University-Industry Interaction on Cleaner Production. The Case of the Cleaner Production Center at the University of Cienfuegos (Cuba)

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Abstract

Universities are key stakeholders in teaching, researching and supporting the implementation of cleaner production activities. This case study discusses the experience of establishing and operating the Cleaner Production Center at the University of Cienfuegos (Cuba).

Establishing, starting-up and running the center during its first four years of activity was supported by two projects targeted to inter-university cooperation. The collaboration allowed to establish a master program on cleaner production which acts as a bridge between the university, and the production industry and the services sector in the province of Cienfuegos. Currently 32 students from the first two promotions graduated and the program of two other promotions is ongoing. The master thesis research works are defined improving the environmental performance of the companies or organizations the student originate from. This results in a measurable improvement of the air and surface water quality in Cienfuegos city. An estimated yearly reduction of the emission of 60 000 ton of carbon dioxide equivalents and of 400 MWh at a cement plant have been realized.

Research activities currently target the pollution inventory of Cienfuegos, energy production from local biomass, and establishing indicators for sustainable development for Cienfuegos. The inter-university collaboration resulted in several publications in international peer reviewed journals.

The successful inter-university North-South collaboration between Cuba and Belgium, targeted at capacity building, transfer of experience and expertise, proved to be most crucial during these first years the center was active. It allowed generating the necessary funds which are often difficult to raise in developing countries. Therefore this is a unique case of building academic experience on Cleaner Production.

Keywords: *cleaner production center, inter-university cooperation, master training, research*

1. Introduction

Universities should use their mission on training, research, and service to society, to strengthen cleaner production (CP) in a sustainable development context. They should deepen the long-term goals of a production that does not use more bio-resources and energy than nature produces, and limit pollution in such a way the environment and human health are not harmed, while the quality of life gradually improves. This should be realized while improving economic (growth, profitability) and social (green jobs, respect for human rights, reducing poverty) competition and environmental performance.

Cleaner production should be addressed both in the production and in the service sector. Industry and agriculture, but also tourism, education, medical care, and administration – to list just these examples – use energy, water, and other environmental resources, and produce pollution. On these aspects CP offers a vision, strategies, and methods. Next to technical interventions, both specific prevention (environmental impact assessment, sustainability assessment, life cycle analysis) and organization management approaches (environmental management systems, green procurement) have been developed. They all necessitate an integrated, comprehensive, multi- and trans disciplinary approach to the complex interface of problems between organizations and their economic, social, and environmental responsibilities (Nath et all., 199?).

The role of universities on CP is particularly important in developing economies and countries with economies in transition. Universities in developing countries should not only produce knowledge by targeted research, they are equally pivotal in increasing environmental awareness and literacy, not only among their students and staff, but also for a much wider audience of stakeholders (Leal Filho W, Manolas E., 2015). Universities should also interpret universal scientific knowledge in the specific (cultural) context of their region, country, province, or city. Universities in developing countries experience here limitations which are related to:

- An academic staff participating less in international networking through conference attendance and publications in international journals. This results in a deficiency in environmental awareness and culture, and points to the need of professional training, equipping the research environment, and integrating staff in the dynamics of international networking among scientists.
- Tensions between academic education and users (industry, agriculture, services) needs.
- Limited resources.
- Experiential learning and multidisciplinary teams. Links with corporate social responsibility (CSR).

This paper aims at reviewing the experience with implementing a university program and project at the University of Cienfuegos (Cuba). After describing the complex context of implementing CP initiatives today in Cuba, the paper focusses on three core aspects: establishing and managing a master degree program, initiating research on CP, and the pivotal role of a center for cleaner production. For each of these aspects the contribution of international inter-university collaboration is addressed.

2. Context

The context in which university programs on CP develop entails international, national, and local aspects. This section analyzes elements describing this multilevel context.

2.1 International

The content of CP and in particular its sustainable development aspects, is driven by the international discourse as initiated by the Brundtland report (WCED, 1987) and further elaborated during the UN conferences in Rio de Janeiro (UN, 1992), Johannesburg (UN, 2002), and again Rio de Janeiro (Dodds and Strauss, 2012). This general context is completed by the related discussions on climate changes and energy transition, biodiversity, and the international implementation of sustainable development initiatives. These discussions allowed defining and analyzing the CP-sustainable development nexus in terms of targets, principles, characteristics, issues, and instruments. Among others, the notion that CP not only contributes to environmental quality, but also to improved financial and managerial benefits and competition, stems from sustainable development. To this discussion programs on CP own their focus on sustainable development, its technical, environmental, and managerial aspects, but also the relation with (green and blue) economy, the policy and legal aspects, and their stakeholder involvement.

The international context on CP is further followed up by initiatives of UNIDO and UNEP, launching programs of which CP is part. Following up Agenda 21, specific CP programs were launched, while later on CP was situated in the wider sustainable production and consumption framework.

The international context is currently important defining the CP-sustainable development interface in the energy transition and the post-carbon era, the spread of hazardous chemicals in the environment (in particular on their relation with welfare diseases, emerging health problems as endocrine disruption, and the environment-human health link), and more efficient actions on biodiversity with a particular focus on sustainable forestry, agro- and aquaculture).

2.2 Cuba

Environmental protection is explicitly addressed by the Cuban constitution which mentions in its article 27 the fundamental principle of the "protection of the environment and the natural resources towards sustainability, ensuring human survival, the well-being and safety of the current and the future generations". The "environmental law" of 1997 points to the responsibility of both the Cuban authorities and the citizens on using natural resources in a rational way, preventing negative impacts on the environment. The legally defined context is implemented by the Ministry of the Environment and its provincial departments.

Since 2000 the country established a national strategy on cleaner production. By 2001 Cuba established the "National network on cleaner production in Cuba". This project was mediated by UNIDO (the United Nations Industrial Development Organization). The project involved both industry (food, sugar) and agriculture (sugar cane). The Cuban environmental agency and the Institute of Genetic Biotechnology (certification) participated in the project making part of five focal points. The project was concluded in 2009. Nevertheless UNIDO continued supporting selected CP projects, which initiated a period characterized by individual initiatives. Thereafter the international organizations situated Cp in a wider context. Since 2004 Cuba participates in the Latin American network on sustainable production and consumption guided by UNEP and UNIDO. Since 2012 the country is also a partner in the UNIDO guided network "Cleaner production and efficient use of resources".

Today Cuba is a country in transition. In this post-economic blockade (and pre-Starbucks Coffee) period, the country opens more to the world and will gradually be integrated in the globalization dynamics. Internally the transition will be based on a review of the social targets and defining the strengths it wants to safeguard (e.g. health and education systems), in coherence with the weaknesses demanding a revised approach (e.g. income, energy efficiency). It is currently unclear however what the effects will be on CP, but it is for granted that the transition will affect the sustainable development interpretation.

2.3 Cienfuegos (Cf)

Cienfuegos is the capital of the province with the same name in the Southern-Central part of Cuba. The city hosts over 150 000 inhabitants. Cienfuegos is the second port city of Cuba where which the throughput increases fast. It borders one of the most beautiful bay landscapes of the country.

Cienfuegos was established during the late 18th century. It owns an important architectural and cultural heritage from its mixed French-Spanish colonial history, which is the bass of its world heritage site (WHS) status. Both the bay and thee WHS are the basis of a developing tourism sector.

The sea port supports the petro-chemical industry which makes Cienfuegos one of the Cuban oil refinery localities with an associated chemical industry of plastics and fertilizer. Next to the petro chemical industry Cienfuegos has food companies (including fish processing), a thermos-electric power plant, and a varied series of small and medium sized enterprises (including coffee roasters, juice production, and cigars), often using outdated technology.

The agricultural sector entails hundred hectares of sugar cane and (semi-) industrial pork farms offering large CP opportunities.

As a provincial capital Cienfuegos hosts a significant administrative sector next to schools, hospitals, and cultural facilities. The large amounts of untreated household and industrial wastewater make the bay, which has only a small and shallow connection with the Caribbean Sea, also one of the most polluted ones in Cuba.

The university studied the need for cleaner production in the city. Managers and technical staff of 26 major companies which together produce over 70% of the emissions of the city, were invited completing a questionnaire. The answers to the questions allowed identifying the state of implementation of CP in the plants. Four aspects were addressed: the presence and the implementation of an environmental management system, energy efficiency, rational use of water, and both solid and liquid waste management. Participants were invited ranking each of these aspects in a 1 (very low) to 4 (high) scale.

Energy efficiency obtained an average score of 2.9/4 and came out as the subject to which most attention was paid. The result is likely influenced by the Cuban National Program for the Rational Use of Energy (PAEC) (Suarez et al., 2012). With a score of 2.6 also the implementation of environmental management systems (EMS) obtained a positive score, which is mainly attributed to the implementation of these systems in major companies,

considering EMS as an instrument enhancing their financial performance. Both the rational water use (0.9) and waste management (0.5) scores were substandard. Merely small and medium sized companies release their waste water untreated in the environment, do not deal with reuse, recycling, or waste prevention strategies, and seem unaware about the value of (drinking) water as an environmental asset.

Over-all the results indicate that in spite of a national strategy, most companies still have important and unmet needs on cleaner production. Even for the aspects with the highest scores, an over 25% uncompleted niche was identified. The survey equally illustrated the continuing importance of end-of-the-pipe technologies, leaving a major space for implementing preventive CP approaches.

2.4 University of Cienfuegos (UCf)

The university totals over 4000 registered students and 450 academic staff. The organization entails faculties of engineering, agro-sciences, economics and management, social sciences, and humanities. The engineering faculty hosts the center for cleaner production.

CP is a strategic priority for the UCf. Next to offering the certified master in CP (and in the years to come a CP Ph. D degree), the university considers these activities as part of the implementation of their societal role in the city and the province. This includes among others the example role on environmental management and sustainable development, linking up the university with industry, SMEs, and the service sector, where the students for the aster program are recruited. Moreover these links are the basis for defining research lines on, among others, CP in the local sugar and cement industry. Part of this is also consultancy on CP, where the university is hampered as state funded Cuban universities are not allowed offering paid consultancy services.

2.5 Stakeholders

As anywhere else, stakeholders on CP in Cienfuegos are varied and show a patchy picture. Directly involved in the CP dynamics are industry, agriculture, tourism, services and authorities. These groups have varied CP agendas. Where industry will merely target technical and managerial aspects, authorities will focus on wider sustainability targets and "smart city" aspects.

The university acts on establishing and maintaining relationships with these groups: information and awareness raising events, internships, master degree thesis projects, and research lines on energy efficiency in e.g. sugar refinery plants, developing indicators for a sustainable Cienfuegos, and developing an environmental management system for the university hospital, are part of the comprehensive package of activities.

3. Cleaner production at the university of Cienfuegos

Implementing this complex context of CP, the university optioned for three strategic lines:

3.1 Master Degree in Cleaner Production-"Maestria in Productiones Mas Limpias"

The program aims at replying to the unmet need implementing CP in particular in the province of Cienfuegos and its capital? The program combines international, Cuban, and local aspects of CP. It is interdisciplinary in its approach and combines scientific, technical, economic, social, communication, and legal-political aspects of CP. Attention is given to models and frameworks integrating these multidisciplinary aspects of CP in a sustainable development context. The program targets all stakeholders, but in particular professionals in industry, agriculture, and the services sector.

The curriculum is structured in four modules, three of which relate to course work, and the fourth allows preparing the thesis. The four modules totalize 12 courses, 10 of which are compulsory, and two are optional. The compulsory courses provide the background to CP. They entail among others lectures on sustainable development, technical aspects of CP (with a focus on energy efficiency, pollution prevention and treatment), economic and social issues, management (including instruments for environmental management), and policy and law. The optional courses are selected from a wide range of university lectures relevant for CP, according to the personal interest of the student. The curriculum accounts for 35 credit units, while the research part (including the thesis) totals the remaining 35 credits. This allows participants graduating within two years, although some option extending this period while allocating more time to their thesis preparation.

After completing the program the "Master in Cleaner Production" will be able taking part in a multidisciplinary CP team. He or she knows how to design, establish, lead, monitor, and assess CP projects and systems. The alumni have skills in proposing, advocating, and evaluating the potential of CP strategies and projects in their organization. The master program is certified according to the Cuban regulations, following an in depth on site audit.

Until 2015, four promotions have been enrolled. As shown in table 1, During the 4 past academic years 118 students enrolled for the program, while 32 obtained the degree; 18 master thesis works are in progress; for the academic period starting in January 2015, no thesis proposals have been presented yet.

Table 1. Overview of the four master in CP programme promotions at the University of Cienfuegos

Promotion	Period		Number of students	Number of theses presented	Number of theses in progress
	Starting	Concluding			
1	September 2009	February 2012	21	16	0
2	September 2011	February 2014	24	16	3
3	January 2013	July 2015	24	0	15
4	January 2015	July 2017	48	0	0

The 32 program participants who graduated all are employed in the sector, most of them with the environmentally most impacting companies in Cienfuegos. Implementing the results of their thesis works had a significant and measureable impact on the environmental quality in the city. In this way the master program not only provides information and training on CP, but also bridges the University Center for Cleaner Production with the stakeholders in the wider Cienfuegos area.

Establishing the program with a motivated, but only partially experienced staff in a country in transition offers specific difficulties.

Part of these problems were alleviated through establishing an international inter-university program supported by the Flemish Inter-university Council (VLIR) of Belgium.

Table 2: VLIR projects supporting the development of CP activities at the University of Cienfuegos

Period	Subject	Aims
Establishment of a CCP (2008-2012)	A Centre for Cleaner Production to contribute to the socio-environmental development of the province of Cienfuegos, Cuba **350 000€**	Training of trainers (capacity building of the Cuban staff). Development of the required infrastructure. Establishment of a CCP and a master program in CP. Initiate research and development activities.
Strengthening of the CCP (2013-2015)	Cleaner Production in the city of Cienfuegos **75 000 €**	Strengthening the capacity of the CCP to perform CP assessment. Achieve a recognition, at local and regional level, as an actor in the study of the environmental problems in the PSS. Certify the master program in the Cuban framework. Extent the laboratory equipment.
Consolidation of the CCP (2016-2019)	Cleaner production network in Cuban HEIs **350 000 €**	Expand the activities a national level. Establish CCPs at the University of Holguín, the Superior Mining and Metallurgic Institute of Moa and the University of Matanzas, based on the experience at the University of Cienfuegos. Initiate a CP network in Cuban HEIs. Set up the master and Ph. D program on CP in collaboration with other Cuban HEIs.

As shown in table 2 VLIR supported three projects with a total amount of 775 000€. Each project covered different aspects of collaboration. On training the projects facilitated exchanging professors, and building capacity in a set

of subdomains on CP with which Cuban teachers were less familiar with (management, communication, drafting, submitting and guiding scientific publications). The staff exchange part of the project allowed for internships at Belgian universities. Intensive courses lectured by Belgian professors included:

- "Industry and sustainable development" which not only focused on principles, but also on instruments including eco-design for products, green labels, environmental indicators, and sustainability reports.
- "Selected topics on CP management", including the CP-human ecology interphase, and life cycle analysis and its applications.
- 3waste water treatment" about the parameters of water pollution, the fate of wastewater in the environment, and domestic and industrial wastewater treatment.
- "Environmental health" on the impact of pollution and occupational exposure on human health.
- "Environmental economics" on the environment-economics relationship, green economics, with particular reference to countries with centralized economies.
- The lectures on "How to write a scientific paper" were skills targeted. They provided information on establishing and following-up a manuscript during the publication process.

The third project (2016-2019) puts the next logical academic step forward and will contribute to installing a Ph. D network on CP in Cuba. Its main targets are twofold:

- Establishing a CP network with the Universities of Holguin and Matanzas, and the Higher Institute of Moa, which all are prepared establishing academic activities on CP.
- Establishing an inter-university program on CP at Cienfuegos.

3.2 Research

As a functional master program needs to be supported by research, in a second strategic line, the University of Cienfuegos established research on CP. Preparatory, initial projects concerned:

- Energy use and efficiency in sugar production plants (Ochoa et al., 2010).
- Optimization of the production in a coffee roaster plant.

These projects showed that minimal, science based approaches allowed realizing significant CP effects.
During a second phase the approach is more systematic: research subjects address preferentially industries, production processes and outcomes with the most impact on the environment in Cienfuegos. This option also allowed for more complex, integrated projects often of direct importance for the thesis works of the "maestria" participants.

Current research lines entail:

- Inventorying the main industrial processes and pollution sources to air, soil, and water in Cienfuegos. The outcome allows ranking the organizations according to their environmental impact and provides a basis proposing revised, less impacting CP strategies and production processes.
- Identification of biomass resources and their energy valorization. The project counteracts the current loss of energy resources in Cienfuegos. It targets identifying opportunities for preventing, recycling, and recovering existing waste streams. Both industry and household waste are targeted. Next to the technical and environmental aspects, an economic assessment of the options is planned for.
- Sustainability indicators for Cienfuegos aims at developing a set of social, economic, and environmental indicators for the quality of life in the city. The research develops a sustainable development model integrating the multiple dimensions, the issues which matter for the city, and the varied stakeholders. The project is targeted towards assessing the state of sustainable development in the city, its evolution over time, and its impact on planning (Cabello-Eras et al, 2014).

The research lines proved most awarding from different points of view:

- Socially, the research addresses the most pressing environmental problems caused by industry, agriculture, and other organizations. It illustrates how the university deals with real life issues in Cienfuegos. The results provide a basis for discussion with the stakeholders and for local recognition.
- The economic impact of the research outcome is currently less documented and will be addressed in the future.

The international inter-university collaboration provide significant support in establishing and maintaining these research lines in multiple ways:

- Organizing internal seminars and personal discussions targeted at establishing, detailing and following-up research orientations.

- Exchange programs and internships for Cuban researchers at Belgian universities and organizations, submerging them in a different research environment and culture.
- Providing assistance participating in international conferences where the project results are presented and discussed with peers.
- Financial support equipping the laboratories and providing operational funds to support (in part) the research lines.

3.3 Center for Cleaner Production (CCP)

In 2008 the university decided establishing a center for cleaner production. The main aim was centralizing and supporting the master and research CP activities. The center originated from a previously established sustainable energy center of which the activities are currently part of the CCP. Moreover the center organizes meetings and workshops at the university-society interphase.

The CCP was established according to the UNIDO-UNEP (2004) methodology advocated for "National Centers for Cleaner Production" and developing a sequential way a conceptual plan, a basic design, a model covering the financial needs (business plan), and the formal establishment of the activities, including a formal registry, installing a management structure, recruiting staff, and preparing logistic facilities.

Developing the center went through three phases: a four year establishment period, including a strong "training of trainers" component; followed by a three year period of strengthening the center and intensifying the relations with the social actors in Cienfuegos; and an upcoming consolidation phase during which the activities will be extended Cuba wide. The upcoming establishment of an inter-university Ph. D program is a topical example of this third phase.

The center makes part of the faculty of engineering. Eight full professors and nine researchers are part of it. It manages the laboratories, organizes the master program and provides a forum for both internal university and stakeholder activities.

The center operates under specific Cuban conditions:
- Cuban companies are state owned and their participation in the market is strongly regulated.
- The University of Cienfuegos is fully funded by the government and is not allowed performing commercial (e.g. paid consulting) activities.

Both aspects hamper reaching budgetary self-sufficiency, which in the short term is alleviated by the international cooperation support. Apart from the financial aspect, the so called "North-South" cooperation significantly contributed to capacity building: the successive projects realized seven short term exchanges and two longer term internships, one of which of core importance in concluding a CP targeted Ph. D.

4. Discussion

Implementing a master degree, establishing research lines, connecting and informing stakeholders, and setting up the first academic coordination center on cleaner production in Cuba, the University of Cienfuegos developed in this way its own strategy in contributing both to the international dynamics CP generated as a practically targeted interpretation of sustainable development, and complying with the needs and expectations of the local community. It does so in a transdisciplinary perspective, contributing to a more sustainable, healthier, and long-term oriented society. The organization addresses not only causes of environmental degradation, but also key persons in business, industry and services, decision makers, and academics. In this way the university contributes to its academic mission on the subject.

This is not the only way higher education worldwide contributes to a CP dynamics in society. More emphasis might be given to campus operations, changing attitudes, and more cooperation (Lozano et al., 2013).

On the other hand, the implementation at the University of Cienfuegos is fair and feasible, moving a country in transition into the wider international CP and sustainable development dynamics. From this point of view it is interesting comparing during the years to come the situation in Cuba with the evolution of CP in other countries experiencing an important economic transition as countries in Central Europe or Vietnam (Quynh Anh Nguyen and Hens, 2015). From this comparison general patterns on implementing academic CP activities might emerge.

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