Calculating life cycle cost in the early design phase to encourage energy efficient and sustainable buildings

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Extended Abstract

Consideration of Life Cycle Costs (LCC) during the early planning phases of buildings is insufficient at the moment. The reasons for this are that on the one hand the focus of clients for whom a building is being built most often remains on the initial investment costs. On the other hand available software tools are complex and the data needed to use them properly is vague during the early design phase – the phase where cost minimising can be most efficient.

The Figure below describes the essential problems of existing LCC-tool methods. Today it is common that the projected investment and operating costs of buildings are based on benchmarks of existing buildings. Top-down approaches do not exist in sufficient detail to be used in the early design phases of a building, when different types of building systems with altering costs have to be compared. These approaches are based on categories such as air-conditioned or non-air-conditioned office buildings without paying regard to the particulars of the building design or technical equipment which is used in the building.

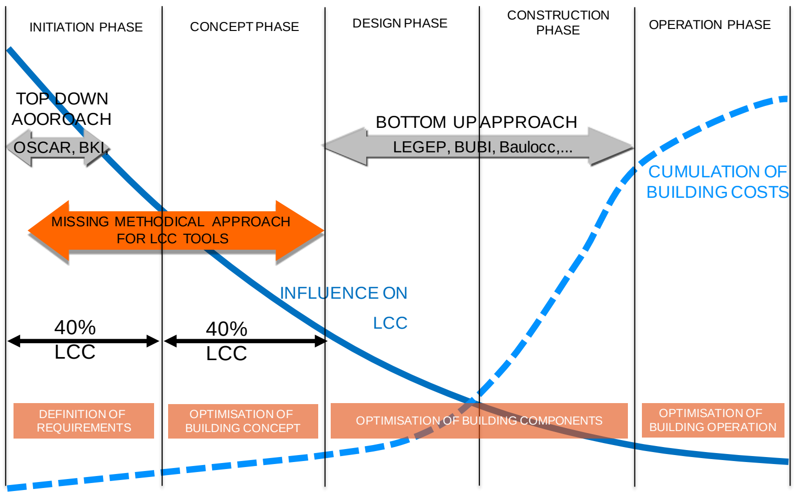

Figure: Missing link in models for calculating life cycle costs during the design phase (Source: original illustration)

Existing software tools for calculation of LCC are based on the bottom-up approach which makes it necessary to enter itemized data (i.e. lime cement plaster, or type of paint coating/finish of paint). On the one hand this requires a great deal of data entry while on the other hand the data is simply not available at the required level of detail in the initiation and early design phases. A quick simulation of different variations, as it is necessary in an iteration process with an integrated planning approach, is only possible through a great expenditure of time and effort.

The objective of the newly developed approach was to model the building in such a way that LCC can already be calculated in the early design phases; even at a point of time when no design for the building is yet available at the definition of requirements. The main concept is to have an 80/20 Pareto principle that is applied in the design process: by using approximately 20 percent of input efforts 80 percent of the indicators should be calculated. Furthermore, the first LCC calculation should be carried out before the first architectural concept is drawn.

The purpose of this LCC model is to calculate costs to provide construction clients of office buildings well-founded basis for decision making in order to:

- inform construction clients about the life cycle costs of buildings in the early demand planning phase: these clients very often do not know about the long term costs of decisions in the demand planning phase. When they can decide on having for instance a passive house at the end of a construction process, they do not know the options and consequences for investment and follow up costs. This is a crucial aspect concerning the decision for sustainable buildings. If consultants and construction clients do not know the financial consequences of their decision in early demand planning phase in detail, this might impede the implementation of energy efficient buildings.

- analyse options for different project solutions in preliminary designs and drafts during the design phases: In this phase, various designs and technical solutions can be analysed regarding the economical effect for the building. By making use of this LCC model as well as the support of a tool, various options concerning design and technology can be analysed very quickly in order to find the optimal economical solutions and not to delay the design process.

In order to make use of this approach models for generating the space allocation program and volume program for the building as well as data for construction costs and operating costs are necessary on an aggregated level. This eventually enables entries to be made before the beginning of design. In addition, an energy calculation model should illustrate the interdependency between the building design, the façade, and the building equipment system. If this is executed in this way, no additional calculation tool is needed. The model design should enable LCC analysis during the design phase for optimisation of the building concept and, to a lesser extent, during the preparation for construction for the optimization of the building components.

By integrating the necessary input data for this model into a software tool, it is possible – with an acceptable expenditure of time and effort – to make reliable statements on prospective investment and operating costs of the building and thereby accelerate the realization of sustainable and energy efficient construction concepts.

The development of a new model for calculating LCC in the early design phase was successfully transferred to the market. There are first projects in the demand planning phase, for architectural competition as well as in the design phase of a building. The results of this model are mainly used to give the construction client valuable information about the future costs of the building.

The development of the mentioned model for early calculation of LCC in the design process was funded by the “ZIT - Die Technologieagentur der Stadt Wien”. The further development of an LCC model for the refurbishment of buildings is supported by the Austrian programme “Haus der Zukunft plus” within the project BIGMODERN.

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Abstract

Consideration of Life Cycle Costs (LCC) during the design phases of construction is insufficient at the moment. The reasons for this are on the one hand based on the fact that the focus of construction clients most often remains on the initial investment costs. On the other hand, available software tools are complex and the data needed to use them properly is vague during the early design phase – the phase where cost minimising can be most efficient. Thus, on the basis of various existing Life Cycle Cost tools, a model which enables detailed forecasts of expected Life Cycle Costs during early design phases was developed.

The new LCC model can illustrate the characteristic values of space efficiency, energy efficiency, and cost efficiency of the investment and operation while presenting an overview of Life Cycle Costs. This is facilitated through:

- separation of the building in about 100 aggregated building elements in varying levels of detail
- database of investment and operating costs for different solutions and different qualities for these aggregated building elements;
- a building model for entry of space allocation and function programs as well as architectural concepts;
- a tailored energy calculation model for realistic energy costs.

All these components are part of the LCC model and were integrated in a software tool. In this way the long-term economic impact of energy efficient buildings can be illustrated quickly during an integrated planning process at the beginning of a building project.

1. Introduction

Life-cycle-costs (LCC) are defined as the total cost of a building or of a specific building component throughout its lifetime, including the costs for planning, design, acquisition, operation, maintenance, demolition and disposal less any residual life. The life-cycle-costs include both investment costs and operational costs throughout the whole functional lifetime, including demolition [1].

Current methods in construction show that in most cases investment cost is still a decisive factor in the construction of a building. However, increasingly it can be seen that the sustainability of a building plays an ever more important role. One of the reasons is the growing demand for buildings with low operating costs coupled with the increasing desire for sustainability evaluation made through sustainable building certification.

LCC is included as a specific criterion in both the German Sustainable Building Council's certification [2] as well as in the Austrian certification for a Total Quality Building [3]. In the German certification system a specific methodology to calculate LCC is defined. The calculation of LCC for the building has to be compared to defined benchmarks in order to receive credits in the sustainability certification scheme. On the contrary, within the Total Quality Building (TQB) system the auditor has to comply with defined calculation standards and has to include certain types of running costs in order to receive credits in the certification system. Standardization proposals are being developed on the European level by CEN's Technical Committee 350. Workgroup 4 of the committee is working on Standard EN 15643-4 [4] for the assessment of economic performance in the framework of a sustainability assessment. LCC is the main indicator for the economic sustainability.

Considering LCC is important in the early design phase in order to optimize the costs for investment and follow up costs. Usually, various options are taken into account in this phase. A Life Cycle Costs Analysis (LCCA) could evaluate these options: What are the consequences in costs of different insulation standards, different energy carriers or different façade systems? Commonly, a more energy efficient building with higher insulation standards has higher costs for the façade, lower costs for the heating system and, consequently, lower energy costs. External shading systems lead to lower costs for the cooling system and lower energy costs, but to higher costs for cleaning and maintenance of these products. This means, that different design options may have consequences on the investment, energy, maintenance, cleaning and operation costs of a building that should be analysed during the design phase. In many cases there is just a shift of running costs, for instance from energy to maintenance and cleaning costs. A LCCA takes all these costs into account. In this concept the "lowest life cycle cost" option, which is pertaining to the building's entire life cycle, is the most economic one [4].

After all, the impact of LCC plays an important role in the value of the real estate. As part of the European project IMMOVALUE [5], research and analysis were conducted on energy efficiency (based on the energy performance certificate), LCC and property value. Findings gathered through interviews [6] showed that sustainable buildings have a higher marketability. At the same time, a clear correlation can be seen between lower operating costs and higher net rent revenues. This illustrates that consideration is given to the inclusion of operation costs in rental costs. International research [7] has shown that sustainable buildings generate higher rent revenues and incur shorter vacancy periods.

These various factors and activities show the growing interest for the methodology of LCC. This method allows for the operating costs of a building to be taken into account at the time of initial investment. Additional information about future operating costs can already be ascertained during early design phases, thereby creating a better basis of available data for planning sustainable buildings.

2. Problem Outline

Figure 1 describes the essential problems of existing LCC approaches. Today it is common that the projected investment and operating costs of buildings are based on benchmarks of existing buildings (e.g. BKI [8], OSCAR [9]). Top-down approaches do not exist in sufficient detail to be used in the early design phases of a building, when different types of building systems with altering costs have to be compared. These approaches are based on categories such as air-conditioned or non-air-conditioned office buildings without paying regard to the particulars of the building design or technical equipment in use in the building. Furthermore, concepts for energy efficient office buildings or those that implement alternative energy systems are not respectively insufficiently taken into consideration. Since specifications are relevant to the past, obviously they cannot be representative of current sustainable building designs.

Existing software tools for calculation of LCC (e.g. LEGEP [10], BUBI [11], Baulocc [12] available on the German-language market) are based on the bottom-up approach, which makes it necessary to enter itemized data (i.e. lime cement plaster, or type of paint coating/finish of paint). On the one hand this requires a great deal of data entry while on the other hand the data is simply not available at the required level of detail in the initiation and early design phases. A quick simulation of different variations, as it is necessary in an iteration process with an integrated planning approach, is only possible through a great expenditure of time and effort.

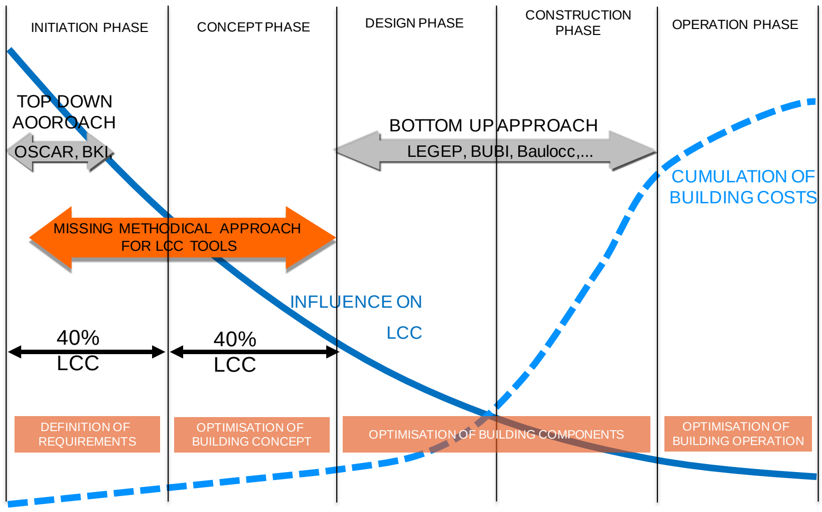

Figure 1: Missing link in models for calculating life cycle costs during the design phase (Source: original illustration)

Likewise, there are countless software programs which calculate economic efficiency or programs for calculating LCC (e.g. LCProfit), that do not come with any cost data pre-sets. Therefore, in order to calculate LCC, the first task is to determine construction and operating costs of the building which again, requires extensive time and effort in the early design phases.
It is exactly in the initial design phase, that taking the long-term economical implications into account is most decisive, as the influence on LCC is most significant in the initial phase of a project. Approximately 80% of all investment and operating costs are determined in the initial and early design phases [13]. Further on in the design phase, the influence on costs declines. Quite the contrary, the accumulation of building costs increases during the design phase. Therefore, it is of the utmost importance to optimize systems in these first phases of a building project. However, just in this period of the project there is a missing link in LCC models in order to assess different design options quickly during the design process.

3. Research Objectives and Purpose

The objective of the newly developed approach was to model the building in such a way that LCC can already be calculated in the early design phases; even at a point of time when no design for the building is yet available at the definition of requirements.

The main concept is to have an 80/20 Pareto principle that is applied in the design process: by using approximately 20 percent of input efforts 80 percent of the indicators should be calculated. Furthermore, the first LCC calculation should be carried out before the first architectural concept is drawn.

The purpose of this LCC model is to calculate costs to provide construction clients of office buildings well-founded basis for decision making in order to:

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- analyse options for different projects solution in preliminary designs and drafts during the design phases. In this phase, various designs and technical solutions will be analysed regarding the economical effect for the building. By making use of the mentioned LCC model as well as the supportof a tool, various options concerning design and technology can be analysed very quickly in order to find the optimal economical solutions and not to delay the design process.

By integrating the necessary input data for this model into a software tool, it should be possible – with an acceptable expenditure of time and effort – to make reliable statements on prospective investment and operating costs of the building and thereby accelerate the realization of sustainable and energy efficient construction concepts.

4. Methodical approach

Figure 2 shows the different phases of a design process. In the initiation phase the requirements are defined. For instance which total area is needed, which quality of building should be carried out? When the requirements are defined, the architect designs the first concepts. In this phase the life cycle costs of the general building concept should be optimised. Later on in the design phase LCC of building components will be analysed.

In order to make use of this approach, models for generating the space allocation program and volume program for the building as well as data for construction costs and operating costs are necessary on an aggregated level. This eventually enables entries to be made before the beginning of design. In addition, an energy calculation model should illustrate the interdependency between the building design, the façade, and the building equipment system. If this is executed in this way, no additional calculation tool is needed. The model design should enable LCC analysis during the design phase for optimisation of the building concept and, to a lesser extent, during the preparation for construction for the optimization of the building components.

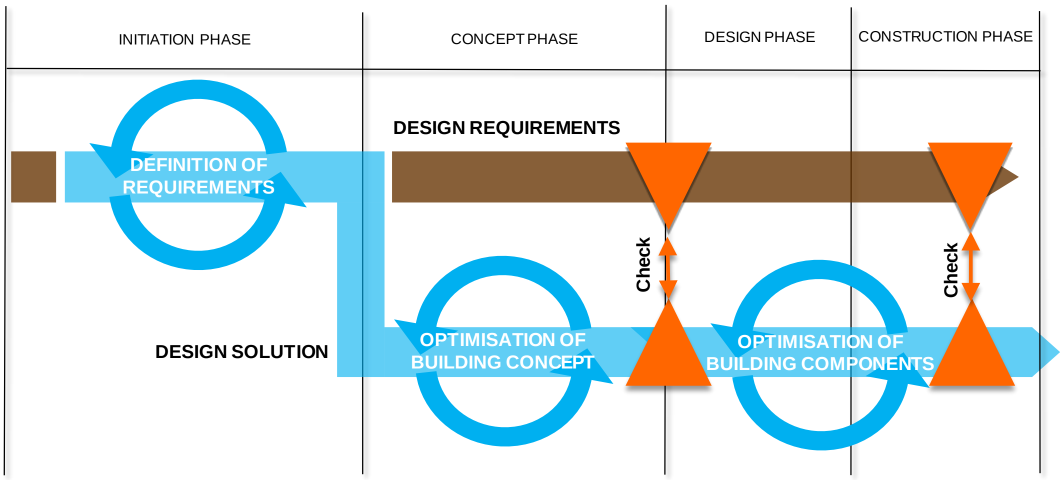

Figure 2: Areas of application of the LCC tool from initiation through to the detailed design phase (Source: original illustration)

5. Realisation of a new LCC model

5.1 Reducing input data

On the one hand there should be little data input comparing to a top-down approach; on the other hand the results should be building specific comparing to a bottom-up method. In order to combine the advantage of the fast cost estimation of the top-down method with the advantage of the accuracy of the bottom-up method it was necessary to take on a new approach.

At the same time, the decision-making process in the design phase was incorporated into the model with great detail. Figure 3 describes the decision making process in a building project. At the bottom there are the stages of life, beginning from acquisition to operation and disposal of the building. On the vertical axis there are the different levels of detail in the decision process. Furthermore, different parts of the building such as structure, envelope, services and finishes are mentioned separately. In general, decisions are made mainly at the strategic phase and system levels during the stage before the construction of a building as shown in figure 3.

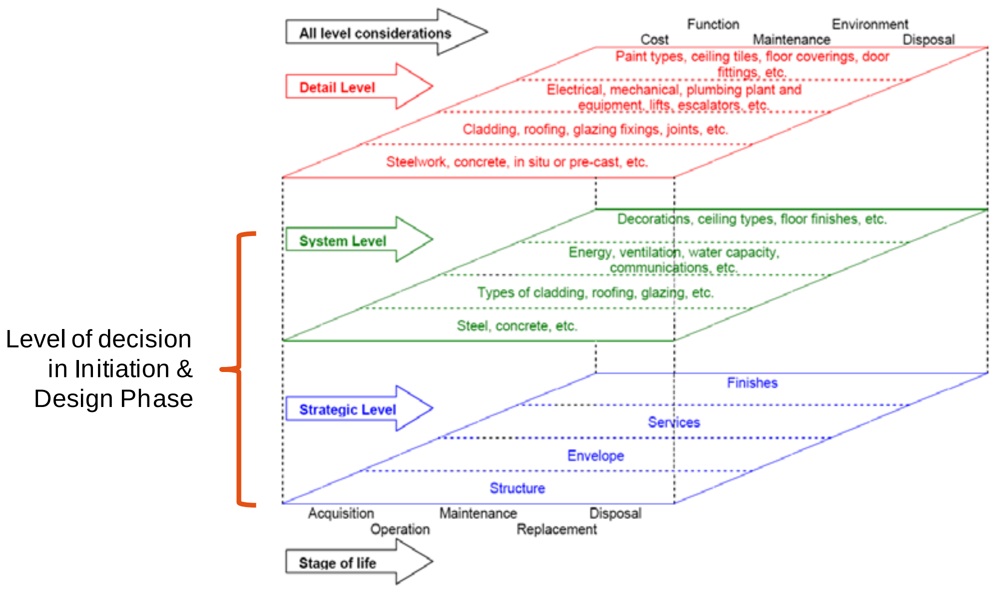

Figure 3: Levels in the decision-making process (Source: European Commission [14])

For this reason, the building was divided into aggregated building elements with the aim of reducing input data. These elements were evaluated regarding the influence on costs and in total amount of a building. Moreover, the relevance for system decisions in the early design phase was taken into account.

Concerning the building, the impact of the various usage areas on cost was investigated, focussing on outlining the effect of special spaces on cost compared with main usage “office” spaces. The primary utilization of an office building, as the names suggest, is for office and administrative use. The main usage spaces are complimented by decentralized spaces such as staircases, elevators, restrooms, as well as centralized special usage areas such as conference rooms, the lobby, cafeteria(s), storage areas or carports. The essential system decisions are made based on the main usage which also generates the main source of costs. Consequently, the building elements for the main usage areas (“office” spaces) need to be provided at a different level of detail than for the special usage areas.

Based on cost analysis, building elements were defined at different levels of detail. Depending on the influence of the usage, aggregation of the building elements was carried out at a different level. For the main usage area, “office”, cost relevant issues are compiled at the level of elements (as defined by Austrian Standard ÖNÖRM B 1801-1 [15]), for less cost relevant issues or planning elements in less cost relevant usage areas at the level of cost ranges (as defined by ÖNORM B 1801-1 [15]).

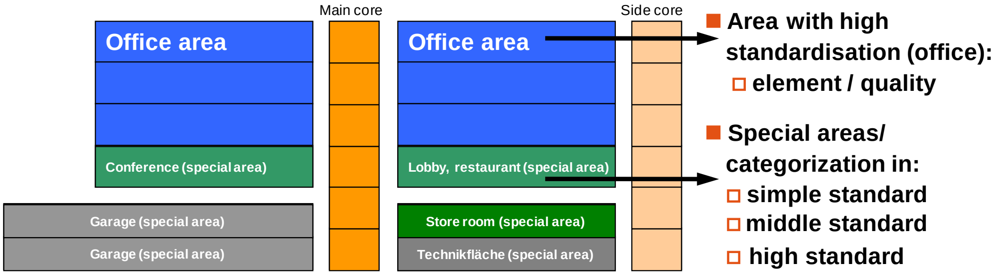

Figure 4: Structure of costs for the main usage “office” space and special usage space (Source: original illustration)

The building elements were consequently compiled from bottom-up aggregated items for the relevant cost drivers. Referring to figure 4 the level of detail for building elements are the system level. For less relevant costs ranges and usages they were bottom-up aggregated in a less detailed level and tested against top-down benchmarks, hence a certain imprecision can be tolerated due to the relevance of the data. For this cost data the level of detail is the strategic level. Thus the number of elements and consequently the amount of data entry is reduced significantly.

5.2 Virtual building model

For the modelling of the building, a virtual building model was developed. This building model is based on the experience the company M.O.O.CON acquired as a result of their client consulting on office buildings. Based on the requirements of the client’s brief, the virtual building model can calculate the approximate volume and surface area of the building at a time where no design drafts for the building have been put forward. Aside from the calculation of volume and surface area this tool can also optimize usable floor space. Optimising the use of floor space is a powerful lever for the reduction of construction and operating costs. Through the reduction of conditioned volume, energy costs can also be reduced.
In this process office spaces and other special spaces in the building are combined in different design variations to floors and building cores. Subsequently, the gross floor space is calculated. Thus, it is possible to optimize the floor space even at this point of time, which in turn leads to

lower follow-up costs. Figure 5 shows the model for optimising the floor space: the columns of the table contain the number of office areas adjacent to one staircase, the rows describe the total number of staircases in the building. The letters “HH” define high rise buildings; “FB” means low rise buildings. The numbers in the coloured cells are the total area of the building. By using this model, the type of building with lowest area can be chosen.

Gebäudebereiche / Kern	Anzahl Kerne																							
	1			2			3			4			5			6			7			8		
	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi	Typ	Etagen	NGF oi
1,0	HH	54	nicht möglich	HH	27	nicht möglich	HH	18	32.417	HH	14	31.792	HH	11	31.324	HH	9	31.206	HH	8	30.955	HH	7	30.486
1,5	HH	36	nicht möglich	HH	18	32.611	HH	12	31.752	HH	9	31.400	HH	7	30.820	FB	6	29.625	FB	5	29.498	FB	5	29.404
2,0	HH	27	nicht möglich	HH	14	30.983	HH	9	30.398	HH	7	29.781	FB	5	28.842	FB	5	28.724	FB	4	28.641	FB	3	28.607
2,5	HH	22	32.890	HH	11	30.545	HH	7	29.856	FB	5	28.455	FB	4	28.324	FB	4	28.236	FB	3	28.201	FB	3	28.174
3,0	HH	18	31.912	HH	9	30.193	FB	6	28.555	FB	5	28.334	FB	4	28.232	FB	3	28.191	FB	3	28.161	FB	2	nicht möglich
3,5	HH	16	31.624	HH	8	29.983	FB	5	28.199	FB	4	28.020	FB	3	27.967	FB	3	27.931	FB	2	nicht möglich	FB	2	nicht möglich
4,0	HH	14	30.898	HH	7	29.417	FB	5	27.978	FB	3	27.861	FB	3	27.815	FB	2	nicht möglich	FB	2	nicht möglich	FB	2	nicht möglich
4,5	HH	12	30.775	FB	6	28.153	FB	4	27.893	FB	3	27.789	FB	2	nicht möglich	FB	2	nicht möglich	FB	2	nicht möglich	FB	2	nicht möglich
5,0	HH	11	30.268	FB	5	27.955	FB	4	27.736	FB	3	27.673	FB	2	nicht möglich	FB	2	nicht möglich	FB	2	nicht möglich	FB	1	nicht möglich
5,5	HH	10	30.273	FB	5	27.765	FB	3	27.609	FB	2	nicht möglich	FB	2	nicht möglich	FB	2	nicht möglich	FB	1	nicht möglich	FB	1	nicht möglich
6,0	HH	9	29.942	FB	5	27.643	FB	3	27.499	FB	2	nicht möglich	FB	2	nicht möglich	FB	2	nicht möglich	FB	1	nicht möglich	FB	1	nicht möglich

Figure 5: Output of floor space values per building sector and number of cores. (Source: M.O.O.CON)

With the introduction of an architectural concept, the data in the building volume model is changed in accordance with the significant geometrical dimensions (essential building area data, façade, building orientation). With minimal additional effort for data entry the existing data can be optimally used.

5.3 Cost database

For the calculation of LCC in early design phase it is essential to have a cost database for investment and running costs in order to be able to calculate LCC very quickly. Therefore, based on the defined building elements and different quality levels of decentralized spaces, the costs for more than 1,000 database elements were calculated. Different sources were incorporated for an estimation of the investment and operation cost. These figures were integrated into a database which was specifically developed for this model.

In order to determine the total cost of the elements comprehensive building data was necessary. This was ascertained by drawing on the virtual building model or the architectural concept. As with the aggregation of the building elements, it was also necessary to keep the amount of required data to a minimum for the calculation of comprehensive building data.

Again, the results of the analysis of the cost drivers were drawn to and an attempt to incorporate only a few significant parameters from the building design was made. All other data should be calculated by algorithms based on these entries. The algorithms were derived from design regulations for office buildings, fire safety regulations, work space regulations and years of experience of various projects of M.O.O.CON. The significant parameters for the efficient use of space such as width and structure of building could easily be entered and changed. The data entry was done through a space allocation and function program in the initiation phase. Common measurements of architectural plans provided at this time were used as a basis during the early design phases.

Building elements could be defined and associated with investment and operating costs based on the structure of the usage area as well as significant system decisions, which contributed to the comfort of the interior (acoustics, visual comfort). For a usage area such as a cafeteria, this meant the definition of different building elements for different standards at a level of cost ranges (such as “high quality cafeteria”). For the office areas building elements for flooring, floor construction, office partitions, hallway dividing walls, noise insulation, etc. were defined (e.g. office area, flooring, carpet, high quality carpet). For the building itself, building elements such as façade, HVAC and many more had to be defined.

5.4 Calculation of energy use and energy costs

Founded on the building model of selected building elements and user specified comfort guidelines, it was now possible to calculate energy consumption based on the calculation for the energy certificate complemented by several significant factors such as the influence of thermal mass, different usage areas, the consideration of daylight, the actual energy consumption of different utilities like lighting, cooling, heating and ventilation.

The energy calculation was divided into different degrees of detail. For the main use of the building the energy consumption was calculated according to an energy balance model by using ISO 13790 [16]. Precisely, the Austrian standards for calculating the energy performance certificate were used (ÖNORM B 8110-6 [17], ÖNORM H 5056 [18], ÖNORM H 5057 [19], ÖNORM H 5058 [20]). For detailed calculation of energy demand for lighting the European standard ÖNORM EN 15193 [21] was incorporated taking the use of daylight into account. To be more precise, additional aspects in comparison to the energy performance certificate were included in order to calculate the energy consumption. The thermal mass was calculated based on a detailed assessment of the respective building elements. The operation time of the building could be inserted individually.

The decentralised areas were calculated very roughly. In these areas the usage of space is normally most important for the energy use (e.g. in the kitchen the internal appliances are more important for the energy use than the system of the façade). In these areas the heating and cooling level is depending on the energy balance of the main usage area. Furthermore, energy demand details based on data of DIN 18599-10 [22] and SIA 2024 [23] were integrated without calculation of an energy balance.

Based on the integration of a detailed energy assessment method and by using an individual operation period as well as comfort date, realistic energy usage scenarios could be compiled. Results of the calculation were compared to the general benchmarks of the OSCAR report [9]. Owing to the programming of a software interface the entry of the building model and of the building elements could be directly linked to the energy cost calculation, making any additional step unnecessary. The linking of the building elements to the use of energy calculation allows for an additional correlation between building design and heating and cooling load of the building's central equipment system. Heating and cooling loads are calculated through the entry of the building's volume and façade design. These loads are indicators for the selection of the dimension of the building equipment systems for heating and cooling. An improved insulation of the façade contributes directly to lower investment and operating costs of the building equipment systems. The chosen method of calculating the energy costs also allows for the selection of alternative energy systems such as heat pumps, photo-voltaic and thermal solar systems.

Based on investment and operating costs provided by a per-element basis (originating from the building elements) as well as building specific calculated energy costs it is now possible to calculate LCC using the net present value method or the method of complete financial plans.

By changing significant parameters (inflation, construction cost index, energy cost index, depreciation period and financing options, etc.) their effect can be simulated. Sensitivity analyses can be done by changing the entered value for calculations. Cost parameter of the building can be varied in Excel allowing for a risk analysis of individual parameters to be carried out.

6. Discussion of methodology

In the test phase of this LCC model investment cost and operating cost data, derived from completed and operating buildings, were compared with corresponding results generated by this model. Through this data it was possible to test the programmed algorithms and the cost estimates and make any necessary change. Having completed the testing phase, it was possible to confirm that the chosen approach leads to extremely short data entry times. There are around 50 data inputs needed for the building geometry and around another 50 for the quality of the building elements. At the same time the cost reliability achievable in this early design phase remained within the margins of +/- 10 to +/- 20% for all simulated projects. Thus, it could be shown that with sufficient knowledge of significant cost drivers the simulation effort can be minimised without compromising on data reliability.

However, this cost data and results of LCC are just limited to a national level. In the test phase buildings from Austria and Germany were calculated. For this region, by taking certain regional factors for costs into account, this model can be applied by using the developed cost data base. Furthermore, there are restrictions in the building types. At the beginning, this model was developed just for office buildings. Now, the building types were extended to nursing homes, hospitals, hotels and schools. In general, these building types that have regular and standardized rooms in the main usage spaces can be used.

The cost data was mainly developed together with big Austrian building and HVAC companies. These companies have their focus on big non-residential buildings. Therefore, data cannot be used for small buildings less than 1,000 square meters are and for residential buildings.

7. Examples for LCC calculations

The focus of the application is on the early design phase of a building project. Here, the LCC tool is used for the following purposes:

- Optimization of life cycle costs in the project initiation and determination of a reference value for life-cycle costs for the planned space and functional program, considering sustainability goals.
- Comparison of life cycle costs of different building designs in the context of an architectural competition
- Optimization of life cycle costs by comparing different solution in the preliminary design and design of a building project

7.1 Assessment in the architectural competition

A public project developer plans a nursing home with high sustainability standards. According to comprehensive sustainability criteria, a reference value for the life cycle cost of the building can be established in the definition of requirements. As a part of the architectural competition, the cost of the competition project was calculated, compared with the reference value and prepared for the jury. Therefore, the jury was able to consider the long-term economic effects of the architectural concept and building services in the competitive decision.

Figure 6 shows the investment costs of the five submitted projects and the reference value for the investment costs divided into costs for structural, HVAC and finishing works. Figure 7 contains life cycle costs in 25 years reference period while figure 8 shows the accumulation of life cycle costs in a time period of 60 years.

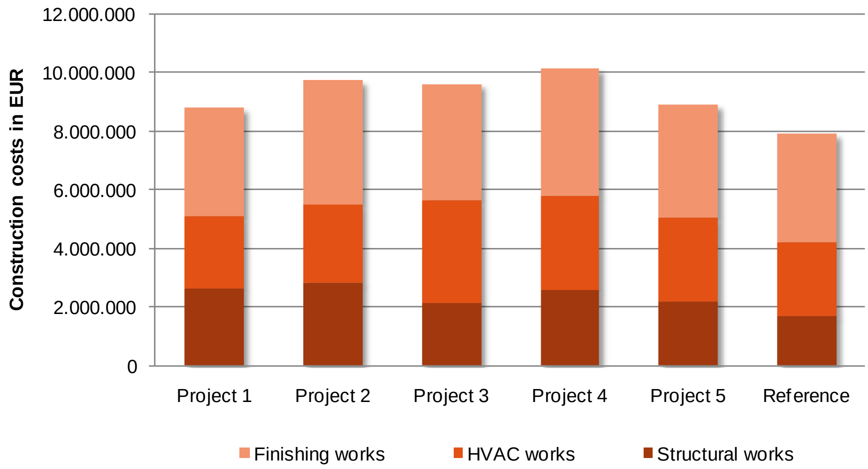

Figure 6: Construction costs in EUR of five projects in the architectural competition in comparison with the reference value (Source: original illustration)

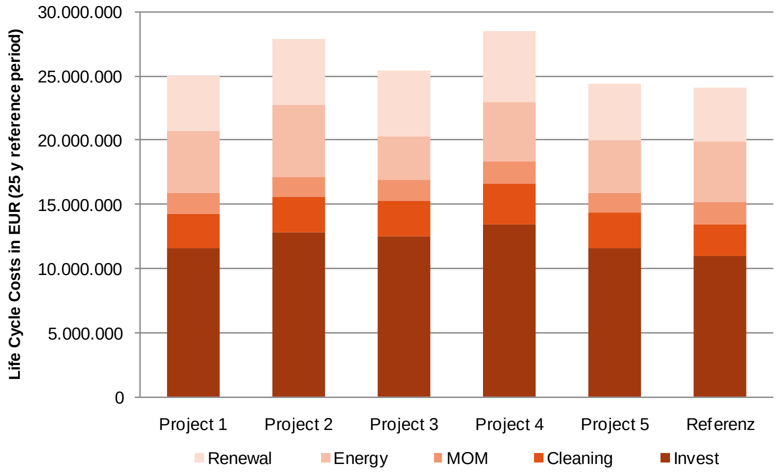

Figure 7: Life cycle costs in EUR of five projects in the architectural competition in comparison with the reference value in 25 years reference period (Source: original illustration)

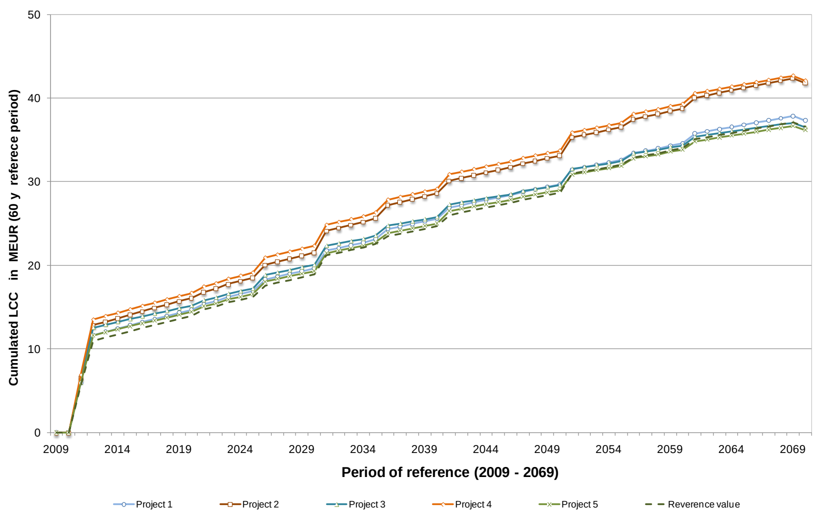

Figure 8: Accumulation of life cycle costs in millions of EUR of five projects in the architectural competition in comparison with the reference value in 60 years reference period (Source: original illustration)

Comparing all projects, there are two projects (No. 2 and 4) that have higher LCC than other projects and the reference value. By using this graphs and cost values, the projects will be analysed regarding the economical effects. The jury will receive the results of graphs, values and of the analysis to incorporate LCC in their decision for the best project.

7.2 Assessment in the preliminary design phase of an office building

A private project developer plans a new office building in passive house standard. For this project approximately 3% additional investment costs for a passive house were compared to the anticipated operating costs. The additional investment costs could be refinanced within 17 years with an assumed energy cost index of 5%. For an institutional development project it is even more important to show the full cost of the building to the future tenants. Only when full costs of energy efficient buildings are on the same level of building with low energy efficiency, such projects can be carried out. The cost of good decision making information about costs in early stages is therefore crucial.

For this project, the cost drivers over the life cycle have been shown in the design phase. Thus, the design team concentrated on the most relevant building elements.

A comparison between different energy sources such as gas, district heating or geothermal energy was carried out; additionally the use of photovoltaic and thermal solar plant was considered. For the upcoming design phase the use of geothermal energy in combination with an activation of thermal mass (peak load with district heating) will be assessed in detail.

8. Conclusion

The development of a new model for calculating LCC in the early design phase was successfully transferred to the market. There are first projects in the demand planning phase, for architectural competition as well as in the design phase of a building. The results of this model are mainly used to give the construction client valuable information about the future cost of the building.

At the moment this model is extended to the refurbishment of buildings. The main aim is to compare different solutions (refurbishment of an existing buildings, construction of a new building) in the initiation phase of a building in order to give the construction client valuable decision making information for the optimal economical solution.

In general, the economical dimension of a building is just one aspect. By advising the construction client in the early design phase all aspects of sustainable building are taken into account. Potential negative and positive aspects of different design solutions are mentioned in order to find the best integrated design solution for the building.

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