Chapter 5
Circular Economy to Decarbonize Electricity

Fayaz Ahmad Malla, Tuan Dung, Suhaib A. Bandh, Afaan Ahmad Malla, and Shahid A. Wani

Abstract The term “circular economy” is being used more and more frequently within industries. In a circular economy, the value of products and materials is maintained for as long as possible. Resource usage and waste are minimized and when a product reaches the end of its life, it is reused to create the next value. Conservation and enhancement of natural capital, optimizing resource productivity and optimizing system-wide efficiency are some of the main principles of circular economy (CE). The Hannover Principles listed the following concepts/rules of the circular economy, which include: Use products as a service, sharing the platform, extended service life and extended lifecycle. Circular economy concept brings multiple benefits to industries and society. In traditional linear economy, producers exploit natural resources to make, produce or create products and services, which are then dumped from the production and consumption line. Circular economy manufacturers focus on extending life and making the most of the value of resources, then managing and recreating these products and resources at the end of their useful life. The prevailing economic model in construction sector in developing countries is linear which use

F. A. Malla (✉)
Department of Environmental Science, Government Degree College Tral (Higher Education Department, Government of Jammu and Kashmir), Pulwama 192123, Jammu and Kashmir, India
e-mail: nami.fayaz@gmail.com

T. Dung
School of Chemistry and Life Science, Hanoi University of Science and Technology, No. 1 Dai Co Viet, Hai Ba Trung, Hanoi 100000, Vietnam

Vietnam National University, VNU Town, Hoa Lac, Thach That, Hanoi 155500, Vietnam

S. A. Bandh
Department of Environmental Science, Higher Education Department, Government of Jammu and Kashmir, Srinagar 190001, India

A. A. Malla
Department of Environmental Science (Government Degree College Baramulla), Indira Gandhi National Open University, Baramulla 193101, Jammu and Kashmir, India

S. A. Wani
Sri Pratap College Campus, Cluster University Srinagar, Srinagar 190001, Jammu and Kashmir, India

S. A. Bandh et al. (eds.), *Renewable Energy in Circular Economy*, Circular Economy and Sustainability, https://doi.org/10.1007/978-3-031-42220-1_5

raw materials to manufacture components that are subsequently used and ultimately end as waste at the end of their lifecycle. The demand for raw materials is predicted to double by 2050. It is therefore necessary to transition from a linear economy to a circular economy.

Keywords Decarbonisation · Linear economy · Circular economy · Wastes · Energy

5.1 Circular Economy (CE)

The "linear" economy, or the so-called "take-make-waste" approach of production and consumption as we used to observe it around us every day is linear economy. In the linear economic system, all the products we need are produced, used, and commonly disposed of, contributing to material resource depletion of the Earth and the accumulation of wastes (Haberl et al. 2019). The circular economy (CE) in contrast to the linear economy. CE is a systematic solution that tackles global challenges such as climate change, biodiversity loss, waste, and pollution and the definition is usually reduced to the 3Rs—Reduce—Reuse—Recycle. In fact, the concept is much more complex, presenting multiple ramifications that involve paradigm shifts in how manufacturing processes, technologies are designed with concerns to environments and sustainability.

5.1.1 Some Definitions of CE

The term "circular economy" is being used more and more frequently within industries as well as various other business sectors. In a circular economy, the value of products and materials is maintained for as long as possible. Resource usage and waste are minimized and when a product reaches the end of its life, it is reused to create the next value.

The EU has adopted a Circular Economy Action Plan (CEAP) in 2015, which is comprehensive, legislative and non-legislative actions aiming to transition the European economy from a linear to a circular model and to have huge economic benefits, contributing to innovation, growth and job creation EU (EC 2016). Ellen MacArthur Foundation (2013) defined the circular economy as based on designed principles that eliminate waste and pollution, keep products and materials in use, and regenerate natural systems.

China Circular Economy Law in China (FDI Gov China 2020) defined circular economy is a general term for activities of reducing, recycling and recovering resources in production.

Minimization means reducing resource consumption and waste generation in production, circulation and consumption. Recycling means the direct use of waste as a product, or the use of waste as a product after repair, rehabilitation or remanufacturing, or the use of all or part of the waste as part of other products. Resource recovery means direct use of waste as raw materials or recycling of waste.

5.1.2 Principles and Pillars of CE

Andrew Morlet (2015) listed three main principles of circular economy, which are:

(a) Conservation and enhancement of natural capital; (b) Optimizing resource productivity at the highest benefit at all times in both engineering and biological cycles; and (c) Drive system-wide efficiency by minimizing and designing to eliminate negative externalities.

The Hannover Principles listed the following concepts/rules of the circular economy:

(a) Insist on the right of humanity and nature to coexist in a healthy, supportive, diverse and sustainable condition.
(b) Recognize interdependence.
(c) Respect relationships between spirit and matter.
(d) Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems and their right to co-exist.
(e) Create safe objects of long-term value.
(f) Eliminate the concept of waste.
(g) Rely on natural energy flows.
(h) Understand the limitations of design.
(i) Seek constant improvement by sharing knowledge.

Some pillars of CE include: Sustainable resources, use products as a service, sharing the platform, extended service life and new lifecycle.

How to implement CE or turning waste into resources and benefits of CE

In those above-mentioned principles of CE, materials can be recovered using the engineering cycle through different iterations: maintenance and repair, reuse and redistribution, refurbishment and remanufacturing, and finally recycling; a biologically derived resource goes a different way of recovery, which cycles back to the biological cycle after the end of its life cycle so that it can be reused as nutrients in the new cycle.

Circular economy concept brings multiple benefits to industries and society. In a traditional linear economy, producers exploit natural resources to make, produce or create products and services, which are then dumped from the production and consumption line, or buried, or even discharged into the environment. In contrast, the circular economy is a sustainable alternative to the aforementioned model. In a circular economy, manufacturers focus on extending life and making the most of the value of resources, then managing and recreating these products and resources at the end of their useful life. As such, the application of a circulating economic model will help reduce waste, emissions, promote the efficient use of resources, and contribute to solving scarcity of natural resources. On the other hand, circularity helps conserve, and support advanced competitiveness for the economy.

In particular, practices of the circular economy and regulations on each sector should be written and implemented. The transition to a CE, a resource-efficient and effective economy, requires the active engagement of all stakeholders such as societal and economic actors, including business, civic society, and political actors.

Moving towards a fully circular economy is a multi-step, complex processes that is mostly policy-driven but require multiple stakeholders' involvement. The government of Vietnam in principle through the Ministry of Natural resources and Environment and ISPONRE should implement laws on these new but multi-benefit areas in general.

In construction and urban development sectors, cities are resource consumption centers and significant producers of greenhouse gas emissions. The prevailing economic model in construction sector in developing countries is linear which use raw materials to manufacture components that are subsequently used and ultimately end as waste at the end of their lifecycle. The demand for raw materials is predicted to double by 2050. Urban communities are central to developing circular economy models. It is essential to analyze the urban structure as a whole.

A systematic review on the criteria and indicators (e.g., circularity, waste volumes) to evaluate and potentially monitor the implementation of circular economy in emerging economies and identify and align these indicators with the interest of nations and advise the CE experts accordingly. To guarantee that the future generations will have sufficient resources like food, water and prosperity, it is therefore necessary to transition from a linear economy to a circular economy (Halog 2021).

5.2 Circular Economy Boundaries

Proof of CE's capacity to meet human needs within planetary boundaries (PBs) is still needed. Circular economy is an umbrella concept that encapsulates and connects separate knowledge areas and experiences in terms of resource efficiency and reduced environmental impacts. Proof of CE's capacity to create the conditions required for meeting human needs within planetary boundaries (PBs) is still lacking.

PBs encompass nine key earth-system processes that define a safe operating space for humanity for maintaining the stability of the earth's life-supporting systems. Due to the extremely general and scientific evidence-based nature of the PB concept and the global and interactive nature of the boundaries, the PBs are not applied regionally and locally (Raufflet et al. 2021).

Vadoudi (2022) proposes a circular indicator adapted from the Material Circularity Indicator for the plastic industry. The circular economy is among the most efficient solutions to guarantee and achieve the sustainable development targets.

5.3 Renewable Energies (RE)

Renewable energies spans from wind, solar, geothermal to tide energy, etc. RE is the energy from a source that is not depleted when used, such as wind or solar power. How to enhance the electricity grid to absorb additional RE? Here are some suggestions for enhancing the electricity grid to absorb additional RE:

- One-stop service for RE
- Enhancing energy efficiency
- Promoting demand management
- Incorporating the Carbon Price such as more stringent Emissions Trading Scheme and increased electricity price
- Increasing in R&D to enhance the efficiency of RE including hydrogen.

5.4 Renewable Energy Trends in Coming Years

According to GECF (GECF…), the trend of growth of renewable energy will continue to grow, as pictured in Fig. 5.1.

5.4.1 Some International Experiences and Examples

Framework act on carbon neutrality and green growth of Korea

Korea has its national carbon neutrality master plan with a planning period of 20 years. The government will adopt "climate-responsive budgeting" and "climate change impact assessments" in major national plans, large-scale development projects, and

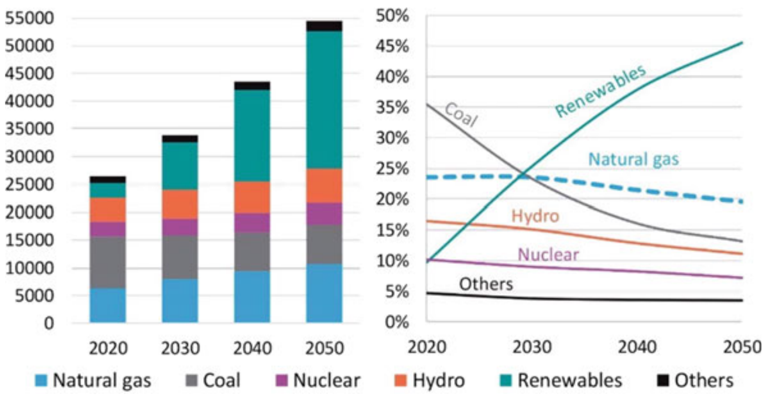

Fig. 5.1 Renewable development in recent and coming years (GECF 2021)

national finance to reduce greenhouse gas emissions. The Act sets the legal basis for GHG reduction policies of each ministry, such as carbon–neutral cities, green transport, and carbon sink expansion. The Act sets the legal basis for Article 6 carbon credit transactions. The South Korean government set up the Korean Climate Action Fund to effectively implement policies towards carbon neutrality and necessary reorganization of industrial structure.

Techno-Industrial transformation strategy—green new deal of Korea announced in 2020

- Solar and wind turbine capacity to 42.7 GW by 2025, up from 12.7 GW in 2019
- Install solar panels on 225,000 public buildings
- Rapidly roll out "smart grids" including "smart meters" in five million more apartments, to help consumers reduce their electricity use
- Invest heavily in the creation of microgrid communities in regional areas and on Korea's many islands. The vision is to create decentralized, low carbon energy systems
- 1.13 million electric vehicles (EVs) and 200,000 hydrogen-powered fuel-cell EVs
- Roll out 45,000 electric vehicle recharging stations (15,000 rapid and 30,000 standard) and 450 hydrogen refueling units
- Implement circular economy initiatives such as reducing and recycling energy using advanced computerized power grids in factories. The plan also involves technology to capture and store carbon emitted from industrial processes and re-using industrial materials.

5.4.2 Renewable Development in Vietnam

Vietnam is fortunate to have a vast potential for renewable energy development. In addition to solar, and onshore wind, Vietnam is endowed with some of the best offshore wind potential globally. The WB analysis shows that about 370 GW of renewable energy generation capacity could be added by 2040 to reduce reliance on fossil fuels. As Vietnam's recent experience shows, this can be achieved largely through private investment. To continue this growth in renewable energy would require improvements in the power system expansion planning and the procurement and regulatory framework to secure the least-cost renewable power sources.

Specifically, the current feed-in tariff policy, which contributed to a rapid growth of renewable energy development, should be replaced by a well-structured, planned and most importantly transparent competitive auction-based scheme to bring in the most efficient and lowest cost privately financed renewable energy projects to meet Vietnam's energy needs sustainably.

Viet Nam will stop building new coal-fired power plants from 2030 as part of its roadmap to realize commitments at the COP26. Viet Nam also aims to reduce the capacity of coal-fired power plants to 13.2% of the country's total power capacity by 2045 from the current 32%.

By the end of last year, the nation's total installed capacity of power plants reached over 78,120 MW, the highest among ASEAN Member States.

5.4.3 US and EU Proposals

US—Inflation Reduction Act set USD 370 billion dedicated to climate change in terms of investment; Reduce 40% of GHG emissions compared 2005 and create 1.5 million jobs, in terms of its impact. EU—Green Deal set EUR 1 trillion in 7 years in terms of investment in wind energy (Fig. 5.2).

With a rising focus on the effective integration of renewable energy, the importance of electric vehicles and reliable, resilient energy supply, energy storage is becoming an increasingly important tool in the electricity ecosystem.

- Energy storage is a critical hub for the entire grid, augmenting resources from wind, solar and hydro, to nuclear and fossil fuels, to demand side resources and system efficiency assets. It can act as a generation, transmission or distribution asset—sometimes in a single asset.
- Asia Pacific region is expected to account for 68% of the $10.84 billion global energy storage market in 2026 and Vietnam is heading in the race. Clime Capital Management is excited to provide critical capital at a key stage in the development of clean energy projects.

5.5 Renewable Energy in CE

One of the key pillars of CE is sustainable resources where renewable energy sources and biodegradable, recyclable or renewable materials are used. The use of renewable energy is a key aspect of producing and achieving circular products and resources. This include the way in which the components of renewable plants or factories are designed, manufactured, built and managed, as well as how their new life is handled.

Some products in renewable energies such as solar panels should be made from sustainable resources to extend its service life and recycled after its service life. In sustainable construction model, measures for integrating waste recycling or reuse of wastewater can be studied, while waste materials can be reused to create roads or embankments. In solar power of renewable energies sector, the electric vehicle batteries can be given a second chance by providing services to the grid or integrating them into storage plants (Enel 2022). In biomass sector, ethanol produced from agriculture by products or waste are also a good example of creating a new Lifecyle of agriculture products and how sustainable resources are used (Hoang and Nghiem 2021). Application of AI can help to obtain the CE targets in renewable energies sector (Hoang et al. 2022).

The circular economy has potential to generate competitiveness in conjunction with innovation and sustainability. In this model, the traditional approach to the

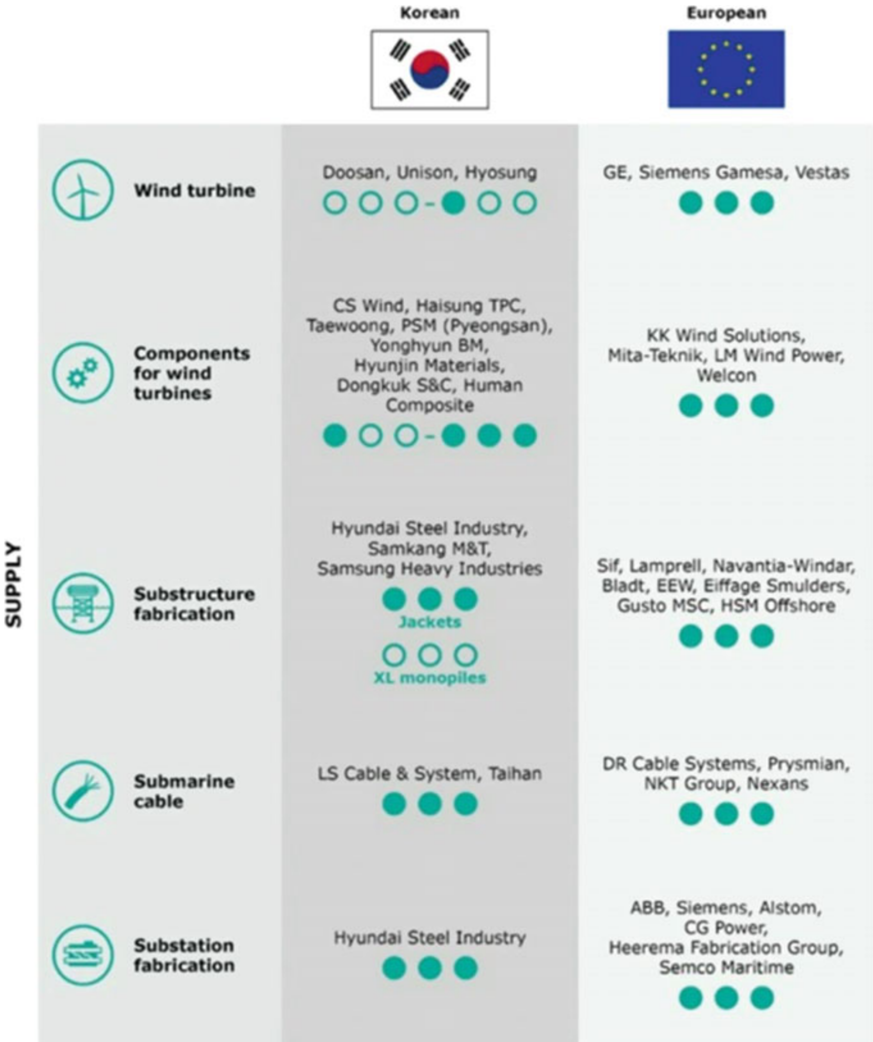

Fig. 5.2 Selected major suppliers for fabrication in the Korean offshore wind market

market, customers and natural resources will change. This allows companies to gain notable competitive advantages such as reduced costs, efficiently use of energy, decreased CO_2 emissions and optimized safer supply chains.

5.6 Decarbonisation of Electricity by Green Hydrogen

Achieving the Paris Agreement's decarbonization targets will depend heavily on the use of green hydrogen. Nearly everyone wants to do better for the planet, but keeping global warming below 2 °C by 2050 would be difficult without a diverse array of zero-carbon energy sources.

Intermittency—environmental, seasonal, and daily cycles that might restrict its usage or efficiency—has slowed the rapid expansion of renewable energy use. These renewable energy sources require a backup when the sun isn't shining and the wind isn't blowing in order to complete the last stretch of decarbonization.

Transportation, electricity generation, and industry are the three largest contributors to global warming in the United States. It's challenging to completely reduce emissions from certain sectors of the economy. Green hydrogen is the only carbon-free alternative that Plug Power believes can decarbonize the aviation, shipping, long-distance haulage, and concrete/steel production industries.

Hydrogen is readily available, and there appears to be no end in sight to the supply. Green hydrogen, which is produced by electrolyzing water to separate the hydrogen and oxygen, is a zero-emissions, "always on" energy source that potentially reverse the tide against resource depletion. Pipeline, over-the-road in cryogenic liquid tanker trucks, or over the road in gaseous tube trailers can get it from the place of production to wherever it's needed. Hydrogen can be created from excess renewable energy and stored in tanks in enormous volumes for longer periods of time, unlike batteries used for electric cars and stationary power, which are unable to store big quantities of electricity for extended periods of time.

Hydrogen has about three times as much energy per unit weight as fossil fuels, therefore less of it is required to have the same effect. Green hydrogen also has the benefit of being able to be created wherever there is water and power, allowing for the creation of other forms of energy such as electricity and heat. Electrolysis of water produces usable quantities of hydrogen (H_2) and oxygen (O_2), which may then be put to use.

For residential usage, green hydrogen may be stored in the same gas pipelines that are currently in place. When processed into a carrier like ammonia, which may be used as a zero-carbon fuel for transportation, it can also serve as a renewable energy source. Electric automobiles and other electronic gadgets may be powered by combining it with fuel cells. In addition, hydrogen fuel cells may be used indefinitely without being refilled or depleted, provided that a source of liquid hydrogen is nearby.

Green hydrogen is now available, despite the fact that its mainstream acceptance may not occur for another decade, according to some specialists in the field. Green hydrogen is used to power Walmart's forklifts in distribution and fulfilment centres, while Edison Motors' municipal bus fleets run on green hydrogen fuel cells. Toyota and other automakers have known for years about the advantages of hydrogen fuel. The Hydrogen Council predicts that hydrogen will make up 18% of the global energy market by 2050, and a recent McKinsey research predicted that the hydrogen economy in the United States could create $140 billion and sustain 700,000 jobs by 2030.

Although green hydrogen on its own won't solve global warming, it's essential to achieving complete economic decarbonization and solving the world's emissions crisis. Rather of relying solely on green hydrogen, Plug Power proposes integrating renewable energy sources including solar panels, wind turbines, battery storage, and hydrogen fuel cells into a single system. It is impossible to realise this future energy infrastructure without utilising green hydrogen.

Without renewable hydrogen, the decarbonization goals of the Paris Agreement cannot be met. Although most people desire to improve environmental conditions, doing so without a wide variety of zero-carbon energy sources might make it impossible to keep global warming below 2 °C by 2050.

Slowing the rapid increase of renewable energy consumption is intermittency, or environmental, seasonal, and daily cycles that may limit its utilisation or efficiency. To get through the last stages of decarbonization, these renewable energy sources need a backup when the sun isn't shining and the wind isn't blowing.

Emissions from transportation, electrical generation, and industry account for the bulk of America's contribution to climate change. Reducing emissions entirely from some economic areas may be difficult. Plug Power maintains that the only viable strategy for decarbonizing industries including aviation, shipping, long-distance transportation, and the manufacturing of concrete and steel is to transition to green hydrogen.

The availability of hydrogen is practically limitless, and it is also quite cheap. Electrolysis of water into its component hydrogen and oxygen atoms yields green hydrogen, a zero-emissions, "always on" energy source with the potential to turn the tide in the fight against resource depletion. From the site of production to its eventual destination, it can be transported via pipeline, over the road in cryogenic liquid tanker trucks, or over the road in gaseous tube trailers. While batteries used in electric vehicles and stationary power cannot store large amounts of electricity for lengthy periods of time, hydrogen may be produced from excess renewable energy and stored in tanks in massive quantities for longer periods of time.

Green hydrogen in the nation's gas pipelines may be used to power homes. As an ammonia-based renewable energy source, it has the potential to be used as a zero-carbon transportation fuel. Therefore, everything that needs energy, including electric automobiles and gadgets, may be powered by fuel cells. In addition, hydrogen fuel cells never run out of energy and don't need to be recharged so long as a supply of liquid hydrogen is readily available.

Green hydrogen cannot solve emissions concerns on its own, but it is necessary for decarbonizing the economy. Plug Power suggests that we build a sustainable energy infrastructure that combines solar panels, wind turbines, battery storage, and green hydrogen. Hydrogen fuel cells that run on green hydrogen are a key component of this planned energy network of the future.

5.7 Decarbonisation of Electricity by Solar on Grid Technology

There is a worldwide energy revolution happening right now. Solar power has seen an 80% drop in price while wind power has seen a 40% drop in price over the previous decade, making them competitive with traditional fuels like coal and natural gas in most global markets. The use of renewable energy sources is growing quickly, and in 2018, they accounted for the great majority of newly installed electrical generation capacity. To expand marginal capacity has become cheaper in most markets thanks to them. Even more importantly, renewables are an integral element of any country's plan to cut greenhouse gas emissions.

But you have no control over Mother Nature's whims. Wind and solar electricity cannot, therefore, offer continuous, 24/7 matching of supply to demand, in contrast to baseload producing facilities powered by coal, natural gas, or nuclear power. We have reached a point of crisis. Cost-effective and reliable electricity is a necessity for cities, states, and nations. Power plant carbon dioxide (CO_2) emission reduction targets have been set by a number of nations. It seems impossible to me that they could handle both tasks simultaneously.

Flexibility, or the ability to deal with the intermittent nature of no dispatchable power sources like wind and solar, is necessary for the successful integration of significant volumes of renewable electricity. Supply and demand can be balanced through a variety of possible approaches. In order to compensate for fluctuations in wind and solar power generation, for example, natural gas and coal plants may increase or reduce output. Using transmission lines, it is possible to standardize output across geographic areas. "Demand side management" programmes aim to reduce consumption by offering financial incentives to customers. As a generator during discharge and a consumer during charge, battery storage might make two types of contributions to the power system. There are solutions like these out there, and their efficacy has been well-documented. Still, few utilities or governments have developed a comprehensive, quantified strategy for decarbonizing the electrical sector.

There is nothing like the current market environment in terms of dynamism. In spite of this, there are commonalities amongst many decarbonization strategies. Decarbonization strategies will depend critically on the capacity to manage the intermittent nature of renewable energy sources like wind and solar. Using integrated bulk-generation, transmission and distribution, and direct consumer offers, this article presents a high-level overview of the technologies and expected costs for achieving full decarbonization of power networks by 2040. Next, we examine the future of four diverse industries. At last, we speculate on how potential changes in technology could affect these paths in the future.

Decarbonization rate of 50–60% is not only theoretically possible, but also the most cost-effective option in many scenarios. After that point, 90% decarbonization is theoretically conceivable but may require extra costs depending on the specifics of the situation. Additionally, both technically and monetarily, providing comprehensive coverage will be difficult.

A decarbonization rate of between 50 and 60% is achievable in most markets with minimal to no out-of-pocket expense beyond what would be expected from purely prudent economic activity. Due to the rapidly decreasing cost of solar, wind, and storage technologies—all of which are essential to any deep-decarbonization scenario—decarbonizing is typically the least priced solution.

Four- to eight-hour intervals of storage are about in sync with the sun's daily cycle. Unlike wind-plus-storage, which cannot provide a constant supply of power owing to wind's unpredictability, "solar-plus-storage" may release the energy it has stored at night. Since the wind usually picks up at night and in the winter, when the sun isn't as powerful, wind and solar power make a great pair. Markets that have access to both solar and wind resources are better able to handle intermittency as a result.

If we are able to decarbonize the energy industry to this degree, it is unlikely that the power grid's efficiency would suffer much. We estimate that 2–5% of the produced power will be lost as a result of curtailment. Individual fossil fuel plant utilisation rates (the proportion of time a plant provides power) also wouldn't deviate very much from their existing levels of approximately 50–60%. Some of these assets, however, would be abandoned when more affordable renewable energy sources entered the market. Almost no additional transmission would be required. Achieving a decarbonization rate of 50–60% would not call for significant changes to the power system, to sum up.

Reducing carbon emissions by 80–90% will be more challenging, expensive, and reliant on market-specific policies. It is possible that increasing storage utilization over longer time periods and tighter demand management will be required, but no unique technologies are required. This might entail redistributing industrial loads or actively controlling HVAC systems in buildings. Sharing baseload resources and consolidating renewable energy supply across a greater region may need additional transmission links in some markets.

At this point in the process of decarbonization, the system's appearance would undergo a radical transformation. We anticipate a curtailment of 7–10% due to the abundance of renewable power output to meet demand during periods of lower production. The utilization of fossil fuel facilities has declined from 65 to 20% as a result of the proliferation of renewable energy sources, however many are kept online as a backup in case renewables are insufficient.

Decarbonization costs are most unpredictable between the 80–90% range. In places where power is more expensive than usual, total system costs might drop by one to two percent per year. There's a chance expansion will happen in cheaper areas.

The path toward total decarbonization is already convoluted, and the cheapest options are subject to alter as the market evolves. Most regions will have to rely on more advanced technology to satisfy energy demands when wind and solar power output are low. While technically feasible, the extra 25% in cost might make it less attractive than other options. The most crucial action toward decarbonizing the power sector is filling up the gaps over the long run. As a result, decarbonizing the remaining 10% of a power infrastructure may be prohibitively costly.

Here are some examples of current technology that might bridge the gap and enable the construction of a fully decarbonized power grid on the global market:

Biofuels. In terms of greenhouse gas emissions, biofuels such as landfill gas and biomethane are completely carbon neutral. However, due to their high price and restricted availability, they are typically only effective when used in addition to other measures.

Carbon dioxide emissions sequestration (CCUS). CCS refers to the process of capturing, using, and storing carbon dioxide (CO_2) from the burning of fossil fuels (CCUS). It has been proven that CCUS is a cost-effective option. Technological progress and scale economies can both contribute to a decrease in cost. Further, CCUS has a finite capacity for carbon capture, thus other technologies will be needed for full decarbonization. CCUS is most likely to be effective in highly interconnected markets where land is scarce for renewables, clean power is valuable across a greater region, and CCUS facilities can be run at or near full utilisation.

Capturing and storing carbon dioxide emissions from the burning of biofuels (BECCS). The BECCS method is based on the burning of carbon–neutral biomass, such as wood pellets and agricultural waste, while collecting or storing the resulting CO_2 emissions. In sum, this results in "negative emissions," in which greenhouse gases are actually removed from the atmosphere. Potential for increasing biomass usage is obscure, and the technology supporting it is in its infancy. Repurposing idled coal power stations into BECCS facilities allows them to take advantage of existing connections while reducing upfront investment costs.

Conversion of natural gas to electricity and back to natural gas (P2G2P). P2G2P technology allows for the storage of excess electricity in the form of hydrogen, which can subsequently be utilised to fuel power plants at peak demand. We can produce "clean gas" that can be stored for several weeks or months using P2G2P technology. It's pricey and ineffective, though. Ten megawatt-hours of generated power only yield around three megawatt-hours of usable power after being converted back to electricity for usage. The flexibility of P2G2P technology, however, may substantially facilitate the adoption of intermittent renewables if there is demand for clean gas in sectors other than the power sector.

Inhaling and exhaling normally (DAC). DAC is capable of capturing carbon dioxide from the atmosphere. Here we have another another negative-emissions technology that might one day replace the electricity sector's residual reliance on carbon-intensive sources. While it is possible and has been demonstrated that CO_2 may be captured, isolated, and sequestered, doing so requires vast amounts of energy. However, there is a steep price to pay for this action. Based on our findings, this strategy is not practical for attaining full decarbonization.

Complete decarbonization in the electrical sector will necessitate a large reduction in fossil-fuel plant utilisation (to roughly 4–6%) compared to the scenario for 80–90% decarbonization. In addition, biofuels, P2G2P technology, or the discovery of novel offsets would likely be required to "net" the carbon emissions of each market. Just as much chopping would go place, approximately.

There will need to be a variety of strategies for decarbonizing power systems across markets because of climate, natural resource, and infrastructure differences (exhibit). Our investigation has led us to identify four separate markets. These markets were chosen to illustrate a range of global features, such as initial carbon intensity, transmission capacity, the quality of clean resources (including both intermittent solar and wind energy and dispatchable hydro and nuclear energy), and the potential for the distributed network to provide flexibility.

5.8 Carbon Foot Prints, Circular Economy and Smart Cities

CE is a regenerative system in which energy and material loops are slowed, closed, and narrowed to reduce resource input and waste, emission, and energy leakage. Longevity in design, maintenance, repairs, reuse, remanufacturing, refurbishment, and recycling are all viable options for reaching this goal. Contrast this with the linear economy (LE). The "Lean Green" (LG) concept is applicable here since it provides a framework for quantifying the environmental advantages of these. Its goal is to bring about the alterations that will cut down on consumption of raw materials, power, water, and other essentials, as well as create resource-saving buildings and implement cutting-edge machinery. Businesses in today's fast-paced, cutthroat market under intense pressure to embrace sustainable practises that strike a good balance between their financial, environmental, and social impacts. The LG manufacturing method has become well-liked (Abualfaraa et al. 2020) because to its integration of lean techniques centred on satisfying customer needs with green practises aimed at lessening the negative effect of the company's operations on the environment. Research studies generally agree that LG and CE may complement one another very well in the industrial industry. The key to efficient results may be found in the common goal of minimising inefficiencies and maximising value. As a result, it makes sense to put them together (Bhattacharya et al. 2019; Silva et al. 2019; Nadeem et al. 2019). In order to accomplish the SDGs, it will be necessary to optimise the use of primary resources in order to prevent or decrease waste and encourage re-use, which is exactly what the CE and the green economy propose to do. They advocate for more than just waste management, however, and instead incorporate the concept of resource loop closure whenever possible. The primary goal is to lessen the amount of garbage sent to landfills and incinerators, hence reducing the loss of resources that could be recycled back into the economy. To encourage ecologically responsible actions, society as a whole will need to shift its perspective.

Reducing environmental consequences such as greenhouse gas emissions and deforestation may be accomplished by reusing and recycling things rather than producing new ones from scratch. Fourteen percent of world emissions come from

EU member states, the USA, Japan, Argentina, and the other Shift nations combined (Teixeira et al. 2021).

Cities play a crucial role in circular economies since they are the primary sites of product consumption and utilisation. Consequently, the role of municipalities in fostering the development of circular, intelligent economies lies largely in the forms of regulation and promotion of consumption. For instance, consider the topic of food. Although urban areas may not have much influence on rural issues such as the renewal of soils and the expansion of agricultural biodiversity, they do play a crucial role in the consumption and, unfortunately, waste of the vast majority of the world's food supply. This is both a massive challenge and a massive opportunity. This trash has to be reduced and redistributed so that cities may become more appealing places to live while also improving environmental health and creating jobs.

Much of the innovation required to restructure our economy will naturally live in, and can be promoted in, cities since they are centres of creativity. When it comes to environmental pollution and health, access to outdoors, and the negative consequences of climate change, cities bear a disproportionate share of the cost. The Ellen MacArthur Foundation predicts that "two-thirds of us" will reside in cities by the year 2050. Our metropolitan centres, which account for only 2% of the Earth's surface area, are responsible for 75% of the world's resource consumption, 50% of its solid waste production, and 60% of its greenhouse gas emissions, all of which contribute to pollution, climate change, and biodiversity loss.

To execute a vision for circularity, promote circular thinking, manage urban space, purchase goods and services that are consistent with the circular economy, and influence markets and habits through legislation, cities are in a prime position to engage with a wide range of stakeholders. To ensure that this new economic system benefits not just our common environment and economy, but also individuals, families, and citizens, it is crucial to promote a civic culture of innovation and experimentation, to align various interests and stakeholders, and to involve inhabitants on deep levels. When viewed as a chance to strategically grow an economy, this economic shift doesn't have to be traumatic for communities. Jobs can be made, residents' quality of life can be enhanced, the economy can become more competitive and attractive, and innovation can be fueled if circular economies are established.

5.9 Conclusion

Circular economy concept brings multiple benefits to industries and society. In traditional linear economy, producers exploit natural resources to make, produce or create products and services. Circular economy manufacturers focus on extending life and making the most of the value of resources before managing and recreating them. The prevailing economic model in construction sector in developing countries is linear which use raw materials to manufacture components that are subsequently used and ultimately end as waste.

Circular economy is an umbrella concept that encapsulates and connects separate knowledge areas and experiences in terms of resource efficiency and reduced environmental impacts. Renewable energies spans from wind, solar, geothermal to tide energy, etc. How to enhance the electricity grid to absorb additional RE? Suggestions include enhancing energy efficiency, demand management, increased electricity price and more stringent Emissions Trading Scheme (ETS) pricing. Vietnam is fortunate to have a vast potential for renewable energy development.

About 370 GW of renewable energy generation capacity could be added by 2040. This can be achieved largely through private investment, writes World Bank's (WB) Vietnam Project Director, Nguyen Phu Trong. Energy storage is a critical hub for the entire grid, augmenting resources from wind, solar and hydro, to nuclear and fossil fuels. Asia Pacific is expected to account for 68% of the $10.84 billion global energy storage market in 2026. Clime Capital Management is excited to provide critical capital at a key stage in the development of clean energy projects.

Keeping global warming below 2 °C by 2050 would be difficult without a diverse array of zero-carbon energy sources. Green hydrogen is the only carbon-free alternative that Plug Power believes can decarbonize the aviation, shipping, long-distance haulage, and concrete/steel production industries. Green hydrogen is now available, but mainstream adoption may not occur for another decade. Hydrogen Council predicts hydrogen will make up 18% of the global energy market by 2050. Plug Power proposes integrating solar panels, wind turbines, battery storage, and hydrogen fuel cells into a single system.

Hydrogen is a renewable energy source with the potential to turn the tide in the fight against resource depletion. Hydrogen fuel cells never run out of energy and don't need to be recharged so long as a supply of liquid hydrogen is readily available, according to Plug Power. Decarbonization strategies will depend critically on the capacity to manage the intermittent nature of renewable energy sources like wind and solar. This article presents a high-level overview of the technologies and expected costs for achieving full decarbonization of power networks by 2040. It examines integrated bulk-generation, transmission, distribution, and direct consumer offers.

"Solar-plus-storage" may release energy it has stored at night. Since the wind usually picks up at night and in the winter, wind and solar power make a great pair. It is possible that increasing storage utilization over longer time periods will be required. Decarbonizing the remaining 10% of a power infrastructure may be prohibitively costly. Here are some examples of technologies that might bridge the gap and enable the construction of a fully decarbonized power grid on the global market (BECCS, CCUS, P2G2P).

The "Lean Green" concept is applicable here since it provides a framework for quantifying environmental advantages. In order to accomplish the SDGs, it will be necessary to optimise the use of primary resources in order to prevent or decrease waste and encourage re-use. The CE and the green economy advocate for more than just waste management but incorporate the concept of resource loop closure whenever possible.

References

Abualfaraa W, Salonitis K, Al-Ashaab A, Ala'raj M (2020) Lean_Green manufacturing practices and their link with sustainability: a critical review. Sustainability 12(3):981. https://doi.org/10.3390/su12030981

Bhattacharya A, Nand A, Castka P (2019) Lean-green integration and its impact on sustainability performance: a critical review. J Clean Prod 236:117697. https://doi.org/10.1016/j.jclepro.2019.117697

Haberl H, Wiedenhofer D, Pauliuk S, Krausmann F, Müller DB, Fischer-Kowalski M (2019) Contributions of sociometabolic research to sustainability science. Nat Sustain 2(3):173–184. https://doi.org/10.1038/s41893-019-0225-2

Hoang T-D, Nghiem N (2021) Recent developments and current status of commercial production of fuel ethanol. Fermentation 7(4):314. https://doi.org/10.3390/fermentation7040314

Hoang T-D et al (2022) Artificial intelligence in pollution control and management: status and future prospects, springer book chapter. https://link.springer.com/chapter/10.1007/978-981-19-1434-8_2

Nadeem SP, Garza-Reyes JA, Anosike AI (2019) Coalescing the lean and circular economy. In: Proceedings of the international conference on industrial engineering and operations management, Bangkok, Thailand

Raufflet E, Lonca G, Chaves R, Boiteux M, Burgan T (2021) Intersections between the planetary boundaries and the circular economy. HEC Montréal

Silva S, Sá JC, Silva FJG, Ferreira LP, Santos G (2019) Lean green-the importance of integrating environment into lean philosophy-a case study. In: Rossi M, Rossini M, Terzi S (eds) Lecture notes in networks and systems. Proceedings of the 6th European lean educator conference (ELEC) 2019, Milan, Italy, 2020, vol 122. Springer

Teixeira P, Sá JC, Silva FJG, Ferreira LP, Santos G, Fontoura P (2021) Connecting lean and green with sustainability towards conceptual model. J Clean Prod 322 (The circularity gap report). https://doi.org/10.1016/j.jclepro.2021.129047. https://www.circularity-gap.world/2021

The circular economy. https://www.enelgreenpower.com/learning-hub/sustainable-development/circular-economy. Enel, Co., Ltd.

The EU's circular economy action plan. https://ellenmacarthurfoundation.org/circular-examples/the-eus-circular-economy-actionplan#:~:text=The%20EU's%20Circular%20Economy%20Action%20Plan%20(CEAP)%20was%20a%20comprehensive,four%20legislative%20proposals%20on%20waste

Vadoudi K, Deckers P, Demuytere C, Askanian H, Verney V (2022) Comparing a material circularity indicator to life cycle assessment: the case of a three-layer plastic packaging. Sustain Prod Consumption