INVESTIGATION OF PRICE BANKS AND LIFE CYCLE INVENTORIES FOR PAN-EUROPEAN LIFE CYCLE COST ANALYSIS SYSTEM

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ABSTRACT

When comparing alternative strategies for a project, owners and users should not only consider the initial capital cost, but also the running costs which are incurred over its operating life. Total life cycle cost (LCC) is a recognized approach to identify the future total cost implications of individual building elements or the entire building in the future. However, as sustainability gained significance in the construction industry, it became clear that LCC is not the only the only factor to be considered. Life cycle assessment (LCA) of a building is also of great importance. LCA need to be performed to determine the effect of the construction and constructed structure on the environment (i.e., CO_2 emission). To provide comparable LCC and LCA results and outputs, significant amount of work is needed to normalize data in existing sources. This paper describes the characteristics of the current databases that can be integrated with the Pan-European life cycle cost analysis (LCCA) system, which is an ongoing EU 7th framework CILECCTA (Construction Industry LifE Cycle Cost Analysis software) project. The goal of the CILECCTA project is to develop an online decision support system for assessment and identification sustainable and economic options for pan-European construction and renovation projects. This tool will provide comparable LCC and LCA results for different project options and assist users in selecting the most appropriate option. It will be compatible with various price banks which supply necessary data for LCC, and life cycle inventories (LCIs) that provide data for LCA across Europe and beyond. The tool will also allow for consideration of uncertainty (e.g., in design and functionality), which is inherent in construction, renovation and through life cycle of a structure. The objective of this paper is to describe the main characteristics (e.g., classification systems, data availability) of existing price banks and LCA databases in Europe.

Keywords: Life Cycle Assessment, Life Cycle Cost, Life Cycle Inventory, Price Bank.

1. INTRODUCTION

When comparing alternative strategies for a project, owners and users should not only consider the initial capital cost, but also the running costs which are incurred over its operating life. Total life cycle cost (LCC) is a recognized approach to identify the future total cost implications of individual building elements or the entire building in the future. However, as sustainability gained significance in the construction industry, it became clear that LCC is not the only the only factor to be considered. Life cycle assessment (LCA) of a building is also of great importance. LCA needs to be performed to determine the environmental impacts of buildings and building products effect (i.e., CO_2 emission). Although, LCC and LCA are moving into the core of modern policies and business decision support, currently, a tool that integrates LCC and LCA does not exist for construction industry. The majority of the available LCC or LCA tools have limited applications, limited flexibility and limited functionality (Langdon 2007). To provide comparable LCC and LCA results and outputs, significant amount of work is needed to normalize data in existing sources.

CILECCTA (Construction Industry LifE Cycle Cost Analysis software) is a EU 7th framework project that aims to develop a Pan-European life cycle cost analysis (LCCA) system that integrates the LCC and LCA perspectives. The goal of the CILECCTA project is to develop an online decision support system for assessment and identification of sustainable and economic options for pan-European construction and renovation projects (Vennström et al. 2010). This tool will provide comparable LCC and LCA results for different project options and assist users in selecting the most appropriate option. It will be compatible with various price banks which supply necessary data for LCC, and life cycle inventories (LCIs) that provide data for LCA across Europe and beyond. The tool will also allow for consideration of uncertainty (e.g., in design and functionality), which is inherent in construction, renovation and through life cycle of a structure. For this purpose, real options analysis will be integrated in the LCCA. The objective of this paper is to describe the key characteristics (e.g., classification systems) of existing price banks and LCA databases in Europe.

2. OVERVIEW OF THE CILECCTA PROJECT

LCC and LCA were developed and are practiced as separate disciplines in the construction industry. There are a number of similarities in these two methods, for example both methods:

- use similar data on inputs of materials and energy
- take into account operation and maintenance
- consider opportunities for recycling vs. disposal
- provide a basis for rational decision making, particularly in appraising options (Langdon 2007).

However, the resulting decisions are different for LCC and LCA. LCC combines all relevant costs associated with an asset into outputs expressed in financial terms as a basis for investment decisions LCA enables decisions to be made on the basis of environmental performance by scoring and rating on environmental criteria, not all of which can be accurately costed. As a result LCC and LCA do not produce a common output (Langdon 2007) and it is one of the challenges of CILECCTA project. The main objective of CILECCTA project is to develop a suite of software for use in the construction industry and this tool will be capable of integrating LCC and LCA and performing Life Cycle Cost and Analysis (LCCA) in coordination with Price Banks (PBs) and Life Cycle Inventories (LCIs) across Europe. The main requirements of the CILLECTA tool were identified as follows:

- It shall be customizable/configurable for whole assets and their components.
- It shall enable the assessment of sustainable options to provide decision support.
- It shall be user-friendly to the 95% of building enterprises that are SMEs (small medium enterprises) across the EU countries and beyond.

More information on CILLECTA can be found at Vennström et al. (2010) and CILECCTA (2011). The first step in developing an LCCA tool that will retrieve data from price banks and LCIs in Europe is to identify the requirements of such a system. Thus, the project team identified and investigated the commonly used price banks and LCIs across Europe. The second step was to identify the main characteristics of these databases and to define the requirements based on the envisioned system and the key characteristics of the databases. The following sections will elaborate the results.

3. IDENTIFIED PRICE BANKS AND LCIS

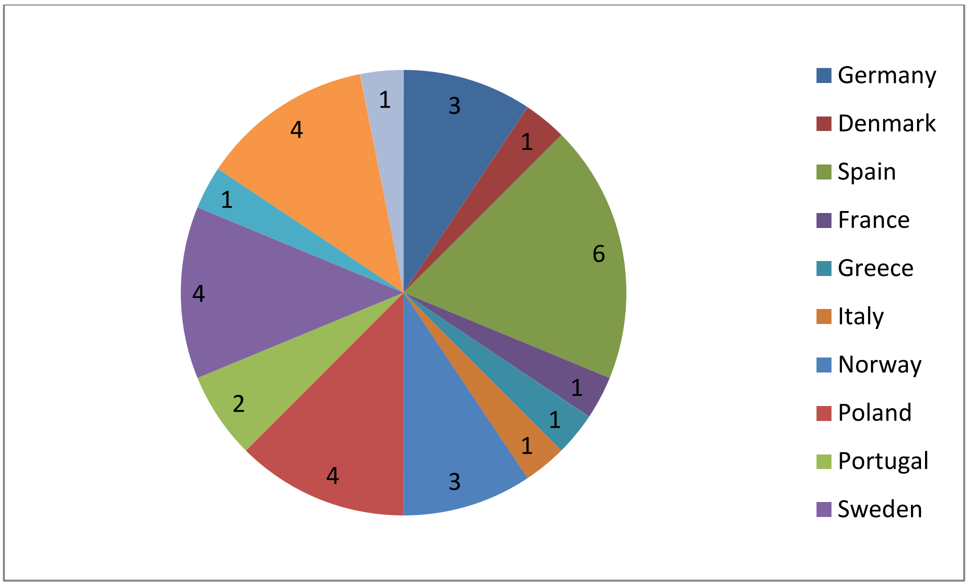
To identify the requirements for the LCCA tool, price banks and LCIs in Europe were identified and characteristics of those databases were investigated to determine the initial requirements for the LCCA software. When identifying the price banks in Europe, not all the price banks and all the countries were considered. Instead, four regions in Europe were defined and the project team tried to identify databases that represent each region.

- North region: Norway, Sweden, Denmark and Finland etc.
- South region: Spain, Portugal, Italy Greece etc.

- East region: Former Eastern Bloc countries and Turkey etc.
- West region: UK, Ireland, Benelux Germany and France etc.

Also, a price bank from the US was included in the list to determine the main characteristics of a major database. A total of 32 price banks from 13 countries were identified in the study. The distribution of price banks among the countries is given in Table 1.

Table 1: Distribution of the identified Price Banks



The same method was used for identification of LCIs across Europe. Besides European databases, LCI databases from other countries were also included. Table 2 lists 38 databases that were identified. Most of the LCI databases indicate raw output data (e.g., CO_2, SO_2) of different production processes. On the other hand, nine of the LCIs are indicator based databases and they provide already "characterized information" (e.g. environmental product declarations) on potential environmental impacts for different processes. This information is called environmental Life Cycle Indicator Results (LCIR), such as global warming potential (GWP). Information on mass and energy flows may be only partly reflected. Table 3 presents an example of LCIR data for a gypsum plaster board from the Ökobau, which a LCI from Germany.

Table 2: Identified LCI databases.

Country	Database code*	Type	Reference / Basis
Germany	DE1	Raw	
	DE2	Raw	
	DE3	Raw	GaBi database
	DE4	Raw	GaBi database
	DE5	Raw	
	DE6	Raw	
	DE7	LCIR	GaBi database
Sweden	SE1	Raw	
France	FR1	Raw	
	FR2	LCIR	
Italy	IT1	Raw & LCIR	GaBi database
Belgium	BE1	Raw	
	BE2	Raw	GaBi database
	BE3	Raw	
Switzerland	CH1	Raw	
	CH2	Raw	
	CH3	Raw	
Denmark	DK1	Raw	
	Dk2	LCIR	Partly GaBi database
	DK3	LCIR	
Netherlands	NL1	Raw	
	NL2	Raw	
	NL3	Raw	
Finland	FI1	Raw	
Spain	ES1	LCIR	
	ES2	LCIR	
UK	GB1	Raw	
	GB2	Raw	
	GB3	LCIR	
Japan	JP1	Raw	
EU	EU1	Raw	Partly: GaBi database
Australia	AU1	Raw	
Canada	CA	Raw	
Taiwan	TW1	Raw	
Korea	KR1	Raw	
USA	US1	Raw	
Thailand	TH1	Raw	
Austria	AT1	LCIR	

Table 3: An example of LCIR data for a gypsum plaster board from the Ökobau dataset

Indicator	Value	Unit
Primary energy, non renewable	36,88	MJ
Primary energy, renewable	1,44	MJ
Derived fuels	0,03	MJ
Water use	11,2	Kg
Excavation residues	3,65	Kg
Domestic and commercial waste	0,008	Kg
Hazardous waste	0,001	Kg
Abiotic resource depletion (ADP)	0,017	Kg Sb-equivalent
Global Warming Potential (GWP 100)	2,34	Kg CO2- equivalent
Acidification Potential (AP)	0,004	Kg SO2- equivalent
Photochemical Ozone Creation Potential (POCP)	0,0004	Kg C2H4- equivalent
Eutrophication potential (EP)	0,0009	Kg PO4 - equivalent
Ozone Depletion Potential (ODP)	0	Kg R11- equivalent

4. CHARACTERISTICS OF THE PRICE BANKS AND LCIS

The investigation of the characteristics of price banks and LCIs were performed through a range of media – phone, email, internet searches and site visits. Multiple criteria were taken into account. The quality of the information that was gathered has different levels of granularity because the databases, mostly price banks, are not always publicly available, and sometimes are regarded as one of the most sensitive part of the providers business. It was found to be difficult to retrieve the most interesting and useful characteristics for some databases.

The characteristic of the identified price banks and LCIs are discussed below:

- *Availability of online data:* The nature and origin of the different datasets are wide (from online database providers to just books or file lists providers). For example, for about 40% of the price banks are online, 29% is available in CD/DVD or can be downloaded from a web site. This implies that it is not possible to connect to some of the identified databasesand retrieve data from them.
- *Databases in various languages:* Most of the price bankc and LCIs that were investigated are available in the native language of the countries that they originated from. A few of them are available in multiple languages, especially the price banks from Northern Europe include English, Swedish, Norwegian, Dutch etc. versions and some Spanish price banks include Spanish, Catalan and Portuguese. Therefore, CILECCTA needs to have multi-lingual capabilities.
- *Diverse and fragmented nature of LCIs:* As indicated in the litreture, there are many university-based and consultancy-based LCI databases which characterize particular industrial sectors and product groups (Curan et. al, 2006). These are generally very diverse and fragmented, with a poor level of harmonisation, due to the involvement of many countries and many actors (e.g., industry, research, public authorities etc.). For countries such as Germany, Sweden, and Switzerland, which have been active in LCI data development, the current challenge is integrating and ensuring comparability and interchangeability of a wide variety of LCI databases.
- *Difficulty in using raw data from LCIs:* LCI databases provides raw data which makes it very hard to compare different options in the LCCA. For example, let's assume that there are two materials, A and B, that can be used interchangeably during construction and the environmental impact of production of those materials will be compared to decide which material should be selected to have less negative impact on the environment. For material A, a raw LCI database provides an output that 0.3 kg SO_3 will be produced and for material B, the output is 0.4 CO_2. In this case, it is not clear which one should be selected since the output is expressed in different units. On the other hand, indicator based databases express the output as a characterized information for each material production, usually in terms of global warming potential etc. Therefore, in this study, it was decided that LCIR databases will be used to enable a comparable LCCA.
- *Types of costs included in the price banks:* The various price banks that were identified all contain different types of costs. Most of them focus on construction costs, but some also include maintenance costs, operation costs and development costs (OMR). The LCCA software needs to be able to represent different types of costs included in the databases.
- *Classification and content of cost items:* Classification system indicates how the data is indexed in a database and which standard is used. Price Bank and LCI databases use different classification systems to define the cost items. It is observed that data about building elements, material, equipment and labour prices are classified based mostly on national standards and about 20% of them are based on organization-specific internal standards. This could potentially lead to problems, because various classification systems do not use the same names for the same categories/cost items.

5. CHALLENGES IN INTEGRATING THE PBS AND LCIS TO THE LCCA SYSTEM

In the analysis performed regarding the characteristics of the identified databases, following challenges were identified in the integration of the existing price banks and LCIs to the LCCA decision support system:

- Data output of the LCIs vary. While most LCIs were based on raw output data, only nine out of thirty-eight were indicator based databases providing "characterized information" on potential environmental impacts. Therefore, in this study, it was decided that LCIR (indicator based) databases will be used to enable a comparable LCCA.
- Most LCIs have a diverse and fragmented nature. These have to be integrated ensuring comparability.
- Except the price banks from Northern Europe, PBs and LCIs are only available in the native language of the countries that they originated from. Therefore, CILECCTA needs to have multilingual capabilities.
- Due to the various types of costs included in the PBs (construction, maintenance, operation etc), the LCCA software needs to be able to represent different types of costs included in the databases.
- One of the most remarkable challenges is regarding the classification systems used. Since most databases use national classification systems, different names exist for the same categories or cost items.

5. CONCLUSIONS

In this paper, the characteristics of the current price banks and LCI databases in Europe and some major countries have been analyzed for providing initial suggestions for an LCCA decision support system. The analyzed PBs and LCIs constitute the potential databases to be integrated with the Pan-European LCCA system, which is being developed as part of a EU 7th framework project called CILECCTA. The aim of developing an LCCA decision support system in CILECCTA project is to create cost effective solutions with least environmental impact in the construction industry.

A total of 32 PBs and 38 LCIs were identified in the study. The investigation of the characteristics of price banks and LCIs were performed through phone calls, emails, internet searches and site visits. The quality of the information that was gathered has different levels of granularity because the databases, mostly price banks, are not always publicly available, and sometimes are regarded as one of the most sensitive part of the providers business. It was found to be difficult to retrieve the most interesting and useful characteristics for some databases.

The characteristics of the databases indicate some challenges in integrating the current price banks and LCIs to the LCCA system. The most important challenges were related to the LCI data output and varying classification systems for building elements and defined resources. Most of the current LCIs provide raw outputs which are in different units for different material production. Since it is not possible to compare such an output for different materials that can be used in the construction, these LCI databases with raw outputs are not found to be appropriate for the LCCA software. Instead, indicator based LCIs are going to be integrated with the LCCA software since they express the output as "characterized information" for each material production, usually in terms of global warming potential etc.

The other challenge is related to different classification systems used in the databases. This challenge also makes it hard to compare data from different databases. In most databases, the building elements are classified based on different classification systems.

Currently, based on the identified characteristics and challenges, the software requirements are being defined for the LCCA software. This will be followed by software development and the developed software will be tested by multiple large scale test cases. The study described in this paper constitutes the one of the first steps for achieving the broader aim of integrating LCC and LCA for the assessment of sustainable and economic options in the construction industry.

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