WORK PACKAGE 4

REPORT D4.1

Overview report on LCC approaches, tools and indicators

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Ad Work Packages 1: Overview of LCCA concepts and their connection with property valuation

Full title of the Project: Improving the market impact of energy certification by introducing energy efficiency and life-cycle cost into property valuation practice

Acronym of the Project: IMMOVALUE

Agreement N°: IEE/07/553/SI2.499204

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Project website: www.immovalue.org

I. Table of Content

II. Glossary

IDM	Information Delivery Manual
IFC	Industry Foundation Classes
IFD	International Framework of Dictionaries
IRR	Internal Rate of Return
LCC	Life Cycle Costing
LCCA	Life Cycle Costing Analysis
NPV	Net Present Value
PV	Present Value
SW	Software

III. Index of Figures and Tables

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1 Introduction

Energy certificates are documents that profile the energy performance of new and existing buildings in the European Union. They are based on the Directive on the Energy Performance of Buildings (2002/91/EC), which is considered important for the European Union's goal of meeting the requirements of the Kyoto agreement. The European Commission's action plan for Energy Efficiency states that energy efficiency in the building sector is a top priority. The 4th of January 2006 was the deadline for the 25 member states to implement the directive in national law.[1]

In Work Package 4 of the ImmoValue project the goal is to provide an overview of LCCA (Life Cycle Costing Analysis) concepts and their connection with property valuation. The idea is that the information in Energy Certificates can be used together with other information in the analysis of a building's LCC (Life Cycle Cost), and that the results can be relevant for the valuation of new and existing buildings.

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[1] Further information about the directive can be found on this webpage: http://www.buildingsplatform.eu/cms/index.php?id=8

2 Different LCC approaches

The basic idea behind the LCC approach is that every cost related to a building should be included when economically assessing and comparing building projects. The simplest way to assess the cost of a building is to look at the cost of the initial investment. This can however lead to economically suboptimal comparisons. Building A might have lower investment costs than building B, but building A can still be more expensive in the long run. The reason is that the running costs of the building B might be so much lower that they more than level out the higher initial investment.

ISO15688-1 defines the life-cycle cost method as "*A technique which enables comparative cost assessment to be made over a specific period of time, taking into account all relevant economic factors both on terms of initial capital costs and future operational costs*".

One ideally wants one single number that takes into account both the initial and the running costs of a building. To do this one has to compare expenses happening at different points in time. There are some variations to how to do this, but most of them are quite similar and yield similar result. In addition it is often desirable to create LCC-indicators that provide additional information, and these can be relevant for valuation.

2.1 Some LCC concepts

In LCCA there are many different concepts that are used to compare the economic attractiveness of alternative investments. The most important is probably Present Value, but other concepts are also explained below. They are all typically used for an alternative relative to a base case.

2.1.1 Present Value

(1) $L = \sum_t \frac{C_t}{(1+i)^t}$

In Formula 1) L is the value of all present and future cost in today's money value of a series of costs (Ct) happening at specific points in time (t) in the future (t is a year in the economic life time of the building; T is the set of all years in this economic lifetime), deflated with the interest rate *i*. This formula assumes that the deflator is constant over time, but it is simple to generalize if wanted.

L is one way to estimate the Life Cycle Cost (LCC).

It is important to note that one has to make a few decisions to get the correct number for L in formula 1:

a) What is the predicted cost for each of the years we consider. Initial, each year between, and final.
b) Related to a), how many years do we consider (what is the economic life time of the building). Notice that the costs in the last period might be negative (a negative cost = an income if there is a residual value in the building) or that it might include costs for demolition etc.
c) What is the deflator we use to compare costs at different point in time (for simplicity it is a constant). This can be different across individuals, firms, markets and countries. It can also be seen as a function of risk – an investment with higher uncertainty typically comes with higher demands for expected profit.

2.1.2 Average yearly cost

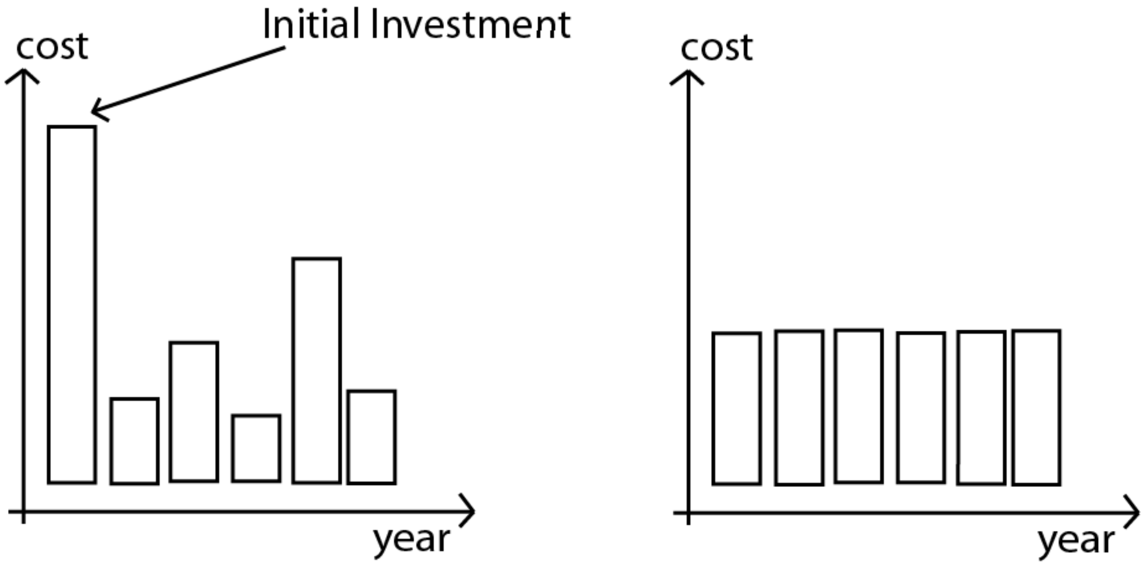

Figure 1, panel a and b: The basic idea behind Yearly Cost

Figure 1a shows the costs as they happen year by year. It is shown above (formula 2) how this can be used to calculate the Total present cost (L) by deflating the costs each year. For some situations it can be easier to relate to the equivalent “average yearly cost” (Figure 1b). The average yearly cost is the value (a scalar) that gives the same Life Cycle Cost as the vector of different costs as used in formula 2. This can be calculated using standard formulas in spreadsheets like Microsoft Excel or OpenOffice.org.

2.1.3 Savings-to-Investment ratio

Savings-to-investment ratio is the ratio of operational savings to difference in capital investment cost. Notice that since this is a ratio it might give a different ranking than for instance the present value formula.

2.1.4 Discounted Payback Time

Discounted payback time is the time required for the cumulative savings from an alternative to recover its initial investment cost and other accrued costs, taking into account the time value of money. It does sometimes give "dangerous" results when it comes to ranking. Being careful if one uses the Payback Time method is especially important in building projects since there tends to be large differences in net income from year to year. There are for instance often large costs in some years into the project when major parts of the building have reached the end of their economic life time.

2.1.5 Internal rate of return

The Internal rate of return (IRR) is the annualized effective return rate on the investment. In other words, another way, the IRR is the discount rate that would make the net present value of the investment's income stream equal to zero.

2.2 Doing LCC calculations in different phases in the buildings (pre)life

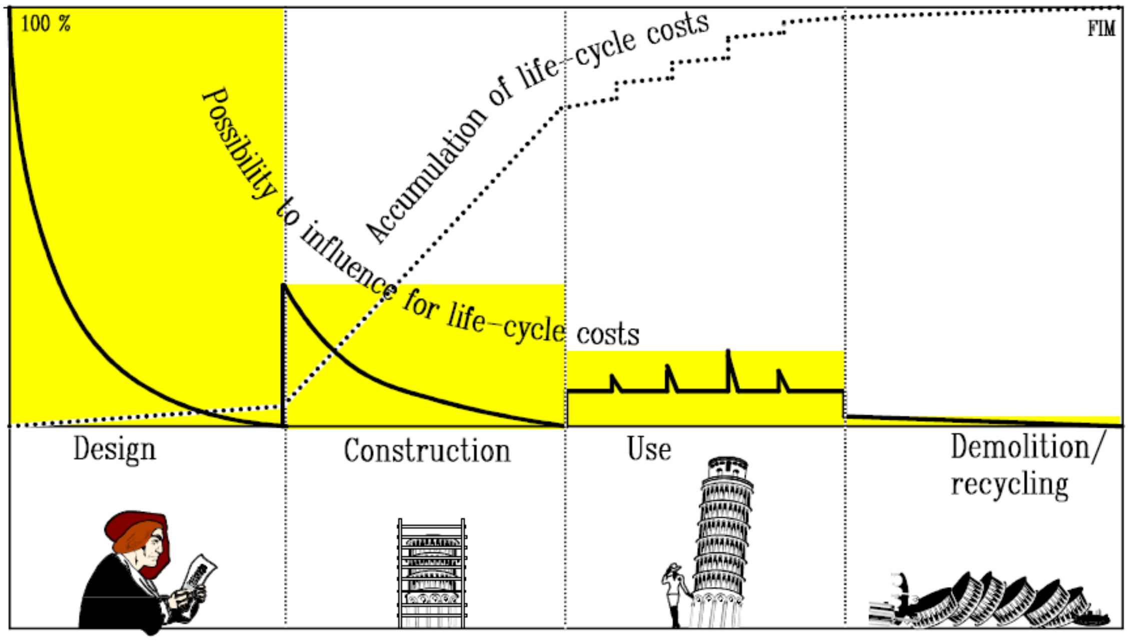

Figure 2: Most parts of life-cycle cost are fixed in early design stages. From Lacasse and Vanier (1999).

LCC can be carried out in different phases of a buildings life. The economic cost of changing the energy performance of a building is typically lower when it is in early planning than if it is already in use, but there might exist “windows of opportunity” to improve the energy performance of a building if parts of it are getting near its end-of-life. In these cases it is necessary to replace the components anyway if the building is to be used in the future, and the net cost of choosing components with better energy performance can be lower.

2.3 The framework suggested by Davis Langdon

The European Commission appointed Davis Langdon in 2006 to develop a common European methodology for LCC. In Langdon (2006) it is stated that „*It was recognised early in the project that LCC is applied in various ways and with different parameters across the EU, and that a single prescriptive methodology would not be appropriate*”. Based on this his report delivers “[..]*a methodological framework for common and consistent application of LCC across the EU without attempting to replace country-specific decision models and approaches*”. Langdon (2006) suggest the following series of steps (and details them) to carry out a LCC analysis, and writes that it is intended to be compatible with ISO 15686-5:

1. Identify the main purpose of the LCC analysis

2. Identity the initial scope of the analysis
3. Identify the extent to which sustainable analysis relates to LCC
4. Identify the period of analysis and the methods of economic valuation
5. Identify the need for additional analysis (risk/uncertainty and sensitivity analysis)
6. Identify project and asset requirements
7. Identify options to be included in the LCC exercise and cost items to be considered
8. Assemble cost and time (asset performance and other) data to be used in the LCC analysis
9. Verify values of financial parameters and period analysis
10. Review risk strategy and carry out preliminary uncertainty/risk analysis [optional]
11. Perform required economic evaluation
12. Carry out detailed risk/uncertainty analysis [optional]
13. Carry out sensitivity analyses [optional]
14. Interpret and present initial results in required format
15. Present final results in required format and prepare a final report

2.4 A useful notation for LCC in the ImmoValue project

The focus in the ImmoValue project is on energy usage/-costs relates to LCC in the perspective of Energy Certificates. If one splits the cost from formula 1) into I (initial investment), E (energy cost vector), M (maintenance cost), O (other costs), and R (residual cost at the last period – might be negative) one can rewrite this equation as:

$$(2)\ L = I_o + \sum_t \frac{E_t + M_t + O_t}{(1+i)^t} + \frac{R}{(1+i)^T}$$

We can decompose the energy costs further into prices and quantities

$$(3)\ L = I_o + \sum_{t=1..T} \frac{\left(p_t^1 * q_t^1 + p_t^2 * q_t^2 * ... * p_t^N * q_t^N\right) + M_t + O_t}{(1+i)^t} + \frac{R}{(1+i)^T}$$

$$= I_o + \sum_{t=1..T} \frac{\sum_{j=1..J}\left(p_t^j * q_t^j\right) + M_t + O_t}{(1+i)^t} + \frac{R}{(1+i)^T}$$

Where j is the index of different energy types (in total J different types). p_t^j is the price of energy source j at time t, while q_t^j is the quantity used of energy source j at time t.

Notice that q, the unit price of each of the energy units (electricity, oil, gas, water born heating etc) has a time notation. It does not have to be constant across time. This allows us to calculate cases where the unit prices for energy have different paths across time.

Formula 3 is useful for considering LCC and creating LCC-indicators (paper D4.2). It directly shows how changes in prices and quantities of different energy sources influences the total Life Cycle Cost, and also the effects of investment cost, maintenance cost, residual costs, other costs and the deflator.

The example most often used in this context is one where a larger initial investment leads to lower LCC costs because of more energy efficient technical solutions. It follows from formula 3 that the higher the energy prices are (the p_j parts), the larger the initial investment in energy efficient solutions can be for a given saving in energy usage (the q_j parts). However, this must bee seen in the light of possible differences in investment costs, residual costs, maintenance costs and other costs. Even the applied deflator might vary because differences in sensitivity might imply a different risk premium.

2.5 Monte Carlo and Sensitivity analysis

ISO 15686-5 mentions Monte Carlo as one way of take uncertainty into account. Using Monte Carlo analysis[2] allows using a distribution of possible costs when calculating the Life Cycle Cost. A client might be interested in seeing the total cost calculated using this method, using for instance 10 percent, 50 percent and 90 percent confidence intervals.

Another way of taking uncertainty under account mentioned in ISO 15686-5 is sensitivity analysis. Sensitivity analysis measures how variation(s)/uncertainty in the output of a mathematical model is changed, qualitatively or quantitatively, to different inputs in the model. In the context of the ImmoValue project the most interesting aspect for sensitivity analysis is changes in Investment costs and operating costs. It can be very informative to see

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[2] See to the following link to Wikipedia for the mathematical/computational details behind the Monte Carlo method: http://en.wikipedia.org/wiki/Monte_Carlo_analysis

how the Present Value of different project alternatives changes with different assumptions in energy prices and changes in other indicators.

Monte Carlo and Sensitivity analysis are relevant for the ImmoValue project since buildings with different energy performance and other differences relating to LCC-indicators might have different risk and sensitivity associated with them. For instance energy prices and maintenance cost might have different uncertainty profiles in an energy efficient building.

2.6 Datamine and data used in LCC

Datamine[3] is a project that is relevant for ImmoValue. Its goal is to implement a harmonised structure for data gathering, based on information that is gathered by issuing Energy Certificates.

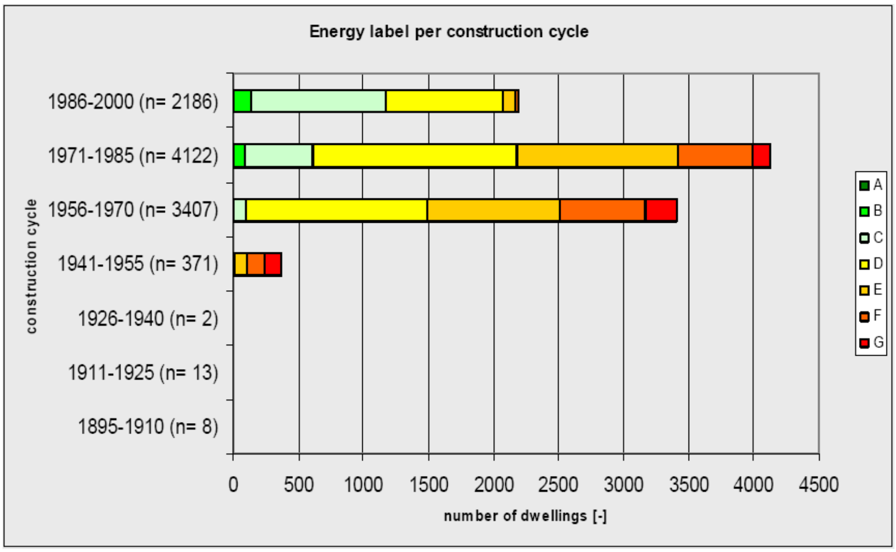

Figure 3: Energy label per construction cycle. From the executive summary in the Datamine project.

Figure 3 shows a graph illustrating the energy certificate buildings constructed in different times period would get. It indicates that newer buildings have far better technical energy performance than older ones, but the potential might be much larger.

In the Datamine project an approach for gathering the following types of data was developed:

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[3] Information, results and publications from the Datamine project can be found on this url: http://env.meteo.noa.gr/datamine/

A. Energy Certificate Data
Basic data of the energy certificate, e.g. certification date, classification of the building according to the national indicators which are used in the energy certificates

B. General data of the building
Basic data of the type and size of the building: e.g. location (city), building utilisation, conditioned floor area

C. Building envelope data
Data describing the thermal performance of the building envelope (enclosing the heated part of the building): U-values and area of the elements, window properties

D. System Data
Data describing the building energy supply systems, e.g. type of heat generation systems, type of heat distribution systems, information on air conditioning systems

E. Calculated Energy Demand (Asset Rating)
Quantitative results of asset rating e.g. heat demand, hot water demand, energy input and output of heat generators and air conditioning equipment, boundary conditions of asset rating

F. Basic Parameters of Operational Rating
Information on the basic conditions of operational rating, the outcome (measured energy consumption) is indicated in the following chapter G

G. Summary of Energy Consumption and Energy Generation
Summary of end energy consumption and energy generation, in the first place for operational rating but also for asset rating.

H. Primary Energy, CO2 Emissions and benchmarks
Primary energy demand and CO2 emissions for both operational and asset rating

Figure 4: The different types of data that the Datamine project focused on.

3 LCC tools

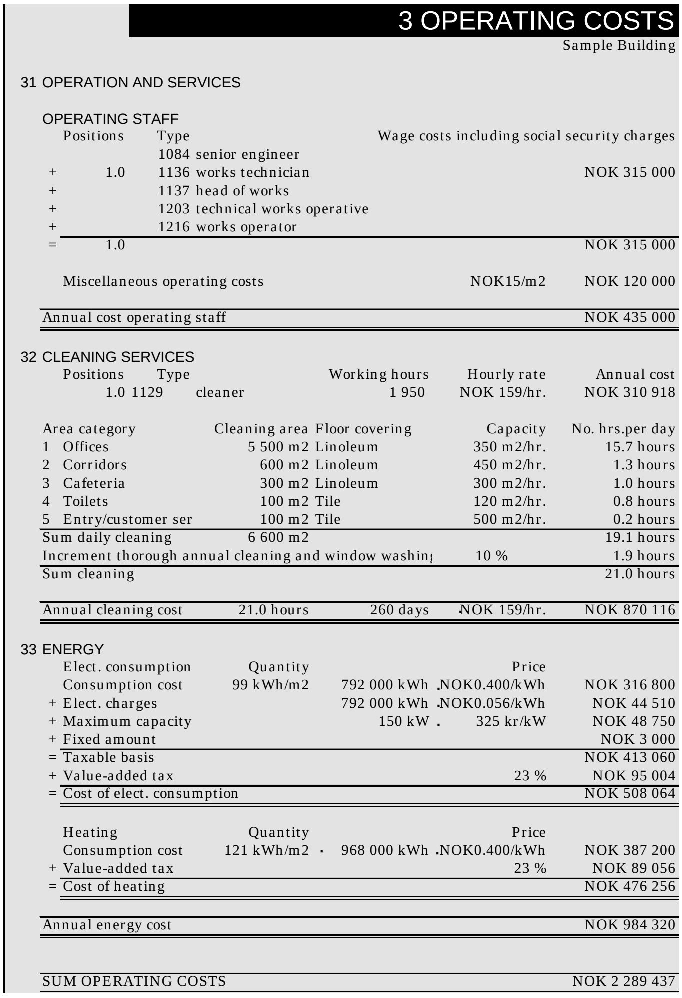
There is at large number of LCC software packages available on the market. Not surprisingly, many of them offer very similar functionality.

These tools have in common that they provide estimates of the Life cycle cost of buildings, but they require different inputs depending on their intended usage. Some are buttom-up, some are top-down.

All of the reviewed LCC tools provide information that can be used to create relevant LCC-indicators for valuing. They typically output information such as energy usage per local area unit, maintenance costs per local area unit, etc.

3.1 LC-profit

A good example of typical LCC software is LC-profit – a free package from “Statsbygg” (a large Norwegian property owner and developer on behalf on the Norwegian government). This software is freely available in English (both the program and the user documentation), and can serve as an example of what is available on the market.



3 OPERATING COSTS

Sample Building

31 OPERATION AND SERVICES

OPERATING STAFF

	Positions	Type	Wage costs including social security charges
		1084 senior engineer	
+	1.0	1136 works technician	NOK 315 000
+		1137 head of works	
+		1203 technical works operative	
+		1216 works operator	
=	1.0		NOK 315 000

Miscellaneous operating costs	NOK15/m2	NOK 120 000
Annual cost operating staff		NOK 435 000

32 CLEANING SERVICES

Positions	Type	Working hours	Hourly rate	Annual cost
1.0	1129 cleaner	1 950	NOK 159/hr.	NOK 310 918

Area category	Cleaning area	Floor covering	Capacity	No. hrs.per day
1 Offices	5 500 m2	Linoleum	350 m2/hr.	15.7 hours
2 Corridors	600 m2	Linoleum	450 m2/hr.	1.3 hours
3 Cafeteria	300 m2	Linoleum	300 m2/hr.	1.0 hours
4 Toilets	100 m2	Tile	120 m2/hr.	0.8 hours
5 Entry/customer ser	100 m2	Tile	500 m2/hr.	0.2 hours
Sum daily cleaning	6 600 m2			19.1 hours
Increment thorough annual cleaning and window washin			10 %	1.9 hours
Sum cleaning				21.0 hours

Annual cleaning cost	21.0 hours	260 days	NOK 159/hr.	NOK 870 116

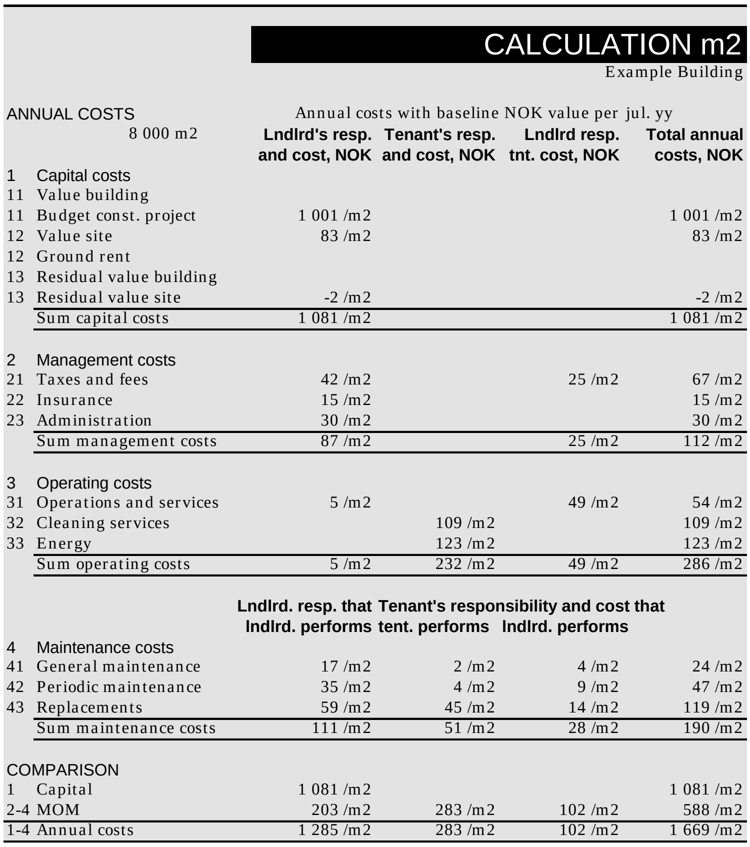
33 ENERGY

	Elect. consumption	Quantity		Price	
	Consumption cost	99 kWh/m2	792 000 kWh	NOK0.400/kWh	NOK 316 800
+	Elect. charges		792 000 kWh	NOK0.056/kWh	NOK 44 510
+	Maximum capacity		150 kW	325 kr/kW	NOK 48 750
+	Fixed amount				NOK 3 000
=	Taxable basis				NOK 413 060
+	Value-added tax			23 %	NOK 95 004
=	Cost of elect. consumption				NOK 508 064

	Heating	Quantity		Price	
	Consumption cost	121 kWh/m2	968 000 kWh	NOK0.400/kWh	NOK 387 200
+	Value-added tax			23 %	NOK 89 056
=	Cost of heating				NOK 476 256

Annual energy cost	NOK 984 320
SUM OPERATING COSTS	NOK 2 289 437

Figure 5a: LC-profit, screen showing operating cost



CALCULATION m2

Example Building

ANNUAL COSTS	8 000 m2	Annual costs with baseline NOK value per jul. yy Lndlrd's resp. and cost, NOK	Tenant's resp. and cost, NOK	Lndlrd resp. tnt. cost, NOK	Total annual costs, NOK
1	Capital costs				
11	Value building				
11	Budget const. project	1 001 /m2			1 001 /m2
12	Value site	83 /m2			83 /m2
12	Ground rent				
13	Residual value building				
13	Residual value site	-2 /m2			-2 /m2
	Sum capital costs	1 081 /m2			1 081 /m2
2	Management costs				
21	Taxes and fees	42 /m2		25 /m2	67 /m2
22	Insurance	15 /m2			15 /m2
23	Administration	30 /m2			30 /m2
	Sum management costs	87 /m2		25 /m2	112 /m2
3	Operating costs				
31	Operations and services	5 /m2		49 /m2	54 /m2
32	Cleaning services		109 /m2		109 /m2
33	Energy		123 /m2		123 /m2
	Sum operating costs	5 /m2	232 /m2	49 /m2	286 /m2
		Lndlrd. resp. that lndlrd. performs	Tenant's responsibility and cost that tent. performs	lndlrd. performs	
4	Maintenance costs				
41	General maintenance	17 /m2	2 /m2	4 /m2	24 /m2
42	Periodic maintenance	35 /m2	4 /m2	9 /m2	47 /m2
43	Replacements	59 /m2	45 /m2	14 /m2	119 /m2
	Sum maintenance costs	111 /m2	51 /m2	28 /m2	190 /m2
COMPARISON					
1	Capital	1 081 /m2			1 081 /m2
2-4	MOM	203 /m2	283 /m2	102 /m2	588 /m2
1-4	Annual costs	1 285 /m2	283 /m2	102 /m2	1 669 /m2

Figure 5b: LC-profit calculation screen.

The input in LC-profit can be either detailed unit costs, performance aspects and quantities for the whole building, or parts of similar buildings if the purpose is to calculate differences in LCC-aspects for two alternatives or two existing buildings when doing valuing.

3.2 BLCC

U.S. Department of Energy provides a software package called BLCC (“Building Life-Cycle Cost”). It is described[4] as “The BLCC computer programs conduct economic analyses by evaluating the relative cost effectiveness of alternative buildings and building-related systems or components. Typically, BLCC software is used to evaluate alternative designs that have higher initial costs but lower operating-related costs over the project life than the lowest-initial-cost design. It is especially useful for evaluating the costs and benefits of energy and water conservation and renewable energy projects. The life-cycle cost (LCC) of two or more alternative designs are computed and compared to determine which has the lowest LCC and is

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[4] This description is from: http://www1.eere.energy.gov/femp/information/download_blcc.html

therefore more economical in the long run. BLCC also calculates comparative economic measures for alternative designs, including Net Savings, Savings-to-Investment Ratio, Adjusted Internal Rate of Return, and Years to Payback. The software can evaluate federal, state, and local government projects for both new and existing buildings. BLCC also contains a module for evaluating non-profit and for-profit projects in the private sector. While the BLCC programs are oriented toward building-related decisions, they can be used to evaluate alternative designs for almost any project type in which higher capital investment costs result in lower future operating-related costs."

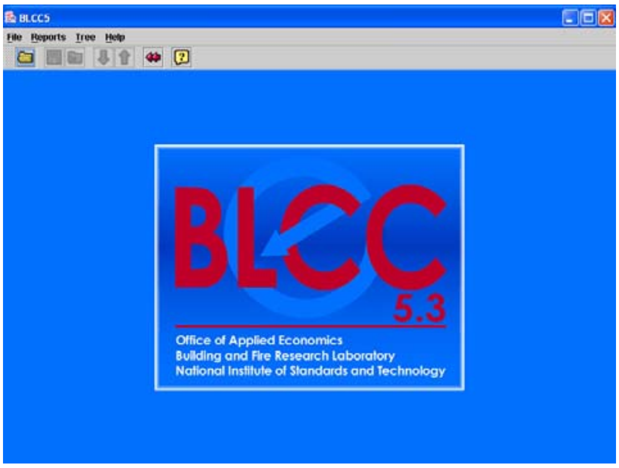
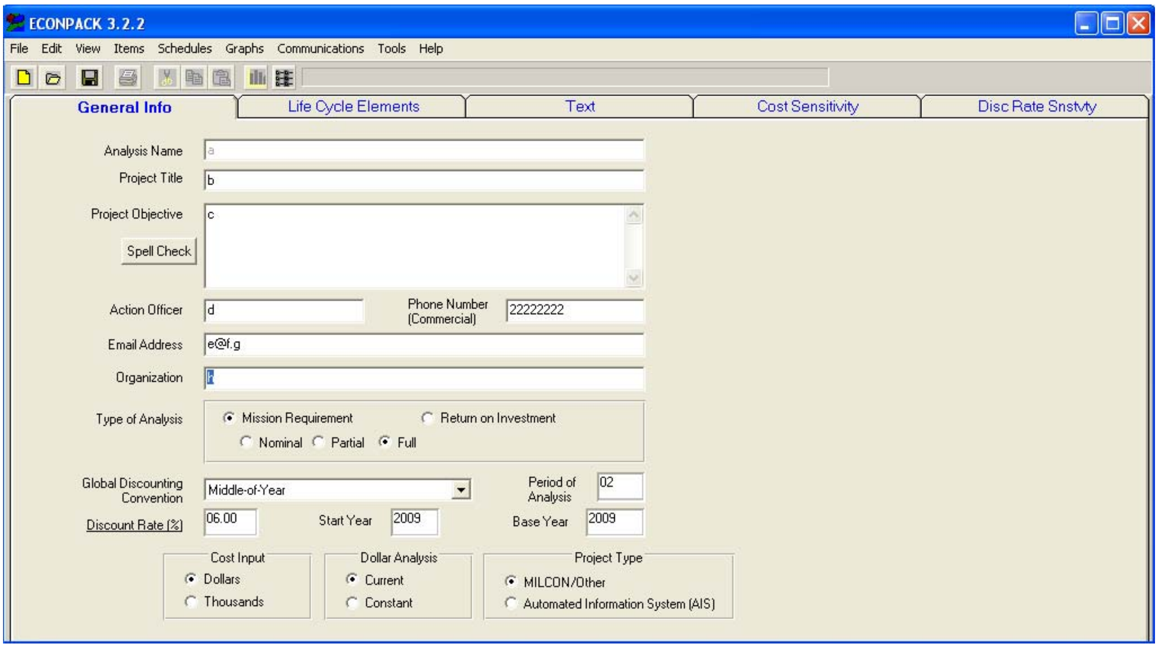


Figure 6: BLCC5

3.3 EconPack



Analysis Name: a
Project Title: b
Project Objective: c
Action Officer: d
Phone Number (Commercial): 22222222
Email Address: e@f.g
Organization: h
Type of Analysis: ● Mission Requirement ○ Return on Investment
○ Nominal ○ Partial ● Full
Global Discounting Convention: Middle-of-Year
Period of Analysis: 02
Discount Rate (%): 06.00
Start Year: 2009
Base Year: 2009
Cost Input: ● Dollars ○ Thousands
Dollar Analysis: ● Current ○ Constant
Project Type: ● MILCON/Other ○ Automated Information System (AIS)

Figure 7: EconPack version 3.2.2

ECONPACK (Economic Analysis Package) is a economic analysis package for economic analysis calculations, documentation and reporting. It is provided by the U.S. Army Corps of Engineers (USACE) and is presented as “*The analytic capabilities of ECONPACK are generic, providing standardized economic analysis methodologies and calculations to evaluate a broad range of capital investment categories such as barracks, hospitals, family housing, information systems, utility plants, maintenance facilities, ranges, runways, commercially financed facilities, and equipment.*”

3.4 LEGEP

LEGEP is an integrated software tool for calculation and estimation of buildings of any use. It includes the building costs, life-cycle-costs (cleaning, maintenance, refurbishment, demolition), energy consumption, ecological impact. .It can be used for new buildings or existing buildings.

LEGEP is a tool for integrated life-cycle analysis. It supports the planning teams in the design, construction, quantity surveying and evaluation of new or existing buildings or building products. The LEGEP database contains the description of all elements of a building (based on German standard DIN 276); their life cycle costs (LCC/WLC) based on DIN 18960 and the final report EU-TG4 LCC in Construction[5]. All information is structured along life cycle phases (construction, maintenance, operation (cleaning), refurbishment and demolition. LEGEP establishes the energy needs for heating, warm-water, electricity and their costs (following EnEV 2002 and EN 832). The environmental assessment comprises the material flows (input and waste) as well as an effect oriented evaluation based on ISO 14040 – 43.

LEGEP is organised along four software tools, each with its own database. The method is based on cost planning by "elements". The database is hierarchically organised, starting with the LCI-data at the bottom, building material data, work-process description, simple elements for material layers, composed elements like windows, and ends with macro-elements like building objects. The data are fully scalable and can be used either "bottom-up" or "top-down".

Output of LEGEP at each phase is a complete, interrelated set of cost, energy, mass-flow and environmental indicators. The number of indicators, which are displayed, can be chosen from the CML indicators. Additional indicators are under implementation (DALY etc.). It is possible to show separately specific indicators or all indicators, for each life cycle phase (new construction, operation, cleaning, maintenance, refurbishment, demolition) of the building.

3.5 RELEX LCC

Relex Life Cycle Cost (LCC) is a tool that calculates the cost of your product over its lifetime. You may include many different types of costs such as design, production, warranty and repair, and disposal. Relex LCC provides support for parametric, analogy, bottom-up, and direct cost analysis types.

By taking inflation factors and different designs into account, you can easily perform a trade-off study of various alternatives over your equipment's lifetime. For example, you may wish to compare an item with a higher initial cost and lower repair costs to an item with a lower initial cost and higher repair costs. You may also want to compare the cost of upgrading existing equipment versus procuring new equipment.

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[5] http://ec.europa.eu/enterprise/construction/suscon/tgs/tg4/lccreport.pdf

This tool is not developed for buildings, but for products and/or projects in general.

More tools for life cycle and life cycle cost assessment can be found on the following website of the European Union:
http://lca.jrc.ec.europa.eu/lcainfohub_test/toolList.vm

3.6 Next generation of LCC tools using IFC, IFD and IDM ?

Several software companies have seen the large potential that lies in LCC calculations using open standards such as IFC[6], IFD[7] and IDM[8]. These calculations can be simple to perform for the user, but at the same time be very powerful since they can be based on Building Information Models (BIMs). In a BIM each of the physical and abstract objects can be associated with detailed information relevant for an LCC calculation.

IFD in itself and together with IFC provides a very large potential for information exchange in the construction industry, between different role, different phases, different projects and different languages. Further information on IFD can be found in the IFD White Paper.[9]

3.7 Prototype version of Calcus

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[6] IFC is an acronym for Industry Foundation Classes. It is an open international standard for storing and exchanging information in Building Information models.

[7] International Framework of Dictionaries. It is an open international standard and a format for defining unique and language-independent terms. It has started to get considerable attention in the construction industry.

[8] Information Delivery Manual. IFC describes what information should be exchange between different roles in the building process, at what time – and how it should be exchanged.

[99] http://www.ifd-library.org/images/IFD_Library_White_Paper_2008-04-10_I_.pdf

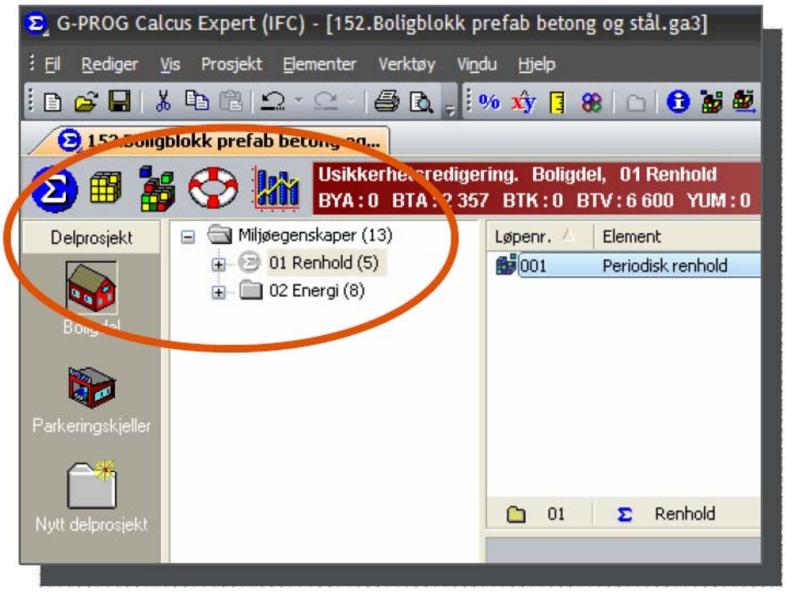

Figure 8: Screenshot from a demo version of a future version of the software tool Calcus from NOIS.

Calcus (Figure 8) is a software tool from the Norwegian Software Developer NOIS. Calcus is used to calculate costs/material requirements etc. in an early phase of a building project. These calculations can be based on a set of built in prototypes for different classes of buildings (schools, blocks-of-flats, etc.).

Sponsored by ”Byggekostnadsprogrammet” [10] in Norway NOIS and its partners are developing a software solution where LCC data is associated with each of the objects in the database that contains prototypes of buildings. The implication is that if the work is done to calculate the initial cost of a building there is no extra work to do a LCC calculation.

NOIS is in the process of building IFC support into Calcus. It is not known at this time if Calcus will be using IFD to associate LCC data with the objects in its database, but technically this should be possible.

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[10] ”Byggekostnadsprogrammet” is a Norwegian organisation that funds projects and initiatives that can improve the productivity and competetivness of the construction industry in Norway.

4 LCC indicators

An indicator can be defined as a number, symbol or special term that says something relevant about what we are interested in.

In this context the data that is directly used to do calculation on energy usage etc. has not been considered as an LCC indicator. Only indicators that provide information on their own have been considered.

When it comes to LCC there are several indicators that could be of interest:

a) Monetary – example: energy cost per square meter for lights and heating
b) Energy based – energy usage per year for light and heating in khw/m2
c) Decomposed energy based: as (b) but decomposed into different energy sources (for instance units of oil/m2, units of electicity/m2, units of remote heating/m2).
d) Relative to norm (percentage of norm). “80 percent of average kwh/m2 when it comes to kwh/m2)
e) Relative to norm in different “classes”: “90 percent of average for buildings constructed in 2010”.
f) Adjusted relative to norm (nonlinear scale): “Energy performance is in the 90th percentile”

More details relating possible LCC-based indicators are given in paper D4.2.

Alternative (c) is interesting since it allows for comparisons over time, region and currencies, but it should be combined with at set of Energy prices in order to give directly relevant information about the potential economic consequences of different alternatives. It might also be desirable to provide a scenario showing for instance the consequences for the LCC result if energy prices in the future are significantly higher than today.

IV. Bibliography

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