GUIDELINES FOR CALCULATION OF TOTAL LIFE CYCLE COSTS

Information about the Project

This paper has been prepared within a framework of the project "Support for Further Improvement of Public Procurement System in Serbia" which is funded by the European Union and implemented by a consortium led by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The main purpose of the project is to support the strengthening and developing of a stable, transparent and competitive public procurement system in the Republic of Serbia in accordance with EU standards, including improved implementation of the public procurement strategic and policy framework for an effective and accountable public procurement system.

The results required from the project include:

- strengthened and further developed the strategic, legal and institutional framework for public procurement aligned with the EU legislation,
- improved implementation of regulations in area of public procurement in practice
- E-procurement platform developed and established and
- strengthened capacities and professional skills of the Serbian Public Procurement Office and other relevant target groups.

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I. INTRODUCTION

Modern public procurement is based not only on transparency, equal treatment and fairness - as basic pillars of this activity - but focuses more and more on getting **efficiency and the best value for money**. The results of the procurement process must respond to the needs of society while using the best resources available on the market. Therefore, public procurement should not be seen only as an administrative process, but also as an instrument for delivering various societal objectives through smart spending.

When contracting authorities/entities buy goods, services or works, they always pay a price and, apparently, the lower the price proposed by a bidder, the bigger are the financial savings. For this reason, in daily practice, contracting authorities/entities very often use the (*lowest) price* as the only criterion for the award of public procurement contracts[1].

However, in times when public funds are less available and needs of a society to be satisfied with those funds are getting bigger, the importance of **running costs** of a product increases.

The purchase price is only an initial cost and a part of the costs to be incurred over a product's life cycle. Even though financial savings are initially obtained when the contracting authority/entity is paying a lower price for buying a certain product, further costs - which may be highly significant - will be generated by the use of that product. All those further costs should be considered in order to make the right choice in the procurement process, because not in all the cases the best value for money means to award the contract to the cheapest offer.

The sum of all costs incurred throughout the lifetime of owning and using a product is usually known as **Total cost of ownership (TCO)**.

TCO is sometimes far greater than the purchase price[2] and can vary significantly between different alternative solutions to a given operational need. Therefore, only consideration of all the costs over the whole life of a product enables decision makers to look at procurement in a more strategic way, beyond the "traditional" approach that is focused on the *lowest price*.

The TCO approach could give to the contracting authorities/entities the opportunity to get:

- Medium and long-term financial savings
- A new perspective on the options available on the market

[1] According to the PPO statistics, in almost 90% of procedures contracting authorities awarded the contracts based on the lowest-price criterion only. The most economically advantageous tender criterion is rarely used, even though the PPL does not contain any limitations or restrictions in this respect.

[2] For instance, it is considered that after six to eight years the operational costs of a building are as high as the cost of its construction. Another example can be found In a study named "*Whole Life Cycle Cost for Chicago-Type Bascule Bridges*" (Yinchung Zhang, David A. Novick, Ahmad Hadavi, and Raymond J. Krizek, Northwestern University, Evanston, IL 60208-3109, USA), where the results of research shows that the total life cost for 75 years period of use of a bridge is about two times higher than its initial cost.

– Better understanding of the impact of choices made during the procurement procedures (including environmental impact).

II. WHAT DOES LIFE CYCLE COSTING MEAN?

The process of identifying and documenting all the costs involved over the life of a product is known as **Life Cycle Costing (LCC).** In other words, LCC is a technique to establish the total cost of ownership, intended to help buyers and owners to determine the direct and indirect costs of the use of a product.

LCC can be used as a strategic managerial tool supporting decision making process in all the phases of the procurement process, including the preparatory phase when working with the organisation's budget.

There are various documents and studies that deal with the subject of Life cycle costs[3], and some examples provided in this document are taken from or inspired by them.

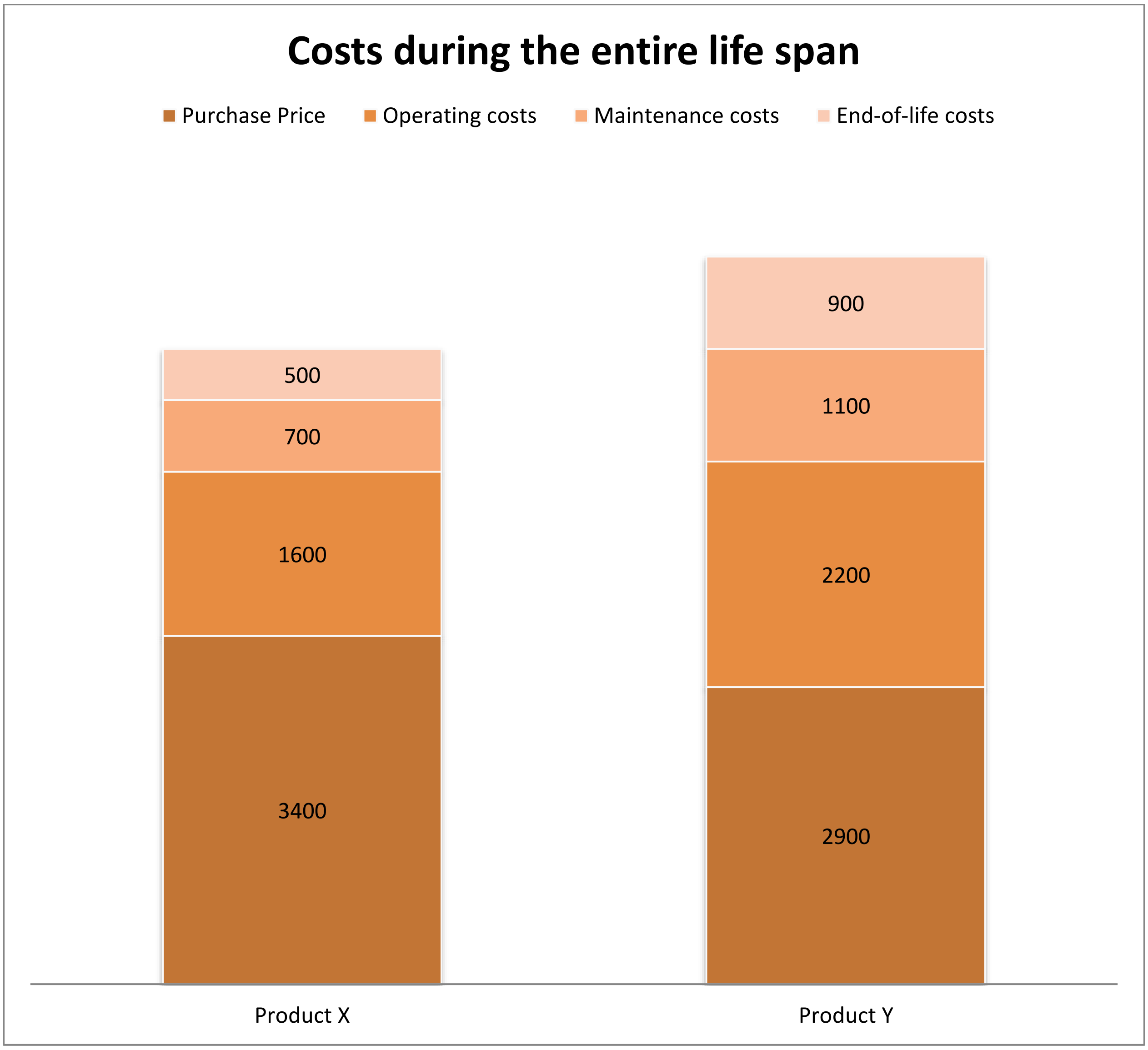
The main idea that emerges from the analysis of those texts is that taking life-cycle costs into account in public procurement makes clear economic sense, and LCC analysis can be used as an efficient tool for getting the best value for money.

Generally speaking, the typical costs to be borne by the buyer in relation to the use of a particular product may be grouped as follows:

- **Initial/investment costs** – this includes the product's purchasing price, other associated costs needed to get it to the point of use - such as costs related to legal fees, transportation, installation, commissioning (if not already included in the purchasing price) - and, where applicable, initial training of users;
- **Operating costs** – this includes for example costs related to energy consumption (e.g. electricity, gasoline, diesel, coal), consumables materials and necessary accessories (e.g. toner cartridges, lubricants, cleaning agents), taxes, insurance costs and/or any other resources needed for the use of the product;
- **Maintenance costs** - include the costs associated with keeping a product in good condition or good working order, by regularly checking it and repairing it, including any spare parts that have to be periodically replaced when necessary, cost of upgrades etc.;
- **End-of-life costs** - include decommissioning and disposal costs.

3 SIGMA Brief 34 Public Procurement - Life cycle Costing (SIGMA OECD Paris, September 2016)
http://www.sigmaweb.org/publications/Public-Procurement-Policy-Brief-34-200117.pdf.
Life Cycle Costing – State of the Art Report (Sustainable Public Procurement Regions (SPP) Project Consortium, March 2017): SPP Regions
http://www.sppregions.eu/fileadmin/user_upload/Life_Cycle_Costing_SoA_Report.pdf.
Handbook on green public procurement prepared by the European Commission (Buying Green!)
http://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf.

We can consider a case where the distribution of the costs during the entire life span of two products (Product X and Product Y) is as in the following example:



If you compare only the initial costs i.e. purchase prices, Product Y is cheaper than Product X (2,900 v 3,400).

However, it is important to compare not only the initial costs. If you compare the total amount of costs/expenditures due to the use of Product Y with the costs/expenditures generated by the use of Product X, it can be easily noted that, until the end of the life of both products, Product X is less expensive than Product Y.

Looking from a medium/long-term perspective, the acquisition of Product X appears as being more efficient than the acquisition of Product Y.

In practice, the above-mentioned situation can be identified both in cases where the subject matter of the contract is less complex (as in Examples 1.1 and 1.2 presented below), as well as in cases where the complexity of the subject matter of contract is very high (as in Example 2 presented below)[4].

Example 1.1 – Supply contract for printers

A contracting authority has decided to replace the old printers. The average number of pages needed to be printed per year is very high – about 48,000 pages - due to the fact that the contracting authority's activity involves contact with citizens, as well as interdepartmental communication. In order to avoid any delays in performing its tasks, the contracting authority established that a number of four new printers should be sufficient (one for each of departments of the contracting authority).

Based on the market analysis it appears that two types of printers (Types A and B) are the most suitable for the purposes of the contracting authority. The printers have the same technical and performance characteristics, but there is a significant difference between their catalogue prices.

The price for Type A - Printer is RSD 45,000/piece, which means that the total purchasing price of four printers would be (if no discount is offered by the seller) **RSD 180,000**.

On the other hand, the price for Type B - Printer is lower: RSD 35,000/piece, resulting that the total price of four printers would be RSD **140,000.**

If the analysis made by the contracting authority ends at this stage, the perception would be that Printer A is more expensive, and the best choice is to buy Printer B. However, the LCC analysis could lead to a different result. In case of printers, one of the most important operational costs is generated by the consumables materials – toner cartridges.

It is expected that the life span of the new printers would be five years, and each unit will be used for printing approx. 1000 pages/month (~ 12,000 pages/year; ~ 60,000 pages/5 years).

The price of one toner cartridge for Printer A is RSD 3,000, whereas for Printer B the price of the toner cartridge is RSD 4.000. Both toner cartridges can be used for printing 1,500 pages. If - due to the lower initial price - the choice of the contracting authority is Printer B, each time when it will need to replace a toner cartridge it will pay RSD 4,000. If it chooses type B printer the cost of replacement of a cartridge would be lower: RSD 3,000.

In accordance with the estimations made by the contracting authority, toner cartridges will be replaced every 1,5 months (after printing 1,500 pages).

Consequently, the operating costs determined by the replacement of the toner cartridges during the expected life cycle of the printers will be:

[4] All examples are hypothetical and are provided with the purpose of explaining the concept of LCC. They do not necessarily reflect real values, which may be different in practice.

For Printer A: 4 printers x 8 toner cartridges/year x 5 years x RSD 3,000 = RSD 480,000

For Printer B: 4 printers x 8 toner cartridges/year x 5 years x RSD 4,000 = RSD 640,000

Therefore, the LCC analysis establishes the total cost of ownership for each type of printers as follows:

For Printer A: RSD 180,000 + RSD 480,000 = **RSD 660,000**

For Printer B: RSD 140,000 + RSD 640,000 = **RSD 780,000**

Conclusions:

1. The initial purchasing price could represent, in some cases, a small proportion of the total costs incurred by a buyer. In this example, the proportion of initial costs is about 27% in case of Printer A and only 17% in case of Printer B.
2. Despite of the fact that Printer B seems to be cheaper in the first stage of the market research, the result of the LCC analysis leads to the conclusion that Printer A is the best choice in this case, ensuring in the next five years financial savings of RSD 120,000.

Example 1.2 – Replacing the supply contract with a service contract

The same contracting authority mentioned in Example 1.1, has decided to address the defined need – 48,000 pages printed per year – by checking from a new perspective the options available on the market.

The question was the following: "*what if, instead of buying printers, we would award a service contract for printing documents?*"

A supplementary market analysis in this respect shows that the average price for printing is about 2.5 RSD/page (taking into account some particular requirements of the contracting authority regarding quality, time of response, working program).

By awarding a service contract, the total costs for printing 240,000 pages (48,000 pages/year x 5 years) can be estimated at a total value of:

240,000 pages x 2.5/page = **RSD 600,000**

This result leads to the conclusion that a better choice for the contracting authority would be to abandon the initial plan of purchasing the printers and switch to the new approach consisting in awarding a service contract for printing, which could ensure supplementary financial savings amounting to RSD 60,000.

Example 2 – Work contract for repairing an old bridge/execution of a new bridge

A contracting authority has decided to create a connection between the shores of a river. Two options are taken into consideration:

A. **Rehabilitation of a 50-year-old bridge** (currently unusable)

Estimated cost of the work: 1.8 MEuro

B. **Construction of a new bridge**

Estimated cost of the work: 3.2 MEuro

At this stage of the analysis, it appears that Option A is the best choice, being with 1,4 MEuro less expensive than Option B.

Applying the LCC analysis, contracting authority will take into account not only the initial cost of investment, but also the costs involved over the entire life of the bridges. Maintenance, repair, rehabilitation and replacement costs are based on bridge inspection reports as well as average costs for similar structures in the area and adjusted for site conditions.

After rehabilitation, the service life of the **existing bridge (A)** could be prolonged by 40 years but, even so, it will require sizeable annual maintenance:

Estimated annual maintenance costs A (average): 64,000 euro

After 40 years the existing bridge should be replaced with a new one.

The **new bridge (B)** will have design features that will eliminate many high maintenance costs and will be constructed so that to achieve 75 years' service life.

Estimated annual maintenance costs B (average): 26,000 euro

The result of the LCC analysis leads to the following figures:

Total cost for option A in the next 40 years:

1.800.000 + 40 x 64.000 = **4.360.000 euro**

Total costs for option B in the next 40 years:

3.200.000 + 40 x 26.000 = **4.240.000 euro**

It appears that the best choice for the contracting authority is to decide the construction of a new bridge instead of rehabilitating the old one.

Please note that the comparison has not taken into discount rates (see Section IV, Point 3).

As can be seen, the LCC analysis is a useful tool for making cost-effectiveness comparisons of available alternatives. After consideration of all available alternatives, thinking in terms of life cycle would help to select the most sustainable option.

III. 2014 PUBLIC PROCUREMENT DIRECTIVES AND LIFECYCLE COSTS

The 2004 Directives provided that a contracting authority could award a public contract by using either the **lowest-price** criterion or the **most economically advantageous tender** criterion.

With the purpose to make contracting authorities/entities think beyond the "*lowest purchase price*", the 2014 Directives provide benchmarks for taking into account all the costs involved in purchasing a product, service or work.

Much greater emphasis is placed on the evaluation of criteria other than simply the purchase price. Article 67 (1) states that "contracting authorities shall base the award of public contracts on the most economically advantageous tender.". The definition of the most economically advantageous tender has been modified by highlighting that "value for money" represents a wider concept, as is explained in Article 67 (2)[5].

Directive 2014/24/EU[6]

> ***Article 67***
>
> ***Contract award criteria***
>
> *1. Without prejudice to national laws, regulations or administrative provisions concerning the price of certain supplies or the remuneration of certain services, contracting authorities shall base the award of public contracts on the most economically advantageous tender.*
>
> *2. The most economically advantageous tender from the point of view of the contracting authority shall be identified on the basis of the price or cost, using a cost-effectiveness approach, such as life-cycle costing in accordance with Article 68, and may include the best price-quality ratio, which shall be assessed on the basis of criteria, including qualitative, environmental and/or social aspects, linked to the subject-matter of the public contract in question. Such criteria may comprise, for instance:*
>
> > *(a) quality, including technical merit, aesthetic and functional characteristics, accessibility, design for all users, social, environmental and innovative characteristics and trading and its conditions;*
> >
> > *(b) organisation, qualification and experience of staff assigned to performing the contract, where the quality of the staff assigned can have a significant impact on the level of performance of the contract; or*
> >
> > *(c) after-sales service and technical assistance, delivery conditions such as delivery date, delivery and delivery period or period of completion. […]*
>
> ***Article 68***
>
> ***Life-cycle costing***
>
> *1. Life-cycle costing shall to the extent relevant cover parts or all of the following costs over the life cycle of a product, service or works:*

5 SIGMA Brief 34 Public Procurement - Life cycle Costing (SIGMA OECD Paris, September 2016).

6 The text is similar in Directive 2014/25/EU, see Articles 82 and 83.

(a) costs, borne by the contracting authority or other users, such as:

(i) costs relating to acquisition,

(ii) costs of use, such as consumption of energy and other resources,

(iii) maintenance costs,

(iv) end of life costs, such as collection and recycling costs.

(b) costs imputed to environmental externalities linked to the product, service or works during its life cycle, provided their monetary value can be determined and verified; such costs may include the cost of emissions of greenhouse gases and of other pollutant emissions and other climate change mitigation costs.

2. Where contracting authorities assess the costs using a life- cycle costing approach, they shall indicate in the procurement documents the data to be provided by the tenderers and the method which the contracting authority will use to determine the life-cycle costs on the basis of those data.

The method used for the assessment of costs imputed to environmental externalities shall fulfil all of the following conditions:

(a) it is based on objectively verifiable and non-discriminatory criteria. In particular, where it has not been established for repeated or continuous application, it shall not unduly favour or disadvantage certain economic operators;

(b) it is accessible to all interested parties;

(c) the data required can be provided with reasonable effort by normally diligent economic operators, including economic operators from third countries party to the GPA or other international agreements by which the Union is bound. […]

It is important to highlight that two types of costs are provided in Article 68 (1) of the EU Directive:

- Costs borne by the contracting authority (costs relating to acquisition, costs of use, maintenance costs, end of life costs, known also as “**direct costs**”)
- Costs due to external environmental effects, which not always are paid by the polluter but are borne by society as a whole (known also as “**indirect costs**”).

Therefore, apart from the direct costs, the use of a product may have an impact on the environment, which will probably require other investments or charges in the future. Such investment/charges might be highly significant; for this reason many public authorities in Europe have taken the approach of establishing a GPP policy or including commitments to GPP implementation within other policies.

Each individual contract will have a different set of potential environmental impacts to be considered. In general, constructed facilities, materials and products may have environmental impacts (e.g. emission of greenhouse gases, eutrophication or land use) due to the processes of manufacture, transport, assembly/disassembly, maintenance and disposal associated with them. These various environmental impacts may have negative consequences on human health, availability of certain resources, soil erosion and others alike. As a result, significant expenditures may be required over the years to counteract such effects and reduce pollution.

According to the Handbook on green public procurement prepared by the European Commission (Buying Green!), the main potential for savings over the life-cycle of a good, work or service may be the following:

Savings on use of energy, water and fuel

The costs of energy, water and fuel consumption during use often make up a significant proportion of the total cost of owning a product, work or service, and of its life-cycle environmental impact. Reducing this consumption makes clear sense both financially and environmentally.

Savings on maintenance and replacement

In some cases the greenest alternative will be one which is designed to maximise the period until replacement and/or minimise the amount of maintenance work which needs to be done. For example, the choice of materials on the exterior of a building or bridge can have a large effect on the frequency of maintenance and cleaning activities. The most sustainable option may be one which helps to avoid such costs, and this can be assessed as part of LCC.

Savings on disposal costs

Disposal costs are easily forgotten when procuring a product or tendering for a construction project. Costs of disposal will eventually have to be paid, although sometimes with a longer delay. Not taking these costs into account when you buy can turn a bargain into an expensive purchase. Disposal costs range from the cost of physical removal to paying for secure disposal. Frequently, disposal is governed by strict regulations, such as those in place under the WEEE Directive[7]. In certain cases, there may be a positive return to the owner at the end of life, for example where vehicles or equipment can be sold on or recycled profitably.

The LCC methodology allows for the assessment of the costs imputed to environmental externalities, so that it makes sense to take into consideration the life cycle costs in order to mitigate/reduce environmental impact.

Consideration of such effects will help to ensure that best-value solutions are identified in both economic and environmental terms. Although the initial price of a greener product is often higher, the TCO of that product could be lower.

Serbian legislation[8] provides the following:

7 Directive 2012/19/EU on waste electrical and electronic equipment (WEEE Directive).

8 The Public Procurement Law, “Official Gazette of the RS”, No. 124 of 29 December 2012, No. 14 of 4 February 2015, No. 68 of 4 August 2015.

Principle of Environmental Protection and Ensuring Energy Efficiency

Article 13

Contracting authority shall procure non-polluting goods, services and works, or those having minimal influence on the environment, or those that ensure adequate decrease in energy consumption – energy efficiency, and, when justifiable, to define environmental advantages of the subject of public procurement, energy efficiency, and total costs of procurement subject-matter's life cycle, as elements of the most advantageous bid taken as the criterion.

A good way of gaining an overview of the environmental impacts of a particular contract is to consult the relevant EU GPP criteria and Technical Background Reports, which explain the main impacts and how they can be addressed in purchasing[9].

The EU GPP criteria are developed to facilitate the inclusion of green requirements in public tender documents. While the adopted EU GPP criteria aim to reach a good balance between environmental performance, cost considerations, market availability and ease of verification, contracting authorities/entities may choose, according to their needs and ambition level, to include all or only certain requirements in their tender documents.

However, environmental externalities are often difficult to be "monetised" in order to be then used in a mathematical formula as part of the LCC analysis. It is expected that European Commission will prepare in the future common methodologies developed at Union level for the calculation of life-cycle costs for specific categories of supplies or services. In Article 68 paragraph 3 of Directive 2014/24/EU is provided that whenever a common method for the calculation of life-cycle costs has been made mandatory by a legislative act of the Union, that common method should be applied for the assessment of life-cycle costs.

A list of such legislative acts, and where necessary the delegated acts supplementing them, is set out in Annex XIII to the Directive 2014/24/EU. So far Annex XIII refers only to the Directive 2009/33/EC[10] which has made mandatory a common method for clean vehicles.

This Directive provides a common methodology for the calculation of operational lifetime costs, the operational lifetime energy as well as the minimum costs to be assigned to certain environmental externalities.

The contracting authorities have to take into account when purchasing road transport vehicles, the following:

a) Energy consumption

b) Emissions of CO_2[11]

9 http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm.

10 Directive 2009/33/EC of the European parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles.

11 Carbon dioxide is the most significant long-lived greenhouse gas in Earth's atmosphere. Since the Industrial Revolution anthropogenic emissions have rapidly increased its concentration in the atmosphere, leading to global warming.

c) Emissions of NOx[12], NMHC[13] and particulate matter[14]

This requirement can be fulfilled by two different options:

- setting technical specifications, or
- including them in the purchasing decision:
  - as award criteria,
  - or with the methodology defined in the Article 6 of the Directive 2009/33/EC, where these impacts are monetised.

This model allocates a monetary value to several types of emission – carbon dioxide (CO_2), nitrous oxide (NOx), non-methane hydrocarbons (NMHC) and particulate matter (PM), as is provided in *Table 1* below:

Table 1

Emissions	Cost for emissions in road transport
Carbon Dioxide (CO_2)	0,00003 €/g
Nitrous Oxide (NOx)	0,087 €/g
Non-methane hydrocarbons (NMHC)	0,001 €/g
Particulate Matter (PM)	0,0044 €/g

The lifetime emissions of each vehicle tendered may then be given a cost, which should be added to other direct costs such as purchase price, fuel costs and maintenance[15].

Within the Clean Fleets EU Project an **LCC Tool** has been prepared[16] in order to assist public authorities and economic operators with the implementation of the Clean Vehicles Directive's

12 NOx is a generic term for the nitrogen oxides that are most relevant for air pollution, namely nitric oxide (NO) and nitrogen dioxide (NO2). High concentration of these gases contributes to the formation of smog and acid rain, as well as affecting tropospheric ozone. Inhalation of such particles may cause or worsen respiratory diseases, such as emphysema or bronchitis, or may also aggravate existing heart disease.

13 Non-methane hydrocarbons (NMHC) are a large variety of chemically different compounds, such as ethane, propane, benzene and toluene that play an important role in controlling air quality, in particular the ozone concentrations. The combined effects of non-methane hydrocarbons and nitrogen oxides contribute to the formation of stratospheric ozone and are responsible for smog, which has a negative impact on visibility, human health, and even the global climate.

14 Particulate matter (PM), knowing also as Particulates, are microscopic solid or liquid matter suspended in Earth's atmosphere. Particulates have impacts on climate and precipitation and are a severe health hazard. For instance, soot particulates, which are produced by diesel combustion, are considered as a cancer risk to humans.

15 See, for instance, the example provided on page 33 of the document *Most Economically Advantageous Tender (MEAT) and Life Cycle Costs (LCC)*, elaborated by WYG International Limited in 2017, within the Project "Strengthening Public Procurement in Serbia".

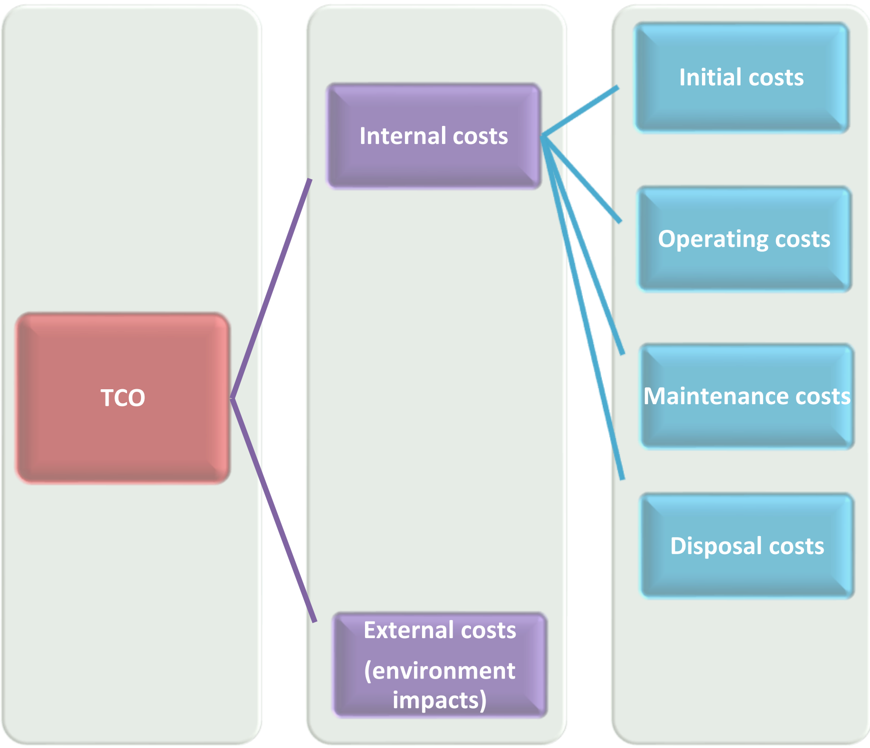
16 http://www.cleanfleets.eu/fileadmin/files/documents/Publications/Final_leaflet/ICLEI_clean_fleets_results_leaflet_HR_low-res.pdf.

provisions and the procurement or leasing of clean and energy-efficient vehicles. The LCC tool has been specially developed to compare the LIFE-CYCLE COSTS of different vehicles when procuring them.

The project aimed to accelerate a broad market introduction of vehicles with higher energy and environmental standards and thereby reduce energy consumption, noise, CO_2 and pollutant emissions.

IV. ASSUMPTIONS IN LCC CALCULATIONS

A complete life cycle cost projection analysis includes financial assessment of all direct and indirect costs, which can be summarised as follows:



When appraising different solutions, a decision-maker is typically facing with alternatives that deliver different profiles of costs and benefits over time. In properly assessing LCC, certain assumption must be considered:

1. Life span

An important issue is to make correct assumptions as regards the length of the product's useful life, which means how long the product will remain usable and will continue to satisfy certain performance requirements. This should be taken into account when you wish to make a life-cycle cost comparison among various alternatives.

For strategic investment decisions in the public sector – such as bridges or buildings – it is typical to select a long period for LCC analysis (70 - 75 years).

All the costs generated by the use of such asset should be taken into account for the whole-time period.

Maintenance costs normally increase with the ageing of the asset, which means that the longer is the life span of the asset, the higher will be the maintenance and rehabilitation costs.

On the other hand, choosing efficient solution for reducing the operational costs (electricity, gas, water consumption, lifespans of building elements and materials) will provide higher savings as the period of use is longer.

Example[17]

Saving on lifetime maintenance costs in Germany

The City of Detmold launched the procurement of a new bus station in 2012. As part of its initial research and market consultation, a sustainability analysis was carried out based on the expected lifetime of the development of at least fifty years. This determined which techniques were most suitable for the project. The open tender then resulted in the use of **photocatalytic concrete**, which converts air and surface run-off pollutants into harmless salts. **This decreases the need for maintenance and reduces costs and environmental effects of cleaning.**

Even in the case of simple products, where maintenance and repair costs are irrelevant, the period of LCC analysis could remain very important for making a life-cycle cost comparison. Longevity and warranty time frames of the products establish the frequency with which those products need to be replaced. This will have a major impact on the cost, especially over a longer period. A cheap product which needs to be replaced frequently may cost more over the long term than a higher-priced product which lasts for more years.

[17] Handbook on green public procurement prepared by the European Commission (Buying Green!).

A typical example is provided in SIGMA Brief 34 Public Procurement - Life Cycle Costing, where is provided a comparison among three types of light bulbs (LEDs, CFLs and Incandescent Standard):

	LED	**CFL**	**Incandescent**
Light bulb life span	30 000 hours	10 000 hours	1 500 hours
Cost per bulb	EUR 8	EUR 3	EUR 0,6
Bulbs needed for 30 000 hours of use	1	3	20
Costs of replacement	**EUR 8**	**EUR 9**	**EUR 12**

It can be noted that the LCC analysis was made on a period of 30 000 hours, in order to ensure the comparability among the three options.

Adding the impact of the electricity's costs, the same period of analysis will be considered:

Watts per bulb (equiv. 60 watts)	10	15	60
kWh of electricity used over 30 000 hours	300	450	1 800
Cost of electricity (assumption: EUR 0.2 per kWh)	**EUR 60**	**EUR 90**	**EUR 360**

The period during which the product will remain usable may be expressed in years (as in case of bridges and buildings), months or even hours (as in case of bulbs) but, in certain cases, it is suitable to use other measurement units.

For instance, Directive 2009/33/EC indicates the *Lifetime mileage* for road transport vehicles, which is expressed in number of kilometres:

Table 2

Vehicle category **(M and N categories as defined in Directive 2007/46/EC)**	**Lifetime mileage**
Passenger cars (M1)	200,000 km
Light commercial vehicles (N1)	250,000 km
Heavy goods vehicles (N2, N3)	1,000,000 km
Buses (M2, M3)	800,000 km

In all the cases it is important to decide on the most appropriate life span to be taken into account during LCC analysis in order to ensure a rational comparison among different solutions.

2. Costs to be considered

Life Cycle Cost methodology takes into account and assesses various costs resulting from the use of goods, services or works during their entire life span.

The main questions are what costs to be taken into account and whether information regarding further expenditures is available. Depending on the characteristics of the product, some costs may be important, while others completely irrelevant. The challenge is to identify the relevant types of costs, which will be incurred during the operating life of the product.

In public procurement, where LCC analysis is performed during the phase of preparation, the initial cost of purchase is equivalent with estimated value of the procurement[18].

A summary of the methods for determining the estimated value has been presented in another document developed in this Project[19].

The initial price of purchase is included in the category of so-called "*one-off costs*", because it is paid only once and not repeated.

In the same category (*one-off costs*), it can be included the cost that should be paid at the end of life of the product, when certain expenditures will be made for disposal. For instance, the demolition will involve significant direct costs at the end of life of a building. Indirect costs may also be relevant because the demolition means not only removing a large quantity of debris, but also managing hazardous materials, like asbestos.

On the other hand, the end-of-life costs shall not be taken into account if the purchaser intends to sell that product before its end of life. In such a case it will be assumed that, at the time of sale, the product will have a so-called *residual value*, and TCO will be calculated based on the following formula:

TCO = initial purchase costs **+** operating costs **+** maintenance costs **- residual value**

A similar approach should be applied where - even if the purchaser uses the product until its end of life - he may be rewarded with a "bonus/premium" for handing over that product for recycling.

Operational and maintenance costs are "*recurrent costs*" during the entire life of the product, because they involved expenditures that shall be constantly made during the entire life of the product, for using it and for ensuring that will continue to satisfy certain performance requirements.

These costs may be of two types:

18 Estimated value of the subject-matter of public procurement is an economic concept that refers to the most likely price that is supposed to be paid by the contracting authority/entity for the purchase of goods, services or works, on a given date and in given circumstances.

19 See the Guidelines: 'DETERMINATION OF THE ESTIMATED VALUE IN PUBLIC PROCUREMENT', http://eupodrska.ujn.gov.rs/methodology-for-determination-of-estimated-value-of-public-procurement/?lang=en.

- **Fixed costs:** costs that remains constant regardless of the level of activity (e.g. costs of insurances, taxes, regular/statutory technical checking etc.).
- **Variable costs:** costs that vary in total depending on the activity level. A variable cost increases as the activity increases, and it falls as the activity volume decreases (e.g. almost all the operational costs related to energy consumption or consumables materials, repairs costs, spare parts etc.).

Knowing with certainty the **exact** operational and maintenance costs for the entire life cycle of a product is, of the course, not possible. Future costs are usually subject to a level of uncertainty that arises from a variety of factors, including:

- The prediction of the length of the product's useful life;
- The prediction of the utilization pattern of the product over time;
- The nature, scale, and trend of operating costs;
- The need for and cost of maintenance activities;
- The impact of inflation.

The LCC process can be as simple as a table of expected annual costs or it can be a complex (computerized) model that allows for the creation of scenarios based on assumptions about future costs during the entire lifespan of the product. The scope and complexity of the LCC analysis should generally reflect the complexity of the product under investigation, the ability to predict future costs and the significance of the future costs to the decision being made by the contracting authority/entity. However, the main goal in assessing life cycle costs is to generate a reasonable approximation of the costs and not to try to achieve a perfect answer. Reasonable assumptions can simplify the analysis and still result in a useful comparison of the alternatives.

In case of simple procurement, the officials involved in LCC analysis can take into account any costs that they feel are appropriate and realistic from the economic perspective.

The LCC method tends to involve much more sophisticated tools and procedures, and requires substantial skills and resources in order to obtain the necessary data in case of complex procurement, such as large-scale infrastructure projects. In such cases, the LCC analysis will require external specialist advice or, at least, access to background data, statistics, reports, studies that have already analysed and assessed the operating and maintenance costs for similar structures.

3. Discount Rate

During the LCC analysis, a decision-maker typically takes into consideration not just the absolute **value** of the costs, but also **when** those costs materialise. Costs that materialise later are usually considered to be easier to manage than those that occur sooner.

Moreover, when an investor, either private or public, makes any kind of expenditures (for example on buying product A), he knows that those expenditures have an implicit cost deriving from sacrificing another objective (such as for example purchase of another option - product B), which achievement will be postponed, due to the fact that money is spent on product A instead of B. In other words, choice of an option A instead of B has its cost. It is very likely that, in the future, the amount of money that he is spending now on product A will not be sufficient for achieving the “sacrificed” objective (the purchase of product B). In other terms, the resources spent have an “opportunity cost”[20] (referred to also as alternative cost). Therefore, the value of immediate costs is considered higher than a similar value which is related to future costs (or, we can say that the value of future costs is lower than the value of the immediate costs).

This important factor needs to be taken into account in LCC analysis and this is the reason why inflows and outflows of a project are discounted by means of a discount rate.

Discount rate takes into account the time value of money and gives the possibility to calculate the present value of the future costs.

From the practical perspective, the question will be how to compare 100 EUR that should be paid now with 100 EUR that should be paid one or more years later. The formula for calculating the present value is the following:

$$\mathbf{PV = V_1/(1+r) + V_2/(1+r)^2 + V_3/(1+r)^3 + \ldots + V_n/(1+r)^n}$$

Where: $\mathbf{V_n}$ is the value of the costs incurred after n years

r is the discount rate (r= r%/100)

Example

For certain equipment, the contracting authority estimates that it will bear in the next 5 years operating costs amounted to RSD 300,000/year, which means a total cost of **RSD 1,500, 000** until the equipment’s end of life.

Applying a discount rate of 4%[21], the present value of the total cost will be the following:

$PV = 300{,}000/(1+0.04) + 300{,}000/(1+0.04)^2 + 300{,}000/(1+0.04)^3 + 300{,}000/(1+0.04)^4 + 300{,}000/(1+0.04)^5$

PV = 288,462 + 277,367 + 266,699 + 256,441 + 246,578 = **RSD 1,335,547**

Operational Costs projected to be paid at the end of:	Absolute Value	Present Value $PV_{yearn} = V_n/(1+r)^n$
Year 1	300,000	288,462
Year 2	300,000	277,367
Year 3	300,000	266,699

20 Opportunity cost is defined as the benefits individual misses out when choosing one option over another.

21 The discount rate applied is an important assumption, as it may have a significant impact on the outcome of the analysis and potentially on the decision as to whether one option (tender) is preferable to another. The usual rate for public sector projects is between 3% and 5%.

Year 4	300,000	256,441
Year 5	300,000	246,578

It can be seen that the present value of each yearly cost is becoming "lower" as the future is "longer". The present value of the total cost is, naturally, lower than the absolute value in the future.

The calculation becomes really difficult where the costs are spread over a very long period of time. For this reason, it is recommendable to use Discount Factors Table (see Annex).

An extract of the Table is showed below:

Discount factors (Present Value of "1 unit" *in the future, at Discount rate r %)*

Discount factor = $1/(1 + r)^n$, r = discount rate%/100, n = length of time

Year/Discount rate	3%	4%	5%
1	0.9709	0.9615	0.9524
2	0.9426	0.9246	0.9070
3	0.9151	0.8890	0.8638
4	0.8885	0.8548	0.8227
5	0.8626	0.8219	0.7835
6	0.8375	0.7903	0.7462
7	0.8131	0.7599	0.7107
8	0.7894	0.7307	0.6768
9	0.7664	0.7026	0.6446
10	0.7441	0.6756	0.6139

V. LCC ANALYSIS IN PRACTICE

The life cycle costing analysis can be used in different phases/stages of the procurement process.

The greatest overall effect will typically be achieved by LCC implementation in the earliest stages of procurement process, i.e. design and development. This can give you a baseline to work and will be helpful for:

- Identifying alternatives and establish different technological solutions to be considered
- Identifying the different cost elements relating to the product
- Defining some general performance requirements for the new solutions.

A. Technical specifications

Traditionally, contracting authorities/entities tend to prepare procurement documentation – in particular, technical specifications – by emphasising inputs (what and how is needed to perform the task) rather than outcomes (the expected result).

In the case of the award of supply contracts, the technical specifications sometimes contain so many details about the goods to be purchased, that they actually turn into an accurate description of a particular model produced by a particular supplier.

Example
Requirements on dimensions or features that must have "fixed" values, which are not relevant for achieving a specific goal, and for which there are no reasonable justifications why not to be acceptable in a reasonable +/- margin.
- "The weight of the equipment shall be 2.75 kg"
- "The size of the kit shall be 21x32x75 cm"
- "The automobile trunk must have the capacity of 504 l"
- "USB entries shall be placed exclusively on the back side of the laptop"

In the case of the award of service contracts, too much emphasis is placed sometimes in tender documents on the excessive description of how the contractor must achieve the result, although the contracting authority/entity is rather interested by the result itself.

Example

Emphasis is placed on the excessive description of how the technical operator must operate, although the contracting authority is interested in obtaining a certain result and not in the way the economic operator achieves the specific objectives of the contract.

In case of a maintenance contract, an objective **need** of the contracting authority could be that contractor must ensure that **any intervention for solving defects shall be performed no later than 2 hours after the event occurrence**.

Instead of defining this need as such, in tender documents is provided the following requirement:

"Tenderers must have a service point, with specialists and spare parts, **no farther than 60 Km from the city**".

Such a requirement does not represent the ultimate goal of the contracting authority (which is *intervention in maximum 2 hours*), but only the way in which that contracting authority believes that the goal can be achieved (*service point placed no farther than 60 Km from the city*).

This is a way of favouring the local companies and obstructing other companies which are not from that city/region, even if the latest could have alternative solutions for fixing the defects/malfunctions of the equipment in 2 hours (e.g. a mobile workstation).

This type of technical specifications not only that artificially narrow the competition but they also make it difficult to use the LCC analysis. Contracting authorities/entities should define the technical specifications rather in terms of performance characteristics, focusing mainly on the results expected ("what to obtain") and without describing the exact manner in which the work is to be performed ("how to do"). This performance-based approach will allow the contracting authorities/entities to stipulate requirements with respect to life-cycle costs, including environmental considerations.

Tenderers should be given the freedom to determine how to meet the contracting authorities/entities' performance objectives. Allowing the variants to be submitted may also be a mean of introducing greater flexibility.

Contracting authorities/entities must ensure that the offers submitted are accurate and credible, by asking the tenderers to provide evidence in support of the information provided.

B. Award Criteria

The role of the award criteria is to ensure a clear benchmark based on which the tenders submitted in the procurement procedure are compared and ranked.

The main difference between technical specifications and award criteria is that whereas the former are assessed on a pass/fail basis, award criteria are weighted and scored so that tenders offering more technical/financial advantages can be given more marks.

Using the LCC analysis at the award stage, the contracting authority/entity can evaluate the quality of the tenders by comparing all the subsequent costs determined by the use of each product offered by the tenderers. The LCC analysis will be applied so as to create a method for evaluating and comparing tenders submitted by interested economic operators.

The rules generally applicable for awarding criteria shall be also observed when LCC analysis is used during the award stage:

- Award criteria must be linked to the subject matter of the contract

  The 2014 Directives provide that award criteria shall be considered to be linked to the subject-matter of a contract where they relate to the works, supplies or services to be provided under that contract in any respect and at any stage of their life cycle, including factors involved in:

  (a) the specific process of production, provision or trading of those works, supplies or services; or

  (b) a specific process for another stage of their life cycle

  even where such factors do not form part of their material substance.

- Award criteria must have been advertised previously

  When contracting authorities/entities evaluate the quality of tenders, they shall use predetermined award criteria, published in advance, to decide which tender is the best.

  All assumptions used in an LCC analysis as well as the typology of the costs that will be taken into account and the method for calculating them shall be clearly stated in the tender documents.

Example

For awarding a supply contract for cars, contracting authority indicates in the tender documents:

<u>Costs that will be taken into account:</u>

- Initial cost (purchasing price) of one car
- Vehicle taxes costs
- Insurance costs
- Costs with fuel
- Annual preventive maintenance costs
- Costs of CO_2 emissions
- Costs of pollutant emissions (NOx, PM, NMHC)

<u>Assumptions:</u>

- Vehicle taxes costs are calculated according to the formula established by the Law/Order no…./…..; formula takes into account European emission standards for passenger cars (Category M), engine capacity and type of fuel
- Insurance costs are considered to be 4% of the current price in each year
- Prices for different types of fuel[22]:
  - Gasoline: RSD 153.5/l
  - Diesel: RSD 163/l
- Costs of CO_2, NOx, PM, NMHC emissions: See Table 1 (above)
- Lifetime of the cars: 200,000 km, 5 years (40.000 km/year)
- Depreciation of the cars: 18% of the initial price/year
- Residual value after 5 years: 10% of the initial price
- Discount rate: 4%

- <u>Award criteria must not confer unrestricted freedom of choice on contracting authorities/entities</u>

22 It is not possible to know exactly how much 1 l of fuel will cost in the next five years. However, this uncertainty should not affect the decision to consider the costs associated with fuel consumption. To ensure a uniform method of assessing all of the submitted tenders, the contracting authority should provide in the tender documents <u>its assumption</u> regarding the unit price.

Award criteria must be formulated clearly so that all "reasonably well-informed and normally diligent tenderers"[23] will interpret them in the same way.

Based on such information, the economic operators participating in the procurement procedure shall understand what the main objectives of the contracting authority/entity are, and how they can get more marks by exploiting certain competitive advantages of their products.

Example

The most economically advantageous tender shall be the one for which the total costs (during the lifetime of the cars) are the lowest. Calculation of the total costs (TCO) will be made according to the following formula:

TCO = Initial purchasing price +

$\Sigma_{(0\text{-}4)}$ Vehicle taxes costs/$(1+r)^n$ +

$\Sigma_{(0\text{-}4)}$ Insurance costs/$(1+r)^n$ +

$\Sigma_{(1\text{-}5)}$ Annual preventive maintenance costs/$(1+r)^n$ +

$\Sigma_{(0\text{-}4)}$ [consumption/100Km x 40.000/100 x unit price/l]/$(1+r)^n$ +

$\Sigma_{(0\text{-}4)}$ [quantity of emissions $_{CO2,\ NOx,\ PM,\ NMHC}$ /Km x 40.000 x unit price $_{CO2,\ NOx,\ PM,\ NMHC}$ /g] /$(1+r)^n$
– Residual value/$(1+ r)^5$

Tenderers are required to provide detailed information regarding prices and technical specifications of the cars they offer. In particular, the following information will be used in the LCC analysis for calculation of TCO:

- Initial purchasing price (influences also the amount of residual value)
- Engine capacity (influences the vehicle taxes costs and insurances costs)
- Type of fuel (influences the vehicle taxes costs and total consumption costs)
- Classification in accordance with emission standards for passenger cars – Euro 6, Euro 5 etc. (influences the vehicle taxes costs)
- Consumption of fuel/100Km (influences the total consumption costs)
- Quantity of emissions/Km - CO_2, NOx, NMHC, PM (influences the total costs of emissions)
- Costs with technical inspections/preventive maintenance of the cars in the first 5 years

[23] See Case C-19/00 SIAC Construction Ltd v County Council of the County of Mayo, paragraph 42.

- Award criteria must not be discriminatory

  Award criteria shall not be formulated in a way which artificially forecloses the market and/or allows one or few economic operators to get more marks for insignificant or even non-existent advantages.

  However, if the needs/objectives of the contracting authority/entity can be justified by economic and/or environmental protection reasons, nothing prevents it to use a system of awarding higher scores for those advantages that are considered *exceptional*. It is obvious that in the market there are economic operators whose products or services are "better" than others, and it will never be full equality in this respect. In fact, such approach is aimed to "favour" the most advantageous tenders and not a particular tenderer, and this is not forbidden by EU Directives.

  This statement remains valid even when in the market there are only few economic operators who are able to achieve a certain level of performance[24].

C. Execution of the contract

During the life cycle of a product, the focus of LCC analysis should shift to cost monitoring and management.

It is important to ensure that the costs, or characteristics of the product that influence the costs, which have been assumed by the winning tenderer, are fully observed during the execution of the contract. The contracting authority/entity shall protect itself against deviations from the initial commitments, by providing specific clauses in the contract, such as payment of damages for poor performance.

Ideally, at the end of a life cycle, the complete cost history of a product would have been tracked, compared with original estimations, reviewed and understood. This process would reduce the uncertainty of future analysis.

[24] See Case C-513/99 Concordia Bus.

SUMMARY OF THE LCC

The purchasing price paid by a contracting authority/entity for a product is only a portion of the costs that shall be incurred over a product's life cycle.

The sum of all costs incurred throughout the lifetime of owning and using a product represent the **Total cost of ownership (TCO).**

The process of identifying and documenting all the costs involved over the life of a product represent the **Life Cycle Costing (LCC).**

LCC analyses usually take into account the following types of costs:

1. **Direct costs**:
    - Initial (purchasing) costs and all associated costs such as delivery, installation, commissioning;
    - Operating costs, such as consumption of energy and other resources;
    - Maintenance costs;
    - End-of-life costs such as removal, recycling and decommissioning.
2. **Indirect costs**, which are costs imputed to environmental externalities

LCC analysis is a useful tool for making cost-effectiveness comparisons of available alternatives and can be used in **all the phases of the procurement process**. The utilization of LCC is often connected with the issue of the Environment and thereby may be integrated into sustainable public procurement policies.

In performing LCC analysis, the following assumption should be properly defined:

- **Life span** which will be used for making comparisons among various alternatives
- **Costs that are relevant** for analysis
- **Discount rate**, which takes into account the time value of money and gives the possibility to calculate the present value of the future costs.

In the procurement process, contracting authority/entity may use the LCC analyses in order to achieve the objective of identifying the most economically advantageous tender, by taking into consideration not only the lowest purchasing price but also the other costs incurred during the life span of the product.

In order to coordinate and consolidate the total life cycle cost calculation of all tenders, contracting authority/entity should:

- define technical specifications rather in terms of performance characteristics, focusing mainly on the results expected and without describing the exact manner in which the work is to be performed

- provide clear information regarding assumptions and formula/methodology that will be used for LCC calculation, which will be equally applicable for all tenders.

Annex: Discount Factor Table[i]

DISCOUNT FACTOR (p.a.) FOR A RANGE OF DISCOUNT RATES

Present Value of $1 in the Future at Discount Rate r%

Year	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
0	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.9009	0.8929	0.8850	0.8772	0.8696
2	0.9426	0.9246	0.9070	0.8900	0.8734	0.8573	0.8417	0.8264	0.8116	0.7972	0.7831	0.7695	0.7561
3	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938	0.7722	0.7513	0.7312	0.7118	0.6931	0.6750	0.6575
4	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350	0.7084	0.6830	0.6587	0.6355	0.6133	0.5921	0.5718
5	0.8626	0.8219	0.7835	0.7473	0.7130	0.6806	0.6499	0.6209	0.5935	0.5674	0.5428	0.5194	0.4972
6	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302	0.5963	0.5645	0.5346	0.5066	0.4803	0.4556	0.4323
7	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835	0.5470	0.5132	0.4817	0.4523	0.4251	0.3996	0.3759
8	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403	0.5019	0.4665	0.4339	0.4039	0.3762	0.3506	0.3269
9	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002	0.4604	0.4241	0.3909	0.3606	0.3329	0.3075	0.2843
10	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632	0.4224	0.3855	0.3522	0.3220	0.2946	0.2697	0.2472
11	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289	0.3875	0.3505	0.3173	0.2875	0.2607	0.2366	0.2149
12	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971	0.3555	0.3186	0.2858	0.2567	0.2307	0.2076	0.1869
13	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677	0.3262	0.2897	0.2575	0.2292	0.2042	0.1821	0.1625
14	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405	0.2992	0.2633	0.2320	0.2046	0.1807	0.1597	0.1413
15	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152	0.2745	0.2394	0.2090	0.1827	0.1599	0.1401	0.1229
16	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919	0.2519	0.2176	0.1883	0.1631	0.1415	0.1229	0.1069
17	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703	0.2311	0.1978	0.1696	0.1456	0.1252	0.1078	0.0929
18	0.5874	0.4936	0.4155	0.3503	0.2959	0.2502	0.2120	0.1799	0.1528	0.1300	0.1108	0.0946	0.0808
19	0.5703	0.4746	0.3957	0.3305	0.2765	0.2317	0.1945	0.1635	0.1377	0.1161	0.0981	0.0829	0.0703
20	0.5537	0.4564	0.3769	0.3118	0.2584	0.2145	0.1784	0.1486	0.1240	0.1037	0.0868	0.0728	0.0611
21	0.5375	0.4388	0.3589	0.2942	0.2415	0.1987	0.1637	0.1351	0.1117	0.0926	0.0768	0.0638	0.0531
22	0.5219	0.4220	0.3418	0.2775	0.2257	0.1839	0.1502	0.1228	0.1007	0.0826	0.0680	0.0560	0.0462
23	0.5067	0.4057	0.3256	0.2618	0.2109	0.1703	0.1378	0.1117	0.0907	0.0738	0.0601	0.0491	0.0402
24	0.4919	0.3901	0.3101	0.2470	0.1971	0.1577	0.1264	0.1015	0.0817	0.0659	0.0532	0.0431	0.0349
25	0.4776	0.3751	0.2953	0.2330	0.1842	0.1460	0.1160	0.0923	0.0736	0.0588	0.0471	0.0378	0.0304
26	0.4637	0.3607	0.2812	0.2198	0.1722	0.1352	0.1064	0.0839	0.0663	0.0525	0.0417	0.0331	0.0264

27	0.4502	0.3468	0.2678	0.2074	0.1609	0.1252	0.0976	0.0763	0.0597	0.0469	0.0369	0.0291	0.0230
28	0.4371	0.3335	0.2551	0.1956	0.1504	0.1159	0.0895	0.0693	0.0538	0.0419	0.0326	0.0255	0.0200
29	0.4243	0.3207	0.2429	0.1846	0.1406	0.1073	0.0822	0.0630	0.0485	0.0374	0.0289	0.0224	0.0174
30	0.4120	0.3083	0.2314	0.1741	0.1314	0.0994	0.0754	0.0573	0.0437	0.0334	0.0256	0.0196	0.0151
31	0.4000	0.2965	0.2204	0.1643	0.1228	0.0920	0.0691	0.0521	0.0394	0.0298	0.0226	0.0172	0.0131
32	0.3883	0.2851	0.2099	0.1550	0.1147	0.0852	0.0634	0.0474	0.0355	0.0266	0.0200	0.0151	0.0114
33	0.3770	0.2741	0.1999	0.1462	0.1072	0.0789	0.0582	0.0431	0.0319	0.0238	0.0177	0.0132	0.0099
34	0.3660	0.2636	0.1904	0.1379	0.1002	0.0730	0.0534	0.0391	0.0288	0.0212	0.0157	0.0116	0.0086
35	0.3554	0.2534	0.1813	0.1301	0.0937	0.0676	0.0490	0.0356	0.0259	0.0189	0.0139	0.0102	0.0075
36	0.3450	0.2437	0.1727	0.1227	0.0875	0.0626	0.0449	0.0323	0.0234	0.0169	0.0123	0.0089	0.0065
37	0.3350	0.2343	0.1644	0.1158	0.0818	0.0580	0.0412	0.0294	0.0210	0.0151	0.0109	0.0078	0.0057
38	0.3252	0.2253	0.1566	0.1092	0.0765	0.0537	0.0378	0.0267	0.0190	0.0135	0.0096	0.0069	0.0049
39	0.3158	0.2166	0.1491	0.1031	0.0715	0.0497	0.0347	0.0243	0.0171	0.0120	0.0085	0.0060	0.0043
40	0.3066	0.2083	0.1420	0.0972	0.0668	0.0460	0.0318	0.0221	0.0154	0.0107	0.0075	0.0053	0.0037

Discount Factor $=1 / (1 + r)^n$

Where r = Discount rate and n = length of time

[i] Reproduced from. *The Farmers Forest: Multipurpose Forestry for Australian Farmers* p121