Life Cycle Inventories of the Latin-American Electricity Production Systems

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Abstract The goal of this project was to enhance the use of the life cycle approach within the Latin-American Region. It was focused on capacity building for developing Regional Life Cycle Inventories. The project was developed by researchers belonging to the LCA community in cooperation with UNEP, and Governmental representatives and statistic offices providing the data. More precisely, this project aimed at building home-grown expertise, including capacity for South-South cooperation, environmental leadership, and also at supporting the use of science-based approaches and evidence-based decision-making in mainstreaming environment in government policies in each of the countries participating in the project. The critical review process is still to be done, but it must be accomplished by June of 2011. The project started with the establishment of general rules for harmonization of sound and comprehensive life cycle inventory data and information. These rules were applied to the field of electricity production, transmission and distribution. This productive sector was chosen due to the fact that it is a common and necessary key input to all economic activities. Results: A quality guideline was developed for the project, based on the one used to build the national Brazilian LCI. Four different LCI were built in ecospold format, based on information collected in four different countries, Argentina, Chile, Mexico and Peru, which cover the hydroelectric and thermoelectric generation processes, and the transmission and distribution systems. Lack of LCA acknowledge in the industrial and public sectors, and difficulties to find reliable public data and information, arise as the major problems in most of the participating countries, even though the electric sector is more incline than other sectors in providing the public with more and more information regarding its

emissions and compliances. The capacity building process and differences between the countries in terms of structure, technology, environmental regulations, among other factors, made the use of a common and detailed quality guideline very difficult to be applied. Thus, capacity building process on LCA in emerging regions seems better to be conducted on a step-by-step basis, which must consider the development of a simpler approach to build generic prototype models that can undergo later a continuous improving process. Data consistency and harmonization appears to be two of the major issues that must be specifically addressed in a Regional quality guideline.

Introduction

This is a first effort in Latin America that involves various countries developing a Regional LCA study. This regional LCI model is going to be used as a prototype for further developments at country level. The participating countries were mostly those that hold consolidated LCA practitioner groups for more than 7 years. Nevertheless, the different LCA research teams have dissimilar levels and experiences developing LCI. Brazil, Mexico and Chile had previously developed national LCA database, and some information coming from those LCI projects had been used in the present study. Peru and Argentina formerly had focus mostly in developing specific LCA studies for industry and LCIA models [1]. In spite of these differences this study successfully accomplished their goals; furthermore, these differences and the national characteristics and conditions, have enriched the results and conclusions of these studies in terms of the understanding of the needs and complexity that must be taken into account to effectively apply life cycle thinking tools to other emerging regions.

Method

As starting point to collect data, the Ecoinvent quality guideline, the ILCD guideline and a LCI Manual previously developed by the Brazilian team, as well as the ISO standard 14040, were considered, and then a common framework for all countries was established. The initial idea delineated in the project proposal, was to model the main electric matrixes of each participating country, covering also the fuel transport, and the electric transmission and distribution systems. But after a period of evaluation (3 to 5 months) about the accessibility to the

information, it became clear that not all teams would be able to collect the necessary information and data to properly characterize their main electricity production systems, neither all operational trams for the electricity delivery to the users. The accessibility to the information was a function of matters such as the level of personal contacts with key actors related to the power sector, the information normally collected and made public by governmental institutions, the specific public policies of companies, and the direct access to power plants information. In the end, each team defined a system boundary for the study according to the information to which that specific research team could have access.

Information and collected data were selected and processed following the methodology described in the framework developed for the project. The Chilean team also used a guideline that was previously developed for the project on national LCI of electricity generation and transmission and which was based on the Ecoinvent guideline. A couple of meeting and various teleconference were performed after the initial evaluation period, to discuss a more realistic approach and scope for the project, the system boundary for each country, functional unit, and the rank and type of data necessary to build a first LCI prototype for Latin America. The electricity production system(s) per country considered for this project is specified in Table 1. The datasets were built in ecospold format. The final meeting was hold at the beginning of April in CILCA2011 in Mexico, where the reports presented by Mexico, Argentina and Chile were reviewed and discussed, in order to evaluate the methodological discrepancies and take actions oriented to produce the final report of the project, which can later be used as a Basic Manual for capacity building and LCI developments in emerging countries and regions. It was also agreed that the report of each country is going to be modified to fit into a common format for using them to illustrate in a simple way the difficulties, requirements, as well as the implementation of the LCI methodology ("the *modus operandis*") when building a LCI. New discussions also came up about the work that must be done by the external critical reviewing panel, which must be coherent with the goal of this project that clearly differ from the ones normally pursued by LCA database developments. It was agree that the terms of references for writing the consolidated report, which will be submitted to the critical reviewing panel, will be proposed by the coordinator of the project to the rest of the project team for further discussion.

Results and Discussion

Three LCI datasets and individual reports were completed at the time of this paper has been written, corresponding to the work made by Argentina, Chile and Mexico. The work conducted in Peru presented 2 month of delaying due to former problems for acquiring information and data. Table 2 and Figure 1 present the LCI results from Argentina and Chile, respectively.

The final guideline (Manual) and the critical review results are going to be presented in the LCM2011 conference.

The conclusion and recommendations of the final project meeting in CILCA2011 were relevant for future life cycle developments and initiatives in emerging regions. This comprises the understanding of both simple and complex situations in emerging regions to deal with acquiring data and information, and the appropriate consideration of site-specific and sector-specific characteristics. The project started very slowly, due to major differences in how industry interacts with academia and governmental institutions. But beyond the particular knowledge and experience that each research team has in the field of life cycle inventories, there is also a huge lack of understanding of professionals of the private, industrial, and public sectors regarding life cycle thinking concept as well as its relationship with indicators such as carbon footprint, being nevertheless part of nowadays vocabulary of the ordinary people. This situation generates difficulties to get industry and public sectors involved in the project and even generate some level of suspiciousness that finally results in a poor collaboration. The implementation of very detailed quality guidelines, such as those developed for Ecoinvent and ILCD, appears as not efficient for capacity building in emerging countries. A LCI Manual as a simplified and more focus version of these kinds of guidelines is recommended, but which must also contains step-by-step examples as well as information and recommendation on how to cope with and give alternative solutions to overcome practical problems. To relate the LCI dataset with a practical and commonly known concept such as carbon footprint, is also important for introducing life cycle thinking and LCI initiatives in this region. The use of LCA softwares such as SimaPro used in this project, is recommended for capacity building, but also for showing a broader range of useful applications for both industry and governmental institutions, making easier the work and the understanding of life cycle thinking and the importance of LCI datasets selection and its place and significance in the life cycle assessment chain.

Tab.1: Electricity Production Systems by Country

Country	Electricity Generation	System boundaries
Argentina		• Extraction of primary energy sources • Transportation to refineries • Refining and purification • Transportation within the territory of raw materials • Power Generation
Chile	Electric matrixes of Central and Northern Chile (SIC and SING)	• Fuel production and transportation; • hydroelectric generation thermoelectric generation • Transmission to main distribution plants. SIC: matrix composed by thermo and hydroelectric plants; SING: only thermoelectric plants
Mexico		Transmission and distribution systems
Peru	Hydroelectric Plant “El Platanal”	The hydroelectric plant

Tab. 2. Inventory corresponding to the Argentinean Interconnected System. Only the thermal power plants operating within the system during the 2008 year have been considered.

Kg / kWh Year 2008	SIN
Atmospheric emissions	
CO2	0,548
NOX	4.82 10-4
SO2	2.09 10-4
PM<10	1.034 10-5
N2O	9.77 10-6
CH4	2.42 10-5
COV	2.59 10-5
Discharges to water	
DBO5	1.28 10-7
SST	1.98 10-9
NO3	1.65 10-7
NO2	3.81 10-9
Natural Resources	
Crude Oil	1.09 10-2
Coal	1.22 10-2
Natural Gas (m3N / kWhEE)	0.186

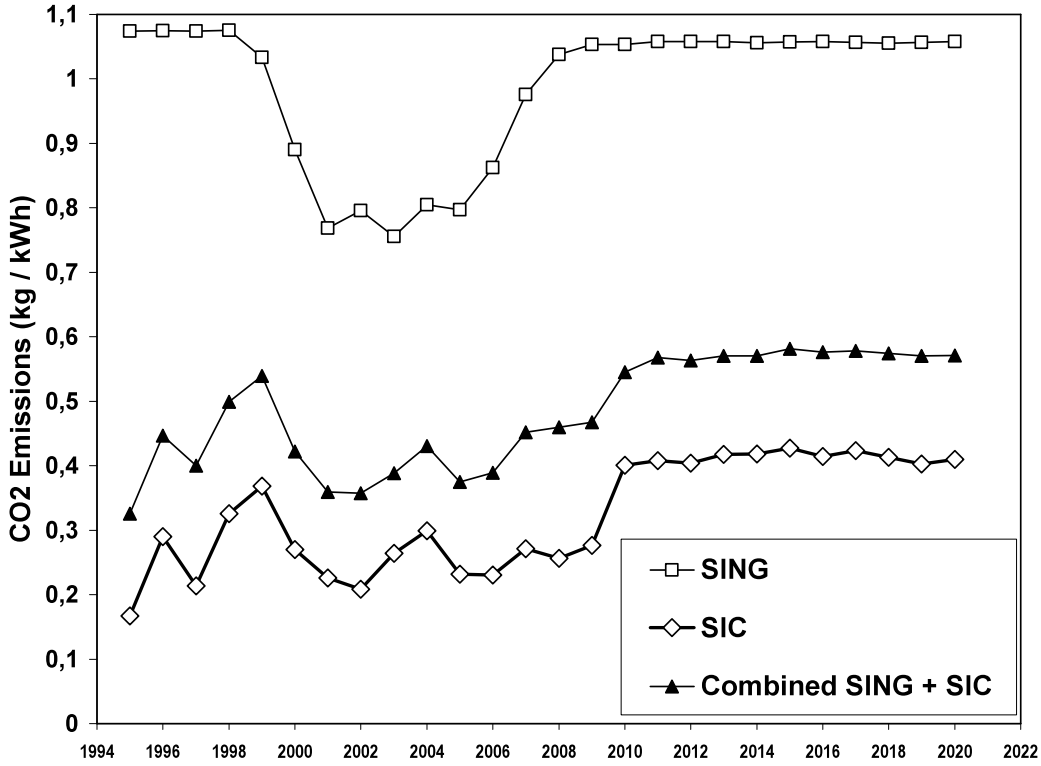

Fig. 1: Direct CO_2 emissions associated to electricity generation in Chile for different mixes over the 1995-2020 period

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