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Integrating cleaner production into sustainability strategies: an introduction to this special volume

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ABSTRACT

This special volume of the Journal of Cleaner Production is built primarily upon articles submitted for the 4th International Workshop Advances in Cleaner Production held in São Paulo, Brazil, in 2013. The 54 articles underscore the urgent need for changing from unsustainable production and societal patterns to sustainable ones. They provide many new approaches to help industries, governments and society to speed up the transition to sustainable patterns. The authors focus on defining and solving problems with special emphasis upon sustainability strategies: raw material replacement, renewable energy, technological developments, product, and policy changes. The central roles of improved corporate management for sustainable societal transitions are explored, with an emphasis upon stakeholder empowerment in promoting implementation of new cleaner technologies within companies, industrial sectors, supply chains and countries. Some authors improved assessment tools for environmental accounting at the biospheric scale. Some authors underscored the need for cooperation among governments, industrial sectors and companies to accelerate the integration of Cleaner Production into policies and practice. Multiple examples of successful integration of CP in national and local policy structures, exemplified how focused work in key industrial sectors is delivering multiplier benefits within and among companies and in the community, at large. The authors documented numerous benefits of holistic integration of local, regional, national and global efforts to accelerate the transition to sustainable development and societal well-being.

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1. Introduction

The term strategy is used in different ways, although it is defined as “the science or art of combining and employing the means of war in planning and directing large military movements and operations” and “ plan, method, or series of maneuvers or stratagems for obtaining a specific goal or result” (MLA, 2014). The expression originated from the Greek στρατηγία (stratēgia), and refers to the ability of formulating a plan to succeed in achieving one or more goals under circumstances of restricted resources and/or uncertainty. The authors of this article used ‘strategy’ and ‘shared mental pictures’ to help society to design and implement short and long-term approaches to achieve the transition to truly sustainable societal development.

Geiser, in 2001, associated CP to the conceptual connection between the production sector and sustainability, considering that CP has helped to the industrial sector to engage in achieving SD goals by defining procedures and by developing the means to implement those procedures. Application of CP can help leaders evaluate alternative approaches to more effectively reduce negative environmental and human health impacts of industry and to accelerate the transition to truly equitable and sustainable societies.

In expanding upon this vision, the articles in this Special Volume (SV) address production and consumption by providing new ideas on, catalyzing innovations eco-product design, improved process control, and incorporating environmental and social issues into management systems. These articles contribute to shifting the standard economic view of environmental protection always being a cost to environmental protection resulting in environmental, social and economic benefits.

The central purpose of this SV is to underscore the importance that academic research places on sustainable planning, by documenting how integration of CP initiatives with SD concepts and

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integrating them with strategy definitions (Mintzberg, 1992) in order to assess and evaluate possible courses of action. In this context, an exciting array of creative research examples of strategies to achieve sustainability is included in this SV.

Most of the articles in this SV were presented during at the 4th International Workshop Advances in Cleaner Production held in São Paulo, Brazil, in 2013, with the challenge to reorient the present unsustainable patterns by integrating CP into sustainability strategies. The representation in Fig. 1 helps the reader to understand the relationships among the different levels in which strategies presented in this SV are being applied. From the base to the top, the pyramid shows increasing coverage and influence on decision-making. For each level of the pyramid, different strategies are applied to different decision-making structures while assessments methods and tools, acting multi-hierarchically, help to monitor decisions made and to redefine strategies, approaches and indicators, when necessary.

2. CP strategies presented in this SV

Results of research are presented and ordered according to their level in the strategy hierarchy, from the top to the bottom of the pyramid shown in Fig. 1. Some strategies deal with the promotion of specific improvements within different levels. At the bottom of the strategy hierarchy, actions are taken within individual companies and management practices are tested and proposed to improve the companies' environmental performance. The area of influence of CP actions is limited to the area of the company, information is available locally, and their effects are evident in the short and medium term. At the top of the hierarchy, several countries and cultures must share strategies in order to achieve common goals. Multi hierarchical strategies can be applied at various levels, such as those assessing improvements that even if applied in a specific sector, have repercussions in other hierarchical levels. The several approaches that seem to be unrelated may interconnect to provide solutions at various levels and scales, thereby, contributing to achieving broader goals.

2.1. Strategies at the global level

At the global level, the broader goals are established by society's perceptions with regard with SD, development and wellbeing. To pursue these goals, the international community is guided visions, strategies and indicators that are designed to provide information on the status of each society, such as the gross domestic product (GDP), which evaluates the economic status, or the Human Development Index (HDI), which is designed to assess the social dimensions of societies. The information provided by these indicators can serve to help leaders establish priorities for action in each country, and to help to accelerate the transition to truly sustainable societal patterns. Another global sustainability strategy deals with the responsibilities for effective integration of knowledge, purposes and skills by academic and non-academic professionals into their work at all levels with regard to societal sustainability.

2.1.1. How to integrate strategies to achieve goals at the global level

Nielsen and Jørgensen (2015), claiming that the development of a method for the "sustainability analysis" of a society would assist in governing the transitional process in the direction of increasing sustainability, presented an exergy-based framework with "sustainability indicators" developed to monitor and indicate whether potential measures undertaken lead the society in the right direction.

Giannetti et al. (2014) provided a comprehensive review in which the current default standard for economic and social progress, GDP, was found to be inadequate for monitoring all of the relevant features for modern societies, governance, eco-system, policymakers and public policies. This review showed that progress indicators measured only in monetary or social terms are limited and restricted, and recommended that it urgent that changes are made in the paradigm of progress to go far beyond GDP by integrating a wide array of non-monetary elements of human well-being and eco-system health into our real world SD journey. This approach was complemented by Frugoli et al. (2014) who compared emergy indices with ten indicators, and suggested that existent socio-economic indicators should be used in combination with biophysical indicators to provide a better understanding of the impacts of economic growth upon sustainable well-being. Both articles made it clear that the currently used measures of 'progress' misguide the elaboration of public and sectoral policies at all levels, and their weaknesses are key stimuli for the development of alternative indices to measure and guide the needed transitions to ***truly equitable and sustainable societies***. These ideas were complemented by Núñez-Delgado (2015), who included in the debate reflections on possible conceptual tools to approach equality and

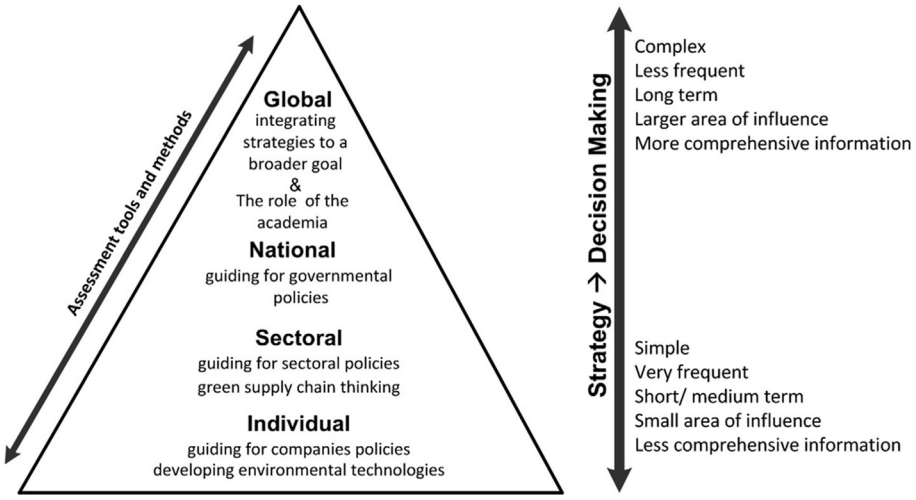

Fig. 1. Decision-making hierarchy and outline of the main characteristics of each decision-making level presented in this SV.

social justice that could be applicable to existing fortunes, country by country.

It is important to highlight that articles dealing with African issues included in this SV (Section 2.4 and 2.5) emphasized that local solutions are more effective than those internationally accepted, and underscored the need of combining social issues with environmental assessment, and the urgent need to develop better ways of measuring the outcomes of CP implementation. Concern was expressed about the need for adapting well known CP strategies to developing countries, not only at company's level (Section 2.4), but also at sectoral and supply chain scale (Section 2.3) and national level (Section 2.2). The authors made it clear that sustainable strategies depend on the country's development model, on the degree of development and on the societal structure in which the plans and policies would be applied.

2.1.2. Initiatives of academia to improve professional activities for SD

Many individual articles and entire SVs of the JCLP have been dedicated to addressing the integration of CP into the High Educational Institutions' curricula, among which we draw attention to the SV: Sustainability in higher education: what is happening? (Garcia et al., 2006), and the SV organized by Ferrer-Balas et al. (2010) in which changes in values, attitudes, motivations, and in curricula were discussed as crucial to make changes in operations, courses, curricula, and research. Recently, an SV dealing with experiences on building Green Universities and in promoting Education for Sustainable Development in developing and emerging countries was organized by Wang et al. (2013), and the perspectives of management in education and sustainable consumption were explored in the SV: Emerging areas in research on higher education for sustainable development – management education, sustainable consumption and perspectives from Central and Eastern Europe (Adomßent et al., 2014). Other SVs on dealing with the connection between CP, SD and universities can be found at http://www.journals.elsevier.com/journal-of-cleaner-production/special-issues/.

Discussions and analyses in those issues covered changes in values, attitudes, motives, curricula, social interactions and the impacts of research. Valuable recommendations provided ways to accelerate progress toward sustainable societal patterns by involving faculties, students, staffs, alumni and other stakeholders inside and outside of the campus boundaries (Almeida et al., 2013). In this SV, Khalili et al. (2014) proposed a methodology via which leaders in higher education can assess the necessity and the urgency for designing training programs that could assist with developing human capital needed to support life in truly sustainable societies. Brones and Carvalho (2014) offered a way the academy could help companies to achieve innovation. They underscored the need for academic leaders to use ecodesign models for classifying and prioritizing their efforts to improve innovation management based upon environmental sustainability knowledge.

2.2. Strategies pertaining to the National level

At the national level, actions involve governmental decisions, regulatory agencies and legislation. With increasing efforts to ensure regulatory compliance and to enhance the ability of enterprises, societies, and local administrators, national governments are developing and implementing policies to promote CP. In many developed and developing countries, CP emerged after the establishment of the basic structure of the official environmental regulatory agency. Professionals, trained in the background designed by governmental agencies and the corresponding 'end-of-pipe', pollution control industries, have developed detailed directives, and a compliance state of mind. Conventional regulatory approaches, based on end-of-pipe, discharge licenses, exaggerated the importance of the interface between the facility limits and their surroundings.

Describing how traditional regulatory structures reduce opportunities for waste exchange, materials recycling and CP solutions, Ribeiro and Kruglianskas (2014) delineated principles of environmental regulatory quality, through a literature review that documented the severe limits of conventional pollution control-based regulatory methods. After documenting the most relevant constraints of customary regulatory approaches, they proposed a three-step methodology to identify and synthesize recommendations to overcome environmental protection challenges by building upon the fact that CP can not only improve processes inside facilities, but also among facilities, and among facilities, their suppliers, customers and within the eco-system upon which all are totally dependent.

A description of how CP emerged under a different developmental model was provided by Palma et al. (2015). These authors took the Cuban process of rural development, and analyzed historical changes for CP introduction from industrial-growth oriented development to guaranteeing food self-sufficiency to renovations reoriented towards CP. Their paper on Cuban agriculture should help to strengthen national policies and help other Latin American countries looking for ways to place agribusiness in the international market without neglecting the care of their local environment.

The authors of several articles in this SV analyzed governmental policies to clarify the urgent need for rapid and significant efforts to reduce environmental pressures, which are threatening the conditions necessary for human wellbeing. National policies to determine future or desirable energy matrices were explored and discussed. In that context, Fontoura et al. (2014) identified opportunities to increase the share of the Brazilian domestic energy through the adoption of biorefineries as sustainable alternatives to fossil fuels and other non-renewable energy sources.

A team led by Murakami reported that within Brazil, there is no clear vision on how to use public policies to ensure material's recycling (Murakami et al., 2014). Therefore, they developed a multiple-case study based upon eleven companies that produce new products using waste. Murakami et al. (2014) stated that by providing governmental, financial support to universities and technological institutes, the spread of CP strategies to SMEs could be accelerated. Their analyses indicated this would accelerate the needed transitions when local governments use policies to effectively and economically use taxes, sanctions, incentives and other public instruments to stimulate CP and recycling.

2.3. Strategies pertaining to the sectoral level

Sectoral policies can provide directions to guide decisions and actions covering a broader territory. Management practices designed to improve the companies' environmental performance can be quickly disseminated over a larger area of influence. As a result CP actions are not limited to the single company but can be catalyzed systematically throughout entire industrial sectors.

2.3.1. Policies and actions applied for sectors

A series of examples of implementation of sustainable strategies revealed that an effective strategy requires input and participation from all levels of management and across all departments. When a sectoral policy is implemented, it is vital to support the policy and to monitor its performance, thereby keeping support of implementing the strategy alive and to ensure that it can be changed to adapt to new situations and contexts. Scenarios based on the

national environmental goals for the Chinese automotive sector were explored by Liu et al. (2014). An LCA study was used to assess the direct and indirect environmental impacts at the production and consumption stages. The results revealed that the indirect impacts at the production stage dominate the total impacts of this industrial sector, through the production of steel, plastic, rubber and other raw materials. Since the indirect environmental impacts were more significant than the indirect economic benefits provided by the development of the automotive industry, a scenario was developed with potential alternatives for the next five years proposed alternatives to implement in the pre-production stage and at the consumption stage to save energy and water and to reduce pollution.

Castillo-Vergara et al. (2014) analyzed the impact generated by the CP Agreement signed between the National Council for CP and the Pisco Sector of the Region of Coquimbo in Peru related to waste handling and water use. An econometric model applied to data from 2006 to 2011 showed the costs and benefits associated with the implementation of the agreement. The reduction in water consumption significantly reduced the costs incurred by the company in water treatment prior to utilization in the plant. The new liquid industrial waste handling system and its direct use in the maintenance of company's roads generated a 600% reduction in water consumption.

An empirical study in the Brazilian metal-mechanic cluster of Serra Gaúcha analyzed the relationships among CP concepts, environmental sustainability and organizational performance in 298 companies (Severo et al., 2014). The results showed that companies found alternative processes to reduce costs and to improve their image while CP methodologies contributed to improving aspects of health and safety and increasing production capacity and flexibility. Policies were investigated to identify and encourage the implementation of industrial symbiosis, which may be achieved through top-down planning, such as practiced in China or via bottom-up planning as illustrated in many eco-industrial parks in other countries. To evaluate how indirect encouragement of symbiosis may prove effective, Zhang et al. (2014) examined the Lubei eco-industrial park, using network analysis. Their results revealed pros and cons of eco-industrial parks in terms of structures and functions.

For several sectors and companies, the strategy for implementing activities designed to enhance sustainability was found as an independent issue, rather than having been integrated as the core of all company strategies and activities. Bridging the 'strategy-as-practice' and 'sustainability strategies,' Egels-Zandén and Rosén (2014) explored the convergence of the sustainability goals and strategic management of a Swedish multinational high-precision mechanical corporation, which is recognized as a world sustainability leader. By means of a longitudinal case study, they identified previously overlooked strategic activities that helped to improve the scope and effectivity of the company's sustainable strategies. Similarly, Rosa et al. (2014) identified the factors that helped to stimulate disclosure of environmental information by Brazilian companies. The level of disclosure of annual sustainability reports of 50 Brazilian companies revealed a lack of information on standards for comparing the goals to reduce the impacts. A study on these 50 Brazilian companies revealed that a small percentage of the companies used specific reports to disseminate environmental information. They recommended that the companies should be mandated to publish sustainability reports. Amplifying this idea, Orsato et al. (2015a) showed that the adhesion to a sustainability index, created for companies listed in stock exchange markets, exposes the intangible values that come from voluntary environmental initiatives, such as access to knowledge, new capabilities, and reputational gain.

2.3.2. Green supply chain thinking

Application of CP to the whole product chain was another important direction investigated by a number of researchers. Each actor in the chain from supplier to consumer has a role and all influence each other. Integrated supply chain management can help the different members of the chain to reduce their individual and joint wastage of materials and energy. Authors in this SV provided tools for reducing waste, materials and energy by linking suppliers to customers. Considering that implementing supply chain sustainability in an emerging economy is a "hard nut to crack", Silvestre (2014) connected CP and sustainability in supply chains by exploring a focal company operating in an emerging economy. Drawing from stakeholder theory and contingency theory, Silvestre's proposed an innovation-centered approach to sustainable supply chain management. The results revealed the difficulties to implement and manage sustainable supply chains due to context-specific challenges.

In an investigation of the drivers of green manufacturing with a fuzzy approach, Kannan et al. (2015a) surveyed 120 leading firms in South India used the fuzzy multi-criteria decision-making approach. They found that compliance with regulations was the essential driver of green manufacturing in India. Stakeholders and customers were the second and third essential drivers, respectively.

Kannan et al. (2015b) used a case study in Singapore to propose and test a multi-criteria decision-making approach to select the best green supplier for a plastic manufacturing company. The use of this approach helped the firms to establish a systematic approach to select the best green supplier within a set of rules, and to analyze the most appropriate alternative available. Guarnieri et al. (2014) evaluated the possibility of outsourcing solid waste management and product take-back by engaging third-party reverse logistics providers. The authors proposed a framework to help decision-makers evaluate and select the most suitable third-party provider. Shaharudin et al. (2014) identified the barriers for managing product returns and recovery in manufacturing firms in Malaysia. Their analyses documented that external barriers such as customers' operational performance and perceptions were the main obstacles for establishing and implementing appropriate policies and strategies to improve take-back and recovery in the manufacturing supply chain. Their findings may help policy-makers in emerging countries in implementing appropriate policies and strategies to improve product returns and recovery of valuable materials by manufacturing firms.

It is noteworthy that the green supply chain studies reported in this SV were concentrated on emerging/developing countries. This suggests that there is increasing confidence in these country's strengths to become leading actors in supplying the inputs necessary for life and human wellbeing. This implies that the transition towards SD, including the introduction of sustainability criteria for sourcing raw materials and other inputs production, is having increasing impacts upon global production, consumption and international trade.

2.4. Strategies pertaining to the individual level

Developing environmental technologies involves approaches that combine technology (processes and tools) and techniques, which deal with the ways that technology is used. Individual initiatives may be seen as independent and localized, but it is always important to emphasize that individual behavior can catalyze systemic changes. It is imperative that a sufficient and varied number of efforts are made, recalling that variations are expected depending on the socio-economic-technical environment, which is also influenced by policies and consumer requirements. Some of the new methods and approaches presented in articles in this SV

are at the experimental phase of development, but represent promising alternatives, which could be scaled up in the near future to help society make valuable improvements.

2.4.1. The development of environmental technologies at the individual company level

The market for pollution control technology remains vital, due to conditions as shown by Bhattacharya et al. (2014) who reported on the distribution of dissolved trace metals in a mangrove wetland in India. The average concentrations of heavy metals exceeded the World of Health Organization's recommended value, and were aggravated by the load of domestic sewage effluents discharged from Calcutta. Moreover, pollution control equipment generates profits, increases employment, and adds to gross national product. Bhattacharya et al. (2014) discussed market and technical barriers, which may inhibit CP diffusion of CP technologies that are under development.

CP technologies are central to the core processes of production and are often thought of as a means to reduce operational costs. Recent developments in “green chemistry,” “green engineering” and “sustainable materials” offer opportunities for new feedstock and intermediate materials, alternative reuse approaches, emission reductions, and production based upon renewable materials. For example, a sustainable antimicrobial finishing of cotton fabrics was presented by Ferrero et al. (2014). The feasibility of the new method, at a semi-industrial level, confirmed the previous laboratory results, which showed strong antibacterial activity and provided increased washing fastness with a negligible impact upon color fastness or upon the ‘hand’ properties of the fabric. In research of the influence of the main operating parameters of the paper production process to reduce CO_2 emissions (Calvo and Domingo, 2014) correlated the operating status of the drying section with CO_2 emissions with an indicator to monitor this production stage.

The feasibility of rainwater harvesting and greywater reuse systems in a large commercial building was studied. It was found that rainwater harvesting in the southern region of Brazil was economically beneficial since the installation of rainwater harvesting systems saved 5400 m^3/month of fresh water (Gois et al., 2014). In an article on the use of sludge of water treatment as a coagulant for treating municipal wastewater (Nair and Ahammed, 2015) achieved a substantially higher contaminant removal compared to using *fresh coagulant* alone. Wolff et al. (2014) mixed the sludge of a water treatment plant of a pulp mill with three types of waste obtained via recovery of chemicals at the same mill (dregs, grits, and lime mud) in order to evaluate their suitability for the production of interior coatings and acoustic bricks. The recovery of waste integrates the pulp mill and the red ceramics industry, thereby contributing to SD in Minas Gerais (Brazil) by using the sludge as raw material in the production cycle of ceramic bricks.

Andersson (2014) documented benefits of using human urine to supplement soils for improving food production in Uganda. She found that urine fertilization resulted in significant increases in yield thereby, enhancing food security and income, especially for people who could not afford to purchase commercial fertilizers. The research illustrated that transdisciplinary research can lead to the development and testing of approaches that contribute to enhanced community sustainability through locally anchored and solutions-oriented generation of knowledge.

Silva et al. (2014) evaluated the environmental performance of the melamine-urea-formaldehyde to replace urea-formaldehyde resin. The cradle-to-gate assessment included material supply and resin production stages; they determined the main hotspots in both resins life cycle and devised ways the trade-offs between the increase in non-toxicological impacts in the resin production stage and the reduction in the toxicological impacts in the resins use phase when melamine mix is increased. The addition of 10% melamine to the urea-formaldehyde resin improved wood panel properties under high humidity conditions. Iritani et al. (2014) explored sustainable strategies through LCA using a case study in a Brazilian furniture industry. Following the product life cycle from cradle-to-gate, they reported that the most significant environmental impacts occur at the stages of raw materials supply and the distribution of the furniture. Two sustainable strategies were proposed to assist the furniture and the wood-based panel industries in improving their environmental profile.

2.4.2. Articles contributing to guidance for company's policies

The survival of businesses requires the integration of environmental, economic and social aspects within private companies, and sustainability strategies may not result in a change in the short run without the integration of environmental and social dimensions to innovations in the companies' managerial systems. In this context, several articles included in this SV report on cases of success, barriers and shortcomings of implementing social and technological innovations into management systems. Sánchez (2014) developed a framework to help organizations to implement new business strategies improving their operational project management, and to fulfill stakeholder's sustainability demands. Jabbour (2014) analyzed the environmental training and environmental management maturity of Brazilian companies. He found that environmental training was positively and significantly related with the maturity of the company's ISO14001 environmental management system. Luz et al. (2014) assessed the relationship between life cycle inventories (LCI) and innovation using a case study of aluminum packaging for soft drinks. They identified points of correlation between the LCI and innovation, which may help organizations to adopt CP actions efficiently enhancing product innovation. Trokanas et al. (2014) presented an innovative approach to calculate industrial symbiosis indicators, with metrics implemented as ontology properties of materials, waste types and processing technologies.

Organizations operate in unstable environments characterized by competitiveness, technological progress, new market requirements, and scarce natural resources. Since this situation requires changes in the operation and companies' management, the integration of certifiable management systems was tested and found to be an effective alternative to start implementing sustainable strategies. His result was corroborated by Nguyen and Hens (2014) who analyzed the response of Vietnamese cement plants to ISO 14001 and verified that the environmental awareness and attention in certified plants improved the operational performance after the adoption of ISO 14001. Their findings suggested that corporate implementation of ISO 14001 has the potential to improve the organizations' environmental performance in developing countries characterized by recent industrial growth. Their results showed significant differences between the certified and non-certified plants on selected environmental indicators like dust, SO_2 and NO_2 as well as a significant improvement after the adoption of ISO 14001.

The joint implementation of the Sustainable Value concept and CP provided benefits concerning the inputs, emissions and waste reduction (Henriques and Catarino, 2014) in the nineteen Portuguese SMEs. Those companies were found to be more competitive than companies that had not implemented Sustainable Value concepts and CP. An indicator that integrates economic, environmental and social aspects was used to monitor the evolution of the sustainability dimensions within the companies. The analysis, using this indicator in different companies, documented benefits due to reduction of inputs (water, energy and materials), emissions and waste.

2.5. Multi-hierarchical strategies: the use of assessment methods and tools

Many authors, emphasized that strategies must regularly be reviewed and revised to ensure that the targets remain relevant to the organization and to fulfill governmental and stakeholder requirements. Strategies must also be monitored and assessed to ensure that the organization's objectives regarding SD are achieved. Assessment is crucial to determine the optimum materials and energy as critical parameters for CP application, and to evaluate the success of actions and tasks completed. There are various tools and methods to assess the organizations environmental performance, such as greenhouse gas assessment, eco-profiles, emergy synthesis and life cycle assessments, each one with constraints, limits and qualities.

The commitments to reduce GHG emissions provided a framework for the national government to establish goals and timetables to be met by using diverse approaches such as by capturing and sequestering greenhouse gases and "decarbonizing" the world's economies. CP can promote decarbonization through energy conservation and improvements in energy use efficiency, and by shifting to a wide array of renewable energies including solar, wind, small-scale hydro, and geothermal and bio-based energy sources.

This SV contains several papers on measuring and reducing GHG emissions and for changing the economy at national, regional and industrial levels. Orsato et al. (2014) investigated the reasons for joining a 'Carbon Club,' with the goal of managing and reducing GHG emissions. From data collected within the Brazilian banking sector, they analyzed institutional pressures, resources and skills to gain insights into the rationales for proactive sustainability management and to contribute to the supplementary development of institutional theory and to advancement of sustainability management in corporations. Wahyuni and Ratnatunga (2014) assessed the carbon strategies and management practices in a so-called "uncertain carbonomic environment," by underscoring that many businesses carbon strategies are undertaken within conditions of uncertain national carbon policy. The carbon strategies and carbon management practices adopted by two companies of the Australian national energy market were evaluated, considering diverse carbon strategies and carbon management practices to deal with conformities. These carbon practices included the extent of carbon emissions, the sector-specific regulatory background and the internal capabilities to deal with carbon emissions. The authors provided practical guidelines for effectively developing carbon management strategies in uncertain environments.

In a subsequent study, Subramaniam et al. (2014) addressed perceptions of managerial risks and opportunities associated with carbon pricing and emissions management. The factors that affected the extent to which carbon-related risks and opportunities were integrated into the organization's formal enterprise risk management system were examined. Their results showed that carbon risk integration is positively connected with the existence of an official carbon strategy, senior management involvement, internal audit oversight, personnel and funds availability and energy sector membership.

Most of the climate impact of energy use is caused by housing, food production and transportation. The GHG emissions, associated with the Brazilian soybean production were assessed by Raucci et al. (2014). They used LCA, to evaluate the main sources of GHG in soybean production in the State of Mato Grosso. Within their study, 55 farms, accounting for 180,000 ha of soybean cultivation, were evaluated. They established mitigation priorities associated to the largest sources of GHG in soybean production: decomposition of crop residues (36%), followed by fuel use (19%), and fertilizer application (16%). Dick et al. (2014) emphasized that animal production is a human activity that influences local ecosystems conservation. Through LCA, they analyzed the main environmental impacts of two typical beef cattle production systems in southern Brazil and discriminated the environmental impacts of different production systems considering local singularities. Ruviaro et al. (2014) assessed the carbon footprint per kg of live weight gain for different beef production systems in Southern Brazil, and proposed improved feeding strategies to help to mitigate GHG emissions. They found opportunities and described techniques to improve livestock productivity and to reduce emissions of beef cattle production: better pasture management, supplementary feeding practices, substitution of forage for food containing less fiber, adequate sanitary control, integrated management of animal wastes and the genetic improvement of animals.

Policies designed to reduce fossil carbon emissions can help to facilitate the shift from oil/coal to hydrogen or renewable sources, such as hydropower (Zhang and Xu, 2014), solar/biomass (Sanches-Pereira and Gómez, 2014; Billen et al., 2014) and wind (Xydis, 2014); and by reducing energy consumption through efficiency improvements and mobility patterns changes (Yağcıtekin et al., 2014). In order to establish a vehicle fleet free from fossil fuels by 2030, Sanches-Pereira and Gómez (2014) presented an analytical framework for monitoring the development of the biofuel system in Sweden, and evaluated its impacts by reaching 10% of renewable fuels by 2020. The framework illustrated how to assess different growth scenarios as well as to use supply and demand pressures onto the system. A case study in Istanbul, Turkey, was used to assess emission impacts and energy requirements of electrically driven vehicles (Yağcıtekin et al., 2014). The possible effects of electrification of urban road transportation on CO_2 emission reduction and the economic benefit in the carbon trade market were investigated to gain an understanding of the pros and cons of providing subsidies for a possible market of electrically-driven vehicles.

Zhang and Xu (2014) developed an embodied carbon budget accounting system for large hydropower plants. The accounting system includes fossil carbon reductions due to the provision of extra services, and to a decrease in adjacent ecosystem services. This approach resulted in a carbon footprint assessment, which revealed that the low fossil carbon status of large hydropower plants is overestimated. Xydis (2014) analyzed wind farm's development potentials in Greece, based on wind energy penetration/integration criteria. He examined ways for the load shed of a wind farm to be used for agricultural purposes, to meet the demand and to offer a less fluctuating electricity production output to the grid. They provided resource analyses results to support decisions on which wind farm optimized layouts can be made.

Bioenergy sources were considered to be promising alternatives for sustainable energy production. The energy produced from microalgae biomass was compared with different electricity sources with respect to GHG emissions and net energy ratios along the supply chain (Medeiros et al., 2014). Using LCA, the authors reported that the net energy ratio of heat from microalgae combustion life cycle was still disadvantageous compared to most of the fossil options, but they identified potential options for improvements in the biomass lifecycle. Electricity from poultry manure was suggested as a cleaner alternative to direct land application. Billen et al. (2014) analyzed a treatment option for poultry manure, by producing electricity via fluidized bed combustion; they found that this resulted in a lower environmental impact than direct land spreading. As advantages for the treatment, they list zero wastewater, low emissions, savings of fossil fuels and recycling of P and K, which make electricity from poultry manure cleaner than electricity from coal. Evaluating the use of renewable energy from a different point of view, Suberu et al. (2014) reviewed the over-use

of fuel wood and its charcoal derivative for energy consumption in three selected Sub-Saharan African countries: Nigeria, Ghana and Uganda. Suggestions on how to confront the challenges associated with the conditions that led to over-exploitation of fuel wood in the area to include the use of renewable energy mini-power grid systems in rural communities, the use of rural biogas energy facilities and small-scale solar-based energy production.

Machado et al. (2014) evaluated the viability of eucalyptus reforestation as an alternative for mitigating GHG emissions since Brazil is one of the largest producers of eucalyptus used for producing pulp and paper. They developed a model for monitoring forest growth and quantifying wood stocks and sequestered carbon. Forest growth was modeled based on eight regions with dissimilar edaphoclimatic characteristics. They found that shortening the harvest cycle from five to seven resulted in an increase of up to 21.0% in the sequestered CO_2 stock. Emergy assessments were used to evaluate how to restore regional sustainability. Nakajima and Ortega (2014) showed the environmental conditions of different horticultural production systems in São Paulo comparing the results to those obtained from five organic horticultural systems located in Rio de Janeiro. The results showed the renewability of Rio de Janeiro's systems higher than that of São Paulo's systems because these last systems respond to market pressures decreasing prices through the increase of production using industrial aggressive inputs intensively. Emergy synthesis was used to evaluate the destruction of Pinus forests in the Mediterranean area (Turcato et al., 2014) and the investment needed for bioethanol production (Patrizi et al., 2014). In the first case, the authors assessed the environmental and economic impacts arising from the ecosystem service provision loss, which if extended to the entire Cinque Terre National Park would lead to a total loss of a million of Euro per year (Turcato et al., 2014). In the second analysis, the physical consistency of the investment required to implement an ethanol biorefinery to accomplish the European plan for the partial substitution of bioethanol for gasoline by 2020 was evaluated by Patrizi et al. (2014). Hypothesizing a system fed by residual energy and straw from local productions, these authors showed that the benefit in saving gasoline, in emergy terms, almost doubles the emergy investment to produce biofuel. Using LCA, Pereira et al. (2014) evaluated the first and second-generation butanol production by the sugar chemistry. Life cycle inventories and mass and energy balances showed that production from bagasse and straw using genetically modified microorganisms presents the best environmental performance among the investigated technological scenarios. The introduction of butanol and the by-product acetone to the product portfolio led to increased profits.

The development of products and their effects on the social environment were analyzed with the help of LCA (Musaazi et al., 2014). These authors combined social and environmental LCA to evaluate two specific sanitary pads, in Uganda. From the environmental LCA, they concluded that the majority of environmental impacts for the African pad are at least half of those of the European product. From the social LCA, they inferred significant social benefits to local producers and recommended that Sub-Saharan African countries should promote policies with the objective of developing local projects for sustainable products instead of relying on imported ones.

3. Concluding remarks

This SV explored recent research on CP and opened the question as to whether CP practices are competing with or adding to each other to achieve a greater goal, considering the scientific gaps and the social needs The initiatives for integration of CP on sustainability strategies can be distinguished according to the definitions outlined by Mintzberg, 1992 (Table 1) and on the hierarchical pyramid (Fig. 2), in which the types of strategy guiding decisions were documented.

Plan and pattern strategies can be quite independent of each other. While plans may go unrealized, patterns appear and represent realized strategy. In general terms, the articles in this SV were designed to respond to the challenges of integrating CP into sustainability strategies, and important research results were published with the objective of:

Table 1
Classification of the articles of this SV according to different types of strategy used by the authors.

Type of strategy	Description	CP option/practice	Article
Plan	When it serves as a guideline to deal with conditions or restrictions. Under this perspective, the strategy is made in advance of the actions to which it applies, and it is developed intentionally to achieve a given goal.	Guiding for governmental policies	Ribeiro and Kruglianskas, 2014; Palma et al., 2015; Fontoura et al., 2014; Murakami et al., 2014.
		Guiding for sectoral and companies policies	Liu et al., 2014; Castillo-Vergara et al., 2014; Zhang et al., 2014; Egels-Zandén and Rosen, 2014; Rosa et al., 2014; Sánchez, 2014; Jabbour, 2014; Nguyen and Hens, 2014; Henriques and Catarino, 2014.
		Green supply chain thinking	Silvestre, 2014; Kannan et al., 2015a, 2015b; Shaharudin et al., 2014; Guarnieri et al., 2014.
Pattern	When strategies, deliberated or not, are learned, and applied. The strategy is a pattern recognized in a stream of actions.	Implementing environmental technologies	Bhattacharya et al., 2014; Ferrero et al., 2014; Silva et al., 2014; Nair and Ahammed, 2015; Gois et al., 2014; Wolff et al., 2014; Calvo and Domingo, 2014; Andersson, 2014.
Position	When it places the position between the internal and the external context, locates the system (country, region, company) in an “ambiance”, by establishing and comparing indices and indicators.	Assessment methods and tools	Orsato et al., 2014; Wahyuni and Ratnatunga, 2014; Subramaniam et al., 2014; Raucci et al., 2014; Ruviaro et al., 2014; Machado et al., 2014; Zhang and Xu, 2014; Sanches-Pereira and Gómez, 2014; Billen et al., 2014; Xydis, 2014; Yağcıtekin et al., 2014; Suberu et al., 2014; Medeiros et al., 2014.
			Patrizi et al., 2014; Turcato et al., 2014; Nakajima and Ortega, 2014; Iritani et al., 2014; Pereira et al., 2014; Dick et al., 2014; Luz et al., 2014; Trokanas et al., 2014; Musaazi et al., 2014.
Perspective	When its content consists of a recognized way of perceiving the world. People share strategy in this respect through their purposes and their activities, and in this context, works through individuals associated by common sense	The role of the academic community	Khalili et al., 2014; Brones and Carvalho, 2014.
		How to integrate strategies to a broader goal	Nielsen and Jørgensen, 2015; Núñez-Delgado, 2015.

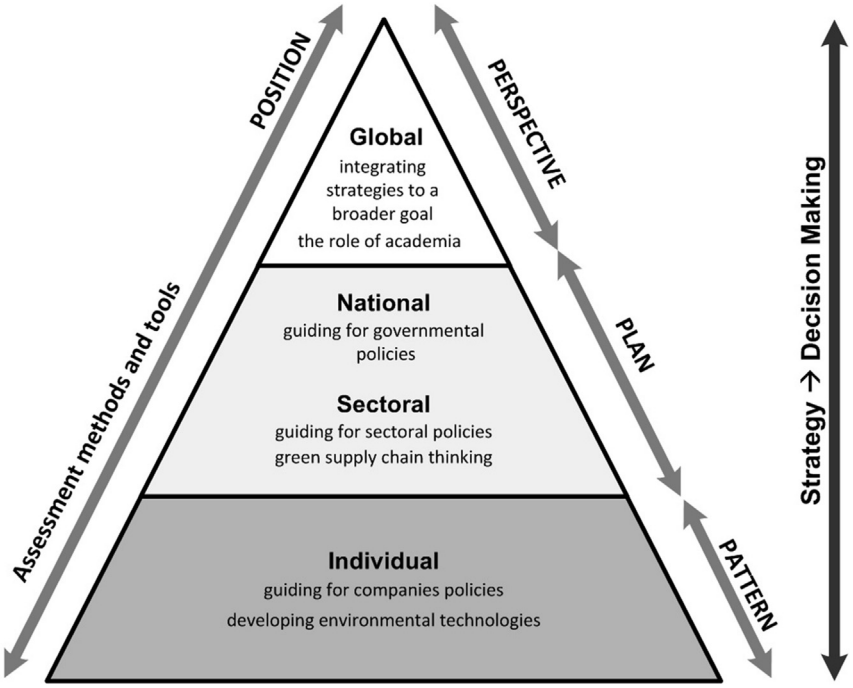

Fig. 2. The decisions hierarchy with the correspondent strategy type for each level and an outline of the main characteristics of each strategic level used by the authors.

1) Enhancing the innovativeness of CP practices and concepts in terms of technologies, management, and measurements.
2) Broadening and deepening the involvement of governments and academics in the design, implementation and management of corporate CP actions.
3) Ensuring that sustainability strategies are regularly reviewed, objectives are implemented, actions are assessed and monitored, performance is evaluated, and clear governance allocates responsibility and actions at the right levels with proper clarity, transparency and consistent enforcement.

By positioning the research of the papers in the decision pyramid and associating it with the type of strategy applied, the editors of this SV hoped to help researchers and decision-makers to understand the coverage of developed and applied strategies in terms of time and scale. It is clear that some strategies, despite being essential, have a small area of influence, have an effect only during the short-term and, therefore, need greater monitoring for possible corrections or reinforcements. Strategies positioned at the top of the pyramid will need more comprehensive information, but their application will affect a broader area with longer term effects.

At a deeper level, industry and governments must achieve an understanding and application of systems thinking, in which the biosphere encompasses all human sub-subsystems: social, economic, and industrial. This SV provided a reflective review of how recent research was committed to and implemented the CP agenda, and that it can act as a guide to developing and implementing sustainability plans at the corporate or regional levels, by highlighting existing good practices and responding to issues identified by governments and by the diverse industrial sectors.

It became clear that there is no 'one-size-fits-all' approach to incorporating CP in sustainability strategies and that each individual strategy can contribute, in a way or another to achieve the broader goal of SD.

The opportunities and urgent challenges that sustainability poses have increased and it is critical that actors, in all dimensions, including governments, universities, industrial sectors, companies and individuals, should be prepared to assume their responsibilities through the development and implementation of comprehensive sustainability policies, goals, strategies and transparent reporting of the results.

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