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Editorial

# Cleaner Production initiatives and challenges for a sustainable world: an introduction to this special volume

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A B S T R A C T

This special volume of the Journal of Cleaner Production is comprised of articles presented at the 3rd International Workshop Advances in Cleaner Production held in São Paulo, Brazil, in 2011. The content underscores the recognition of the pressing and inescapable need for making changes from unsustainable to sustainable production and consumption patterns. The **48** articles from 15 countries provide different, but complimentary approaches to help industrial and societal sectors in advancing on their paths towards sustainability. Initiatives and challenges are included, which systematically address problems affecting raw material changes, technological modifications, product and policy changes. The findings range from proposals for alternative uses of wastes, substitution of raw materials for environmentally friendlier substances, optimization of industrial processes by source reductions of wastes and emissions and documented economic and environmental advantages of a wide array of initiatives. The roles of operational and managerial practices are also stressed, highlighting the role of diverse stakeholders as promoters of implementation and internalization of innovative cleaner technologies within companies. Systemic assessment tools are employed and experimented with in order to more effectively evaluate the environmental performance of systems on the biosphere scale. The methodological procedures and proposals presented can help in the design and management of production systems, for governmental and corporate policy development, for implementing and monitoring CP Programs, prevention and mitigation strategies, and evaluation of the outcomes of CP initiatives in the production and service sectors.



## 1. Introduction

Cleaner Production (CP) is an area of basic and applied research, which embraces concepts and methodologies from different disciplines. The research efforts often focus on a diversity of industrial and societal domains in order to effectively understand and manage the overall system, which includes many processes on various scales, so that different environmental, economic and sustainability perspectives can be addressed. The articles in this special volume address initiatives on the search and testing of more environmentally friendly processes, the challenges faced for both the implementation of concepts and their acceptance, the challenges faced in monitoring and building upon the progress as well as alternatives and barriers & opportunities for sustainable consumption and production in a global context.

In this context, the necessity of using methodological instruments in order to determine the real environmental costs and benefits of any CP application is recognized. It is essential to use proper evaluation methodologies to support decision-making; it is furthermore, necessary to identify where improvements are needed with the use of decision support tools. The use of managerial tools within companies helps the managers and other employees to monitor and compare the environmental-economic improvements regularly, as steps towards more effective, CP systems. However, environmental-economic improvement is an extremely broad term that can include improvements in raw material's selection and usage, and energy use, aspects affecting worker's health and safety, emissions to air, water and land, including solid waste for landfill disposal, and the environmental impact of products during utilization and at their end-of-life management. For this reason, there are many approaches used for determining the optimal balance between economic and environmental aspects.

Since its first edition, the Advances in Cleaner Production team, in partnership with JCLP, has published a special volume containing the best papers presented during the event (Bonilla et al., 2010, 2013), and most of the articles in this, third special volume were presented at the 3rd International Workshop Advances in Cleaner Production held in São Paulo, Brazil, in 2011. By providing examples of implementation and evaluation of CP options (alternative operational practices, raw material changes, technological modifications and product changes) the editors hope to inspire manufacturers to incorporate CP concepts and approaches to improve their environmental assessment and performance as objective aspects in their products and services and to save considerable time and effort on their continual improvement journey. We also hope environmental protection officials will increasingly develop policies and programs to support the rapid implementation of the CP concepts throughout all industrial and service sectors in their countries. Additionally, we

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hope consultants and educators will effectively benefit from and build upon the wisdom contained in the 48 articles in this special volume.

This introductory article is structured as follows: in Section 2 the editorial team included the articles that deal with the search and adoption of environmentally friendlier solutions designed to advance production and consumption towards sustainable development (SD). Academic results are presented and sometimes, applied to real world industrial systems that are working to reduce the wastage of resources and operational costs through the rational use of raw materials, water and energy, through process changes and improved monitoring and management.

Section 3, includes articles pertaining to practical, in-company experiences of the inter-relationships among managerial, auditing and monitoring tools, which have been found to be relevant in improving the design and implementation of the required measures targeting SD.

In Section 4, the editorial team explored what can be learned from initiatives devoted to understand and guide the relationships between the companies and their stakeholders, and the search of appropriate methods.

Methods such as Life Cycle Assessment (LCA), Emergy and Exergy analysis are explored and discussed in Section 5. The methods are designed, not only to enable the evaluation of CP practices for processes and products, but also to enable a more complete understanding of corporate environmental performance from the point of view of the biosphere. In the conclusions, initiatives and the remaining challenges on the shift from sustainability measuring and planning to enhanced system transformation towards a sustainable world are discussed.

## 2. The search for environmentally friendlier solutions

The adoption of environmentally beneficial technological solutions based upon scientific research is addressed in several papers in this section (See Table 1.) In order to achieve the desired improvements, basic academic research results are being increasingly integrated into real-world systems. These papers are based upon the experiences that have transformed basic concepts and findings into transformative new production processes at the industrial scale. CP practices such as dematerialization, materials replacement, materials reuse and process changes were proposed and evaluated. With the main scope of finding environmentally friendly solutions for specific problems, the authors used accounting methodologies to accurately document their results.

Research designed to improve the environmental performance of various systems by reducing the amount and/or toxicity of waste, wastewater and emissions are also included. An enzyme produced by a new strain of *Bacillus subtilis* for hide unhairing (Dettmer et al., 2013) designed to reduce the chemical oxygen demand, biological oxygen demand, total nitrogen, and sulfides in the residual wastewater of leather manufacturing. The enzymatic unhairing process reduced unhairing time by more than 50%, eliminated the need for deliming, which suggests that this solution can replace the traditional chemical processes. The analysis of the environmental performance of a new industrial cleaning process, compared to conventional cleaning using chemical detergents, documented that the new method results in dramatic reductions of greenhouse gas emissions (GHG) in the cleaning of printed circuit boards (Lindahl et al., 2013). The life cycle cost analysis of that new cleaning method documented that it is less expensive than the

**Table 1**
These are the articles in special volume with the main scope of proposing/experimenting with new technological approaches to achieve improved solutions.

| Article title | System | Specific scope | Methodology | Country |
|---|---|---|---|---|
| Environmentally friendly hide unhairing: enzymatic hide processing for the replacement of sodium sulfide and deliming | Tannery | Material replacement | Effluent/residues analysis | Brazil |
| Industrial cleaning with Qlean Water – A case study of printed circuit boards | Printed circuit boards manufacturing | Material reduction | LCA; Life Cycle Cost | Sweden |
| Process efficiency comparison of a sandwich-core saw blade and a conventional saw blade used in stone-machining. | Stone-machining | Process change/assessment | Energy consumption; noise reduction measurements | Turkey |
| Integration of eco-design tools into the development of eco-lighting products | Lighting products manufacturing | Material replacement | LCA | United Kingdom |
| System analysis of slag utilisation from vanadium recovery in an integrated steel plant | Steel production | Improved material efficiency | System analysis | Sweden |
| Storage of carbon dioxide in geological reservoirs: is it a cleaner technology? | Carbon capture and storage | Process assessment | Review | Brazil |
| Recycling of anaerobic digestates by composting: effect of the bulking agent used | Composting | Material replacement | Effluent/residues analysis | Spain |
| Home and vermicomposting as sustainable options for biowaste management | Composting | Material replacement | Effluent/residues analysis | Spain |
| Production and income of basil in and out of season with vermicomposts from rabbit manure and bovine ruminal contents alternatives to urea | Composting | Material replacement | Effluent/residues analysis | Argentina |
| Aspects for a cleaner production approach for coal and biomass use as a decentralized energy source in southern Brazil | Biomass/coal co-firing, | Process change/assessment | Economic evaluation | Brazil |
| Cleaner production: Levulinic acid from rice husks | Agro-industry | Waste reuse | Effluent/residues analysis | Brazil |

equivalent chemical-based cleaning. The authors highlighted that cleaning is a key part of the electronic industry and documented that the large-scale adoption of this cleaning method could result in significant positive environmental and economic benefits.

Technology changes were proposed by Yilmaz (2013) in order to reduce energy consumption and occupational noise levels during the production of eco-lighting products. With regard to energy consumption, the development of an eco-lightning product, based on eco-design tools and lifecycle design, was written by Su and Casamayor (2013). The comparison between a prototype and an existing LED lighting product of the same category showed that the new product performs the required functions with fewer environmental burdens in the impact categories of 'Resources' followed by 'Human Health', than the existing lighting products.

The paper with a case study, based on the process integration approach, documented the degree to which metallurgical slag can be used without compromising the quality of the resultant steel (Lundkvist, 2013). Several approaches were evaluated to improve the environmental sustainability in the production system by maximizing the material efficiency through vanadium recovery and by use of slag, thereby minimizing the stored/deposited slag quantities.

Câmara et al. (2013) documented the extent of the storage of carbon dioxide in geological reservoirs that can be considered a cleaner technology. The environmental technologies to store $CO_2$ were classified according to their scope as 'end-of-pipe,' technologies (used to store waste and mitigate emissions) and cleaner technologies, when $CO_2$ is captured from anthropogenic sources and used as a raw material for other processes.

Three articles addressed the usual fate of organic wastes and researched alternative technological solutions to utilize them. Composting of the solid portion of digestates was explored as a viable method to manage wastes and to obtain composts with potential agricultural use (Bustamante et al., 2013). This treatment reduced potential impacts when compared to agricultural application of untreated digestates. Depending on the selection of the co-composting agents, it was found to be possible to optimize the process, thereby improving the composition and quality of the final compost. Lleó et al. (2013) examined the viability of vermicomposting as an alternative for the industrial treatment of the organic fraction of municipal solid waste. High-grade quality compost was obtained from the organic fraction of municipal solid waste for both composting and vermicomposting alternatives. The use of vermicompost from rabbit manure was evaluated and compared with the use of bovine ruminal wastes and urea (Cabanillas et al., 2013). The authors documented that vermicompost from rabbit manure and bovine ruminal contents, derived of rural and agro-industrial refuse respectively, are viable and economically more beneficial than the production and usage of synthetic urea in the production of basil, in and out-of-season.

The use of agricultural wastes to generate energy and to produce chemicals was researched (Gomes et al., 2013). They found by technological evaluations of co-firing of biomass and coal, that the use of the southern Brazilian coal together with silvicultural wastes (with limestone added) reduced the production of solid wastes and decreased atmospheric emissions through the implementation of a decentralized energy generation system The results documented the feasibility and sustainability of increasing biomass usage. The researchers also found from combustion essays that the biomass can be used to support the implementation of a decentralized steam generation system based upon renewable sources produced in the region.

Bevilaqua et al. (2013) reported on research designed to use residual rice husks for the production of levulinic acid produced by pressurized hydrolysis. The production of this marketable chemical, starting from an agricultural waste, contributes to better handling of agro-industrial residues and produces additional economic returns to the local farmers.

Investments on CP approaches can enhance the environmental performance significantly, but implementation of CP programs *per se* does not guarantee the continuity in environmental improvements unless management systems are used to ensure that the CP activities are continuous and systematic on the journey toward SD.

## 3. Initiatives to improve environmental managing, auditing and monitoring within firms

Enterprises include several functions, such as production, marketing, sales, human resources, logistics, safety and environment, which interact with each other and with the environment. Practices such as rationalizing the usage of raw materials, water and energy, may impede the loss of valuable materials, reducing operational costs. In this context, papers are included that focused upon research to implement and monitor process changes and to internalize CP practices within companies and sectors (Table 2).

Nápoles et al. (2013) developed a mathematical programming model for sustainable water management. The distribution and storage of natural and alternative water sources complies with the demands of the different users while preserving water levels in the natural water bodies. The program, applied to the city of Morelia, Mexico, helped them to maximize the total profitably by implementing an optimized solution. A stepwise process applied to the selection of sustainable water management strategies for a mining complex in Brazil provided support for incorporating environmental risks into corporate decision-making (Freitas and Magrini, 2013).

To determine whether lean manufacturing and human resource management interfere in the greening of Brazilian automotive companies, Jabbour et al. (2013) built a conceptual framework to evaluate data gathered from 75 companies. The main results revealed that environmental management influences operational performance in a positive way, and that lean manufacturing has a greater influence on environmental management compared to the influence of human resource management. The systematic understanding of the relationships among different approaches and managerial practices confirmed the need of internalization of directives, policies and certificates. The relationship between lean manufacturing and environmental management was also examined by Aguado et al. (2013). The authors emphasized that these two concepts are not easy to implement simultaneously, and proposed a general approach, based on environmental innovation, to assist firms in combining efficiency and sustainability. Their case study documented how incomes, social responsibility and sustainability can be improved when environmental innovation is applied to transform the traditional production system into a lean system.

In regard to the effective integration of environmental issues by means of tools for improving information sharing and communication, Muñoz et al. (2013) developed an ontological framework to integrate data and information associated with environmental issues in the enterprise structure. The ontological model was applied in a case study to test an enterprise decision-making support tool for combining information systems, which adapts and recognizes the different elements associated with the enterprise functions, and facilitates the evaluation of the environmental performance of the enterprise. In this case study, the strategic decisions associated with impact minimization (human health, ecosystem, climate, resources categories) of transport among the enterprise's production facilities and distribution centers were computed and compared to the optimal solutions corresponding to the economic objectives.

**Table 2**
These are the articles in special volume with the main focus of proposing and experimenting with managerial assessment methods to implement, monitor, and internalize CP practices.

| Article | System | Specific scope | Methodology | Country |
|---|---|---|---|---|
| Sustainable water management for macroscopic systems | Water management | Process assessment | Mathematical programming | Mexico |
| Multi-criteria decision-making to support sustainable water management in a mining complex in Brazil | Mining industry | Process assessment | Analytical hierarchy process | Brazil |
| Environmental management and operational performance in automotive companies in Brazil: the role of human resource management and lean manufacturing | Automotive companies | Managerial assessment | Survey | Brazil |
| Model of efficient and sustainable improvements in a lean production system through processes of environmental innovation | Industry | Managerial assessment | Lean production | Spain |
| Considering environmental assessment in an ontological framework for the enterprise sustainability | Industry | Managerial assessment | Ontological framework | Spain |
| A review of environmental monitoring and auditing in the context of risk: unveiling the extent of a confused relationship | Industry | Managerial assessment | Review | Brazil |
| Quality tools applied to Cleaner Production Programs: a first approach towards a new methodology | Industry | Managerial assessment | Quality tools | Brazil |
| Application of multi-criteria decision analysis in design of Sustainable Environmental Management Systems | Energy drinks and diet bars | Managerial assessment | Multi criteria decision analysis | United States |
| Identification and conception of cleaner production opportunities with the Theory of Inventive Problem Solving | Milk production | Process change/assessment | Theory of inventive problem solving | Brazil |

Viegas et al. (2013) performed a detailed literature review to elucidate concepts and characteristics of environmental monitoring and auditing, although they are generally separated, are often misinterpreted and confused with each other. The authors used adaptive management principles for improving both environmental monitoring and auditing, especially for filling gaps between the operational and managerial aspects of organizations. They recommended that the adaptive management set of principles should ensure: flexibility, consideration of uncertainties, participatory overtures and continuous learning, can enhance the practical inter-connections among the diverse facets of their management system.

The use of well-known tools such as quality assurance tools to implement and maintain a CP program were used by Silva et al. (2013a-c). They concluded that these tools could enhance the success of a CP program by improving comprehensiveness of implementation. Khalili and Duecker (2013) developed an environmental management system, which integrated the traditional environmental management system platform with a multi-criteria decision-making model (ELECTRE III). The system was designed to support design and implementation of justifiable solutions to environmental problems faced by industries. A case study of the management of waste streams at a manufacturer of energy drinks and diet bars illustrated how the proposed system can be designed and implemented. The search for innovative solutions using the '*theory of inventive problem solving*,' (TRIS) to support the growing need for CP operations was tested in three milk producing companies in the Southern region of Brazil (Kubota and Rosa, 2013). Their study identified and tested opportunities for improvement within the dairy companies. For them TRIS proved to be a valuable and innovative tool to search for ways to improve environmental efficiency in their companies. The authors suggested that function analysis might become an alternative to mass balance, especially in companies that lack available data and information.

## 4. Initiatives to improve environmental managing, auditing and monitoring beyond the firm's borders

The relationships among companies, suppliers and consumers play important roles in the search for sustainable production models, which involve inter-company collaboration along the whole supply chain. Several articles in this section addressed the relationships among the companies and their stakeholders, the connections among managerial, auditing and monitoring tools, and the use of environmental certificates (Table 3).

According to Agenda 21, the action plan for sustainable development ratified at the 1992 Rio Earth Summit and reinforced during the agenda of the Rio+20 conference, a main cause of the extensive deterioration of the global environment is the unsustainable pattern of consumption and production. Therefore, the examination of ongoing practices, management approaches exercised by companies, and inherent barriers and opportunities may help researchers and company leaders to accelerate the changes from the present patterns to those that help to ensure not only the quality of life, but also to minimize the use of natural reserves to not jeopardize the opportunity for future generations to fulfill their

**Table 3**
These are the articles in this volume with the main scope of proposing/experimenting with sustainable consumption and/or production models to improve the relationships among companies, suppliers and consumers and to reduce the total environmental burdens.

| Article | System | Specific scope | Methodology | Country |
|---|---|---|---|---|
| Corporate sustainability in emerging markets: insights from the practices reported by the Brazilian retailers | Retail; emerging markets | Managerial assessment | Sustainability report | Brazil |
| Product-service systems: a literature review on integrated products and services | Product-service system | Material reduction | Review | Brazil |
| Diversity, scale and sustainability in human systems: towards a research agenda | Small scale industry | Production/consumption patterns | Analysis | United Kingdom |
| Can collaboration between firms and stakeholders stimulate sustainable consumption? Discussing roles in the brazilian electricity sector | Electricity sector | Production/consumption patterns | Survey | Brazil |
| The effect of pressure from secondary stakeholders on the internalization of ISO 14001 | Stakeholders/ certificates | Managerial assessment | Survey | New Zealand |
| Integrated environmental permit through Best Available Techniques: evaluation of the fish and seafood canning industry | Fish and seafood canning industry | Managerial assessment | Best Available Techniques | Spain |
| Assessment of the public administration tools for the improvement of the eco-efficiency of small and medium sized enterprises | Small and medium enterprizes | Managerial assessment | Survey | Venezuela |
| How can the sales of green products in the Brazilian business-to-business market be increased? | Green products | Managerial assessment | Survey | Brazil |
| An interpretive structural modeling approach for the barrier analysis in implementing green supply chain management | Suppliers | Managerial assessment | Interpretive structural modeling | Denmark |
| Measuring environmental management disclosure in industries in Brazil with item response theory | Industry | Managerial assessment | Item response theory | Brazil |
| Flexibility in reverse logistics: a framework and evaluation approach | Reverse supply chain | Managerial assessment | Review | United Kingdom |
| Overview of coordination contracts within forward and reverse supply chains | Supply Chain | Managerial assessment | Review | Denmark |
| Barriers to green supply chain management in Indian mining industries: a graph theoretic approach | Mining industry | Managerial assessment | Survey | Denmark |
| A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach | Supply Chain | Managerial assessment | EMS; fuzzy logic | Denmark |
| Integrated fuzzy multi criteria decision making method and multi objective programming approach for supplier selection and order allocation in a green supply chain | Supply chain | Managerial assessment | Fuzzy logic | Denmark |

needs (Delai and Takahashi, 2013). One of the propositions to readjust current consumption patterns is the concept of product-service system (PSS), which serves as a competitive option for many companies, which seek to reduce consumption by modifying the way their products and services are designed, marketed and used. Products and services are integrated and provided simultaneously to a user over a time span. A literature review on the product-service system, including 149 papers published from 2006 to 2010 (Beuren et al., 2013), provided details on the concept and its practical applications. Since consumers are inexperienced in using products without owning them, and providers are inexperienced in offering integrated product-service sets, knowledge and experience regarding the PSS business models are needed. However, diverse business models premised on a small scale and PSS were proposed as ways to break the dependence upon over-production (Wells, 2013). Despite the commonly held assumption that large and centralized manufacturing plants are more resource efficient than small ones, the author found that continuous expansion of the market volume may undermine efficiency gains. The author examined the relationships among diversity, location, scale and sustainability in anthropogenic systems with the use of examples from brewing, steel production, and printing at conditions in which he found that smaller scale can yield sustainability advantages.

The role of stakeholders is considered to be crucial to change consumption and production patterns both positively and negatively. A positive example was built upon collaboration among stakeholders in the Brazilian electricity sector. Results regarding social interactions among different social actors made it clear that actions taken by the Brazilian Electricity company, involving a large number of stakeholders, reduced electricity consumption in the Northeastern region (Silva et al., 2013a-c). However, there were also examples showing that the influence of stakeholders was limited. Illustrative of that was a study of 328 Australian and New Zealand firms that was designed to determine if independent third parties can act as a governance mechanism to stimulate their green practices (Castka and Prajogo, 2013). The authors provided findings that ISO 14001 certification of a firm was often accepted by secondary stakeholders as a satisfactory signal of the firms' environmental

efforts, but that the pressure from these stakeholders does not contribute to the firm's internalization of ISO 14001 into their daily practices. Consequently, firms select minimal or partial actions for compliance with the specifications of ISO 14001, by focusing on attaining the certification rather than on organizing and implementing a solid environmental management system.

In reviewing the internalization of the Integrated Pollution Prevention and Control Directive through the application of the Best Available Techniques (BAT) and their influence on the overall environmental performance of companies, Bugallo et al. (2013) investigated the degree of implementation of the Directive (updated in 2010 by Directive, 2010/75/EU) in the fish and seafood canning industry of Galicia, Spain. The results revealed that the degree of implementation of BAT in these plants was unsatisfactory, especially regarding the lack of implementation of procedures for improved process management.

Assuming that the public environmental administration is a key stakeholder, Fernández-Viñé et al. (2013) surveyed the potential use of legislation, taxes, price policies, green procurement, ecological education and eco-innovation support to stimulate small and medium-sized enterprises to improve their production models. Despite the fact that public administration has few effectual mechanisms for monitoring environmental legislation compliance in Venezuela, the tools selected, based upon the difficulties and to the time needed for implementation, are taxes and subsidies, followed by advertising for responsible consumption. The same inference was drawn from research concerning the sales of "green products" in Brazil (Tomasin et al., 2013). A green marketing strategy was proposed, based upon the profitability and losses analysis of distributors. The authors found that green product suppliers can create value for their distributors by procuring products with highest technical specifications, but to assure sales, distributors must explore these technical specifications along with financial and advertisement support provided by the supplier.

The barriers to the implementation of green supply chain management (GSCM) in small and medium enterprises in the Indian auto component manufacturing sector were analyzed (Kannan et al., 2013a) with the use of interpretive structural modeling (ISM). The method interpreted the mutual influences amongst twenty-six barriers identified from the literature, interviews with department managers and a survey amongst manufacturers. The authors found that different auto component manufacturing industries have differing barriers for the implementation of GSCM, especially for maintaining the environmental awareness, the supplier barrier is the dominant one.

The criteria for supplier evaluation, based on the triple bottom line concepts, were illustrated by a numerical example done by Trierweiller et al. (2013). They used the item response theory (IRT) to measure environmental management disclosure. A set of twenty-six items, agreed upon by environmental experts and based upon data from 638 Brazilian companies in ten sectors, was developed to produce a measurement scale for environmental management disclosure. When the production sectors were compared, it was found that the agricultural production sector had the worst results, while the mining and paper sectors had the best performance. The advantage of using IRT is that the scale created can be interpreted by cataloguing and connecting groups of concepts that dominate the company's performance facilitating the identification of opportunities for improvement.

An effective way to manage uncertainty and variance in operational and organizational systems is by introducing greater flexibility. Bai and Sarkis (2013) examined flexibility in reverse logistics. A reverse logistics flexibility framework separated into operational and strategic flexibilities was used through a performance evaluation by a third party, reverse logistics, provider's model. Using illustrative data, sensitivity results helped the researchers to evaluate the technique's robustness with various reverse logistics performance factors. Kannan et al. (2013) explored contracts as mechanisms to coordinate forward and reverse supply chain structures, and showed that inspite of the rapid extension of different forward supply chains with increasing focus on recycling and reverse logistics, this field of research continues to remain far behind the progress made by industry. These authors observed that the analysis of contract implementation among supply chain members must improve both in theory and practice, with specific attention to be allocated to the fields covered by contracting literature on reverse supply chain versus the fields covered by forward supply chains.

Increasing numbers of Industries are implementing environmental management systems to acquire an improved social image, as well as to comply with governmental regulations. To obtain an improved social image, mining industries are increasingly implementing CP practices, and adopting green supply chain management practices. The possibility of working with the environmental and image criteria to represent complex interactions between business and environmental risks simplified the analysis when compared with approaches based exclusively on economic valuation. Kannan et al. (2013b) presented a graph and matrix approach to identify the barriers to green supply chain management implementation, by focusing on a reduction of the adverse impacts of supply chain activities as well as a minimization of energy and material usage within the Indian mining industry. The authors reported that different manufacturing industries have different barriers for the adoption of green supply chain management, but the supplier barrier is the dominant one.

Asserting that companies can identify and prioritize opportunities for improvement of their sustainability performance is based on implementation of sustainable supplier evaluation, multi criteria decision methods based on fuzzy logic were proposed (Kannan et al., 2013b,c; Maridoss et al., 2013). The methods were designed to reduce the environmentally and socially negative impacts of companies' activities by decreasing the subjectivity of decision-makers' preferences. The criteria for supplier evaluation based on the triple bottom line concepts were illustrated by a numerical example. The objective of the mathematical model was maximizing the total value of purchasing and minimizing its total cost simultaneously. The efficiency and application of proposed approach was illustrated with a case study in an automobile manufacturing company. The obtained results may help firms establish a systematic approach for tackling green supplier selection and order allocation problem in realistic situation.

## 5. The search for assessment methodologies and indicators for supporting decision-making

The adoption of environmentally friendlier solutions and the implementation of proper managerial techniques may or may not benefit the global environment. A way to assess the real environmental costs and benefits of any practice is the proper use of quantitative assessment methodologies in supporting decision-making. Measuring CP results quantitatively is of critical importance. The search for appropriate methods and indicators, which address both productivity and environmental aspects of a system, is still a challenge. The methods must be designed to enable not only evaluation of the suitable CP practices for a product or process and its comparison with other equivalents, but also the quantitative measurement of improvements of the existing process or product, for facilitating the development of new products. Moreover, measuring methods can help to obtain knowledge about the environmental performance of the system on the biospheric scale by evaluating

downstream and upstream impacts. In this way, changes within the companies, such as the substitution of an input or a process, may be monitored in a quantitative and holistic way. In this regard, several researchers proposed and experimented with accounting methodologies designed to enhance the understanding of the systems and to evaluate the CP strategies applied to improve their environmental performance. Multiple systems were assessed with the use of single and multiple methods, some of which also used multi-criteria approaches (Table 4).

Life cycle assessment (LCA) is widely used to assess one or several impact categories in diverse systems. CP strategies were applied to improve the environmental performance of an earthwork project needed to expand the Oil Refinery Camilo Cienfuegos, Cuba (Cabello et al., 2013). The LCA of construction activities identified the main environmental impacts to be: energy consumption, global warming and human toxicity. Based on the hierarchy of waste management, it was possible to reduce the amount of soil used by the earthwork project, and to reduce diesel consumption and greenhouse gas emissions by about 41%.

LCA analysis was also employed to evaluate a reverse logistics model for returnable packaging, developed by Silva et al. (2013a–c). The returnable packaging model reduced costs and the use of materials by 18%. The model was compared with the conventional disposable model; the results showed that reverse logistics lowers environmental impacts concerning global warming potential, abiotic depletion potential, acidification potential, and photochemical ozone creation potential.

One of the main driving forces promoting the use of sustainable energy sources is the increasing level of GHG. Hence, the carbon footprint method is being broadly used. An LCA of a second-generation bioethanol production chain is included within the GHG balance of the Province of Siena to assess the effect of the use of 10% bioethanol in the transport sector by 2020 (Patrizi et al., 2013). The results showed that the province produces enough straw to support the bioethanol production chain and that the use of this bioethanol in Siena's transport sector could result in a 6% reduction of the net $CO_{2eq}$ emissions.

Güereca et al. (2013) presented the GHG emission inventory of the Institute of Engineering at Universidad Nacional Autónoma de México based on the academic and research activities developed in 2010, where 42% of the GHG emissions were generated by the use of electricity and 50% by transportation. Four scenarios for potential reduction were developed. The most efficient measure for reducing GHG was to change commuting patterns by practicing remote working and private car sharing.

Figueirêdo et al. (2013) assessed the carbon footprint of Brazilian yellow melon production to evaluate reduction potentials and improvement options, providing melon producers with an insight into the carbon emissions of their product, and options to reduce them. The results revealed that the total yellow melon carbon footprint can be reduced by 44 percent if melon fields are located in pre-existing agricultural areas, and no plastic field trays are used in melon production. The GHG emissions from melon transport are relatively unimportant in the total footprint.

Combined and extended methodologies were explored with the objective of filling gaps of one or another analytical method. A systematic, economic input–output LCA regarding carbon emission reduction potential was conducted for a typical household biogas system (Zhang et al., 2013). The balance of $CO_2$ emissions, associated with the construction, operation, and demolition and the benefits due to energy and fertilizer substitution were considered to be essential for the management

**Table 4**
These are the articles in this volume with the main objective of proposing and experimenting with methodologies and indicators for supporting decision-making.

| Article | System | Specific scope | Methodology | Country |
|---|---|---|---|---|
| Improving the environmental performance of an earthwork project using cleaner production strategies | Earthwork project | Process assessment | LCA | Cuba |
| Comparison of disposable and returnable packaging: a Case study of reverse logistics in Brazil | Returnable packaging | Process assessment | Reverse logistics; LCA | Brazil |
| Environmental feasibility of partial substitution of gasoline with ethanol in the province of Siena | Transport sector | Process change/assessment | Greenhouse Gas emissions; LCA | Italy |
| Carbon footprint as a basis for a cleaner research institute in Mexico | University | Process assessment | Carbon Footprint | Mexico |
| The carbon footprint of exported brazilian yellow melon | Agro industry | Process assessment | LCA; Carbon Footprint | Brazil |
| Carbon emission reduction potential of a typical household biogas system in rural China | Household biogas system | Energy reduction | Greenhouse Gas emissions; Hybrid LCA | China |
| Extended exergy analysis of the Turkish transportation sector | Transport sector | Resource consumption | Extended exergy; | Turkey |
| On the exergetic capacity factor of a wind – solar power generation system | Wind – Solar Systems | Energy reduction | Exergetic Efficiency | Denmark |
| Carbon footprint and emergy combination for eco-environmental assessment of cleaner heat production | Natural gas; biomass | Process change/assessment | Emergy; carbon footprint | France |
| Assessing the replacement of lead in solders: effects on resource use and human health | Solder manufacturing | Material replacement | Emergy; LCA; DALY | Brazil |
| Can we use the energy intensity indicator to study "decoupling" in modern economies? | Countries | Indicator assessment | Statistical correlation | Italy |
| Energetic-environmental assessment of a scenario for Brazilian cellulosic ethanol | Biorefinery | Process change/assessment | Multi-criteria analysis | Brazil |
| Choosing cleaner and safer production practices through a multi-criteria approach | Metal finishing | Managerial assessment | Multi-criteria analysis | France |

and efficient use of a biogas project. This research showed the extent to which biogas produced is not a totally a fossil carbon-free fuel and that the reduction potential in the long-term is less than expected.

The Turkish transportation sector was evaluated by extended exergy accounting (EEA) method (Seckin et al., 2013). The authors pointed to the urgency of a new transportation policy that may be used to change the current unsustainable pattern of the sector in the future. Exergy analysis was also used in the evaluation of the efficiency of a wind-solar power generation system (Xydis, 2013). Exergetic efficiency power density maps were developed to provide a basis for project developers to make better decisions.

A combination of carbon footprint and emergy synthesis was used to evaluate the replacement of fossil fuel by biomass in a central wood-fired heating plant in Nantes, France (Jamali-Zghal et al., 2013). The authors defined a maximum supply distance, beyond which biomass transportation becomes environmentally more intensive when compared to a fossil fuel fired heating system. The combination of carbon footprint and emergy evaluation allowed the researchers to establish the minimum theoretical wood burner efficiency concerning $CO_2$ reduction and the resources to be saved. Noticing that human health and environmental concerns are not usually considered at the same time, Almeida et al. (2013) used a combination of emergy synthesis with the DALY indicator (Disability Adjusted Life Years) to assess the impact of manufacturing of soft solders on the environment and on the human health on-site and on the whole life cycle. The results revealed that the total replacement of tin-lead solders may lead to an increase in resource use and to an increase of hazardous emissions during the extraction/processing stage. A discussion on how the decision-making process for materials substitution can be influenced by the choice of the system's boundaries was presented.

The usefulness of the economic performance indicators, often applied to sustainability analysis was challenged by looking at the Economic Energy Intensity of 133 countries over the period 1960–2009 (Fiorito, 2013). The analysis revealed that the problems with this indicator were generated by the attempt to compress into a single number, different pieces of information, that refer to different dimensions (monetary and energy flows) and to different scales.

Agostinho and Ortega (2013) compared the sustainability of conventional ethanol plants with biorefineries using a multi-criteria approach. They combined the results obtained from embodied energy analyses, ecological rucksack studies, emergy accounting and gas emission inventories. The final indicators showed that the biorefinery scenario has a better performance than conventional ethanol plants for some aspects but worse for others. This is because a system with better performance for all indicators is rare, but also because indicators are constructed with emphasis on some variables that were selected and classified according to pre-established goals (to assess the resource use, emissions, yield, etc). The authors reported that, at large-scale, the ethanol produced by both plants cannot be considered as a renewable energy source since they depend on large amounts of water, soil, fossil fuels, minerals, and other resources. Claiming that the existent methods LCA or carbon balance methodologies lack the technical, economical and social criteria, Laforest et al. (2013) proposed a decision-making tool based on a multi-criteria analysis approach to encourage manufacturers to implement cleaner and safer production practices in the metal finishing sector. A systemic analysis of an industrial facility and its environmental performance was used to identify fifteen criteria that were structured in hierarchical targets pertaining to: water, soil, air, the workstation of the operators, the production processes, etc. This tool enabled the company leaders to choose the practices, which were most appropriate for particular company not only on financial criteria, but also from social, environmental and technical perspectives.

## 6. Concluding remarks

The content of this special volume underscores the urgent need for transformation of the current production models, methods and values. This volume is divided into four sections, which addressed: the search for environmentally friendlier solutions; initiatives to improve environmental managing, auditing and monitoring; and the search for and testing of assessment accounting methodologies for supporting decision-making. The articles, without providing a unique or unequivocal solution, elucidated issues of sustainability being explored and experimented with in different ways within different contexts. There was a consistent search for transformation, experimentation and reflexive learning because of the dynamic conditions. The articles contained in Section 2 made it clear that the search for environmentally friendlier solutions with the development of CP alternatives includes:

- Rationalizing the use of raw materials, water and energy inputs
- Reducing the loss of valuable and or scarce materials and operational costs
- Reducing the volume and/or toxicity of waste, wastewater and emissions related to production
- Reusing and/or recycling the maximum of primary inputs and packaging materials
- Improving environmental performance by the implementation of environmental management systems.

### *6.1. All of these approaches are vital to build the foundation for new, more sustainable production models*

The articles in Section 3, are comprised of initiatives designed to improve environmental managing, auditing and monitoring', and to suggest that initiatives within companies can certainly improve the companies' individual environmental performance, especially with the aid of monitoring and management tools. The articles in Section 4, addressed initiatives that extended the range in organizing the performance of supply chains, either by controlling suppliers and consumers, or by developing cleaner technologies to deal with waste and emissions, despite being accompanied by greater difficulty of implementation and operation, were devoted to promote environmental gains at a larger scale.

Finally, in Section 5, initiatives for developing and experimenting with quantitative methods for combining the anthropogenic/biosphere activities to support decision-making were included. Methodologies such as LCA, emergy and exergy accounting, carbon balance, and multi-criteria analysis were selected and applied by means of case studies in order to supply managers and decision-makers with quantitative tools to monitor and assess functions, which interact with each other inside and outside companies.

This special volume brought together four types of initiatives for controlling and improving operational performance in anthropogenic systems in order to prevent or to reduce environmental damages and the challenges to integrate and internalize these initiatives into daily activities. The complexity of the problems to be faced the next years becomes clear throughout the articles dealing with different systems from numerous points of view. A sustainable world requires such diverse sets of insights, theories,

methodological tools and appropriate procedures to be developed, tested and extensively applied, if we are to progress towards sustainable societal patterns.

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## References

Agostinho, F., Ortega, E., 2013. Energetic-environmental Assessment of a Scenario for Brazilian Cellulosic Ethanol. Journal of Cleaner Production 47, 474–489.

Aguado, S., Alvarez, R., Domingo, R., 2013. Model of Efficient and Sustainable Improvements in a Lean Production System through Processes of Environmental Innovation. Journal of Cleaner Production 47, 141–148.

Almeida, C.M.V.B., Madureira, M.A., Bonilla, S.H., Giannetti, B.F., 2013. Assessing the Replacement of Lead in Solders: Effects on Resource Use and Human Health. Journal of Cleaner Production 47, 457–464.

Bai, C., Sarkis, J., 2013. Flexibility in Reverse Logistics: A Framework and Evaluation Approach. Journal of Cleaner Production 47, 306–318.

Beuren, F.H., Ferreira, M.G., Miguel, P.A.C., 2013. Product-service Systems: A Literature Review on Integrated Products and Services. Journal of Cleaner Production 47, 222–231.

Bevilaqua, D.B., Rambo, M.D., Rizzetti, T.M., Cardoso, A.L., Martins, A.F., 2013. Cleaner Production: Levulinic Acid from Rice Husks. Journal of Cleaner Production 47, 96–101.

Bonilla, S.H., Almeida, C.M.V.B., Giannetti, B.F., Huisingh, D., 2013. Key elements, stages and tools for a sustainable world: an introduction to this special volume. Journal of Cleaner Production 47, 1–10.

Bonilla, S.H., Almeida, Cecília M.V.B., Giannetti, B.F., Huisingh, D., 2010. The roles of cleaner production in the sustainable development of modern societies: an introduction to this special issue. Journal of Cleaner Production 18 (1), 1–5.

Bugallo, P.M.B., Andrade, L.C., López, R.T., Iglesias, A.M., 2013. Integrated Environmental Permit through Best Available Techniques: Evaluation of the Fish and Seafood Canning Industry. Journal of Cleaner Production 47, 253–264.

Bustamante, M.A., Restrepo, A.P., Alburquerque, J.A., Pérez Murcia, M.D., Paredes, C., Moral, R., Bernal, M.P., 2013. Recycling of Anaerobic Digestates by Composting: Effect of the Bulking Agent Used. Journal of Cleaner Production 47, 61–69.

Cabanillas, C., Stobbia, D., Ledesma, A., 2013. Production and Income of Basil in and Out of Season with Vermicomposts from Rabbit Manure and Bovine Ruminal Contents Alternatives to Urea. Journal of Cleaner Production 47, 77–84.

Cabello, J.J., Sagastume, A., Hernández, D., Hens, L., Vandecasteele, C. Improving the Environmental Performance of an Earthwork Project Using Cleaner Production Strategies. Journal of Cleaner Production 47, 368–376.

Câmara, G.A.B., Andrade, J.C., Júnior, A.S., Rocha, P.S., 2013. Storage of Carbon Dioxide in Geological Reservoirs: Is It a Cleaner Technology? Journal of Cleaner Production 47, 52–60.

Castka, P., Prajogo, D., 2013. The Effect of Pressure from Secondary Stakeholders on the Internalization of ISO 14001. Journal of Cleaner Production 47, 245–252.

Delai, I., Takahashi, S., 2013. Corporate Sustainability in Emerging Markets: Insights from the Practices Reported by the Brazilian Retailers. Journal of Cleaner Production 47, 211–221.

Dettmer, A., Cavalli, E., Gutterres, M., Ayub, M.A.Z., 2013. Environmentally Friendly Hide Unhairing: Enzymatic Hide Processing for the Replacement of Sodium Sulfide and Deliming. Journal of Cleaner Production 47, 11–18.

Fernández-Viñé, M.B., Gómez-Navarro, T., Capuz-Rizo, S.F., 2013. Assessment of the Public Administration Tools for the Improvement of the Eco-efficiency of Small and Medium Sized Enterprises. Journal of Cleaner Production 47, 265–273.

Figueirêdo, M.C.B., Kroeze, C., Potting, J., Barros, V.S., Aragão, F.A.S., Gondim, R.S., Santos, T.L., de Boer, I.J., 2013. The Carbon Footprint of Exported Brazilian Yellow Melon. Journal of Cleaner Production 47, 404–414.

Fiorito, G., 2013. Can We Use the Energy Intensity Indicator to Study "decoupling" in Modern Economies? Journal of Cleaner Production 47, 465–473.

Freitas, A.H., Magrini, A., 2013. Multi-criteria Decision-making to Support Sustainable Water Management in a Mining Complex in Brazil. Journal of Cleaner Production 47, 118–128.

Gomes, G.M.F., Vilela, A.C., Zen, L.D., Osório, E., 2013. Aspects for a Cleaner Production Approach for Coal and Biomass Use as a Decentralized Energy Source in Southern Brazil. Journal of Cleaner Production 47, 85–95.

Güereca, L.P., Torres, N., Noyola, A., 2013. Carbon Footprint as a Basis for a Cleaner Research Institute in Mexico. Journal of Cleaner Production 47, 396–403.

Jabbour, C.J.C., Jabbour, A.B.L.S., Govindan, K., Freitas, W.R.S., Teixeira, A.A., 2013. Environmental Management and Operational Performance in Automotive Companies in Brazil: The Role of Human Resource Management and Lean Manufacturing. Journal of Cleaner Production 47, 129–140.

Jamali-Zghal, N., Amponsah, N., Lacarrière, B., Le Corre, O., Feidt, M., 2013. Carbon Footprint and Emergy Combination for Eco-Environmental Assessment of Cleaner Heat Production. Journal of Cleaner Production 47, 446–456.

Kannan, G., Nicoleta, M., Devika, M., 2013. Overview of Coordination Contracts within Forward and Reverse Supply Chains. Journal of Cleaner Production 47, 319–334.

Kannan, G., Kaliyan, M., NoorulHaq, A., Yong, G., 2013a. An ISM Approach for the Barrier Analysis in Implementing Green Supply Chain Management. Journal of Cleaner Production 47, 283–297.

Kannan, G., Barve, A., Muduli, K., Yong, G., 2013b. Barriers to Green Supply Chain Management in Indian Mining Industries: A Graph Theoretic Approach. Journal of Cleaner Production 47, 335–344.

Kannan, G., Khodaverdi, R., Jafarian, A., 2013c. A Fuzzy Multi Criteria Approach for Measuring Sustainability Performance of a Supplier Based on Triple Bottom Line Approach. Journal of Cleaner Production 47, 345–354.

Khalili, N.R., Duecker, S., 2013. Application of Multi-criteria Decision Analysis in Design of Sustainable Environmental Management Systems. Journal of Cleaner Production 47, 188–198.

Kubota, F.I., Rosa, L.C., 2013. Identification and Conception of Cleaner Production Opportunities with the Theory of Inventive Problem Solving. Journal of Cleaner Production 47, 199–210.

Laforest, V., Raymond, G., Piatyszek, E., 2013. Choosing Cleaner and Safer Production Practices Through a Multi-criteria Approach. Journal of Cleaner Production 47, 490–503.

Lindahl, M., Svensson, N., Svensson, B.H., Sundin, E., 2013. Industrial Cleaning with Qlean Water e A Case Study of Printed Circuit Boards. Journal of Cleaner Production 47, 19–25.

Lleó, T., Albacete, E., Barrena, R., Font, X., Artola, A., Sánchez, A., 2013. Home and Vermicomposting as Sustainable Options for Biowaste Management. Journal of Cleaner Production 47, 70–76.

Lundkvist, K., 2013. System Analysis of Slag Utilisation from Vanadium Recovery in an Integrated Steel Plant. Journal of Cleaner Production 47, 43–51.

Maridoss, D., Khodaverdic, R., Olfat, L., Jafarian, A., Kannan, G., 2013. Integrated Fuzzy Multi Criteria Decision Making Method and Multi Objective Programming Approach for Supplier Selection and Order Allocation in a Green Supply Chain. Journal of Cleaner Production 47, 355–367.

Muñoz, E., Capón-García, E., Laínez, J.M., Espuña, A., Puigjaner, L., 2013. Considering Environmental Assessment in an Ontological Framework for the Enterprise Sustainability. Journal of Cleaner Production 47, 149–164.

Nápoles, F., Serna-González, M., El-Halwagi, M.M., Ponce-Ortega, J.M., 2013. Sustainable Water Management for Macroscopic Systems. Journal of Cleaner Production 47, 102–117.

Patrizi, N., Caro, D., Pulselli, F.M., Bjerre, B., Bastianoni, S., 2013. Environmental Feasibility of Partial Substitution of Gasoline with Ethanol in the Province of Siena (Italy). Journal of Cleaner Production 47, 388–395.

Seckin, C., Sciubba, E., Bayulken, A.R., 2013. Extended Exergy Analysis of Turkish Transportation Sector. Journal of Cleaner Production 47, 422–436.

Silva, D.A.L., Renó, G.W.S., Sevegnani, G., Sevegnani, T.B., Truzzi, O.M.S., 2013a. Comparison of Disposable and Returnable Packaging: A Case Study of Reverse Logistics in Brazil. Journal of Cleaner Production 47, 377–387.

Silva, D.A., Delai, I., Castro, M.A., Ometto, A.R., 2013b. Quality Tools Applied to Cleaner Production Programs: A First Approach Towards a New Methodology. Journal of Cleaner Production 47, 174–187.

Silva, M.E., Oliveira, A.P.G., Gómez, C.P., 2013c. Can Collaboration between Firms and Stakeholders Stimulate Sustainable Consumption? Discussing Roles in the Brazilian Electricity Sector. Journal of Cleaner Production 47, 236–244.

Su, D., Casamayor, J.L., 2013a. Integration of Eco-design Tools into the Development of Ecolighting Products. Journal of Cleaner Production 47, 32–42.

Tomasin, L., Pereira, G.M., Borchardt, M., Sellitto, M., 2013a. How Canthe Sales of Green Products in the Brazilian Business-to-business Market Be Increased? Journal of Cleaner Production 47, 274–282.

Trierweiller, A.C., Peixe, B.C.S., Tezza, R., Bornia, A.C., Campos, J.M.S., 2013. Measuring Environmental Management Disclosure in Industries in Brazil with Item Response Theory. Journal of Cleaner Production 47, 298–305.

Viegas, C.V., Bond, A.J., Ribeiro, J.L.D., Selig, P.M., 2013. A Review of Environmental Monitoring and Auditing in the Context of Risk: Unveiling the Extent of a Confused Relationship. Journal of Cleaner Production 47, 165–173.

Wells, P., 2013. Diversity, Scale and Sustainability in Human Systems: Towards a Research Agenda. Journal of Cleaner Production 47, 232–235.

Xydis, G., 2013. On the Exergetic Capacity Factor of a Wind e Solar Power Generation System. Journal of Cleaner Production 47, 437–445.

Yilmaz, N.G., 2013. Process Efficiency Comparison of a Sandwich-core Saw Blade and a Conventional Saw Blade Used in Stone-machining. Journal of Cleaner Production 47, 26–31.
Zhang, L., Wang, C.B., Song, B., 2013. Carbon Emission Reduction Potential of a Typical Household Biogas System in Rural China. Journal of Cleaner Production 47, 415–421.

C.M.V.B. Almeida*, S.H. Bonilla, B.F. Giannetti
*LaProMa, Laboratório de Produção e Meio Ambiente, Programa de Pós-Graduação em Engenharia de Produção, Universidade Paulista, São Paulo, Brazil*

D. Huisingh
*Institute for a Secure and Sustainable Environment University of Tennessee, Knoxville, TN, USA*
*E-mail address:* donaldhuisingh@comcast.net

* Corresponding author.
*E-mail addresses:* cmvbag@unip.br (C.M.V.B. Almeida); bonilla@unip.br (S.H. Bonilla); biafgian@unip.br (B.F. Giannetti)

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