CILECCTA

A user-oriented, knowledge-based suite of Construction Industry LifE Cycle CosT Analysis software for pan-European determination and costing of sustainable project options

CILECCTA is a large-scale collaborative project co-financed by the European Commission under the 7th Framework Programme Cooperation.

The project has brought top class academics and industrial researchers, associations and enterprises together in a consortium to develop a suite of software that will enable the assessment of sustainable strategies providing decision support for the construction industry and its associated supply chains.

The software will be capable of full Life Cycle Cost Analysis (LCCA). It will be compatible with codified Price Banks (PBs) as well as Environmental Life Cycle Indicator Results (LCIRs) across Europe. It will also be customisable/configurable for whole assets and their components.

CILECCTA defined the following technical objectives:

- development of a new theoretical options-based underpinning for advanced LCCA calculations;
- identifying at least 4 Price Banks and 4 LCIs (northern, eastern, western and southern European) that can be made available to the project for analysis and integration;
- benchmark of best practice in codification and access architectures for each PB and LCI;
- integration of best practice into a single common codification and access scheme for all identified PBs and LCIs;
- development of an optimised software architecture for access to PBs and LCIs;
- specification, build and testing of the CILECCTA software suite version (0.1+X) capable of integration with the PB and LCI access architecture and with LCCA, design, planning and project management tools;
- development of a simple, user-friendly interface minimising the need for specialist knowledge in its use;
- large scale demonstration of the efficacy of the CILECCTA software in three major construction projects.

The results so far

The CILECCTA project aims to make two important advances over the existing methods of financial life-cycle costing (LCC) and environmental life-cycle analysis (LCA):

- the CILECCTA method will include explicit consideration of future uncertainty, in contrast to current approaches to LCC and LCA which require that the future life-cycle of construction projects is predicted in detail
- the CILECCTA method will integrate both LCC and LCA, in contrast to current approaches where they are treated separately and use different tools.

Scientific work was devoted to developing these theoretical propositions into well-defined procedures, to be used as the basis for software development.

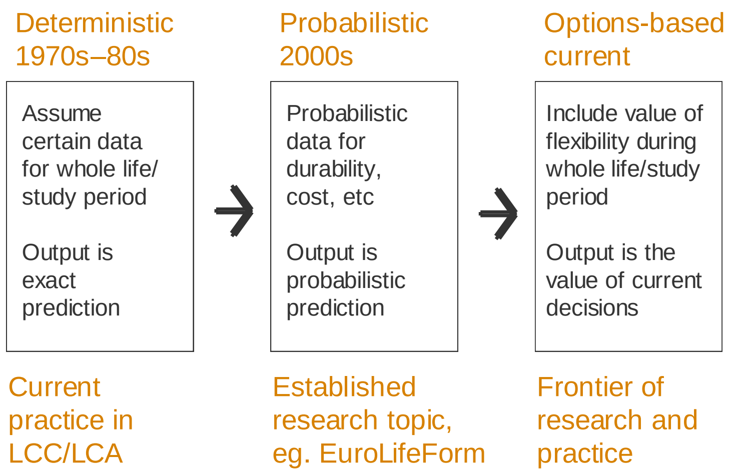
Future uncertainty

Current LCC/LCA tools require precise data input ('single-point estimates') for all variables throughout the chosen study period. With this precise input data the tools generate precise values for life-cycle cost and environmental impact. This is the ***deterministic approach*** to LCC/LCA.

However, for construction projects the study period is typically 20-50 years (or even longer), and over this timescale many variables are certain to change, e.g. the price of fuels / energy carriers and building products, the service life of building products, refurbishment measures, the usage of buildings and infrastructure, etc., which directly and indirectly influence the cost and environmental impact of buildings over their entire life-cycle.

In view of this uncertainty it is preferable for the variables in LCC/LCA tools to be given ranges of values rather than precise values. If this is done the outcome is a range of values for life-cycle cost and environmental impact. This is the ***probabilistic approach*** to LCC/LCA. Research has been carried out on probabilistic LCC/LCA but it is not yet established in current tools.

The CILECCTA method will adopt the probabilistic approach and allow for data values to be defined as ranges, typically 'three-point estimates' (lowest conceivable value, most likely value, highest conceivable value). If three identical values are entered, it defaults to the deterministic approach. Probabilistic outcomes will be modelled using Monte Carlo simulation.



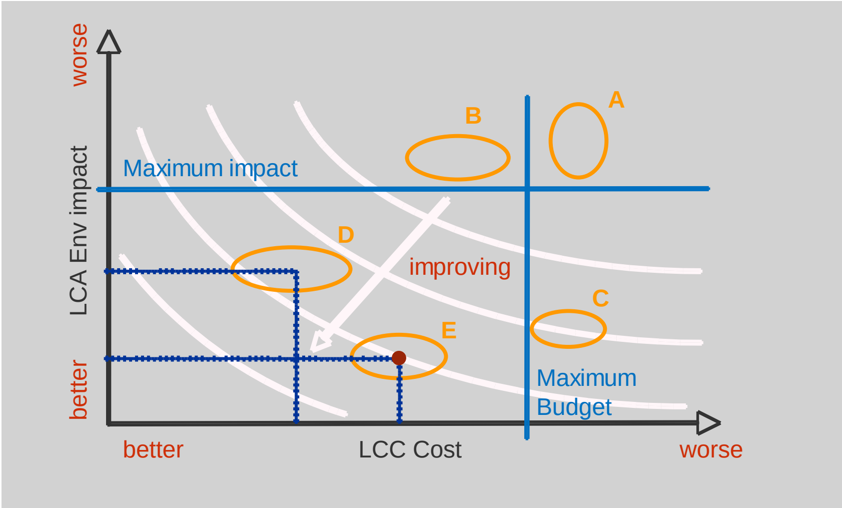
With the probabilistic approach, a further enhancement is possible. A construction project has a branching tree of possible life-histories, with future decision-makers deciding which branch to select at decision-points in the future. Although this makes prediction difficult, the future decisions improve life-cycle performance because they respond to situations that are unpredictable at the time of design or construction. The opportunities for future decision-makers to take alternative decisions can be called ‘life-cycle options’. Using more familiar terminology, a project with many life-cycle options is flexible.

The CILECCTA software will adopt the ***life-cycle options approach*** and allow for the evaluation of flexible design strategies, i.e. include an estimate of the value of flexibility. Initially the scope of flexible strategies will be limited, but the CILECCTA structure will allow for future enhancement of this feature.

Integration of LCC and LCA

The integration of financially-oriented LCC and environmentally-oriented LCA presents significant challenges. The two procedures are distinct and are quantified in different units. In addition they originated in very different contexts – investment efficiency for LCC and environmental conservation for LCA – and adopt different assumptions; for example, time preference (the increased weight given to costs or benefits that occur in the near future compared to those that are further in the future) is formalised through a discount rate in LCC, but in LCA a discount rate is not normally used.

In the CILECCTA software, the data required for both the LCC and LCA evaluation of a construction project or proposal will be held as a single dataset, and both evaluations will be made. However, because of the differences between LCC and LCA it is not feasible to aggregate the results of the two evaluations into a single number. LCA itself measures environmental impact with respect to a large number of environmental factors; all of these impacts will be calculated separately for some applications like building certification schemes. In the CILECCTA approach the two evaluations, financial and environmental, are considered to be integrated by portraying the results on a two-dimensional graph, with one axis for financial LCC and the other for environmental LCA (the different factors of LCA being aggregated into a single value).



When comparing alternative designs or strategies (including flexible strategies) for a construction project, each alternative is represented by a point on this graph corresponding to its cost and environmental performance. With probabilistic LCC/LCA the points are replaced by areas corresponding to the probabilistic range of cost and environmental values. It is possible that some alternatives have high cost and low environmental impact, whereas others have low cost and high environmental impact: the trade-off between cost and environmental impact, leading to the overall preference between alternatives, is a matter for the decision-maker, and may vary between decision-makers.

The relative weighting of an individual decision-maker can be represented by contours on the two-dimensional graph; the alternative on the highest contour being favoured. Other decision-makers' weightings would be represented by different sets of contours on the same graph of financial and environmental results.

Value chain cost analyses

The commercial availability of resources and preliminary products is of vital importance for industry. One aim of manufacturing companies is to understand structural dependencies in the availability of resources, in terms of both environmental impacts and cost, within the entire value chain. Both ecological and economic information are relevant for sustainable and holistic strategic planning.

Within CILECCTA, a methodology is developed that models the influence of varying energy prices along the value chain of products by combining elements of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC).

LCC evaluates the cost of a product over its entire life cycle. However, existing approaches do not consider the influence of energy input price alterations in upstream processes on the costs of materials. But for decision makers it is crucial to know e.g. at what oil price investments in new materials or a change of feedstock from fossil to renewable becomes profitable. LCA, on the other hand, contains technical information on raw material extraction, production, use and end of life of products, but does not usually analyze economic aspects.

Therefore, a new approach is suggested, combining elements of LCC and LCA. LCA provides a functional model for the entire value chain with energy and mass flows of all upstream processes. This model is enhanced with economic parameters, such as energy prices, material prices and selling prices of final and intermediate products. This combination provides a cost model for the production of a product along its entire value chain.

The connection of all upstream elements and processes results in a dynamic, functionally linked cost model and allows for calculation of the final product price based on fluctuating input prices over the entire value chain.

With this method, ecological and economic impacts of different solution under different boundary conditions can be analyzed from a life cycle perspective. It is therefore an enhancement to existing methods LCA and LCC. This approach can be of great help for decision makers in comparing long-term investments and as support tool for strategic decision making. Furthermore, it enables LCC and / or LCA experts to enrich their analysis with a long-term price forecast for energy price sensitive products, parts and materials.

Data collection

Price Banks and Life Cycle Inventories in the European region were identified, and their database structures surveyed and analysed.

Their architecture, presentation format and content were benchmarked and best practice parameters were established by conducting a poll was amongst the partners, to which the Delphi Method was applied. Usability and functionality were subject of an independent market research.

Three aspects were identified as being of critical importance:

- Customizability - Types of Costs included, Classification of Data Structure and Codification
- Ability to interact with external systems - Integration with SW programs and Output formats
- Efficiency - Programmatic accessibility, Access architecture, Data security and editing.

In the case of LCI there are two types of data available for use. A “pure LCI database” offers datasets which contain pure LCI information on different processes, regardless of whether unit or aggregated processes are displayed. With the help of so called “characterization factors” and adopting the methodology of “Life Cycle Impact Assessment”, input and output flows are transferred into potential environmental impacts. Secondly, Indicator-based LCI databases contain already “characterized information” on potential environmental impacts for different processes, so called environmental Life Cycle Indicator Results (LCIR). Information on mass and energy flows may be only partly reflected.

All Price Bank and Life Cycle Inventory databases use some form of classification system to identify where costs belong. Since CILECCTA deals with numerous databases across Europe there are many different classifications to take into consideration.

The solution is therefore to create a common mapping between a set of standardized categories or concepts and the various classifications used in the datasets. A mapping tool using the IFD Library was recommended as the solution. The tool will store globally unique identifiers and their meaning in a central repository, which all data providers can access via the CILECCTA Software. IFD, the International Framework for Dictionaries, is a standard for ontology based on internationally-accepted open standards.

By using the IFD Library combined with the mapping approach, the CILECCTA project will be able to access data from many different providers. Each data provider will implement a common interface that accepts a standardized input and returns a standardized set of return values. The mapping approach guarantees that the different categories are globally unique and therefore the interface to each data provider will be kept very simple.

Integrated performance/ feature specification for option based LCCA software

The CILECCTA consortium has put great efforts in defining the state of the art of existing software for LCC or LCA data and analysis. Their key features and functionality have been categorised and analysed and the CILECCTA partners have used this information as input to the software specification process.

The CILECCTA partners have also specified the functionality the CILECCTA software should incorporate in order to provide the user with a probabilistic LCCA analysis tool that handles uncertainty and flexibility in building projects, and also lets the decision maker(s) compare economic and environmental results.

The CILECCTA partners have visualized an overall workflow to create a mutual understanding of the underlying work processes that this software will support.

The CILECCTA way of comparing economic results (LCC) and environmental results (LCA) is to relate them through an “environmental portfolio”. This shows both cost and environmental dimensions for the alternatives under consideration, and allows the user to take account of both dimensions when determining the preferred decision. As the project work progresses, other tools for results analysis might be developed, e.g. indicators.

Expected impacts of CILECCTA

According the European Construction Industry Federation (FIEC) the European building industry has a total value in EU27 of €1,304 Bn (€1,438 Bn including Norway and Turkey), equivalent to 10.7% of the EU27 GDP. Moreover it provides 16.4 Mn jobs (18.2 Mn including Norway and Turkey), which equates to 30.4% of EU27 industrial employment, distributed amongst 2.9 Mn enterprises (3.2 Mn including Norway and Turkey) of which 95% have fewer than 20 workers and are SMEs.

There is an overwhelming need expressed by the construction sector for greater industrialisation and for improved use of resources. This need is echoed by increasingly sophisticated clients who are worried by uncertainties, particularly in fuel prices, and wish to define the best strategies for development, use and demolition of buildings and their components.

The very diverse nature of national and even regional standards of construction materials used seriously complicates the ability to do business outside the historical region of a construction company. The development of the IFD based, CILECCTA's mapping tool, will overcome significant barriers' in this area.

The greatest impact of the CILECCTA project will be on enterprises that are developing assets for medium to long term use. The generation of sustainable alternatives and the ability to choose carefully between them on an economic, whole life cycle cost basis has never been so important to such organisations. Secondary impacts on the construction sector will be no less important. These will include:

- Greater certainty in planning decisions
- Improved resource efficiency in asset development, use, maintenance and demolition for recycling
- Availability of 100% of construction products on the EU-wide open market
- Enhanced communications and information transfer amongst the workforce at and between sites.

Described in simple terms, the different stages in the life of a building include: specification – design – construction – operation and refurbishment – demolition. The CILECCTA Software is first off all useful in the beginning, the specification phase. It will be a powerful method for considering environmental and cost factors from all the stages in the life of a building already before the construction starts. By including cost and environmental effects of the on-site construction process and off-site industrial production a fair comparison can be made. The CILECCTA Software will support collaborative work where the various stakeholders interact and influence each other's values and proposals, working with a life cycle focus. For example, on-site construction leads to more waste and waste handling than factory-made building elements, and the advantages will be visible during an evaluation of alternatives. A widespread use of the software, including a connection to updated databases with the latest industrially made building elements, will support a faster uptake in the sector.

For an industry that is dominated by SMEs it is vital that all the CILECCTA developments can be implemented by all enterprises – no matter what their size. It is very important therefore to create software that is intuitive, easy to use in any language and accessible to all construction staff whether on or away from site. Reaching SMEs with the software will be the single most important achievement – enabling an SME-dominated sector to become a fully efficient, knowledge-based and value-added network.