CSR, Sustainability, Ethics & Governance
Series Editors: Samuel O. Idowu · René Schmidpeter

Paolo Taticchi
Paolo Carbone
Vito Albino *Editors*

Corporate Sustainability

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Corporate Sustainability

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To Eva, Gaetano, and Francesca
Vito Albino

To Ina, Andrea, Alessandro and Riccardo
Paolo Carbone

This book is dedicated to:
my wife, who proceeds with me in life and supports me with her love,
my parents, for sustaining me in all the difficult moments of the academic career,
Piero Lunghi, a great friend who transferred me passion for working and ambition in life.
Paolo Taticchi

Preface

Sustainability is one of the key issues of today's society as confirmed by the increasing attention of governments, media, academics and industry.

A quoted definition of sustainability and sustainable development (SD) is that of the Brundtland Commission of the United Nations: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Such a definition leads directly to the three pillars of sustainability, which are the economical, social and environmental dimensions. The concept of sustainability is therefore close to the concept of "quality of life".

In fact, referring to a new vision of human well-being as represented by the quality of life (health status, education and skills, environmental quality, etc.) and the material living conditions (income, jobs, housing, etc.) of humans, the idea of sustainability is related to maintaining well-being over time. This is possible if different types of capital are preserved: natural, economic, human and social. Therefore, sustainable development has to maintain and enhance such capitals avoiding the pure exploitation of resources.

In the context of sustainable development (SD), businesses that are often referred as part of the problem can be part of the solution. As a consequence of that, world academics with different backgrounds (e.g. strategy, operations, accounting, supply chain, and technology) are today dealing with sustainability trying to understand how this affects the traditional way of doing business, and, as well, how traditional businesses are affected by sustainability.

The topic of business sustainability is multidisciplinary in nature, and its complexity calls for putting in place a wide variety of research approaches, such as action research, case studies, surveys, model development, etc.

Models and tools are needed to assess current sustainability of businesses, define areas of improvement and drive initiatives. Sustainability measurement initiatives add the necessary knowledge needed to verify programme effectiveness and to provide objective information for guiding strategic actions.

This book intends to give the state of the art of sustainable-corporations-related topics under a number of perspectives, which include: economy, finance, measurement and reporting, organizing for sustainability, green products, green buildings and IT.

Nowadays, it is possible to affirm that sustainability is a new consolidated discipline in business and management that encompasses and gives more structured support to a large diversity of businesses.

The research value of the chapters provides good insights to address future research and define a proper research agenda for the coming years.

Further, the relevance of the topics addressed makes the book or the individual chapters an interesting read for academics, practitioners, consultants and more generally, for people interested in business evolution and sustainability.

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Università di Perugia, Italy — Prof. Eng. Paolo Carbone
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Green Economy

Vito Albino

1 Introduction

In the last decade significant warnings about the health of the planet were stated (e.g. IPCC 2007). At the same time a large debate about the future of Kyoto Protocol rose since USA made decision to not ratify the Agreement and some countries like China were emerging as new manufacturing (and polluting) poles of the world. As the financial turbulence arrived, the attention of the governments and of the public opinion shifted towards this new crisis. 2009 was marked by the convergence of several global crises. Around the world, people suffered the consequences of financial and economic turmoil, with fluctuating food prices and shortages (FAO 2010), and energy market insecurity. Governments put together immense economic stimulus packages. The economic, food, and energy crises did not unfold in isolation from other environmental and social challenges. They are linked in many ways to continuing biodiversity loss, ecosystem degradation, and climate change. Then, more determined steps are needed to protect the ecosystems that support economic growth and sustain life on earth, as well as to eradicate extreme poverty, i.e. to meet the Millennium Development Goals (UN 2011).

At present, we realize that the economic model pioneered by today's industrial countries is not viable for the world as a whole. In fact, today's economy is profoundly out of balance with the world's ecological resource system. Solving environmental problems can entail substantial costs for some industries even though it will create thousands of new companies and millions of jobs, laying the foundation for the transition to a green economy and growth.

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Moreover, the idea of development is now under discussion as the financial and economic crisis has demonstrated that we need new values and approaches. As Sen[1] (UNDP 2011a) suggests: "Human development, as an approach, is concerned with what I take to be the basic development idea: namely, advancing the richness of human life, rather than the richness of the economy in which human beings live, which is only a part of it". Then, humans must not be neglected in any reasoning about development. In the 2011 Human Development Report (UNDP 2011b) the joint challenge of sustainable and equitable progress is the major focus as there is a mutual relationship between environmental degradation and inequality. This strong commitment to focus both at humans and nature has been shown by the General-Secretary of UNESCO, Irina Bokova (UNESCO 2011): "Sustainable growth must be inclusive, it must be socially equitable, and it must protect our ecosystems and climate. The mantra of 'grow today, clean up later' can no longer stand – for developed or developing countries. The time when we could put off difficult choices is over. There are no more shortcuts. We must build inclusive, green societies and economies by investing in human development and social capital. New challenges require innovative solutions, which must harness also indigenous knowledge for sustainable development. These will be born from new ways of thinking and attitudes by people of all ages and from all walks of life. No society can afford to leave anyone aside. Green societies must allow women and men to contribute equally in leading and building a more sustainable future. We need a change of culture to tackle climate change".

The next UN Conference on Sustainable Development (Rio+20), to be held in Rio de Janeiro, Brazil, from 4 to 6 June 2012, offers an opportunity to reset the world on a sustainable development path. The two themes of the Conference are a green economy within the context of sustainable development and poverty eradication, and the institutional framework for sustainable development.

The transition to a sustainable and socially equitable economy, i.e. a green economy, can shape the future of the next generation, in particular, in terms of jobs (EC 2011a; UNEP/ILO/IOE/ITUC 2008).

Successful green economies will require visionary systems thinking and smart, effective government regulations and economic incentives. It is a change in our culture and in the way we think. At stake are our future and the health of the planet on which the economy depends.

In the next section, we will describe the conceptual pillars supporting the development of a green economy. Subsequently, we will present the definition of green economy and the performance indicators required to evaluate development progress and policy effectiveness.

[1] See also (Anand and Sen 1996, 2000; Sen 1999).

2 Towards a Green Economy

Today more than ever, in the context of climate change and world economy adjustment, it has become clear that our global community has to adopt more sustainable lifestyles to both reduce the use of natural resources and greenhouse gas emissions moving towards low-carbon societies and green economy (UNEP 2011). This is crucial in order to decouple economic growth from the environment exploitation and degradation, in both developing and developed countries, as well as to create the opportunity for the poor to meet their basic needs. In fact, in many countries social inequality, often caused by economic disparities in the distribution of economic assets and income, is discriminating people and affecting human dignity; and large economic and social disparities may lead to social instability, thus damaging economic development.

In the last years the debate about the concept of a new and green economy has dramatically grown. Several reasons drive the political and academic attention to consider a new economy and society based on a different set of principles and values. Some of these reasons have emerged since the Rio Conference, that has been held in 1992 in Rio de Janeiro and is known as the Earth Summit II. During the Opening session, Maurice Strong, the Secretary General of the Conference, gave the introductory talk stating[2] that industrialized countries have "developed and benefited from the unsustainable patterns of production and consumption which have produced our present dilemma. It is clear that current lifestyles and consumption patterns of the affluent middle class – involving high meat intake, consumption of large amounts of frozen and convenience foods, use of fossil fuels, appliances, home and work-place air-conditioning, and suburban housing – are not sustainable. A shift is necessary toward lifestyles less geared to environmentally damaging consumption patterns".

Then, the economic model of industrial countries is not affordable for the world as a whole because of its impact on the economy, environment, and social inequality. As stated in 1992 in Sect. 4.3 of Agenda 21,[3] "the major cause of the continued deterioration of the global environment are the unsustainable patterns of consumption and production, particularly in industrialised countries, which is a matter of grave concern, aggravating poverty and imbalances".

2.1 Sustainable Development

Sustainable development is a pattern of resource use, that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come. The term was used by the United

[2] http://theobamafile.com/_associates/MauriceStrong.htm

[3] http://www.un.org/esa/dsd/agenda21/res_agenda21_04.shtml

Nations World Commission on Environment and Development that published "*Our Common Future*", also known as the Brundtland Report (Brundtland Commission 1987), from the name of the Chairman of the Commission, Gro Harlem Brundtland who was the former Prime Minister of Norway. The Commission coined the famous definition of sustainable development as the one that "meets the needs of the present without compromising the ability of future generations to meet their own needs".

The report was inspired by the results of the United Nations Conference on the Human Environment (Stockholm Conference) which had introduced environmental concerns to the development problem. The Brundtland Report placed environmental issues firmly on the political agenda; it aimed to discuss the environment and development as one single issue.

This Report and the work of the World Commission on Environment and Development were the base for the convening of the 1992 Earth Summit and the adoption of Agenda 21, the Rio Declaration, and to the establishment of the Commission on Sustainable Development.

The transition to more sustainable patterns of consumption and production is the core of sustainable development. More specifically, referring to production activities (agriculture, resource extraction, manufacturing) and to their impact on the environment, sustainable production means[4] the "creation of goods and services using processes and systems that are non-polluting, conserving of energy and natural resources, economically efficient, safe and healthful for workers, communities, and consumers, and socially and creatively rewarding for all working people". The concept of sustainable production is relevant for all countries as both developed and underdeveloped economies usually do not apply sustainable productions. In particular, in industrially developed countries, a kind of "rebound effect" has been observed. In fact, innovations have reduced industrial energy use and emissions of specific pollutants. Ironically, efforts to improve the environmental compatibility of goods and services or to enhance their economic performance have opened up opportunities to consume more of them and, thus, to negate the benefit derived from the original improvements.

Sustainability encompasses all components of the production system. Goods and services can be: (i) safe and ecologically sound throughout their life cycle; (ii) as appropriate, designed to be durable, repairable, readily recycled, compostable, or easily biodegradable; (iii) produced and packaged using the minimal amount of material and energy possible (Dangelico and Pontrandolfo 2010). Processes are designed and operated such that: (i) wastes and ecologically incompatible by-products are reduced, eliminated or recycled on-site; (ii) chemical substances or physical agents and conditions that present hazards to human health or the environment are eliminated; (iii) energy and materials are saved, and the forms of energy and materials used are most appropriate for the desired ends; (iv) work spaces are designed to minimize any hazard.

[4] Lowell Center for Sustainable Production, http://www.sustainableproduction.org/abou.what.php.

Then, all stages of the product lifecycle (from production of raw materials through manufacture, use and disposal of the final product) economically, socially, culturally, and physically benefit when sustainability principle is adopted. To move towards a sustainable business the following actions can be adopted (Hawken 1993):

- Replace nationally and internationally produced items with products created locally and regionally;
- Take responsibility for the effects they have on the natural world;
- Do not require exotic sources of capital in order to develop and grow;
- Engage in production processes that are human, worthy, dignified, and intrinsically satisfying;
- Create objects of durability and long-term utility whose ultimate use or disposition will not be harmful to future generations;
- Change consumers to customers through education.

Green innovation processes support sustainable business models also encouraging resource efficiency, sustainable infrastructure, green jobs and better quality of life. For instance, some business models are now changing. In particular, in the last decade globalization transformed company's supply chains selling products whose components are manufactured and assembled in different continents. This approach is now under careful evaluation since environmental and operational problems have shown some weaknesses which ask for radically reinvent supply chains (see, for instance, (Lee 2010; de Treville and Trigeorgis 2010)). Then, innovation can accelerate the achievement of long-term sustainable development by reducing future economic, environmental and social costs, strengthening economic competitiveness and reducing poverty.

2.2 *From Resource Constraints to Resource Efficiency*

A major role in sustainability is played by the availability of resources. The existence of some constraints for resources and their impact on the evolution of the economic systems have influenced different economists. Thomas Robert Malthus (1766–1834) has developed theories concerning population and its increase or decrease in response to various factors. In his book *An Essay on the Principle of Population* (Malthus 1996), published from 1798 to 1826, he observed that sooner or later population gets checked by famine, disease, and widespread mortality. Malthus considered epidemics, famines, or wars as events that masked the fundamental problem of populations overstretching their resource limitations.[5]

[5] "The power of population is so superior to the power of the earth to produce subsistence for man, that premature death must in some shape or other visit the human race. The vices of mankind are active and able ministers of depopulation. They are the precursors in the great army of destruction,

However, Malthus was not able to recognize the extraordinary role of science and technology in the incoming industrial revolution. The progress of medicine and its impact on the demographic dynamic, the fertility reduction of western families as a rational choice since 1870 have strongly modified the context in which Malthus has developed his theory.

Two hundred years later, the book *The Limits to Growth* (Meadows et al. 1972) echoes some of the concerns and predictions of Malthus, but its impact was impressive as 1 year later the Kippur War demonstrated how the world was vulnerable to oil price shock and crisis and how relevant can be natural resources for the world economy. In the book the consequences of a rapidly growing world population and finite resource supplies were analyzed. The research was commissioned by the Club of Rome to build a model to simulate the interactions between the Earth's and human systems. Five variables were examined in the original model, on the assumptions that exponential growth accurately described their patterns of increase, and that the ability of technology to increase the availability of resources grows only linearly. These variables were: world population, industrialization, pollution, food production and resource depletion. The authors intended to explore the possibility of a sustainable feedback pattern that would be achieved by altering growth trends related to the five variables. The purpose of the research was not to make specific predictions, but to explore how exponential growth interacts with almost finite resources. Because the size of resources is not known, only the general behavior was explored.

Many prominent economists, scientists and political figures criticized *The Limits to Growth*. They attacked the methodology, the model, the conclusions, and the rhetoric behind the project. They stated that technology could solve all the problems the book was concerned about, but only if growth continued apace. By stopping growth too soon, someone warned, the world would be "consigning billions to permanent poverty". The main limit of *The Limits to Growth* lies on the fact that population, capital and pollution grow exponentially in all models, but technologies for expanding resources and controlling pollution are permitted to grow, if at all, only in discrete increments. In the successive decades high values of innovation rate showed that it is not easy to build reliable forecast for this variable. Twenty years later a new book, "*Beyond the Limits*" (Meadows et al. 1992), has been published to update the modeling of the consequences of a rapidly growing global population. The authors addressed many of the criticisms of the previous book, but still they caused controversy and mixed reactions.

Successively, the concept of resource efficiency emerged as the driver for continuous progress. The Club of Rome promoted a new research whose results have been published in the book "*Factor Four: Doubling Wealth – Halving*

and often finish the dreadful work themselves. But should they fail in this war of extermination, sickly seasons, epidemics, pestilence, and plague advance in terrific array, and sweep off their thousands and tens of thousands. Should success be still incomplete, gigantic inevitable famine stalks in the rear, and with one mighty blow levels the population with the food of the world" (Malthus 1996).

Resource Use" (von Weizsäcker et al. 1996). The main conclusion of this research is that it is possible to increase efficiency in the use of resource by a factor equal to four. Several examples are provided to show how resource efficiency can be the key to deal with the problem of sustainable development.

Tracking production and consumption patterns is the first step in management aimed at optimizing resource efficiency. A better understanding of material and energy flows will help meet the challenges associated with economic growth, habitat destruction, pollution, and climate change.

In the last few decades, awareness that our growth-oriented society may be overreaching the Planet's carrying capacity has been increasing. Through the development of interdisciplinary perspectives, the cumulative environmental effects of human activities are becoming more evident.

The fundamental issue addressed by resource efficiency is how to improve the management of both production and consumption. Poor management contributes to natural resource depletion, ecosystem destruction, pollution, climate change, and waste of materials. Resource efficiency employs a variety of approaches to reduce resource use and environmental impacts per unit of production, trade, or consumption over the entire life cycle of goods, services, and materials.

Industrial ecologists and material chain analysts examine processes on many different scales. Some compare the delivery and consumption of industrial materials, and the accumulation of by-products, to the metabolism of living entities (Ayres 2008; Haberl et al. 2008; Korhonen 2001; Krausmann et al. 2008). According to this approach, growth in industrial metabolism is a major driver of global environmental change (Ayres and Warr 2009). Managing projected supply and demand is the objective of sustainable consumption and production, and of resource efficiency strategies (Jackson 2009). Reducing global materials use, or at least stabilizing it at the current level, will require major reductions of metabolic rates, above all in industrialized countries. Gains in the efficiency of materials use could contribute to a decoupling of economic growth from the use of both materials and energy, but this would require effective and innovative management strategies to avoid rebound effects (Bleischwitz et al. 2009; Krausmann et al. 2009; Lutz et al. 2004; OECD 2009).

Improved resource efficiency, which supports sustainable consumption and production, has become an increasingly accepted objective for management decisions, from the household to the international environmental governance levels. Developed countries recognize that pursuing resource efficiency, and innovating to minimize waste of materials and energy use, present opportunities to lower costs and to share relevant technologies with developing countries (Jackson 2009; OECD 2009). For instance, in 2009 the "Global Market Transformation for Efficient Lighting" initiative has been launched. It is accelerating a global market transformation towards energy-efficient lighting technologies, and then the development of a worldwide strategy to phase out incandescent bulbs, thereby reducing global greenhouse gas emissions (UNEP 2009).

Governments, civil society, and the private sector could all take advantage of the global economic slowdown to reorient their business plans and economic objectives

towards sustainable development, and to accelerate the transformation towards a green economy and sustainable prosperity. For instance, to achieve a transition in the energy and transport sectors towards the comparatively radical shifts in consumption and production patterns that many experts consider necessary, implementation efforts need to begin as soon as possible (IEA 2009a, b).

Scientists working in a number of fields warn that we risk crossing the thresholds that define "planetary boundaries" (Rockström et al. 2009). Understanding the significance of these boundaries, and how to pull back and operate within safe limits, will require continual refinement of analytical tools, drawing on the lessons of the past, and the development of sustainable solutions to environmental challenges such as decoupling of resource use and environmental impacts from economic growth. Accepting limitations on use of the planet's resources, and improving our understanding of interactions among Earth systems, would make it possible to implement solutions through sustainable resource management rather than geo-engineered technological fixes (Read 2008).

2.3 *Triple Bottom Line: Evaluating Social, Environmental and Economic Issues*

In a context of sustainable development, business accounting cannot be limited to economic and internal aspects. Social, environmental and economic issues have to be included when evaluating business impact. This approach has been proposed in the 90's as the "triple bottom line (TBL)" or the "people, planet, profit (3P)". TBL accounting means expanding the traditional reporting framework to take into account ecological and social performance in addition to financial performance. TBL was coined in 1994 by John Elkington (1994), co-founder of SustainAbility, a consulting company. The 3P concept was proposed to Shell company by SustainAbility. It was later expanded and articulated (Elkington 1997). In fact, the TBL approach cannot be interpreted as simply traditional corporate accounting profit (which nevertheless remains an essential starting point for the computation) plus social and environmental impacts unless the profits of other entities are included as a social benefit.

To improve accounting for social, environmental and economic issues, there are several business excellence frameworks used around the world, including the Baldrige Performance Excellence Framework in the United States, the EFQM Excellence Framework in Europe, and the Australian Business Excellence Program in Australia. These independent scoring methods can support monitoring and measurement that can serve the many stakeholders that want to know about performance for TBL.

2.4 Natural Capitalism and Human Development

Sustainable development points out that the environment and humans have to be central in any project of future, but with a new perspective. Natural resources and humans are not the means but the goal of development. Following this view, two more important principles have been considered.

Lovins et al. (1999) introduced the term "natural capitalism" to describe a future in which business and environmental interests increasingly overlap, and in which businesses can better satisfy their customers' needs, increase profits, and help solve environmental problems all at the same time.

The natural capitalism is based on the concept that natural and human capitals have to be included in the balance sheet as well as the economic one. Since nature is rooted in biomes and people in communities, they cannot be shipped and traded like money or goods without damaging them. Then, natural capitalism has strong implications in the evaluation of globalization (Hawken et al. 1999).

Four principles are assumed in the natural capitalism: (i) increasing resource productivity; (ii) redesigning industry on biological models with closed loops and zero waste; (iii) shifting from the sale of goods (for example, light bulbs) to the provision of services (illumination); (iv) reinvesting in the natural capital that is the basis of future prosperity.

The first principle requires that production output is obtained using less resources such as fuels, minerals, water. At the same time, products have to be dematerialized and have to last longer.

The second principle is inspired to biomimetic production which closes the loops in extraction and manufacturing and turns waste into value. Industrial symbiosis (Korhonen 2001) is an example of such a production organization where a production process use another process' waste as primary input and so on.

For the third principle the manufacturer can lease the service of a good, without selling it, and then this condition provides powerful incentives for durability, quality, and reuse.

The reinvestment in nature, i.e. the fourth principle, means to restore and enhance nature's fecundity, boosting ecosystems' ability to provide even more food, fiber, and free ecological services, and hence to enhance life for all beings.

Referring to humans, the human development approach has been proposed in part as a response to the growing criticism to the leading development approach of the '80s, which presumed a close link between national economic growth and the expansion of individual human choices. Human development is a development paradigm that is about much more than the rise of national incomes. It concerns the idea of future where people can develop their full potential and lead productive, creative lives in accord with their needs and interests. People are the real wealth of nations. Development is thus about expanding the choices people have to lead valuable lives. This is about much more than economic growth, which is only a means – if a very important one – of enlarging people's choices.

Fundamental to enlarging these choices is building human capabilities, i.e. the range of things that people can do or be in life. The most basic capabilities for human development are to lead long and healthy lives, to be educated, to have access to the resources needed for a decent standard of living, and to be able to participate in the life of the community. Without these, many choices are simply not available, and many opportunities in life remain inaccessible.

In seeking that something else, human development is rooted in human rights and freedom. In pursuing capabilities and realizing rights, people must be free to exercise their choices and to participate in decision-making that affects their lives. Human development and human rights are mutually reinforcing, helping to secure the well-being and dignity of all people, building self-respect and the respect of others.

The economist Amartya Sen, Nobel laureate in 1998, provided the conceptual foundation for the alternative and broader human development approach defined as a process of enlarging people's choices, and enhancing human capabilities and freedoms. Then, human development is concerned with the advance of the richness of human life rather than of the economy in which human beings live (Sen 1999).

Since 1990 the human development concept has been adopted to produce the Human Development Reports published yearly under the auspice of the United Nations Development Programme (UNDP). The idea of human development has always been considered flexible and the concept of human development can evolve over time and vary both across and within countries. Human development is related to some issues currently considered the most important, namely: social progress (access to knowledge, nutrition and health), economic growth, efficiency in terms of resource use and availability, equity, participation and freedom (democratic governance, gender equality, civil and political rights, and cultural liberty), sustainability in ecological, economic and social terms, human security (joblessness, famine, conflict, etc.).

3 Green Economy Definition

In a world at the same time demanding better lives for the global population and requiring responses to the environmental problems, a dramatic change is needed. Growth and development have to be sought improving human well-being, providing decent jobs, reducing inequalities, tackling poverty and preserving the natural capital upon which we all depend (EC 2011b).

All this cannot be based on slowing growth, but rather promoting the right kind of growth. Such a growth can be sustained by a green economy that offers an effective way of promoting sustainable development, eradicating poverty and addressing emerging challenges.

A green economy (UNEP 2011) is "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. A green economy is an economy or economic development

model based on sustainable development and a knowledge of ecological economics. Its most distinguishing feature from prior economic regimes is direct valuation of natural capital and nature's services as having economics value (see[6] TEEB and Bank of Natural Capital) and a full cost accounting regime in which costs externalized onto society via ecosystems are reliably traced back to, and accounted for as liabilities of, the entity that does the harm or neglects an asset".

A similar definition for green economy is provided by the OECD referring specifically to the green growth. Green growth (OECD 2011a) is about "fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies. To do this it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities".

Green growth has thus several dimensions that have to be considered in order to catch its deep and revolutionizing meaning. In particular, the sustainable and inclusive growth is considered as a fundamental condition for a right kind of growth. Then, a green economy can be thought of as one where growth is low carbon, resource efficient, and socially inclusive. This growth should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. These investments need to be catalyzed and supported by targeted public expenditure, policy reforms and regulation changes. The development path should maintain, enhance and, where necessary, rebuild natural capital as a critical economic asset and as a source of public benefits, especially for poor people whose livelihoods and security depend on nature.

Green economy is not just about the environment. Certainly, we must move to find harmony with natural systems. But doing this requires human creativity, and access to knowledge, and the widespread participation of everyone as an extension of democracy. Social and ecological transformation have to go hand-in-hand.

Green economy and green politics both emphasize the creation of positive alternatives in all areas of life and every sector of the economy. Green economy does not prioritize support for either the public or the private sector. It argues that both sectors must be transformed so that markets express social and ecological values, and the state becomes merged with grassroots networks of community innovation. For this to happen, new economic processes must be designed, and new rules of the game written, so that incentives for ecological conduct are built into everyday economic life. The state can then function less as a policeman, and more as a coordinator. This is a very different kind of "self-regulation" than current profit- and power-driven market forces. The basis for self-regulation in a green economy would be community, and intelligent design which provides incentives for the right things.

[6] See http://www.teebweb.org for TEEB, i.e. The Economics of Ecosystems Biodiversity, and http://bankofnaturalcapital.com/ for the Bank of Natural Capital.

Six sectors mainly characterize a green economy:

- Renewable energy (solar, wind, geothermal, marine including wave, biogas, and fuel cell);
- Green buildings (green retrofits for energy and water efficiency, residential and commercial assessment; green products and materials, and LEED construction);
- Clean transportation (alternative fuels, public transit, hybrid and electric vehicles, car sharing and carpooling programs);
- Water management (water reclamation, greywater and rainwater systems, low-water landscaping, water purification, storm water management);
- Waste management (recycling, municipal solid waste salvage, brownfield land remediation like Superfund cleanup, sustainable packaging);
- Land management (organic agriculture, habitat conservation and restoration; urban forestry and parks, reforestation and afforestation and soil stabilization).

Moving towards a green economy necessitates preserving and investing in the assets of key natural resources. It also involves the proper valuation of natural capital, and, in more general terms, a revision of the way in which we measure growth and progress. In a green economy many challenges can be transformed into economic opportunities, not only reversing negative environmental trends, but also driving future growth and jobs. The green economy offers opportunities to all countries, irrespective of their level of development and the structure of their economies. While in many cases investments to move towards a green economy can result in short-term win-win solutions, in other cases a medium term perspective will be needed, and transitional costs will have to be addressed, including through "pro-poor" policies. Even though there is no "one-size-fits-all" model, there are common challenges and solutions, and countries will benefit from exchanging experience and improved international cooperation.

At the same time, moving towards the green economy does not start from zero. There are already a number of strategies in place that countries can build on, such as: climate change, biodiversity, sustainable consumption and production, research and innovation, all of which can contribute to enabling a green economy. Future national and international green economy strategies should build on and strengthen these, as is happening in Europe 2020 Strategy, and recently in the roadmap for moving to a competitive low carbon economy by 2050.

International organisations, including UNEP and the OECD, are promoting green economy initiatives and green growth strategies. The International Labour Organisation is developing programmes to support a socially fair transition towards green, decent jobs. Jobs are green[7] when they help reduce negative environmental impact and ultimately lead to environmentally, economically and socially sustainable enterprises and economies. The G20 countries are also increasingly engaging in the green economy agenda.

[7] More precisely, green jobs are decent jobs (UNEP/ILO/IOE/ITUC 2008) that: (i) reduce consumption of energy and raw materials; (ii) limit greenhouse gas emissions; (iii) minimize waste and pollution; and (iv) protect and restore ecosystems.

Based on the above initiatives, to achieve the transition to a green economy we need to address three interlinked policy dimensions (EC 2011b):

– Investing in the sustainable management of key resources and natural capital ("what");
– Establishing the right market and regulatory conditions ("how");
– Improving governance and private sector involvement ("who").

UNEP whose aim is to assist governments in "greening" their economies by reshaping and refocusing policies, investments and spending towards a range of sectors,[8] supported the Global Green New Deal (Barbier 2009). Such a policy response to the financial and economic crisis should make a major contribution to reviving the world economy, saving and creating jobs, and protecting vulnerable groups. It should promote sustainable and inclusive growth and the achievement of the Millennium Development Goals, especially ending extreme poverty by 2015. Also, it has to reduce carbon dependency and ecosystem degradation.

4 Performance Indicators

Measuring the true progress towards a green economy is not easy as different aspects have to be considered. Governments are requested to develop reliable indicators, and environmental and social accounting. However, measuring progress requires comparable metrics and indicators to be in place (EC 2011b). Then, the definition of a system of indicators able to build an environmental and social accounting defined and agreed at the international level is needed. This system has to be integrated with the economic accounting system through existing initiatives such as the international system for integrated environmental and economic accounting (SEEA), the UNDP (Human Development Report) and the OECD (Measuring the Progress of Societies).

A number of organisations have been working to provide various forms of indicators that can reflect the state of the environment and natural assets, well-being and the quality of life. These indicators should be used alongside Gross Domestic Product (GDP). However, only some of these indicators have so far been used widely in communicating policy needs, such as the Ecological Footprint and the Human Development Index.

United Nations should promote the transparency of national reporting and agree on the use of robust indicators at national and at global level in order to measure this wider sense of progress in addition to GDP.

[8] Sectors such as clean technologies, renewable energies, water services, green transportation, waste management, green buildings and sustainable agriculture and forests. More information are available on the website www.unep.org/ greeneconomy.

4.1 Ecological Footprint

The Ecological Footprint (EF) is a measure of the impact of human demand on the Earth's ecosystems (Wackernagel and Rees 1996). It is based on a standard measurement of a unit's influence on its habitat caused by the process of consumption and pollution. Human demand is compared with planet Earth's ecological capacity to regenerate. In fact, it represents the amount of biologically productive land and sea area needed to regenerate the resources a human population consumes and to absorb and render harmless the corresponding waste. For instance, a country's footprint (demand side) is the total area required to produce all the materials (food, water, etc.) that it consumes, absorb the waste it generates, and provide areas for its infrastructures (built-up areas). On the supply side, biocapacity is the productive capacity of the biosphere and its ability to provide a flow of biological resources and services useful to humanity (Moran et al. 2008).

Using this assessment, it is possible to estimate how much of the Earth (or how many planet Earths) it would take to support humanity if everybody lived a given lifestyle. For 2006, humanity's total ecological footprint was estimated at 1.4 planet Earths – i.e., humanity uses ecological services 1.4 times as fast as Earth can renew them. Every year, this number is recalculated – with a 3 year lag due to the time it takes for the UN to prepare and publish all the underlying statistics.

Today calculation standards are reliable to get comparable and consistent measures. Then EF is widely used by scientists, businesses, governments, agencies, individuals, and institutions working to monitor ecological resource use and sustainable development.

By measuring the footprint of a population's unit (i.e., individual, city, business, nation, or all of humanity) its pressure on the planet can be assessed and the ecological assets can be managed more wisely. Moreover, personal and collective actions can support the transition towards a world where humanity lives within the Earth's bounds. This approach can also be applied to an activity such as the manufacturing of a product or driving of a car. This resource accounting is similar to life cycle analysis wherein the consumption of all resources (energy, raw materials, water, etc.) is converted into a normalized measure of land area called "global hectares" (gha).

Per capita ecological footprint is a means of comparing consumption and lifestyles, and checking this against nature's ability to provide for this consumption. The tool can inform policy by examining to what extent a nation uses more (or less) than is available within its territory, or to what extent the nation's lifestyle would be replicable worldwide. The footprint can also be a useful tool to educate people about carrying capacity and over-consumption, with the aim of altering personal behavior. Ecological footprints may be used to argue that many current lifestyles are not sustainable. Such a global comparison also clearly shows the inequalities of resource use on this planet. For instance, in 2007, the average biologically productive area per person worldwide was approximately 1.8 global hectares (gha) per capita. The EF per capita for U.S. and Canada region was 7.9 gha, whereas for Africa and Asia 1.4 gha and 1.8 gha, respectively (Table 1).

Table 1 EF and biocapacity for region (Data 2007, Source: www.footprintnetwork.org)

Region	EF of consumption (gha/pers)	Total biocapacity (gha/pers)	Ecological (deficit) reserve (gha/pers)	Population (millions)
Europe	4.7	2.9	(1.8)	730.9
Africa	1.4	1.5	0.1	963.9
Asia	1.8	0.8	(1.0)	4,031.2
US & Canada	7.9	4.9	(3.0)	341.6
Latin America & the Caribbean	2.6	5.5	2.9	569.5
Oceania	5.4	11.1	5.8	34.5
World	2.7	1.8	(0.9)	6,671.6

Since 2006, a first set of ecological footprint standards exist that detail both communication and calculation procedures. They are available at www.footprint-standards.org and were developed in a public process facilitated by Global Footprint Network and its partner organizations.

The ecological footprint of some denotative countries of each region is reported in Table 2 It is based on 2007 data from the Global Footprint Network published in 2010. The world-average ecological footprint in 2007 was 2.7 global hectares per person (18 billion in total). With a world-average biocapacity of 1.8 global hectares per person (12 billion in total), this leads to an ecological deficit of 0.9 global hectares per person. If a country does not have enough ecological resources within its own territory, then there is a local ecological deficit and it is called an ecological debtor country. Otherwise, it has an ecological remainder and it is called an ecological creditor country.

4.2 Human Development Index

As said before, the most basic capabilities for human development are to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community. The Human Development Index (HDI) is a summary composite index that measures a country's average achievements in three basic aspects of human development: health, knowledge, and income. It was first developed by Mahbub ul Haq, Amartya Sen and other leading development thinkers for the first Human Development Report in 1990. Introduced as an alternative to conventional measures of national development, such as GDP and the rate of economic growth, HDI is a new way of measuring development by combining indicators of life expectancy, educational attainment and income into a composite index. The breakthrough for the HDI was the creation of a single statistic which was to serve as a frame of reference for

Table 2 List of countries ordered by EF (Data 2007, Source: www.footprintnetwork.org)

Country	EF (gha/pers)	Biocapacity (gha/pers)	Ecological remainder (if positive) (gha/pers)	Population (millions)
UAE	10.68	0.85	−9.83	6.25
Denmark	8.26	4.85	−3.41	5.45
United States	8.00	3.87	−4.13	308.67
Canada	7.01	14.92	7.91	32.95
Australia	6.84	14.71	7.87	20.85
Netherlands	6.19	1.03	−5.16	16.46
Sweden	5.88	9.75	3.87	9.16
Norway	5.56	5.48	−0.08	4.72
Spain	5.42	1.61	−3.81	44.05
Saudi Arabia	5.13	0.84	−4.29	24.68
Germany	5.08	1.92	−3.16	82.34
France	5.01	3.00	−2.01	61.71
Italy	4.99	1.14	−3.85	59.31
UK	4.89	1.34	−3.55	61.13
South Korea	4.87	0.33	−4.54	47.96
Japan	4.73	0.60	−4.13	127.40
Russia	4.41	5.75	1.34	141.94
Mexico	3.00	1.47	−1.53	107.49
Brazil	2.91	8.98	6.07	190.12
Ukraine	2.90	1.82	−1.08	46.29
Turkey	2.70	1.32	−1.38	73.00
Argentina	2.60	7.50	4.90	39.49
South Africa	2.32	1.14	−1.18	49.17
China	2.21	0.98	−1.23	1,336.55
Nigeria	1.44	1.12	−0.32	147.72
Bangladesh	0.62	0.38	−0.24	157.75
Puerto Rico	0.04	0.14	0.10	3.95

both social and economic development. The HDI sets a minimum and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1. The components of HDI are reported in Fig. 1.

The education component of the HDI is now measured by mean of years of schooling for adults aged 25 years and expected years of schooling for children of school going age. Mean years of schooling is estimated based on duration of schooling at each level of education. Expected years of schooling estimates are based on enrolment by age at all levels of education and population of official school age for each level of education. The indicators are normalized using a minimum value of zero and maximum values are set to the actual observed maximum values of the indicators from the countries in the time series, that is, 1980–2010. The education index is the geometric of two indices.

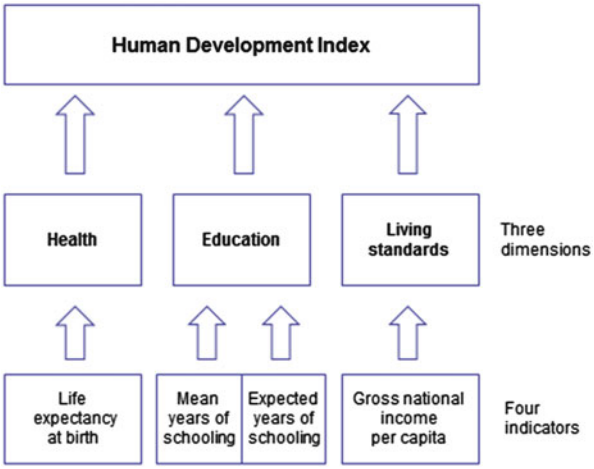

Fig. 1 The components of HDI

The life expectancy at birth component of the HDI is calculated using a minimum value of 20 years and maximum value of 83.2 years. These are the observed maximum value of the indicators from the countries in the time series, 1980–2010. Thus, the longevity component for a country where life expectancy birth is 55 years would be 0.554.

For the wealth component, the goalpost for minimum income is 163 USD (purchasing power parity, PPP) and the maximum is 108,211 USD (PPP), both observed during the same time series and measured by Gross National Income[9] (GNI) per capita instead of GDP per capita. The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The scores for the three HDI dimension indices are then aggregated into a composite index using geometric mean.

The HDI emphasizes that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone. Then, HDI can also be used to question national policy choices, asking how two countries with the same level of GNI per capita can end up with such different human development outcomes. For example, the Bahamas and New Zealand have similar levels of income per person, but life expectancy and expected years of schooling differ greatly between the two countries, resulting in New Zealand having a much higher HDI value than the Bahamas. These relevant contrasts can directly stimulate debate about government policy priorities. These varied

[9] GNI includes remittances and foreign assistance income, and then provides a more appropriate economic picture of many developing countries.

Table 3 HDI for G20 countries (Source: UNDP 2011b)

Country	HDI (2011)	Country	HDI (2011)
Australia	0.929	Mexico	0.770
USA	0.910	Saudi Arabia	0.770
Canada	0.908	Russia	0.755
Germany	0.905	Brazil	0.718
Japan	0.901	Turkey	0.699
South Korea	0.897	China	0.687
France	0.884	South Africa	0.619
Italy	0.874	Indonesia	0.617
UK	0.863	India	0.547
Argentina	0.797		

pathways to human development show that there is no single formula for sustainable progress and that impressive long-term gains can and have been achieved even without consistent economic growth.

The Human Development Report 2011 (UNDP 2011b) is titled "*Sustainability and Equity: A Better Future for All*". In this report it is argued that urgent global challenges of sustainability and equity must be addressed together. Policies at the national and global level have to focus on these interlinked goals if some benefits are expected for the world's poor majority. Past Reports have shown that living standards in most countries have been rising – and converging – for several decades now. Yet the 2011 Report projects a disturbing reversal of those trends as environmental deterioration and social inequalities continue to intensify, with the least developed countries diverging downwards from global patterns of progress by 2050.

The Report shows further how the world's most disadvantaged people suffer the most from environmental degradation, including in their immediate personal environment, and don't have political power. As a consequence, this condition makes harder for the world community to reach agreement on needed global policy changes. The Report also outlines opportunities for effective synergies in the quest for greater equality and sustainability, especially at the national level. The Report further emphasizes the human right to a healthy environment, the importance of integrating social equity into environmental policies, and the critical importance of public participation and official accountability. In Table 3 the HDI values for G20 countries are shown.

In Fig. 2 HDI and EF values are depicted for some countries showing significant disparities among regions. This comparison points out that the progress towards the green economy has to be measured with composite indices as different aspects need to be evaluated at the same time.

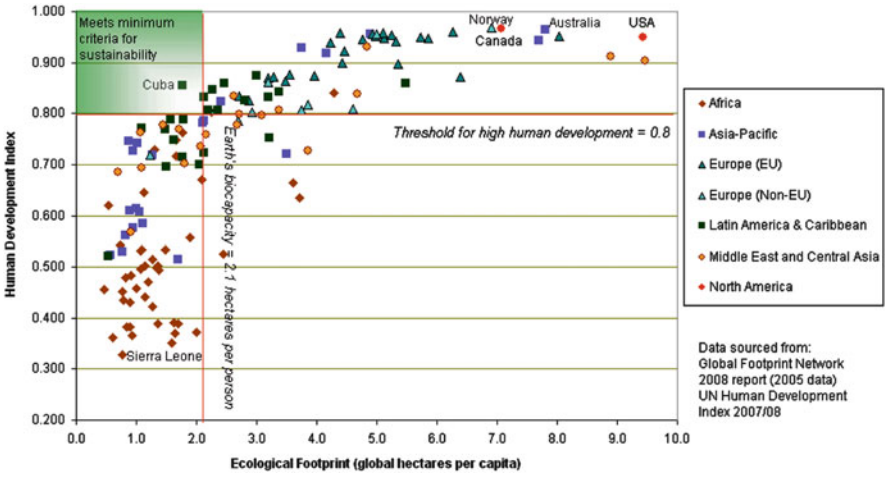

Fig. 2 HDI versus EF for different countries (Source: UNEP 2011)

4.3 Towards a New System of Indicators

Through substantive analysis, the OECD pointed out some of the limits of official statistics for measuring the progress of societies. Further impetus[10] to the progress measuring research was given by the Commission on the Measurement of Economic Performance and Social Progress – also known as the Stiglitz-Sen-Fitoussi Commission[11] – convened by French President Nicolas Sarkozy with the participation of the OECD. This commission was motivated by the fact that economic development measures need to be enhanced and a gap between the statistical measurement of socio-economic phenomena and citizen perception of the same phenomena exists. Moreover, GDP was considered an inadequate metric to gauge well-being over time particularly in its economic, environmental, and social dimensions, some aspects of which are often referred to as sustainability.

The actual relevance of the report is double with respect to the financial and environmental crisis as metrics incorporating assessments of sustainability (e.g.

[10] It is worthful to remember as one of the first impetus on the topic was the wonderful speech of Robert F. Kennedy at the University of Kansas on March 18, 1968 (http://www.youtube.com/watch?v=77IdKFqXbUY).

[11] The Commission was chaired by Joseph E. Stiglitz (Columbia University), Amartya Sen (Harvard University) was Chair Adviser, Jean-Paul Fitoussi (Institut d'Etudes Politiques de Paris and Observatoire Français des Conjonctures Economiques) was the Coordinator of the Commission. Members of the Commission are renowned experts from universities, governmental and intergovernmental organisations, in several countries (USA, France, United Kingdom, India) and fields like social capital, physical and mental well-being, and happiness. The Commission held its first plenary meeting on 22–23 April 2008 in Paris. Its final report has been made public on 14 September 2009. For more information visit the website: www.stiglitz-sen-fitoussi.fr/.

increasing indebtedness) would have provided a more cautious view of economic performance, and market prices are distorted by the fact that there is no charge imposed on carbon emissions; in fact no account is made of the cost of these emissions in standard national income accounts.

The Commission (Stiglitz et al. 2009) concluded in September 2009 that a broad range of measures and indicators about people's well-being and societal progress should be used alongside more standard economic measures such as GDP. As a result of the Commission work, the significance of measuring well-being and progress has been placed firmly on the political agenda at the very highest level, as evidenced by such developments at the national (major initiatives in Australia, Finland, France, Germany, Italy, Japan, Korea, New Zealand, Slovenia, Spain, the UK, the USA) and the international level (G20, EU).

The most important distinction introduced by the commission refer to current well-being and sustainability measure. Current well-being relates to economic resources (e.g. income) and non-economic aspects of peoples' life (e.g. what they do and what they can do, how they feel, and the natural environment they live in). Sustainability refers to whether the current levels of well-being can be sustained over time and depends on whether stocks of capital that matter for our lives (natural, physical, human, social) are passed on to future generations.

In particular, well-being is multi-dimensional as it is based on: material living standards (income, consumption and wealth), health, education, personal activities including work, political voice and governance, social connections and relationships, environment (present and future conditions), insecurity of an economic as well as a physical nature. Also, objective and subjective dimensions of well-being are both important. Objective measures such as measures of people's health, education, personal activities and environmental conditions should be improved; robust, reliable measures of social connections, political voice, and insecurity that can be shown to predict life satisfaction should be developed. Quality-of-life indicators in all the dimensions covered should assess inequalities (across people, socio-economic groups, gender and generations).

Subjective well-being encompasses cognitive evaluations of one's life such as happiness, satisfaction, positive emotions (for instance, joy and pride), and negative emotions (such as pain and worry); suitable measures should be developed.

The assessment of sustainability is complementary to the question of current well-being or economic performance, and must be examined separately. Sustainability requires the simultaneous preservation or increase in several stocks: quantities and qualities of natural resources, and of human, social and physical capital.

Referring to the need of more complete and reliable evaluation of the progress, OECD is very active since long time ago. As recently sustained by the OECD (2011a), green growth is about fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies. The measurement framework proposed by the OECD (Fig. 3) thus permits the definition of four inter-related groups of indicators (Fig. 4):

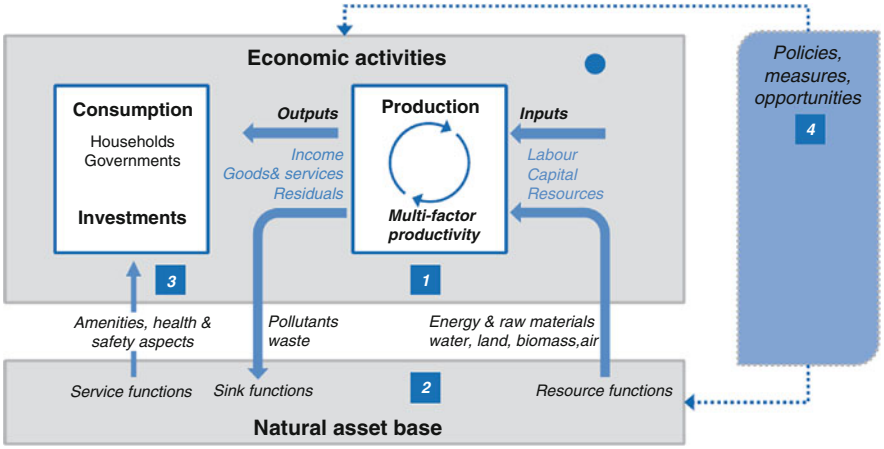

Fig. 3 Green growth: measurement framework (Source: OECD 2011a)

1 – The environment and resource productivity of the economy	• Carbon and energy productivity • Resource productivity: materials, nutrients, water • Multi-factor productivity
2 – The natural asset base	• Renewable stocks: water, forest, fish resources • Non-renewable stocks: mineral resources • Biodiversity and ecosystems
3 – The environmental dimension of quality of life	• Environmental health and risks • Environmental services and amenities
4 – Economic opportunities and policy responses	• Technology and innovation • Environmental goods & services • International financial flows • Prices and transfers • Skills and training • Regulations and management approaches
Socio-economic context and characteristics of growth	• Economic growth and structure • Productivity and trade • Labour markets, education and income • Socio-demographic patterns

Fig. 4 Green growth indicators groups and topics (Source: OECD 2011a)

– Indicators monitoring the environmental and resource productivity of production and consumption, to capture the need for efficient use of natural capital which is rarely quantified in economic models and accounting frameworks;
– Indicators describing the natural asset base, as a declining asset base presents risks to growth and sustained growth requires the asset base to be maintained;
– Indicators monitoring the environmental dimension of quality of life, capturing the direct impacts of the environment on people's lives, through e.g. access to water or the damaging effects of air pollution;
– Indicators describing policy responses and economic opportunities, which can be used to evaluate the effectiveness of policy in delivering green growth and where the effects are most marked.

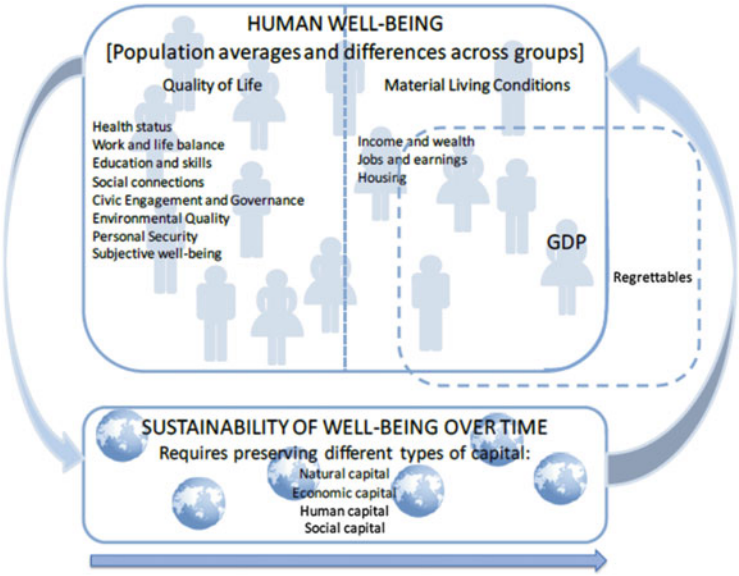

Fig. 5 Framework for OECD well-being indicators (Source: OECD 2011b)

They are complemented with generic indicators describing the socio-economic context and characteristics of growth.

Indicators can be selected on the basis of criteria such as their policy relevance, analytical soundness, and measurability. The selected set should be neither exhaustive nor final and has to be considered flexible as countries can adapt it to different national contexts.

Referring to the well-being indicators, OECD (2011b) provides some interesting insights (Fig. 5). In particular, the material living conditions (or "economic well-being") determine people's consumption possibilities and their command over resources. While this is shaped by GDP, the latter also includes activities that do not contribute to people's well-being (e.g. activities aimed at offsetting some of the regrettable consequences of economic development) while it doesn't include non-market activities that expand people's consumption possibilities. Quality of life, defined as the set of non-monetary attributes of individuals, shapes their opportunities and life chances, and has intrinsic value under different cultures and contexts.

The sustainability of the natural and socio-economic systems where people live and work is critical for well-being to last over time. Sustainability depends on how current human activities impact on the stocks of different types of capital (natural, economic, human and social). However, suitable indicators for describing the evolution of these stocks are still lacking in many fields.

5 Conclusions

In this chapter the concept of green economy is introduced referring to the main principles inspiring it. Sustainable development, resource efficiency, triple bottom line, natural capitalism and human development are recognized as the main conceptual pillars supporting economic and social transition. In fact, green economy results in improved human well-being and social equity, while significantly mitigating environmental pressures and ecological scarcities. This can be achieved if a change in the people culture will support smart, effective government regulations and economic incentives.

The green economy offers opportunities to all countries, irrespective of their level of development and the structure of their economy. However, for each country the transition towards the green economy has to be based on a country-specific model and the green growth has to be monitored in order to evaluate policy effectiveness and development progress.

Ecological footprint and human development index are identified as the most known indicators that can be used alongside Gross Domestic Product. However, the need for a new system of indicators is outlined referring to the current debate about the measures of human well-being and its sustainability related to the preservation of different types of capital: natural, economic, human, and social.

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Industrial Sustainability

General Guidelines and Implications

Flavio Tonelli, Steve Evans, and Gian Carlo Cainarca

1 The Wider Context and the Scale of Challenge

1.1 Planet/Eco-System Context and Short Term Historical View of Industry

Given the body of evidence demonstrated in the previous chapters, it is quite evident that the current trajectory of the human ecological footprint is not sustainable. Our understanding of the Earth's environment and the negative impact of industrial activity on it raises concerns about the way we design and build the techno-sphere today. Since 1700, the volume of goods traded internationally has increased some 800 times. In the last 10 years, the world's industrial production has increased more than 100-fold. In the early 1900s, production of synthetic organic chemicals was minimal; today, it has reached over 225 billion pounds per year in the US alone. Since 1900, the rate of global consumption of fossil fuel has increased by a factor of 50. What is important is not just the numbers themselves, but their magnitude and the relatively short historical time they represent (for further information see Graedel and Allenby 2009). These dynamics pose unparalleled challenges for existing industrial systems and infrastructure of production, distribution, and consumption. By 2050, in fact, the global industrial system is expected to double its output using 50 % of current resources and generating 20 % of current CO_2. Thus, the industrial system will be central to the world economy through the coming century, and if we really want a resilient economy, this will only be feasible through a very different 'low-carbon, resource-efficient' approach. In Allwood

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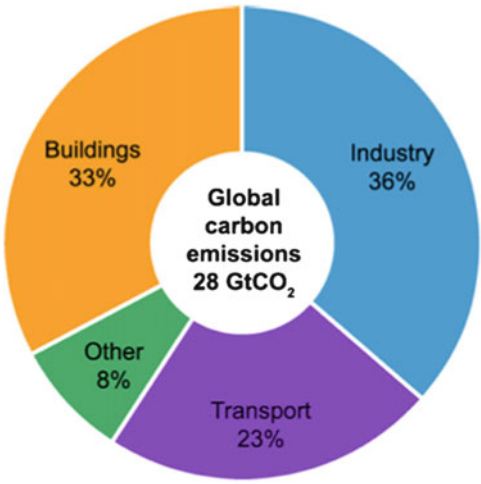

Fig. 1 Global CO_2 emissions

et al. 2011, a breakdown of global CO_2 emissions shows that industry accounts for about 36 % of total (Fig. 1).

On average, research and studies report the following improvement opportunity areas:

- 30 %+Global Warming Gas emission from industry;
- 20 %+energy in manufacturing;
- 90 % of waste is 'commercial & industrial'.

The need to reduce or contain the ecological footprint of the industry will affect the whole industrial system; the current industrial system has a total "efficiency" of converting raw material into valuable product of about 10 %. In other words, almost 90 % of extracted resources failing to reach and remain – for more than 6 months – in the hands of the customer.

But what is wrong in the current system? In a world with infinite supply of both raw material and sinks for waste, such system inefficiencies could be irrelevant; in a world with finite capacity, a complex ecosystem, operating close to the boundaries, this industrial system wasting so much material, energy, water, producing unsustainable CO_2 levels is, for sure, not a well-designed system.

Yes, this is a man designed system so why should it be impossible to change thinking about industry, not only as part of the problem but as part of the solution towards an industrial system able to deliver the 'stuff of the world' using less than a quarter of current bio-capacity. In other words leading to a reduction of 75–90% in the use of carbon-based energy and similar scale reductions in resource use and material flows, while delivering the same value.

The role of industry is crucial to this transition phase; leading companies are preparing for this on two fronts:

- Rapidly reducing the resource- and energy- intensity in producing existing goods;
- Investigating the options for a radical re-design of the industrial system.

A redesigned industrial system should:

– Add the same value with 25 % of materials and energy (Factor4);
– Make use of the 90 % of discarded extracted materials;
– Use benign materials that can be reused according to 'cradle-to-cradle' concept;
– Refurbish and reuse sophisticated long-lasting components;
– Mimic and nurture the environmental niches.

The scale of the challenge requires a mass approach, unfortunately much of the current knowledge is held within a few producers/manufacturers, with some not yet organized academic pockets of excellence.

The term revolution is appropriate since, quoting Einstein "*. . .the thinking it took to get us into this mess is not the same thinking that is going to get us out of it. . .*" Current industrial system overload can be reduced through consciousness adoption of ETS approach: Efficiency, Technology, and Substitution. The technology dimension, in particular, strongly interacts with almost every facet of our lives, and interacts with almost every facet of the natural world. It is this fundamental interdependence that creates the strong linkages between the studies of sustainable engineering, industrial ecology, and more specific methodologies. Furthermore, the integration of technological development with social and environmental systems is a key tenet of sustainability (as is made explicit in the master equation). This interaction/expression has important implications for industrial sustainability (Paramanathan et al. 2004), which we will investigate and debate in more detail in the following section/next paragraphs, as being an enabling factor of sustainability within the companies.

2 Introducing Sustainability in Industrial Systems

2.1 What Does Sustainability Mean As a Term?

It is useful at this point to define what we mean by sustainability. Besides others, the International Institute of Environment and Development defines sustainable development (a synonym of sustainability in this context) as "A development path that can be maintained indefinitely because it is socially desirable, economically viable, and ecologically sustainable". This definition, like many others, provides minimal guidance to engineers, scientists, political leaders, and citizens. In order to better contextualise the industrial sustainability a different representation from Ball et al. (2011) can be reported; in this figure all the aforementioned dimensions and the contribution of industry are satisfactorily defined, especially with respect to the environmental dimension. In fact, since 1970, analysis of the environment has increased and improved, presenting society with the problematic conclusion that industrial operations are not without consequences (Fig. 2).

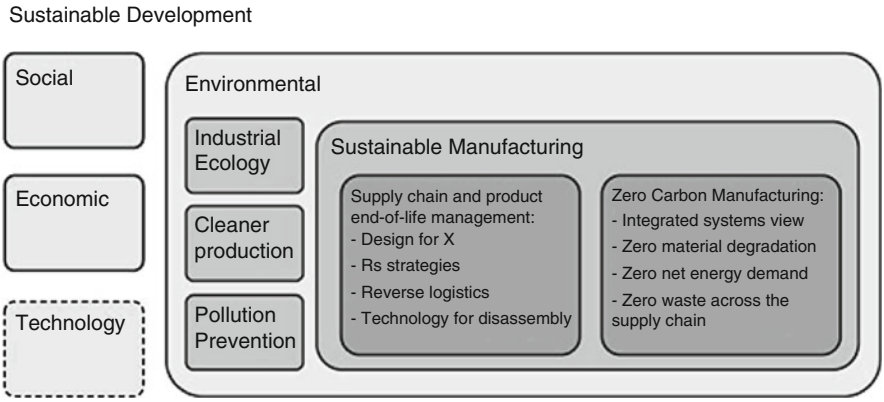

Fig. 2 Sustainable development dimensions and sustainable manufacturing contribution

In order to proceed with the next paragraphs, we need a more precise definition of industrial sustainability in order to help clarify the research, implementation areas, and their interactions.

In this text **industrial sustainability** refers to the end state of a transformation process where industry is part of, and actively contributing to, a socially, environmentally and economically sustainable planet. Industrial sustainability is also commonly used to refer to the process of catalysing, planning and delivering the changes necessary to meet that goal. Hence Industrial Sustainability simultaneously refers to the goal and the path, and works as both noun and verb.

While it is not clear exactly what that transformation path will look like, it is growing ever clearer that it needs action at material, product, process, plant and system of production levels. Beginning with a strong effort to learn how to manufacture today's products with the lightest environmental and social footprint, we can expect the future industrial system to change fundamentally at the system level if we are to learn to live within our means.

Some findings from literature evidence that in order to sustain human society on the long-term economic development needs to be decoupled from environmental impact through technological and societal changes. Moreover, the concepts of Industrial Ecology, such as systems view and industrial ecosystem, take a macro-level perspective on closing the loop of resource flow, while Cleaner Production and Pollution Prevention look at intra-enterprise improvements, but are less integrated approaches and do not adopt a systems view. Finally, many activities are generally focused on product design and product end-of-life management while alternative approaches are focused on manufacturing technology, supply chain management and product-service systems.

A further step in understanding and managing industrial sustainability requires its operationalization. Operationalizing industrial sustainability, it is necessary to determine what it is we wish to sustain, who are sustain it for, and for how long. Most operational planning durations fall into the 25–50 year range. We will refer to this through the concept of the rate of change needed in industrial system,

articulated over a 3-stage change (efficiency, technology, system changes) to get there by 2050.

2.2 The Transitions from Traditional Manufacturing

Starting from the aforementioned improvement areas, industrial manufacturers are exploring significant savings in energy, water, waste and materials in their plants and throughout their supply chains. In this first phase eco-efficiency approach is the first step in industrial sustainability or in other words a simple way of doing "good business". A second phase, also called eco-effectiveness, should, although, consider better approaches, focuses on a more efficient use of energy, water and materials as closed-loop processes to eliminate waste streams from entering the environment, considering the product's entire life cycle and practices that restore renewable resources and communities, accordingly to the concept of sustainable supply chains (Gupta et al. 2011).

2.3 The Orientation of Leading Manufacturers

Companies leading in sustainability are integrating their strategy into the corporate governance and operating frameworks of their companies. Social and environmental risks are identified as business risk categories and are formally embedded into enterprise risk management processes. As a result, sustainability decisions become an integral part of business decision making, commercialization and capital management processes, the business planning cycle, and customer and supplier relationships. This would require a fundamental reassessment of how and where value is added, consumed, and recovered (Vargo and Lusch 2004), operating a transition from open to closed value cycle. Exploring the sustainability domain today differs from the recent past drivers such as regulations, politics, management philosophy and ethics, environmentally conscious customers, customer satisfaction, protection and conservation. Current issues concern the availability of limited and rapidly diminishing resources as security of the supply of key raw materials and supply of energy (Meadows et al. 2004). New considerations will drive design and implementation of manufacturing systems and supply-chains, such as environmentally conscious design and manufacturing (ECDM) described by Sarkis (1995) or those described in the following table adapted from Dornfeld et al. (2009) (Table 1).

2.4 From Strategies to Frameworks and Tools

We can clearly observe that many companies are tackling sustainability using different tools and processes, while external advocates propose their own frameworks and tools. The following list indicates a number of the more popular frameworks, such as:

Table 1 Sustainable supply chains design considerations

Transportation	Supplier – location	
Economic	*Economic*	*Social*
Accessibility	Part quality	Quality of life
Availability	Resource availability	Pay rates
Lead Times	Lead times and inventory	Working conditions
Risk	Risk	Health care
Environmental	*Environmental*	
Emission	Electricity mix	
Resource use	Resource availability	
Distance	Electricity demand	
	Emission fate	
	Regulations	

- The Natural Step framework,
- The Industrial Ecology model,
- The Cradle-to-Cradle model,
- Sustainability by Design,
- The Natural Capitalism model,
- Product Service Systems
- Eco-system Services model.

Each of these frameworks has a clear history (for example, the Natural Capitalism and Eco-system Services models both use standard economic thinking to explain sustainability) and can demonstrate some utility. It is not yet clear which frameworks offer most utility in which industrial situations, and this can be a source of confusion.

In addition we have a long list of tools designed to help us implement our vision, ranging from analytical tools, which help us to quantify what our performance is today and guide progress:

- Life Cycle Assessment (LCA),
- Material Input per Unit of Service (MIPS),
- Environmental Risk Assessment (ERA),
- Material Flow Accounting (MFA),
- Cumulative Energy Requirements Analysis (CERA),
- Environmental Input-Output Analysis (env, IOA),
- Life Cycle Costing (LCC),
- Total Cost Accounting (TCA),
- Cost-Benefit Analysis (CBA),

as well as procedural tools to help structure the journey:

- Environmental Management Systems (EMS),
- Environmental Audit (EA),
- Eco-Design (ED),

- Closed Loop Supply Chain Management (CLSCM),
- Environmental Performance Review (EPR),
- Total Quality Environmental Management (TQEM).

2.5 Specific Actions Towards Industrial Sustainability

From a practical point of view, in order to begin a transition towards industrial sustainability, companies have to decouple economic development from environmental impact mainly through technology (having less influence on societal changes); they should take appropriate actions at macro-level perspective – i.e. closing the loop of resource flow – while continuing with intra-enterprise improvements such as cleaner production (CP) and pollution prevention (P2). Since SM activities are generally focused on product design and product end-of-life management, alternative approaches focused on manufacturing technology, supply chain management and product-service systems, have to be explored.

It is clear that industrial sustainability is a rapidly developing subject, with practitioners learning about what works and what doesn't very quickly, and with a growing number of researchers trying to develop both specific solutions and useful frameworks. Currently implementation guidance is going through a phase of divergence – there are a growing number of consultancies, government organisations and in-company implementers who are developing, using and advocating their own implementation frameworks, which is to be expected when a subject is relatively new and complex. Observations of practicing companies suggest that there are common themes across many of these frameworks such as: the use of management by targets, the use of existing management systems wherever possible (such as Quality Management), the increasing involvement of non-traditional stakeholders, an initial focus on energy use and waste which often broadens out to a deeper understanding of material and energy efficiency, an initial focus on internal operations that grows to involve others (such as suppliers and customers), material substitution (but a limited willingness to innovate the product initially).

These companies are leading in terms of environmental performance, but even the leaders are only now beginning to target the system-level challenges of industrial sustainability – how to make sustainability an integral part of the management system, how to co-operate with others to innovate the system, how to make strong social performance an integrated part of the company system (not philanthropy), how to innovate the way they do business (the 'business model') so that environmental and social performance is internalised.

Given the emergent nature of the subject it may be prudent not to advocate individual frameworks or tools yet. It may be more useful to agree ways in which good practices (the things that work well for some frameworks under some conditions) are shared, and therefore enable the development of second stage frameworks as we converge on sensible practices. Indeed it is far more urgent to

have industry energetically use as many frameworks and tools as exist, and so increase the speed of learning about industrial sustainability implementation practices.

3 Derive Implications for Sustainable Manufacturing and Supply Chain Design

3.1 A System Design Approach

According to the traditional view, product design and process technology typically determine the types of pollutants emitted, solid and hazardous wastes generated, resources harvested and energy consumed. Unfortunately, in a business environment of resource and energy supply uncertainty, the traditional view and the related business model, requiring the continuous exploitation of new markets for growth, the enhancement of products to maintain demand and global sourcing to sustain margins, whilst absorbing the costs of compliance with end of life cycle legislation, is clearly unsustainable.

Such a traditional production system design is based on the development of separate management sub-systems and separate commercial sectors: production/industry, consumption/retail, and waste. This three separate sub-systems design process, driven by self-interest, leads to an unavoidable sub-optimization. The greatest example of which is the value that we carefully add to our materials as we transform them into saleable products, only for that value to be passed into a waste system that cannot identify or use the value fully, and which has very little competence or incentive to create closed-loop material cycles.

Such unsatisfactory design approach needs to be restructured according to new principles:

- Show scope, (lack of) connection and alignment of the three separate systems,
- Clearly identify the material life cycle stages,
- Connect these stages with material flows,
- Seek to increase and maintain value AND thermodynamic state,
- Reduce waste during the industrial processes.

Direct process implications of this revised approach are:

- Yield improvements (less waste),
- Energy and material increased efficiency,
- More recycling rate;
- Less water, land, soil pollution,
- Reduced virgin material extraction.

Practically adopting the aforementioned principles requires a different systemic view starting at unit process level up to entire supply-chain and product/process life cycle.

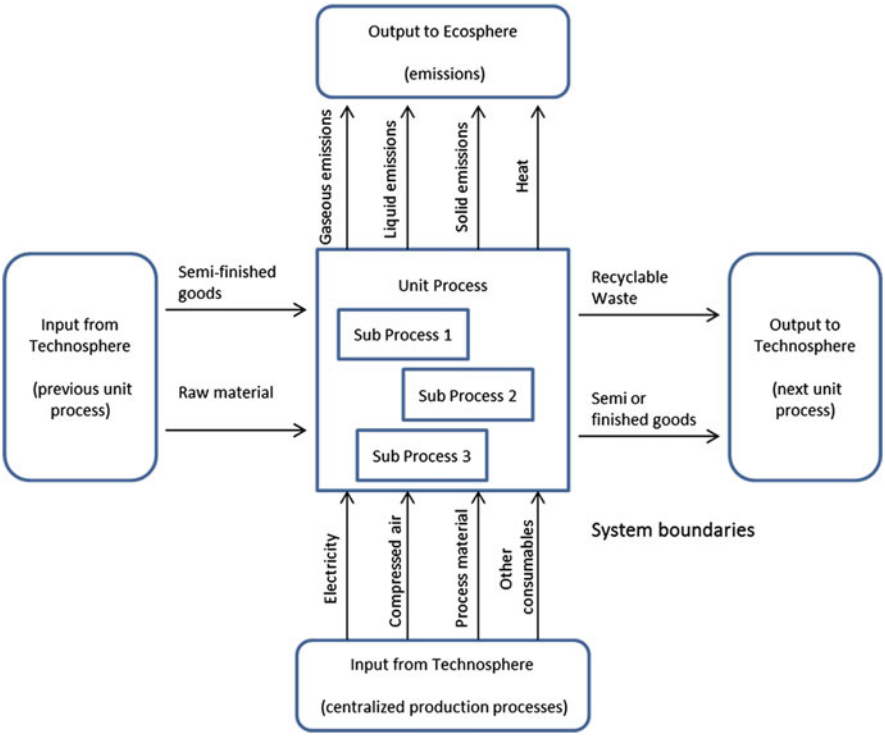

Fig. 3 Manufacturing unit process input/output flows (Adapted from Dornfeld 2009)

Concerning the unit process level, the following model describes the inputs and outputs adding the fundamental environmental viewpoint in terms of negative impacts on the eco-sphere (Fig. 3):

Each process unit takes in materials and energy in various forms and creates the planned output (valuable product or semi-finished product) together with output waste (some of which may be recycled, and much of it will be emitted to air, land or water). At this level, clearly, our aim is to tackle the problem of creating more valuable output using less of the valuable inputs and creating less of the waste outputs, and we can adopt various techniques to do this (re-manufacturing, more efficient processes, use renewable energy, etc. . .).

At the process unit level of a single manufacturing process, this is a useful description and helps us find solutions, but those solutions are narrow – it is not directly obvious that making a product last longer with the customer will reduce the overall flow through a single manufacturing process. For these reasons it is reasonable to extend the model at a number of levels within the entire industrial system, beginning at single production processes and ending with the boundary representing the entire industrial system and its interaction with the ecological system (as emphasised in industrial ecology).

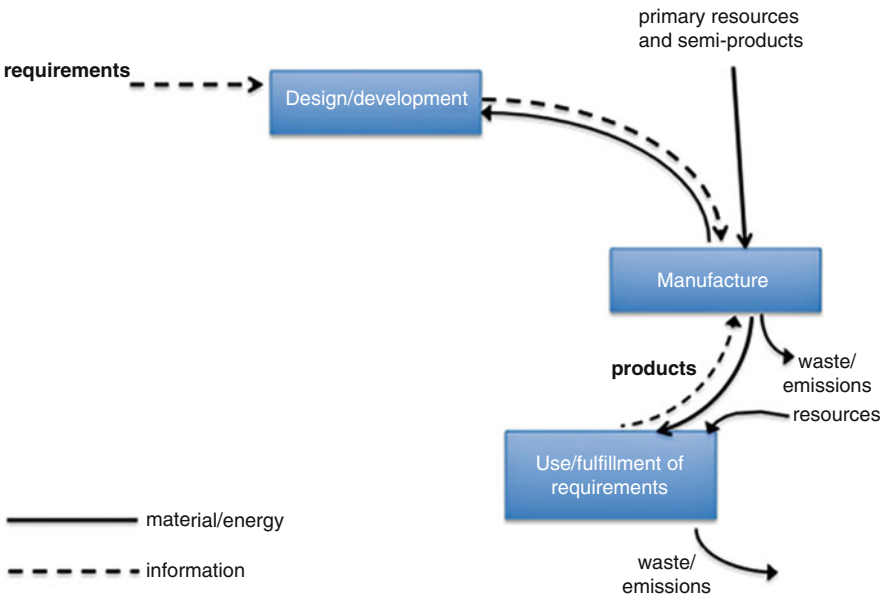

Fig. 4 Traditional manufacturing system

Building this multilevel and multistage analysis requires a wider perspective; the basic unit process (even multiple ones), can be incorporated in a box we will name Manufacture. It is useful to consider that the box called manufacture is representing many things, ranging from a single process, to a factory that makes end products, to a chain of supply to a global industrial system. This box is traditionally linked to Design/development and Use/fulfilment of requirements box, with input of resources and output of wastes (see Fig. 4).

A first improvement implemented in modern countries has been the waste treatment approach at the product end-of-life, by adding Waste treatment and Lanfill final disposal boxes as shown in Fig. 5.

A second important step has been implemented through the recycling process of end-of-life products, introducing the concept of circular loop, as shown in Fig. 6. At this stage, the components of the product life cycle are defined through four typical stages: acquisition and processing of the necessary resources, manufacture, use, and reuse/recycling/disposal. Collection/sorting of used material and Reuse/recycling boxes, are devoted to reduce the need to produce other products to satisfy customer requirements (in this sense second-hand usage can be considered a particular case of collection/sorting and eventual refurbishment).

Nowadays, a third step has been introduced, accordingly to material and energy productivity improvement of manufacturing system, adding the generation of reusable discards in manufacturing stimulating a "prompt scrap" sub-cycle, as Fig. 7 shows. In this latter case internal products or semi-finished products can be re-used or re-manufactured reducing scrap and waste rate. This step is still

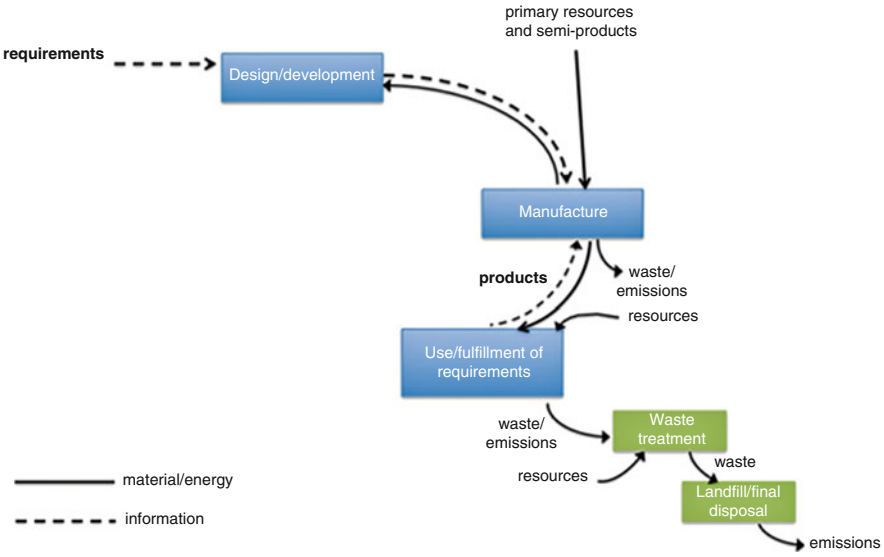

Fig. 5 Product end-of-life waste treatment process

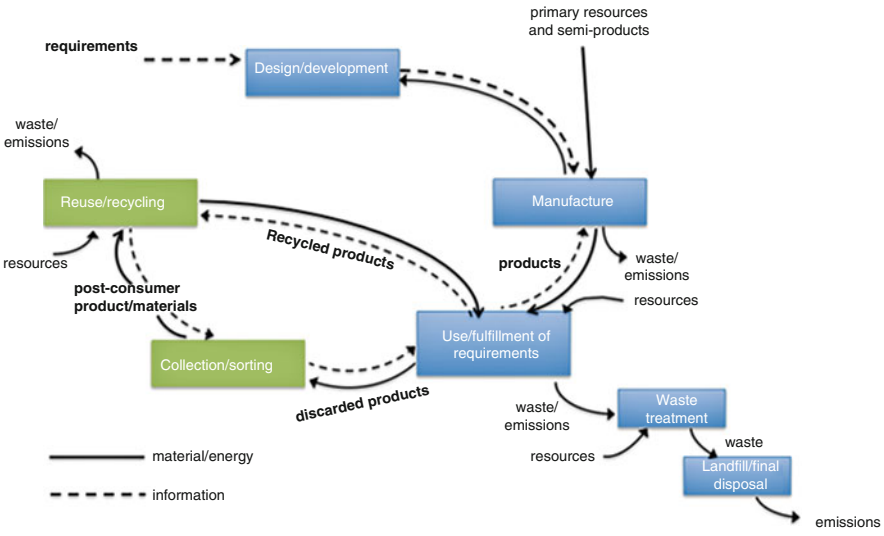

Fig. 6 Product end-of-life reuse/recycling process

undergoing because of technological implications: i.e. introducing equipment for collecting/re-manufacturing/re-cycling, implementing reverse flows inside existing factories and layouts, modifying planning and scheduling criteria for equipment allocation, . . .

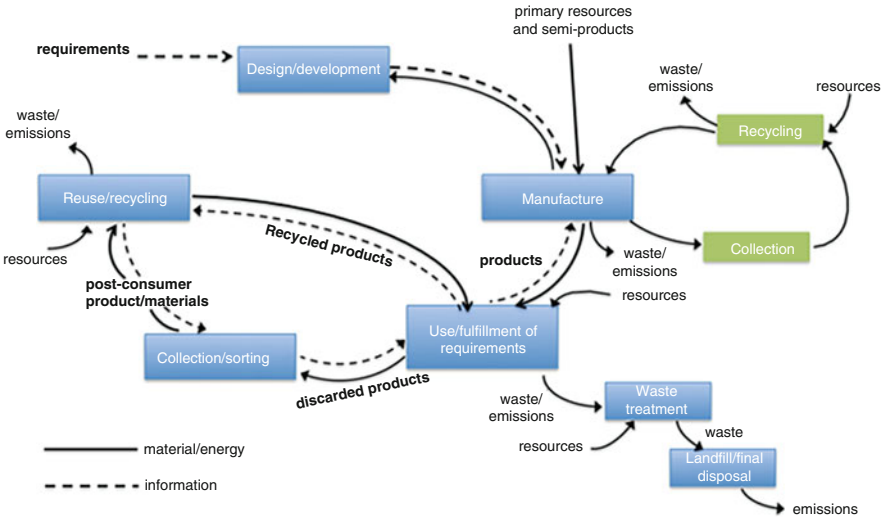

Fig. 7 Manufacturing collecting and recycling process

The last proposed step adds two important aspects:

1. Recovering resources (named "secondary") from Reuse/recycling box at the product end-of-life to be input to Manufacture box in order to reduce drastically the virgin material extraction,
2. Revising Design/development box in order to overcome actual limitations in disassembly, recovering, reusing, and recycling current generation products.

This can be considered the most difficult, yet valuable, step since it involves product and manufacturing processes redesigning (Fig. 8).

In the complete diagram, resources, either from primary ("virgin") or secondary (recycled) sources, are required to a greater or lesser degree at a number of points in the cycle, and emissions occur at a number of points as well, depicting the performance of a product through its life as well as the performance of an extended manufacturing system. These are not the same thing and their interactions have to be handled with care – for example, it is challenging for manufacturers to re-use old product at the end of their useful customer life, even with the technical competence to refurbish the product the customers may not want old designs (one of Xerox's great achievements has been to maintain the design discipline of modularity over an extended period of time, thus enabling the re-use of entire modules without affecting the ability of future customers to have the product they want). The inputs and outputs and useful tactics can be applied at different levels but must be understood and analysed at the appropriate level. This is important because as the scope of the system increases then the ability of a single person or organisation to effect the planned change is diminished. Only through co-operation with others will system level changes be able to happen.

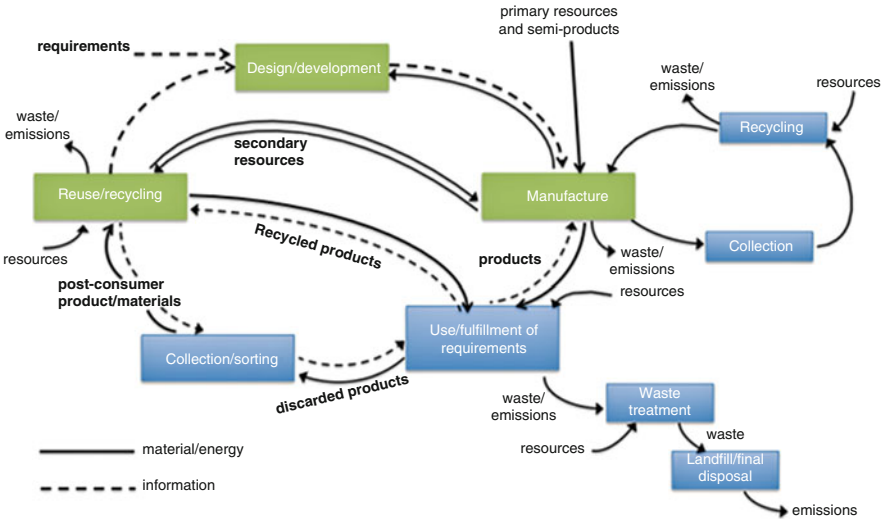

Fig. 8 Complete product/process lifecycle with flows and impacts (Adapted from Graedel and Allenby 2009)

In parallel to changes needed in how we view the technical system of production, we have to influence the business system as well. Emerging opportunities for industry include:

- Re-internalizing externalities,
- Changing current attitudes (more is better, don't expect the system to change, choose safe and well-known materials),
- Extending knowledge of other complementary/synergic systems and technologies in order to join up multiple systems of production and waste,
- Acquiring a whole system design approach (when stuck, do not slice a problem into smaller solvable sub-problems),
- Exploring new technology opportunities, new materials, or new products that apply off-the-shelf materials that are currently under-used or use existing materials well.

3.2 Sustainability Performance Measurement and Management

In recent years, performance measurement and management (PMM) has received much attention from researchers and practitioners (Taticchi et al. 2008; Arena et al. 2009; Cagnazzo et al. 2009, 2010). Nevertheless, the consistency of the current PMM body of knowledge in relation to sustainability, in terms of models and

frameworks reveal the inconsistency of available PMM systems to meet the sustainability challenge. Suggestions for addressing future research are given Taticchi et al. 2010, where six milestones were identified as essential:

1. Understanding of Cause-Effect Relationships between different performance indicators,
2. Control of Time Dimension (LCA),
3. Measurement of Leadership Commitment,
4. Measurement of Contributes and Effects of/on Stakeholders,
5. Evaluation of Financial Outcomes,
6. Industry Specificity.

With these regards, only 7.7 % of the models/frameworks reviewed suggest an LCA approach to performance indicators or provide guidelines depending on industry typology. In order to have a complete overview of sustainability PMM, please to refer to Chap. 2 of Sect. 3 of this book.

3.3 Implications on Material and Energy

Newly designed production system has to take into account two different resource efficiency trajectories: materials and energy. An updated and useful representation of the main implications is represented in the following picture where material efficiency means providing material services with less material production and processing, while energy efficiency, especially for energy intensive industries, aims to reduce the energy required to perform a transformation/production process (Fig. 9).

A useful trend has seen the rise of energy and waste hierarchies as guiding principles. These simple visualisations help new and mature organisations to structure their approaches, on the assumption that actions higher up the hierarchy are normally superior (Fig. 10).

Unfortunately the higher actions (reduce, re-use) are less common, even if more effective from business and environmental viewpoints. In part this is caused by the greater requirements for co-ordination and working with other organisations (for example, re-use may require a producer to find a way to get their end-of-life products back to their factory) (Table 2).

3.4 Positioning Research Contributions

The evolution towards a ‘sustainable’ production systems, also identified by some Authors with the acronym of Sustainable Supply Chains (SSCs), require a fundamental shift from fragmented and functional approach to an holistic one, with a

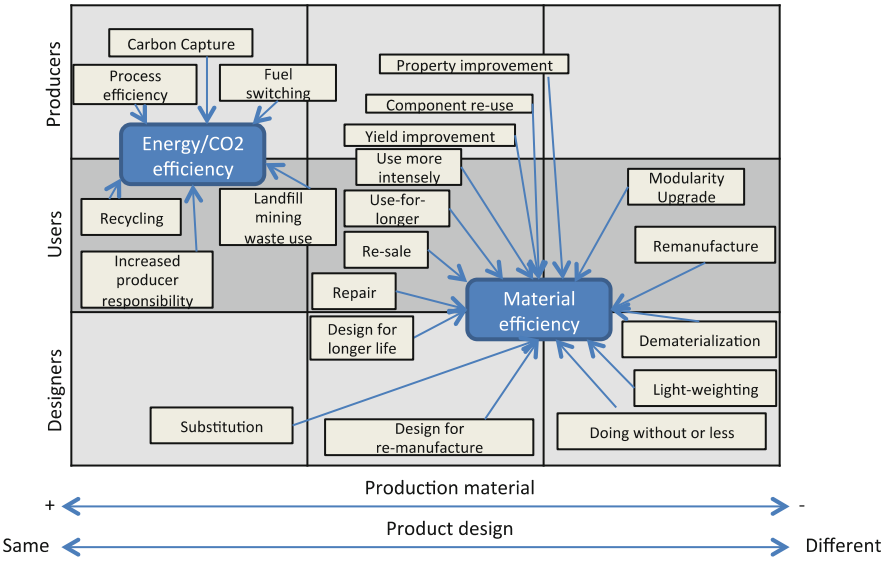

Fig. 9 Material efficiency contrasted with energy efficiency (Adapted from Allwood et al. 2011)

Fig. 10 Energy and waste hierarchies

Table 2 The energy management hierarchy (Adapted from Special Report – GHG Management & Reporting IEMA 2011)

Avoid	Eliminate GHG emissions when organizations change business model, rationalise or move premises
	Adopt new business models and products or services
Reduce	Reduce total energy usage and improve energy efficiency
	Reduce energy usage at peak times
Substitute	Adopt renewable and low carbon technologies
	Target suppliers, goods and services with lower embodied emissions
Compensate	Investigate carbon offsets and compensate for unavoidable emissions

fundamental reassessment of the value creation. New sustainability concept and constructs, as well as high level structures, have been analysed and proposed such as:

- The challenge of Closed-Loop Supply Chains (Guide et al. 2003),
- Sustainable supply chains: An Introduction (Linton et al. 2007),
- Sustainability in the Supply Chain domain (Carter and Rogers 2008),
- Energy efficiency in Supply Chain and climate change (Halldorsson and Kovacs 2010).

The fundamental reconsideration required to move the first steps towards the sustainable supply chain domain introduces several sources of complexity:

- Dependencies between supply and consumption exist (Svensson 2007),
- Management of inter-organization relationships is well known but not oriented to sustainability (Skjott-Larsen et al. 2007),
- Replacing a traditional value proposition with a sustainable value proposition is hard to implement (Srivastava 2007),
- Bounded unidirectional rather than bidirectional view of material flows,
- Fragmentation limiting a systemic understanding,
- Limited number of sustainability initiatives that have proven to be economically viable to date.

The investigation of literature and existing industrial experiences can be useful in drawing the most common limitations of the current way of thinking; first no *panacea* working in all industries, for all products, and for all customers exists, since examples like Xerox and Toyota (Evans et al. 2009) can provide useful insight but specific models need to be developed across different industries. In order to face the industrial sustainability problem an unprecedented level of cooperation is required between the external agents in the supply network and an organization's internal functions because sustainable solutions must extend the value chain beyond conventional boundaries. A sufficient (quickly growing) body of literature exists but with limited focus and narrow perspective, and in practice few tools are available to help industry in calculating the whole system performance approaching a large problem solving process (Evans et al. 2009).

3.5 The Role of Organizational Change and Its Implications

From organizational point of view, moving towards sustainability implies, as reported in the previous paragraphs, a paradigm shift to a holistic approach. The frequent literature references, concerning the cultural change, witness that the organization tool outlines and allows the strict interrelations between economical, social, environmental, and technological domains. The exploration of organization fundamentals with respect to sustainability moves through the organization levels, ranging from producing, consumption, and recovering. The initiatives required to communicate and share the "finiteness" of the planet – in order to translate the

holistic perspective for all the subjects of the socio-economic context – must involve every level from the inter-organization to the intra-organization ones, until the single individual. If for this latter, the reflections about environment perspective are similar to the ones of commons, concerning the organizational levels the situation is quite different.

Inter-organization level: in general terms, inside the organization ecosystem, we can find interrelating actors related to guidance subjects/enterprises or system evolutionary orientation/direction diffused within the enterprises. The sustainability, with respect to environmental, social, and economical domains, can arise only through the deliberated action of Institutions or Leading enterprises. Concerning Institutions, the power of orientation/enforcement in guiding the change of the entire ecosystem doesn't necessitate of additional explanation. A different situation arises when we look at autonomous action of leading enterprises, which perceiving instances of social values – implicit or explicit – understand that sustainability could represent a precondition to avoid decline. The holistic approach featuring these enterprises build up on the capacity of managing the network – inducing behaviours and practices environmentally virtuous – either for supply side (raw material sources) and for demand side (consumer, recovering, reuse, recycle, . . .). In organizational terms, the literature presents reference models useful also in the sustainability context; the paradigm shift from "push" to "pull" logic and the implications inducted in the reorganization of industrial activities offer a valid example of governance models more coherent and efficient with respect to new expectations of the social context. To completely appreciate the potentialities of the network management it is sufficient reminding some of the "cultural" changes occurred in the last quarter of the previous century; from continuous improvement to total quality management and all related innovations in terms of processes governance. It is easy to see similarities between the need to coordinate the innovation effort – spread either at intra- and inter-organizational levels – with the requirement to harmonise the ecological sense of individuals. Diversities of coordination approaches – for instance Japanese and Western enterprises relationships towards suppliers and partners – offer a confirmation that in the sustainability context not all the strategic choices have to be voluntary by definition. Hence leading enterprises' role in reshaping the ecosystem is significant; they have to decide between "involve" or "force" the participation of the others actors, starting from the final user, who has to share and award the holistic and ecological choice of sustainability, up to those involved in complementary activities. This focus on the leading companies, although, doesn't exclude an active role of all the others subjects sharing the holistic approach; they can and must transform the ecological innovation in a competitive tool. To this concern, the compliant with environment standards – more than allowing emancipation from blocked relationships – allows to begin virtuous paths to identify improvements areas, and focalize on the environmental efficiency, with potential social-economic benefits, and thus, resources to utilise for new improvements seeking (see the Toyota example). The coordination of activities is based on negotiation – definition of standards of targets to achieve – on commitment, and execution, including the tools

to verify the success of the various steps (Skjott-Larsen 2007). The technology's role arises here in all its importance being determinant either on "hard" innovation and organizational assets, as a tool allowing the holistic approach to become reality.

Intra-organization level: one of the best steps descriptions to walk the proposed revolutionary journey is, probably, offered by Andrew J. Hoffman in "From Heresy to Dogma". Even if focussed only on oil and chemicals enterprises, Hoffman outlines the organizational transformation required to accomplish a green vision; the top management commitment – as put in evidence also in the Quality case – represents a kind of discriminant pre-condition to legitimate every action in an environmental orientation. It is exemplary following as when the legitimisation of stakeholders progress, the enterprise strategy adapts to scenarios evolution and how, consequently, the enterprises evidences, inside, the definition of new priorities with incremental transformation of strategy and structure (see Table 3). In 90s, the big US Companies begin to pay attention to environmentalism creating new executive positions. In 1991, 49 out of Fortune's top 100 present a vice-president for environment topics and the percentage is still greater if we look at top 50, where the environmentally oriented companies are 39.

3.6 *Extending the Perspective: Towards Sustainable Supply-Chains*

Accordingly to the previous analysis of industrial sustainability problem, possible answers can be presented, acting on two main directions: the product dematerialization towards services and the improvement of efficiency in manufacturing products. The former direction has been explored in the last decades and first interesting approaches have been formalized:

- 'Serviticization' concept (Cook et al. 2006),
- Product Service Systems (Baines et al. 2007; Evans et al. 2007; Taticchi et al. 2009; Tonelli et al. 2009).

Concerning the second research direction, as stated by Svensson (2007), existing models do not provide an integrated perspective of the flow systems and therefore the means of developing a systemic understanding of the sustainable value proposition; a situation that is perpetuated by a tendency to consider the systems for the supply of products and their recovery as separate entities. Improvements of supply network can be articulated in many different research streams ranging from technology improvements (Jovane 2008) at machine level to network collaboration. Looking at the collaboration level, current and future research concerned with developing environmentally sustainable supply chain business models must focus on the identification and the management of information and interfaces between customer, marketing, design, operations, logistics, and external agents of the entire supply network. Important development phases should foster improvement

Table 3 From Andrew J. Hoffman (2001)

	Industrial environmentalism	Regulatory environmentalism	Environmentalism as social responsibility	Strategic environmentalism
Phases	1960–1970	1970–1982	1982–1988	1988–1993
Organizational structure and culture	*Problem solving*: considered an ancillary aspect of conducting business, it is handled primary as an operating-line function	*Technical compliance*: although elevated to a separate corporate department, it remains an ancillary role with low organizational power, focused strictly on legal requirements	*Managerial compliance*: moving beyond mere technical responses, managerial structures are developed to achieve compliance based on internal constraints. Environmental responsibilities begin to diffuse throughout the organization	*Proactive management*: organizational boundaries blur, allowing direct influence by external interests. The environmental department reaches new levels of organizational power. Environmental considerations begin to be pushed across functional lines and back down into the operations, integrating them into both process and product decision

products durability and performance, incorporation of external supply networks, inclusion of the customer and the usage phase, as well as activities to recover residual value through economies of scale in:

- Reuse,
- Remanufacture,
- Recycling.

This would require a completely new supply chain paradigm with suppliers able to provide the services to support Original Equipment Manufacturer (OEM) and third party recovery specialists for reverse flows, including end-of-life. In this new paradigm several aspects need to be considered:

- Overcoming Porter's value chain model,
- Extending green supply chain, reverse logistics, and closed loop supply chains,
- Incorporating design for sustainability,
- Considering all the life cycle information flows including dismissal and recovery phases (Brodin and Anderson 2008).

The implications of this paradigm shift are not negligible influencing strongly marketing, design, and operations. From the marketing point of view more attractive value propositions have to be created by leveraging on extending product life cycles, capturing and recovering end-of-life product, and ensuring safe disposal/reuse of components and materials. The lifetime extension of a product or service, for instance, requires that organizations focus on their involvement in the whole life of the product or service and be aware that it is still their responsibility even if it has been temporally passed to a user. In a broader view of marketing strategies, selling and compliance ones outline the importance of adopting a proactive approach, whilst spinning, harvesting and 'enviropreneur' ones highlight the need to develop integrated, long-term, customer focused strategies. These may entail reconsideration of the 'entire product life cycle' or value cycle through a re-evaluation of both product and process designs.

However, once a product has reached the end of its normal life cycle the efficiency with which the recovery process can be conducted and the extent to which products can be reused, components can be remanufactured and materials recovered is almost entirely determined by a product's design. For these reasons new sustainable design approaches should articulate on two stages:

1. Consumption of resources at all stages of life cycle
   - Less material in product/service, package, production, distribution, recovery,
   - Minimizing hazardous materials,
   - Less energy consumption for the use-phase.
2. Extending product life cycle
   - Improving customer perception of fashion, pride of ownership, durability.
3. Facilitating dismantling phase.

Obviously, an acceptable solution for disassembly must involve consideration of the cost of remanufacturing activities against the revenue that can be derived from the recovered material and products. A reasonable approach should take into account the following aspects:

- More extensive use of modular design,
- Use of standard interfaces for disassembly,
- Less standard parts to disassemble (reducing volume and variety),
- Minimum transportation costs for disassembling when not performed by OEM,
- Use of 'smart' materials (fasteners that revert to their original state on the application of heat),
- Use material 'easy' to be recycled with minimum of energy input or degradation,
- Reduced on durable packing or environmental friendly,
- Labelling of parts and subassemblies to be coded and easily identified,
- Reduced disassembly time and operations.

Marketing and design, alone, do not provide a truly sustainable production model; only when operational activities are considered in conjunction with new product/service offerings and enhanced product design features for sustainability, the full benefits can be realized. Jovane et al (2008) propose a reference model for proactive action to develop and implement CSM. They build on the work of Yoshikawa who promotes the idea of minimal manufacture and maximum service within a closed loop supply chain. However, when products eventually reach the end of their economic life not all of them will contain valuable components and/or materials that make the recovery of these products economically viable, for instance because of incorporating these recovery activities in an original equipment manufacturer (OEM) significantly increases the complexity of the organizations operations. For example, production planning/control will be more difficult because of, amongst others, the variability that exists in the quantity and timing of returns, the variety of products and generations of products being processed and the unknown demand the recovery operation places on the firm's resources; inventory management will also become more difficult because of the variability in recovery rates; facility costs are likely to increase because of the need for additional facilities to disassemble a wider range of products than would normally be processed through forward assembly operations; the skills and capabilities of the firm's labour force will also need to be extended to accommodate the increased product mix in the disassembly operations (Linton 2007).

Thus, new operational issues seems to be related to extend process efficiency beyond end-of-pipe approach, increase volume of disassembly processes (economies of scale), even with third parties, concentrating parts coming from different locations and mitigating complexity growth in standard operations, establish new relationships with key suppliers and third party recovery specialists. To this concern, logistics implications have to be coherently addressed; deciding on how and where a product is manufactured and retrieved will impact on service levels (where customers are involved), logistical costs (handling and transportation), facility costs (warehousing and storage pending reprocessing) and, the

environmental impact of transportation. Vertically integrated organizations have the benefit of improved communication flows between disassembly and design, even if the complexities of the bidirectional flows will increase the difficulties of planning transportation. Unlike forward logistics, which are concerned with delivering large volumes as efficiently as possible to a few outlets, recovery involves the collection of products of unknown quality in small variable volumes from many pickup points frequently involving third parties with whom product information must be shared. Indeed, economies of scale can be more easily achieved by third parties who are able to reduce transportation costs by aggregating loads between pickup points and collection centres. A complete discussion of issues in environmentally conscious manufacturing and product recovery can be found in Ilgin and Gupta 2010, while the complexity of controlling distribution supply-chain can be found in Alessandri et al. 2011.

Finally, sustainable business models also raise questions of resource location (to support primary and secondary material flows), vertical integration and cooperation with third parties, the sharing of proprietary information, whether to adopt technological developments in manufacture (e.g. process integration), and the role of product characteristics and industry standards.

4 Discuss and Formulate Open Questions and Plans for Tomorrow Activities

The alternative business model summarized and presented in this chapter introduces many novel elements starting from a different consumer acceptance in terms of products and services, and secondary product usage.

Designing products for extended life-cycles, and re-using sub-assemblies and components thanks to a distributed community for re-manufacturing and recovering appears to be of crucial importance for material efficiency targets. On the organizational side, the vertical integration of secondary value stages and/or the creation of strategic partnerships within global and local supply networks – with reverse flows and value recovery activities – are required conditions to guarantee the feasibility of a sustainable model.

The practical adoption of sustainable industrial models leads to important considerations and implication for politicians, educators/researchers and for manufacturers in the short & long term.

A first enabling step would be for industry, government and academia to co-operate in the development of a common definition of industrial sustainability and sustainable manufacturing as well as a common way to assess and reward sustainable industrial practices. Such a vision would not be prescriptive in setting out precisely how each component of the industrial system should work in the future, instead it must concentrate on the ‘system conditions’ that encourage improvement and co-operation and seek to increase experimentation so that we

can improve the speed of learning about what works and what doesn't. Those nations, supply chains, factories and businesses that learn most quickly how to operate in a world of resource and energy scarcity will hold a competitive advantage that will become ever more powerful.

Our vision is a sustainable industrial system that delivers high value to its growing base of customers around the globe, while using, at most, a quarter of the current resources. Such a system would be very different to today's global industry – less homogenous with different business models and different relationships, creating different products and services. It is not at all clear what such a system would look like, indeed there may be very different industrial systems working alongside one another. The urgency for change is now feeding through from scientists into mainstream government, business and academic thinking. The rate of change is likely to increase and we can observe many businesses quietly tackling parts of the challenge. The path to a sustainable industrial system is difficult to plot – we are simply too naïve in our understanding of the relationship between industry and ecosystem and we lack sufficient experience to plan the whole journey.

This offers a rich ground for academia over the coming decades; indeed we might expect that the deliberate design of a sustainable industrial system becomes a specific skill, requiring education and research to match. The immediate need is for rapid changes to existing systems and it is possible to observe a pattern from some of the pioneering manufacturers. These suggest that academia must improve its understanding of how industry impacts the ecosystem, must seek out new collaborators in a deliberate programme of problem-solving research and education, must explore a variety of new mental models to describe the industrial system and must collectively gather and learn from practice.

Based on this each of us can make informed choices about whether and how to change our own teaching and research to support the delivery of well-informed students and new knowledge.

4.1 Recommendations for Educators

- Every manufacturing and engineering design course must have a substantial component of teaching that explains climate change and resource productivity, and explains how the industrial system interacts with the social and environmental systems of the planet.
- All qualifications to be 'time lapsed', so that practicing engineers and manufacturers are encouraged to renew their knowledge. Part of that renewal would include specific components on sustainable industrial systems and biological systems.
- Universities to cooperate urgently in developing teaching material that is locally appropriate.

- Creation of a virtual and real International Summer School for teachers of the Sustainable Industrial System, in order to significantly accelerate the development of faculty capability.
- All topics taught to manufacturing and engineering students should be looked at in terms of their contribution to sustainability, and all student projects should include at least some discussion on sustainability impact.
- Encourage interaction with environmental scientists and policy students on the positive role that the industrial system can play in making modern society more sustainable. These students would benefit greatly from learning the improvement, problem-solving and innovation skills that manufacturing and engineering design student's gain.
- Measure and improve the total energy and material used to deliver our education (per student) and engage faculty staff and students in improving that.
- Team up with any local manufacturers who have experience in improving resource productivity – providing them with student resource and providing academia with teaching resource.

4.2 Recommendations for Researchers

- Encourage large, problem-solving research (e.g. the human genome project) where we avoid duplication of research effort if possible, and agree to tackle specific topics.
- Develop the new field of 'design of sustainable industrial systems'.
- Investigate which models of new industrial systems can deliver the radical changes required.
- Work with local industry on problem-solving projects, preferably with other disciplines and preferably with ambitious targets for improvement, that cover the whole industrial process.
- Agree on formats for making research available to other researchers and practitioners in a manner that encourages its use in practice. Current journals do not achieve this.
- Agreement on standards for measuring and assessing progress toward sustainability, to encourage transparency in both academia and industry in reporting results.
- Build tools to help industry calculate what the best performance of a whole system might be.
- Build a database of good examples and share globally.

4.3 Recommendations for Industrialists

- Find out what is possible today without radical change and implement this quickly – don't be content with less than 10 % improvement.
- Identify your largest two to four environmental impacts and engage with existing communities and universities who might know how to tackle these.
- Join with universities and/or unions and/or governments in benchmarking your performance against similar companies and against best possible targets.
- Pester your government to change policies so they reward the positive activity of doing more with less.
- Work with customers, suppliers, competitors, governments and others to promote system-level change.
- Investigate radical change of the industrial system and your potential role in it.

4.4 Recommendations for Policy Makers

- Funding of technological innovation and sustainable innovation should not be separate.
- Understand what the current 'best-in-class' performance is for all products and systems, so that we know how near (or far) the majority of products and systems are from this.
- Demand best-in-class products and manufacturing practices from suppliers (such as Japan's 'Top Runner' scheme). This works for both government procurement and, through legislation, for consumer products and systems.
- Support and reward significant reductions in energy and resource use.
- Facilitate industry cooperation delivering system-level change.
- Ensure that the full energy and resource 'shadow' for all products and services are available to producers and consumers.
- Support massive re-education of the existing workforce, as they are best placed to deliver immediate change.
- Recognise that a low-carbon economy is fundamentally different and support efforts to explore these differences.

Finally, far to be intended as a specific research agenda on the topic of sustainable industrial systems, but is an attempt at describing how research might change and what could be valuable open questions to investigate.

- What are implications of operational business continuity and resilience on the long-term to justify significant investments plans?
- Can meta-models integrate specific optimization and life cycle analysis models supporting better design of the business proposition?
- How can we increase co-operative forward planning and action, so that system level changes become feasible?

- How can business in high labour-cost countries promote material efficiency if it requires more local labour, while material and energy are small contributors to the costs of mass production?
- How can developing economies implement industrial sustainability into their development path?
- How can we encourage information and practice sharing so that industry rapidly improves its current efficiencies?
- Where to localize manufacture or re-manufacture (globalization vs eco-industrial-niches)?
- Given that most goods can be maintained indefinitely, what drivers would promote more intense use, maintenance, repair and re-sale rather than disposal and under what conditions would this not be advantageous?
- A key driver of profit in production has been increased differentiation, yet design for re-manufacturing and re-use would favour standardization. How can these needs and opposing forces be resolved?
- How to optimize reverse supply chains considering economic and environmental factors/costs?
- What are the opportunities for significant dematerialization of material services and how can they be promoted?
- What are operational, process and logistical implications of adopting new or substitute materials and technologies?
- Where would the greatest future benefits from remanufacturing occur, and how would they be promoted?
- What might drive demand for component re-use, and how would the required supply chain operate profitably?
- What are operational and technological issues involved in effectively tracking products throughout the full value cycle?
- How to develop scheduling models for re-manufacture on a much larger scale than currently envisaged and possibly using external agents collaborating with several OEMs?

5 Conclusions

Industrial systems have evolved through competition and technological change, always seeking to do more with less than the competition and so survive into the next generation. This Darwinian metaphor is compelling and often useful, yet it fails to capture our uniquely human ability to predict and plan. Only humans, and by implication also our industrial systems, can see a future peril that has never been seen before and prepare for it.

We argue that those industrial organisations that predict and plan for a sustainable future are likely to survive into the next generation. Learning how to use significantly less material and energy to create the same or better customer value, while creating little or no waste is not only a sensible long-term strategy but a

compelling argument in today's volatile world. Such businesses will be resilient to some of the forces bearing upon them. The moment for significant action is now.

Case Study List and Sources

In this section some short case studies are used to illustrate both the current state of practice and show that no single framework or tool is yet dominant, indeed each organisation has followed a quite different path which is very carefully contextualised – for example, many companies have begun their journey deliberately limiting the level of innovation expected from their customers (though not all).

VITSOE. Manufactures and distributes high quality furniture around the world. Its key product is a universal shelving system (the 606) that won multiple awards for design excellence and is part of the collection at the Museum of Modern Art in New York City. Vitsoe was founded in Frankfurt, Germany in 1959. In 1995 Vitsoe moved all aspects of the company and production to the UK and since then, sales at Vitsoe have risen year on year by 20 %. Vitsoe focuses on generating steady growth by constant, incremental improvements to the quality of both product and customer service, which the company is able to control fully by selling direct.

What Trigger Is the Company Responding To?

The cost of most consumer products has dropped significantly in today's markets, ensuring that little value is attached to the products, allowing them to become disposable (repair being unavailable or uneconomic). Trends in fashions also increase the disposability of consumer items, leading to significant amounts of wasted resources.

What Was the Response?

Vitsoe's differentiated position has been to ignore high fashion, creating timeless, robust products that favour simplicity and flexibility. Vitsoe creates furniture that lasts longer and concentrates on reuse not disposal. All new components are designed and manufactured to be compatible with the original system. The designs use non-toxic material and create very little waste during production. Vitsoe has invested in reusable packaging for its suppliers and for shipping products to its customers. By pursuing this position, Vitsoe has minimised the impact of its activities on the environment.

Bottom Line Benefits

By encouraging the user to buy only what is needed, the customer relationship is established on the principle of long-term value. More than half of Vitsoe's customers are existing customers who are adding to, rearranging or reinstalling their furniture, which may have been bought as long ago as 1960. Customers buy Vitsoe's furniture because they can reuse it, rearrange it and take it with them; they understand that they are making a genuine lifelong investment.

Wider Lessons

Vitsoe has not received any incentives, tax breaks, grants or loans to support its desire to take a longer-term view of the design and support for its products; and yet they have survived almost 50 years in the market.

XEROX. Is a global document management company which designs, manufactures, sells and supports printers, multifunction systems, photo copiers, digital production printing presses, and offers related consulting services and supplies. Founded in the USA in 1906, Xerox is famous for its invention of the plain paper copy and the laser printer.

What Trigger Is the Company Responding To?

Xerox has been recovering used equipment since the 1960s. In the late 1980s and early 1990s there was a drive to develop a more formal system to maximize the profitability of using recovered equipment in remanufacturing operations. In parallel, Xerox began its 'Waste-free Products and Factories' initiative in 1991.

What Was the Response?

The company shifted its operation from a product based system (selling a photocopier plus maintenance) to one in which it provides a service (selling the ability to produce copies). The service model is intended to improve customer experience and to incentivise and enable Xerox to address the minimisation of waste throughout the design, make, use and end-of-life stages.

Xerox has produced toner which requires less mass per page, and their High Yield Business Paper can utilise 90 % of a tree, whilst typical paper uses only 45 %. Modular product design, wide product compatibility across models, integrated return logistics, ease of assembly and disassembly and the development of hi-tech

quality assurance methods has allowed reuse of over 90 % of components and remanufacturing of products. The 'Waste-free Products and Factories' initiative passed a major sustainability milestone by diverting more than 900,000 t of electronic waste from landfills around the world.

Bottom Line Benefits

The remanufacturing of products can lead to significant eco-efficiency gains (see chart), reducing the resource consumption and waste production of Xerox as a business. Parts that enter local repair programmes in the UK are reported to result in annual savings of $4 million.

Wider Lessons

By bringing the product under their control Xerox have the opportunity and the motivation to deal with both through-life and end-of-life issues. Some analysts

suggest that the strength of the Xerox remanufacturing based business model is inherent in the type of products they produce – the products are large, robust, easy to disassemble and valuable when remanufactured. The company has made a substantial investment in developing the systems and technologies which support a resource-efficient, service-based business model.

Toyota Motor Europe. Operates nine manufacturing facilities within the Greater Europe area. These range from the two oldest, Burnaston and Deeside UK (1992), to the newest in St Petersburg, Russia (2007). These plants operate a comprehensive range of processes for engine and transmission manufacture and full vehicle assembly operations.

What Trigger Is the Company Responding To?

Environmental protection is one of Toyota's 'Guiding Principles', first issued in 1992, and further documented in the Toyota Earth Charter. Using these documents as a blueprint for action and applying their management tools, including The Toyota Way and The Toyota Production System, each region developed a series of 5-year action plans. These plans set challenging targets to continually reduce environmental impact and were disseminated to all levels of each plant. Toyota Motor Europe (TME) is now part way through the fourth 5-year action plan.

What Was the Response?

Taking the global aim of zero emissions and a roadmap towards the ultimate eco car as inspiration for the manufacturing companies in Europe, TME developed their own vision 'Towards the ultimate eco factory'. This vision was based upon a strong foundation of legal compliance and risk reduction, with special focus on four major key performance indicators: energy/CO_2, water, waste and air emissions (Volatile Organic Compounds – VOC). These represent the most significant manufacturing plant environmental impacts.

Bottom Line Benefits

By adopting these principles the European manufacturing environmental impact was significantly reduced. In many areas significant cost savings have also been realised. Toyota UK (TMUK) demonstrates this continual improvement since 1993:

Some practical examples of TMUK's activities and achievements:

- Zero waste to landfill – achieved in 2003 (2 years ahead of target)
- Waste water recycling – 100,000 t of water saved per year
- CO_2 reduction within the boiler house (4,500 TC02e per year below 2004 levels)
- Decoupling of CO_2 emissions with increasing production volumes since 2003
- 25 % reduction in energy use per vehicle in paint booths

Wider Lessons

TMUK and a plant in France, were selected as two of five global Toyota 'sustainable plants' which serve as best practice development models for the Toyota organisation. These plants focus on achieving leading environmental performance, increasing the use of renewable energies and ensuring the plants are in harmony with their local surroundings. Toyota also contributes to a wider audience by sharing information and activity with a wide range of interested parties.

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Carbon Emissions Management and the Financial Implications of Sustainability

Janek Ratnatunga and Kashi R. Balachandran

1 Introduction

1.1 The Greenhouse Effect

The balance of scientific evidence indicates that the world is facing significant risks associated with the potentially damaging consequences of climate change. As stated in the Garnaut Report (2008):

> Climate change is a diabolical policy problem. It is harder than any other issue of high importance that has come before our polity in living memory. Climate change presents a new kind of challenge. It is uncertain in its form and extent, rather than drawn in clear lines. It is insidious rather than (as yet) directly confrontational. It is long term rather than immediate, in both its impacts and its remedies. Any effective remedies lie beyond any act of national will, requiring international cooperation of unprecedented dimension and complexity. While an effective response to the challenge would play out over many decades, it must take shape and be put in place over the next few years. (The Garnaut Climate Change Review, Final Report, 2008 p. xviii)

The Earth manages to regulate concentrations of greenhouse gases through a system of *sources* and *sinks*. In nature, carbon – in the form of carbon dioxide (CO_2) and methane – is sourced or *emitted* by burning and rotting of vegetation and other organic matter (called Carbon Sources). Conversely, CO_2 is *absorbed* (or sequestered) by trees, plankton, soils and water bodies, which are termed 'Carbon Sinks'. As can be seen, the contradiction that arises with regards to the Greenhouse

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Effect is that one of the main sources of CO_2 is also its principle sink (i.e. vegetation in various forms). This scientific contradiction then follows through to contradictions observed in the norms and values of how the community deals with the issue, how the discourse of the subject has been shaped, and also the impact of social constructions such as emission trading schemes that have been recommended as possible solutions.

Although there is a debate raging about the 'true-cause' of climate change, the strict criteria of evidence-based science is now being replaced by knowledge construction using the *Precautionary Principle* which reverses the burden of proof and encourages a precautionary response when there is insufficient knowledge to initiate preventative and control reactions (Snedeker 2003).[1] In simple terms, the principle states that "*it is better to be safe than sorry*". Under this principle, the imbalance in greenhouse gas emissions calls for greater attention and precautionary measures to be implemented.

The debate on how best to tackle climate changes perceived to be impacted by human activity has two distinct but interrelated approaches. These are called *'start of pipe'* and *'end of pipe'* solutions. The former solution relies on finding alternative sources to power our industries, buildings and motor vehicles. The latter relies on the behaviour modification of countries, organizations and individuals to reduce the consumption of power which must be obtained from high carbon emitting sources. Both solutions also have two underlying catalysts for change: *ethical*, because it is the "right thing" to do, and *economical* because we can save money and resources. The international response to global warming and climate change was the *Kyoto protocol* (under which over 150 countries have agreed to strive to decrease CO_2 emissions).[2] This protocol is largely economic/regulatory (i.e.) rather than ethical or moral.

Under the Kyoto Protocol, a country can emit more CO_2 than its assigned amount only if it can simultaneously sequester the equivalent amount in *'allowable'* carbon sinks, which include *afforestation* and *reforestation* activities undertaken since 1990.[3]

[1] In the fourth assessment report released by the Intergovernmental Panel on Climate Change (IPCC), around 2,500 scientists and reviewers from 130 countries concluded that evidence for global warming is now virtually indisputable (Carbon Disclosure Project 2008).

[2] More recently, the Copenhagen Climate Summit (2009) attempted to establish a new legally binding global climate framework for the period from 2012 when the first commitment period under Kyoto expires. However, the high expectations for the conference were followed by more diminutive outcomes. The conference was only salvaged by a last minute US brokered political accord which was agreed to by several countries (and involved $US30B in new and additional resources, including forestry and investments through international institutions), but it failed to achieve broad consensus. The outcomes of the Durban Climate Summit in December 2011 are still unknown at time of writing.

[3] These have to be 'incremental', i.e. a new tree planted. Pre-1990 trees still existing are not considered as sinks for carbon credit purposes, as they have reached maturity and are in 'balance' as to the amount of carbon sequestered and emitted. Some developed countries are giving developing countries 'grants' to use in preventing illicit logging. Such grants are outside the Kyoto protocol.

Since Australia's ratification in 2007, the United States is the only major developed country that has not, as yet, ratified the Kyoto Protocol.[4]

1.2 Carbon Emissions Management Approaches

For businesses and individuals in countries subjected to strict CO_2 emissions reduction targets (under the Kyoto protocol or other regulation), it would necessitate a number of lifestyle changes (from organizations and individuals in that country) to achieve a substantial decrease in CO_2 emissions. Examples of the lifestyle changes that are required by governments, organizations and individuals to reduce CO_2 emissions were listed by the TIME Magazine (2007). A few of the carbon reduction methods suggested for business were (1) change light bulbs to low emission, (2) switch off lights at quitting time, (3) let employees work close to home, and (4) buy green power, etc.. The carbon reduction methods suggested for individuals were (1) to fly straight between locations, (2) hang up a clothes line, (3) insulate your water heater, etc. These are mainly 'end-of-pipe' solutions.

As businesses and individuals modify their behavior to become more carbon conscious, there could be a shift in world trade. In recent years, there has been a significant shift from 'localization' to 'globalization', especially with the opening up of China, India and the Eastern block (Levitt 2006). However, as more people are encouraged to work closer to home, buy produce from the local farmer, and have a 'Green Wedding' by buying wine and other consumables locally (TIME 2007), then a shift back to localization due to carbon related reasons is possible. This shift in world trade has been termed as, *'Carbalization'*.

'Carbalization' is based on the concept of *product-distance* (in miles or kilo meters), i.e. the distance a product travels to get to its place of final purchase for consumption. Separate studies by the oil giant BP and the German Institute for Physics and Atmosphere released earlier this year revealed the world's shipping could have a more serious impact on global warming than air travel.[5] Although CO_2 emissions on a per-kilogram basis were significantly lower for shipping when compared with air freight, it is distance that has been targeted as most imports of fast moving consumer goods (FMCGs) are mostly imported via shipping lines. An example is given of imported bottled water from Europe using approximately 80 kg of CO_2 emissions per

[4] Developing countries, including China, India and Indonesia, have ratified the protocol but are 'exempted' from reducing CO_2 emissions under the present agreement, despite their large populations, and high emissions levels. China ranks only behind the USA in carbon emissions, and in some rankings is the number one emitter. Australia also has not, as yet, agreed to any reduction targets, despite being the largest 'per-capita' polluter.

[5] Annual emissions from shipping made up 5 % of the global total, while the aviation industry, which is subject to far greater scrutiny, contributes only 2 % (Vidal 2007). CO_2 emissions from ships do not come under the Kyoto agreement, and therefore, only a few studies have been undertaken.

metric tons of bottles to be shipped to Australia, whilst from Egypt it is 70 kg and from nearby Fiji only 20 kg (Perkins 2007). The message from such analyses is similar to the TIME magazine (2007) recommendations, i.e. buy from sources where the product or service originates as close as possible to point of purchase.

Recently China (the second biggest polluter behind the USA in some studies and the biggest polluter in others) has stated that economic considerations come first and thus will only consider reducing carbon emissions as a secondary issue. Thus, Chinese products will continue to be 'cheaper', not only due to cheap labor, but also due to the non-inclusion of carbon costs. Countries that import such products will not only adversely affect the economic viability of their own country's businesses, but also they will be the target of the Chinese 'dumping' carbon emissions on them. The only way (other than forcing China to accept their responsibilities by negotiation) is to place a countervailing tax on such imports (similar to that placed when companies 'dump' products via transfer pricing) based on a fair allocation of carbon costs to Chinese products. It is evident therefore, that striving for more efficient carbon management by businesses and individuals for achieving sustainability goals will have significant economic impacts on organizations and resultant financial implications.

Schumacher (1997) has recognized the inherent contradictions in orthodox economic thinking, as follows: *If one mistakes what is an end in itself, and treats it as a means, then there is degradation of life. And conversely, if one takes what is really a means to be an end and elevates it to the status of an end (e.g. cost efficiency), then there is degradation of oneself.*

Thus Schumacher (1997) would argue that the actions and impacts of the behavioral responses to climate change by business entities should *not* necessarily be monetized, i.e. that the reduction of CO_2 emissions is a *value in itself*. This indicates that individuals and business entities voluntarily take actions (mostly 'end-of-pipe' solutions) to reduce greenhouse gas emissions (Fig. 1).

Following the line of argument presented by Schumacher (1997), the financial implications of such phenomena should report the consequences of CO_2 emissions reducing actions by business entities in terms of *value to society*, rather than in monetized economic values.

Unfortunately, economic rationality gets in the way of the Schumacherian ideal, in that voluntary responses by individuals and business entities have been minimal. The Chicago Climate Exchange (2007), set up to trade in *Voluntary Emissions Reductions (VERs),* closed in November 2010, due to a lack of business. Therefore, the argument put forward is that the driver that will best elicit the appropriate CO_2 emission reducing behavioral response from countries and business entities would be a mandatory ration limit, with monetary consequences if this limit was exceeded.[6] This would have not only a Schumacherian *consequence*, but also a

[6] One such scheme is a certified carbon allowances and trading scheme set up under Kyoto principles. Other approaches involve some form of taxation, issuance of permits or imposition of fines.

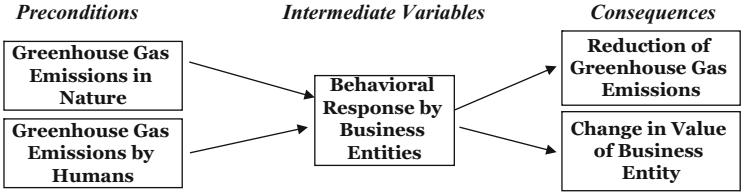

Fig. 1 The Schumacherian ideal

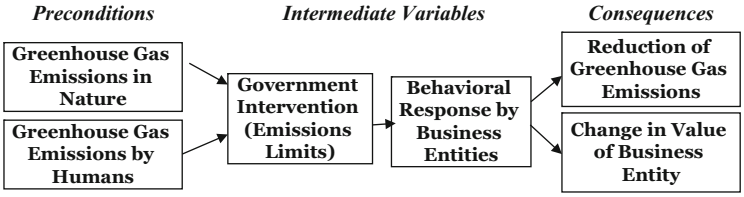

Fig. 2 The carbonomics solution

resultant impact on the *monetary value* of the business entity. This is referred to as the *Carbonomics solution* and could be both 'start of pipe' and 'end of pipe' responses (Fig. 2).

The carbonomics solution is that, in order to meet the quota targets accepted under the Kyoto Protocol, countries can in turn, set quotas on the emissions of business entities (and perhaps in the future, those of individuals). Thus, many countries are considering 'managing' their CO_2 targets through its regulation of business entities and individuals in their own countries in four principle ways:

- By *taxation*. Here the government imposes a straight tax on CO_2 emissions. The advantage of this is that it is immediately implementable, transparent and similar tax regimes could be harmonized around the globe perhaps under the oversight of the International Monetary Fund. The disadvantage is that business may absorb or pass on the tax to consumers, and not cut emissions (Tounson 2007).
- By imposition of a *penalty*. This is similar to a tax, in that any government fines or penalties imposed on companies for exceeding some ration limit may be absorbed or passed on the to consumers, and not cut actual emissions.
- By charging a *fee to pollute*. This license or permit to pollute up to a certain ration limit is again similar to a tax, in that companies may absorb or pass the cost on to consumers, and not cut actual emissions.
- By setting a *carbon price*. Here carbon credits[7] or 'permits' are issued free or sold or auctioned to business entities permitting the emission of a certain

[7] A 'Carbon credits', also called a *'Renewable Energy Credit (REC)*, represents *one metric ton of* CO_2 either removed from the atmosphere or saved from being emitted.

quantity of greenhouse gases in a particular period (i.e. a permitted quota).[8] The setting of floor and ceiling prices will be done by the Government, but trading in these carbon credits will determine market price. This system is known as a *'cap and trade' system*. This will be discussed in more detail in the next section as it appears to be one of the few approaches that will actually reduce CO_2 emissions.

- By *approving* certain organizations to issue 'abatement certificates': These are legitimate carbon credits, created by undertaking work to either increase the capacity of sinks, or reduce CO_2 emissions from sources. Here, greenhouse performance levels are set whereby those that can deliver a particular product with emissions below the ration or 'cap' can earn (create) abatement credit certificates. For example, power stations can create credits to the extent their greenhouse intensity of their electricity is lower than a predetermined level.[9] Another example would be an organization that grows trees for the purposes of CO_2 sequestration and the creation of 'accredited' carbon credits.[10] These abatement certificates are then sold to polluters. As yet such credits are not part of the booming international trade, but tend to be recognized and traded regionally.[11]

It is clear that the need for carbon emissions management will produce winners and losers in both the product and allowances markets, and in organizations and countries. In the products and services market the *winners* will be 'low carbon intensity' firms and those that can pass on their carbon costs. Some of these firms could earn windfall profits. The *losers* will be 'high carbon intensity' firms and those that are unable to pass on their carbon costs. In the allowances market, the *winners* would be countries 'on-track' for meeting Kyoto standards. These countries (and companies within them) will have a higher proportion of required allowances allocated free, and could earn windfall profits from the sale of these allowances. The losers will be countries a long way from Kyoto compliance, that will need to purchase a higher proportion of allowances from the market. In the rest of this chapter, we discuss the financial implications of carbonomics on sustainability; especially how the (global) costs and revenues of CO_2 emissions and sequestrations can be captured by accounting systems for reporting purposes; built into the cost and prices of different products and services; and used for strategic decision making in business organizations.

[8] Some countries (e.g. the UK) were considering providing each of their citizens an annual carbon emissions quota via a 'personal allowance' ration card which would have to be handed over every time a form of non- renewable energy was purchased – at the filling station, or when buying tickets for a flight – for points to be deducted. This possibility has diminished due to political considerations.

[9] This approach is known as a Solution-based market that prescribes targets in terms of units of production from a prescribed sub-section of abatement technologies such as megawatts-hours of electricity generated from renewable energy.

[10] In New South Wales, Australia, companies that carry out work to reduce greenhouse gases can create 'Abatement Certificates" under the Greenhouse Gas Abatement Scheme. These are then purchases by polluters such as Electricity retailers who have been imposed annual reduction targets.

[11] Since 2003, about 37 million tons (worth more than A$ 400 million) have been traded, making NSW one of the largest carbon trading markets in the world. Dusevic (2007, p. 12).

2 Financial Implications of Sustainability

Traditionally, the monetary basis on which the various stakeholders of business entities make their investment and other commercial decisions, and evaluate the results of those decisions, has been through the framework of financial accounting. Due to the wide-ranging use of financial reports by multiple stakeholders, in order to ensure the numbers reported can be relied upon, the profession has developed an auditing and assurance framework which provides a 'true and fair' assessment of such reports and the quantification of the economic values therein.

However, in terms of financial reporting, the current financial accounting information systems appears to be ill-equipped to provide the framework required for reporting to multiple stakeholders as to how an organization is meeting its environmental sustainability responsibilities, especially the challenge of reducing global warming (Ratnatunga 2007; Ratnatunga et al. 2011). While quantification in monetary terms has been accounting's sine qua non in reporting to shareholders on an organization's economic performance, it is also well documented that monetary measurement alone can be severely limited when reporting on sustainability performance issues. This is because the actions undertaken and the resultant impacts cannot always be valued in monetary terms.[12] Thus alternative social constructs have been proposed (and used) to report on an entity's corporate social responsibility (CSR), mostly using non-monetary measures. Despite these alternative social constructs, however, the accounting profession worldwide (using orthodox economic thinking) still seeks to parameterize the discussion within a conventional accounting framework.

2.1 Cap and Trade Emissions Trading Schemes

An emission trading scheme (ETS) approach for reducing emissions has been proposed in several international jurisdictions, as well as Europe and more recently in Australia. Emission trading is an approach used to constrain pollution by providing specific economic incentives to encourage companies to achieve carbon reductions. An ETS is often referred to as a 'cap and trade' scheme. The government sets a limit or *cap* on the amount of a carbon that a company can emit. Companies are issued emission permits or rights from the government and are required to hold an equivalent number of *allowances* (or *credits*) which represent the right to emit a specific amount of carbon. Under an ETS, the total amount of allowances and credits cannot exceed the cap, limiting total carbon emissions to that specified level. Companies that need to increase their emission allowance will have to purchase carbon credits from entities that pollute less. The transfer of

[12] One cannot put a monetary value on the extinction of a species due to environmental degradation.

carbon credits or allowances is referred to as a trade. In effect, the buyer is paying a price for polluting, while the seller is being rewarded for having reduced carbon emissions by more than the required amount. In theory, companies that can readily reduce emissions most cheaply will do so, achieving the pollution reduction at the lowest possible cost to society.

The *European Union Emission Trading Scheme* (EU ETS) first introduced emissions caps based on 8 % reduction of emissions on the 1990 baseline. Allowance trading started late in 2004, and the ETS scheme was initiated in January 2005. Under the EU ETS, the governments of the EU Member States agree to national emission caps which have to be approved by the EU Commission, allocate allowances to their industrial operators, track and validate the actual emissions against the relevant assigned amount, and require the allowances to be retired after the end of each year.

While Australia plans to establish an ETS (now) by 2013, an effective and transparent ETS presupposes a raft of regulatory and market mechanisms to be established to ensure the smooth running of the scheme. Given the largely experimental nature of the proposed ETS in Australia, there remains considerable uncertainty as to full economic costs and other impacts to be imposed on Australian industry, particularly for the largest carbon emitters.

The Garnaut Report (2008) noted that the implementation of an emissions trading scheme will require resolution of issues relating to financial accounting standards and tax treatment, including avoiding distortions between the purchase of emissions permits and other options for meeting emissions targets – that is, pursuing tax neutrality between purchasing a permit, undertaking capital expenditure to reduce or sequester emissions, investing in research and development or reducing production. To be effective, the Garnaut Report (2008) states that an ETS must be established on some basic guiding principles including:

Principle 1: Scarcity needs to be aligned with the emissions target – in other words, the quantity of permits must reflect national emissions reductions targets and trajectories. Scarcity of permit supply needs to be a certainty to avoid risk discounts and premiums, due to suspected quantity increases or decreases, being factored into prices.

Principle 2: Credibility of institutions. Trading scheme institutions must be of an enduring and credible nature, without which there could be a rapid collapse of any established carbon trading market. Further, institutions must be sufficiently robust to withstand political pressure for arbitrary changes. Finally, operating rules of these institutions must also be "reliable, steady and transparent".

Principle 3: Simplicity of rules. Rules of the scheme should be easily implemented and explained. A consistent approach in implementing the rules will be important, while any "special rules concessions and exemptions should be avoided". A reduction in the simplicity of the scheme will result in more uncertainty and possibly increased transaction costs.

Principle 4: Tradability of permits. To achieve these permit characteristics the benefits they bestow must be (i) unambiguous, (ii) their terms and conditions of

trade need to be commonly understood, (iii) there needs to exist ready access to the market, (iv) transactions should be at minimal cost and (v) offer and bid prices need to be transparently available.

Principle 5: Integration with other markets. The emissions trading scheme must be able to coexist and integrate with international markets for emissions entitlements as well as with other financial, commodity and product markets in the domestic and international economy.

Not only would the introduction of a carbon trading scheme in a country have an impact at the business organization level, it could also be argued that the monetization of CO_2 emissions can actually help at the local community level in terms of sustainability if a carbon emission trading (monetized or bartered) becomes a widespread phenomenon. Such a scheme could, arguably, result in significant changes in the countryside of many countries. For example, farmers and others in local communities have worked hard to get rid of their trees because they hindered agriculture, or were required for building and even for fuel. Although in many countries such logging was illegal, there were no monetary incentives to prevent such activity. Now, post-Kyoto, the world recognizes that these very trees deserve a bit more 'credit' than that, and appear to be willing to pay money for the carbon sequestration abilities of these trees. Local farmers wanting financing to grow trees for various reasons, including preventing soil erosion, will now be paid by brokers acting on behalf of carbon emitters to undertake this activity. A cost in earlier times would now become a revenue source. Those arguing this position would thus claim that the capital market system may actually save the world (which, after all, is the ideal that Schumacher is after). The proponents of this view see this as a clear example of how orthodox economics may well create the platform for global sustainability.

2.2 Carbon Emission and Sequestration (CES) Accounting

The mechanism for calculating the quantum of CO_2 either emitted by a source or sequestered in a biomass sink is referred to as 'carbon accounting'. This has very little to do with monetary values usually associated with the term 'accounting'. Therefore, in this chapter it will be referred to it as 'carbon emission and sequestration (CES) accounting'. Any CES accounting mechanism must be sufficiently robust that the carbon trading market has confidence that the amount of carbon sequestered can be both measured and considered to be equivalent in its impact on global warming potential to the CO_2 released to the atmosphere from activities producing greenhouse gases.

As can be appreciated, the detailed requirements for a CES accounting system are continually being developed by organizations such as the *Intergovernmental Panel on Climate Change*[13] (IPCC 2007) Any CES accounting standard developed

[13] The IPCC along with Al Gore, the former USA Vice-President, won the 2007 Nobel Peace prize for their work on reducing global warming.

by a country or NGO will need to be consistent with the IPCC principles before credits generated from carbon sinks can be used in an emissions trading regime under the Kyoto Protocol.

The accounting profession would want one standardized system (one size fits all) to use pertaining to CES measures. The danger here is the possibility that the system adopted would serve vested interests of business organizations (that are principally polluters) at the expense of other stakeholders. These other stakeholders would therefore applaud the lack of standardization in the early days of grappling with such measures; with the view that the measurement systems that survive would be the ones that are adaptable to varying stakeholder requirements (see Stafford Beer 1975). The surviving CES measurement systems should, however, be subject to some regularity and transparency requirements, especially if the CES measures are to be priced for trading.

Unfortunately, the current situation is that, although the interest in the carbon trading market is high, the new market is largely unregulated and lacks transparency (Ratnatunga and Balachandran 2009). Government policy in countries such as the USA and Australia is in a constant state of change, and questions of measurement and pricing required for an efficient trading system are far from settled. In essence business organizations and individual customers[14] have no way of discriminating between the providers who claim that in their scheme is better able to measure (for example) that (Tandukar 2007):

$$X \text{ trees} = \text{the sequestration of } Y \text{ tons of } CO_2 \text{ emissions} = \$Z \tag{1}$$

Although Schumacher (1997) would probably prefer the equation to be limited to the first two variables, i.e. view the sequestration of Y tons of CO_2 emissions to be *a value in itself,* the introduction/existence of a carbon emissions trading market will enable the third variable, a monetary value ($Z) to be determined. In turn, as there will be real dollar transactions involved, these monetary values will need to be reported in organizational financial statements under current Generally Accepted Accounting Principles (GAAP) of most countries.

However, without agreed CES measurements, the variation possible in the middle section of the equation could lead to gross distortions of whatever dollar value was offered in a carbon trading exchange; i.e., as the sequestration or emissions measured could be a range of values (rather than a deterministic 'agreed' value) so would the dollars received or paid for such.

Whatever the methodology or approach that is ultimately 'agreed' in terms of CES measures, the issue for the accounting profession is the monetary value ($Z) of the CO_2 that these CES Accounting measurements say has been either removed from the atmosphere or saved from being emitted by an organization's products,

[14] Sergey Brin, the founder of Google is reported as having bought carbon credits to offset the immense amount of CO2 emitted by his private Boeing 767, but confesses he is not sure if it really achieves anything (Krauthammer 2007).

services, equipment and processors. The existence of an efficient carbon trading market would be able to put a price on this in terms of a Carbon Credit (or allowance). In addition, the traditional accounting reports would need to recognize that certain non – current assets (or liabilities) could also give rise to *future* carbon related revenues and expenses. Such balance sheet items may have a 'market' for the tangible asset (e.g. a power plant or forest), but not for its related intangible asset or liability, i.e. the CO_2 sequestration or emissions ability of such CO_2 sinks and sources. If you buy or sell the tangible, you would need to consider the value of the related intangible (see Ratnatunga et al. 2011 for a detailed discussion of this issue).

In such instances, the accounting profession would need to obtain the services of outside consultants, such as environmental scientists and biologists to undertake CES accounting projects. The use of such external experts is not uncommon, however. The accounting profession often incorporates reports from company directors, actuaries, business analysts, engineers, quantity surveyors, lawyers etc., especially in the area of balance sheet asset valuation and fair-value accounting. Using expert opinions in accounting for CO_2 flows would be no different. However, accounting standard setters have been reticent in accepting expert opinions as balance sheet values of intangible assets, and one could envisage them having concerns with values generated via CES accounting.

2.3 CES Accounting: Assurance and Verification

An important issue in the discourse on CES accounting is that of *assurance and verification*. An entity's carbon accounts will need to be independently verified by qualified assurors before they are accepted for use in an emissions trading regime. There needs to be accountability, transparency and integrity in relation to compliance arrangements, especially in relation to the inputs that are going into such a trading scheme. If such assurance is not present, then business organizations are not going to have comfort or certainty in investing in such a market.

Before any 'assurance' can be given, however, the framework for reporting must be first agreed upon, i.e. a necessary condition for an assurance engagement is that first the reporting framework is accepted as suitable criteria for CES accounting. We have already discussed, however, the confusion in the plethora of measurement protocols available for CES Accounting.

Currently, similar to the situation regarding numerous CES Accounting methodologies and approaches, the auditing and ranking of environmentally sustainable initiatives is in chaos with dozens of organizations offering accreditation and auditing services, across the globe, but none being committed to a standardized methodology for auditing or reporting corporate effort. Walters (2006) lists at least 11 such organizations, none having standards compatible with another. The most commonly used methodology is the Global Reporting Initiative (GRI 2007).

From the above discussion it is clear that there are many vested complementary and conflicting interests driving the discourse on carbon emissions trading. However, the (financial) auditing profession has been slower than the organizations listed in Walters (2006) in providing assurance standards and therefore has had only a very limited impact on how the discourse is being shaped. This is despite the anecdotal evidence that indicates that the auditing profession is 'salivating' at the potential of conducting CES audits.

To date however, the auditing profession's own input to the discourse has been very limited with significant contradictions and resistances engendered by environmental accounting techniques resulting in incomplete efforts of accountants and their allies to overcome them (see Lohmann 2009). The *International Auditing and Assurance Standards Board* (IAASB) has issued *IASE 3000, Assurance Engagements other than Audits and Reviews of Historical Financial Information* (IAASB 2004) to cover the assurance on sustainability reports. It is a framework that applies equally to assurance engagements on historical financial information and on other information. In a country that has adopted ISAE 3,000, any assurance engagement on other than historical financial information is to be undertaken by the auditing firms in accordance with ISAE 3,000. The *American Institute of Certified Public Accountants* (AICPA 2005) also put out *Statement of Position 03–2: Attest Engagements on Greenhouse Gas Emissions Information*, but this provides very little in terms of detail.

It must be pointed out that ISAE 3,000 is a very general standard for assurance engagements that covers a wide range of possible subject matter, with sustainability being just one. Due to the broad scope of sustainability, numerous challenges exist regarding the suitable criteria required to fulfill the assurance requirements of relevance, completeness, reliability, neutrality and understandability. The IAASB approved a project in December 2007 to address professional accountants' responsibilities with respect to assurance engagements on carbon emissions information. This project concerns professional accountants' responsibilities with respect to assurance engagements on carbon emissions information. It will consider what specific guidance is necessary beyond the general requirements of ISAE 3,000. The project hopes explore the need for guidance regarding assurance about carbon offsets. Also, while not a primary focus of the project, the IAASB is of the view that an ISAE on this topic will likely be of assistance to financial statement auditors when considering the carrying value of emission trading rights. The final output of this project is likely to be a new International Standard on Assurance Engagements (ISAE).

An organization called *AccountAbility*, with its assurance standard AA1000 AS, has been one of the first groups providing guidance on assurance for sustainability assurance engagements (Mock et al. 2007). AccountAbility recently enhanced the AA1000 AS assurance standard by issuing a *Guidance Note on the Principles of Materiality, Completeness and Responsiveness as they Relate to the AA1000 Assurance Standard* AccountAbility (2007).

It will be perhaps easier to build assurance standards for carbon emissions reports as the subject matter is more easily defined and measured (especially

when an efficient carbon emissions trading market exists). However, to date, no specific carbon emission standard has been released by any professional accounting organization. Neither AA1000 AS nor ISAE 3,000 provides specific guidance or standards regarding CES accounting assurance. This has stifled the auditing profession's responsiveness in undertaking engagements relating to climate change issues. The problem remains that until proper CES accounting standards are agreed to, there would be significant constraints in developing specific standards for undertaking CES assurance.

3 Carbon Financial Statement Accounting

From the foregoing discussion, it can be seen that the discourse on the reporting of the monetary values generated by CES accounting measures, is dominated by orthodox economic thinking and not Schumacherian meta-economic logic of considering CO_2 sequestration activity as a value in itself. However, the traditionalists would argue (as a point of conjecture) that just as the price-mechanism was the 'invisible-hand' of commerce (Smith 1776), the carbon price would be the invisible hand that enables the Kyoto protocol to be expressed in terms of the interconnectedness between humans and nature.

The conventional means by which economic activity is reported is via financial accounting and the resultant financial statements. However, interesting financial accounting issues and controversies arise in the suggested conventional treatments of accounting for credits depending on if an allowance or credit is:

- Granted free to a business entity by a government,
- Purchased in an auction run by a government,
- Purchased in a free-market, or
- Created by an organization allowed by an International or State Authority to issue them.

The main issues revolve around typical questions that arise within the conventional GAAP paradigm. It will be demonstrated that the position of the financial accounting profession to issues raised by carbon trading is by no means clear, and most recommendations are fraught with controversy and contradiction. The main problem is that the accounting profession wants to apply their one size fits all method to all measures; a position that may not be viable in a new carbonomic paradigm. For example, if a particular country's government rations CO_2 emissions via a 'cap and trade' allowance scheme, then that allowance will have a monetary value and the following questions will follow: Does the requirements of the Kyoto Protocol give rise to an asset (carbon sink) or a liability (carbon source)? If a separate asset is recognized, what is the nature of that asset? Is there 'income' when the allowance is received, or is income deferred until the allowance is traded? If income is recognized, how is it measured? Should the potential penalty, which will be incurred if a participant fails to deliver sufficient allowances to cover its actual

emissions, be recognized as a contingent liability, and if so, how should it be measured?

Note that these are right questions to ask only if carbon emissions are placed within a traditional framework where carbon sinks as assets and emissions as liabilities are seen from the perspective of an organization (i.e. shareholder interests); rather than from a Schumacherian perspective. However, as we have no other models of measuring the effects of carbon emissions and sequestration (as yet) we should at least try and fit them into a traditional model and see whether the results make any sense. Therefore, these and other questions (and contradictions), and suggested answers and solutions within the conventional paradigm will be discussed in this section in order to understand how the discourse is shaping within the profession.

Some in the accounting profession have argued that a rationed 'carbon allowance' is an *intangible asset*; i.e. a *"right to pollute"*. For instance, International Financial Reporting and Interpretations Committee (IFRIC) issued IFRIC 3 'Emission Rights in March 2004 which proposed measurement and disclosure rules for ETSs. IFRIC 3 required that:

(i) Rights (allowances) are intangible assets that should be recognized in the financial statements in accordance with IAS 38 *Intangible Assets*.
(ii) When allowances are issued to a participant by government (or government agency) for less than their fair value, the difference between the amount paid (if any) and their fair value is a government grant that is accounted for in accordance IAS 20
(iii) As a participant produces emissions, it recognizes a provision for its obligation to deliver allowances in accordance with IAS 37 *Provisions, Contingent Liabilities and Contingent Assets*. This provision is normally measured at the market value of the allowances needed to settle it.[15]

Depending on the business, it could be argued that this category of intangible assets can be accounted in three ways: as items of *inventory* if the organization is set up to trade in 'allowances'; as *financial assets*; and as *derivatives* by accounting for them as a cash flow hedge. If it is considered a *financial asset*, the allowance could be reported as a new category of intangible asset, i.e. one that could be measured at fair value with changes in value recognized in profit or loss.[16]

[15] However, IFRIC 3 was unpopular in Europe and was subsequently withdrawn in June 2005. Financial reporting and valuation issues relating to ETSs were reintroduced on the IASB agenda December 2007; however the IASB still appears to be a long way from developing a comprehensive standard on carbon emission rights.

[16] If intangible assets arise due to a third party transaction such as a purchase of a carbon allowance, then it can meet the accounting profession's reliability test. However, carbon credits created internally by carbon sinks cannot be recognized until they are sold in open trading. An inconvenient truth is that the profession has great difficulty with internally generated intangible assets such as brand values and intellectual property, and it is still coming to terms with reporting issues arising due to carbon trading.

The counter argument is that, for many organizations, the existence of government and other controls (rationing) in the carbon emissions area would more likely result in a *liability* situation, if the entity's CO_2 emissions are greater than the allowable ration granted (or purchased).

Following these different viewpoints, the profession has recognized at least three treatments of carbon allowances even within the traditional accounting framework as follows:

(1) If the allowance is obtained as a *government grant* (when allowances are allocated by governments for less than fair value) then it is first recognized as an intangible asset at cost (debit: intangible asset; credit: cash). Then, the intangible asset is increased to fair value with the difference between cost and fair value recognized as revenue on a systematic basis over the compliance period (debit: intangible asset; credit: revenue).[17] As an organization emits carbon the intangible asset is used up at market value (debit: expense; credit intangible asset). Any gains or losses that result in disposing of the intangible asset are recognized in the income statement.
(2) If the allowance is purchased as an *asset,* then it is recorded at fair value pertaining to the carbon allowances held (debit: intangible asset; credit: equity reserves).[18] Again, as an organization emits carbon the intangible asset is used up at market value (debit: expense; credit intangible asset).
(3) If under a carbon rationing scheme a *liability* arises for the obligation to deliver carbon allowances equal to emissions that have been made, then it is recorded at fair value (debit: expense; credit: liability), and ultimately purchasing in an open market 'carbon credits' equal to the shortfall (debit: liability; credit: cash) at market value.[19]

To account for such treatments in a carbon rationing scheme, a *net model* has been proposed whereby an entity does not recognize allocated allowances (they remain off-balance sheet), and accounts for actual emissions only when it holds insufficient allowances to cover those emissions by buying carbon credits (debit: expenses; credit: cash) at market price.

Traditionally, however, the accounting profession prefers the separate recognition of assets and the liabilities and the different treatment of such; i.e. to treat carbon assets (i.e. allowances) independent of the liabilities (i.e. obligations). Accordingly, netting off (i.e. offsetting) of the assets and liabilities in such cases will not be permitted.

[17] Questions as to whether such revenue is taxable or exempt from tax will be based on a specific country's tax policy.

[18] The fair value would be based on market values if a trading scheme exists. Similar questions of 'fair value' pertain to share investments, i.e. there are reporting differences if the shares are held as 'investments' or as 'inventory' in a fund management company.

[19] Note that a 'Liability' is a present obligation arising from past events. The issue of a 'carbon permit' relating to a possible future event is more a contingent liability, although the IASB has recommended abolishing this latter term.

Thus an *amortizing model* has been proposed whereby an entity recognizes allocated allowances as an asset (debit: asset; credit: equity reserves as deferred income) at cost price, but then amortizes the allowances as it pollutes (debit: expense; credit: asset) and simultaneously release the deferred income to revenue (debit: equity reserves; credit: revenue). In this method, the entity recognizes a liability for actual emissions only when it holds insufficient allowances to cover those emissions (debit: expense; credit: liability). The liability that the entity incurs as it emits is measured at the cost of the allowances held by the entity. However, ultimately the entity has to purchase 'carbon credits' in an open market equal to the shortfall (debit: liability; credit: cash), and there would be an over/under provision of this liability depending on market price. Clearly, pricing and the valuation of carbon allowances (permits) is a key to this method of accounting.

In the United States, the guidance contained in the Federal Energy Regulatory Commission's (FERC) *Uniform System of Accounts* is the only accounting guidance currently available that explicitly addresses emission allowances. FERC requires business entities to recognize emission allowances on a historical cost basis. The Financial Accounting Standards Board (FASB) has researched the actual practices of business entities, and reports that whilst there is a diversity of practices, most follow the FERC guidelines. The FASB also reports that some business entities follow an intangible asset model for emission allowances and that there is no authoritative guidance that addresses the accounting for carbon credits.[20]

Other guidelines have been issued, but often withdrawn subsequently. For example, the Emerging Issues Task Force (EITF) *Issue No. 03–14 Participants' Accounting for Emissions Allowances under a 'Cap and Trade' Program*, attempted to address emission allowances by providing a comprehensive accounting model for participants in a cap and trade emission reduction program and alternative views for classification. This was removed as it was seen by some to have implications beyond cap and trade emission programs and by others as irrelevant as they did not perceive a practice issue or diversity in the accounting for emission allowances.

Another example of the unfocused discourse in the accounting profession was the International Financial Reporting Interpretations Committee's *IFRIC 3: Emission Rights* that attempted to address how participants might account for cap and trade emission trading schemes. IFRIC 3 stated that allowances are intangible assets and should be measured at fair value when received from the government. The grant of allowances was to be recognized as income on a systematic basis over the compliance period.

However, in 2005, the International Accounting Standards Board (IASB) voted to withdraw IFRIC 3 in light of (a) the reduced urgency for an interpretation, (b) requests from the IFRIC to amend IASB standards, and (c) concerns expressed by the European Commission. In late 2005 the IASB decided to add a project to its agenda to provide a comprehensive model for emission allowances similar to issues

[20] http://www.fasb.org/project/emission_allowances.shtml (accessed April 18, 2007).

discussed in IFRIC 3. This is yet to be released. In a recent paper Cook (2009) states that one such solution for the IFRIC to consider is to maintain the status quo.

A further example of the financial accounting profession's inability to deal with the issue is that after the *FASB Statement No. 153 Exchanges of Nonmonetary Assets* was issued in December 2004, questions arose in practice related to its scope and, specifically, whether exchanges of emission allowances (vintage year swaps) should be accounted for at fair value or on a carryover basis. In August 2006, the *Technical Application and Implementation Activities (TA&I) Committee* approved a recommendation for the Board to add a project to its agenda to address the nature of emission allowances and clarify the accounting for vintage year swaps of emission allowances by participants in emission trading schemes. This project also is yet to report.

In Australia, carbon allowances that are to be obtained via a rationing system (that is proposed to be introduced in 2013) would probably be seen as government grants, and thus fall under the Australian Accounting Standards Board's *AASB 120 Accounting for Government Grants and Disclosure of Government Assistance* standard, which states that such grants are intangible assets, and must be recognized as income over the periods necessary to match them with the costs for which they are intended to compensate. This, in effect, is the *amortizing model,* but there is some debate as to the recognition of 'deferred income'. As the IASB has stated that only assets and liabilities may be shown on the balance sheet, then revenue received but not yet recognized as income (i.e. deferred income) is not a liability and thus cannot be shown on the balance sheet. But it cannot be shown as an Equity Reserve either, as AASB 120 states that government grants cannot be credited directly to shareholders' interests. There is clearly contradiction and confusion here.

Even if the IASB decides to recognize deferred income as a balance sheet item, the release of the government grant to revenue by reference to the initial value of the allowances can also cause volatility as the liability that arises as the entity emits is measured by reference to the current market value of the allowances. Even if the entity elects to measure the allowances subsequently at market value, a mismatch arises because some gains and losses are reported in the income statement and others in equity.

Thus it can be seen that under the amortizing model, carbon allowances/liabilities could represent a significant figure that potentially could have an impact on the "bottom line" volatility of a company's reported financial statements. This perceived (artificial) volatility in the income statement would be a major concern for CFOs, as they would have to record a gain in the value of emission rights to equity, but the loss related to revaluing the liability as a profit or loss item. Further, the current traditionalist thinking is that they would need to record a loss in the value of emission rights against previous gains recognized in equity, but the gain related to revaluing the liability would be recorded in profit or loss.

The accounting treatment is a little clearer in Australia for reporting 'unconditional government grants'. This is covered by *AASB 141 Agriculture*. An unconditional government grant must be recognized as income on receipt. However, a conditional government grant is recognized as income on receipt only when certain

conditions are met. Further, even if it could be argued that a carbon permit issued to offset increased future costs arising from a cap and trade scheme is a conditional government grant, the issue of recognizing deferred income remains. If the carbon permit is not recognized as even a conditional grant, all the income needs to be recognized (and taxed) in year of receipt, even though the related cost is in a future period, thus effectively negating the *matching principle* of GAAP.

Issues that are still to be considered by the accounting profession are on how to account for allowances and obligations if there is *no active market*,[21] and the accounting requirements of *brokers and other position-taking institutions* that are not subject to an emission limit or cap. The non-existence of a market price would be seen as not meeting the reliability and relevance test required in conventional accounting reporting.

The most concerning issue, however, stems from the failure of conventional GAAP to recognize and measure intangible assets that are *not acquired*. This failure presents a significant problem in accounting for carbon sources and sinks that are not acquired (such as the internal development of assets with the potential to generate future RECs). In this area, a shift in conventional thinking is required (see Ratnatunga et al. 2011).

Here, business entities will also need to consider issues such as *fair value* accounting[22] and *impairment* of assets. As fair value accounting and asset impairment tests are still the subject of much debate in the profession with regards to even conventional tangible asset valuations, an *inconvenient truth* is that business entities to date have very little guidance from accounting and assurance standard setters as to the treatment of carbon related intangible assets (and intangible liabilities), especially those that are internally generated (i.e. not acquired).

Finally, the unique tangible/intangible nature of carbon related assets makes their accounting treatment under conventional accounting frameworks fraught with difficulty, especially in organizations such as forestry companies that have carbon sequestration assets (sinks). These entities may find these 'assets' instantly becoming carbon emitting sources (liabilities) should their trees be destroyed in a forest fire. Whilst accepting that there are situations in business life that organizational assets contain elements of contingent liability, *such that in the instant the asset is wiped off the books a liability arises;* most of these contingent liabilities are litigious in nature. A plane (tangible asset) that crashes, or a dangerous side effects that is discovered in a drug patent (intangible asset) may not only wipe out the assets from the balance sheet, but also simultaneously give rise to a class action

[21] Pricing of allowances may be difficult to determine in the absence of a liquid market: The suggested approach of adopting mark-to-market accounting could have a significant impact on a company's profit and loss. The volatility in prices would need to be reflected in the income statement; as such profit and loss figures could be subject to disturbances with severe price spikes (that could easily happen in a thin market).

[22] This pertains to intangible assets with the potential to generate future carbon credits, and not the value of the credits themselves, i.e. in the case of tangible assets, the value of the machinery, not the value of the inventory produced by the machinery.

contingent liability.[23] However, carbon sinks such as trees are simultaneously carbon sources as well, as they shed leaves etc., whilst growing. Thus any metric to value the *carbon sequestration* capabilities of these assets must simultaneously capture their *carbon emission* capabilities. Ratnatunga et al. (2011) suggest that such a valuation model should not value *assets* (what an organization 'has') but instead value *capabilities* (what an organization 'can do').

4 Carbon Business Accounting

From the discussion earlier on carbonomics, carbalization and carbon emissions trading, it can be seen that business entities will need to consider new business practices in order to take advantage of (or at least not be disadvantaged by) the mandatory carbon rationing and trading schemes under the Kyoto protocol. The existence of a carbon rationing and trading market has the potential of affecting an organization's business strategy, financial performance and ultimately value, and thus accountants and other business information providers need to consider measurements and strategies outside of conventional paradigms.

This requires a good understanding of a number of elements of cost management and management accounting, and also of economics and business finance in an integrated manner, such as the economic modeling of demand and supply of carbon credits and allowances, forward and spot pricing, financial analysis, cost analysis and risk analysis, risk management of reputation, business support, cash flow and business value, capital allocation and the (possible) International Financial Reporting Standards (IFRS) directives for financial reporting of carbon emissions management and related transactions. In addition, taxation issues of direct carbon taxes, value-added (VAT) and goods and services (GST) taxes, and transfer pricing implications of carbon trading need also to be considered.

In this section of the chapter, it will be seen that some of the classic ideas of cost accounting may be central to the study of 'carbon costs'. The costing scheme proposed in the paper is shown to be a good fit with the traditional life-cycle analysis of overhead cost allocations, where the overhead in question is the costs of reducing global warming. It is demonstrated that if the overhead is allocated in a precise fashion over the life of a product or service, goods and services that seem to be low cost from a product costing viewpoint become high cost from a life-cycle viewpoint and perhaps should not be manufactured or provided. Once product costs are known, the wider issues of strategic business accounting (comprising management accounting and business finance) need to be considered.

[23] The IASB is, however, considering abolishing the term 'contingent liability'.

4.1 Carbon Strategic Cost Management

Traditional cost management relates to accounting for direct and indirect costs[24] and the assignment of such costs to cost objects such as products, services, customers and organizational processes. A cost can be attached 'directly' to a cost object if it is traceable solely to that cost object; and if not, it is allocated (see Sharma and Ratnatunga 1997 for a comprehensive discussion of costing systems). Recent discussions in the cost accounting literature have been mainly to do with the allocation of indirect costs; i.e. if using Traditional allocation systems with a single cost driver (such as direct labor) or using Activity Based Costing Systems (with multiple cost drivers) better describes the cause-effect relationships found in products, services, customers and organizational processes (Cooper and Kaplan 1988). In product costing, the 'cost' is computed up to the stage that goods are available for sale. Costs incurred subsequent to the product being sold are usually not calculated, except in the case where a product carries a warranty, or some other after-sales service component; then the expected cost (based on a probability estimate) of that service is incorporated into the cost (and therefore its price). Some costings may also include the cost of money blocked in accounts receivable, i.e. the credit period being treated as an 'after-sales service' that has a cost associated with it.

Carbon cost management is a subset of the push towards 'environmental cost accounting' (see Mathews 1997, Adams 2004) that highlights the cost impacts 'beyond' those related to a specific cost object such as a product. Let us take a product such as a computer printer as an example. Typical environmental costs (both prior and subsequent to the sale) are:

Raw Material: The environmental costs are simply the cost of the raw materials such as plastics, cartridges and steel in 'waste'. Much of such raw material is brought into 'usable form' for manufacturing using significant energy and thus has related CO_2 emissions.[25] Every time a raw material is used and does not become a product, it becomes waste. Even when such material become saleable products, when the product becomes obsolete it goes into landfills as waste.

Labor: Labor requires energy to function, such as traveling time to a production facility and air conditioning etc. at the facility, and thus there are significant CO_2 emissions associated with its use. Prior to the sale of the product, the typical labor environmental costs would be the labor component of an off-specification product that becomes waste. Post sale, the labor costs that are required for re-cycling of parts is an environmental related cost, which also generates CO_2 emissions.

[24] These cost categories are based on the nature of the expenditure items, such as the cost of raw materials, human input (labor) and overhead (rent, depreciation etc.)

[25] Such as the energy used in mining and processing the materials.

Overhead: Utility costs, such as water and energy, are also often overlooked in determining the true cost of waste generation, both before and after a sale. These costs are a significant item in CO_2 emissions management.

Waste Management: The most obvious environmental expenses are the treatment and disposal costs of waste generated in the production process. Again these require significant energy and thus have associated CO_2 emissions. Other waste management costs may include the expenses to collect samples, paper work, permit fees, consulting fees, and (potentially) fines for violations. The flip side of the hidden costs and impacts of waste generation is the hidden benefits resulting from actions taken to improve the environmental performance of a particular facility.

Recycling: This is a form of waste management at the obsolescence end of the product life cycle. This requires a three pronged approach: (1) the opportunity cost calculation (including the environmental impacts) of recycling components of existing hardware vis-à-vis using new components (2) locking in recycling cost efficiencies at the design stage of new hardware (3) using a cost-benefit analyses of the first two stages to influence Government policy on tax credits etc. for undertaking such environmentally sustainable programs. The U.S. Environmental Protection Agency (EPA) has an Environmental Accounting Project which encourages business to understand the full spectrum of their environmental costs and integrate these costs into decision-making.[26]

Note that in undertaking a life-cycle costing exercise using carbon allowance costs, the issue of transaction costing versus opportunity costing needs to be recognized. Some studies may take an opportunity cost approach and determine that the freely allocated allowances are worth the same as purchased allowances. Others may take a more transactional 'environmental compliance approach' and treat as a 'hard cost' only the cost of purchased allowances over the year.

As pointed out before in discussing CES accounting and assurance, there are many 'accreditation' approaches in the environmental arena all having different measurement metrics. These measurement approaches also have a direct impact on carbon cost calculations. Whilst no study or approach can be considered definitive, there is clearly a need for accurate carbon cost accounting using life-cycle costing techniques, that should not only consider costs to bring to the point of sale a product or service, but also consider the carbon costs prior and subsequent to the manufacture of the product or the performance of the service. Such costs are elaborated in Table 1.

[26] See http://www.epa.gov/oppt/library/pubs/archive/acct-archive/index.htm

Table 1 The whole-of-life impact of carbon emission efficiencies on costs and revenues

Areas of *cost reduction* or *revenue generation* via efficient carbon cost management:	Pre – sale environmental impact	Post – sale environmental impact[a]
Raw materials	Production waste	Landfill waste
Human input	Wasted time on rejects and recovery	Time to separate recyclable components
Traditional overhead expenses		
Electricity	All of these overhead items have carbon emissions that will affect if the organization is a *net- sequester* or *net-emitter*. Techniques utilized to reduce CO_2 emissions via using alternative energy sources etc., will impact on the carbon credit cost item shown under the Environmental overhead category	
Rental		
Marketing		
Transportation		
Administration		
Depreciation of machinery		
After sales service costs		
Environmental overhead		
Regulatory costs	Meeting emissions standards	Litigation costs of environmental pollution
Waste management	Production waste	Landfill waste
Recycling	These costs can be reduced via the proper design of components at pre-production stage. Such design costs should be amortized over life of product, via Life-Cycle costing	
Amortisation of design costs		
Carbon credits	This can be a cost or revenue item depending on if the organization is a *net-sequester* or *net-emitter*	Purchase/sale of carbon credits depending on if the organization is a *net-sequester* or *net-emitter*
Financing costs		
Stock holding costs	These costs include cost of capital, excess handling, obsolescence, deterioration, stock administration and insurance	These costs include cost relating to warranty returns such as excess handling, deterioration, stock administration and insurance
Debtors costs	None	These costs include cost of capital and the risk of bad debts
Carbon tax	This tax could be an additional cost or revenue item (Tax Credit) depending on if the organization is a *net- sequester* or *net-emitter*	

[a]These post environmental costs can be incorporated into product costs using probability estimates

4.2 Carbon Strategic Management Accounting

The decisions requiring carbon emissions management cuts across a wide spectrum of strategic issues, from overall objectives, to marketing, new product development, pricing, international business, promotion, supply chain management, finance and risk management. Clearly an integrative approach, such as that suggested by Kaplan and Norton (2000) is required, with 'carbon thinking' being important

part of the strategy-focus of the organization. This carbon-focused thinking will require new tools and management practices if the accounting profession is to remain at the forefront of providing relevant information for decision making in this new economic paradigm of carbonomics. Ratnatunga and Balachandran (2009) reported the results of a comprehensive survey that captured the totality of the decision related issues emerging in the carbon space, which is presented in Table 2.

5 Summary

The concentrations of greenhouse gases in the atmosphere have risen dramatically leading to an out-of-balance greenhouse effect that most scientists believe will continue to cause a very rapid warming of the world's climate. The possibility of costly disruption from rapid climate change either globally or locally, calls for greater attention and precautionary measures to be put in place. Governments, business entities and consumers would be impacted by the extent to which such precautionary measures are incorporated in their decision making process.

Despite Schumacher (1997) urging that such precautionary measures should be undertaken for their intrinsic value, governments are taking a rational economic view in considering 'carbon regulation' approaches. These regulatory approached range from taxes and penalties to the issuing of licenses and permits to a full Emissions Trading Scheme. All measures require the calculation of a carbon credit, which represents one metric ton of CO_2 either removed from the atmosphere or saved from being emitted. Carbon credits are seen as the 'invisible-hand' of reducing global warming by forcing business entities to consider issues such as trading in carbon allowances (or permits); investment in low- CO_2 emission technologies; counting the costs of carbon regularity compliance and passing on the increased cost of carbon regulation to consumers through higher prices.

It has been shown that the economic decisions of organizations operating within a carbon trading scheme, and the consequences of the resultant behavioral responses will impact the accounting profession significantly. Unfortunately, in terms of financial reporting, the current financial accounting framework appears to be ill-equipped to provide the information required by business entities to meet the challenge of climate change. This is mainly because accounting information systems based on the accounting equation are not designed to cope with the valuations of intangible assets (and liabilities) such as CO_2 sources and sinks. As such, despite emissions trading being prevalent in most developed countries (within and outside the Kyoto protocol), the accounting standard setters have yet to come up with agreed methodologies relating to revenue, expense, asset and liability values required to account for such activity. Whilst there is some discourse in the profession as to how best to report on the income statement (*profit and loss*) effects of CO_2 trading, there has been no discourse as to how to value the underlying assets that produce or use carbon allowances on the *balance sheet*.

Table 2 Issues in carbon strategic management accounting

SMA issue	Carbon management impact
Business policy	
Primary objective	Sustainable value creation
Competitive advantage	Carbon efficiency seen as a marketing mix variable in product differentiation. An Efficient Carbon Management (ECM) focus also taken in cost leadership strategies
Line-of-business	ECM seen as a potential line-of-business
Competition and industry structures	Adding a sixth force to Porter's Five Forces Model – the impact on the Industry of Carbon regulation (Porter 1980, 1983)
Gap analysis	Strategies considered to close gap between current emission levels and future emission targets
Environmental externalities	Considered 'internalities' in product-market decision making and HRM
Risk management	Consideration of the impact on cash flows and reputation of the company as a result of the carbon strategy positioning of the company. Risk vs. Reward outcomes (e.g. cash flow at risk) should be considered
Human resource management	
Corporate culture	A carbon lifestyle culture from grass roots level upwards. Low carbon footprint activities encouraged. Excellence sought in seeking continuous improvement in ECM
Empowerment	Employees given resources and responsibility to participate in ECM in lowering the organization's carbon footprint
Marketing strategy	
Products and markets	Carbon impact considerations considered systematically in all product-market strategies
Marketing research	Undertaken to determine the needs of customers in terms of participating in reducing carbon emissions and the incremental price they are willing to pay for this (carbon consciousness)
Market segmentation	Separating customers geographically, demographically and psychographically in terms of their carbon consciousness
Positioning strategy	Consideration of taking an 'active' or 'passive' positioning in terms of ECM as a source of competitive advantage
The product life cycle (P.L.C.)	Consideration of the carbon footprint left by product throughout its life cycle, especially in the decline and obsolescence stages
Market penetration strategies	Using carbon efficiency of existing products as an attribute to sell more to existing carbon conscious customers
Market development strategies	Using carbon efficiency of existing products as an attribute to sell new carbon conscious customers in new segments
Product development strategies	Incorporating carbon efficiency as an attribute in new product designs to keep existing carbon conscious customers loyal to the brand
Diversification strategies	Leaving industries having products and markets seen as high carbon emitting to new industries better long-term carbon sustainable prospects (includes investments in JIs, and CDMs under Kyoto)

(continued)

Table 2 (continued)

SMA issue	Carbon management impact
Experience curves	Organizations with high experience in ECM products and services should have lower costs.
Budgeting for marketing activities	Budgets will incorporate ECM activities as potential revenues and cost savings. Carbon trading activities could be considered a separate line of business
Product marketing strategies	
The product portfolio (BCG) matrix	Star products will have high market share and high market growth opportunities in industries with better long-term carbon sustainable prospects
New product development (NPD)	Designing products and services to meet carbon emission targets and marketing them as such
Product abandonment approaches	Product Review Teams to consider carbon footprint in addition to profitability targets
Inflation	The passing on of mandatory carbon costs and taxes as higher prices to consumers will cause inflation
Packaging	Consideration given to carbon footprint of packaging, in terms of functionalism, convenience, recyclability and also image
After-sales service	The carbon emission in terms of materials, labor and overhead of undertaking work due to meeting warranties and other after sales services should be costed into the product
Pricing strategy	
Pricing analysis	Carbon costs, carbon related competitor activity and the value of low-carbon footprint products to carbon conscious customers should be considered in such analyses
Elasticity of demand	The impact on demand due to changes in prices if carbon costs are incorporated.
Skimming	Selling to high carbon conscious customers willing to pay a price well above costs
Penetration	Absorbing carbon costs of products and services sold to low carbon conscious customers to develop brand awareness. Productivity improvements can only be obtained either by lowering costs via ECM or changing customer carbon consciousness levels
International business strategy	
Exporting vs. international operations	Carbon costs can be reduced via Joint Implementation (JI) and Clean Development Mechanism (CDM) investments as per the Kyoto protocol
Price differentials and carbon dumping	Competing with countries that do not have carbon costs. Influencing government policy to impose countervailing carbon taxes
Hedging policies	Ensuring that carbon credits in the overseas country is not devalued in terms of the parent country carbon credit pricing
Promotional strategy	
Promotional "Pull" strategy (via advertising etc.)	An Integrated Marketing Communication (IMC) approach should be taken to promote how the product or service is reducing carbon footprint, e.g. via purchasing carbon offsets

(continued)

Table 2 (continued)

SMA issue	Carbon management impact
Promotional "Push" strategy (via sales force)	Sales Force budgets, targets and incentive schemes geared towards extolling the attributes and pushing low carbon impact products. Traveling times on sales calls minimized to reduce carbon emissions. Bio-fuel cars used as sales vehicles
Sales response functions	Response of sales volume to carbon related promotions tracked
Media selection strategies	Electronic media given higher priority to print media in order to reduce paper usage
Supply chain strategies	
Product-distance	Carbon emission measurements in terms of Product-Distance. The longer the distance and the more players in the channels of distribution the higher is the carbon costs
The level of service	The Service – Cost Trade-off required ensuring that the right product gets to the right place at the right time, should consider the carbon emissions required to provide this level of service
Distribution cost accounting	Computation of carbon related costs in order processing, warehousing, transportation, credit control, and inventory control
Transportation and simplex models.	The use of these models to reduce transportation time and resulting reduction in carbon emissions
Channel control	Consideration of the motivation, relationships and conflict issues that arise when channels are asked to on-sell products and services using ECM approaches themselves
Channel adaptability	Consideration of the adaptability of channels to changes in product-market combinations as a result of reducing carbon footprint
Distribution cost control	Using ratio analysis to ensure that, in addition to economic analysis, ECM in supply chain activities are also evaluated
Performance evaluation	
Strategic financial structures (Gearing)	Consideration if carbon related investments should be financed via debt or equity. Ability to obtain shareholder and debt holder funding at favorable rates due to the use of such financing in ECM activities
Weighted average cost of capital (WACC)	If financing of carbon related investments can be isolated, then calculating an organization's carbon related Cost of Equity and Debt to calculate its overall Carbon-WACC. The equity and debt market may value discount carbon intensive businesses (causing high financing costs) and place a value-premium on low carbon emitting businesses (causing low financing costs)
Corporate performance perspectives	ROI and residual income (EVA) used to evaluate not only economic performance but ECM performance. If carbon related revenues and costs can be isolated as a separate line of business, this will enhance the evaluation
Strategic value analysis	Calculation of value enhancement (or diminution) due to strategies relating to carbon related investments and operations

(continued)

Table 2 (continued)

SMA issue	Carbon management impact
Valuing strategic investments	Valuation premium given to investments in ECM, such as investments in alternative energy assets and abatement activities. Examples are wind, biomass, solar, geothermal, nuclear and clean coal
Valuing strategic operations	These include operational adjustments to incumbent assets, changes to energy prices, efficiencies in waste management, purchasing and sale of carbon credits and carbon related taxation
Free cash flows	Net cash flows generated by carbon related activities less investments in carbon related non-current and current assets
The business value	The net present value of expected future cash flows generated by strategic investments and operations in carbon related business
The balanced scorecard	Corporate report card to incorporate financial and non-financial KPIs with carbon focus. This could in addition to, or incorporated with the customer, innovation, internal business processes and financial focus
Economic value added (EVA)	A charge against revenue is made for the cost of investments in carbon efficient assets. A separate Carbon-EVA can be calculated if carbon related net-income, investments and cost of capital can be isolated

Source: Ratnatunga and Balachandran (2009)

Therefore, it has been left to organizations outside the accounting profession to develop carbon sequestration and emissions (CES) accounting measurements and reporting frameworks. These have proliferated, with only few providing detailed approaches and metrics, and all being incompatible with each other. This lack of consistency has then resulted in almost no development in assurance standards, from within or outside the accounting profession.

The cost and management accounting profession must also re-engineer itself to be a 'winner' in this new economic paradigm. Business entities especially need to consider issues such as trading in carbon allowances (or permits), investment in low- CO_2 emission technologies, counting the costs of carbon regularity compliance, and passing on the increased cost of carbon regulation to consumers through higher prices. Consumers need to consider if, given a choice, they are willing to pay a higher price for CO_2 neutral products and services so as to play their part in reducing CO_2 emissions.

These decisions and their consequences will impact the accounting profession significantly, especially the business accounting areas of strategic cost management and strategic management accounting. Information from the strategic cost and management accounting systems will be particularly useful in this new economy, termed carbonomics, that climate change and sustainability has forced upon us. New costing techniques need to be considered to evaluate the 'whole-of-life' costs in terms of carbon emissions relating to products and services. Similarly, new thinking will be required to provide strategic management accounting information

for business policy, HRM, marketing, new product development (NPD), promotional, pricing, international business, supply chain management strategies and the resultant evaluation of performance evaluation.

The inconvenient truth is that the accounting profession is hampered by a conceptual framework that is ill equipped to meet the challenge of climate change which requires a move from orthodox economic thinking to (ultimately) Schumacherian ideals. This particularly so in financial accounting, but also pertains to current approaches to cost and management accounting that focus on current costs and short-term decision making. As a result, it is most likely that the paradigm shift required to capture the totality of the financial implications of the sustainability agenda will be from outside the accounting profession.

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Sustainability and Business at a Crossroads: The Idea of Positive Investments in Creating Shared Value

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1 Introduction

In this chapter, I discuss two distinct and innovative economic theories that re-define what sustainability and, more specifically, what business sustainability is and should be. I elaborate on the normative dimensions of the concept of sustainability as developed by Professors Joseph E. Stiglitz, Amartya Sen and Jean-Paul Fitoussi, on the one hand, and examine the principle of Creating Shared

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Value as offered by Professor Michael E. Porter and Mark Kramer, on the other (Stiglitz et al. 2009; Porter and Kramer 2011).

At a time of increased calls in society for the need to reconsider the foundations of the existing market system in search of new and more sustainable forms of capitalism, these two theories of sustainability carry a powerful transformative potential. They innately integrate society's economic and social prosperity with the notion of long-term "*positive investments*" made today to ensure economic, social and environmental durability tomorrow. Moreover, they offer roadmaps for two distinct and innovative post-redistributive ways of thinking and assessing sustainability for its economic, societal and environmental value.

I first elaborate on Stiglitz et al.'s normative argument for sustainability that considers it an intergenerational, forward-looking activity that ensures transferability of sustainable assets or "stocks" – economic, social and environmental – from us to future generations. At a macroeconomic level, this approach looks at sustainability as a set of positive investments and wealth creation today, both in qualitative and quantitative terms that could define the well-being of future generations.

I then focus on Porter and Kramer's principle of Creating Shared Value that also builds on the notion of sustainability as a new way of achieving economic growth and societal value. I show how Porter and Kramer reconnect economic value with social progress, while challenging the business status quo and requiring major transformation in the way companies model and implement their business strategies and value chains.

Thus, at a microeconomic level, their idea of Creating Shared Value serves as a source of a company's competitive advantage, and it clearly announces a novel agenda for organizing business, creating strategy, and thinking of social progress and economic prosperity. Broadly speaking, the principle of Creating Shared Value is focused on finding new sustainable forms of economic and social value through local business environments called clusters.

In my view, these two distinct economic theories are complementary in their efforts to redefine the concept of sustainability, addressing respectively its macroeconomic and microeconomic dimensions. Critical of the excesses of globalization, both theories allude to an innovative and what I call a post-redistribution approach that emphasizes the role of localized or contextual forms of long-term investing strategies to drive economic and social growth. This approach leads also to a call for collective action in open and transparent markets for all stakeholders – businesses, suppliers, governments, NGOs, citizens and communities. It democratizes business by opening the channels of participation in economic society and social decision-making to diverse members of a global society, including those who have been traditionally underserved, unprivileged and under-represented. Finally, it encourages localized and contextualized forms of long-term investment public-private partnerships that can help alleviate poverty, reduce inequality and prevent ecological degradation, thus ensuring sustainability to future generations.

2 Redefining Sustainability: Positive Investments *now* to Ensure Durability in the Future

Before turning to a more detailed analysis of Porter and Kramer's understanding of Creating Shared Value and how it affects the business model of a corporation, I want to focus on the broader intellectual context underpinned by another recent influential academic and public policy work on sustainability. In what follows, I will discuss Stiglitz et al.'s approach to sustainability as a transfer of "all stocks of resources" from the present to the future. This approach presents a paradigmatic shift in the way we think today of sustainability and sustainable development in general. Moreover, it makes a valuable economic and normative contribution to the sustainability discourse at a macroeconomic level. It argues for creating a new intergenerational, forward-looking shared value understood as economic, environmental and social assets and resources, a set of "positive investments" made today that would allow us to define and maintain the durability of people's future economic, social and ecological well-being.

2.1 Sustainability as Taking Stock in the Future

In their report commissioned on behalf of French President Nicholas Sarkozy on the measurement of economic performance and social progress, Stiglitz et al. undertake an important step forward in reformulating the question of sustainability. The authors build on the Brundtland Commission's earlier definition of sustainable development as an intergenerational, forward-looking exchange that is framed by the capacity to meet "the needs of the present without compromising the ability of future generations to meet their own needs" (UN Resolution 1987). Yet Stiglitz et al. focus their analysis on what they consider to be a key, and in their own words, often overlooked aspect of the Brundtland's concept of sustainability, namely the idea of sustainability as distribution of resources within as well as between generations.

According to their thesis, sustainability should be seen as a capacity of present generations to pass to future generations the "stocks" of all accumulated resources. The authors use the terms "stocks" interchangeably with "wealth" or "capital" resources. For them, sustainability should be separated from simply measuring the well-being of present generations; it should be perceived as a process of assessing and predicting the future. It is a process of transferring to the future sufficient amounts of all available assets and resources that will matter to people's well-being and quality of life. By stressing the idea of *resource* accumulation today and its transfer from the present to the future, Stiglitz et al. enrich the existing understanding of sustainability. Their approach is comprehensive; the list of stocks of resources encompasses all natural, physical, human and social capital.

This list of stocks is not only all-inclusive; it is open-ended to future input. For example, in addition to the transfer of the "stock of exhaustible resources," sustainability accounts for assets that are defined by the way we "maintain the quantity and quality of all the other renewable natural resources that are necessary

for life" (Stiglitz et al. 2009). This approach raises the questions of "how much physical capital – machines and buildings – we pass on, and how much we devote to the constitution of the human capital of future generations, essentially through expenditure on education and research" (Stiglitz et al. 2009).

Finally, it reflects the quality of societal institutions that current generations build today to ensure the good quality of life tomorrow. Such understanding of sustainability envisions all these *stocks of resources* as in process, highlighting both their evolution and unpredictability in future periods. At the same time, it aims to ensure a qualitatively positive transformation to the future, one that is built on the conditions of economic, social and ecological well-being.

For Stiglitz et al. sustainability is a question of preserving or increasing all of these "capitals" or "stocks" today, so that we can ensure their future durability. The authors stress the need for an increase in both the quantities and qualities of natural resources, of human, social and physical capital. These are *all* existing stocks of quantitative and qualitative resources, the authors write, "that underpin human well-being" (Stiglitz et al. 2009). Assessments of sustainability, the authors write, "must be made on complete inventories of these stocks, and a good assessment of how they are currently changing, and of what are their expected paths of evolution" (Stiglitz et al. 2009).

This intergenerational, forward-looking approach to sustainability is confronted by what the authors refer to as challenges or "main stumbling blocks" based on the inability today to predict and identify the dimensions of sustainability tomorrow. For instance, it is almost impossible to evaluate sustainability economically in money units because, as the authors assert, today "market prices are nonexistent for quite a large number of the assets that matter for future well-being" (Stiglitz et al. 2009). Even when they are available, the authors continue, there is no guarantee that they will adequately reflect how these different assets will matter for future well-being due to "market imperfections, myopia and uncertainty" (Stiglitz et al. 2009).

At the same time, it is impossible to firmly know the themes of sustainability tomorrow. Predicting future interactions between the economy and the environment is difficult, and uncertainty dominates normative discourse. For example, the authors stress, it could be argued that our descendants may become highly sensitive to the relative scarcity of some environmental goods to which we pay little attention today because they are still relatively abundant, and this requires we immediately place a high value on these items just because we think that our descendants may wish to do so (Stiglitz et al. 2009). These two challenges – monetary risk and normative uncertainty about issues of sustainability – invite us to think of a new approach to defining and evaluating sustainability, both in quantitative and qualitative terms.

2.2 The Idea of Positive Investments

With their work on assessing sustainability, Stiglitz et al. make an important argument for *positive* investments as a plausible way to think of and evaluate sustainability in an intergenerational, forward-looking manner, as opposed to negative investments or the so-called "non-sustainability" (Stiglitz et al. 2010).

This series of positive investments sums up the idea of transferring "wealth," "stocks" or "capital" in the future in both quantitative and qualitative ways, ensuring economic and socio-environmental prosperity. The well-being of future generations compared to ours, the authors argue, will depend on what resources we pass on to them and on whether we leave enough of these resources (Stiglitz et al. 2009). The sustainable future thus depends on both the good quality of resources we pass on to future generations and the quantitative sufficiency of those resources.

The approach of positive investments captures the *upward* change of rate with which all of these global resources – natural, physical, human and social stocks – are evolving. At a global, macroeconomic level, positive investments would ensure that countries do not "over-consume their economic wealth" and that they support a sufficient rate of accumulation or renewal of "produced capital, be it human or physical" (Stiglitz et al. 2009). In this sense, sustainability in forms of positive investments is contrasted by instances of non-sustainability such as low savings, low investment in education, and insufficient reinvestment of income generated by extraction of fossil fuels for countries that strongly rely on this source of income (Stiglitz et al. 2009).

The idea of positive investments requires more than balancing off or, in other words, correcting the negative societal and ecological impacts caused by depletion of natural resources or environmental catastrophes. For example, after an ecological disaster, when governments and businesses try to help restore the level of the initial environmental stock, they may invest in new eco-friendly technologies to rebuild the natural habitat to its pre-crisis level, and thus increase economic activity and prosperity.

Yet the idea of positive investments goes beyond these corrective efforts. Sustainability is more than overcoming the deficits of overconsumption of or underinvestment in resources today. If sustainability is thought of as a series of positive investments in terms of an increase in economic activity and financial prosperity, it should also be perceived as a means of improving and enhancing the quality of life in social and environmental terms. Through investments in technological innovations and changes, current generations could restore environmental degradation and create opportunities for preventing future pollution by investing in eco-friendly business solutions and lifestyles. Similarly, through a series of positive investments, current generations not only can help alleviate poverty and overcome economic inequality today; they can bring forth social and economic prosperity to the future.[1]

[1] The idea of sustainability as positive investments is implied in other literature on sustainable forms of capitalism. For example, some authors consider positive investments as the ability of the market system to "engage and deliver positive results for an ever-growing number of the world's citizens." This notion refers to the ability to better manage capitalism's damaging environmental and other impacts, while amplifying and disseminating the benefits of capitalism more widely (Bower et al. 2011). According to others, positive investments should serve as a means to stop diminishing economic prosperity that is thought to be a result of an oversupply of destructive products like "bad" loans (i.e. over creation of "bads") and undersupply of "good" products (i.e. under creation of "goods") – products that have authentic benefits like health foods. Sustainable capitalism requires reversing this imbalance by increasing investments in global public "goods" and mitigating the risk of global public "bads" (Haque 2011).

2.3 *"Accounting" for Sustainability*

Stiglitz et al. propose an innovative theoretical framework to assess for sustainability by tracking the rate of change in resource investments in an intergenerational way. What they offer is a means of assessing the path on which sustainability assets will flow and evolve over time through accounting instruments. For example, they propose large-scale projection models that show how future changes in all stocks or capital – natural, physical, human and social capital – will affect well-being, and how increases in these stocks today are likely to improve or help maintain future well-being (Stiglitz et al. 2010). A sustainable future is seen prospectively as "an opportunity set that is at least as large as what is currently available to living generations" (Stiglitz et al. 2010).

In addition, the authors call for "a priori definition of how this path translates in terms of well-being at all future dates," that is, a discounted sum of well-being over future periods (Stiglitz et al. 2010). This approach of "discounting" future well-being or future "opportunity set" – of economic, environmental and social stocks – is innovative and different from other macroeconomic redistribution approaches, especially those that measure sustainable development as a transfer of wealth and resources from developed to developing countries to combat economic inequality or environmental degradation.

Instead, by discounting future projections of well-being or future "opportunity sets," the authors argue, we may be able to *anticipate* future declines or increases in well-being below or above current levels. We can capture in advance countries that are on unsustainable paths because of insufficient rate of accumulation or of renewal of their produced capital – human or physical.

For example, a non-sustainable future in a case of forecasted environmental degradation of a natural resource will be reflected in increases in the relative accounting or "imputed" prices of those environmental stocks today – a strong forewarning of future non-sustainability (Stiglitz et al. 2010). One can argue that this approach will also equip us with knowledge of emerging areas of resource overconsumption or underinvestment, therefore increasing our capabilities for action through positive investments.

Finally, the idea of accounting for sustainability can be viewed as a powerful metaphor for *our* responsibility – we of present generations – to envision and think about the future in a responsible and accountable way. It puts the emphasis on our current efforts to project and envision future well-being, to track the rate of change needed to achieving that well-being, and to ensure that we make positive investments.

3 Porter and Kramer's *Post-redistribution* Approach to Creating Shared Value

We saw with Stiglitz et al. that making positive investments aims to ensure sustainability and value creation transferrable to the future. Sustainability is seen as an intergenerational, forward-looking project that captures the accumulation and

transfer of wealth from today to tomorrow. The project is a global, macroeconomic agenda of rethinking sustainability in conditions of economic risk as well as social and environmental unpredictability.

Porter and Kramer's model, on the other hand, focuses on the question of how to perceive of such sustainability at a microeconomic firm level. In what follows, I discuss their concept of Creating Shared Value as an instance of positive investments in the specific contextualized business localities known as clusters. Like the model of Stiglitz et al., the principle of Creating Shared Value argues for positive investments that can lead to economic and social growth – a joint value creating agenda that can improve the quality of people's lives, alleviate poverty and bring forth ecological justice in local communities. Moreover, such positive investments enhance a company's competitive advantage.

3.1 The Integration Argument

Porter and Kramer cast the idea of Creating Shared Value as a critique of the corporate social responsibility (CSR) approach in management and corporate mindset that thinks of societal issues as peripheral to the concerns of business. Corporate social responsibility, they argue, presents too narrow a vision of a company's social responsibility – the fact that businesses "have overlooked opportunities to meet fundamental societal needs and misunderstood how societal harms and weaknesses affect value chains" (Porter and Kramer 2011). Considered as an "externality" that aims merely at "doing good" by focusing solely on citizenship, philanthropy, or corporate sustainability, the CSR approach is also held to be separate from profit maximization, with an agenda determined by "external reporting" and its impact limited by corporate footprint and CSR budget.

In contrast, Porter and Kramer argue that the approach of Creating Shared Value should be considered as broader than corporate sustainability and as integral to firms' competitive advantage and profit maximization because of the way businesses create economic and societal benefits relative to cost. At its core, this approach is about *sustainability as value creation* for both the company and the society in which it operates.

To be sure, Porter and Kramer's integration argument is not an isolated effort. There have been other recent attempts to integrate a sustainability mindset with business strategy. For example, the "*responsible business*" perspective has been critical of corporate responsibility programs described as "often slower and less effective than transformations grown from the businesses outward," and its supporters find such programs to be generic and separated from running the business (Sanford 2011). Their argument is that "working from the level of a business to achieve responsibility overcomes this fragmentation by generating customized responses to actual challenges" (Sanford 2011). Similarly, the proponents of the "*sustainable business*" perspective also argue for the integration of environmental, social and ethical issues into a company's business model and

strategy, claiming that such integration can serve as an indicator of management quality and of a well-run corporation (Cramer and Karabell 2010).

In this regard, sustainable business means whether a company "delivers value for investors, customers, and employees, improves the living standards of its employees and the communities it touches; makes wise use of natural resources; and treats people fairly" (Cramer and Karabell 2010). Finally, the "*value creation*" perspective further insists on the need to integrate "sustainability into strategic-planning" as a means to "identify new growth opportunities while reducing [companies'] exposure to legal, resource, and socio-political risk" (Lowitt 2011). The proponents of this approach defend the integration of sustainability and business strategy as a means toward greater efficacy and long-term business viability.

What is distinct and innovative about Porter and Kramer's principle of Creating Shared Value, however, is their proposition about radically transforming business strategies and practices by moving toward localized forms of value chain – the way companies interact with local suppliers, customers and communities. The principle of Creating Shared Value calls for a broader redefinition of value creation as business policies and operating practices. It enhances the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates. The concept refers to the need for new management strategies that a company could employ in addressing environmental, social and governance issues that traditionally have been considered business externalities or non-financial. This is an integration of business strategy with social needs awareness in recognition that today "societal needs, not just conventional economic needs, define markets" (Porter and Kramer 2011).

3.2 Transforming Business Via Local Clusters

While Stiglitz et al. discuss sustainability as an inter-generational project with *temporal* dimensions that connect the investments in the present with the future of next generations, Porter and Kramer's approach integrates sustainability and business at a microeconomic level looking for *local* or community business solutions in the social and economic context of a company's operations and business activities. In so doing, the authors call for a "new locational thinking" about business strategy and management. This new type of thinking has significant impact on transforming business internally – at the level of strategy – but also externally by critically rethinking the conventional forms of vertical integration of value chain and its effects on economic and social value creation.

In defining the principle of Creating Shared Value, Porter and Kramer outline the role of products and innovation in achieving economic and social growth, placing an emphasis on the role of local clusters as the natural foundation of such growth. This is a paradigmatically novel way of integrating sustainability and business strategy within the prisms of a company's local economic, environmental and

social activities. In his earlier elaboration on clusters, Porter defines them as "a kind of new spacial organizational form in between arm's-length markets on the one hand and hierarchies, or vertical integration, on the other" (Porter 1998). Porter contrasts them to the conventional and more rigid, in his view, forms of vertical integration of value chain.

Once considered a source of competitive advantage, vertical integration refers to value chain activities of a company that connect all functions of design, production, selling, delivery and support of products, including both upstream (suppliers) and downstream (consumers) aspects of the business (Magretta 2011). Porter characterizes clusters as an alternative and more "robust" way of organizing the value chain that is more efficient, effective and flexible in comparison to vertical integration.

Clusters encompass, for example, suppliers of specialized inputs and providers of specialized infrastructure, local customers, and governmental and other institutions such as universities, standards-setting agencies, think tanks, vocational training providers and trade associations (Porter 1998). They are organizational business forms that offer opportunities for sophisticated competition between firms and for engaging all stakeholders.

This approach highlights a new locational way of thinking about Creating Shared Value that represents an innovative transformation of business strategy. It is a new way of doing business that interacts more dynamically and in an integrated fashion with local suppliers, customers and communities of operations. This perspective requires building strong local capabilities for economic profitability along with producing positive social and ecological impact. Moreover, clusters, in Porter and Kramer's view, will give a company a major competitive advantage. They provide a better quality of local business environment, higher quality transportation infrastructure, more availability of well-educated employees, and a more efficient and fair legal system to resolve disputes between companies at a local level (Porter 1998).

3.3 Post-redistribution Approach

At a time when the challenges and needs facing society are ever increasing, customers, employees and communities are asking business to step up and do more (Porter and Kramer 2011). The societal urgency produced by the pressures of growing economic inequality and environmental degradation gives rise to new questions about the purpose and role of the corporation in society. The concept of Creating Shared Value can be seen as a new type of corporate behavior involving a series of business investments with positive economic and social impact. Indeed, as Porter and Kramer stress in their work, the principle of Creating Shared Value is not just about economic profit, or about personal values. Nor is it about "sharing" values in the form of revenues already created by firms, the so-called "redistribution" approach (Porter and Kramer 2011). Instead, Creating Shared Value

represents what one can call a new *post-redistribution* approach to achieving positive economic and social impact. Let me explain.

As Porter reiterates in his work, the idea of a strategy implies uniqueness – in this case, the development of products and services that make a company distinct. A successful strategy also entails a longer time horizon because "building out a unique position in the market takes a series of investments over time" (Magretta 2011). By implementing the principle of Creating Shared Value, business can expand the overall amount of value creation. Companies do that through "shared value investments" in the local clusters that include, for example, new procurement practices and supporting clusters of suppliers, among others. This form of shared value investments increases the competitiveness of a company and the health of the community around it. According to the authors, providing jobs and wealth creation for communities and their citizens is a form of "appropriate investments" that can have a "profound effect . . . on productivity and innovation" (Porter and Kramer 2011). In the end, the return will be greater economic value and broader strategic benefits for all participants (Porter and Kramer 2011).

Seen in this way, the principle of Creating Shared Value encourages businesses to engage in *long-term* investments in communities of operations that expand "the total pool of economic and social value" (Porter and Kramer 2011). For example, Porter and Kramer point to the implementation of Creating Shared Value principle in building new procurement business practices with local suppliers. "By increasing access to inputs, sharing technology, and providing financing, companies can improve supplier quality and productivity while ensuring access to growing income" (Porter and Kramer 2011). This form of business investment moves beyond an orthodox understanding of corporate contribution to society based on either corporate philanthropy or revenue redistribution.

Instead, it encourages forms of investments in the clusters of a company's operations to stimulate productivity and innovation. This new business strategy requires *investing* in building local supplier capabilities both in the developed and developing world and working intensively with suppliers by providing them with advice on production practices, guaranteeing their bank loans, and helping secure essential inputs for their plants. A shared value perspective might focus, for example, on investments that improve supplier-farmers' growing techniques or strengthen the local cluster of supporting suppliers and other institutions in order to increase efficiency, yields, product quality, and sustainability, in general (Porter and Kramer 2011).

We see that the normative virtue of the principle of Creating Shared Value lies in the linking of economic and social progress with a changing business strategy and value chain toward more localized business and social solutions. Porter and Kramer see in this principle a powerful transformative potential that through a series of initial long-term positive investments can achieve economic and societal prosperity. As capitalism begins to take hold in poorer communities, Porter and Kramer assert, "new opportunities for economic development and social progress increase exponentially" (Porter and Kramer 2011).

The Creating Shared Value approach not only drives competitive advantage; it can help solve important economic, societal and ecological issues such as alleviating unemployment and poverty, improving education and providing access to participation in the formation of new local businesses. Through their innovative eco-friendly products and services and innovative environmental management programs, companies can address environmental degradation and pollution at local levels, helping to facilitate the transition to an environmentally sustainable economy.

3.4 Clusters Versus Globalization?

Porter and Kramer's idea of clusters and their argument for investing in new local business forms can be seen as a critique of excessive forms of globalization. Outsourcing to other locations and countries, the authors insist, creates transaction costs and inefficiencies that offset lower wage and input costs (Porter and Kramer 2011). Moreover, global business strategies that rely on outsourcing and cheap labor markets create impediments to productivity and innovation, and the creation of shared value. For decades, competition has been driven by input costs wherein multinationals will choose those locations that have some important endowment (e.g. natural harbor or a supply of cheap labor), thus enjoying a comparative advantage. Today, however, Porter remarks, "competitive advantage rests on making more productive use of inputs, which requires continual innovation ... [and] clusters reveal that the immediate business environment *outside* [of] companies plays a vital role as well" (Porter 1998).

As a new locational trend of thinking about sustainability and business, the principle of Creating Shared Value is not *anti*-globalization per se. What it calls for is a *contextualization* of business strategy with positive economic and social impacts in a company's global operations. It is a globally applicable principle that encourages economic and social growth in the localities and regional operations of a multinational company in both developed and developing countries. Multinational companies are encouraged to transform their business strategies and practices by creating local clusters of prosperity in the various locations of their operations by investing and building capabilities for working with local customers and suppliers in various business and geographic contexts.

Through positive investments in localized business formations, multinational companies have the potential to contribute to the economic and social growth and prosperity in their global operations. They can improve the quality of people's lives and protect the natural environment in different communities, thereby enhancing the uniqueness of their strategy and competitive advantage. They also can explore innovative strategies for engaging with business partners, suppliers and customers while involving other societal stakeholders in the process of pursuing economic and social shared value.

4 Participation in Open and Transparent Markets

The concept of Creating Shared Value can be broadened to serve as a foundation for *democratizing* business by mobilizing and including in the collective action all stakeholders – businesses, suppliers, customers, governments, NGOs, investors and citizens in communities of operations. This collective action requires novel forms of business cooperation based on coordination and trust that foster new forms of local engagements. It also demands opening the channels and access to participation in economic and social interactions to all members of the community and society to create economic and social value. The principle of Creating Shared Value thus helps redefine the *rules* of the process of engagement and participation in economic and social activities as well as in decision-making.

As Porter insists, "the enduring competitive advantage in a global economy lies increasingly in local things – knowledge, relationships, motivation" (Porter 1998). Clusters provide better access to resources and information, and the "mere co-location of companies, suppliers, and institutions creates the *potential* for economic value" (Porter 1998). More importantly, clusters have the potential to form "open and transparent markets" that provide conditions for both economic and social growth in that they secure reliable suppliers and give them incentives for quality and efficiency while also substantially improving the incomes and purchasing power of local citizens (Porter and Kramer 2011).

The idea of open and transparent markets blurs the distinction between the for-profit and nonprofit world, between private and public types of investments in Creating Shared Value. It bridges the traditional divide between the responsibilities of business and those of government and civil society. From a society's perspective, Porter and Kramer argue, "it does not matter what types of organizations created the value. What matters is that benefits are delivered by those organizations . . . that are best positioned to achieve the most impact for the least cost" (Porter and Kramer 2011).

Local clusters open access to and encourage participation in the global economy for all members of society. They include new types of NGOs that "understand the importance of productivity and value creation. . . [and] have often had a remarkable impact" on society, as well as governments and public institutions that, through their programs such as public spending for specialized infrastructure or educational programs, can enhance a company's productivity (Porter 1998).

Finally, investments by companies in training programs, infrastructure, quality centers and testing laboratories also contribute to increased productivity (Porter 1998). All investments at the cluster level are examples of a post-redistribution approach to creating economic and social growth, and they have the potential for collective benefits – the creation of common shared value.

Because of their inclusive nature, open and transparent markets are global and interconnected with empowering societal potential. They reflect the notion of "participatory parity," a political concept of justice developed by the political philosopher and theorist Nancy Fraser. For Fraser, the idea of participatory parity emphasizes the dismantling of all "institutionalized obstacles that prevent some

people from participating on a par with others, as full partners in social interaction" (Fraser 2009). When applied to Creating Shared Value, the idea of participatory parity appeals to opening all channels of information and providing access to all members of the community to important resources in the economic and social interactions of the local business environment. It is an inclusive project of participation and engagement of all businesses, suppliers and local stakeholders in a community's economic and social well-being.

Such approach to open and transparent markets is also in tune with another progressive concept of "democratization of commerce" developed by C. K. Prahalad, a thinker of the Bottom of the Pyramid market approach to alleviation of poverty and ecological justice in underserved communities. For Prahalad, democratization of commerce means providing to every person access to the benefits of the global economy.

Democratization of commerce, C.K. Prahalad writes, is based on all people having the right to exercise their role as consumers, producers, entrepreneurs, investors and innovators (Prahalad 2010). This democratizing or participatory idea about inclusion and access calls for providing access to information, access to credit and micro financing, and access to regional and national markets. It also requires a new form of active and collaborative engagement of the private sector with civil society, governments and philanthropists.

Like the Creating Shared Value approach, the democratization of commerce is an effort to respond to the global–local tension in business, namely the need of multinational companies to bring "world-class products and global standards of quality and safety to ... [underserved] markets," while making the solutions "locally responsive" (Prahalad 2010). Large private-sector firms, C. K. Prahalad writes, have to rapidly learn about local customers, their needs and aspirations. They have to start co-creating business solutions, gaining local knowledge, accessing specialized skills, reducing capital intensity and overhead, gaining trust, and becoming locally relevant (Prahalad 2010).

In closing, we can see how these approaches of sustainability for creating prosperity in open and transparent markets complement Stiglitz et al.'s meta-argument, discussed earlier, that emphasizes the active participation and engagement of current generations in providing the path toward a sustainable future. Through positive investments today and by engaging all stakeholders, we can identify new ways of pursuing and assessing sustainable wealth of our economic, social and environmental capital tomorrow.

In presenting these theories, I have tried to compare two complementary views about what sustainability is, how the concept is related to the economy and to business, and to show the role of positive investments in helping to ensure a sustainable future. We saw how these models stress the need to change conventional ways of thinking of and assessing sustainability by proposing radical new forms of post-redistribution of all resources. At a macroeconomic level, we think of it as an intergenerational series of positive investments that seek to ensure the transfer of all stocks of capital – natural, physical, human and social – from today to tomorrow.

And at a microeconomic level, we think of it as a new locational type of strategy and business practice that integrates a company's agenda for economic, social and environmental progress with the involvement of all stakeholders, as in the principle of Creating Shared Value.

Taken together, these approaches re-envision the way we can think of sustainable development, connecting all participants – national governments, local communities, investors, citizens, and businesses – in novel and urgent forms of participatory action. They all stress the need for positive investments made today in a forward-looking and cross-sectional way to create shared value for all tomorrow. They serve as a meaningful roadmap to pursuing economic prosperity, societal growth and ecological well-being.

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Integrating Sustainability in Capital Budgeting Decisions

Marinilka Barros Kimbro

1 Background

There is a growing emphasis, social awareness and an implicit expectation that firms need to behave in a more socially responsible and sustainable manner. Global warming, climate change, escalating energy costs and environmental degradation issues have increased public scrutiny regarding the role of firms as actors and agents in part responsible for these problems. Firms are responding to these pressures and they are managing them by attempting to identify all social, environmental and economic impacts in order to control, assess, prevent and eventually correct failures from actions that potentially have an adverse effect on human, animal or plant life. Corporate commitment to sustainability is increasingly evidenced by firms' participation in voluntary risk assessment and reporting initiatives such as: the UN's Global Compact (GC), the FTSE4 Good Indices, the Global Reporting Initiative (GRI), the Dow Jones Sustainability Indexes (DJSI) or through the compliance to International Standards Organization certifications (ISO 14001 and ISO 26000).

Traditionally, environmental costs and benefits have generally been identified in product and process design, in operations and plant location selection. However, there is evidence that the majority of firms *do not* consider environmental impacts in capital budgeting decision making and analysis (Vesty 2011). There are also concerns that conventionally accepted analytic methodologies – like Net Present Value (NPV), Discounted Cash Flow (DCF) or Internal Rate of Return (IRR) – do not favor sustainability related investments (Hopwood 2009). Commonly used capital budgeting techniques are constructed in ways that indeed can create bias *against* the selection of sustainable alternatives in capital selection. For example, certain benefits related to sustainable projects might require larger investments that

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require longer paybacks in order to develop positive cash flows. Also, positive qualitative factors of sustainable alternatives might be hard to quantify and the risk related nature of less-sustainable alternative investments might be difficult to incorporate in the cost of capital. Additionally, one might argue, that discounting NPV techniques assume –incorrectly- that the benefit of future biodiversity preservation and "natural capital" conservation will decrease in future years. In other words, it will be incorrect to assume that the *future* benefits of a sustainable investment will be *less valuable* than the present benefits of conservation as the application of the discounting techniques imply. The Economic and Biodiversity Report of 2008 notes: "that a 4 % discount rate means that we value a natural service to our grandchildren (50 years hence) at one-seventh the utility we derive from it (today), a difficult standpoint to defend" (TEEB 2008). Furthermore, there are many hidden costs that are "buried" in overhead or in general expenses that is not captured in current capital budgeting analysis. Managers could select equipment without understanding and evaluating the Full Cost or Life-Cycle impacts that capital assets might have. For example, firms might acquire equipment that requires to be cleaned with a hazardous substance, or uses a refrigerant that affects the ozone layer, or is cooled with fluids which become contaminated during the production process, or is lubricated with hazardous lubricants that require workers to use protective equipment that must be removed and disposed of in a special manner. Without a good understanding of all the hidden costs associated with the acquisition of capital assets, firms cannot effectively make capital budgeting decisions.

In this Chapter, I will discuss how to integrate sustainability issues into capital budgeting decisions by attempting to articulate a practical approach for capital budgeting that incorporates sustainability and environmental analysis into decision making by evaluating eco-efficiency (EE) analysis through how Life-Cycle-Assessment (LCA), life-cycle costing (LCC) and Full-Cost Accounting (FCA) techniques. Also, I will discuss how to incorporate the risks associated with environmentally risky capital projects into the discount rate of the cost of capital.

2 Firm Commitment to Sustainability

Firms typically go through three levels, stages, approaches, or "mindsets" regarding how they integrate sustainability issues into their decision making processes: compliance, cost avoidance and strategic approach. In the compliance level, environmental and sustainability analysis are primarily driven by the need to meet government or industry regulations. In this compliance stage, a firm's efforts are guided primarily towards calculating the minimum costs associated with existing compliance requirements. In the cost avoidance phase, firms have typically gained experience by measuring compliance costs and they have "learned" to appreciate the benefits of prevention, and "move" into the mindset of "investing to save" through a cost avoidance process that tries to anticipate environmental costs. Managing sustainability using a "strategic" mindset requires firms to approach

sustainability issues proactively, by actively incorporating environmental costs and benefits as opportunities to capitalize from the knowledge and understanding they provide about operations, processes and systems. Unlike the compliance and cost avoidance mindsets – both of which deal with environmental costs as constraints – the strategic approach sees environmental costs as a strategic business opportunity to create value.

Firms have become increasingly sensitive to environmental and sustainability issues for many reasons: they might need to comply with current or future government or industry regulations and standards, they need to identify costs through product and process improvements that reduce inputs and waste or they might just need to manage their image. Undoubtedly, managers need to measure and manage legal and regulatory costs as well as societal costs associated with public expectations regarding the need to preserve the environment using natural resources carefully. But also, firms need to recognize that operating in a sustainable manner generates environmental benefits, savings, revenues, and ultimately value which might or might not be measurable. Regardless of the level of commitment to sustainability issues – compliance, cost avoidance or strategic – managers can benefit from understanding how to integrate sustainability into the important task of deciding which capital assets to use in order to maximize shareholders' and stakeholders' value while respecting the earth and the environment.

3 What Is Capital Budgeting?

Capital budgeting is also called capital allocation decision making, asset appraisal analysis, capital investment appraisal and capital planning. Capital budgeting is the process by which an organization determines which long term assets and investments – such as the acquisition of machinery, plant, building facilities, equipment, land, research and development – are worth pursuing in order to support the firm's operations and organizational goals. The process of acquiring long term assets has significant strategic and operational importance since capital expenditures usually represent a significant commitment of financial resources which remain invested over a long period of time. Decisions related to the replacement of serviceable – but obsolete equipment – in order to achieve cost reductions; or capital expenditures necessary to increase product output or achieve market expansion; all involve detailed and significant analysis.

Firms commit cash to a capital project or investment because they expect to generate even more cash in the future. The value of a capital project is based on how much discounted cash a project might generate in the future; the higher the NPV or return, the greater the value of the project.

3.1 Capital Budgeting Methodologies

Firms with short term horizons, as a general rule, end up making suboptimal allocation decisions. "Buying the cheapest" is no longer the acceptable approach used in modern capital budgeting. Although traditional short-term horizon techniques such as payback or accounting rate of return (ARR) are still used as secondary methods, discounted cash flow (DCF) methods, including net present value (NPV) and internal rate of return (IRR) are the primary and preferred methods in contemporary capital budgeting analysis (Kim and Farragher 1981). Most firms realize that the least expensive investment opportunity is rarely the best alternative in the long-run. It is well established that long-term models to decision making using DCF and NPV analysis that incorporate the time value of money and the need to earn an internal rate of return that is higher than the cost of capital, are undoubtedly the preferred approaches to make capital allocation decisions.

Capital budgeting methods have evolved significantly during the last 20 years. Before the 1980s firms rarely used DCF and NPV methods; however by 1999, 75 % of surveyed firms admitted using DCF and NPV to evaluate capital budgeting decisions (Graham and Harvey 2001; Moore and Reichert 1983). Today, DCF/NPV and IRR are the primary quantitative methods used in capital budgeting analysis (Kim and Farragher 1981). As mentioned earlier, the payback and the accounting rate of return are still used as a secondary screening in capital budgeting.

The payback estimates how long it will take to recover the original investment, by dividing the original cost of the investment by the annual cash flows that the investment creates; the shorter the payback, the greater the project's liquidity. On the other hand, the payback creates an implicit bias in favor of short-term investments since it ignores the cash flows that the investment might generate after the payback period, as well as the variability of these cash flows and the time value of money. Similarly, the (ARR) measures the return of the original investment cost ignoring the time value of money and the cash flow variability.

Since virtually all capital budgeting decisions are analyzed with the use of computer software, it is relatively easy to calculate all methods, and the difficulty is limited to estimating the residual value and cash flows that the capital project can generate, evaluating the risk and cost of capital, and measuring the intangible benefits of acquiring the asset. Hence the real difficulty of deciding which investment to choose is not the determination of which method to use, but rather, it is determining the inputs necessary for these calculations: (1) How much cash flow each project will generate each year; (2) how to incorporate the uncertainty and risk of these cash flow predictions into the cost of capital for *each* project; (3) What is the "real" life of each capital asset: from "cradle to grave"; and (4) The cost-of-capital or risk measure that will be used to discount the predicted cash flows for each alternative

In order to calculate NPV for each capital asset alternative, we need to: determine the cash outflow of the initial acquisition costs (CF_0), estimate the cash flows

NPV = Total Present Value (PV) of future cash flows (CF_i)-Initial cost of the project (CF_0) (1)

$$NPV = \sum_{i=1}^{n} \frac{CF_i}{(1+r)^i} - CF_0$$

r = discount rate
n = time period of the project or investment

Fig. 1 NPV formula

(CF_i) for each year in the life of the asset, the cost of capital (r) for each asset, and the number of years (i) that will be discounted on the true life of the asset: "from cradle to grave" (Fig. 1).

4 Incorporating Sustainability into NPV and DCF: Predicting Cash Flows

4.1 Stage One: Identify, Evaluate and Measure General Costs and Benefits

In evaluating a DCF/NPV analysis the firm must estimate all future cash flows that each investment generates. Cash flows for the life of *each* project – from cradle to grave – must be estimated. In order to predict these future cash flows, the impact of all areas affected by the proposed capital expenditure must be evaluated as well as the riskiness of the expected cash flows, which will later be used to estimate the cost of capital.

A basic screening of the traditional capital budgeting items to be included in the cash flow calculation will be the first step in quantifying cash inflows and outflows. Table 1 is a good starting point for this.

In order to incorporate sustainability into the estimation of cash flows, Life cycle assessments (LCA) and life cycle costing (LCC) must be used in the analysis. LCA and LCC enable firms to better understand the financial and environmental effects – both costs and benefits- of capital assets, products, services and activities and thus is an essential tool needed to predict future cash flows.

One approach of evaluating cash inflows and outflows is to ignore items that do not vary in cost between one option to another. Equal costs will cancel out from the NPVs of all the capital options and thus the focus of a capital budgeting analysis should be on measuring incremental inflows, outflows, costs and savings that vary from one option to another. However, as a matter of practice most of the cash inflows and outflows differ significantly from one capital alternative to the other.

Table 1 Initial inventory of costs and benefits

Costs			
Initial, operating, remediation, externalities and other costs	Yes or no. If yes, explain and quantify	Savings	Yes or no. If yes, explain and quantify
Purchase price		Increase production, revenues and sales	
Taxes		Tax rebates	
Transportation costs		Tax savings	
Interest/financing costs		Energy savings	
Installation costs		Water conservation savings	
Energy use (assume increasing costs in cash flows)		Revenues from recycled externalities	
Emissions and impacts		Reduced costs of inputs	
Costs of monitoring emissions		Waste disposal costs savings	
License and permit costs		Remediation/clean up costs savings	
Calibration costs		Calibration costs	
Plant or land space		Space savings	
Maintenance costs		Maintenance costs savings	
Training costs		Training costs savings	
Repair costs		Repair costs savings	
Material inputs (ink, detergents, fuel, etc.)		Material inputs savings	
Insurance costs		Insurance costs savings	
Insurance fees to cover handling of hazardous substances		Reduced fees to cover handling of hazardous materials	
Waste disposal costs		Waste disposal savings	
Landfill costs and taxes		Landfill costs and taxes savings	
Remediation/clean up costs		Shut-down costs savings	
Shut-down costs		Fines and prosecutions savings	
Fines and prosecutions		Increase in useful life	
Capital asset disposal costs		Disposal costs savings	
Useful life			

4.2 Estimating Cash Flows Using Life-Cycle-Costing (LCC)

Many environmental costs are hidden in overhead and general administrative expense accounts, and their impact is not properly priced into the assets and activities that created them. Relevant costs and benefits information are clearly

key components of capital investment analysis that unfortunately are too often ignored. LCC analysis clearly helps to identify these costs.

Eco-efficiency requires an integrated assessment of environmental and economic aspects of assets and services from a life-cycle perspective. The concept of life-cycle includes *everything*. Life-cycle implies the inclusion of all costs and benefits of a capital investment from "cradle to grave". In other words, LCC assessment goes beyond the typical "useful-life" methodology frequently used in accounting. Unlike economic analysis, in LCC all impacts of a capital asset are summed up along the whole life-cycle in order to give a complete understanding of the entire impact of owning a capital asset. LCA and LCC involve the recognition and analysis of all costs and cash outflows as well as the benefits and cash inflows. The costs of buying, financing, installing, maintaining, operating, repairing, replacing and disposing of an asset are considered outflows of cash. All energy savings, rebates, tax-savings, depreciation, productivity improvements, are considered inflows of cash. These cash inflows and out-flows are projected over the life of the asset, adjusted for inflation and anticipated uncertainty, to determine the NPV of each capital project. LCC involves a comprehensive evaluation of all direct and indirect environmental impacts of a capital asset throughout its life and beyond its "useful" stage. Managers who duly identify and analyze the full scope of a capital assets environmental consequences, will be better equipped to make optimal investments that will price *a priori* pollution prevention rather than remediation and'end of the pipe' solutions.

4.3 Stage 2: Use LCA for Initial Environmental Screening

In this stage an initial environmental screening is performed going through all potential indirect and direct items that have a high probability of having an environmental impact. Since the capital budgeting decision involves the selection between different asset alternatives, all possible impacts must be measured and assessed *before* going through any financial analysis. The following "checklist" is a good starting point of assessment. Table 2 offers an example of an initial environmental screening checklist that could apply for the purchase of a machine or equipment. Of course, each organization and asset class will have particular issues that should be tailored accordingly. The information from the Initial assessment "checklist" will provide raw data and information that could be the starting point of a quantification of sustainability and environmental costs.

4.4 Stage 3: Evaluate Eco-efficiency and Quantify Impacts

If the environmental screening reveals that the asset does create waste or externality, then this item must be evaluated and its impact must be categorized using an

Table 2 Environmental screening

Environmental Inventory	Yes or no	If yes, please explain which material or chemical	Remediation or disposal costs	Toxicity potential from 1–5
1. Require hazardous raw materials?				
2. Require hazardous lubricants?				
3. Require hazardous cleaning agents?				
4. Create waste water?				
5. Emit particles into the air?				
6. Generate heat or noise?				
7. Do employees need special protection equipment or clothing in order to operate around asset?				
8. Require plant modification to offset environmental impact?				
9. Have non-recyclable parts?				
10. Do parts need special disposal?				
11. Require reporting to regulatory agency (EPA)?				
12. Require inspections to regulatory agencies?				
13. Do parts and maintenance equipment require special storage facilities?				
14. Do parts and maintenance equipment require special transportation?				
15. Require special disposal?				

impact category similar to the one presented in Table 3. Many of these costs are "external" costs that are generally not considered in capital budgeting decisions. These "externalities" have an impact on human health or eco-systems through the release of toxic substances. Unfortunately, it is neither the firm nor the consumer that bears these costs, but society as a whole and – eventually – future generations. These impacts are obviously more difficult to quantify and it is up to the firm to assess the weight it will give these in the capital budgeting analysis. On the other hand, it would seem reasonable and responsible to integrate these costs in the decision making if legislation can be foreseen that internalizes external costs for certain waste, emissions, materials or externalities. This could be the case for CO_2 taxes on fossil fuels or carbon emission taxation. For a more detailed analysis various assessments have been developed that help quantify toxicity potential (Bunke and Graulish 2002; Bunke et al. 2003).

4.5 Buildings: Other Tools for Estimating Cash Flows

In terms of capital investments in buildings, several green ratings systems have developed metrics that define and measure both current and future building

Table 3 Impact assessment and eco-efficiency analysis

Impact assessment	Item	Measurement unit	Source
Waste	W	kg of waste equivalent	All
Toxic waste	TW	kg of toxic waste equivalent	Manufacturing
Air pollution	AP	kg sulfur oxides (SO_2) equivalents	Manufacturing, combustion, power plants
		kg of nitrogen oxides (NO_2) equivalents	Manufacturing, transport
		kg of carbon monoxide (CO) equivalents	Manufacturing
		kg of particulates	Manufacturing
		Kg of Mercury (Hg) equivalents	Manufacturing, power plants
		kg of volatile organic compounds (VOCs)	Manufacturing, solvents, transportation
Indoor air quality	IAQ	kg of radon (Rn) equivalents	Land sites, mineral extraction
		kg formaldehyde (H_2CO) equivalents	Manufacturing, maintenance and cleaning
		kg of asbestos	Plant insulation
		kg of volatile organic compounds (VOCs)	Manufacturing solvents
Inspection costs	IC	# of inspections per year	Plant and equipment
Global warming potential	GWP	kg of carbon dioxide (CO_2) equivalents	Manufacturing, transportation
		kg of methane (CH_4)	Manure, agriculture, solid waste, landfills
Water acidification potential	AP	kg of sulfur dioxide (SO_2) equivalents	Manufacturing, power plants
		kg of ammonia	Manufacturing, food processing
Ocean acidification	OA	kg of carbon dioxide (CO_2) equivalents	Manufacturing, transportation
Aquatic eutrophication potential	aEP	kg of phosphate ($PO_4^{3}-$) equivalents	Fertilizers
		kg of nitrates (NO_3)	Fertilizers
Terrestrial eutrophication potential	tET	kg of phosphate ($PO_4^{3}-$) equivalents	Fertilizers
Photochemical ozone creation potential	POCP	kg of ethylene C_2H_4	Chemical plants, petro-chemical, agriculture

performance. Buildings' "green metric" systems that can be employed and integrated into the capital budgeting process are: Leadership in Energy and Environmental Design for Existing Buildings and Operations and maintenance (LEED-EB O&M); Green Globes for Continual Improvement of Existing Buildings (CIEB), the Green Guide for Health Care (GGHC) and BRE Environmental Assessment Method (BREEAM).

4.5.1 The Cost of Capital

The value of a capital investment is the expected cash flow discounted at a rate that reflects the riskiness of the cash flow. If this value is greater than the original investment cost, then the project has a positive NPV, if it is less, it has negative NPV. Positive NPV projects create value, while negative NPV projects destroy value.

The discount rate or the cost of capital is a function of the weighted average cost of capital (WAAC) as well as the project's perceived riskiness, with risky projects requiring higher returns than less risky projects. Risk can be defined as the probability of exposure to any event or action that will adversely affect an organization ability to create value. There is some evidence that firms evaluate risky investments by estimating expected values, standard deviations, semi-variances of net cash flows for each alternative investment, as well as multiple-criteria capital budgeting models under risk by using higher discount rates that incorporate higher risk factors (Kwak et al. 1996; Lin 1993; Pike 1983).

The importance of integrating risks into management decisions and in particular into capital allocation decisions cannot be underestimated. These risks might be: strategic, operational, reporting or compliance risks (Epstein and Recj 2005). Sustainability issues are a component of each of these risk categories. Strategic risks relate to the firms choice of strategies and include industry, transaction, technological, political and organizational risks. Operational risks relate to threats from ineffective business processes. Reporting risks, relate to the reliability, accuracy and timeliness of information systems – both internal and external. Compliance risk relate to the inability of the firm to comply with applicable laws and regulations.

There are two approaches of integrating environmental risks into capital budgeting decisions. We can develop a Sustainability Risk Rate or we can quantify the Sustainability Cost NPV that will capture the sustainability exposure of each project.

In order to develop the "Sustainability Risk Rate" we need to evaluate each capital project, through an environmental risk inventory and an eco-efficiency assessment. Using these tools the firm must determine a risk rate that will be added to the cost of capital of the project, therefore increasing the discount rate and "penalizing" the project with a higher discount rate and thus a lower NPV.

Another way of quantifying the risks is to calculate a Sustainability Cost NPV by quantifying the sustainability negative impacts and subtracting this amount from each project's NPV calculation. This involves identifying, classifying and quantifying risks by multiplying each probability times each measurable impact for each capital project and then discounting these risk exposures in order to arrive at a negative NPV or sustainability cost measure that will be subtracted to the positive NPV for each project.

Risk Exposure = (Probability of failure) × (Cost of failure)

Calculating the Sustainability Cost NPV:

1. Calculate the potential costs associated with each risk category.
2. Estimate the probability that each risk could materialize.
3. Multiply the potential cost of each risk by its expected probability to calculate the expected value of each risk.
4. Estimate when the risk may develop. In the case of machines the probabilities might increase as the asset gets older.
5. Calculate the NPV of each risk.
6. Aggregate and add the NPVs of all sustainability risks.
7. Subtract the Sustainability Cost NPV from the NPV calculation for each capital alternative.

5 Conclusion

There is evidence that most firms do not consider environmental impacts in capital budgeting decision making and analysis (Vesty 2011). There are also concerns that conventionally accepted analytic methodologies like: DCF, NPV and IRR; do not favor sustainability related investments and could even create bias *against* the selection of sustainable alternatives in capital selection. Furthermore, there are many hidden sustainability related costs that are "buried" in overhead and in general expenses that are not captured in current capital budgeting analysis.

This chapter highlights the importance of identifying, measuring and evaluating all costs and savings of alternative capital investments. Using Life-Cycle Assessment (LCA) we can identify sustainability related costs from "cradle to grave" in order to provide a template by which hidden environmental costs and benefits can be identified, analyzed and priced.

I developed a model that integrates sustainability risks into the cost of capital and into NPV calculations.

1. Identify, evaluate and measure general costs and benefits using an Initial Inventory Analysis
2. Estimate Cash Outflow required to acquire a capital investment: CF_0
3. Use LCA for the initial environmental screening checklist.
4. Evaluate eco-efficiency and quantify impacts.
5. Estimates Cash Flows for the life of the investments ($CF_1, CF_2, CF_3, CF_4, \ldots$)
6. Estimate the sustainability risk rate and add it to the cost of capital *(r)*.
7. Or, in the alternative, compute the NPV of the sustainability costs and subtract it to the projects' NPV.
8. Select an NPV Investment that has a positive NPV.

In today's highly connected and well informed markets firms realize that acknowledging and managing sustainability related risks is no longer an option but a necessity for firm survival. Firm value encompasses all the activities of a company. Some of these activities have wider impacts on society and the environment than others, but they all have the potential of creating sustainable growth and development.

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A Study of Consumer Attitudes and Behaviour Towards Sustainability in Bradford, UK: An Economical and Environmentally Sustainable Opportunity

Zahid Hussain and Jasdeep Singh

1 Key Writings in Sustainability

There are a wide variety of sustainability definitions, however through focusing on some key indicators of sustainability, it will allow us to understand the complexity surrounding sustainability, and it will be argued that all indicators and dimensions of sustainability should be of equal importance. In this section critiques and supporters of sustainability will be presented, and it will be portrayed that at the moment certain motives outweigh one another due to influences from the consumer and commercial worlds (Fig. 1).

1.1 Definition of Sustainability

With regards to legislations, sustainability is usually referred in literature as sustainable development. This is the common term that is used by many authors' and legislative guidelines however it must be noted that there is a fine yet distinct difference between the two as highlighted by O'Riordan (1988) whom stipulates that the term sustainable development was brought into the limelight to add more weight and importance to development in the physical sense such as buildings and infrastructure, because growth and development needed to be re-directed rather than stopped. The term sustainable development was firstly used in the Brundtland Report so as to place equal importance on the economic dimension of sustainability

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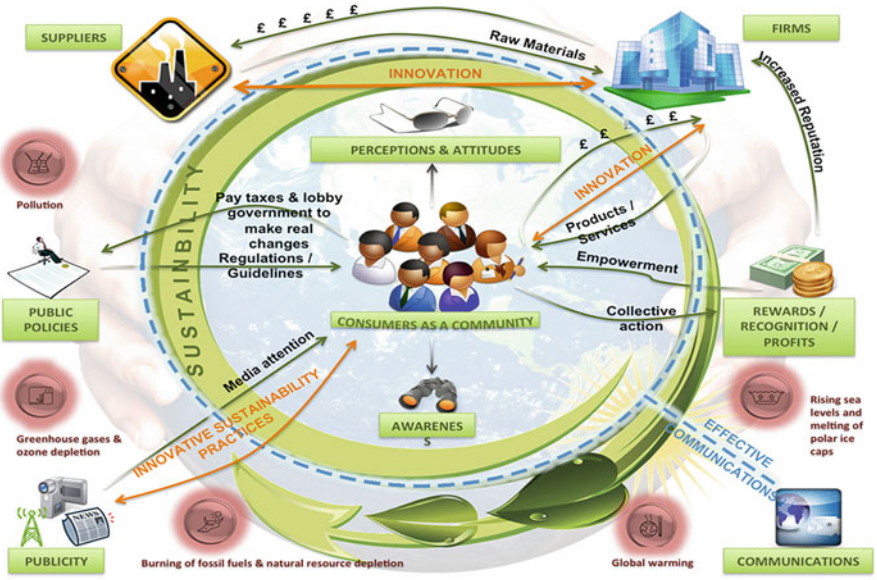

Fig. 1 Rich picture of sustainability

by meeting the needs of the people, thus reducing the high dependency on the ecological dimension of sustainability, which may have hindered growth and development. As stated in Henriques (2001) defines sustainability as: *Sustainability is the capability of an organisation (or society) to continue its activities indefinitely, having taken due account of its impact on economic, social and environmental capitals.* (p. 32). In contrast to this the Brundtland Report as quoted by Dresner (2008) defines sustainable development as: *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* (p. 73). O'Riordan (1988), and Desai (n/d) as stated by Dresner (2008, p. 70) criticize the definition of sustainable development as being too vague. According to Kidd (1992) modern era sustainability stems from six distinct roots:

1. Biosphere
2. Resource/environment
3. Ecological/carrying capacity
4. Critique of technology
5. No growth/slow-growth
6. Eco-development

Bell and Morse (1999) commit that the ecological/carrying capacity root is the spine of sustainability as seen in Fig. 2. Through analysis the biosphere, resource/environment, ecological/carrying capacity and critique of technology roots can be seen to adhere to the ecological/environmental dimension.

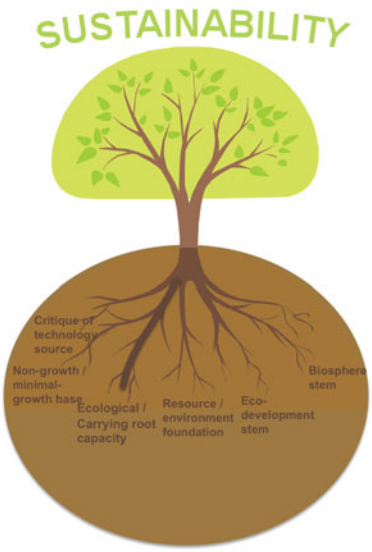

Fig. 2 The roots of the modern view of sustainability (Source: Bell and Morse (1999, p.6))

The no-growth/slow-growth and eco-development roots attach themselves to the economic dimension, meaning that no original roots apply to the social dimension. This ultimately means that there is an imbalance in the importance of each dimension, with the social dimension being left in the background. This ties in with the purpose of this research as it aims to identify the shortcomings and understand the relationship between sustainability and the social dimension from the consumers' perspective.

1.1.1 Types of Sustainability

Authors such as Ison et al. (2002), Dresner (2008) and Bell and Morse (1999) all agree that there are two main types of sustainability, weak and strong.

1.1.2 Indicators of Sustainability

In order to measure the rate and effectiveness of sustainability, a typical set of key sustainability indicators are crucial. Bell and Morse (1999) present key indicators based on qualitative techniques rather than the typical quantitative approach, similarly aligned with the research to be conducted in this thesis, as it will involve both a qualitative and quantitative aspect. By looking at Fig. 3 we can see the three perspectives of sustainability; sociological, economic and environmental, but the issue is which perspective should have prominence?

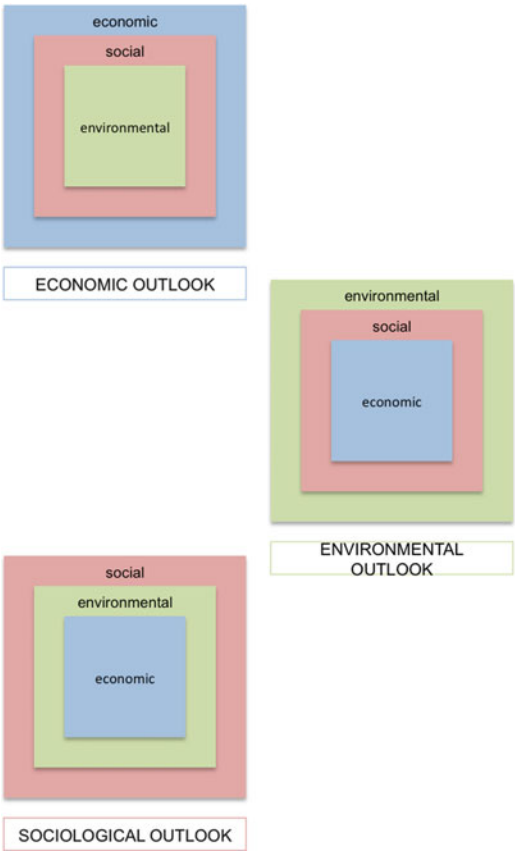

Fig. 3 The three perspectives of sustainability (Source: Henriques (2001, p. 42))

However Fig. 4 depicts an equal weighting and integration of all of the three perspectives of sustainability in order to achieve harmony between all of the dimensions.

The contemporary sustainability indicators are expressed by Edwards (2005) as the 'Three E's plus one': (1) ecology/environment, (2) economy/employment, (3) equity/equality, (4) education. We can assume that these indicators provide a good balance as the indicators are spread across the three dimensions of sustainability with an increased weighting for the social dimension with the equity/equality and education indicators. Authors such as Wise (1999), Sibbel (2009) and Edwards (2005) all permeate that the education indicator is the catalyst for change in the future, as from knowledge, collective action can be achieved through overcoming the problems of normative, emotional and cognitive obstacles thus altering the value structure of communities.

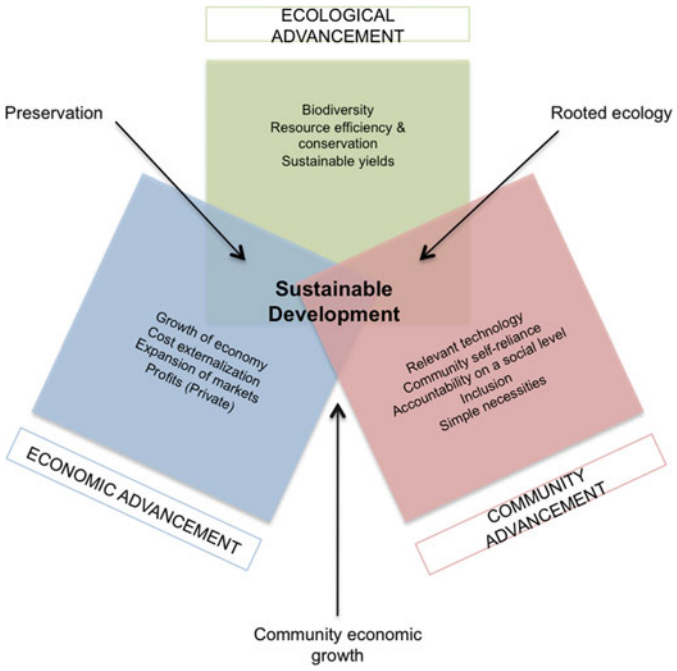

Fig. 4 Balancing sustainability perspectives depicting the interactions between ecological, economic and social development (Source: Bell and Morse (2003, p. 4))

1.1.3 Past Studies of Sustainability and Consumers

With the advent of the sustainability revolution, the focus of sustainability is on understanding how consumer attitudes and behaviour can be manipulated to primarily benefit the environment but more importantly to maximise levels of profits, as businesses and the national level governments look to capitalise on the opportunity to lull consumers into ensuring the long-term prosperity of the social, economic and ecological dimensions.

Consumer Attitudes

The Guardian (2010) conducted research into 'consumer attitudes and perceptions on sustainability' documenting the impact of ethical and environmental impacts on consumer buying behaviour. The survey was conducted in 2010 and involved 766 members of the Guardian News and Media consumer Brand Aid Panel. This research presented that consumers were more or less equally concerned about a range of various environmental sustainability issues but the top three concerns consumers had regarded pollution, over-use of resources and climate change, a

finding that mirrored the expectations of Edwards (2000) whom expressed that the fair distribution of resources was a necessity for collective action as a community. This cements the issue of consumers expressing the values of the equity/equality indicator developed by Edwards (2005), signalling a move in the right direction. The European Commission (2009a, b, c) conducted similar research into establishing attitudes towards sustainable consumption and production by interviewing 26,500 people in 2008 across the 27 EU member states which resulted in consumers acknowledging that minimizing waste, eco-friendly production and efficient sustainable modes of transportation are the key actions with greatest impact on solving environmental issues. In a similar research conducted in 1994 by Macnaghten et al. (1995) consumers portrayed an apparent mistrust and disbelief in politicians and claims made by public bodies or institutes with regards to sustainability. It involved eight types of focus groups with six to ten people in each group, the groups were split into the following; young men, Asian women, mothers, unemployed men, retired, rural professionals, working class women and young professionals. The research aimed to explore public perceptions of sustainability in Lancashire, similarly aligned to the context of the research we are to conduct but with a difference being that it is based in Lancashire on a county level whereas our research is based on a city/metropolitan level.

Consumer Perceptions

An interesting discovery by Marsh et al. (2010) and The Guardian (2010) suggests that consumers perceive sustainable products as having a premium price tag. However Homburg and Matthies (2010) as stated in Hanss and Böhm (2010) suggests that the key to achieving sustainability is through understanding what consumers associate with the term sustainability, how important the sustainability dimensions are in relation to each other and what is considered as sustainable purchase decisions in order to boost sustainable consumption. Marsh et al. (2010) used interviews and questionnaire analysis of 14 people from different backgrounds and looked into their behaviour towards sustainability in fashion and established that self-image and peer acceptance played a big role upon the consumer buying decision even though the consumers had good ecological awareness. The research outlined that in a situation where self-image or peer acceptance is of importance then this would take precedence over the sustainable choice regardless of the consumers' attitudes towards sustainability, suggesting that sustainability options need to be desirable.

In The Guardian (2010) consumers place sustainability in fourth position ahead of brand loyalty in the deciding factors to buy, as firstly the quality of the product, secondly the price of the product and thirdly the availability of the product are the key deciding factors. However in European Commission (2009a, b, c) sustainability is placed in third position behind price but again ahead of brand loyalty. The Guardian (2010) establishes that a high majority of consumers would be willing switch to products with a low environmental impact, however he fails to consider

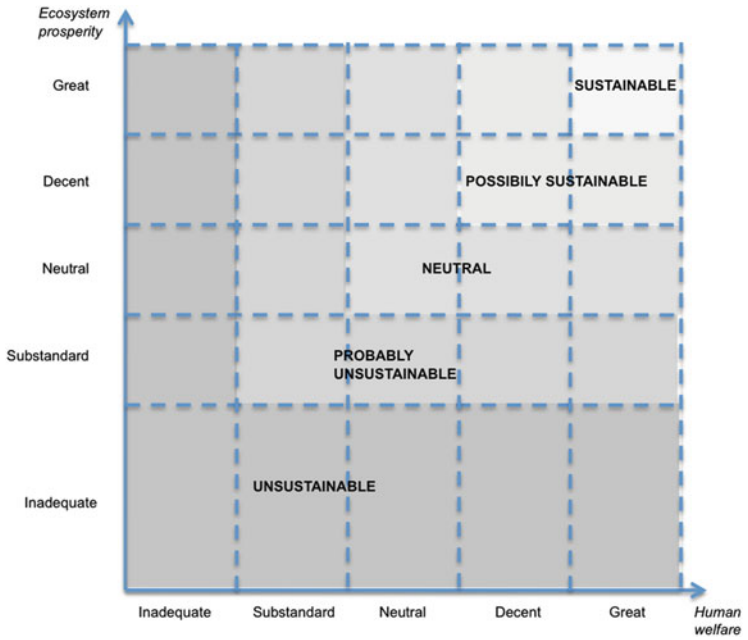

Fig. 5 The IUCN (World Conservation Union) barometer of sustainability (Source: Bell and Morse (2003, p. 43))

that what this suggests is that consumers are willing to embrace environmentally friendly products if firstly the quality of the products are equal to non-environmentally friendly products currently on the market, the price is equivalent to current products without the premium and thirdly that the environmentally friendly products are easily available.

These findings suggest that consumer perceptions of sustainability have developed over the years, as initial research conducted to understand the perceptions of sustainability by UK citizens by Macnaghten et al. (1995) and Macnaghten and Jacobs (1997) suggested that a majority of respondents did not understand the concept of sustainability or ecological issues which would affect current and future generations. Importantly however the research looked into ways of improving the awareness and understanding of sustainability and it mainly identified that the respondents suggested that education would improve the understanding and awareness of sustainability, thus indicating a need for development in the social dimension, which gradually would lead to a change in social values as perceived by Edwards (2005).

Figure 5 portrays a barometer of sustainability through which we can visualise the past, current and future stages of sustainability. In the past, human wellbeing could be classed between bad and good but the ecosystem wellbeing would be classed as being bad ultimately meaning that such actions and attitudes would be unsustainable. In current times, human wellbeing can be classed between poor and

good with the ecosystem wellbeing being classed between poor and good as well, meaning that current attitudes and actions still remain potentially unsustainable, intermediate or potentially sustainable. However the aim is to become fully sustainable in the future which will require human well-being to be classed as good alongside the ecosystem wellbeing being classed as good.

Edwards (2005) presents a variety of sustainability labels or accreditations that consumers may identify during purchasing that should guide purchase decisions through identification of sustainable products. According to Hanss and Böhm (2010) however these labels proved to create confusion amongst consumers as they did not recognise them due to the wide variety being used, however a point to consider is that the findings of The Guardian (2010) indicate that consumers would only place trust in a brand/product/company/institution if there was accreditation through environmental awards, scientific backing or positive media coverage. Additionally, The Guardian (2010) indicated that the term 'greenwash' was losing momentum as consumers were increasingly becoming wary of companies whom used this practice to appear environmentally friendly. However looking at household income levels The Guardian (2010) identified that the higher household income levels showed a greater degree of awareness towards environmental impacts when buying groceries and utilities than compared with lower level income groups. This suggests that there might be a link between the level of knowledge/education, profession and income levels in the understanding, attitudes and behaviours of consumers towards sustainability, as there is very little understanding about this possible perspective, which is why this thesis will aim to explore this area. The research conducted by Macnaghten et al. (1995) has become old and irrelevant as social values have changed over time dramatically, which is why this research will provide an updated insight into modern consumerism.

Community Action

> We must be the change we wish to see in the world- Mahatma Gandhi

Power (2004) stipulates that a sustainable community depicts characteristics that uphold all ecology/environmental, social and economic dimensions of sustainability. Laguex (1999) suggests policy creation by people and institution is greatly influenced by communities and therefore it can be assumed that for social cohesion to form it is vital for the formation of communities acting together to further sustainability. Communities need to embrace values and initiatives such as the fair distribution of resources as suggested by Edwards (2005) and embracing equity/equality.

There have been several sustainability policies that incorporate communities into their efforts. These policies have been developed at state, national and international levels with the most noticeable being the Earth Charter. Edwards (2005) conveys the most thorough and collaborative attempts towards sustainability was made by the Netherlands in the state level policy titled NEPP established in 1989.

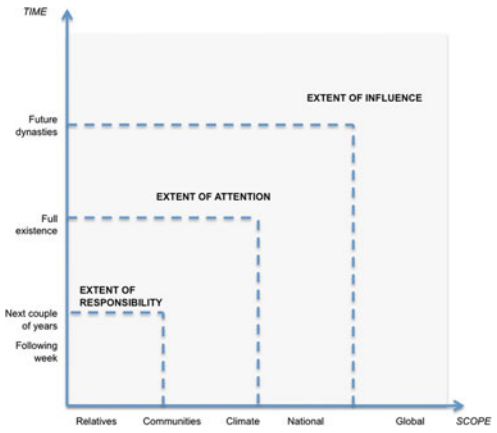

Fig. 6 Horizons of influence, attention and responsibility in sustainability (Source: Bell and Morse (2003, p. 13))

This policy has continually developed inspiring many other nation states to follow suit.

Figure 6 illustrates the importance of communities and the power of their collective action, as we can see that communities have a horizon of responsibility over the next few years but one which will most definitely act as an influence for future generations. The importance of national and international awareness is also depicted as only through achieving all of the three horizons will sustainability efforts be effective. In the research conducted by Macnaghten et al. (1995), the findings suggested that consumers associated the word sustainability as being a global issue that could only be solved if the global community acted together. The consumers also showed a strong feeling towards the fair distribution of resources an aspect that is further picked up recently in the research conducted by The Guardian (2010). However what this does indicate is that consumers in 1995 did have the correct social values to allow social, economic and environmental change to be realised in the future. A feeling of empowerment, which is brought about by a sense of belonging through collective action as a community, consumers gain positive experience in engaging in sustainability. However other than this, there has been no significant research into the perceived depth of involvement as a community consumers believe they are attached to or involved in and are a part of. These communities may be in the form of sustainable organisations or bodies or institutions that provide advice, develop products or technologies or even hold meetings to engage people at a community level with a global level issue. This insight will provide a valuable analysis of how many people are affiliated with these communities and how much they engage with the communities, ultimately providing us with information suggesting which sustainable communities are most prevalent and consumer attitudes towards these communities. Other aspects that our research will build upon is understanding the depth of knowledge each consumer group has based upon certain variables such as age, occupation or income which will allow us to determine any links and therefore suggest recommendations.

Importance of Communications

The Guardian (2010) has stipulated that effective communications are made only possible through affiliations or accreditations with credible third parties. This can be understood to be a very logical and important means of ensuring that companies live up to their expectations and commitments and that its actions support its assertions as the companies will be open to scrutiny from independent third parties such as environmental bodies whom will judge the performance of the companies and report their findings. Thøgersen (2005) however highlights that communication made by the government should not be heavily pressing on the consumer because it might lead to de-motivation which in turn would lead to a sense of helplessness. According to Thøgersen (2005) one effective form of communication would be to use facts related to an issue which the consumer can relate to, secondly through the use of guilt appeals consumers tend to show a greater degree of responsibility. However guilt appeals tended to be counter-productive as companies whom used such means of communications resulted in consumers exhibiting negative attitudes towards the advertisement and organisation if the consumer believed there was manipulative intent in the communications. The other method of communications would be through using control appeals, which would not create a heightened sense of responsibility.

Controversially Giddens in Dresner (2008) conveys that growth of communications has fuelled globalisation because as ideas and fashion are spread around the globe so quickly that they cannot be kept up as they are not in line with tradition and therefore cannot be planned for, which in turn has led to the hindrance in sustainability efforts. However according to Mader (2008) companies perceive communicating green messages to the mass media as being too expensive and difficult, as there is a prospect of limited profitability even though Dolan (2002) suggests that through communicating green messages as sustainable marketing companies can increase brand equity and reputation. Communication of green messages would only be beneficial is sustainability is addressed as a multi-faceted topic concerning the ecology/environmental, social and economic dimensions. Consumers perceive business practices as being a fad, and other research has conveyed the same response towards politicians and their policies, which is why it is suggested that companies must seek to educate consumers rather than just having a short-term incentive of achieving profits whilst at the same time window dressing the corporate image as being sustainability promoters. This research thesis aims to explore how sustainability communications can be made more effective and positive from the perspective of consumers, which is important, as the consumers are the intended targets of the communications.

Effect of Public Policies

Thøgersen (2005) states that one of the main aims of consumer policy is to ‘empower’ consumers to be able to make informed decisions through means of

information and education. In relation to sustainability this would mean consumers being able to make sustainable buying choices through for example identifying labelling that confirms the product as being sustainable. The public policies must in alignment with community values and expectations.

According to Wilkins (2008) political discourse has put a much greater emphasis upon the protection of the ecology/environmental dimension rather than on other aspects such as economic welfare and social fairness. However this stance is supported by Fischer et al. (2007) whom indicates that the hierarchical system of where the ecology/environmental dimension should prevail in front of the social and economic dimensions. Macnaghten et al. (1995) stipulated that consumers believed that public policies developed by politicians were influenced entirely by commercial organisations. This meant consumers believed that policies were being introduced for primarily creating profits rather than primary concern being to save the environment. In suggestions made by The Guardian (2010) they suggest that maybe the new government may provide 'some leadership in this area' however conclusively the research does not attempt to understand whether consumers place any trust in politics or politicians and if so how much because research conducted earlier by Macnaghten et al. (1995) had suggested that consumers would not trust the government or any public body to act primarily in the interest of the ecology/environment. This shortcoming however will be overcome in the research that we conduct as we will try to understand whether consumers in the modern era trust politicians and public bodies to advance sustainability and after this finding then suggest whether a private or public body route would be best.

Thøgersen (2005) portrays that public policies may empower consumers to establish sustainable lifestyles. Thøgersen (2005) suggested that politicians should not solely rely on existing and traditional consumer policy instruments firstly due to the fact that consumers have no trust or confidence in the credibility of policies or politicians and secondly because the rate of change towards sustainability is really slow, which is why a fresh new approach is necessary. In their research Lafferty and Meadowcroft (2000) concluded that governments need to take a more pro-active stance and increase their commitment towards sustainability if they wish to influence and convince consumers that they are acting in the primary interests of ecological and social welfare. Further Wise (1999), Sibbel (2009) and Edwards (2005) argue that educating consumers about sustainability will act as a catalyst towards change.

We have established that consumer information and education is a key tool in consumer policy success. This is why Zelezny (1999) recommends that sustainability education is beneficial and Vaughan et al. (2003) suggest that education with regards to sustainability should be included in the school curriculum and in higher education as positive changes in attitudes are realised instantaneously as children would influence their parents as well, long-term changes are also realised. This is why Thøgersen (2005) stipulates that sustainability education and information should not be limited to just mass media campaigns, a move typical of businesses to promote their products and services or by the government to promote awareness as a short term solution. He stipulates that there are very limited

possibilities of realizing changes that promote sustainability to consumers through standards or legislative restrictions. Instead what he suggests is that the desired change can be realised through varying consumer choices of product offers available and removing pervasive subsidies, ultimately meaning that products should be priced correctly in the first place. Research conducted by Wier and Calverley (2001) suggests that if sustainable products are priced more affordably to suit a large majority of consumers whom are restricted to budget constraints (Thøgersen 2005) then this has proven to show that consumer choices adjust overtime in favour of choosing sustainable products. This finding re-instates the finding that consumers still place price as the most influential indicator when making a decision to buy. Our research will aim to establish whether consumers trust politicians to act in the primary interest of the environment and highlight what consumers believe would make a real change towards supporting sustainability.

Significance of Rewards/Recognition/Profitability

According to Capozucca et al. (2009) it is suggested that companies whom exhibit a pro-active behaviour and take the lead in promoting sustainable practices and products through making consumers envisage that sustainability is achievable without sacrificing quality or availability or having too pay a premium price, then these businesses will successfully engage all consumers in creating a new market. However businesses have hindered to engage in this activity due to a prospect of limited profitability, as consumers are not willing to pay a premium price for products regardless of their attitudes towards sustainability. Figure 7 depicts the zones of responsibilities of a company, and what areas and stakeholders it can either control or influence with sustainable practices or schemes. As can be seen from the diagram the company can definitely control the actions of employees and suppliers but also has partial control over customers and the impact of its actions on the environment as highlighted by Henriques (2001). An interesting point to notice is that the company has a wider and greater zone of influence, which covers the whole of the customers, suppliers, local communities and the public. This means that good practice and promotion of sustainability stemming from companies would be beneficial as it causes a ripple effect that should influence the attitudes and actions of all the stakeholders.

Further to this Capozucca et al. (2009) recognizes that politicians and governments are trying to establish better ways of regulation and controlling price externalities without compromising standards of living and the report suggests that businesses should aid politicians through adopting sustainable practices and developing sustainable products. At the current moment there is little if any, monetary rewards or regulatory requirements for companies to promote sustainability. However with reference to The Guardian (2010) the research suggests that consumers would highly trust companies that had been accredited through environmental bodies and/or awards, so engaging in sustainability would be beneficial for companies in the long term as accreditation is a form of

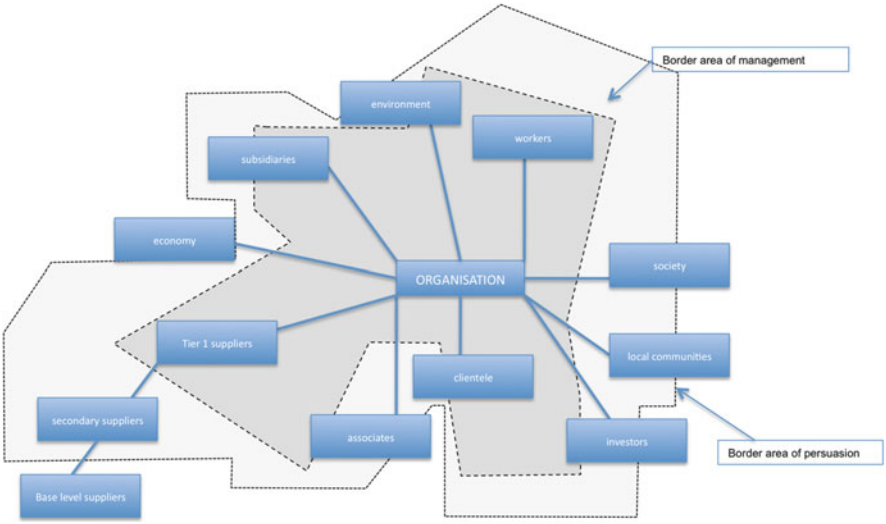

Fig. 7 Zones of company responsibilities (Source: Henriques (2001, p. 28))

recognition which in turn would boost consumer confidence in the company, attracting potential consumers and therefore increasing revenues and hopefully lead to an increase profits.

The issue is that these gains are not easily quantifiable and according to Wirtenberg et al. (2007) it is a very difficult task to promote sustainability and it is very expensive to implement, without any assumption on how long the payback period will be as the current business model is centered upon maximising profitability but this business model will have to change in order to accommodate any sort of sustainability, a view that is supported by Capozucca et al. (2009). Businesses can benefit from cost efficiencies and through generating top-line growth as per the views of the World Business Council on Sustainable Development. Hussain (2012) co-ordinates that the current sustainability agenda is being driven by the triple bottom line concept with profit being at the forefront ahead of people and planet. However from a consumer perspective, the significance of recognition from the society is crucial to making the individual experience empowerment, which is achieved through appreciation and acceptance of their contributions. From a business perspective Strandberg Consulting (2009) outlines that recognition is vital for the business in achieving cost efficiencies, an enhanced reputation, increased customer loyalty, improved access to capital, better ability to plan strategically for the future and better supply chain management. Strandberg Consulting (2009) have also conveyed that companies whom implement sustainability into their corporate agendas experience less volatility in their stock price returns. Such is the increasing significance of sustainability that Price Waterhouse Cooper's conducted a survey in 2003 of company CEO'S, in which

it reported that 79 % of CEO's agreed that sustainability is vital to the profitability of any company and 71 % of CEO's said that when implementing a sustainability program they would forgo short term profitability in exchange for long-term shareholder value.

Role of Publicity

Hanss and Böhm (2010) suggest that consumers increased awareness and perception of sustainability in what Edwards (2005) describes as the 'sustainability revolution' has been realized because of the increased publicity of sustainability issues by the media after 1997 in which the research conducted by Macnaghten and Jacobs (1997) of UK citizens suggested very low awareness and understanding of sustainability. Another valid reason for this increase in awareness is down to sustainability featuring in many political agendas across the globe, as it has slowly become a global issue.

However during the 1990s media attention towards environmental issues took a turn as the media only publicised events or issues regarding sustainability containing some type of scandal or events that included celebrities. This led to a hostile environment for businesses that was a direct result of a 'consumer backlash' as suggested by Crane (2000) because of businesses making deceitful or over the top sustainability claims. With the media becoming critical of business claims towards sustainability, many companies believed that it would be best to keep a low profile with regards to green issues, however companies should have realised that this opportunity could have been used to correct and fine tune green practices. Further to this, with sustainability issues becoming a daily agenda for consumers, this means that consumers are gaining direct experience of the issues involved, as they have to adapt their practices or engage in initiatives such as recycling schemes. The issue is that consumers initially relied upon the media for information on sustainability because it was a virgin topic, which had a novelty and novelty element to it because consumers had little or no knowledge of sustainability, but now this is not the case and he believes that this might be because consumers have developed sufficient knowledge over the years and/or the problem is still existent but media coverage is insufficient to maintain consumer interest in the issue. He conveys that a degree of boredom has been attached to sustainability due to the continued existence of the issues, which has been summarised by Dunlap (2002) as novelty being a long lost asset. What this suggests is that the effect of media attention is only maximized if the issue in question is either new or the issue is cast in dramatic and persuasive manner a thought that is supported by Thøgersen (2005) through the use of guilt appeals.

1.1.4 A Step Forward

> What is the good of having a nice house without a decent planet to put it on? Henry David Thoreau

Regulations relating to sustainability are relatively recent; according to Baroudi et al. (2009) the majority of sustainability standards act as soft law such as The Rio Declaration and therefore acts as guidance for companies to follow if they wish. Agenda 21 the global programme of action on sustainable development contains chapters on the social dimension of sustainability. But non-compliance with the agenda does not constitute a legal offence as Agenda 21 simply acts as guidance. As Bell and Morse (2003) stipulate there are no sustainability guidelines or regulations that are applicable to consumers, rather much a consistent array of guidelines are available for businesses, with legislation being very limited in this field. But what needs to be raised is the issue that in the future these standards would need to be transformed into being mandated, so the forward thinking company would essentially act now to form a culture of continuous improvement in sustainability planning.

However a common consensus is that many researchers believe that the way forward is through education, values that can be instilled into consumers through sharing collective knowledge as a community that should lead to a collective action and a sense of empowerment. In the research thesis we shall determine whether consumers of today agree that education would be the most effective way of increasing awareness and promoting sustainability. Prothero et al. (2011) recent research suggests that the government should take the lead with regards to increasing consumers' environmental and social awareness. This is advice is contradictory to the findings mentioned earlier by Macnaghten et al. (1995), which is why it is important to determine the stance of consumers against sustainability being managed by politicians and how it influences them.

The main differentiating point between this study and previous research is that none of the other research has asked the question of whether they believed that action should have been taken earlier? And whether they believe collective action, as a unified global community with a common agenda should be brought into action through legislative rules that have to be adhered to on a mandatory basis rather than just acting as guidelines?

2 Primary Research

2.1 Research

This research is analytical in nature and explores how sustainability is perceived by consumers and explain why consumers have particular attitudes towards sustainability. The research is also predictive in that we shall speculate that higher

levels of education help consumers better understand and implement sustainability practices and that a more pro-active and long term stance needs to be taken by companies a view supported by IGD (2011), and society in order to ensure the sufficient advancement of sustainability. Through adopting both an analytical and predictive approach we shall be able to fully understand and justify the current stance of consumers towards sustainability and suggest ways to improve consumers attitudes and awareness relating to sustainability. As this research considers the less tangible aspects such as the attitudes and perceptions of consumers it will adopt a qualitative approach. Further to this, the research will be typical of inductive research as we aim to explore what sustainability means to consumers, however this will be very time consuming but the results attained may provide extra insight that may not have been discovered before.

The reasons why this approach has been taken is because questionnaires facilitate the collection of data through asking people to respond to the set of questions without having to incur costs in moderating the communication as in focus groups and telephone interviews. By using postal questionnaires substantial time will be saved as the questionnaires will be completed by the respondents at their earliest convenience and so will allow us greater time to analyse the results once the data is collected. As a benchmark we shall aim to achieve a response rate of 30 % or more and a target sample number of 150 people. To ensure that the questionnaires are designed effectively and efficiently, we shall pilot the questionnaires amongst several consumers initially to gain feedback from them as to whether they think the questions are easy to interpret and suggest what things can be improved or changed. Through ensuring that the questionnaire is well designed, processing and analysis of the results will be made much easier as the results can be quantified.

2.2 Data Collection

Our research data collection instrument was a questionnaire that consisted of 20 questions, which were mainly multiple choice but also included a variety of open-ended, measurement scale and graphical style questions. The questionnaire was spread out over three pages and the questions were arranged in a logical sequence according to which objective the questions answered and also which sub-set topic the question belonged to within the sustainability group. These sub-set topics gave the questionnaire a valid structure as questions related to key topics that influenced sustainability and topics that were identified and discussed within the literature review, thus acting as a set of key criteria. Firstly however, the following information had to be filled in by the respondents, as these variables are key to the analysis of the results:

- Gender
- Age
- Postcode

- Occupation
- Level of income
- Level of education

These variables are really crucial to this research, as based upon these variables we look to establish the effect that these variables may have upon consumers perceptions and attitudes towards sustainability and in doing so look to identify any links between these variables and differences in perceptions and attitudes of consumers. The seven sub-set topics are as follows:

- Awareness (questions 1–4)
- Perceptions and attitudes (questions 5–9)
- Communications (questions 10–12)
- Communities (questions 13–15)
- Public policies (questions 16–18)
- Rewards and recognition (question 19)
- Publicity (questions 20)

Out of the total 155 respondents, 122 respondents completed the postal questionnaire and 33 respondents completed the questionnaire in-person at a retail store. The postal questionnaires were distributed on a random basis throughout Bradford ensuring that several postcode areas were covered to ensure a consistent and fair representation of consumers in Bradford. The respondents had the option to either post the questionnaires back through a pre-paid envelope that was included or they could simply hand in the completed questionnaires at pre-designated convenience stores appropriately distributed across Bradford. The majority of postal questionnaires were received back through the post within 2 weeks however a very small minority chose to drop the completed questionnaires at some of the designated drop off points. For the in-person questionnaire, with permission from the partners of the retail store, I was allowed to engage with customers in-store and ask them whether they would be willing to participate in the research. The retail store was a multi-award winning convenience store named J&H Local that is located on the outskirts of Bradford that has a strong customer footfall bringing in customers from all areas of Bradford.

2.3 Data Analysis

The qualitative data was generated from the open-ended questions that will be analysed in such way that key recurring information from each question and questionnaire will be extracted and then coded. This provides us with the ability to study and interpret this coded information and then look at the significance of the remaining qualitative information. The qualitative information will then be interpreted using a consistent data structure that will also apply to the quantitative information. The benefits of doing this, is that we shall be able to gain an

understanding of the issues according to different hierarchical levels. Further to this, it will allow us to conduct further analysis through identifying how the variables effect the sub-topics of sustainability. The data structure will contain the following aspects:

- Gender
- Age
- Postcode
- Occupation
- Level of income
- Level of education

For the measurement scale question number six that uses a ranking system, the data will be analysed using a meaningful scoring system. To use such a scoring system for analysing a question that involves the indication of preferences is supported by Pretty et al. (1995) and Abeyasekera et al. (2000). The scoring system will involve the following aspects:

- 1ST PREFERANCE = 4 POINTS
- 2ND PREFERANCE = 3 POINTS
- 3RD PREFERANCE = 2 POINTS
- 4TH PREFERANCE = 1 POINT

The option with the highest score will ultimately prove to be the most critical in the evaluation. Further to this, this will allow us to conduct statistical analysis of the results through conducting mean analysis.

The quantitative data that arises from the multiple-choice and graphical questions will also be subject to quantitative analysis using the same data structure so as to ensure comparability. All of the results will be presented graphically in the form of either bar, pie or radar charts.

3 Results

3.1 Awareness

For this topic we shall present the results of question numbers; one, two, three and four.

3.1.1 Q.1-Awareness of Environmental Impacts of the Products Bought and Used

Figure 8 indicates that still a large majority of the consumer population in Bradford roughly 4 in 10 (39.9 %) consumers are unaware of the true extent of sustainability

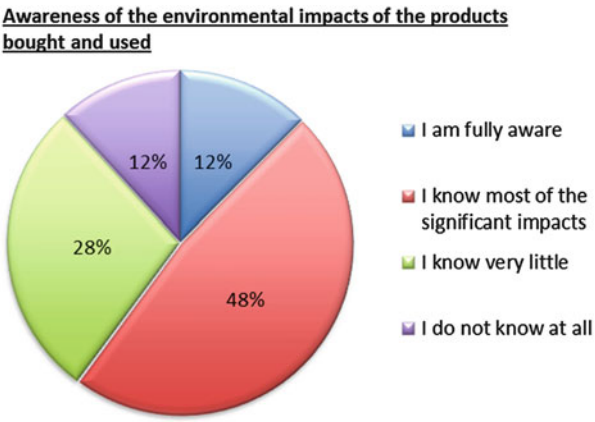

Fig. 8 Q1. How much do you know about the environmental impact of the products you buy and use?

and how their product consumption and use has an indirect negative effect on the environment throughout the value chain process, from the cradle to the grave.

Socio-demographic Considerations

An interesting discovery is that the *62+* age group has greater awareness of environmental products than the youngest age group, as only 6.2 % indicated that they *know very little*, with an equivalent amount of 18.8 % indicating that they *know nothing at all*. The age group that displayed the best awareness of environmental impacts was *51–61* as 77.4 % of the consumers in this age group indicated that they either are *fully aware* or *know most of the significant impacts*, with the *29–39* age groups trailing behind in second place with 70.4 %. This can be directly correlated to *students* and *retired* people, as 81.9 % of *retired* consumers indicated that they are *fully aware* or *know most of the significant impacts* compared to a substantially lower 33.3 % of students.

However the most decisive result obtained is that 15.6 % of consumers who had no university degree indicated that they *know nothing at all* and 30.3 % indicated that they *know very little* about the environmental impacts. However in comparison to this 2.4 % of consumers with a university degree indicated that they *know nothing at all* and 23.8 % indicated that they *know very little*.

3.1.2 Q.2-Awareness of Sustainability Labels/Eco-Labels?

Figures 9 and 10 that depicts the relativities, the *Rainforest Alliance* logo in comparison to the other logos is recognised 17 % of the time with the *Energy Saving Trust* being recognised 20 % of the time just behind the *Forest Stewardship Council* at 23 % of the time. The huge lack of awareness of the *European*

$QuesTwo Frequencies

		Responses		Percent of Cases
		N	Percent	
Awareness of sustainability symbols[a]	Q.2 - European Sustainability	22	6.5%	16.5%
	Q.2 - Fairtrade	114	33.9%	85.7%
	Q.2 - Forest Stewardship Council	76	22.6%	57.1%
	Q.2 - Energy Saving Trust	66	19.6%	49.6%
	Q.2 - Rainforest Alliance	58	17.3%	43.6%
Total		336	100.0%	252.6%

Fig. 9 Q2. Are you aware of any of the following sustainability labels/eco-labels?

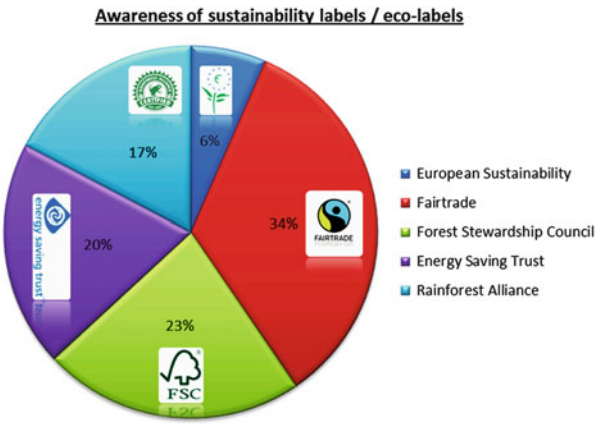

Fig. 10 Q2. Are you aware of any of the following sustainability labels/eco-labels?

Sustainabilty logo can be seen with just 6 % awareness compared to the 34 % represented by the Fairtrade symbol.

Socio-demographic Considerations

In general *females* indicated a greater degree of awareness of the logos across the majority of the logos in comparison to their *male* counterparts. The *females* recognized the other three logos bar the *Energy Saving Trust* and *Rainforest Alliance* to a greater combined degree of 20.5 % in comparison to the *males*.

Again the results indicated that consumers with *a university degree* showed greater total awareness of the sustainability logos by a greater net degree of 32.7 % than compared to consumers who did *not have a university degree* at all.

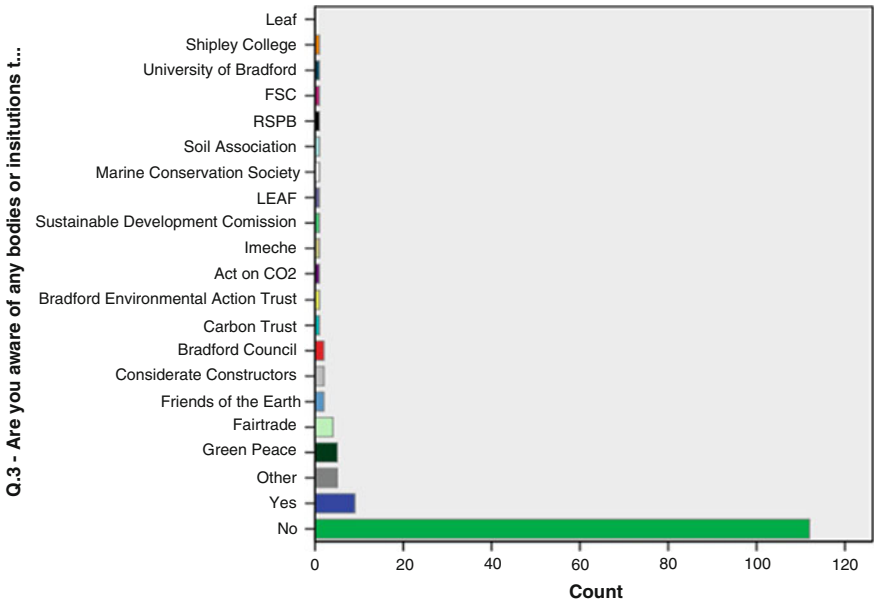

Fig. 11 Q3. Are you aware of any bodies or institutions that promote sustainability?

3.1.3 Q.3-Awareness of Bodies/Institutions Promoting Sustainability?

Roughly only a quarter (26.4 %) of Bradford consumers answered that they *are aware* of a body/institution that promoted sustainability. Out of this 26.4 %, 20.6 % of consumers mentioned a particular body/institution that promoted sustainability, with *Greenpeace* being stated the most amount of times by consumers accounting for a minuscule 3.3 % awareness overall. As can be seen from Fig. 11, a very large majority of consumers, exactly 72.3 % indicated that they are *not aware* of any bodies/institutions that promote sustainability. A small minority of consumers (5.8 %) simply indicated that they *are aware* of bodies/institutions but did not state any.

Socio-demographic Considerations

The age groups of *18–28* and *29–39* indicate a lower degree of awareness of bodies/institutions that promote sustainability than compared with the older age groups. The *18–28* age group represents 26 % awareness, the *29–39* indicates 21.4 % awareness compared to the *62+* age group which represents the highest awareness at 31.3 %. Interestingly, from an income perspective the results indicate that the income group of *£30,000–£45,000* that can be attributable to medium class society shows the highest degree of awareness with 40.9 % indicating and stating a body/institution that promoted sustainability. The income groups at either end of the scale

representing the lower class and higher class societies indicated lower awareness, with the < *£15,000* group showing 16 % awareness and the > *£60,000* group showing 26 % awareness. Repeatedly, the results indicated that 40.5 % of consumers whom had attained a *university degree* showed that they are aware of a body/institution that promoted sustainability compared to 22 % who had *no university degree*.

3.1.4 Q.4-Most Effective and Influential Form of Communication?

Approximately 6 in 10 consumers (59.3 %) answered that *media campaigns* were perceived as being the most effective and influential in promoting the awareness of sustainability with *education classes/courses* being the second preferred choice with 2 in 10 consumers (20.7 %). A small minority of consumers at 7.3 % believed that *government publications* was the best choice and 12.7 % believed that commercial schemes would be the most effective and influential.

Socio-demographic Considerations

Consumers that work in the *education* sector also believe that the most effective and influential form of communication to promote awareness of sustainability would be through *media campaigns* ahead of *educational classes/courses*, as typically every profession group has more than a 40 % weighting in preference for media campaigns. However, 37.5 % of housewives believe that commercial schemes would be the most effective and influential form of communication. On the other hand 45.5 % of *retired* consumers believe that *educational classes/courses* are the most effective and influential form of communication. However, in both of these professions *media campaigns* came in second place.

3.2 Perceptions and Attitudes

For this topic we shall present the results of question numbers; five, six, seven, eight and nine as depicted.

3.2.1 Q.5-Perceived meaning of sustainability?

A staggering roughly 5 in 10 (52.1 %) Bradford consumers were *not sure (24.4 %)* or gave the *wrong answer (11.1 %)* or indicated that sustainability meant *nothing (3.7 %)* to them and a further 12.9 % of consumers failed to answer the question. Shockingly only 2.2 % of consumers most accurately described sustainability through *economic, social and ecological dimensions*, with a further 25.2 % of

Meaning of sustainability			
		Count	Table Valid N %
Q.5 - What does sustainability mean to you	Wrong answer	15	9.7%
	Not sure	33	21.3%
	Nothing	5	3.2%
	Long term management of Earth's resources from social, economic and environmental aspects to ensure going concern	3	1.9%
	Long term responsibility to maintaining the environment	34	21.9%
	Prolonging use of natural resources	11	7.1%
	Going goncern	16	10.3%
	Reducing carbon emissions/footprint	6	3.9%
	Renewable energy	2	1.3%
	Recycle	5	3.2%
	Re-use	3	1.9%
	Last gasp attempt	2	1.3%
	No answer	20	12.9%
	Total	155	100.0%

Fig. 12 Q5. What does sustainability mean to you?

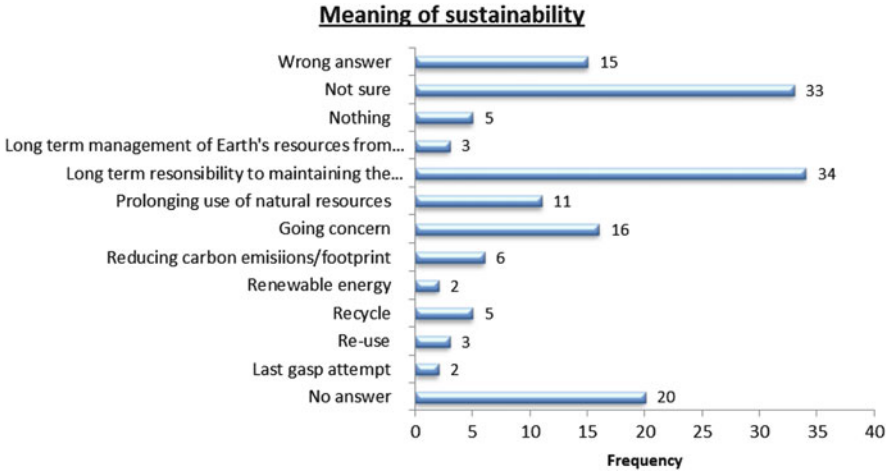

Fig. 13 Q5. What does sustainability mean to you?

consumers adequately defining sustainability through *long term responsibility towards managing the environment* (Figs. 12 and 13).

Socio-demographic considerations

Consumers in the *£30,000–£45,000* income bracket indicate a lower overall misunderstanding of sustainability at 28.5 % which is lower than the lowest and highest income groups. The $<$ *£15,000* income group indicates a total misunderstanding of

Fig. 14 Q6. How important are the following aspects when making a decision on which products to buy?

43.5 %. The > *£60,000* income group indicated a total misunderstanding of 38.1 %. Surprisingly, consumers whom have a *university degree* perceive a better understanding of sustainability at 69.9 % (4.8 % of consumers gave the correct definition plus 64.3 % of consumers gave a reasonable definition) than compared with those with *no university degree* at 53.8 % (1.1 % of consumers gave the correct definition plus 52.7 % of consumers gave a reasonable definition).

3.2.2 Q.6-Perceived Importance of Aspects When Buying Products

As can be seen from Fig. 14 *quality* is in number one position of importance closely followed by *price* in position number two, then *availability* in third position and lastly comes *sustainability*. This diagram is representative of the correct modal positions of each of the aspects. A total of seven consumers did not answer this question.

Socio-demographic Considerations

The > *£60,000* income group indicates that the *price* aspect is of no concern which is why only 14.3 % of consumers regard price as being the most important aspect, which is considerably less than the average of 42.4 % consumers of the other income groups. The *18–28* and *29–*39 age groups gave less importance to the *sustainability* aspect than the *40–50, 51–61 and 62+* age groups whom at least gave consideration to *sustainability* in first position ranging in-between 13 % and 15 %. Interestingly, 48.7 % of consumers with a *university degree* and 55.1 % of consumers with *no university degree* place *sustainability* in fourth place.

3.2.3 Q.7-Attitudes Towards Low Environmental Impact Products and Services

Overwhelmingly 44.8 % of consumers answered that they would *give their loyalty* to a company that was offering products and services with a low environmental impact. However 2 in 10 (20.8 %) Bradford consumers indicated that their loyalty would *not be won* and a further 34.4 % of consumers were *not sure* as to whether they would become loyal to a company offering products and services with a low environmental impact. This ultimately leaves an indecisive result as a considerably large amount of consumers whom indicated *not sure* will be basing their decision on an external variable such as *price, quality* and *availability*. Only one respondent did not answer.

Socio-demographic Considerations

The age group *18–28* indicates a perceived decrease in loyalty at 36.4 % towards companies whom provide products and services that have low environmental impact than compared with all of the other age groups whose average *yes* to loyalty is 48 %. The most decisive age group is *51–61* in which a staggering 61.3 % of consumers said *yes* in giving their loyalty to a company offering products and services with a low environmental impact.

3.2.4 Q.8-Is Sustainability Being Exploited as a Marketing Tool?

A large proportion of consumers at 5 in 10 (50.6 %) answered *yes* that they do believe that companies are exploiting sustainability as a marketing tool. A small minority of 14.3 % of consumers indicated *no* in that they do not believe that sustainability is being exploited as a marketing tool, with a further 35.1 % of consumers answering that they are *not sure*. Only one respondent did not answer.

Socio-demographic Considerations

Consumers whom have a *university degree* depict a slightly more sceptical attitude towards the actions of a company as 54.8 % answered *yes* in comparison to the 49.1 % of consumers with *no university degree*. Further to this, 7.1 % of consumers with a *university degree* answered *no*, compared to 16.4 % of consumers with *no university degree*.

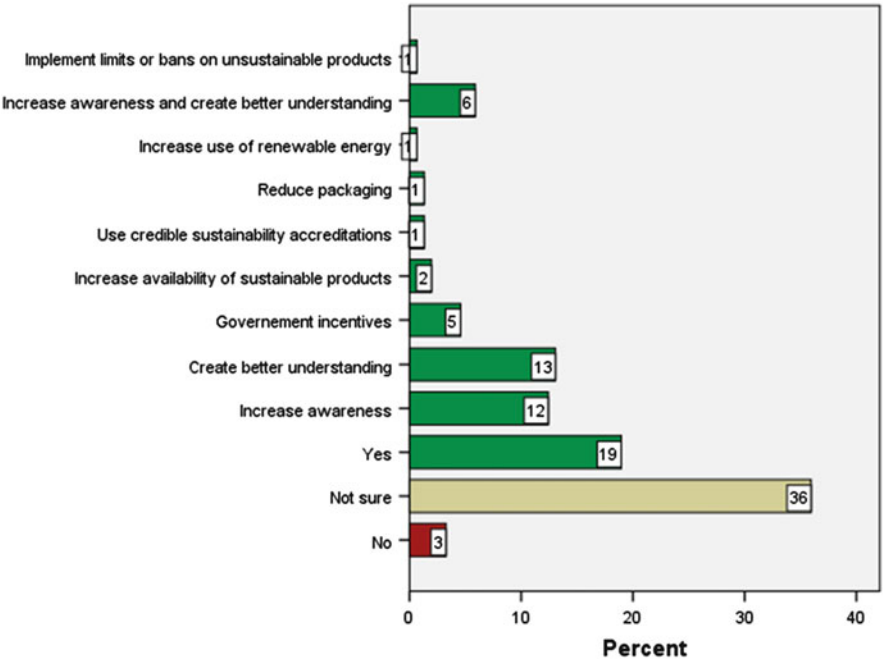

Fig. 15 Q9. Do you believe more effort should be made to promote and advance sustainability?

3.2.5 Q.9-Should more Effort be made to Promote Sustainability?

Roughly 4 in 10 (39.2 %) Bradford consumers indicated that they are either *not sure (35.9 %)* or *no (3.3 %)* to whether more effort should be made to promote and advance sustainability. However, positively a larger proportion of consumers at 6 in 10 (61 %) people believed that *yes* more effort should be made. Only two consumers did not answer.

As can be seen in Fig. 15, the most popular way in which consumers believe that sustainability should be promoted and advanced is through *creating a better understanding (13 %)* or through *increasing awareness (12 %)*. This result is further cemented through further support by 6 % of consumers whom believe that both *increasing awareness and creating a better understanding* is necessary, leading to a combined support of 31 %.

Socio-demographic Considerations

The interesting fact however is that *40–50* has a higher 58.8 % response and the *51–61* has an even higher response of 70 % stating *yes*. Looking at professions/ industries, *unemployed* consumers and *housewives* indicate a much lower degree of support to advance sustainability with just 25 % answering *yes* compared to 72 % of

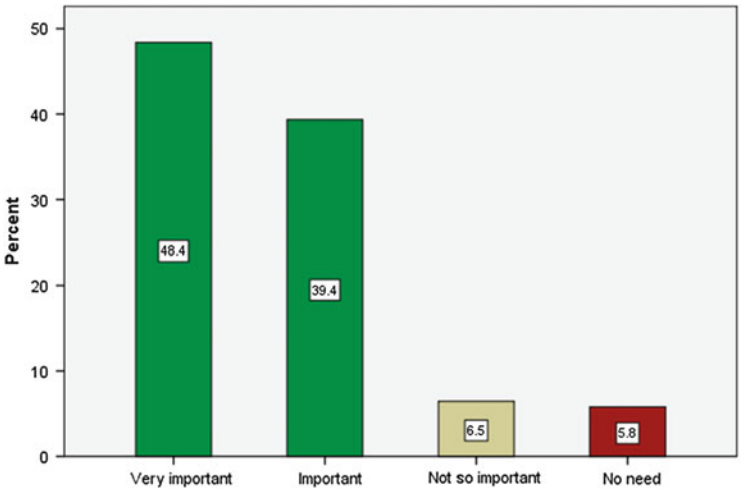

Fig. 16 Q10. How crucial do you think it is for companies to report and communicate their environmental performance?

business consumers. Consumers placed in either the *£45,000–£60,000* or > *£60,000* groups generally indicate a greater degree of support for advancing and supporting sustainability. The *£45,000–£60,000* group indicates 83.3 % answered *yes* and the > *£60,000* group indicates that 78.2 % answered *yes*. This in comparison to the < *£15,000* group in which 56 % of consumers answered *yes*, indicates that the highest income groups that are bordering on upper-middle class society and high class society, show a greater degree of support in believing that more effort should be made to promote and advance sustainability. 78.6 % of consumers with a *university degree* answered *yes*, compared to only 53.2 % of consumers with *no university degree*. 43.1 % of consumers with *no university degree* answered that they were *not sure*.

3.3 Communications

For this topic we shall present the results of question numbers; ten, eleven and twelve.

3.3.1 Q.10-Communication and Reporting of Environmental Performance?

Roughly 9 in 10 (87.7 %) Bradford consumers believe that it is either *very important (48.4 %)* or *important (39.4 %)* for companies to report and communicate their environmental performance (Fig. 16).

Socio-demographic Considerations

The *62+* age group has indicated at 18.8 % the highest support out of any of the groups for answering that there is *no need* for companies to report and communicate their environmental performance. However 11.1 % of consumers in the *18–28* age group answered that it is *not so important* for companies to report and communicate their environmental performance, which is the highest proportion for any age group. Interestingly consumers whom have a *university degree* showed a greater degree of support for companies to report and communicate their environmental performance with 57.1 % answering that it is *very important* and only 2.4 % indicating that there is *no need*. Comparing this to consumers with *no university degree*, 45 % indicated it is *very important* and 7.2 % answered that there is *no need*.

3.3.2 Q.11-Inspiration/Encouragement to Participate in Sustainable Practices?

A staggering 7 in 10 (68.2 %) Bradford consumers answered that they have *not* been inspired or encouraged to participate in sustainable practices or initiatives, with 3 in 10 (31.8 %) people said that they *yes* they had been influenced or encouraged to participate in sustainable practices or initiatives. Only one consumer did not answer.

Socio-demographic Considerations

The age group with the highest proportion of consumers at 79.5 % whom indicated that *no* they have never been encourage or inspired to participate in sustainable practices is the *18–28* age group. This is then closely followed by the *29–39* age group with 71.4 % and then by the *62+* age group with 68.8 %. Interestingly, through analysing postal codes as depicted in Fig. 17, consumers whom live in postcode areas *BD3 (11.1 %) and BD 4 (14.3 %)* indicate a very low degree of answering *yes* with an average response to *yes* of 12.7 %. However 30.8 % of consumers living in postal code area *BD9* responded answering *yes*, with an increased amount of consumers at roughly 4 in 10 (39.3 %) people in postal code area *BD15* answering *yes*.

Eight in ten Bradford consumers in the *< £15,000* income group have indicated that *no* that they have never been inspired/encouraged to participate in sustainable practices or initiatives, the highest rate out of any of the income groups. Interestingly, 52.4 % of consumers whom have obtained a *university degree* answered *no*, a much lower figure than compared with 73.6 % of consumers whom had *no university degree*.

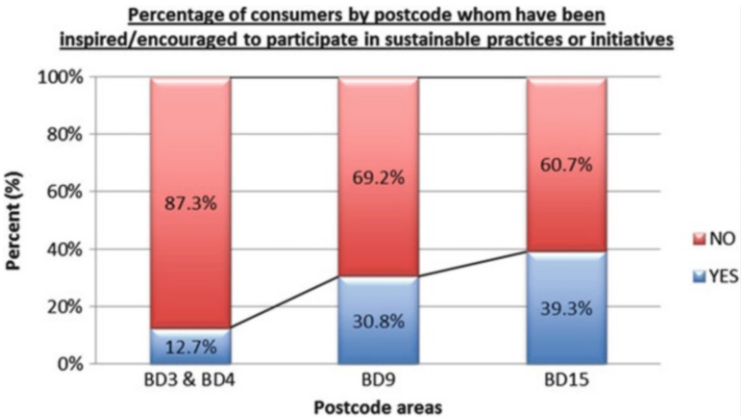

Fig. 17 Q11. Have you ever been inspired/encouraged to get involved in sustainable practices or initiatives?

3.3.3 Q.12-Current Sustainability Practices/Initiatives

33.3 % of Bradford consumers indicated that they did *nothing* in terms of participating in any sustainability practices or initiatives. The most commonly occurring activity with 43.7 % of consumers participating is *recycling* ahead of the second most popular activity with only 7.9 % of consumers is *Energy saving equipment/technologies/insulation* and then with 5.6 % of consumers is actively seeking to *buying sustainable products*. A staggering 29 people failed to answer this question, an apparent anomaly in responses received may be because these consumers simply may not be involved in any such sustainable activities and therefore chose not to answer the question.

As can be seen in Fig. 18, other activities that consumers are involved include; 3.2 % of consumers are a member of a *sustainability committee/organization*, 2.4 % have adopted and follow *ISO14001/9001 standards* at work, 1.6 % volunteer towards *community work* and a further 1.6 % actively seek to *re-use materials* as much as possible in every aspect of daily life and 0.8 % of the sample population have made themselves aware of *COSHH regulations* at work.

Socio-demographic Considerations

The results show that 3 in 10 (30.3 %) *male* consumers currently are involved in *no* sustainability practices or initiatives, which is slightly better than compared with approximately 4 in 10 (38 %) *female* consumers whom answered *no*. Interestingly, 44.1 % of consumers in the *18–28* age group indicated that they are currently involved in *no* sustainability practices or initiatives which is the highest amongst the age groups, as this gradually seems to improve as the age increases up until the point that the *51–61* age group has 32.1 % consumers that said they do *nothing* and

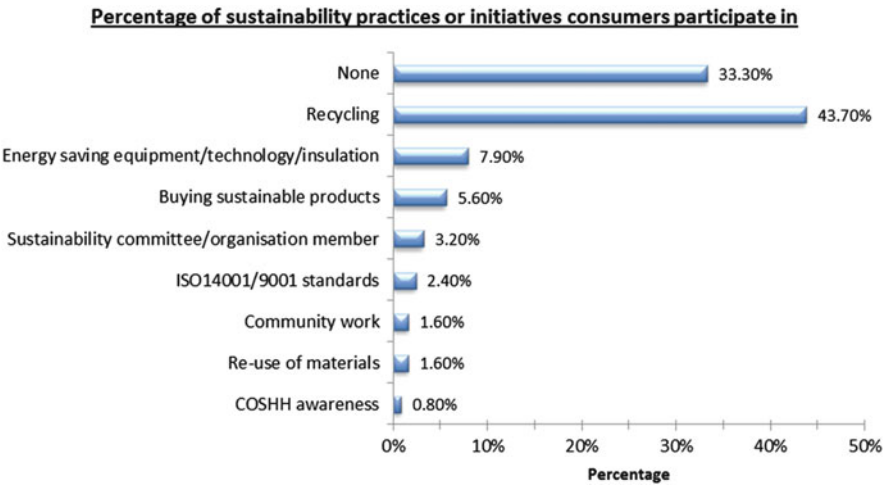

Fig. 18 Q12. What sustainability practices or initiatives are you currently involved in?

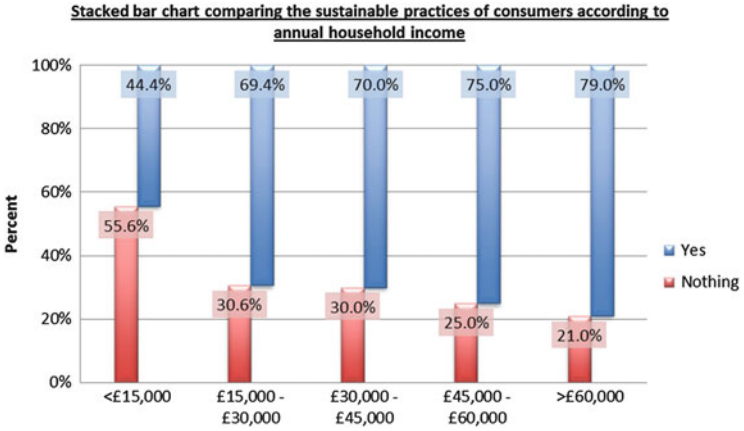

Fig. 19 Q12. What sustainability practices or initiatives are you currently involved in?

surprisingly 0 % of consumers in the *62+* group answered that they did *nothing*, as a large majority of these consumers at 83.3 % were involved in *recycling*.

Looking at household income as seen in Fig. 19, essentially what has been revealed is that the lower the income group is, the higher the rate is of consumers whom do *nothing* in terms of sustainability practices or initiatives and therefore the lower the rate of consumers whom are consistent with *yes* in that they are involved in some sort or type of sustainability practice or initiative. As an incredible 55.6 % of consumers in the *< £15,000* group, 30.6 % of consumers in the *£15,000–£30,000*, 30 % of consumers in the *£30,000–£45,000* group, 25 % of

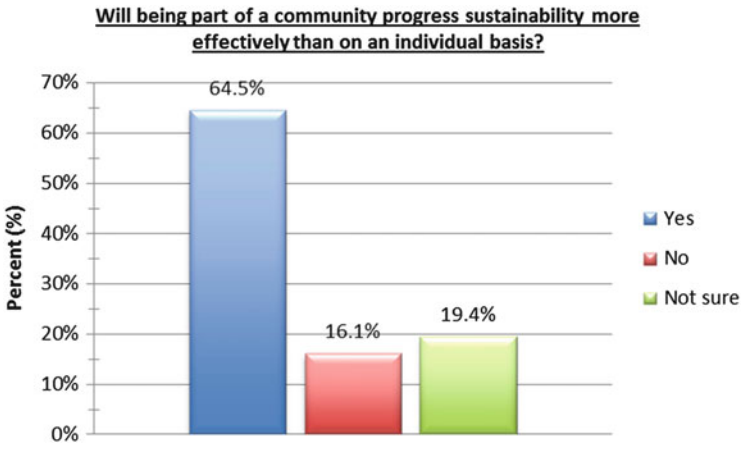

Fig. 20 Q13. Do you think that being part of a community will help to progress sustainability more effectively than on an individual basis?

consumers in the *£45,000–£60,000* and 21.1 % of consumers in the *> £60,000* group indicated that they did *nothing*.

Finally, a greater degree of consumers with a *university degree* exhibited that they were involved in some type or form of sustainability practice or initiative as only 25.7 % of these consumers indicated that they did *nothing* compared to 36.3 % of consumers who have *no university degree*.

3.4 Community

For this topic we shall present the results of question numbers; thirteen, fourteen and fifteen.

3.4.1 Q.13-Would Being Part of a Community Benefit Sustainability?

Positively a large majority of consumers at 64.5 % indicated that *yes* being part of a community will help to progress sustainability more effectively than on an individual basis. However, a small minority of consumers at 16.1 % answered that *no* they believe it will make to no effect, and further to this roughly 2 in 10 (19.4 %) Bradford consumers indicated that they were *not sure*. The results are illustrated in Fig. 20.

Again a number of consumers have indicated that they are *not sure* which may imply that other external factors are influencing the decision of consumers, and such factors may be like the *availability of time* and the *willingness of individuals* to collectively act as a community in order to make a positive effect.

Socio-demographic Considerations

Approximately 6 in 10 Bradford consumers in both the age groups of *18–28* and *29–39* answered that *yes* being part of a community would help to progress sustainability more effectively than on an individual basis. This however, represents a lower degree of consumers answering *yes* compared to all the other age groups, as for example the *40–50* group has 73.5 % consumers answering *yes* and 64.5 % of consumers in the 51–61 group answering *yes*.

Looking at professions/industries, the results indicate that 37.5 % of consumers in both the *housewives* and *unemployed* status indicated that *no* being part of a community will not help to progress sustainability more effectively than on an individual basis. Interestingly however, again a further 37.5 % of consumers in both the *housewives* and *unemployed* statuses indicated that *yes* being part of a community would be more beneficial. However this indicated that these groups have the highest degree of consumers whom answered *no* and the lowest degree of consumers whom answered *yes*. Looking at annual household incomes, the results indicated that consumers whom were placed in the lower to middle income groups such as $<$ *£15,000*, *£15,000–£30,000* and *£30,000–£45,000* had a higher degree of consumers at an average of 67.73 % indicating that *yes* being part of a community would help to progress sustainability more effectively than on an individual basis compared to the lower average of 56.05 % of consumers in the *£45,000–£60,000* and $>$ *£60,000* income groups that indicated *yes*.

3.4.2 Q.14-What/Who Is Associated as Being the Main Community?

Overwhelmingly 65.2 % of Bradford consumers answered that they believe *the locality in which you live* is what they associate as being their main community. Narrowly coming into second place with 13.5 % of consumers vote is *a particular group of people* closely followed by *your place of work* with 12.3 % of consumers in third place. A minority of consumers at 6.5 % indicated that *your place of worship* was what they associate as their main community and lastly 2.6 % of consumers answered *your place of education*. Quintessentially, 0 % of consumers indicated that they associated their main community as being *a political institution*, possibly hinting a strong consumer discontent and dissociation with politicians and political activities/policies.

Socio-demographic Considerations

Interestingly a greater degree of consumers that reside in the postcode areas of *BD3* and *BD4* indicated that they associate their main community as being *your place of work* with 33.3 % of consumers in *BD3* and 42.9 % of consumers in *BD4* which leads to an average 38.1 % of consumers. These proportions of consumer votes are equally the same for both of these postcodes for choosing *the locality in which you*

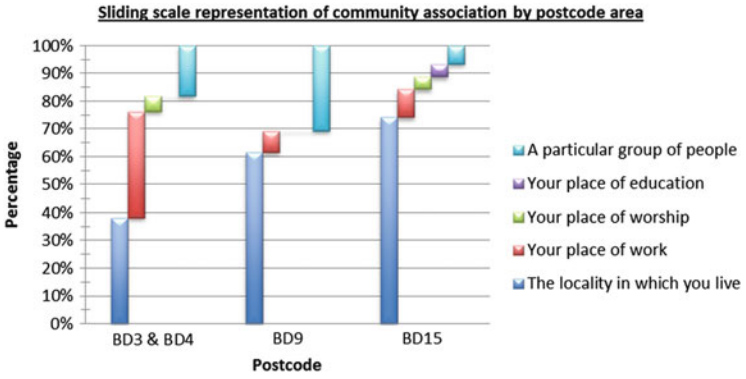

Fig. 21 Q14. What/who would you associate your main community as being?

live, which therefore exhibits the lowest percentages of support for this option than any other postcode area. Further to this, the postcode area of *BD9* indicated that a greater degree of consumers at 61.5 % answered that their main community is *the locality in which you live*. However the postcode area of *BD15* has an even higher degree of consumers at 74.2 % answering that they associate their main community as being *the locality in which you live*. This apparent sliding scale of associations based on postcode areas is depicted in Fig. 21.

Uniquely the results have indicated a correlation between the level of household income and the choice made by consumers to the association of their main community. It can be seen that as the income level groups increase in value, the degree of consumers whom associate the *locality in which you live* as their main community begins to decrease on a continuous basis as shown in Fig. 22.

3.4.3 Q.15-Willingness of Consumers to Participate in Sustainable Practices as a Community

Approximately 46.5 % of Bradford consumers indicated that they were either *very willing (11.6 %)* or *willing (34.9 %)* to participate in sustainability practices as a community. However, roughly 4 in 10 (38.7 %) consumers indicated that *maybe* they may join in sustainable practices as a community, thus suggesting that again consumers are being influenced by external factors such as the *availability of time* and taking consideration of *financial constraints* as also previously identified in question number 13. The remaining 14.8 % of consumers answered that they are *not willing* to participate in any sustainable practices as a community.

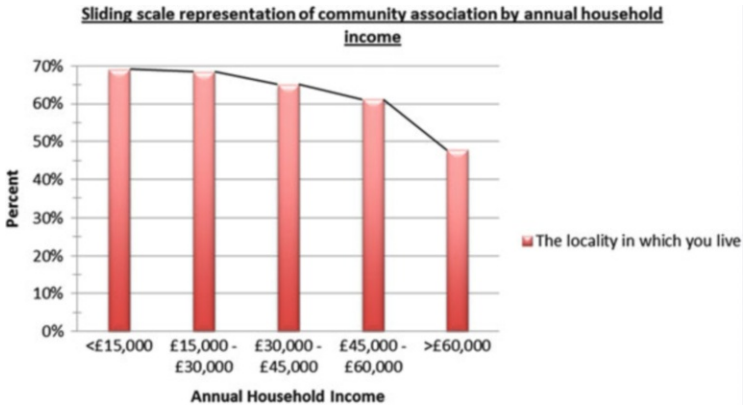

Fig. 22 Q14. What/who would you associate your main community as being?

Socio-demographic Considerations

Interestingly the results indicated that a greater majority of *females* at 18.3 % indicated that they would be *not willing* to participate in sustainability practices as a community compared to 11.6 % of *males*. Looking at age groups, only 6.2 % of consumers in the *62+* group indicated that they would be *very willing* and only 25 % of consumers said that they would be *willing* to participate in sustainability practices as a community, the lowest proportions of consumers for these options out of all the age groups. Thus, 37.5 % of consumers in the *62+* age group answered that they would be *not willing* to participate in sustainable practices as a community, the highest proportion out of any age group again.

Looking at annual household incomes, the results indicate a strong correlation between the level of household income and the willingness of consumers to participate in sustainability practices as a community, as is depicted in Fig. 22. The tendency is that the lower the income group level, the lower is the willingness of consumers to participate in sustainability practices as a community. The *< £15,000* income group has a combined willingness of 34.6 %, compared to the *£15,000–£30,000* group which has a combined willingness of 48.8 %, the *£30,000–£45,000* group has a combined willingness of 52.1 % and the *£45,000–£60,000* group has a combined willingness of 66.7 %, but the *> £60,000* group has a slightly lower combined willingness of 60.8 %. This slump at the end may be due to lack of time for high earning professionals and families whom may have many professional responsibilities which do not allow the slightest of flexibilities than compared with domestic responsibilities. The results further indicate that consumers whom have a *university degree* have a greater tendency to have a greater combined willingness at 71.4 % compared with the 38.7 % combined willingness of consumers whom have *no university degree*.

3.5 Public Policies

For this topic we shall present the results of question numbers; sixteen, seventeen and eighteen.

3.5.1 Q.16-Consumer Confidence in Politicians

Astonishingly approximately 9 out of 10 (87.1 %) Bradford consumers indicated that *no*, they do not trust politicians to act in the best interest of the environment when setting policies relating to sustainability. The remaining minority of consumers at 12.9 % indicated *yes* they do trust politicians. This result reinforces the assumptions made in question number 14, as this proves that a very large majority of Bradford consumers have indicated a strong discontent and dissociation with politicians and political activities/policies, due to a simple loss of trust which has resulted in a lack of confidence.

Socio-demographic Considerations

There are not many significant variations or correlations that can be presented seen as though the result of this question is so one-sided. However, a higher degree of *male* consumers at 89.5 % indicated that *no*, they do not trust politicians to act in the best interest of the environment when setting policies compared to 83.3 % of *female* consumers. Interestingly, by age groups the highest number of consumers whom indicated *yes* they do trust politicians is the *18–28* age group with roughly 2 in 10 (22.2 %) consumers indicating this and in second place is the *29–29* age group with 14.3 % of consumers indicating *yes*. Looking at household income groups, the *< £15,000* group has the lowest degree of consumers whom trust politicians as only 7.7 % indicated that *yes* they trust politicians compared to the highest of only 16.7 % of consumers in the *£45,000–£60,000* group.

3.5.2 Q.17-Ways in Which a Real Change Can Be Made

Collectively 54.4 % of consumers indicated that either *education (17.6 %)* or *media (16.8 %)* or both *education & media (20 %)* was the best way to make a real change towards promoting sustainability. However 17.6 % of the sample population indicated that they were *not sure* as to how a real change can be made. A further 8 % of consumers believed that the best way to make a real change was through *collective action* by which every consumer was part of a community that collectively looked to promote sustainability, as these consumers believed that the collective knowledge and force of consumers in a community would be the best way. In addition to this 5.6 % of consumers indicated that *a pro-active* attitude was

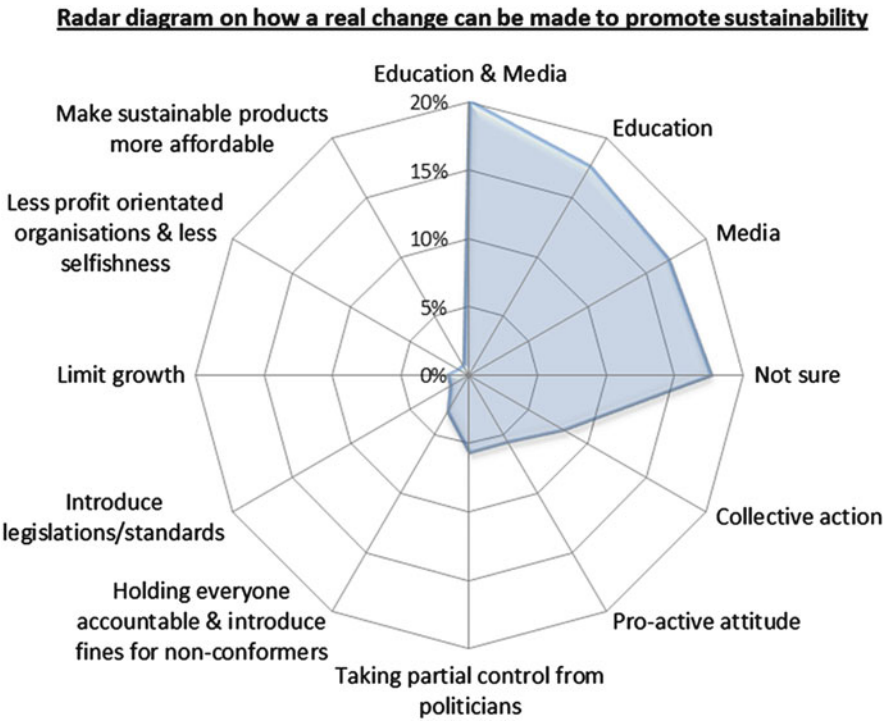

Fig. 23 Q17. How do you think a real change can be made towards promoting sustainability?

required from consumers, companies and the government in order to create positive momentum towards making a real change. Another 5.6 % of consumers however answered that *taking partial control from the politicians* was the best way to make a real change towards promoting sustainability (Fig. 23).

Other slightly more harsher options that consumers suggested included 3.2 % of consumers saying that *everyone should be held accountable and fines should be introduced for non-conformers*, a further 1.6 % of consumers suggested that the best way to make a real change would be to *introduce legislations/standards* and another 1.6 % consumers suggested to *limit growth* of the population and a very small minority of consumers at 0.8 % indicated that *nothing can be done* in their view. Other minority motions included 0.8 % of consumers indicating that there should be *less profit orientated organisations and less selfishness* and a *further* 0.8 % of consumers indicated that by *making sustainable products affordable* a real change will be made towards promoting sustainability. Surprisingly nearly 2 in 10 (19.4 %) Bradford consumers failed to answer this question by leaving it blank, which may suggest that the consumers may not be sure as to how a real change can be made towards promoting sustainability.

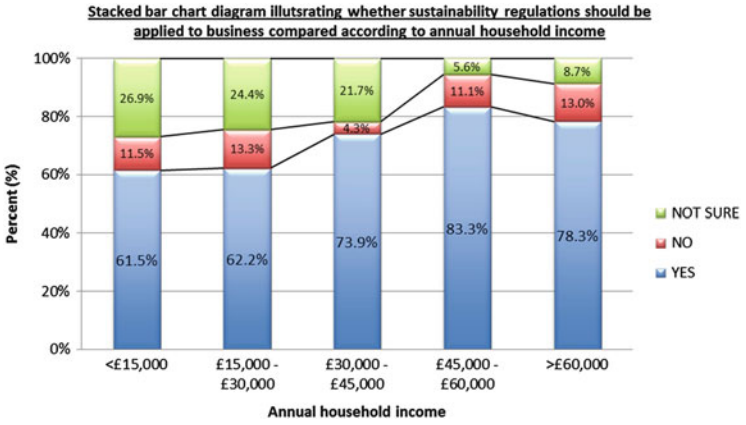

Fig. 24 Q18. Should sustainability regulations be applied to businesses?

Socio-demographic Considerations

Looking at age groups, 48.5 % of consumers in the *18–28* group indicated that the best way to make a real change towards promoting sustainability was through *education (10.3 %)* or *media (17.9 %)* or *education & media (10.3 %)*. However surprisingly this is one of the lowest levels of support for such options compared with the other age groups whom have a combined average of 61.48 % of consumers indicating that either *education* or *media* or *education & media* are the best options in their view. Looking at annual household income groups, the results indicate that 30 % of consumers in the *< £15,000* group indicated *education* as the sole option to make a real change towards promoting sustainability, and this proves to be the highest percentage of support for solely *education* out of any of the income groups. Similarly, 20.9 % of consumers with *no university degree* indicated that solely *education* was the best way to make a real change towards promoting sustainability. This proves to be a higher degree of support for this option as only 8.1 % of consumers with a *university degree* indicated that *education* solely was their choice.

3.5.3 Q.18-Should Sustainability Regulations Be Applied to Businesses?

Approximately 7 in 10 (70.3 %) Bradford consumers indicated that *yes* sustainability regulations should be applied to businesses. Another approximately 2 in 10 (19.4 %) consumers indicated that they were *not sure* as to whether sustainability rules should be applied to businesses with the remaining minority of consumers at 10.3 % answered *no*. The results are illustrated in Fig. 24.

Socio-demographic Considerations

Interestingly, as can be seen in Fig. 24 the results portray that the general tendency is that the lower the income is then generally the level of support decreases for consumers answering *yes* in that sustainability regulations should be applied to businesses. The support gradually rises from 61.5 % of consumers indicating *yes* in the *< £15,000* income group to a peak of 83.3 % in the *£45,000–£60,000* income group and then slightly dips of to 78.3 % in the *> £60,000* income group. Approximately a staggering 9 in 10 (90.5 %) Bradford consumers with a *university degree* indicated that *yes* sustainability regulations should be applied to businesses which is much higher in comparison to 63.1 % of consumers with *no university degree* saying *yes*.

3.6 Rewards and Recognition

For this topic we shall present the results of question number nineteen.

3.6.1 Q.19-Likeliness of Increased Engagement in Sustainability if Support/Guidance/Education is Available?

62.6 % of consumers answered that *yes* they would be more likely to engage in sustainability if they received support/guidance/education, with only 13.5 % of consumers answering *no* and the remaining 23.9 % of consumers indicated that they were *not sure*. A relatively high amount of consumers indicated *not sure* which again may be influenced by external factors such *availability of time* or *financial constraints* and *willingness*.

Socio-demographic Considerations

Looking at profession/industry group, consumers whom are *housewives* indicated the lowest degree of support within the group with only 12.5 % answering *yes* that they would be more likely to engage in sustainability practices and instead had the highest degree of consumer support at 62.5 % for indicating that they were *not sure*. Approximately 7 in 10 (71.4 %) Bradford consumers with a *university degree* indicated that *yes* they would be more likely to engage in sustainability practices which is much more optimistic than the 59.5 % of consumers that answered *yes* and had *no university degree*.

3.7 Publicity

For this topic we shall present the results of question number twenty.

3.7.1 Q.20-Will Increased Positive Publicity from the Media Influence Consumers to Become more Sustainable?

63.9 % of consumers answered that *yes* they believe that increased positive publicity from the media would influence them to become more sustainable, with only 13.5 % of consumers answering *no* and the remaining 22.6 % of consumers indicated that they were *not sure*. Again, a relatively high amount of consumers indicated *not sure* which again may be influenced by external factors such as *availability of time* or *financial constraints* and *willingness*.

Socio-demographic Considerations

There are not many significant variations or correlations that can be presented seen as though the result of this question is one-sided and that the responses by consumers seem to be spread comparatively equally amongst the groups.

However 76.2 % of consumers with a *university degree* indicated that *yes* they believe that increased positive publicity from the media would make them more sustainable with only 9.5 % of these consumers indicating they were *not sure*. However, a lower proportion at 59.5 % of consumers with *no university degree* indicated *yes*, with a higher proportion of consumers at 27 % answering that they were *not sure*.

3.8 Recommendations

When companies are engineering products/services, they must primarily pay attention to the important aspect of price, so that they ensure that the sustainable offering is affordable for consumers. They must also ensure that the quality is either at the same level or higher than products/services that are not sustainable. To a certain degree availability of sustainable products/services needs to be good as well in order to ensure convenience and repeat purchases, and maintain consumer loyalty. However the results indicated that commercial schemes seem to be less dominant and influential than media campaigns, and therefore companies must harness the power of media campaigns to promote sustainable products, thereby increasing awareness and at the same time educating consumers.

> Governments, businesses and individual citizens need to take action in order to create more sustainable societies. EC (2009, p. 1)

A strong community ethos is required to excel the effectiveness of sustainability especially for consumers in the lower level income groups, in a bid to encourage increased participation and awareness. This will only be made possible if consumers take the initiative to set up community movements and a way to boost such activities would be the government providing grants for consumers to promote sustainability through creating community associations.

An interesting question is that should private sustainability promoting bodies/institutions similar to quangos have a deciding and influential hand in the formation of sustainability regulations, so as to re-entrust some credibility into the minds of consumers as to the actions taken to improve the state of the environment and society rather than just focusing on the economy, which will be an exciting dimension to explore in future research. But the BBC (2012) have published that these quango organisations are on the decrease as the current coalition government is on the initiative of cost cutting and as a result many of quangos have stopped receiving funding.

> Our quality of life, prosperity and economic growth depend on living within ecological limits. EC (2009, p. 1)

Crucially it must be emphasised that positive publicity is required to renew consumer interest in sustainability and convert the topic from being associated with boredom as identified by Thøgersen (2003), thus increasing the awareness of sustainability through media campaigns. Introducing sustainability education at an early age is vital for future generations of consumers to have a better understanding of sustainability, but essentially this research has established that from the consumer perspective sustainability is very much in the background.

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Setting Managing Sustainability Goals

David Schatsky

1 Environmental Goals Are a New Competitive Arena

Companies are increasingly being assessed not only by their environmental performance but by the environmental goals they set. Stakeholders look for meaningful, quantitative, aggressive environmental performance goals. Environmental goals are becoming an arena of corporate competition and public declarations of goals can be a way of staking out a position of leadership. UPS, for example, claims to be the first company in its industry to issue a sustainability report and to publicize its goals for business practices that protect the environment (UPS 2006). Companies use goals to help them become leaders as well. Conagra Foods CEO Gary Rodkin announced its sustainability goals in 2010 saying, "We've set these new transparent sustainability goals to ensure we are a leader in continuously improving the way we make food, and to continue to create more awareness for what others can do to improve as well." (Agence France 2010)

2 Environmental Goals Have Key Differences from Other Corporate Goals

In many ways, environmental goals are not that different from any other corporate goals. They provide focus. They are a statement of commitment. They provide a target to manage to, a yardstick to assess performance, and serve as an indicator of whether tactics are working or need revision. They can give stakeholders a common view of where an enterprise is going that can help align and coordinate efforts, making successful outcomes more likely.

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But while companies have disclosed financial, customer satisfaction or other goals for a long time, many companies are relatively new to setting public environmental goals (other than compliance goals). There are established measures of financial performance that apply across industries yet appropriate environmental goals can vary widely among industry sectors. All companies track financial data but companies new to thinking about environmental performance may find they do not have ready access to environmental data. They have to develop the capability of measuring environmental performance before they can set environmental goals.

3 Many Factors Influence the Selection of Sustainability Goals

At most companies, numerous factors influence the selection of sustainability goals (Fig. 1). According to a recent Green Research survey of sustainability executives, materiality is the most commonly cited major influence on sustainability goals. Three-quarters of respondents said their company's most significant environmental impacts were a primary influence on the goals they had established. Alignment with strategy is the second-most cited response. Although sustainability is an area of increasingly important corporate competition, just 15 % of respondents cited competitors as an influence on the sustainability goals they set. We believe this understates competition as an influence. It comes up regularly in our conversations with sustainability execs. Jane Madden, senior vice president, corporate social responsibility and sustainability at Edelman, a major public relations firm, noted that clients she advises about sustainability goals frequently ask about their competitors. Though only 7 % of respondents to the survey cited the influence of non-profits or government agencies as a main influence on their sustainability goals, hundreds of companies have participated in the EPA Climate Leaders program, embracing goals stipulated by that program. In the end, leading companies look at a range of inputs in selecting sustainability goals, and this is appropriate.

4 Goals, Targets and Timelines

The effective expression of a goal must have three key aspects: the issue the goal is dealing with; a quantitative target; and a timeline (Fig. 2). Examples of issues include greenhouse gas emissions, water consumption and volume of packaging. Quantitative targets may be absolute numbers, such as "150 million tons," or percentages, such as "a 50 % reduction." The timeline is the year by which the goal is to be achieved. Goals related to prior performance also need to specify a "base year." Below we look at how leading companies establish goals, targets and timelines.

Fig. 1 Factors that influence sustainability goals (Source: Green Research Sustainability Executive Survey (6/11), n = 27)

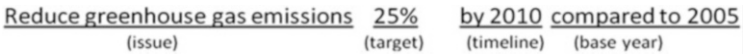

Fig. 2 Anatomy of a sustainability goal

5 Consult Widely and Create a Coherent Framework for Goal Setting

Green Research recommends that companies consult with a broad set of stakeholders to determine the areas in which to define sustainability goals. When Kraft Foods decided to step up its focus on sustainability in 2006, it conducted background research, undertook competitive analysis and consulted with environmental NGOs and internal experts to identify six main areas that matter most to the company and where they felt they could make the biggest impact. The areas are agricultural commodities; energy; packaging; water; waste; and transportation and distribution. The company encapsulated those areas into a framework for setting sustainability goals that it calls the "sustainability wheel" (Fig. 3). All of the company's sustainability goals relate to some section of the wheel.

Kraft decided initially to set goals in areas over which it had direct control over and for which it already had some data. These were water consumption, waste production, packaging, energy use. Areas dependent on the actions of others or for which data gathering still needed to be established would come later. Green Research considers this approach a best practice.

Services firms will arrive at very different goals than manufacturers. Jones Lang LaSalle, the big real estate services firm, recognized that its customers'

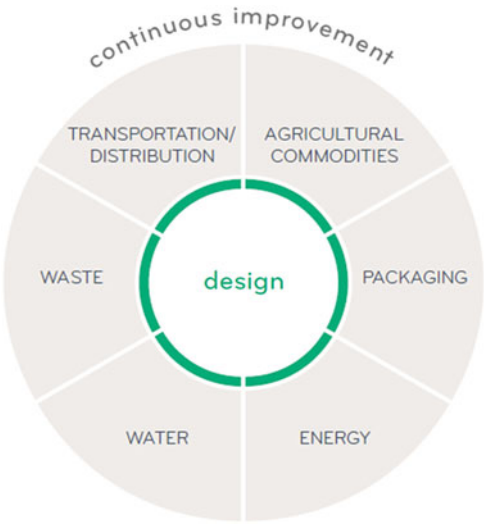

Fig. 3 Kraft Foods' sustainability wheel (Source: Kraft Foods 2010 Sustainability Report)

environmental impacts dwarfed the company's own and that it had influence over those impacts through its management practices. So its primary sustainability goal is helping its clients reduce their carbon emissions.

6 Reducing Greenhouse Gas Emissions Is the Most Popular Goal

Given the policy and popular focus on climate change, it's unsurprising that the most common area for sustainability goals is reducing greenhouse gas emissions (Fig. 4). Every one of the respondents to our survey has such a goal on the books, though some have not gone public with their goal. It is conventional wisdom that, after greenhouse gas emissions, water is emerging as the next big focal point of sustainability strategy. Judging simply by the impact areas listed in our survey, the story is a bit different. After setting GHG emissions reduction goals, companies tend to establish a suite of goals, including water, solid waste and recycling, which appear with similar frequency on the list.

It's worth noting that twice as many respondents to our survey indicate that they have internal goals relating to hazardous materials than have public goals regarding this area. In our experience, companies set an internal goal and refrain from publicizing it for a variety of reasons:

- Belief that it is not very relevant to external stakeholders
- It is not as material as other public goals
- Lack of good tracking systems
- Lack of confidence in their ability to meet their goals, sometimes because

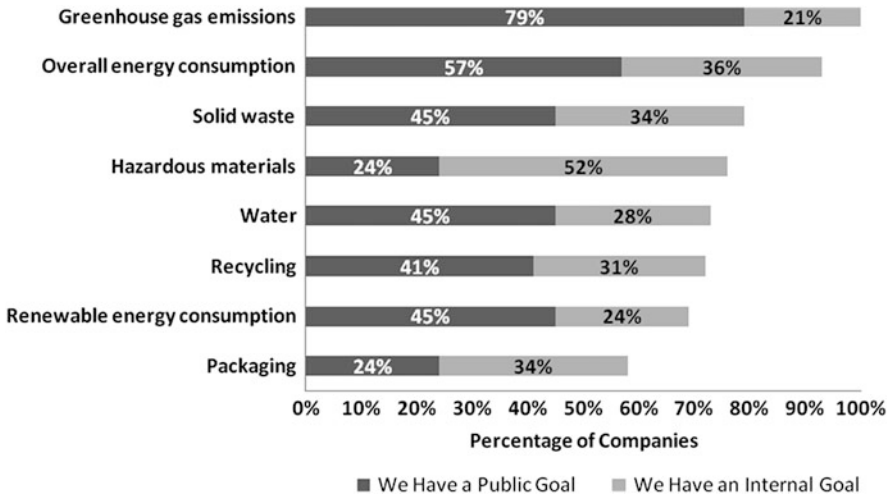

Fig. 4 The most common sustainability goals (Source: Green Research Sustainability Executive Survey (6/11), n = 29)

- Dependence on third parties to achieve a goal

It is likely that some combination of these factors is the reason for this disparity.

7 "Stretch" Goals Most Common

Most companies characterize at least some of their sustainability goals as "stretch goals" – they are challenging but probably achievable – or "realistic" – meaning they are based on an assessment of the current performance and what the company believes is achievable (Fig. 5). A target is the quantitative dimension of a goal and can mean the difference between a stretch goal and a "slam dunk."

Targets for realistic or stretch goals are best set by means of a bottom-up process. The first step in this process is to baseline current performance by calculating a carbon footprint, waste production or water consumption, for example. Companies then look at what projects are already planned that may impact performance (either positively, such as energy efficiency retrofits, or negatively, such as expansion plans) and determine what additional initiatives they can take would improve performance. In some cases, capital investments are assessed and the return on investment of those investments needs to be modeled. A company's ability to commit to investments or projects that impact a goal is a key influence over what targets can it sets. Global financial services firm Barclays told us, for instance, that limits on what can physically be accomplished in a given time frame can sometimes influence targets more than capital constraints. Installing submeters in bank branches, for example, can only be done outside of business hours.

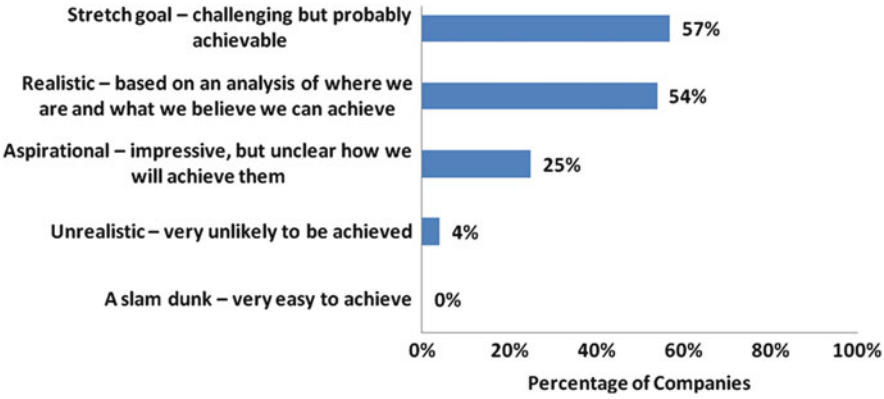

Fig. 5 How aggressive companies' goals are (Source: Green Research Sustainability Executive Survey (6/11), n = 28)

Suppliers may present an opportunity for improving environmental performance. Dell tells us, for instance, that it consults its suppliers' product roadmaps when formulating product sustainability goals. Macro trends may also play a part in target setting. Telefónica, the Spain-based telecommunications company, modeled macro energy consumption trends in each of its major geographical market as part of its goal-setting process.

8 Set Targets by Combining Bottom-Up and Top-Down Analysis

A bottom-up analysis is rarely sufficient for determining appropriate targets (Fig. 6). Often targets originate at the top. Some companies look at the targets other companies have announced. Some consult NGOs, industry bodies or government agencies for guidelines on appropriate environmental impact reduction targets. Cummins, for instance, took on a goal from the EPA Climate Leaders program: a 25 % reduction in carbon intensity by 2010 compared to 2005. (The company achieved a 28 % reduction). And it is a charter member of the newly launched Save Energy Now LEADER program with the U.S. Department of Energy, pledging to reduce energy intensity by 25% by 2015.

A quarter of respondents to our survey have "aspirational" sustainability goals, top-down goals intended to inspire and motivate. A classic formulation of an aspirational goal is one by InterfaceFLOR, which has pledged to "Eliminate any negative impact the company may have on the environment by 2020." Aspirational goals can bring excitement to a sustainability strategy, but can engender grumbling from mid-level executives if they are held accountable for achieving them.

Some companies have a mix of realistic, stretch and aspirational targets. Fujitsu's targets for reducing greenhouse gas emissions represent such a mix. Its

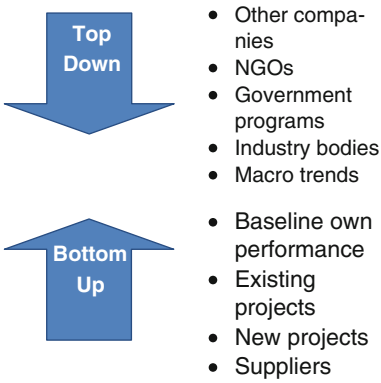

Fig. 6 Bottom-up and top-down analysis

"Green Policy 2020" is a commitment to reduce CO_2 emissions in Japan by 30 million tons by 2020 with an interim target of a 15 million ton reduction by 2012. The 30 million ton target is a top-down goal, while the 15 million ton target was developed through bottom-up analysis. Product energy efficiency is supposed to deliver a three million ton reduction, for example, with the balance achieved through various solutions including more efficient data centers. The 15 million ton goal was allocated between the regional head of sustainability, the regional head of data centers, and the company's environment strategy group in Japan.

Kraft Foods told us it set its goals based on bottom-up and top-down factors. The company looked at others in its peer groups to see what commitments they were making; it looked at its past performance; expected gains from projects already on the books; and potential gains from new projects. In the case of its goal of reducing packaging volume by 150 million pounds by 2011, about 25–30 % of that reduction would have been achieved by projects already planned. To achieve the full goal, the company needed to do a lot more. In total, it took some 200 projects together to meet the target. The company ultimately exceeded the target – ahead of schedule, booking a 175 million pound reduction in packaging by 2009.

To guide the target-setting process, Sustainability executives should judge their company's track record and culture and answer the following questions:

- Does the company have a history of setting and achieving challenging goals?
- Does the company have a culture that prizes excellence in operations?
- Can you identify the initiatives and investments that have a high likelihood of helping to achieve a substantial share of the target?

9 Set Targets Three to Five Years Out

Green Research believes that sustainability targets should be set for a period of 3–5 years. Shorter than that and the overhead of frequently reviewing and resetting targets can become burdensome. Longer than that and the individuals accountable

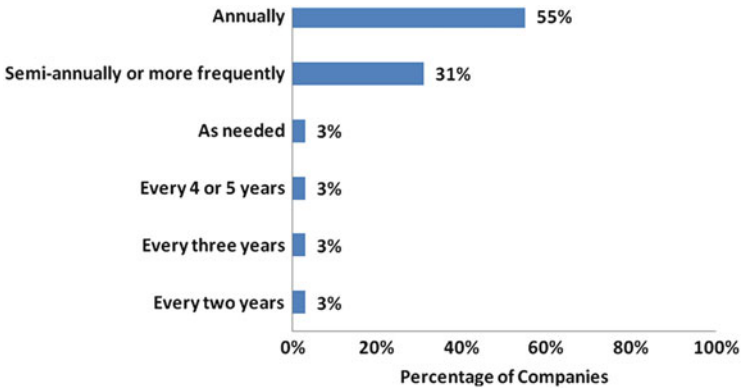

Fig. 7 Frequency with which goals are reviewed and revised (Source: Green Research Sustainability Executive Survey (6/11), n = 29)

Fig. 8 Plans, goals and visions

Time Horizon	Nature of Target
Annual	Operating Plan
Three to Five Years	Goals
Ten Years or More	Aspiration

for the goals may have moved onto new jobs before their success or failure is reckoned. This is the philosophy followed by Kraft Foods, which established 6-year targets in its first round of public sustainability goals and 5-year targets for its cycle starting 2011. A majority of the respondents to our survey said their company reviewed and revised environmental goals at least annually (Fig. 7). But public goals tend to change much less frequently than that (Fig. 8).

10 Experts Should Set Goals; Operating Execs Should Own Them

In dozens of interviews with sustainability executives, Green Research has identified what it believes to be an effective process for defining and committing to sustainability goals (Fig. 9). While the specifics may vary from company to company, an effective sustainability goals process general includes these elements:

- CEO-level support for the sustainability strategy
- Functional experts in areas like facilities, energy, packaging and so forth work to propose specific goals and plans for meeting them
- Operating executives review, review and then take ownership of those plans
- The CEO and/or the board approves the plans and holds operating executives accountable for executing them.

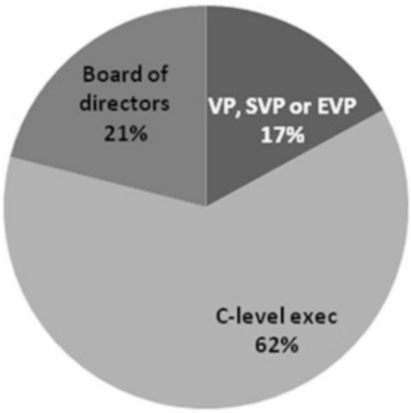

Fig. 9 Levels of management that approve goals (Source: Green Research Sustainability Executive Survey (6/11), n = 29)

Flooring manufacturer Shaw Industries has a "Growth & Sustainability Council" that approves sustainability goals. It's comprised of senior leadership from all business and functional areas of the organization. The Council convenes quarterly to assess progress, set goals (or ratify those proposed at a lower level) and ensures the alignment of sustainability strategy with the company's long- and short-term corporate objectives.

At Barclays, the head of sustainability and the head of corporate real estate jointly present a sustainability plan including carbon offset commitments to the Group Operating Committee (GOC), which is comprised of chief operating officers of the business units. Once the GOC approves capital requirements for the mitigation plan it goes to the group chief executive officers, who can ask for changes. Then it goes to group board for final approval.

Executive commitment is critical for ensuring operating executives are held accountable for execution plans and achieving goals. And coordinating sustainability strategy centrally can ensure strategic alignment and synergies and foster better communication. As one executive at a manufacturing company told us, "We have a lot of pockets doing environmental work that report up to various vice presidents. There's a lot of good work going on but it's siloed and not coordinated. How much more we could do if there were central goals!"

11 Senior Management Should Review Progress Quarterly

Leading companies manage sustainability goals like any other corporate goal: with a structured process for setting targets, clear accountability, periodic review, and appropriate incentives for performance. Progress toward sustainability goals, like progress on any other important goal, should be reviewed at least quarterly by senior management, something that a majority of the respondents to our survey say happens at their company. But some 40 % of respondents say sustainability goals are reported

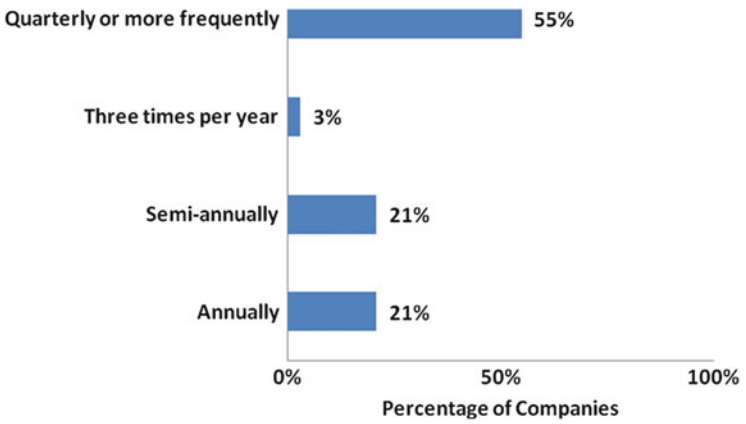

Fig. 10 Progress reporting frequency (Source: Green Research Sustainability Executive Survey (6/11), n = 29)

to senior management less frequently than that (Fig. 10). Telefónica reports on energy consumption every 6 months. The company says collecting consumption data is still a slow process: smart meters are in use in only a few of their geographies; elsewhere they rely on standard invoicing processes to obtain consumption data. The company hopes to move to a monthly reporting process when feasible. Green Research believes quarterly reporting reduces performance risk.

12 Ensure that Specific Individuals Are Accountable for Sustainability Results

It's an axiom of management that to achieve a goal, someone must be accountable for it. If everyone or no one is accountable for achieving a goal, there's a high likelihood that the goal will get neglected. Green Research sees a wide disparity in how companies address accountability for sustainability goals. We know of one major telecommunication equipment supplier with an ambitious corporate carbon reduction goal but no internal accountability for that goal. The company's chief sustainability officer struggles to get buy-in to goals from department heads who have no accountability for meeting them. "Those are not my goals," responds the head of the IT department. "*My* goals for the year are availability, uptime, number of applications supported, and budget. And I don't pay for my own electricity." "What's missing," says the CSO, "is sustainability in the middle. The CEO is committed; the green teams are committed. But the guys in the middle won't until they have the goals and objectives do it."

Kraft Foods follows the best practice of tracing every sustainability goal to a specific executive owner. For example, its packaging goals are owned by the head of research & development. Manufacturing goals (such as energy, water, waste and

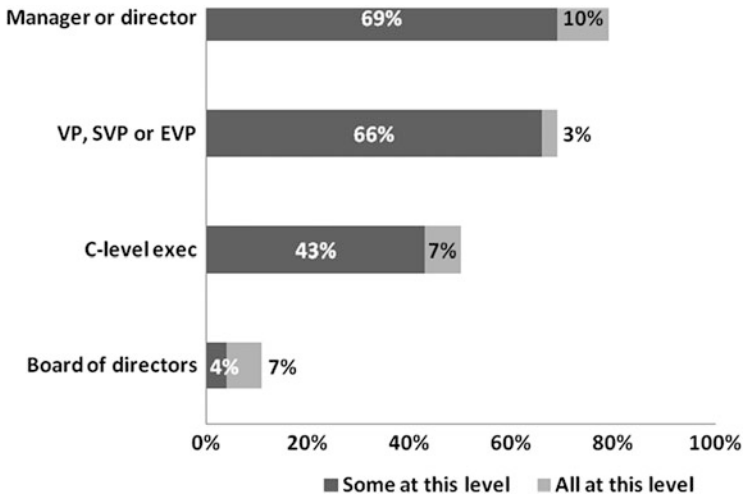

Fig. 11 Executives with compensation tied to environmental performance (Source: Green Research Sustainability Executive survey (6/11), n = 29)

cost) are owned by the head of operations. Where appropriate, global goals are broken down to regional subgoals, for which regional executives are accountable.

Shaw Industries uses a management model known as RACI for setting goals. RACI is an acronym that identifies the principal stakeholders in any decision, who may be Responsible, Accountable, need to be Consulted, or need to be Informed. The company tries to ensure that everyone on the RACI chart for a given goal is present when the goal is discussed.

13 Tie Compensation to Achievement of Sustainability Goals

To heighten commitment to environmental sustainability goals, companies should incorporate them in executives' performance appraisal process and compensation packages. Nearly 70 % of respondents to our survey say that some or all execs at the VP, SVP or EVP level are compensated in part based on the attainment of environmental goals (Fig. 11). This relatively strong result is due, we believe, to the fact that our respondents tend to be leaders in environmental sustainability. The prevalence of sustainability-linked goals in companies generally is likely much lower. Even among this group, it's worth noting that lower levels in the management hierarchy are more likely to have some compensation tied to environmental goals than higher levels. Just 50 % of companies tie CEO compensation to environmental goals, while nearly 80 % tie the comp of some managers or directors to such goals. While CEOs shouldn't necessarily be held accountable for every

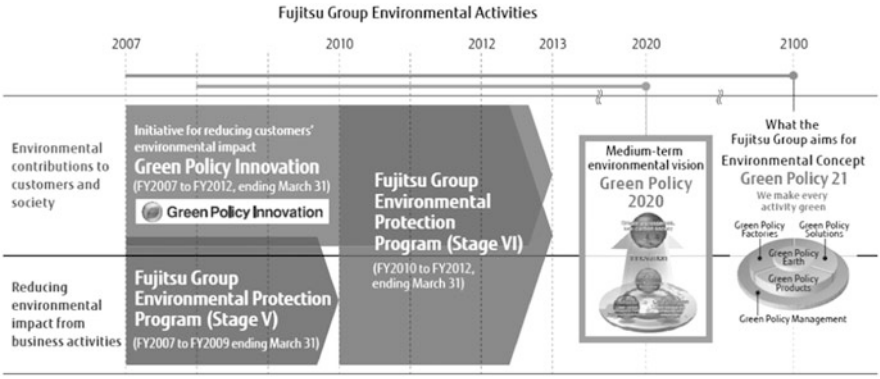

Fig. 12 Fujitsu environmental programs (Source: 2010 Fujitsu Group Sustainability Report)

environmental goal, we believe that if a company has a serious sustainability strategy, the CEO should bear some compensation risk for the major goals. We recently heard from a chief sustainability officer who told of receiving a call from the head of the company's compensation committee. The topic: how had the CEO performed relative to her sustainability goals? In this case, the chief sustainability officer had influence over some of the CEO's compensation.

14 Communicate Clearly, Simply and Consistently about Sustainability Goals

Companies set sustainability goals not only to drive change but to communicate with stakeholders inside and outside the company. The role of goals as a communications vehicle should not be underestimated. Indeed, consultancy SustainAbility measured a recent dramatic increase in the number of professional sustainability watchers who perceive Unilever as a sustainability leader. It links that increase to the company's release of its Sustainable Living Plan in the fourth quarter of 2010. Similarly, according to SustainAbility, perception of U.K. retailer Marks & Spencer as a sustainability leader continued a sharp upward trend in 2007, the year it release its Plan A. That improvement continues this day, following the company's release of revised and expanded goals in 2010.

Both of those companies exemplify the best practice of encapsulating an ambitious program under a simple rubric with compelling themes: "Sustainable Living," and "Plan A" (because there is no Plan B).

Fujitsu Group's message, by contrast, is complex (Fig. 12). Its numerous (and worthy) sustainability initiatives are difficult to sum up because they are described by various names with different timeframes:

- Green Policy Innovation, FY2007-FY2012
- Fujitsu Group Environmental Protection Program (Stage VI), FY2010-FY2012
- Green Policy 2010
- Green Policy 2021

We would advise Fujitsu to work toward more streamlined messaging.

15 Go Public with Goals, or Have a Good Reason Not To

As we have seen, public sustainability goals can help drive results and communicate with stakeholders. They are a tool for positioning and an arena for competition as well. So shouldn't every company declare public sustainability goals?

Probably. But some companies struggle with this. According to Edelman's Jane Madden, some clients are reluctant to publicize goals because they are afraid of failing to achieve them. We believe this is a weak rationale. After all, public companies rarely avoid giving financial guidance; indeed, they are expected to. We believe such concerns reflect a relatively less mature management processes and practices for sustainability goals – the prevalence of which was one of the reasons we undertook to write this research.

We know of another company that has announced a greenhouse gas reductions goal but no other goals, even though it says it has dozens of other internal sustainability goals. The reason: the company is geographically diverse, and operates with dramatically different infrastructures and conditions around the globe. This is an unpersuasive justification as well. While regional variations must be a factor in how goals are allocated, there is no inherent reason why those goals can't be aggregated and reported out.

We know of a company in a highly competitive industry that sets its sustainability goals with the goals of its archrival in mind, and avoids publicizing goals where possible to avoid setting off a sustainability arms race that might pressure it to commit to more than it is ready for. Not such a laudable rationale but understandable.

One good reason for not disclosing goals is a lack of credible data for measuring performance. Telefónica, for instance, has internal waste reduction goals but acknowledges it still possesses only spotty data in certain geographies. For now, those goals remain internal or disclosed only under non-disclosure agreements.

Finally, the case of Apple is noteworthy. The famously innovative technology product designer and marketer has been highly reluctant to disclose sustainability goals and justified its opposition to creating a sustainability report on the grounds that doing so would be redundant, time consuming and costly. Those objections lack credibility to us. We speculate that the real explanation is that voluntarily disclosing this kind of information is antithetical to the company's culture of secrecy, which has served it very well and is a pillar of its strategy. The company says it would rather be judged by its results than its goals, which is fine. But it

remains dogged by negative attention that it could help mitigate by being more transparent with sustainability goals. Green Research believes all companies must define and communicate well-considered sustainability goals or else risk being seen as aloof or out of touch.

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Environmental Management Systems: Enabling Tools Towards Sustainability?

Luca Cagnazzo, Emanuele Raggi, and Paolo Carbone

1 Introduction

In recent years since the widespread adoption of the ISO 14001 international standard and the continuous update of the European EMAS scheme, along with the effects of many other environmental management schemes, environmental management systems (EMSs) have gained increasing acceptance among companies. In fact, the latest 2010 ISO survey reports that as many as 250,000 ISO 14001:2005 certificates have been issued in 155 countries (The ISO Survey of certifications 2010).

The development of a basic environmental management system is based on

- An initial environmental analysis identifying the company status with respect to the environment;
- The identification of an environmental policy, providing guidance and setting company directions with respect to the environment;
- The determination of objectives, set coherently with the environmental policy;
- The installation of a management system (processes, responsibilities, documents, data, . . .) supporting the achievement of identified objectives;
- The usage of feedback and control mechanisms, such as a system of corrective/preventive actions, management reviews and internal/external audits.

The instantiation of an EMS in a company requires interpretation of requirements and adaptation of the management system in relation to the application constraints. As pointed out in Ghisellini and Thurston (2005) with respect to the ISO 14001 EMS, the result is a management and not a performance standard, because the continuous improvement requirement does not strictly imply reduction

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in environmental impacts. This limit has partially been overcome by the latest EMAS scheme. This is based on the ISO 14001 requirements but takes into account additional elements that make it a more demanding EMS: public reporting, stricter legal compliance verifications, performance improvements required also for the environment and not only regarding the management system, make the achievement of EMAS registration more difficult, but assuring higher probability of effectiveness in reducing environmental pollution. This was a design objective of this EMS, according to Morrow and Rondinelli (2002).

The introduction of an EMS in a company generates modification in the company's organization and may be considered as a potential motivator for addressing the broader topic of sustainability that encompass, in different applications, business, environmental and social subjects. In fact according to Steger (2000) the social dimension is missing completely in current EMSs, but nevertheless "Environmental management systems are tools to better reconcile corporate economic and ecological goals, but they cannot substitute politically set standards for environmental protection." At the same time tangible results have been reported linking EMS with environmental improvements (Steger 2000). Also the value of certification is considered in these processes (Steger 2000): "Certification per se may not bring significant performance improvements. It can, however, have important behavioral and managerial impacts that contribute to better environmental performance." Also the whole set of metastandards (e.g. ISO 14001, ISO 26000) that allow general management practices to be standardized, become guidance documents for sustainable development (Rondinellia and Vastagb 2000). An interesting perspective on sustainability is proposed by MacDonald (2005), in which sustainability objectives of an organization are managed to:

1. Eliminate its contribution to systematic increases in concentrations of substances from the Earth's crust,
2. Eliminate its contribution to systematic increases in concentrations of substances produced by society,
3. Eliminate its contribution to systematic physical degradation of nature,
4. Eliminate its contribution to the undermining of humanity's ability to meet its needs worldwide.

ISO 14001 is seen as a technical tool on which to base the achievement of such objectives (MacDonald 2005).

Owing to these motivations, the goal of this research is that of verifying if the adoption of a structured EMS can be thought of as a tool enabling the company's path towards sustainable strategies and operations. This research question will be answered by means of qualitative, quantitative and case study-based research analyses.

2 A Literature Analysis Comparison Between EMS and Sustainability

2.1 Research Methodology

The research methodology adopted in this work is a systematic review of scientific papers. A systematic review provides information about the effectiveness of interventions by identifying, appraising, and summarizing the results of otherwise unmanageable quantities of research (Light and Pillemer 1984; Mulrow 1994). The use of a systematic review is justified since in the management field, the traditional narrative literature reviews have been widely criticized for the lack of relevance due to the use of personal and usually subjective as well as biased methodologies by authors Fink (1998), Hart (1998).

To mitigate this gap, it has proposed to apply the specific principles of the systematic review methodology usually used in medical sciences (Transfield et al. 2003). The main difference between a systematic review and a traditional narrative review is that, contrary to the latter, the former uses a rigorous, replicable, scientific and transparent process (Cook et al. 1997). Journals' relevance for the literature review are evaluated through one of the most accepted database, Web of Science, and search engine named ISI Web Of Knowledge. Journals' selection for the current study has been pursued evaluating results provided by the research engine and sorted by relevance in relation to the keywords selected by authors.

In order to make a comparison between the evolutions in the EMS and Sustainability subjects and to find similarities and differences between them, this research part has been conducted following two different approaches: a quantitative research, that has been extended to all works suggested by the Web Of Science database (such as articles, conference reviews, books and all other sources), and a qualitative research, in which authors considered only empirical articles published in scholarly journals and excluded non-empirical studies (conceptual works, qualitative studies, etc.) as well as those disseminated using a number of different media (book, internet, etc.) (Becheich et al. 2006). This choice allowed authors to have a better comparable body of research, which enhances the quality of the systematic review results.

The authors extended the literature review by covering a period of 40 years, from 70s to 2011, which guaranteed a sufficient amount of articles to validate research results. In the first part of this research, all the items have been involved for a quantitative analysis. In the second part, the authors read the titles so as to firstly exclude the main part of the body of papers evaluated as being not inherent the purpose of this research. Secondly the authors excluded other papers after reading the abstracts, which were irrelevant to the research goals. The remaining articles have been entirely read, to exclude those, which were definitely evaluated as not interesting for the literature analysis.

2.2 A Quantitative Literature Analysis

This analysis has been performed in order to examine the literature regarding both subjects related to EMSs and sustainability and to identify similarities or evidenced correlations. The dataset used in this work was constructed using the ISI Web of Knowledge database. The keywords used for the queries have been chosen with the aim of covering all studies and works discussing from one side the EMS implications, involving also the ISO 14001 and EMAS implementations, and the Sustainability concept from the other side: such keywords are "EMS", "Environmental Management System", "ISO 14001" and "EMAS" for the former (hereinafter for simplicity just "EMS") and "Sustainability" for the latter, searched in the main article topics (such as the title, abstract and keywords). These words have been selected because of their relevance on the topics of interest. The research has not initially been refined on specific research areas in order to involve all works published in the last decades.

For the EMS research output, the resulted dataset contained 28,390 articles, published in 8,327 sources. The majority of the sources are journals and conference proceedings. In particular, the main types are classified as follows: articles (20,039), proceedings papers (8,556), reviews (1,342), meeting abstracts (357) and the remaining are editorial materials (340), news items (105), book reviews (93), notes (86), letters (78), book chapters (45), corrections (8), reprints (6), discussions (5), software reviews (3), biographical item (1), correction addition (1), database review (1), hardware review (1), item about an individual (1), music performance review (1), record review (1).

The 10 sources with the highest numbers of papers are: Journal of environmental management (278), Environmental management (259), Prehospital emergency care (239), Resuscitation (233), Journal of cleaner production (232), Annals of emergency medicine (212), Water science and technology (206), Environmental modelling software (189), Academic emergency medicine (181), Acta horticulturae (181) as shown in Fig. 1.

Figure 1 suggests that the most active sources on the topic belong to the medical and health sectors as well as the environmental management guidelines.

The same research has been performed for the "Sustainability" research topic and the resulted dataset contained 36,861 articles, published in 7,976 sources. Also in this case, the majority of the sources are journals and conference proceedings: mainly articles (25,388), proceedings papers (9,643), reviews (1,758), editorial materials (1,411) and book reviews (846). The 10 sources with the highest numbers of papers are: Ecological economics (673), Journal of cleaner production (392), Wit transactions on ecology and the environment (368), Agriculture ecosystems environment (260), Forest ecology and management (257), Energy policy (255), International journal of sustainable development and world ecology (247), Water science and technology (234), Journal of environmental management (210), Journal of sustainable agriculture (208) (Fig. 2).

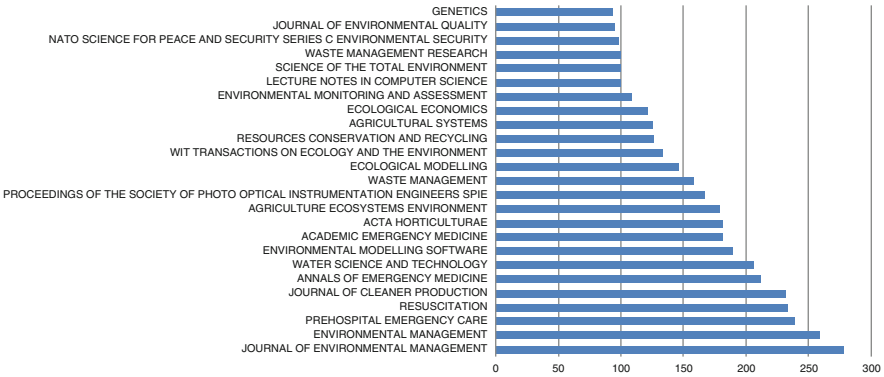

Fig. 1 The most important publications on EMS with respect to number of appeared documents (articles, letters, . . .)

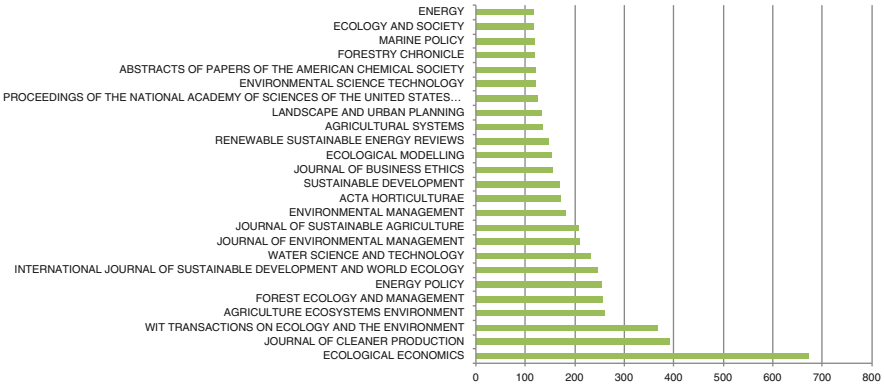

Fig. 2 The most important publications on Sustainability with respect to number of appeared documents (articles, letters, . . .)

As evidenced in Fig. 2, the Sustainability concept has been investigated under the environmental and business perspective: looking at the first 25 sources in fact, they mainly discuss the Economy pillar of the sustainability, such as "Ecological Economics" or "Journal of cleaner production" do, and the environmental implications of sustainability, such as "Wit transactions on ecology and the environment" and "Agriculture ecosystems environment".

In order to better understand the dissimilarities between the EMS and Sustainability literature, the most important 20 subject areas for EMS are illustrated in Fig. 3.

Similarly for the literature on Sustainability, the most important 20 subject areas are depicted in Fig. 4.

From the comparison of data in Figs. 3 and 4, it is immediately clear that in the first six subject areas regarding both topics there are five common subject areas.

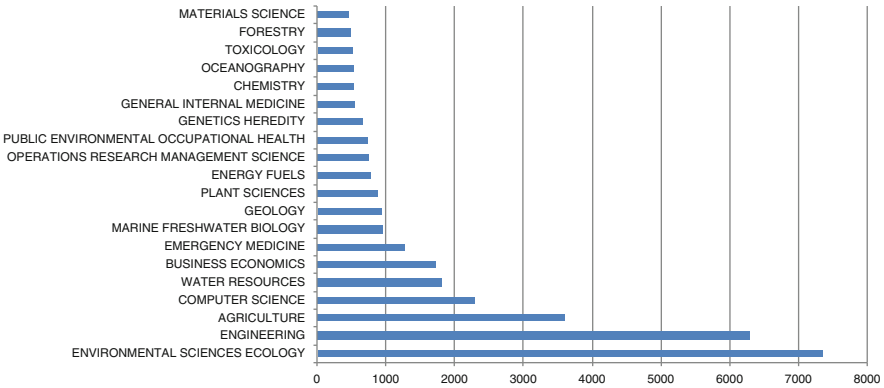

Fig. 3 Research subject areas under the topic "EMS"

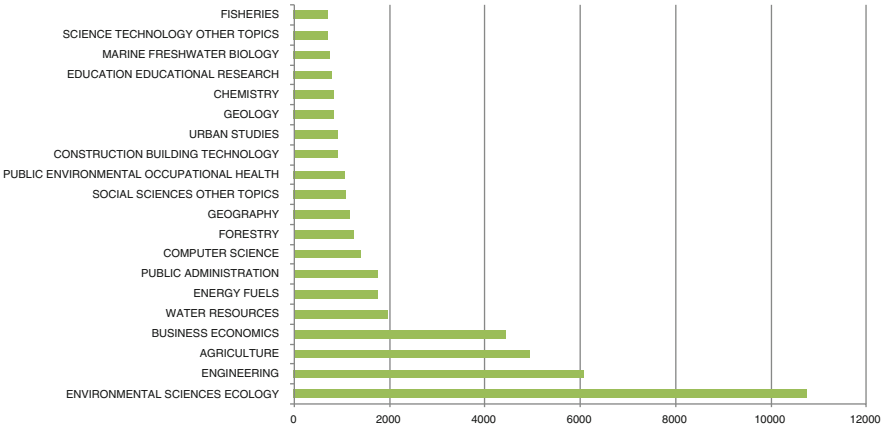

Fig. 4 Research subject areas under the topic "Sustainability"

This is to be interpreted as an indication of some possible contact points between them.

From a chronological point of view, the earliest paper included in the dataset regarding the EMS literature was published in 1970 and the most recent in 2011, since the 2012 has been excluded (more than the 75 % of publications included in the dataset have been published since January 2000), as showed in Fig. 5.

The same trend is evidenced when it comes to publications regarding Sustainability, as shown in Fig. 6.

The authors with higher number of articles included in the EMS dataset are Huang (152 articles), Chang (75), Li (52), Khan (35) (Fig. 7), while the most productive authors in the area of Sustainability are Marchettini (40), Bastianoni (39), Dincer (38), Folke (35) (Fig. 8).

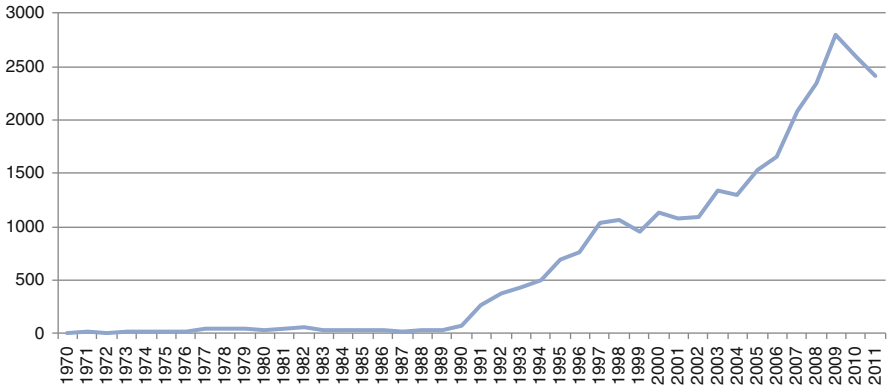

Fig. 5 Number of published articles over the years (Keyword "EMS")

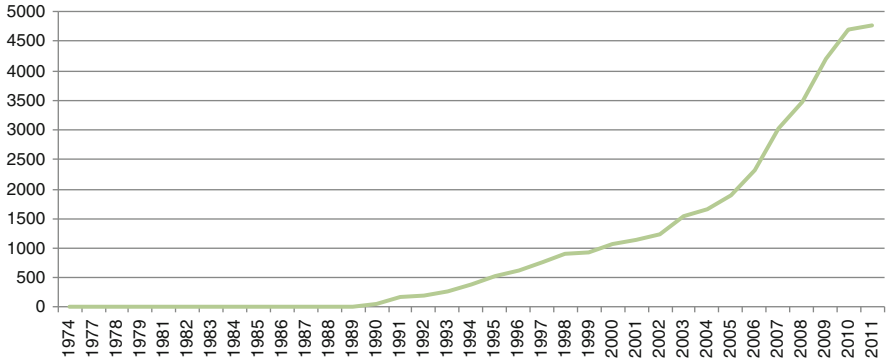

Fig. 6 Number of published articles over the years (Keyword "Sustainability")

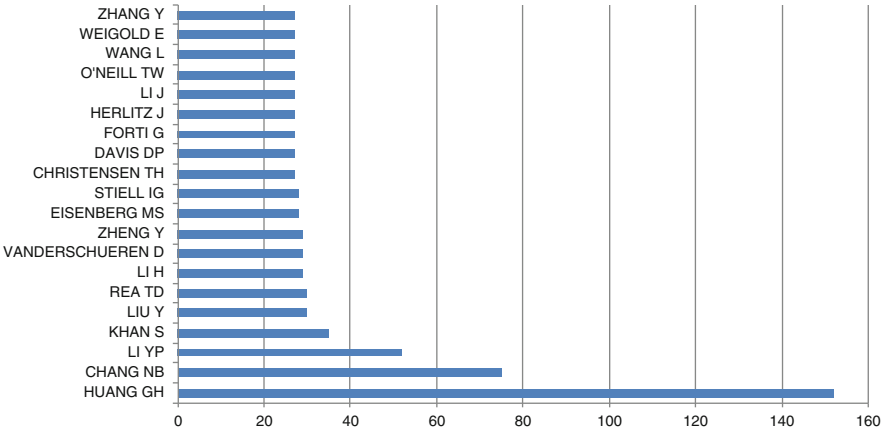

Fig. 7 The most productive authors in the dataset (Keyword "EMS")

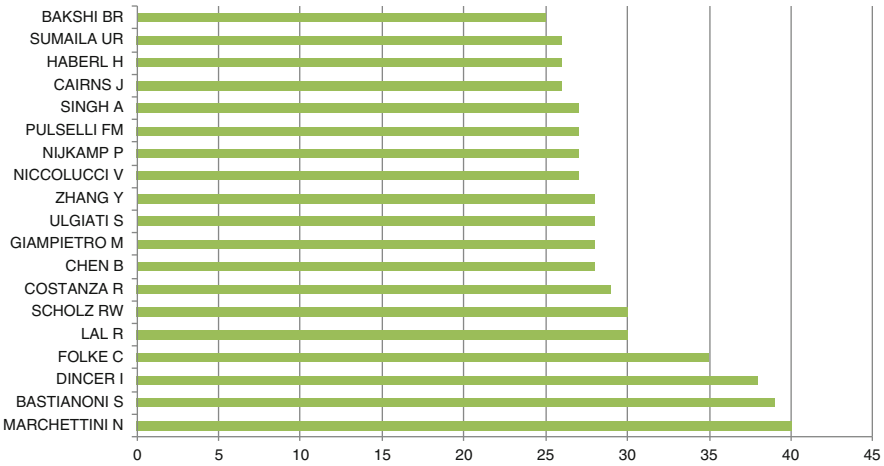

Fig. 8 The most productive authors in the dataset (Keyword "Sustainability")

The countries most involved in the EMS researches are USA (8,945 papers), England (1,997), China (1,901), Canada (1,761), Australia (1,679), Germany (1,641) and Italy (1,107) (Fig. 9).

Very similar considerations can be done for the countries most involved in the Sustainability researches, that are USA (10,106 papers), England (3,756), Australia (2,877), Canada (2,476), Germany (1,850) and Netherlands (1,618) (Fig. 10).

2.3 A Qualitative Literature Analysis

The results listed in Sect. 2 allow authors to appreciate the link between EMS and Sustainability. To reinforce or refuse the thesis that EMS contributes to Sustainability, it is interesting to deepen what some of the main works in literature say about this connection, if exists, in different applications, business aspects or environmental and social subjects.

In particular, Lam et al. (2011) investigated how EMSs interact with green specifications and whether or not they complement each other. In their findings they gave the reasons for adopting green specification and highlight environmental issues that may not be addressed by solely adopting EMS. The authors present the results of a recent survey of practitioners concerning their opinions towards green specifications and possible impacts arising from their adoption. From the result of their survey, a framework for developing green specification is deemed valuable for the cities that are striving for sustainability. Additionally the level of acceptable changes brought about by green specifications as perceived by different industry stakeholders is found to be unrelated to whether they were from organizations implementing EMS or not.

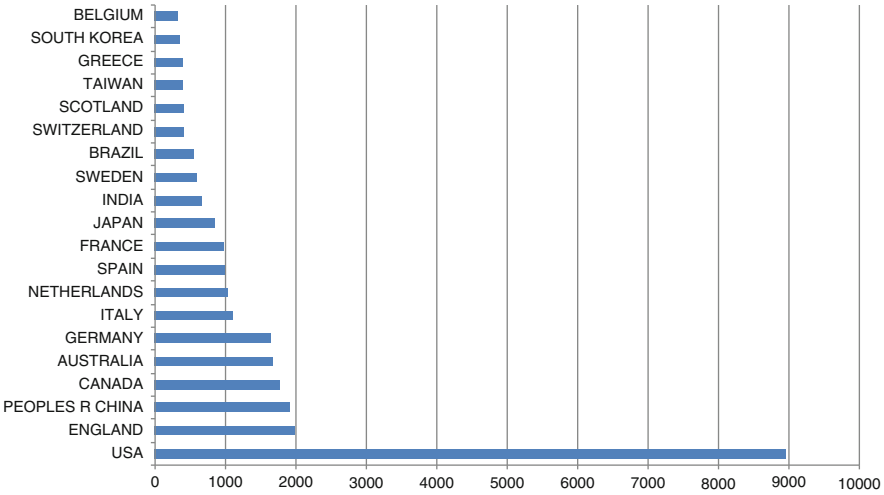

Fig. 9 Countries with the largest number of published documents in the dataset (Keyword "EMS")

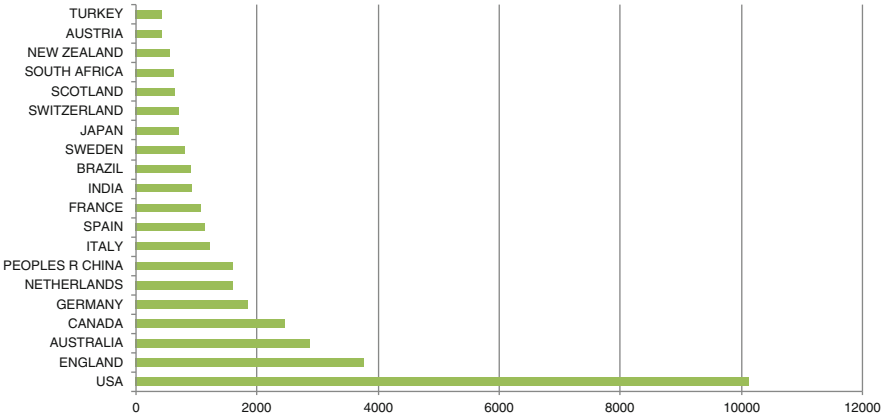

Fig. 10 Countries with the largest number of published documents in the dataset (Keyword "Sustainability")

Curkovic and Sroufe (2010) conducted a case based research to demonstrate that ISO 14001 registration can be leveraged across the supply chain into a competitive advantage. By looking at ISO 14001 registered firms, they compared different amounts of integration and sustainability in the supply chain. The general objective in their study was to explore the strategic supply chain implications of ISO 14001 adoption with the aim of building theory, and to identify possible relationships or effects that may occur during the process, and not to describe average effects of the industries. The process was structured as follows: sample selection, interview

protocol, data collection and data analysis. Respondents were asked to provide perceptual information at the plant level regarding ISO 14001. Results showed that reasons for not embracing the new standard are now more generally categorized as risks. These risks are financial, exposure, change management and lagging the competition. These risks are typically more scrutinized by resource constrained plants or by those plants that may choose only to obtain registration after others in the industry have successfully obtained registration. The data reduction and categorization process created the following six main concepts for pursuing ISO registration listed in order of most prevalent to least prevalent: (1) competition; (2) customers; (3) image/reputation; (4) risk mitigation; (5) resource conservation; (6) cost reduction. Paradoxically, cost reduction and competition are also listed as a reason for registration, but in the reverse order of the risk attributed to not registering. Lambert and Cooper (2000) stated that supply chain management represents a significant paradigm shift of modern business management by recognizing that individual businesses compete with each other no longer as solely autonomous entities but rather as supply chains. Supply chain design is integral in order for an organization to accomplish its EMS and sustainability goals. Choosing to partner with suppliers that have policies supporting an organization's EMS is at the heart of the effectively implementing a sustainability strategy. Supply network structure can help support such a strategy and be characterized as emphasizing non-power based relationships and inter-firm coordination as well as the informal social system that are linked through a network of relations (Chen and Paulraj 2004).

Gonzalez et al. (2008) analyzed the existence in the implementation of environmental practices between companies that possess any certifiable environmental management system (ISO 14001 or EMS) and those that do not have any such system. Their study also investigates whether companies with a certified EMS are also making additional environmental demands on their suppliers. They found a positive relation between the possession of certified EMS, specifically ISO14001 and eco-management and audit scheme, and the environmental demands that these organizations impose on their suppliers. The environmental demands on suppliers increase with customer organization size but the degree of internationalization, measured by the rates of imports and exports, does not show a significant relationship to these pressures. The automotive sector underwent an important expansion process in the 1990s motivated by trend towards globalization and decentralization of activities, all of which led to the outsourcing of a large part of the manufacturing of automotive components. They proved that three types of practices (e.g. environmental product design, reduction of material usage, and managerial aspects) are found to be more developed in those companies that have implemented some form of certified EMS. Additionally the proved that there was no difference between those companies that have implemented only ISO 14001 and those that have also decided to jointly implement ISO 14001 and EMAS. Their study carried out a positive relation between the possession of certified EMS and demands that the company imposes on its suppliers to adopt environmental practices. These demands mean that environmental concerns diffuse upstream in the supply chain. A number of studies show that the adoption of environmental management practices provides

benefits or advantages to organizations (Gonzalez-Benito and Gonzalez-Benito 2005). These benefits include possible improvements in productivity, competitiveness, business profitability, or a green image. These advantages may be achieved by establishing two basic objectives (Johnson and Wang 1998): (a) reducing the waste generated, (b) maximizing the efficiency of the resources employed (by means of recycling, reuse or any other type of reclamation activities).

Handfield et al. (2002) propose that ISO 14001 certification may be a motivating factor for the implementation of beneficial corporate environmental practices, a critical issue, which is open to debate and thus research in the field.

Wagner (2008) analyzed the hypothesis that environmental management systems (EMS) and managerial activities to reduce negative environmental impacts which are not part of EMS have a positive influence on the probability of firms to carry out environmental innovations. Based on binary and multinomial discrete choice models, the relationship of a number of determinants on the occurrence of environmental innovations is studied using data collected during the "European Business Environmental Barometer 2001–2002" survey in nine European states. This study finds that environmental management systems are associated with process innovations. Unfortunately his study does not find that environmental management systems are associated with product innovations. For product innovations, mainly information of consumers and eco-labelling activities show a positive association. Market research on the potential of environmental innovations positively relates to both process and product innovations. Importantly, firm size is not found to have any effect on the probability of a firm carrying out environmental product or process innovations. Market research on green products likely leads to a better understanding of profitable demand for product innovations with environmental benefits, for example in cooperation with lead users. As well, it enables firms to identify environmentally oriented customer segments. Therefore its strong positive effect on environmental product innovations can be explained well. The additional effect on process innovations is more surprising, it may however be explained by the fact that an environmental product innovation can also imply changes in the production process and in the strategy behind the EMS.

Rubik and Teichert (1997) suggest that for reasons of reputation and credibility, firms forcing environmental product innovation also need to show above-average environmental performance in production, which may imply simultaneous promotion of environmental process innovation and improvements of the EMS. Environmental innovations can be defined as "...measures of relevant actors (firms, ..., private households), which: (i) develop new ideas, behavior, products and processes, apply or introduce them, and (ii) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets" (Rennings 2000). Rehfeld et al. (2007) state that the specification of the direction of technological change defined by (ii) is an essential definition criterion for environmental innovations. Rennings (2000) furthermore shows that from (ii) the double externality characteristic of environmental innovations can be derived, which can also be used to delineate them from other innovations.

Eltayeb et al. (2010) tried to assess the actual environmental, economic and intangible outcomes resulting from the adoption of green supply chain initiatives. Their study used a structured questionnaire derived from the literature and employing a mail survey to collect responses from a group of 569 ISO 14001 certified firms in Malaysia. The results of testing the hypotheses that predicted that green supply chain initiatives have positive effect on the outcomes showed that eco-design have significant positive effect on the four types of outcomes (environmental outcomes, economic outcomes, cost reductions and intangible outcomes). Reverse logistic was found to have significant positive effect on cost reductions only. However, green purchasing was not found to have significant effect on any of the four types of outcome. Through designing environmentally friendly products and taking back products and packaging, business organizations can generate benefits to the environment, in the form of reduced waste and better resource utilization, in addition to economic benefits and cost reductions to the organizations. The traditional green initiatives are associated with many weaknesses and problems. The end-of-the-pipe approach does not eliminate pollutants, but merely transforms them from one medium to another (Sarkis 2001). Moreover, focusing green practices inside organizations may expose the organization and the relative EMS structure to negative environmental performance of other organizations in its supply chain. For instance, the poor environmental performance of small suppliers can affect badly the performance and image of buying companies (Christmann and Taylor 2011). Green supply chain is defined as "the extension of the traditional supply chains to include activities that aims at minimizing environmental impacts of a product throughout its entire life cycle, such as green design, resource saving, harmful material reduction and product recycle or reuse" (Beamon and University of Washington 1999). While environmental management principles and standards provide powerful tools that have a potential to generate significant improvements to environmental performance of organizations, their focus is restricted only on creating and documenting environmental policies and procedures (Curkovic et al. 2005). Such policies and procedures may represent efforts to improve environmental performance only within the organization's operational boundaries rather than being extended throughout the supply chain (Bansal and Celland 2004).

Massoud et al. (2010) examined the variations in perceptions of a number of environmental and human resource constructs that are operationalized and measured in the field at Mexican maquiladoras. Differences between organizations with a certified EMS, informal EMS and no EMS are examined. The authors found that significant facility differences existed for all environmental management practices and perceived environmental performance across all levels of EMS, with certified EMS facilities being the highest, informal EMS facilities being second and facilities with no EMS being lowest. An EMS has the primary purpose of preventing negative effects on the environment and improving a firm's environmental practices. This is achieved by developing environmental programs and practices. The adoption of cleaner production processes, greener products, and measures of environmental performance also contribute to the successful

implementation of an EMS (Gupta 1994). An EMS is a voluntary approach, which can lead to the reduction of environmental impacts such as pollutant emissions (Szymanski and Tiwari, 2004). Previous research also suggests that a strong link exists between human resource (HR) factors and the implementation of an EMS (Daily et al. 2007). The environmental programs and practices associated with an EMS are considered important factors in reducing the impact of business on the natural environment. For example, green technologies and products as well as metrics to evaluate and monitor environmental performance can lead to improved environmental performance (Gupta 1994). An EMS can play an important role in a firm's environmental performance. Environmental management standards, such as ISO 14001, have been shown to be positively related to both environmental performance and operational performance (Sroufe 2003a; Epstein and Roy 1997) also point out that ISO 14001 can contribute to organizational learning by developing core capabilities, skills, and knowledge. Sroufe (2003b) found that firms with existing informal EMSs saw little benefit in expending additional time and resources to attain ISO 14001 certification. Other studies support these findings, but also show further benefits. Certification has added benefits such as greater visibility, procedural legitimacy, and external recognition. It also assists in maintaining and improving an existing EMS (Jiang and Bansal 2003).

Holton et al. (2009) present key findings from four case studies undertaken to investigate how the leaders in corporate sustainability in the UK precast concrete industry were managing for sustainability. It was found that by adopting a compliance approach, characterized by the development of management systems and continuous performance improvement cultures, the four companies were engaged in the activities and developing the capabilities necessary to manage for sustainability, and had progressed naturally to the efficiency phase of corporate sustainability. The most important aspects to be pointed out are the following: (a) Managing for sustainability in each company began with a compliance approach based primarily on the development of ISO 14001 certified environmental management systems, (b) the principal benefit of developing certified management systems was the development in each company of a continuous performance improvement culture, (c) by adopting a compliance approach there was evidence that the four companies studied had progressed naturally to the efficiency phase of corporate sustainability, (d) the is a tendency for organizations to focus on improving only their environmental performance and therefore only achieve progress towards eco-efficiency. In order to develop a comprehensive efficiency approach to sustainability, there is also a need to achieve complementary progress towards socio-efficiency, the four companies were achieving this by broadening their sustainability focus and making better use of their human capabilities, (e) the commitment of senior management in each company was essential for the success of the change process, but it was also important for that commitment to be transferred down through the company and for change agents to be established at different operational levels, (f) the development process is characterized by gradual, planned, continuous and ongoing incremental change, but to progress beyond this may require more transformational change and strategic repositioning and

(g) developing management systems and continuous performance improvement cultures has led to each company engaging in the activities and developing the capabilities necessary to manage for sustainability. Dunphy et al. (2003) suggest that managing for sustainability is critical to the development of corporate sustainability. Roome (1998) states that managing for sustainability is fundamentally about strategic organizational development and change, change in management structure, systems and competencies.

Boiral and Gendron (2010) investigates the extent to which certification auditing can contribute to the realization of organizational accountability for sustainable development. The work illustrates the pertinence of studying the auditing function from a cross-disciplinary view point, and of paying attention to the process by which auditing travels from one discipline to another. They are proposing an integrative and dynamic model of the institutionalization process and myth formation surrounding sustainability auditing. Their model indicates that the legitimacy of certification auditing is anchored in rational myths that reveal significant discrepancies and decoupling between, on the one hand, the imagery of rationality and rigor surrounding auditing and, on the other hand, the actual audit processes as taking in the field. In recent years, certifiable standards on reporting and management practices for sustainability have been increasingly adopted by organizations across the world. Standards on sustainability reporting, such as the Global Reporting Initiative (GRI) framework, mainly aim to improve the reliability and transparency of environmental, social and economic disclosures (Unerman et al. 2007). Standards on management practices, such as ISO 14001, are focused on the implementation of control systems, the central purpose of which is to manage an organization's environmental and social responsibility (ISO (International Organization for Standardization) 2008).

Firms choose to seek environmental management systems (EMS) certifications such as ISO 14001 for a variety of reasons. Takuya Takahashi and Masao Nakamura (2010) put forward a hypothesis that firms seek ISO 14001 certifications for their establishments when their operations involve low degrees of complexity. Another hypothesis they consider, is that firms facing more uncertainty in their operations (and hence more risk) seek ISO 14001 certification. These hypotheses have not been addressed in the literature and are of particular interest to business managers and policymakers. They empirically test these hypotheses using mathematical models. Their findings support the first as well as the second hypotheses. This suggests that firms tend to certify more routine and less complex operations first, and that firms use ISO 14001 certifications as an insurance scheme. Environmental concerns continue to play an important role in firms' management decisions. Many firms decide to adopt some form of environmental management system (EMS) to address such concerns. Furthermore, some firms choose to be certified under recognized international standards. For example ISO 14001 is an international, voluntary standard certification scheme for an EMS managed by the International Organization for Standardization (ISO). Broadly speaking, there are at least two types of circumstance, one external and the other internal, in which firms are likely motivated to seek EMS certifications (Rivera-Camino 2001). These types

of circumstance are explained as follows. The first type of circumstance is characterized by the presence of external pressures being placed on firms, where such pressures come from bodies that are external to the firms such as governmental agencies and markets in which the firms operate (Khanna and Anton 2002) (e.g. strict government regulations, market considerations, green consumers and environmental friendliness). The second type of circumstance in which firms are motivated to certify, arises when the firms face significant internal pressures. Many factors that might cause these two types of circumstance may interact with each other and promote firms for firms to adopt EMS certifications unless the firms have environmentally conscious managers and human resources. Takuya Takahashi et al. (2009) therefore argued that cost-minimizing and risk-averse firms decide to seek ISO 14001 environmental management certifications based on two considerations: (i) the cost of certification based on the degree of complexity of their operations (i.e. routine operations are certified first) and (ii) the benefit of using ISO 14001 as an insurance scheme against the uncertain, but major, environmental risks that might be inherent in their operations. Such economic decisions by firms seems plausible because of the known high costs associated with applications for and maintenance of such certifications over time on one hand, and the potentially high costs of uncertain environmental disasters that might occur on the other.

In general, companies make choices based on the opportunities and advantages they can obtain as an outcome of their behaviors, as any other societal organism. According to Morrow and Rondinelli (2002) the choice of installing and managing an EMS is motivated by drivers such as stakeholder pressures, regulatory pressures, ability, parent company's influence, and market conditions. While many such reasons apply to large companies, the behavior of small and medium enterprises (SMEs) is different. SMEs may see EMSs almost as a mandatory issue, especially if they operate in certain markets (e.g. energy). Their rationale for the implementation of EMSs is often based on a large number of heterogeneous factors (Uchida and Ferraro 2007). While implementation related aspects such as improved risk management capabilities and reduction of environmental impacts are of interest in these cases, reputational implications are often prevalent in determining willingness to realize an EMS. Especially in SMEs, the possibility to enter the *club* of members managing a certified EMS represents a goal that is seen as having market potential in accordance to the club theory (Kollman and Prakash 2002). In some cases the path is eased by public funding, in accordance to public policies aimed at increasing the competitiveness of SMEs. While 'external' factors seem to be prevalent as motivation drivers (Uchida and Ferraro 2007), the outcomes are nevertheless of positive impact: managers learn how to cope with new management systems resulting in an overall environmental benefit. It is practical experience of the authors of this work that – as reported in the literature (Uchida and Ferraro 2007; Kollman and Prakash 2002; Iraldo et al. 2010) – one of the main positive outcomes in SMEs, is the awareness in the legal implications and actual weaknesses of the current organization, that lie major benefits when seeking registration of EMSs. An SME suddenly realizes the amount of national and regional laws and regulations that must be obeyed to fulfill legal obligations, that simply was not aware of.

It has to be observed that SMEs approach EMS certification and verification starting from ISO rather applying directly the EMAS scheme. This is both because of different complexity in EMSs and because of marginal gain in reputation resulting by the application of EMAS, as opposed to the ISO scheme as perceived from the viewpoint of a SME.

Moreover, consider that co-financing by public funding may induce unwanted needs in companies, such as the attitude of *collecting* management systems (quality, environmental, health and safety, . . .), for the only reason that public funds can be exploited to increase visibility of the company. Also, it is already recognized that dealing with such systems may divert attention of companies away from other more mission-related tasks.

3 Discussion

The quantitative and qualitative analyses highlight an increasing interest in both research topics related to EMSs and sustainability. Both scientific and empirical evidences support the consideration that the benefits in adopting EMSs in organizations overcome the associated drawbacks and limits. Through the implementation of an EMS, companies, as well as other stakeholders, increase their sensitivity and awareness with respect to the enlarged view offered by sustainable principles and strategies. This aspect is in fact implied by the contents of the qualitative analysis and of the case study described in Sect. 4. Although there are no clear evidences both in literature both in real industrial cases about the fact that EMSs direct support the economical and social perspectives, companies experience a positive influence in adopting EMSs on the environmental aspects, making them valuable tools towards sustainability. Higher discipline devoted to the environment and the related regulations and a more proactive attitude are both positive outcomes resulting in practical EMSs implementations. Apart from specific industrial sectors such as the chemical one or the forestry, where social effects of EMSs implementations can also be of great impact, marginal social outcomes result from their application in many service and in other manufacture oriented businesses. Regarding the economical implications, evidences seem not to be found in the analyzed literature. While it is true that wastes can be reduced as a consequence of an increased attention by management, it is also to be considered that implementation of an EMS is a complex and complete industrial project. Consequently, initial investments can be considerable and may have a medium time payback period. If policies and objectives are not strongly enforced, this could be a reason for the company to early drop the EMS realization and fail to benefit from additional implications in the sustainability area.

As additional evidence, consider that several of the companies listed in the Dow Jones Sustainability Index manage a certified ISO 14001 EMS, thus supporting the correlation between sustainability and EMSs. While the existence of this relationship can be stated as evidenced by the considerations in this chapter, EMSs must be

accompanied by other strategic actions if the risk of drinking old wine in a new bottle is to be avoided.

4 Case Study

In order to remark the statements in Sect. 3, it is valuable to consider, as an example, the case of a small company offering cleaning services, whose path toward the realization of an EMS, has recently been analyzed by the authors. The adopted EMS has clarified which laws were applicable and to which extent. Major behavioral differences before and after application regarded the disposal of waste belonging to the European List of Waste (The European Waste Catalogue) and the correct application of the upcoming Italian waste traceability system, that is about to become mandatory for all companies producing wastes. In both cases the company realized that previous behaviors were not complying. In the case of cleaning services the environmental impacts are clearly marginal and cannot be reduced below a certain level, given that cleaning products must be used. Consequently the initial environmental review that is listed in ISO 14001 and ISO 14004 and easily becomes the basis for the environmental statement under EMAS, did not highlight major opportunities for improvements with respect to the environment: low-pollution cars were already in use for allowing operators to reach cleaning sites and eco-products were already used – when possible – for the operations. Nevertheless the company went through a process that produced knowledge for all involved actors. This a benefit resulting every time certification is sought: managers and representatives within the company make a large step forward in their appreciation of the details in an EMS, consultants helping the company reach certification, enlarge their view on this subject by solving new application specific issues, the certification body increases knowledge by allowing its auditors to be exposed to new challenges in interpreting and applying normative requirements. Comprehensively, all stakeholders have a competitive advantage that has its peaks during the pre- and certification-audits. In the mentioned case about the cleaning services, the company had an additional benefit in the development and strengthen of an own network of relationships: with partner organizations (suppliers and customers) and with the local chamber of commerce. Suppliers were involved to specify properties of cleaning products and to update accompanying documents, customers were involved because of the adoption of new procedures requiring accident prevention and thus a certain level of collaboration by the site owners. The chamber of commerce was involved to help interpret national regulations regarding waste disposal. None of the topics discussed with these partners was given for granted: each subject posed new challenges and thus true increase in knowledge was gained at least in this local circle of actors.

We can then say that besides the evident environmental benefit a knowledge increase benefit results for the society as a whole. In this specific case, other side effects were the increased sensitivity of the company with regards to obeying all

applicable rules. The fact that not all environmental laws were followed, raised concerns towards health and safety and social accountability issues, that are only marginally implied by the EMS requirements. Thus, a thorough analysis was performed in the ample set of related norms. Two outcomes resulted: the correct application of all rules, comprising new procedures to care for collaborators health issues and improved quality of labor contracts that modified constraints of both parties to comply with national labor contracts and a mechanism to keep all this information updated. Obviously a much more robust organization resulted from all these operations. The role of certifiers and auditors was also important: they brought their expertise in the process and provided both technical and managerial insights, highlighting the company strengths and help improving its weaknesses. As an example, the certification organization provided the company with a 30-page length *check-list* to verify legal compliance against the provided set of updated laws.

5 Conclusion

Sustainability is a key issue of today society. Within this context, business sustainability is part of the problem, and can be part of the solutions. Recent researches have demonstrated that companies affect and are affected by sustainability, and that sustainability opens both opportunities and threats.

However, how to stimulate Sustainability in the companies? Are there enabling tools (such as EMSs) that could directly increase the company Sustainability?

In answering these research questions, it's important to investigate if there is a direct correlation between EMSs and an increasing level of company sustainability. This has been investigated in this work.

Through a triple approach (quantitative and qualitative research plus a case study analysis), the authors could conclude that an EMS can be thought of as a tool enabling the company's path towards sustainable strategies and operations. This is especially evident for the environmental and, less, for the social pillars; nothing can be demonstrated for the economical impact, since there are no clear evidences about the EMSs influence on that.

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The Green Option Matrix to Characterize Green Products and Practices

Applications to the Upholstered Furniture and the Footwear Industries

Rosa Maria Dangelico and Pierpaolo Pontrandolfo

1 Introduction

Nowadays, to become 'green' is both a need and an opportunity for companies. The reasons that push firms to go 'green' can be very different, such as legitimacy, competitiveness, and ecological responsibility (e.g. Shrivastava and Hart 1995; Bansal and Roth 2000; González-Benito and González-Benito 2006; Murillo-Luna et al. 2008). As a result, a growing number of companies are embracing environmental sustainability into their strategies (Dyllick and Hockerts 2002). In this context, the development of green products is becoming more and more relevant. In fact, the Green Paper on Integrated Product Policy (Commission of the European Communities 2001) states that one way to achieve the target of sustainable development is "a new growth paradigm and a higher quality of life through wealth creation and competitiveness on the basis of greener products". The development of green products can also be a means for companies to achieve competitive advantage. For example, Porter and Reinhardt (2007) highlight the need for companies to adopt a strategic approach to climate and to take action now, underlining the opportunity to gain competitive advantage by creating green

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products, able to exploit climate-induced demand (such as hybrid cars). Therefore, the number of companies facing the green product challenge is supposed to rapidly grow in the next years. This is coherent with the growing trend of companies that obtain yearly the European Eco-label for their products. In fact, while at the end of 2000 about 50 companies obtained European Eco-label for their products, at the beginning of 2010, this number has grown to more than 1,000.

In the literature, research on green product innovation is growing in interest (e.g. Baumann et al. 2002; Pujari et al. 2003; Rehfeld et al. 2007). In particular, green products are receiving increasing attention as means to improve companies' performance (Pujari 2006; Chen et al. 2006; Chung and Tsai 2007). However, the debate regarding what constitutes a green product (e.g. Chen 2001; Baumann et al. 2002; Berchicci and Bodewes 2005) is still ongoing. Similarly, there is much uncertainty among firms on the product dimensions to be considered to develop green products.

This paper aims at providing a description and a characterization scheme of the main different options to develop green products. The goal is then providing a matrix useful for companies to compare industrial sectors' green products and practices and to communicate to stakeholders the environmental features of their green products and practices.

The paper is structured as follows: Sect. 2 reports a literature review of the main definitions and classifications of green products, whereas Sect. 3 proposes a new dimension of characterization, so developing the *Green Option Matrix* (GOM), which represents a guide for companies to position their own green products and communicate them to stakeholders, analyze competitors' green products, so highlighting new spaces to be explored for green product design. In Sect. 4, the proposed matrix is used to analyze green products and practices developed by a sample of companies belonging to the upholstered furniture and footwear industries, while in Sect. 5 directions for companies on how to use the GOM are provided. Finally, in Sect. 6 discussion and conclusion are reported.

2 Definitions and Classifications of Green Products

The many meanings of the word 'green' have been discussed in the literature (e.g. Kleiner 1991; McDonagh and Prothero 1996; Miller and Szekely 1995; Silverstein 1993). In particular, McDonagh and Prothero identify several dimensions of green, such as ecological, political, corporate social responsiveness, fair trade, conservation, non-profit, new-consumerism, sustainability, and equality. These concepts are very broad and embrace very different aspects, so generating confusion on the meaning of 'green' and not giving clear directions to companies willing to become green. Similarly, at the product level, several attempts have been made to define what a green product is (e.g. Peattie 1995; Roy et al. 1996; Ottman 1997). Nevertheless, there is still confusion on what constitutes an environmentally friendly product (Baumann et al. 2002; Berchicci and Bodewes 2005).

Some authors have tried to define 'green products'. Peattie (1995, p. 181) defines a product as 'green' *when its environmental and societal performance, in*

production, use and disposal, is significantly improved and improving in comparison to conventional or competitive products offerings. This definition highlights the different life cycle phases during which a product can show its environmentally friendly features.

Reinhardt (1998, p. 46), focusing on green business, state that: *a business creates products that provide greater environmental benefits, or that impose smaller environmental costs, than similar products*. This definition points out that green products are not only those products with a lower environmental impact, but also those providing higher environmental benefits compared to conventional products.

Ottman et al. (2006, p. 24) state that *although no consumer product has a zero impact on the environment, in business, the terms 'green products' or 'environmental product' are used commonly to describe those that strive to protect or enhance the natural environment by conserving energy and/or resources and reducing or eliminating use of toxic agents, pollution, and waste*. This definition stresses the main types of environmental focus of green product development, namely energy, resources, pollution and waste.

The Commission of the European Communities (2001) defines green products as products that *use less resources, have lower impacts and risks to the environment and prevent waste generation already at the conception stage*. This definition emphasizes the importance of designing products as 'green' since the conceptualization phase.

Several other authors have highlighted the distinctive features of green products (Table 1).

The many definitions and characteristics of green products prompt the need to develop a coherent framework in which integrating them. Although in some definitions and characteristics of green products the social performance is mentioned, in this paper, we chose to refer to a product as 'green' only on the basis of its environmental performance.

In the literature, different perspectives to classify products have been identified, namely marketing, organization, engineering design, and operations management (Krishnan and Ulrich 2001). Green product design can be thought of as a fifth perspective (Sousa and Wallace 2006). In fact, the natural environment represents a driver to redesign existing products or to create new ones, making them more energy efficient or less material intensive (Shrivastava 1995).

Several green product classifications have been developed driven by distinct classification purposes. Taxonomy dimensions can be product characteristics (e.g. Rombouts 1998), level of environmental impacts (e.g. Hanssen 1999), or types of environmental improvement strategies (e.g. Park et al. 1999; Rose et al. 1999). Kaebernick and Soriano (2000) use a simplified approach to assess the conceptual design phase, by classifying products into groups according to their environmental features. They consider four product life cycle phases (materials, process, usage, and disposal) and divide products into two groups, distinguishing two kinds of impact drivers, namely energy based and material based. Sousa and Wallace (2006) develop an automated classification system guiding the identification of product groups based upon environmental categories. Dewberry and Goggin

Table 1 Review of the characteristics of green products

Authors	Characteristics associated with the 'green' nature of a product
Elkington and Hailes (1988)	Not endangering the health of the consumer or of others
	Causing no significant damage to the environment during manufacture use or disposal
	Not consuming a disproportionate amount of energy during manufacture, use and disposal
	Not causing unnecessary waste, either because of overpackaging or because of an unduly short useful life
	No use of materials derived from threatened species or from threatened environments
	Not involving unnecessary use or cruelty to animals
	Not adversely affecting other countries, particularly the third world
Simon (1992)	Reduced raw material, high recycled content
	Non-polluting manufacture/non-toxic materials
	No unnecessary animal testing
	No impact on protected species
	Low energy consumption during production/use/disposal
	Minimal or no packaging
	Reuse/refillability where possible
	Long useful life, updating capacity
	Post-consumer collection/disassembly system
	Remanufacturing capability
Schmidheiny (1992)	Eliminate or replace product
	Eliminate or reduce harmful ingredients
	Substitute environmentally preferred materials or processes
	Decrease weight or reduce volume
	Produce concentrated product
	Produce in bulk
	Combine the functions of more than one product
	Produce fewer models or styles
	Redesign for more efficient use
	Increase product life span
	Reduce wasteful packaging
	Improve reparability
	Redesign for consumer reuse
	Remanufacture the product
Peattie (1995)	Recyclability
	Resource efficiency
	Emissions
	Impact on ecosystems
	Social impact
	Sustainability of resource use
	Waste and disposal
	Eco-efficiency of production and organization
Robert (1995)	Minimize the use of nonrenewable materials
	Avoid the use of toxic materials
	Use renewable resources in accordance with their rate of replenishment

(continued)

Table 1 (continued)

Authors	Characteristics associated with the 'green' nature of a product
Shrivastava and Hart (1995)	Low environmental impact during usage
	Easily composted, reused, or recycled at the end of their useful life
Roy et al. (1996)	Capable of lessening global environmental problems
	Energy efficient
	Easily repairable
	Designed to last, or to be reused, reconditioned or recycled
	Generates minimum pollution and waste
	Can be disposed of safely
	Minimal use of materials, including packaging
	Manufactured from renewable or abundant resources, or recycled materials
	Manufactured, if possible, locally and from locally obtainable materials to reduce transport requirements
	Environmental information on product available to purchaser
	Not harmful to human health
	Satisfies a genuine human need
Luttropp and Lagerstedt (2006)	Do not use toxic substances and utilize closed loops for necessary but toxic ones
	Minimize energy and resource consumption in the production phase and transport
	Use structural features and high quality materials to minimize weight
	Minimize energy and resource consumption in the usage phase
	Promote repair and upgrading
	Promote long life
	Invest in better materials, surface treatments or structural arrangements
	Prearrange upgrading, repair and recycling
	Promote upgrading, repair and recycling
	Use as few joining elements as possible
Ljungberg (2007)	Reduce the materials and the use of energy for a product
	Reduce emissions, dispersion and creation of toxics
	Increase the amount of recyclable materials
	Maximize the sustainable use of renewable resources
	Minimize the service intensity for products and services
	Extend the useful life for a product
	Assess and minimize the environmental impact
	Having a "functional economy"
	Use "reverse logistics"
	Increase the efficiency in the usage phase

(1996) develop an *Ecodesign Matrix*, subsequently used by Roy et al. (1996), to classify the environmental impact of products on the basis of two dimensions: main life cycle stage (production, use, and disposal) and environmental focus (energy, materials/resources, pollution/toxic waste). Peattie (1995) classifies products on the basis of their eco-performance, distinguishing different shades of 'green' (from deep green to black) and types of products (absolute green or relative green). In

particular, **absolute green products** contribute to the improvement of society or the environment, whereas **relative green products** reduce the harm they cause to society or environment. This distinction recalls the one made in Reinhardt's (1998) definition. The concept of absolute green product is quite close to those of 'ameliorative product', defined as a product necessary to survive environmental deterioration (Ryan et al. 1992; p. 13), and of 'sustainable-function product', defined as "a product (or service) that reduces a negative impact in its surroundings to such an extent that the reduction exceeds the impact caused by the product's lifecycle itself" (Wever et al. 2008; p. 201). As highlighted by Wever and Boks (2007), despite its high potential, this type of innovation lacks of academic attention.

Based on these considerations, this paper expands the *Ecodesign Matrix* proposed by Dewberry and Goggin (1996), adding a third dimension for green products' characterization, i.e. the type of environmental impact. In the next Section, the three dimensions will be explained and integrated in a tridimensional matrix.

3 The Green Option Matrix (GOM)

In order to synthesize and integrate in a coherent framework the different dimensions of green products and to give relevance to the different types of contributions of green products towards the environment, a tridimensional matrix is developed.

Starting from the consideration that every product (even green ones) impacts on the environment (Peattie 1995), it is important to clarify when, why, and how much a product is green. It is then necessary to point out:

1. **When**, i.e. the **phase of the product life cycle** during which the green features are expressed;
2. **Why**, namely the reason why the product can be considered green, which involves recognizing the main **environmental focus** of the product;
3. **How much**, that is the **type of impact** on the natural environment.

With regard to the **phase of the product life cycle**, we will consider three main phases: (i) before usage (including materials' extraction, production processes, transportation processes), (ii) usage, and (iii) after usage (end-of-life).

By **environmental focus** we refer to the main category of environmental impact of a green product, as the latter can improve its impact on the environment with emphasis on materials (including water), energy, or pollution (emissions and toxic waste). We can then distinguish green products, on the basis of their main environmental focus, respectively as green products focused on materials, energy, and pollution.

Once recognized the three main types of environmental focus of green products, it is possible to specify the **type of impact**, which we name as less negative, null, or positive. A product can be considered green, in terms of one of the three

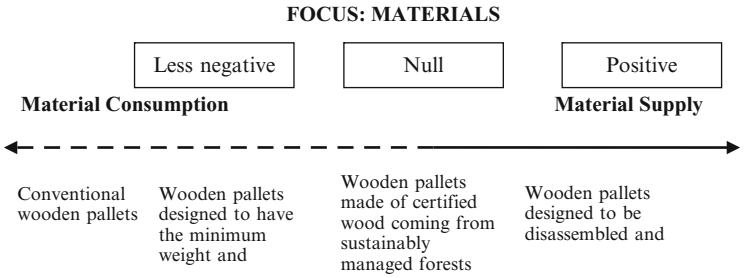


Fig. 1 Green products with a focus on materials and levels of environmental impact (Evaluation referred to a specific focus and life cycle phase)

environmental focus, if it has an environmental impact lower than conventional products, or if it has a null impact, or if it positively contributes to environment, reducing environmental impact of other products. Below we detail the definition with respect to every environmental focus.

A green product with a focus on **materials** is, for example, a product that:

- Is produced using less amount of materials than conventional products (less negative environmental impact);
- Uses only recycled materials or natural/biodegradable materials at a sustainable rate (null environmental impact);
- Is designed to be reused, disassembled and remanufactured, or it is made of materials that can be recycled, reducing then the environmental impact of other products that will not require the consumption of virgin materials (positive environmental impact).[1]

In Fig. 1 some examples of green products with a focus on materials and the respective levels of environmental impact during a specific phase are shown.

Similarly, a green product with a focus on **energy** is, for example, a product that:

- Is more energy efficient than conventional products, or if part of the energy used comes from renewable energy sources (less negative environmental impact);
- Uses only energy from renewable sources (null environmental impact);
- Produces energy from renewable sources, and in so doing reduces the environmental impact that will be caused by other products (positive environmental impact).

In Fig. 2 some examples of green products focused on energy and the respective levels of environmental impact during a specific phase are shown.

A green product with a focus on **pollution** is, for example, a product that:

[1] Products with a positive impact with regard to the focus 'materials' recall the concept of "cradle to cradle", since they allow a new life for materials.

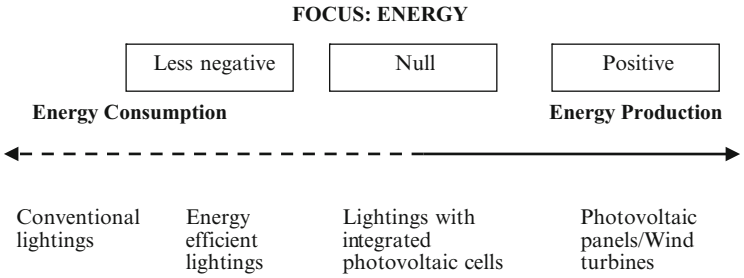


Fig. 2 Green products with a focus on energy and levels of environmental impact (Evaluation referred to a specific focus and life cycle phase)

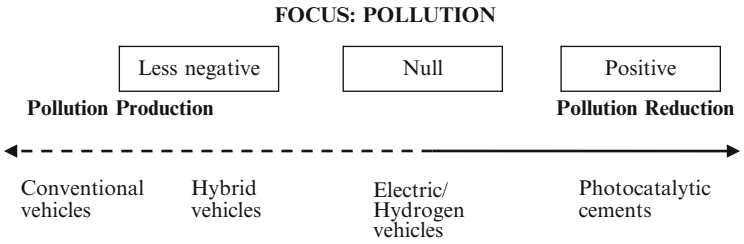


Fig. 3 Green products with a focus on pollution and levels of environmental impact (Evaluation referred to a specific focus and life cycle phase)

- Is less pollutant than conventional products (less negative environmental impact);
- Does not pollute (null environmental impact);
- Reduces pollution caused by other products (positive environmental impact).

In Fig. 3 some examples of green products with a focus on pollution and the respective levels of environmental impact during a specific phase are shown.

In particular, a greater attention should be addressed to the third point of each kind of products, i.e. products with **positive environmental impact**. In fact, while other products can be considered 'green' as they create less environmental problems than conventional products, these products contribute to **solve environmental problems**, which in turn implies a negative environmental footprint and then a reduction on the environmental footprint due to other products. In this sense, a green product with positive impact can be considered as an "environmental helper". Note that, as the evaluation of the product impact is done with specific regard to a given focus and phase rather than over the whole life cycle, a product with a positive impact might not be such over the entire life cycle.

Based on the above we propose the *Green Option Matrix* (GOM) (Table 2) that allows green products to be characterized according to the discussed dimensions.

Table 2 The green option matrix

		Environmental focus								
		Materials			Energy			Pollution		
Life cycle phase →		BU	U	AU	BU	U	AU	BU	U	AU
Environmental impact	Less negative									
	Null									
	Positive									

4 The GOM Applied to the Upholstered Furniture and the Footwear Industries

Upholstered furniture and footwear industries represent two important specialization fields of Italian manufacturing and a relevant part of the whole Italian economy. However, the growth of emerging countries' economies significantly challenges the competitiveness and the existence itself of these two industries in the developed countries. Under this perspective, green product development might represent a viable way to pursue a strategy of differentiation. Moreover, developing green products is increasingly becoming a new trend in these two industries worldwide (see for instance Albers et al. 2008; Evans 2007).

The GOM is then used to analyze the different features of green products developed by a sample of companies belonging to upholstered furniture and footwear industries, showing commitment towards the development of green products and practices. In particular, the sample companies have been identified through a web search of relevant keywords.[2] Relevant data have been collected by means of content analysis of companies' websites and sustainability reports (e.g. Wolfe 1991; Krippendorf 2004).

In this way, green products and related practices developed by each company in the sample have been identified and positioned in the GOM. In particular, to this purpose we developed and used a structured procedure involving three main steps: step 1, identifying the focus area(s) to which the improved environmental performance of the product/practice or the environmental benefits determined by the product/practice refer; step 2, identifying to which phase(s) of the product life cycle the improved environmental performance of the product/practice or the environmental benefits determined by the product/practice refer; step 3, identifying the type of environmental impact of the considered product/practice. These steps are depicted in Appendix A.

[2] Keywords: *green sofa* (or *upholstery* or *upholstered furniture* or *shoe* or *footwear*), *eco sofa* (or *upholstery* or *upholstered furniture* or *shoe* or *footwear*), *environmental sofa* (or *upholstery* or *upholstered furniture* or *shoe* or *footwear*), *eco-friendly sofa* (or *upholstery* or *upholstered furniture* or *shoe* or *footwear*), *environment-conscious sofa* (or *upholstery* or *upholstered furniture* or *shoe* or *footwear*), *sustainable sofa* (or *upholstery* or *upholstered furniture* or *shoe* or *footwear*).

Results are then aggregated by industry, so as to develop a matrix for each sector, which represents the different undertaken actions.

For the sake of clarity, the tridimensional matrix is presented by means of three separate matrices, each of which focusing on a specific environmental focus.

4.1 Upholstered Furniture

4.1.1 Environmental Focus 'Materials'

In Table 3, the GOM filled with green products and practices developed in the upholstered furniture industry is shown, with a focus on *materials*.

In the 'before usage' phase, companies have reduced their products environmental impact ('less negative'), through efficient production processes, in terms of reduction of water and raw materials use. Specifically, efforts have been made to reduce size and weight of sofas, therefore at the same time both saving materials and reducing energy consumption and pollution due to transportation. Some companies also use water footprint indicators to reduce water consumption. To have a 'null' impact some companies have used materials that are recycled or natural and coming from renewable sources for sofa frames, coating, filling, or packaging. Practices adopted by companies that can be conceived as having a 'positive' impact are the reuse or recycle of production wastes or by-products that can then be used to manufacture new products. In the 'usage' phase firms have tried to reduce the environmental impact of sofas by extending their lifecycle, through the use of highly resistant materials or providing maintenance kits for leather.

Referring to the 'after usage' phase, in order to have a 'null' impact, actions have been devoted to use biodegradable materials. In order to have a 'positive' impact, many firms have designed products, components, and packaging to be easily disassembled (avoiding adhesives), reused and recycled.

The 'usage' phase is the one in which fewer actions are identified, especially with regard to null and positive impacts, leaving then opened for firms opportunities to explore innovative options.

4.1.2 Environmental Focus 'Energy'

Table 4 shows the GOM filled with green products and practices developed in the upholstered furniture industry, with a focus on *energy*.

With regard to the 'before usage' phase, products have been designed to use less materials, materials requiring little amount of energy to be produced, and/or materials locally available ('less negative' impact). Furthermore, several green practices have been adopted to make production and transportation processes more energy efficient ('less negative' impact), use renewable energy sources ('null' impact) and generate energy from waste ('positive' impact).

Table 3 Green option matrix for the environmental focus materials in the upholstered furniture industry

	Life cycle phase		
Impact	Before usage	Usage	After usage
Less negative	Reduction of sofa's size and weight, with a consequent reduction of the coating	Use of materials with high resistance to wear, tear, abrasion, dirt and characterized by easy maintenance (e.g. flakes of polyester fiber, canovaccio linen, hemp, ramie, steel springs)	–
	Use of nylon for seat fasteners (it is 40 % in weight derived from renewable resources)		
	Use of water footprint indicator to reduce water consumption	Maintenance kit used for leather (it allows to extend lifecycle of the sofa)	
	Initiatives to promote the use of digital documents and forms that allow to save paper and ink		
Null	Use of natural (e.g. 100 % natural latex, soy-based foam) or recycled materials to fill the sofa cushions	–	Use of biodegradable materials (e.g. bioplastics, natural fibers, 100 % natural latex, wood particle board)
	Use of fabrics that are either organic, natural or made from renewable plants (e.g. cotton, linen, silk, wool, ramie, and jute)		
	Use of recycled content fabrics (e.g. ecological cotton obtained from recycled T-shirts; fiber made from plastic bottles)		
	Use of recycled steel constructions		
	Use of FSC certified wood for the frame		
	Use of chipboard frames		
	Use of recycled material for packaging		
	Pieces covered in recycled truck traps for transport		
	Use of eco-friendly leather		

(continued)

Table 3 (continued)

Impact	Life cycle phase		
	Before usage	Usage	After usage
	Use of natural and renewable materials (e.g. bamboo, sustainable Kirei grass and wheat boards) Use of vegetable-based dyes into fabric Use of Oeko-Tex certified wool fabric that employs organic dyes Use of recycled wires		
Positive	Use of waste eco-friendly leather to manufacture gloves and keychains Recycling of waste materials (e.g. paper, plastic, aluminum products, wooden frames, cardboards, fabrics, trimming, and fibers) through a waste management company that distributes raw materials for use in other products Donation of virgin foam scarps to local art schools or center for autistic children Unused springs sold as scrap steel Initiatives to make global cotton production better for people producing it and for the environment	–	Use of recyclable materials for the frame (e.g. tubular aluminum, chipboard frame) Use of recyclable materials for packaging (e.g. polyolefin plastic film, cardboard with polypropylene straps without the use of adhesive tape) Use of recyclable materials for coating and filling (e.g. flakes of polyester fiber, goose down, canovaccio linen, jute, hemp). For example, moulded polyurethane foam parts can be ground up to obtain a mixture for use in low-value sheets (e.g. gymnastic mats, underfelt, footwear), leather can be ground up and reused for regenerated leather products, hemp can be made into a 100 % biodegradable plastic. Recycling of old furniture in the factory

Table 4 Green option matrix for the environmental focus energy in the upholstered furniture industry

	Life cycle phase		
Impact	Before usage	Usage	After usage
Less negative	Reduction of the coating (this requires less energy for processing) Use of the raw materials that are available close to the manufacturing plant (this reduces energy consumption due to transportation) Use of soy-based foam (which requires little amount of energy to be produced) Use of canovaccio linen (it is produced with very low energy consumption) Initiatives to reduce the use of paper (and consequently of the energy employed to print documents and forms) Reduction of electricity consumption (e.g. pressure on air compressors turned down, weather stripping panels installed on loading docks, lights turned off when not in use, use of natural light as much as possible) Initiatives to optimize transportation loads, thereby reducing the number of trips and the total energy consumption (e.g. use of flat packs, transportation of sofas packaged disassembled)	–	Use of tubular aluminum for the frame (it requires little amount of energy to be recycled)
Null	Use of energy from renewable sources to provide power to machines (e.g. solar panels and windmills)	–	–
Positive	Incineration of wastes to obtain energy (e.g. thermal destruction of ecological polyurethane in modern incinerators; the heating system for wood frame factory and fuel for wood-drying kilns is generated by burning scrap wood and sawdust)	–	–

With regard to the 'usage' phase no products and practices have been identified. This may be due to the fact that sofas do not use energy during the usage phase. However, this may also represent an innovation opportunity area to be explored for companies.

In the 'after usage' phase it can be mentioned the use materials requiring little amount of energy to be recycled.

4.1.3 Environmental Focus 'Pollution'

Table 5 shows the GOM filled with for green products and practices developed in the upholstered furniture industry, with a focus on *pollution*.

In the 'before usage' phase, most practices are developed to reduce emissions due to production and transportation ('less negative' impact) and with attention to avoid the use of toxic substances ('null' impact).

Table 5 Green option matrix for the environmental focus pollution in the upholstered furniture industry

	Life cycle phase		
Impact	Before usage	Usage	After usage
Less negative	Use of raw materials that are available close to the manufacturing facility (this reduces emissions due to transportation)	Use of wood panels with lowest class of formaldehyde emission	–
	Use of carbon footprint indicator for each sofa		
	Reduction of HAPs and VOCs by switching from duplication of fluid used in making fabric cutting patterns to use of plotters and recycled paper		
	Use of paints and coatings with the lowest possible VOCs		
	Use of components whose manufacturing does not emit CFCs		
	Initiatives to optimize transportation loads, thereby reducing the number of trips and CO_2 emissions (e.g. use of flat packs, transportation of sofas packaged disassembled)		
Null	Tanning processes free from harsh chemicals or metal	Use of materials that are non-toxic and do not have irritating effects on human skin, such as allergic reactions (e.g. organic or natural cotton, ecological polyurethane, 100 % natural latex)	Use of goose down (it does not pollute)
	Use of vegetable-based dyes into fabric	Water and neutral white soaps to clean the sofa (they have no environmental impact)	Use of foam containing organic halogen-free retardants
	Use of organic cotton (it is cultivated using methods that do not require genetic engineering and the use of toxic elements such as pesticides)	Use of Oeko-Tex certified wool fabric that employs organic dyes	
	Use of ecological polyurethane foam that does not contain Freon or other blowing agents	Use of foam containing organic halogen-free retardants	

(continued)

Table 5 (continued)

Impact	Life cycle phase		
	Before usage	Usage	After usage
	Use of 100 % natural latex (the only blowing agent used for the production of latex foam is air; avoidance of CFCs emissions)	Use of hemp (this fabric it is naturally non-toxic and pest-resistant)	
	Use of foam whose production process is free of ABAs, CFCs and auxiliary CO_2		
	Use of water-based glues and adhesives with no VOCs emissions		
	Use of solar energy to provide clean power to machines (reduction of GHGs emissions)		
	Elimination of toxins in the work environment		
	Use of aspiration's cabins in the department of bonding to defend the health and the welfare of workers		
	Use of flakes of polyester fiber (not harmful in any stage of production and assembly)		
	Use of totally chlorine-free paper		
Positive	–	Use of ecological polyurethane foam (it does not attract or generate dust; it is resistant to insects and parasites; it is bacteriostatic and bactericidal; it is washable and sterilizable)	–
		Use of flakes of polyester fiber (it does not allow the development of bacteria and mould)	

In the 'usage' phase, we can mention actions undertaken to make products safe for the human health, through the use of materials with low levels of emissions ('less negative' impact), non-toxic and non-irritating ('null' impact), and that do not attract or generate dust, resist to insects and parasites and/or are bacteriostatic and bactericidal ('positive' impact).

In the 'after usage' phase it can be mentioned the use materials that do not pollute when disposed.

4.2 Footwear Industry

4.2.1 Environmental Focus 'Materials'

In Table 6, the GOM filled with green products and practices developed in the footwear industry is shown, with a focus on *materials*.

Most of the companies' efforts seem to be focused in the before usage phase. The environmental impact is reduced ('less negative') by means of reduction of raw materials use or adoption of raw materials that require lower water consumption to be produced. Also, manufacturing processes are adopted that reduce the water consumption or the waste generation. Efforts are carried out to reduce the packaging size as well. Some companies also resort to material sourcing from sustainable suppliers (such suppliers undergo an environmental audit concerning all environmental focuses, which is why this practice is reported in the energy and pollution tables below, as well). In the same lifecycle phase, companies pursue a 'null' environmental impact by using several different types of renewable or recycled materials for both the product and packaging. In some cases the null impact is achieved through the use of wood coming from sustainable managed forests. Practices that can be conceived as having a 'positive' impact concern the reuse or recycle of raw materials and wastes as well as the use of natural fibers that involve benefits for the ground where they are cultivated.

In the 'usage' phase, the study has identified the use of natural materials for shoe parts that are in contact with the skin as a practice characterized by a 'null' impact. The use of particular fibers that involve benefits for the skin of the persons wearing the shoes has been recognized as having a 'positive' impact.

Referring to the 'after usage' phase, biodegradable or compostable packaging is classified as a practice characterized by a 'null' impact. Companies positively contribute to the environment ('positive' impact) by resorting to reusable packaging or ways to make the product recyclable. Among the practices presenting a 'positive' impact in the 'after usage' phase, there is also the implementation of programs aimed at converting, recovering and recycling post-consumer packaging, products or components.

4.2.2 Environmental Focus 'Energy'

Table 7 shows the GOM filled with green products and practices developed in the footwear industry, with a focus on *energy*.

The analysis on the energy focus could ascertain practices characterized by either a less negative or a null environmental impact. In the 'before usage' phase, companies implement actions aimed at reducing the energy consumption of production processes, or increasing the efficiency of energy generation systems, or optimizing transportation, or reducing size or weight of packaging (all of these

Table 6 Green option matrix for the environmental focus materials in the footwear industry

	Life cycle phase		
Impact	Before usage	Usage	After usage
Less negative	Reduction of products and packaging size Reduction of raw materials use Reduction of waste generation in manufacturing processes Reduction of water use in manufacturing processes Use of Kenaf, which requires a minimum amount of water in comparison to conventional row crops Material sourcing from sustainable suppliers (e.g. leather from tanneries that have achieved Silver or Gold rating with regard to environmental sustainability)	–	–
Null	Use of renewable materials (organic cotton, gum rubber, rice husks, bamboo, hemp, cork) Use of lenpur, which is a material made from wood coming from sustainably managed forests Use of recycled plastic (e.g. plastic from recycled soda bottles used for durable shoelaces) Soles made from recycled tires Use of recycled materials for packaging (e.g. leaflets made in recyclable cardboard)	Use of natural materials for shoe parts that are in contact with the skin	Biodegradable or compostable packaging
Positive	Use of kenaf, which is a material that enables	Use of fibers that, thanks to the adding of	Reusable packaging

(continued)

Table 6 (continued)

Impact	Life cycle phase		
	Before usage	Usage	After usage
	ground to be weeds-free after cultivation making it softer Process that converts scrap rubber into a recycled compound reusable in rubber products Reuse and/or recycle of raw materials and wastes	seaweed, promotes the remineralization of the skin as well as involves anti-inflammatory effects	Recyclable products (e.g. bionic canvas, green rubber) Programs to convert, recover and recycle post-consumer packaging, products or components (e.g. from the rubber in a running track to the carpet padding)

present a 'less negative' impact). In several cases we identified the use of renewable energy sources in production processes ('null' impact).

Finally, with respect to the 'after usage' phase, we identified efforts for using products or packaging that can be recycled with high-energy efficient processes ('less negative' impact) or reused without requiring any processing ('null' impact).

4.2.3 Environmental Focus 'Pollution'

Table 8 shows the GOM filled with for green products and practices developed in the footwear industry, with a focus on *pollution*.

With regard to the focus on pollution, the analysis highlights that almost all green practices concern the 'before usage' phase, with the only exception being the use of adhesive products made from water ('null' impact in the after usage phase). The reduction of toxic substances use in raw material processing and product manufacturing, transportation emissions, and water consumption are the practices characterized by a 'less negative' impact. The elimination of chemicals, hazardous wastes, and chromium and similar heavy metals are the ascertained efforts characterized by a 'null' impact. Finally, the use of kenaf is classified as having a 'positive' impact, as kenap crops can absorb smog.

5 How Companies Can Put the GOM into Practice

The green option matrix can be used by companies as a market analysis tool to study competitors' green product offering and as a communication tool for public relations activities. If the purpose of the matrix is conducting a market analysis of

Table 7 Green option matrix for the environmental focus energy in the footwear industry

	Life cycle phase		
Impact	Before usage	Usage	After usage
Less negative	Low energy consuming production processes (e.g. lean energy mapping processes) Material sourcing from sustainable suppliers (e.g. leather from tanneries that have achieved Silver or Gold rating with regard to environmental sustainability) Transport optimization Use of more efficient energy generation systems in production processes Size and weight reduction of packaging (e.g. lighter and smaller shoeboxes)	–	Products or packaging that can be recycled with high-energy efficient processes
Null	Use of renewable energy sources in production processes	–	Products or packaging that can be reused without any process
Positive	–	–	–

competitors' green products offering, first, a market analyst should identify the company's main competitors as well as their green products, then, an environmental expert, able to recognize these products' environmental focus, phase of life cycle, and type of impact, should position them in the matrix. The positioning of green products and practices of a sample of companies belonging to the upholstered furniture and footwear industries indeed represents an example of the use of the matrix as a market analysis tool. The matrix filled out with competitors' green product offering could then be taken into account by the top management, for decisions making about the green product portfolio management. For example, a company can decide the share of new products with environmental features similar to the ones of competitors' products, as well as the share of more innovative green products. In the former case new products would be positioned in already filled cells of the matrix deriving from the market analysis, in the latter case these products would be positioned in empty cells.

If the purpose of the matrix is to communicate to stakeholders the company's environmental efforts, first, managers knowledgeable about environmental performance of products and processes (e.g. head of environmental management/affairs or head of HSE management) should position in it the company's green products and practices. Then, people in charge of public relations should further elaborate the matrix to make it more easily readable and understandable by stakeholders. We suggest such a matrix to be included in the company's environmental/sustainability report.

Despite the above discussed benefits, it is not straightforward to identify to which cell of the GOM a given real product/practice should be assigned. To support companies in this task we further detailed the procedure reported in Appendix A as

Table 8 Green option matrix for the environmental focus pollution in the footwear industry

	Life cycle phase		
Impact	Before usage	Usage	After usage
Less negative	Reduction of toxic substances use in raw material processing and product manufacturing (reduction of pesticide use; reduction in the use of chemical and hazardous materials; reduction in consumption of solvents)	–	–
	Reduction of emissions due to transportation (lighter and smaller packaging; selection of geographically close fabric suppliers; optimization of logistics processes)		
	Use of Kenaf, which requires a much lower amounts of fertilizers and pesticides, in comparison to conventional row crops		
	Material sourcing from sustainable suppliers (e.g. leather from tanneries that have achieved Silver or Gold rating with regard to environmental sustainability)		
Null	Elimination of chemical substances (e.g. glues with direct injection onto uppers)	–	Use of adhesive products made from water
	Elimination of hazardous wastes		
	Manufacturing processes that do not use chromium or other heavy metals (e.g. white tanning)		
Positive	Use of Kenaf, which absorbs smog during cultivation	–	–

a checklist (Appendix B), benefiting from the analysis conducted in the two industries. Specifically, after the detailed screening of the implemented products and practices, we characterized them according to the *environmental impact* (less negative, null, positive), then developed a short general description of any group of products (practices) recognized as similar, finally used such a description as an item of the checklist, which a company can easily use as a reference to position actual products (practices).

6 Discussion and Conclusion

This paper has stressed that despite several definitions and classifications of green products, an integrated characterization seems to be still lacking in the literature. In fact, most of the contributions available in the literature generally put emphasis on single aspects that can be associated with the greenness of a product. In particular, this paper has explicitly recognized a specific type of green products, which previous tools (such as the Ecodesign matrix) do not highlight: products contributing to the improvement of the environment. We define such products as having a positive impact in that they reduce the environmental impact of other products.

A new dimension to better characterize green products has then been introduced, "type of environmental impact". It can assume three different levels, i.e. less negative, null, and positive, whose meaning is slightly different according to each of the three environmental focus (materials, energy, and pollution). A *Green Option Matrix* (GOM) has been developed to integrate this new dimension with environmental focus (materials, energy, and pollution) and life cycle phase (before usage, usage, and after usage).

The GOM has then been used to analyze and characterize green products and practices developed by a sample of companies belonging to the upholstered furniture and footwear industries.

Several questions were posed at the beginning of this paper. First, we raised the point about why very different products, becoming more and more widespread in the market (such as hybrid cars, recycled products, photovoltaic cells, and bioplastics to name a few), can be claimed as 'green'. Our study, by helping to structure the knowledge about products' environmental features, highlights the multi-facets features of 'greenness' and provides us with a roadmap to understand commonalities and differences among several types of green products.

Another question we raised was related to practices that should be implemented by companies willing to develop green products. By conducting an analysis of green products and practices developed by a sample of companies belonging to the upholstered furniture and footwear industries, and positioning them in the GOM, we suggest a wide range of options that could be implemented by companies that are starting to shift towards more sustainable business models. Due to a rapid increase of the public interest towards environmental issues, companies are feeling more and more in duty bound to communicate to stakeholders their environmental efforts. While several guidelines exist for reporting overall firms' environmental performance (see for instance the Global Reporting Initiative), similar tools have not been developed for products. Of course, the environmental excellence of products can be communicated through eco-labels or in terms of LCA results. However, not for all product categories eco-labels exist (think of products related to the production of renewable energy), and, when available, they generally give a synthetic indication of high environmental performance, without providing a detailed picture of the different types of environmental focus, impact, or life cycle phase that the product addresses. On the other hand, communicating LCA results could be misleading for customers if producers of competitive products do not do the same. The GOM may thus represent a suitable way for firms to communicate environmental features of their green products.

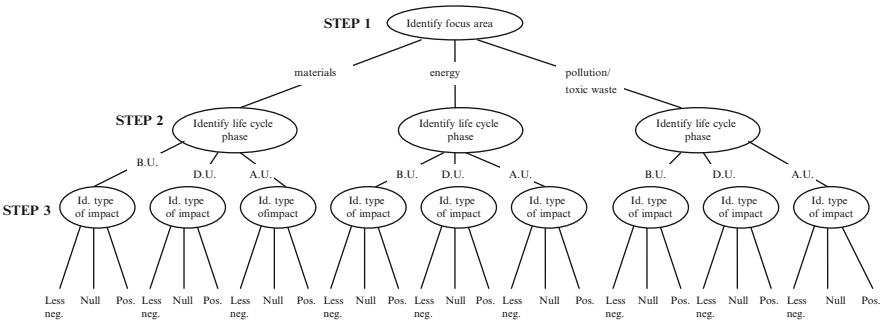
This study has several implications for companies. The GOM, in that helps structure the knowledge about green products and practices (referable to a single company as well as to a whole sector), may represent a useful tool for companies that want to develop green products. In particular, the value of this matrix can be twofold: (i) as a market analysis tool, helping companies to analyze competitors' green products and practices, so providing tangible directions to green their products, as well as suggesting directions to be explored, by identifying areas wherein green products or practices have yet to be developed (empty cells of the

GOM); in this sense the GOM can support green product portfolio management; (ii) as a communication tool, helping companies in their communication strategies to stakeholders about the environmental impacts of their products or practices (in particular we suggest the filled out GOM to be included in a company's environmental/sustainability report). It should be noticed that, since the use of the GOM as a communication tool helps companies to be specific in their green claims (the GOM forces a company to explicit the *when*, *why*, and *how much*), it prevents them from making general claims of 'ecological', 'green', sustainable' products, so reducing the risk of green washing.

Among the possible limitations of our study, we would stress that the GOM is not proposed as a tool to assess the environmental impact of products. In fact, a careful evaluation of a product environmental impact would require the use of life cycle assessment tools and should take into account the conditions of use of the product itself as well as external factors, such as the state of the ecosystem, which may affect its impact. The proposed approach is indeed qualitative in terms of the estimated environmental impact as well as referred to specific phases and specific types of environmental focus, rather than quantitative and measured over the entire life cycle. Such an approach has been adopted since it is coherent with the main purpose of our study, which is to offer an easy tool to managers for green product market analysis and communication. Methodologies and tools for a quantitative assessment of the environmental impact (such as LCA software) are already available and out of the scope of this study.

Furthermore, even though we developed the checklist to the best of our knowledge and analyzing companies recognized as sustainability leaders, we cannot exclude that additional items should be added to it, as a result of the technological progress as well as the existence of green products and

Appendix A



Steps to characterize green products and practices

Appendix B

CHECKLIST to guide the characterization of green products and practices

- STEP 1

In which one(s)[3] of the following focus areas does the product/practice display improved environmental performance compared to industry standards or determines environmental benefits?

- Materials (including water) → *go to the section 'materials'*
- Energy → *go to the section 'energy'*
- Pollution/toxic waste → *go to the section 'pollution/toxic waste'*

Section 'Materials'

- STEP 2

In which phase(s) of the product life cycle does the product/practice display improved environmental performance compared to industry standards or determines environmental benefits?

[3] Note that more than one choice is possible for steps 1 and 2. In such cases, all the related sections need to be considered.

- Before product usage → *go to the section 'before product usage'*
- During product usage → *go to the section 'during product usage'*
- After product usage → *go to the section 'after product usage'*

Before Product Usage

- STEP 3

Select the description that better reflects the product or practice and derive the corresponding type of impact.

Product or practice description	Corresponding type of impact
Eco-efficient production processes	Less negative
Reduction of product or packaging's size and weight	Less negative
Use of recycled materials for product or packaging	Null
Use of materials not containing harmful or toxic substances for product or packaging	Null
Use of renewable materials for product or packaging	Null
Use of environmentally certified raw materials for product or packaging	Null
Production waste recycling/reuse	Positive
Production water recycling/reuse	Positive

During Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Product with extended lifecycle/high durability	Less negative
Eco-efficient products, requiring/allowing the use of less materials	Less negative
Products using renewable raw materials (where competitive products use non renewable ones)	Null
Products that during use are in contact with peoples' skin and are made of natural/certified materials	Null
Products allowing to extend lifecycle of other products	Positive

After Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Product or packaging partly made of biodegradable materials	Less negative
Product or packaging partly made of recyclable materials	Less negative
Product or packaging completely made of biodegradable materials	Null
Product or packaging completely reusable, remanufacturable, or recyclable	Positive

Section 'Energy'

- STEP 2

To which phase(s) of the product life cycle the improved environmental performance of the product or the environmental benefits determined by the product refer?

- Before product usage → *go to the section 'before product usage'*
- During product usage → *go to the section 'during product usage'*
- After product usage → *go to the section 'after product usage'*

Before Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Products requiring less energy to be produced or installed	Less negative
Reduction of product or packaging's size and weight	Less negative
Use of practices reducing energy consumption in production plants	Less negative
Transport optimization	Less negative
Use of more efficient energy generation systems in production processes	Less negative
Use of renewable energy sources in production processes	Null
Use of cogeneration plants to provide electricity, heating, and cooling in production processes	Positive
Generating energy from exhaust hot gas/waste in production processes	Positive

During Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Energy efficient products, attachments, components	Less negative
Size and weight reduction of products used for transport	Less negative
Thermal insulating products/materials	Less negative
Energy conserving products	Less negative
Products working through energy coming from renewable sources by themselves generated	Null
Products increasing energy generation efficiency	Positive
Products generating energy from renewable energy sources	Positive

After Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Products or packaging that can be recycled with high energy efficient processes	Less negative
Reusing products or packaging without any processing	Null
Waste products recyclable into fuel	Positive

Section 'Pollution/Toxic Waste'

- STEP 2

To which phase(s) of the product life cycle the improved environmental performance of the product or the environmental benefits determined by the product refer?

- Before product usage → *go to the section 'before product usage'*
- During product usage → *go to the section 'during product usage'*
- After product usage → *go to the section 'after product usage'*

Before Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Reduction of emissions in production processes	Less negative
Reduction of emissions due to transportation	Less negative
Use of renewable energy sources in production processes	Null
Avoidance of the use of hazardous materials and chemicals in production processes	Null
Redevelopment of brownfield land/cleaning up of contaminated sites	Positive
Transforming production waste in fuel	Positive

During Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Energy efficient products, attachments, components	Less negative
Size and weight reduction of products used for transport	Less negative
Products with reduced electromagnetic waves emissions	Less negative
Products reducing pollution/release of toxic substances during their use	Less negative
Products avoiding pollution/release of toxic substances during their use	Null
Products avoiding/reducing pollution/release of toxic substances of other products	Positive

After Product Usage

- STEP 3

Select the description that better reflects the product or practice:

Product or practice description	Corresponding type of impact
Products with reduced amount of toxic substances – e.g. CFCs, radioactive materials, PVC – (thus generating a reduced amount of toxic waste)	Less negative
Products avoiding the use of toxic substances (thus not generating toxic waste)	Null
Products that reduce the pollution in the environment wherein disposed	Positive

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Sustainability Measurement and Reporting: Impacts on Finance, Stakeholders Communication and Internal Measurement Practices

Paolo Taticchi

1 Introduction

Declining ecosystems, limited natural resources, population growth and increasing economic disparity have pushed the sustainability debate significantly in the last decade. However, attention to environmental and social needs originates back to the late 80s, as confirmed by the popular notion of "sustainable development" (United Nations 1987) that states: "development that meets the need of the present without compromising the ability of future generations to meet their own needs".

Further, the world financial crisis, accounting and remuneration scandals, and suspicion about the social and environmental implications of businesses have led to growing demand for transparency about corporate behavior on a whole range of issues (Kolk 2008). In this context, sustainability has become an often-mentioned goal of businesses, nonprofits and governments, that being part of the problem origin can become part of the problem solution.

Edwards (2005) identifies in this the so called "sustainability revolution".

In fact, in the business "as usual" approach, environmental concerns are seen as an impediment to business success, regulatory compliance is viewed as simply another cost of doing business, and, therefore, in order to avoid compromising

Measurement is the base of management; reporting is the base of communication. This paper explores how the topic of sustainability if affecting traditional business activities in terms of measurement and reporting practices. Perspectives investigated include: finance and investments, stakeholders communication and engagement, internal measurement and management systems. Emerging frameworks related to these perspectives are presented and discussed. The picture that appears is a strong impact of the sustainability topic, and a significant evolution of the traditional performance measurement and reporting practice.

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profits, the prevailing attitude is to meet only the minimum compliance requirements.

Instead, under the effects of the "sustainability revolution", sustainable practices, in lieu of being seen as an impediment to business development, are seen as business opportunities.

A quoted definition of corporate sustainability is that of Dow Jones Sustainability Indexes (2012): "a business approach that creates long-term shareholder value by embracing opportunities and managing risks deriving from economic, environmental and social developments". Such a definition leads directly to the three pillars of sustainability, that are the economical, social and environmental dimensions. The concept of sustainability is therefore close the concept of "quality of life". The shared choice of accepting the sustainability concept as composed of the three before mentioned dimensions, led to another widely adopted idea, which is the "Triple Bottom Line". Such a paradigm, manifests the need of evolving traditional frameworks and measuring criteria forward new models able to understand and relate economical, social and environmental performances which have equal balance. Bonacchi and Rinaldi (2007) provide a comprehensive picture of the strengths, weaknesses and issues of Triple Bottom Line (TBL) approach.

TBL has become the main inspiration of today well-established accredited organizations that provide international reporting frameworks such as the Global Reporting Initiative (GRI) and the International Federations of Accountants (IFAC). However, there is neither a universal standard method for computing the TBL nor a universally accepted standard for the measures that comprise each of the three TBL categories.

Similarly to the topic of sustainability, interest on performance measurement and reporting has notably increased in the last 20 years (Taticchi and Balachandran 2008). Particularly, it is important to note the evolution of focusing performance from a financial perspective to a non-financial perspective. Companies have understood that for competing in continuously changing environments, it is necessary to monitor and understand firm performances. In this context, economic, environmental and social performance of firms needs to be understood, managed and properly disclosed to external stakeholders. Moreover, measurement has been recognized as a crucial element to improve business performance (Sharma et al. 2005). As a consequence of that, proper measurement and reporting (M&R) frameworks can facilitate the comprehension of sustainability drivers, the management of processes and the communication/engagement to/with stakeholders, and therefore lead to superior sustainability performance and competitive advantage.

Although extensive research has been carried out to investigate the needs and characteristics of performance measurement frameworks for large organizations, there is a distinct lack of published research on the role performance measurement and reporting tools can play in order to support sustainability projects.

This paper, based on the comprehension of relevant literature and evidences from business practices, highlights the impacts of sustainability on three related areas:

1. Finance and investments;
2. Stakeholders communication and engagement;
3. Internal measurement and management systems;

2 The Impacts of Sustainability

2.1 Sustainability Impacts on Finance and Investments M&R Practices

Epstein (2008) identifies two major impacts of sustainability on finance/investment practices:

1. It aims to increase long-term shareholder value;
2. Sustainability leaders are increasingly expected to show superior performance and favourable risk/return profiles.

Such a forecasts from the academic literature find reality in markets: a recent report released by investment bank Goldman Sachs found that companies that are considered leaders in environmental, social and governance (ESG) policies are also leading the pack in stock performance, by an average of 25 % (United Nations Global Compact 2012).

As a consequence of this, concepts like Corporate Social Responsibility (CSR) and Environmental, Social and Governance (ESG) are spreading through the normal language of bankers, investors and companies.

Firms are developing their own frameworks to analyze sustainability performance of companies, and optimize investments in the short and long term. Within this context, the "GS Sustain" framework developed by Goldman Sachs is well established (Goldman Sachs 2012).

Another important evidence, is the development and consistency of sustainability-financial indexes. Among these, the most popular is doubtless the "Dow Jones Sustainability Index (DJSI)". The Dow Jones Sustainability Indexes are the first global indexes tracking the financial performance of the leading sustainability-driven companies worldwide. Based on the cooperation of Dow Jones Indexes and SAM they provide asset managers with reliable and objective benchmarks to manage sustainability portfolios (Dow Jones Sustainability Indexes 2012). Today, approximately 60 DJSI licenses are held by asset managers in 16 countries to manage a variety of financial products including active and passive funds, certificates and segregated accounts. In total, these licensees presently manage over eight billion USD based on the DJSI (Dow Jones Sustainability Indexes 2012). The underlying research methodology accounts for general as well as industry-specific sustainability trends and evaluates corporations based on a variety of criteria including climate change strategies, energy consumption, human resources development, knowledge management, stakeholder relations and corporate governance (Dow Jones Sustainability Indexes 2012). Figure 1 presents the framework at the base of DJSI corporate sustainability assessment.

Every year, DJSI invites the 2,500 largest companies (in terms of float-adjusted market capitalization from all industries within the Dow Jones Global Total Stock Market Index) to participate the assessment. The last is carried out through a

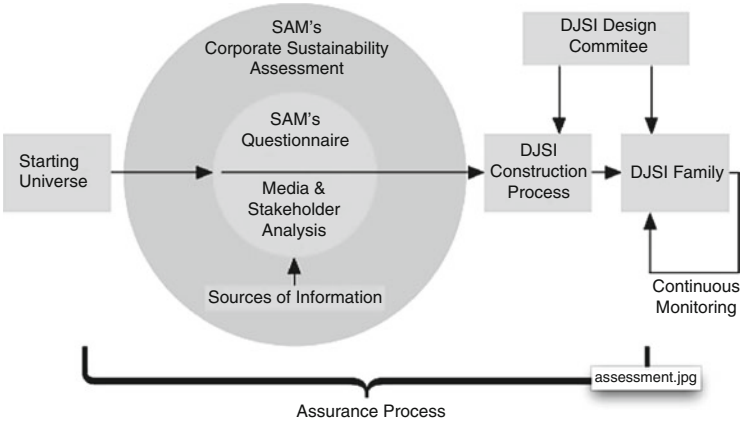

Fig. 1 DJSI framework for corporate sustainability assessment (Source: Dow Jones Sustainability Indexes 2012)

questionnaire consisting of about 80–120 questions on TBL issues, both generic and sector-specific. Assurance on disclosure by verifying companies' answers with the supporting documentation they provide, by controlling publicly available information and published company reports. Further, to ensure quality and transparency of the assessment process itself, an independent external audit on the assessment process is carried out every year by Deloitte consulting firm. Based on collection and analysis of questionnaire results, companies are therefore ranked on a sector basis and indexes are built with reference to sector, performance and geography parameters. As example, Table 1 presents the "Global Supersector Leaders" of 2012.

The increasing interest for sustainability in the finance sector is driving the growth of new data and indexes providers. Among these, it's important to mention Bloomberg that today provides ESG data for more than 5,000 worldwide companies (Bloomberg 2012).

2.2 Sustainability Impacts on Stakeholders Communication and Engagement M&R Practices

Stakeholders play a crucial role in today business activities. However, different stakeholders are interested (and influence) in different aspects of business sustainability. For instance, shareholders are mainly interested on financial information, risk issues and corporate governance as a consequence of their interest in maximizing profit return. Employees are interested instead in labor policies, remuneration practices and working environments, so as to feel safe and guaranteed during their working services. Customers, as market judges, are interested in a broad range of issues that include product safety, environmental and social impacts

Table 1 DJSI world, Global Supersector Leaders 2012 (Adapted from Dow Jones Sustainability Indexes 2012)

Company	Sector	Country
Bayerische Motoren Werke AG (BMW)	Automobiles & Parts	Germany
Australia & New Zealand Banking Group Ltd	Banks	Australia
UPM-Kymmene OYJ	Basic Resources	Finland
Akzo Nobel NV	Chemicals	Netherlands
GS Engineering & Construction Corp	Construction & Materials	South Korea
Itausa – Investimentos Itau SA	Financial Services	Brazil
Unilever NV	Food & Baverage	Netherlands
Roche Holding AG	Health Care	Switzerland
Siemens AG	Industrial Goods and Services	Germany
Swiss Re	Insurance	Switzerland
Telenet Group Holding NV	Media	Belgium
Repsol SA	Oil & Gas	Spain
Koninklijke Philips Electronics N.V.	Personal & Household	Netherlands
GPT Group	Real Estate	Australia
Lotte Shopping Co. Ltd.	Retail	South Korea
Alcatel-Lucent SA	Technology	France
KT Corp.	Telecommunications	South Korea
Air France-KLM	Travel & Leisure	France
Iberdrola SA	Utilities	Spain

of production activities, after-sale services. All these issues and areas of interest fit in the sustainability landscape.

Traditional measurement and reporting practices have addressed only partially these needs. In this context, for example, traditional financial reports are not anymore sufficient for addressing shareholders request of information. "One Report", popular book by Eccles and Krzus (2010) has set the ground for a new approach to corporate reporting and more generally disclosure to stakeholders.

Within this context, relevant change is driven by two aspects:

1. Need of an integrated approach to reporting based on triple bottom line information;
2. Shift from stakeholders' communication (one flow communication) to stakeholders' engagement (two flows communication).

The last aspect, is particularly relevant and affecting significantly business practices.

In fact, in order to increase quality and transparency of information, companies are today requested to identify relevant stakeholders, and engage them in order to understand what kind of information divers stakeholders ask to disclosure.

This process of engagement is not easy, and required strong commitment as well as the capability of using all kind of tools and technologies, particularly those offered by the Web 2.0.

Good examples of these new practices are found for example in Avon, the cosmetic company, that engages its associates through the use of global intranets, regional newsletters and surveys; or large retailer Wal-Mart, that engages stakeholders largely through the use of social networks such as Facebook, Youtube and Twitter.

Regarding the first aspect, related to integrated reporting, a number of reporting frameworks are leading the scenario. Among these, it is a must to mention the Global Reporting Initiative (GRI), the Carbon Disclosure Project and the UN Global Compact.

The GRI is a not for profit network-based organization involving some 30,000 experts of different kind of organizations. Funded in 1997, it results from the collaboration of CERES (Coalition for Environmentally Responsible Economies) and UNEP (United Nations Environment Program). Promoters of the concepts of integrated reporting (so as to integrate financial, environmental, social and governance performance), GRI launched in 2000 the first version of its "Guidelines" (today at the third generation).

The GRI's framework consist of the "Sustainability Reporting Guidelines", the "Sector Supplements", the "National Annexes" and the "Boundary and Technical Protocols" (GRI 2012).

The sustainability reporting guidelines provide guidance for defining report content, quality and boundary as well as indication for standard elements of disclosure, that include strategy and profile of the organization, and standard indicators related to economic, environmental and social performance. The social dimension covers labor practices, human rights, society and product responsibility. In terms of content and quality of the report, the GRI framework is based on ten principles that are: materiality, stakeholder inclusiveness, sustainability context, completeness, balance, comparability, accuracy, timeliness, clarity and reliability.

The requested number of sustainability performance indicators to be disclosed depends on the desired level of application (three levels of disclosure are identified namely A, B and C) and eventual certification by third parties (A+, B+ and C+).

The need of sector-specific disclosure is addresses by the sector supplements, which identify key sustainability impacts and related performance indicators for 12 industries including construction and real estates, electric utilities, financial services, oil and gas and media. Similarly, national annexes provide guidelines for capturing national and regional sustainability issues. Last, boundary and technical protocols provide information for ensuring materiality and quality of information to be disclosed on reports.

Today, more then 4,900 organizations have adopted the GRI Guidelines (GRI 2012) as the base of their integrated reporting, and the framework is becoming popular also in the SME (Small and Medium Enteprises) environment. Success of the GRI framework can be probably identified in the "multistakeholder approach", that represents the shared process of the guidelines' design that has seen a strong collaboration of governments, companies and universities.

Similarly to the GRI, the Carbon Disclosure Project (CDP) is based on a multi-stakeholder approach and offers a framework for assessing the impacts of business

activities with a focus on environmental issues (mainly carbon and water issues). Companies are therefore assessed based on o questionnaire, that evaluates management, climate change risk & opportunities, emissions and other relevant information. Based on data collected, a score methodology developed by PricewaterhouseCoopers LLP is then applied for assessing organizations. In order to demonstrate a strong interest on sustainability and the importance of sustainability disclosure, the CDP groups 655 institutional investors that allocated $ 78 trillions for investments in companies that show superior sustainability performance (Carbon Disclosure Project 2012). This highlights again the connection between sustainability reporting and the finance world. Indexes are also available for evaluating "Carbon Disclosure Leadership" and "Carbon Performance Leadership".

Finally, the UN Global Compact framework is probably the most popular (due to his flexibility and low level of requirements), since identifies 10 principles for disclosure over four areas, that include: human rights, labour, environment and anti-corruption (see Fig. 2). Basic guidelines are provided to companies for reporting on these ten areas in a flexible way.

2.3 Sustainability Impacts on Internal Measurement and Management Systems

Organizations are involved in measuring the sustainability of their business with mainly three goals: communicating and engaging stakeholders, improve operations and align people to strategies. The pursuit of these three objectives is often disconnected, leading to the achievement of different systems and reporting techniques. Frameworks presented in the previous paragraph such us the GRI represent the effort of converging forward a unique standard approach to measurement/reporting but evidence from reality confirms that this is goal is still fare to reach. Further, doubt has been raised about the consistency and effectiveness of such a sustainability reports, which appear useful for external communication, but often not practical for management aiming at business sustainability control and improvement (Brunklaus et al. 2008).

A comprehensive analysis of emerging systems for measuring business sustainability can be carried out by looking at two aspects: first, the impact of sustainability on performance measurement indicators and second, the impact on performance measurement frameworks.

Traditional performance measurement and management (PMM) literature distinguishes between two basic classes of performance indicators: strategic (or managerial) performance indicators and operational performance indicators. The majority of emerging literature on sustainability measurement agrees on this distinction, and locates sustainability indicators in one of the two categories. The

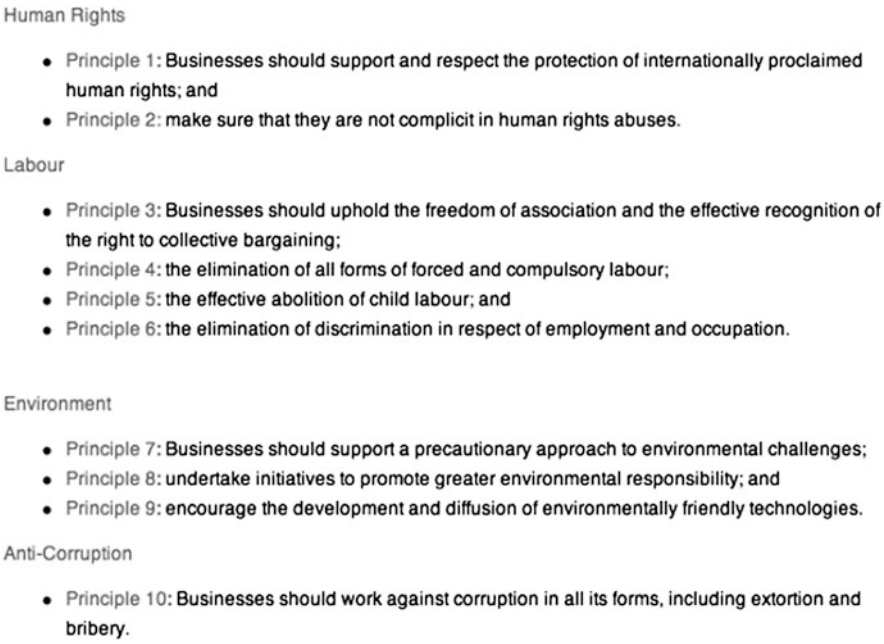

Fig. 2 Principles of the UN Global Compact framework (Source: United National Global Compact 2012)

remaining part instead positions sustainability indicators as a separate set of measures, generating therefore a third category.

Sets of sustainability indicators have been proposed by many organizations. For example, the GRI framework previously introduced identifies "core" and "additional" indicators a company should use for measuring and reporting its economic, social and environmental performance to generic stakeholders. Indicators described vary depending on the sector specification. Further, sustainability indicators are recommended by standards bodies, as in the case of the International Standard for Environmental Management System (ISO 14001) and the European Eco-Management and Audit Scheme (EMAS). Furthermore, diverse set of metrics related to full cost and triple bottom line issues have been developed by accounting scholars (Bebbington et al. 2007).

Similarly to indicators, research has been developed in order to propose and build new frameworks for sustainability measurement as described ahead.

Van der Woerd and Van den Brink (2004) propose an evolution of the popular Balanced Scorecard, namely the "Responsive Business Scorecard" (RBS), which enables companies to score at profit, people and planet and at the same time to incorporate stakeholders' demand into internal operations to improve firm performance. RBS includes five perspectives that are: customer & suppliers, financiers & owners, society & planet, internal process and employees learning. Epstein (2008) offers a sustainability measurement framework that develops over four areas that

are inputs (external, internal and business context, human and financial resources), processes (leadership, strategy, structure and systems), outputs (sustainability performance and stakeholder reactions) and outcomes (long term corporate financial performance). Further, the "Sustainability Evaluation and Reporting System" (SERS) (Perrini and Tencati 2006) describes an integrated methodology aimed at monitoring and tracking from a qualitative and quantitative viewpoint the overall firm performance based on a relational view of the firm and the strategic value of stakeholder relations. Bonacchi and Rinaldi (2007) propose a performance measurement system based on two managerial instruments, namely "sustainability DartBoards" and "sustainability Clovers" that establish a set of primary and secondary measures, connected to stakeholder satisfaction, and are able to sense and articulate both win–win and trade-off situations. The Full Cost Accounting Sustainability Assessment Models (SAM) experimented by Bebbington et al. (2007) in the UK and New Zealand based on economic, environmental, social and resource impacts demonstrated the potential contribute of traditional accounting technologies. Ultimately, Taticchi et Al. (2009, 2010, 2012) provide general guidelines for the development of integrated frameworks for performance measurement as well as Cagnazzo et Al. (2009) for the supply chain context, and Tonelli et Al. (2009) for the assessment of organization both product-service oriented.

3 Conclusions

This chapter has investigated the topic of sustainability with reference to its impacts on traditional measurement and reporting practices. Particularly, the issue was investigated in relation to three main areas: finance and investments, stakeholders communication and engagement and, internal measurement and management.

With reference to finance and investments, the impact of the sustainability topic is clear. In fact, there is evidence of a growing number of investments that are driven by the assessment of sustainability performance of firms. As a consequence of this, new financial frameworks are emerging for assessing sustainability performance of organizations (such as the DJSI) and new suppliers are providing sustainability data (such as Bloomberg). The recent financial crisis has pushed the need of transparency, and it is opinion of the Author that the area of sustainable investing will grow dramatically in the next years, calling consequently for the development of new tools and frameworks.

The sustainability role in stakeholders communication and engagement M&R practices was further discussed. In this area, both research and evidence from industries seems to have achieved a considerable level of maturity. Framework such as the Global Reporting Initiative reflects this maturity, and current level of diffusion as well as trends in adoption let assume that GRI could become the main standardized form of sustainability reporting for large corporations worldwide. Such a methodology has proofed to be successful for managing communication forward a diverse set of stakeholders (this is facilitated by the stakeholder

engagement process that sets the foundation of the methodology), but appears to have limits for the management of internal performance of organizations.

Last, the chapter discussed the emerging body of sustainability research in the area of internal measurement and management systems. In this regard, even if a number of methodologies have been proposed in literature, the research field appears to be immature and frameworks have not yet emerged for this purpose. Therefore there is hope that models similar to the traditional balanced scorecard will emerge, in order to support internally sustainability measurement and management processes.

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Sustainable Use of IT

Zahid Hussain and Mohammed Addris Bostan

1 Sustainability Definition and Application IT Industry

The word sustainability is derived from Latin, sustinere (tenere: hold, keep; comprehend; represent; support; and sus: up) (Myetymology). The most widely quoted definition of sustainability and sustainable development is that of the Brundtland report to the United Nations on March 20, 1987:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (UNWCED 1987)

The report highlighted three fundamental components to sustainable development: environmental protection, economic growth and social equity and was primarily concerned with securing a global equity, redistributing resources towards poorer nations whilst encouraging their economic growth. The report also suggested that equity, growth and environmental maintenance are simultaneously possible and that each country is capable of achieving its full economic potential whilst at the same time enhancing its resource base. The report also recognised that achieving this equity and sustainable growth would require social and technological change.

The term "*Green*" is often viewed from a purely environmental standpoint, even though there may be other benefits to "going green" beyond saving the planet. Conversely "sustainability" is a much broader term that denotes preparing the business for resource savings and optimisation (GCIO).

The environmental impact of conducting business, especially in the area of IT, continues to receive increased attention on all fronts; from customers and

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employees to regulatory agencies and local communities. In recent times, environmental considerations have become explicit criteria for making decisions, right alongside financial considerations. Applying an environmental lens to strategic decision making is becoming more commonplace, focusing on the win-win benefits associated with balancing what might once have been seen as competing interests.

"Sustainable IT", "Green IT" and "green computing" are interchangeable terms used to describe environmentally responsible use of computers and related resources. Such practices include the implementation of energy-efficient central processing units (CPUs), servers and peripherals as well as reduced resource consumption and appropriate disposal of electronic waste (e-waste) (Brighthub).

Computer systems are a central part of the modern workplace, homes and communities. Technology continues to advance rapidly and the IT community needs to make sure this progression is focused on serving individuals, society and businesses in an efficient and sustainable manner.

2 Green IT Concepts

The affects of IT on the environment are many; each stage of a computer's life has some degree of impact. From production to throughout its use and into its disposal, present environmental problems. Manufacturing computers and their various electronic and non-electronic components consumes electricity, raw materials, chemicals, and water, and generate hazardous waste. All these directly or indirectly increase carbon dioxide emissions and impact the environment. The total electrical energy consumption by servers, computers, monitors, data communications equipment, and cooling systems for data centres is steadily increasing, resulting in increased greenhouse gas emissions.

2.1 Green Hardware Initiatives

The complexities of greening hardware devices cannot be considered in isolation and a more holistic approach is required. This approach must take into account the manufacturing and logistics operations as well as the utilisation of the end product. The main advances have focused on increasing energy efficiency whilst at the same time providing faster processing power; however computer manufacturing is also recognised as a significant cause for environmental concern (IBM). Manufacturers and designers are increasingly adopting manufacturing processes that consume fewer resources and produce less waste by focusing on the areas below:

- Reducing the resources consumed and the waste generated when producing computers or components,
- Developing cleaner manufacturing processes,

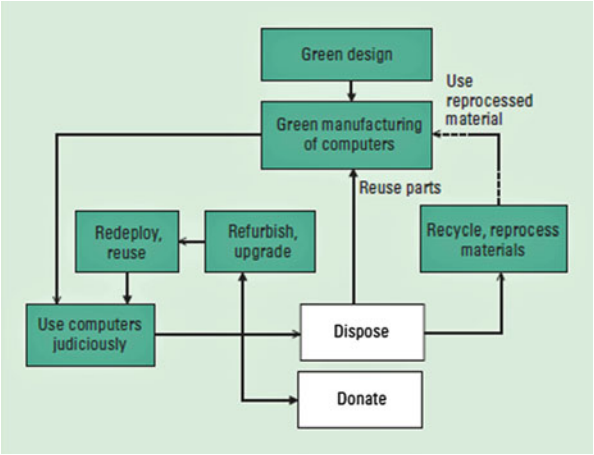

Fig. 1 Green IT lifecycle

- Minimising the energy and other resources that computers consume, and
- Enabling computers and components to be used (and thereby stay out of the waste stream) longer.

(Goldberg 1998)

The four areas above provide a strong framework to achieving environmental sustainability from the design, manufacturing, use and disposal of IT; making IT greener throughout its entire lifecycle (Fig. 1).

(Murugesan 2007)

Computer hardware is developing at a fast pace with every new version of chipset, desktop, server, storage system and wireless router not only becoming smaller, but also evolving to better support business and user requirements as they move to the latest mobile, Virtualization and green technologies.

As mentioned green hardware technologies are offering faster processing power whilst at the same time providing energy efficiency. Computer chipset speed is one of the most important factors when choosing hardware and the latest innovations are all about multi-core. Although the chips themselves aren't getting any bigger, their capabilities are scaling quickly as they evolve from the dual-core models to the quad-cores and six-cores of today (Intel).

Multi-core processor architecture entails placing two or more execution cores, within a single processor. The operating system perceives each of its execution cores as a discrete logical processor with all the associated execution resources. By apportioning up computational work among multiple execution cores, a multi-core processor can perform more work within a given clock cycle. This enables enhanced performance, reduced power consumption, and more efficient simultaneous processing of multiple tasks (Searchdatacentre).

As the complexity and operational expenses of IT infrastructure continues to increase, blade servers as a solution are becoming increasingly common.

The integrated nature of the blade platform enables organisations to solve energy and space challenges as well as improve the flexibility of their infrastructure. As the requirements for space decrease, so do those for power and cooling and because they're smaller, they tend to consume less power than traditional servers (Blade).

Server Virtualization has made the computer industry paradigm shift from "1 application = 1 server" to running many environments on a single machine. Virtualization is software technology which uses a physical resource and divides it up into virtual resources called virtual machines (VM's). Virtualization allows users to consolidate physical resources, simplify deployment and administration, and reduce power and cooling requirements. While virtualization technology is most popular in the server world, it is also being used in data storage such as Storage Area Networks, and inside of operating systems (Techrepublic) (Source: Brighthub1)

The transition from being very 'personal hardware dependent' to a world where resources are shared is slowly and unobtrusively becoming apparent. Many organisations have already transitioned to using a cloud environment for many of their business operations. The cloud utilises the resources from the computers as a collective virtual computer, where the applications can run independently from particular computer or server, making the hardware less important to how the applications work. The applications can take advantage of all that computing power as if they were running on one particular machine. Cloud computing also allows for flexibility, depending on the demand, the cloud resources can be allocated accordingly without the need for assigning specific hardware for the job all reducing the environmental impact (CIO).

Whilst there is much activity in greening servers with various initiatives as discussed, the desktop environment has also received a plethora of new initiatives and products all designed to reduce the environmental impact. However, the desktop environment's users are also being influenced by the choices they make; and perhaps the biggest choice that is made every day is whether to power down the PC at the end of the day.

By leaving computers on all night for a year, a UK company with 10,000 PCs wastes:
1.4 million kWh
£168,000
828 t CO_2 emissions (1E)

Many organisations are investing in desktop power management technologies to effectively improve the environmental footprint of their IT leading to immediate and sustained reduction in energy and to a large extent shape users' behaviour.

Desktop computing virtualisation is emerging as a viable alternative to the traditional desktop PC, both from an environmental perspective and financially. Desktop virtualization separates a personal computer desktop environment from the physical machine. The resulting "virtualized" desktop is stored on a remote central server, instead of on the local storage of a remote client; thus, when users work from their remote desktop client, all of the programs, applications, processes, and data

used are kept and run centrally. The idea behind desktop virtualization is the ability to apportion resources to users as and when they require it thereby reducing both cost and the environmental impact (Citrix).

In addition to desktop virtualisation, the use of thin client technology is also increasing (Internetevolution). Thin clients are essentially a bare-bones client machine, used to query the server, which in turn does the bulk of the work. The absence of dynamic or moving parts to serve one's computing purpose entails less generation of heat. This is mainly because thin clients make use of solid state devices like flash drives instead of hard drives.

Although there is a difference between virtual desktops and thin clients, the current trend is to use them in conjunction with each other. Instead of complete user desktops, thin clients are used to radically reduce costs and environmental impact, leading to:

- Less heat generated means less carbon impact.
- Less electronic wastes since there are fewer parts to replace.
- Less complexity involved in thin client manufacture which cuts down costs from the point of production at the supplier's chain.
- Thin client transport from manufacturer to distributors and to retailers occupies less volume due to its compact dimension of only a fifth of a regular PC, which equates to lesser transport requirement (Wyse).

The concepts of virtual desktops and thin clients may have started out as independent solutions; however their combined use makes them a compelling and viable alternative to organisations looking to cut down significantly on their cost and environmental footprint.

Finally, it is important to acknowledge the switch from CRT (Cathode Ray Tube) to LCD (Liquid Crystal Display) not only for easier transportation but also as an energy efficient device. Whilst LCD monitors have been embraced for a number of years, very few purchasing decisions have included environmental impact and instead the focus has been on elements such as contrast, brightness, aspect ratio and ergonomic options (CNET).

2.2 Green Software Initiatives

Green software, it would seem is very much in its infancy, relying on hardware to help organisations achieve their carbon reduction goals (Computer Weekly). Software actually plays a big role too, from the drivers to the operating system and even extends to application software. Energy efficiency should be considered as a component of the software design strategy. The efficiency of the software can have a profound impact on the way in which the software interacts with the hardware and the resultant energy consumption.

The green software dichotomy is apparent through the application of software to support green initiatives, such as server virtualisation and SaaS (Software as a

Service), utilising cloud architecture. Furthermore, software designed to help businesses address the growing need to maximise energy efficiency and reduce costs associated with power and cooling are on the increase with major vendors offering energy management software.

A number of large IT suppliers have also created carbon or environmental management systems that go well beyond existing corporate environment software or carbon footprint calculators, in that they are marketed as decision-making, rather than inventory-building, tools. Such detailed analysis allows organisations to manage and cut emissions, and thus help them make more cost and environmentally effective decisions. These systems assist organisations to work out the carbon cost of the transaction as well as the business cost and ultimately help then decide where to spend their money to ensure the maximum return on the triple bottom line (IBM1).

Collaboration technologies, whilst not directly impacting the green IT agenda do provide organisations with the facility to reduce their carbon footprint by reducing the need for employees to travel to meetings. Collaboration applications through a powerful combination of technology and design integrates advanced audio, ultra-high-definition video, and interactive collaboration tools with the underlying network as the platform to deliver an immersive remote meeting experience (Cisco).

2.3 Green Data Centre Concepts

The evolution of distributed computing has led to an explosion in data centre complexity as the number of servers, storage devices, and local and wide area networks has grown exponentially. At the same time, processors continue to become more powerful but applications remain rigidly tied to specific servers, leading to low server utilisation across the data centre. Measuring and improving energy efficiency within data centres is becoming increasingly important for organisations to consider.

One of the largest issues within data centres is underutilised servers with performance levels of between 7 % and 15 %, an architectural artefact of the "one server, one application" general guideline. This low utilisation and the desire to increase productive performance for servers has been an integral factor behind server virtualisation projects (Gartner).

Temperature is a critical factor in the modern data centre, and it is only becoming more so. Increased processor speeds, smaller server form factors, and higher server rack densities have all contributed to tremendous challenges for data centre administrators in the areas of cooling and air movement. Many data centres in use today were built very conservatively in the 1980s and 1990s around unreliable equipment. Most mainframes and servers wouldn't even run if the inlet temperature is warmer than 28 °C thus cooling the entire data centre, even though most of the equipment didn't require cooling at all (Openxtra).

Power density in the data centre is increasing due to blades, more condensed and faster processors and a proliferation of stacked servers. These advances in

technology make cooling placement critical. Instead of cooling the entire data centre due to the least common denominator, adaptive cooling isolates these high-density areas to be cooled when needed. The idea is to cool specific hot spots with regularity instead of the entire room at the same level. As power density increases and servers become much more advanced, it makes sense to raise temperature conditions in the data centre, although many companies question whether today's servers are still susceptible. HP and Dell warranty their servers to 35 °C and rackable servers at 40 °C (Searchdatacentre1).

Airflow is often ad hoc in the data centre with hot air from one server drifting into the inlet of another although most data centres have rectified this with hot and cold aisles to keep the air isolated. Newer "green" data centres have energy-saving, low-carbon emitting "free cooling" technology. Free-cooling systems make use of low outside air temperatures for chilling water used in air conditioning, rather than traditional energy intensive refrigeration systems, immediately reducing energy requirements. A fully developed air management strategy can produce significant and measurable economic benefits and should be the starting point when implementing a data centre energy savings program (EWeek).

2.4 Green Storage Concepts

As hard drive prices have fallen, storage farms have tended to increase in capacity to make more data available online. This includes archival and backup data that would formerly have been saved on tape or other offline storage (CIO1).

In the drive to make IT infrastructure greener, data storage technology is becoming a key piece of the puzzle. Historically, enterprise users have relied on relatively large 3.5 in. hard disk drives, which are kept constantly spinning at very high speeds to increase performance but required inordinate amounts of power and rack space, representing a significant overhead in the data centre. The management of storage resources has also contributed to increased overheads as organisations have traditionally allocated physical chunks of storage to particular departments, servers or applications leading to over provisioning of hard drive space, wasting energy as the disks spin with allocated but unused space.

More efficient network-attached storage (NAS) systems are becoming prevalent in data centres. Although tape still has a place for long-term storage needs, online disk-based storage eases implementation of lifecycle management while enabling new efficient storage models such as continuous data protection (CDP). Such capabilities help better support mobilisation because users are not tied to one place for their storage (Computer Weekly).

A variety of techniques have emerged to help reduce the power and space overhead in storage infrastructures. Slimming down disks to 2.5 in. makes them easier to spin and reduces power usage by approximately 45–50 % (Storage News). Other green storage tactics include thin provisioning, tiered storage and data

de-duplication, while virtualization technology makes hard drive provisioning more efficient, allocating storage capacity exactly where it is needed without wasting it.

Solid State Drive (SSD) technology once thought to be too expensive for the traditional business enterprise is gradually becoming mainstream as enterprises search for faster storage processing systems for their most vital applications. SSD flash technology can cost as much as 30 times more than Fibre Channel drives on a per-gigabyte basis, but the cost has been decreasing 50–70 % per gigabyte each year. Organisations are recognising the benefits in terms of much greater reliability, durability and performance, as well as the need for less power. SSDs have no moving parts and generate virtually no heat, making them much more attractive in the data centre due to their faster response times and low energy consumption (enterprisestoageforum).

2.5 Green Metrics

Implementing standards and metrics can help ensure that a data centre is run smoothly. By clearly defining metrics an organisation can increase its productivity. As the data centre is the hub for the entire business, making sure that a data centre has clearly defined metrics must be a requirement for a green IT strategy.

The Green Grid has published two metrics to cover data centre efficiency, Power Usage Effectiveness (PUE) and Data centre Infrastructure Efficiency (DCiE). PUE is defined as the total facility power divided by the IT equipment power. The reciprocal of the PUE, the DCiE, is defined as: IT equipment power/total facility power $\times$ 100 %.

The DCiE metric is the ratio of power delivered to the IT loads to the total power into the data centre. In buildings that combine data centres and office space, it's important to measure the specific power consumption.

The IT equipment power is defined as the power consumed by the equipment that is used to manage, process, store or route data in the data centre. The core components include the electrical load associated with all the IT equipment, such as compute, storage and network equipment, along with supplemental equipment, such as keyboard, video & mouse (KVM) switches, monitors and workstations/laptops used to monitor and run the data centre.

Total facility power involves everything that supports the IT equipment load, including:

- Power delivery components, such as an uninterruptible power supply (UPS); switch gear; generators; power distribution units (PDUs), which are part of the UPS; and distribution losses external to the IT equipment
- Cooling system components such as chillers, computer room air conditioning units (CRACs), direct expansion air handler (DX) units, pumps and cooling towers
- Other miscellaneous component loads, such as data centre lighting

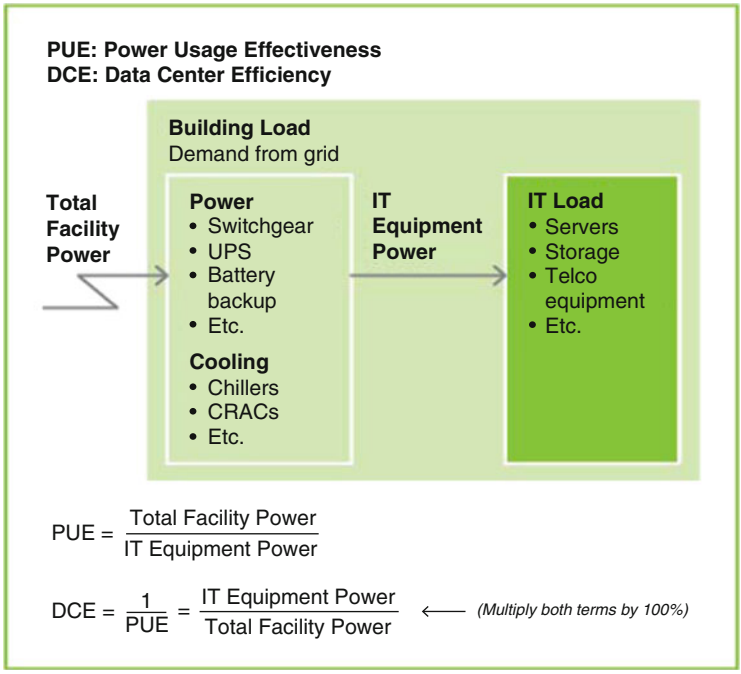

Fig. 2 PUE and DCiE calculation (Source: Green Grid 2008)

Although these metrics are ostensibly the same, using them together shows the efficiency of data centre from two perspectives (Fig. 2): the data centre energy used to power the IT equipment and the effect on the total power needed.

The biggest issue with the PUE and DCiE metrics is that they do not fully account for variations in IT load. The simplicity of the metrics means that they provide a single snapshot of the energy efficiency of the data centre at a given moment in time. This snapshot can and will vary with time, IT load and the efficiencies of the components, such as CRAC units that consume large amounts of energy. Despite these limitations, the simplicity of the calculations

Despite the limitations, these metrics have been well-received in the industry. The same issue that causes the problems described above namely, the simplicity of the metrics is also the main reason for the endorsement, the European Union's Code of Conduct on running data centres (Datacenterdynamics).

In addition to data centre metrics, computer products are also subject to energy efficiency standards. Energy Star is an international standard for energy efficient consumer products. It was first created as a United States government program by the Clinton Administration in 1992, but Australia, Canada, Japan, New Zealand, Taiwan and the European Union have also adopted the program. New Energy Star 4.0 specifications for computers became effective on July 20, 2007 and Energy Star 5.0 became effective on July 1, 2009 requiring the use of electrical energy efficient computer power supply units (Energy Star).

Whilst not directly measuring energy efficiency, products certified by the Electronic Product Environmental Assessment Tool (EPEAT) are judged on 23 required attributes that make up an environmental performance rating and also include a further 28 optional attributes.

In summary, the EPEAT criteria include:

- Restrictions on hazardous substances in compliance with the European RoHS Directive for cadmium, mercury, lead, hexavalent chromium, and certain brominated flame retardants
- Batteries must not contain lead, cadmium, and mercury
- Use of polyvinyl chloride (PVC) and chlorinated plastics is also limited
- Recycled plastic content criteria
- Ability to be disassembled for recyclablility
- Warranty criteria
- Upgradability
- Energy conservation criteria
- End of life criteria, such as a product take-back program or battery recycling
- Corporate guidelines, including an environmental policy consistent with ISO 14001, an environmental management system, and corporate reporting
- Reduction/elimination of toxics in packaging
- Recycled packaging content, and packaging that can be reused or recycled

(EPEAT1)

EPEAT certifies products at three different levels:

- Bronze – product meets all 23 required criteria
- Silver – product meets all 23 required criteria plus at least 50 % of the optional criteria
- Gold – product meets all 23 required criteria plus at least 75 % of the optional criteria

According to the Green Electronics Council's EPEAT 2007 Environmental Benefits report (EPEAT2), the following savings were realised in 2007:

- 42.2 billion kwh of electricity were saved
- 174 million metric tons (including 3.31 million metric tons of greenhouse gas) were eliminated
- 365,000 metric tons of water pollutant emissions were eliminated

While Energy Star rates energy efficiency, EPEAT covers other factors including the amount of toxic material used in electronics, manufacturers' recycling and take-back policies, and packaging all positively impacting the environment and reducing the carbon footprint.

The majority of legislation in existence is focused on restricting or reducing the use of environmentally harmful or toxic chemicals and materials in the manufacture and design of IT and other electrical equipment, as well as ensuring that materials

used in the construction of IT equipment are either highly recyclable or environmentally benign. This responsibility falls on both the vendor of the equipment and on the user.

3 Green Organisational Performance

Organizational performance can be impacted by structure, objectives, people and technology; and these in turn can be influenced by the organisation's environment.

The message of Leavitt's diamond is simply – every element of organizational life affects every other: change the technology and you change the task and ought to change the structure and the people. Change the people, and they will find new ways of performing tasks and the technology must adjust, as must everything else.

The record of implementing information systems is mixed. While many projects transform business operations and enhance organisation performance, others fall short of expectations. Long term studies (Boddy and Gunson 1996; Currie 1997; Drummond 1996) show that IT projects fail to meet expectations of those who initiate them.

Nadler et al. (1995) developed a useful way of classifying types of organisational change based on form: incremental, discontinuous and organizational response to the need for change: anticipated, reactive.

The change management process as proposed by Lewin 2010 provides a potential overall framework for building more effective organisations.

Whilst Lewin's models of organisational change are well established, the implementation of a Green IT strategy and the impact of the change on the employees need to be carefully considered. Adams et al. (1976) suggest that an individual will pass through all the experiences during change however, the rate of change will depend on the impact to the individual's working practices and how accepting or threatening the change is perceived.

Results of unsuccessful changes, such as a decrease in morale or productivity, may negatively affect an organization, and ultimately lead to organizational failure. Okumus and Hemmington (1998) identified and investigated the barriers and the sources of resistance to change and concluded that the more radical the change, the more likely it is to be met with significant resistance. They identified communication, training, participation, involvement, and organisational culture as strategies to overcome resistance to change. Whilst the study centred on changes within the hotel industry, the areas identified to overcome resistance can be applied to any organisation and industry sector. First-order change is incremental; involving behavioural adjustments considered appropriate within an organisation's established set of implicit or explicit beliefs about how it does or should act. It is based on the assumption that a schema in use can guide individuals to grasp and implement new behaviours (Bartunek and Moch 1987).

Second-order change refers to changes in the cognitive frameworks underlying the organization's activities, changes in the deep structure or shared schemata that

generate and give meaning to these activities (Gersick 1991; Egri and Frost 1991). It is based on the assumption that a new schema is sometimes required if new behaviours are to be understood and adopted.

A schema has three general dimensions, which can be theoretically identified as causality, valence, and inferences. Causality in a change schema provides the knowledge framework that explains why change occurred (Lau and Woodman 1995). Valence allows a person to evaluate the significance or meaning of a specific event, person, process, or relationship (Markus and Zajonc 1988). Inferences enable a person to predict the future by specifying the likelihood of the occurrence of events or behaviour.

The major problem in unsuccessful change is a lack of communication. Studies show that many companies fail to keep managers and employees informed about how changes are to proceed in their organizations. Communicating the organisation's new mission and vision is seldom carried out in an effective and satisfactory manner. Moreover, senior managers often do not provide training for the middle-level managers who are responsible for implementing change (Koonce 1991). The more employees are involved, the less their resistance to change will be. Changes do have an influence on attitudes toward organisational change and commitment and should be carefully planned and implemented.

3.1 Operating Environment

There is plenty of evidence that the context in which organisations operate profoundly shape their nature and development. Whilst the idea of organisations adapting to the environment is not in itself problematic, it is a question of how it is conceptualised. Mullins (1985): 12 claims that organisations are viewed in their total environment.

Over the years, research has demonstrated that an organization operates best when its structure and processes fit, or match, the corresponding mission environment. Contingency theorists argue that organizational effectiveness is influenced by the "degree of fit" between the requirements of the environment and the characteristics of the organization (Burton and Obel 1998).

Quinn 1988; Rohrbaugh (1983) noted that different conceptualisations of organizational effectiveness were associated with four common organizational perspectives, which they categorized as:

- The human relations model
- The open systems model
- The rational goal model (closed systems perspective)
- The internal process model (closed system perspective)

Using multivariate analysis, they found three value dimensions that underlay these different and seemingly conflicting conceptualizations of organizational effectiveness:

- Organization structure, which distinguishes between organizational flexibility/adaptability and control/stability
- Organizational focus, which distinguishes between an internal and an external orientation
- The means-ends continuum, which distinguishes between an emphasis on outcome objectives or the means by which these objectives are to be achieved, such as processes and/or important causal attributes.

Quinn and Rohbaugh (1983); Quinn (1988) noted that organizations were likely to experience tension among organizational effectiveness attributes; all organizations have a need for some level of stability as well as a need to be flexible and adaptable; a need for control and discipline as well as a need to allow some degree of freedom and autonomy; a need for rational formal structures and non-rational informal relations. They concluded that effectiveness depended upon the ability of an organization, and its managers, to strike the right balance among these critical attributes, as required by the organization's objectives and situation.

3.2 Culture

The values and norms of a culture do not emerge fully formed. They are the evolutionary product of a number of factors, including the prevailing political, economic, social and educational factors. Thus, the management challenge for many organisations is to be able to adapt their organisations to culturally distinct environments without losing organisational consistency.

Institutional theory holds that the beliefs, goals, and actions of individuals and groups are strongly influenced by various environmental institutions (Scott 1995), and that their role in doing this is subtle but pervasive. To achieve this balance requires organisations to develop the cultural sensitivity and ability to manage and leverage learning to build future capabilities (Bartlett and Goshal 1998).

Culture refers to the system of meaning, values, beliefs, expectations and goals shared by members of a particular group of people and that distinguish them from members of other groups. It is a product of 'the collective programming of the mind (Hofstede 1991) that is acquired through regular contact with other members of the group.

It is useful to identify clear framework for analysing and understanding cultural differences.

Hofstede identified four key dimensions and later included the fifth, LTO, which impact on natural cultural differences:

- *Power distance* – At the core of this dimension lies the question of involvement in decision making. In low power-distance cultures, employees seek involvement and have a desire for a participative management style. At the other end of this scale, employees tend to work and behave in a particular way because they accept that they will be directed to do so by the hierarchy or the organisation.

- *Individualism – Collectivism* – This dimension reflects the extent to which individual's value self-determination as opposed to their behaviour being determined by the collective will of a group or organisation.
- *Masculinity* – This is possibly the most difficult dimension to use in an organisation context. In practice, the difficulty is more to do with terminology and linguistics, in Hofstede's work the dimension related to values. In highly "masculine cultures" dominant values relate to assertiveness and material acquisition. In highly "feminine cultures" values focus on relationship among people, concern for others and quality of life.
- *Uncertainty Avoidance* – This dimension is concerned with employees' tolerance of ambiguity or uncertainty in their working environment. In cultures which have high uncertainty avoidance, employees will look for clearly defined, formal rules and conventions governing their behaviour.
- *Long term Orientation* – Long-Term Orientation is the fifth dimension of Hofstede which was added after the original four to try to distinguish the difference in thinking between the East and West. With an understanding of the influence of the teaching of Confucius on the East, long term vs. short term orientation became the fifth cultural dimension.

Cultural considerations may be achieved by a framework, which addresses both the style and working processes and provides a clear context for examining the cultural and process elements of performance.

Although much can be achieved by working with specific teams, the truly successful players are likely to be those which embed the change through integrated changes to selection, development, reward and recognition policies and practices. In doing this the value of effective cultural working can be captured at many levels in the organization and teams, be they project based or permanent, will tend to reach high performance levels more rapidly and consistently. This in turn can help organizations build capability and competitive advantage.

3.3 Organisational Agility

Increasingly, organizations find themselves operating in environments characterized by unprecedented, unrelenting, and largely unpredictable change. So it's not surprising to find that serious searches are underway for new and better ways of strategizing, organizing, and operating and managing in dynamic and turbulent circumstances. The proscriptions and prescriptions are many and varied, and most have profound implications for the management of people (Dyer and Shafer 1999).

Organizational agility is seen as both critical to business success and as growing in importance over time. The benefits of enhanced agility include higher revenues, more satisfied customers and employees, improved operational efficiency, and a faster time to market. There are three distinct types of agility: strategic, portfolio,

and operational. Strategic agility consists of spotting and seizing game-changing opportunities. Portfolio agility is the capacity to shift resources – including cash, talent, and managerial attention – quickly and effectively out of less promising business areas and into more attractive ones. And operational agility involves exploiting opportunities within a focused business model (McKinsey).

Recent research has conceptualised agility as an organisation level competency to sense and respond to shifts in the business environments (Sambamurthy et al. 2003). Capabilities including IT infrastructure and entrepreneurial alertness are important enablers of agility (Sambamurthy et al. 2003). An organisation's IT capabilities, core competencies and entrepreneurial orientation could differ under different environmental conditions impacting organizational performance and agility (Melville et al. 2004; Piccoli and Ives 2005).

4 Legislation and Regulations

In July 2008, the UK government informed 10,000 businesses that they could be affected by the Carbon Reduction Commitment (CRC), a climate change and energy saving scheme that became effective as of April 2010 and is central to the UK's strategy for controlling carbon dioxide (CO_2) emissions. The scheme will address CO_2 emissions not already covered by Climate Change Agreements and the EU Emissions Trading System. Participating organisations will have to purchase allowances equivalent to their emissions each year with 2010 being a "footprint" year for organisations to capture their total carbon emissions. Allowances will be sold to participants at a fixed price of £12 per ton of CO_2 as of 2011 with auctioning of carbon allowances starting in 2013 (DEFRA).

The proliferation of data centres required the constant addition of server, cooling and ventilation equipment that led to an ever-increasing demand of energy and increased presence of toxic and hazardous substances such as lead, mercury, cadmium, and others. This made people look at ways to apply green technology in computing to mitigate the serious environmental and health concerns.

The 1997 Kyoto Protocol for the United Nations Framework Convention on Climate Change mandates reducing carbon emissions. The Kyoto Protocol made computer manufacturers undertake energy audits to calculate the electricity used by the device over its lifetime and determine the quantum of carbon dioxide emissions to take remedial action.

Under the Kyoto Protocol, industrialised countries and those in transition to a market economy (the so-called "Annex I countries") have agreed to limit or reduce their emissions of six greenhouse gases. Each gas has a global warming potential (GWP) based on its radioactive capacity compared with CO_2. The GWP for each gas is determined by the Intergovernmental Panel on Climate Change (IPCC) and reviewed from time to time. The six greenhouse gases addressed by the Kyoto Protocol are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)

The Protocol sets quantified emission limitations and reduction obligations with respect to a basket of six gases. Of these, carbon dioxide (CO_2), which derives from the burning of fossil fuels such as coal, oil and gas, is the most important. Methane (CH_4) and nitrous oxide (N_2O) emissions are also substantial contributors to the problem (UNFCC).

The European Union's adoption of Restriction of Hazardous Substances (RoHS) in February 2003 restricts the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ether in the manufacture of electronic and electrical equipments. The implementation of the RoHS was through the Waste Electrical and Electronic Equipment Directive (WEEE) of 2005. On 11 January 2008, a new set of RoHS Regulations (Statutory Instrument 2008 No.37) was laid before the UK Parliament to come into force on 1 February 2008. These Regulations were updated in 2009, when amending Regulations were laid before Parliament on 11 March and came into force on 6 April 2009. This directive set targets for collection, recycling, and recovery of electrical goods, aimed at reducing toxic e-waste (RoHS).

These regulations forced manufacturers to use non-hazardous materials in the production of chipsets, processors, and companion chips as well as reducing their carbon footprint.

5 CSR and Ethical Operations

The relationship between business ethics and CSR is often discussed. The concepts are sometimes interpreted differently (Murphy 2002). Business ethics tends to be more internal in its orientations while CSR is more external, but the orientation is not an absolute one. Ethics usually deals with the individual level, while CSR is associated with the organizational level.

In business ethics we have to include corporations as an ethical constitute unit. Business ethics is more than applied ethics (Ulrich 2002). There is no area free from normative presuppositions and economics, is a strongly normative "ideal theory" of rational actions in a traditional point of view.

An organisation's target is to achieve economic profit. Different ways to achieve profit depend on the organisation's focus, and their stakeholders are important for a long term profit orientation. As a starting point for proper classification of CSR is it relevant to focus on one of the following aspects of the reality: economics, ethics, politics and social integration (Garriga and Melé 2004). This hypothesis is inspired

and rooted in aspects that can be observed in any social system: adapting to the environment, goal attainment and social integration. Different researchers (Adolphson 2004; Bansal 2005; Carroll 1991; Jones 1995; Vogel 2005; Windsor 2006) have separated CSR based on motive where economic and ethics represents each side and is mutually exclusive. These perspectives mean that CSR either has an economic focus with a profit motive or an ethical focus with an obligation for social betterment motive. This "either-or" perspective polarizes the discussion and distracts attention from the space where economics and ethics converge and where potential solutions exists (Bansal 2005).

Economic focus understands CSR as a measure of profits. It is recognised that the corporation is an instrument for wealth establishment and that this constitutes its ground social responsibility with only the economic aspect of the interactions between business and society measured. Any expected social activity is accepted if it is consistent with wealth creation (Garriga and Melé 2004). Ethical focus argues that the relationship between business and society is embedded with ethical values. From an ethical perspective and as a consequence, companies should accept social responsibility as an ethical obligation more than any other consideration (Garriga and Melé 2004). Ethical CSR implies that companies focuses upon ethical perspective. Approaches are focused on the ethical requirements that strengthen the relationship between business and society (Garriga and Melé 2004). In general these approaches are based on values that state the right thing to do or the obligation to create a good society and that organisations are obligated to make a payment in kind for using society's infrastructure, land, air, water, plants, and animals to generate profit. They have a duty to reimburse society for the negative externalities their activity generates.

Ethical CSR uses a basic share principal of moral reflection on tolerating expensive public policy and practicing broad self restraint and altruism. Altruism is voluntary contribution to society and stakeholders based on other regarding attitudes. Altruism may involve uncompensated or costly contribution to stakeholders or general welfare.

6 Future Trends and Direction

A mixture of trends and issues, including energy demand and cost, legislation, growing environmental awareness and corporate social responsibility, are coming together to drive the adoption of green IT. Not only can green IT help to minimize the environmental impact of business, it can help to save energy, and therefore have a direct and significant benefit for any organization's bottom line.

While the green IT movement is currently being driven by the 'early adopters' – those organizations with a forward-looking and responsible attitude towards the environment – the movement is still in its infancy. However, in coming years it is very likely that growing legislation, regulation and even taxes and levies will make it a legal obligation for organizations to reduce their carbon footprint.

More importantly, however, growing social, governmental and consumer pressure could mean that organizations not taking their environmental responsibilities seriously will suffer financially – from both the perspective of continuing to needlessly waste energy and in terms of consumer choice. Already, a growing number of organizations are differentiating themselves on their adoption of ethical business strategies, and this trend is only likely to increase, as energy costs soar, environmental damage continues and energy security becomes a major global issue.

As one of the largest energy consumers in any enterprise, the IT department has to start considering the total lifetime impact of procuring and operating IT equipment on the environment, and on the bottom line. Green IT offers significant cost savings through energy efficient hardware and best practices, and for the reasons outlined above, is set to become one of the most important issues over the next decade.

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The Green Building Revolution: Advancing Sustainability at Exponential Speed

Jeffrey S. Seigel

1 Introduction

Rule 1. When understanding "Green Building", think in terms of Sustainability, Triple Bottom Line and its impact on Society.

Rule 2. Buildings emit more CO_2 than any other industry. In the US, the Building Sector emits 39 % of CO_2, more CO_2 than the Transportation or Industry Sectors.

Rule 3. Buildings are responsible for 39 % of CO_2 Emissions, 71 % Electricity Consumption, 40 % of Energy Use, 12 % of Water Use and 65 % of Waste Output.

Rule 4. Green Building Processes have a huge impact on CO_2 Reduction and Energy, Water, and Waste Reductions. Green Buildings reduce CO_2 Emissions by 33–39 %, reduce Energy Use by 40 %, reduce Water Use by 40 % and reduce Waste Output by 70 %.

Rule 5. Green Buildings make excellent economic sense. Building values increase, rent values increase, (ROI) return on investments increase, occupancy rates increase and operating costs decrease.

This chapter is a compilation of research that the author believes will enhance your understanding of Green Building and Sustainability. The author has listed ten rules for the reader to follow; each rule will be discussed in detail throughout this chapter. The author hopes that the reader grasps the gravity of how the Green Building Revolution will impact and benefit our society and our planet. Green Building is a component of Sustainability and the Triple Bottom Line, dealing with the environment, social justice, education, conservation, carbon reduction, etc. The context of "Green Building" is much broader than constructing or renovating a building.

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Rule 6. Building are the primary (#1) CO_2 emitter, they produce 39 % of CO_2 Emissions, 71 % Electricity Consumption and 40 % of Energy Use. Any Green Building Methodology that reduces these statistics has a positive impact on society. The author is well versed in LEED (Leadership in Energy & Environmental Design); LEED will be the basis for discussing Green Building Processes.

Rule 7. There are different types of LEED Rating Systems: New Construction (NC), Existing Buildings: Operations & Maintenance (EB:O&M), Commercial Interiors (CI), Core & Shell (CS), Schools, Retail, Healthcare, Homes, Neighborhood Development.

Rule 8. The LEED System is based on 100 points and has four levels: Certified: 40–49 points, Silver: 50–59 points, Gold: 60–79 points and Platinum: 80 points and above.

Rule 9. Green Building Process: Select your Rating System (New Construction, Healthcare, Schools, etc.). Develop a LEED Strategy/Plan addressing five Green Building Categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources and Indoor Environmental Quality. Evaluate which categories to pursue (based on preference, complexity, cost, etc.), add up your selected points and decide which LEED Level to pursue (Certified, Silver, Gold or Platinum).

Rule 10. Corporation are embracing "Green" Technologies/Corporate Sustainability. Sustainability and The Triple Bottom Line are integrally related to Green Building; it is imperative to understand how these three concepts correlate. Green Building is a component of Sustainability and the Triple Bottom Line, dealing with the environment, social justice, education, conservation, carbon reduction, etc. The context of "Green Building" is much broader than constructing or renovating a building.

2 What Is Sustainability?

There is no singular definition of Sustainability and the word is starting to become a commonly used term with a diverse scope from environmental to social issues. The author believes that sustainability or sustain means to maintain or continue, survival, maintenance, continuity, not losing ground or going backwards. The author typed in "Definition of Sustainability" in Google and received almost two million hits. The Environmental Protection Agency/EPA (2012) provided the following definition of sustainability:

> Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. Sustainability is important to making sure that we have and will continue to have, the water, materials, and resources to protect human health and our environment.

The author endorses the definition of the *Brundtland Commission, United Nations* (1987), when understanding "Sustainable Development".

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

2.1 What Is the Triple Bottom Line?

Civilization inherits the earth from their parents, and then nurtures the earth for their children. What is the "Triple Bottom Line (TBL or 3BL)"? The "Triple Bottom Line" is the three pillars of Sustainability: People, Planet & Profit. In the Corporate Environment or Corporate Social Responsibility (CSR), these three pillars deal with Social Justice (People), Environment (Planet) and Economics (Profit).

Rule 1. When understanding "Green Building" think in terms of Sustainability, Triple Bottom Line and its impact on Society.

When researching the "Triple Bottom Line", The Earth Charter (2012) discusses "a sustainable global society founded on respect for nature, human rights, economic justice, and peace." Now how does "Green Building" work into this context of Sustainability, Triple Bottom Line (People, Planet & Profit), and enhancing society?

3 What Is Green Building?

The author typed "Green Building" in Google (2012) and received over one billion hits.

> The Environmental Protection Agency (2012) gave the following definition for "Green Building";
>
> Green Building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green Building is also known as a sustainable or high performance building. Green Buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by: efficiently using energy, water, and other resources, protecting occupant health and improving employee productivity and reducing waste, pollution and environmental degradation.
>
> The United States Department of Housing (2012) defines Green Building:
>
> Green Building, an approach to sustainable development that is designed to result in a property that reduces its impact on the environment, costs less to operate, and improves the residents' quality of life. Green Building considerations start with site selection and include building placement and design, materials and techniques used in construction, and all the systems, appliances, and fixtures within the building.

3.1 What Is Green Building's Impact on Society? Green Building Facts and Statistics

What is Green Building's impact on society? The following statistics used in this chapter can be found in the US Green Building Council (2012) website. The USGBC has created an extensive Green Building methodology called LEED (Leadership in Energy & Environmental Design) and this chapter will be discussing this methodology/scorecard in detail. The author suggests that you peruse www.usgbc.org.

Green Buildings/LEED-Certified buildings are designed to:

1. Lower operating costs and increase asset value
2. Reduce waste sent to landfills
3. Conserve energy and water
4. Be healthier and safer for occupants
5. Reduce harmful greenhouse gas emissions

Buildings are the primary (#1) CO_2 Emitters, Transportation is #2 and Industry is # 3. When you think of how much CO_2 is emitted by cars or coal plants, remember that Buildings are # 1. Think of how many buildings there are across the globe; no doubt they emit a lot of CO_2. Green Building Practices can help reduce these CO_2 emissions immediately.

Rules 2. Buildings emit more CO_2 than any other industry. Buildings #1.

3.2 What Are the Impacts of US Buildings on Resources?

US Green Building Statistics

- Buildings – 39 % of CO_2 Emissions
- Buildings – 71 % Electricity Consumption
- Buildings – 40 % of Energy Use
- Buildings – 12 % of Water Use
- Buildings – 65 % of Waste Output

Rule 3. Buildings use a tremendous amount of water, energy and electricity resources and are responsible for a huge amount of CO_2 emissions and waste output. We learned in Rule 2, Buildings emit more CO_2 than any other industry. Buildings are responsible for 39 % of CO_2 Emissions, 71 % Electricity Consumption, 40 % of Energy Use, 12 % of Water Use and 65 % of Waste Output (Fig. 1).

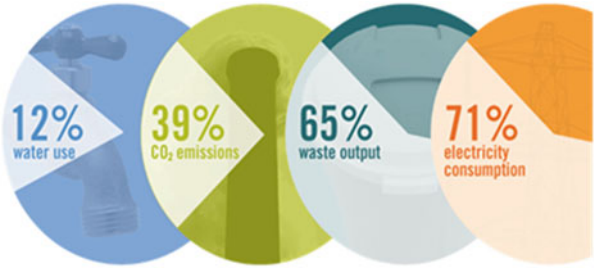

Fig. 1 US Building Impacts (www.usgbc.org)

3.3 What Are the Reduction Impacts of Green Building Techniques on US Buildings? US Green Building Statistics

- Green Buildings – Reduce CO_2 Emissions by 33–39 %
- Green Buildings – Reduce Energy Use by 24–50 %
- Green Buildings – Reduce Water Use by 40 %
- Green Buildings – Reduce Waste Output by 70 % (Fig. 2)

Rule 4. Green Buildings can have a huge impact on CO_2 Reduction and Energy, Water, and Waste Reductions. Green Buildings reduce CO_2 Emissions by 33–39 %, reduce Water Use by 40 %, reduce Waste Output by 70 % and reduce Energy Use by 24–50 %. These statistics illustrate the importance of how Green Building can reduce energy, water and waste consumption.

3.4 What Are the Economic/Business Benefits of Green Building?

US Green Building Statistics:

- Operating Costs – Reduce 8–9 %
- Building Value – Increases 7.5 %
- Return on Investment – Increases 6.6 %
- Occupancy Ratio – Increases 3.5 %
- Rent Ratio – Increases 3 %

Rule 5. Green Building makes excellent economic sense. Building values increase, rent values increase, (ROI) return on investments increase, occupancy rates increase and operating costs decrease. Looks like a veritable "Win-Win" scenario.

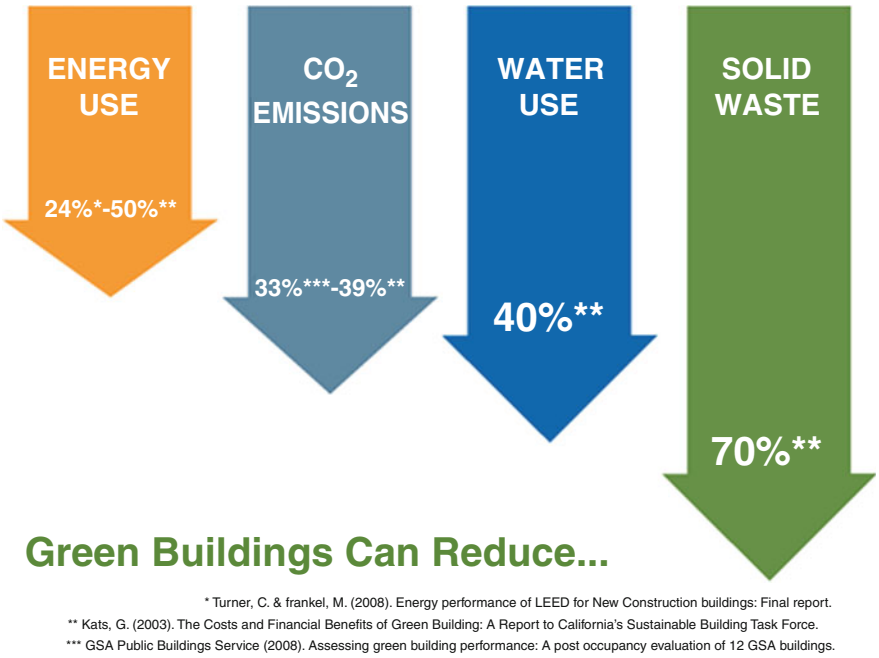

Fig. 2 Reduction Impacts of Green Building (www.usgbc.org)

4 Green Building Scorecard, Reporting and Processes

Thus far, this chapter has established the definition of "Green Building" and how it fits into the global context of Sustainability and the Triple Bottom Line. It has also discussed the Impacts of Buildings on Water, Energy and Waste Resources, Reduction Impacts of Green Building Techniques on US Buildings, and the Economic Benefits of Green Buildings. In this section, we are going to discuss global Green Building Reporting Methodologies; Green Building Scorecards that outline Green Building Processes. Different countries use different methodologies for reporting Green Building. In the United States, we use a Green Building Scorecard called LEED (Leadership in Energy and Environmental Design, www.usgbc.org). In the UK, Netherlands Spain they use a Green Building Scorecard called BREEAM (Building Research Establishment Environmental Assessment Method, www.breeam.org). In Canada, they use Green Globes (www.greenglobes.com); in Australia and New Zealand they use Green Star (www.gbca.org.au). We have included an extensive list of countries and their Green Building Reporting Systems. The author is well-versed in LEED, thus LEED will be the methodology used to discuss Green Building Processes in this chapter. Each Green Building Reporting System has its unique benefits and characteristics. We already discussed that Building are the #1 CO_2 emitter of any industry, that they produce 39 % of CO_2 Emissions, 12 % of Water Use, 65 % of Waste Output, 71 % Electricity

Consumption, and 40 % of Energy Use. These statistics are absolutely staggering and any Green Building Methodology that helps reduce these consumption statistics has a positive impact on our society.

Rule 6. We already discussed that Building are the #1 CO_2 emitter, they produce 39 % of CO_2 Emissions, 71 % Electricity Consumption and 40 % of Energy Use. Any Green Building Methodology that reduces these statistics has a positive impact on society. We are well-versed in LEED, thus LEED will be the basis for discussing Green Building Processes.

4.1 Global Green Building Reporting Systems: Wikipedia (2011)

- Australia: Nabers/Green Star
- Brazil: AQUA/LEED Brasil
- Canada: LEED Canada/Green Globes/Built Green Canada
- China: GBAS
- Finland: PromisE
- France: HQE
- Germany: DGNB/CEPHEUS
- Hong Kong: HKBEAM
- India: Indian Green Building Council (IGBC)/GRIHA
- Indonesia: Green Building Council Indonesia (GBCI)/Greenship
- Italy: Protocollo Itaca/Green Building Council Italia
- Japan: CASBEE
- Korea: KGBC
- Malaysia: GBI Malaysia
- Mexico: LEED Mexico
- Netherlands: BREEAM Netherlands
- New Zealand: Green Star NZ
- Philippines: BERDE/Philippine Green Building Council
- Portugal: Lider A
- Republic of China (Taiwan): Green Building Label
- Singapore: Green Mark
- South Africa: Green Star SA
- Spain: VERDE
- Switzerland: Minergie
- United States: LEED/Living Building Challenge/Green Globes/Build it Green/NAHB NGBS/International Green Construction Code (IGCC/ENERGY STAR)
- United Kingdom: BREEAM
- United Arab Emirates: Estidama
- IAPGSA Pakistan Institute of Architecture Pakistan Green Sustainable Architecture

- Jordan: EDAMA
- Czech Republic: SBToolCZ

4.2 What Is the LEED Green Building Reporting Process?

USGBC (2012) created LEED, or Leadership in Energy and Environmental Design, as an internationally recognized Green Building Certification System providing third-party verification that a building or community was designed and built using strategies intended to improve performance in metrics such as energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. Developed by the USGBC in March 2000, LEED provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

4.3 What LEED Delivers?

LEED-certified buildings are designed to:

1. Lower operating costs and increase asset value
2. Reduce waste sent to landfills
3. Conserve energy and water
4. Healthier and safer for occupants
5. Reduce harmful greenhouse gas emissions
6. Qualify for tax rebates, zoning allowances and other incentives in many cities

4.4 LEED Rating Systems

1. New Construction (NC)
2. Existing Buildings: Operations & Maintenance (EB: O&M)
3. Commercial Interiors (CI)
4. Core & Shell (CS)
5. Schools (SCH)
6. Retail
7. Healthcare (HC)
8. Homes
9. Neighborhood Development (ND)

Rule 7. There are different types of LEED Rating Systems: New Construction (NC), Existing Buildings (EB): Operations & Maintenance (EB: O&M), Commercial Interiors (CI), Core & Shell (CS), Schools, Retail, Healthcare, Homes, Neighborhood Development. Step One: select your Rating System.

4.5 LEED Scorecards and Points System

USGBC/LEED 2009 for New Construction/Major Renovations Project (2012)

1. Sustainable Sites 26 Possible Points
2. Water Efficiency 10 Possible Points
3. Energy and Atmosphere 35 Possible Points
4. Materials and Resources 14 Possible Points
5. Indoor Environmental Quality 15 Possible Points
6. Innovation in Design 6 Possible Points
7. Regional Priority 4 Possible Points

100 base points; 6 possible Innovation in Design and 4 Regional Priority points:

Certified 40–49 points
Silver 50–59 points
Gold 60–79 points
Platinum 80+ points

Rule 8. The LEED System is based on 100 points and has four levels: Certified: 40–49 points, Silver: 50–59 points, Gold: 60–79 points and Platinum: 80+ points.

4.6 Five LEED Categories

1. Sustainable Sites
2. Water Efficiency
3. Energy and Atmosphere
4. Materials and Resources
5. Indoor Environmental Quality

Sustainable Sites

Site selection and development are important components of a building's sustainability. The Sustainable Sites category discourages development on previously undeveloped land; seeks to minimize a building's impact on ecosystems and waterways; encourages regionally appropriate landscaping; rewards smart transportation choices; controls storm-water runoff; and promotes reduction of erosion, light pollution, heat island effect and construction-related pollution

(continued)

Water Efficiency

Buildings are major users of our potable water supply. The goal of the Water Efficiency category is to encourage smarter use of water, inside and out. Water reduction is typically achieved through more efficient appliances, fixtures and fittings inside and water-conscious landscaping outside

Energy and Atmosphere

According to the U.S. Dept of Energy, buildings use 39 % of the energy and 74 % of the electricity produced each year in the US. The Energy and Atmosphere category encourages a wide variety of energy-wise strategies: commissioning; energy use monitoring; efficient design and construction; efficient appliances, systems and lighting; the use of renewable and clean sources of energy, generated on-site or off-site

Materials and Resources

During both the construction and operations phases, buildings generate a lot of waste and use large quantities of materials and resources. The Materials and Resources category encourages the selection of locally, sustainably grown, harvested, produced and transported products and materials. It promotes waste reduction as well as reuse and recycling, and rewards the reduction of waste at a product's source

Indoor Environmental Quality

The U.S. Environmental Protection Agency estimates that Americans spend about 90 % of their day indoors, where the air quality can be significantly worse than outside. The Indoor Environmental Quality category promotes strategies that improve indoor air as well as those that provide access to natural daylight and views and improve acoustics

Rule 9. Green Building Process: Select your Rating System (New Construction, Healthcare, Schools, etc.). Develop a LEED Strategy/LEED Plan addressing five Green Building Categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources and Indoor Environmental Quality. Add up your selected points and decide which LEED Level to pursue (Certified, Silver, Gold or Platinum). Remember, the higher the LEED Level (Gold and Platinum), the more difficult to attain and the higher the cost. Tweak your LEED Plan to ascertain your results; you may not achieve or be awarded every point you pursue.

4.7 Green Building Impact on Corporate Sustainability

McGraw Hill/USGBC (2012) states that by 2009, 80 % of Corporate America was expected to engage in "Green" at least 16 % of the time; and 20 % engaged 60 % of the time. The author has been working with LEED/Green Building Programs at Pepsi HQ, Nestle Waters HQ, Starwood HQ, USAA, Bank of America, GE, USAA and many others. The author has noticed an exponential increase in Corporate Green Building practices and we expect these practices to become more prevalent; we have also noticed that the cost for these "Green Building" improvements are getting lower and more affordable. Green Building has become a primary

component in their Sustainability/CSR Programs and discussed in their Annual Reports, Sustainability/CSR/GRI Reports, Stakeholder Meetings, etc.

Rule 10. Corporations are embracing "Green" Technologies/Corporate Sustainability. Sustainability and The Triple Bottom Line are integrally related to Green Building; it is imperative to understand how these three concepts correlate. Green Building is a component of Sustainability and the Triple Bottom Line, dealing with the environment, social justice, education, conservation, carbon reduction, etc. The context of "Green Building" is much broader than constructing or renovating a building.

5 Conclusion

The author is privileged to share this research with you, discussing the benefits of Green Building Practices and how they are becoming globally embraced. To conclude this chapter, the following facts illustrate the importance of implementing and enforcing Green Building Practices.

- Buildings emit more CO_2 than any other industry. In the US, the Building Sector emits 39 % of CO_2, more CO_2 than the Transportation or Industry Sectors.
- Buildings are responsible for 39 % of CO_2 Emissions, 71 % Electricity Consumption, 40 % of Energy Use, 12 % of Water Use and 65 % of Waste Output.
- Green Building Processes have a huge impact on CO_2 Reduction and Energy, Water and Waste Reductions. Green Buildings reduce CO_2 Emissions by 33–39 %, reduce Energy Use by 40 %, reduce Water Use by 40 % and reduce Waste Output by 70 %.
- Corporations are embracing "Green" Technologies and implementing them in their Sustainability/CSR/Stakeholder Programs. Corporations believe that Green Building makes good business sense.
- Lastly, the author believes that eventually, there will be no Green Building Methodologies of Scorecards; all buildings will be built with standardized energy and water efficiencies, recycled materials, and improved indoor air quality (low VOC paints, adhesives, carpets). More cities, states and countries will develop mandatory Standardized Green Building Codes that will be implemented and enforced.

The reader has been educated on Green Building definitions, statistics, issues and processes. What can you do as individuals, cities, countries? Green Building Practices are readily available and many strategies can be implemented at relatively low costs. You can spread the word that Green Building has a huge impact on the sustainability of our society and planet to our companies, communities, states and countries. You can share the economic and social benefits of Green Building. You can share the simplicity of Green Building. Ultimately, Green Building practices will be codified at some point; perhaps in the form of local, national or global Green

Building Codes. However, government solutions are embraced and enacted very slowly. You can start the process immediately by sharing this research one person at a time; one building at a time; one step at a time.

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[1] The bulk of the data, statistics and charts used in this Green Building Chapter was provided by the US Green Building Council/USGBC (2012) – www.usgbc.org. Most of the other references were used primarily for basic terminology definitions.

Existing Buildings' Energy Upgrade: An Economical and Environmentally Sustainable Opportunity

Anna Laura Pisello and Franco Cotana

1 Introduction

Building energy conservation has become a crucial issue both for environmental and economical perspectives of the global problem. In despite of all the International pressure for improving buildings' energy performance, the global economic-financial crisis is delaying this process, given also several market barriers. At the same time the building sector represent the 36 % (Green Building Council 2011a) of total global energy consumption, and there is a huge opportunity for both companies and buildings' owners to obtain environmental benefits with profitable investments.

In these years a huge research effort has been focused on energy performance optimization through several interesting methods for assessing building energy efficiency (Pisello et al. 2012a) also involving a complex multi-building approach for reducing the energy requirement of specific urban contexts (Pisello et al. 2012b; Xu et al. 2012).

Given the slow buildings' renovation rhythm, also exasperated by the actual global crisis, the upgrade interventions are assuming an increasingly important role in the built environment scenario. For this reason the purpose of this contribution is to answer several questions about building energy performance improvement, involving both engineering and economics issues. At the beginning of this chapter we will explain what specifically the retrofitting procedures are, which could be the main engineering interventions on buildings, and which could be the typical market barriers against the implementation of the process.

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The start-point of this contribution is the research related to buildings' energy retrofitting procedures in terms of engineering practice (Ge et al. 2009) and in terms of operations management through continuous commissioning practice (Liu et al. 1997; Pisello et al. 2012c). This specific procedure is often able to achieve important energy conservation amounts with low-cost interventions on existing buildings.

Considering also the necessity to apply an effective integrated process, this contribution provides an interesting interpretation while coupling technical and economical perspectives of the complex issue. The case study assessment translates this approach into operative practice guidelines, giving us the possibility to relate the engineering interventions to the benefits in terms of energy requirement reduction and indoor comfort optimization, and finally to the economical-financial effort.

2 What Is Building's Energy Retrofit

The energy efficient retrofit is a complex of procedures that involves multiple disciplines. It is aimed at improving buildings' energy efficiency, indoor comfort conditions, and also at reducing the building life-cycle environmental impact.

The retrofit subject starts with an energy assessment but it necessary involves an exhaustive investigation of both the economic and the environmental side of the complex issue. In fact the improvement of buildings' energy efficiency is not the only purpose of the retrofit, because the cost-effectiveness and the environmental variables are the protagonists of this issue as well.

The retrofit path begins with the building energy audit to figure out where, when, why and in which way energy is used following efficient or inefficient procedures. A careful energy audit is the most performing tool for outlining the building energy performance with respect to all the equipment. The beginning purpose is indeed to draw the scenario Zero, that is the scenario before the retrofit. Walking through the energy audit allows to the progressively understanding of these main features:

- The equipment energy consumptions trends and costs,
- The indoor thermal behavior and the relative indoor comfort conditions in different locations within the space,
- The occupants' satisfaction level with respect to each specific building use: retail/commercial, industrial, office space, residential, etc.
- The operation and maintenance strategies already implemented within the building controls.

With all these elements we are able to discover the power consumption of every individual equipment, its energy efficiency, and its capability to achieve indoor comfort conditions with respect to the cost level corresponding to the baseline (scenario Zero).

Applying this procedure for example to the lighting system, we can evaluate the system energy consumption for the scenario Zero, indoor comfort failures, possible improvement in reducing consumption achievable with new efficient technologies,

relative costs and benefits, etc. In this way we can mark out several strategies that could be implemented considering different project goals. For example we can define profitable procedures to achieve different budget levels, comparing the results with the specific project budget constraint; or different comfort levels. Building retrofit purpose could also involve several innovative procedures if we need to implement specific innovative technologies, that could make us able to obtain specific acknowledgments and credits.

In every retrofit activity the project goal clear definition is the first step of the integrated design process. Building energy retrofit is indeed a complex procedure that needs deep and fertile integration of different competences, to achieve the project goal in terms of energy efficiency, environmental impact and cost effectiveness.

2.1 Buildings Environment and Benefits of the Energy Upgrade

The purpose of this analysis is to outline an explicative and objective panorama of the building energy improvement, trying to make order within the vortex of information coming from different market and energy sources.

What it is already acknowledged is that improving energy efficiency through a successful strategy is important for several reasons. It allows to reduce utility bills of energy and water, to optimize indoor comfort level, to extend the life of all the equipment, and to finally reduce the environmental impact due to the facilities management improvement.

Within this complex scenario the main difficulty is the quantification of the financial and environmental benefits that these green strategies provide. In fact there is often no objective comparison with the conventional buildings' construction practice and financial mechanism. Thus this is the main reason why it is still difficult to quantify these interventions in a coherent way with respect to traditional types of investments. Also the common benefits, such as energy savings, should be looked at through a life cycle cost assessment, not just assumed in terms of upfront costs. In fact it is obvious that from a life cycle savings standpoint, each saving source coming from investment in sustainable retrofit dramatically exceed any additional upfront costs (Kats et al. 2003).

Thus the questions we should answer now are not just based on the specific activity cost effectiveness, even if in the following paragraphs we will deal with this issue as well. But the strategic questions to answer should concern all the sources of benefits that energy retrofit is able to carry out for companies, not just limiting the issue to a common source of investment, and the relative cash flow.

Building energy upgrade has to be seen by companies as an intelligent path to save money of course, but at the same time, to improve brand public image and affiliates productivity concerning the environmental satisfaction, lowering

absenteeism and healthcare costs, refreshing employee attention and affection to the purpose. The retrofit path will lead to the competitive differentiation, the sustainability and brand equity improvement, with relatively modest cost.

All these remarks arise from a buildings' environment picture of reality all over the world that points out the oncoming upgrade demand on existing buildings estate. According to facts, all over the world buildings account for more than one third of the global greenhouse gasses (Green Building Council 2011b). Despite the International policies constraints the projections over the next 25 years forecast a growing of CO_2 emissions from buildings that is faster than those from any other sector. In particular commercial building will increase this, growing velocity of 1.8 % a year through 2030 (U.S. Green Building Council press release 2007). Focusing on urban environment, buildings are responsible for more than 50 % of greenhouse gas emissions in most cities and for more than 70 % in largest cities such as New York and London (William J. Clinton Foundation 2011). Thus, given the necessity to reduce the environmental stress operating on buildings sustainability optimization, it is actually trivial to understand that a methodical action on existing buildings is actually necessary, given that buildings yearly new construction is close to 1 %.

2.2 Market Growing Attention and Obstacles Along the Way

Analyzing the most recent information collected by the Energy Efficiency Indicator global survey in 2011 (Institute for Building Efficiency 2011), there is an undeniable increasing attention paid on controlling energy consumptions and optimizing building energy efficiency (Fig. 1 [Institute for Building Efficiency 2011]). Only the 3 % of the participants to the survey, that have the complete market and energy responsibility of their buildings, declares to have not forecasted any energy reduction for 2012, while the 58 % expects to reduce energy consumption following internal or public purpose of energy retrofitting.

Despite the proven energy and economical opportunity to optimize energy efficiency of existing buildings, a huge amount of potential is still contributing to the "energy efficiency gap", especially for those companies and households where energy efficiency does not represent the highest financial concern compared to other sources of cost.

With respect to the data concerning the energy use in buildings (industrial, institutional, commercial, and residential sector), it is possible to outline typical barriers to buildings energy uograde. These are:

– Huge settlement effort: a successful building energy upgrade is still perceived like a insurmountable amount of time consuming operations for analyzing different strategies, that are not often managed by the same person, company or authority.

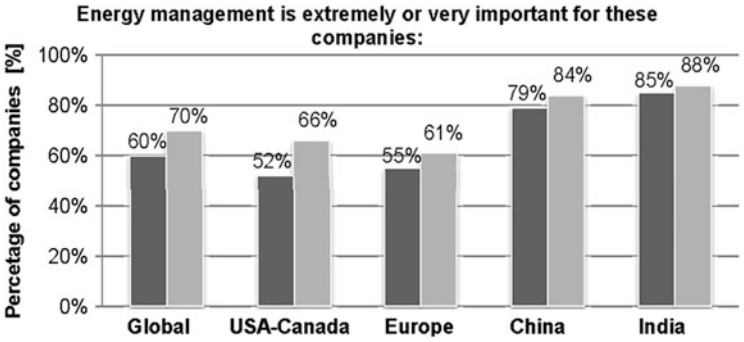

Fig. 1 Companies that identify energy management as extremely or very important

- Public barriers: they are actually due to the instability of public energy policies, that are often more focused on energy supply issue than energy efficiency improvement (GreenMax Capital 2009).
- Lack of information and awareness about opportunities: many occupants of residential buildings or small companies are not conscious about the effective results of retrofit, both from an energy and environmental field, and also from an economical point of view. Furthermore, for example in households sector, energy performance is still related to social and private occupants' attitude. Many studies demonstrate the huge effect of human and social attitudes in reducing building energy use (Xu et al. 2011) and that the average time needed to implement new technologies within the attitudes is about 4 years (de T'Serclaes 2007).
- Chaos in the energy price perception: the common perception about energy price is often unclear and governed by time-variable public subsides that for sure help the market running, but at the same time, they contribute to create a sort of fog perception about effective costs. This element also aggravates the first barriers just described.
- Lack of technical expertise: the reference people usually addicted to energy retrofitting, especially for single houses or small interventions, are still often focused just on one specific ring of the energy chain. Thus it is often necessary to consult different people from different organizations to achieve a complex and successful building energy retrofit, with the relative analysis of the intervention cost-effectiveness. This tortuous path makes the retrofitting less accessible and attractive for both households and companies.
- Energy saving randomness: the saving prediction is deeply related to the effective building operations, occupants' behavior and equipment maintenance process following the retrofit. This element contributes to give the impression that achievable benefits and related investment payback is not really quantifiable. At the same time ex post energy monitoring and continuous commissioning is reasonably applicable just in large retrofitting interventions. Thus this barrier impacts especially small buildings' owners.

– Indirect link between investment and consequent benefit: in the retrofitting process often the decision maker, or the building owner, is responsible for the retrofitting investment, but he is often not the direct beneficiary of the energy saving benefits. That is the reason why this kind of market has to be assessed considering several kinds of benefits, not just maintaining the traditional cost-benefit criteria. At the same time the decision maker can take advantage from other sources that are difficult to quantify, like higher rents, public incentives, brand image.

The analysis of upgrade constraints make frankly understand the multipurpose issue, for all the reasons just mentioned. There are indeed so many externalities that cannot be assessed through a single judgment criteria. Analyzing the energy retrofitting drivers (Institute for Building Efficiency 2011) all over the world, even if there is an increasing attention to the energy management, the main purpose is the financial benefit, and the main barrier is related to the investment cost. The list below represents the global 2011 classification of the drivers of efficiency with respect to the companies' perception about the energy efficiency interventions' implementation:

1. Energy cost saving
2. Government incentives and rebates on utilities prices
3. Brand public image green improvement
4. Increasing energy security
5. Greenhouse gas reduction
6. Existing facilitation policies.

In this phase of the analysis it is important to deepen the barriers specifically related to the financial effort of the energy improvement investment. First of all the initial cost of the investment is often a barrier difficult to overcome, especially during International economic crisis periods like this. The risk associated to the investment is often made huger by the difficulty to monitor the real benefit after retrofitting. These same benefits are the result of many factors involving both technical improvements (energy equipment and controls efficiency) and human features (increasing awareness and social constraint). Also the discount rate, being related to the investment risk level, could be seen as a random variable for the reasons just explained. And for the same reasons the traditional opinion views the energy efficiency investments more risky than reality, when they are naturally able to reduce the dependence to the randomness of the fuel price.

Another fundamental element is the payback time. During last years experience the building retrofitting investments were perceived as long-term investments just for the lack of ability in assessing and monitoring the following benefits. This misunderstanding is also demonstrated by the building's lifetime that is naturally longer than 30 years, and that naturally makes this kind of intervention particularly appropriate. In the case study section of this chapter we indeed will deal with one of the several successful retrofit investments, where the beginning assumption was to reach a payback time shorter than the lease period at all.

3 Main Building Energy Upgrade Initiatives

The purpose of this section is not to give a technical explanation of possible retrofitting strategies, because there is already a very exhaustive literature concerning different strategies. On the contrary in this phase we want to introduce the whole-building approach specifically aimed at analyzing, comparing, and optimizing the effectiveness of each action.

The main focus of the whole-building upgrade approach is not to look at individual technologies, trying to maximize the effect of each technology independently. By this time real experience is able to demonstrate that the best result in terms of energy saving could be reached by the optimization of the single strategies, integrated within a whole complex initiative that could involve both stand-alone buildings but also network of buildings. Typical energy savings amount arise up to 30–50 % given by a whole-building energy improvement, while focusing on just one technology, the typical saving potential hardly passes the 5 % of whole energy saving.

The most representative example of this approach is the Empire State Building initiative. In this chapter we will specifically analyze a successful global upgrade within this building as case study. The Empire experience have linked several needs about energy optimization, environmental pressure, sustainability issue, cost-effective requirement. Starting from many different input data, the program achieved 38 % of energy saving by implementing a smart system of interventions with a 3-year payback time of the whole investment. The approach consisted of the integration of several measures from the very beginning of the design process. The beginning phase consisted of the assessment of all the possible ideas proposed by several groups, that were more than 60, through periodical charrettes and several presentations organized within integrated review workshops. With the same methodological approach also the building energy audit was completed. Following these previous findings, it was possible to outline a list of potential facility improvement measures aimed at balancing:

- The energy performance optimization
- The carbon footprint reduction
- The maximization of the energy savings
- The positive net present value.

Through the integrated continuous approach, each implemented strategy was chosen and designed considering both single and multiple effects optimization. So for example a renovation of a thermal equipment technology is placed side by side to a passive strategy in order to achieve single benefit related to each technology but also to optimize the mutual effectiveness of multiple interventions. At the Empire this comprehensive approach guided the renovation of the chillers, just after reducing the 30 % of the cooling requirements by windows insulation improvement. Thus the complex intervention at the Empire has concerned eight projects mutually interacting to reach the final 38 % energy saving (Fig. 2).

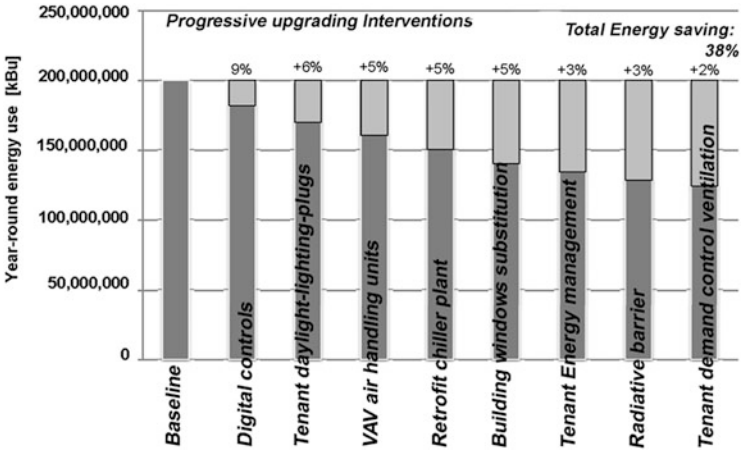

Fig. 2 Reduction of energy requirement within the ESB due to integrated energy retrofits interventions

The Empire Experience created a replicable sustainability model that involves innovative design techniques and O&M (Operation and Management) (Piette et al. 2001) strategies for promoting environmental integrated strategies in existing buildings.

Given the key role of operational efficiency in existing buildings, next section will specifically concern building retro-commissioning/re-tuning as fundamental and relatively inexpensive tool for improving energy efficiency and reducing greenhouse gasses emissions due to buildings life cycle.

3.1 Improving Control and Operations Strategies

In this section we analyze a specific kind of building energy upgrade based just on equipment operations and BEMS (Building Energy Management Systems) techniques (Doukas et al. 2009). The main techniques and the potential benefits of improving building's energy efficiency through operational and control improvements are assessed. This method, also named "building re-tuning (Hatley et al. 2011)", consists of identifying fruitful operations changes that could achieve energy and economical benefits and other possible problems requiring intervention or repair through no-cost or low-cost methods.

Continuously monitoring and solving buildings' operational problems for reducing energy waste are primarily implemented through modifications on the building control system. This kind of actions are mainly no-cost strategies or they could involve few low-cost improvements typically with less than 3 years payback time (Hatley et al. 2011). Building re-tuning includes the identification and the comparison in terms of energy efficiency and cost-effective potential of several

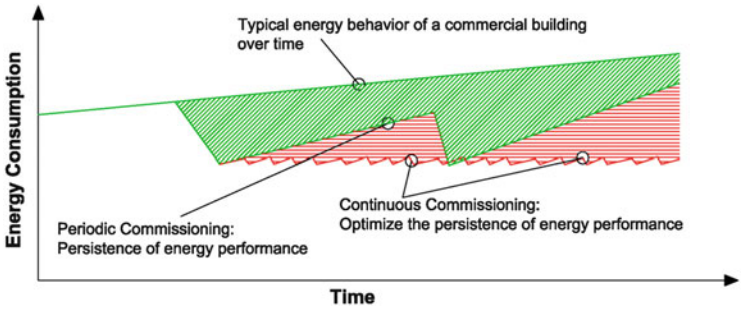

Fig. 3 Building energy typical trend with respect to different commissioning strategies

opportunities for improving energy efficiency. This continuous commissioning program consists of several operations with respect to different building's use and energy plants typologies (Fig. 3 [Hatley et al. 2011]). The main intervention areas are:

- Building's occupants re-scheduling, with respect to the real occupants behavior;
- Temperature and pressure control of the discharge air;
- Heating and cooling control of the Air Handling Units (AHU);
- Management of the fresh air of AHU and economization procedures;
- Intelligent energy zoning, with respect to the monitored thermal zones requirements;
- Actions on the central plant technology and control system.

This kind of intervention on existing buildings could be implemented through a technical sequence consisting of these basic steps:

- Building beginning information;
- Data collection and analysis;
- Identification of operations troubles and outline of resolution procedures;
- Strategies implementations;
- Findings and verification of the improvements;
- Analysis of the impacts in terms of energy and economic benefits.

Collecting preliminary building information means to gather building features that could be useful for the following operative phase. These informations are typically already known by managers and operators. They consists in outlining the overall building design (shape and geometry), defining the main energy equipments of the HVAC system. Another important step consists of the definition of the thermal zones with their equipment features and the typologies of the automation and control system.

The following step consists of investigating potential operational issues that require time history analyses and optimization improvements. After this, the effective intervention is scheduled through a monitoring plan where all the relevant parameters are collected and trend logs are implemented in the control system.

During the fulcrum of the retuning process operators and control managers are able to analyze the trend-data and begin to implement the first interventions. For making them able to do this, a specific training could be very useful for achieving the best optimization result (Bobker et al. 2011). Starting from the assessment of the building meter profile, many important elements could be registered, such as the energy demand and time of use, occupied/unoccupied periods and other weekend events. They could lead to specific improvement strategies concerning the rescheduling with respect to occupants attitude especially during night hours, weekends, and holidays.

After walking down through the building, it is the time to use the knowledge learned from trend data (PNNL 2011), report all the findings, and choose the design optimization strategies for energy saving. Then it is possible to calculate the year-round energy performance before and after those techniques implementation within the same building. Given the necessity to report and demonstrate the actual energy consumption and savings, it is very important the monitoring process and the building simulation procedures, that are assuming a crucial role within the whole building energy upgrade approach.

Results and findings could also represent the baseline for elaborating and implementing an exhaustive decision support model, hopefully based on the BEMS typical logic (Levermore 2000), able to integrate all the decisive components. To obtain fruitful results, these components typically are (Doukas et al. 2007):

- The sensors' system, that comprehends all the indoor and outdoor sensor for monitoring energy performance and thermal behavior concerning the building environment;
- The controller equipment, that involves all the valves and actuators;
- The decision support unit, that is able to link the sensors results with the intelligent system techniques for selecting and applying appropriate interventions. This is also the specific function aimed at communicating with building's operators through specific interfaces system.
- The building energy database, that collects all the building's data useful for implementing the procedure.

4 Case Study Analysis

Given the main role of the ESB (Empire State Building) as a distinguished prototype for demonstrating the economic and environmental benefits of energy upgrading of buildings, in this section a specific case study within the ESB will be analyzed as "platinum" sustainability intervention.

This case study concerns the office green improvement (Heider and Hartley 2010) of the Swedish construction company Skanska, that occupies the whole 32nd floor of 2,267 m^2 (24,400 ft^2) space. The model project mission was to create a

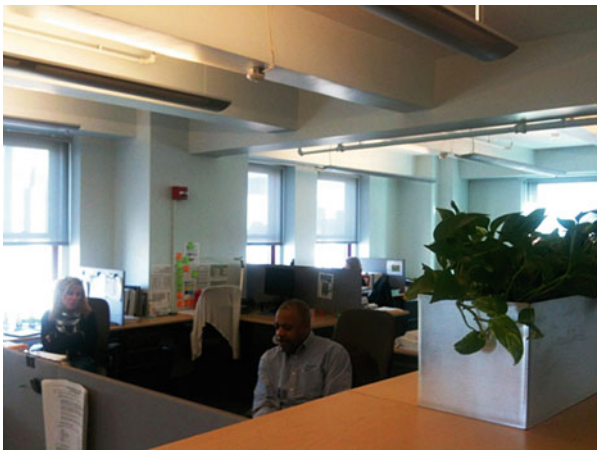

Fig. 4 Natural daylight available at the office workstations of Skanska office

LEED Platinum interior space, with the same budget of a traditional high quality office that could represent a sustainability prototype. The project was also aimed at realizing a comfortable work environment for up to 90 people, with modern and flexible space organization, and the cost-effectiveness of every solution was analyzed within the mission of a less than 5 years ROI value.

4.1 Design Approach for Maximizing Sustainability Benefits of the Retrofit

The design process mission consisted of maximizing the energy efficiency and the occupants' individual controls, the outside natural view and daylight potential (Figs. 4 and 5), tracking all costs and monitoring energy use, with the zero construction waste trough recycling and reusing procedures.

The project consisted in the integration of several architectural and engineering solution and the post-intervention electricity demand was monitored and compared with the previous Skanska high quality office space in Manhattan. After the first year of monitoring Skaska operator were able to register a 57 % of electricity costs with respect to the previous office. So the 15-years saving forecast becomes more than $650,000, considering just the electricity requirements (Tables 1 and 2 [Heider 2011]).

Currently the monitoring system at ESB is able to measure and monitor all the equipment and utilities consumptions. Thus the Skanska new office space could represent a perfect example and baseline reference for future green retrofits. The year-round energy saving associated to the retrofit is more than 185,000 kWh (from about 211 kWh/m^{2}per year to about 91 kWh/m^{2}per year with reference to the ESB

Fig. 5 Outside view of Manhattan from Skanska office at ESB

Table 1 Energy study: utility consumption of the previous Skanska high quality office in Madison Avenue, NY, NY

136 Madison Ave (high quality office)					
	2008			Total annual, actual	Comparison annual
	JAN actual	FEB actual	MAR actual		
Cost [$]	3,677	3,921	4,209	57,506	85,039
Consumption [kWh]	13,760	15,520	17,920	220,853	326,595
Avg cost per kWh	0.27	0.25	0.23	0.26	0.26
Energy cost/rentable SF	0.22	0.24	0.26	2.36	3,49

office conditioned space). The two main comfort and efficiency improvements were the windows full height scheme and the under-floor air distribution system. The first one guaranteed the daylight to 99 % of occupants with the transparent area by 19 % of the external partitions, achieved by the full exposure windows (6'-4" height).

Following the energy model of the under-floor air system, Skanska engineers predicted 27 % of energy saving for the reduction of the static pressure, with the consequent reduction of the fan energy use, and the increase of the supply air temperature. Large energy saving was also achieved by installing variable-frequency systems, able to control and regulate the airflow with respect to the real indoor requirements.

Table 2 Energy study: utility consumption of the new Skanska office at Empire State Building

Empire State Building, 32nd floor LEED Platinum					
	2009			Total annual actual	Comparison annual
	JAN actual	FEB actual	MAR actual		
Cost [$]	1,989	1,987	2,500	34,358	345,718
Consumption [kWh]	10,516	10,506	11,686	173,996	173,996
Avg cost per kWh	0.19	0.19	0.21	0.19	0.19
Energy cost/rentable SF	0.08	0.08	0.1	1.41	1.87

According to ASHRAE Standard 90.1-2010 (ASHRAE Standard 2010), the lighting system comprehended LED lamps in all the workstations and further optimization results were reached by installing occupancy sensors and daylight dimming controls.

4.2 Economic and Environmental Benefits

Thanks to the possibility to know the retrofit project and the operational costs, it is possible to analyze the life-cycle assessment of the intervention at Empire State Building.

In despite of the beginning costs of $4,624,262, that is higher than a traditional best quality office, the amount of the investment is going to pay for itself in 5 years (ROI less than 5 years). The project also benefited from the NYSerda (New York State Energy Research & Development) grant by $20,527, achieving a net gain of $492,869 (Table 3)

Another issue to consider in retrofit interventions is the indoor environmental benefit provided by HVAC improvement and specific comfort optimization strategies. Variable Air Volume diffusers allowed to bring additional outdoor air when necessary for high density zones. Specific attention was paid to the environmental quality of materials and resources such as carpeting, paints, adhesives, wood furniture. The indoor air quality was also guaranteed by high performance filters (MERV 13). Following the LEED for Commercial Interior guidelines also the water use was controlled and reduced by 40 %, providing high water efficient equipment.

The global environment benefits of Skaska office space retrofit is translated into a carbon footprint analysis. This analysis showes an equivalent CO_2 emission reduction by almost 80 t per year[1] (Table 4).

[1] Considering the New York City conversion factor of 0.86 lb CO_2/kWh.

Table 3 Project cost analysis summary

Total project cost	
High quality office budget [$]	4,413,404
Actual costs [$]	4,624,262
LEED premium [$]	210,858
Energy saving (NPV for 15 years) [$]	683,200
NYSERDA grant [$]	20,527
Net positive [$]	492,869

Table 4 Environmental impact of the project: carbon footprint calculation

Carbon footprint analysis	
Annual kWh (Traditional high quality office)	326,595
Annual kWh (@ ESB, 32nd floor office)	141,383
Annual saving [kWh]	185,212
NYC CO_2 footprint for electricity	1.72 kg/kWh
Carbon footprint reduction [tons/year]	683,200

5 Conclusions

In this chapter an integrated assessment of building energy upgrade is proposed considering several aspects that necessary interact within this issue. This contribution deals with a preliminary technical explanation about what building retrofit is, followed by an evaluation of the most common technical practices and innovative solutions. Also a global economical assessment is reported, specifically concerning market barriers and typical barriers also related to the current peculiar economic global situation. The purpose of this integrated analysis is to provide a method for evaluating and choosing the most fruitful global energy upgrade strategy with respect to different variables. This assessment method could provide a flexible tool for guiding the communication between different actors of the integrated process. The project team of the building energy upgrade intervention has to be formed by technicians, operators, designers, stakeholders, etc. The highest barrier against the building energy improvement success is often represented by the huge gap between these different skills we are trying to link following the proposed approach.

Given the huge environmental pressure, the reduction of the environmental pressure attributable to the built environment through this kind of integrated strategies is becoming always more relevant. Also, considering the economic global crisis, we analyze in particular no-cost and low-cost procedures for optimizing energy saving through operations and management strategies.

Also the case study represents a very useful prototype of integrated design for existing building energy upgrade. In facts the Skanska office space at the Empire State Building could became an useful example for guiding future improving interventions by integrating the energy approach with the indoor comfort issue and the economical and environmental constraint.

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