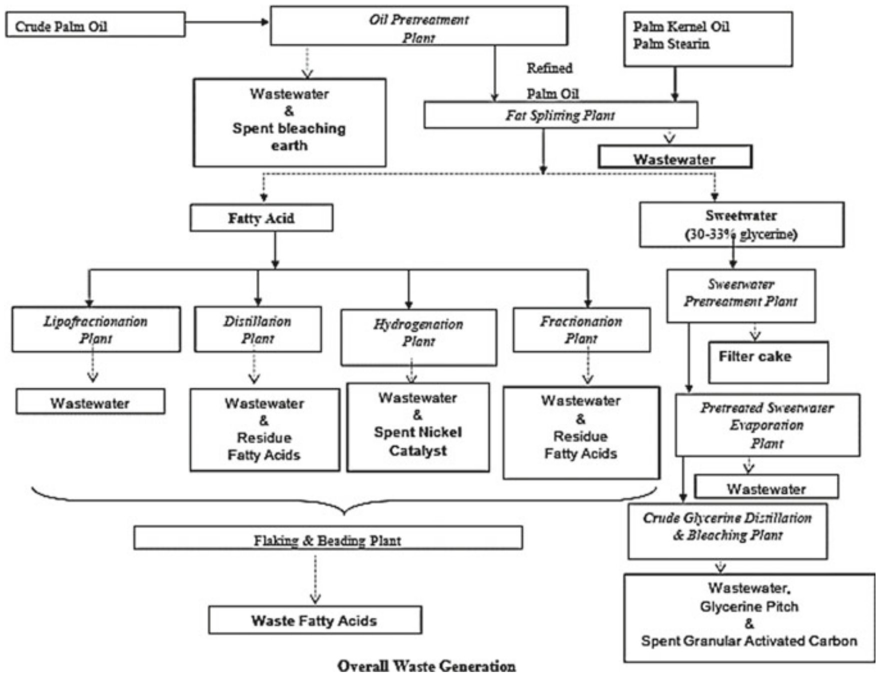

Fig. 6 Processes involved in oleochemical processing plant (Agamuthu 2001)

An example of complex waste generated from oleochemical industry is given here and is based on the source (Agamuthu 2001). The Palm-Oleo Sdn. Bhd. plant processed 364 metric tons of oil daily and in result produced a total of 20 metric tonnes of waste. There were multiple waste streams due to the extensive manufacturing processes (Fig. 6). The oil pre-treatment process generated 2.2 tonnes of spent bleaching earth daily, and after the pre-treatment the oil would go through fat splitting process. Fatty acids from fat splitting process then went through four different processes separately such as lipofractionation, distillation, hydrogenation and fractionation. While residue fatty acid was generated from distillation and fractionation process, 0.17 tonnes spent nickel catalyst was generated from hydrogenation process. Flaking and beading process also resulted in the generation of fatty acid waste. A total of 14.2 tonnes of residue fatty acid was generated from the above-mentioned processes. The pre-treatment of sweetwater generated 0.78 tonnes of filter cake waste. From crude glycerine distillation and bleaching plant, 0.49 tonnes of glycerine pitch and 1.3 tonnes of spent activated carbon were generated, respectively. Wastewater was also produced from all the processes, and a total of 0.62 tonnes of wastewater sludge was generated from the treatment of wastewater. The only scheduled waste generated from manufacturing processes was spent nickel catalyst.

From the oil pre-treatment process, spent bleaching earth was treated by oil extraction process using hexane to remove the oil from the earth material. After the analysis, the ratio of 1:3 (wt:vol) of spent earth to hexane was found to be optimum ratio for oil extraction. Whereas, from distillation and fractionation process, residue fatty acids were recycled back in fat splitting plant to produce sweetwater and split residue fatty acids. While glycerine was manufactured from sweetwater, split residue fatty acids went through hydrogenation and distillation processes to produce 80% of fatty acids and 20% of fatty acid pitch that were sold. Research on methods of managing spent nickel catalyst waste revealed the possibility of reuse of spent nickel catalyst. Therefore, spent nickel catalyst was reused back in the hydrogenation process by taking 15 kg of spent nickel and 5 kg of virgin nickel. Lastly, spent activated carbon was reused for treated wastewater bleaching process. Due to reuse, recycling and reclaiming, the demand for virgin raw materials by the production plant and the quantity of total waste generated were reduced. It also resulted in total savings of RM 1 million a year. After the findings of waste audit and research, the execution of cleaner production led to the practice of 4R (reduce, reuse, recycle, reclaim).

4.2 Acetylene Plant

This Malaysian case study is a good example of industrial cascade and is based on the source (Agamuthu 2001). An acetylene production plant at Sitt Tatt Industrial Gases that produced 2400 m^3 of acetylene from 900 kg of calcium carbide and 6000 L of water daily (Fig. 7). The by-product of acetylene production was generation of carbide sludge which was in slurry form with pH of 12–13. DOE limit of pH is 6–9 and anything below or above this range is considered scheduled waste. So, approximately 3800–4200 tonnes of scheduled waste in the form of carbide sludge were being generated annually. Before the implementation of closed-loop initiative,

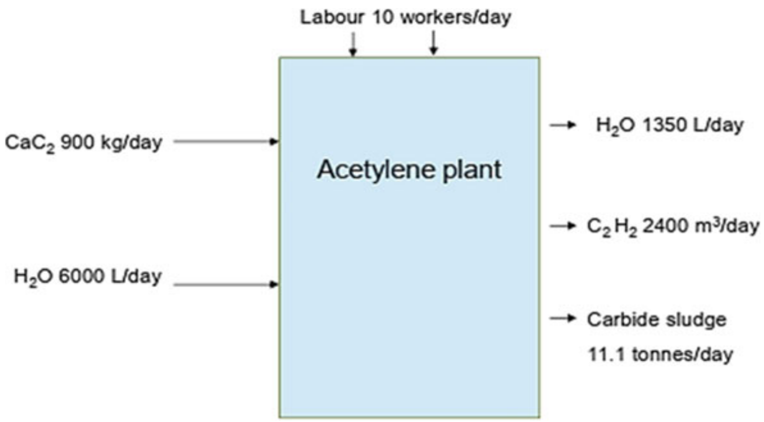

Fig. 7 Mass balance of acetylene manufacturing plant at Sitt Tatt Industrial Gases before the implementation of closed-loop initiative

ponding system was used for sludge treatment. After the treatment, the sludge was sent for final disposal at landfill. However, the treatment of sludge in ponding system turned out to be inefficient as it required greater space for expansion and was an environmental hazard due to potential health hazard to acetylene plant workers. The situation used to get worse in rainy days as sludge would overflow and pollute the surrounding monsoon drains resulting in odour problems.

For reducing waste generation, vacuum filtration was deployed to extract water from the sludge; whereas, flocculation technology was implemented to render carbide slurry as resource for potential buyers. Therefore, by investing RM 1 million in carbide sludge waste treatment and recovery facility, acetylene manufacturing company could save a total of RM 500,000 per year by recycling water and avoiding landfill charges (RM 300,000 by recycling water and RM 200,000 by avoiding landfilling). Moreover, medical expenses were also avoided by 20% (RM 31,000 per year) due to the elimination of health hazards by termination of ponding system for carbide sludge treatment. The treated carbide sludge was sold at RM 1,200 per tonne to another cosmetic manufacturing company that required basic material for neutralization. Hence, it resulted in the income of RM 1 million annually. Therefore, total waste generation was minimized by adopting cleaner technology and cascading waste between two manufacturing industries. Moreover, the implementation of cleaner technology also reduced the intake of freshwater for manufacturing processes.

4.3 Tex Cycle Sdn. Bhd.

Tex Cycle Sdn. Bhd. comes under the Tex Cycle Technology Berhad which is an investment firm for several other companies as well. Tex Cycle Sdn. Bhd. is an ISO 14001 certified company that recycles and recovers scheduled waste in Malaysia. It collects contaminated used rags, wipes, gloves and containers/drums, etc., from various companies. Moreover, Tex Cycle also converts damaged materials into safe recyclable products that are suitable for reuse. It has over 1000 customers from all over Malaysia. The following case study is based on the source (Tex Cycle, n.d.).

Scheduled waste is transported from waste generator to Tex Cycle; then the scheduled waste is weighed and sorted out depending on the type. Afterwards, in the recycling section, contaminated rags/wipes/gloves are washed in industrial washing machines and dried. Then, they are sent to the finishing section where they are folded and packed. From the finishing section, washed materials such as rags, wipes, gloves are either sent back to respective companies for reusing, or sent to recyclers (cleaned rubber material is sent to rubber recyclers) or converted into new coproducts. On the other hand, contaminated containers/drums are washed in the triple rinse washing system and after drying are either sent back to respective companies or to respective recyclers. At the end of the cleaning processes, two types of waste are generated: damaged materials and wastewater. The complete cycle of recycling is shown in Fig. 8.

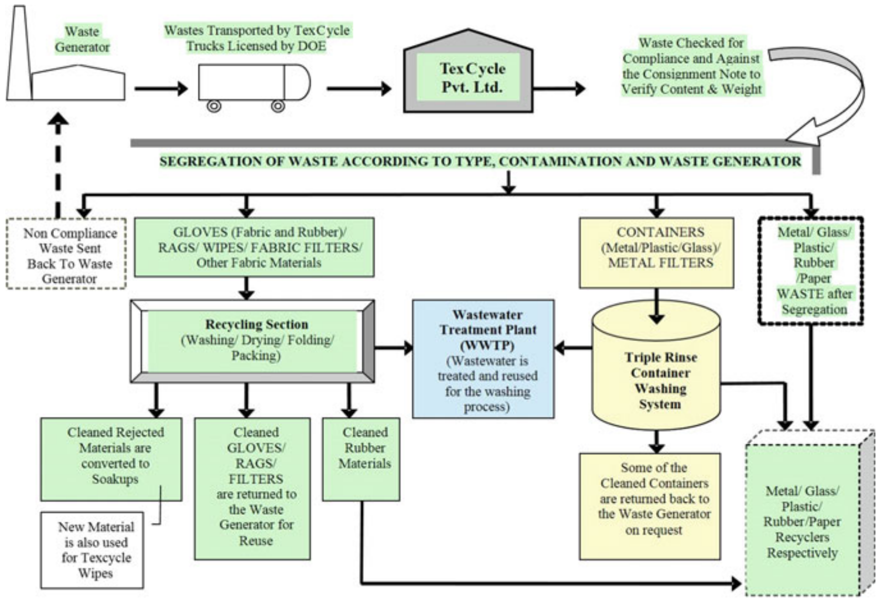

Fig. 8 Flow diagram of processes related to recycling of scheduled waste at Tex Cycle Sdn. Bhd.

Raw wastewater is treated on-site. The main steps in wastewater treatment are electro-coagulation, ozone diffusion (applied in two separated steps) and treatment with UV light, activated carbon as well as reverse osmosis process (Fig. 9). Hence, wastewater is recycled and is reused for the washing step again. Whereas, damaged materials (rags/wipes, etc.) after washing are converted into coproducts such as shoe covers, chemical spillage soak-ups, wipes and floor mats.

The annual savings from reducing freshwater intake by recycling wastewater are RM 63,000. Energy input is also reduced by using solar energy in heating water for washing and for sludge treatment (lime is also added to sludge to reduce the drying time). Additionally, coproducts like Tex Cycle (TC) sorbent bags, wipes are also rented by industries. Their durability is higher than other wipes, hence they last longer. Besides, waste materials are received and additional profit is also gained by Tex Cycle by selling these coproducts to other recyclers.

4.4 Building Construction at University Technology Petronas

Usually, the management of construction and demolition (C&D) waste in Malaysia involves illegal dumping at roadsides; whereas, a minimal quantity of C&D waste is disposed at landfill. Furthermore, the composition of C&D waste generated in Malaysia is shown in Fig. 10. Pertaining to C&D waste, a three-storey office build-

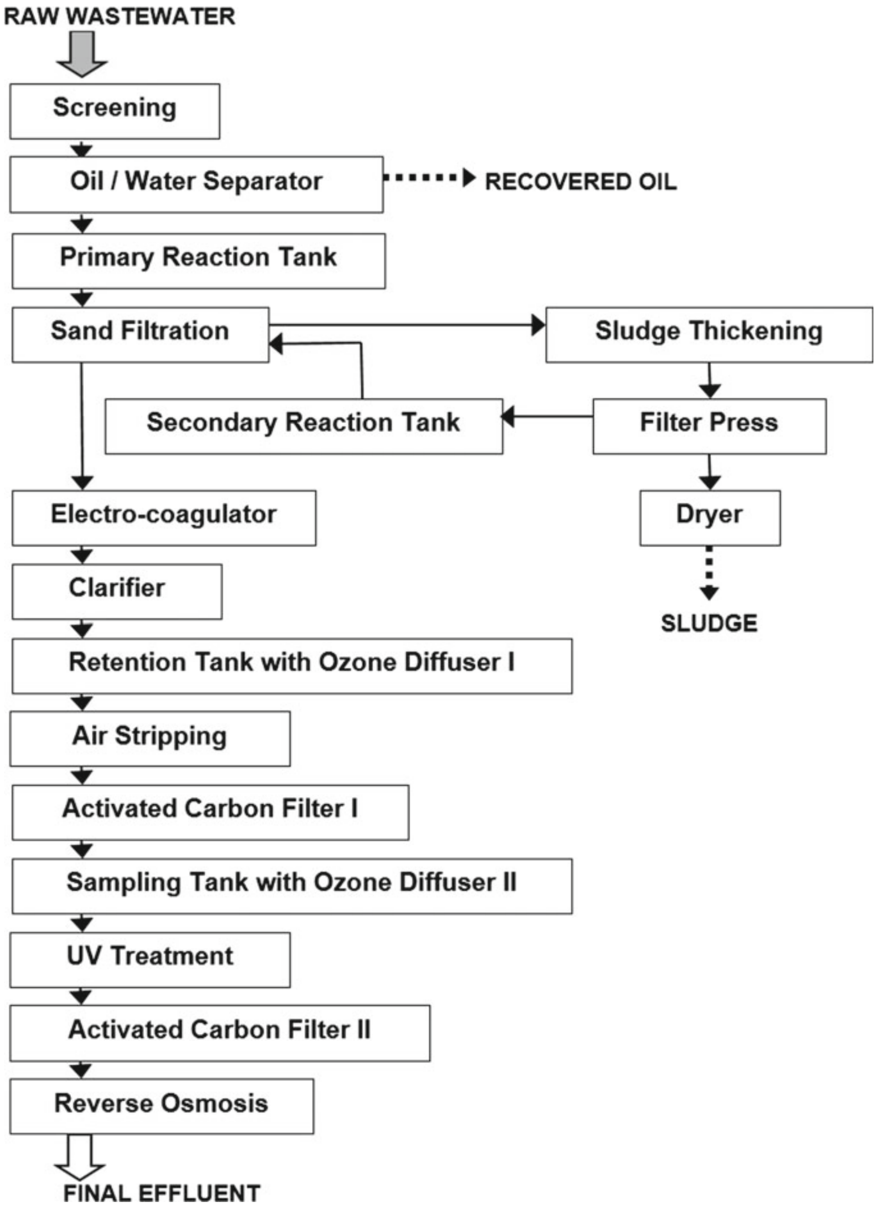

Fig. 9 Wastewater treatment at Tex Cycle Sdn. Bhd

ing was being constructed in the campus of University Technology Petronas that is located in Seri Iskandar, Perak, Malaysia.

This case study, based on the source (Umar et al. 2016), concerns a construction site comprised of 21,225 m^2. The methods taken to reduce operational waste generation were just-in-time approach, site assessment and adequate and secured storage of materials. The construction material was ordered only when it was required; therefore, waste generation from storage of materials for long period of time was avoided. Continuous supervision and assessment of construction site throughout construction further reduced the waste generated as construction activities were supervised. An appropriate and secure storage site was selected on-site to store glass, plasterboards, etc. During construction, recovery of timber offcuts for creating jack studs, noggins and blocking was executed by place makers; whereas, supplier took drainage, plumbing and polystyrene offcuts (resulting from sheathing). Polystyrene offcuts were utilized for recycling.

In addition to the measures taken to avoid waste generation during construction activities, C&D waste generated was recycled and reused (Table 3). Three types of waste were generated from construction of three-storey building, namely timber (74 truck load), metal scraps (5 truck load) and domestic waste (28 truck load). Timber and metal scraps were reused. Hence, 73% of C&D waste was recycled or reused. Assortment of antiseptic wood waste was performed, followed by shredding into woodchips. The potential utilization of these woodchips can be in the form of producing compost and animal bedding, or manufacturing of particleboard, or application as biofilter medium. This is quite an achievement in itself as the general practice of C&W waste management is either illegal dumping or disposal at landfill.

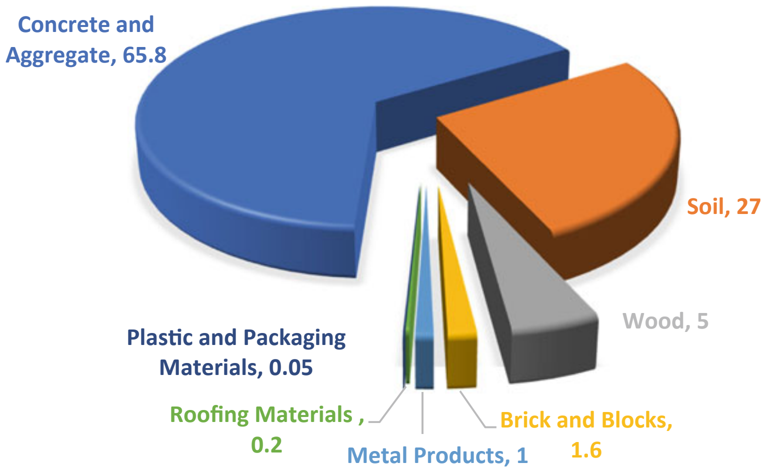

Fig. 10 Composition of construction and demolition waste in Malaysia (Begum et al. 2007)

Table 3 Management of construction and demolition waste generated from construction site at UTP, Perak, Malaysia (Umar et al. 2016)

Type of construction and demolition waste generated	Measure taken
During construction	
Timber offcuts	Reclaimed
Plumbing and drainage offcuts	Taken back by supplier
Polystyrene offcuts	Recycled
At the end of construction	
Timber	Recycled/reused
Metal scraps	Recycled/reused
Domestic waste	Disposed at landfill

5 Discussion and Analysis

There are several reports released by government authorities that provide the latest data on environmental performance. For instance, pollution inventory data including scheduled waste generation is given in Environmental Quality Reports. Based on the Environmental Quality Reports of the last eight years (2009–2016), it is evident that scheduled waste in Malaysia has been managed by several methods such as by prescribed activities that include final disposal in secure landfill or incineration, by recovery and by special management. As mentioned in the legislation section above, under regulation 7 of Environmental Quality (Scheduled Waste) Regulation 2005, Department of Environment Malaysia has been promoting the special management of scheduled waste. The special management referred to is directing the scheduled waste towards unlicenced facilities especially for recycling and reuse. Moreover, special management of scheduled waste by unprescribed facilities also practises the treatment of hazardous waste to render it unhazardous and eventually disposed at sanitary landfill. The management of scheduled waste by prescribed facilities is strikingly less compared to other waste management options (Fig. 11).

Since 2010, approximately 50% of scheduled waste generated has been approved contingently for handling under special management. Whereas, the second most practiced approach is recovery of waste at local and foreign facilities. In 2016, 28% of scheduled waste generated was reused after going through special management. The amount of scheduled waste reused has been approximately above 20% for the last seven years (2010–2016), except for year 2010 when it was 19.7% (Fig. 12). Majority of the scheduled waste that is reused is fly ash and bottom ash generated by industry and coal-fired power plant. While fly ash and bottom ash have been utilized by cement manufacturing industries in Malaysia, other scheduled waste such as heavy metal sludge, mineral sludge, gypsum, spent mixed oil, glue, contaminated active carbon and petroleum by-products are reused back by the respective companies that generate these scheduled wastes. On the other hand, the amount of scheduled waste recovered at local and foreign facilities has been variable for the last eight years (2009–2016). The highest amount of waste sent for recovery was 40.4% in 2009,

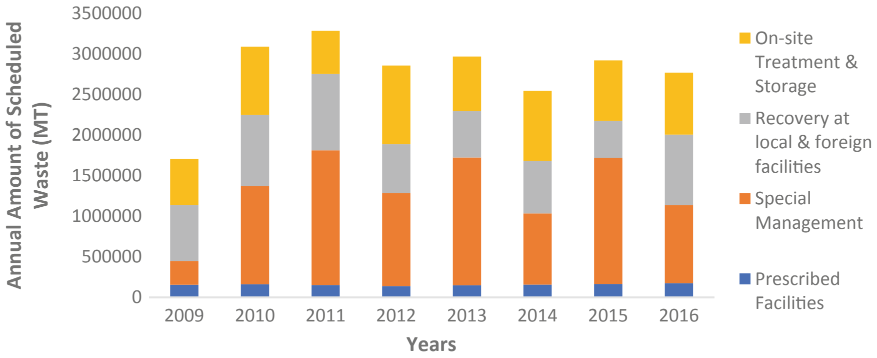

Fig. 11 Management of scheduled waste generated in Malaysia annually from 2009 to 2016 (Environmental Quality Report)

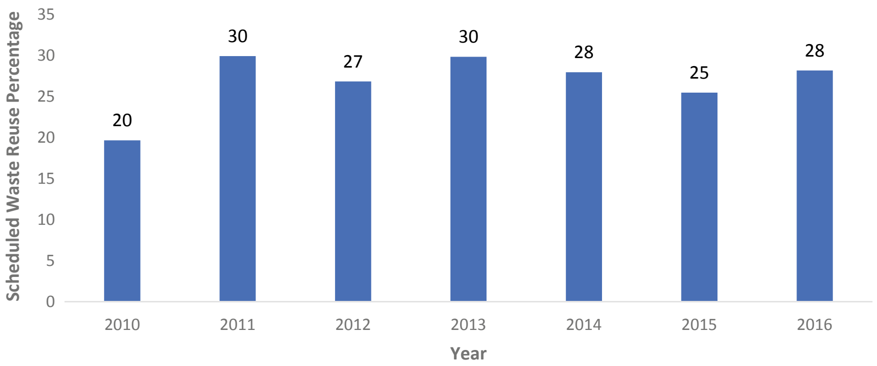

Fig. 12 Total percentage of scheduled waste reused under special management (Environmental Quality Report)

and the lowest amount of waste sent for recovery was 15.5% in 2015 (Fig. 13). In 2010, out of 1,206,568.31 metric tonnes of scheduled waste managed under the special waste management, 50.34% was reused as raw material in industries and the rest (49.64%) was emplaced at approved sanitary landfill. It is evident that even in the absence of legislations for circular economy.

Eleventh Malaysian Plan, another government document, reported the success of Tenth Malaysian Plan in implementation of 3R (reuse, reduce and recycle) program as domestic recycling rate increased from 5.0 to 10.5% in just two years (2010–2012). It was the result of intensified efforts in achieving the recycling targets of Tenth Malaysian plan. Consequently in 2013, National Biomass Strategy 2020 was initiated to abet waste to wealth initiatives by assessing the opportunities for developing new industries in Malaysia that will yield high-value products (exportable) from agricultural biomass waste. Currently, power is generated using palm oil biomass pellets. Another outcome of the Tenth Malaysian plan was reduction in GHGs emission due

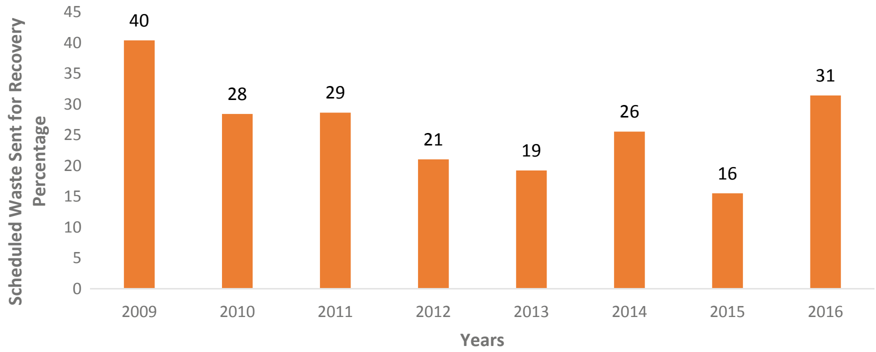

Fig. 13 Total percentage of scheduled waste recovered (Environmental Quality Report)

to waste management initiatives taken. Since 2013, GHGs emission of 33.1 million t CO_2eq and 4 million t CO_2eq were avoided by energy recovery from empty palm oil fruit bunches and by activities involving paper recycling, respectively (Eleventh Malaysian Plan 2018).

As highlighted in the Tenth Malaysian Plan, Malaysia generates the plethora of biomass. There have been many studies by Malaysian scholars that propose sustainable utilization of biomass waste for producing bioproducts to achieve circular green economy. While palm oil industry continues to contribute to the gross national income in Malaysia, a single tonne of crude palm oil results in nine tonnes of biomass. Currently, local industries are focused on the production that attract subsidies, i.e. bioenergy, feed-in-tariff, biogas, etc. Similarly, prevailing exploitation of biomass also yields biofertilizer, pellets, dried long fibre and biogas. Thus, coproduction from biomass is envisioned for bio-based products, polymers, pharmaceutical and food ingredients, fine, specialty and platform chemicals, as well as bioenergy and biofuel for sustainable production. Additionally, it will also reduce the dependency on fossil fuel. The recovery of recyclable, high-value chemical such as levulinic acid, electricity, metal, biofertilizer and fuel from urban or municipal solid waste could be achieved due to prominent innovative biorefinery configurations from establishment of integrated processes. Extracting only 5 wt% of levulinic acid from waste feedstock increases the profitability by 1.5-fold, thus eradicating the requirement for subsidies such as gate fees paid by local authority to waste processor (Sadhukhana et al. 2018).

Another source of biomass waste generation in Malaysia is organic food waste. The daily generation of food waste in Malaysia is 15,000 tonnes, out of which 3000 tonnes are appropriate for consumption (Malaysians waste 2016). Such a quantity corresponds to 1.5 million bags of 10 kg rice, which would be appropriate for feeding 7.5 million people every day (The Bigger Battle, n.d.). This food waste not only diminishes the chances of human consumption but also increases the pressure on food production. If the current rate of food consumption and generation of food waste is continued, then at least 70% of global food production needs to increase by 2050 (How to Feed, n.d.). Generally, the global trend has been such that the food suppliers are the developing countries and consumers are the developed countries. Therefore, to meet the expected demand of global population, projected to proliferate by 34% in 2050, an investment of $83 billion in agriculture of emergent nations is required yearly for the 32 years. Hence, policy making is the focal point for funding resource-efficient technologies for the economy of developing nations (Sadhukhan et al. 2018).

The transport sector in Malaysia contributes the most to global warming potential (GWP). Yet, biofuel blending can reduce the impacts of transport sector on GWP. While there is still time for conventionalizing the electric vehicle, provisional support for the research and development of biofuel could deaccelerate GWP impact of transport sector. It can be achieved by crude palm oil (CPO) upgradation for manufacturing the drop-in biofuel in compliance with the Roundtable of Sustainable Palm Oil (RSPO) standard and by modification of subsisting fermentation to get butanol. The efficiency of butanol is higher than bioethanol and could be utilized 100% in predominant engine, in addition to integration of gas clean-up technology in prevalent AD system for the production of compressed natural gas (CNG). However, the ultimate emphasis must be on resource recovery from waste (RRfW), carbon dioxide reduction (CDR) and carbon capture and reuse (CCR) integrated biorefineries for additional extraction of resources such that absolute recovery or reclamation is achieved from waste (Sadhukhan et al. 2018).

Unlike European Union and Japan, Malaysia also does not have regulatory framework for ELVs. However, a new proposal of procedural outline is unveiled for local ELV recycling establishments as discussed earlier in the chapter. It is hoped that the framework will provide an alternative in acquiring raw materials in an environmentally sound manner and will increase resource circulation. Therefore, the findings of the research can be used to develop a platform for coprocessing between ELV recycling industry and construction manufacturing industry. Further research on reusability and recyclability of product could offer many prospects for circular economy in construction (Wong et al. 2018). A similar initiative has been proposed by DOE for establishing industrial ecology around ELVs.

A significant contribution to the national economy and the development of necessary infrastructure has been made by construction industry in Malaysia. Regrettably, this important industry also produces one of the single largest waste streams in the country. Segregation at source or practice of 3R, as well as disposal of C&D waste in landfills is not widely practised by majority of the contractors. Additionally, correct handling, storing and transportation of construction wastes are also the responsibilities of the contractor. Yet, significant amount of C&D waste is generated due to inadequate knowledge or experience of contractor, excessive purchasing of materials beyond requirement, inapt storage (resulting in damages to raw material) and reworking. Absence of regulations and guidelines for construction industry and subsequent enforcement contribute to the construction of waste generation (Ikau et al. 2016). At present, collection rate of C&D waste is 15%, whereas the remaining 85% is left uncollected (Aiming for Zero 2015). On the other hand, a total of 851 illegal dumpsites in Malaysia were identified by the roadside in 2015 (Mah et al. 2018). However, despite the mismanagement of C&D waste, the current practice of disposal at open dumps or in landfills is not a sustainable mean of handling increasing C&D waste (Fauziah and Agamuthu 2003) As mentioned earlier, a five-year plan named CITP initiated by Construction Industry Development Board (CIDB) targets 20% recycling of construction waste and to also reduce the generation of irresponsible waste because construction waste can be resold or recycled. For instance, bricks, doors, lighting fixtures and stairway banisters can be resold; whereas, glass can be recycled into fibreglass or used in place of sand for paving and asphalt can be reused by turning it back into aggregate (Aiming for Zero 2015). Therefore, the only way to sustainable management of construction waste in Malaysia is the implementation of circular economy in construction industry via closed-loop initiatives, industrial symbiosis or cascading.

Malaysian Investment Development Authority (MIDA) launched an incentive for establishment of Waste Eco Park (WEP) in 2016. Conceptually, Waste Eco Park encourages industries to recycle and/or recover waste, besides treatment activities and targets sustainable waste management by encouraging corporations to invest in facilities and infrastructure that will manage waste holistically as proposed in the Eleventh Malaysian Plan. The functioning of Waste Eco Park will involve WEP developers: the party who will be responsible for the necessary infrastructure establishment and will be main stakeholder for ensuring holistic waste management inside Waste Eco Park, WEP managers; designated by WEP developer who will assure efficacious coordination, execution and operation of Waste Eco Park and WEP operators; who will partake in holistic waste management and realize national target of reduction in waste disposal, by promoting recovery and increasing recycling of waste, in addition to sustenance of waste management ecosystem (MIDA 2018). Unfortunately, WEP has not been established till date.

It is evident that Malaysian waste management authorities have realized that landfilling is not the long-term solution for sustainable waste management. Even though, developing nations are currently reaping the economic benefits of linear economy, it is also clear that linear economy approach will not last long as natural resources are finite and remediation costs of environmental damage will continue to increase to a point that it will surpass the economic gains. Therefore, the longevity of economic development cannot be sustained without resource circulation by implementation of circular economy. Malaysian authorities have acknowledged the need of sustainable production and consumption by incorporating it in the Eleventh Malaysian Plan and by launching initiatives to promote 3R in the waste management. However, Malaysia is being hindered by the lack of direct regulatory framework on circular economy and consequently the lack of eventual enforcement of legislations. If there is one thing to be learnt from China's successful administration of circular economy, it is the process of reaching towards the goal of circular economy and the most significant top-down and bottom-up approach. Top-down approach is warranted by legal schemes. In China, these regulatory requirements were set by Circular Economy Promotion Law, by Circular Economy Pilot Demonstrations program and the Eco-industrial Park program founded by various government agencies. On the other hand, bottom-up approach is taken by individual enterprises, industries that take part in eco-industrial enterprises to embrace the idea of circular economy. This acceptance of circular economy idea happens when these ideas make financial sense to enterprises due to changing dynamics of market triggered by high prices of energy and resources and deregulation of market entry. Since 1970s, Chinese industries have been adopting bottom-up approach (Mathews and Tan 2011). Malaysia does not have explicit top-down and bottom-up approaches till date. But, there are attempts to implement resource circulation in Malaysia in the form of promotion of regulation 7 of Environmental Quality (Scheduled Waste) Regulation 2005 by DOE, or the programs initiated by SWCorp, CIDB and MIDA, respectively. There are also tax incentives on green technology that can encourage resource circulation. Despite the absence of specific regulations on circular economy, it can be said that there has been uncoordinated implementation of top-down approach by several government authorities as well as bottom-up approaches by individual enterprises as shown in the case studies.

6 The Benefits of Circular Economy

As circular economy is not implemented at national or municipal level in Malaysia, the benefits of circular economy are only confined to the enterprises that are practicing circular economy at enterprises. Due to the implementation of circular economy at firm level, the impact on GDP is not significant.

Based on the case studies described in this chapter, the following benefits were availed:

1. Reduction in resource consumption
2. Reduction in waste generation
3. Economic benefit
4. Reduction in energy consumption
5. Environmental Protection.

Table 4 gives the summary of benefits attained from the implementation of closed-loop initiatives at respective firms in case studies. The benefits of circular economy are interrelated. For instance, the reduction in resource consumption was achieved by recycling and reusing wastes, including wastewater, as raw material in the manufacturing processes. It led to total reduction in waste generation as well, since waste was being incorporated in the manufacturing processes instead of disposal at landfill. Both reduction in resource consumption and reduction in waste generation not only saved expenditures of acquiring raw material and landfilling, respectively, but in some cases also generated extra revenue by selling waste to potential buyers or producing coproducts from waste. Circular economy will not be completely zero waste until energy source is also renewable. Therefore, as shown in Tex Cycle Sdn. Bhd., using solar energy reduced the intake of electricity from local electric grid. Lastly, by adopting circular economy, environment is also protected from pollution of waste, especially scheduled waste, i.e. spent nickel or highly basic carbide sludge and by avoiding extraneous extracting of raw material from the environment.

Table 4 Summary of benefits of implementation of circular economy

Benefits	Oleochemical plant	Acetylene manufacturing plant	Tex Cycle Sdn. Bhd.	Construction site at UTP
Reduction in resource consumption	Reuse of earth material, fatty acid residue and spent nickel	Water is recycled within plant. Carbide sludge is used as resource in cosmetic manufacturing company	Reusing water and producing coproducts from damaged materials	C&D waste was recycled and reused resulting in reduction in consumption of wood and metal resources
Reduction in waste generation	Waste generation is only reduced to sludge	Neither wastewater is produced nor carbide sludge	Waste generation is only reduced to sludge	73% of waste generation was reduced
Economic benefit	Annual savings of RM 1 million	Annual savings of RM 500,000 and annual income of RM 1 million	Annual savings of RM 63,000	Not given
Environmental protection	Yes	Yes	Yes	Yes

7 Collaboration with Other Countries

In 1996, under the Danish Cooperation for Environment and Development (DANCED), several projects introduced the implementation of circular economy at firm level or cleaner production in Malaysia for the first time. Standards and Industrial Research Institute of Malaysia (SIRIM) under the Ministry of Science, Technology and Innovation (MOSTI) employed a technical cooperation programme between the Government of Malaysia and the Government of Denmark. These projects were promoting cleaner production through environmental and energy audits, demonstration sites and the dissemination of information via two platforms, namely Cleaner Technology Extension Services (CTES) and the Cleaner Technology Information Service (CTIS) (Yusup et al. 2015).

Although still in the planning stage, a concept of industrial symbiosis in rubber manufacturing industries was developed in 2008. This industrial symbiosis is a collaboration between Malaysia and Thailand to form a rubber city in Kedah, Malaysia (Kedah Rubber City, n.d.). Potential industrial symbiosis is proposed in a study by Sharib and Halog (2017) as shown in Table 5. Therefore, implementation of circular economy at municipal level in Malaysia is at planning stages that is being collaborated with Thailand.

In order to achieve the commitment of reducing carbon footprint, Malaysia is planning to utilize biodiesel blends in its transportation sector. To accomplish this

Table 5 Proposal of industrial symbiosis in rubber city, Kedah, Malaysia (adopted from Sharib and Halog 2017)

Waste	Waste generator	Annual quantity	Potential usage of waste	Industrial symbiosis
Ammonia Nitrogen	Rubber block process	9,880 kg	Ammonia waste	Conversion into fertilizer
Total solid waste		70,720 kg	Rubber crumb filler or polymer asphalt	Cement concrete indus-try/polymer asphalt binder
Rubber waste	Tyre production	988 kg	Rubber crumb	Cement concrete industry or polymer asphalt binder
Wastewater from cooling system		2,198,716 kg	Recycle water	Feed-in cooling water system
Rejected glove pieces	Glove manufacturer	530,660 pieces	Rubber latex converted into powder form	Incorporation into rubber filler
Sludge or rubber traps		6727.80 kg	Rubber waste latex into carpet backing	Incorporated into carpet backing
Methane	Wastewater integrated facilities	Not available	Methane recovery	Feed-in natural gas used for glove manufacturing
Treated effluent			Biofertilizer	Fertilizer company
Biomass wastes and residues	Cogeneration electricity	Not available	Production of heat and electricity	Feed-in electricity generation for the industries in Rubber City

target, Malaysia had collaborated with Japan for the implementation of biofuels in Malaysian transport sector. A collaborating initiative between Malaysia and Japan was validated in April 2010 for environment and energy. Moreover in 2008, Yanmar, a private Japanese firm, made an investment in a Malaysian research facility specialized in biodiesel, for carrying out research and analytical work for biodiesel fuel that had started industrial cooperation in biofuels between Japan and Malaysia (Lim and Lee et al. 2012). At present, Malaysia's intention of 10% biodiesel blend by 1 January 2017 had been delayed. Therefore, Malaysia is blending 7% of biodiesel. The delay has been due to the lack of subsidy support and the high price of feedstock compared to low prices of petroleum prices. On the other hand, the Eleventh Malaysia Plan aims at 15% biodiesel blend in transport sector by 2020 (Biofuels Annual 2017). In order to implement circular economy sustainably, dependence on renewable energy sources need to increase gradually to a point of complete phasing out of non-renewable energy sources. Thus, Government of Malaysia must continue promotion of biodiesel blends.

8 Conclusion

Malaysia does not have a legal framework on the implementation of circular economy like other nations, i.e. China, Japan and Germany. However, there are certain sections in Environmental Quality Act 1974, Solid Waste and Public Cleansing Management Act 2007 and regulation 7 in Environmental Quality (Scheduled Waste) Regulation 2005 that promote the practice of resource circulation. Malaysia incorporated sustainable production and consumption in the Eleventh Malaysian Plan and aims to take holistic approach towards national waste management. Under the umbrella of the Eleventh Malaysian Plan, Malaysia targets to reduce 40% of GHGs emission intensity from GDP compared to 2005 level and reach 22% of recycling of MSW with a long-term goal of becoming zero waste nation. Additionally, SWCorp launched SWCorp Strategic Plan from 2014 to 2020 to promote sustainable solid waste management services, and CIDB initiated CITP that has a target of incorporating 20% of recycled construction and demolition waste (tonnage) by year 2020 from the baseline of 2016.

DOE has released guidelines on coprocessing of scheduled waste in cement manufacturing industry. Apart from coprocessing in cement manufacturing industry where waste exchange is being practised in all nine plants, research models on industrial ecology are at proposal stages only as they have not been implemented. Furthermore, DOE has also put forward proposals on industrial ecology involving bleaching earth factory and abandoned car management. Lastly, Malaysian Automotive Association presented the proposal on the processing of End-of-Life Vehicles (ELVs) that can lead to coprocessing with construction industry. DOE is also promoting coprocessing under the regulation 7 of Environmental Quality (Scheduled Waste) Regulation 2005 where scheduled waste undergoing "special management" is reused and recycled. Moreover, recovery from scheduled waste is also practised at local and foreign facilities.

Several opportunities of sustainable waste management and resource circulation have been highlighted by the research findings.

i. The generation of biomass in Malaysia is extremely high; therefore, it is proposed that in addition to waste to energy approach applied to biomass, bioproducts can also be produced. It is envisioned that coproduction of bio-based products from biomass will be carried out resulting in outputs such as fine, specialty and platform chemicals, food and pharmaceutical ingredients, polymers, together with biofuel and bioenergy.
ii. Biofuel production and its usage in national transport sector can help decouple the economic development from GWP. The recommended routes for production

of biofuel are crude palm oil (CPO) upgradation for yielding drop-in biofuel, in compliance with the Roundtable of Sustainable Palm Oil (RSPO) standard, reconstructing current fermentation to attain butanol. The efficiency of butanol is higher than bioethanol and can be used completely in predominant engine. Moreover, by incorporating gas clean-up technology in existing AD system, CNG could also be produced.

iii. A processing framework of ELVs is proposed that will provide substitute for acquiring raw materials in an environmentally sound manner, hence will increase resource circulation. The findings of the research can be used to develop a platform for coprocessing between ELV recycling industry and construction manufacturing industry.

Establishment of Waste Eco Park program by MIDA promotes recycling and recovery of waste, in addition to treatment activities and aims to achieve sustainable waste management by encouraging investments in facilities and infrastructure towards said goals that are also aligned with the Eleventh Malaysian Plan.

In order to successfully implement the circular economy, top-down and bottom-up approach is required. While, Malaysia does not have explicit top-down and bottom-up approaches till date, there have been attempts to implement resource circulation in Malaysia as top-down approach in form of promoting regulation 7 of Environmental Quality (Scheduled Waste) Regulation 2005, by DOE, or the programs initiated by SWCorp, CIDB and MIDA. There are also tax incentives on green technology that eventually improves resource circulation.

The case studies presented manifest the practice of circular economy at enterprise level that imply the willingness of some firms to take part in bottom-up approach. The benefits of implementation of circular economy at enterprise level are reduction in resource consumption, reduction in generation of waste, protection of environment and human health, reduction in energy consumption, cost savings by reusing or recycling the waste and additional profit gain by selling waste to potential industries.

International collaboration in the implementation of circular economy started with cooperation with Denmark in 1996 where cleaner production was employed in several companies. Malaysia's collaboration with Japan in biodiesel blends started in 2008, and Malaysia aims to blend 15% of biodiesel by 2020. Lastly, rubber city in Kedah, Malaysia, is at planning stage where Malaysia will cooperate with Thailand to implement industrial symbiosis.

References

Agamuthu, P. (2001). *Solid waste: Principles and management*. Kuala Lumpur, Malaysia: Institute of Biological Sciences, University of Malaya.

Aiming for Zero Construction Waste by 2030—Metro News: The Star Online. (2015). Retrieved from https://www.thestar.com.my/metro/community/2015/11/20/aiming-for-zero-construction-waste-by-2030-seminar-looks-at-adopting-sustainable-practices-in-a-bid/. Accessed on August 20, 2018.

Begum, R. A., Siwar, C., Pereira, J. J., & Jaafar, A. H. (2007). Implementation of waste management and minimisation in the Construction Industry of Malaysia. *Resources, Conservation C.-S. and Recycling, 51*, 190–202.

Biofuel Annual 2017—GAIN Report. (2017). Retrieved from https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Kuala%20Lumpur_Malaysia_10-24-2017.pdf. Accessed on September 10, 2018.

CITP KPIs for sustainable development. (2018). Retrieved from http://www.cidb.gov.my/index.php/en/focus-areas/sustainable-construction/citp-kpis-for-sustainable-development. Accessed on August 2, 2018.

Department of Environment (2018a) Acts. Retrieved from https://www.doe.gov.my/portalv1/en/tentang-jas/perundangan/akta-kaedah-peraturan-arahan-2/akta. Accessed on August 2, 2018.

Department of Environment (2018b) Regulations. Retrieved from https://www.doe.gov.my/portalv1/en/tentang-jas/perundangan/akta-kaedah-peraturan-arahan-2/peraturan. Accessed on August 2, 2018.

Eleventh Malaysian Plan, 2016–2020. (2018). Retrieved from http://epu.gov.my/en/rmk/eleventh-malaysia-plan-2016-2020. Accessed on August 2, 2018.

Environmental Quality Report—Enviro Knowledge Center. (n.d.). Retrieved from https://enviro.doe.gov.my/ekmc/. Accessed on July 27, 2018.

Fauziah, S. H., & Agamuthu, P. (2003). Municipal solid waste management: a comparative study on selected landfill in Selangor. In *Proceedings of Environment 2003 Environmental Management and Sustainable Development for Better Future Growth*. Penang, Malaysia: USM Publisher.

Fauziah, S. H., & Agamuthu, P. (2012). Municipal solid waste management in Malaysia: Strategies in reducing the dependency on landfills. In *International Seminar and Workshop on Landfill Operation and Management in Tropical Country*, 27–28th August 2012, Bandar Acheh (pp. 13–19).

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114,* 11–32.

How to Feed the World in 2050. (n.d.). Retrieved from http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf. Accessed on August 25, 2018.

Ikau, R., Joseph, C., & Tawie, R. (2016). Factors influencing waste generation in the Construction Industry in Malaysia. *Procedia—Social and Behavioral Sciences, 234,* 11–18.

Isa, H. (2012). *Implementation of Basel Convention in Malaysia*. Retrieved from https://www.researchgate.net/publication/293820586_Implementation_of_Basel_Convention_in_Malaysia/related. Accessed on August 20, 2018.

Keddah Rubber City—Northern Corridor Economic Region. (n.d.). Retrieved from http://58.27.59.207/v3/?page_id=8851. Accessed on September 4, 2018.

Korhonen, J., Honkasalo, A., & Seppala, J. (2018). Circular economy: The concept and its limitations. *Ecological Economics, 143,* 37–46.

Lim, S., & Lee, K. T. (2012). Implementation of biofuels in Malaysian transportation sector towards sustainable development: A case study of international cooperation between Malaysia and Japan. *Renewable and Sustainable Energy Reviews, 16,* 1790–1800.

Mah, C. M., Fujiwara, T., & Ho, C. S. (2018). Life cycle assessment and life cycle costing toward eco-efficiency concrete waste management in Malaysia. *Journal of Cleaner Production, 172*, 3415–3427.

Malaysians waste 15,000 tonnes of food waste daily—Nation. (2016). Retrieved from https://www.thestar.com.my/news/nation/2016/05/24/malaysians-waste-15000-tonnes-of-food-daily/. Accessed on August 25, 2018.

Mathews, J. A., & Tan, H. (2011). Progress toward a circular economy in China. The drivers (and Inhibitors) of eco-industrial initiative. *Journal of Industrial Ecology, 15,* 435–457.

MIDA—Malaysian Investment Development Authority—Tax Incentive for Green Industry. (2018). Retrieved from http://www.mida.gov.my/home/tax-incentives-for-green-industry/posts/. Accessed on August 7, 2018.

Mohr, Y., & Manaf, L. B. (2017). Solid waste management transformation and future challenges of source separation and recycling practice in Malaysia. *Resources, Conservation and Recycling, 116,* 1–14.

Sadhukhana, J., Martinez-Hernandez, E., Murphya, R. J., Ngc, D. K. S., Hassimd, M. H., Nga, K.S., et al. (2018). Role of bioenergy, biorefinery and bioeconomy in sustainable development: Strategic pathways for Malaysia. *Renewable and Sustainable Energy Reviews, 81*, 1966–1987.

Sharib, S., & Halog, A. (2017). Enhancing value chains by applying industrial symbiosis concept to the Rubber City in Kedah, Malaysia. *Journal of Cleaner Production, 141,* 1095–1108.

The Bigger battle against food wastage. (n.d.). Retrieved from http://www.theheatmalaysia.com/Main/The-bigger-battle-against-food-wastage. Accessed on August 25, 2018.

Tex Cycle. (n.d.). Retrieved from http://www.texcycle.com.my/texcyclesdnbhd/index.html. Accessed on September 6, 2018.

Umar, U. A., Shafiq, N., Malakahmad, A., Nuruddin, M. F., Khamidi, M. F., & Salihi, I. U. (2016). Impact of construction waste minimization at construction site: case study. *Jurnal Teknologi, 78,* 33–40.

Wong, Y. C., Al-Obaidi, K. M., & Mahyuddin, N. (2018). Recycling of end-of-life vehicles (ELVs) for building products: Concept of processing framework from automotive to construction industries in Malaysia. *Journal of Cleaner Production, 190,* 285–302.

Yusup, M. Z., Wan Mahmood, W. H., Salleh, S. R., & Rahman, M. N. A. (2015). The implementation of cleaner production practices from Malaysian manufacturers' perspectives. *Journal of Cleaner Production, 108,* 659–672.

An Overview of Circular Economy in Mauritius

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Abstract Solid waste management remains an ever-increasing issue in small island development states like Mauritius, with landfilling being the main disposal option as opposed to more sustainable solutions like recycling and resource recovery. This article provided an overview of circular economy, the initiatives taken towards promotion of recycling and the challenges faced by the recycling industry in Mauritius. While some recycling is carried out on the island, this is still in its infancy stage due to several obstacles faced by the recycling industry such as lack of financial incentives, lack of critical mass of recyclables and poor quality of recyclables. However, based on the several forthcoming projects to boost circular economy in Mauritius, it is expected that the solid waste management system is called for a major overhaul in the future, with major focus on recycling and resource recovery.

Keywords Solid waste management · Circular economy · Recycling · Small island developing state · Composting · Landfilling

1 Introduction

Mauritius is a small island developing state of surface area 1865 km^2, located to the east of Madagascar in the Indian Ocean. Over the years, the island has experienced continuous development having diversified its economy. Coupled with economic growth, the population of Mauritius has also increased and reached 1.22 million in 2018 (Statistics Mauritius 2019). Besides, the level of human development index has also significantly increased owing to a higher standard of living. The downside of all these developments is that solid wastes generation has continuously increased over the years. Over the past 10 years, solid wastes generation has been increasing at an average annual rate of 3.1%, reaching over 540,000 tons in 2018. With over 95% of the solid wastes generated on the island landfilled, this does not represent a sustainable approach, albeit that the landfill is a sanitary site.

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The issue of solid waste generation and management is not limited to small island developing states like Mauritius but also extends to developed economies. Well aware of the negative impacts of improper waste management and coupled with the depletion of non-renewable resources, the concept of circular economy has been gaining increasing attention worldwide over the years (Ghisellini et al. 2016). Circular economy is closely linked with United Nations Sustainable Development Goal (SDG) 12 on 'Responsible Consumption and Production' (United Nations 2019). Specifically, target 12.5 '*By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse*' (United Nations 2019) ensures that circular economy is maximised, as established in the waste management hierarchy. Several attempts and initiatives have been taken over the years to have a more diverse solid waste management system in Mauritius prioritising reduce, reuse and recycling over landfilling in line with the waste management hierarchy and the concept of circular economy. This article provides an overview of the measures taken in Mauritius to achieve circular economy over a linear approach and also outlines the forthcoming solid waste management projects aiming at resource recovery and recycling.

2 Reduce, Reuse and Recycling Initiatives in Mauritius

Reduce, reuse and recycling (3Rs) are the most preferred options in the solid waste management hierarchy. Several initiatives have been taken to promote the 3Rs in Mauritius through either policy decisions, provision of incentives or promulgation of specific regulations, as further detailed.

2.1 Deposit-Refund Scheme on Glass Bottles

The deposit-refund scheme is established on 700-ml and 330-ml glass bottles. The deposit is USD 0.35 for 700-ml glass bottles and USD 0.17 for 330-ml glass bottles. This system ensures that the glass bottles are returned to the retail outlets following which, they are routed to the beverage manufacturers for rinsing and disinfecting purposes prior to refilling. Through the deposit-refund mechanism, most glass bottles are reused instead of disposed at the landfill.

2.2 Home Composting Scheme

The home composting scheme was established under the Maurice-Ile-Durable programme in 2013 and consisted of the provision of home compost bins to households to encourage source segregation of wastes and promote the practice of compost production and usage. Another objective of this scheme was to reduce the amount of wastes going to the landfill. From 2013 to 2016, 30,326 bins were distributed to households by the local authorities across the island. For the national budget for financial year 2018/2019, another 10,000 home composters were earmarked to be distributed to households. Considering that a household in Mauritius has an average of four persons and the waste generation rate is estimated at 1.22 kg/capita/day, the provision of one compost bin per household helps divert at least 0.9 tons of solid wastes away from the landfill annually (considering that 50% of the municipal solid wastes in Mauritius consists of organic matter).

2.3 Incentives on Exportation/Recycling of PET Bottles

In 2015, the Mauritian Government came forward with an incentive on PET bottles. This comprised a provision of USD 0.14 for each kg of waste PET bottles/flakes exported or recycled but was applicable only if an exporter/recycler processed at least 1 ton of PET bottles/flakes in a calendar year. In line with the Government initiative of 2015, the incentive of USD 0.14/kg PET bottles was increased to USD 0.42/kg PET bottles providing that the recycling was carried out in Mauritius. These two incentives were introduced to boost the recycling/exportation of PET bottles.

2.4 Excise Duty on Non-biodegradable Plastic Food Containers

More recently, since May 2019, the Mauritian Government introduced an excise duty of USD 0.056 for each non-biodegradable plastic food container purchased. The objective of this measure is to promote responsible consumption and production, thereby reducing the generation of single-use non-biodegradable plastic food containers such as polystyrene takeaways, plastic plates, bowls, cups and trays.

2.5 Legislative Frameworks

2.5.1 Environment Protection (Polyethylene Terephthalate (PET) Bottle Permit) Regulations 2001

In 2001, Government promulgated the Environment Protection (Polyethylene Terephthalate (PET) bottle Permit) Regulations 2001 to ensure the environmentally sound management of PET bottles. These Regulations were based on the concept of extended producer responsibility, implying that the producers of PET bottles had to pay for the waste and pollution they create. Under these Regulations, no responsible person is allowed to bottle or cause to be bottled any beverage in a PET bottle unless he has a permit. The conditions imposed under this permit are that the permit holder needs to submit an annual return on the quantity of PET bottles produced and collected for recycling/exportation. As a consequence of these Regulations and for practical reasons, the Beverage Bottling Companies, grouped under the Bottler's Association, ensured the collection of post-consumer PET bottles by sub-contracting Polypet Recyclers Ltd. to collect post-consumer PET bottles across the country. These Regulations thus prompted the collection of PET bottles across the island, with the outcome being that 40–45% of PET bottles marketed in Mauritius are now being collected. The major PET exporter in Mauritius namely Polypet Recyclers Ltd. sorts the PET bottles by colour, removes the caps and labels and then shred the PET bottles into flakes which are then exported to a company in South Africa. On average, Polypet Recyclers Ltd. exports 1,000 tons of PET flakes on an annual basis.

2.5.2 Local Government (Registration of Recycler and Exporter) Regulations 2013

The Local Government (Registration of Recycler and Exporter) Regulations were promulgated in 2013 in view to regulate the recyclers and exporters involved in the recycling industry. These Regulations also enabled the establishment of a database of recyclers and exporters in Mauritius and the amount of waste materials recycled locally or exported for recycling. As at current date, there are more than 30 registered recyclers/exporters involved in the recycling/exportation of paper/carton, e-wastes, glass, photographic and printing wastes, plastics, textile wastes, used batteries, waste oil, used tyres and timber/wood.

2.5.3 Environment Protection (Banning of Plastic Bags) Regulations 2015

In view to reduce the generation of plastic bags which have been causing significant environmental nuisances in Mauritius, the Environment Protection (Banning of Plastic Bags) Regulations were promulgated in 2015. These Regulations restrict the importation, manufacture, sale or supply of plastic bags, with the exception of those exempted under the first schedule of the Regulations. With these Regulations in place, there has been a major shift from the use of non-biodegradable plastic bags to biodegradable ones.

Table 1 List of registered recyclers in Mauritius

Companies	Materials recycled	Amount recycled annually (tons)
BEM Enterprises Ltd.	E-wastes Photographic and printing wastes	163.5
RVE Ltd.	E-wastes	Not available
Mauritius Glass Gallery	Glass	70
Surfrider Co. Ltd.	Plastics (PET, LDPE, HDPE)	380
Phillipe Polybags Manufacturer Ltd.	Plastics (PP, HDPE, LDPE)	30
Recycling Industries (Mauritius) Ltd.	Textile wastes	300
Virgin Oil Company (Mauritius) Ltd.	Mineral used oil	4,415
Ecofuel Ltd.	Mineral used oil	484
Compagnie Mauricienne de Commerce Ltee	Used tyres	139.5
Pallet World Ltd.	Wood/timber	1,824

3 Overview of the Recycling Industry in Mauritius

As aforementioned, there are currently more than 30 registered recyclers/exporters contributing to recycling and resource recovery in Mauritius. With regard to local recycling, there are ten registered recycling industries as summarised in Table 1.

4 Best Practices of Circular Economy in Mauritius

One of the best practices of circular economy in Mauritius is the implementation of the project ‘Enhancement of resource productivity and environmental performance of Micro, Small and Medium Enterprise in six African countries through the concept of Industrial Symbiosis’ under the SWITCH Africa Green (SAG) Programme. Under this project, waste is considered as a resource which can be valourised; for instance, waste from one firm can be an input/raw material for another firm. Through this project, a considerable amount of wastes from hotels, textile industries, sugar factories and food manufacturing industries have been diverted away from the landfill and used as raw/secondary materials in other industries. For instance, 86 tons of broken wafers from a biscuit manufacturing industry have been used as animal feed; 42 tons of textile wastes from a hotel have been sent to a sugar manufacturing industry for use as boiler fuel while 141 tons of used toners from a printing house have been diverted to a cartridge manufacturer.

5 Challenges Faced by the Recycling Industry

Despite the several initiatives taken by the Mauritian Government to boost the recycling industry, recycling is still in its infancy stage in Mauritius. Based on previous meetings with local registered recyclers/exporters, some of the challenges faced by the recycling industry in Mauritius are:

5.1 High Cost of Investments

High costs of investments for new equipment are one of the reasons often raised by local recyclers for not being able to increase their recycling capacities. Consequently, while it is often argued that the availability of recyclable materials is not an issue, the recyclers cannot increase their processing capacity to accept a greater amount of recyclable materials as they do not have the financial means to invest in large equipment.

5.2 Lack of Financial Incentives

In line with the aforementioned challenge, the local recyclers often complain about a lack of financial incentives to boost the recycling industry. This includes incentives on importation of new equipment, loan facilities or grants.

5.3 Critical Mass of Recyclables

As opposed to Sect. 5.1, some recyclers also complain of a lack of recyclables to make their recycling process economically feasible. They often report that huge transportation costs for collection of a small amount of recyclables do not make the recycling business lucrative. With the setting-up of a material recovery facility, the amount of recyclables will undoubtedly increase and the critical mass will then be achieved to make the recycling process more viable.

5.4 Low Quality of Recyclables

Another challenge faced by the recycling industry is the low quality of recyclables available due to contamination with other wastes, particular organics. With Mauritius not currently adopting waste segregation at source, all the wastes are collected comingled and this considerably reduces the quality of the recyclables. However, this challenge must be alleviated with the setting-up of a material recovery facility and the implementation of source segregation of wastes.

6 Future Plans to Promote Circular Economy

6.1 Setting-up of a Material Recovery Facility

A new strategy and action plan has been developed for solid waste management in Mauritius with focus on resource recovery and recycling. As part of the strategy document, a feasibility study on the setting-up of a material recovery facility consisting of a compost plant, a sorting unit and a civic amenity centre is currently being carried out. Following this feasibility study and the setting-up of the material recovery facility, the waste management system in the western part of the island will undergo considerable change. Waste segregation at source will be privileged through the provision of two bins (one for wet wastes—organics and one for dry wastes—recyclables). The wet wastes will be directed to the composting plant while the recyclables will be sent to the sorting unit for subsequent separation into paper, glass, plastics, etc. The sorted recyclables will then be sent to registered recyclers/exporters in Mauritius. As for the civic amenity centre, this will allow local citizens to deposit their household hazardous wastes and bulky wastes. Through the setting-up and operation of the material recovery facility, it will thus be ensured that target 12.5 of SDG 12 is thus achieved, in line with the concept of circular economy.

6.2 Setting-up of a Scrapyard Facility for End-of-Life Vehicles

End-of-life vehicles are becoming a major issue in Mauritius and these are often dumped illegally on bare lands and roadsides thereby posing a potential threat to human health through the onset of vector-borne diseases. Besides, these end-of-life vehicles also represent a major eyesore and impact on the status of Mauritius as a touristic destination. To tackle this issue, the Mauritian Government has recently launched a bidding exercise to procure of the consultancy service for carrying out a feasibility study for the setting-up and operation of a scrapyard facility for end-of-life vehicles in Mauritius. Following the feasibility study and the setting-up and operation of the scrapyard facility, end-of-life vehicles will thus be de-polluted and dismantled in an environmentally sound manner and the dismantled components will then be subjected to recycling.

6.3 Setting-up of Sites for Temporary Storage of Construction and Demolition Wastes

Construction and demolition (C&D) wastes represent a major issue in Mauritius, with a significant being illegally dumped at different locations on the island, including river beds, thus causing flooding and environmental nuisances. With construction and renovation works expected to continue in the future, the generation of C&D wastes is anticipated to further increase. Since these wastes take relatively large spaces in the landfill, disposal is thus not a sustainable solution. Furthermore, natural resources such as rocks (for making aggregates) are getting depleted and alternatives need to be sought. To alleviate both these problems, it was thus decided by the Mauritian Government to install sites for the temporary storage of C&D wastes. Upon generation, the C&D wastes components will have to be segregated at source and then stored at the temporary sites prior to being collected by stone crushing plants for recycling into aggregates, by individuals for reuse for backfilling purposes or by recyclers for conversion into new products. Through this C&D wastes storage system, the recycling of the components of C&D wastes will be boosted, thereby being in line with SDG 12 (Target 12.5). As at current date, the bidding documents are being prepared for the setting-up of a C&D waste storage site.

6.4 Setting-up of an E-Waste Management System

Around 8,000–9,000 tons are estimated to be generated in Mauritius on a yearly basis and need to be managed in an environmentally safe and sound manner. In this context, a comprehensive e-waste management system is currently being set up by the Mauritian Government. The system will be based on the extended producer responsibility wherein importers, local manufacturers and assemblers of selected e-goods will have to take responsibility for the resulting e-wastes. An advanced recycling fee will be charged on the selected e-goods to fund the collection, dismantling and recycling of e-wastes that will be collected. Pending the coming into operation of this e-waste management system, a national household e-waste collection campaign was carried out in 2015 and a second one is currently being carried out. Through these campaigns, it is thus being ensured that e-wastes are managed in a sustainable manner, promoting recycling and the concept of circular economy.

7 New Budgetary Measures

As announced in the budget for financial year 2019/2020, several measures have been proposed with the aim of promoting resource recovery, recycling and a circular economy approach in Mauritius. These measures are as follows:

- **Used tyres**

To promote the recycling of used tyres, an amount of USD 59.5 will be refunded for each ton of used tyres recycled locally or exported for recycling.

- **Financial incentive on PET bottles**

The incentive on PET bottles recycling has been increased from USD 0.14 for each kg of waste PET bottles/flakes exported or recycled to USD 0.42 for each kg of PET bottles exported for recycling.

- **Tipping fee for recycling of wastes**

In a further attempt to increase resource recovery and recycling, the Mauritian Government has indicated that a tipping fee of USD 8.5 will be provided for each ton of wastes taken from transfer stations to be recycled.

8 Conclusions

This article evaluated the current status of recycling and resource recovery in Mauritius while also outlining the challenges faced by the recycling industry in Mauritius. While some recycling is practised on the island, circular economy is still in its infancy stage due to several obstacles faced by the local recyclers. Nevertheless, it is expected that with the implementation of the forthcoming projects such as scrapyard facility, C&D wastes storage sites, material recovery facility and e-waste management system and recycling will receive a major boost in Mauritius. Notwithstanding this fact, some support from the Mauritian Government will be needed to further promote recycling on the island via financial incentives, loan and grant schemes for recyclers.

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References

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114,* 11–32.

Statistics Mauritius. (2019). *Population and vital statistics Republic of Mauritius year 2018*. Ministry of Finance and Economic Development.

United Nations. (2019). *Sustainable development goal 12*. Available from: https://sustainabledevelopment.un.org/sdg12. Accessed June 6, 2019.

Circular Economy: Nigeria Perspective

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1 Introduction

Nigeria is a lower middle-income country and is ranked as the largest economy in Africa with a gross domestic product of 444.92 billion (www.imf.org). The country is located on the western coast of Africa, has an area of 923, 763 km^2 and is bounded by Benin Republic in the west, Niger Republic in the north, Cameroun in the east and Gulf of Guinea in the south. Nigeria got independence from the UK on the 1st of October 1960 and later became a Republic in 1963. The country has maintained its lead in Africa as the most populous country from a population of approximately 31 million in 1953 (Grolier Incorporated 1962) to the present population of about 197 million. Nigeria emerged from various forms of socio-economic developments since independence and now has 36 states and the nation's Federal Capital Territory (FCT), Abuja. Each state and the FCT are further divided into 774 local government areas which are administrative subdivisions.

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In recent years, Nigeria has made significant progress in socio-economic development after getting out of recession in 2017. Population and socio-economic development are key indices that dictate the quantity and quality of solid wastes. Hence, based on population and per capita generation rate of 0.49 kg/capita/day (Nnaji 2015), the output of solid wastes is over 35 million tons per annum. Specifically, solid waste is multidimensional in context when viewed as a nuisance or resource with multiplier effects on various aspects of human life and the environment. The incessant indiscriminate disposal of municipal solid waste is increasing and is linked to poor governance, population growth, poor standards of living, and low level of environmental awareness and poor management of environmental understanding.

The inability of government agencies to manage these enormous quantities of wastes has led to an increase in the associated societal, economic and environmental burdens of solid wastes. Several strategies have over the years been developed involving the active participation of households, public, private, non-governmental and community-based organizations, and Federal, State and Local Government Agencies. The specific goals of several actors involved in solid waste management in Nigeria are to protect public health, maintain and sustain the quality of the environment, to furnish economic returns and act as source of livelihood and to conserve materials and probably generate some forms of energy.

However, these strategies are faced with several challenges which are responsible for the present low levels of collection service, moderate level of resource recovery and underdeveloped disposal method (Aremu and Sule 2010). The challenges are altogether related to traditional, financial, political, social, institutional, regulatory and technical conditions of the country.

Nigeria has a curtailed institutional, legislative and national strategic plan for the management of solid wastes. Solid waste management operational schemes vary from city to city in Nigeria. However, municipal solid waste management system in Nigeria has traditionally been under strong grass-roots control where local governments are responsible for its management. This responsibility in most instances is transferred to State Governments or its agencies, in addition to performance of key oversight functions while the Federal Government provides guidelines and infrastructure. The commonly practised linear economy promotes increasingly use of fossil fuels and relies on continual economic growth and generates waste. The traditional linear economy of manufacture, use and dispose is prominent in Nigeria on a macro-level, perhaps partly because of the weak legislative framework for sanitation and management of solid wastes. No legislation exists for the minimization/control of solid waste generation; hence, industries and households engage in subjective forms of solid waste reduction and reuse while recycling activity is majorly by the private sector. The inherent huge amounts of solid wastes generated create severe health and environmental challenges to linear economies like Nigeria. Private sector participation in municipal solid waste management in Nigeria like other developing countries is mostly for economic gains. Generally, open dumps at the outskirts of the city where the nuisance level to humans is minimal are used as disposal sites. On the other hand, when there are avenues to capture the energy embedded in these wastes, it could be a sustainable way of producing electricity, heat and fuel to meet basic needs (Aremu and Ganiyu 2019).

According to World Economic Forum (2018), circular economy aims to design out waste from a take–make–use–dispose model to a reduce–reuse–recycle model. In the circular economy, maximum value is extracted from materials or items considered as "wastes" as much as possible, thereby attaining a "zero" waste society. In contrast to the traditional linear economy, it is a cyclical regenerative approach in which reduction, reuse and recycle of wastes dominate the polity. The circular economy is gaining global acceptance and Nigerians, like other developing countries, practise circularity in certain aspects of life. These aspects include microlevel involvement in household waste reduction and reuse strategies, and informal markets involving waste scavengers, merchants and recyclers. That notwithstanding, widespread impact on the society is not felt. Moreover, there is no legislation yet in Nigeria to kick-start the operation of a structured circular economy system despite the fact that the country is well-positioned to take advantage of this concept. Therefore, there is the need for Nigeria to move into a more circular economy by mainstreaming its principles and practices into local, state and national road maps for sustainable transition from linear to circular economy.

2 The Legislative Framework and Government Support Towards Implementing 5R's and Circular Economy Initiatives in Nigeria

The increasing complexity and quantity of wastes produced in Nigeria has been of increasing concern. Industrial and technological developments have taken a new turn as against what was in the past, together with global trade, which has resulted in enormous economic growth that has enhanced human welfare. However, this development path is rooted in exponentially increasing resource usage, causing increase in solid waste generation.

The circular economy in Nigeria is a change in response to the need for an ecological economy that requires human activities that are consistent with the 5 R's principles: reduce, repair, reuse, recycle and recover (Ying and Li-Jun 2012; NPSW 2018).

The Nigerian concerns for circular economy result from various factors including lack of a legislative framework to control the incidence of unsound waste management practices and inadequacy of existing infrastructure to adequately manage the amount and types of waste generated, amongst other factors. The core problem of solid waste management in the country is attributable to the non-implementation of existing laws and legislations, need for the upgrade of obsolete legal instruments, inadequate budgetary provisions and funding mechanisms, and poor monitoring and evaluation mechanisms as to guide the environmentally safe and sound practices in solid waste management. Solid waste management programmes have been operated without a national policy and this has attracted criticisms from various stakeholder groups on solid waste management in the country.

The Federal Ministry of Environment (FMEnv) with support from the United Nations Industrial Development Organization (UNIDO), other technical partners and critical stakeholders in the public and private sectors developed the National Solid Waste Management Policy as a statement of intent to be implemented as a procedure or protocol in the management of solid waste in Nigeria.

Nigeria operates a three-tier of Government—the Executive, Judiciary and Legislature.

The Executive approves/enforces laws made by the Legislative arm of Government. To achieve this mandate, it has several Federal ministries, Department and Agencies to cover all aspects of human endeavours.

The National Assembly represents the Legislature whose primary function is to make laws. It consists of two Chambers—the Upper and Lower Chambers. The Upper Chamber (Senate) is comprised of 109 Senators while the Lower Chamber (House of Representatives) consists of 360 Representatives. The primary function of the judiciary is to interpret laws. The highest appellate court supreme court is headed by the Chief Justice of Nigeria.

The Federal Government of Nigeria is charged with establishing institutional and legal frameworks for solid waste management. The Nigerian policy on solid waste management encompasses the Executive, Legislature and Judiciary at the Federal, State and Local Government. The policy outlines the key sources of solid waste in Nigeria so that segregation, collection, transportation, storage, treatment and disposal of waste are carried out in a manner that provides protection for the environment and human health and in compliance with legal requirements.

The institutional framework within the Legislature responsible for policy and regulatory matters on solid waste and the environment in general is the Senate Committee on the Environment and Ecology and the House Committee on the Environment at the Federal level. Both committees play important roles that enact appropriate legislation that will:

(a) Foster successful implementation of the "Policy Guidelines" and "Action Plans" for a sustainable and effective management of solid waste within all the territory of Nigeria.
(b) Ensure the inclusion of solid waste management (SWM) in the National Development agenda of the country.
(c) Regulate the design, establishment and performance standards for landfills and all solid waste management technologies to be utilized within the country.
(d) Prevent the indiscriminate disposal of solid wastes into and onto land.
(e) Prevent the indiscriminate disposal of solid wastes into water bodies.
(f) Ensure that appropriate assessment is carried out on SWM facilities before the commencement of operation and at defined time periods throughout the life of the facility.

(g) Incorporate applicable principles and domesticate appropriate international conventions, protocols and treaties into solid waste management laws and management practices within the country.
(h) Focus strongly on environmental and solid waste data procurement, storage and management.
(i) Review old laws and regulations and adopt new regulations that will make SWM programmes achievable.
(j) Review and reform existing national/state legislations and regulations relating to SWM in order to create a legislative framework which gives legal effect to this Policy and facilitates a comprehensive, integrated and sustainable approach to SWM.
(k) Ensure SWM programme evaluation and long-term priorities settings are made and achievable.

The State and Local Government legislatures at their individual levels of governance shall have the right to introduce more stringent legislation in their areas of jurisdiction, but at all times standards must not be lower than that stipulated at the Federal level. The State and Local Government legislatures shall reserve the right to add, delete or change solid waste management taxes and fees to enforce scale-up of waste management activities. Legislative discretion is, however, required to ensure the burden of solid waste taxes and is not too high as to become a disincentive to effective and sustainable SWM.

In terms of solid waste management in Nigeria, the Judiciary is responsible for the interpretation of principles, protocols, rules and legislations, and the trial of solid waste management legislation defaulters. Basically, the judiciary shall:

(a) Have jurisdiction and power over all solid waste matters specified under any environmental protection law, regulations or sanitation and waste management laws of the country (Federal, State and Local Government levels).
(b) Provide mechanisms for the resolution of solid waste jurisdiction and management concerns between different tiers of government, public institutions, private agencies and individuals.
(c) Establish specialized tribunals for solid waste management issues, as undertaken in other areas of national life such as with trade or labour disputes.
(d) Provide public access to solid waste management dispute resolution and remedy.
(e) Provide solid waste management dispute resolution mechanisms, public interest litigation protocols, class action legal processes and the ability to represent and protect the interest of future generations.
(f) Be guided on environmental sentencing information.

3 Compliance and Enforcement

The compliance and enforcement of the National Solid Waste Management Policy enacted in 2018 to follow the Federal Government of Nigeria 5R's hierarchy for solid waste management (reduce, repair, reuse, recycle, recover) shall include:

(a) Protection of environmental standards.
(b) Enforcement of regulations and legislation.
(c) Compliance with international treaties and standards.

4 Sanctions

1. The Federal Ministry of Environment (FMEnv) in conjunction with the State Ministry of Environment (SMEnv) shall develop guidelines for various categories of offences, non-compliance and associated sanctions and penalties.
2. Major offences of high impact shall be documented in national plan of action.
3. Relevant laws on solid waste management stipulating service standards and operations shall be enacted and adequately disseminated.
4. The FMEnv/SMEnv/NESREA/States Waste Management Authorities shall impose penalties, taxes, fines and charges for non-compliance to solid waste management standards and regulations.

The existing documents in Nigeria which contain some form of regulations related to solid waste management are:

i. Constitution of the Federal Republic of Nigeria
ii. National Policy on Environment, revised
iii. Federal Environmental Protection Agency Act, 1992
iv. Environmental Impact Assessment Act of 1992
v. National Environmental (Sanitation and Wastes Control) Regulations, S.I No. 28 of 2009
vi. National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations S.I.9 of 1991
vii. National Environmental Protection Management of Solid and Hazardous Waste Regulations S.I.15 of 1991
viii. The National Guidelines and Standards for Environmental Pollution Control in Nigeria
ix. The National Environmental Standards and Regulations Enforcement Agency Act, 2007 (NESREA Act)
x. The National Environmental (Electrical/Electronic Sector) Regulations 2011, as gazette in Federal Government Gazette No. 5, Vol. 98. In the gazette, the 3R's of waste management was expanded to 5R's, namely reduce, repair, reuse, recycle and recover

xi. The National Oil Spill Detection and Response Agency Act 2005 (NOSDRA Act)
xii. Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
xiii. National Environmental (Base Metal, Iron and Steel Manufacturing/Recycling Industries Sector) Regulations, 2011
xiv. National Policy on Municipal and Agricultural Waste Management, 2012 (Draft)IO
xv. National Environmental (Pulp and Paper, Wood and wood Products sector) Regulations, S.I 34 of 2013
xvi. National Environmental (Motor Vehicle and Miscellaneous Assembly Sector) Regulations, S.I 35 of 2013
xvii. Merchant Shipping Act, 2007
xviii. Merchant Sea Dumping Regulations, 2013
xix. Nigerian Maritime and Safety Administration (NIMASA) Act, 2007.

5 Institutional Arrangements for Solid Waste Management in Nigeria

The institutions responsible for solid waste management in Nigeria are:

(i) Senate Committee on Environment and Ecology
(ii) House Committee on Environment and Habitat
(iii) Federal Ministry of Environment (FMEnv)
(iv) National Environmental Standards, Regulation and Enforcement Agency (NESREA)
(v) Environmental Health Officers Registration Council (EHORCON)
(vi) Nigerian Maritime Administration and Safety Agency (NIMASA)
(vii) National Oil Spill Detection and Response Agency (NOSDRA)
(viii) Department of Petroleum Resources (DPR)
(ix) Abuja Environmental Protection Board (AEPB)
(x) States Ministries of Environment (SMEnv)
(xi) States Environmental Protection Boards, Agencies, Commissions, etc.
(xii) Local Governments' Authorities (Departments' of Environment and Health, Works, etc.)
(xiii) Waste/Refuse Management Authorities
(xiv) Private sector—formal and informal ("Scavengers") in Solid Waste Management.

6 Future Plans and Targets in the Country or Any Localized Targets

The main problems are related to collection, transportation and disposal, with one-third to half of the solid waste generated in the developing countries remaining uncollected (Sujauddin et al. 2008; Thanh et al. 2011; Wilson et al. 2012; Olukanni et al. 2016; Olukanni and Oresanya 2018). Due to the myriad of challenges related to solid waste management in Nigeria, the idea in the minds of governments, institutions and all stakeholders in waste management sector now is the concept of circular economy. The concept recognizes that population growth and traditional (linear) processes, where majority of products are eventually disposed of after use, are unsustainable. The actual performance of the public sector in Nigeria has left much to be desired, and many government-owned enterprises are not responsive to the changing requirements of the growing and dynamic economy because they do not have the required tools for effective service delivery (Olukanni and Nwafor 2019). Relying on PPP without providing the necessary legal and institutional framework will not produce the desired results in effective waste management. As Nigeria is faced with the pressure to provide critical services to its population, the way forward is to deliver the needed infrastructure to carry out the essential services by using the resources effectively and produce maximum benefits for the citizenry.

The development of material supply chain management through the combination of waste hierarchy thinking should now be in place, and there is a need for sustainable energy solutions. As a result of the scarcity of raw materials necessary for technological innovation, encouragement of progressive development of circular economy models should be of utmost priority and modalities should be set to put this in place, with increasing awareness of social, financial and economic barriers.

Furthermore, the practice of collecting, transfer, treating and disposal of solid waste (integrated solid waste management) has become a necessity. It has become a common knowledge that most wastes have a recovery value; that is, they can be recycled and reused, which ultimately reduces the pressure of consumption of fresh materials in the production line. Especifically, material recovery is a strategy low-income earners use as a survival strategy. Figures 1 and 2 show scavenging activities are dumpsites while Figs. 3 and 4 show salvaged materials. The idea is to first sort out plastics, paper and other combustibles after which the solid wastes are set ablaze so as to be able to retrieve the incombustibles like iron and aluminium.

The scavengers sell the salvaged materials to middlemen who, in turn, sell to recycling industries. Table 1 shows the prices of some salvaged materials. The prices are varying from N30 to N55.

Material recovery facilities (MRF) are provided in some places to recover valuable resources from wastes by Local Authorities or recyclers. A case in point is the waste to wealth initiative set-up by the government of some states such as Lagos, Ogun, Oyo, Ekiti and Osun (Olukanni and Aremu 2017), and some universities are currently driving different initiatives. These projects are geared towards effective waste management processes to reduce, reuse and recycle waste materials.

Fig. 1 Scavenging activities at a dumpsite before burning (to retrieve combustibles)

Fig. 2 Scavenging activities at a dumpsite after burning (to retrieve incombustible)

Fig. 3 Salvaged metals

Fig. 4 Salvaged plastics

Table 1 Prices of some salvaged materials

Recyclable waste materials	Average percentage of each item in the waste stream (%)	Prices of recyclables in Naira/kg
Pet bottles	12.69	N 55
Paper	3.79	N 5
Plastic food packs	11.92	N 30
Nylon	9.07	N 30
Tin cans	4.41	N 35
Tetra packs	5.72	N 35
Food waste	52.40	Compostable
Total	100.00	

Polyethylene Terephthalate Ethylene (PETE) bottle waste (plastic waste) generation is getting beyond levels that communities and cities are comfortable with, and the uncontrollable effect is becoming alarming even as it gets through to the water bodies. Promoting healthier lifestyles and commitment to build a sustainable and friendly environment is the way forward. Evidence from pilot project tagged "Waste to Wealth" (W2 W) initiative, which commenced in 2015 at Covenant University in Nigeria, shows that materials and valuable resource can be harnessed and converted to useful products. The idea of driving this scalable project is to:

(i) promote excellence in plastic waste reduction management by enhancing environmental sustainability and sustainable strategies;
(ii) create and implement innovative strategies that engage relevant stakeholders to reduce plastic use;

(iii) provide students at all levels with direct experience in environmental management through environmental stewardship, academic internship, paid positions and volunteer opportunities; and
(iv) Carry out research on the reuse of the plastic waste as partial substitutes for other construction materials and other engineering infrastructures.

Figure 5 shows an accumulation of sorted plastics ready for recycling. The accumulated plastics were derived from scavengers who source for plastics from households, commercial centres and dumpsites. Figure 6 shows a small-scale metal recycling facility in Lagos, Nigeria. Cans are melted in open pits for export to Japan and India.

Fig. 5 An accumulation of sorted plastics ready for recycling

Fig. 6 A small-scale metal recycling facility in Lagos, Nigeria

7 The Challenges

Circular economy is relevant for adoption essentially because of its sustainable development concept, promotes zero waste of materials, resource efficiency and especially low energy utilization, thus providing several advantages to the society and nature. Nigeria has mostly remained locked into the linear economy model despite various circular economy advances made globally (Ogunmakinde 2016).

Nigeria, like many African countries, does not have large-scale recyclable collection from source, less than 12% of waste is formally recycled from dumpsites in an unsafe and hazardous condition. The poor waste disposal methods lead to clogged drains, flooding and other environmental problems.

8 Municipal Waste Management

Over 35 million tonnes of municipal solid waste are produced yearly in Nigeria, including food waste, textiles and plastics.

Tires: an estimated 90% of tires are imported used from abroad and therefore are disposed off regularly, requiring a better solution than landfilling.

Biomass: Agriculture is the dominant sector in rural areas (70% of the workforce), generating a massive quantity of residue, impacting the ecosystem.

9 E-Wastes

Dell, HP and a host of electronics manufacturers have created an alliance that will purchase electronic waste from consumers for recycling purpose. Currently, Hinckley a company established by in 1989 by HP developed a sustainable business model on e-waste and the first and leading registered electronic waste recycler in Nigeria. The developed recycling facility can share the metals but important elements such as gold, copper, mercury are not extracted due to lack of equipment.

10 Plastic Waste

According to Weblers, eight (8) million tons of plastics make their way into the ocean annually, 100,000 tons of PET bottles are produced in Nigeria annually and 91% of plastics are not recycled. Lagos currently generates about 730,000 tons of plastic waste annually with just 5% recycled. The World Bank projects that plastic usage in Lagos is set to grow at 9.6% annually leading to about 1.9 million tons by 2025.

Extended producer responsibility gradually been practised in Nigeria. For example, the food and beverages industry have formed a recycling alliance under Coca-Cola to collect all plastics and packaging materials which are thereafter recycled. This model is based on polluter pays principle, where the manufacturers of packaging materials are now responsible for managing of used plastic.

11 Research and Opportunities

Circular economy is a concept that has been increasingly gaining ground in global conversations over the past few years. A few cities and companies have already started executing this concept as new business models and technologies emerge, the opportunities for agriculture, manufacturing and waste management can be harnessed to improve livelihoods and reduce poverty.

12 Private Sector Practices in Nigeria

Sunray Ventures developed “Green Compass Recycling” to introduce the principles of Circular economy to Africa, with a focus on electronic and electrical waste. According to Sunray Ventures, e-waste generated in Nigeria is growing by 8% per annum as 80% of electronic goods imported into Africa are second-hand. In providing solutions for Nigeria, the Sunray Ventures Founder shared that a GC plant covering 7,000 hectares of land will be developed in Lagos, while discussions are on-going with six (6) states in the country on effective waste management measures and service.

Lagos Deep Ocean Logistics Base (LADOL) suggested that “Local Content Policy” in sectors like the oil and gas companies have to be challenged to adopt best business practices. Investment in skills, training and jobs is critical to driving a sustainable circular economy in the country, for instance, through its “Upskilling Academy—World Class Campus” which set a target of training 2,000 Nigerians annually by 2022.

Lafarge Africa Plc in 2018 outlined initiatives driven by the company to support the circular economy. The “Geocycle Nigeria” by Lafarge initiative according to Lafarge is a global network that specializes in co-processing and alternative raw materials with cement mineral content. They also mentioned that the “RoadCem” innovative product which is ideal for sustainable road construction, reduces the need to repair bad roads and a soil-stabilizing cementitious binder and calcium hydroxide enabling plasticity and enhanced strength.

13 Research Supporting Circular Economy in Nigeria

Nigeria committed itself to move towards zero waste at the United Nations (Anukam 2011). There is dearth of research works targeted directly at circular economy in Nigeria. However, many works have reported studies related to various aspects of the circular economy (3R's) such as reduce, reuse/repair and recycle or the 5R's such as refuse, reduce, reuse/repair, recycle and recovery/repurpose/rot. These research works, looking into the various components (either 3R or 5R), support the attainment of circular economy in Nigeria and help in her bid to achieve sustainable development.

Ogunmakinde (2016) developed a circular economy-based waste management framework for Nigeria and assessed its adaptability to the management of construction wastes. Ezeohaa and Ugwuishiwu (2011) conducted a literature review to investigate the potential of abattoir wastes to befoul the environment, or cause hazards to human health, and harm to living resources and ecological systems. The paper proposes some research considerations on the pollution potential of abattoir wastes in Nigeria and developed optimized abattoir waste management strategies that would ensure reduction in environmental pollution.

There are many researches in Nigeria which reported studies related to the conversion of solid waste to energy products through torrefaction, pyrolysis and gasification.

Few researches reported the upgrading of solid waste through densification techniques such as briquette, pelletization and cubing while others studied how to determine the optimum location of waste to energy facilities in Nigeria. Lasode et al. (2015) evaluated the amount of wood waste available for energy generation in Ilorin, Nigeria through the assessment of twenty potential energy facility sites. They used the single facility location with rectilinear distance model to determine an optimum location for an energy generating facility based on the impact of four major constraining factors: the net amount of waste available, transportation cost, social effect and environmental effect. The most feasible location away from the optimum location was chosen through the construction of a contour, which is within the Industrial zone of Ilorin, Nigeria.

14 Special Learning

The circular economy concept is gathering momentum, but significant effort is required to move the level of an idea to action. There is an increasing understanding of what the circular economy offers. Hence, important strategies must be put in place to address some of the most pressing environmental, economic and social challenges of the twenty-first century, while also providing positive economic benefits. There are a lot for Nigeria and her populace to learn from the developed economies on the policies and strategies to adapt to achieve the desired goal. There is need for the government to action to her commitment to zero waste through sound policy frameworks that will address the emerging challenges of attainment of set objectives. The problems militating against effective waste management in Nigeria has attained an emergency status. A circular economy task force may be required to address specific barriers to the attainment of the goals under the auspices of the National Environmental Standard and Enforcement Agency (NESREA) as was created at the G20 Summit in Germany on July 2017 (World Economic Forum 2018). Efforts must be geared towards bringing the private and public sector into collaborations to scale impact around circular economy initiatives.

15 Factors Affecting the Implementation of Circular Economy in Nigeria

The problems militating against municipal waste management in Nigeria are numerous and diverse, and these problems are related to economical, technological, psychological and political aspects.

(a) Poor Funding

This is one of the major problems constraining the waste management sector. Incapability of purchasing new waste collection trucks, limited staffs, poor vehicle maintenance, unsubsidized waste storage containers, inability to purchase equipment amongst others are all attributed to a shortage of capital. Actualizing waste management projects require consistent funding to achieve answers to strategies yet to be implemented.

(b) Poor Legislation and Implementation of Policy

The constitutional strength of municipal waste management policy is weak and ineffective. Also, the implementation of this policy is not monitored. The policy is not well structured and definitely tends to be weak. There are instances in which due process is obstructed and sanctioned penalty is not expended on certain municipalities and individuals. Policies are yet to be aimed at the 3R's of waste management—reduce, reuse and recycle. Government policies on waste are not revisited, reaffirmed, restructured and upgraded in a comprehensive tune and form.

(c) Limited Infrastructures and Professionals

Limited solid waste infrastructures are one of the major contributing indexes of poor waste management system in Nigeria. The environmental protection agencies and waste management personals are not experts and exposed to workshops and trainings that meet international standards on technology use, information management and knowledge management. Most of the state environmental protection agencies lack adequately trained personals.

(d) Level of Awareness in Nigeria

Populace awareness on sustainable waste management is still very poor, and effort by the agencies to increase awareness is still very low. Municipal members are not well informed on the adverse effects of indiscriminate and improper disposal of waste and also the benefits of such act.

(e) Recovering and Recycling

Access to possible recyclable material possesses great difficulty due to poorly limited recycling programmes. The informal recycling programmes involve scavengers' effort search of recyclable items. Presently, the informal sector renders the service of retrieving and recycling of materials in Nigeria. The introduction of an advance formal recycling programme presents positive and accelerating outcomes for municipal waste management sector.

(f) Disposal

The landfill disposal technique of waste materials with a dearth of treatment processes and open dumping possesses increasing public health hazards to human lives, animals and plants. However, the emission of poisonous gases such as methane and carbon dioxide cause alteration of weather, leading to climate change.

16 Drive for Circular Economy

A. Cultural belief wastes are viewed as invaluable and useless materials rather than wealth. Wastes are not seen as valuable materials that can be recycled for actual use, material recovery and energy recovery. The value of waste to people enhances the actualization of the process involved in the management of waste. The conception of waste as worthless is inherently linked with societal organized cultural systems of where things belong. However, consumer's activities are largely a function of common societal cultural values and norms.
B. Communication channels: the dearth of an effective communication channels affects the knowledge acquisition of municipalities in the management of waste. Communication channels such as mass media and posters are often adopted in the transfer of new information rather than the face to face which involves one on one practical interaction process.
C. Collaboration with International Solid Waste Management Organization/Agencies: the existence of limited collaboration with International Solid Waste Management organizations impedes rapid sustainable development within the waste sector. Interaction with International waste agencies is rarely a focus area for waste management.
D. Centralized Waste Collection Containers: in Nigeria, centralized municipal storage containers are not in place. This presents the municipalities with placement challenges of sorted and recycled materials of different categories. The need for centralized municipal collection points is not viewed as a means to a solution for recycling and material recovery. Thus, such agenda is not included in platform for waste management. The available funds are not directed to meet the purchase

of the waste storage containers for managing waste management. Purchase of municipal storage containers for different collection point is indeed necessary.

E. Packaging and Product Producer Involvement: the involvement of packaging producer in the management of waste is limited. Producers' interests are mainly in the production of content packages rather than the management of these packages. Due to the low level of material and energy recovery, material cost is not maximized and this directly affects the cost of packaging production. With the increasing effect of improper waste management, the manufacturing sector interest lies mainly on profitability rather than waste reduction.

F. Personnel morale field workers in charge of waste collection and transportation often have low morale. Their performance is determined with the extent of stigmatization encountered on the job, poor remuneration and stagnant promotion. Field staffs are not also encouraged by the consumer's manner of habitual waste storage.

17 Proposed Knowledge Management Solutions

The presentation of knowledge management solutions in the management of municipal waste in this context is not only in terms of technology centred approach but rather a people centred approach. With respect to municipal waste management, the people-centred approach focuses on individuals that fall within the municipal waste management chains. This includes municipal waste generators, packaging firms or producers and waste management companies while the technology centre approach focuses on the use of ICT's as knowledge and information repository in the management of municipal waste.

People should be orientated knowledgeable to conceive waste as being a valuable resource for material and energy recovery and also on the environmental consequences of waste dumps on drainage channels, streams, pathways and roadsides.

The more interaction with international waste agencies is required to close up existing gaps between developed and developing countries and to ensure efficient municipal waste management. This interaction would open doors to new coping strategies of managing waste effectively in Nigeria, amongst which is knowledge The need for information flow between waste generators, producers and waste management companies is vital in bridging the knowledge gaps.

The communication and exchange of knowledge are facilitated between waste generators and producers of recyclable packages such as plastic, tins and cartons provided comprehensive descriptive logos or labels are inscribed with expressions in English and three major languages on such containers have been recyclables. The recovery process of these recyclables from consumers will be possibly not challenging if certain incentives are attached to the return of such items. These incentives are consumer-generated incentives that are derived at the point of purchase as the cost of the actual containers is already added to the purchasing cost of the items. The transfer of information and knowledge to municipalities should be undertaken by waste management (social workers) companies through effective communication channels involving face-to-face communication. Aside other means of communication, the face-to-face channel of communication should be employed by the municipal waste management companies to interact with and orientate members of the municipalities on disposal habits, sorting and storing of waste in an environmental friendly manner. The importance and benefits attached to waste separation, proper storage, collection and effective waste management needs to also be communicated. The eye contact and interaction between the sender and receiver help to achieve the desired goal to a large extent. Efficient management of waste is promoted if municipal storage containers are available at subsidizing price. The storage containers should be of different colours indicating the various categories of municipal waste for a particular storage container. In bridging the knowledge gap existing between packaging and product manufacturers; and waste management companies, the need to deliberate and share knowledge on what ought to and can be reuse and recycled to produce the actual container or alternative containers and energy is paramount. A cohesive collaboration between the packaging manufacturer and waste companies will enhance the prerequisite knowledge and information transferred to communities. Hence, some level of participation is required of them in order speed up actualization process.

References

Anukam, L. C. (2011). Statement on the round table on moving towards zero waste and sound management of chemicals, The 19th session of the UN Commission on Sustainable Development (High-level Segment), Federal Republic of Nigeria. Available at: https://sustainabledevelopment.un.org/content/documents/425nigeria.pdf. Accessed June 14, 2019.

Aremu, A. S., & Sule, B. F. (2010). Policies, practices and challenges of municipal solid waste management in Nigeria. *Environmental Issues, 3*(1), 1–10. Published by the Department of Geography and Environmental Management, University of Ilorin, Nigeria.

Aremu, A. S., & Ganiyu, H. O. (2019). Waste to energy: Developing countries' perspective. In S. Ghosh (Ed.), *Waste management and resource efficiency* (pp. 167–176). Singapore: Springer.

Ezeohaa, S. L., & Ugwuishiwu, B. O. (2011). Status of abattoir wastes research in Nigeria. *Nigerian Journal of Technology, 30*(2), 143–148.

Grolier Incorporated. (1962). *The American peoples Encyclopedia*. New York, NY: Spencer Press Inc.

https://www.imf.org World Economic Outlook. (April, 2019). Assessed June 7, 2019.

https://www.worldbank.org. Nigeria overview. Assessed June 8, 2019.

Lasode, O. A., Balogun, A. O., Aremu, S. A., Akande, K. A., Ali, M. C., & Garuba, A. O. (2015). Optimum location analysis for wood waste-to-energy plant in Ilorin, Nigeria. *Journal of Solid Waste Technology and Management, 41*(1), 50–59.

National Policy on Solid Waste Management. (2018). Federal Republic of Nigeria.

Nnaji, C. C. (2015). Status of municipal solid waste generation and disposal in Nigeria. *Management of Environmental Quality: An International Journal, 26*(1), 53–71.

Ogunmakinde, O. E. (2016). Developing a circular economy-based construction waste management framework for Nigeria, Poster Presentation at the Conference of the Faculty of Engineering and Built Environment (FEBE), University of Newcastle, Australia (FEBE). Available at: https://Www.Researchgate.Net/Publication/318337956_developing_a_circular_economy-based_construction_waste_management_framework_for_nigeria/references. Accessed June 14, 2019.

Olukanni, D. O., Adeleke, J. O., & Aremu, D. O. (2016). A review of local factors affecting solid waste collection in Nigeria. *Pollution, 2*(3), 339–356.

Olukanni, D. O., & Aremu, O. D. (2017). Provisional evaluation of composting as priority option for sustainable waste management in South-West Nigeria. *Pollution, 3*(3), 417–428.

Olukanni, D. O. & Oresanya, O. O. (2018). Progression in waste management processes in Lagos State, Nigeria. *Journal of Engineering Research in Africa (JERA), 35*, 11–23.

Olukanni, D. O., & Nwafor, C. O. (2019). Public-private sector involvement in providing efficient solid waste management services in Nigeria. *Recycling, 4*(19), 1–9.

Sujauddin, M., Huda, S. M., & Hogue, A. T. (2008). Household solid waste characteristics and management in Chittagong, Bangladesh. *Waste Management, 28,* 1688–1695.

Thanh, N. P., Matsui, Y., & Fujiwara, T. (2011). Assessment of plastic waste generation and its potential recycling of household solid waste in Can Tho City. *Vietnam. Environmental Monitoring, 175,* 23–25.

Waste Management World. (2019). https://waste-management-world.com/a/the-future-of-the-circular-economy. Site accessed on 10/06/2019.

Wilson, D. C., Rodic, L., Scheinberg, A., Velis, C. A., & Alabaster, G. (2012). Comparative analysis of solid waste management in 20 cities. *Waste Management Research, 30,* 237–254.

World Economic Forum. (2018). Platform for accelerating the circular economy. Available online at: http://www3.weforum.org/docs/WEF_PACE_Platform_for_Accelerating_the_Circular_Economy.pdf. Accessed June 14, 2019.

Ying, J., & Li-Jun, Z. (2012). Study on green supply chain management based on circular economy. *Physics Procedia, 25,* 1682–1688.

Circular Economy Initiatives in Norway

Kåre Helge Karstensen, Christian John Engelsen and Palash Kumar Saha

1 Introduction

Circular economy is a principle of economic activity that aims to ensure that resources remain in the economy for as long as possible. This may be achieved by reducing raw material consumption, waste generation, emissions and energy consumption. The waste and recycling industry represent the largest part of the circular economy today, and it is estimated that more than 600 million tons of wastes can be recycled or reused in Europe (EC 2015).

The European Waste Framework Directive (WFD 2008) issued by the European Commission lays out common recycling targets and strategies for the EU Member States. The objective is to achieve a level playing field and improved resource efficiency in waste management. Six Member States landfilled less than 3% of their municipal waste in 2011, while 18 States landfilled over 50%, with some exceeding 90% (EC 2015).

Circular economy has a significant growth potential in Europe and in Norway. On average, recycled materials only meet less than 12% of the EU demand for materials (EC 2019). EU alone may save 600 billion US dollars annually after 2025 if industrial companies are able to turn their business around a circular economy (MacArthur and McKinsey 2015). In addition, such a transformation can create more than two million jobs by 2030, according to the EU Commission.

Norway is not a member of the European Union but have access to trade and other forms of relationship through a European Economic Area Agreement, which also means that Norway needs to comply with various EU directives, as the WFD. The waste hierarchy, i.e. prevention, recycling, material recycling, energy utilization and final processing in order of priority, constitutes the framework for the regulatory development in the EU and Norway.

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In Norway, the total material recycling level in 2017 was around 45%, which indicates a huge potential for circular economy initiatives (SSB 2019). Norwegian recycling companies must have access to international markets, on the same basis as other importers and exporters of raw materials. Harmonized and open waste markets, across national borders, strengthen the willingness to invest in the industry. Furthermore, a level playing field is crucial for the ability to invest in profitable, innovative and resource-efficient waste and recycling facilities.

Norway has a mixed economy with state and private ownership in, for example, the petroleum sector (Equinor), hydroelectric energy production (Statkraft) and aluminium production (Norsk Hydro). This provides a sound basis for growth in Norwegian circular economy which involves both private industry and the government.

2 Minimizing Resource Consumption and Rationalizing Resource Utilization Based on 3Rs (Reduce, Reuse and Recycle)

The linear economy of "take-make-dispose" is not sustainable in the long run, given the volatile resource prices, supply disruptions, economic losses and environmental strain. A circular economy is a regenerative system in which resource input and waste, emission and energy leakage are minimized through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, recycling and upcycling. The aim is to keep the value and utility of products, materials and components as high as possible for as long as possible. A circular economy will contribute to reduce future resource scarcity, help reduce climate impact, provide opportunities for innovative services and deliver new levels of economic efficiency and resource productivity.

The total generation of all non-hazardous and hazardous waste in Norway was 11.7 million tons in 2017. Around 21% of the waste was placed at landfills which indicate that there is still a significant potential to contribute to the circular economy. In particular, about the inorganic waste types like concrete, masonry, various types of slag, fly ash and dust which constitute 50% of the landfilled materials. However, for other waste streams, for example municipal solid waste, organic hazardous waste and EE waste, a sound waste management system is implemented for high recovery rates.

Innovation in the waste sector in Norway is guided by the waste hierarchy and the circular economy principles. Valorization of these waste streams is possible due to ambitious policy, well-functioning waste management systems, innovative technology and good communication between the different stakeholders in the region.

3 Legislative Framework and Government Support Towards Implementing 3Rs and Circular Economy Initiatives

3.1 Government Strategy

In 2015, the Norwegian government appointed an Expert Committee to propose a national strategy to promote "green competitiveness" towards 2030 and the low-emission-society in 2050 (Regjeringen 2015). Norway and the EU are prioritizing a circular economy agenda to deliver the next generation of jobs, growth and investment. Research funds, innovation support, consumer demands and legislative requirements will provide opportunities for those businesses using resources more productively.

The Norwegian government presented a White Paper to Parliament on waste policies in a circular economy with an emphasis on increasing reuse and recycling on 21 June 2017. The White Paper also outlines Norway's strategy to strengthen international commitment to combat marine litter through cooperation in the Nordic region, the EU, other regional fora and through the UN (NMCE 2017).

Long-term goals on waste reduction in different industries are also in the pipeline. Recently, an agreement with the food industry was established aiming to reduce food waste by 50% by 2030. The Norwegian Ministry of Climate and Environment announced that a similar type of collaboration will be established with the textile industry.

Norway has a tradition of using national policy targets combined with regulations, economic incentives, information and extended producer responsibility (EPR) schemes. Agreements between the branch/trade and the government on producer responsibility have promoted efficient waste management and product optimization for packaging, waste electrical and electronic equipment (WEEE) and PCB-containing glazing units, and taxes/fees have encouraged recycling and established a market for waste. At the regional level, counties are free to set their own targets and develop local/regional plans. This has been important for optimal and adapted resource efficiency in Norway (EEA 2016).

3.2 Extended Producer Responsibilities

The fundamental idea behind EPR is to place a responsibility for the post-consumer phase of certain goods on the producers. According to OECD, EPR is a policy approach under which producers are given a significant responsibility—financial and/or physical—for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals. In Norway, the EPR is implemented for products that contain dangerous substances and materials that are important to recycle (NMCE 2004):

- Electrical and electronic (EE) products
- Batteries
- Packaging
- Vehicles
- Tyres
- Double-glazed glass containing PCB.

3.2.1 Electrical and Electronic Products

Electrical and electronic products may contain health and environmental harmful substances. The collection, sorting and treatment of the waste derived from these products are regulated in the directive of waste electrical and electronic equipment (WEEE) (Directive 2012/19/EU), which is implemented in Norway.

All producers and importers in Norway are required to be a member of a compliance scheme for WEEE. An environmental fee is added to the price of goods coming out on the market. The amount of the fee is determined by the costs associated with collection and recycling of the product. In order to follow up producers and importers of EE products and resourced companies, the Norwegian Environment Agency has established the EE register. The EE register has an overview of all manufacturers and importers of EE products and informs them of what duties the waste regulations impose on them.

All municipal recycling stations are obliged to receive EE waste from consumers—completely free of charge. The same applies to retailers selling the same type of product that the consumer wishes to discard, regardless of brand. Therefore, municipalities and retailers must also be affiliated with an approved compliance scheme for handling the EE waste.

3.2.2 Batteries

The battery directive (Directive 2006/66/EC) has the objective of improving the environmental performance of batteries by regulating the use of certain substances in the manufacture of batteries (lead, mercury, cadmium, etc.) and setting standards for the waste management of these batteries. The interpretation and implementation of this directive in Norway has put the responsibility of a safe and sound management of waste batteries on the battery producer. This means that the entity that puts the battery product on the market is considered as a producer. The producer may transfer the EPR tasks to an authorized third party (compliance organization).

Table 1 New recycling targets of packaging waste laid down by EU (Directive (EU) 2018/852) and the recycling level in Norway in 2016

Material fraction	Recycling target 2025 (%)	Recycling target 2030 (%)	Recycling Norway 2016[a] (%)
All packaging waste	65	70	50
Plastic	50	55	45
Wood	25	30	4
Ferrous metal	70	80	Not given
Aluminium	50	60	Not given
Metal total	Not given	Not given	83
Glass	70	75	90
Paper and cardboard	75	85	80

[a]SOE Norway (2019)

3.2.3 Packaging and Packaging Waste

In 2017, the Norwegian waste regulation (NMCE 2004) was revised, and the producer responsibility for packaging was added. This implies that all entities that annually import or produce more than 1,000 kg of packaging wastes must finance collection, segregation and material recycling.

The financing is conducted by membership of a compliance organization authorized by the Norwegian Environment Agency. In the directive amendment (Directive (EU) 2018/852) to directive on packaging and packaging waste (Directive 1994/62/EC), new material recycling targets for packaging waste are provided; see Table 1. The recycling level in Norway is also shown in the same table, and it can be seen that the Norwegian level is roughly close to the EU target for 2030. Recycling of wood is an exception, as around 96% is energy-recovered in Norway.

3.2.4 Vehicles

Manufacturers and importers are responsible for the collection and recycling of discarded vehicles in Norway, so-called full producer responsibility. According to the directive on end-of-life vehicles (Directive 2000/53EC), the reuse and recovery for all end-of-life vehicles, by 2015, should have been minimum of 95% by an average weight per vehicle and year. Within this target, the reuse and recycling shall be a minimum of 85%. The same target is also implemented in the Norwegian waste regulations (NMCE 2004).

Around 140,000 car wrecks are collected in Norway annually. This represents 95% of the total scrapped cars. The recycling of car wrecks is mainly about the recycling of parts, material recycling of metal and other materials such as plastic and glass, as well as energy recovery. The rest goes to final disposal.

The company Autoretur AS has been responsible for collecting and recovering discarded vehicles. The company has good geographical coverage in Norway. The recycling and reuse level of car wrecks was 87.7% in 2018 (Autoretur 2019).

3.2.5 Tyres

The tyre industry is responsible for the collection and recycling of car tyres. Consumers have the right to deliver discarded tyres for free at the tyre dealers. Between 45,000 and 50,000 tonnes of car tyres are collected, which make up about 4 million discarded tyres a year.

It is prohibited to place tyres on a landfill, and Norsk Dekkretur AS is responsible for collecting, storing and processing discarded car tyres. In 2018, the 60,411 tonnes of used tyres were collected in Norway (Norsk Dekkretur 2019).

The following treatment and disposal methods were used: co-processing in cement industry (75%), material recycling (20%), reuse (2%) and the rest fraction of water, metals and residual waste (3%). Hence, none of the collected tyres were placed on a landfill.

3.2.6 Double-Glazed Glass Containing PCB

Manufacturers are obliged to ensure that any waste holder can deliver PCB-containing insulating glass for proper handling against a consideration that does not exceed the normal price for the delivery of insulating glass panes without PCBs to ordinary waste recycling plant. The manufacturer must cover the additional costs beyond this. The Norwegian Environment Agency determines for three years at a time what is considered the maximum normal price for the delivery of insulating glass routes without PCB.

The Norwegian company Ruteretur AS was established in 2002, after an agreement was signed between the Ministry of the Environment and the owners of Ruteretur. The company is a non-profit company that collects discarded PCB glass panes throughout the country and ensures that these are handled safely. Ruteretur is owned by the industry itself, via branch organizations in the building and construction industry.

4 Future Plans and Targets in the Country/a Particular State/Localized Initiatives

4.1 Circular Bio-economy

Around 651,000 tonnes of waste were processed at biogas and composting plants in 2017, and 56% was used for biogas production (SSB 2019). This is a significant increase in the last 5 years. Some of the reasons may be the prohibition to dispose biodegradable waste in landfill from 2009.

Biogas is a common term for the gases methane (CH_4) and carbon dioxide (CO_2) that occur when organic materials (e.g. food waste) decompose. If the waste decomposes without access to oxygen, it is left with about 60% CH_4 and 40% CO_2. These gasses are suitable for different purposes and are today mainly used for transport and food production.

Around 350 buses were running on biomethane in 2016. Given that they run a total of 70,000 km each year, this alone gives a climate gain of more than 30,000 tonnes of CO_2. Unlike diesel, biomethane also releases very little soot particles and does not impact the local air quality with particles that are harmful to the lungs. It is, therefore, ideally suited for high-traffic roads located in densely built-up areas.

In addition, one can utilize CO_2 from the biogas in greenhouses. Plants need CO_2 and sunlight to grow (i.e. photosynthesis). If the carbon dioxide in the greenhouse is made from food waste, it is an excellent example of how we can use the resources we already have around us to form circular value chains, rather than resorting to fossil sources.

In addition to the biogases produced from the waste, the “left-over” is biofertilizer which has similar properties like other manure. Biofertilizer can be used in organic farming. It adds important nutrients to the soil and thus reduces the need for fertilizers. In addition, carbon is stored in the soil. If the biogas plants are utilized fully in Norway, they can produce 600,000 tonnes of liquid biofertilizer directly to agriculture or as input goods in commercial fertilizer, compost, garden soil or growth soil. When biofertilizer is used for new food production, this is in practice circular economy, i.e. the resources in the waste (nutrients) are used over and over again. In addition, soil is supplied with carbon that prevents erosion and depletion. Biogas is, therefore, an important instrument in order for Norway to be able to achieve the EU’s goal of material recycling.

4.2 Norway's Programme to Combat Marine Litter and Microplastics

Approximately 80% of the litter that ends up in our oceans comes from land-based sources. The problem is in the oceans, but important solutions are on land. Improvements in waste management should, therefore, be a key priority. Sixteen of the top 20 producers are middle-income countries (majorly in Asia), where fast economic growth is occurring, but waste management infrastructure is lacking. Assuming no waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the marine environment from land is predicted to double by 2025 (Jambeck et al. 2015).

Norway has established a programme to combat marine litter and microplastics in developing countries. The impact of the assistance programme will be to "Prevent and significantly reduce marine litter and microplastics from sources in partner countries". Activities to be supported by this programme are to be implemented exclusively in countries that are major sources of marine litter, as, for example, in Asia. Norway wants to enhance international cooperation to prevent marine littering within the framework of the UN Environment Assembly.

The government has allocated around 35 million USD in 2018. Norway has also taken the initiative to make improved waste management and prevention of marine litter focus areas of the World Bank's fund PROBLUE. Combatting marine plastic pollution is a long-term commitment; Norway intends to spend 200 million USD to assist developing countries combatting marine litter and microplastics over the next four-year period (State Secretary Jens Frølich Holte's addresses at the seminar Stepping Up to Stop Marine Plastic Pollution in Washington, DC, USA).

The Norwegian Government also intends to reduce emissions of microplastics from key land-based sources in Norway and strengthen the clean-up efforts of plastics from along the Norwegian coastline. It has recently been decided to establish a National Centre in Lofoten/Vesterålen that will hold a central role in the clean-up effort. A grant scheme will also be introduced for local authorities that want to implement measures to reduce marine litter and microplastics as local authorities are key players in carrying out measures against marine litter and microplastics.

5 Examples of Research Projects

5.1 OPTOCE

International action is a key to tackle the most significant sources of plastics litter in the oceans, i.e. insufficient waste management infrastructure in developing countries and emerging economies. The project "Ocean Plastic Turned into an Opportunity in Circular Economy (OPTOCE)" aims to demonstrate the feasibility of using public–private partnerships to collect wastes from polluted hot spots, major river basins and beachfront areas and to treat the wastes in local industries (https://optoce.no). Pilot demonstrations will be conducted where non-recyclable plastic wastes will be energy-recovered in local energy-intensive industry, constituting a win-win concept and a fundamental pillar in circular economy. Such practice will increase the treatment capacity for wastes significantly, reduce the need for landfilling and incineration, reduce the consumption of non-renewable fossil fuels and virgin raw materials in energy-intensive industries, and finally reduce the release of greenhouse gases. Recyclable fractions will be sent to recyclers.

Lessons learned will be shared through a regional multi-stakeholder forum enabling awareness raising, capacity building and efficient replication across the continent. The forum will bring together relevant stakeholders to demonstrate cost-efficient and sustainable solutions to urgent local problems with global impacts. Initial partner countries are China, India, Thailand, Vietnam and Myanmar, but the final selection will be subject to their baseline situation and their willingness to engage in the project with own resources. Other countries might be considered. Opportunities and challenges linked to plastics are increasingly global, and addressing them will significantly contribute to achieving the 2030 Sustainable Development Goals. SINTEF has been implementing several waste recovery projects in Asia the last twenty years.

5.2 SFI Circular

The project, SFI Circular, aims to create new business opportunities that increase value creation and competitiveness in the Norwegian industry (SINTEF 2018). At SFI Circular's core are the academic partners SINTEF, NTNU and Nord University together with industrial enterprises in Norway committed to making a transition to a circular economy. SFI Circular will focus on identifying, evaluating and implementing innovative opportunities for value creation from adapting circular economy principles within and across different sectors. SFI Circular creates value by pooling resources from many industries and sectors.

5.3 PlastiCircle

The project, under the European Union's Horizon 2020 research and innovation programme, aims to develop and implement a holistic process to increase recycling rates of packaging waste in Europe including improvement of the plastic packaging waste chain from a circular economy approach (http://plasticircle.eu).

The target is to increase collection of plastic waste by 10%, and thus, the implementation of PlastiCircle approach in Europe has the potential to increase collected plastic by 860,000 tonnes, create 500–1,400 new companies and generate 12,000–33,000 new jobs. There are multiple partners in the project from Norway, Spain, UK, Italy, Netherlands, Romania, Slovenia, Belgium and Germany. SINTEF is the only partner from Norway, and its main contribution will be the integration and validation of the results on collection, transport, sorting and recycling. SINTEF also contributes to transport optimization, recycling and life cost analyses.

5.4 Construction, Demolition and Surplus Material Projects

The WFD includes a target for recovery of construction and demolition waste (C&D waste). Within 2020, the preparing for reuse, recycling and other material recovery of non-hazardous construction and demolition waste (excluding naturally occurring material) shall be increased to a minimum of 70% by weight.

The target was added during the final negotiations of the Directive text, and instructions for verifying compliance were established in 2011 (Arm et al. 2017). Norway has implemented the WFD and must comply with this target through the partnership of the European Economic Area. The directive is intended to be an overall key driver for circular-driven economy for C&D waste.

Although most of the C&D waste material recovery in Norway is by unbound use like road constructions and backfilling operations, there are ongoing initiatives that focus on recycling the waste entirely into new building products (e.g. concrete and paving blocks). Some of the ongoing circular economy-based C&D waste initiatives are mentioned below:

- Recycled aggregates from excavation materials are used in road construction and concrete production (RESGRAM) 2016–2020. The overall objective for the treatment and recycling plant is to convert more than 90% of the incoming excavation materials into commercial products, supported by Research Council of Norway (RCN 2016a, b).
- Use of local materials (Kortreist Stein) 2016–2019. The main objective of the project is to develop new technological solutions and tools, smart business models and good regulation processes to be able to utilize rock materials from infrastructure projects and local quarries in a superior and sustainable manner, supported by Research Council of Norway (RCN 2016a, b).

5.5 SINTEF Priority Programme on Circular Economy

SINTEF group priority programme on circular economy is a holistic approach through the focus on circular economy (SINTEF 2019). SINTEF combines technological expertise with economic and environmental expertise to provide our customers with multidisciplinary solutions. Important topics are development of optimization models combining technological possibilities with economic and environmental effects, development of innovative business models and new forms of cooperation as well as developing the materials and technology of tomorrow.

5.6 Lessons Learned

A study of the 15 companies in Norway concluded that collaboration is essential for how businesses transition to, and operate, circular business models. Moreover, Norwegian industry's characteristics of trust and reciprocity generate favourable conditions for close collaborations. Collaborating in clusters and industrial parks further enhances the strategic benefits, as it is proposed to facilitate for specialization, knowledge-sharing, relation-specific investments and utilization of complementarities (Zagragja and Rydningen 2016).

Deloitte has studied the circular economy practices of the 50 largest Norwegian companies and compared them with the global pioneers. Some of the important findings of a study by Deloitte on Norwegian circular economy benchmark (2018) are the following:

- Successful innovators that look beyond product performance and CE principles can provide valuable input as a source of innovation.
- Circular economy allows economic growth while optimizing the use of resources and transformed patterns of production and consumption chains.
- Norwegian firms innovate primarily within the network, process and product performance and focus the least on channel for distribution.
- Compared to the global benchmark, there is untapped potential for Norwegian companies to leverage opportunities related to the circular economy business development; consumer goods industry in Norway outperforms the global players.

Integrated waste treatment practice is a win-win concept and a fundamental pillar in circular economy; waste and discharges in one industry are used as inputs and resources in other industries. This waste management practice will increase the treatment capacity for wastes significantly, reduce the need for landfilling and incineration, and reduce the consumption of coal and raw materials in energy-intensive industries, like cement manufacturing, and finally reduce the release of greenhouse gases.

The winners of tomorrow will be the companies that are able to create more value out of less resources. This demands an innovative mindset, a long-term perspective, new business models and willingness to collaborate.

5.7 National Recycling Initiatives Contributing to a Circular Economy

5.7.1 Waste Sorting and Treatment for Household Wastes Generated in Oslo

The Oslo Energy Recycling Agency's (EGE) main task is to sort household waste from the municipality of Oslo, produce district heating and make biogas and biofertilizer (Oslo Municipality 2017).

The lifecycle-based waste management system in Oslo plays an important role in helping the city to reach the climate goals like material for recycling of 50% by 2018, reduce greenhouse gas emissions by 95% by 2030 and achieve climate neutrality by 2050. An important contribution is EGE's two optical sorting plants at Haraldrud and Klemetsrud, where source-separated household waste is sorted, as shown in Fig. 1. Expanded source separation of food waste and plastic packaging helps reduce greenhouse gas emissions and improve local air quality. It also aids in the recovery of valuable resources found in waste products.

Waste sorting is done with the aid of a fully automated optical sorting process for source-separated household waste, separated into bags with specific colours. The optical sorting plants are equipped with cameras that can identify the colours of the bags with about 98% accuracy.

The three lines at Haraldrud and Klemetsrud can sort 150,000 tonnes of household waste per year; the Haraldrud sorting plant is currently the world's largest, as per

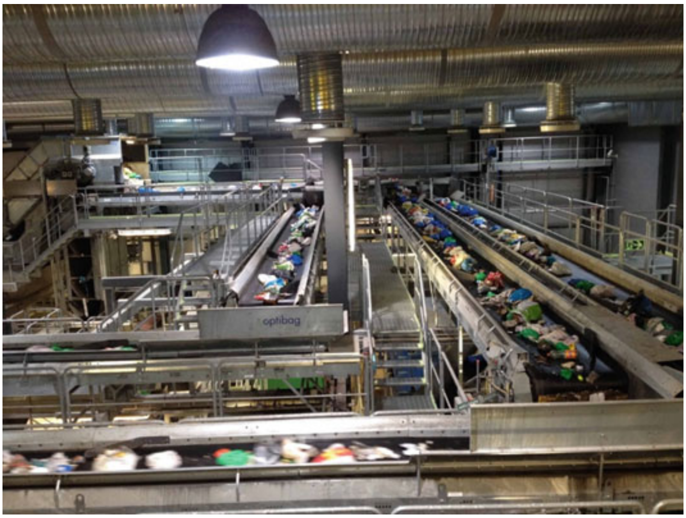

Fig. 1 Optical sorting of waste at Haraldrud

June 2017. The various stages of the sorting process are briefly described in the following.

Households in Oslo city sort their waste into three categories: food is sorted in green bags; plastic packaging in blue bags and residual waste in regular shopping bags. This type of waste separation is an addition to existing systems for sorting paper and cardboard, glass, metal and hazardous waste. A major advantage of this system is that the bags can all be placed into the same bin and transported in the same vehicle to the waste management plant.

- Pre-sorting: During the first sorting stage, larger unwanted elements and loose waste are sifted through a robotic pre-sorting process at the plant, where only blue, green and common plastic bags are allowed through. Unwanted waste of all sizes is removed and sent off for incineration, while the rest of the bags continue to the next step in the sorting process.
- Preparation for optical detection: When the robotic pre-sorting stage is complete, household wastes in the bags are distributed onto three conveyer belts equipped with robotic arms. The robotic arms rearrange the bags into a line, getting them ready for optical reading and sorting. The distance between the bags makes it easier for the optical cameras to read the colour and prevent the bags from being on top of each other.
- Optical sorting: When the bags arrive for optical reading, the cameras detect the colour of the bags with 98% accuracy. There are two sensors that detect green bags, one sensor that detects blue bags, and one sensor that detects both. Blue and green bags are removed with the aid of robotic arms, while those bags that are neither blue nor green continue further for recycling. The blue and green bags are transferred onto separate belts, where the colour codes are detected a second time through what is known as negative sorting. This process discards bags and elements which are neither blue nor green, but which may have been removed in error in the previous stage. The bags are then sent to separate containers. These optical sorters have a 98% detection rate.
- Blower: The blue bags undergo yet another quality control. To weed out the blue bags that contain waste other than pure plastic packaging, a blower or negative sorter has been installed on the blue belts. Lightweight bags can pass, but bags that are too heavy (more than about 600 g) are sent off for recycling. These are bags that contain waste other than plastic. The blue bags which are light and accepted by the blower continue to the compactor container. Plastic waste in the blue bags is sent to treatment plants in Germany and Sweden, where it is sorted into 5–7 categories. The plastic is melted into granules and then used as raw material in making new plastic products.
- The energy of the residual waste is recovered in Haraldrud and Klemetsrud waste-to-energy plants. The recovered energy is utilized for district heating and electricity production.

5.7.2 Advanced Plastic Sorting Facility for Household Waste

Romerike Waste Processing IKS (ROAF) works with the collection, sorting, recycling and recycling of waste. ROAF owns and operates the most modern household waste sorting plant in Europe and have an extensive responsibility to manage the resources in the waste in a responsible manner. They work continuously to reduce the ecological footprint of our operations and consider the environment in everything we do. The household wastes from 200,000 citizens in the suburbs of Oslo are collected. The sorting facility commenced operation in 2014, built at a budget of 25 million euros. The sorted materials are then sent to recycling.

ROAF has developed one of the most advanced sorting facilities in the world utilizing near-infrared (NIR) technology to sort out five different plastic qualities, metals and even paper from the residual waste stream. ROAF also administers several closed landfills as well as a landfill on the same site as the sorting facility. This list of equipment includes conveyors, NIR machines, drum screens, vibrating screens, shredder, bag openers, ballistic separator, Eddy current separator, magnetic separators, wind sifter and star screen. Dry, clean plastic can be recycled as many as ten times, and one kilo of recycled plastic saves the environment for two kilos of oil, which would otherwise have been used in the production of new products. It is more energy demanding to produce new plastic, than to reuse what already exists.

The advanced plastic sorting facility has resulted in the need for only two waste bins inside each household for the residual waste, i.e. one bin for food waste and one bin for other non-recyclable residual waste including plastics. This makes it easier for the consumers to focus on the household segregation (metal, paper, glass in addition to food and residual waste). The ROAF facility is sorting out around 2,500 tonnes per year for plastic material recycling.

5.7.3 Co-processing of Wastes in Norway

Co-processing is defined as use of a waste in an industrial process as an input material, additionally or in substitution of standard (primary, natural) input materials. Co-processing implies that there is a substitution effect together with the use of the waste, i.e. that the waste substitutes a fuel, a raw material, an auxiliary material or any combination of these in the process. Co-processing is widely used in the cement production. The co-processed wastes in cement industry substitute very often both the fuel and raw materials. In the cement clinker production, material temperature of up to 1,450 °C is needed to ensure the sintering reactions. Furthermore, the clinker needs to be burned in the excess of 2–4% oxygen. Hence, the cement kiln has many inherent features, which makes it ideal for hazardous and non-hazardous waste treatment (e.g. high temperatures, long residence time, surplus oxygen, dry scrubbing of the exit gas by alkaline raw material).

In Norway, two cement kilns are operated by Norcem AS. Both plants practise installed co-processing. It is emphasized that a dedicated incinerator for hazardous waste has never been built in Norway. A political decision was taken in the early

1990s to use the Norcem cement plants to destroy the organic hazardous liquid wastes. These plants substitute today approximately 70% of its coal need with waste-derived fuel, both hazardous and non-hazardous wastes. This strategy increases the waste treatment capacity significantly, reduces the need for landfilling and incineration, reduces the coal and raw material consumption in the cement industry and contributes to reduce greenhouse gases. The waste-derived fuel in the Norcem Brevik cement plant is from the following sources; 20% from municipal solid waste, 21% hazardous wastes, 9% from anode carbon, 5% from animal meal and 2% from waste oil.

The use of alternative fuels replacing fossil fuel is one of the key factors for the cement industry in western Europe in becoming sustainable. In addition to higher competitiveness, the use of more alternative fuels will also contribute to lower direct CO_2-emissions due to the use of biomass-based fuels and indirectly by avoiding landfilling and incineration of other waste types. The Brevik plant is a modern cement manufacturing process using the latest BAT/BEP technology, i.e. dry process with pre-heating and pre-calcination, advanced exit gas quenching and cleaning, and online exit gas monitoring.

5.7.4 Carbon Capture Projects in Norway

The Norwegian Government has initiated a full-scale carbon capture and storage (CCS) project in Norway. There are two capture projects that are part of the pre-engineering project: Fortum Oslo Varme waste-to-energy plant in Oslo (i.e. Klemetsrud plant) and Norcem cement plant in Brevik (Fortum 2019). Both facilities plan to capture around 400,000 tons of CO_2. This amount is equivalent to removing 60,000 cars from the road for a year.

The CO_2 will be transported by ship from the capture plant to an onshore facility on Norway's west coast for temporary storage. The CO_2 will then be transported via a pipeline to a subsea reservoir in the North Sea for storage. Equinor, with its partners Shell and Total, are responsible for the planning of the storage facility. The storage concept study will be completed during the course of 2019 followed by an advanced planning study. Once these studies are completed for all stages of the CCS chain, the basis for an investment decision will be in place. The projects are considered to be pioneering at an international level.

The Klemetsrud plant is a large source of emissions with annual emissions of more than 400,000 tons of CO_2. By capturing the emitted greenhouse gas, and subsequently storing it, it will be possible to reduce the fossil CO_2 emissions by around 12% per year. In 2016, Aker Solutions set up a test facility for carbon capture at Klemetsrud incineration plant. The pilot project lasted five months and captured successfully 90% of the carbon from the waste incineration. If approved, the carbon capture technology can be spread to Norway's 17 waste incineration plants, and even to the approximately 450 others in Europe. The Norwegian Parliament is expected to make an investment decision for the project in 2020/2021. The project will then be able to commence operations in 2023/2024.

Norcem and Heidelberg Cement Northern Europe have a vision of zero emissions of CO_2 from concrete products as seen over its lifecycle in 2030. To achieve this vision, it is necessary to capture CO_2 from cement production. In 2013, Norcem started a capture project to test different technologies in the plant in Brevik. The projected was finalized in 2017 which included a feasibility study for use of the amine technology from Aker Solutions. Furthermore, funding was assigned in the Norwegian state budget for 2018 for the last stage (FEED study) before the final construction. The aim of the ongoing FEED study is a detailed review of the project to provide a basis for an investment decision. The study will be ready by the end of 2019. After a third-party review, the Norwegian Government will submit a proposal to the Parliament to realize the project. If a decision to invest is made, the project will then enter a three-year construction phase. The cement clinker plant with full-scale carbon capture may thus be in operation in 2024.

6 Concluding Remarks

A circular economy is a regenerative system in which resource input and waste, emission and energy leakage are minimized through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, recycling and upcycling. An ultimate result of circular economy is that the term “waste” should disappear from our vocabulary. Hence, waste materials play a key role in the implementation of initiatives that contribute to circular economy.

The legislative framework for circular economy in Norway is based on the European directives that need to be implemented through the European Economic Area agreement between EU and Norway. The directives and the Norwegian legislation impose an increasing responsibility on the producer of consuming products, i.e. extended producer responsibility. This has been implemented for a number of large product groups (e.g. electrical and electronic equipment) which results in large waste streams. The producer responsibility is to a large extent successful and contributes to a safe and sound waste management which results in increased reuse, material recycling and energy recovery.

Many national and international circular economy projects are initiated in Norway. They are developed from the common sustainability perspective which focuses on the circular economy in particular. The R&D projects have different funding instruments and comprise research on different smart materials, design solutions, separation processes, carbon capture, legislative enablers, economic models, social factors, etc.

The focus on ocean plastic is high in Norway, and a strategy is decided by the government. This is also reflected in newly started projects that focus on reducing plastic and microplastic to enter the oceans (e.g. OPTOCE). Furthermore, the ongoing initiatives also have high international collaboration which is decisive to implement circular economy on a global scale. Furthermore, the governmental participation in the further development is important as both political and economic incentives are some of the cornerstones in circular economy.

References

Arm, M., Wik, O., Engelsen, C. J., Erlandsson, M., Hjelmar, O., & Wahlström, M. (2017). How does the European recovery target for construction & demolition waste affect resource management? *Waste Biomass Valor, 8,* 1491–1504.

Autoretur. (2019). *Annual report on Environment 2018* (in Norwegian).

Deloitte. (2018). *Norwegian circular economy benchmark 2017*, March 2018.

EC (European Commission). (2015). *Proposal for a directive of the European Parliament and of the Council, amending Directive 2008/98/EC on waste*. European Commission 2015/0275 (COD).

EC (European Commission). (2019). Report from the Commission to the European Parliament, the Council, the European Social Committee and the Committee of the Regions on the on the implementation of the Circular Economy Action Plan, European Commission, COM (2019) 190 final.

EEA (European Environment Agency). (2016). More from less—Material resource efficiency in Europe 2015 overview of policies, instruments and targets in 32 countries. Country profile of Norway. European Environment Agency May 2016.

Fortum. (2019). A full-scale carbon capture and storage (CCS) project initiated in Norway. www.fortum.com/media/2018/11/full-scale-carbon-capture-and-storage-ccs-project-initiated-norway.

Green Visits (Oslo region), Wastes in the circular economy. http://www.greenvisits.no/waste-in-the-circular-economy/.

MacArthur and McKinsey. (2015). Growth within: A circular economy vision for a competitive Europe. In S. Gurewitsch (Ed.), Report prepared by Ellen MacArthur Foundation and McKinsey Center for Business and Environment. 2engage.

NMCE (Norwegian Ministry of Climate and Environment). (2004). Regulations on waste (FOR-2004-06-01-930) (in Norwegian).

NMCE (Norwegian Ministry of Climate and Environment). (2017). Waste as resource—Waste policy and circular economy. Norwegian White Paper 45 (Meld. St. 45, 2016–2017, Melding til Stortinget) (in Norwegian).

Norsk Dekkretur. (2019). Annual report 2018—Collection and treatment of discarded tyres, www.dekkretur.no/. Accessed 9/7-2019 (in Norwegian).

Oslo Municipality. (2017). *Fact sheet: Optical sorting of household wastes*. City of Oslo, Waste-to-Energy Agency, https://www.oslo.kommune.no/.

RCN (Research Council of Norway). (2016a). Recycled aggregates from excavation materials used in road construction and concrete production (RESGRAM). RCN project number 256506/O20.

RCN (Research Council of Norway). (2016b). Use of local materials (Kortreist stein). RCN project number 256541/O20.

SINTEF. (2018). SFI Circular—Value creation in a green economy. www.sintef.no/en/projects/sfi-circular-value-creation-in-a-green-economy.

SINTEF. (2019). *Circular economy research*. www.sintef.no/en/circular-economy.

SOE Norway (State of The Environment Norway). (2019). Packaging waste (in Norwegian). www.miljostatus.miljodirektoratet.no. Accessed 9/7-2019.

SSB (Statistics Norway). (2019). Most of the biological waste are used for biogas production. www.ssb.no (in Norwegian).

WFD (Waste Framework Directive). (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. OJ L 312, 22.11.2008.

Zagragja, A., & Rydningen, J. K. (2016). *Circular economy in Norway—A qualitative study of how collaboration across firms, industries and sectors act as an enabler of a circular economy in Norway*. Norwegian School of Economics (NHH), Bergen, Spring 2016.

Circular Economy of Municipal Solid Waste (MSW) in Korea

Seung-Whee Rhee

1 Introduction of Waste Management in Korea

1.1 Regulation for Waste Management

Korean economy is characterized by the service-centered industrial structure and heavy industries are regarded as main source of economic growth. Rapid industrialization in Korea had been achieved by high rate of economic growth by export-driven heavy industry. In 2016, gross domestic product (GDP) of Korea is U$29,730 per capita which is 27th in the world (International Monetary Fund 2016). This economic growth results in an aggravated environmental load. In particular, it had a significant impact on the environment in the area of the most industrial complexes. Municipal solid waste is slightly increased due to increased income and consumption while commercial wastes are rapidly increased in its volume due to increased business activities and expansion of economy (Min et al. 2013). Recently, the amount of construction and demolition waste as a commercial waste is dramatically increased due to a lot of reconstruction projects implemented throughout all the nation.

An efficient waste management system was designed by regulations in Korea. To manage the waste, the regulations were implemented such as Waste Management Act, Act on the Promotion of Saving and Recycling of Resources, Act on Promotion of Purchase of Green Products, Construction Waste Recycling Promotion Act, and Act on Resource Circulation of Electrical. The purpose of major waste regulation was shown (Table 1).

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Table 1 Purpose of major waste regulation

Regulation	Purpose
Waste management act (Enact 1986; Korea legislation research institute 2016)	The purpose of this act is to promote the efficient use of national resources by facilitating the proper environment-friendly disposal and recycling of construction waste generated during construction works, etc., so as to contribute to the development of the national economy and the advancement of public interests
Resource circulation basic act (Enact 2018; Ministry of Environment, Korea 2016)	The purpose on the resource circulation basic act is (1) efficient use of resources and suppression of waste generation, (2) promote recycling and proper disposal of generated waste and reduce consumption of natural resources and energy, and (3) it defines the basic requirements for preserving the environment and creating a sustainable resource circulation society
Act on the promotion of saving and recycling of resources (Enact 1992; Korea Legislation Research Institute 2016)	The purpose of this act is to contribute to the preservation of the environment and sound development of the national economy by facilitating the use of recycled resources by means of controlling the generation of wastes and facilitating recycling
Act on promotion of purchase of green products (Enact 2004; Korea Legislation Research Institute 2016)	The purpose of this act is to prevent waste of resources and environmental pollution and contribute to the sustainable development of the national economy by encouraging purchase of green products
Construction waste recycling promotion act (Enact 2003; Korea legislation research institute 2016)	The purpose of this act is to promote the efficient use of national resources by facilitating the proper environment-friendly disposal and recycling of construction waste generated during construction works, etc., so as to contribute to the development of the national economy and the advancement of public interests
Act on resource circulation of electrical and electronic equipment and vehicle (Enact 2007; Korea Legislation Research Institute 2016)	The purpose of this Act is to establish a resource recycling system for the efficient use of resources and contribute to environmental conservation and the sound growth of the national economy by placing restrictions on the use of hazardous substances, encouraging manufacturers to produce products readily recyclable, and facilitating the optimum recycling of wastes thereof to ensure that recycling of electrical and electronic equipment, as well as vehicles, can be promoted appropriately

1.2 *Current Status for Wastes*

(1) Definition and Classification of Wastes
Under the Waste Management Act in Korea, the term "wastes" means such materials as garbage, burnt refuse, sludge, waste oil, waste acid, waste alkali, and carcasses of animals, which have become no longer useful for human life or business activities. In Korea, wastes are divided into household wastes and commercial wastes by source and volume of generation as shown in Fig. 1. Commercial wastes also are classified by construction waste, general waste, and controlled waste. Controlled waste means the commercial wastes specifically enumerated by Presidential Decree as hazardous substances such as waste oil and waste acid, which may contaminate environments or medical refuse, which may cause harm to human bodies (Min et al. 2013).
Management of waste in Korea is operated by a dual system. The local government has responsibility for the management of municipal solid waste (MSW), and the discharger in industrial sectors has responsibility for the management of commercial waste. And Ministry of Environment has the responsibility of inspection and supervision for all wastes.

(2) Current Status of Waste Generation
Total waste generation has been steadily increased from 2004, and an average annual increase is 3.2% for the past ten years (2005–2016). Total waste generation in 2016 was 429,139 t per day. Waste is generally composed of municipal wastes (12.5%) and commercial wastes (87.5%). Municipal wastes were anticipated to steadily rise due to an increase in population and economic growth.

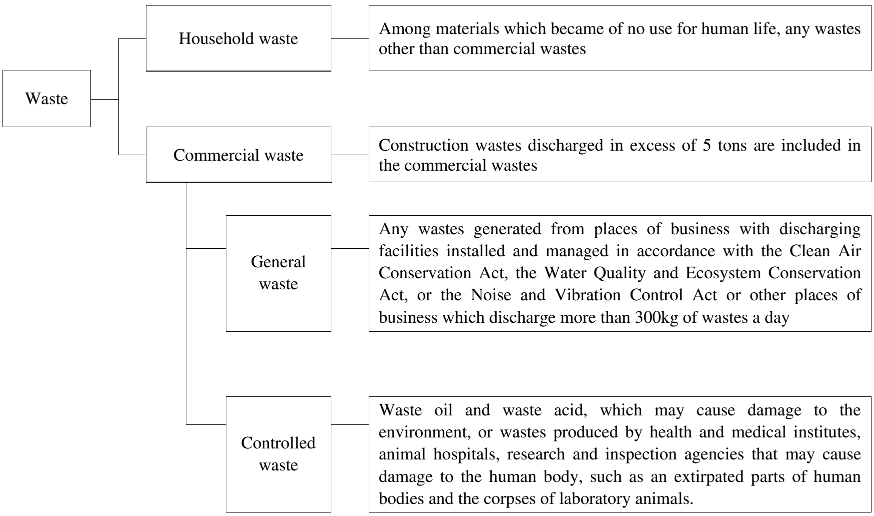

Fig. 1 Classification of waste in Korea

But, several policies for controlling waste generation (e.g., regulations on disposable goods and a volume-based rate system) have led to a gradual reduction in the generation amount of waste. The generation of MSW is similar to 1.03 kg/cap./day in 2004 to 1.01 kg/cap./day in 2016 (Ministry of Environment 2016). Commercial wastes have increased by an annual average of 3.7% over the past ten years (2006–2015) because of a rise in industrial activities, the expansion of economic activities, and energy-intensive industrial/economic structures (Korea Energy Agency 2016). Among commercial wastes, construction wastes are 52.7%, which accounts for the largest portion of commercial waste generated. This ratio indicates that construction waste dramatically increased as a result of a rise in construction and reconstruction (Ministry of Environment 2016) (Table 2).

(3) Current Status of Waste Treatment

In order to manage the municipal solid waste effectively, it is important to reduce waste generation and recycle waste as much as possible. In the case of municipal solid wastes, the implementation of the "volume-based rate system" has promoted waste separation at the sources and significantly increased recycling, and then the rate of generation of MSW has gradually been decreased. The recycling rate has shown a steady increase in 2016 because Korea government has been focusing on establishing EPR system to improve recycling rate, expanding recycling facilities suitable to regional conditions developing advanced technologies and encouraging the use of recycled products. Since the recycling of construction waste is very high, recycling rate of commercial waste

Table 2 Trends in waste generation (Ministry of Environment, Korea 2017) (*unit* 1000 t/day)

Year	Municipal wastes	Commercial wastes				Total	MSW (kg/cap./day)
		General waste	Construction wastes	Controlled wastes	Subtotal		
2004	50.0	105.0	158.5	8.2	271.7	321.7	1.03
2005	48.4	112.4	134.9	8.6	255.9	304.3	0.99
2006	48.8	101.1	169.0	10.0	280.1	328.9	0.99
2007	50.3	114.8	172.0	9.5	296.3	346.6	1.02
2008	52.1	130.8	176.4	9.6	316.8	368.9	1.04
2009	50.9	123.6	183.4	9.1	316.1	367.0	1.02
2010	49.2	137.9	178.1	9.5	325.5	374.7	0.96
2011	48.9	138.0	186.4	10.0	334.4	383.3	0.95
2012	49.0	146.4	18.6	12.5	345.5	394.5	0.95
2013	48.7	148.4	183.5	12.4	344.4	393.1	0.94
2014	49.9	153.2	185.4	13.2	351.8	401.7	0.95
2015	51.2	155.3	198.2	13.4	366.9	418.2	0.97
2016	53.8	161.1	199.4	13.7	374.2	429.1	1.01

Table 3 Status in municipal solid waste treatment (Ministry of Environment, Korea 2017) (*unit* ton/day)

Year	Landfilling	Incineration	Recycling	Total
2004	18,195	7224	24,588	50,007
2005	13,402	7753	27,243	49,398
2006	12,601	8321	27,922	48,844
2007	11,882	9348	29,116	50,346
2008	10,585	10,349	31,138	52,072
2009	9471	10,309	31,126	50,906
2010	8797	10,609	29,753	49,159
2011	8391	11,604	28,939	48,934
2012	7778	12,261	28,951	48,990
2013	7613	12,331	28,784	48,728
2014	7813	12,648	29,454	49,915
2015	7719	13,176	30,352	51,247
2016	7909	13,610	32,253	53,772

is increased. In Korea, zero landfill disposal policy is activated in several cities because it is so difficult to find new landfill site (Ministry of Environment 2011). The recycling rate of commercial wastes has been increased for the past ten years. Among commercial waste, the recycling rate of general wastes has been increased by year. In the case of construction waste, their recycling rates are very high at 98.1% because they are mostly single material that can be recycled with ease. However, the reporting system for the management of a construction waste without considering the secondary waste may be overestimated the recycling of construction waste. Since construction waste mainly consists of incombustible materials, the incineration rate is too low as 0.4%, and landfilling is only 1.5%. The recycling of commercial waste may be significantly increased from 2018 because waste disposal charge system, in which a kind of charge for wastes landfilled or incinerated is applied, be activated in January 2018 by Resource Circulation Basic Act (Tables 3 and 4).

2 Resources Circulation Basic Act

2.1 Introduction

In 2015, Republic of Korea imported 94.8% of primary energy due to minimal natural energy and resource. In 2016, Korea' oil consumption was ranked the eighth-largest consumer (2763 k barrel/day) on the world, and imports of oil in Korea were ranked

Table 4 Status in commercial waste treatment (Ministry of Environment, Korea 2017) (*unit* ton/day)

Year	General wastes					Construction wastes				
	L.F[a]	Inc.[a]	Recycling	Others	Total	L.F	Inc.	Recycling	Others	Total
2004	13,616	7044	73,189	11,139	105,108	10,976	2949	134 557	7	148,489
2005	16,604	7326	76,957	11,532	112,419	3491	871	130 451	93	134,096
2006	8897	7709	74,761	9732	101,099	3935	1179	163,871	–	168,985
2007	22,503	7478	76,740	8,086	114,807	3169	1131	167,705	–	172,005
2008	24,285	6937	92,615	6940	130,777	2914	1423	172,110	–	176,447
2009	27,531	6926	82,155	6992	123,604	2792	1283	179,276	–	183,351
2010	23,309	7983	99,627	6956	137,875	2200	919	175,001	–	178,120
2011	23,037	8307	100,750	5867	137,961	2598	987	182,832	–	186,417
2012	21,802	9570	111,974	3044	146,390	4118	1017	181,494	–	186,629
2013	24,629	9339	111,867	2608	148,443	3362	1247	178,929	–	183,538
2014	24,606	8797	118,363	1423	153,189	2956	976	181,450	–	185,382
2015	23,578	9669	121,397	661	155,305	3210	1059	193,365	–	198,260
2016	24,065	128,185	128,185	92	162,129	3058	738	195,648	–	199,444

[a]L.F: Landfilling, Inc.: Incineration

the sixth-largest importer (2763 k barrel/day) on the world (Korea National Oil Corporation 2016). Also, 90% of the mineral resources used in Korea were imported due to poor natural resources (Ministry of Trade, Industry and Energy 2016; Park 2015). Further construction of landfills is difficult in a country where waste generation per unit area is the fourth largest among OECD countries. Approximately, 56% of the landfill and incineration waste can be recycled (Ministry of Environment, Korea 2017). So, it is necessary to reduce the consumption of natural resources and energy by promoting proper disposal of generated waste (Hahm 2016; Hoon 2009).

2.2 Purpose

The purpose of Act on fundamentals on resource is as follows:

(1) Efficient use of resources and suppression of waste generation. (2) Promote recycling and proper disposal of generated waste and reduce consumption of natural resources and energy. (3) It defines the basic requirements for preserving the environment and creating a sustainable resource circulation society (Korea Legislation Research Institute 2016).

2.3 Fundamental Principles

(1) Waste generation reduced by efficient use of resources.
(2) When waste is expected to generation, the waste is considered the convenience and hazardous of circulation use and disposal.
(3) The generated waste should be circulation use and disposal of based on the following (a–d) in a technically and economically feasible range.
(a) The all or part of waste should be reused as much as possible.
(b) The all or part of waste that cannot be reused should be recycled as much as possible.
(c) The all or part of waste that cannot be reused and recycled should be recovered energy as much as possible.
(d) The waste that cannot be reused and recycled following (a–c) dispose of waste by reduction of impact on human and environment.

2.4 Major Content of the Act

The major contents of Resources Circulation Basic Act consist of construction of infrastructure for resource circulation, means for promoting resource circulation, and supporting the resource circulation industry.

(1) Construction of infrastructure for resource circulation
The content of the Act includes basic principles of resource circulation and the responsibilities of each subject (state, local government, business, citizen, etc.). The state should promote the resource circulation culture so that the citizen's understanding of the resource circulation society can be enhanced and the resource circulation culture widely spread throughout society. In order to promote international cooperation for the transition to a resource circulation society, the state shall take necessary measures such as provision of information and technical and economic support.
(2) Means for promoting resource circulation
The Minister of Environment and the provincial governor should introduce the performance management system of resource circulation as a means of promoting resource circulation, set annual target of resource circulation, and verify their performance to expand demand for recycling resources. Also, the Minister of Environment may impose and collect fees of waste disposal when the waste is disposed of by incineration or landfill, although the waste can be recycled.
(3) Supporting the resource circulation industry
The Minister of Environment may exclude from the waste by recognizing environmentally and economically viable materials as circulatable resources. Recognized circulatable resources are excluded from the regulation of waste because they are not waste. In order to foster the resource circulation industry, the state and the local government can provide financial and technical support for the petty resource circulation facilities. In addition, the Minister of Environment may operate an information center that manages and provides information such as technology to promote the use of waste and circulatable resources.

3 Circular Economy of Municipal Solid Waste

3.1 Paradigm Shift of Waste Policy for Circular Economy in Korea

In the meantime, the policy of waste management was mainly aimed at building a comfortable living environment by the method of cradle to grave. Due to climate change, raw materials and energy depletion, however, the policy direction is changed that wastes are recycled as much as possible by the method of cradle to cradle. If recycling is impossible, incineration or landfill can be used finally. The paradigm changes of waste policy from "cradle to grave" to "cradle to cradle" are shown in Table 5. The waste policy, based on the principle of resource circulation, is aimed at minimizing landfill and incineration of waste and maximizing recycling by refraining from a single use and disposal of wastes to create a resource circulation society in

Table 5 Paradigm shift of waste policy for circular economy in Korea (Ministry of Environment, Korea 2015)

Category	Previous waste policy	Current waste policy
Motivation	Worsened environmental pollution due to waste	Climate change, raw material, and energy exhaustion
Objective	Create clean living conditions	Construct a resource circulation society
Implementation strategy	Reduction recycling → treatment	Efficient production and consumption → material recycling → energy harvesting → advancing treatment
Main tasks	Volume-based waste fee system, EPR, and building the treatment facilities	Resource recyclability evaluation, recycled product quality certification, waste to energy, and merger of treatment district
Concept	Waste	Resource (circulation)
Economical support means	–	Performance management system, waste disposal fee system, and economical support for the resource circulation industry

which wastes and an emitted energy are recirculated within the economic activity areas for as much as possible (Ministry of Environment, Korea 2017).

3.2 *Build the Means to Promoting the Recycling for Circular Economy*

(1) Recognition system of circulation resources
Among the waste, substances and goods that do not adversely affect the environment and human health can be recognized as "circulation resources" by recognition system. The overview of recognition system of circulation resources was shown in Fig. 2. If the waste meets the recognition standard through strict screening by government, it can be feely circulated and used as a resource that is not subject to regulation such as collection, transportation, storage, treatment, and use under the Waste Control Act. The recognition standard as circulation resources are as follows: (1) Not harmful to the environment and human health and (2) Possibility of trade (highly economical). The first detailed standards are solid waste (water content less than 85%), non-mixed wastes by other types of waste or foreign substances, and wastes that can be used as raw materials with-

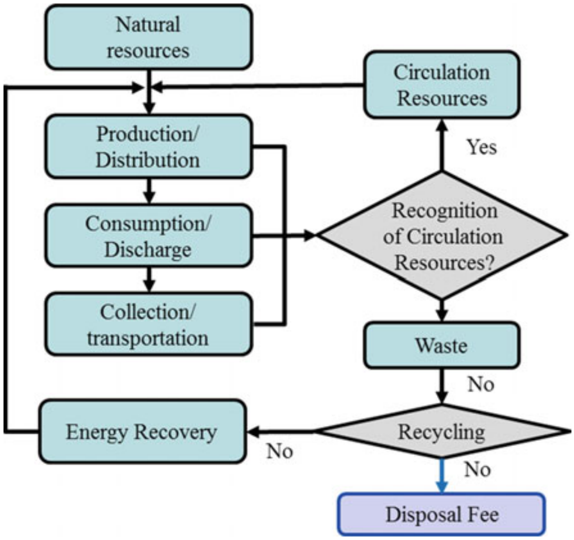

Fig. 2 Overview of the recognition system of circulation resources (Ministry of Environment, Korea 2017)

out further processing, etc. The second detailed standards are recyclability, the possibility of continuous payment, and sufficient market demand, etc. Wastes excluded from circulation resources are food waste, sludge, animal residues, liquids (water content over 85%) or gaseous wastes, and hazardous wastes, etc.

(2) Performance Management System

The performance management system of the resource circulation is a system that establishes resource circulation goals and evaluates and manages their performance in consultation with major industries (1500 businesses in 18 industries such as electric power generations and steel industries) that discharge a large amount of waste. The performance management system of the resource circulation is managing the performance targets in order to improve the system of circulation use in industries. Companies that have outstanding outcomes for the resource circulation can be provided some incentives such as a financial aid and a technical support from related government agencies. Even if the performance was not satisfied, it could be worked as effective measures through technical diagnosis and industrial needs (Ministry of Environment, Korea 2017). Through the performance management system of resource circulation, it may be expected to reduce waste generation at workplace and to substitute circulated resources for natural resources.

(3) Waste Disposal Fee System

The generation amount of household waste except hazardous waste in Korea is 404,812 ton/day in 2015. Recycling rate (85.2%) for household waste is much higher than landfill (8.7%) and incineration rate (5.9%). Since landfill and incineration costs are very low compared to recycling costs in Korea, approximately 56% of recyclable wastes have been landfilled and incinerated (Ministry of Environment, Korea 2017). In order to improve recycling rate and to solve the

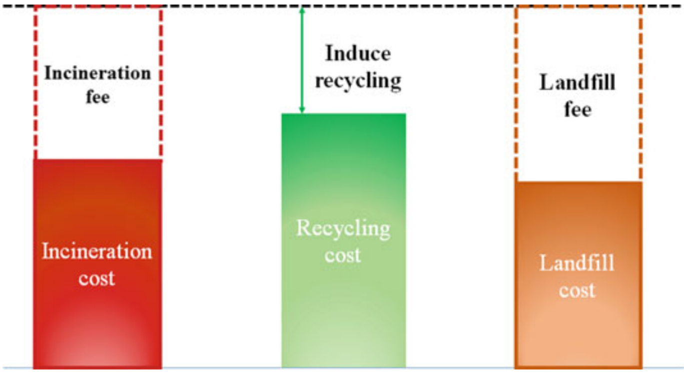

Fig. 3 Concept of waste disposal fee (Choi et al. 2017)

problem of losing recyclable resources by landfill and incineration, the waste disposal fee will be applied in Korea from 2018. The concept of the system of the waste disposal fee was shown in Fig. 3. As shown in Fig. 3, recycling rate was not promoted because the cost of recycling is much higher than that of landfill and incineration. In order to increase recycling rate, the target rate of recycling can be induced by public opinion, social position, and economical level. The gap between recycling cost and incineration or landfill cost is the basic guideline to decide incineration or landfill fee. As the same method, landfill fee can be decided by comparing the treatment cost. By introducing the waste disposal fee for landfill and incineration, the waste amount of landfill and incineration naturally will be decreased, and recycling will be increased eventually.

It may be desirable that waste amount of landfill will be decreased, and the life of landfill facilities will be extended as long as possible. However, the certain amount of waste should be treated by incineration facilities because of sustaining an overall efficiency in incineration facilities.

(4) Economical Support the Resource Circulation Industry

In order to foster the resource circulation industry, the government and the local authority can provide financial and technical supports for the petty resource circulation facilities. The targets to support businesses for the development of resource circulation society are the installation and operation of facilities, research and technology development, and recycling business using circulation resources. Since costs required for supporting on businesses are secured from waste disposal fee, the disposal fees of landfill and incineration of waste are used for the development of the resource circulation industry. In order to designate circulation resources of high quality, the Ministry of Environment, Korea, will provide a label certification for circulation resource (Lee and Kang 2016). Also, it is necessary to activate the transaction of circulating resources to foster the resource circulation industry.

In order to expand the information exchange between the consumer and the supplier and to facilitate the transaction on the circulation resource, the information center for circulation resource will be operated by the Ministry of Environment. In order to provide recycling technology and information as well as distribution of waste resources, the information center for circulation resource will be established.

By renovating the information center for circulation resources, resources exchange for wastes and used goods can be traded by an online trading market. The major contents of the information center for circulation resource are shown in Fig. 3. In order to search company and transaction effectively, the information center for circulation resource provides various functions such as Geographic Information System (GIS) of waste recycling company, bidding and trading function of circulation resource, waste estimating function, and resource distribution function.

If the transaction of circulating resources is activated through the financial and technical support of the resource circulation industry, it will have the following advantages:

1. The economic effect due to the increase in the recycling rate of waste may be about U$ 3.2billion and about 10,443 employment hiring effects (Ministry of Environment, Korea 2017).
2. Improve profit structure, foster recycling market, and enhance competitiveness of related industry through the increase waste transactions and the reduction of processing costs.
3. Establishing the guideline for a resource circulation society that can respond effectively to oil prices and raw material prices through the formation of resource circulation network between suppliers and consumers of used goods and waste resources (Table 6).

Table 6 Major content of the information center for circulation resource

Type	Major content
Flow resource operation	– Matching with best flow service provider
Providing resource circulation information	– How to recycle the waste and providing price information – Recycling technology policy trends – Environmental regulation information
Online bidding service	– Estimation on service – Online bidding without fees
Circulation resource activation campaign	– Activate circulation resource information center – Expansion of resource circulation culture through campaign

3.3 Circular Economy Flows in EPR System

As the world faced increasing environmental crises including waste treatment and diminishing natural resources and energy supplies, most advanced countries tried to shift waste management policy from waste disposal system to a resource circulation system. In 2000s, producer's responsibility was strengthened to improve recycling policy goals and implementation plans by increasing collection and recycling their waste products by Act on the Promotion of Saving and Recycling of Resources. In Korea, extended producer responsibility (EPR) was introduced from 2003 to place responsibility of recycling on producers determining structures and materials and to make upgrade in the reduction, reuse, and recycling of waste by encouraging manufacturers to consider the environment through the overall processes of product design, manufacturing, distribution, consumption, and disposal (Korea Environment Cooperate 2016).

The EPR system is basically applied to existing items such as cotton pack, glass bottles, and tires under the waste deposit system, and packaging materials such as paper packaging, metal cans, and plastic packaging were subjected to EPR system. In 2004, film-type packaging materials and fluorescent lamps were added, and manganese batteries, alkaline manganese batteries, and Ni-MH batteries were added in 2008. Now, the target items in EPR system are four types of package such as metal can, glass bottle, carton pack, synthetic resin packaging materials and seven types of product such as tire, fluorescent lamps, batteries, lubricants, buoys for aquaculture, bale silage file, cultivating laver plate.

From the viewpoint of circular economy, material and money flows in EPR system are shown in Fig. 4. For the recycling of wastes from products or packaging materials on the manufacturer of the products, in EPR system, producers and importers of products or packaging materials should recycle an obligation rate of wastes from products or packaging materials which was decided by the consultation between government and producer's association. The obligation rate was publicly disclosed every year and was assessed in consideration of the annual quantity shipped, the quantity separated and collected, and recycling results, etc. When producers and importers do not satisfy with the obligation rate, they should be subjected to recycling fine which was imposed within a scope of 130% of the actual recycling expenses. Producers and importers that exceed their obligation rate can accumulate ("bank") their results for up to two years. In Korea, most producers and importers have paid recycling deposit to the association, which remitted recycling expenses to recycling companies to fulfill the obligation rate of its members.

Since the Resources Circulation Basic Act has been implemented in 2018, the flow of money in the recycling of waste in the EPR system has changed. Residues (secondary waste) remaining after recycling are finally disposed of by landfill or incineration. Since the government in Korea implements a waste disposal fee system for landfilling and incineration of waste by the Act, the fare must be paid for final disposal. The government can provide economical support to the recycling facility

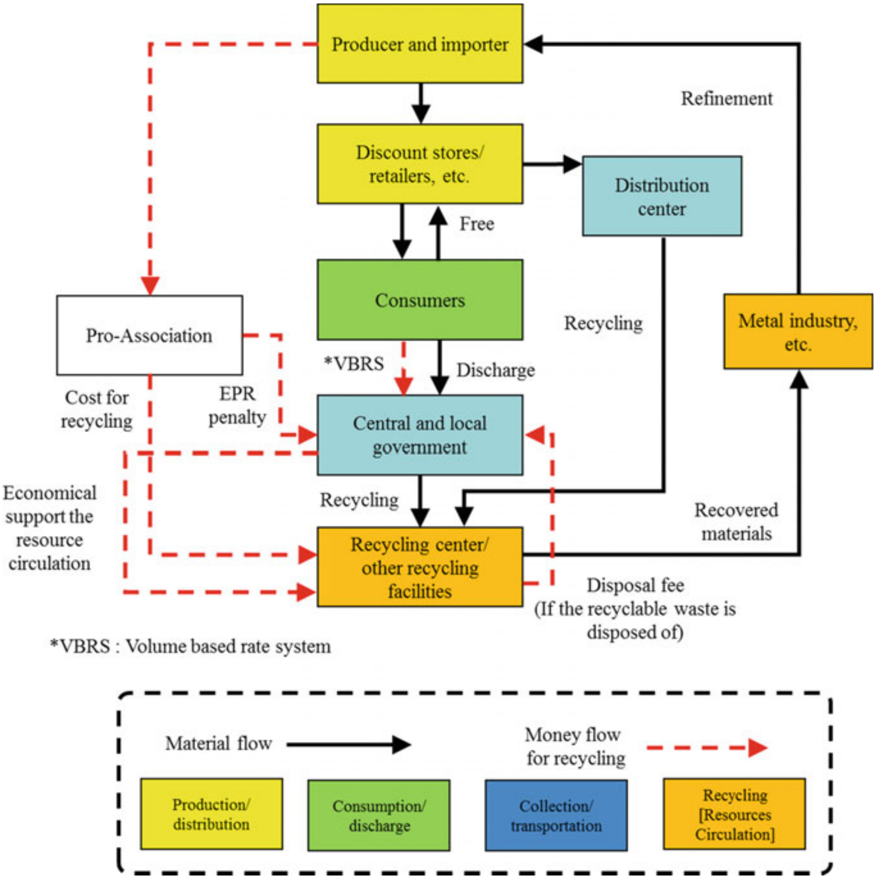

Fig. 4 Circular economy flows in EPR system (Rhee et al. 2018)

using the money from the waste disposal fee. Finally, recycling is promoted, and a resource circulation system is established through the circular economy.

On the other hand, E-wastes and waste vehicles are not managed by EPR system but are managed by Eco-Assurance System (Eco-AS) in Korea. For the implementation of resource circulation, the management of E-waste in Eco-AS is implemented in two means depending on the role of the subjects related discharging E-waste: prevention and post management. As a privative means, manufacturers and importers must comply with the standards for hazardous materials in products and improve materials and structure of the products to facilitate recycling. The post management is a means to promote the recycling of E-wastes and waste vehicles similar to the EPR system. This is a system that encompasses EU RoHS, WEEE, and ELV directive. In Eco-AS, the circular economy flows for E-waste are similar to that of EPR (Fig. 4), with additional privative means.

4 Summary

In Korea, the amount of waste generated has also increased in proportion to economic growth, and new policy measures for waste management have become necessary. In the meantime, the policy of waste management was mainly aimed at building a comfortable living environment by the method of cradle to grave. Due to climate change, raw materials and energy depletion, however, the policy direction is changed that wastes are recycled as much as possible by the method of cradle to cradle. The current waste policy is aimed at minimizing landfill and incineration of waste and maximizing recycling by refraining from a single use and disposal of wastes to create a resource circulation society in which wastes and an emitted energy are recirculated within the economic activity areas for as much as possible. In accordance with the changes in the waste management paradigm, the Resources Circulation Basic Act was enacted from 2018. In order to implement the resources circulation of waste, measures of economic support for waste recycling are needed. The Resources Circulation Basic Act consists of infrastructure for resource circulation, means for promoting resource circulation, and supporting the resource circulation industry to expand the recycling industry. Since the government in Korea implements a waste disposal fee system for landfilling and incineration of waste by the Act, the fare must be paid for final disposal. The government can provide economical support to the recycling facility using the money from the waste disposal fee. Finally, recycling is promoted, and a resource circulation system is established through the circular economy.

References

Choi, H. J., Choi, Y., Lee, S. Y. & Rhee, S. W. (2017). Comparison of domestic and international waste disposal fees for the Resource Circulation Basic Act. *Korea Society of Waste Management*, *87*.

Hahm, T. S. (2016). The tasks of waste legislation system and Framework Act on Resource Circulation. *Kyung Hee Journal, 51*(4), 339–365.

Hoon, J. (2009). The comprehensive waste management laws and the need for the enactment of the basic resource circulation laws. *Korean Environmental Law Association, 31*(2), 115–143.

International Monetary Fund. (2016). Gross Domestic Product. http://www.imf.org/. Access date November 25, 2016.

Korea Energy Agency. (2016). 2016 Korea Energy Handbook.

Korea Environment Cooperate (KECO). (2016). Extended producer responsibility system. http://www.keco.or.kr/kr/business/resource/contentsid/1563/index.do. Access date November 28, 2016.

Korea Legislation Research Institute. (2016). Waste Management Act (2015). https://elaw.klri.re.kr/kor_service/lawView.do?hseq=46237&lang=ENG. Access date November 28, 2016.

Korea Legislation Research Institute. (2016). Act on the promotion of saving and recycling of resources (2015). http://elaw.klri.re.kr/kor_service/lawView.do?hseq=33581&lang=ENG. Access date November 29, 2016.

Korea Legislation Research Institute. (2016). Act on promotion of purchase of green products (2014). http://elaw.klri.re.kr/kor_service/lawView.do?hseq=31683&lang=ENG. Access date November 29, 2016.

Korea Legislation Research Institute. (2016). Construction waste recycling promotion act (2015). http://elaw.klri.re.kr/kor_service/lawView.do?hseq=37131&lang=ENG. Access date November 29, 2016.

Korea Legislation Research Institute. (2016). Act on resource circulation of electrical and electronic equipment and vehicle (2016). http://elaw.klri.re.kr/kor_service/lawView.do?hseq=37412&lang=ENG. Access date November 28, 2016.

Korea National Oil Corporation. (2016). Oil supply and demand status in Korea. https://www.knoc.co.kr/sub03/sub03_1_1.jsp. Access date November 27, 2016.

Lee, I. S., & Kang, H. Y. (2016). A review on the direction of the framework act on resource circulation for establishing a resource circulation society. *Journal of Korean Institute of Resources Recycling, 25*(6), 82–91.

Min, D.-K. & Rhee, S.-W. Management of municipal solid waste (MSW) in Korea In A. Pariatamby, M. Tanaka (Eds.), *Municipal solid waste management in Asia and the Pacific Islands*, pp. 173–194. Berlin: Springer.

Ministry of Environment, Korea. (2009). 1st basic plan for resource circulation (2011–2015).

Ministry of Environment, Korea. (2015). 2015 White Paper of Environment 2015, p. 436.

Ministry of Environment, Korea. (2016). Resources circulation basic act. http://www.law.go.kr/lsSc.do?menuId=0&p1=&subMenu=1&nwYn=1&section=&tabNo=&query=%EC%9E%90%EC%9B%90%EC%88%9C%ED%99%98%EA%B8%B0%EB%B3%B8%EB%B2%95#undefined. Access date November 30, 2016.

Ministry of Environment, Korea. (2017). National waste generation and treatment status 2016.

Ministry of Environment, Korea. (2017). What is a resource circulation society?", https://www.me.go.kr/issue/resource/. Access date January 25, 2017.

Ministry of Environment, Korea. (2017). Policy direction of resource circulation. http://eng.me.go.kr/eng/web/index.do?menuId=364. Access date: May 25, 2017.

Ministry of Environment, Korea. (2017). Transition to a resource circulation society, Choice for future generations. *Environmental Policy Briefs 5*, 19–31.

Ministry of Environment, Korea. (2017). Explanation on recognition system of circulation resources (draft).

Ministry of Environment, Korea. (2017). Information center for circulation resource. https://www.re.or.kr/common/viewIntroPage.do. Access date May 24, 2017.

Ministry of Trade, Industry and Energy. (2017). Trends of import and export in 2016 and prospects of imports and export in 2017. http://www.motie.go.kr/motie/ne/presse/press2/bbs/bbsView.do?bbs_seq_n=158958&bbs_cd_n=81&currentPage=1&search_key_n=title_v&cate_n=&dept_v=&search_val_v=%EC%88%98%EC%B6%9C%EC%9E%85. Accessed August 18, 2017.

Park, J. H. (2015). Frequently looking energy statistics. Korea Energy Economics Institute.

Rhee, S. W., Choi, H. J. & Choi, Y. (2018). Resources circulation of E-waste in Korea (Republic of). In The 13th International Conference on Waste Management and Technology (ICWMT 13), Beijing.

Circular Economy in Republic of Serbia and Region

Milan Pavlović, Miroslav Vulić and Aleksandar Pavlović

Abstract The presented paper shows the current importance of the CE (circular economy) to the sustainable development of the Republic of Serbia. Following the European Commission's decision back from 2015 regarding the transformation of the linear economy into the circular economy, several laws were introduced in Serbia and are in the process of implementation, with the goal to stimulate investments in the CE Waste Management. The amendments to the Waste Management Law also give significant contribution to the CE development. The Ministry of Environmental Protection has signed an cooperation agreement with the National Alliance for Local Economic Development (NALED) regarding sustainable development of the CE in Serbia. International cooperations with institutions such as GIZ, OSCE, etc., are as well of significant importance to the CE development. This paper provides a numerous examples of good CE practice in Serbia. Serbian Chamber of Commerce, through cooperation with the Permanent Conference of Cities and Municipalities (SCTM), gives their contribution to the development of CE by supporting various activities in the economic field and the green jobs openings. In the future development, period is expected that CE should significantly increase GDP.

Keywords Serbia · Circular economy · Recycling · Resources · Sustainable development

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1 Introduction

In order to stimulate economic growth and social progress, while preserving a healthy and clean environment, the European Union introduced a significant new legal framework at the end of 2015 and committed enormous resources to modernize the economy, strengthen its stability and competitiveness and create new jobs. Circular economics is the antithesis of the so-called linear economic model, which involves the uncontrolled exploitation of natural resources and flow of materials from the factory through the user to the landfill. The circular economy is changing business models, habits and ways of thinking, both for manufacturers and consumers, as the new eco-design of a product extends its lifespan through repair, re-modeling and recycling. All processes take place using renewable energy. New habits among consumers in Serbia will shift the focus from manufactured products to services, while the role of buying products will be taken over by renting them.[1]

2 How Resource Consumption Is Minimized, and Resource Utilization Is Rationalized Based on 3Rs (Reduce, Reuse and Recycle) and Circular Economy in the Areas of

(a) *Municipal waste management*
Serbia has adopted a National Waste Management Strategy, which is a basic document that provides the conditions for rational and sustainable waste management at the Republic level, in line with the European waste management policy. The strategy envisages the creation of multi-municipal regions and the construction of regional landfills for trans-stops and recycling stations. In order to address the problems arising from inadequate waste management at each municipality level, it is necessary to introduce a Local Environmental Action Plan (LEAP). This document covers the process of involving both regional and local community representatives, and it leads to the definition of specific measures to be taken and finances that must be invested in environmental protection and restoration. LEAP refers to its name at the level of local communities (municipalities and cities). The goal of LEAP is to be realistic and achievable within a certain time interval and within a certain budget (Đurđević et al. 2011).

(b) *E-waste*
The Ministry of Environmental Protection has signed an agreement to cooperate with the National Alliance for Local Economic Development (NALED), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), home appliances maker Gorenje and drinks firm Coca-Cola HBC Srbija on a project to improve the management of electrical and electronic waste in Serbia, according to a statement from the ministry.

[1] *Upravljanje otpadom i otpadnim vodama u opštinama*, (GIZ) – Project IMPACT.

The project is aimed at creating a level playing field on the market and ensuring the state secures a comprehensive fee collection. CEO of Gorenje in Serbia, which shoulders a EUR 3 million annual environmental fee burden and faces unfair competition from companies that do not pay this levy, according to reports. The goal is to create a single electronic register of producers and importers and reform the fee collection system through changes to procedures, as well as to improve the waste collection system in municipalities, according to a statement from NALED (National Alliance for Local Economic Development). Of more than 11,000 producers and importers of products which after use become special waste streams—such as home appliances and IT equipment—only 49% filed annual reports to the authorities on quantities sold in 2017, NALED said, noting that these reports serve to collect environmental protection fees.

Companies that fail to pay the levy represent unfair competition given that the fee accounts for up to more than 10% of the retail price of a product.[2]

Today, there are a large number of smaller e-waste collectors in Serbia that forward it to the largest collectors for further distribution, export or processing at the national level.

(c) *Plastics wastes*

Raising the purchase price for plastic packaging in Serbia would bring positive changes to the recycling system. In addition to reducing plastic waste in the environment, such a move would bring the possibility of additional income to the poorest and marginal sections of society, such as the Roma population. The Roma population, whose existence in most cases depends on the collection of raw materials through urban checkpoints, plays a crucial role for informal recyclers in society. They provide an excellent example of a circular and sustainable economy in practice, which reflects positively on the environment and the economy in the context of resource reuse.[3] In order to process plastic waste, the Republic of Croatia has significantly higher purchase prices than in Serbia, including processing capacities, so that a large part of the collected plastic waste (especially PET packaging) ends up being exported to Croatia where it is processed.

Another solution to the problem of recycling in Serbia would be the direct employment of informal raw material collectors. Such a move would give marginalized groups social rights, but also integration into a society where individuals are currently invisible. It is estimated that around 50,000 people in Serbia are involved in informal collection of raw materials, while a quarter are under eighteen. Of that figure, 90% are Roma.

However, in order to begin to address the issue of plastic waste in Serbia, it is necessary, with political will, to change the institutional framework that will enable these positive changes. Those changes will bring benefits not only to the environment but also to the people who are an integral part of it (see Footnote 3).

[2] https://balkangreenenergynews.com/project-launched-improve-e-waste-management-serbia/.

[3] https://www.masina.rs/?p=6778.

(d) *Hazardous wastes*
Proper management of hazardous waste remains a challenge as data on the actual treatment of that type of waste is lacking. To begin with, introducing hazardous waste registers and identifying capacities and barriers to hazardous waste management systems in Serbia will improve record keeping and traceability. These registers will gradually be expanded to other types of waste, as is already the case in several EU Member States.[4]

(e) *In industries*
The new model of economic development over the next decade necessitates two interconnected twists: the first turn is of a structural character with a focus on industrial growth, investment and export, and the second turn is aimed at accelerating the reform processes of European integration (Mihajlov et al. 2014).
In an effort to achieve industrial development in different sectors, Serbia faces the threat of generating large quantities of by-products. Large industrial plants are considered to be the most important waste generators.
According to the Environmental Report of the Republic of Serbia for 2014, the amount of generated industrial waste in 2014 was about 6.12 million tons of waste. Of these, 5.9 million tons were non-hazardous waste, and approximately 210 thousand tons were hazardous waste. The largest producers of industrial waste are thermal power facilities, while fly ash from coal was generated in the amount of 4.1 million tons, accounting for 60% of the total amount of waste produced during 2014.[5] Of the total amount of waste produced, 1,579,213 t (26%) reported the treatment, while 4,545,768 t (74%) remained at the sites where the waste was produced. Table 1 shows the treatment of waste produced in 2014, based on the Environmental Report of the Republic of Serbia for 2014 (Luković 2016).

Table 1 Manner of industrial waste treatment in 2014[a]

Waste character	Waste produced (2014)	Amount of waste handed over for temporary storage to another company (2014)	Amount of waste handed over for disposal (2014)	Amount of waste handed over for treatment (2014)	Exported amount of waste (2014)
Dangerous	209,877	168,811	6538	30,215	1769
Non-dangerous	5,915,105	5.038	204,883	591,158	10,778

[a] *Izveštaj o stanju životne sredine Republike Srbije za 2014.* godinu, Ministarstvo poljoprivrede i zaštite životne sredine, Agencija za zaštitu životne sredine, 2015

[4] Stevanović Čarapina, H.

[5] *Izveštaj o stanju životne sredine Republike Srbije za 2014.* godinu, Ministarstvo poljoprivrede i zaštite životne sredine, Agencija za zaštitu životne sredine, 2015.

Table 2 Number of registered vehicles with average number of ELV in the last 3 years in the Serbia

Year	Number of registered passenger cars	Average number of ELV (5.35% of the number of registered cars)
2016	1,824,628	97,618
2017	1,968,787	105,330
2018	1,999,771	106,988

(f) *Research*

Table 2 shows number of registered vehicles with average number of ELV in the last three years in the Serbia.

We observe the average vehicle, Zastava—Fiat brand which is the most represented in Serbia. Beside ecological contributions, for the circular economy in Serbia, the most important is quantity of ferromagnetic materials that contains in Zastava—Fiat vehicles and that is 68%.[6] Total weight of the Zastava—Fiat vehicle is 835 kg (Milivojević et al. 2009), and the volume of ferromagnetic materials and accordingly is 567.8 kg (0.5678 t).

For the circular economy in 2018, according to the mentioned data if the recycling at the level of 100%, Serbia would have 60,747.8 tons of ferromagnetic resource materials. This amount is very important for sustainable development, since Serbia does not have its own resources of ferromagnetic ore. Significant contribution is also in the reuse of used parts from the recycling process ELV. In addition to the obtained ferromagnetic materials, ELV recycling in comparison with the production of ferromagnetic materials from the source materials saves energy consumed in the production of same by 70–80%, and that is another significant contribution of the circular economy to the development of Serbia.

There are many sustainable development models of ELV management, based on recycling, material reduction, reuse and expansion of the economic capacities of centers for ELV treatment, which could help with mentioned problem.

3 What Are the Legislative Framework and Government Supports Toward Implementing 3Rs and Circular Economy Initiatives

At the end of 2015, the European Commission (EC) adopted a new legal framework encouraging the transition of the economy into a circular economy through investments, modernizing and empowering Europe's economy, increasing its competitiveness and securing sustainable economic growth in the future. The circular economy is another economic model that seeks to extend the product's life and

[6] *Cirkularna ekonomija kao šansa za razvoj Srbije*, Organizacija za evropsku bezbednost i saradnju (OEBS), Misija u Srbiji.

return all waste material into the production process. This achieves the efficient use of resources, the reduction of environmental pollution, with the financial savings and the creation of new business opportunities to make waste from one industry a resource for another industry. This package of European regulations aims to contribute to reducing the generation, and improve the quality of waste management, saving energy and reducing the consumption of resources by 2030.

The Republic of Serbia has been following the processes of adopting and introducing a circular economy in the European Union (EU) and has responded swiftly by adopting EC recommendations on circular economy. One of the important development documents for the realization of a new vision of development is the National Sustainable Development Strategy for the Republic of Serbia, which was adopted in 2008 and covers the period until 2017. The strategy provides guidance for further action in the field of sustainable development, in accordance with key documents adopted by the United Nations in 2012 at the RIO + 20 conference. According to the adopted document, states are invited to take opportunities for sustainable growth and new alternative strategies through the green economy.

The Ministry of Agriculture and Environmental Protection recognized the need for amending the law and, in cooperation with the Serbian Chamber of Commerce, the Permanent Conference of Cities and Municipalities (SCTM), business associations, civil society organizations (CSOs), proposed amendments to laws in the field of environmental protection, including amendments to the Law on Waste Management. On February 2016, such changes opened the space for the introduction of a circular economy and the creation of green jobs. The strategic concept for economic growth and GDP growth is the efficient use of resources and renewable energy, as well as the employing of comparative benefits of the natural environment. By introducing a new institutional structure, it creates a foundation that can support a "third" investment cycle in which green infrastructure is a growth driver and includes wastewater management, waste management and renewable sources of energy.

The first step toward a circular economy in the new legislative framework is measures that support the principle of waste management hierarchy, and in particular prevention of waste generation.

Namely, the amendments to the law stipulate a number of measures within the strategic documents, as well as a number of stand-alone measures that represent a significant support for the prevention of waste generation. These are measures concerning the design, production and consumption of products. The aim of these measures is to influence the reduction of waste generation at an early stage of product production by extending the life of the product, reducing the hazardous substances in it, as well as by facilitating the "easy return" of the product to the life cycle after it becomes waste 3Rs. The prevention principle is one of the most important pillars of circular economy and sustainable development as well as support for the 3Rs model (Fig. 1).

Amendments to the law also introduce a new priority in the waste management hierarchy: so-called preparing for reuse. This priority is supported by amendments to the law through a series of stand-alone measures that the responsible authority is

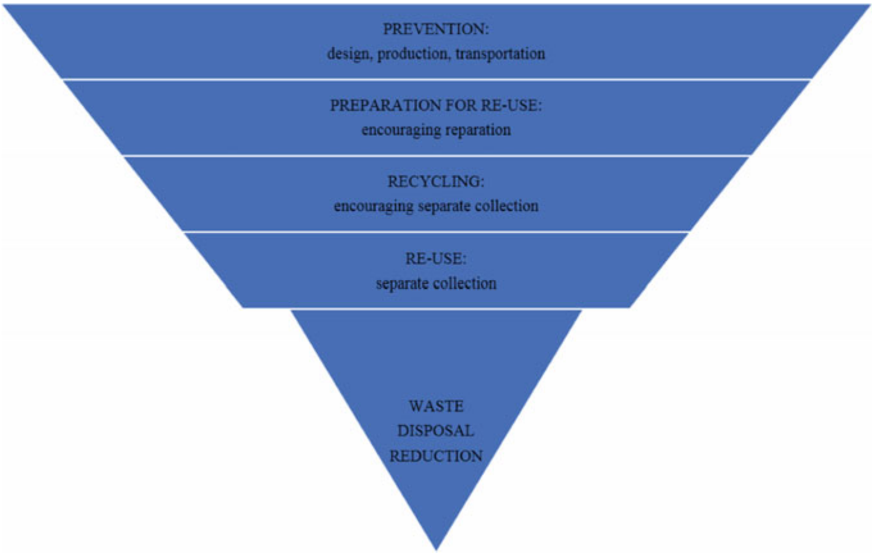

Fig. 1 Principle of waste management hierarchy (see Footnote 6)

obliged to take in order to address the introduction and strengthening of the product reparation system.

Also, the new legal solutions introduce a number of stand-alone measures related to the improvement of the volume, as well as the quality of recycling, through the establishment of a separate waste collection system, as well as a number of measures that are or should be further elaborated with strategic documents related to reducing the disposal of biodegradable waste at landfill, encouraging composting and anaerobic digestion.

A novelty in the legislative framework is the introduction of the notion of "by-products" and "end of status waste," which mean the return of materials to production, that is, the return of waste to the life cycle (circular economy).

Amendments to the law elaborate in detail the procedure by which a substance is obtained in a manufacturing process, and where the purpose of that process was not to obtain that substance, is entered in the register and obtained the status of by-products. The law, therefore, prescribes the procedures and conditions under which a substance receives the status of a substance that can be used as a raw material. The law provides for a number of conditions for obtaining the status of "by-product": that the substance was created as part of the production process, but that the target production process is not the emergence of that substance, that its further use is possible without processing, that the use of that substance is certain and allowed, which means that it does not endanger human health and the environment. Mandatory documentation has been prescribed and submitted with the request. The burden of proof of fulfillment of all prescribed conditions rests with the owner of the substance. Once all the requirements have been met, the register is entered. The by-products registry is a new type of registry prescribed by the most recent amendments to the law. Throughout the process of proving the status of by-products, the law also provides for the application of European Union guidelines.

Legislative solutions also elaborate the conditions and procedure by which a waste, after carrying out a reuse operation, can be registered and received a "end of waste" label, meaning that it can be recycled back into its life cycle and used as raw material. The law also stipulates conditions for gaining the end of waste status. The conditions for gaining the end of waste status imply that the item or substance is usually used for special purposes, that there is a market and demand for such substance or items, that the material or item meets the technical requirements for special purposes and the conditions prescribed by the standards for those products, and that their use does not lead to adverse effects on human health and the environment.

The amendments further differentiate and elaborate two procedures for evaluating compliance with technical requirements and product standards, namely: the procedure carried out by the owner of that waste, on the basis of which the self-declaring claim is made, and the procedure conducted by the ministry responsible for environmental protection, based on which a Declaration of Conformity of Products is issued, all in accordance with the Law on Technical Requirements for Products.

In terms of the circular economy, the by-product can in some way be said to be a step closer to the circular economy than the end of waste status, since from the by-product with less investment is obtained raw material. Obtaining end-of-waste status, on the other hand, involves undertaking reuse operations to bring the waste back into its life cycle.

The obligations of local self-government contained in the amendments to the law relating to the selection and separate collection of waste also represent a prerequisite for further strengthening of important components of the circular economy principles (see Footnote 6).

4 Example of Best Practices

Below is a description of several manufacturing activities in Serbia that are examples of good practice, which we hope will serve as an incentive to start activities in other industries.

Tire recycling
Tackling waste tires and/or tires, respectively, are both environmentally friendly, energy-efficient and economically viable. The physical properties of the tires used are of great value because they are non-toxic and their shape, and weight and elasticity make them usable for processing into a large variety of products, whether as granules or dust.

Eco-recycling Ltd. Sirig[7] is one of two waste tire recycling factories in Serbia and has the highest percentage of waste recycling with modern technology. Over

[7] http://www.eco-recycling.rs.

82,000 tons of recycled waste tires and other types of rubber waste have been treated at the plant since 2009. The installed capacity is 45,000 tons of waste tires per year. This is the only plant in Europe to recycle large dump tires from the mine (up to 3.5 m in diameter and up to 2.6 t in weight). In the process of tire recycling, the percentage of rubber granulate is highest—60%, steel wire 35% and the rest is canvas—5%. The recycling process at this factory is 100% environmentally friendly, i.e., there is no damaging impact to the environment. The recycling process creates no further waste substance, it is all usable, and it is of utmost importance that there are no associated environmental pollutions—into the air, water or land. Research has shown that the mechanical recycling process is far more favorable to the environment and the nature than incineration for energy purposes. It is through recycling into a rubber granulate which enters the reuse cycle that we achieve conservation of natural resources. 127.8 kilojoules (kJ) of energy is required to produce 1 kg of new rubber, while only 2.32 kJ of energy is required to produce 1 kg of rubber granulate.

Elements of the mechanical tire recycling process are: collection, sorting, tearing of steel cables, cutting to the permitted dimension, mechanical recycling process, primary cutting (shredding), granulation (multiple stages), sieving and packing storage. This company uses logistics in collecting tires at 36 locations in Serbia from small waste generators (individuals, tire repair shops, agricultural goods) and large generators (landfills, industry, rubber, mining, transportation, tire distributors). The treatment of waste tires gives the material used for the production of new rubber products in the following industries and fields: construction (roof insulation, sound barriers in construction, waterproof membranes, rubber tubes), traffic (addition of asphalt to increase brake safety, vibration, noise reduction, construction of traffic infrastructure/signaling and parts for new cars, railroad crossings), sports and recreation (grounds for sports fields and playgrounds), households (production of household rubber parts, protective rubber coverings and horticultural items) and agriculture (barn lining and for equestrian sport) (Fig. 2).

In Serbia, there are several small companies that make finished products from recycled rubber, most of which are floor coverings for industry, public buildings, construction and agriculture (see Footnote 6).

Recycling multilayer packaging for beverage and liquid food packaging
In Serbia, there are two significant plants for the production of multilayer packaging for the packaging of liquid food and beverages: Tetrapack in Gornji Milanovac and Elopak in Zemun. Serbia is the leading consumer of packaging in the region with about 12,000 tons of this type of packaging used annually (Fig. 3).

The problem with collecting multilayer packaging for packaging liquid food and beverages is that, until recently, this type of packaging waste was completely uninteresting to the collector, and the only way to dispose of this type of packaging was to dispose of it in landfill or incinerate it in cement plants where it was used as an alternative fuel. Exports for recycling were economically very expensive because the closest facilities were located in the Czech Republic, Germany and the Netherlands, which increased the costs on the annual level.

Fig. 2 Examples of new rubber products obtained after treatment of waste tires (see Footnote 6)

Fig. 3 Multilayer packaging for packaging liquid food and beverages (see Footnote 6)

Multilayer carton packaging for the packaging of liquid food and beverages is a material consisting of three components whose average content in the tetrapack is: paper 74%, polyethylene 22% and aluminum 4% . All materials used in the manufacture of multilayer packaging for the packaging of liquid food and beverages are of a very high quality because they are intended for packaging food, so that after utilizing the substance that was packaged in this type of packaging, it retains all its high properties and quality. Accordingly, it is in the general interest that, once this type of packaging becomes packaging waste, all the materials that make up its component are maximally utilized by returning to industrial production instead of being dumped. This also reduces the greenhouse effect, which causes this type of waste by releasing methane into the air. In addition to this practical benefit, there is a legal obligation to reduce bio-waste at landfills, under the European Landfill Directive, which obliges to reduce the total amount of bio-waste at landfills.

Due to the high representation of paper, recycled paper fibers are used to produce a variety of paper products. Currently, through processing at Swiss papier d.o.o. in

Rača, they receive towels paper and one-sided smooth paper for product packaging and bag production and is a classic example of biomass.[8,9,10].

Multilayer layer carton recycling—production of waterproof eco boards
Waterproof eco panels are construction material consisting of pressed pieces of recycled tetrapack. They meet the extremely high requirements for the consistency of design, homogeneity and minimal modification of properties, providing excellent capabilities for modern construction and a variety of other applications. In EU countries, a total of 30% of all packaging placed on the market is recycled. The first place in the recycling of multilayer cardboard packaging holds Germany, with a recycling percentage of 68%. In Serbia, 12,000 tons of multiple cardboard packaging are generated annually. The process of recycling multiply cardboard packaging is similar to the process of recycling paper—the collected packaging is inserted into a pulp machine (large mixer) into which water is added. Tetrapack contains 75% paper, 20% polyethylene (plastic) and 5% aluminum. The Environmental Protection Agency (EPA) has proven that paper recycling leads to a 35% reduction in water pollution and 74% less air pollution than in paper production.

The panels made at the factory "Feplo" Ltd., Cacak, are waterproof, and their production is completely environmentally friendly because no adhesives, additives or formaldehydes are used. The raw material used is waste tetrapack, which has so far been deposited at landfills, so the product is 100% environmentally friendly. Up to 20 kg of Tetrapack is required to make a 2.5-square-foot Feplo board, so using it, the company takes care of and protects the environment. 250 tons of waste tetrapack are installed monthly in the production of eco boards.[11]

Plastic recycling
Company "Brzan plast,"[12] deals with the processing of waste raw materials from PET packaging and packaging plastic. The company organizes collection, purchase, processing (cutting, washing, drying, production of recycled granulate) and production of new products for the needs of economy, agriculture and population. Organized collection through the purchase of old plastic films reduces the pollution caused by inadequate disposal, as well as the burning of worn-out films, which currently account for over 5% of all landfill waste. The company produces construction foil and bags of different thicknesses and sizes from recycled granulates, which save up to 50% in the relative foil made of granules.

In order to improve production technology in Brzan plast, a mobile diesel baler press was constructed for the first phase of plastic waste processing. A PET grinder mill was also constructed and manufactured, which won the first innovation award at the International Utility Equipment Fair. By design, the mill has advanced features and is significantly cheaper than mills for these purposes in the EU countries. The

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[8] https://www.tetrapak.com/rs/about/tetra-pak-fabrika-u-gornjem-milanovcu.

[9] www.elopak.com.

[10] http://www.swissqualitypaper.com/.

[11] http://www.feplo.rs/index.html.

[12] http://www.brzanplast.com/.

company has also developed recycling lines for PET, polyethylene and tetrapack (see Footnote 6).

Heating with the coffee weed briquette
The coffee weed is a silver membrane that is separated from the fruit of the coffee during the production process and is a by-product of the roasting process. The results of the study show that the coffee weed has exceptional thermal power and is a classic example of biomass.

This research prompted the representatives of Strauss Adriatic d.o.o. Šimanovci to establish cooperation with the Innovation Center of the Faculty of Mechanical Engineering in the design of a boiler room for the heating on briquette from coffee weeds. Given that 140 tons of coffee weed briquette produced annually is enough for about three months of heating, the boiler room is designed to burn other forms of biomass. From 1 November 2011, Strauss Adriatic d.o.o. Šimanovci applies a unique biomass heating system, more specifically with the coffee weed briquette. Thanks to the savings that this heating system brings, the investment pays off in less than a year and a half. This kind of heating can be said to be unique, because there is no information that coffee weed is used in a similar way in the region, and beyond.

The most important effect of this type of heating is the reduced emission of carbon dioxide into the atmosphere, i.e., greenhouse effect gases (see Footnote 6).[13]

Ash processing
In the Republic of Serbia, over 6 million tons of ash are produced annually, and a large amount is used in the construction industry, more precisely, in the cement industry. Today in the world, ashes are used for three purposes: in cement production, in construction and in infrastructure, and as a clean development mechanism (CDM) mechanism.

Depending on the quality, the production of classic Portland cement uses 10–15% of fly ash, which is mostly obtained from small thermal power plants (e.g., Svilajnac), for good ash handling, i.e., proper storage and disposal. Large thermal power plants will only in future be of interest to manufacturers of Portland cement due to the steady growth of production. For this reason, you will notice that in Serbia, the consumption of ash for the production of cement is negligible, and it amounts to about 5% of the production of ash. The use of ash from thermal power plants is very widespread in the production of various types of cement, which are of great importance, especially in the protection of buildings from erosion-causing acid rain, as they extend their usage life.

On June 25, 2015, the Government of the Republic of Serbia adopted the Decree on technical and other requirements for ash as construction material intended for use in the construction, reconstruction, rehabilitation and maintenance of public-purpose infrastructure, especially in the construction of transport infrastructure. The regulation lays down the conditions for the use of ash as a building material in Serbia, instead of stone, sand or gravel. Such practices have been taking place in the US and EU for over 50 years (see Footnote 6).

[13] http://www.doncafe.rs/.

5 Future Plans and Targets in the Country or Any Localized Targets

Serbia is in a transition period of market liberalization and is recognized by the United Nations (UN) as a country with a transition economy. An essential feature of a transition economy is the enlargement and popularization of domestic production and service delivery.

Serbian manufacturers will be obliged in the coming period to comply with EU rules and standards in order to market their production capacity in this large market.

Currently, Serbia follows a linear model of production, and a very poorly organized waste treatment system is estimated, which is estimated at 5–7%, the share of primary energy from renewable sources (about 21%), as well as a very low level of awareness of sustainable development and the circular economy, which is characterized by and the absence of an educational body to deal with the circular economy and legislation. This structure does not support the development of new systems that would foster a transition to a circular economy.

In such a situation, Serbia faces two paths:

The first road is of a reactive nature, where Serbia would continue to commercialize a product that follows a linear model, respecting only a minimum of conditions (primarily environmental regulations) to market and enlarge markets for product services. In this model, it is actually necessary to raise the economy to a level that satisfies larger markets in terms of capacity and quality. This would improve the economy, and thus improve the competence of the entire Serbian supply. It defines world trends that will dominate the longer period of development of the society in the world (minimum until 2050) and which include, among other things, the continuation of the urbanization of society, the inaccessibility and scarcity of natural resources and water, the strengthening of bargaining power of customers and the growth rate of the sharing economy.

The second path is of a proactive nature, where the Serbian economy would, with additional investments, move away from the linear pattern and free the economic entities and society from obligations that would result from the investments necessary for the adaptation of the system in the later phase. The Serbian economy must go through the development of world social and market trends, and this is a new opportunity to reduce the time gap between the technological and economic backlog (estimated at 15–40 years) by introducing the latest systems. At present, the implementation of the circular economy is nominally more expensive, but the benefits can be expected much earlier, since Serbia would join the pioneers in introducing the concept and creating a circular market and would drastically reduce the necessary transition costs foreseen in the future. In addition, the EU has large funds of professional and financial assistance, which it is ready to place in the development of the circular economy. Such a path would read briefly as follows:

Serbia is investing resources in the establishment of the circular market starting in 2017, by increasing the institutional capacity to support such development, raising the social capacity to accept it, changing the economic system to a more qualitative, circular economy, and by 2035, this way of doing business will become the dominant business paradigm in Serbia which approximates all world trends. Partial education reform is affecting the creation of a new profile of workers who will be more educated in the CE field, while the market becomes vocationally independent. By investing in renewable energy, the state and the market become more independent from fossil fuel imports. The creation of a modern services market (rather than a product) becomes evident. Such a market is growing rapidly in the world, and it is predicted that the transition to such a market will provide the creation of products of service, which have from 2 to 10 times higher market value. In doing so, Serbia is moving away from the process industry, and using this model is moving toward a service type of economy.

The proposed solution that is promoted by the world's largest research and government apparatus is circular economy (see Footnote 6).

5.1 *Situation in Serbia and Potential Opportunities for Circular Economy Development*

The Serbian economy is coming out of recession and is focusing more on stimulating entrepreneurship, and, with GDP rising, the unemployment rate is slowly declining. It is important to note that there is still a noticeable shortage of vocationally educated workers in Serbia, and a lack of jobs for classically educated staff is evident. This information may lead to the conclusion that profilers are created in the Serbian education system, which does not meet the current business trends, and despite the high unemployment rate, the market is dependent on imports. The growth of total investments has been a positive trend in the last five years; however, there is generally no strategic commitment to improving modern systems. For example, there is no infrastructure to create an enabling environment that promotes green technology investment, waste management or investment in renewable energy (RES) generation systems. Although Serbia is fairly energy independent (only 27.6% of energy is imported), we cannot come to the conclusion that we are generating enough energy within the country's borders, as industrial activity is still very weak. Increasing industrial activity or potential has led to an increase in energy use; considering that Serbian entrepreneurs are not currently overly concerned with energy efficiency, it is quite expected that there will be a gradual increase in energy needs. On the other hand, only 25–30% of renewable resources are used for energy generation, while the energy use profile shows a low percentage of energy use from RES (about 21%), which leaves much room for improvement of business in that market, which has two visible benefits: increasing energy independence states and increasing energy capacity while ensuring cleaner production. In particular, close to 40% of hydro capacity is unused, while biomass potential exceeds 80% of unused capacity. Water and biomass production are defined as national priorities, whose share in RES generation needs to be increased.

The growth of industrial production as well as entrepreneurial activity was recorded. The growth development of a predominantly process industry is the declared goal of an industry development strategy until 2020 and, as such, enables the enhancement and revitalization of traditional business systems. However, this impedes to some extent the introduction of state-of-the-art technical and technological systems that would allow a faster transition to the eccentric economy.

Finally, activities from the end of 2015 and the beginning of 2016, which improve the institutional framework for regulating waste management, environmental protection and generation, are showing positive developments. In addition, through the IMPACT project, through a joint initiative of the German Organization for International Cooperation (GIZ), the OSCE Mission to Serbia, the Ministry of Agriculture of the Environmental Protection and the Serbian Chamber of Commerce, a series of roundtables was held, in which five cities across Serbia (Sremska Mitrovica, Subotica, Kragujevac, Nis and Novi Pazar) gathered stakeholders to raise their capacities and raise awareness of the importance of applying the circular economy in Serbia. These overall actions will gradually be animated and then strengthened institutional and social capacities for the transition to CE.

At the same time, following the recommendations of the European Commission, an initiative has been launched at the national level to consider the strategic importance of the transition of the Serbian economy to this model by the Serbian Chamber of Commerce, the Ministry of Agriculture and the Environment and the Ministry of the Economy of the Republic of Serbia, and with the support of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH "Municipal Waste and Waste Water Management—IMPACT" (see Footnote 1).

It can be concluded that the capacity to implement the new business philosophy is slowly increasing; however, structural obstacles and an outdated strategic national commitment have somewhat curbed the circular economy, which is in line with contemporary European and world aspirations for future.

Table 3 presents an overview of the indicators and activities that need to be implemented in order to accelerate the transition to a circular economy in the Republic of Serbia (see Footnote 6).

As we can see from Table 3, development policies in Serbia have not yet recognized the circular economy as an opportunity for future development. What is recognized in the research is that a strategic orientation in this direction is necessary in order for the policies at the state level to influence the change of opinion of the local government. An enabling environment in the form of creating a new institutional framework, measures and policies would create a conductive environment for the introduction of the new concept CE and thus enable companies and the wider community to benefit as easily as possible from the modernization of the economy. On the other hand, it is necessary to meet the adequate demand for this kind of system of products and services, and counterbalance in the form of willingness of local communities to accept and demand such products and services is equally necessary.

It is important that the whole process is accompanied by both formal and informal dual education, as well as the correct informing of the public about the details,

Table 3 Derived indicators of the situation and activities toward achieving the circular economy in Serbia (Veselinov 2016)

Type of development	Current status	Development activities
Laws and approximation to the EU	–	↗
Law enforcement related to sustainable development and environmental protection	–	↗
Regulations for RES generation	–	↗
Definition of "sustainable development" in legislation	–	–
Definition of the term "circular economy" in legislation	–	↗
National strategic commitment to green economy	–	–
National strategic commitment to sustainable development	–	–
Incentive activities for RES development	–	↗
Incentive activities for the development of waste management	–	↑
Incentive activities for the development of the circular economy	–	–
Encouraging activities for the development of green entrepreneurship	–	↗
More effective implementation of RES, CE and waste management laws	–	↗
Creating stimulating circumstances for the development of eco-design and clean production	–	↗
Waste management infrastructure	–	↗
Renewable energy generation capacities	–	↗
Introducing Circular Economy into the Education Program	–	–
Energy efficiency in the economy	–	–
Total treated waste (industrial and domestic)	–	↗
Level of social and business awareness of the concept of circular economy	–	↗
Collaboration with international organizations to enhance capacity to implement circular economy	–	↗
Number of civil society organizations engaged in CE promotion	–	↗
State bodies responsible for the development, implementation, and monitoring of CE	–	↗
Innovation and innovation investment for CE	–	–

Legend Dashes represent the state of | arrows represent activities
On a scale of 1–4: Red (1)—very bad | Orange (2)—the shift is minimal, almost impossible to record | Yellow (3)—shift visible but weak | Green (4)—Shift visible

importance and urgency of responding to the benefits of the newly introduced changes (see Footnote 6).

6 Research Supporting and Any Special Learning and International Collaboration, Etc.

Within GIZ IMPACT project and in cooperation with the OSCE—Mission to Serbia, Serbian Chamber of Commerce, and the Ministry in charge of environmental protection affairs, a series of round table sessions was launched throughout Serbia with the aim to promote circular economy, sustainable development and new legal solutions in the area of waste management.

Thanks to the support of the OSCE Mission to Serbia, in the previous period, a significant step ahead was made in strengthening of the civil society, especially in the area of environmental protection; in their capacity of promoters of advocacy and promotion of circular economy, civil society organizations provide a significant contribution to efforts aimed at familiarizing citizens with the concept of sustainable economic growth in an interesting manner.

Aarhus centers, as important CSOs (Civil Society Organizations), have capacities which institutions and organizations may engage in their efforts to make information in this area more easily accessible. The new manner of production and utilization of products calls for innovative technologies, which open up new possibilities for cooperation between educational institutions and the civil sector. The main principles of circular economy comprise all elements needed for strong economic and social progress with preservation of the environment. Based on the precious experiences of SCOs in awareness raising, these organizations are recommended as leaders in advocating for necessary changes.[14]

The level of circular economy of the surrounding countries depends on EU membership. Countries in the EU member states follow the European legislation already defined above, while countries such as Bosnia and Herzegovina, Northern Macedonia and Montenegro have both a legislatively and operationally lower level of implementation of the circular economy in social and economic development than Serbia.

7 Any Special Mention May also Be Added

7.1 Advantages and Applications of Circular Economy in Serbia

The introduction of a circular economy would have many positive effects, including the following:

1. Production standardization with the introduction of ISO standards (14001, 9001, OSHAS18000, 30000, 30001 …), but also with the introduction of other "sustainable" and "environmental" standards and certificates;
2. The transition from the classic process and processing industry to the innovative industry with a far higher value of final products;
3. The transition from a manufacturing to a service economy, which also promises a higher market value;

[14] *Circular Economy—Closing the loop*, Organizacija za evropsku bezbednost i saradnju (OEBS), Misija u Srbiji.

4. Raising social awareness on issues of future development of society, such as sustainable development, active democratization of society through public influence on decision making, social inclusion, reduction of consumerism and greater appreciation of domestic, local products and services;
5. Establishing stronger links with international companies moving to sustainable business and implementing the circular economy, in addition:

   a. introduction of best available technologies (BAT),
   b. introduction of know-how from foreign markets,
   c. facilitating the transition to the common labor market through the employment of foreign experts and education of local experts.

6. Establishing links with global development partners and networks of organizations, such as the UN and the EU, with:

   a. facilitated access to project financing, with the aim of modernizing production and markets,
   b. introduction of modern understandings of market organization that enable greater adaptability of Serbian overall economic supply,
   c. a step toward the modernization of society,
   d. greater involvement of civil society,
   e. strengthening and enhancing relations with countries promoting CE through mutual projects.

7. Introducing the concept of sustainable development as a turning point for opening new markets, including:

   a. Waste management
   b. Renewable energy sources
   c. Reverse logistics
   d. Service activities
   e. Knowledge economy
   f. High state infrastructure projects
   g. Projects of industrial symbiosis and establishment of eco-industrial parks
   h. Organized systems for overhaul, repair and re-production

i. Waste and pollution treatment
j. Increase in employment rate
k. New technologies
l. Green innovation
m. CE-based green entrepreneurship.

8. Promoting the modern strategy and direction of Serbia, which improves its rating for investments from major global funds, especially EU development funds;
9. Capacity building in Serbia in order to become a center of knowledge and experience about CE in the region of South East Europe;
10. Entering the market of modern energy trade and a potential pioneering position to create the so-called smart grids;
11. Education of experts in the latest forms of business and social activity;
12. Reduction of adverse environmental effects, conservation of natural resources (including minerals, metals, other materials, water and air) and biodiversity.
13. Modernization of industrial plants, which, with proper coordination, would be supported by large investors in new technologies; creating conditions for "cleaner production";
14. Improvement of waste tax and levy models (plastics, cardboard and paper, metals, glass, etc.) in industry and households (including household and bio-waste), which would increase the eco-fund to further develop green innovation;
15. Energy independence;
16. High vocational independence (through education empowerment);
17. Significant savings on modernization of the economy (through savings of materials, energy, water, treatment of pollution, circulation of the same substance);
18. Reducing the technological gap relative to developed countries;
19. Opening up new markets abroad for the placement of products and services (value and knowledge export);
20. Creating a knowledge economy and facilitating a green economy i
21. Sustainable development of society (see Footnote 6).

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References

Đurđević, J., Rajković, D., & Đurđević, S. (2011). *Waste management in Serbia through action „Očistimo Srbiju", Quality Festival* (pp. 315–320). Faculty of Engineering University of Kragujevac, Kragujevac, Republic of Serbia.

Mihajlov, A., Stevanović Čarapina, H., Staudenmann, J., Tadić, M., Stokić, D., Tsutsumi, R., et al. (2014). Potreba ozelenjavanja ekonomije u Srbiji. *Journal of Social Sciences and Humanities, LIMES plus*, 17–24.

Luković, A. (2016). *Development of an eco-industrial network-based model for managing industrial waste flow* (Doctoral dissertation). Faculty of Occupational Safety, University of Niš, Niš, Republic of Serbia.

Milivojević, J., Grubor, S., & Milovanović-Kanjevac, K. (2009). Vehicles at the end of life cycle as a renewable source of high quality material. In *Quality festival* (pp. 28–32). Kragujevac, Serbia: University of Kragujevac.

Veselinov, M. (2016). Master istraživanje Budućnost cirkularne ekonomije u Srbiji, Grac.

Circular Economy for Sustainable Resource Management: The Case of Packaging Waste Sector in Thailand

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Abstract The status of circular economy (CE) in Thailand is reviewed in this chapter. The current CE practices and policy instruments used towards sustainable resource management in Thailand are presented as well. CE indicators for Thailand are extensively studied and summarized in the paper. Based on the review, it is established that the existing policies and programs on CE are focused more towards 3R concepts and less on other sub-sects of CE such as products-as-services, next life sales, product transformation, collaborative consumption, etc. Currently, CE indicators are primarily based on 3R concepts, whereas it is recommended that the other sub-sects of CE should also be taken into consideration to measure the actual CE progress. Employing packaging waste in Thailand as a case study, the current circular economy practice and key barriers to CE implementation were assessed to propose appropriate policy measures for sustainable waste and resources management. There has been an increase in packaging waste in the municipal solid waste (MSW) stream, of which plastic poses a key challenge in the urban waste stream. The current flow of packaging waste is predominated by recycling as downcycling. Most packaging waste remaining at landfills is one-time-use packaging. According to the comprehensive assessment, consumers had positive attitudes towards 3R practices and were conscious of waste problems. Economic incentives and regulatory instruments in line with a new waste management policy framework are recommended to overcome the barriers hindering CE implementation. Packaging waste management policy framework and policy measures are established through this study.

Keywords Circular economy · 3R · Sustainable resource management · Municipal solid waste · Packaging waste · Indicators · Barriers · Policy

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1 Status of Circular Economy in Thailand

Consideration on circular economy (CE) is vital for Thailand in order to ensure the sustainable consumption and production since the resource utilization and waste generation is continuing to increase in the country. Actions are being taken to promote the initiatives on CE including 3R, cleaner production, eco designing, industry symbiosis, etc., by the Thai Government. Recycling in Thailand has been become significant in municipal solid waste (MSW) management practice after 1990s as an alternative to the open dumping and landfilling practices, emerging as the second most common method of MSW management. Though these dispersed initiatives help to effectively manage the waste, the CE concept has a potential to aggregate them and increase its efficiency in micro, meso, and macro level. After several decades of initiating number of waste management strategies, steps to introduce CE as a sustainability concept have been taken. For example, the Ministry of Industry has proposed a "circular economy framework" in 2018 as a part of the government's S-curve policy. The Ministry has also developed circular economy roadmap in collaboration with the private companies and United Nations Industrial Development Organization. Under the S-curve policy, the circular economy will be applied to the targeted industries and this model will include framework, regulation, and initiatives for all companies. The Thailand S-curve policy (Thailand 4.0 Policy) will be effective for growth of 10 S-curve industries (viz., Next-Generation Automotive, Intelligent Electronics, Advance Agriculture and Biotechnology, Food Processing, Tourism, Digital, Robotics and Automation, Aviation and Logistics, Biofuels and Biochemicals, and Healthcare) in terms of widening investment and opportunities. Thailand is stepping towards the sustainability achievements in near future through CE implementation.

2 3R to Minimize the Resource Consumption in Thailand

Several national policies, plans, regulations, projects, and programs have been developed to enhance the implementation of 3R that in-turn supports circular economy in Thailand. The national-level initiatives to support 3R practices are summarized in Fig. 1.

The Government has been encouraging cooperation among various stakeholders to promote the 3Rs principles as illustrated in Fig. 2. It has identified the importance of the community participation in 3R practices, hence, there are programs introduced such as composting and recycling waste bank. The community is empowered through capacity building, guidelines, and instructions. Steps are taken to initiate recycling-oriented society ensuring the collaboration of central government, local administration as well as private stakeholders. The in-house segregation, reuse, and recycling are well focused by the Thai government. In addition, the central government facilitates

1. Policies

- Green Industry Policy
- Government Green Procurement Policy
- Government's smart city policy
- National Policy and Plan on 3R and E-wastes management

2. Plans

- National integrated waste management and 3R strategic plan
- National master plan on the Cleaner Production and Cleaner Technology
- Strategic Plan on E-wastes
- Strategic Plan on Packaging and Packaging Waste Management
- Action Plan for Thailand Zero Wastes
- The National 3R Strategy Plan
- National Environmental Basic Plan
- National Solid Waste Management Master Plan
- Pollution Management Plan
- Roadmap on waste and hazardous waste management

3. Law and regulations

- Law for Promotion of 3R (draft)
- Municipal Solid Waste Act (draft)
- Waste Electrical and Electronic Equipment Act (draft)
- Law for Promotion of Source Separation

4. Projects and programs

- Zero Waste Project
- Clean and Green City Project
- Green Junkshop program
- Pollution Prevention Program
- Green Industry (GI) Project
- Take – back program for end back program for end -of -life products
- Thailand green purchasing network
- Industrial Waste Exchange Program (industry symbiosis)
- Thai Green Label Schemes
- One community one Recycling Program
- Recycling waste bank
- Eco industrial town project

Fig. 1 Initiatives to implement 3R in Thailand (Country Report 2017; PCD 2018a)

the local governments to maintain environmental-friendly waste management system through technical and financial support. Promotion of public–private partnership programs, promotion of waste recycling business, introduction of deposit-refund systems, and take-back programs also contribute to 3R implementation in the country. Over 200 communities implement the 3Rs and several municipalities have reduced waste up to 30–50% through 3R practices (PCD 2018b).

The Pollution Control Department has currently developed National 3Rs Strategy in collaboration with UNEP Regional Resource Centre for Asia and the Pacific

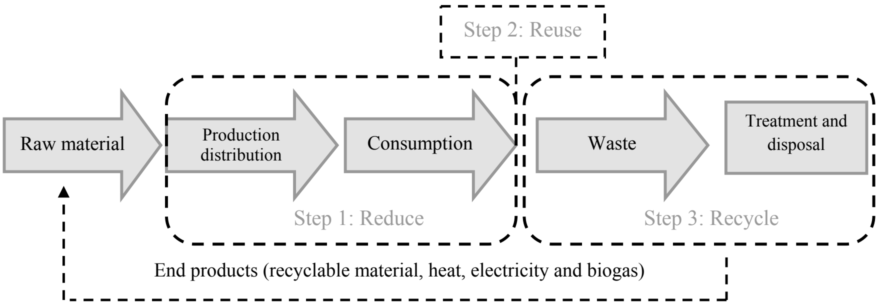
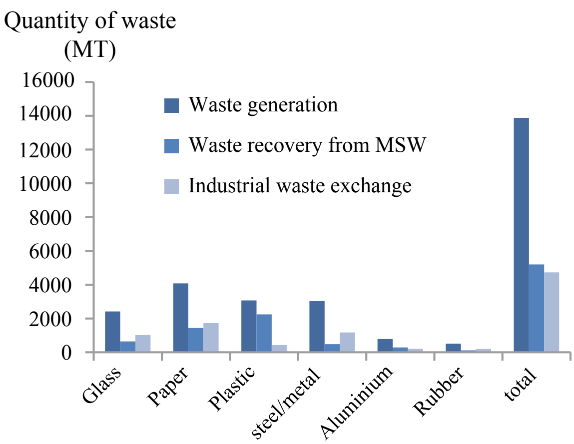


Fig. 2 National 3Rs principle (Piyapanpong 2018)

under Advance Waste Management in Asia and the Pacific (Wangwongwatana 2018). Though solid waste recovery is around 22%, the recycling of e-waste is not well implemented. The government plans to ban imports of electronic and plastic waste in future and promote e-waste management by extending the producers' responsibility. The vision on solid waste management is broad and clear in Thailand where it is aimed to increase the percentage of properly disposed and recycled waste up to 75% by 2021 from the current 49% (Pollution Report 2015). The following Figs. 3, 4, 5, 6 and Table 1 from Thailand provide evidences for the potential of resource recovery through recycling and reuse allowing minimization of virgin resource use.

Box 1: Reducing Metal Waste Through 3R Activities at a Semiconductor Manufacturing Site by Toshiba Semiconductor (Thailand) Co., Ltd. (Toshiba 2018)
Toshiba Group is working to reduce waste generation by minimizing the volume of waste generated per unit activity, which indicates business process

Fig. 3 Waste recovery by type of material in 2016 by amount (Wangwongwatana 2018)



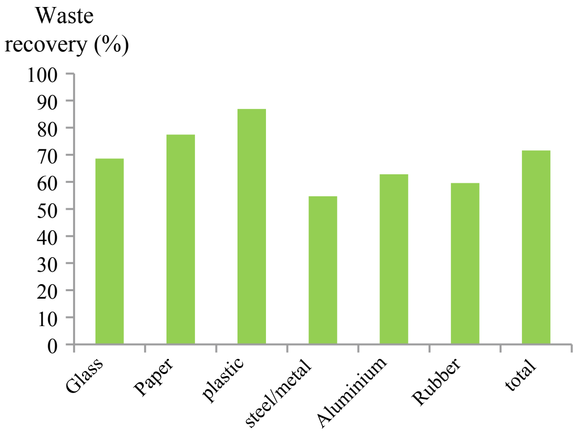


Fig. 4 Waste recovery by type of material in 2016 by percentage (Wangwongwatana 2018)

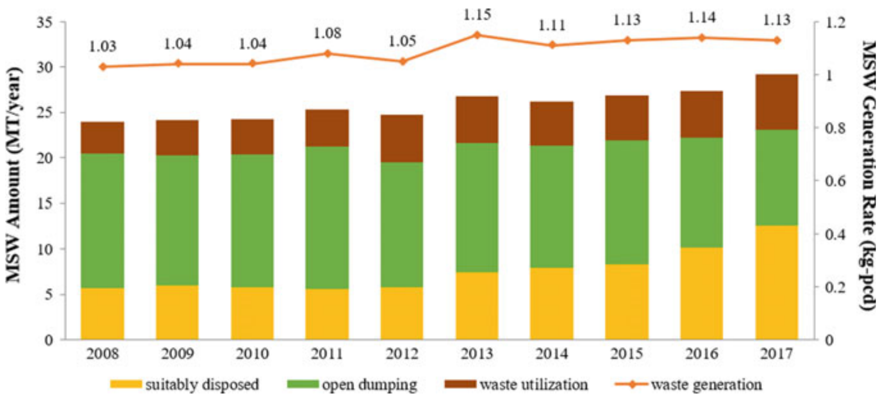


Fig. 5 Historical trend of waste disposal and utilization in Thailand (PCD 2018c)

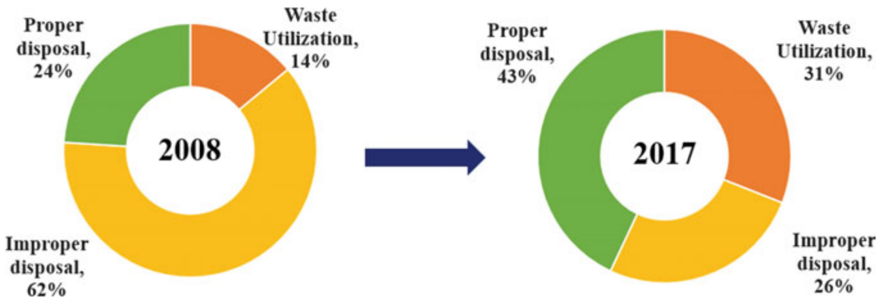


Fig. 6 Municipal solid waste re-utilization (PCD 2018c)

Table 1 Potential for recyclability and reusability of municipal solid waste, industry waste, and resource recovery facilities (Pollution Report 2015)

Category	End of life use	Recycle rate	Resource recovery facilities/infrastructures in cities
Glass	Reuse/recycle	–	–
Paper	Recycle	>70% (high)	Every major cities
Plastic	Recycle	>70% (high)	Every major cities
Steel/metal	Recycle	(50–60%) (average)	Every major cities
Aluminium	Recycle	–	–
Rubber	Recycle/reuse		–
Construction waste	Recycle	<50% (low)	Few major cities
E-waste	Recycle	<50% (low)	–

efficiency improvement, as well as by reducing the total volume of waste to a level below the Earth's environmental capacity. Toshiba Semiconductor (Thailand) Co., Ltd., has been established in 2013 which manufactures small-signal devices and optical devices. By implanting 3R strategies, the company is able to firstly reduce the generated waste by 22.95 tonnes/year by replacing conventional lead frames with high density type frames resulting in increase of material utilization efficiency up to 242%. Secondly, the generated waste has been reduced by 1.45 tonnes/year by making the shape of the mould resin smaller, which has resulted 466% material utilization efficiency eventually.

The company also has promoted recycling of electronic parts, including spray cans and batteries, to achieve its goal of reducing the final disposal amount to zero to meet Thailand's administrative standard. As a result, the company has achieved "Zero Waste to Landfill Achievement Award 2015". In 2013, Toshiba Thailand Co., Ltd. has carried out a pilot project to collect and recycle end of life electric and electronic devices in order to respond to future recycling legislation and in its marketing strategy.

3 Existing Indicators for Assessment of CE in Thailand (Pollution Report 2015; UNPAN 2004; National Statistic Office 2018)

There are a number of indicators in national and institutional level that are available in Thailand. Based on the review of current status of Circular Economy status in Thailand, few of them are presented in Table 2.

Table 2 Existing indicators for CE assessment

S. No.	CE indicator	Unit
1.	Total municipal waste generated, collected, transported and disposed	Tonnes per municipality (or) Tonnes per capita
2.	Municipal solid waste utilization	Tonnes per year
3.	Composting plants to treat organic waste	Capacity per year
4.	Biogas plants to treat organic fraction of municipal solid waste	Capacity per year
5.	Material recycling facility for waste processing	Capacity per year
6.	Incinerators for waste treatment	Capacity per year
7.	Open or Sanitary Landfill for waste disposal	Capacity per year
8.	Budget for solid waste management (under the Provincial Environmental Quality Management Action Plan)	Million Baht
9.	Village units with mechanism for reporting waste processing and disposal	No. per region
10.	Eco-label products placed in market	% increase per year
11.	Hazardous waste generation by industries	Tonnes per year
12.	Operational waste management facility in industry	Capacity per year
13.	Waste utilization by industries Ex: Co-fuel in cement kilns	Tonnes per year
14.	Hazardous waste shipped overseas for management	Tonnes per year
15.	Waste to renewable energy generation	MW per year

4 Possible Indicators to Measure CE in Thailand

The study recommends possible indicators for measuring the CE in future in Thailand. These indicators consider the aspects of urban infrastructure for Municipal Solid Waste Management in ‘smart city’ context. Notably, the proposed indicators consider other sub-sectors of CE other than 3R aspects such as products-as-services, next life sales, product transformation, collaborative consumption etc. The study recommends a holistic approach for measuring CE especially in Thailand, as presented in Table 3.

5 Policy Instruments Used Towards Sustainable Resource Management in Thailand

Regarding the Natural Resources and Environmental Policy, the government aims to enhance waste disposal systems and improve disposal capacity of local administrative authorities. National waste management policies also include promoting the private sector’s role in research and development for recycling, minimizing waste generation by promoting the 3Rs hierarchy, promotion of source reduction and separation, waste recovery for composting, and producing biogas. In terms of waste management facilities, the plan includes establishment of such infrastructure. Currently, the country’s waste management framework is based on the waste to energy concept. Each focal area (e.g. landfill, incineration) were covered by a number of laws/acts, regulations, standards, and technical guidelines of the National Solid Waste Management Policy. However, existing policies and laws lack regulations that cover the entire system of waste management and also lack economic instruments to encourage stakeholder participation and contributions. (Amrehn 2013; WMS 2018; Piyapanpong 2018; Wangwongwatana 2018; Country Report 2017; Kamuang and Siriratpiriya 2017).

In terms of policy instruments to promote sustainable resource management in Thailand, the four types of instruments are mainly used. These policy instruments support the resource management particularly for implementing 3R strategies in the country, and it is summarized in Fig. 7.

6 Current CE Practices in Thailand

6.1 *Promotion of Green Public Procurement*

Green Public Procurement (GPP) been initiated in Thailand in 2005 by Pollution Control Department of the Ministry of Natural Resource and Environment. The Royal Thai Government has obtained the approval of the Cabinet Resolution in 2008 for the first Green Public Procurement Promotion Plan 2008–2011 and in 2012 for

Table 3 Possible indicators for measurement of CE

S. No.	Category	CE indicator	Unit
1.	Social	Public private partnerships for CE implementation	No. per year
		Programs to promote CE in schools/religious activities	No. per year
		Purchase of recycled products in households and industries	Baht per year
		Self-help women groups that promote CE activities	No. per region
		Level of awareness of citizen on CE	Qualitative indicator
		NGOs and private sectors that promote CE through community campaigns, workshops and conferences	No. per region (or) No. per 1000 persons
2.	Financial	Savings through innovation by producers as part of CE activities	Baht per year
		Revenue to government through penalties, taxation etc., during enforcement of regulation promoting Circular Economy	Baht per year
		Circular subscription (sharing high quality products) E.g. Baby clothes	% waste reduction each year
		Financial incentives to promote community in Circular Economy	Baht per year
		Increase in income to rag-pickers and waste dealers through CE activities	% increase each year
		Expenditure incurred by a manufacturer to fulfil 'Extended producers responsibility'	Baht per year
		Savings through installation of energy efficient appliances in households and industries	kWh/year (or) Baht per year
		Budget spent by local/provincial/national government for CE implementation	Baht per year (or) % each year
		Retail shops providing repair services/recycling facilities	No. per region (or) No. per 1000 persons
		Expenditures on Research and Development to achieve Circular Economy	Baht per year

(continued)

Table 3 (continued)

S. No.	Category	CE indicator	Unit
		Subsidies to industries to promote CE activities	Baht per year
3.	Technological	New business models such as Uber, Ola, Grab etc.	No. per 1000 persons
		Reverse Vending Machine installed	No. per 1000 persons
		Environmental related media advertisement	No. per year (or) Baht per year
		E-waste collection centres	No. per 1000 persons (or) No. per region
		Promotion of public transport utilisation	% increase in users each year
		Active Mobile apps that promote Circular Economy	No. per region
		Improving awareness, attitude and perception about CE through social media	No. of views about CE in each region
4.	Political	Laws, regulations, amendments etc., for CE implementation	No. per year
		Political will: Policies, programmes etc., to encourage CE activities	No. per year (or) Baht per year
		Green public procurement by the country	% of GDP
5.	Environmental	Provision of bins for material segregation	No. of sets per 1000 persons
		New investment in renewable energy	Baht per year
		Production of Bio-based products	Tonnes per year
		Consumption of Bio fuels by the entire population	Tonnes per year
		Construction or up gradation as Green Building	No. per region
		No. of industries declare environmental stewardship	No. per region
		No. of industries that are part of Industrial Symbiosis	No. per region

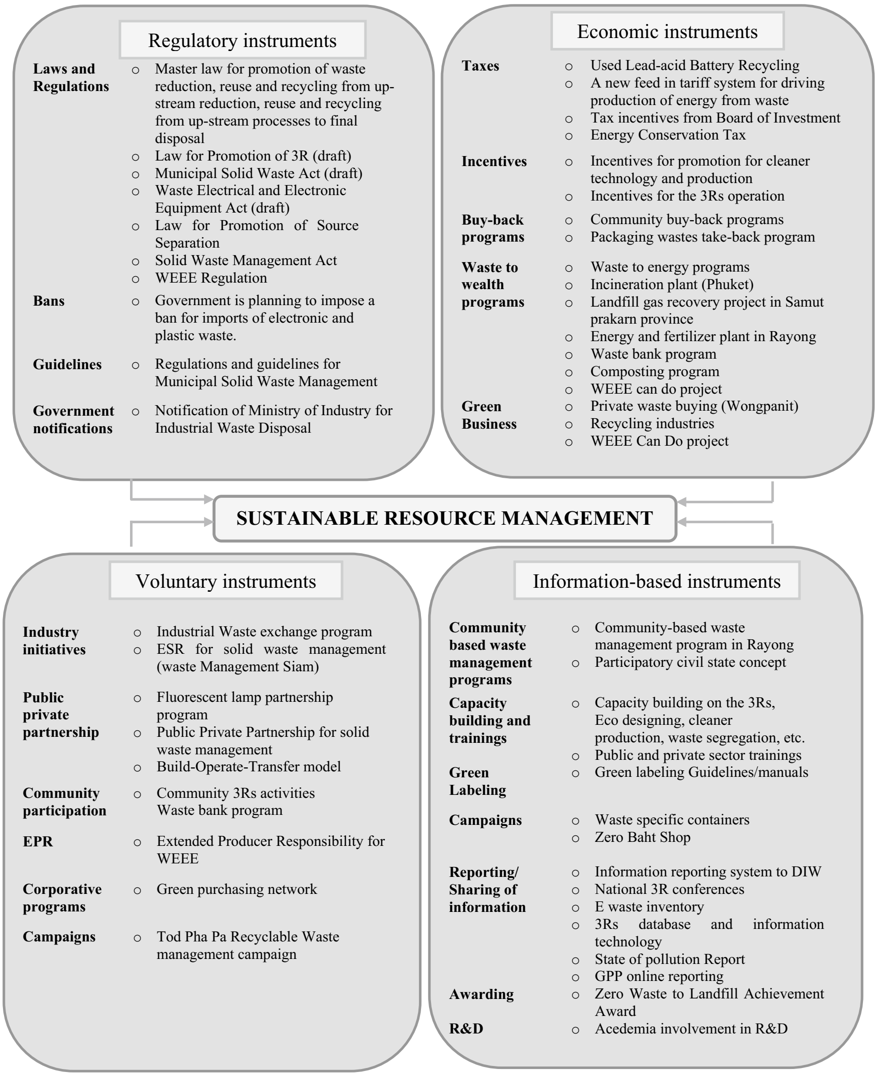


Fig. 7 Policy instruments related to sustainable resource management

the second Green Public Procurement Promotion Plan 2013–2016. With the second GPP promotion Plan, it has planned to implement GPP more widely from central to local authorities and public organizations. Under the first Promotion Plan, the GPP criteria of 14 products and 3 services of high common usages have been announced, whereas under the second Promotion Plan it has been expanded up to 17 products and 5 services. The 11th National Economic and Social Development Plan and the Environmental Quality Management Plan 2012–2016 have integrated the GPP into the sustainable consumption and production plan. The selection of Green Goods

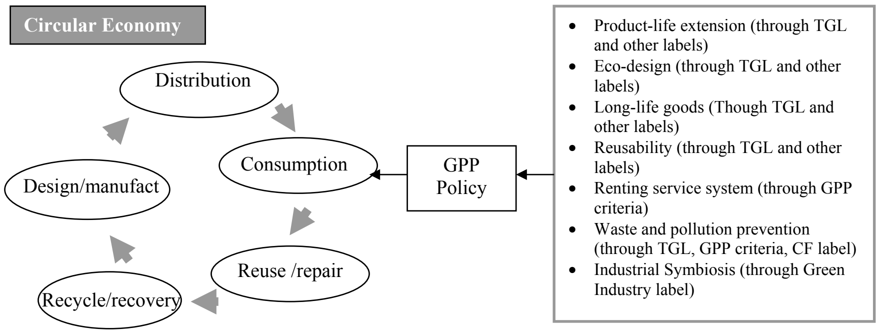


Fig. 8 GPP in promoting circular economy in Thailand

and Services under GPP in Thailand refers to the ecological schemes including Thai Green Label (TGL), Green Leaf label and Green Hotel, Green Industry label, Green Cart Label and Carbon Footprint (CF) label (UNEP 2018).

GPP as presented in Fig. 8 is based on the life cycle consideration of the goods and services procured by the government. Resource extraction, manufacturing, use, and disposal phase of the products or/and services need to be environmentally friendly to become prioritized in GPP of Thailand. Thus, GPP confirms less waste and pollution generation, recyclability, reusability or material recovery, and high resource efficiency, keeping the material in value chain for long period of time closing the energy and material loops. There is a greater possibility to expand the facilities for recycling, repairing, and material recovery as these practices are well recognized by the public procurement process. For example, in GPP, products with less environmental impacts; use of renewable resources, recycle content, less energy, less or no toxic substances, less material, use of clean technology, less packaging, and less environmental impacts during the use phase, provide collection system after end of life and durability are given consideration; which support circular economy in Thailand (Bunyagidj 2009). Photocopier rental service is one of the good examples for the CE business model which through GPP promotes paper recycling (Tippamongkol 2014). Recycled plastic use is one of the considerations as well.

6.2 *Environmental, Green Label, and Green Certification*

The Green Label is an environmental certification awarded to specific products with minimum detrimental impact on the environment in comparison to other alternative products. The scheme has been initiated in 1993 by the Thailand Business Council for Sustainable Development (TBCSD) and was formally launched in 1994 by the Thailand Environment Institute (TEI) in collaboration with the Thai Industrial Standards Institute (TISI). Thai Green Label covers around 124 products and services including products made from recycled plastics, air conditioners, computers, paper, and photocopier. The Thai Green Label and Green cart label consider the environmental concerns in whole life cycle which assist in closing energy and material loops (TEI 2018). Other than the TGL, Thailand enjoys the benefits of other environmental labels including Green Cart Label, Carbon Footprint Label, Carbon Reduction Label, Energy Label, Green Leaf Label, and Green Cart Label as shown in Fig. 9.

Thailand's Greenhouse Gas Management Organization (TGO) in cooperation with the Thai Environment Institute (TEI) established "Carbon Reduction Label" scheme by using Life Cycle Assessment (LCA) approach. Carbon Footprint Label informs the quantity of GHG emissions from each production unit throughout the whole life cycle (cradle-to-grave) of a product. Carbon Footprint Label provides an alternative to consumers to contribute towards reducing GHG emissions by purchasing low emission products and services (Supappunt 2011). 233 products from 68 companies have been certified under Carbon Footprint Label in Thailand in 2011 (Environnet 2018). Since the material consumption is a cause for carbon emission, it can be reduced by closing the energy and material loops keeping the material long term in the value chain. Thus, the Carbon Footprint Label allows the industries to confirm their actions towards material recycling, reusing, and reducing.

Box 2: Siam Cement Group; "SCG Eco Value" in Promoting Circular Economy (SCG 2008, 2018)

Siam Cement Group of Thailand is one of the companies which promote CE and has obtained the first self-declared environmental labelling called "SCG eco value" label since 2009. The label criteria are in accordance with the ISO 14021 standard and the label is a Type II environmental label according to the ISO classification. The criteria concern about the product life cycle including product design, reduction in raw material, energy and water consumption during production and use, the use of renewable materials and energy, recyclability, waste reduction, and emission of greenhouse gases. In 2013, SCG has 82 "SCG eco value" products and services certified contributing to 26% of revenue from sales, while the target SCG eco value sales volume is one-third of revenue from sales in 2015. SCG paper is environmental-friendly corrugated paper that reduces the use of pulp for at least 8%. It considers about three main areas:

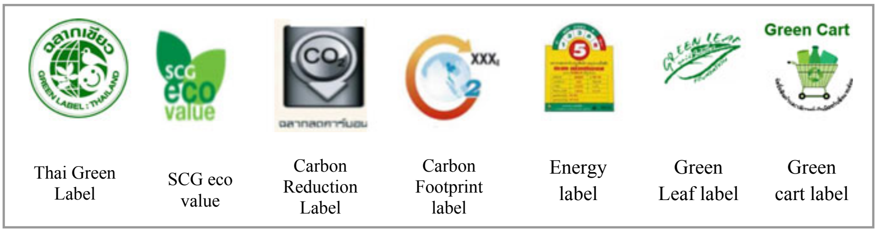


Fig. 9 Environmental labels supporting the circular economy in Thailand

Green Process considers as the environmentally friendly approach in papermaking. It starts from growing trees which will be used for making paper pulp, to the responsible use of water in the production process. Wastes or by-products from the production process are treated using internationally accepted standards.

Green Product involves the initiative to create public awareness on the responsible use of paper and the benefits of using environmentally friendly paper. The company educates the public that used paper can be recycled in order to reduce wastes, minimize the impact on the environment, and maximize the use of natural resources.

Green Mind is the key to achieve the entire green process. SCG paper has successfully implemented a new culture of paper use within the organization by implanting a new value and guideline for responsible paper usage. This is built on the belief that the organizational culture should be shared with the general public in order to encourage consumers to do their part by taking action in using recycled paper and maximizing paper usage.

6.3 Public 3R Campaign in Collaboration with the Private Sector

Thailand recognizes and encourages the community participation in 3R practices for sustainable consumption patterns, business opportunities, and to identify the facilities for safe disposal of the waste. The community participation in 3R is promoted by the private sector as well as the government sector of the country. The following case study elicits the cooperation of private sector to support community to manage waste creating a better opportunity to have an economic benefit.

Box 3: Public–Private Partnership for Sustainable Plastic and Waste Management (SCG 2018)

Thailand is the sixth biggest contributor of ocean plastic waste in the world which generates around 1.03 MT per year. 3% of these end up as ocean plastic. Plastic generation in Thailand is around 12% of total waste which is higher than the amount in China (11%). The government, private and community-level initiatives are being implemented in Thailand to address plastic waste generation. The Plastic Industry Club under the Federation of Thai Industries and Business Council for Sustainable Development in collaboration with private and civil society has initiated "Public–Private Partnership for Sustainable Plastic and Waste Management". The partnership involves SCG chemicals Co., Ltd., Dow

Thailand Group, IRPC PCL, PPT Global Chemical PCL, Siam Piwat Co., Ltd., and Thai Plastic Industries Association.

The partnership has declared its intention to reduce waste and promote sustainable plastic and waste management adopting CE for at least five years collaboratively with the partners. The initiative aims to mobilize actions to reduce plastic in Thai ocean to less than 50% by 2027. The initiative will help promote the standard of recycling business, support entrepreneurs to develop innovation and technology for sustainable plastic management using 3Rs (reduce, reuse, recycle) principle, educate consumers and the public about the proper disposal of waste and waste management and encourage behavioural changes, pilot a clean city model in Khlong Toei District and in Rayong Province, develop Thailand Plastic Material Flow Database to measure the project's success and serve as an internationally accepted plastic database for Thailand.

6.4 Voluntary 3R Initiatives By Producers

In Thailand, there are number of 3R initiatives which have been initiated in different levels involving different stakeholders. Some of these initiatives are mandatory such as standards, law, and regulations, yet some are voluntary. Though some of the voluntary initiatives are less efficient than mandatory actions, there are number of success stories are available in the global as well as regional levels. Some of the voluntary 3R initiatives have been started by the public sector, private sector, or by the communities itself. In Thailand, take-back programs, waste bank program, extended producer responsibility for WEEE and public–private partnership are some of the examples for such initiatives which promote 3R.

7 Packaging Waste Management Practices in Thailand

Packaging is defined as "all products made of any materials of any nature to be used for the containment, protection, handling, delivery, and presentation of goods, from raw materials to processed goods, from the producer to the consumers". The definition of waste is given as "any substance or object which the holder disposes of or is required to dispose of". Thailand Packaging Association (TPA) estimated that the amount of all packaging materials has tended to increase, and particularly plastic packaging which has increased at a rapid rate given its flexible characteristics.

Packaging waste comprised 22.5% (by wet weight) of total MSW, and of this plastic was the major type of packaging found in the waste stream (15.8%), followed by glass (3.5%) and paper (3.2%). Over the last decade, plastic has increased from

15.8 to 29.3% due to the increased amount of packaging waste (increasing from 22.5 to 35.2%). The proportion of paper and glass packaging has reduced and can be explained by the current trend of substituting plastic packaging for paper and glass.

Waste audit was carried out at institutional level and food waste was found to represent the highest proportion of total waste (58%). Packaging waste accounted for about 37.1% by wet weight, which constitutes around one-third of total waste. Plastic packaging presents the largest proportion in the waste stream (25%), plastic bags and Styrofoam were also included as plastic packaging. Lesser waste components included glass bottles (6.5%), paper packaging (e.g. beverage cartons, paper cups, folding boxes) (4%), and metal (e.g. coffee cans made of steel, beer can made of aluminium) (1.6%) that has the lowest proportion compared to other packaging materials (1.6%). The overall composition indicates that single-use packaging make up 57% of total packaging waste. It is clear that consumers generate a large amount of single-use packaging that ends up in landfill simply because these materials are not reusable and not sellable. These types of packaging materials adopt a linear approach (i.e. take-make-waste). Comparison of composition of packaging waste in 2005 and 2015 is presented in Fig. 10.

According to existing law, packaging waste by definition refers to general solid waste generated by households as regulated and structured in the Enhancement and Conservation of National Environmental Quality Act of 1992, the Public Health Act of 1992, and the Cleanliness and Orderliness of the Country Act of 1992. Local government is the main responsible authorities for managing (collecting, transporting, and disposal) municipal solid waste that includes all packaging waste within their administrative area. There are no rules, regulations or law enforcement for controlling the generation of packaging waste and managing the entire waste stream of packaging. Producers and importers are not subjected to take any responsibility for their post-consumer packaging products. Therefore, packaging waste is often thrown away and mixed with general household waste and consequently ends up in final disposal.

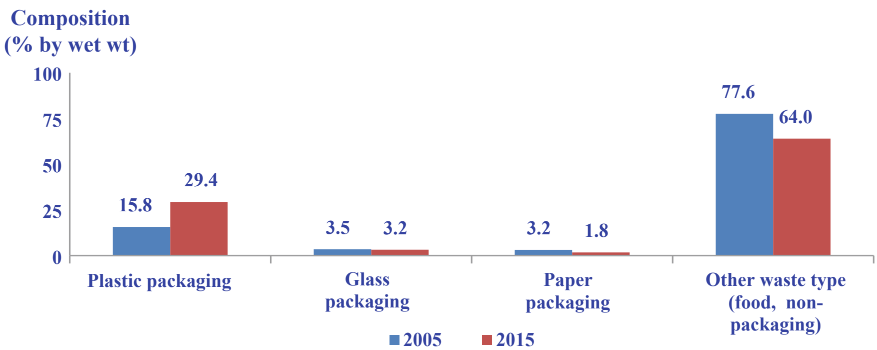


Fig. 10 Packaging waste in MSW in 2005 and 2015 (% by wet weight)

Currently, there are inadequate waste collection services in the country. About 57% of local administration organizations that provide waste collection and disposal services diverted only 7.88 million tonnes or 53% of total volume waste collected to controlled waste disposal facilities, e.g. to incinerators with air pollution control or engineered landfill. Waste was delivered to 466 waste disposal sites managed by both the public and private sectors. In contrast, about 47% of the total volume of waste collected or 6.93 million tonnes was disposed of through open dumping. For the remaining 43% of local authorities that do not provide waste transport services, they disposed of 6.53 million tonnes per year, which accounts for a total of 13.5 million tonnes per year that was disposed of inappropriately. Since 2008, the volume of waste has trended upwards but the capacity of LGAs to collect and properly manage waste remains limited. There is a lack of regulations and ineffective policy implementation to control waste generation, as well as long-term planning and cooperative planning among stakeholders to reduce waste upstream.

The national target of waste management was announced in the Environment and Pollution Control Plan 2012–2016. The rates of safe disposal and waste utilization are the only two waste management indicators used as planning instruments at national level. The target is set as follows:

- Rate of safe disposal—should not be less than 50% of total waste generated.
- Rate of waste utilization—this should not be less than 30% of total waste generated.

The review of waste management practices and policies indicated a lack of proactive and innovative measures in response to linear consumption and production patterns. Business as usual is no longer the right way to achieve sustainable waste and resource management; it requires changes in policy and upstream management as well as consumption behaviour. Detailed flow of post-consumer packaging materials by informal and formal sectors is presented in Fig. 11.

Employing packaging waste in Thailand as a case study, the main objective of this report is to assess the current circular economy practice, and to analyze and identify key barriers to CE implementation and to propose appropriate policy measures to enhance sustainable waste and resources management. The research engaged three main key stakeholder groups: producers, consumers, and the public sector. A set of CE indicators was adopted from previous studies that proposed relevant CE indicators. Barriers identified in this study are based on responses from stakeholders in the packaging waste management sector. A mixed-method approach was adopted for consumer behaviour analysis using questionnaire-based surveys. Waste compositional analysis, field observations, and key informant interviews were conducted to investigate the characteristics of material flows. Subsequently, in-depth interviews using semi-structured interview questions were carried out to gather data on attitudes and opinions towards CE development from key informants which were then qualitatively analyzed.

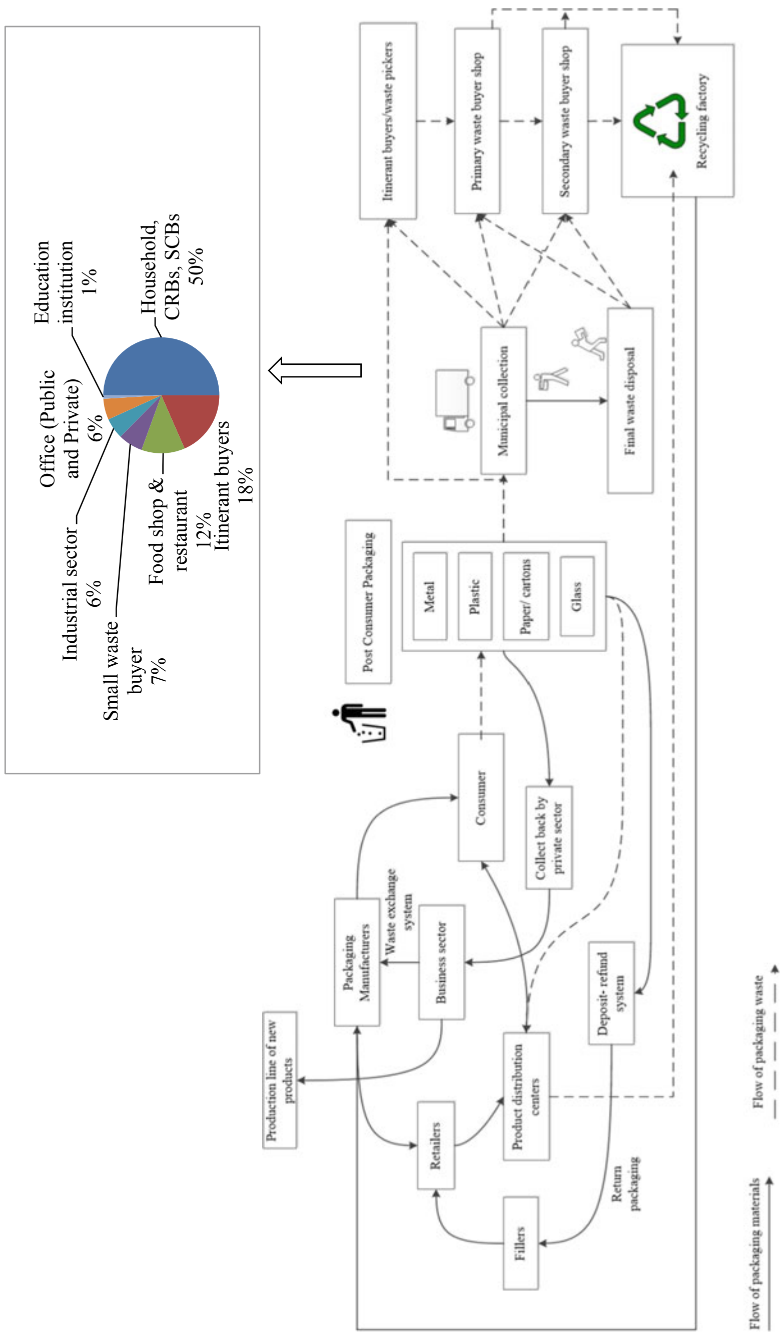


Fig. 11 Detailed flow of post-consumer packaging materials by informal and formal sectors

8 Overview of Packaging Waste Situation

Packaging waste management and disposal have generally been performed in an unsystematic manner, with no waste separation practiced at public waste drop-offs due to limited awareness and the lack of waste segregation culture and environmental knowledge. Waste collection and separation systems are insufficient to support proper waste separation schemes. Therefore, packaging waste is unsegregated and mixed with other types of waste in the MSW stream, even though much of the packaging could be recycled.

Most post-consumer packaging that can be recycled is collected and sorted for recycling by waste pickers, scavengers, and itinerant buyers (known as the informal sector). They play a major role in PCP collection for recycling systems in Thailand. The government reported that about 6567 tonnes per day of recyclable materials were traded through junk shops. Of these, 47.06% was from household, community, and school recyclable banks and municipal collection; 17.36% from itinerant buyers; 11.41% from local food shops and restaurants; 6.46% from smaller waste buyer shops; 5.45% from the industrial sector; 3.15% from the private sector and office buildings; 2.35% from government offices; 0.9% from education institutions; the rest from other sources. Collected recyclables were then transported to the following sites: Secondary waste buyer shop (40.33%), Recycling factory (22.13%), Larger waste buyer shops within the same area (20.26%) or outside the area (6.48%), Entrepreneurs (8.14%), and Others (2.66%).

Several practices and initiatives relevant to post-consumer packaging recovery and utilization are already in place, which are mainly driven by value and demand of PCP materials by retailers and business operator/production sectors:

- Deposit-refund system—glass containers for beverages.
- Outsourcing a third party company to collect back their brand-packaging product.
- Collection for recycling by large product distribution centres across the regions.

According to current packaging waste management practices, it is clear that they are mainly based on a voluntary approach, driven by the value of PCP for recycling as raw materials. There have been few policy efforts from government or city authorities in supporting and enhancing the circular flow of waste and resources. Conventional management practices with expected immediate solutions gain more popularity among city decision makers. Most waste is therefore handled in a reactive manner through open dumping. Upstream or demand-side management of packaging waste and resources was overlooked. A new paradigm for waste management supported by policy backup is required to deal with upstream issues in order to move up the waste management hierarchy and prevent waste entering downstream.

9 Indicators for CE Assessment

Based on the framework and selection of methods in the literature (ADB 2008; IGES 2013) and relevant indicators, Table 4 presents a summary of applied CE indicators that have been used for assessment. Indicators proposed were used to assess and evaluate how close Thailand is to implementing CE with regard to the performance of packaging waste management practices by all stakeholders. A list of relevant indicators (consisting of both qualitative and quantitative measures) for CE assessment in packaging waste management sectors in the context of a country with an economy in transition was adopted.

10 Analysis of Policy Instruments

It is clear that the policy approach applied in developed countries is mainly focused on the reduction of resources/materials used, which aims to reduce the generation of upstream waste (primarily by manufacturers, producers). Regulatory and economic instruments are used to enforce and provide incentives for the production sector. On the other hand, existing policy instruments used in Thailand and other developing countries are only planning instruments (particularly at national level). There have been no regulatory or economic measures to address waste issues, nor effective measures to control overconsumption that lead to increased use of resources and waste generation. Waste management initiatives taken are only top-down guidelines planned at the national level. Figure 12 presents policy instruments used in most developed countries. In contrast, in developing cities, the main focus of policy action has been on resource recycling rather than controlling the use of upstream resources (prevalent in developed countries). It is believed that recycling has clear benefits and generates income and job creation for the poor and unemployed. In this regard, developing countries tend to put greater emphasis on waste recycling as part of the solution and overlook the causes of problems emerging from consumption behaviour. The approach used for waste and resource management relies on recycling (downstream) rather than reduce and reuse. Needless to say, introduction of policy instruments to enhance resource use should be modified to fit into local circumstances. Therefore, barriers and difficulties associated with implementation of CE for packaging in developing countries must be identified to find appropriate policy instruments.

Table 4 Selected CE indicators

	Indicator
Consumption	– Waste generation rate – Packaging waste composition in MSW stream – Degree of awareness and participation in 3R waste program – High/low consumption (purchasing behaviour/waste avoidance) – Opinion and attitude towards waste and resource use – Knowledge related to 3R – Perception towards recycled packages – Characteristics of waste flow
Production	– Existence of company's tools/mechanisms to recirculate packaging material flow – Company agreement on waste reduction with collaborative partner/availability and increasing number of green business partnerships – Opinion on designing for reuse or using recycled materials – 3R activities through industrial symbiosis – Quantity of packaging materials through industrial waste exchange program – Quantity of recycled material in production process – Reduction of virgin material used in production process
Public authority/policy and management sector	– Reduction policy for certain types of packaging waste – Key waste regulation (key rules/regulations and incentives) – Type and accessibility to recycling bins/performance of collection system – Policy target on waste reduction rate – Number of NGOs and think tanks that are active in 3R – Attitude and perception of officers/decision makers – Collaboration with NGOs and think tanks that are active in 3R – Government support for closed-loop recycling, R&D on product design for reuse and recycling

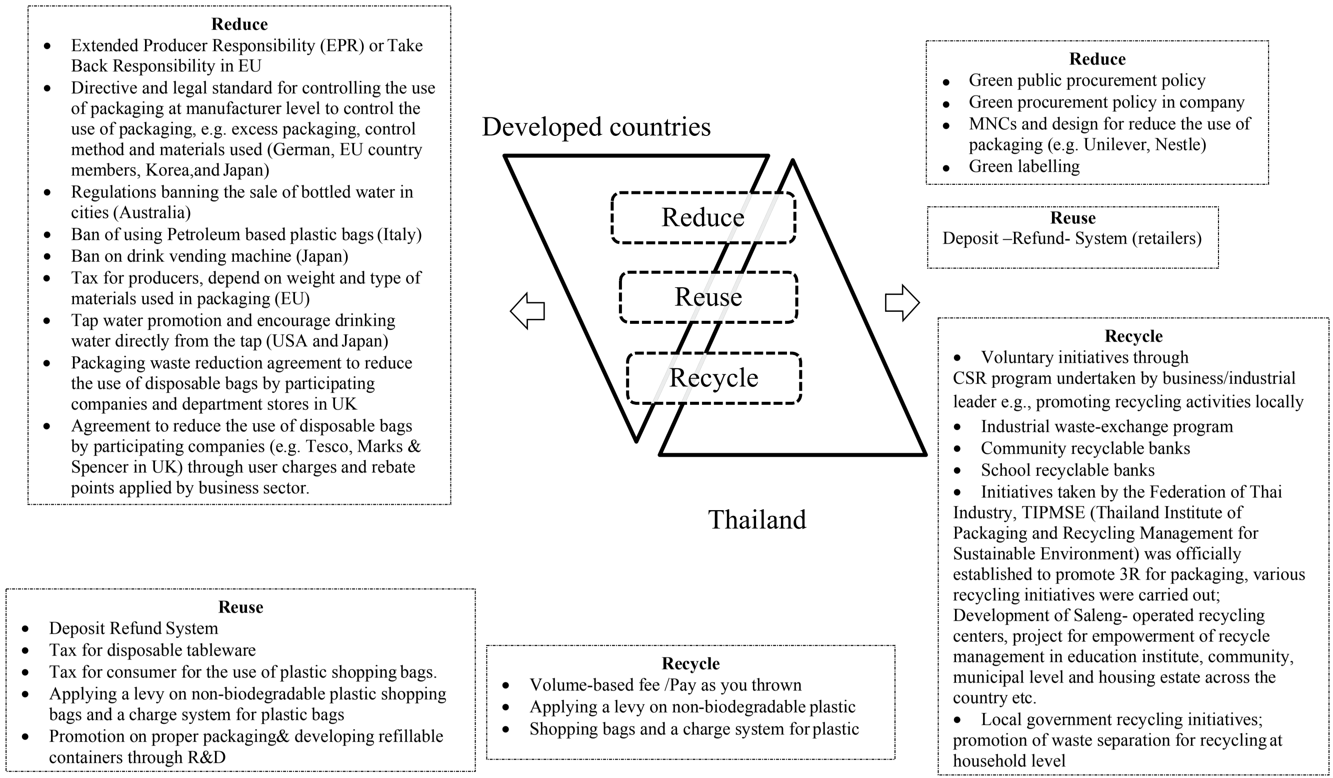


Fig. 12 Summary of policy instruments used for waste and resources management

11 Assessment of Consumer Behaviour

Nearly half of the respondents consume and buy food from shops, food kiosks or markets using one-time-use packaging (e.g. plastic bags, plastic food trays, and plastic Styrofoam) that mostly end up in final landfill. Only 6% used reusable materials or bring their own tableware. A total of 93% of respondents take plastic bags from a shop even if they buy less. Institutional respondents appeared to have less concern about 3R practices and waste issues than the municipal group who interacted more with local government waste management practices and had more waste management choices, e.g. by generating a reasonable income through selling PCP waste at competitive prices to different tiers of junk shop, CRBs, etc. The latter group strongly believed in the positive role of recycling and waste separation practices for better waste management.

11.1 Environmental Consciousness

Most respondents reuse plastic bags from shops mainly for carrying other goods or for use as garbage bags (42.9%), whereas 39.7% answered that they sometimes reuse, and a minority of around 8.4–9% said they rarely or never reused plastic bags. 37.4% of respondents never implemented any waste reduction effort, respectively, whereas 31.8% sometimes took personal containers to a shop, respectively. About 65% (at institutional level) and 38% (at municipal level) stated that they never attempt to reduce waste by taking their own container to buy food or beverages. Economic incentives would be an important factor for encouraging waste reduction at institutional level, whereas municipal respondents stated that disposable packaging was most convenient and that they did not have choices to avoid packaging waste that was convenient.

11.2 Knowledge on Waste Management Hierarchy

The first priority in the waste hierarchy is accorded to “reduction of waste” followed by “reuse” and “recycling”. Findings indicated that consumers were in a dilemma in prioritizing the 3R’s based on the waste hierarchy due to the lack of understanding about its importance.

11.3 Waste Disposal Behaviour

There are four alternatives to dispose of recyclable packaging waste: (a) to discard and mix with general waste; (b) self-segregate recyclable waste at source and offer to house cleaners or informal sector; (c) segregate and sell waste to earn money; (d) take segregated materials to waste separation facilities. At the institutional level, the latter was available, whereas at the municipal level these disposal options were available only in public areas such as large shopping centres, some commercial establishments or in other municipal areas. Discarding unseparated waste into a single bin was the primary and common disposal method. Meanwhile, methods of waste disposal are different at municipal and institutional levels. People opined that "inadequate waste separation facilities" was the main hindrance to their practice of waste separation. It is suggested enforcement of policy should come after creating an environment for practicing 3R. People were demotivated to practice 3R because they did not trust in an operational and waste collection system that dumps all types of waste and mixed them together downstream. People opined that the specific type of waste sorting will reduce confusion about what is "wet" and "dry" waste.

Box 4: Features of Packaging Material Flow: A Case at the Institutional Level

Waste generation at the AIT campus is around 427 tonnes per year. Most waste generated is disposed of at general waste bins and then collected by waste collectors and deposited at the transfer station on campus, before being taken by Tha-Khlong Municipal truck to final disposal. Recyclables and saleable materials are mainly segregated by households and waste collectors who sell their own segregated materials through Cash for Trash program activities and other waste dealer shops. Also, some recyclables were separated at waste separation facilities provided in the institution under waste separation initiatives on campus.

It was estimated that a total of 158.8 tonnes per year of packaging waste was produced on campus. An estimated total of 19.9 tonnes per year is recycled through campus waste collectors, accounting for 12.5% of total packaging waste. About 1.52 tonnes per year (1%) were processed through the Cash for Trash program and 1.28 tonnes per year (0.8%) through the Packaging Waste Separation project. The Cash for Trash program and Packaging Waste Separation project are campus initiatives that aim to reduce the amount of waste. It is clear that waste separation facilities have an impact by increasing the recycling rate, to almost 2%, which created jobs and generated extra income for waste collectors. The collected packaging that can be recycled amounted to 14.3% of total packaging waste, but the majority of packaging material was processed through the linear approach (take–make–use–dispose); about 85.7% of packaging that becomes waste was sent to final landfill.

An explanation for the low recycling rate of packaging material was the increase in one-time-use packaging that has emerged from current unsustainable production and consumption patterns reflecting changes in purchasing and consumption lifestyle. Considering the percentage by wet weight of packaging that can be recycled and packaging that cannot be recycled, about 34% was recyclable while 66% was non-recyclable. The conventional approaches to waste management, as well as voluntary measures, have limited effectiveness in enhancing CE flow. The informal sector is a significant player in waste collection for recycling and substantially enhances the recycling rate. However, the majority of waste is handled in a straight line, not in a circular model of material flow. Based on these results, communication and active participation from consumers in 3R practice are prerequisites.

12 Analyses of Barriers in Relation to CE Practice

12.1 Consumer Perspectives

The most significant factor was relevant to consumer behaviour and their awareness, particularly the lack of recycling culture in the locality, and a non-environmental attitude prevailing. People were discouraged to segregate waste mainly because "*it is time consuming*". Convenience and fast service using readily 'throw away' packaging are the first requirements that correspond with current consumer lifestyle. Meanwhile, "waste reduction and separation, environmental cleanliness, and issues relevant to reducing environmental burdens are not perceived as being a high priority in present-day lifestyles". Cluster of barriers from consumer perspective is depicted in Fig. 13.

Management barriers raised by respondents included limited access and distance to waste separation bins and lack of sufficient processing and separation facilities. A key suggestion raised by respondents included encouraging source separation by demonstrating systematic food waste and recyclable waste collection on a specific day in the week; this could ensure the impact of separation practices along with proper policy implementation. Management and technical issues were raised as the most significant barrier (43.4%), followed by information and knowledge (34.7%), while awareness (17.3%) appeared to less important compared to the municipal group.

Awareness and consumer behavioural barriers act as the most significant factors at the municipal level. However, management was the common barrier cited by respondents from both groups, including a lack of proper waste separation facilities and appropriate distance to recycling bins. Furthermore, capacity and inadequate processes of local government to perform proper waste collection were also concerning factors. Information and communication about the classification of waste, and lack

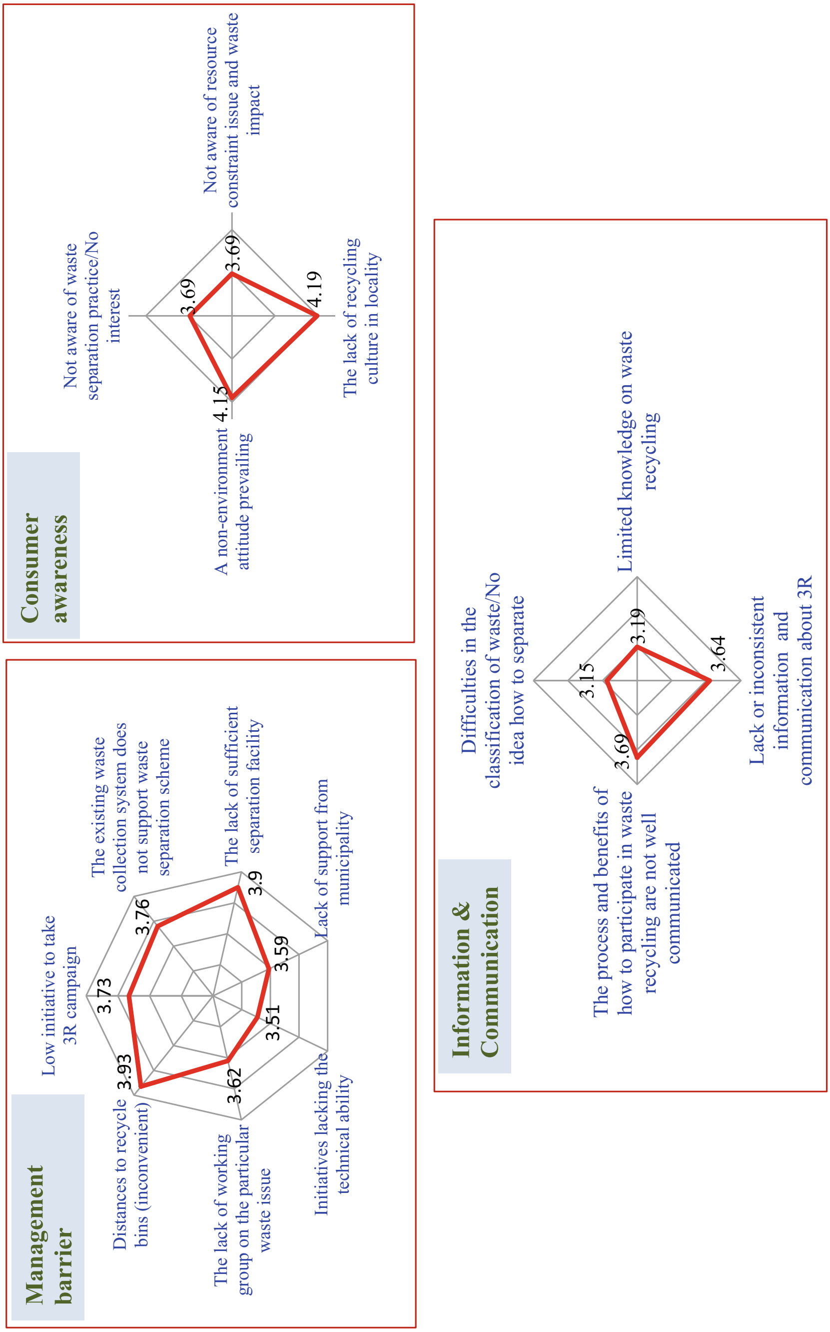


Fig. 13 Cluster of barriers in relation to CE: consumer

of or inconsistent information about waste reduction, reuse, and recycling were cited as other important factors at the institutional level.

12.2 Producer Perspectives

Management barriers, consumer awareness, and behaviour, as well as difficulty in communicating with consumers, were cited as major challenges. Management barriers refer to responsible management practices and processes by government authorities to facilitate the flow of packaging materials, particularly when PCP reaches the downstream level. Barriers to the CE transformation of the packaging sector are connected to the lack of proper waste separation infrastructure, and inadequate processes to cover the entire system of waste management. Recyclables contaminated with food waste or prohibited substances from other waste types are not accepted for remanufacturing or recycling in an upcycling flow, and this significantly reduces resource recovery in the system. The lack of a waste reverse logistics system was another factor stemming from management issues. This barrier was associated with limited infrastructure to support efficient collection after use and an efficient system to return post-consumer packages. Furthermore, when the reverse logistics of waste in the country is still underdeveloped, recycling or investing in recycling activities will increase the cost of production. Encountered barriers from producer perspective are presented in Fig. 14.

Consumer awareness and behaviour were raised as other critical issues. Manufacturers that initiated packaging reduction by minimizing volume and weight, as well as carrying out product concentration to minimized packages, have learned that

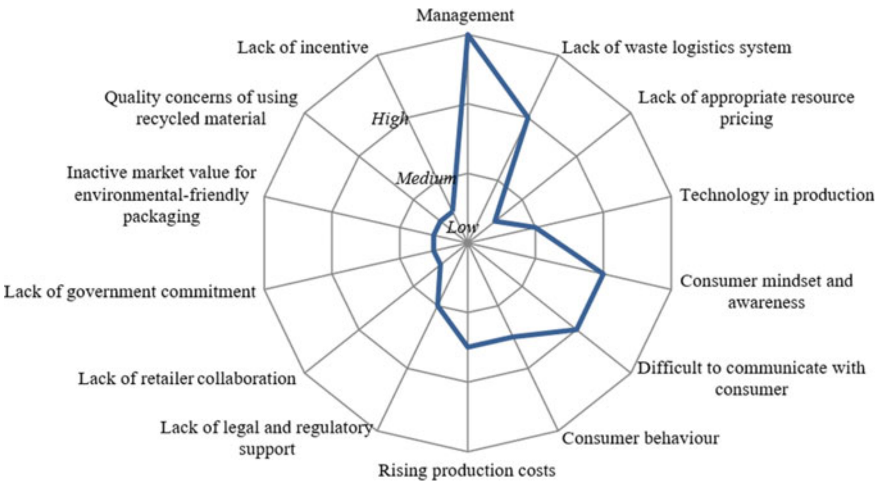


Fig. 14 Encountered barriers in CE: producer perspectives

consumers do not yet favour green/eco-friendly packaging, which has demotivated their efforts to expand green production. One example is of a company that considered the use of bioplastics instead of petroleum-based disposables, where use of the former was generally not accepted by clients and production chains mainly because of product perception and associated cost. Environmental criteria are not part of purchasing decisions compared to consumers in developed economies. Moreover, the lack of waste separation negatively affects the quality and quantity of post-consumer packaging and its utility for recycling. This creates significant loss of raw materials for remanufacturing in closed-loop recycling.

12.3 Decision Maker Perspectives

The lack of legal and regulatory support for CE practices and implementation, and weakness of policy coherence to improve cross-cycle management, and lack of cross-sector integration of waste and resources were cited as critical barriers. Due to the lack of decision-making information and environmental criteria, decision makers of local government authorities adopt conventional approaches rather than innovative, long-term, and sustainable solutions. It is recommended that decision-making criteria are established for local government budget allocations for waste and resource management, especially for local implementing bodies who decide on the most preferable sustainable plan and policy option, e.g. the following CE practices and the waste hierarchy. This should promote a paradigm shift away from the business-as-usual conventional approach. Encountered barriers from decision maker perspective are presented in Fig. 15.

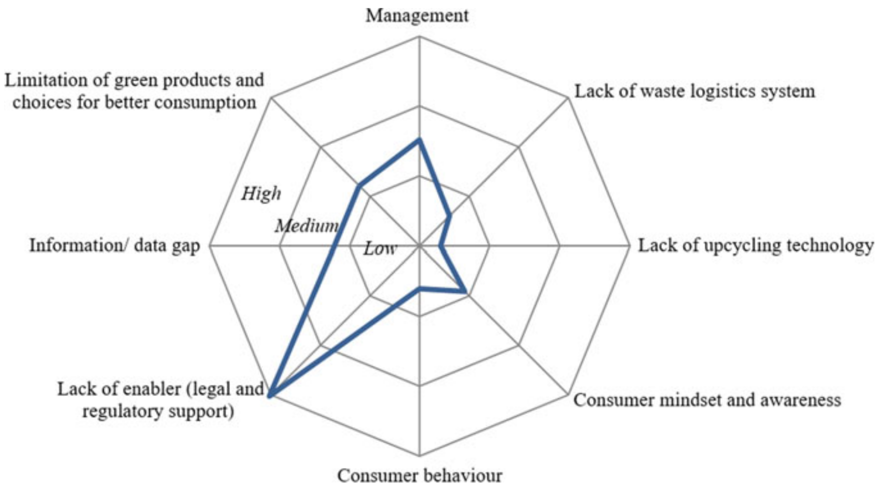


Fig. 15 Encountered barriers in CE: decision maker perspectives

Secondly, inadequate waste and resource management processes and lack of management capacity were clustered into the management barrier. These include unsystematic waste collection and final disposal practices at local level, and lack of facilities and infrastructure and knowhow for making use of PCP in material cycle loops. In addition, the lack of management capacity of city authorities is another important factor limiting the effective implementation of CE.

Lastly, information and data gaps were pointed out as an important factor. Barriers mentioned in this category include lack of systematic baselines and environmental reporting, as well as research studies to support decision-making. Currently, information and reliable data are missing or incomplete. Environmental reporting should be carried out and information should be pertinent, addressing trends and critical analyses for policy makers with monitoring reports of previous relevant waste programs. Good communication and information sharing is useful for planning and designing of CE initiatives, including to form CE-relevant policy, planning, and programs.

13 Recurring Common Factors

13.1 Management Barriers

Based on stakeholder perceptions, management is the most common and significant hurdle to CE implementation which obstructs sustainable resource and recycling flow. Inadequate waste management infrastructure, waste separation facilities, and waste collection systems disrupt waste separation practice. Overcoming management barriers will therefore reduce negative impacts and improve recycling and recovery rates. From the perspective of manufacturers, the government sector has failed to facilitate waste flow in a circular model due to a lack of management capacity to foster appropriate policy implementation and also implementation gaps at operational level. The lack of incentive measures to engage people to practice 3R was another issue most frequently cited, and clustered into the management barrier by producers. However, management barriers gravitated more towards the lack of a holistic process in addressing waste and resource issues: these included fragmented decision-making and planning; low initiative to practice 3R; incoherent practices between waste collection and final waste treatment methods; and the lack of management capacity to manage collected waste which relied on construction (business-as-usual approach in transporting waste from source to landfill).

13.2 Information and Communication

The significant barrier for implementing CE initiatives and progress towards circular economy policy development was the lack of mutual understanding, in specific the following:

- Lack of environmental reporting among decision makers.
- Lack of action research studies about the use of recycled PCP.
- Poor environmental information and weak communication.
- Poor consumer awareness and behaviour.
- Lack of waste logistics systems.

13.3 Emerging Factors

Emerging factors hindering CE implementation in Thailand includes socioeconomic development that affect the evolution of policy, implementation of CE from institutional level to broader scale (city/national level), product design and recycling; discrepancies in international regulations; and difficulties in making the business case for adopting CE under the current economic situation. Barriers associated with the early stages of 3R policy implementation, include management of basic infrastructure, downstream management processes, and consumer behaviour. In addition to barriers mentioned by stakeholders, the author of this paper observed the following emerging barriers from this study. Firstly, lack of CE indicators, including both policy and performance management indicators regarding waste and resource sectors. It is recommended that environmental reporting based on proposed indicators can help make informed decision-making processes. Secondly, lack of political will among organization leaders in each sector, where CE practices were often seen as low priority and leaders lack the long term and holistic perspective of addressing waste and resource challenges; this acted as one factor that influenced operational practices at lower tiers. In most cases, the current solution is characterized by a lack of short- and long-term vision and upstream management. Lastly, there is no integration of the informal sector into formal PCP waste collection, e.g. resource recovery or lack of think tanks with responsibility for waste and resource logistics according to CE flow.

14 Overcoming Barriers for Sustainable Waste and Resource Management

Overcoming such barriers requires a mix of policy instruments that support CE flow and enhance ongoing activities and practices. Table 5 presents a series of policy recommendations for better CE practices at both the supply side (manufacturer, retailer) and demand side (consumer). Based on research findings, a policy framework for

Table 5 Recommended policy measures to address barriers

Policy intervention/CE domain	Economic/fiscal instruments	Legal and regulatory instruments	Social-psychological instruments
Consumer	Consumer behaviour and awareness as a barriers • Change from flat rate waste of PCP waste collection fee to variable rate • Introduce price for using unnecessary packaging, e.g. charge for unnecessary plastic bag/containers) • Encourage retailers and the commercial sector to provide incentives through fiscal instruments targeted at their customers, and then to apply a charge on disposable packaging to retailers who provide plastic bags to their customers as a long-term measure		Management barriers • Provision of proper waste separation facilities • Improve access to waste separation facilities Lack of waste logistics barrier • Set up resource management hubs and responsible bodies in each region, incorporating informal sector collection for improving reverse logistics to recapture value of PCP waste
Government	Management barrier • Provide extra budget or prize for LGAs who initiate innovative CE practice in collaboration with stakeholders (fiscal incentive)	Management barriers • Issue common standard of waste separation practice for stakeholders • Set up national and local targets for PCP waste reduction, waste, and waste to landfill • Establish technical standards for effective waste collection and disposal by LGAs • Revise or amend existing law and regulations to increase stakeholder participation in recycling and enhance the circular flow of PCP	Information and communication barriers • Develop and use CE indicators as basis for monitoring the existing situation of waste and material flow • Set up requirements and guide local implementing bodies to develop environmental reporting • Initiate and support R&D in upcycling technology/innovative packaging • Organize national and local waste and resource management workshops Consumer behaviour and awareness, and information and communication barriers • Carry out proactive packaging waste reduction campaigns and awareness-raising activities • Provide environmental education for schools, colleges and higher education institutions • Make agreements between government and local retailers, commercial sector, and department stores in reducing packaging waste

(continued)

Table 5 (continued)

Policy intervention/CE domain	Economic/fiscal instruments	Legal and regulatory instruments	Social-psychological instruments
Producers and retailers	Management barrier • Establish a fee proportional to weight and volume of packaging	Management barrier • Regulate specific standard to control excessive packaging • Set up a mandatory rate for closed-loop recycling, upcycling, and downcycling by PCP type	Consumer behaviour and awareness, and management barriers • Establish packaging waste reduction agreement between government entities, and/or academic institutions, universities • Promotion in the use of reusable food and beverage containers

sustainable waste and resource management is proposed in Fig. 16. This framework recommends a series of mixed policy instruments including regulatory measures, incentives and financial instruments, information and communication measures, and policy intervention at both national and local levels.

15 Conclusion

Circular economy has gained much attention in the current development agenda in many countries. At global and regional levels, it is regarded as a new paradigm towards sustainable development. The current CE practices and policy instruments used towards sustainable resource management in Thailand are also presented. CE indicators for Thailand are extensively studied and summarized in the paper. Based on the review, it is established that the existing policies and programs on CE are focused more towards 3R concepts over the other sub-sects of CE such as products-as-services, next life sales, product transformation, and collaborative consumption. Likewise, CE indicators are arrived primarily based on 3R concepts at present. Therefore, it is recommended that the other sub-sects of CE should also be taken into consideration for arriving at the CE indicators.

Current CE practice is assessed and packaging material flow are examined in order to establish potential opportunities for enhancing CE practice for sustainable resource and waste management. Based on each of stakeholder groups, the result shows that consumers show positive attitudes towards roles of CE practices for better management of resource waste, however, the degree of awareness and knowledge does not have positive impacts on consumer behaviour unless regulatory and economic measures are applied. Producers have started initiatives as part of CE practices that are carried out on a voluntary basis. The roles of the government sector in encouraging purchasing of green products and greener production are also weak. Although there are waste reduction initiatives at the country level, they do not include participation

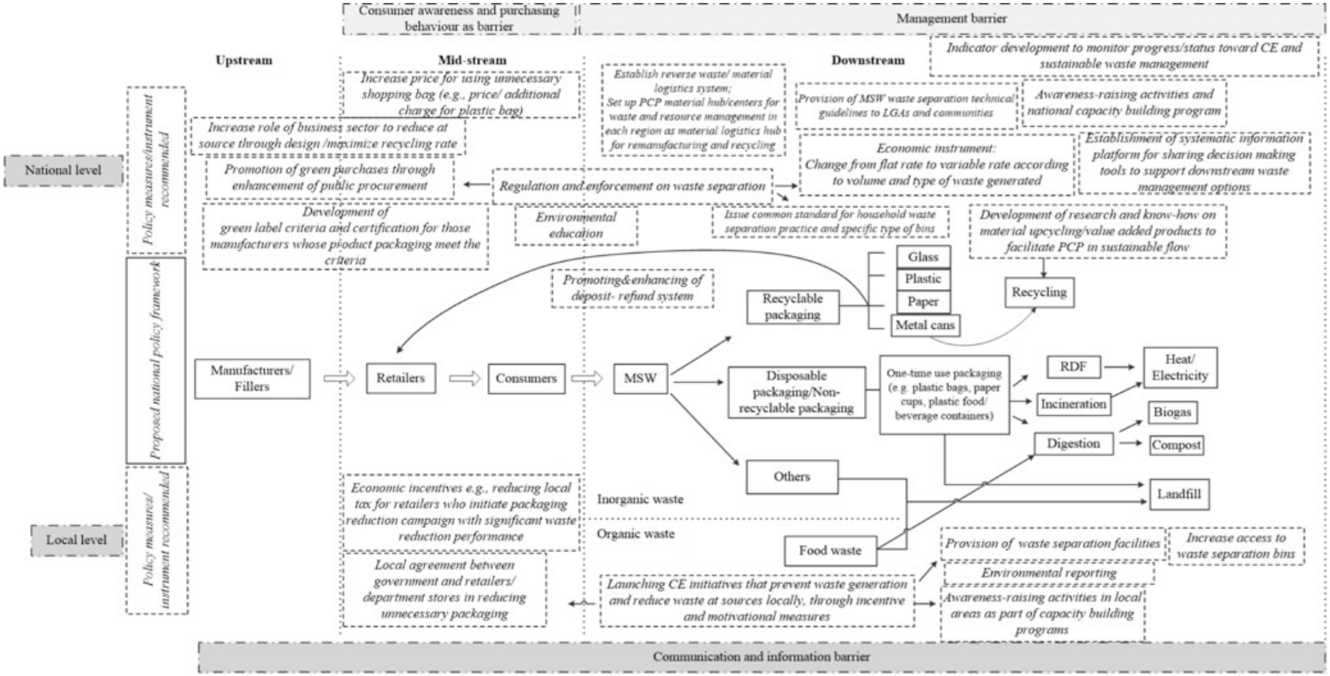


Fig. 16 Proposed policy framework and instruments—holistic waste management based on an expanded waste management hierarchy

of local and household levels; only government entities were engaged in these waste reduction initiatives.

The results of PCP material flow analysis indicate that recycling is the most active cycle and there are great opportunities to ascent the waste management hierarchy to move towards better CE resource flow. To overcome the challenges and barriers, environmental education is needed to prompt consumers to adopt new consumption patterns that favour CE. Economic and regulatory instruments are required for better CE implementation in resource management sector.

References

ADB. (2008). *Toward resource-efficient economies in Asia and the Pacific*. Japan: Asian Development Bank.

Amrehn, J. (2013). *Technologies and management of municipal solid waste in Thailand: Status quo and current developments*. Retrieved at https://www.unescap.org/sites/default/files/Day%202.9_King%20.

Bunyagidj. (2009). *The success story of Thai green public procurement project and opportunity of socially responsible investment in Thailand*. Retrieved at https://www.slideshare.net/guest3b0c1d17/cb-apo-2009.

Country Report. (2017). Country 3R progress report (draft). *Eighth Regional 3R Forum in Asia and the Pacific "achieving clean water, clean land and clean air through 3R and resource efficiency—A 21st century vision for Asia-pacific communities, Indore, Madhya Pradesh, India*, 9–12 April 2018.

Environnet. (2018). *Carbon labelling*. Retrieved at http://www.environnet.in.th/en/archives/1503.

IGES. (2013). *The 3Rs and sustainable resource circulation – progress in Asia and research activities in IGES*. http://www.uncrd.or.jp/content/documents/Hanoi%203R%20ForumPS4_IGES.pdf.

Kamuang, T. & Siriratpiriya, O. (2017). *The Kingdom of Thailand. Country Chapter; State of the 3Rs in Asia and the Pacific*.

National Statistic Office. (2018). *Environment and energy*. Retrieved at http://web.nso.go.th/.

PCD. (2005). *Municipal solid waste character observation and analysis in all municipalities project*, Bangkok, Thailand. Retrieved at http://infofile.pcd.go.th/waste/Reportwaste.pdf?CFID=8235539&CFTOKEN=60317797.

PCD. (2018a). *The Pollution Control Department's roll on pollution management*. Retrieved at http://wepa-db.net/3rd/en/meeting/20161130/PDF/14%20Thailand_Country%20updates_WEPA-present%20Hanoi-Thailand-Revised.pdf.

PCD. (2018b). *3Rs initiatives in Thailand*. Pollution Control Department. Ministry of Natural Resources and Environment. Retrieved at https://www.env.go.jp/recycle/3r/en/s_officials/02_02/14.pdf.

PCD. (2018c). Pollution control department. Ministry of natural resources and environment. Retrieved at http://www.pcd.go.th.

Piyapanpong, S. (2018). *Thailand's 3Rs strategy*. Pollution Control Department Pollution Control Department Ministry of Natural Resources and Environment. Retrieved at http://www.uncrd.or.jp/content/documents/Session4_Piyapanpong.pdf.

Pollution Report. (2015). *Thailand state of pollution report*. Pollution Control Department Ministry of Natural Resources and Environment. ISBN. 978-616-316-327-1.

SCG. (2008). *SCG paper goes green for sustainability and profitability*. Retrieved at https://www.scg.com/en/08news_release/01_news/detail.php?ContentId = 1925.

SCG. (2018). *SCG eco value; sustainable development*. Retrieved at https://www.scg.com/en/05sustainability_development/eco-value.html.

Supappunt, P. (2011). *Carbon footprint label in Thailand*. Retrieved at http://www.neaspec.org/sites/default/files/Carbon%20Footprint%20Label%20in%20Thailand_Phakamon.pdf.

TEI. (2018). *Criteria for carbon reduction label certification*. Retrieved at http://www.tei.or.th/carbonreductionlabel/rule-e.html.

Tippamongkol, J. (2014). *Green public procurement in Thailand*. Regional workshop on sustainable public procurement and harmonization of eco-labelling. Retrieved at http://www.thai-german-cooperation.info/userfiles/20140521_02_SPP_thailand.pdf.

Toshiba. (2018). *Environment*. Retrieved at https://www.toshiba.co.jp/env/en/.

UNEP. (2018). *A review of green public procurement practices in Thailand. Strengthening the capacities and improving the knowledge on green public procurement and ecolabelling in the ASEAN + 3 region*. Retrieved at http://www.oneplanetnetwork.org/sites/default/files/review_of_green_public_procurement_practices_in_thailand.pdf.

UNPAN. (2004). *Co environmental indicators of Thailand*. Retrieved at http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan015287.pdf.

Wangwongwatana, S. (2018). *3Rs and waste management in Thailand*. Retrieved at http://www.uncrd.or.jp/content/documents/RT1_04_Thailand_rev.pdf.

WMS. (2018). *Corporate social responsibility*. Retrieved at http://wms-thailand.com/index.php/en/csr.

Developing the Circular Economy in the European Union

Andrew Farmer

Abstract The European Union has adopted legislation and other supporting policies across a range of areas to facilitate the development of a Circular Economy. Building on earlier initiatives on waste management and resource efficiency, the policies coalesced in the 2015 Circular Economy Action Plan. This sets out a series of actions covering several issues, with a particular focus on resource efficiency, improved waste management and support for innovation. EU waste law has been revised promoting increased recycling, and most recently to tackling the growing problem of single-use plastics. However, while there are actions to support waste prevention, there are not legal targets on this issue. There are still challenges for joined-up action to deliver a Circular Economy. This includes addressing the nature of consumption by citizens, as well as technical issues such as how secondary materials meet objectives in chemicals and product legislation. A further challenge is the wide diversity of waste and materials management across the EU, such as very different recycling rates between countries. Delivering a Circular Economy means leaders needing to push with innovation and laggards needing help to achieve basic waste and material objectives.

Keywords Circular Economy · European Union · Resource efficiency · Plastics · Extended producer responsibility · Recycling · Waste

1 Introduction

Many of the chapters in this book explore the Circular Economy from a national perspective. This chapter, by contrast, explores the Circular Economy for a regional grouping of countries—the European Union (EU). The EU has some characteristics found in nation states in other parts of the world, but other characteristics that are unique.

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From the perspective of non-EU countries, examining progress towards a Circular Economy by the EU is important and interesting for different reasons. These include:

- Several actions to promote a Circular Economy concern issues such as product quality and, through this, there are consequences for international trade. The EU is a single internal market for trade and trade policy with non-EU countries is the competence of the EU, rather than its Member States. The size of the EU economy means that decisions affecting what is allowed within its internal market have consequences for manufacturers of products in non-EU countries wishing to export to the EU market.
- The EU is the source of much law (and other policies, including financing) directly and indirectly related to the Circular Economy. In many areas, this is more important that laws and policies at the national level in the EU. Lessons learned from the success (or otherwise) of EU law and supporting policies are useful in other contexts.
- There are also many issues in delivering the Circular Economy which are best decided and implemented at national or local level. Understanding how such division of roles from EU to national to local have been determined in the EU may have useful lessons for other countries.

The EU economic model has been and, largely, still is, a linear one—a take—make–consume–dispose economic model—rather than a circular model where the utility of products, components and materials retains their value (EMF 2015a). The linear economic model of material use in the EU is not sustainable, and for many materials, the consumption in the EU far exceeds planetary boundaries (Steffen et al. 2015). In contrast, a Circular Economy “provides opportunities to create well-being, growth and jobs, while reducing environmental pressures” (EEA 2016a). EEA (2016a) described the key characteristics and enabling factors of a Circular Economy, summarised in Tables 1 and 2. It will be seen that different EU policies variously attempt to contribute to delivering one or more key characteristics and/or provide one or more of the enabling factors.

In 2001, the European Commission estimated that between 6 and 12% of all material consumption was avoided due to waste prevention, eco-design and recycling policies and activities, and it estimated that existing technology could increase this to 10–17% (EC 2011b). For many industries, a Circular Economy would save significant costs, e.g. 12–23% of current material input costs for those manufacturing complex durable goods (EMF 2012), as well as significant savings for food, beverages, textiles and packaging businesses. One study estimated cost savings of various Circular Economy policies to businesses in the EU of €245–604 billion per year (AMEC Environment and Infrastructure and Bio Intelligence Service 2014). Changing waste management practices could create 178,000 new direct jobs by 2030 (EC 2015). Another study (James et al. 2016) estimated that adoption of resource efficiency practices by business in the EU could create 1.2-3 million jobs, generate €114–324 billion in gross value added and reduce non-fossil fuel raw material demand by 70–184 Mt. There is, therefore, potential to deliver an economy which is

Table 1 Key characteristics of a Circular Economy (derived from EEA 2016a)

Key characteristic	Examples
Less input and use of natural resources	• Minimised and optimised exploitation of raw materials, while delivering more value from fewer materials • Reduced import dependence on natural resources • Efficient use of all natural resources • Minimised overall energy and water use
Increased share of renewable and recyclable resources and energy	• Non-renewable resources replaced with renewable ones within sustainable levels of supply • Increased share of recyclable and recycled materials that can replace the use of virgin materials • Closure of material loops • Sustainably sourced raw materials
Reduced emissions	• Reduced emissions throughout the full material cycle through the use of less raw material and sustainable sourcing • Less pollution through clean material cycles • Fewer material losses/residuals • Build up of waste minimised • Incineration and landfill limited to a minimum • Dissipative losses of valuable resources minimised
Keeping the value of products, components and materials in the economy	• Extended product lifetime keeping the value of products in use • Reuse of components • Value of materials preserved in the economy through high-quality recycling

more circular, and this would have significant economic, social and environmental benefits.

Before exploring EU policy on the Circular Economy, it is necessary to consider the constitution and legal structure of the EU. For non-EU observers, the legal and practical workings of the EU may seem confusing. Under the EU Treaty, competence for different issues is vested at EU or Member State level or both. For example, trade policy is the competence of the EU level, but most health policy is determined at Member State level. All EU legislation is proposed by the European Commission, but is amended and adopted by representatives of the Member States (by ministers in the Council and by elected Members of the European Parliament). With regard to legislation affecting the Circular Economy, two types of law are particularly important to highlight:

- Directives: these are the most common and set binding obligations on Member States. They may set a target to be achieved (e.g. recycling) or a process to be

Table 2 Enabling factors of a Circular Economy (derived from EEA 2016a)

Enabling factors	Examples
Eco-design	• Products designed for a longer life, enabling upgrading, reuse, refurbishment and remanufacture • Product design based on the sustainable and minimal use of resources and enabling high-quality recycling of materials at the end of a product's life • Substitution of hazardous substances in products and processes, enabling cleaner material cycles
Repair, refurbishment and remanufacture	• Repair, refurbishment and remanufacture given priority, enabling reuse of products and components
Recycling	• High-quality recycling of as much waste as possible, avoiding downcycling • Use of recycled materials as secondary raw materials • Well-functioning markets for secondary raw materials • Avoidance of mixing and contaminating materials • Cascading use of materials where high-quality recycling is not possible
Economic incentives and finance	• Shifting taxes from labour to natural resources and pollution • Phasing out environmentally harmful subsidies • Internalisation of environmental costs • Deposit systems • Extended producer responsibility • Finance mechanisms supporting Circular Economy approaches
Business models	• Focus on offering product–service systems rather than product ownership • Collaborative consumption • Collaboration and transparency along the value chain • Industrial symbiosis
Eco-innovation	• Technological innovation • Social innovation • Organisational innovation
Governance, skills and knowledge	• Awareness raising about changing lifestyles and priorities in consumption patterns • Participation, stakeholder interaction and exchange of experience • Education • Data, monitoring and indicators

undertaken (e.g. to prepare waste management plans). However, directives must be "transposed" into Member State law before they become effective. This means that they may be adapted to Member State circumstances (e.g. taking account of administrative structures).
- Regulations: these are "directly applicable" on the entities to which they apply—they do not require transposition into Member State legislation. An important example relevant to the Circular Economy is most EU chemicals legislation—important regarding the placing of secondary raw materials on the market that may contain some contaminants.

In all cases, EU law needs to be applied to be effective. This can be a significant challenge in some cases. Member States can be slow to meet legal obligations in directives—such as meeting waste management targets, so hampering delivering of the building blocks of a Circular Economy. Measures put in place can also trigger non-implementation behaviours, also seen with waste law—from ad hoc illegal waste dumping to organised crime on waste and on secondary raw materials.

This chapter focuses on EU policies aiming to deliver a Circular Economy. It is not possible in the space available to explore the challenges of implementing each and every policy at Member State level. However, it is important to keep in mind that adoption of an obligation in EU law does not mean that an objective has been achieved—it is only the first step in a process and that many policies (and many steps) are being taken to move the EU towards a more Circular Economy.

This chapter begins by exploring the early development of policies relating to resource efficiency. It then proceeds to explore the current policies on the Circular Economy which have evolved from these earlier policies. It continues by exploring the particular issue of plastics as a case where the action is being taken, but where the challenge is enormous. The chapter concludes with some final remarks on the future challenge in delivering the Circular Economy.

2 Developing CE Policy

Circular Economy policy in the EU today is the result of an evolution of policies relating to waste management, product policy and resource efficiency developed over many years. This section explores these policies, as understanding these is necessary to understand how current Circular Economy policy is structured. This section will focus on the evolution of strategic policy thinking on resource efficiency as the basis for later Circular Economy Policy. However, alongside these strategic developments, it is very important to highlight actions on specific policies which each contribute to delivering resource efficiency and are important elements within later Circular Economy policy. These include:

- EU waste management policies that establish targets for recycling, limitations on landfill, requirements to plan waste management, etc., and these include:

  - The Waste Framework Directive.
  - The Landfill Directive.
  - The Waste Shipment Regulation.

- Making products more resource-efficient, such as promoting recycling and reducing hazardous substances through better design, producer responsibility in the EU internal market:
  - End-of-Life Vehicles Directive.
  - Packaging and Packaging Waste Directive.
  - Batteries and Waste Batteries Directive.
  - Waste Electrical and Electronic Equipment (WEEE) Directive.
  - Directive on the Restriction of Hazardous Substances (ROHS).
  - Energy Using Products Directive.
- Actions on improving the awareness of consumers to make better purchasing choices regarding resource efficiency.
  - Regulation on an EU Eco-labelling of specific products.
  - Directive on the labelling of household appliances for energy and other resource use.
- Supporting eco-innovation to deliver a resource-efficient economy:
  - Environmental Technology Action Plan (ETAP)—technology platforms to foster eco-innovation through funding and the sharing of ideas.
  - Greening Public Procurement (GPP) Initiative—public procurement can be a major driver to support resource-efficient products and practices.
  - Research, Development and Funding through the range of EU financing mechanisms from Regional Funds to research funding.

EU environmental policy is framed around Environment Action Programmes, which usually set the guiding principles for policy development for the forthcoming ten years. Under the Sixth Environment Action Programme (covering the period 2002–2012), the European Commission was to develop "Thematic Strategies" (i.e. strategic policies) for waste and also for natural resources. To support this development, initial ideas were set out in 2003 Communication "Towards a Thematic Strategy on the Sustainable Use of Natural Resources" (EC 2003). In 2005, the European Commission then published the Thematic Strategy on Sustainable Use of Natural Resources alongside the Thematic Strategy on Waste Prevention and Recycling (EC 2005). This was the first initiative at EU level taking an overall approach to tackling the environmental aspects of resource use.

The objective of the Natural Resources Thematic Strategy was to "reduce the negative environmental impacts generated by the use of natural resources in a growing economy", aiming to reduce "the environmental impact of resource use while at the same time improving resource productivity overall across the EU economy" and "More value—Less impact—Better alternatives". This Thematic Strategy emphasised a whole life cycle approach. However, while it set out these broad conceptual objectives, it did not set out specific detailed objectives. It stated that the aim was to stay “below the threshold of overexploitation” for renewable resources, but did not define objectives for non-renewable resources. In particular, it focused on resource use causing fewer impacts, rather than determining fully sustainable consumption patterns and taking actions to achieve these. In particular, the early discussion had suggested that the Thematic Strategy should include quantitative targets “for resource efficiency and the diminished use of resources”, but these were not included as it was argued that the state of knowledge at the time was not sufficient.

The next major EU policy initiative relevant to resource efficiency was the 2008 Raw Materials Initiative (EC 2008). The aim of the initiative was to develop strategic thinking on the EU’s dependence on critical raw materials. It was established around three areas:

- fair access to non-energy raw materials from international markets;
- fostering sustainable supply of raw materials from EU sources; and
- boosting resource efficiency through increased recycling and lower resource consumption.

To achieve these objectives, the following steps were identified:

- defining critical raw materials;
- launching EU strategic raw materials diplomacy with major industrialised and resource-rich countries;
- addressing access to, and sustainable management of, raw materials in trade agreements;
- promoting sustainable access to raw materials in the field of development policy through budget support and cooperation strategies;
- improving the regulatory framework related to access to land;
- increasing the EU knowledge base by encouraging better networking between national geological surveys; and
- promoting innovative exploration and extraction technologies, recycling, materials substitution and resource efficiency.

To take forward the objectives and actions of the 2008 Raw Materials Initiative, the European Commission published a 2011 Communication on “tackling the challenges in commodity markets and on raw materials” (EC 2011e). This progressed policy in raw materials to some extent, increasing the emphasis on the recycling of materials (a step towards a Circular Economy—although the term is not used). It also recognised that one of the problems in delivering resource efficiency in the EU was lack of proper implementation of waste legislation which is the foundation of the better management of materials. The 2011 Communication also explored wider policy issues in more detail, such as the role of EU trade policy and development policy.

In 2011, the European Commission also published “A resource-efficient Europe—Flagship Initiative of the Europe 2020 Strategy” (EC 2011a). It is important to stress that this initiative was produced under the Europe 2020 Strategy rather than simply under the processes begun with the 6th Environment Action Programme. The Europe 2020 Strategy was the EU’s overall strategy for jobs and economic growth.

Thus, resource efficiency was embedded as an objective necessary for future sustainable economic development (not just as an environmental policy), providing new economic opportunities, improved productivity, reduced costs and increased competitiveness.

The Flagship Initiative identified three conditions to deliver an economy that is resource-efficient and low-carbon:

- coordinated action, with political visibility and support, in a range of policy areas;
- urgent action (given long investment lead-in times); and
- empowering consumers to consume in a resource-efficient way, to drive continuous innovation and ensure that efficiency gains are not lost.

While the Flagship Initiative was a clear step forward from the 2005 Thematic Strategy (such as identifying the need to address some consumption issues and in providing a wider overview of relevant policies), it did not identify specific actions many policy areas should take to deliver resource efficiency other than those policy actions that had already been announced.

The next step was later in 2011 with the publication by the European Commission of the "Roadmap to a resource-efficient Europe" (EC 2011d). Accompanying this was background analysis and a review on the implementation of the 2005 Thematic Strategy (EC 2011c). The Roadmap reiterated the emphasis of the Flagship Initiative that transforming the EU economy to be resource-efficient was necessary for future economic development and environmental sustainability. It set out:

- A general vision for 2050;
- intermediate milestones for 2020; and
- specific policy actions for three themes.

For 2050, the Roadmap stated that resources should be managed sustainably and that natural capital and ecosystem services should be properly valued. While this was fine to the extent stated, the Roadmap did not describe what the economy of 2050 would look like for resources to be managed sustainably. The milestones for 2020 also tended to set out objectives already established in EU policy and, therefore, little additional idea for what 2050 should look like. In discussing economic transformation, the Roadmap identified that action was needed on strengthening green public procurement, increased life cycle thinking on products, support to businesses on improving resource efficiency, full implementation of EU waste law and reviewing waste targets, stimulating demand for recycled materials and supporting recycling facilities, boosting research and innovation spending, phasing out environmentally harmful subsidies by 2020, and achieving a "major shift" from taxation of labour towards environmental taxation, and adapting prices to reflect the real costs of resource use. Many of these policy ideas had already been flagged in previous policy statements.

The ideas concerning resource efficiency came together in the development of the EU's Seventh Environment Action Programme (7th EAP) (EU 2013). This established the objective to turn the EU into a resource-efficient, green and competitive low-carbon economy. It emphasised the need for more effective waste management policies and their better implementation, but also that achieving resource efficiency is not possible through "environmental" policies alone. Therefore, the 7th EAP stressed the need to integrate resource efficiency objectives and policy into many different policy areas. It stated "Some existing policy instruments relating to production and consumption are limited in scope. There is a need for a framework that gives appropriate signals to producers and consumers to promote resource efficiency and the Circular Economy. Measures will be taken to further improve the environmental performance of goods and services on the Union market over their whole life cycle including measures to increase the supply of environmentally sustainable products and stimulate a significant shift in consumer demand for such products".

Further, the 7th EAP stated that "innovation to improve resource efficiency is required throughout the economy to improve competitiveness in the context of rising resource prices, scarcity, raw material supply constraints and dependency on imports". Innovation in the design phase is important in this regard as the 7th EAP noted that 80% of all environmental impacts of a product during its life cycle originate in its design phase. The innovation of design will contribute to product durability, reparability, reusability, recyclability, recycled content and product lifespan.

The 7th EAP, therefore, brought together the different elements of resource efficiency policy that had evolved since the adoption of the 6th EAP. This created the basis for the formulation of policies explicitly framed around the concept of a Circular Economy.

3 Circular Economy Policy in the EU Today

Current EU Circular Economy Policy is based on the Circular Economy Action Plan (CEAP), adopted by the European Commission in December 2015 (EC 2015). It aims to "stimulate Europe's transition towards a Circular Economy which will boost global competitiveness, foster sustainable economic growth and generate new jobs" and it sets out a series of actions to start to deliver this. These actions cover several issues, but there is a particular focus on resource efficiency, improved waste management and support for innovation—all of which are themes strongly highlighted in earlier policy development. Measures developed as a result of the Action Plan have included the Circular Economy Monitoring Framework (EC 2018c) (see below) and revision of existing waste legislation.

However, while policy development on the Circular Economy has progressed, it is important to consider how well the EU is doing in relation to core material flows with waste generation and recycling. As a key contribution to the Circular Economy, the EU has made some progress in reducing waste production (seeking to decouple waste generation from economic growth) and in improving recycling rates, but there are areas where problems remain. The European Environment Agency (EEA 2018b) found that overall municipal solid waste generation in EEA countries declined between 2004 and 2012 by only 2%. This demonstrates the challenge facing household consumption issues (and upstream to manufacturers, etc.). However, if

Table 3 Recycling rates for municipal solid waste and for packaging rates in the EU between 2004 and 2014 (*Source* EEA 2016b)

Date	Municipal waste	Packaging waste
2004	30.6	
2005	31.9	54.6
2006	32.9	57
2007	35.1	59.2
2008	36.7	60.5
2009	37.7	62.4
2010	38.5	63.3
2011	39.8	63.5
2012	41.7	64.4
2013	42.4	65.2
2014	43.6	

mineral wastes are excluded, about half of the total waste in the EU-28 and Norway is produced by the manufacturing and service sectors. These have shown better performance than municipal waste overall. Waste generation from manufacturing in the EU-28 and Norway declined by 25% between 2004 and 2012 (the economic value of the sector increased by 7%), and for the service sector, the decline was 23% (with an increase in economic output of 13%). EEA (2018b) considered that the improvements might be due to several reasons: "efficiency improvements in production processes and management, changes in the structure of the manufacturing sector, increase in activities in services sector and a shift towards less-intensive waste generating activities".

It is also important to consider the variation across Europe. Table 3 shows the recycling rates for municipal solid waste and for packaging rates between 2004 and 2014. While there have been improvements, the rate of change is relatively slow. Some Member States, such as Sweden, have very high rates, while others, such as in southeast Europe, still have low rates (EEA 2019a).

One action in the Circular Economy Action Plan, therefore, was to revise EU waste law to drive improved waste management as this is clearly an issue that needs addressing. The revised waste legislation entered into force in 2018 (Directive 2018/851/EU). This contains a number of actions supporting the delivery of the Circular Economy (Fig. 1), including setting obligatory targets for Member States for a number of waste management issues.

However, while these are important legislative additions, there are no obligatory targets for waste prevention or reuse, although both need to be included within wider waste management planning. Having said this, the directive does require Member States to take measures to achieve this and that such measures should, *at least*, include (Article 9):

(a) promote and support sustainable production and consumption models;

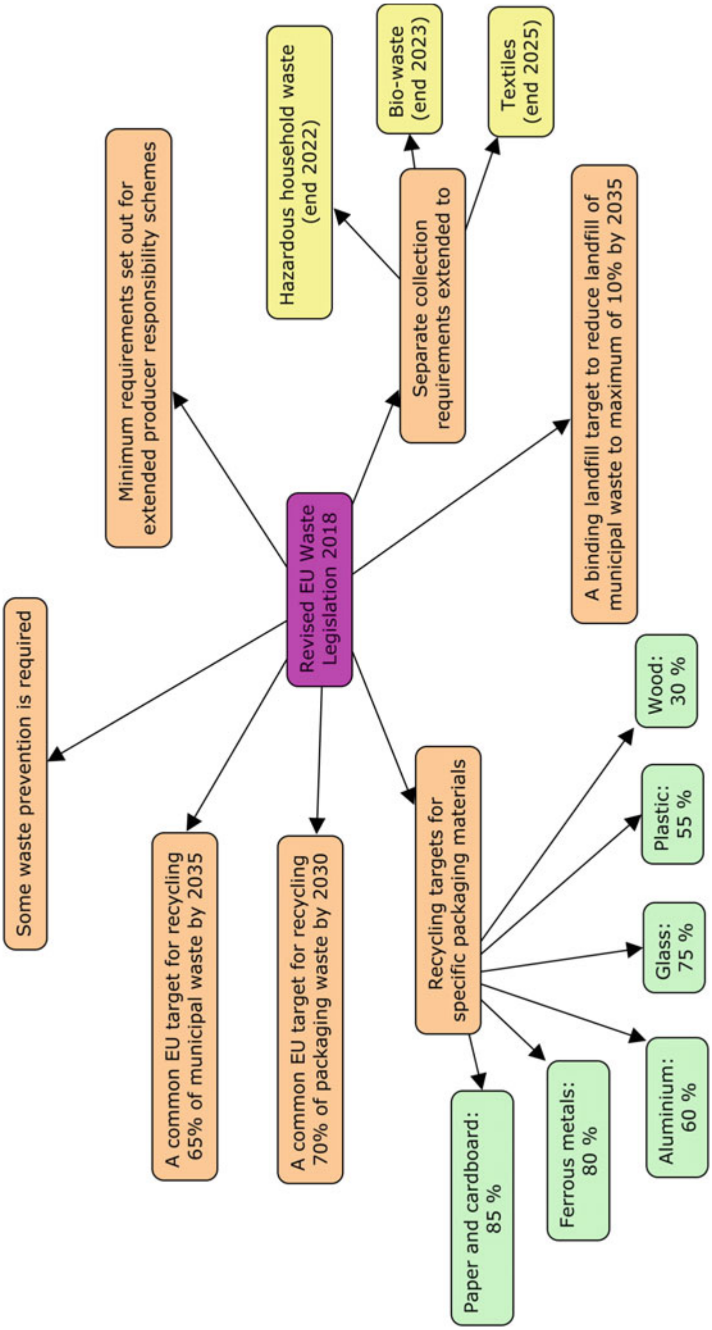

Fig. 1 Scope of revised EU waste law in 2018 contributing to delivering the Circular Economy

(b) encourage the design, manufacturing and use of products that are resource-efficient, durable (life span and the absence of planned obsolescence), reparable, reusable and upgradable;
(c) target products containing critical raw materials to prevent the materials from becoming waste;
(d) encourage the reuse of products and the setting up of systems promoting repair and reuse, in particular for electrical and electronic equipment, textiles and furniture, as well as packaging and construction materials and products;
(e) encourage the availability of spare parts, instruction manuals, technical information, or other instruments, equipment or software enabling the repair and reuse of products without compromising their quality and safety;
(f) reduce the waste generation in processes related to industrial production, extraction of minerals, manufacturing, construction and demolition;
(g) reduce the generation of food waste in primary production, in processing and manufacturing, in retail and other distribution of food, in restaurants and food services as well as in households;
(h) encourage food donation and other redistribution for human consumption, prioritising human use over animal feed and the reprocessing into non-food products;
(i) promote the reduction of the content of hazardous substances in materials and products, without prejudice to legal requirements in chemicals legislation;
(j) reduce the generation of waste, in particular waste that is not suitable for preparing for reuse or recycling;
(k) identify products that are the main sources of littering and take appropriate measures to prevent and reduce this;
(l) aim to halt the generation of marine litter as a contribution towards the SDG goal to prevent and significantly reduce marine pollution of all kinds; and
(m) develop and support information campaigns to raise awareness about waste prevention and littering.

The European Commission is also planning further revision of current EU waste law. This includes a review of the Waste Shipment Regulation by the end of 2020. This Regulation implements the Basel Convention for the EU, but does more than this. A specific objective of the review is to see how to make it more coherent with Circular Economy objectives. A particular challenge is the movement of waste and of secondary raw materials within the EU. Although the EU has an internal market, such movement is hampered by different aspects of the implementation of EU waste law in different Member States. For example, there are different approaches to determining End-of-Waste status—so determining when materials can re-enter the market (Make it Work and IMPEL 2019). As a result, secondary raw materials accepted in one Member State may not be accepted in a neighbouring Member State. This hampers the market in such materials and increases the perception of risk by business. Various actions can be taken to address this at Member State level, but the ongoing review of waste law at EU level is an important element of this (Make it Work and IMPEL 2019).

A report on the implementation of the Circular Economy Action Plan was published in 2017 (EC 2017a, b, c). It noted that actions had been taken on several areas: food waste, eco-design, organic fertilisers, guarantees for consumer goods, and innovation and investments. However, the report did not quantify progress in the Circular Economy itself or examine whether the actions taken had been effective. Indeed, in some areas, progress has been slow, e.g. on eco-design.

In 2018, a further major policy initiative was adopted—the Circular Economy Package. This package included the EU Strategy for Plastics in the Circular Economy (EC 2018a), explored in detail below.

It also included a proposal for the Circular Economy Monitoring Framework (EC 2018c). This is focused around ten indicators across four issues: “production and consumption”, “waste management”, “secondary raw materials” and “competitiveness and innovation”, providing data at a national level, building on national monitoring systems. It builds on earlier EU monitoring, i.e. the EU Resource Efficiency Scoreboard and the Raw Materials Scoreboards (Pardo and Schweitzer 2018). The data show that while there are improvements in many Member States with respect to waste management (e.g. quantities and types of waste going to landfill), progress on true circularity of materials is more limited (only 11% of materials were reused).

An important element of the Circular Economy Package was a Communication on the interface between chemicals, product and waste legislation. The presence of contaminants in secondary raw materials affects their ability (and desirability) to be utilised by businesses and individuals. The material may be circulating in the economy, but are contaminants conflicting with objectives to reduce toxicity in the environment? Under EU law, chemicals legislation regulates the presence of chemicals in products, etc., and, therefore, a review of how chemicals law and Circular Economy policy interact is important—including the information needs to understand what substances are where and the consequences for their presence in secondary raw materials.

A key policy element in the delivery of management of waste and materials in products is extended producer responsibility (EPR). This has been an important part of EU policy on different product types—packaging, vehicles and electronic goods. EU law typically requires Member States to ensure EPR schemes are established at a national level and one or more producer responsibility organisations (PROs) may be established through fees levied on manufacturers to support this. It is useful to examine vehicles, electronic goods and packaging as examples.

To support the circularity of materials in vehicles, the EU adopted the End-of-Life Vehicles (ELV) Directive in 2000 (Directive 2000/53/EC). This required that by 2006 Member States should reach ELV targets of 80% reuse/recycling and 85% reuse/recovery. For 2015, the targets increased to 85% reuse/recycling and 95% for reuse/recovery. To achieve this, Member States had to introduce new legislation, ensure manufacturers took responsibility for take-back of old vehicles and ensure facilities, and systems were developed to support this. The last report on the implementation of the Directive (EC 2017c) found good achievement of the targets. Some Member States were slow to start, but by January 2013, nine had already reached the 2015 targets of 95% for reuse/recovery and 17 Member States had reached those of 85% for reuse/recycling per vehicle. Others were close to achieving the target, although the Commission noted that "the reuse and recovery target of 95% is challenging for several Member States".

Member States had adopted measures encouraging vehicle manufacturers to limit the use of hazardous substances in vehicles in order to facilitate dismantling, reuse and recovery. They had also taken measures to ensure economic operators had set up systems for collecting ELVs and that owners could deliver old vehicles to facilities at no cost to themselves. The Commission noted that the achievement of the high recycling targets was due to:

- the development of new post-shredding technologies;
- the substantial reduction in heavy metals used in new cars;
- the implementation of coding standards to facilitate dismantling and better use and reuse and recovery of components and materials; and
- more and improved treatment facilities.

While this is a strongly positive outcome for this waste stream and an important element in the Circular Economy, it is important to note that there were 3.5–4.5 million vehicles per year with "unknown whereabouts". In other words, they may be illegally dismantled or exported. Thus, ensuring compliance with the legislation is still a challenge and is important to ensure full circularity of these materials.

The first Directive on waste electrical and electronic equipment (WEEE) was adopted in 2002 (Directive 2002/96/EC). This support the creation of collection schemes for consumers. The Directive was revised in 2012 (Directive 2012/19/EU), with additional provisions. Further, in 2017 the European Commission adopted the "WEEE Package" including common methodologies for calculating the weight of WEEE and reports on whether the scope and targets in the Directive should be changed. The use of EPR is central to the implementation of the Directive.

Eurostat (2019) has highlighted the increasing challenge of dealing with WEEE. For example, between 2015 and 2016, the amount of electrical and electronic equipment put on the EU market increased by 2.9% from 9.8 million tonnes to 10.1 million tonnes. Larger appliances from households formed 55.6% (2.5 million tonnes) of the WEEE in 2016, followed by IT and telecommunications equipment (14.8%) and consumer equipment and photovoltaic panels (13.5%). However, the amount of WEEE collected varies significantly across the EU from 1.6 kg per inhabitant in Romania to 16.5 kg per inhabitant in Sweden in 2016.

The WEEE Directive requires that "from 2016, the minimum collection rate shall be 45% calculated on the basis of the total weight of WEEE collected" and "from 2019, the minimum collection rate to be achieved annually shall be 65% of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85% of WEEE generated on the territory of that Member State" (with lower rates allowed for some eastern European countries). However, Leroy (2019) has shown that for many Member States, there is a major gap between current collection rates and the target. One major concern is that two-thirds of WEEE are not reported and, therefore, cannot be accounted for in the statistics. He emphasised that improved tracking and, in particular, enforcement is necessary for WEEE not to leak from the economy. This is important for protection of the environment from toxic substances in WEEE, but, in particular, to deliver a Circular Economy for those materials. EPR and the PROs its supports can contribute to improving the situation, but compliance requires action by national authorities as the drivers for illegal activity are significant.

EPR is also an important part of the management of packaging waste in the EU. Following early packaging legislation, the first comprehensive EU law was adopted in 1994—Directive 94/62/EC on packaging and packaging waste. Watkins et al. (2017) reviewed the use of EPR in packaging in the EU Member States. They found a diversity of EPR schemes, including fee modulation for producers in some countries based on the level of recyclability of plastic in the packaging. Key strengths identified in the study included:

- EPR schemes support the creation of better waste management systems, such as recycling facilities and the money raised reduces the costs to public budgets.
- The schemes have led to increased recycling and, as a result, development of technologies to support this and development of markets for secondary raw materials.

However, when considering EPR schemes for packaging across the EU as a whole, Watkins et al. (2017) found several weaknesses, including:

- Diversity of approaches leading to different rates of implementation, performance and data gathering.
- Lack of monitoring and control in some instances.
- Problems of free-riders.
- There is limited evidence of an impact on the eco-design of packaging.

Finally, it is important to note that other EU policy initiatives are also supporting the objectives of the Circular Economy, including:

- The Working Plan under the Eco-design Directive (EC 2016) aims to extend product lifespan and the reusability of products and components and recyclability of materials.
- The renewed Industrial Strategy of the EU states that its objective is to build industry based on Circular Economy principles (EC 2017a).
- The EU has made available funding through several instruments to support Circular Economy objectives, including those of the European Investment Bank, European Fund for Strategic Investments, Regional Funds and research funding (Pardo and Schweitzer 2018).
- Taking initiatives with third countries, including a 2018 Memorandum of Understanding on the Circular Economy with China and organises Circular Economy Missions such as in Japan, India and Indonesia (Pardo and Schweitzer 2018).

Current EU policy on the Circular Economy is, therefore, taking place along a series of strands under the overall policy umbrella. The following sections look at one aspect in more detail—that of plastics—where the interacting themes and policies of the Circular Economy (such as the nature of consumption, waste management challenges and use of EPR) all come together.

4 Focus on Plastics

Plastics are a particularly urgent challenge for the Circular Economy. The EU is a major producer and importer of plastics and generator of plastic waste. European marine waters are impacted by marine litter. The Chinese waste ban poses a new challenge for the management of plastic waste, but even if the waste that is collected is managed correctly, a large amount still leaks into the environment as litter. As a result, action on plastics needs to address not only the effective management of the material once produced, but measures to reduce plastic use as this is needed to reduce waste production and leakage.

The 2015 Circular Economy Action Plan highlighted the need to tackle the problem of plastics. One of the first actions taken was to use revise existing EU law on packaging and packaging waste (Directive 94/62/EC) to introduce additional measures regarding plastics (adopted as Directive 2018/852/EU). This introduced an objective for Member States to recycle 50% of plastic packaging by weight by 2025 and 55% by 2030.

Another action of the Circular Economy Action Plan was to produce a strategy for plastics. In January 2018, the European Commission published the European Strategy for Plastics in a Circular Economy (EC 2018a). The Strategy aims to be the foundation for a "new plastics economy", with a focus on design and production for reuse, repair and recycling with more sustainable materials and less plastic pollution. The Strategy sets the following objectives:

- Promotion of alternatives to disposable plastics;
- adoption of legislation on single-use plastics (see below);
- all plastics packaging in the EU to be reusable or recyclable in a cost-effective manner by 2030;
- recycling of over 50% of plastics waste generated in Europe by 2030;
- sorting and recycling capacity to increase by four times and improved separate collection by 2030;
- demand for recycled plastics to increase by four times, supported by an established market;
- greater use of innovative materials and alternative (i.e. non-fossil fuel) feedstocks for plastics production, where they are demonstrably more sustainable;
- increased use of circular solutions to promote plastic waste prevention, such as reverse logistics for packaging and alternatives to disposable plastics;
- a significant decrease in the leakage of plastics into the environment; and
- a leading role for the EU in the global context of dealing with plastic waste and pollution.

The European Commission provided a list of measures to implement the Strategy (EC 2018b) (Fig. 2).

Following on the commitment in the Plastics Strategy, the European Commission published a proposal for legislation (a directive) on single-use plastics in May 2018 and, in this regard, the EU is following the action on plastics by several of its Member

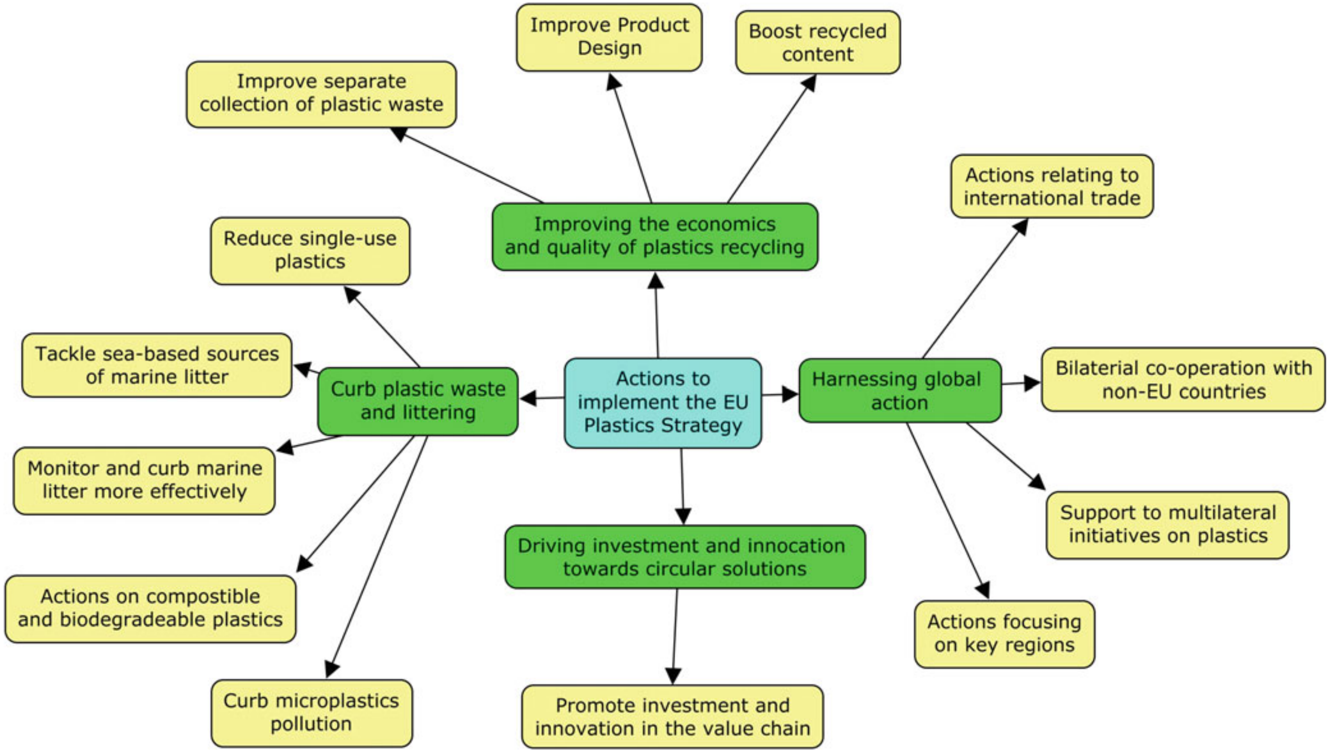

Fig. 2 Measures to be taken to implement the EU Plastics Strategy

States and countries around the world (UN Environment 2018). This proposal moved relatively quickly through the legislative adoption within the Council and European Parliament. The measures contained in the new directive include:

- An EU-wide ban of single-use plastic cotton buds, straws, plates and cutlery (with exemptions until 2023), beverage stirrers, balloon sticks, oxo-degradable plastics and expanded polystyrene food containers and cups;
- an obligation for Member States to adopt measures to achieve a 25% reduction of the consumption of food containers and cups for beverages;
- an obligation for Member States to reduce post-consumption waste from tobacco product filters containing plastic by 50% by 2025 and 80% by 2030;
- introduction of Extended Producer Responsibility (EPR) schemes that include the cost of clean-up and awareness-raising measures;
- harmonised standards and an EPR scheme for fishing gear;
- a 50% collection target and a 15% recycling target for fishing gear by 2025;
- targets for separate collection of plastic bottles (2025–77%; 2029–90%);
- an obligation to separately collect 90% of beverage containers and ensure they are produced from 35% recycled content by 2025;
- an obligation to prevent the use of hazardous chemicals in the composition of sanitary items; and
- an obligation to label products to inform consumers about the presence of chemicals of concern in certain single-use plastic products.

Watkins and Schweitzer (2018) critically examined the legislation on single-use plastics. They noted that while it is important to have such objectives, "many EU countries already lead globally on recycling". As a result, while a 90% collection target for single-use plastics looks tough, some EU Member States already exceed this target. Watkins and Schweitzer (2018) noted that Germany already recycled 93.5% of its PET bottles in 2015 and France is aiming to collect 100% of recyclable plastic waste by 2025 (République Française 2018) and to achieve 100% recycling of plastic by the same date.

The target under the revised waste legislation is to recycle 55% of plastic packaging by 2030. Watkins and Schweitzer (2018) argue that this is low compared to the targets for most other materials and lower than the overall target of 60% for municipal waste.

However, recycling targets are only one part of tackling plastics. Further up the waste hierarchy are measured to prevent plastic waste—these may include bans on certain types of products (so stopping the waste stream arising) or general targets for waste prevention. Watkins and Schweitzer (2018) note that higher recycling rates are hampered by the diversity of polymers, additives and materials found in plastic waste, the chemical limits on mechanically recycling polymer chains and the information gaps which exist between products and waste management. For plastics existing mechanical recycling processes also often require the input of virgin materials. Furthermore, plastics are generally recycled in open loops into lower-value products (downcycling) such as fibres for textiles. This is not true circularity as the material eventually must be disposed of. To address this challenge will require innovation and research, although prevention in the first place is more desirable. EU waste law includes objectives for waste prevention and for reuse as it promotes the waste hierarchy in Member States' waste planning. However, the law does not include binding targets for Member States.

Bans are another policy approach included in the new directive on single-use plastics. Bans can be used where there are clear problems with certain products (e.g. littering), where recycling may be a problem and where the function can be readily substituted by a non-plastic alternative (or a multi-use plastic alternative). Several Member States have already introduced bans, such as plastic bags in many shops in Malta, cotton buds to be banned in Italy in 2019 and in France in 2020 and plastic cups and plates in France from 2020. Bans can also apply to the use of particular types of plastics in products, as seen by the banning of the use of plastic microbeads in products in a number of Member States. In 2018, the European Chemicals Agency published a note on the potential scope of an EU-level restriction on certain uses of microplastics (ECHA 2018).

Another approach to bans is through Green Public Procurement—this does not ban a particular product on the market, but due to the purchasing power of public institutions this can have a significant impact on the use of plastics and can drive investment by producers in alternatives. An example is a commitment that the UK central government offices are to be made single-use plastic-free (HM Government 2018).

To support the implementation of the Strategy and the new directive, improved information is needed. Therefore, within the Circular Economy Monitoring Framework described earlier, there are several indicators relevant to plastics: plastic packaging recycling rates, secondary raw materials' share of overall materials demand, and the volume of imports and exports of selected recyclable raw materials.

A new development in EU policy is seen with plastics in that the proposals for the EU's budget for 2021–2027 include a proposed plastics-related "tax". The proposal is for a contribution from each Member State to the EU budget based on the amount of non-recycled plastic packaging waste in each country, at a rate of €0.80 per kg. This would raise up to €7 billion in revenues from 2021 to 2027 (European Council 2018). Taxes and charges for plastics are found at Member State level, but the introduction of taxes for environmental purposes at EU level is unusual.

Taking forward action on plastics requires more than EU-level law and supporting policy. The European Environment Agency (EEA 2019b) explored actions taken across 27 EU Member States (not Cyprus), plus Iceland, Norway, Switzerland and Turkey to tackle plastic waste, finding 173 waste prevention measures either implemented or planned. It found:

- In nearly half of the countries, plastic waste has been declared a priority waste;
- 105 of the measures identified concern the production phase of plastic and 69 measures concern the consumption phase. A few measures were mandatory (e.g. plastic bag charges), but most were voluntary measures or information measures, such as to consumers;
- 37 of the measures were market-based instruments, most being plastic bag charges;

- only nine countries had adopted explicit waste prevention targets in their prevention programmes; and
- there are examples of bans of some plastic products/uses.

The different types of action that are possible at a national level are large. Make it Work and IMPEL (2019) identified five types of routes to achieving more sustainable production and use of plastics, with examples of actions being undertaken for each of these.

Less use of plastics:

- Plastic-free shopping: Gram is a Swedish packaging-free grocery store. The challenges it faces are mainly related to the market conditions and the competition with conventional retail. The solutions to these challenges are found in addressing consumer behaviour and in setting the right prices.
- Rather than leaving waste behind for the municipality to clean-up, in Amsterdam event organisers have to take at least five measures to make their events more sustainable as a condition to the event permit that is required for larger events. Measures either increase reuse or reduce use and littering of plastics.
- The OneLess campaign in London has sought to reduce the use of single-use plastic bottles. Shops, stations and attractions have introduced alternatives such as water fountains. Events such as the London Marathon are taking action to reduce their use of plastic.

More reuse of plastics:

- A UK scheme which incentivises consumers to bring back their used appliances for recycling.
- A French start-up scheme (Reconcile) providing reusable lunch boxes at a popular high-end lunch restaurant. Each has a deposit that is refunded when they are returned.

Reducing littering and extraction of litter from the environment:

- Research in Germany is trialling different alternatives for fishing nets, to reduce littering of seas and beaches.
- Several examples of ghost nets being collected from seas and beaches and recycled into yarn for new products.

Recycling:

- Several companies specialise in producing nylon yarn from waste such as fishing nets for the production of stockings and carpets.
- A new chemical technology has been developed in the Netherlands to break down products from polyethylene (clothing, plastic bottles) into monomers and rebuild PET polymer from these for use in new products.

Addressing the presence of substances of very high concern (SVHC):

- The Swedish government is conducting a survey to look into the health and environmental performance of different alternatives for the use of plastics, such as in artificial grass.

- The national waste programme of the Netherlands contains a SVHC decision tree, which helps to structure the decision-making process of the regulator, in those cases where a certain SVHC in a waste flow poses an environmental risk when it is transformed into a product and put onto the market.

5 Conclusions and Looking to the Future

The EU has made important steps forward in the last decade to support a more Circular Economy in the EU. It has recognised that there is no "magic bullet" to achieve this, but that action is required across a wide range of policy areas. Progress in some areas is, however, better than others. Much greater action is, for example, required in policy areas such as eco-design and in environmental tax reform (mostly at Member State level), as well as enhancing supporting policies such as funding.

Critically, the EU and most Member States do not have targets to reduce waste production, which is a key starting point. There are some examples in some countries, but overall while EU law requires action to be taken on waste reduction, the lack of a target is likely to mean that positive action is fragmented. The revised EU Waste Framework Directive does state that the European Commission should consider such targets by 2024, but this is some time in the future and it would be years before such a target would prove effective.

Linked to this, however, are the information challenges for a Circular Economy—how to measure waste prevention, material flows, the quality of secondary raw materials, etc. This is not just a matter of tracking policy implementation, but about the confidence of businesses and consumers for specific materials and products in the economy. Improved tracking, traceability and overall data reliability are essential to an effective Circular Economy.

There are also further links with other policy areas to explore. There is considerable emphasis currently on the bioeconomy, such as promoted by the European Commission (EC 2012). Much of this concerns bioenergy as a climate mitigating tool. However, biomaterials may also substitute existing materials, e.g. bioplastics. The two policy areas do, as noted by EEA (2018a), have similar objectives and areas of intervention, including food waste, biomass and bio-based products. The EEA argues that the policy agendas would benefit from stronger links.

Ultimately, the circularity of materials in the economy, while an important aim, does not itself address the over-consumption that takes place in the EU. It makes the EU more sustainable, rather than sustainable in absolute terms. Increasing circularity aids living within planetary boundaries, but further actions will be required to meet this boundary. Pantzar et al. (2018) noted that Europe needs to address what it consumes and that "This will require concerted efforts throughout society, including more conscious decisions by individuals, ambitious commitments by companies and incentives and legal intervention by policymakers". They argue that "The focus of

EU-level intervention to date partly reflects the fact that demand-side policy measures often fall under the legal competence of Member States, and partly that many of the potential policy options for addressing consumption have not been seen as politically viable". A key problem, they argue is that modern western society is built on a growth-based and linear economic model which largely fails to internalise external costs of production and end of life. As a result, it "encourages short-term and highly wasteful consumption patterns where a decrease in consumption is inherently considered negative".

Clearly, actions being taken to support the Circular Economy go some way to address some of this short-termism, but more radical action will be required to meet a truly sustainable Europe.

References

AMEC Environment & Infrastructure and Bio Intelligence Service. (2014). *The opportunities to business of improving resource efficiency—Final report on behalf of the European Commission, Contract Ref. 070307/2011/610181/ETU/F.1, Northwich*. http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/report_opportunities.pdf.

EC. (2003). *Towards a thematic strategy on the sustainable use of natural resources*. (COM(2003)572). https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0572:FIN:EN:PDF.

EC. (2005). *Thematic strategy on sustainable use of natural resources alongside the thematic strategy on waste prevention and recycling*. (COM(2005)670). https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0670:FIN:EN:PDF.

EC. (2008). *Raw materials initiative—Meeting our critical needs for growth and jobs in Europe*. (COM(2008)699). https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0699:FIN:EN:PDF.

EC. (2011a). *A resource-efficient Europe—Flagship initiative of the Europe 2020 Strategy*. (COM(2011)21). https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0021:FIN:EN:PDF.

EC. (2011b). *Analysis associated with the roadmap to a resource efficient Europe, Part II, accompanying the document 'Roadmap to a resource efficient Europe'*. (SEC(2011)1067). http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf.

EC. (2011c). *On the progress of the thematic strategy on the sustainable use of natural resources*. (SEC(2011)1068). http://edz.bib.uni-mannheim.de/edz/pdf/sek/2011/sek-2011-1068-en.pdf.

EC. (2011d). *Roadmap to a resource-efficient Europe*. (COM(2011)571). http://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2011)0571_/com_com(2011)0571_en.pdf.

EC. (2011e). *Tackling the challenges in commodity markets and on raw materials*. (COM(2011)25). http://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2011)0025_/com_com(2011)0025_en.pdf.

EC. (2012). *Innovating for sustainable growth: A bioeconomy for Europe*. (COM(2012)60). https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0060:FIN:EN:PDF.

EC. (2015). *An EU action plan for the circular economy*. (COM(2015)614). https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF.

EC. (2016). *Ecodesign working plan 2016–2019*. (COM(2016)773). https://ec.europa.eu/energy/sites/ener/files/documents/com_2016_773.en_.pdf.

EC. (2017a). *Investing in a smart, innovative and sustainable industry—A renewed EU Industrial Policy Strategy*. (COM(2017)579). https://eur-lex.europa.eu/resource.html?uri=cellar:c8b9aac5-9861-11e7-b92d-01aa75ed71a1.0001.02/DOC_1&format=PDF.

EC. (2017b). *Report on the implementation of the circular economy action plan*. (COM(2017)33). http://ec.europa.eu/environment/circular-economy/implementation_report.pdf.

EC. (2017c). *Report on the implementation of directive 2000/53/EC on end-of-life vehicles for the periods 2008–2011 and 2011–2014*. COM(2017). http://ec.europa.eu/environment/waste/elv/pdf/elv_eur_lex_europa.pdf.

EC. (2018a). *A European strategy for plastics in a circular economy*. (COM/2018/28). http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy.pdf.

EC. (2018b). *Annexes to a European strategy for plastics in the circular economy*. (COM(2018)28) Annexes 1–3.

EC. (2018c). *Communication on a monitoring framework for the circular economy*. (COM(2018)29). http://ec.europa.eu/environment/circular-economy/pdf/monitoring-framework.pdf.

EEA. (2016a). *Circular economy in Europe: Developing the knowledge base*. European Environment Agency, Copenhagen. https://www.eea.europa.eu/publications/circular-economy-in-europe.

EEA. (2016b) *Recycling rates in Europe by waste stream*. https://www.eea.europa.eu/data-and-maps/daviz/recycling-rates-by-waste-streams-1#tab-chart_2.

EEA. (2018a). *The circular economy and the bioeconomy: Partners in sustainability*. European Environment Agency, Copenhagen. https://www.eea.europa.eu/publications/circular-economy-and-bioeconomy.

EEA. (2018b). *Waste generation*. https://www.eea.europa.eu/data-and-maps/indicators/waste-generation-1/assessment.

EEA. (2019a). *Municipal waste recycled and composted in each European country*. https://www.eea.europa.eu/data-and-maps/daviz/municipal-waste-recycled-and-composted-3#tab-chart_3.

EEA. (2019b). *Preventing plastic waste in Europe EEA report no 02/2019*. European Environment Agency, Copenhagen. https://www.eea.europa.eu/publications/preventing-plastic-waste-in-europe.

EMF. (2012). *Towards the circular economy—economic and business rationale for an accelerated transition, Volume 1, Ellen MacArthur Foundation, Isle of Wight*. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf.

EMF. (2015a). *Concept. What is a circular economy? A framework for an economy that is restorative and regenerative by design*. https://www.ellenmacarthurfoundation.org/circular-economy/concept.

EMF. (2015b). *Delivering the circular economy—A toolkit for policymakers*. Ellen MacArthur Foundation, Isle of Wight. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_PolicymakerToolkit.pdf.

EU. (2013). *Decision no 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D1386&from=EN.

ECHA. (2018). *Note on substance identification and the potential scope of a restriction on uses of 'microplastics'*. European Chemicals Agency, Helsinki. https://echa.europa.eu/documents/10162/13641/note_on_substance_identification_potential_scope_en.pdf/6f26697e-70b5-9ebe-6b59-2e11085de791.

European Council. (2018). *Proposal for a council decision on the system of own resources of the European Union (COM/2018/325 final—2018/0135 (CNS)*. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1527242435118&uri=CELEX%3A52018PC0325.

Eurostat. (2019). *Waste statistics—electrical and electronic equipment*. https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics_electrical_and_electronic_equipment.

HM Government. (2018). *A green future: Our 25 year plan to improve the environment*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf.

James, K., Mitchell, P., & Mueller, D. (2016). *Extrapolating resource efficient business models across Europe*. REBus Project. http://www.rebus.eu.com/wp-content/uploads/2017/07/Extrapolating-resource-efficient-business-models-across-Europe.pdf.

Leroy, P. (2019). Bridging the distance to target. In *Proceedings of the First International Symposium on Electronic Waste and End of Life Vehicles* (pp. 16–24), Jeju, South Korea, 19–22 May 2019.

Make it Work and IMPEL. (2019). *Make it Work and IMPEL Guidance—Making the circular economy work*. IMPEL, Brussels. http://minisites.ieep.eu/work-areas/environmental-governance/better-regulation/make-it-work/events/2019/02/rome-making-the-circular-economy-work-connecting-policy-law-and-practice-march-2019.

Pantzar, M., Strube, R., Gionfra, S., & Modee, K. (2018). *Sustainable consumption—Policy approaches for systems change*. Paper for the Think 2030 Conference on Science-Policy Solutions for a More Sustainable Europe. https://ieep.eu/uploads/articles/attachments/6ba62504-96f4-463a-b077-b37cb739043a/Think%202030%20Sustainable%20consumption.pdf?v=63710011359.

Pardo, R., & Schweitzer, J. P. (2018). *A long-term strategy for a European circular economy—Setting the course for success*. Paper for the Think 2030 Conference on Science-Policy Solutions for a More Sustainable Europe. https://ieep.eu/uploads/articles/attachments/f99f1ac9-83a0-47e0-a0a2-74f3ce528ad8/Think%202030%20Circular%20Economy.pdf.

République Française. (2018). *Feuille de route économie circulaire: 50 mésures pout une économie 100% circulaire*. https://www.ecologique-solidaire.gouv.fr/sites/default/files/Feuille-de-route-Economie-circulaire-50-mesures-pour-economie-100-circulaire.pdf.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science, 347*(6223), 1259855. https://science.sciencemag.org/content/347/6223/1259855.

UN Environment. (2018). *Single use plastics—A road map to sustainability*. https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pdf?sequence=1&isAllowed=y.

Watkins, E., Gionfra, G., Schweitzer, J. P., Pantzar, M., Janssens, C., & ten Brink, P. (2017). *EPR in the EU plastics strategy and the circular economy: A focus on plastic packaging*. Institute for European Environmental Policy, Brussels. https://ieep.eu/uploads/articles/attachments/9665f5ea-4f6d-43d4-8193-454e1ce8ddfe/EPR%20and%20plastics%20report%20IEEP%2019%20Dec%202017%20final%20rev.pdf?v=63680919827.

Watkins, E., & Schweitzer, J. P. (2018). *Moving towards a circular economy for plastics in the EU by 2030*. Paper for the Think 2030 Conference on Science-Policy Solutions for a More Sustainable Europe. https://ieep.eu/uploads/articles/attachments/4e8d42a2-c8a8-4d40-bae0-c3429b10fe4d/Think%202030%20Circular%20economy%20for%20plastics.pdf?v=63710011292.

Status of Plastics Waste in Circular Economy in the USA

Serpil Guran, Ronald L. Mersky and Sannidhya K. Ghosh

Abstract Circular economy, an economic system where waste is utilized as an economic input, is currently the subject of much interest. Methods to incorporate all wastes into circular economy have not been developed. This paper discusses the current status and options for including plastics wastes in circular economy in the USA. Utilizing some plastics wastes as fuel is the most feasible path to doing so at present. Completely closed-loop circular economy for plastics would require fundamental changes in how plastics-based products are designed and manufactured.

Keywords Circular economy · Recycling · Plastics waste

1 Introduction

The term *circular economy* has become popular in recent years (Kok et al. 2013), but the concept is not new. The basic definition of circular economy is simply an economic system based on what is traditionally defined as *waste* being redefined as an economic input, as opposed to a *linear economy* (Fig. 1) in which materials are extracted, used, and disposed of (Hoomweg and Kennedy 2013). Some definitions of circular economy also include reduction of nonrecoverable pollutants and increased durability of products (lengthening of the circle) (Lahti et al. 2018). Circular economy can therefore in practice be considered essentially synonymous with the term *zero waste economy*.

Waste is something that is considered to be of negative value and therefore is designated for removal, by its owner (Michelini et al. 2017). Historically, waste

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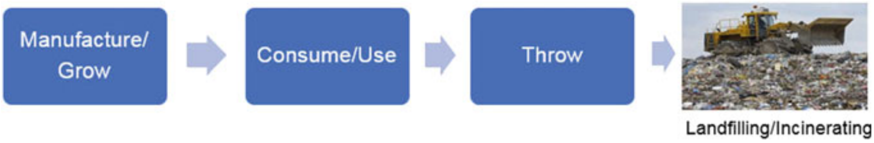

Fig. 1 Linear economy resource management approach

management has been performed for the purposes of sanitation, health, and esthetics (Michelini et al. 2017). As such, waste was managed by disposal, except in cases where the waste was economically and functionally competitive with virgin materials. More recently, secondary (waste) materials use (more popularly referred to as *recycling*—a term that, like circular economy, indicates the cyclic nature of the process) has been encouraged or mandated for perceived environmental benefits, rather than only free-market reasons. Circular economy is an expansion of encouraged or mandated recycling—it is an economy *requiring* a cyclical materials system. To achieve such implies not just materials recovery, but also that the cyclical use of materials be incorporated in all aspects of the economy—including product design, manufacture, and use.

Plastics materials are an increasingly large quantity and percentage in the US waste stream. From Table 1, it is noted that total plastics in the USA MSW increased from 390,000 US tons in 1960 to 34,500,000 in 2015—an increase of almost 90 times (2015 data are the most recent published by the US EPA). From Table 2, it is seen that at the same time, period plastics increased from 0.4% to 13.1% of the USA MSW. No other single waste material has had nearly that rate of growth.

A significant reason for this quantity and percentage increase is substitution of plastics (a newer material) for older materials (glass, metals, and paper) in existing products. Tables 1 and 2 indicate a slowing of plastics wastes' quantity and percentage increases (as plastics become mature materials) but the increase still continues.

Given the large, and still increasing, portion of plastics in the USA MSW, it is critical for the USA economy to incorporate plastics wastes into production of new products if a circular economy is to be achieved.

2 Governmental Involvement in MSW

Nationwide US waste management laws began in 1965 with the "Solid Waste Disposal Act" (Fig. 2). This was followed by the Resource Conservation and Recovery Act (RCRA) of 1976. The RCRA program, implemented by the US EPA and its partner states, tribes, and local governments, protects communities and the environment from the improper management of solid and hazardous waste, cleans land and water, conserves resources, and empowers citizens by delivering information and opportunities that enable communities to participate in decision-making processes.

Table 1 Materials generated[a] in the municipal waste stream, 1960–2015 (thousands of tons) (5)

Paper and paperboard	29,990	44,310	55,160	72,730	87,740	84,840	71,310	68,610	68,050
Glass	6720	12,740	15,130	13,100	12,770	12,540	11,520	11,480	11,470
Metals									
Ferrous	10,300	12,360	12,620	12,640	14,150	15,210	16,920	17,880	18,170
Aluminum	340	800	1730	2810	3190	3330	3510	3530	3610
Other nonferrous	180	670	1160	1100	1600	1860	2020	2230	2220
Total metals	*10,820*	*13,830*	*15,510*	*16,550*	*18,940*	*20,400*	22,450	23,640	24,000
Plastics	390	2900	6830	17,130	25,550	29,380	31,400	33,390	34,500
Rubber and leather	1840	2970	4200	5790	6670	7290	7750	8210	8480
Textiles	1760	2040	2530	5810	9480	11,510	13,220	15,240	16,030
Wood	3030	3720	7010	12,210	13,570	14,790	15,710	16,120	16,300
Other[b]	70	770	2520	3190	4000	4290	4710	5120	5160
Total materials in products	*54,620*	*83,280*	*108,890*	*146,510*	*178,720*	*185,040*	*178,070*	*181,810*	*183,990*
Other wastes									
Food	12,200	12,800	13,000	23,860	30,700	32,930	35,740	38,670	39,730
Yard trimmings	20,000	23,200	27,500	35,000	30,530	32,070	33,400	34,500	34,720
Miscellaneous Inorganic Wastes	1300	1780	2250	2900	3500	3690	3840	3970	3990
Total other wastes	33,500	37,780	42,750	61,760	64,730	68,690	72,980	77,140	78,440
Total MSW generated—weight	88,120	121,060	151,640	208,270	243,450	253,730	251,050	258,950	262,430

[a]Generation before materials recycling, composting, combustion with energy recovery, or landfilling. Does not include construction and demolition debris, industrial process wastes or certain other wastes. Details may not add to totals due to rounding
[b]Includes electrolytes in batteries and fluff pulp, feces and urine in disposable diapers

Table 2 Materials Generated[a] in the Municipal Waste Stream, 1960 to 2015 (percent of total generation) (5)

Paper and paperboard	34.0%	36.6%	36.4%	34.9%	36.0%	33.4%	28.4%	26.5%	25.9%
Glass	7.6%	10.5%	10.0%	6.3%	5.2%	4.9%	4.6%	4.4%	4.4%
Metals									
Ferrous	11.7%	10.2%	8.3%	6.1%	5.8%	6.0%	6.7%	6.9%	6.9%
Aluminum	0.4%	0.7%	1.1%	1.3%	1.3%	1.3%	1.4%	1.4%	1.4%
Other nonferrous	0.2%	0.6%	0.8%	0.5%	0.7%	0.7%	0.8%	0.8%	0.8%
Total metals	*12.3%*	*11.4%*	*10.2%*	*7.9%*	*7.8%*	*8.0%*	*8.9%*	*9.1%*	9.1%
Plastics	0.4%	2.4%	4.5%	8.2%	10.5%	11.6%	12.5%	12.9%	13.1%
Rubber and leather	2.1%	2.5%	2.8%	2.8%	2.7%	2.9%	3.1%	3.2%	3.2%
Textiles	2.0%	1.7%	1.7%	2.8%	3.9%	4.5%	5.3%	5.9%	6.1%
Wood	3.4%	3.1%	4.6%	5.9%	5.6%	5.8%	6.3%	6.2%	6.2%
Other[b]	0.1%	0.6%	1.7%	1.5%	1.6%	1.7%	1.9%	2.0%	2.1%
Total materials in products	62.0%	68.8%	71.8%	70.3%	73.4%	72.9%	70.9%	70.2%	70.1%
Other wastes									
Food	13.8%	10.6%	8.6%	11.5%	12.6%	13.0%	14.2%	14.9%	15.1%
Yard trimmings	22.7%	19.2%	18.1%	16.8%	12.5%	12.6%	13.3%	13.3%	13.3%
Miscellaneous Inorganic wastes	1.5%	1.5%	1.5%	1.4%	1.4%	1.5%	1.5%	1.5%	1.5%
Total other wastes	38.0%	31.2%	28.2%	29.7%	26.6%	27.1%	29.1%	29.8%	29.9%
Total MSW generated—%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[a]Generation before materials recycling, composting, combustion with energy recovery or landfilling. Does not include construction and demolition debris, industrial process wastes or certain other wastes. Details may not add to totals due to rounding
[b]Includes electrolytes in batteries and fluff pulp, feces and urine in disposable diapers

Fig. 2 The evolution of significant RCRA legislation Adapted from RCRA's Critical Mission and the Path Forward, 2014 (USEPA 2014)

RCRA also serves as a legislative basis for EPA's Sustainable Materials Management (SMM) program, which is a systemic approach for promoting using and reusing materials over their life cycle. The program has four primary goals: to decrease the disposal rate; reduce environmental impacts; increase socioeconomic benefits; and increase the capacity of communities to adopt SMM practices. The SMM program set three strategic priorities as follows:

– The built environment
– Sustainable food management
– Sustainable packaging.

3 Plastics Recycling

Table 3 shows the US recycling rates for MSW component materials, 1960–2015. It is notable that plastics wastes have the lowest recycling rates of all MSW categories except food (which, as a wet waste, has only recently been subject to significant organized source separation in the USA).

There are multiple reasons to explain the low plastics recycling rate, including:

<u>Collection/transport/separation</u>

- some plastics (i.e., EPS) are of very low density, making transport per weight expensive and energy inefficient.
- plastics are often strongly attached to other plastics or nonplastic materials (i.e., multi-polymer packaging, appliances) making separation into pure polymers expensive if not feasibly impossible.
- some plastics waste (i.e., agricultural) are produced in remote areas.
- contamination (most likely the result of single-stream recycling practices).

<u>Technological</u>

- Thermoset plastics cannot be remelted and reformed, significantly limiting their input into new products.
- Depolymerization is not yet commercialized.

Table 3 Materials recycled and composted[a] in municipal solid waste, 1960–2015 (percent of generation of each material)

	Percent of generation of each material								
	1960	1970	1980	1990	2000	2005	2010	2014	2015
Paper and paperboard	16.9%	15.3%	21.3%	27.8%	42.8%	49.5%	62.5%	64.7%	66.6%
Glass	1.5%	1.3%	5.0%	20.1%	22.6%	20.7%	27.2%	26.0%	26.4%
Metals									
Ferrous	0.5%	1.2%	2.9%	17.6%	33.1%	33.0%	34.3%	33.4%	33.4%
Aluminum	Neg.	1.3%	17.9%	35.9%	27.0%	20.7%	19.4%	20.1%	18.6%
Other nonferrous	Neg.	47.8%	46.6%	66.4%	66.3%	68.8%	71.3%	69.5%	67.6%
Total metals	*0.5%*	*3.5%*	*7.9%*	*24.0%*	*34.8%*	*34.3%*	35.3%	*34.8%*	*34.3%*
Plastics	Neg.	Neg.	0.3%	2.2%	5.8%	6.1%	8.0%	9.6%	9.1%
Rubber and leather	17.9%	8.4%	3.1%	6.4%	12.3%	14.4%	18.6%	17.5%	17.8%
Textiles	2.8%	2.9%	6.3%	11.4%	13.9%	15.9%	15.5%	14.8%	15.3%
Wood	Neg.	Neg.	Neg.	1.1%	10.1%	12.4%	14.5%	15.9%	16.3%
Other[b]	Neg.	39.0%	19.8%	21.3%	24.5%	28.2%	29.1%	28.7%	27.7%
Total materials in products	10.3%	9.6%	13.3%	19.8%	29.7%	32.0%	36.6%	36.6%	36.8%
Other wastes									
Food[c]	Neg.	Neg.	Neg.	Neg.	2.2%	2.1%	2.7%	5.0%	5.3%
Yard trimmings	Neg.	Neg.	Neg.	12.0%	51.7%	61.9%	57.5%	61.1%	61.3%
Miscellaneous Inorganic wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total other wastes	Neg.	Neg.	Neg.	6.8%	25.4%	29.9%	27.6%	29.8%	29.8%
Total MSW recycled and composted—%	6.4%	6.6%	9.6%	16.0%	28.5%	31.4%	34.0%	34.6%	34.7%

[a]Recycling and composting of postconsumer wastes; does not include converting/fabrication scrap. Details may not add to totals due to rounding
[b]Collection of electrolytes in batteries; probably not recycled. Neg = Less than 5000 tons or 0.05%
[c]Includes collection of other MSW organics for composting

4 Legislative and Industrial Initiatives

Most USA governmental actions aimed at managing plastics wastes have occurred at the local level. Some municipal governments have banned or restricted the use of specific plastics products that are perceived as being particularly problematic (single-use bags, straws). Such actions may reduce plastics wastes but do not provide for reintroduction of wastes into circular economy.

Some states have taken actions. California, for example, has passed a regulation requiring that some disposable food service items be reusable, recyclable, or compostable by 2021 (Rajbanshi 2019; California Legislative Information 2018). However the regulation is limited to certain items at certain state facilities, so its scope is not broad. Also, rather than causing plastics items to be reintroduced into circular economy, the result could instead be substitution for non-plastics items.

At the federal level, legislation has been proposed to introduce extended producer responsibility to manufacturers of plastics packaging (Product Stewardship Institute 2019). However the proposal also calls for bans or disincentives for some plastic products and container deposits. Also it is unclear if this will become law and, if so, in what form.

Overall, there is not significant law to encourage plastics in circular economy.

The plastics industry has been willing for decades to find uses for some plastics collected in recycling programs. However the overall USA plastics recycling rate, as of 2015, is 9.1% (USEPA 2019) (although some specific products have much higher rates). This indicates that industry has not yet found much circular economy pathway for plastics.

5 Options for Plastics in Circular Economy

There is currently not any indication that the mentioned obstacles will be overcome in the near future. Therefore, it appears that, if the USA is to move toward a circular economy (Fig. 3), fundamental changes in plastics wastes are needed. This would include replacing some current polymers in products, redesign of many products, and elimination of some products. This runs contrary to usual free-market economics and would have many secondary consequences. It is not feasible.

For plastics in the USA, utilizing some plastics wastes as fuel appears to be the most feasible current method for plastics to be a part of movement toward circular economy.

The USA can transform current stalled inefficient plastics recycling operations and create innovative solutions. Creating an effective infrastructure is a key to achieve transformation and the solutions can be listed as follows (Bara and Leonard 2018):

– Producing plastics from nonfossil feedstocks
– Displacing fossil energy by renewable energy during the production and distribution of plastics

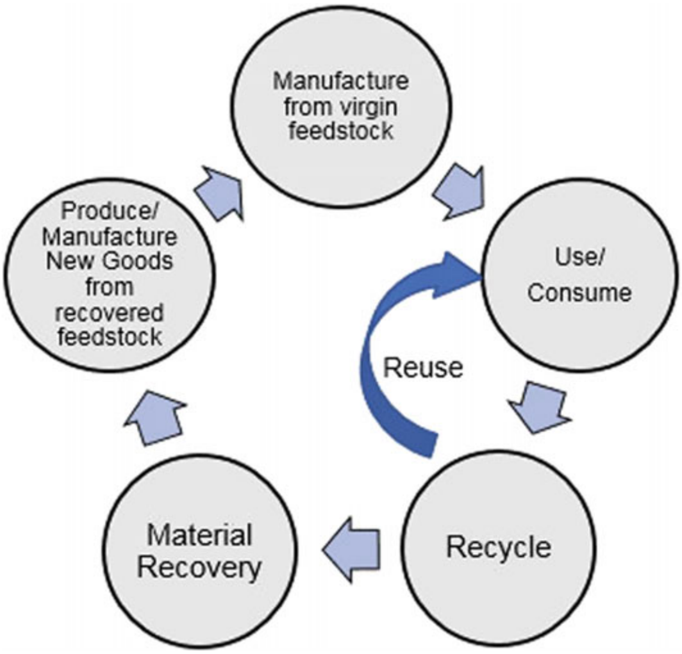

Fig. 3 Closing the loop for circular economy

- Market transformation through technological innovation: Researching and developing new production processes to achieve longevity, reusability, and reduce the waste
- Considering plastic waste as a resource
- Developing new sustainable business models
- Market-based incentives
- Development of new institutional infrastructure
- Supportive regulations
- Collaboration between researchers, businesses, consumers, and decision makers
- A systems approach to identify the opportunities and creating an ecosystem that strategies and policies can impact each other efficiently.

References

Bara, R., & Leonard, S. A. (2018). Plastics and the circular economy. A STAP document.

California Legislative Information. (2018). https://leginfo.legislature.ca.gov/faces/billCompareClient.xhtml?bill_id=201720180SB1335.

Hoomweg, D., Bhada-Tata. P., & Kennedy, C. (2013). Waste production must peak this century. *Nature, 502*, 615–617.

Kok, L., Wurpel, G., & Ten Wolde, A. (2013). *Unleashing the power of circular economy*. Amsterdam, Netherlands: IMSA and Circle Economy.
Lahti, T., Wincent, J., & Parida, N. (2018). A definition and theoretical review of circular economy, value creation, and sustainable business models: Where are we now and where should research move in the future? *Sustainability, 10,* 2799–2817. https://doi.org/10.3390/su10082799.
Michelini, G., Moraes, R. N., Cunha, R. N., Costa, J. M. H., & Ometto, A. R. (2017). From linear to circular economy: PSS conducting the transition. *Procedia CIRP*, 2–6. https://doi.org/10.1016/j.procir.2017.03.012.
Product Stewardship Institute. (19 July, 2019). *Waste Advantage Magazine*. https://wasteadvantagemag.com/extended-producer-responsibility-epr-proposal-for-packaging-hits-the-national-stage/.
Rajbanshi, R. (19 July, 2019). Upcoming California law could set stage for recycling definition debate. *Waste Dive.*. https://www.wastedive.com/news/upcoming-california-law-could-set-stage-for-recycling-definition-debate/559078/.
USEPA. (2014). Protecting communities-restoring land-conserving resources: RCRA's Critical Mission & The Path Forward. https://www.epa.gov/sites/production/files/2015-09/documents/rcras_critical_mission_and_the_path_forward.pdf.
USEPA. (2018). Advancing sustainable materials management: 2015 fact sheet-assessing trends in material generation, recycling, composting, combustion with energy recovery and landfilling in the United States.
USEPA. (2019). Plastics: Material-Specific Data. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data.

Circular Economy in Vietnam

Huynh Trung Hai, Nguyen Duc Quang, Nguyen Trung Thang and Nguyen Hoang Nam

Abstract The chapter presents the situation of waste generation and waste management in Vietnam, a middle-income country that has the fastest growth economies within the last 30 years. Along with the development, the country is now faced with the increase of waste in many types, especially the domestic waste, while the infrastructure for waste management is still inadequate. Vietnam has not any specific term on circular economy; nevertheless, the necessary of circle the natural resources has been emphasized in many momentous legislation documents and also found in many actual sub-models for recycle and reuse of waste. In fact, the volume of recycled materials in Vietnam is still small comparing to the input of the economy, and still far from its target on reducing the landfill rate of collected waste. Because of that, in the near future, Vietnam is still focused on 3R policy to build a proper infrastructure before applying the circular economy concept and frame for the sustainable development of the country.

Keywords Vietnam · Circular economy · Recycling · Waste management

1 Introduction

Vietnam is located in Southeast Asia region with an area of 330,000 km^2. The country's population continues to increase from 86.95 million in 2010 to 94.67 million in 2018 (General Statistics Office of Viet Nam 2018). Since 1986, Vietnam's economy has experienced impressive growth with average rate GDP 6.63% per year in the period of 1986–2017, and GDP growth rate in 2018 was the highest in ten years, at 7.08% (Fig. 1). This has brought Vietnam into the world's fastest growth economies and transformed Vietnam from poor to a middle-income country. At the end of 2018, the size of the economy has increased by over 17.4 times, from US$ 14 billion in

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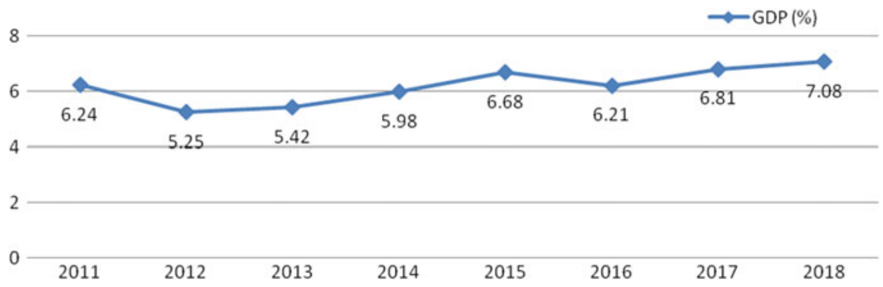

Fig. 1 Vietnam GDP growth 2011–2018. *Source* Adapted from GSO (2018)

1985 to US$ 224 billion in 2018, ranking 44th in the world by nominal GDP and 34th by purchasing power parity. This economic growth is due to strong industrialization of the country in the last 30 years since the adoption of renovation policy.

Vietnam is also experiencing rapid urbanization. In 2018, there have been 828 urban areas/cities in the country, including 02 municipalities, 19 grade I, 24 grade II, 46 grade III, 85 grade IV, 652 grade V cities; and the urbanization rate reached 38.4% (increased 0.9% in comparison with that in 2017) (MOC 2019). Urban population has increased from 26.5 million people (accounted for 30%) to about 33.8 million people in 2018 (accounted for 36%) (Fig. 2).

Rapid population growth, industrialization, and urbanization have led to a significant increase in waste generation, especially in urban solid waste in Vietnam.

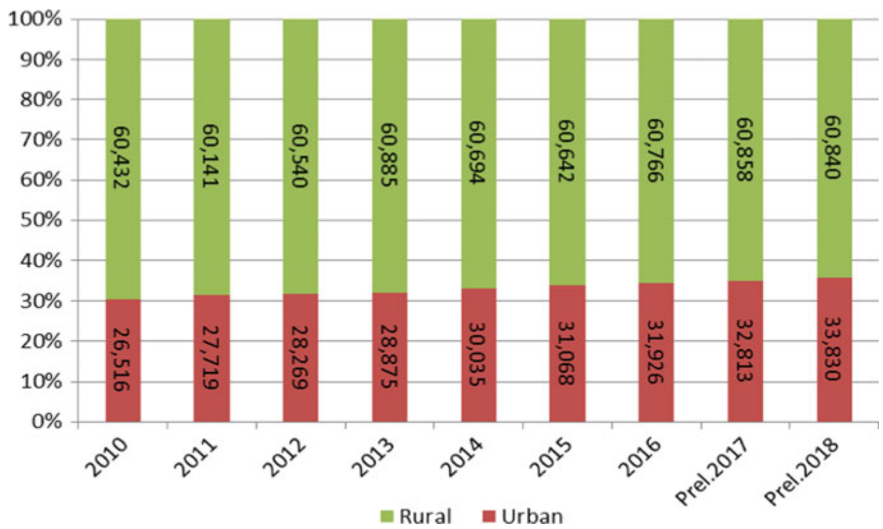

Fig. 2 Vietnam population 2010–2018. *Source* Adapted from General Statistics Office of Vietnam (2018)

Besides, with increasing middle-income population and fast development of electronics and information communication technology (ICT) such as mobile phone, air conditioner, and other products (Table 1), while consumption pattern is still unsustainable, the country has also faced emerging issues such as e-waste, marine plastic debris, construction waste.

Waste generation in Vietnam is increasing. The volume of generated household solid waste in 2018 is about 25.5 million tons, in which urban household waste is about 38,000 tons/day and rural household waste is 32,000 tons/day (Ministry of Natural Resources and Environment 2018). The organic material accounts for 50–60% of the household waste (Ministry of Natural Resources and Environment 2015). It is forecast that the household waste increases by 10–16% per year (Ministry of Natural Resources and Environment 2017).

With regard to waste management, although regulated by the law, generally, household waste has not been separated at source. The collection rate of municipal solid waste (MSW) is quite high in urban area, 85–85.5%, but still low in a rural area—just 40–55% (Ministry of Natural Resources and Environment 2018). Waste recycling is still low, estimated as about 8–12% of the total generated MSW (Ministry of Natural Resources and Environment 2011). Recycling activities are usually implemented by informal sector, carried out in households in craft villages with rudimentary technologies, and causing environmental pollution. Regarding treatment and disposal, nearly 75% of MSW, is still landfilled, mainly in unhygienic dumping sites. Incineration has been implemented in rural area nationwide without energy recovery (Ministry of Natural Resources and Environment 2018). There are few projects on waste-to-energy treatment with waste incineration for electricity generation in Hanoi, Quang Binh, Binh Duong, and Can Tho.

Besides the household waste, hazardous waste (HW), plastic, e-waste, and construction and demolition (C&D) waste are also emerging in Vietnam.

Hazardous waste (HW)

Domestic HW in urban areas includes batteries, accumulators, tube lights, which have not been collected and treated separately but discharged with domestic solid waste to landfills. The rate of HWs in domestic waste brought to landfill is about 0.02–0.82% of total MSW (Ministry of Natural Resources and Environment 2016).

Medical HW accounts for about 20% of medical solid waste, mainly pathological and infectious waste. The medical HW of 40% hospitals and health facilities is incinerated in 2017 (Ministry of Natural Resources and Environment 2017). There are still hospitals which do not have specialized incinerators and treat the HWs in manual incinerators or discharge directly to ordinary landfills.

Industrial HW is mostly generated from light industries, chemicals, and metallurgy and has been estimated to account for about 15–20% of total industrial solid waste (Ministry of Natural Resources and Environment 2017). In 2016, the amount of industrial HWs generated nationwide was about 874,588 tons (Government Party Committee 2018). In addition, HW is also imported under scraps such as metal scraps, plastic, rubber tires, automobile and vessel cover with impurities, lead batteries, and

Table 1 Quantity of some manufactured electronic products in Vietnam (2006–2016)

Products	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Printer *(Thous. pieces)*	–	–	8955.9	9,420.5	23,519.2	15,467.9	15,721.7	29,629.4	27,465.8	25,820.1	25,847.6
Telephone *(Thous. pieces)*	–	–	3,210.9	9,120.9	9,405.7	11,047.8	9,680.5	5,531.2	5439.5	5868.1	5654.4
Mobile phone *(Mill. pieces)*	–	–	0.0	6.4	37.5	79.6	109.4	132.0	181.4	235.6	193.0
Assembled television set *(Thous. pieces)*	2445.6	2927.5	3106.7	3005.9	2800.3	3099.2	2600.4	3112.3	3425.9	5512.4	10,838.6
Digital camera *(Thous. pieces)*	–	–	3750.7	3158.7	3273.0	1468.9	0.0	0.0	0.0	–	–
Batteries (1.5 V) *(Mill. pieces)*	277.3	342.8	330.4	393.2	397.0	415.1	443.9	423.9	457.9	474.0	508.7
Household fridge and freezer *(Thous. pieces)*	793.4	946.1	1000.8	1306.8	1540.9	1507.1	1632.2	1734.9	1521.5	1610.4	1600.5
Household washing machine *(Thous. pieces)*	339.8	414.5	532.2	491.4	467.4	656.1	851.3	930.9	916.4	1284.8	2040.1
Household electric fan *(Thous. pieces)*	1809.6	2930.7	2914.7	5561.0	7174.1	7045.8	5905.0	5336.4	5524.4	6694.0	6770.5
Air conditioner *(Thous. pieces)*	189.0	284.5	313.1	325.2	343.7	355.3	393.4	414.1	286.6	534.3	613.5

Source General Statistic Office (2018) used electronic products (such as computer monitors, electronic circuit boards). The number of illegal import of HWs has been recorded over the years: In 2011, 17 cases with 573 tons of HWs were detected and 30 cases with 3868 tons in 2012 and 13 cases with 323 tons were detected until July in 2013 (Ministry of Natural Resources and Environment 2015).

The amount of industrial HWs has been collected and treated increasing year by year, 165,624 tons in 2012, 186,657 tons in 2013 (increased 12.7% compared to 2012), 320,275 tons in 2014 (up 93.4% compared to 2012), nearly 400,000 tons in 2015 (Ministry of Natural Resources and Environment 2015), and 752,181 tons in 2016 (reaching the collection and treatment rate of 90%) (Government Party Committee 2018). By March 2018, there are 114 HW treatment facilities licensed by MONRE nationwide (Government Party Committee 2018). Most HW treatment facilities are private enterprises (accounting for 97%). The collection, transportation, and treatment of HWs in remote areas still face many difficulties, especially for the owners of HWs generation with a small amount (<0.6 tons/year) because it is hard to find the treatment facilities for signing treatment contracts.

Plastic Waste

Globally, 322 million ton of plastic were produced in 2015 (Plastic Europe 2017), and the production and consumption of plastic products made up nearly five million tons in 2015 in Vietnam. In 1990, plastic consumption per capita only was 3.8 kg/year; however, it increased fast to 41 kg/year in 2015 (*Vietnam Plastic Association*).

There is no official statistics of plastic waste; however, Vietnam has been reported to be the fourth in top five countries in marine plastic waste generation and discharged around 0.28–0.73 tons marine plastic debris annually (Jambeck et al. 2015). According to a World Bank study, lower middle-income countries including Vietnam have the percentage of plastic waste of 12% (Hoornweg and Bhada-Tata, 2012) of total municipal solid waste (MSW). MONRE also estimated that plastic waste accounts for about 8–16% of the total going into a landfill (MONRE 2011). It is estimated that the number of plastic bags used is over 30 billion bags per year, and only a small proportion of about 17% of the bags are regularly reused; the rest becomes waste after a single use (MONRE 2012). Two big cities, Hanoi City and Ho Chi Minh City, generate averagely about 80 tons of plastic waste and bags per day. Plastic bags account for 7–8% the waste generated in Hanoi and about 10% in Ho Chi Minh City (Ministry of Natural Resources and Environment 2017).

Plastic bags are taxed in Vietnam (50,000 VND/kg) according to the Law on Environmental Tax. However, environmentally friendly plastic bags are exempted from the tax. Till 2018, there are 43 products of 38 companies that have been certified by the Ministry of Natural Resources and Environment (MONRE). In Vietnam, plastic waste has not been treated separately but usually landfilled together with MSW.

E-waste

In Vietnam, e-waste comes from four main sources: households; offices; industry; and used electronic equipment imported from abroad. Vietnam has no official statistics of

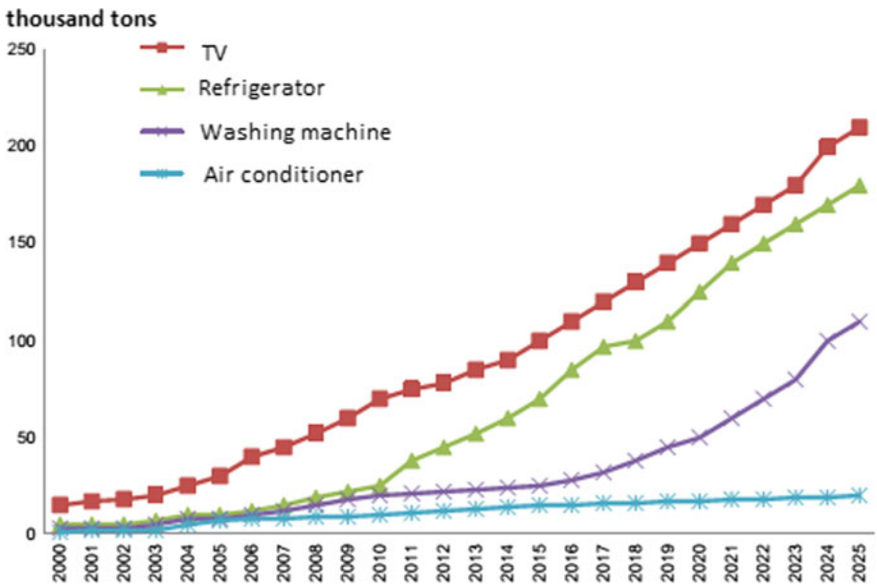

Fig. 3 Increase of electronic equipment waste in Vietnam. *Source* Nguyen et al. (2009)

e-waste but only estimated data in several researches. According to an international study, Vietnam created 116 thousand tons e-waste with 1.3 kg/inhabitant compared with 16 million tons, which represented 3.7 kg/inhabitant in Asia and 41.8 million ton in the world in 2014 (Baldé et al. 2015). This number is increased to 141,000 tons in 2016 (Baldé et al. 2017). Nguyen et al. (2009) also estimated over 110 thousand tons of e-waste generated in Vietnam in 2014, and the amount tends to increase in the coming years (Fig. 3).

Potential for resource recovery from e-waste is high because iron and steel constitute about 50% of the e-waste, followed by 21% of plastic, 13% of nonferrous metals, and others (UNEP 2007).

E-waste is classified and managed as HW in Vietnam and the extended producer responsibility (EPR) mechanism has been applied since 2016. However, there is still a large gap between regulations and implementation. It is hard to operate the taking-back system when currently informal sector plays a main role in e-waste treatment. Instead, e-waste is usually collected and separated by private collectors and then sold to maintenance/refurbishing shops and dismantling facilities. Valuable parts and materials are sold to private maintenance system and will be used to repair other damaged. Most valuable materials such as iron, copper, aluminum, and plastic are recycled with outdated technology, rudimentary equipment, and causing serious environmental pollution (MONRE 2011).

Construction and Demolition Waste (CDW)

CDW is composed mainly of sand, broken bricks, glass, concrete, and metal and accounts for about 10–15% of urban solid waste. In municipalities include Hanoi and Ho Chi Minh City, construction solid waste accounts for 25% of urban solid waste (Ministry of Natural Resources and Environment 2017). In other provinces, CDW accounts for 12–13% of urban solid waste (Ministry of Natural Resources and Environment 2017). The management of CDW has not been paid attention to, in many places, the CDW owners (or collecting and transporting facilities) dump solid waste to roads, vacant areas and drainage canals, polluting the environment, landscape, clogging the drainage system. CDW often buried together with domestic solid waste.

2 Resource Consumption and Utilization in Vietnam

2.1 Legislation on Circular Economy

Together with the development of economy and living standard, the natural resource consumption is also increasing tremendously and leads to the need for utilization of a limited resource to serve a new emerging economy in Vietnam.

Up to the present, even the circular economy term is not referred in any legislation; nevertheless, the Vietnamese Government has made the great effort for the minimization and utilization of resources consumption in many fields of the economy.

In term of legislation, the National Plan on Environment and Development for the period 1991–2000 (*issued by the Decision No. 187-CT dated June 12, 1991*) is considered as first strategic foundation for sustainable development in Vietnam, though it did not refer directly to the minimization of resources consumption and utilization of natural resources. Nevertheless, under the deployment of this plan, the first Environmental Protection Law (No. 29-L/CTN dated 27 December 27, 1993, of the National Assembly Chairman), in the Article 1, has declared that: "Environmental protection stipulated in this law are activities to keep the environment clean, clean, improve the environment, ensure ecological balance, prevent, and overcome bad consequences of people and natural disasters to the environment, ***exploitation, and use reasonably economically the natural resources.***" This oriented idea has been repeated in many following legislation documents such as the Directive No. 36/1998/CT-TW of the Political Bureau (dated June 25, 1998) and the Resolution No. 41/NQ-TW (dated November 15, 2004) on Environmental Protection in the period of accelerating industrialization and modernization of the country, the Environmental Protection Law 2005 (*No. 52/2005/QH11 dated November 29, 2005*). Among these documents, the Resolution No. 41/NQ-TW, which legalized by Decision No. 34/2005/QĐ-TTg dated February 22, 2005, by Prime Minister highlights environmental protection policy in combination with socioeconomic development is the first legislation that is referred to the term *"waste reuse and recycle"* (without *reduce*). In the Environmental Protection Law 2005, in Article 3, the term "*reduce, reuse and recycle of waste,*" or 3R, is first time denoted, and 7 years after, it is the first time "*solid waste reuse and recycle*" is considered as an indicator for monitoring and assessing results of environmental protection to 2020 (*on the National Strategy on Environment Protection to 2020, with Visions to 2030, which was approved by the Prime Minister in his Decision 1216/QĐ-TTg on September 05, 2012*).

In case of MSW, landfill is still dominated treatment method in Vietnam despite many efforts of the Government to promote 3R initiative. Although it is known as the most useful and cost-effective treatment, composting is taken a very small proportion (Luong et al. 2013). In 2006, under the funding and aids from JICA (~3 million USD), Hanoi is the first city in Vietnam has been deployed a 3R project which is based on the segregation at source of municipal solid waste. The objective of this 3-year project is to establish a harmonious 3R system, to encourage people to segregate their waste at home to improve the MSW management and disposal capacity in Hanoi. These kinds of MSW are recommended to classify organic waste, recyclable wastes, and non-biodegradable wastes. The project ended with an acceptable result, especially the changing of social awareness on waste classification. 80–90% waste is sorted, helps reducing 30–40% of the amount of waste to landfill, saving disposal costs, reducing environmental pollution, and even producing organic fertilizer from segregated organic waste, bringing economic efficiency. Nevertheless, after 10 years, it is not found any applicable to maintain and extend the result, mostly because lacking a proper infrastructure to deal with the sorted waste flows, as well as lacking sustainability in policy.

2.2 Situation on Resource Consumption and Utilization

In fact, as in many developing countries, Vietnam has been conducted 3R model for a long time, especially in agriculture field. Starting from the utilization of cultivation and breeding wastes, it was extended into different types of closed farm that now have been developed all over the countries. In the case of industry, the recycling of metals, paper, and plastic has been conducted from 1960s, mostly for providing the materials for production industry, which was still limited even in term of scale, capacity, and sources. The recycling activities were boomed in 1990s, just after the beginning of ***Doi Moi*** process, when the government untied the private sector for economic activities, with the development of "craft villages," the term referred to "one or more residential areas of villages or other similar residential points in a commune or town that have rural professions producing one or more different types of product" (*Circular No. 116/2006/TT-BNN dated December 18, 2006, providing guidance on implementation of some articles of the Government's Decree No. 66/2006/ND-CP dated July 7,* 2006, *on development of rural professions*). Up to 2014, there were 5096 craft villages nationwide, of which 1748 villages were officially recognized, attracting about 11 million workers, the average income of village workers is 2–3 times higher than that of agricultural workers (Ministry Agriculture and Rural Development. *Research topics of socioeconomic efficiency in the development of craft villages nationwide. Survey of craft villages of MARD*, 2014). Among these craft villages, there are about 100 recycling craft villages, with 80% is metal recycling villages, the others are paper and plastic recycling. The properties of these recycling villages are: (1) not regulated by any specific laws and regulations; (2) informal sector that uses rudimentary, simple and backward technologies that do not meet technical and environmental protection requirement; (3) low quality and production efficiency; and (4) dealing mostly with the domestic scrap, which is normally polluted and not well-sorted.

In other side, waste and scraps are important input sources for the industry. In several industry branches such as steel and paper production, it is accounted up to 50% of the required demand. Especially in case of paper industry, nearly 70% production is from scrap, while 60% steel facilities are used scrap as major input source (electric arc furnace—EAF). All the paper facilities in Vietnam are now attached with scrap reproduction line. Nevertheless, only a part of domestic scrap (waste) is used, due to their low quality and small collected volume (that have been done by the private sector). For steel production, Vietnam is needed about 20 million tons of steel ingot, while only produces 11.4 million tons of steel ingot (billet and slab) in 2017 (Khai 2018). To serve the material requirement of EAF facilities, it is needed over 9 million tons of scrap steel in 2017, in which the imported scrap accounted for more than 50% as seen in Table 2 (4.7 million tons). This number in 2013 was only 5.6 million ton of scrap, in which, 2.3 million ton is imported.

The domestic paper industry is produced about 3 million tons out of 4.5 million tons demand for pulp and paper, including 3.5 million tons of packaging paper in 2017 as seen in Table 3. According to Ministry of Industry and Trade (Ministry of Industry and Trade 2018), about 70% material input is paper scrap (mostly to server the packaging production). Out of 2 million tons of scrap, only 40% comes from domestic sources, and the rest is imported.

In case of plastic industry, the demand material for plastic production is estimated at about 5 million tons of plastic in 2018 and will reach 10 million tons on 2023 according to the Vietnam Plastic Association (Vietnam Plastic Association 2018). Nevertheless, the domestic supply is only 780 thousand tons of virgin plastic pellets (up to May 2018) and about 400 thousand ton of recycled plastic pellet, and the rest is based on the imported pellet and scrap (which is predicted to reach 3 million ton on 2023).

Table 2 Demand of billet, steel scrap, and imported steel scrap of Vietnam (Mill. ton)

Demand	2015	2016	2017	6 first months 2018 (estimated data)
Billet	5.6	7.8	11.4	6.2
Billet from BOF	1.4	2.3	4	2.7
Billet from EAF	4.2	5.4	7.5	3.5
Scrap demand for EAF	5	6.5	9	4
Domestic supply scrap	1.7	2.5	4.3	1.5
Imported scrap	3.3	4	4.7	2.5

Source MOIT (2018)

Table 3 Consumption demand, scrap, and imported paper scrap of Vietnam (1000 ton)

Demand	2017	2018
Total product demand	4265	4942
– Packaging paper	3179	3818
Total production	2801	3764
– Packaging paper	2219	3046
Domestic supply scrap	–	1682
Imported scrap	1400	2068

Source Vietnam Pulp and Paper Association VPPA, 2019, can be obtained from: http://vppa.vn/thi-truong-giay-nam-2018-va-du-bao-nam-2019/

The imported scrap of steel, paper, and plastic is summarized in Table 4, showing the fact that instead of the utilization of the domestic resources (including wastes), Vietnam is still depended on the imported scrap and waste, despite its efforts on management of domestic waste and scrap.

Besides, fly ash and slag from thermo power plants are also can be reused in high amount by the construction material production industry, such as mineral additives for cement production, concrete additives, concrete and light concrete mixer, autoclaved aerated concrete mixer, unburned brick, construction backfill material. According to the Decision 452/QD-TTg of the Prime Minister, up to 2020, 56 million ton of fly ash and slag will be reused as:

– 14 million ton for mineral additives for cement production;
– 8 million ton for mixer in clinker production (replace clay);
– 7 million ton for brick production;
– 2 million ton for mineral additives in concrete production and unburned brick;
– 25 million ton for construction backfill material.

Table 4 Imported turnover of scrap

Type of scraps	HS code	2016		2017		6 first months 2018	
		Volume (thousand ton)	Venue (million USD)	Volume (thousand ton)	Venue (million USD)	Volume (thousand ton)	Venue (million USD)
Plastic scrap	3915	245.8	43.5	385	70.9	277.7	63.3
Paper scrap	4707	641.3	126.5	1438.5	340.6	1062.3	209.8
Steel scrap	7204	3895.5	870.7	4727.8	1396.6	3480[a]	1.220[a]

[a]8 first months of 2018
Source Estimated from General Statistic Office and General Department of Customs's data)

Besides, it is needed to count 19 million tons of gypsum (flue gas desulfurization gypsum from thermo power plants and phosphor gypsum from chemical and fertilizer plant), which can be reused in cement and gypsum production, as well as backfill material for construction.

Recycling rate of organic waste from MSW and other common materials such as paper, plastic, glass and iron, copper, lead, aluminum is accounted for about 8–12% of collected urban MSW (MONRE 2011). Since there is not any clear and official statistic to estimate the reuse and recycling rate, based on the above data, the recycling rate can be estimated less than 10% of domestic and industrial waste, in average. It is not considered the recycling and reuse waste from agriculture and other productive sectors. The number is still far compared to the target of the National Strategy on Integrated Solid Waste Management to 2025 to reduce the landfill rate under 30% of collected waste.

3 Legislative Framework and Government Supports Toward Implementing 3Rs and Circular Economy Initiatives

As discussed elsewhere, the issues of natural resource depletion, pollution, and climate change risk have raised the need for a change in the development model of Vietnam, where a transition from a linear economy to circular economy could be sensible. Therefore, some legislative framework to support the transition has been forming gradually in the country.

3.1 Documents of the Communist Party

Resolutions, directives, and documents of Congress of the Communist Party of Vietnam (CPV) are known to play top roles in orienting and guiding the socioeconomic development of the country. Accordingly, the State Government would establish national strategies, action programs, or action plans to specify and implement the orientation. Some key documents related to are discussed in chronological order to highlight the development of Vietnam's orientation toward circular economy over time.

– *Directive No. 36/1998/CT-TW by the CPV in 1998*

This directive was the first document to address the need of clean technologies "*to consume less raw materials, reduce energy leakages and waste*" in industrial production (Communist Party of Vietnam, Political Bureau 1998), which were partly aligned with today's concepts of circular economy.

– *Resolution No. 41-NQ/TW by the CPV in 2004*

This resolution set the first basis for reduce, reuse, and recycle (3Rs), cleaner production, extended producer responsibility (EPR) and renewable energy in Vietnam by stating the following task.

> Encouraging the thrifty use of natural resources and energy; producing and using clean energy, renewable energy, products and product packaging that are not harmful or less harmful to the environment; Recycle and use recycled products. To step by step apply measures to force producers and importers to recollect and manage the used products that they produced and/or imported. (Communist Party of Vietnam, Political Bureau 2004)

Accordingly, in 2005, the State Government established an Action Program with 12 main tasks and 16 actions for ministries to implement Resolution No. 41-NQ/TW (Government of Vietnam, Prime Minister of Vietnam 2005). Noticeably in there, Task 6 directed that "*Promote the formulation and replication of cleaner production models, forming and developing environment industry, creating markets, promoting environmental service enterprises, developing environmental economy*"; and Task 10 is to "*Exploiting and using natural resources economically and efficiently, issuing and implementing policies to encourage thrifty consumption, use of renewable energy, clean energy, limit exploitation, and use of fossil fuels.*" Following the government's action program, many Provincial People's Committees (PPCs) in Vietnam also established their action plans to implement the tasks at a provincial level.

– *Directive No. 29/CT-TW by the CPV in 2009*

This directive was to affirm the continuous implementation of the tasks set by Resolution No. 41-NQ/TW in the new period of development (Communist Party of Vietnam, Secretariat Committee 2009). In addition, it also emphasized the need to enhance the production and use of environmentally friendly products. This was later followed up by Resolution No. 06/NQ-CP of the State Government, which assigned the National Action Program on Sustainable Production and Consumption to the Ministry of Industry and Trade (MOIT) for implementation (Government of Vietnam 2012d).

– *Socioeconomic Development Strategy period 2011–2020 by the CPV in 2011*

The Socioeconomic Development Strategy was established in the Document of the Eleventh Party Congress. It set an overall objective of "fast and sustainable development" for the country (Communist Party of Vietnam, The 11th Central Executive Committee 2011). The strategy continued to emphasize the principle of "*Managing, exploiting and using resources effectively*" and "*Developing environmentally friendly and green economy; conducting sustainable production and consumption; gradually develop clean energy, clean production, clean consumption.*" In addition, it set some detailed environmental targets, such as 95% of solid waste, 85% of hazardous waste, and 100% of medical waste from cities were treated. However, there was not any target for recycling.

– *Resolution 24-NQ/TW by the CPV in 2013*

The resolution emphasized the principle of efficient exploitation and use of natural resources, enhancing the use of renewable energy, new materials and promoting recycling. Most importantly, it set a task of "*transformation of economic growth model associated with restructuring the economy toward green growth and sustainable development*" (Communist Party of Vietnam, 11th Central Executive Committee, 7th Congress 2013). This indicated that the party had recognized the need, and it desired for a transformation of the economy. This was the second time in the history that such desire for an economic transform was expressed in a document of CPV. The first time was seen during the renovation "Doi Moi" in 1986 (Van Arkadie 2003), which was the biggest milestone of Vietnam's economy, resulting in unprecedented rapid growth for a decade later (Nguyen 2014, p. 10).

Accordingly, the State Government established an Action Program of nine main tasks in 2014 to implement Resolution 24-NQ/TW (Government of Vietnam 2014b). In there, Task 3 directed that "*Continue establishing and improving policies to encourage, support and promote the use of energy-saving technologies and equipment, water-saving, exploitation and use of renewable energy and new materials, and recycling in production and service activities*", and Task 9 addressed to "*promote the consumption of recycled products and environmentally friendly products.*"

3.2 Legislation and Policies Related to Circular Economy

With the orientation of CPV's documents, the National Assembly and State Government issued plenty of legislation and policies that supported circular economy The system of legal documents in Vietnam is summarized in Table 5.

Firstly, some key laws associated with circular economy are as follows:

– *Law on Environmental Protection in 2005 and in 2014*

Since 2005, the Law on Environment Protection had stated to encourage the development of clean energy, renewable energy, environmentally friendly products, and reduce, reuse, recycle (The National Assembly of Socialist Republic of Vietnam 2005). In 2014, the amended law specified the commitment in 8 Articles. In addition, it even set the first move for green public procurement in Article 44:

> Head of state budget-funded institutions shall bear their responsibility for preferring eco-friendly products and services that have been recognized as ecolabels under legal regulations.
> – Clause 2, Article 44 of the Law on Environment Protection 2014 (The National Assembly of Socialist Republic of Vietnam 2014)

Accordingly, many follow-up legal documents were issued to clarify and implement the commitment of the law. For instance, Decree 19/2015/ND-CP was established to further specify the list of businesses and activities that could get preferential policies and supports from the government (Government of Vietnam 2015); Circular

Table 5 Vietnam's system of legal documents

Authority	Legal documents
National Assembly	Constitution, law, resolution
Standing Committee of the National Assembly	Ordinance, resolution
President of State Government	Order, decision
State Government	Resolution, decree
Prime Minister	Decision, directive
Ministers and head of ministry-level bodies	Decision, directive, circular, joint circular (issued collectively by different ministries or by a ministry and a political and social organization)
Justice Council of the Supreme People's Court	Resolution
Chief Justice of the Supreme People's Court/Head of the Supreme People's Prosecutor	Decision, directive
People's Council	Resolution
People's Committee	Decision, directive

Source Adapted from Nguyen (2014) and Gardner (2019)

No. 128/2016/TT-BTC was issued in 2016 to clarify the export duty exemption and reduction for environment-friendly products and products from recycling and waste treatment (Government of Vietnam, The Ministry of Finance 2016) (Table 6).

– *Mineral Law in 2010, Law on Water Resources in 2012, and Land Law in 2013*

All of the three laws emphasized a principle that resources must be exploited and used in a thrift, safe and effective manner, ensuring integrated, multi-purpose, fair and reasonable use, harmony of benefits and equality in interests and obligations among organizations and individuals (The National Assembly, The National Assembly of Socialist Republic of Vietnam, 2010; 2012, 2013).

In addition, the State Government issued plenty of strategies (which were approved by Prime Minister's decisions) that supported one or more aspects of circular economy as follows:

– *Sustainable Development Strategy of Vietnam period 2011–2020* included a task to build a system of integrated solid waste management, in which solid wastes are classified at source, collected, reused, recycled, and thoroughly treated with appropriate advanced technologies (Government of Vietnam, Prime Minister of Vietnam 2012a). However, up to date, only Ho Chi Minh City established Decision 44/2018/QD-UBND to regulate the municipal solid waste classification in the city (Ho Chi Minh City People's Committee 2018) (Table 6).
– *National Strategy on Environment Protection by 2020, with a vision toward 2030* detailed plenty of measures to enhance cleaner production and reduce, reuse, recycle (3R) (Government of Vietnam, Prime Minister of Vietnam 2012b).

Table 6 Summary of key legislation and policies related to circular economy in Vietnam

Life cycle stages	Key legislation and policies
All stages	– Law on Environmental Protection in 2014 stated to encourage the development of *clean energy, renewable energy, environmentally friendly products and reduce, reuse, recycle* – National Strategy on Environment Protection by 2020, with a vision toward 2030 detailed plenty of measures to enhance the *reduce, reuse, and recycle (3R) and cleaner production* – National Green Growth Strategy addressed the task of promoting 3R, improving *energy efficiency, sustainable production, sustainable consumption and lifestyle* – National Action Plan on Sustainable Production and Consumption up to 2020, with a vision to 2030 set six comprehensive tasks and detailed goals for the period of 2016–2020 and 2021–2030 – Decision No. 1469/QD-TTg approved the Master Plan on development of Vietnam's construction material industry through 2020, with a vision toward 2030 and set *the tasks of improving resource and energy efficiency, reuse and recycle of construction material*
Resource extraction and production	– Mineral Law in 2010, Law on Water Resources in 2012 and Land Law in 2013 – Strategy on Cleaner Production in Industry to 2020 set 4 tasks and 4 measures to develop the model of *cleaner production in industry* – Decision 403/QD-TTg approved adjusted master plan for Vietnam's coal to improve the effectiveness and thriftiness of exploitation, processing and use of coal
Distribution and consumption	– Circular No. 128/2016/TT-BTC clarified the *export duty exemption and reduction for environment-friendly products and products made from recycling and waste treatment* – Decision 16/2015/QD-TTg regulated recollection and treatment of discarded products (including *e-wastes, some hazardous waste, and end-of-life vehicles*) – Resolution No. 579/2018/UBTVQH14 (on environmental tax) set a tax of VND 50.000 per kilogram of plastic bag

(continued)

Table 6 (continued)

Life cycle stages	Key legislation and policies
Waste collection and management (i.e., MSW, e-waste, plastic wastes, hazardous wastes)	***All waste management***: – Sustainable Development Strategy of Vietnam period 2011–2020 included a task to build *a system of integrated solid waste management* – Decree 38/2015/ND-CP regulated management of wastes and discarded materials (including *municipal solid wastes, industrial wastes, biochemical wastes, some hazardous wastes, and imported plastic wastes/scraps*) – Decree 19/2015/ND-CP provided *a list of environmental protection activities (including waste management) that would be supported and prioritized by the government*; and Circular No. 212/2015/TT-BTC provided detailed guidelines for the *tax incentives for environmental protection activities (including waste management)* ***MSW management***: – National Strategy for General Management of Solid Waste to 2025, with a vision toward 2050 addressed plenty of *measures to improve the classification, collection, reduce, reuse, and recycle of MSW* – Decision 44/2018/QD-UBND of Ho Chi Minh City People's Committee in 2018 regulated the MSW classification in the city ***Hazardous waste management***: – Circular 36/2015/TT-BTNMT provided a list of hazardous wastes and regulated the hazardous waste management – Circular 58/2015/TTLT-BYT-BTNMT detailed regulations on *medical waste* management for recycling purposes – Circular 08/2017/TT-BXD detailed regulations on reusing and recycling of *construction solid waste*

The measures included improving institution and legal system for 3R, reducing the production and use of bags, and packaging that are difficult to decompose, waste-recycling capacity building programs, supporting the establishment of recycling businesses, forming concentrated recycling industrial zones, technology exchanges, market development of recycled products, financial supports for recycling products, enhancing producer responsibility. This strategy was then followed by a plan for implementation (Government of Vietnam, Prime Minister of Vietnam 2014a), Decision 50/2013/QD-TTg and Decision 16/2015/QD-TTg that regulated the recollection and treatment of discarded products (Government of Vietnam 2013; 2015) (Table 6).

– *National Green Growth Strategy* also addressed the task of promoting 3R, improving energy efficiency, sustainable production, and sustainable lifestyle and consumption (Government of Vietnam, Prime Minister of Vietnam 2012c). Noticeably, this was the first strategy to recommend an establishment of Recycling Law.
– *Strategy on Cleaner Production in Industry to 2020* set four tasks and four measures to develop the model of cleaner production in the industry (Government of Vietnam 2009).
– *National Strategy for General Management of Solid Waste to 2025, with a vision toward 2050* addressed plenty of measures to improve the classification, collection, reduce, reuse, and recycle of solid waste (Government of Vietnam, Prime Minister of Vietnam 2018). In addition, the strategy also set numerous targets, i.e., by 2025, replacing all normal plastic bags by eco-friendly plastic bags at commercial centers and supermarkets, 80% of sub-products from agriculture must be collected, reused, recycled into environmentally friendly raw materials and products.
– *National Action Plan on Sustainable Production and Consumption up to 2020, with a vision to 2030* set six comprehensive tasks and detailed goals for the period of 2016–2020 and 2021–2030. The tasks included not only 3R, energy-saving, and effective use but also changes in supply chains.

Accordingly, the ministries and local governments issued decisions and circulars to implementing the strategies and action plans. Some key legislation and policies are summarized in Table 6.

As can be seen in Table 3, the government has set plenty of legislation and policies related to some aspects of circular economy. However, the current focus is waste collection and management, where some guiding Circulars of Ministries and Decisions of People's Committee have been in issued.

The "upstream" of materials and products' life cycles (e.g., thrifty resource extraction, better designing in production) has not been addressed by such guidance. Even with the "downstream" distribution and consumption, to date, Decision 16/2015/QD-TTg has not been followed up by any guiding circular. Thus, the implementation of the decision on managing e-wastes, hazardous waste, and end-of-life vehicles is relatively limited.

In addition, the current legislation and polices are fairly broad, and there is a lack of specific regulation for particular issues or materials. For instance, there is no specific regulation for plastic waste management. Therefore, some plastic waste is, in fact, regulated in MSW management.

In conclusion, although the term "Circular Economy" has not been officially used in any CPV's document or legislation and policies, many aspects of circular economy have been addressed and supported. They include consuming less raw materials; reducing energy leakages, enhancing the use of renewable energy, limiting the use of fossil fuels; reducing the use of plastic and promoting the use of environmentally friendly products; encouraging reduce, reuse, and recycle (3R); promoting sustainable production and consumption, especially green supply chain and green public procurement. These indicate that the Communist Party of Vietnam and the State Government have great desire for the transition and have actually initiated it toward circular economy. However, some detailed legislation and policies are needed to foster the implementation. In addition, circular economy is not only about waste management but most importantly, it is about restoration and regeneration (Ellen MacArthur Foundation 2012). Thus, resource efficiency and redesign require more attention from policymakers.

4 Example of Best Practices

4.1 Agro and Poultry

Garden–Fishery–Husbandry model (or VAC, in Vietnamese) is a closed farm model that is combined in a farm the cultivation in garden, aquaculture activities in pond and animal breeding. The waste of an activity can be used as the nurture for other activities within the farm. The VAC model can be considered as a high biological intensification model, creating an overall farming system, effectively utilizing resources on land, water, and energy to help achieve high economic efficiency with low investment, while contributing to minimizing environmental pollution. Other similar models are also developed such as Forestry–Garden–Fishery–Husbandry, Garden–Fishery–Husbandry–Field, gradually demonstrating outstanding economic efficiency in the agricultural sector. Nevertheless, such kind of model is still on the progress and faced with many serious issues such as lack of water resources, lack of experience, and much depending on type and price of farm's output (Vu and Son 2013).

4.2 The Use of Fly Ash and Slag from Thermo Power Plant

The ash reprocessing and reuse technology in Vietnam now have a strong development from 1990s, especially after 2005 (Doan and Thang 2010):

- *Early in the 90s*, on March 25th, 1993, the first enrichment factory has been constructed to process the fly ash of Pha Lai Thermal Power Plant, with the capacity of 80,000 tons/year. First 1.200 ton of enrichment ash was transported to Hoang Thach Cement Factory and successfully put it into production. After that, Ministry of Construction has been decided to allow the Pha Lai Plant's ash to be used as an additive for cement production in Hoang Thach, Bim Son, and Hai Phong Plants.
- *From 1997–2005*: The enriched ash and slag have been started to use in large size concrete production for the construction of hydropower dam such as Bai Thuong dam (Thanh Hoa), Tan Giang dam (Ninh Thuan), Long Song dam (Binh Thuan).
- *From 2005–present*: The dissemination of ash reprocessing factory in a larger scale.

Enrichment ash and slag with burning loss rate below 11% can be used for mixing ash into the cement with an average rate quantity between 10 and 20%. Therefore, cement producers also have huge demand for fly ash and slag. For cost reduction and improvement production quality (especially with the large block size concrete, waterproof or anti-heat possibility of concrete), enrichment slag can be mixed with cement with a rate ranged from 20 to 40% (Thang and Quy 2011). Due to that account, the fly ash and slag quantity are needed as additive for cement industry can be increased in the following year.

In general, up to now, many enrichment factories have used the ash and slag reprocessing method to recover coal as a burning agent and produce the various cement and concrete additives with high quality and low cost. The ash reprocessing and reuse technology development were available and conformable with the government's policy and can minimize the environmental pollution impact toward the sustainable development.

4.3 Composting

Composting is an useful form for recycling of organic waste that could help to increase the recycling rate. Municipal solid waste in Vietnam has a high potential for composting since it contains 50–60 of food waste and other biodegradable waste (Ministry of Natural Resources and Environment 2015).

The centralized composting facilities have been operating in Vietnam over the last two decades. In 2011, MONRE reported that about 10 composting facilities with capacity of about 200 ton/day, and 1 composting facility with a capacity of 600 ton/day is in operation. At that time, these plants have not operated enough designed capacity due to the consumption of organic fertilizer and many difficulties in production such as energy consumption, technical problem, impact to environment and more important, the quality of fertilizer that cannot compete with the other kinds. The mixed MSW must be mechanically sort in the facility, and this makes the compost product less purifies and reduces the market of the products. Most of MSW go to composting plant is not in situ separated; thus, the residue after compost process is remained high even in product and coproduct. Hoornweg et al. (2000) also noted for the fail of some Asian countries when relying on mixed municipal waste as their main feedstock due to this.

Possibly thanks to the deployment of the National Strategy for integrated solid waste management, the proportion of MSW composting increases. It is reported that as of November 2016, Vietnam has about 35 centralized solid waste treatment plants with composting line, concentrated in urban areas were invested and put into operation. Total capacity of processing is increase to 7500 tons/day (the average capacity is from 100 to 200 tons/day) with major processing technologies are composting production (25 facilities) and combine with other technology such as combustion or combination (Ministry of Construction and JICA 2017).

4.4 Seraphin Technology

Seraphin technology, similar to some other technologies that are recommended in Vietnam such as ASC technology and MBT-CD-08 technology, is composed of five main technology groups, which can be combined into a closed technological chain system or can work separately as shown in Fig. 4.

The unsorted MSW will be put on the sorting line to sort waste into four main groups including metals, polymer waste (plastic, rubber, leather), biodegradation waste (food waste, garden waste, etc.), and non-biodegradation waste. The sorting line is semi-autooperation together with manual sorting. Metals will be continuously

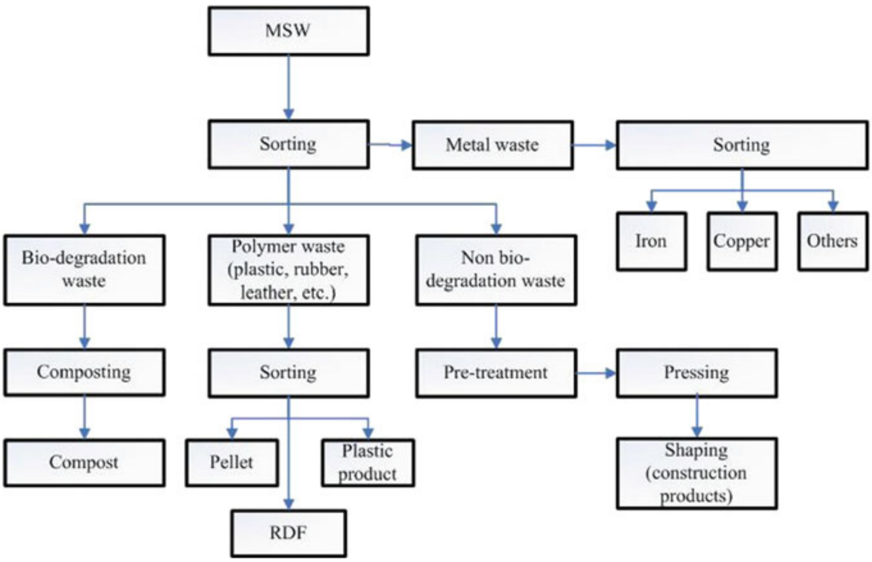

Fig. 4 Seraphin technology and its coproducts

sorted into ferrous and nonferrous metals and then bring to a metal recycling plant. The polymer waste will be sorted into different kinds and then transfer to pellet production, plastic production, and RDF production depending on each kind of material. The biodegradation waste is composted into compost, and the non-biodegradation wastes will be brought to the pressure curing workshop, where they are made into construction product.

This technology can handle most of the components in MSW and is feasible and proper to the composition of MSW in Vietnam.

4.5 Co-processing Technology in Cement Kilns

Co-treatment of hazardous waste in cement kilns requires modern cement production technology as dry technology, pre-baked rotary kiln. Besides, the application of hazardous waste treatment requires careful study of the process of discharging waste into the kiln so as not to affect the cement production process as well as ensuring the efficiency of the production process. Because of that, up to now, the technology is applied in only two cement production facilities in Vietnam, INSEE Ecocycle, formerly known as Holcim Cement Company (Kien Giang), with the capacity of HW treatment is about 242 thousand ton/year and Thanh Cong Group Joint Stock Company (Hai Duong) with the capacity of 190.000 ton HW/year. Figure 5 shown the volume of waste and hazardous waste has been treated in INSEE, and the ratio of waste and HW can be treated in the cement kiln.

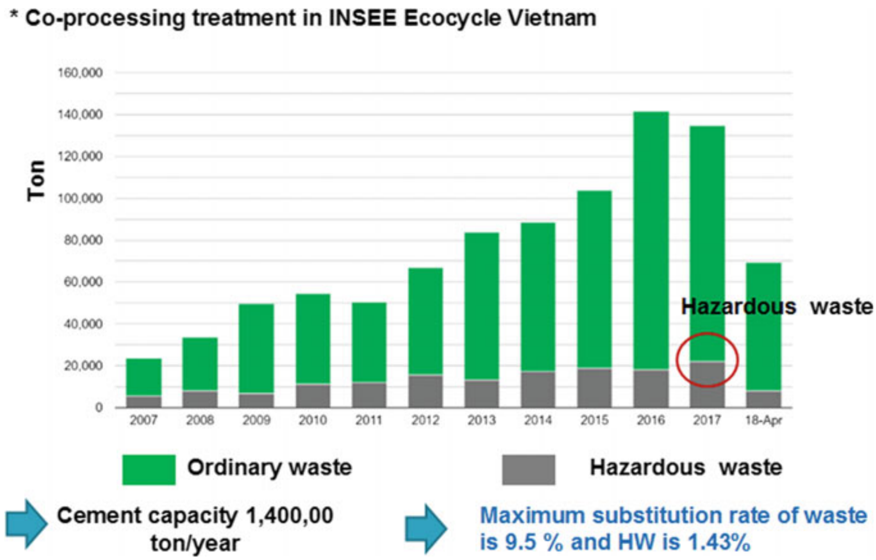

Fig. 5 Waste and hazardous waste co-processing treatment in INSEE Ecocycle Vietnam

The technology of HW co-treatment in cement kilns has many great advantages such as can operate at high temperatures, resulting in high destruction efficiency, handling many types of hazardous waste in large quantities, including waste containing halogen. Especially, it gets great economic efficiency due to saving natural resources including mineral and fossil fuels. In addition, the types of HW treated in cement kilns are also more thoroughly treated, no generating secondary slag ash because the secondary ash has come into the final product. It is needed to consider that these two companies have the largest capacity compared to other hazardous waste treatment plants, 432 thousand tons of hazardous waste/year on a total of 1,300,000 tons of all licensed HW treatment facilities.

5 Future Plans and Targets

In Vietnam, socioeconomic and sector development strategies and master plans are issued for every 10 years while plans are developed for 5 years and every year. The country has just finished many strategies and master plans for the period 2011–2020 and is now preparing strategies/plans for 2021–2030.

As analyzed by Ellen MacArthur Foundation, circular economy comprises of three core principles: (i) conservation and development of natural capital; (ii) optimization of natural resources use by circulating products, materials, and components; (iii) foster system effectiveness by designing and revealing out externalities (Ellen MacArthur Foundation 2017). Thus, circular economy promotes cycles in all stages of product life cycle including exploitation of raw materials, manufacturing, logistics and distribution of products, consumption, and disposal of products.

In that aspect, strategies, and plans related to CE in Vietnam are as follows:

- Socioeconomic Development Strategy for 2011–2020 (SEDS)
- National Strategy for Sustainable Development 2011–2020 (NSSD)
- National Strategy on Environmental Protection to 2020, vision to 2030 (NSEP)
- National Strategy on Integrated Solid Waste Management to 2025
- Revised National Strategy on Integrated Solid Waste Management to 2025
- National Strategy on Climate Change (NSCC)
- National Strategy on Green Growth (NSGG)
- Strategy for Clean Technology Use to 2020, vision 2030 (SCTU)
- National Energy Development Strategy to 2020, with 2050 vision (NEDS)
- Vietnam Strategy for Renewable Energy to 2030 (VNSRE)
- Strategy on Cleaner Production in Industry to 2020 (SCPI)
- National Action Program on Sustainable Consumption and Production (NAPSCP).

Regarding promoting cleaner production and GHG reduction, a number of targets on the improvement of energy consumption, development of renewable energy, cleaner production have been set by different strategies and plans (Table 7). It is observed that, there are lack of specific targets on efficient use of resources, such as water, land, and mineral (e.g., domestic material consumption—DMC). Although

Table 7 Targets for cleaner production and GHG reduction

No	Indicators	Targets, %		Source
		To 2020	To 2030	
I	*Targets for cleaner production and energy recovery*			
1	Rate of high energy-consuming and polluting industries implement road map for renovation toward clean technology	60–70	100	SCTU NAPSCP
2	Percentage of new business and manufacture facilities apply clean technology	100	–	SCTU
3	Rate of production facilities apply cleaner production technologies	50	–	SCPI
4	Reduction of the intensity of energy, raw material, fuel per unit of product	8–13	–	SCPI
5	Share of green industry and waste recycling in GDP	42–45	–	NSGG
6	Level of reduction in energy consumption for producing an unit of GDP	2,5–3/year	–	NSGG
7	Share of renewable energy in total energy consumption	5	–	NSED
8	Rate of livestock waste utilized for biogas	10	50	VNSRE
9	Rate of municipal solid waste treated with energy recovery	30	70	VNSRE
II	*Targets for GHG reduction*			
1	Reduction rate of GHG compared with business as usual (BAU) scenario	–	8	NDC

(continued)

Table 7 (continued)

No	Indicators	Targets, %		Source
		To 2020	To 2030	
2	Average level of GHGs emissions reduction	Reduced by 10–20 from 2010	Reduced by 1–2 per year by	NSGG
3	Reduction of GHG emission in the energy sector compared with the BAU	5	25	NSGG

Source Adapted from different government documents

objectives for resource efficiency have been addressed in a number of policy documents such as Government of Vietnam, Prime Minister of Vietnam (2012b), Government of Vietnam, Prime Minister of Vietnam (2012a), Party Resolution 24-NQ/TW (2013), specific targets for each type of resource (water, land, mineral) have not been clearly set for any specific milestone. There is a very general target of reduction of intensity of energy, raw material, fuel per unit of product to reach 8–13% by 2020 (Table 7). The reason is difficulties in measurement and monitoring of these indicators.

With regard to 3R and waste management, initially, the National Strategy on Integrated Solid Waste Management to 2025 issued in 2009 set a number of targets. Many of these targets were very ambitious, such as a collection of municipal solid waste (MSW) and especially recycling targets (85% in 2020 and 90% in 2025), collection rate in rural area. (Table 8). Recognizing this issue of feasibility of the strategy, in 2018, the Prime Minister has issued a Decision 491/QD-TTg to revise this strategy and a number of targets. According to the revised strategy, collection rate for MSW and rural household waste have slightly reduced to 90% and 80%, respectively, by 2025. A significant change is the inclusion of the target for waste diversion rate from landfilling to reach 70% by 2025.

Besides, the Vietnam Strategy of Renewable Energy to 2030 has also set targets for energy recovery from waste. Specifically, there are two targets: (i) Rate of livestock waste utilized for biogas (10% by 2020 and 50% by 2030) and (ii) Rate of municipal solid waste treated with energy recovery (30% by 2020 and 70% by 2030) (Table 7).

In general, targets for 3R and waste management in Vietnam are quite comprehensive and cover most aspects. However, some there still lack some important targets such as recycling rate of waste, rate of retrieval, and treatment of discarded products under the EPR mechanism. In the coming years, Vietnam must build up a system of database on waste management so that the targets can be monitored sufficiently and adjusted toward feasibility.

Table 8 Targets on 3R and waste management

No	Target	Targets[a], %		Revised and new targets to 2025[b]
		To 2020	To 2025	
1	Rate of municipal waste collection	90	100	90%
2	Recycling rate of municipal waste	85	90	–
3	Collection rate of construction and demolition (C&D) waste in urban area	80	90	90%
4	Recycling rate of construction and demolition (C&D) waste in urban area	50	60	60%
5	Reduction rate of plastics bags in supermarket compared with 2010	65	85	100%
6	Rate of municipalities implementing waste at source segregation and recycling facilities	80	100	
7	Collection rate of non-hazardous industrial waste	90	100	100%
8	Reuse and recycling rate of non-hazardous industrial waste	75	–	
9	Collection rate of solid waste from households in rural area	70	90	80%
10	Collection of solid waste from craft villages	80	100	
11	Rate of electronic and electrical producers established and pronounced collection points for extended producer responsibility (EPR) mechanism.	–	–	100%
12	Rate of waste disposed by direct landfilling	–	–	<30%
13	Rate of landfilled residue after treatment in a newly constructed waste treatment facility	–	–	≤20%
14	Percentage of slags from thermal power plants, chemical, fertilizer plants recycled, reused and treated as raw materials for production and construction	–	–	80%

(continued)

Table 8 (continued)

No	Target	Targets[a], %		Revised and new targets to 2025[b]
		To 2020	To 2025	
15	Rate of livestock waste collected, reused, recycled for composting, biogas	–	–	80%
16	Rate of agricultural residue from agricultural production collected, reused, and recycled	–	–	80%

Source a—National Strategy of Integrated Solid Waste Management to 2025, vision to 2050 (Prime Minister Decision 2149/QD-TTg); b—Revised National Strategy of Integrated Solid Waste Management to 2025, vision to 2050 (Prime Minister Decision 491/QD-TTg)

6 Research Supporting and International Collaboration

In term of international supporting and collaboration, Vietnam has received many supports from international governments and organizations in the field of environmental protection. In 1990s, the international collaboration mostly developed under bilateral collaboration projects between Vietnam and some developed countries such as Canada (Vietnam Canada Environment project, from 1995 to 2006), Sweden (under SIDA Environment Fund, from 1997 and The Strengthening Environmental Management Program—SEMA, 1997–2003), Holland, Denmark (DANIDA, from 1993), Switzerland and Japan, as well as international organization such as UNIDO, UNEP, UNDP, WB. Most of projects are focused on improving institutional capacity under aids and nonrefundable aids form. From 2000s, the collaboration was extended to many other bilateral partners and multilateral partners. The form of collaboration was switched from aids to partnership and joint project, especially when Vietnam is classified as lower middle-income country in 2010. These projects are covered most areas of environmental management such as environmental impact assessment, pollution control, treatment of residual chemical pollution, biodiversity conservation, and climate change, which are emerged issues in Vietnam. Nevertheless, the supporting and collaboration in 3R policy and natural resources utilization are still limited and just focused on small actual field, such as the 3R project in Hanoi 2006–2009 that is funded by JICA. The main reason Vietnam does not have suitable framework (legislation and human resource) for the change of natural resource consumption in macrolevel.

7 Conclusion

The 3R strategy is admired as an important factor for an effective production and consumption platform of a sustainable development society. The application of 3R is considered as a future fundamental way to deal with the limitation of human development, especially how to utilize the natural resource for current and future development, while keep reducing waste generation and preventing the pollution. In the 3R strategy, the content of recycle and reuse is considered to be of special importance, when they allow an important flow of wastes to come back production cycle.

From resource utilization perspective, in a material circulation society (or closed economy), 3R, in general and recycle, in particular, not only aims to treat or reduce the amount of waste generated, but also to create new industries that are corresponding to the type of wastes and development needs, thereby bringing waste back into the production process.

Vietnam, as a developing country, has been facing serious problems in the use of natural resources and environmental pollution. Because of that, 3R is considered as one of the decisive approaches to effectively protect the environment, contributes to socioeconomic development in a sustainable way, and is one of the essential tools to ensure the major objectives of the development.

Nevertheless, in Vietnam, the term circular economy is still absent in any legislation document. Even in the case of waste recycle and reuse, it is first to consider because of the benefit rather than a harmonized approach that can make the development sustainably. Thus, in Vietnam, it is easy to see an example in waste recycle, reuse; nevertheless, it is very difficult to force these activities in the form of circular economy. In other words, Vietnam does not have any real example that can show the continuous and sustainable cycle of substances. Instead of material cycle, it can be seen much of small loop that cannot join together to form the base of circular economy.

The most important issue now for Vietnam is to build a foundation for a circular economy. This foundation should base on the construction of a unification policy that can integrate different efforts on economic and social development, environmental protection and saving natural resources into one direction. This issue is, surely, needed the support from other countries, to top-down planning of the whole economy of Vietnam, instead of trying to solve waste and environmental problems separately with the development of economy.

References

Baldé, C., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). *The global e-waste monitor—2017*. United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna.

Baldé, C. P., Wang, F., Kuehr, R., & Huisman, J. (2015). *'The global e-waste monitor-2014* (p. 22). Bonn, Germany: United Nations University, IAS—SCYCLE.

Communist Party of Vietnam, 11th Central Executive Committee, 7th Congress. (2013). *Resolution No. 24-NQ/TW: Proactive response to climate change, improvement of natural resource management and environmental protection (dated 3 June, 2013)*, Hanoi.

Communist Party of Vietnam, Political Bureau. (1998). *Directive No. 36/1998/CT-TW: Strengthening environmental protection in the period of industrialization and modernization (dated 25 June, 1998)*, Hanoi.

Communist Party of Vietnam, Political Bureau. (2004). *Resolution No. 41-NQ/TW: Environmental protection in the period of industrialization and modernization (dated 15 November, 2004)*, Hanoi.

Communist Party of Vietnam, Secretariat Committee. (2009). *Directive No. 29-CT/TW: Continuing the implementation of Resolution No. 41-NQ/TW (dated 21 January, 2009)*, Hanoi.

Communist Party of Vietnam, The 11th Central Executive Committee. (2011). *Socio-economic Development Strategy 2011–2020 (dated 16 February, 2011)*. Document of XI Congress of the Party, Hanoi.

Doan, H.D., Thang, K.C., et al. (2010). *Recycling and reuse ash from coal fire power plants in Vietnam*. In: Proceedings of Third National Conference on Mineral Enrichment, The Publishing House of Natural Science and Technology.

Ellen MacArthur Foundation. (2017). Inforgraphic: Circular economy system diagram. Retrieved from https://www.ellenmacarthurfoundation.org/circular-economy/infographic.

Gardner, R. (2019, June 26). *Southeast Asian legal research Guide: introduction to Vietnam & its legal system*. Australia: The University of Melbourne. Retrieved from https://unimelb.libguides.com/c.php?g=402982&p=5862045.

General Statistics Office of Viet Nam. (2018). Retrieved 25th February 2019 from https://www.gso.gov.vn/default.aspx?tabid=714.

Government of Vietnam. (2012d). *Resolution No. 06/NQ-CP: Issuing the Government's action program 2011–2016 (dated 7 March 2012)*, Hanoi.

Government of Vietnam. (2014b). *Resolution No. 08/NQ-CP: Issuing action program of the Government to implement Resolution No. 24-NQ/TW on Proactive response to climate change, improvement of natural resource management and environmental protection (dated 23 January, 2014)*, Hanoi.

Government of Vietnam. (2015). *Decree 19/2015/ND-CP: Detailing the implementation of a number of articles of the law on environmental protection (dated 14 February 2015)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2005). *Decision No. 34/2005/QD-TTG: Issuing action program of the government to implement Resolution No. 41-NQ/TW on environmental protection in the period of industrialization and modernization (dated 22 February 2005)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2009). *Decision No. 1419/QĐ-TTg: Approval of the strategy on cleaner production in industry to 2020 (07 September 2009)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2012a). *Decision No. 432/QD-TTg: Approval of sustainable development strategy of Vietnam period 2011–2020 (dated 12 April, 2012)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2012b). *Decision No. 1216/QD-TTg: Approval of national environmental protection strategy by 2020, with a vision toward 2030 (dated 05 September 2012)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2012c). *Decision No. 1393/QD-TTg: Approval of the national green growth strategy (25 September 2012)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2013). *Decision 50/2013/QD-TTg: On prescribing retrieval and disposal of discarded products (dated 9 August 2013)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2014a). *Decision No. 166/QD-TTg: Issuing the plan for implementation of national environmental protection strategy by 2020, with a vision toward 2030 (dated 21 January 2014)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2017). *Decision 452/QD-TTg of the Prime Minister approving the project on promoting the handling and use of ash, slag and gypsum of thermal power, chemical and fertilizer plants as secondary material source for construction materials and in construction works (12 April 2017)*, Hanoi.

Government of Vietnam, Prime Minister of Vietnam. (2018). *Decision No. 491/QĐ-TTg: Approving adjustments to national strategy on integrated solid waste management to 2025 with a vision towards 2050 (07 May 2018)*, Hanoi.

Government of Vietnam, The Ministry of Finance. (2016). *Circular No. 128/2016/TT-BTC: On export duty exemption and reduction for environment-friendly products and products from recycling and waste treatment prescribed in the Government's Decree No. 19/2015/ND-CP of February 14, 2015, detailing a number of articles of the law on environmental protection (dated 9 August, 2016)*, Hanoi.

Government Party Committee. (2018). *Report on assessment of 5 years implementing resolution 24-NQ/TW on proactive response to climate change, strengthening resource management and environmental protection*.

Ho Chi Minh City People's Committee (2018). *Decision 44/2018/QD-UBND of the People's Committee on regulation the municipal solid waste sorting in the city (dated 14 November 2018)*, Ho Chi Minh City.

Hoornweg, D., & Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management* [Urban development series; knowledge papers No. 15]. The World Bank, Washington DC.

Hoornweg, D., Thomas, L., & Otten, L. (2000). *Composting and its applicability in developing countries*. Working Paper Series 8, Published for the Urban Development Division. The World Bank, Washinton DC.

Jambeck, J. R., Andrady, A., Geyer, R., Narayan, R., Perryman, M., Siegler, T., et al. (2015). Plastic waste inputs from land into the ocean. *Science, 347,* 768–771.

Khai, C. D. (2018). *Review of Vietnam Steel Industry in 2017, and outlook for 2018*. On the 2018 Southeast Asia Iron and Steel Institute Conference: ASEAN Steel Industry—Next Leap of Transformation.

Luong, N. D., Giang, H. M., Thanh, B. X., & Nguyen The Hung. (2013). Challenges for municipal solid waste management practices in Vietnam. *Waste Technology, 1*(1), 17–21.

Ministry of Agriculture. (December 18, 2006) *Circular No. 116/2006/TT-BNN providing guidance on implementation of some articles of the Government's Decree No. 66/2006/ND-CP dated July 7, 2006 on development of rural professions*.

Ministry of Agriculture and Rural Development. (2014). *Research topics of socio-economic efficiency in the development of craft villages nationwide*. Survey of craft villages of MARD.

Ministry of Construction and JICA. (2017, September). *Overview of Vietnam solid waste, project on capacity building on integrated municipal solid waste management in Vietnam*.

Ministry of Industry and Trade. (2018, August 13). *Official letter No. 6340/BCT-XNK of the Minister to providing information on scrap import and use as production material*.

Ministry of Natural Resources and Environment. (2011). *National state of environment report 2011—Solid waste.* Vietnam Publishing House of Natural Resources, Environment and Cartography.

Ministry of Natural Resources and Environment. (2015). *National state of environment report 2011–2015* (pp. 54). Vietnam Publishing House of Natural Resources, Environment and Cartography.

Ministry of Natural Resources and Environment. (2016). *National state of environment report 2016-Urban environment* (pp. 92). Vietnam Publishing House of Natural Resources, Environment and Cartography.

Ministry of Natural Resources and Environment. (2017). *National state of environment report 2017—Waste management*. Vietnam Publishing House of Natural Resources, Environment and Cartography.

Ministry of Natural Resources and Environment. (2018). *Report on solid waste management in Viet Nam*. Workshop with Ministry of Environment of Japan.

MONRE. (2011). *National state of environment report 2011-solid waste* (pp. 20). Vietnam Publishing House of Natural Resources, Environment and Cartography.

MONRE. (2012). Master Program of Strengthening control of environmental pollution caused by using non-biodegradable plastic bag in daily life up to 2020.

Nguyen, N. H. (2014). *Some economics of climate change adaptation in Vietnam* (Ph.D. Thesis, Faculty of Business, Economics and Law, La Trobe University, Melbourne, Australia). Retrieved from http://arrow.latrobe.edu.au:8080/vital/access/manager/Repository/latrobe:37965.

Vu, N. D., Son, N. H. (2013). Summary assessment of combined agroforestry models orientated for stable development along the corridor of Ho Chi Minh road, A Luoi district, Thua Thien—Hue. *Journal of Science*. *47*, 67–75. ISSN 1859-3100. (HCMC University of Education).
Plastic Europe. (2017). Plastic—the fact (pp. 16).
Nguyen, D. Q., Yamasue, E., Okumura, H., & Ishihara, K. N. (2009). Use and disposal of large home electronic appliances in Vietnam. *Journal of Material Cycles and Waste Management*, *11*(4), 358–366.
Thang, K. C., & Quy, N. Đ. (2011, October) *Current state and perspective of coal fire power plant' ash reuse and recycling in Việt Nam*. In: Proceedings of Conference on Gypsum Recovery (held by Vietnam Association for Building Materials), Hanoi.
The National Assembly of Socialist Republic of Vietnam. (2005). *Law on environmental protection*. Hanoi.
The National Assembly of Socialist Republic of Vietnam. (2010). *Mineral law*. Hanoi.
The National Assembly of Socialist Republic of Vietnam. (2012). *Land on water resources*. Hanoi.
The National Assembly of Socialist Republic of Vietnam. (2013). *Land law*. Hanoi.
The National Assembly of Socialist Republic of Vietnam. (2014). *Law on environmental protection*. Hanoi.
UNEP. (2007). E-waste: Volume I, Inventory Assessment Manual, 2007 (pp. 30).
Van Arkadie, B. (2003). *Viet Nam: A transition tiger?* Canberra, Australia: ANU E Press.
Vietnam Plastic Asscociation (2017). Overview of Vietnam Plastic Industry 2010–2015. Retrieved from http://vpas.vn/gioi-thieu/tong-quan-nganh.html.
Vietnam Plastic Association. (2018, August 8). *Official letter No. 39/CV-HHNVN of the Vietnam Plastic Association to Prime Minister and other related Ministries and offices on the Situation and Solution suggestion for imported plastic scrap issue.* HCMC.