DOI: 10.52950/ES.2023.12.1.006

A TOOL FOR EVALUATING PUBLIC PROCUREMENT IN THE CONTEXT OF LIFE CYCLE COSTS

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Abstract:

The paper deals with the issue of selection procedures. The goal is to show how it is possible to incorporate a view of life cycle costs into the tender process, and not only deal with the aspect of investment costs. The paper is proposed by the Life Cycle Cost Inspector (LCCI). LCCI divides investment opportunities into individual components with their own operating characteristics and costs, allowing for a clear comparison of different investment alternatives. The tool considers acquisition costs, operating costs, and disposal costs over a specific period. LCCI also allows for reverse evaluation, where investment costs are modified based on efficiency. The tool's universality enables its use across various sectors, not just the construction industry. The author aims to shift public practice from tendering "on price" to "tendering on quality" by providing a simple methodology for comparing investment options based on the entire life cycle costs. The application is based on the Building Cost Information Service (BCIS) standard issued by the Royal Institution of Chartered Surveyors (RICS).

Keywords:

Evaluation Tool; Life Cycle Costs; Tender

JEL Classification: C51, L74

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Citation:

DANIEL MACEK (2023). A Tool for Evaluating Public Procurement in the Context of Life Cycle Costs. International Journal of Economic Sciences, Vol. XII(1), pp. 116-126., 10.52950/ES.2023.12.1.006

Introduction

A prerequisite for a successful project is its thoughtful planning and control during the entire life cycle. If we omit any phase, in reality there is not only an immediate reduction in its economic value, but also a reduction in its other attributes, such as functionality, reputation, public perception or impact on the environment (Naji 2020). An example can be the neglect of a building during its maintenance. Inefficiently spent operating resources will cause an impact on the operation of internal technical equipment, loss of warranties and a dramatic impact on operating costs (Ganah 2015). However, errors made at different stages of a construction project will also have different impacts on life cycle costs.

A common problem in the public construction sector is the so-called "on price" procurement, which means that tenders are evaluated on the basis of the lowest price offered. In construction projects, the purchase price is only a fraction of the total costs that the public owner will have to pay over time (Kelly 2021, Yu 2020). For that reason, it is very inefficient to buy buildings at a low price but pay even more in the operational phase. The problem is not only the cost component but also the impact on the environment and the treatment of resources and finally on the structural issues of each economy (Lukavec et al 2017, Jasova et al 2017). A possible solution is to evaluate the building not on the basis of the purchase price, but on the basis of a set of evaluation criteria (Ksiazek-Nowak 2021).

Complex evaluation systems are increasingly being used all over the world, and the Czech Republic is no exception. Contemporary studies and conferences focused on sustainable buildings confirm the added value for participants in the construction project (Hromada et al 2021). Certification systems must be understood as a tool that has many ways of implementation and types of approach. The experience of countries such as the United States and Great Britain should be used for the correct application of the evaluation of environmentally friendly buildings in the country (Niewerth 2022, Hromada et al 2021). As an example, let us consider the use of the BREEAM certification system for public sector buildings in Great Britain. In the Czech Republic, certification systems are used primarily for private sector buildings. There is no government regulation or tool to evaluate the proposed solution in relation to the investment costs incurred to the operating costs and which also addresses environmental sustainability (Marovic 2021, Ballesteros-Perez 2021, Machova, 2022).

Complex assessment of buildings is currently coming to the fore due to the rise in energy prices, operating costs and the development of certification systems used by the private sector. The result of a comprehensive evaluation is an effort to more effectively manage the design parameters of buildings, the effectiveness of the investment costs incurred and the projected internal environment (Lenderink 2022). An example is Great Britain, which uses the BREEAM certification system for new buildings. Another example is the United States of America, which uses the LEED certification system, which includes a requirement to create a dynamic simulation of the building's energy efficiency (Heralová 2014, Scofield 2013).

The paper focuses on defining the vision with which the Czech public sector would enter contracts. This set direction should be continuously followed even in times of changes in ruling political parties, because one of the biggest risks is the periodic change of direction, key workers (with whom knowledge and information also leave) and already set rules. The goal is to point out the area of digitization and its impact on building design and operation planning. An example is Building Information Modeling (BIM). An integral part is the creation of a methodology using life cycle cost assessment in such a way that it is possible to determine the effectiveness of investment costs (CAPEX) in relation to operating costs (OPEX).

Literature Review

The increasing trend towards digital documentation has significantly transformed various aspects of our daily lives and industrial practices, as paper-based documents are being replaced by their digital counterparts that are stored in servers and processed through ICT technologies (Matějka 2018). This has resulted in a vast amount of data being generated, which companies can utilize to enhance their competitiveness. While certain fields, like healthcare or manufacturing, have already embraced the concept of Big data Analytics, others are yet to do so. For instance, civil engineering firms store a large volume of digital documents, including past project records and responses to public/private tender procedures, but fail to effectively utilize this data (Mikulik 2022). The primary hurdle in the effective use of such information is their storage approach, which views them as archives rather than valuable knowledge that can be inferred and utilized to benefit the business (Esposito and Tamburis 2019, O'Neill 2013).

Serial tendering is better than other types of tendering when it comes to cost reduction, where civil infrastructure projects need a significant increase in the amount of tough planning, financial expenditures, engineering work, and resources of a different character than other types of construction projects. The effects of a lack of funding cause decrease in the completion speed of the project on time. The need to reduce the cost of bidding on recurrent civil infrastructure projects is critical (Mohammed and Erzaij 2022, Pojar 2022).

Unlike the traditional price-focused lowest bid (LB), the best value (BV) tendering process selects the contractor that offers a product or service that is most beneficial to the procurement entity in various aspects (Mehrabani 2020). Existing pricing models, including cost-based probabilistic models and market-based neoclassical microeconomic theory, were developed for LB. Very few operational models exist for BV tenders due to the difficulty of measuring the price differences with respect to the variance of product or service quality (Yu, Wang and Wang 2013, Heralová 2018).

The procurement of public construction projects must walk a fine line between the corruption of state officials and collusion of contractors. The method of awarding projects to the lowest responsible tenderer was originally implemented to guard against corruption of state officials. Alternatively, best value procurement has been used for decades, but here problems arise owing to the necessity of subjective judging of measures other than price to compare bids, giving rise to time- and money-consuming protests (Scheepbouwer, Gransberg, and del Puerto 2017).

Tender documents often lack clarity and are incomplete, making it difficult for contractors to appropriately price projects. A general view is that the quality of tender documents has declined, which has affected the bidding strategies of contractors. However, the academic literature has focused mainly upon the views of contractors (van der Meer 2022, Hanak 2021). To obtain a more balanced view of tendering practices, in-depth interviews were conducted with 10 practitioners (client, consultant, and contractor) who are involved in a common project at the same time in the UK construction industry. The contractor was satisfied that the quality of tender documents had been consistent. By contrast, both the client and the consultant agreed that the quality of tender documents is an ongoing issue (Khoso 2021). During the study it was revealed that tendering practice is influenced by the relationship between stakeholders or the unbalanced access to information rather than the accuracy and analysis of tender documentations (Whang 2022, Cole 2013).

Procurement practices are often characterized by competitive tendering. The overarching purpose of this is to ingrain transparency, probity, and value for money into the processes of acquiring goods and services. When tenderers collude and clients are unable to detect them, bids will become uncompetitive. Yet, there have been a limited number of effective practical tools and methods developed that can be used by procurement authorities, controllers, and public officials to detect collusive tendering (Signor 2020, Ellingerova 2020).

Materials and Methods

The aim of this chapter is to present the tool "Life Cycle Cost Inspector" (LCCI) for the evaluation of public procurement offers based on life cycle costs, and not to be limited to the investment part only. LCCI was created by the author of this thesis for the purpose of a clear comparison of several investment opportunities, taking into account future financial flows (mainly operating expenses) and the total value obtained for the investment funds used. The primary objective of the LCCI is to compare several investment alternatives, in the context of both acquisition costs (CAPEX) and operating costs (OPEX), possibly also the costs of ecological disposal over a certain period of time. This method is based on the division of a given investment opportunity into individual components (e.g. heating, cooling, electrical installation, etc.) that have their own operating characteristics (and thereby generate corresponding investment and operating costs). Subsequently, the financial flows for the selected period, including acquisition costs, are determined for each component. Each component is separately defined by the following parameters:

- basic unit (e.g. square meters, common meters, pieces, etc.),
- unit price,
- purchase price,
- and lifespan.

Once the parameters are defined for each variant and for each variant component, it is possible to perform a calculation and comparison within the selected time period. An additional function of the LCCI is the reverse evaluation – investment costs can be modified based on a targeted evaluation of efficiency.

Only and only by evaluating all the costs generated by a given investment opportunity can we responsibly determine the value we will get for the funds spent (based only on financial flows - other factors such as social, macroeconomic or strategic are not considered here). For that reason, it is also possible to choose a variant with a higher investment rate, due to lower life cycle costs. This procedure is significantly neglected in current public practice. Only by creating auxiliary tools and simple methodologies can we create content for contracting authorities, on the basis of which it will be possible to move from the preference of tendering "on price" to "tendering on quality".

The advantage of LCCI is its universality, which allows it to be used not only for investment opportunities within the construction sector, but also for investments within different sectors. It is a simple principle transformed into an evaluation tool enabling a clear comparison based on the methodology of expressing the value of future financial flows associated with the costs of the entire life cycle of all compared options. In this way, the author tries to provide a tool that clearly compares several variants and puts into context the ratio between the investment part of costs (CAPEX) and operating costs (OPEX).

The division of constructions and their entry into the application is based on the Building Cost Information Service (BCIS) standard issued by the Royal Institution of Chartered Surveyors (RICS) (Building Cost Information Service of RICS, 2012).

1 Total Value Earned for Funds Spent

The overall economic impact of a public contract can be evaluated based on the earned value achieved for a certain amount of funds within the given contract. The method of measuring the effectiveness of public procurement based on the measurement of achieved value is very well known (especially in Western countries) as it is a suitable tool for measuring procurement with alternative supply systems, such as public-private partnerships. By calculating the net present value, it is possible to recalculate future financial flows to a common denominator. For this reason, we do not evaluate based on initial investment alone, which would automatically disqualify bids that are not among the lowest in terms of bid price. An important factor for calculating the value is time in particular. To take into account financial flows at different times and convert them to the value at time 0 (present value), a discount factor or discount rate is used (it depends on the expression of the unit).

As already stated, the discount rate is used to convert future cash flows into present value. But it is important to mention that it is not only an expression of the time difference between individual financial flows, as other factors are also included in the calculation, such as a certain uncertainty (although also affected by time). The higher the level of uncertainty, the higher the discount rate will be. Determining the discount rate itself is a challenging task. There are a number of ways and methodologies to determine the discount rate. The cornerstone of the calculation is the assumption that a certain value of future financial flows X has a smaller value than the same value of X in today's money (at time 0). One reason is inflation - the purchasing power of money changes over time. However, the value of money does not change over time only because of inflation. The value also changes due to the possibility of investing money at time 0 with a certain return percentage, thereby achieving a higher value over a certain period of time.

Different investment opportunities for different time frames can only be responsibly compared if we are comparing the same numbers with the same denominator. By calculating NPV, we arrive at these same denominators and obtain corresponding values for various investment opportunities. NPV is the cornerstone of the Life Cycle Cost Inspector tool, which is covered in the following chapters.

2 LCCI – Case Study Complete Building Evaluation

LCCI offers two distinct assessment methods. The first method focuses on a comprehensive assessment of the entire building, where the examined building is divided into basic components, such as heating, perimeter construction, etc. The breakdown of components is based on the Building Cost Information Service (BCIS) standard issued by the Royal Institution of Chartered Surveyors (RICS). (Building Cost Information Service of RICS, 2012). After the initial breakdown, each of the components is assigned an investment and operating characteristic. These characteristics are then converted to current money and thus evaluated without time distortion. Examples of component breakdown are shown in the table below (Table 1).

Table 1: Building components indicating operating costs

A	B	C	D
Component	CAPEX (EUR)	LCC cycle (years)	Total cost of acquisition and operation of components (65 years cycle) (EUR)
Basics	823,302 €	70	0 €
Supporting structure	4,838,803 €	70	0 €
Overhanging structures	1,756,362 €	70	0 €
Roof construction	664,938 €	25	1,488,924 €
Staircase	2,073,773 €	30	357,013 €
Perimeter walls	1,676,847 €	30	1,198,653 €
Windows and exterior doors	2,485,059 €	30	3,552,768 €
Internal walls and partitions	379,847 €	20	1,013,470 €
Surfaces - walls	413,317 €	10	2,185,142 €
Surfaces - floors	413,317 €	10	2,052,185 €
Surfaces - ceiling	413,317 €	15	721,743 €
Sanity	119,015 €	10	666,010 €
Water supply	153,018 €	15	533,308 €
Heating	1,645,553 €	10	5,558,375 €
Ventilation system	3,091,121 €	10	23,063,999 €
Electrical installation	4,856,285 €	10	36,234,539 €
In Total	25,803,873 €		78,626,130 €

Source: Arcadis CZ s.r.o., 2022

The total costs of acquisition and operation, which are shown in the table (Tab. 1 column D), are calculated on the basis of investment costs, operating costs and other costs associated with acquisition, operation and eventual end of the life cycle. It is important to note that some components will be purchased repeatedly during the period under review. In the example, this is a time period of 65 years. According to the life characteristics of the individual components (Table 1, column C), the costs associated with the acquisition are repeated, according to the ratio of the examined period and the life cycle.

The next step is to convert the selected characteristics into current money according to the NPV calculation, thereby obtaining the total operation and maintenance costs for the given time period expressed in current money.

Table 2: Total cost of restoration and maintenance

Type of Costs	In Total
Renewal and maintenance costs - annually (65 years)	3,049,031 €
Restoration and maintenance costs - total (65 years)	78,626,130 €
Discounted cost of renewal and maintenance - annually (65 years)	17,483 €
Discounted cost of renewal and maintenance - total (65 years)	5,953,008 €

Source: Arcadis CZ s.r.o., 2022

The discount rate used for the calculation was compiled on the basis of specific risks for the given project, inflation and the interest rate for a safe investment. The case study proves that:

- renovation and maintenance costs during the life cycle of the building significantly exceed investment costs,
- conversion to present value allows the appraiser to compare the impact of individual components on total costs.

3 LCCI - Case Study Comparing Two Investment Opportunities

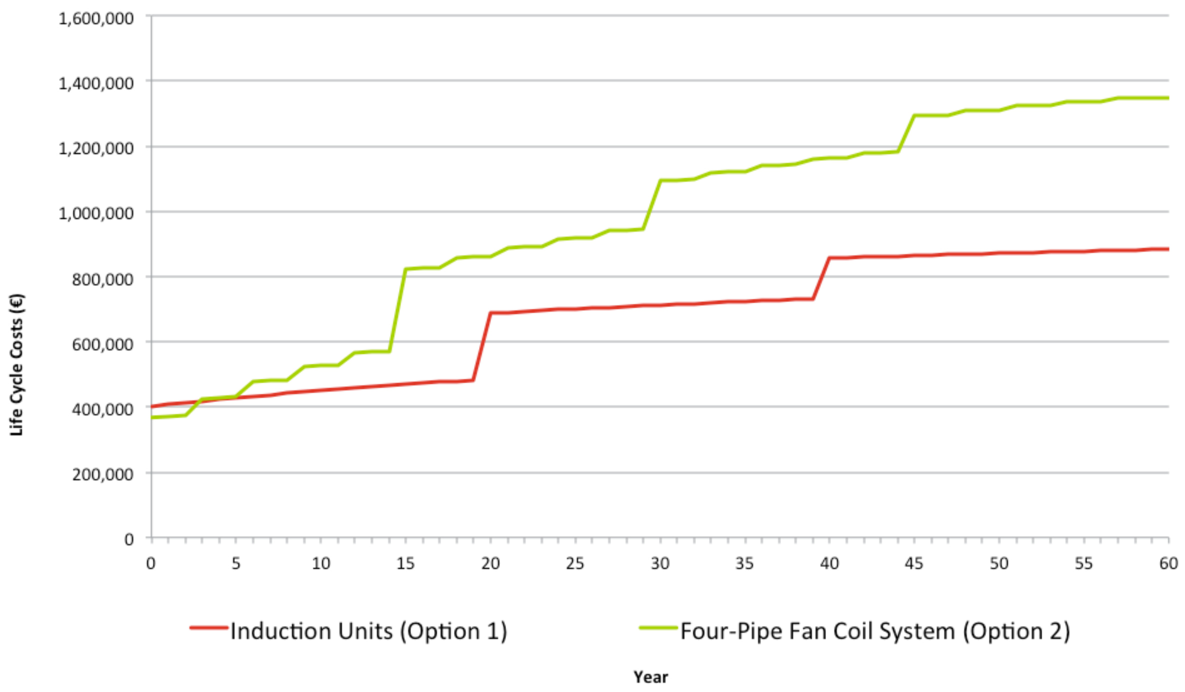
Another use of LCCI is also the evaluation of multiple investment opportunities, where all cash flows associated with acquisition, operation or disposal are recalculated by discounting to present value. This makes them mutually comparable. Two investment opportunities for the acquisition of a new heating system were selected for demonstration in this chapter. The first option is to choose a traditional heating system in the form of convectors (fan-coil). The second option is to ensure the heating of the building using chilled beams.

The first option, let's call it "Option 1", is the purchase of cooling beams. The name is misleading, as the cooling beams offer not only cooling but also heating. The beams are usually placed visibly under the ceiling structure. Fresh air is brought directly into the beams where either heat or cold is induced. The lifetime of the systems is expected to be 20 years. Operating costs are minimal, mainly due to the elimination of all moving parts (such as fans used in convectors). The only maintenance required is cleaning and vacuuming. Another saving is the need for a lower temperature of hot or cold water, due to the use of the induction system.

An alternative is a four-pipe convector system. Let's label it "Option 2". The life of the systems is expected to be approximately 15 years. The system includes mechanical fans, filter media, heating and cooling elements, four pipes carrying hot or cold water media. During operation, it is possible to switch between cooling and heating, always according to the current need. This occurs especially in the spring and autumn months, when one side of the building needs to be cooled and the other, on the contrary, heated. The convector system requires more demanding maintenance, which is always described by a specific manufacturer. In this case, the fans are replaced every three years. Filter cleaning is scheduled every six months. For that reason, higher funds must be allocated for operation and maintenance.

In normal practice, the evaluator would now be faced with the task of comparing both investment opportunities. Based on common practice, he would probably opt for the option with the lower purchase price, since the operating characteristics would not be quantified. However, thanks to LCCI, it is possible to make a comparison in greater detail and with the resulting comparison. The overall comparison is shown in the graph below (Figure 1).

Figure 1: Component comparison - induction beams and Fancoil system



Source: Author

The calculated data are shown in the table below (Table 3). The investigated period was 25 and 60 years. The expression of money is shown in the table in both future and present values.

Table 3: Overview of component analysis - Induction units vs. Convectors

Type of Cost	Induction units (Option 1)	Convectors (Option 2)
Purchase price	401.517 €	368.157 €
Life cycle cost (25 years)	951.483 €	1.245.408 €
Life cycle cost (25 years) – discounted	701.172 €	918.073 €
Net savings (25 years)	293.926 €	0 €
Net savings (25 years) - discounted	216.901 €	0 €
Life cycle cost (60 years)	1.554.890 €	2.680.392 €
Life cycle cost (60 years) – discounted	882.546 €	1.349.265 €
Net savings (60 years)	1.125.502 €	0 €
Net savings (60 years) - discounted	466.719 €	0 €

Source: Author

The comparison shows that induction units have a higher purchase price than convectors. However, after three years of operation, the difference is evened out, as the operation of the induction units is more economical. After the third year of operation, the operational advantage of induction units deepens.

Let's imagine that only investment optics would be used to evaluate the options, through which convectors would become the winning solution. Although the investor would save at the beginning, he would pay more for the operation itself. Based on a more detailed analysis in the table (Table 3), we see that the induction units generate a net saving of 293,926 Euros during 25 years of operation and 216,901 Euros after conversion to the current value. In the case of 60 years of operation, it is 1,125,502 Euros and 466,719 Euros after conversion to the current value.

Conclusions

The reduction of operating costs goes hand in hand with the design of environmentally sustainable buildings, and only then can the implementation of LCCI and a comprehensive building assessment become more prominent in the minds of investors. A sustainable building, which is created based on an emphasis on life cycle costs, is characterized by a large number of not only energy-saving measures. Green certification systems, with their clearly defined and measurable evaluation (of course within the same system), determine the level of "greenness", which then allows potential buyers or tenants to form an idea of possible operational savings and marketing advantages.

LCCI is a tool whose accuracy is clearly determined by the accuracy and quality of the data entered. Without market knowledge and data credibility, it is impossible to evaluate and interpret the results. LCCI offers two distinct assessment methods. The first method focuses on a comprehensive assessment of the entire building, where the examined building is broken down into basic components, such as heating, perimeter construction, etc. The breakdown of components is based on the Building Cost Information Service (BCIS) standard issued by the Royal Institution of Chartered Surveyors (RICS) (Building Cost Information Service of RICS, 2012). After the initial breakdown, each of the components is assigned an investment and operating characteristic. These characteristics are then converted to current money and thus evaluated without time distortion.

After creating a user account through the administrator, it is possible to add individual projects. The project means either comparing options with investment and operational characteristics, or entering data for a complete building, which has investment costs divided in the BCIS structure. The evaluation is based on the interpretation of the calculated discounted and undiscounted life cycle costs by an expert consultant and assessor in the selected years examined (year 25 and year 60 are recommended). The weights of the evaluation criteria, including the weight of the LCCI, are set by the tenderer and must respect the essence of the subject and the performance of the tender.

Despite the advantages and disadvantages of a comprehensive assessment of life cycle costs, it is necessary to realize that a comprehensive assessment of buildings is only a tool, and as a tool it must be used only by professionals who have the necessary experience and knowledge to use it effectively. Even a certified building, and thus referred to as a "green" building, may not achieve significant operational savings compared to non-certified buildings. One of the most significant obstacles during the certification of buildings is the lack of knowledge related to construction practice and the emphasis on the application of structural systems, which as a result do not contribute to the reduction of operating costs. Since certification systems bring new requirements to the construction process, it is necessary to consider the consequence of the unpredictable impacts of new construction systems. This is defined, among other things, by the black swan theory, which was described by Nassim Taleb (Taleb 2007) and which talks about unpredictable phenomena that deviate from the normal phenomena of construction practice. This theory is also significant in relation to the use of new certification systems, when lack of interest in a possible solution can have a significant impact on a construction project.

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