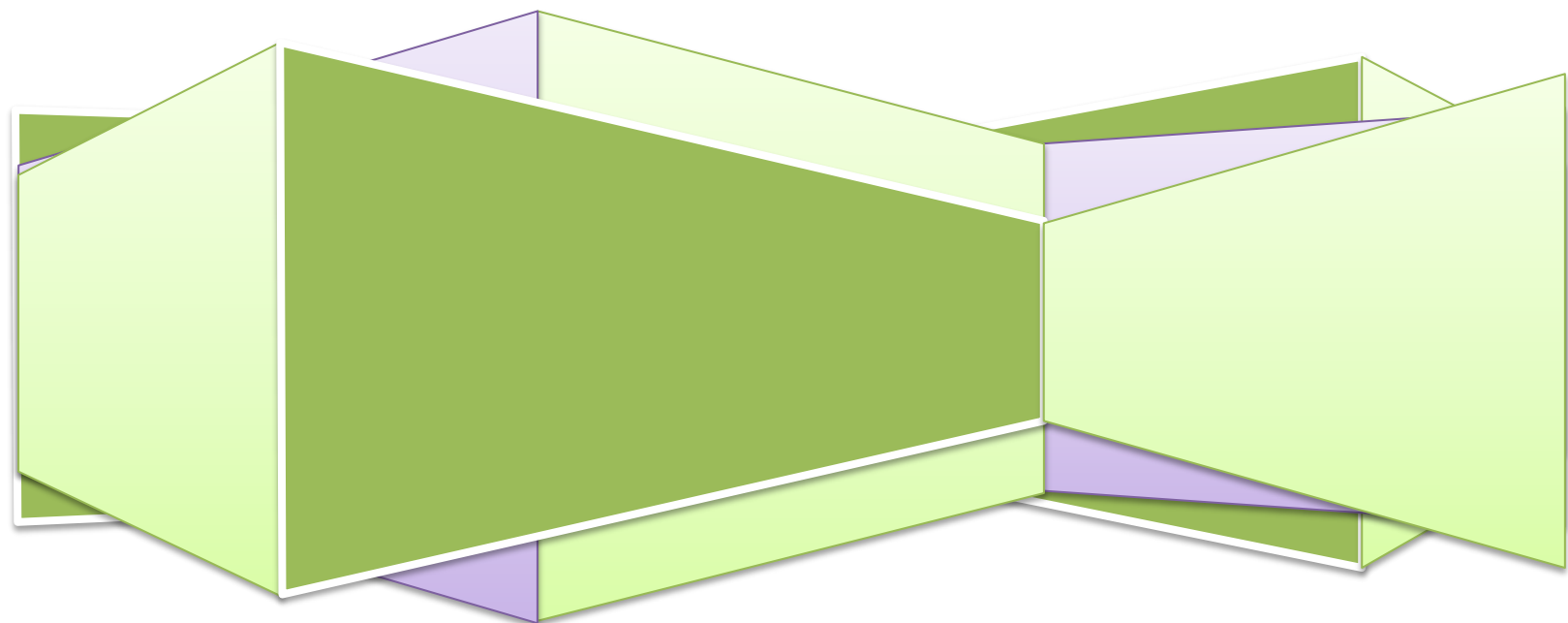


# LCC Methodology and Resources

Guide for the use of Life Cycle Costing in Green  
Public Procurement

University of Patras



## **Disclaimer**

Information provided in this document is as accurate as of June 2019 and while efforts were made to present as accurate information as possible, it is in the nature of laws and its various interpretations to change. This document serves for informational purposes only as well as for informal guidance. This means that none of the information presented within the document serves or should serve as legal or law advice, but exists only to present general guidelines. Of course, information provided in this handbook naturally consists of generalities and may not apply to all situations. To avoid misinterpretations of the proposed guidelines, we highly recommend that readers of this handbook consult legal professionals before taking any action, since as mentioned above, nothing on this document should be considered as legal advice. Readers should guarantee that during the tendering process, all European and International laws and constitutions are followed.

## Chapter 1. Introduction

This methodology has been created within the GPP4Growth project of the European program Interreg Europe, and serves as a deliverable for the activity A4.1 *“Defining common lifecycle costing methods and resources in GPP”*. Its aim is to *“develop indicators and define evaluation areas to allow public authorities & stakeholders better understand the lifecycle costing approach and benefits, and provide them with resources to apply harmonized Lifecycle costing (LCC) methods in their regions”*. It is a collection of the necessary knowledge needed to understand the basic principles behind LCC, and presents a number of available tools that can be used to apply LCC in some of the most commonly procured items within the public sector.

Therefore, this practical guide can be considered as a two-step process. The first step is to familiarize the user with the concepts of LCC, i.e. how it is defined, what are the associated benefits and challenges and how someone can learn more.

The second step is to connect the theoretical basis outlined in the first step with the practical application of LCC concepts in public procurement. In this step the document aims to familiarize the reader with the most well-known and popular tools on LCC application that have been developed to help procurement officers automate the estimation of lifecycle costs in an easy, user-friendly way for a range of commonly purchased products. It also provides the reader with multiple resources on the subject for further reading.

### 1.1. How to use this handbook

For the readers who want to learn about Green Public Procurement (GPP) in general, as a concept that contains LCC, we suggest to go to **Chapter 2. Green Public Procurement**.

For readers who are now starting to familiarize with LCC, we suggest to start from **Chapter 3. Life Cycle Costing** which presents the basic LCC concepts. We suggest the same to readers who have a small background on LCC but want to revisit and solidify their knowledge on the matter.

For readers who are already familiar with the above concepts, we suggest them to go to **Chapter 4. LCC in practice**. There they can find useful information on how to apply basic LCC considerations for a range of basic products and what available tools have been developed to

ease this procedure. The products we tackle in this guide are indoors/outdoors lighting, vehicles, office Information Technology (IT) equipment – computers and monitors - and vending machines. The choice of the products was based on the procurements needs of public authorities (PAs), the main target group of this guide. The above products are both common and frequent in PAs tenders, while they are characterized by heavy energy consumption, allowing the benefits of long term planning (i.e. through LCC) to become more evident and significant.

For each product category, we have identified well-known tools that have been developed to ease the application of LCC concepts by procurers. For each tool we provide a quick overview and a description of its methodology. We also try to explain any feature of a tool that might be a little more advanced or complicated.

For readers who want to dive deeper in the LCC practices and issues, **Chapter 5. Resources** provide more material on the subject. We have included European directives, tools, guides and reports that tackle the issue from several perspectives. This methodology was heavily based on these resources and the reader could find them extremely helpful.

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## Chapter 2. Green Public Procurement

### 2.1. GPP4Growth project

The new EU public procurement system, effective since April 2016, creates new opportunities for public authorities to stimulate eco-innovation, resource efficiency and green growth by using new award criteria in calls and tenders that pay particular attention on environmental considerations.

Aimed at improving resource-efficient economy policies, the GPP4Growth project brings together 9 partners from 9 countries (such as Greece, Italy, Poland, Belgium, Spain, Latvia, Bulgaria, Ireland and Malta) involving the managing authorities & regional bodies influencing regional & national policy instruments. The project aims at exchanging experiences and practices and improving their partners' capacity on implementing resource efficiency policies that promote eco-innovation and green growth through Green Public Procurements (GPP). The project is intended to be conducted over the course of 5 years, starting from 2017 up until 2021. The project's total budget has been set to 1.704.769 €.

GPP4Growth is approved under the European Program INTERREG EUROPE, an interregional cooperation programme 2014-2020 that represents the continuation of the INTERREG IVC Programme 2007-2013. It is one of the instruments for the implementation of the EU's cohesion policy, a policy used by to pursue harmonious development across the EU by strengthening its economic, social and territorial cohesion and stimulate growth in the EU regions and Member States. The programme targets at promoting exchange of experiences on thematic objectives among partners throughout the EU on the identification and dissemination of good practice with a view to its transfer principally to operational programmes under the "Investment for Growth and Jobs" goal but also, where relevant, to programmes under European Territorial Cooperation goal.

Taking into account the different pace and conditions among the GPP4Growth regions in the setup and management of GPP, and the different approaches followed to foster green growth through GPP, interregional cooperation will allow exchange of experiences and information on environmental criteria to be used to improve the implementation of resource efficiency policies,

saving thus time and effort. Interregional cooperation will allow integration of lessons learnt into policies, such as green criteria in tendering, monitoring green contracts' performance and market availability of green products, with the aim to support the least favored regions to integrate GPP and reduce disparities.

The exchange of experience & policy learning activities have been organised in 5 interrelated areas that complement each other:

- Joint analysis and peer reviews: thematic studies and guides on relevant policy aspects.
- Public dialogue: consultation with regional stakeholders on key issues.
- Interregional learning & capacity building: workshops, existing experience visits and policy learning events.
- Transferable policy methods & resources: digital lifecycle costing method to support regions in GPP and policy learning, and policy briefs to transfer lessons learnt beyond partnership.
- Policy impact: joint development of action plans and implementation monitoring.

National, regional and local public authorities responsible for environmental quality and resource efficiency, regional & environmental development agencies, business support actors and SME/business community representatives and universities or higher education institutes providing research knowledge are the project's targeted groups. It is also important to mention the fact that other public authorities and bodies governed by public law or private non-profit bodies that are involved in resource efficiency, are included in the same target groups.

The GPP4Growth regions are expected to play an important role by using their purchasing power to choose green goods & services, and promote sustainable consumption & production patterns. The project's main activities involve developing stakeholder groups and meetings with stakeholders, identification of good practices and building up knowledge capital through thematic studies, surveys and analyses, as well as holding policy learning events. In addition, the development of regional action plans to improve the relevant policy instruments, the definition of policy performance indicators and monitoring of action plans implementation are some other activities also envisioned in the GPP4Growth activities.

As stated above, GPP4Growth aims to improve the implementation of resource efficiency policy instruments, incorporating green public procurement procedures to support businesses to adopt life-cycle cost approaches and improve the overall management of resources and waste. The project will support the involved public authorities to integrate green public procurement procedures through sharing practices and experiences between regions and actors relevant to resource efficiency and businesses green growth, and transferring lessons learnt into regional policies and action plans.



As for the expected changes this project will create, GPP4Growth aims to increase the number of businesses in partner's regions that integrate environmental factors and costs when purchasing goods and/or providing supplies, services and works over 7%. Also, an increased capacity of 200 staff of public administrations to effectively implement resource efficiency policies applying GPP is expected. Furthermore, GPP4Growth will work towards producing investments worth of 10.000.000 € in order to promote new green products and services development and last but not least, the project will generate increased knowledge awareness of over 1000 stakeholders on the influence of GPP on the adoption of sustainable consumption and production patterns by businesses.

## 2.2. What is GPP

Europe's public authorities consume 17% of the European GDP on goods, supplies, services and works and hence, they can use their purchasing power to choose environmentally friendly and resource-efficient goods and services, including energy efficient IT equipment, electronic and electrical equipment supplies, office furniture from sustainable timber, low-energy on water saving products, cleaning services using environmentally friendly cleaning products, sustainable construction works, electric, hybrid or low-emission vehicles,

More specifically, the new rules will enable public authorities to set-up, publish and manage calls and contracts that require businesses/bidders to:

- comply with environmental obligations.
- integrate environmental costs in their offers based on a life-cycle cost approach, taking into account costs associated with the use, maintenance and end-of-life of supplies, services or works.
- deliver goods fulfilling the requirements of environmental labels.

Europe's public authorities are major consumers and by using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production - what we call Green Public Procurement (GPP) or green purchasing. GPP is already defined by the European Commission as a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle when compared to goods, services and works with the same primary function that would otherwise be procured [1]. As a result, they can significantly contribute to the adoption of sustainable consumption and production patterns and the promotion of regional green growth GPP, i.e. by applying new environmental criteria in tenders.

Buying green means reducing the use of natural resource and waste production, using renewable raw materials and energy sources, phasing out hazardous chemicals. It also means promoting green economy and stimulation eco-innovation and resource efficient public services, while at the same time, improving the quality of life of citizens while ensuring the protection of environmental heritage.

Although GPP is a voluntary instrument, it has a key role to play in the EU's efforts to become a more resource-efficient economy. It can help stimulate a critical mass of demand for more sustainable goods and services which otherwise would be difficult to get onto the market. GPP is therefore a strong stimulus for eco-innovation. GPP can also be a major driver for innovation, providing industry with real incentives for developing green products and services. This is particularly true in sectors where public purchasers represent a large share of the market. GPP may also provide financial savings for public authorities – especially if we consider the full life-cycle costs of a contract and not just the purchasing price. For example, purchasing energy-efficient or water-saving products helps towards significantly reducing utility bills, or reducing hazardous substances in products can cut disposal costs.

Techniques such as life-cycle costing, specification of sustainable production processes, and use of environmental award criteria are available to help contracting authorities identify environmentally preferable bids. Authorities who implement GPP will be better equipped to meet evolving environmental challenges, for example to reduce greenhouse gas emissions or move towards a more circular economy. With GPP, procurement services can:

- reduce their energy and environmental footprint, contributing to tackling climate change.
- reduce the environmental impact.
- contribute to the eco-friendly use of natural resources.
- promote innovation and competitiveness.
- act as an example for the private sector.
- save public resources, taking into account LCC costs.

While GPP seems to be a very effective measure towards eco-innovation and environmental protection, not all regions have implemented it. So, in order to be effective, GPP requires the inclusion of clear and verifiable environmental criteria for products and services in the public procurement process. The European Commission and a number of European countries have developed guidance in this area, in the form of national GPP criteria. The challenge of furthering take-up by more public sector bodies so that GPP becomes common practice still remains. As does the challenge of ensuring that green purchasing requirements are somewhat compatible between Member States - thus helping create a level playing field that will accelerate and help drive the single market for environmentally sound goods and services.

### 2.3. Benefits

We have already mentioned the project's goal, exchanging experiences and practices and improving their partners' capacity on implementing resource efficiency policies that promote eco-innovation and green growth through Green Public Procurements (GPP). Below, we present in a more detailed fashion the benefits that derive from the GPP implementation. More specifically, GPP presents the following opportunities and advantages:

- Improvement of the quality of the environment.
- Improvement in the purchasing management system and in goods and services cost evaluation.
- Identification of areas that show inefficiency.
- Demonstration that benefits outweigh investment costs.
- Improvement of the Public Administration's image.
- Improvement of the access to tenders and funding for the Public Administration.
- Improvement of the local economy.
- Improvement of overall management of natural resources and waste in businesses by using renewable raw materials and energy sources, phasing out hazardous chemicals.
- Stimulation of the uptake of environmental technologies.
- Promotion of green economy.
- Improvement of the citizens' quality of life.
- Protection of environmental heritage.
- Creation of new green jobs.
- Diffusion of environmental management tools and environmental certifications.
- Promotion of sustainable consumption & production patterns.

### 2.4. Approaches

Eco-friendly devices and services into the public sector helping central governments to succeed in meeting the objectives the EU has set in the environmental field. By using environmentally friendly LCC approaches, efficient financial incentives for enterprises can be provided, while the demand of green criteria in public procurements may push the market to innovative directions and to adopt greener procedures and provide friendlier products. So, to successfully introduce and integrate environmental criteria, all stages of a public contract must be fulfilled, from the pre-contractual stage to the implementation phase of the contract. The aforementioned stages are described in detail in the following paragraphs.

- **Subject of the contract and technical specifications:** The subject of the contract and the possible environmental impacts of its implementation are inextricably linked to the technical specifications that will be selected, whereas the technical specifications are essentially the description of the subject matter of the contract using technical terms. These terms must be listed in the contract documents and be stated clearly, accurately and leave no room for multiple interpretations so that they are understood in the same manner by all the contestants (usually done by referring to European, national or international standards, or by reference to specific performance or functional requirements).
- **Award criteria of the contract:** The directives and consequently the national legislation provide an exhaustive list of selection criteria and related evidence. A plethora of criteria is related to environmental parameters, such as human and technical resources, experience and recommendations, qualifications, environmental management systems and programs, supply/detection chain management systems, product samples and conformity assessment certifications. All the above stated criteria that will be selected must be related to the subject of the contract and generally proportionate.
- **Contract awarding:** In this phase, an assessment of bid quality and cost comparison will be conducted. So far, a major change in the legal status has been the adoption of the most economically advantageous tender (MEAT) and the abolition of the lowest price criterion. However, the criterion of the lowest price is still used extensively, due to the fact that it is envisaged that the most economically advantageous tender may be found only on the basis of the purchase price of the good. As an outcome, the adoption of the award criterion of the most economically advantageous tender would result in making the contracting authorities' interested in products, services and works that offer the best value for money across the life cycle of the product, for example taking into consideration operational, maintenance and disposal costs.
- **Contract execution:** It is an absolute necessity to rightfully respect the general principles of the public procurement. Procurement implementation conditions should be linked to the subject matter of the contract and should not be imposed retroactively with an unlawful amendment to essential terms. Meanwhile, all environmental protection terms have already been set out in the proclamation and contract documents in general and this cannot change at the execution stage.

## 2.5. Challenges

While GPP seems to be a very effective measure towards eco-innovation and environmental protection, not all regions have implemented it, and this happens for a number of reasons stated below:

- Many regions are characterized by lack of legal clarity, knowledge, expertise and resources in applying GPP criteria and the environmental impacts of goods, services and public works.
- The benefits awareness is limited and the GPP political support is lacking.
- There is extensive lack of political will and familiarity with GPP.
- Inertia for change by the Public Administration and lack of dialogue between Public Administration departments.
- Difficulty in involving responsible people of Purchasing system in environmental issues.
- There is limited knowledge on the potential of green products found in the market.
- Risk of delays of the tendering procedures, also due to resources.
- Poor market availability of green goods and services in some sectors.
- Difficulties in finding the ecological criteria to be included in green tenders and applying them without adjustments.
- Missing or unclear information provided by suppliers.
- Lack of confidence and security in the quality of green products.
- Increased costs of green goods, services and works for several products or situations.
- Added complexity of drafting green tenders.
- There are different procedures across EU, making it difficult for interested bidders.
- The authorities in the public sectors usually do not cooperate well with one another missing the opportunity to learn from each other.

As a result, in some regions, only a small minority of public organisations systematically considers environmental criteria when selecting suppliers, service providers and contractors.

## 2.6. Best practices

One way to overcome several of the aforementioned challenges, is by promoting good practices. Overall, a good GPP practice can be defined as a “green” tender that:

- addresses a common problem or issue (e.g. resource efficiency, air pollution, waste management) experienced by different public administrations, regions, and industries

- makes an original contribution or offers a significant improvement to a shared problem compared to existing practices
- has been proven successful by providing measurable or demonstrable results or by going through internal or external validation and evaluation
- can be easily transferred into other organizational or regional settings.
- Is characterized by scalability (i.e. GPP method) allowing the involvement of many enterprises within the tendering process
- Has small extent of encountered problems and difficulties that have hindered the successful implementation of the tendering process

These characteristics make the application of the same or similar aspects of these successfully implemented practices easily duplicated by other procurers, thus avoiding many of the problems involved by GPP integration (e.g. lack of knowledge, legal concerns, market preparation etc.). Therefore, an important part of the GPP4Growth project was to identify and promote best practices in the partner's regions. Most of the cases that were identified included GPP approaches to tendering in high-impact sectors, such as construction and renovation works, sustainable transport, food and catering services, electricity, waste management, energy saving products, IT and office supplies. The selected cases were replicated in other areas/settings, or demonstrated high transferability potential as they addressed common needs among public administrations, regions and industries.

Below we present 3 best practices examples that stood out as "good" -and are also correlated to LCC methods and resources.

### **Environmentally friendly large executive vehicles (Ireland)**

#### **Background**

The tendering procedure was published in September 2016 by the Office of Government Procurement (OGP). The OGP - the contracting authority - is an office within the Department of Public Expenditure and Reform engaged with setting up tenders for goods and services on behalf of the public service. The OGP acknowledges the importance of green public procurement, and have been stipulating environmental criteria in their contracts for road transport vehicles (especially passenger cars and light duty vehicles) for a number of years now. In this contract, the contracting authority has gone one step forward, procuring the supply of environmentally friendly heavy goods vehicles for addressing public authorities' transportation needs (e.g. police, schools, and army) [3].

#### **Subject**

## Single Supplier Framework Contract for Large Executive Vehicles .

### **Procurement objectives**

The country has a strong commitment to reducing greenhouse gas (GHG) emissions and to preserving natural resources. After extensive market analysis the OPG has drawn a tender document with specific requirements for the supply of a number of vehicles. The contracting authority has dictated that the expenditure on vehicles to be covered by the proposed Framework Contracts should not exceed €650,000 for each lot.

### Criteria and specifications

This single supplier framework was divided into three lots as described below. Each lot would result in a separate contract (i.e. framework agreement), while tenderers were able to submit proposal(s) for one or multiple lot(s).

- Lot 1 – “E” or “Large Executive Saloon” segment class types and fit out.
- Lot 2 – “E” or “Large Executive Estate” segment class types and fit out.
- Lot 3 - J’ or ‘Large Sports Utility Vehicles” segment class types and fit out.

Framework Agreements have been awarded for each lot on the basis of the most economically advantageous tender (MEAT), as identified in accordance with the following qualitative and cost award criteria.

- Tender price per vehicle (excl. VAT)
- The cost of the marked fit out
- Lifetime service cost calculated by multiplying the tender price for the standard service by the number of each service over the expected lifetime of the vehicle (i.e. 10 years or 500,000kms).
- The cost of lifetime energy and environmental impacts in accordance with Directive 2009/33/EC. The lifetime mileage will be 500,000Kms and the fuel prices will be those payable on the closing date for receipt of tenders under the OGP contract for supply of automotive fuels by charge-card.

To comply with environmental requirements, the bidders had to provide the following information, upon which their economical offer cost was to be calculated.

- Fuel consumption litres per 100 km
- CO2 emission kilograms per kilometre (the applicable cost is 0.035€ per kg)
- NOx emission grams per kilometre (the applicable cost is 0.0044€ per g)
- THC emission grams per kilometre (the applicable cost is 0.001€ per g)
- Particulate matter grams per kilometre (the applicable cost is 0.087€ per g)

## **Results**

Due to the very specific tender conditions involving the purchase of large executive vehicles (practically addressed to large enterprises from the automotive sector), only a limited number (i.e. 6 bidders in total) of suppliers participated in the tendering process. Overall, the process was concluded successfully awarding 4 contracts (3 with BMW Group and 1 with Audi Ireland) for the supply of the procured services/goods. The new vehicles are expected to create substantial fuel consumption savings (30-50% compared to the previous ones) and to alleviate the environmental pressures associated with fossil fuel consumption, resulting in a corresponding reduction in CO<sub>2</sub> and particulate matter emissions.

## **Conclusions**

The tendering procedure was carried out without significant problems. The contracting authority did not receive any request from interested parties for further information or/and clarifications regarding the award criteria or the required documentation. This can be mainly attributed to contracting authority's accumulative experience and competence to carry out green procurement processes, as well as its legal expertise in applying environmental criteria. The award criteria used in this particular tendering process can be employed (as a standardised practice) in any other process concerning the procurement of environmentally friendly vehicles for promoting resource efficiency and environmental protection.

## **Street lighting renovation in Preili City (Latvia)**

### **Background**

The municipality of Preili is located in the southeast part of Latvia, in the Latgale Region among three large cities - Daugavpils, Rēzekne and Jēkabpils. In 2013, Preili's County Council, aware of environmental and climate challenges, decided to proceed with the modernisation of the street lighting system, seeking to promote energy efficiency and environmental protection. The investment notably comprised the replacement of obsolete (halogen) light bulbs with LEDs that can combine an excellent light quality with an exceptionally long lifetime. In this context, the Council - the contracting authority - announced its first green public procurement. The tender call was prepared based on European Commission's GPP guidelines for street lighting. The procurement process did not complete successfully in 2013 due to lack of financial resources and



as a result the tender was postponed for two years. Finally, the municipality managed to receive funding in the form of a conditional grant from the national government and more especially under the National Climate Change Financial Instrument, and moved on with the implementation of green procurement in June 2015 [4].

### **Subject**

The replacement of old luminaries with new, more energy efficient LED light-emitting diodes with intensity control or dimming function contributing to a street lightning renovation.

### **Procurement objectives**

The tender was for the replacement of a total of 64 fixtures that illuminate the city of Preili's main streets, cycle paths and pavements. In the past, maintaining these light sources required the replacement of these bulbs at the end of their lifecycle (once per year) while carrying out maintenance and repairing was a really expensive and time-consuming task. Therefore, the County Council published a (updated) tender in 2015 for the purchase of LED technology lighting fixtures for municipality's three main streets. The main procurement objectives were to a) reduce greenhouse gas emissions caused by inefficient street lighting, b) create financial savings from reduced electricity bills, and c) improve environmental protection and citizens' quality of life.

### **Award criteria**

The contract was awarded to the bidder offering the most economically advantageous tender (MEAT). Price was the sole criterion, however all the specifications were defined in such a way to ensure that a LED lighting solution will come up. The following technical specifications were employed for the supply of high efficiency lighting fixtures.

- **Colour rendering.** This requires lamps with a colour rendering index >75. This index measures the ability to reproduce the colours of various objects faithfully in comparison with an ideal or natural light source. Typically, light sources with a high CRI are the most desirable.
- **Watt Efficacy.** The tender prescribed two categories of lighting fixtures (i.e. bulbs) with different lumen/wattage requirements; namely lamps with minimum 90 LED watts and high energy efficiency lamps with minimum 110 LED watts. The higher the lumens or wattage, the more light is produced for the least amount of energy.
- **Color temperature.** The municipality opted for a color temperature of between 3,000 and 4,000 Kelvin which provides a warm white color and is best suited for street lighting.
- **Lifespan.** The municipality procured the purchase of LED bulbs with a lifespan that should exceed 20,000 hours. This measure indicates the number of hours before light output drops to 70% of the initial output.

- **Intensity control or dimming function.** The supply of LED bulbs had to be accompanied with dimmers, which are devices that allows to adjust the brightness of street lighting. By changing the voltage waveform applied to the lamp, it is possible to lower the intensity of the light output.

In addition, bidders had to demonstrate three-year experience in similar works (i.e. renovation of lighting systems) while the personnel to be involved in renovation works should have relevant qualifications (e.g. project management, occupational safety and electrical installation or engineering) and multi-annual working experience (to be demonstrated through certificates and references). What is more, the tenderers had to provide the technical sheet with the specifications of lamps and luminaires, or a written declaration to demonstrate compliance with the aforementioned criteria.

## **Results**

All bidders managed to meet the technical requirements prescribed in the call. The Latvian company “Indigo Būve” was finally awarded the contract for renovating Preili’s street lighting, as it offered the lowest price (€168,736). The company proceeded with the installation of 46 new LED lights with a power output of 91W and 18 LEDs with a power output of 113W. All fixtures were accompanied by a light dimming feature. By changing to a LED lighting solution, the municipality was able to decrease its energy consumption in comparison to the previous street lighting system, where halogen bulbs were used. The primary energy consumption was decreased from 73MWh to 20MWh (i.e. 73% decrease), creating substantial energy savings and reducing greenhouse gas emissions. Financially, the new LED lighting solution is saving the municipality approximately €8,000 per year at today’s energy price (€0.16 per kWh). This figure would be even bigger if we had incorporated the savings from the decreased need to service/maintain lighting fixtures.

## **Conclusions**

The tender encountered some difficulties, which were stemmed from procurement officers’ lack of experience in carrying out green tenders. To address this shortcoming, the contracting authority prepared the tender based on the GPP criteria developed by the European Commission for the Street Lighting and Traffic Signals product group. However, the most significant barrier that hindered the smooth implementation of the tender and led to its delay is related to budget issues. The implementation of green public procurement in low-income municipalities depends on EU funds to a large extent and the available funding for this type of activity. In Preili, the first tender attempt was interrupted in 2013, and got renewed in 2015 when a grant from the government was provided. Finally, this GPP practice demonstrates high transferability potential

considering that the needs addressed are common among EU regions and municipalities and the demonstrated achieved benefits outweigh investment costs by far. The Preili County Council acts as a knowledge/dissemination platform for other Latvian municipalities wishing to renovate their street lighting system, by employing a green approach to tendering.

## **Procuring recycled paper through an environmental management system (Greece)**

### **Background**

Amaroussion is a suburban city with more than 100,000 inhabitants, located in the north-eastern part of the Athens agglomeration (Greece). Amaroussion's procurement activities are driven by municipality's commitment to improve environmental performance and sustainability. To this end, all tendering procedures are being carried out through an Environmental Management System (EMAS), which prescribes the technical specifications for procuring environmentally friendly products and services. Amaroussion was the first municipality in Greece to be registered under the EMAS scheme in 2006. In addition, the municipality has received the National EMAS Award (2009) for applying green criteria in its purchasing practices [2].

### **Subject**

Procuring sustainable paper to cover municipality's office needs

### **Procurement objectives**

The municipality published in 2006 a request for tenders, inviting suppliers to submit a bid to supply the municipality with recycled paper (A4 sized). The quantity requested was 430 packets in total. Each packet had to include 5 units with 500 pieces of multi-purpose copier paper each. The primary objective was to cover municipality's needs for paper by implementing a public procurement process that will assist in a) reducing the demand for natural resources to be used as raw materials during the production, b) excluding dangerous substances as ingredients, c) favouring products that are re-useable and recyclable, and d) promoting packaging material made from recycled material.

### **Criteria and specifications**

The contract was to be awarded to the supplier offering the most economically advantageous tender (MEAT) and complying with a number of technical and environmental criteria. Before publishing the call, the municipality conducted a research to evaluate the availability of recycled paper (A4 sized) in the Greek market and to define the quality specifications that can be satisfied by local suppliers, whilst ensuring the least negative impact on the environment. Based on the research, the following sustainability award criteria were applied:

- At least 80% of the paper's raw material should be from recycled paper fibre.
- No chlorine substances during the manufacturing process (TCF – Totally Chlorine Free)
- The level of paper brightness should be greater than 80 according to ISO 2470
- Their compatibility should be according to the DIN 19309, AFNOR Q11-012

## **Results**

The tendering procedure was successfully implemented, even though only one supplier managed to comply with the environmental requirements prescribed in the call. Prioritising environmentally friendly products (such as recycled paper) has contributed in lessening municipality's reliance on natural resources, minimising health risk associated with the use of chemical substances and preventing hazardous effects on water ecosystems and soil degradation. As the Municipality of Amaroussion is registered under ISO 14001, all suppliers are now acquainted with its environmental policy concerning GPP. Furthermore, this practice paved the way to include environmental and sustainability criteria in all municipal tenders.

## **Conclusions**

The procurement process did not go without problems. Public authorities experienced difficulties in identifying suppliers that were able to fulfil the defined environmental criteria. The results showed that the market was not mature enough to adopt green business practices. This was also due to the limited demand for environmentally friendly products and services, resulting from the lack of environmental culture within the society. Another problem encountered during the implementation was that the price for recycled material was 25% higher, compared to the typical paper. To overcome this barrier, the municipality collaborated with 6 other Greek public entities to increase the amount of purchased paper and therefore achieve a better price. Indeed, this approach managed to reduce the price significantly, resulting in paying only 6% more for the recycled paper. There have been many municipalities that have applied the same tender requirements to procure recycled (A4 sized) paper for covering their office needs. Therefore, this practice demonstrates high transferability potential as the needs addressed are common among public administrations across the EU, and the tendering procedure does not entail significant implementation risks nor organisational resistance.

## Chapter 3. Life Cycle Costing

### 3.1. Definition

Life Cycle Costing (LCC) is a concept that we all are familiar with and apply it in our daily lives, even if we do not realize it. Simply put, we apply a form of LCC whenever we are trying to decide if something we wish to buy is a good idea, not only based on its purchasing cost but also its cost while using it and maintaining it. Two obvious examples are buying a car or an air conditioning unit. Examining the fuel consumption of the car or the energy consumption of the AC unit is crucial for us to decide if purchasing the product will prove financially beneficial.

If we apply the same logic and we take into consideration all related costs that arise by purchasing a product or service before we proceed to its purchase, then we have applied LCC. As the Article 68(2) of Directive 2014/24/EU defines it:

*Life-cycle costing (LCC) shall to the extent relevant cover parts or all of the following costs over the life cycle of a product, service or works:*

*(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.*

We can immediately realize the long term financial benefits of the above approach even for small purchases. When the same logic is applied in organizations with large monthly purchasing needs where efficient spending is crucial, the long term benefits become substantial and almost necessary. This has been embraced in the last several years, both by the private and the public sector, who are taking drastic actions to incorporate LCC, as much as possible, in their financial practices.

## 3.2. Benefits

LCC can be complicated in the beginning and it adds an extra level of research and investigation during a procurement process. However, its recent uptake by large organizations and international institutions (mainly the European Commission - EC) proves that its benefits far outweigh the extra burden.

- The first obvious benefit is the reduction of costs as it was mentioned above. Knowing in advance what a total cost will be for a series of products or services, can help the buyer choose the most long term cost efficient option. In large corporations or public authorities who have large and consistent purchasing needs and the spending efficiency is crucial, the cost reductions can be substantial.
- The second benefit of adopting LCC during the purchasing process and closely related to the first one, is the transparency of future operational costs. Early investigation of future needs (e.g. high maintenance or cheap disposal) will lead to informed and aware buyers who can make their purchasing decisions based on the highest value for money option.
- Another benefit which applies mostly in large projects where design is also a part of the early process is steering design decisions towards the reduction of total costs. An example of this would be in construction projects (e.g. for renovation) where requests for offers would also take into account the LCC prospects of each offer.
- Finally, another important advantage in incorporating LCC is its flexibility regarding the meaning of the word “value” in our decision for the product or service with the most value for money. Value may refer to purchasing cost, to the quality of the product or to the environmental impact of the purchase. While the latter is such an important consideration, currently the economic evaluation of the environmental externalities (i.e. broader consequences, especially on the environment) in LCC, presents many issues, such as high complexity and debatable results. Considering the major challenges of human impact on the environment that we face globally, there is a lot of effort (and progress) in the methodologies monetizing the environmental impact (such as the gas emissions), trying to address these issues and make LCC for environmental externalities a more straightforward and efficient process.

The ecological considerations of purchased products or services will become more and more important. Contrary to the financial analysis, where short term benefits can even surpass in significance the long term effects in some cases, this is not the case for the environmental analysis. Focusing on the long term effects is the only sustainable option, thus making LCC a perfect (and in many cases necessary) tool to achieve that goal.

At this point, it would be helpful to mention that there is an entire field that analyzes methods for quantifying environmental impacts of products and services (e.g. emissions and waste), called Life Cycle Assessment (LCA). While LCA and LCC share many common characteristics, the objectives of these two tools are different and one should not be confused with the other.

### 3.3. Flexibility

By definition LCC refers to the consideration of several costs related to the purchase of a product or service, that is acquisition costs, maintenance and usage costs, end of life costs and costs related to environmental externalities expressed in monetary value. However, the level of adoption can be partial, meaning that one can select to take into consideration only a subset of these costs during the procurement.

One of the most common approaches, if someone decides to make a purchase with criteria beyond the typical lowest acquisition costs, is to also evaluate the maintenance, usage costs and end of life costs and to avoid the monetary evaluation of the environmental externalities which as mentioned above, is not an easy task yet. This approach is called Total Cost of Ownership (TCO). The TCO is an estimate of the direct and indirect costs of a product now and in the future and its focus is strictly on the financial consequences concerning that particular product.

The full embrace of LCC, if someone decides to adopt it, includes the calculation of the TCO and then goes several steps further. One extra consideration is accounting for possible consequential costs or benefits to the organization that cross over other sectors. For example, will the organization gather knowledge by purchasing this product, will it present opportunities of future collaboration and expansion, will it increase its effectiveness in other aspects? If the answer to the above questions is yes, then it may be for the benefit of the organization to purchase this product even if it will lead to an extra short-term financial cost.

Also, in LCC, the focus transcends the limits of the organization that makes the purchase and evaluates the direct and indirect impact of any optional purchase to the society. It then expresses this impact into monetary value, through a well-defined and broadly accepted methodology in the literature, and adds this amount to the expected cost. The social aspect that is usually examined is mainly the environment, but can also be the impact on (un)employment, health and education. For example, a public institution may identify that the usage of a specific product is connected with increased gas emissions. This may weigh negatively in purchasing this product even if its purchase would be beneficial in the TCO context because the monetary equivalent of the increased gas emissions would change the offer to non-beneficial financially.

A visual representation of the above is presented in Fig. 1 by ISO 20400.

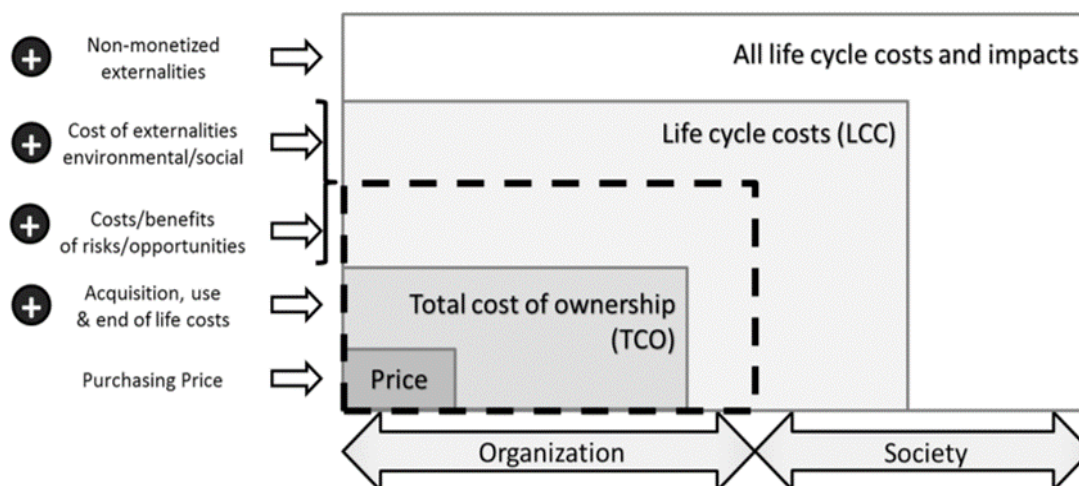


Fig. 1. Different levels of LCC application (source: ISO 20400)

The level that each organization decides to incorporate LCC in its procurement practices depends on its priorities. In the private sector, where short term financial success is imperative for its survival, most limited approaches may be chosen. However, in public authorities who ultimately serve society, and the external impacts (out of the organization limits) will eventually reach the society itself, there is a strong motivation to ensure that LCC is adopted to its full potential.

Unfortunately, as mentioned before, the well-defined and broadly accepted methodologies required to make the cost estimations for the societal consequences and allow for the full utilization of LCC, are not a reality for many products yet. While there have been significant efforts (e.g. the efforts of public institutions to monetize the CO2 emissions related to a product), it is still a field with many challenges still to be addressed.

This is why, in this methodology, when we present the environmental externalities connected with the purchase of a product, we mention both the ones for whom there is a financial representation in the tools mentioned but also the externalities that they are not considered during the calculation of the LCC with the help of the tools. For the latter, we decided to provide the background (cause) of these externalities and provide the relevant European GPP criteria. Since this is not considered LCC due to the lack of the estimation of the corresponding financial costs, we include them for two reasons. First, in a possible future update of this methodology, there might be progress on the monetary evaluation methodologies for these particular externalities. Thus, there will be added easier within the LCC context. Secondly, environmental aware officers may find helpful The GPP criteria even if not connected strictly with LCC.



### **3.4. LCC in public procurement**

Public procurement is an excellent field for LCC application because procurement needs of public authorities are characterized by regularity, commonality and of large quantity. Regularity makes the adoption of LCC easier, since the methodology of tendering will be consistent. For example, if a public authority utilizes LCC for purchasing paper, it may use the same approach two years later when their need in paper will reemerge. Commonality in needs also makes the LCC adoption and expansion easier, this time across different public authorities. A successful tender based on LCC principles in a common P.A. procurement case, such as for indoor lighting, can be easily transferred to another P.A, and even an unsuccessful one may prove helpful and provide lessons to all public authorities in the region. Finally, the regularity and commonality in P.A. needs lead to a large demand for a specific basic range of products. As explained earlier, the large demand maximizes the long term financial and environmental benefits of the LCC approach and provides incentives for the market to adjust faster to the new requirements.

It was for the above reasons that EC decided to strongly promote LCC practices across the public authorities in alignment with GPP policies in European countries. By 2016 every European country had to incorporate to its national law the EU directives 2014/24/EU, 2014/25/EU, which allows and promotes a life cycle cost approach in all public procurement with focus on the environmental impact. Since this introduces a new layer in public procurement procedures which is followed by a series of challenges, it requires calculated studying and careful planning in order to harvest the most benefits. To this end, EC has also financed a number of projects with the objectives to promote LCC in European regions, to study proper methodologies for several basic products, to evaluate and maximize possible benefits and to develop a range of tools that accommodate the incorporation of LCC in public procurement practices.

### **3.5. Challenges**

LCC in procurement adds an extra layer to an already complex field which is procurement. Therefore, it is evident that it will be accompanied with several challenges that need to be addressed. According to the LCC State of the Art report [5] by Regional Networks for Sustainable Procurement (SPP) the main challenges are the need for reliable data for the proper calculations to take place, the complexity of environmental issues making their evaluation uncertain and difficult, the lack of users knowledge and familiarization of LCC concepts in procuring departments and the occasional conflict between cost efficient and environmental friendly solutions. The report has also identified a set of solutions that address these challenges. Among others, it suggests the proper selection of products and services that benefit most by LCC practices, the establishment of a policy framework with clear environmental objectives, the

utilization of monitoring during the lifecycle to refine future LCC applications and the training and networking of public authorities staff.

## Chapter 4. LCC in practice

The objective of this chapter is threefold. The first objective is to translate the LCC concept into practical steps and considerations when procuring particular products. This means answering questions such as which features should procurers pay attention to, which criteria should help them towards their goals etc. The second objective is educating procurers on the environmental repercussions of these products and what are the available tools to minimize them. Thirdly, for every product, we present available tools that have been developed by public authorities and institutions to ease the application of LCC in these products by automating calculations of complex features, such as the long-term cost of energy consumption.

As explained earlier, the process of expressing environmental externalities to monetary value presents many challenges. Therefore many of these externalities are not part of the LCC calculation that takes part in the presented tools. However, we have included them in the description for two reasons. First, in a possible future update of this methodology, there might be progress on the monetary evaluation methodologies for these particular externalities. Thus, it will be easier to expand this methodology and it will be good for the procurement officers to already have a perception of the full repercussions attached with the purchase of each product. Secondly, for these externalities we decided to provide the relevant European GPP criteria. It is a good opportunity to provide alternatives to these issues for environmentally concerned readers, even if these criteria do not belong within the context of LCC but in GPP in general.

### 4.1. Lighting

#### LCC principles

Lighting is one of the products/services where LCC has been largely incorporated by public authorities. The reasons for its success are the advancements in energy efficient lighting technology, the fast reduced payback period due to resulting reduced electrical bills and the support of its usage by public authorities. According to the preliminary report for the Revision of the EU Green Public Procurement Criteria for Street Lighting and Traffic Signals [15], by 2017 many old types of lamps have been or are being phased out, such as the High pressure mercury, the Halophosphate Fluorescent Lamps and the High Pressure Sodium (HPS) lamps. According to the same report, while the latter type (HPS) by 2015 was the dominant road lighting technology with 53% of market share, in the projects where new luminaires are installed, LED luminaires are dominating the market. The following table from the Procurement & Design Guidelines for LED Street Lighting by Premium Light Pro shows the advantages in energy efficiency when using LED technology compared to alternatives taking into account their extended lifetime [5].

Table I. Sample values of power density indicator / annual energy consumption indicator (AECI) for a two-lane road for motorized traffic [5]

Lighting class	Lamp type				
	High pressure mercury	Metal halide	High pressure sodium	Low pressure sodium	LED
M1		45/5.0		34-41/4.0-5.3	25-32/3.0-3.8
M2	100/10.8	50/4.6		31-40/3.2-4.2	24-27/2.4-2.5
M3	84/6.0	47/3.6	40/2.8-3.1	34-38/2.5-2.6	23-25/1.5
M4	90/5.0	60/3.1	41-47/2.3-2.5	34-42/1.8-2.4	23/1.1
M5	86/3.2	30/0.9	47/1.7	38-45/1.1-1.6	24/0.8
M6	85/1.9	37/0.6		45-49/0.2-1.2	20-27/0.4-0.5

As long as the performance requirements in street lighting (e.g. luminance, glare etc.) are met based on national laws and/or European standards (e.g. EN 13201), the factors that should be taken into considerations when estimating LCC are the following:

**Energy efficiency:** Technology has made big leaps in producing lamps with high energy efficacy (lm/W). High Pressure Sodium and LED lamps showcase double energy efficacy compared to High Pressure Mercury lamps. Although the lamp technology is a major factor towards energy efficacy, the latter depends on many other factors, such as the proper design of the overall lighting structure, the chosen geometry, the incorporation of dimming control etc. According to a case study on street lighting where multiple options for reducing life cycle costs were examined, it was found that the options that reduced energy consumption were the main contributors to life cycle cost reduction [6].

**Lifetime:** Another important factor in reducing LCC is product lifetime. Longer time before product failure may compensate for increased purchasing price. There are two factors that should be taken into consideration when estimating a product's performance vs time based on the IEC 62722-2-1 standard.

The first factor is the performance depreciation of the product. One metric to estimate that is called average rated life  $L_x$  and it corresponds to time needed for a lamp's luminance performance to degrade to (100-x percent). For example,  $L_{80} = 20000$  hours means that after 20000 hours of operation, the lamp's output will decrease by  $100-80 = 20\%$ . A second metric for performance depreciation is called rated life  $L_xBy$  and indicates the time that needs to pass in order for the products that may perform maximum at level x to be at the percentage of y. For example,  $L_{80B20} = 30000$  hours means that after that time, 20% of the products will perform at 80 luminous flux or less. The second factor of the product's lifetime is the time to abrupt failure  $C_z$  which indicates the time after which the z % of the installed products will have failed. The manufacturers usually provide the above metrics for their products and for a range of applications.

**Dimming:** Dimming is the capability of adjusting the illumination levels of a light source to meet to specific locational, operational or temporal needs. Taking into account the weather and/or the traffic conditions through timers, light sensors and traffic detectors, these strategies can save a large percentage of unnecessary operation time in maximum illumination. Timers may provide the necessary information to change illumination levels between dusk and night. Light sensors help in adjusting the output to weather conditions which affect the lighting needs, such as cloudy days. And finally, in low traffic, where full operation is completely pointless, traffic sensors may lead to substantial savings as well.

**LCC calculation:** The formula for LCC calculation based by Joint Research Centre (JRC), the European Commission's science and knowledge service [15] is given by:

$$LCC = \sum CAPEX + \sum (PWF \times OPEX)$$

where:

LCC is the life cycle costing.

CAPEX (Capital Expenditures) is the purchase price (including installation) or so-called capital expenditures.

OPEX (Operational Expenditures) are the operating expenses per year or so-called operational expenditures, such as operating and maintaining the lighting system, costs for electricity, relamping, repair, maintenance and end of life.

PWF is the present worth factor with  $PWF = (1 - 1/(1+r)^N)/r$ .

N is the product life in years.

r is the discount rate.

Note that the Net Present Value (NPV) of the OPEX is equal to  $PWF \times OPEX$ . OPEX can be composed of several expenditures, e.g. electricity and re-lamping. The PWF is usually smaller than one which means that an advantage is given to costs and expenses that can be postponed.

Calculating CAPEX is somewhat straightforward. They mainly include the purchasing price and the installation/labor costs. OPEX in lighting systems mainly include electricity costs, maintenance/labor costs (lamp replacement, repairing, checking, cleaning etc.) and end of life costs (uninstallation, disposal). The calculation of such costs however is more complicated, since it encompasses the prediction of volatile financial costs. For the prediction of these future costs to be as accurate as possible, the calculation must take into account interest, inflation and discount rates.

A common approach is to calculate the discount rate  $r$  as interest rate minus inflation rate. Discount rates are used to calculate the Net Present Value (NPV) in TCO or LCC calculations to compare costs and benefits that occur in different time periods [6]. The Total Cost of Ownership (TCO) is equal to the Capital Expenditures (APEX) and the Net Present Value (NPV) of all Operational Expenditures (OPEX). Currently in preparatory studies for ecodesign a discount rate of 4 % is used, but given the current economic conditions this can be lower, e.g. 2% [15].

## Externalities

There are three main environmental concerns when considering lighting solutions. Gas emissions (such as CO<sub>2</sub> and acidifying gases) related to the electricity consumption, light pollution and poor resource efficiency due to low material lifetime.

**Gas emissions.** Fossil fuels generated electricity is a major contributor to greenhouse gases and as a result to climate change. In LCC, there has been particular progress in calculating electricity's impact in climate change in monetary terms. The first three tools presented below, do include that particular impact and provide the financial calculation of this impact to the user. So far, this is the only externality that is considered in calculating lighting's LCC in the tools presented. Therefore, there are two ways that could and should be adopted to decrease LCC when procuring lighting systems (so far). The first is selecting systems that reduce the electricity consumption which affects LCC both through the reduction of TCO and the externality's impact (by adopting solutions, such as high luminance efficacy luminaires and dimming technology systems that they have been discussed earlier). The second way is to promote electricity generated from renewable energy sources which affects the LCC from the externality aspect. This is often done by utilizing contracts that cover the entire electricity provision (e.g. electricity needs for buildings) and not solely for lighting. Various verification methods exist in all European countries that can be used in the tender process and guarantee the source of the energy, such as national Guarantee of Origin schemes and/or ecolabels.

**Resource efficiency.** Resource efficiency is connected to the lifetime of materials used in the lighting system. Selection of longer lifetime products also affects the total cost of ownership, thus it has been discussed in the previous section.

**Light pollution.** Light pollution is defined as the presence of anthropogenic light in the night environment. It is exacerbated by excessive, misdirected or obtrusive uses of light, but even carefully used light fundamentally alters natural conditions. As a major side-effect of urbanization, it is blamed for compromising health, disrupting ecosystems and spoiling aesthetic environments. One of the major factors of light pollution is street lighting and is caused by over-illumination and by light "leaking" beyond the direction it is intended to go. This increased and "trespassing"

illumination may cause sleep cycle disruptions to humans and animals and may have crucial impacts to ecological dynamics (such as navigational problems to birds and insects).

For this type of externalities by lighting, there is no methodology included in the tools that can express it in monetary terms, i.e. it cannot be included in LCC calculation. There are, however, three main considerations when designing and installing a street lighting system that can help alleviate the issues above, that is worth to mention in case an officer wants to address this issue in a context outside of LCC and related more to GPP.

Firstly, the directional efficiency of the system must be increased by proper design choices and selecting luminaires with high upward light output ratio (ULOR) or Ratio of Upward Light Output (RULO), which is the amount of light emitted above the horizontal plane at the position of the luminaire. EU green criteria for RULO are set to 0.0 % to minimize light pollution. LED technology is quite efficient in exhibiting low light “leakage” and high directional efficiency.

Secondly, the intensity of lighting should not exceed the necessary levels for what it is intended. This can also be achieved by proper lighting system design and through the utilization of technologies that allow adjustable lighting. Dimming through sensors and other means (e.g. timers) that adjust the light sources to the current conditions has already been discussed.

A third consideration regarding the minimization of ecosystem disruption is the light source parameters. It has been shown that many species are mostly affected by light emitting in specific spectrum. For example, Earth's atmosphere scatters and transmits blue light better than yellow or red light, therefore first generation blue-light LED road luminaires are more polluting than sodium lamps. As a result, luminaires that are characterized by low emission in those waves should be preferred. EU GPP criteria uses the G-index value to evaluate the blue light content of the luminaire and it should be taken into account when the task in hand in lighting in areas where wild life may be present, e.g. in parks or forest areas.

### **Available LCC tools**

Lighting is one of the largest sources of energy consumption under direct control of public bodies. By deploying innovative and advanced street lighting technologies e.g. LED fixtures, we can improve visibility and reduce light pollution, while at the same time, we minimize energy consumption by 50%.

Nowadays, innovative lighting solutions are advancing at a rapid pace and look promising in terms of energy savings however a vast amount of indoor lighting systems used in the private and public service sector are still based in former technologies (e.g. T8 Fluorescent tubes with electromagnetic ballasts and halogen lamps). By replacing these technologies with innovative LED indoor lighting systems would certainly prove to be beneficial throughout time. Instead of conducting retrofit of existing luminaires which could result in emerging challenges by having to

alter lighting distribution accordingly, it is highly recommended to replace both luminaires and lamps [12]. By increasing the efficiency, optimizing the luminaire design and developing flexible lighting control systems, we may enhance the lighting performance using cost-efficient methods for different indoors/outdoors lighting and traffic conditions. For example, LED Lighting methods include flexible lighting control, user-controller luminaires, imitation of outdoor lighting variation over the day, as well as smart lighting and better use of daylight. Since there is very little information on how to efficiently apply energy-saving lighting system in outdoor areas, it seems necessary to shed some light and tackle the underachievement of the market penetration by providing knowledge to the proceeding market and by taking advantage of the large potential for improving local and national policies that support the implementation of LED lighting systems [5].

To this end, several authorities have developed LCC tools that ease the transition to new, energy efficient lighting solutions both for outdoors and indoors applications. Many tools are limited in calculating TCO and they do not utilize full LCC (with externalities) though some do. Below we present several such tools and we provide details on their basic functionalities and features to help procurement professionals and decision makers at federal, local and municipal levels. While the list of tools presented is not exhaustive, we believe it is a great start for any person who is in charge of commissioning new outdoor/indoor lighting installations or renovating existing, ones to familiarize themselves with the available solutions.

*[Generic luminaire by the European Commission - Outdoors and indoors applications - \(http://ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm \)](http://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)*

The LCC Calculation tool for generic luminaire has been developed by the European Commission (EC) in order to be used for the tender evaluation [8]. The main feature of this tool is the evaluation of direct costs for both indoor and outdoor lighting throughout the product life cycle in support of public procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs) and has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products.



## "Life Cycle Costing (LCC) calculation Tool"

v. 1.0 2007/2016

Developed by:  
STUDIOFIESCHI  
& SOCI  
Scuola Superiore  
Sant'Anna

**Warning**

Please note: this Tool has been developed and tested with Excel 2013 and 2010. In order to use it, macros have to be activated. To enable macros, go to File => Options => Trust center => Trust Center Settings => Macro settings and select "Disable all Macros with notification". In the yellow banner, select "Enable content" to activate the macros.

**Introduction**

This is an electronic tool designed to perform life cycle costing (LCC) for a specific range of products commonly featured in public tenders. The tool, distributed by the European Commission, derives from provisions made in the new Directive 2014/24/EU, which significantly innovate the tender evaluation and award process through placing considerable importance on LCC.

The main feature of this tool is the evaluation of direct costs throughout the product life cycle in support of public procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs). The tool has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products. The information on externalities obtained with this tool shall not be used to measure and communicate the life cycle environmental performance of products, since the tool is not compliant with the Product Environmental Footprint (PEF) methodology in annex I to the Commission Recommendation of 9 April 2013.

For more information about GPP and LCC, see [http://ec.europa.eu/environment/gpp/index\\_en.htm](http://ec.europa.eu/environment/gpp/index_en.htm)  
For more information about PEF, see <http://ec.europa.eu/environment/eussd/smgp/index.htm>

INSTRUCTIONS			
• Use coloured buttons to access the forms to fill in data			
• Use grey buttons to browse the tool			
• The table below includes a complete list of the available sheets.			
• Detailed instructions are included in the User's Guide			

Sheet name	Content
MAIN	Select the general settings (e.g. tool language, currency, exchange rate).

	Product category	Reference product	Available actions
• IT_PC	Office IT equipment	Computer	Insert, edit or delete products.
• IT_DS	Office IT equipment	Computer Display	Insert, edit or delete products.
• IT_IE	Office IT equipment	Imaging equipment	Insert, edit or delete products.
• LT_GL	Office & street lighting	Generic luminaire	Insert, edit or delete products.
• WG_OV	White goods	Ovens	Insert, edit or delete products.
• WG_RA	White goods	Refrigerating appliance	Insert, edit or delete products.
• WG_DW	White goods	Dishwasher	Insert, edit or delete products.
• WG_WM	White goods	Washing machine	Insert, edit or delete products.

GO TO MAIN

GO TO REFERENCES

**Fig. 2. Introduction of the LCC tool**

**How to use ([http://ec.europa.eu/environment/gpp/pdf/LCC\\_tool\\_user\\_guide\\_final.pdf](http://ec.europa.eu/environment/gpp/pdf/LCC_tool_user_guide_final.pdf))**

To use the tool, firstly complete the General Data that are to be used for all products within this product family. Then, enter the discount rate that represents the difference in value between the costs in the future (lower value) versus the costs in the present and the Amortization coefficient, which allows a product cost to be distributed over different time periods on the basis of its life and deterioration. Then it is necessary to type the electricity price costs per kWh and the number of purchased items.

After completing the General Data, move on to the Product Specific Data, where each time it is possible to create, edit or delete new product. After filling in the Supplier and Product name, it is then possible to specify the detailed data for each product. For example, to complete single lamp selling cost and number of lamps per luminaire. Also, the luminaire selling price and price for equipment needed (excluding lamps and luminaires) and costs referring to costs for delivery and transportation of the product from the vendor to the public administration must be defined. Other costs include luminaire and lamp installation costs. As for the use and end-of-life data that

must be filled, it is necessary to specify the total power absorbed by the luminaire, the total number of operating hours yearly, the maintenance and service costs, the expected lifetime of the product in years and the end-of-life costs that include costs of waste collection, disassembling, etc.

The screenshot displays a software interface for data entry. On the left, there are two tables: 'GENERAL DATA' and 'PRODUCT SPECIFIC DATA'. The 'GENERAL DATA' table includes fields for Discount rate, Amortization coefficient, Electricity price, Country, Economic period, and Number of purchased items. The 'PRODUCT SPECIFIC DATA' table lists various lifecycle phases like Purchase and Use & end-of-life with their respective input names, units, and values. On the right, a window titled 'Office & street lighting | Generic luminaire' is open, showing a detailed 'Purchase' sub-table with input fields for costs like Single lamp cost, Lamps per luminaire, Luminaire cost, Equipment cost, Delivery expenses, Luminaire installation cost, and Lamp installation cost, all measured in EUR. Buttons for 'INSERT PRODUCT DATA' and 'GO TO OUTPUT' are visible at the top right of the main interface.

Product category		Office & street lighting		
Product		Generic luminaire		
USE MODE		Tender evaluation		
GENERAL DATA				
N°	INPUT NAME	UNIT	VALUE	
1	Discount rate	%	11.00%	
2	Amortization coefficient	%		
3	Electricity price	EUR/MWh	12	
4	Country	-	EU	
5	Economic period	Years	0	
6	Number of purchased items	#	3	
PRODUCT SPECIFIC DATA				
N°	LIFE CYCLE PHASE	INPUT NAME	UNIT	My Sup - My Prod
1	Purchase	Single lamp cost	EUR	
2		Lamps per luminaire	n	
3		Luminaire cost	EUR	
4		Equipment cost	EUR	
5		Delivery expenses	EUR	
6		Luminaire installation cost	EUR	
7		Lamp installation cost	EUR	
8	Use & end-of-life	Weighted energy consumption	kWh/1000 hours	
9		Annual operating hours	Hours/year	
10		Maintenance/service contract costs	EUR/year	
11		Expected luminaire lifetime	Years	
12		Cost of disposal	EUR	
13		Waste collection costs	EUR	
14		Disassembling costs	EUR	

Fig. 3. Filling the 'Use and end-of-life' data

After completing the required fields, return to the main page, where by pressing the 'Insert Product Data' button a new product can be added, or an existing product can be edited or deleted. If the 'Go to Output' button is selected, the LCC calculations are divided into sub-categories.

- The General Information presents generic supplier and product information.
- The LCC Results – Direct costs sub-category divides the overall costs into acquisition costs, costs of use, maintenance costs and end-of-life costs, presented in a diagram.
- The Distribution of costs over time subcategory is another chart that show how costs alternate in time.
- The Externalities subcategory depicts the effects in climate regarding the electricity usage.

Additionally, the use is given the options to either ‘Display Results for total purchased items’ or ‘Show overall LCC results’. It is also possible to print the excel, export the results to a specific folder or open the exports folder. All the above stated functions are separated into different buttons for convenience.

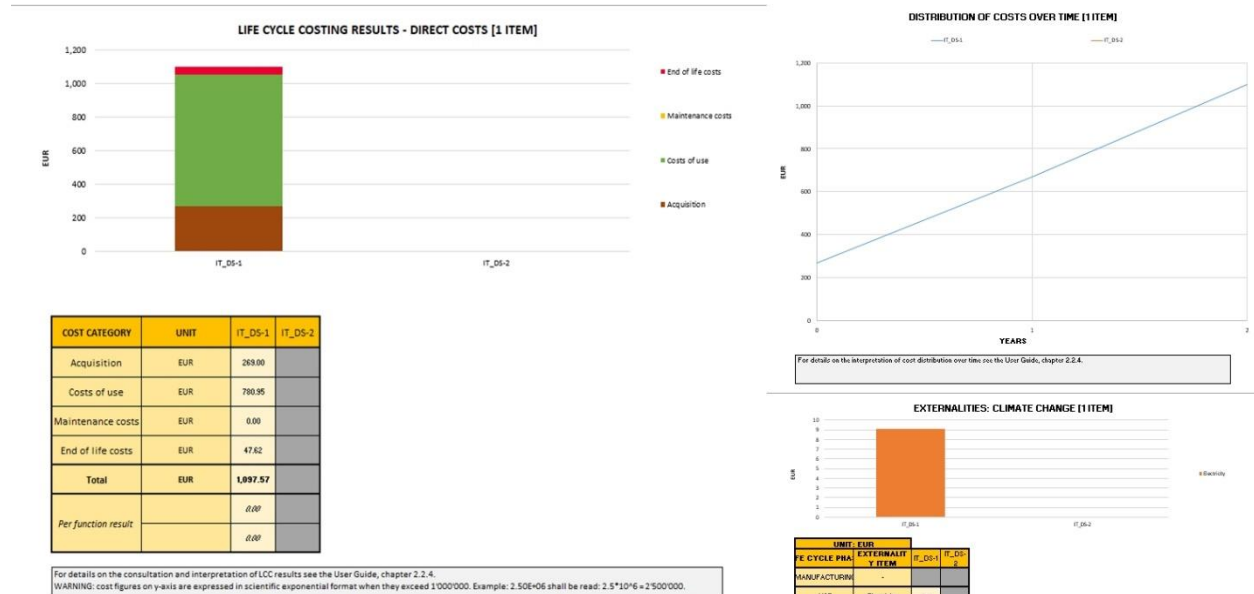


Fig. 4. Results of the LCC tool

***Lighting System by the National Agency for Public Procurement - Indoors applications -***  
***(<https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>)***

The following tool, developed by the National Agency for Public Procurement, is designed especially for the procurement of indoor lighting and thus, it can be used when choosing criteria or in the evaluation of tenders [9]. It also allows to the user to efficiently calculate the climate impact, heavily based on the power consumption coming from the lighting system currently operating.

More specifically, the tool can provide an approximation of the costs correlated to the system. It is widely accepted that for an installed lighting system, the operating energy cost is a large component of the overall cost, if not the largest, and we can see different scenarios during the usage time by testing different rates of price changes. If we select to use an LCC tool in the evaluation of tenders, the procurement documents should certainly describe the parameters used in the calculation. The criteria are ready for download by visiting the National Agency for

Public Procurement’s website. Yet, one thing to consider using an LCC-tool is to only include the large cost items, or costs that is expected to differ between different suppliers, whereas externality costs for environmental parameters can be included and calculated only if their monetary value can be determined and verified in a way that is standardized. As for the tenders’ evaluation, the LCC cost will be included as a parameter in order for the most cost-efficient tender to be evaluated. Quality criteria for the lighting system, such as light quality, are not included in the tool and must be specified separately in the tender documents.

The LCC tool is based on present value method to be able to calculate future cost to present value, an equation that is included in the tool. Other parameters such as discount rate, electricity pricing and economic periods are just some of the criteria that are expected to affect the result and should be decided upon consulting the Contracting Authority (CA).



**Fig. 5. Introduction of the LCC tool**

**How to use**

The LCC tool for the Indoor Lighting System calculates total LCC costs in the same manner as the Outdoor Lighting System LCC tool, yet there exist a few noticeable changes. First things first, the building descriptions based on the data provided by the CA must be entered such as the number

of rooms that share the same room type and the coverage area expressed in  $m^2$ , so that the tool can calculate the room type's LENI-number, a factor that represents the energy usage per  $m^2$  for each room type. In this tool, there is an option to add or remove types of luminaire, as well as adding or removing room types inside the LCC tool.

The rest of the data is provided by the supplier and is divided in two categories, Luminaire Type 1 and Luminaire Type 2. Both categories require the same amount of information, beginning from input fields that require from the supplier to enter the number of luminaires that are included in the suggested solution per room type and the total price per luminaire. Then, the supplier must type the material and labour installation costs per luminaire and the effect that a luminaire has on the indoor system (including operation losses). From a pre-defined dropdown list, select the intending type of control (this will either include manual or manual with presence detection or manual with both presence detection and daylight). Next LCC tool criteria include defining reductions correlated to the manual control factor, the daylight factor and the presence detection control factor. The total reduction factor for control is locked and equal to 1 for every defined room type. Upon entering an estimation of the maintenance costs per year (including costs for cleaning/surveillance/lighting source/electrical ballasts), the only field remaining is the external control device cost (different sub-category named as Control Device), a cost that must be specified per room type. When completed, the LCC calculator will provide the LCC cost outcome.



Introduction	LCC-calc. A1	LCC-calc. A2	LCC-calc. A3	LCC-calc. A4	Tool-parameters	Reduction factors control	Climate impact factors	Result	Response sheet
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LCC-calculation System alternative 1

**Calculation conditions (given by the contracting authority)**

PROJECT:

DATE:

ADMINISTRATOR:

1.1 Usage time	<input style="width: 80%;" type="text"/>	years
1.2 Discount rate	<input style="width: 80%;" type="text" value="1.75%"/>	
1.3 Electricity price	<input style="width: 80%;" type="text"/>	SEK/kWh
1.4 Annual electricity price change	<input style="width: 80%;" type="text"/>	
1.5 Climate impact electricity usage (optional)	<input style="width: 80%;" type="text"/>	kgCO2/kWh
1.6 Operating hours system	<input style="width: 80%;" type="text"/>	h/year

With the buttons you can add or remove types of luminaires (rows) and types of room (columns).

Add type of luminaire	Add type of room
Delete type of luminaire	Delete type of room

Description of building and lighting suggestion

**DESCRIPTION OF THE BUILDING (provided by the CA)**

Room types		Room type 1	Room type 2	Room type 3	Room type 4
Number of rooms of the same type	qty	1	1	1	1
Area	m <sup>2</sup> /room	1	1	1	1

**DATA (from supplier)**

**LUMINAIRE TYPE 1**

2.1 Number of luminaires	<input style="width: 80%;" type="text"/>				
2.2 Price per luminaire	<input style="width: 80%;" type="text"/>	SEK/piece			
2.3 Material and labour costs per luminaire	<input style="width: 80%;" type="text"/>	SEK/piece			
2.4 Effect per luminaire incl. operating loss	<input style="width: 80%;" type="text"/>	W/piece			
2.5 Type of control (choose from list)	<input style="width: 80%;" type="text"/>	None	None	None	None
2.6 Reduction factor manual control	<input style="width: 80%;" type="text"/>				
2.7 Reduction factor presence detection control	<input style="width: 80%;" type="text"/>				
2.8 Reduction factor daylight control	<input style="width: 80%;" type="text"/>				
2.9 <b>Total reduction factor for control</b>		<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
2.10 Maintenance costs	<input style="width: 80%;" type="text"/>	SEK/year			

**LUMINAIRE TYPE 2**

2.1 Number of luminaires	<input style="width: 80%;" type="text"/>				
2.2 Price per luminaire	<input style="width: 80%;" type="text"/>	SEK/piece			
2.3 Material and labour costs per luminaire	<input style="width: 80%;" type="text"/>	SEK/piece			
2.4 Effect per luminaire incl. operating loss	<input style="width: 80%;" type="text"/>	W/piece			
2.5 Type of control (choose from list)	<input style="width: 80%;" type="text"/>	None	None	None	None
2.6 Reduction factor manual control	<input style="width: 80%;" type="text"/>				

Fig. 6. Filling data of the LCC tool

The LCC tool result variables for the Indoor Lighting System are identical to the result variables from the Outdoor Lighting System. It is possible to see the result for an entire building, which includes the LCC total cost, the energy cost per year, the energy cost if full time usage occurs and the experienced climate impact. In addition (and as opposed to the tool for outdoor systems), the user can also see metrics regarding the room types, such as the total cost per room type and the LENI-number per room type. The constructed diagrams are also the same with the LCC outdoor tool, revealing firstly the total LCC costs divided into investment, energy and maintenance costs and secondly the energy usage and climate impacts per year.

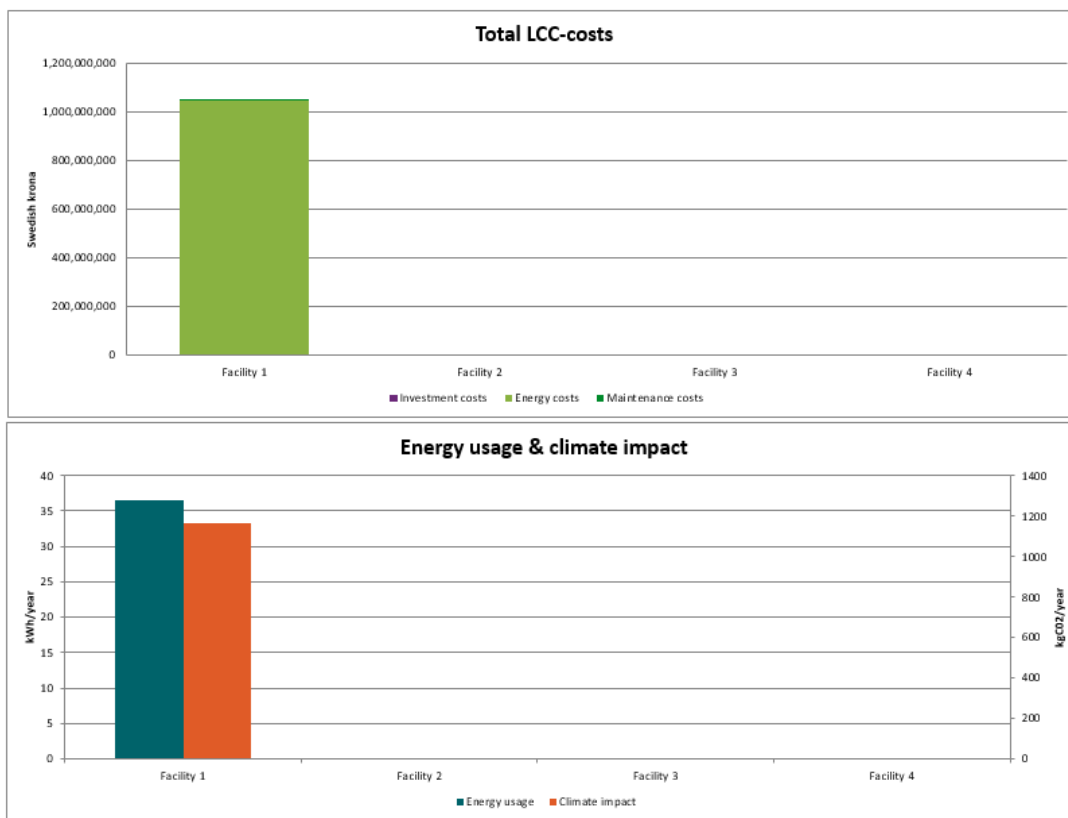


Fig. 7. Results of the LCC tool


*Lighting System by the National Agency for Public Procurement - Outdoors applications – (<https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>)*

As with the Indoor Lighting System from the National Agency for Public procurement, the following tool applies to outdoor lighting and is designed especially for the procurement of outdoor lighting. It can be used when choosing criteria or in the evaluation of tenders, while also allowing the user to efficiently calculate the climate impact, based on the energy consumed in the operation of the lighting system (as also described with the indoor lighting system) [10].

More specifically, the tool can provide an approximation of the costs correlated to the system. It is widely accepted that for an installed lighting system, the operating energy cost is a large component of the overall cost, if not the largest, and the user can see different scenarios during the usage time by testing different rates of price changes. If a procurer wishes to use an LCC tool in the evaluation of tenders, the procurement documents should describe the parameters used in the calculation. The criteria are ready for download by visiting the National Agency for Public Procurement’s website. Yet, one thing to consider using an LCC-tool is to only include the large

cost items, or costs that is expected to differ between different suppliers, whereas externality costs for environmental parameters can be included and calculated only if their monetary value can be determined and verified in a way that is standardised. As for the tenders' evaluation, the LCC cost will be included as a parameter in order for the most cost-efficient tender to be evaluated. Quality criteria for the lighting system, such as light quality, is not included in the tool and must be specified separately in the tender documents.

The LCC tool is based on present value method to be able to calculate future cost to present value, an equation that is included in the tool. Other parameters such as discount rate, electricity pricing and economic periods are just some of the criteria that are expected to affect the result and should be decided upon consulting the Contracting Authority (CA).



The National Agency  
for Public Procurement


## LCC-calculation for procurement of outdoor lighting systems

Version 1.1  
Date: 2016-11-23

Introduction
LCC-calc.
Result
Tool-parameters
Response sheet
Climate impact factors

### Introduction

General instructions for how to use the tool.



**What is LCC?**

LCC stands for life-cycle costing. By using an LCC-tool one obtains a total picture of the costs associated with the use phase of a product, service or works. Comparisons can be made between different product alternatives and solutions. A life-cycle costing perspective can be used in many parts of the procurement process, and is also useful when working strategically with the organisation's budget.

**How shall I use the tool?**

This tool is designed especially for the procurement of outdoor lighting. The tool can be used in the need's analysis, when choosing criteria and in the evaluation of tenders. In this tool you can also calculate the climate impact based on the energy usage from the lighting system.

In the need's analysis, the tool can be used to get an early indication for the costs associated with the lighting system. For a lighting system, the operating cost for energy is a large component of the overall cost. By testing different rates of price increases, one can see different cost scenarios during the usage time. The contracting authority can also compare different alternative solutions through, for example, including or excluding control systems.

If using an LCC-tool in the evaluation of tenders, the procurement documents must describe the parameters used in the calculation. How shall the parameters be documented and which methods for measurements shall the data be based upon? Procuring entities can use the procurement criteria "The lighting system's life cycle cost (LCC)". The criteria can be downloaded through the National Agency for Public Procurement's website. One rule of

1. Introduction
2. LCC-calc.
3. Result
4. Tool parameters
5. Response sheet
6. Climate impact factors
+

**Fig. 8. Introduction of the LCC tool**

### How to use

The Outdoor Lighting System LCC Tools begins by demanding the General Calculation Conditions to be entered. These conditions are specified by the CA and includes criteria such as usage time (where we consider the luminaire with the best expected lifespan specifications), a discount rate that represents the approximate estimation of future costs to present costs, electricity prices and annual electricity price changes. Other parameters such as total operating hours per year,



operating hours when the system is on full power and operating hours when the system is consuming reduced level powers.

The next category is the Data filled by the Supplier. The user is presented with columns that include filling data for the specific facility, as well as an additional facility options for consideration. By using the “Add Column” button, it is possible to add new options to be considered, whereas using the “Remove Column” deletes the last extra option. The supplier data is divided into sub-categories, starting off with the Investment Costs, where we type the luminaires quantity, the total price for each luminaire (per piece), the material and labour installation costs per luminaire, the number and the price per pole and foundation (if the poles are tender-included), finishing the calculation with the external control device cost.

The Operating Costs are calculated by completing the effect each luminaire has (this includes operating losses and system effects), as well as the effects from the reduced power level available.

The Maintenance Costs include parameters such as light source cost per luminaire, labour cost for replacing light sources and the interval for replacing light sources according to the operation and management plan. Of course, light sources are not the only criterion, since electrical ballast cost per luminaire, labour cost for replacing electrical ballasts and the interval for replacing electrical ballasts, again according to the operation and management plan. Upon completing the aforementioned parameters, lifespan fields come into play, requiring from the supplier to enter luminaire and pole lifespan, the labour cost for the inspection of the system and the inspection interval in years. Finally, we complete the labour cost for surveillance and the surveillance interval in years and the LCC tools now has to calculate the LCC cost based on the data collected from the input fields.



Introduction   LCC-calc.   Result   Tool-parameters   Response sheet   Climate impact factors

**Calculation conditions (specified by the CA)**

PROJECT:

DATE:

ADMINISTRATOR:

1.1 Usage time  year

1.2 Discount rate  1.75%

1.3 Electricity price  SEK/kWh

1.4 Annual electricity price change

1.5 Climate impact electricity usage (optional)  kgCO<sub>2</sub>/kWh

1.6 Operating hours of the lighting system (total)  h/year

1.7 Operating hours full power  h/year

1.8 Operating hours power level 1  h/year

1.9 Operating hours power level 2  h/year

With the buttons you can add or remove columns (investment options).

Add column

Remove column

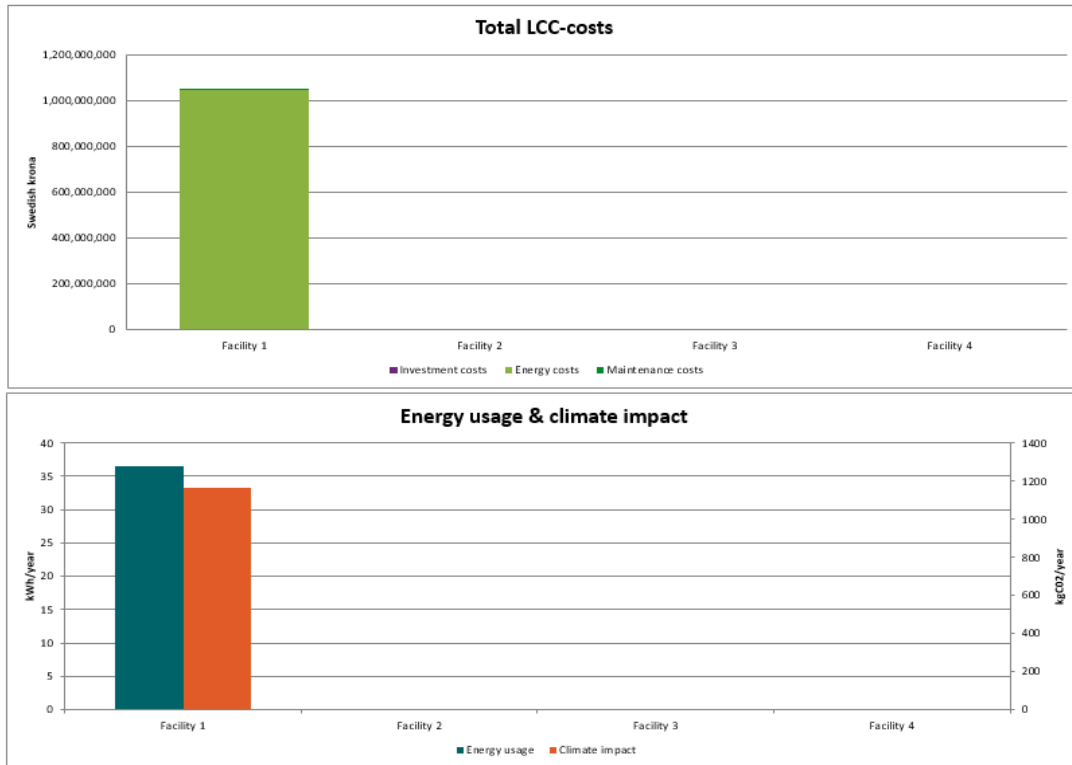
Data from supplier

Name		Current facility	Option 1	Option 2	Option 3	Option 4
<b>Calculation of investment costs</b>						
2.1 Number of luminaires	qty					
2.2 Price per luminaire (incl. light source, electrical ballast, control device)	SEK/piece					
2.3 Material and labour costs per luminaire	SEK/piece					
2.4 Number of poles and foundations	qty					
2.5 Price per pole and foundation	SEK/piece					
2.6 Material and labour costs per pole incl. foundation	SEK/piece					
2.7 Cost of external control device (incl. operation start-up and license fees)	SEK					
<b>Calculation of operating costs</b>						
3.1 effects	W					
3.2 Reduced power level 1	W					
3.3 Reduced power level 2	W					

Fig. 9. Filling data of the LCC tool

The results gathered from the LCC calculation provide an initial total cost for the specific facility and the alternative facilities. After the total cost, the tool presents the energy costs per year and in full usage time, while also estimating the climate impact per year. In the end, the tool reveals the energy cost savings per year, compared to our current facility.

By changing tabs in the Excel tool and moving to the result tab, not only are the statistics based on the previously defined total LCC costs available, but the user can also see 2 diagrams per study case. The first diagram divides the total LCC costs into investments, energy and maintenance costs, all 3 graphs with different colors, whereas the second diagram depicts both energy usage in comparison with the climate impacts.



**Fig. 10. Results of the LCC tool**

*SEAD by the Clean Energy Ministerial - Outdoor applications -*  
<https://superefficient.org/tools/street-lighting-tool>

The Super-efficient Equipment and Appliance Deployment (SEAD) Street Lighting tool is an Excel-based tool that calculates expected energy use, light performance and LCC costs for outdoor lighting upgrades from the most common road infrastructures. It is an initiative of the Clean Energy Ministerial and a task within the International Partnership for Energy Efficiency Cooperation and gives the opportunity to quickly and with ease evaluate the efficiency, the quality, the technical compatibility and the lifetime costs of different street lighting products, targeted for government procurement officials. As a result, it may help municipal officials in making more informed procurement selection to mitigate the complexity that buying new street lighting products involves [11]. It should be noted that the tool focus on Total Cost of ownership and does not include costs related to externalities (full LCC).

The SEAD street lighting tool identifies the optimal lighting product for any circumstances, allowing users to evaluate without much complexity lighting products e.g. LEDs and conventional fixtures, based on technical specification, lighting quality, costs and energy savings.



Fig. 11. Introduction of the LCC tool

**How to use ([https://staging.superefficient.org/uploads/site/SEAD-Street-Lighting-Tool-Reference-Guide\\_v1.pdf](https://staging.superefficient.org/uploads/site/SEAD-Street-Lighting-Tool-Reference-Guide_v1.pdf))**

The lighting tool appeals to many different cases of users. First time users from small municipalities may perform basic assessments of lighting options by using common road configurations. Experienced light designers may visualize products for specific road and pole infrastructures through a variety of different choices at the same time. Users that are manufacturers can provide consistent recommendations about the optimal lighting fixtures for specific road configurations. More specifically, the LCC tool allows us to identify best outdoor lighting solutions for common road layouts, analyze and compare large numbers of lighting fixtures at the same time, calculate potential energy savings and cost reductions after applying efficient street lighting methodologies and reach up to 50% in energy savings.

The SEAD Street Lighting tool is available in 4 languages, in English, Spanish, French and Russian. The tool's functionality is divided into subcategories that include:

- Input about road and lighting fixtures, where the tool assumes uniform pole placement and lane configuration only for straight roads.
- Input through IES files about photometric data that can be used to calculate light quality on the road surface for more than one fixture at a time.
- The tool calculates the appropriate metrics and decided if the user-described fixtures pass or fail the light quality criteria based on relevant lighting standards.
- Performing the LCC analysis for fixtures that are compared to a single baseline fixture.

The input that must be provided by the user is divided into 5 sub-categories. The first category is the Road Description, where road geometry inputs describe the general size and shape of the road section, alongside with the poles' placement and their size. Road Geometry section includes factors such as the number of road lanes, the lane width and the median width (documented as the median space between two travel directions). Light Geometry refers to pole placement, mounting height of the luminaire (documented as the distance above the surface road that the fixture is installed), pole placing, pole setback (distance from the edge of the road to the pole's base) and arm length. Last field that must be completed is the road surface type, which describes the amount of light that reflects on the surface of the road from the observer's point of view.

**SEAD Street Lighting Tool v1.8.1**

Progress: 1 Describe Road | 2 Set Lighting Targets | 3 Choose Fixtures | 4 Identify Costs | 5 Confirm Inputs

*Road geometry inputs describe the size and shape of the road section, as well as the placement and size of poles. Enter values for both baseline and upgrade. If you are replacing fixtures only, enter the same values in both columns.*

Description:	Baseline	Upgrade	Units
<b>Road Geometry</b>			
Number of Lanes			Lanes ?
Lane Width			meters ?
Median Width			meters ?
<b>Light Geometry:</b>			
Pole Placement			?
Luminaire Mounting Height			meters ?
Pole Spacing			meters ?
Pole Setback			meters ?
Arm length			meters ?
<b>Pavement Type (only required for luminance calculations)</b>			
Road Surface Type		Standard Surface	?

View your inputs:

Baseline Update Baseline View

The diagram shows a cross-section of a road with a vertical axis from 1 to 17. A yellow line is drawn at height 7. Red dots representing poles are located at height 3. Yellow circles representing luminaires are located at height 3, with their light beams extending upwards.

Fig. 12. Filling data of the LCC tool

Step 2 of the tool is Setting the Lighting Targets. When measuring the quality of the light, it is possible to use two different measurements, illuminance (light that is hitting the road) or luminance (light that the observer sees). The tool allows for the use of both metrics, or if only one of them. As for the calculation method, the tool supports two different methods, either the Illumination Engineering Society of North America RP-8-00 (IES) or the Commission Internationale de L'Eclairage Standard 115:2010 (CIE). It is best to choose the CIE standard to follow European standards for the LCC tools.

Step 3 of the tool requires the User to choose if desired to add new fixtures or delete existing ones, under the 'Choose Fixtures' Tab. In order to add a fixture, the user must select the appropriate fixture data by obtaining the IES files from the manufacturer. The tool also several sample fixtures, in case the user intends only to quickly test the tool's functionality. If the user decided to delete a fixture, he selects the fixture data to remove from the list of all available fixtures and is required to confirm the data deletion.

Step 4 of the SEAD tool is the Costs Identification. Variables such as operating hours per year, electricity price, percentage of energy inflation rate per year and discount rate (used for calculating net present value and return on investment) must be filled in order for the user's input to be completed.

The tool's final step is only an Input Confirmation category and is needed in order to perform all calculations. A 'Quick Check' present information over user's input and by selecting 'Review All Inputs', information is presented regarding all inputs and fixtures. By selecting 'Calculate Scenario Results' after reviewing all inputs, the tool begins the LCC calculations.

The tool's output is located in the final tab named 'Results'. For every fixture input, the LCC tool reveals metrics for the Annual Energy Consumption, Illuminance, Luminance, Total Cost of Ownership (TCO) and investment returns across time. The tool saves the output file in the same folder with a date timestamp for when the calculations were made.

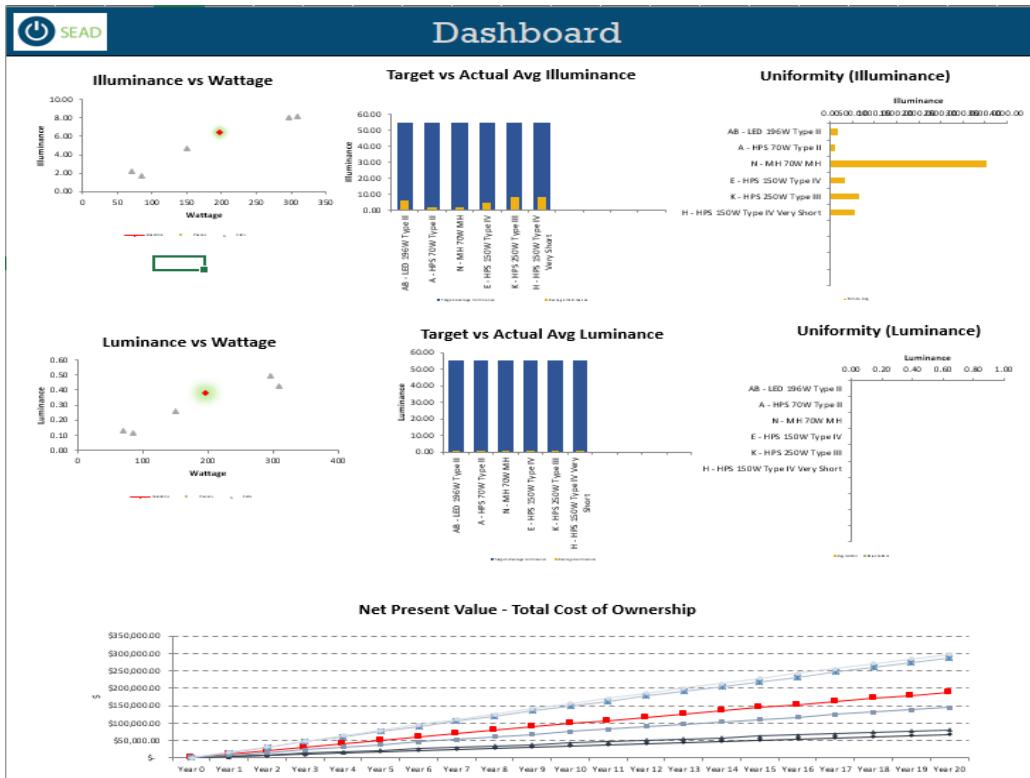


Fig. 13. Results of the LCC tool

## 4.2. Vehicles

### LCC principles

Local governments in association with public transport operators across Europe are increasingly looking for alternatives in terms of replacing petrol and diesel vehicles for their fleets, regardless of the vehicle ownership and the type of service they offer (e.g. public transport vehicles or waste collection). This results in considering new technologies such as hybrid, full electric, gas or biofuel-driven cars, offering the opportunity to cities to present themselves as environmentally conscious by purchasing clean and energy-efficient road transport vehicles [13].

The Directive 2009/33/EC on the Promotion of Clean and Energy Efficient Road Transport Vehicles focus on public purchasers and private companies that offer public transport services in order to consider energy consumption and environmental aspects before buying or leasing road vehicles. It widely acknowledged the need for specific measures towards enhancing energy savings and integrating climate change objectives into transport and energy policies, in accordance with actions to address excessive energy usage and greenhouse gas emissions in the transport sector. Under this scope, the Union is obliged to continue the efforts in developing cleaner, smarter and safer vehicles based on public procurements, as well as stimulate environmentally friendly innovations and promote clean vehicles on the basis of public procurement. This initiative is supported under the condition that vehicle manufacturers, oil/fuel suppliers and repairers take a technology-neutral and performance-based approach and by managing to stimulate the market for clean and energy-efficient road-transport vehicles, vehicle manufacturers and the industry in general are highly encouraged to invest and develop casual vehicles such as passenger cars, buses and trucks under low energy consumption, CO<sub>2</sub> emissions and pollutant emissions requirements. As a result, if sufficient demand for clean and energy-efficient vehicles is created, even though these types of innovative vehicles initially cost more than conventional ones, it could be ensured that the automobile economy would see cost reductions for such vehicles [14].

*Important note: Readers of this methodology should be aware that according to an evaluation of the directive [20], EC concluded that the directive contained complex and incoherent elements in its monetization methodology. This has led the Commission to put the directive under review. According to [5] EC may abandon the monetization and may introduce an absolute definition of clean vehicles in order to set consistent and coherent mandatory procurement targets. Therefore readers should be cautious of any changes take place in the directive, in the future.*

Based on the Directive 2009/33/EC by the European Commission, in order to calculate LCC, we must firstly consider the following metrics:



- **Environmental Externalities:** Undoubtedly, the biggest impact on the market in accordance with the optimal cost/benefit result, can be achieved by including lifetime costs for energy consumptions, CO<sub>2</sub> and pollutant emissions as award criteria in procuring vehicles for public transport services. By defining acceptable ranges for CO<sub>2</sub> and pollutant emissions (such as NO<sub>x</sub>, NMHC and particulate matter), as well as other environmental impacts that should be taken into consideration by contracting authorities, entities and operators, the directive provides harmonization and flexibility to the contract authorities, entities and operators on their current situation. Thus, the EC proposes committing in achieving greenhouse gas emissions reductions at least 20% by 2020.
- **Energy Consumptions:** To further improve energy efficiency, the Directive targets at a 20% reduction in energy consumption rate, inclusion of 20% renewable energy and a 10% share of the renewable energy for transporting, so as to secure energy supply by diversifying the fuel mix.

Table III. Data for the calculation of operational lifetime costs of road transport vehicles

Fuel	Energy content
Diesel	36 MJ/litre
Petrol	32 MJ/litre
Natural Gas/Biogas	33-38 MJ/Nm <sup>3</sup>
Liquefied Petroleum Gas (LPG)	24 MJ/litre
Ethanol	21 MJ/litre
Biodiesel	33 MJ/litre
Emulsion fuel	32 MJ/litre
Hydrogen	11 MJ/Nm <sup>3</sup>

Table IIIII. Lifetime Mileage per vehicle category

Vehicle category (M and N categories as defined in Directive 2007/46/EC)	Lifetime mileage
Passenger cars (M <sub>1</sub> )	200 000 km
Light commercial vehicles (N <sub>1</sub> )	250 000 km
Heavy goods vehicles (N <sub>2</sub> , N <sub>3</sub> )	1 000 000 km
Buses (M <sub>2</sub> , M <sub>3</sub> )	800 000 km

- LCC calculation: In order to efficiently calculate the operation lifetime costs for energy consumptions and CO<sub>2</sub> and pollutant emissions (e.g. NO<sub>x</sub>, NMHC and particulate matter), the following methodology should be followed (keep in mind that manufacturers are highly encouraged to provide data for total lifetime energy consumption, CO<sub>2</sub> and pollutant emissions to improve transparency and comparability between manufacturer data):
  - Energy Consumption LCC calculation: The LCC cost of a vehicle's energy consumption is calculated after firstly defining the fuel consumption per kilometer in energy consumption per kilometer units. If the input is provided in different units, it will be converted into energy consumption per kilometer based on Table II which lists the energy content for different fuels. Afterwards, the calculation should use a single lowest value for the cost per unit of energy. After this step, the vehicle's operational lifetime cost is calculated by multiplying the lifetime mileage (see Table III) by the energy consumption per kilometer and by the cost per unit of the energy.
  - CO<sub>2</sub> emissions LCC calculation: The LCC cost of a vehicle's CO<sub>2</sub> emissions are calculated by multiplying the lifetime mileage by the CO<sub>2</sub> emissions in kilograms/kilometer and by the cost per kilogram.
  - Pollutant emissions LCC calculation: The LCC cost of a vehicle's pollutant emissions is calculated by adding the LCC costs for both NO<sub>x</sub>, NMHC and particulate matter, where each LCC cost of the pollutants can be calculated by multiplying lifetime mileage by the emissions in grams/kilometer and by the cost per gram.

### Available Tools

*Generic Clean Fleets by the European Commission* – (<http://www.clean-fleets.eu/home/>)

The Clean Fleets project offers a life cycle cost calculation tool which aims to assist public authorities and public transport operators in buying clean and energy efficient vehicles that fully comply with the Clean Vehicles Directive (CVD) and more specifically, with the Directive 2009/33/EC on the Promotion of Clean and Energy Efficient Road Transport Vehicles [13].

## You must enable Macros to use this worksheet

Please click on the Options button and  
select 'Enable this content'

The Clean Fleets Life Cycle Cost Calculator is an easy to use tool to allow a comparison of the life cycle costs (LCC)/total costs of ownership (TCO) of different vehicles and bids within a procurement process.

The tool is fully compliant with the Clean Vehicles Directive (CVD) (2009/33/EC). It includes the option of applying the Operational Lifetime Costing methodology from Directive. This methodology monetises the environmental impacts of fuel consumption and tailpipe emissions.



Co-funded by the Intelligent Energy Europe  
Programme of the European Union

The contents of this spreadsheet are the sole responsibility of the Clean Fleets  
project and can in no way be taken to reflect the views of the European Union

**Fig. 14. Introduction of the LCC tool**

**How to use ([http://www.clean-fleets.eu/fileadmin/files/documents/Publications/Clean\\_Fleets\\_Guide\\_screen\\_version.pdf](http://www.clean-fleets.eu/fileadmin/files/documents/Publications/Clean_Fleets_Guide_screen_version.pdf))**

The LCC Calculator from the Clean Fleets project takes into consideration a wide range of variables and parameters in order for the total LCC calculation to be as accurate as possible. Firstly, the user must specify the *General Conditions*, such as the contract period of vehicle ownership, the discount rate which manages to turn future costs into present costs (under the idea that future costs will probably be lower than present costs) and the number of distinct different vehicle models we intend to compare.

Next the *Acquisition Costs*. In this category, the user is prompted to type the full name of the vehicle models for each model they wish to compare and the number of vehicles (per model) that they intended to purchase or lease. For the cost of acquisition (per unit) to be successfully calculated, the purchase price or an annual lease price per vehicle must also be defined.

The next category is the *Operating Costs per Vehicle*. In the first fields that must be completed, an estimation in kilometers (km) of the annual vehicle use and for each one and its specific fuel type must be entered. Then, by suggesting a converter with complies with the Certificate of Conformity (CoC), the fuel consumption per vehicle (liters/100km) and the fuel price must be added. For the vehicles that support second fuel types such as PHEVs or dual fuel cars, the second type of fuel should be defined, this fuel's consumption per vehicle and its' fuel price, otherwise

these fields should be left blank. Upon completing the aforementioned fields, the LCC tool calculates the operating costs (per unit).

The Maintenance Costs per Vehicle are completed rather quickly, since the user is only prompted to provide an estimation over the annual maintenance costs (including spare parts) and the annual fixed costs for servicing the equivalent vehicle.

Taxes and Other Costs per Vehicle are also included in the LCC Calculation. The vehicle tax and the insurance costs should first be entered followed by the total infrastructure investment costs (e.g. electric charge points for new vehicles) and lastly, other costs that should be taken into consideration (e.g. higher parking rates for standard cars, grants for buying clean vehicles etc.).

The Emissions per Vehicle (a.k.a Operational Lifetime Cost, OLC) is an optional section, yet though of high importance. The OLC methodology applies using the data provided on car and vans CoC and will produce a monetary cost which should be considered alongside the other LCC parameters. Assuming that to the user applies the OLC methodology from the CVD (the precise methodology of the CVD must be followed), the CO<sub>2</sub> emissions (in g/km) as per CoC or the Clean Vehicle Portal and a lifetime cost of CO<sub>2</sub> emissions/unit should be entered. Variables such as Nitrous Oxides (NO<sub>x</sub>), Particular Matter (PM) and Non-methane hydrocarbons must also be taken into consideration and completed accordingly. After completing the cost of pollutant emissions/unit, the user is prompted to complete the type of reference fuel before tax, the cost of reference fuel before tax and the lifetime cost of energy consumption/unit, thus leading to the calculation of the operation lifetime cost/unit.


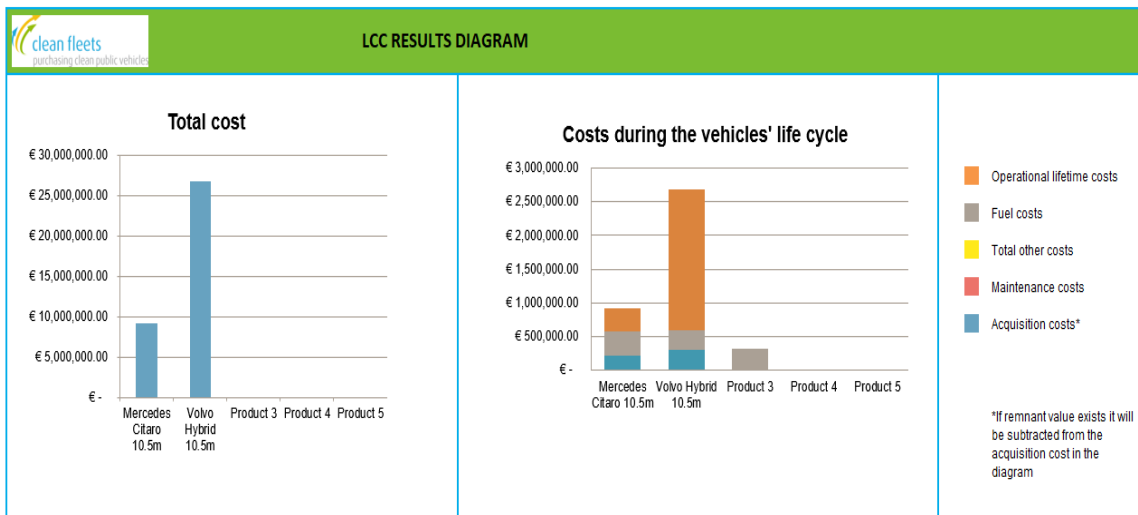
		<b>VEHICLES - LIFE CYCLE COST (LCC) CALCULATOR</b> Please fill in the white cells only			
<b>GENERAL CONDITIONS</b>					
Contract length/period of vehicle ownership	Year	10			
Discount rate	%	2			
Number of bids/offers		2			
<b>ACQUISITION COSTS</b>					
<b>Name of bidder/vehicle model</b>	<b>Mercedes Citaro 10.5m</b>		<b>Volvo Hybrid 10.5m</b>		
Number of vehicles		10		10	
Purchase price	€/unit	217,800.00	€/unit	310,000.00	
Lease price	€/unit/year		€/unit/year		
<b>COSTS OF ACQUISITION / UNIT</b>		<b>217,800.00</b>		<b>310,000.00</b>	
<b>OPERATING COSTS PER VEHICLE</b>					
Annual use of vehicle	km	80,000	km	80,000	
Type of Fuel		Diesel		Diesel	
Fuel consumption per vehicle	l/100km	41.9	l/100km	32.6	
Fuel price	€/l	1.22	€/l	1.22	
Add a second fuel type (PHEVs, dual fuel)?		No		No	
Type of Fuel				Petrol	
Fuel consumption per vehicle	#VALUE!		l/100km	250	
Fuel price	€/l		€/l	1	
<b>OPERATING COSTS / UNIT</b>		<b>363,903.20</b>		<b>283,027.49</b>	
<b>MAINTENANCE COSTS PER VEHICLE</b>					
Estimated annual maintenance costs (or) Annual service agreement	€/unit/year		€/unit/year		
<b>MAINTENANCE COSTS / UNIT</b>		<b>-</b>		<b>-</b>	
<b>TAXES AND OTHER COSTS/SUBSIDIES PER VEHICLE</b>					
Vehicle tax	€/unit/year		€/unit/year		
Insurance costs	€/unit/year		€/unit/year		
Infrastructure - one off investment costs (or) Infrastructure - annual costs	l/year		l/year		
Other costs/subsidies (with or without expansion)					
<b>TOTAL OTHER COSTS AND SAVINGS/ UNIT</b>		<b>-</b>		<b>-</b>	
<b>EMISSIONS (OPERATIONAL LIFETIME COST-OLC) PER VEHICLE - OPTIONAL SECTION</b>					
Do you wish to apply the operational lifetime cost methodology from the Clean Vehicles Directive?		Yes			
CO <sub>2</sub> Emissions	g/km	1	g/km	864	
<b>Lifetime cost of CO<sub>2</sub> emissions / unit</b>		<b>26.64</b>		<b>20,736.00</b>	
NO <sub>x</sub> (Nitrous oxides)	g/km	0.24	g/km	0.24	
PM (Particular Matter)	g/km	0.0029	g/km	0.0029	
NMHC (Non-methane hydrocarbons)	g/km	0.007	g/km	0.007	
<b>Lifetime cost of pollutant emissions / unit</b>		<b>1,052.24</b>		<b>1,052.24</b>	
Reference Fuel		Diesel		Diesel	

Fig. 15. Filling data of the LCC tool

Last but not least, the *End of Life costs* category requires filling a field representing the amount that the user expects the vehicle to be worth in sales or parts or scrap at the end of usage.

After filling the final field, the LCC Calculator reveals the Total LCC per unit, as well as the Total LCC and provides further diagrams including total costs per product and costs during the vehicles' life cycle.



[> BACK TO LCC-CALCULATION](#)

**Fig. 16. Results of the LCC tool**

### 4.3. Office IT Equipment

#### LCC principles

The fact that some EU member states apply individual criteria while others apply GPP office IT equipment criteria creates a lack of harmonization in the EU. This results in increased overall administrative costs for businesses and set obstacles in the internal market, a market heavily influenced by fashion trends and life spans. During the Office IT equipment's life cycle, several environmental and social impacts are relevant to all products, such as component manufacturing, energy consumptions, hazardous constituents, battery material, waste reduction, spare parts recycling and noise emissions. Furthermore, upgradability consideration is also a must, mostly referring to considering environmental impacts such as energy performance, noise, hazardous substances, durability, upgradability, recyclability and IT support training courses on green management of IT products.

The LCC approach requires taking into consideration all costs over the whole product's lifetime, beginning from purchase through usage and maintenance costs to disposal, as far as Office IT Equipment is involve. This includes costs such as the purchasing price, energy consumption and equipment disposal. Without a doubt, buying energy efficient models is a win-win situation since it reduces both running costs end mitigates environmental impacts. For many office IT products (if not for all), the most significant environmental impact is the energy consumption during the product's lifetime, especially when we are referring to office products such as office Personal Computers (PCs), laptops and monitors. In fact, most studies show that in general, an office PC consumes 3 up to 4 times more power than the primary power needed for material production (measured assuming 8 operating hours a day over 260 days). Despite the fact that the trend is towards small devices such as a laptop, which typically uses from 50% to 80% less energy than a PC, these devices also tend to have smaller lifecycles due to excessive competition from other manufacturers. Even though energy saving modes of IT equipment offer noteworthy improvements, both active and idle modes show large differences and variations among different market models, with the active mode being held responsible for the vast majority of total energy consumption in most of the cases [16].

As previously stated, as far as computers are concerned, the popularity, availability and increased functionality the offer have shaped them into one of the most common pieces of equipment in houses and offices. During their life-cycle, the energy consumption seems to be the most significant environmental impact and should be highly considered. Since different market products differentiate form other in their energy consumptions depending on their modes (ON, OFF, or SLEEP), it is absolutely necessary to define comprehensive requirements to procurements that target to ensure mitigation of environmental impacts [17].

**Energy Consumption.** The current GPP Technical Specification requires compliance with the latest version of Energy Star, which currently is version 6.1, since this version involves stricter Typical Energy (TEC) in kWh, thus leading to potential improvements.

Table IV. Computer Power Consumption improvement potential with Energy Star v6.0 specs

Improvement potential (Power consumption compare to $TEC_{MAX}$ )	Models (US Energy Star database as of January 2015)	
	Desktops	Notebooks
<i>20-39% lower</i>	32%	69%
<i>40-59% lower</i>	17%	11%
<i>60-79% lower</i>	4%	4%
<i>over 80% lower</i>	-	-

To efficiently mitigate large amounts of power consumption for PC equipment, it is necessary to reduce energy consumption on the graphics card of the PC, since the Graphics Processing Unit (GPU) ultimately sets the energy benchmark for each computer. More specifically, by using discrete graphics cards which boost high performances in professional applications such as offering Full-HD video capabilities or 3D rendering and provide optimal picture quality and speed, the TEC allowance can rise between 52% to 188% for desktops and from 100% to 429% for notebooks. On the other hand, by using conventional integrated graphics cards that are placed inside a PC's motherboard and share resources, basic TEC allowance ranges rise from 57% up to 96% for desktops and from 14% to 100% for notebooks, but certainly lower than the discrete GPU demands. This reveals an interesting insight that is no other than the fact that discrete GPU allowance could possibly equal the PC's core power consumption in idle mode!

To tackle this GPU energy allowance issue, 3 different methods are proposed.

- a) First option is to set a threshold value to the maximum number of allowances available, so as to ensure that a PC that produces high power consumption rates is not deemed compliant and more specifically, setting the threshold value to 90kWh for desktop PCs and to 33kWh for notebook PCs.
- b) Second option is to permit discrete GPUs in office equipment PCs only if they are switchable or highly scalable (for example, consuming minimal power when the computer is in modes that do not require GPU processing), setting the threshold to 18kWh for pre-enabled switchable GPUs.



- c) Third option is to set stricter allowances for discrete GPUs from the allowances described in the Energy Star Requirements, thus promoting GPU innovations from competitive manufacturers.

To reduce energy consumption for the equivalent PC monitors (televisions and displays are both included), again we will have to follow the energy requirements benchmark set by the Energy Star Program Requirements for Displays. Currently at its version 6.0, it sets the new standards by introducing numerous newly added requirements.

- For example, the program includes ‘ON’ power mode consumption requirements for televisions whose screen size varies from 12 to 30 inches and for monitors over 30 inches.
- In addition, the program sets a new maximum energy requirement for ‘SLEEP’ power mode, equal to 0.5 Watts for all displays and a mandatory requirement which forces all computer displays to enter ‘SLEEP’ power mode after losing connection to the host.
- Last but not least, the program proposes a hierarchy that tests network connected products that operate in ‘SLEEP’ mode and lighting conditions for testing products that support Automatic Brightness Control (ABC) by default.

▪ **Table V. Computer Display Power Consumption improvement potential with Energy Star v6.0 specs**

Improvement potential (Power consumption compare to $P_{ON-max}$ )	Models (US Energy Star database as of July 2015)
<i>10-19% lower</i>	28%
<i>20-39% lower</i>	33%
<i>40-59% lower</i>	5%
<i>60-79% lower</i>	1%
<i>over 80% lower</i>	-

For both computers and monitors, award criteria are bound to offer extra points if a computer’s TEC value or a computer display’s energy consumption value, are lower than the Energy Star requirements ( $E_{TEC-max}$  for the computers,  $P_{ON-max}$  for computer displays), to which the core criteria for energy savings are aligned with. The points are given according to the percentage of the energy consumption improvement and of course, the higher the consumption, the more points will be awarded.

**Lifetime Extension.** In order to efficiently tackle the various environmental impacts that are caused by factors such as shorter lifespans, raw material extraction and manufacturing processes, higher attention should be paid in prolonging the lifetime of computers. This ultimately leads to

a necessity of providing measures that offer features such as upgradeability and reparability of products which would be replaced early as a whole computer unit in case of poor performance or defectiveness or single PC components. In general, PC components such as the motherboard and the CPU are difficult to upgrade while other components such as a Hard Disk Drive (HDD), a Solid State Drive (SSD) or memory components can be replaced or exchanged with ease.

One thing to consider is prolonging the product warranties while keeping in mind the fact that the provision of longer standard (at no extra cost) guarantees reflects on the manufacturer's confidence in their product's lifetime. Since pricing of the parts was deemed impossible to be dictated in this criterion, since specific prices for compatible parts could highly discourage replacement or repairing, setting the core warranty period at 2 years minimum and the comprehensive warranty at 3 years minimum may re-ignite confidence in products with no extra warranty costs. The warranty shall also cover repair and replacement, including a service agreement with options for pick-up and return or on-site repairs, while also guaranteeing that the products are in conformity with the contract specifications at no additional costs. In case of defective batteries, the manufacturer shall solely cover the expenses. Additional points are provisions towards the tenderers for each additional year of warranty and service agreement offered that is more than the minimum technical specification, prolonging warranties and service agreements.

A further option to be taken under consideration is the market availability of spare parts, for which the tendered shall guarantee their availability for at least five (5) years from the purchase date. Since many public bodies admit that they have the necessary knowledge of repairing or replacing defective PC parts without invalidation the product's warranty, spare parts should not only be manufactured specifically for the company model, but also be "backwards-compatible" to support a wide variety of models. The parts shall remain available for the core period of 2 years and the comprehensive period of 3 years whereas by offering "backwards-compatibility", storage or battery components are made available using improved capacity or performance specifications (since they are manufactured months after the PC's build), specifications which would surely reflect on technological innovations and advances, eliminating the need for stocking older and obsolete parts. For the computers, HDD/SSD, memories, rechargeable batteries, screen assembly and LCD backlight are deemed easily accessible and replaceable using universally available tools, whereas for the monitor displays, those parts include power and control circuit boards, screen assembly and LCD backlight and stands. All these components have relatively high failures rates or tend to offer strong influence on the product's lifespan, so we choose to focus specifically to those. Tenderers are encouraged to put forward spare parts prices, including indicative labour costs for replacements, thus promoting competitiveness between manufacturers to reduce repair and upgrade product costs.

## Externalities

In order to identify the major environmental impacts of computers and monitors, the European Commission reviewed the existing Life Cycle Assessment studies on these products from 2007 and conducted its own research. The research showed that the severity of environmental externalities change depending on the type of products. Specifically, it was found that for products with high energy consumption, such as desktop computers, the focus should be on the energy efficiency of these products. For products with low energy consumption, the focus should be on the potentially hazardous materials that may be used during the manufacturing, processing or dismantling the product. Below, we describe the main environmental externalities related to the use, production and dismantlement of computers and monitors that should be considered when procuring office IT equipment.

**Energy consumption.** Energy consumption, closely linked with greenhouse gas emissions, has proven to be the main cause for hazardous environmental impact for stationary computers (such as desktop computers and workstations) and their displays. In LCC, there has been particular progress in calculating electricity's impact in climate change in monetary terms. The tool presented below, does include that particular impact, providing the financial calculation of this impact to the user and explaining their methodology in their guide.

**Hazardous materials.** The Joint Research Centre of EC and the Institute for Prospective Technological Studies conducted a report identifying the hazardous substances that may be present in IT office equipment products. The report concluded that the products may contain hazardous materials, like metals and alloys, plastic additives, contaminants and biocides that may cause harm to human health through the usage or improper waste treatment of the product. Currently, there is no LCC tool (that we know of) that includes a monetization methodology for this kind of externality. However, if any procuring officer wants to take into consideration adding criteria or awards that promote products with very low or none concentration of these hazardous substances, they should tend to GPP criteria. Tools that may help the verification of the products compliance with these criteria are the Reach Candidate List of high concern substances based on the Reach regulation, the list of restricted materials mandated under the Restriction of Hazardous Substances (RoHS) directive and the IEC 62474 database on material declaration. The EU GPP criteria provides detailed guidance on the restrictions that should be applied for different products (e.g. CPUs, displays etc.) and officers with ecological awareness should rely on them for any externalities that are not included in LCC, yet.

**Lifetime.** Manufacturing components for computers and displays involves the extracting and processing of materials which may be hazardous, require large energy consumption or cause land transformation. The research by the European Commission on the LCA analysis of computers and

displays products revealed that it is difficult to directly limit the negative aforementioned effects through the setting of green criteria, because these processes encompass approaches where criteria are difficult to apply, e.g. for confidentiality reasons. An indirect approach to reduce these effects through procurement procedures, is to encompass criteria that either extend the lifetime of these products or promote the recycling of their components. Both of these approaches result to a decreased need of these materials and hence to a reduced environmental deterioration.

Extended lifetime through the extended durability and increased upgradability is also connected to TCO and has been discussed earlier. End of life management to improve recyclability and efficient dismantling is covered below.

**End of life recycling.** This part is heavily based on the extraction processes of the hazardous materials contained in IT products. Currently, there is not any monetization methodology for these costs and as a result they do not fall within LCC range yet. For the sake of completeness and for the environmentally aware procuring officers, GPP solutions are given (i.e. available GPP criteria) that address these issues.

The European Commission (EC) suggests two ways to improve end of life management of products to reduce environmental externalities due to hazardous material within the components of office IT equipment. The first way is to ensure that the design of the product follows certain rules that ease the extraction process of its recyclable materials. Examples include avoiding paints of coating that are 'incompatible with recycling', or avoiding glue-on metal with plastic components in favor of easily removed components. In practice, the easier method for ensuring recyclability according to EU GPP criteria is through the ISO 11469 and ISO 1043-1 standards on the marking of plastic casings, enclosures and bezels of the product over a particular weight. For comprehensive compliance with the EU GPP criteria, evidence for the avoidance of the problematic paints and the easy removal of the recyclable components should be asked, although the verification of these can be somewhat difficult.

The second way to achieve improved end of life management with less environmental impact is by promoting products whose design has taken into consideration the easy extraction of valuable critical metals and raw materials at the dismantling phase. Many components of IT equipment, like motherboards and hard disk drives, have significant concentrations of Critical Raw Materials (materials identified as crucial for EU industry) and valuable metals, such as Cobalt, Silver, Gold, Palladium etc. Promoting product design that makes their extraction time efficient and economically viable leads to a reduction of environmental externalities linked to these materials land extraction, production and processing. For the verification of products that comply with efficient dismantling and extraction materials, EU GPP criteria suggests a protocol for creating a “dismantling test report” provided by a specialized Waste Electrical and Electronic Equipment (WEEE) recycling firm.

## Available Tools

*LCC tool for Computers and Monitors from the European Commission –  
([ec.europa.eu/environment/gpp/pdf/EC\\_LCC\\_Tool\\_Computers\\_final\\_updated\\_13Mai2019.xlsx](http://ec.europa.eu/environment/gpp/pdf/EC_LCC_Tool_Computers_final_updated_13Mai2019.xlsx))*

This LCC tool for Computers and Monitors has been developed for procurement practitioners in public organizations in the EU. It was designed for procurement both below and above the thresholds for application of the EU 2014/24/EU directive on public procurement, yet it can also be used in private sector purchasers and even the general public. This LCC tool is designed to be used during tendering processes, however it can also be used before tendering to assess the LCC of the current situation and evaluate different solutions to help guide pre-tendering market engagement activities or to narrow down different technological solutions. The LCC tool may be used for desktop computers (e.g. Integrated Desktop Computers and Thin Clients), Portable Computers (e.g. Notebooks, Tablets) and Computer monitors.

The tool's purpose is to encourage and facilitate the wide application of LCC among public authorities in the EU, so that organizations can make more cost-effective decisions in the procurement processes for computers and monitors. The tool has been designed in a way that allows users to consider different cost categories and, at a preliminary stage, it is important to have the full costs picture for better planning. However, inclusion of all these categories in the tendering process is not needed, if there is a good reason to exclude them. For example, if a cost driver is difficult to quantify and no reference standard exist, it can be excluded from the LCC but used as a technical specification, award criterion or contract clause instead. Using the tool during tendering allows considerations related to initial acquisition costs, operating and maintenance costs, other costs and costs of environmental externalities.

# Introduction

## Scope of the tool

This tool has been designed to evaluate the life cycle costs of the following types of products as defined in Regulation (EU) No 617/2013 on ecodesign requirements for computers and computer servers:

- **Desktop computers** incl. Integrated Desktop Computers and Thin Clients.
- **Portable computers**: Notebooks, Two-In-One Notebook, Portable Thin Client, Portable All-In-One Computer and Tablets.
- **Computer monitors**.

The products not covered are workstations nor small servers.

*It has been programmed for Microsoft Office 2010 and is compatible with LibreOffice 6.*

## Structure of the tool

The tool contains seven tabs or sheets:

- 1) **Introduction**, that briefly outlines the content of the tool.
- 2) **LCC inputs & results**, where the LCC parameters and information is compiled and results presented. In this tab contracting authorities have to provide the basic parameters for the calculations (contract duration, evaluation period, discount rate, etc.), data from bidders is automatically integrated from the "Bidder response sheet" (see below) and LCC is calculated for each product offered. If you modify this tab (e.g. by hiding cost parameters that are not relevant in case of a leasing contract), you need to also adapt the bidder response sheet to ensure consistency by hiding the relevant rows and columns. When entering costs for their evaluation, VAT should not be included.
- 3) **Bidder response sheet**, where bidders provide, in a standard manner, the data needed to calculate the life cycle costs of their offers. The information provided in this sheet is automatically imported into the "LCC Inputs & Results" tab for the calculation of the life cycle costs. When entering costs for their evaluation, VAT should not be included.
- 4) **Graphic results**, this sheet provides a graphic representation of the LCC results in the form of a bar chart showing the contribution of each cost category to the total LCC of each product. If you want to compare different offers visually, you can input the results of each of them in different columns to have a graphical output of the different offers.
- 5) **Definitions & formulas**, this sheet provides clear definitions for each of the parameters and formulas used in the tool. Contracting authorities will have to make sure that the standards used to define certain parameters are consistent with the technical specifications (especially in relation to energy use for the calculation of operational costs).
- 6) **Reference data**, this contains the data sets used for some calculations. It includes the currency and CO<sub>2</sub>eq emissions of the national electricity mix for EU countries, as well as the standard use patterns defined by Energy Star (the standard used as reference for the energy

Fig. 17. Introduction of the LCC tool

## How to use

[ec.europa.eu/environment/gpp/pdf/EC\\_LCC\\_computers\\_guide\\_final\\_updated\\_Mar2019.pdf](http://ec.europa.eu/environment/gpp/pdf/EC_LCC_computers_guide_final_updated_Mar2019.pdf)

As far the tool's structure is concerned, it is divided into seven categories:

- 1) **Introduction**: that briefly outlines the content of the tool.
- 2) **LCC inputs & results**: where the LCC parameters and information are compiled and results presented. In this tab, contracting authorities have to provide the basic parameters for the calculations (contract duration, evaluation period, discount rate, etc.), data from bidders is automatically integrated from the "Bidder response sheet" (see below) and LCC is calculated for each product offered. If a tab is modified (e.g. by hiding cost parameters that are not relevant in case of a leasing contract), it is necessary to also adapt the bidder response sheet

to ensure consistency by hiding the relevant rows and columns. When entering costs for their evaluation, VAT should not be included.

- 3) Bidder response sheet: where bidders provide, in a standard manner, the data needed to calculate the life cycle costs of their offers. The information provided in this sheet is automatically imported into the "LCC Inputs & Results" tab for the calculation of the life cycle costs. Once again, when entering costs for their evaluation, VAT should not be included.
- 4) Graphic results: this sheet provides a graphic representation of the LCC results in the form of a bar chart showing the contribution of each cost category to the total LCC of each product. If the user wants to compare different offers visually, he can input the results of each of them in different columns to have a graphical output of the different offers.
- 5) Definitions & formulas: this sheet provides clear definitions for each of the parameters and formulas used in the tool. Contracting authorities will have to make sure that the standards used to define certain parameters are consistent with the technical specifications (especially in relation to energy use for the calculation of operational costs).
- 6) Reference data: this contains the data sets used for some calculations. It includes the currency and CO2 emissions of the national electricity mix for EU countries, as well as the standard use patterns defined by Energy Star (the standard used as reference for the energy consumption as defined in the EU GPP criteria.)
- 7) Calculations: this sheet shows the calculations needed to transform all present and future costs to a total net present value.

In the LCC Inputs & Results tab, input must be provided from Contracting Authorities and Bidders.

- As a Contracting Authority, users should fill in only the cells in white in section A of the "LCC Inputs and Results" tab. The cells in grey are completed or darkened automatically based on information from other cells and tabs. It is important not to delete any cells or tabs. If the user wants to eliminate some parameters, they should hide them instead, using the [+] on the left and top margins. For some parameters, users might not have the information and will need to request it from other departments within their organization or other public agencies. Afterwards, users should protect all sheets except the "Bidders response sheet" to allow bidders to provide their data but avoid possible unwanted modifications in the other sheets. To protect them, one sheet at a time must be selected and then users must go to the top Menu / Tools / Protection / Protect Sheet and input a password of their choice to protect the sheet.
- As a Bidder, users fill in only the cells in white in the "Bidder response sheet" (which are copied automatically in section B of the "LCC Inputs and Results" tab) and protect the sheet to avoid unwanted modifications by the contracting authority. To do so, users must select the sheet and go to the top Menu/ Tools / Protection / Protect Sheet and input a password of their choice to protect the sheet.

In overall, the steps to complete the LCC tools can be summarized as follows:

1) **Decide the cost categories to be included in the LCC and the offers’ structure**

The tool has been designed to consider different cost categories and options. If for some of them, namely “other costs” users do not have the appropriate data, they can exclude them from the calculations. Also, users should decide what energy data must be provided to evaluate operational costs due to energy consumption and if they will include the environmental externalities or not. Based on those decisions, they should hide (don’t delete) the unused cost categories. Also, based on the tender lots structure - e.g. if each lot is for one specific product or if a lot is composed of several products – is should be defined how each offer should be presented, so that bidders know where to input their data and how it will be aggregated if several columns of the tool are used for the same offer.

2) **Complete Section A of the LCC tools with the user’s parameters**

The tool will use data provided by the bidder and parameters provided by the contracting authority to calculate life cycle costs. Based on the cost categories decided, users fill in section A of the “Inputs and Results” sheet of the tool with their parameters (e.g. evaluation period, discount rate, electricity costs). This will be the basis for the calculations and should be included in the tool provided in the tendering documents, to ensure transparency.

A. Data provided by the contracting authority: Common parameters for the calculation of life cycle costs					
<b>Identification of the product:</b>					
c	Reference of the product in the tender:				
c	Type of equipment:	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]
c	Number of units to be provided:	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]
<b>Basic parameters for the calculations of LCC:</b>					
	Country:	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]
	Currency:	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]
	Duration of the service agreement according to the tender:	years	0.00	0.00	0.00
c	LCC evaluation period:	years	0.00	0.00	0.00
c	Discount rate (optional):	%	0.0%	0.0%	0.0%
	Electricity price:	kWh	0.00	0.00	0.00
c	Electricity annual price increase (optional):	%	0.00	0.00	0.00
<b>Other costs by the authority (optional):</b>					
c	Other initial one-off costs:	/unit			
c	Insurance, taxes and fees:	/year unit			
	Interest costs:	/year unit			
c	Other annual costs:	/year unit			
c	Depreciation rate for the residual value of the product (in purchase contracts):	%			
<b>Energy consumption data to calculate operational costs:</b>					
c	Energy consumption will be evaluated based on:		[CLICK TO CHOOSE]	[CLICK TO CHOOSE]	[CLICK TO CHOOSE]
c	Own time use profile for computers:				
	Off:	%			
	Sleep:	%			
	Long-idle:	%			
	Short-idle:	%			
	Own time use profile for monitors:				
	Off:	%			
	On:	%			
<b>For the consideration of environmental externality costs (optional):</b>					
	CO2-eq emissions of the national electricity mix:	kg CO <sub>2</sub> eq/kWh	0.000	0.000	0.000
	or				
c	Insert CO2-eq emissions of your electricity contract:	kg CO <sub>2</sub> eq/kWh		0.00	0.00
c	Cost of CO2-eq:	€/t CO <sub>2</sub> eq		0.00	0.00
<b>B. Data provided by bidders: Information about their offer (provided THROUGH THE BIDDER'S RESPONSE SHEET)</b>					
c	Do not input data here, this data comes automatically from the "Bidder response sheet".				
	Product description:				

Fig. 18. LCC Input Category (for Contracting Authorities)



### 3) Request bidders to complete the ‘Bidder’ response sheet of the tool

In the tender documents, it is required bidders to present the appropriate information through the “Bidder response sheet” of the tool and to protect that sheet when sending their offers to ensure that no data manipulation can happen during the evaluation process. The information in this sheet is linked to the “Input & Results sheet” so it is important to keep the provided structure to ensure the correct calculation of LCC results.

**Bidder response sheet**

Economic offers will be evaluated using a life cycle costs approach, as stated in the tender document. In order to consider your bid for the award of the contract, please provide the information related to your offer by filling the WHITE cells of the relevant columns with your bid's data.

Products description			
<b>Identification of the product by the contracting authority:</b>			
Reference of the product in the tender:		0	0
Type of equipment:		[CLICK TO CHOOSE]	[CLICK TO CHOOSE]
Number of units to be supplied	units	0	0
<b>Product offered by the bidder:</b>			
Product name and model			
Data to evaluate the economic offer based on LCC and be eligible to the award of the contract			
<b>Economic offer for the contract broken down by:</b>			
c	Acquisition cost (including accessories cf. tender specifications)	/unit	
c	Cost of delivery, installation and start-up (cf. tender specifications)	/unit	
c	Service cost (cf. tender specifications)	/year.unit	
c	Purchase cost at the end of the contract (only if foreseen in the tender)	/unit	
<b>Energy consumption of the computer:</b>			
c	Energy consumption in Erec value	kWh/year.unit	
	or		
	Power in off mode	Watt	
	Power in sleep mode	Watt	
	Power in long-idle mode	Watt	
	Power in short-idle mode	Watt	
<b>Energy consumption of the monitor:</b>			

Fig. 19. LCC Input Category (for Bidders)

### 4) Use the LCC results to evaluate the cost award criterion

As different formulas and weightings are used by contracting authorities to evaluate costs, the LCC tool does not itself calculate a score for each tender – but provides the cost values to be included in this calculation. Users may calculate the cost score for each bid based on the LCC results and the cost award criterion weighting and formula indicated in the tender documents. By combining this with the other award criteria established in the tender documents, users will be able to select the offer with the best overall results.

C. LCC Results (per column and in total)			
Investment costs (acquisition & installation)		490,00	510,00
Service costs		0,00	0,00
Operation costs		68,81	39,45
Other costs		0,00	0,00
Externalities costs		48,26	27,67
Remnant value		-5,40	-5,62
<b>Life cycle cost</b>		<b>601,67</b>	<b>571,50</b>
Energy use	kWh	1200,00	688,00
CO2-eq emissions	kg CO <sub>2</sub> eq	580,53	332,84
<b>Total investment costs (acquisition &amp; installation)</b>		<b>1000,00</b>	
<b>Total operation costs</b>		<b>0,00</b>	
<b>Total maintenance and service costs</b>		<b>108,26</b>	
<b>Total other costs</b>		<b>0,00</b>	
<b>Total externalities costs</b>		<b>75,93</b>	
<b>Total remnant value</b>		<b>-11,02</b>	
<b>Total life cycle cost</b>		<b>1173,17</b>	
<b>Total energy use</b>		<b>1888,00</b>	
<b>Total CO2-eq emissions</b>		<b>913,37</b>	

Fig. 20. LCC Results Category

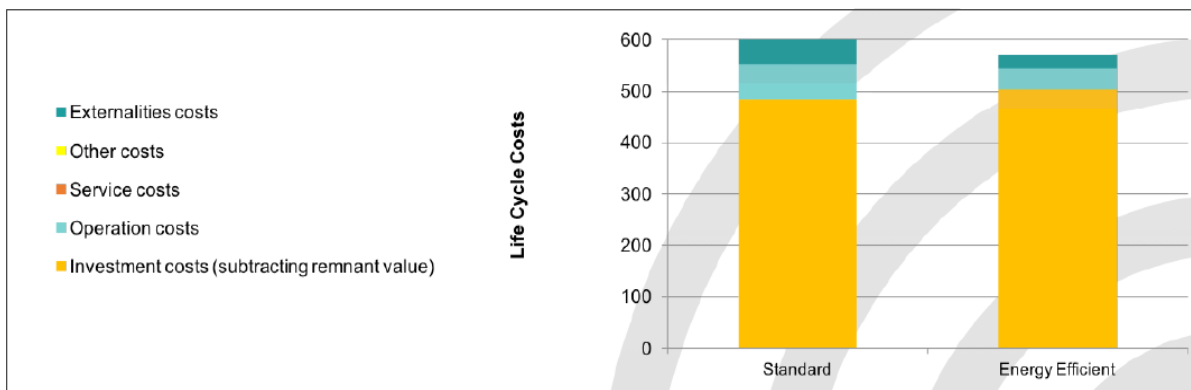


Fig. 21. LCC Graphic Results Category

*Office IT LCC tool from the European Commission –*  
[ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm](http://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)

The LCC Calculation tool for Office IT Equipment (includes both stationary computers, portable computers and display devices) has been developed by the European Commission (EC) in order to be used for the tender evaluation. The main feature of this tool is the evaluation of direct costs computers and monitor displays throughout the product life cycle in support of public

procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs) and has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products [8].

### "Life Cycle Costing (LCC) calculation Tool"

v. 1.0 2010/12/2016

Developed by:  
STUDIO FIESCHI & SOCI  
Scuola Superiore Sant'Anna  
Università del Piemonte Orientale

**Warning**

Please note: this Tool has been developed and tested with Excel 2013 and 2010. In order to use it, macros have to be activated. To enable macros, go to File => Options => Trust center => Trust Center Settings => Macro settings and select "Disable all Macros with notification". In the yellow banner, select "Enable content" to activate the macros.

**Introduction**

This is an electronic tool designed to perform life cycle costing (LCC) for a specific range of products commonly featured in public tenders. The tool, distributed by the European Commission, derives from provisions made in the new Directive 2014/24/EU, which significantly innovate the tender evaluation and award process through placing considerable importance on LCC.

The main feature of this tool is the evaluation of direct costs throughout the product life cycle in support of public procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs). The tool has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products. The information on externalities obtained with this tool shall not be used to measure and communicate the life cycle environmental performance of products, since the tool is not compliant with the Product Environmental Footprint (PEF) methodology in annex I to the Commission Recommendation of 9 April 2013.

*For more information about GPP and LCC, see [http://ec.europa.eu/environment/gpp/index\\_en.htm](http://ec.europa.eu/environment/gpp/index_en.htm)*  
*For more information about PEF, see <http://ec.europa.eu/environment/eussd/smg/index.htm>*

INSTRUCTIONS			
• Use coloured buttons to access the forms to fill in data			
• Use grey buttons to browse the tool			
• The table below includes a complete list of the available sheets.			
• Detailed instructions are included in the User's Guide			

GO TO MAIN

GO TO REFERENCES

Sheet name	Content		
MAIN	Select the general settings (e.g. tool language, currency, exchange rate).		
	Product category	Reference product	Available actions
IT_PC	Office IT equipment	Computer	Insert, edit or delete products.
IT_DS	Office IT equipment	Computer Display	Insert, edit or delete products.
IT_IE	Office IT equipment	Imaging equipment	Insert, edit or delete products.
LT_GL	Office & street lighting	Generic luminaire	Insert, edit or delete products.
WG_OV	White goods	Ovens	Insert, edit or delete products.
WG_RA	White goods	Refrigerating appliance	Insert, edit or delete products.
WG_DW	White goods	Dishwasher	Insert, edit or delete products.
WG_WM	White goods	Washing machine	Insert, edit or delete products.

Fig. 22. Introduction of the LCC tool

**How to use ([http://ec.europa.eu/environment/gpp/pdf/LCC\\_tool\\_user\\_guide\\_final.pdf](http://ec.europa.eu/environment/gpp/pdf/LCC_tool_user_guide_final.pdf))**

To use the tool (whose function appeal to both PCs and monitors), firstly the user should complete the General Data that are to be used for all products within this product family. First off, enter the discount rate that represents the difference in value between the costs in the future (lower value) versus the costs in the present and the Amortization coefficient, which allows a product cost to be distributed over different time periods on the basis of its life and deterioration. Then, enter the electricity price costs per kWh and the number of purchased items.

After completing the General Data, the user should move on to the *Product Specific Data*, where each time they may create, edit or delete new product. After filling in the Supplier and Product name, the user must then specify detailed data for the products. For example, the tool expects inputs regarding the purchasing cost established by the vendor, the delivery expenses (referring entirely to the delivery and transportation of the product from the vendor to the public administration) and further installation costs that might appear. As for the use and end-of-life data, the input that must be filled includes specifying the typical energy consumption annually, the warranty duration during which appliance failures are repaired by the producer with no extra charges to the public administration, and the maintenance and service costs, as well as the expected product lifetime and the disposal costs (end of life costs). Alternatively, if the user does wish to complete the typical energy consumption field, they may click in the 'Alternative data' button which unlocks further 6 fields instead of the typical energy consumption. Those fields briefly refer to the idle mode consumption (computer's state where all software is loaded but the machine is not asleep), sleep mode consumption (computer's state where the computer operates at a low power state when not in use) and off mode consumption (computer's state where it is connected to a power source and does not provide any on mode or sleep mode functions), all in Watts. Additionally, the other 3 fields require data in hours per year regarding the operating hours in both idle mode, sleep mode and off mode.

Product category	Office IT equipment
Product	Computer Display
USE MODE	Tender evaluation

Nº	INPUT NAME	UNIT	VALUE
1	Discount rate	%	5.00%
2	Amortization coefficient	%	
3	Electricity price	EUR/kWh	2
4	Country	-	EU
5	Economic period	Years	0
6	Number of purchased items	#	1

Nº	LIFE CYCLE PHASE	INPUT NAME	UNIT	Supplier - Product
1	Purchase	Purchasing cost	EUR	
2		Delivery expenses	EUR	
3		Installation cost	EUR	
4		Annual electricity consumption	kWh/year	
5	Use & end-of-life	On mode consumption	W	
6		Sleep mode consumption	W	
7		Off mode consumption	W	
8		Operating hours in on mode	Hours/year	
9		Operating hours in sleep mode	Hours/year	
10		Operating hours in off mode	Hours/year	
11		Warranty	Years	
12		Maintenance/service contract costs	EUR/year	
13		Estimated maintenance costs	%	
14		Expected product lifetime	Years	
15	Cost of disposal	EUR		

Fig. 23. Filling data of the LCC tool

After completing the required fields, we return to the main page, where by pressing the 'Insert Product Data' button a new product may be added, or there is an option to edit or delete an existing one. If the user clicks on the 'Go to Output' button, the LCC calculation is divided into sub-categories such as:

- The General Information presents generic supplier and product information.
- The LCC Results – Direct costs sub-category divides the overall costs into acquisition costs, costs of use, maintenance costs and end-of-life costs, presented in a diagram.
- The Distribution of costs over time subcategory is another chart that show how costs alternate in time.
- The Externalities subcategory depicts the effects in climate regarding the electricity usage.

Additionally, the options to either 'Display Results for total purchased items' or 'Show overall LCC results' are provided. It is also possible to print the excel sheet or to export the results to a specific folder or open the exports folder. All the above stated functions are separated into different buttons for convenience.

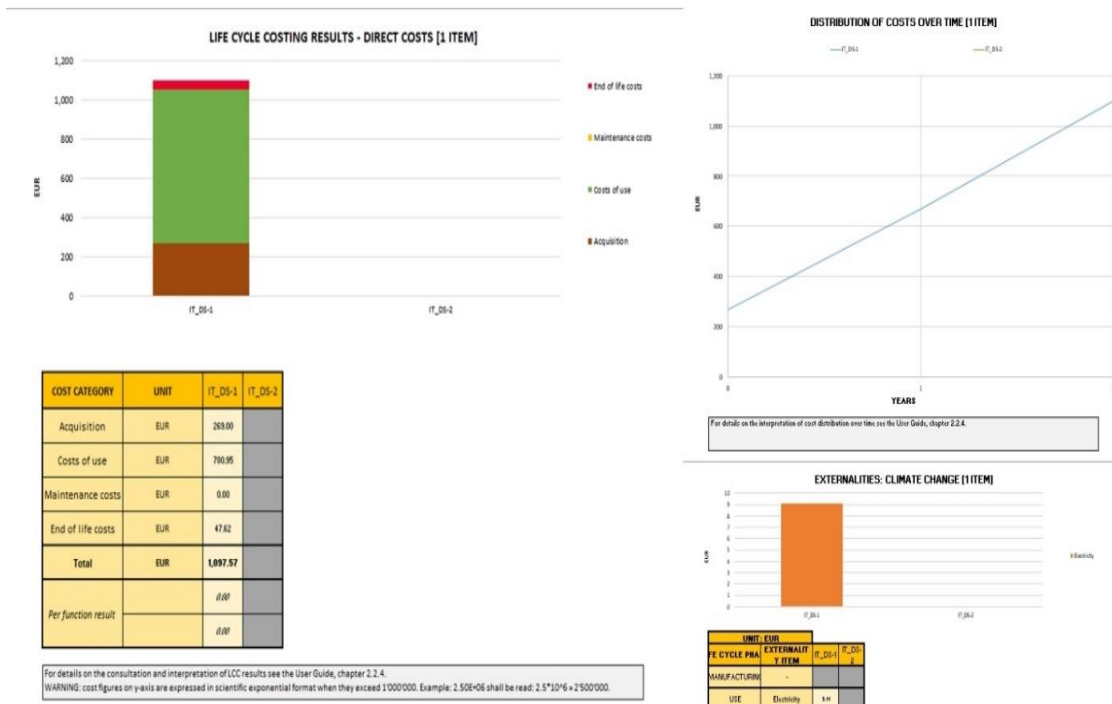


Fig. 24. Results of the LCC tool

## 4.4. Vending Machines

### LCC principles

Generally speaking, vending machines are primarily used in order to server beverages or snack items, yet we are seeing more and more flexible machines capable of serving additional items (mostly electronic) such as electronic devices like telephones or gaming consoles. They are considered highly effective since they give the consumers the ability to instantly buy food and other products quickly and without any restrictions. They mostly offer convenience to their customers by being trendy, easy to use and offering a wide range of products. In addition, they operate 24/7 and are mostly placed within the working area of the employees or near areas of interest that attract many customers. This results in helping employees that are looking to grab something to eat by not having to leave the workspace to find appropriate lunch food.

Vendors are the ones responsible for restocking the machines on a regular basis and are also obliged to regularly provide maintenance services to machines that are designed to operate non-stop daily. Lighting is a relevant aspect of vending machines, both from a marketing point of view and for operating costs. In fact, energy consumption for lighting covers only, covers a significant share of the total demand, nearly up to 30-40%. By making such machines operate 24/7, a large amount of energy consumption can be minimized when the machine is not being used by an operator, thus mitigating power demand and leading to reduces annual costs. Thus, the use of different and more efficient lighting systems (e.g. LED systems) can reduce this percentage, making lighting a less relevant aspect [18].

During the product's life cycle, there are a number of significant elements to be taken under consideration.

- **Key aspects:** During the product's production phase, key aspects (generic information useful to identify direct and external costs) include material acquisition (e.g. pre-coating coil, steel) and distribution materials. During the product's use phase, energy consumption and undesirable CO<sub>2</sub> emissions are our focus of interest whereas during the product's end-of-life phase, we are interested in treating waste materials (e.g. plastic or metal components).
- **Direct and External Costs:** During the product's production phase, the manufacturer's interest rest only upon the purchasing costs of the materials needed (external costs are not included), whereas during the product's use phase, the operating costs, as well as the electricity costs shall be taken into consideration. External costs are solely related to electricity consumption.

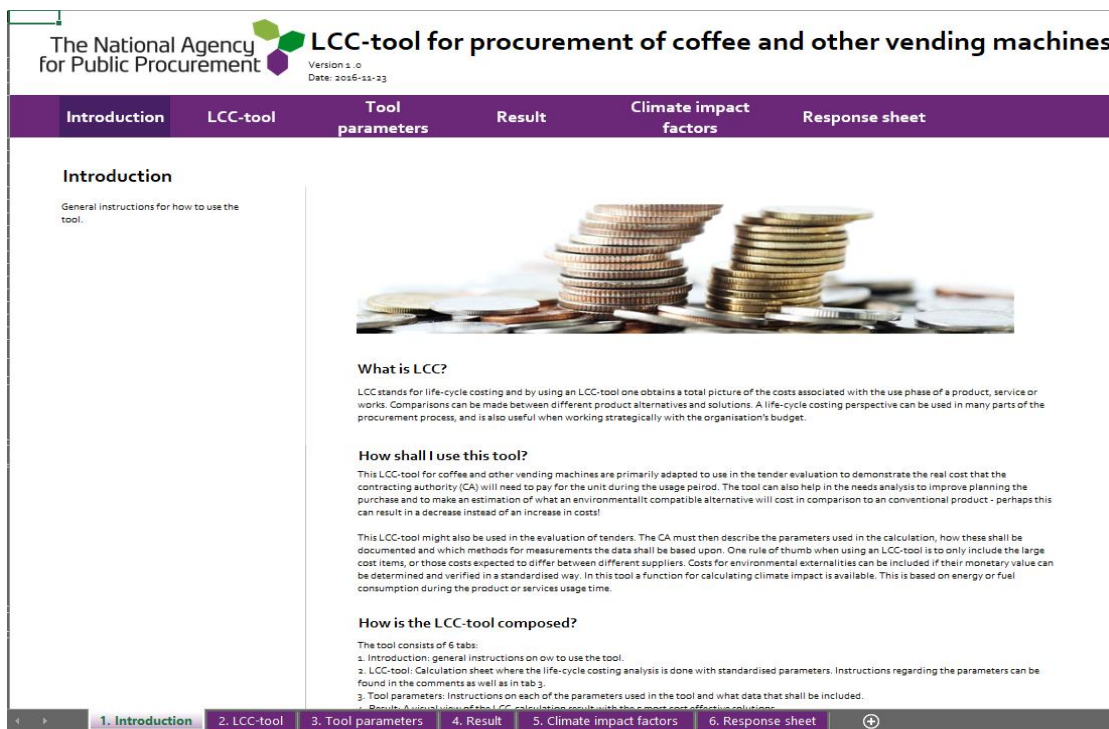
**Environmental Impacts:** During the product’s production phase, our concerns rest only upon heavy metal emissions, particulate matter and volatile organic compounds. During the product’s use phase, undesirable CO<sub>2</sub> emissions and acidification must be held into account. During the product’s end-of-life phase, we are interested in mitigating particulate matter and volatile organic compound emissions.

**Available tools**

*LCC tool by the National Agency for Public Procurement –*  
[\(https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/\)](https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/)

The LCC tool for vending machines is also developed by the National Agency for Public Procurement, is adapted to use in the tender evaluation in order to demonstrate the real cost that the CA will have to pay for the unit during the period of usage. The LCC tool aims to improve the planning phase before purchasing a product, alongside with a cost reduction estimation of what an environmentally-friendly alternative will cost as opposed to a conventional product [19].

In the same manner with the other tools by the National Agency for Public Procurement, environmental externality costs are accepted by the tool only if the supplier, who is responsible for filling in the LCC data, can accurately determine and verify the product value in a standardized way.



**Fig. 25. Introduction of the LCC tool**

## How to use

The tool's first category that must be completed is the *Calculation Conditions*. Parameters such as the number of products, the usage time for each product, the discount rate which determines the future costs to present value percentage and the energy price are the first parameters to begin with. Other criteria include annual usage in hours that the machine was used, the changes in annual prices, the impact from electricity usage in the environment and the financing costs whether we are leasing or renting the products through a third party e.g. an investment bank.

The next category is the *Data from the Supplier*. The investment costs include the initial investment cost and the cost of delivery, installation and operation start-up. Operation and Maintenance costs include filling the product's energy usage. Additional criteria in this sub-category are the service and maintenance costs, as well as the labour costs for service and maintenance. Other costs include insurance, taxes and fees if the product requires insurances or if the product is subject to taxes or fees, renting or leasing costs, disposal costs and finally, residual product value if the product has a (documented) second hand value after the given usage time.

The National Agency  
for Public Procurement

**LCC-tool for procurement of coffee and other vending machines**  
Version 1.0  
Date: 2016-11-23

Introduction
LCC-tool
Tool parameters
Result
Climate impact factors
Response sheet

**Calculation conditions** (specified by the CA)

PROJECT:

DATE:

ADMINISTRATOR:

1.1 Quantity	<input style="width: 100%;" type="text"/>	qty
1.2 Usage time	<input style="width: 100%;" type="text"/>	year
1.3 Discount rate	1.75%	
1.4 Price of energy	<input style="width: 100%;" type="text"/>	sek/kWh
1.5 Annual usage	<input style="width: 100%;" type="text"/>	hours/piece
1.6 Annual price increase (optional)	<input style="width: 100%;" type="text"/>	
1.7 Climate impact from energy usage (optional)	<input style="width: 100%;" type="text"/>	kg CO <sub>2</sub> e/kWh
1.8 Financing cost if leasing or renting	<input style="width: 100%;" type="text"/>	sek/year/piece

Data from supplier

Name	Alternative 1	Alternative 2	Alternative 3	Alternative 4
<b>Investment costs</b>				
2.1 Price	sek/piece			
2.2 Cost of delivery, installation and operation start-up	sek/piece			
<b>Operation and maintenance costs</b>				
3.1 Energy usage: kWh/H3 per piece (stand-by, idle phase)	kWh/piece			
3.2 Service and maintenance costs	sek/year/piece			
3.3 Labour costs	sek/year/piece			
<b>Other costs</b>				
4.1 Insurances, taxes and fees	sek/year/piece			
4.2 Renting or leasing costs	sek/year/piece			
4.3 Disposal costs	sek/piece			
4.4 Residual value	sek/piece			

Result

1. Introduction
2. LCC-tool
3. Tool parameters
4. Result
5. Climate impact factors
6. Response sheet
+

Fig. 26. Filling data of the LCC tool



The results provide total cost estimation over all the proposed alternatives. After the total cost, the tool presents the operating costs per year, while also estimating the climate impact per year. By changing tabs in the Excel tool, if we move to the result tab, not only do we find statistics based on the previously defined total LCC costs, but we can also see 2 diagrams per study case. The first diagram divides the total LCC costs into investments, operation, maintenance and other costs, all 4 graphs with different colors, whereas the second diagram depicts both energy usages in comparison with the climate impacts.

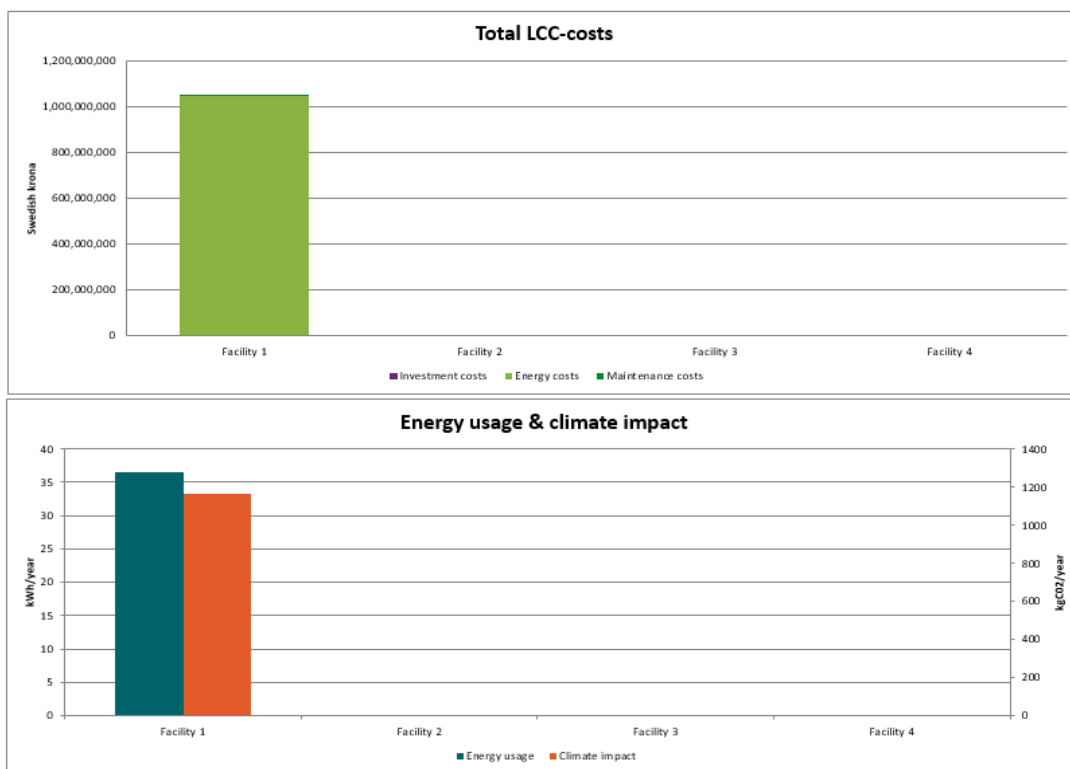


Fig. 27. Results of the LCC tool

*LCC tool by the European Commission –*  
[ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm](http://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)

The LCC Calculation tool for vending machines has been developed by the European Commission (EC) in order to be used for the tender evaluation. The main feature of this tool is the evaluation of purchase and use & end-of-life costs throughout the product life cycle in support of public procurement procedures. The tool may also provide complementary information on the evaluation of environmental externalities (indirect costs) and has been developed in line with

Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products. As a result, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products [8].

## "Life Cycle Costing (LCC) calculation Tool"

v. 1.0 20/07/2016

Developed by:  
STUDIO FIESCHI & SOCI

Scuola Superiore  
Sant'Anna

Warning

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Introduction

This is an electronic tool designed to perform life cycle costing (LCC) for a specific range of products commonly featured in public tenders. The tool, distributed by the European Commission, derives from provisions made in the new Directive 2014/24/EU, which significantly innovate the tender evaluation and award process through placing considerable importance on LCC.

The main feature of this tool is the evaluation of direct costs throughout the product life cycle in support of public procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs). The tool has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products. The information on externalities obtained with this tool shall not be used to measure and communicate the life cycle environmental performance of products, since the tool is not compliant with the Product Environmental Footprint (PEF) methodology in annex I to the Commission Recommendation of 9 April 2013.

For more information about GPP and LCC, see [http://ec.europa.eu/environment/gpp/index\\_en.htm](http://ec.europa.eu/environment/gpp/index_en.htm)  
For more information about PEF, see <http://ec.europa.eu/environment/eussd/smgp/index.htm>

INSTRUCTIONS			
•	Use coloured buttons to access the forms to fill in data		
•	Use grey buttons to browse the tool		
•	The table below includes a complete list of the available sheets.		
•	Detailed instructions are included in the User's Guide		

GO TO MAIN

GO TO REFERENCES

Sheet name	Content		
MAIN	Select the general settings (e.g. tool language, currency, exchange rate).		
	Product category	Reference product	Available actions
• IT_PC	Office IT equipment	Computer	Insert, edit or delete products.
• IT_DS	Office IT equipment	Computer Display	Insert, edit or delete products.
• IT_IE	Office IT equipment	Imaging equipment	Insert, edit or delete products.
• LT_GL	Office & street lighting	Generic luminaire	Insert, edit or delete products.
• WG_OV	White goods	Ovens	Insert, edit or delete products.
• WG_RA	White goods	Refrigerating appliance	Insert, edit or delete products.
• WG_DW	White goods	Dishwasher	Insert, edit or delete products.
• WG_WM	White goods	Washing machine	Insert, edit or delete products.

Fig. 28. Introduction of the LCC tool

**How to use ([http://ec.europa.eu/environment/gpp/pdf/LCC tool user guide final.pdf](http://ec.europa.eu/environment/gpp/pdf/LCC_tool_user_guide_final.pdf))**

To use the tool, the user should begin by completing the General Data that are to be used for all products within this product family. Then enter the discount rate that represents the difference in value between the costs in the future (lower value) versus the costs in the present and the Amortization coefficient, which allows a product cost to be distributed over different time periods on the basis of its life and deterioration. Then, the electricity price costs per kWh and the number of purchased items should be entered.

After completing the General Data, the user should move on to the Product Specific Data, where each time they may create, edit or delete new product. After filling in the Supplier and Product name, the user must then specify detailed data over the product. The purchase costs include filling in factors regarding the price of product costs (established by the vendor, plus taxation), delivery and transportation costs of the product to the Public Administration by the vendor and Installations costs, if the occur. As for the use and end-of-life data, the user must specify the

annual electricity consumption, maintenance/service contract costs, an expected lifetime for the product in years and end-of-life product costs. If the intended product is specifically a hot beverage vending machine, then in the use & end-of-life subcategory, more factors appears such as energy consumption in idle mode, average daily beverages served, annual operating days and energy consumed for dispensing one liter of hot beverages. The user can either fill only the annual electricity consumption or else, he may enter the factors mentioned above instead of the annual electricity consumption. The product warranty duration (period of time during which the producer is obliged to repair any appliance failures at no extra cost for the final user) also be entered to complete the necessary input.

Product category		Vending machines		
Product		Cold vending machine		
USE MODE		Tender evaluation		
GENERAL DATA				
Nº	INPUT NAME	UNIT	VALUE	
1	Discount rate	%	12.00%	
2	Amortization coefficient	%		
3	Electricity price	EUR/kWh	32	
4	Country	-	EU	
5	Economic period	Years	0	
6	Number of purchased items	#	4	
PRODUCT SPECIFIC DATA				
Nº	LIFE CYCLE PHASE	INPUT NAME	UNIT	SUPPLIER - PRODUCT
1	Purchase	Purchasing cost	EUR	
2		Delivery expenses	EUR	
3		Installation cost	EUR	
4	Use & end-of-life	Annual electricity consumption	kWh/year	
5		Warranty	Years	
6		Maintenance/service contract costs	EUR/year	
7	Use & end-of-life	Estimated maintenance costs	%	
8		Expected product lifetime	Years	
9		Cost of disposal	EUR	
10	Use & end-of-life	Storage volume	Liters	

Vending machines | Cold vending machine

**Use & end-of-life**

Annual electricity consumption  kWh/year

Warranty  Years

Maintenance/service contract costs  EUR/year

*Estimated maintenance costs*  %

Expected product lifetime  Years

Cost of disposal  EUR

Storage volume  Liters

SUPPLIER - PRODUCT

**Fig. 29. Filling data of the LCC tool**

After completing the required fields, the user should return to the main page, where by pressing the ‘Insert Product Data’ button they may add a new product, or edit or delete an existing one. If the user clicks on the ‘Go to Output’ button, the LCC calculation is divided into sub-categories.

- The General Information presents generic supplier and product information.
- The LCC Results – Direct costs sub-category divides the overall costs into acquisition costs, costs of use, maintenance costs and end-of-life costs, presented in a diagram.
- The Distribution of costs over time subcategory is another chart that show how costs alternate in time.

- The Externalities subcategory depicts the effects in climate regarding the electricity usage.

Additionally, the user is given the options to either ‘Display Results for total purchased items’ or ‘Show overall LCC results’. They may also print the excel sheet or export the results to a specific folder or open the exports folder. All the above stated functions are separated into different buttons for convenience.

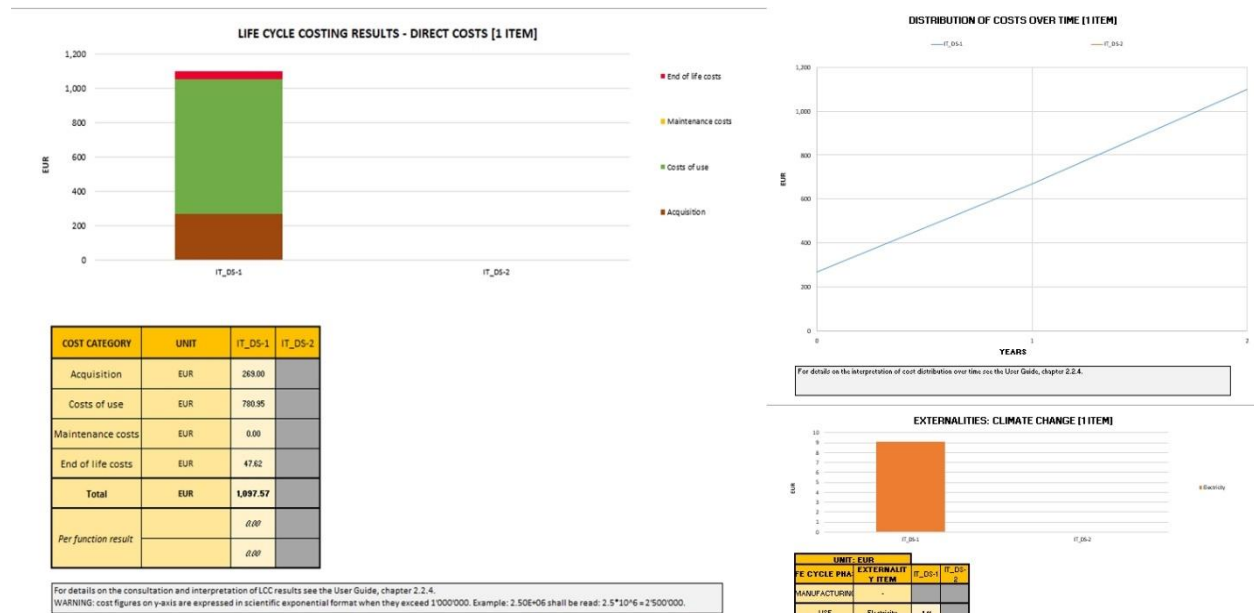


Fig. 30. Results of the LCC tool

## Chapter 5. Resources

It must have been clear at this point, that sustainable procurement requires a significant shift in standard public procurement practices. New concepts, new ideas and new objectives require the education of the involved participants, both the procurement officers and the market stakeholders in order for them to successfully adjust to the new reality. To this end, a plethora of resources has been developed by European or national initiatives to accommodate the smooth transition and integration of the new practices. Below, you will find a collection of the most important knowledge sources covering most practical aspects of applying GPP. This includes among others GPP principles, legal considerations, case studies and product specific guidance. This handbook was heavily based on the resources below and the reader is strongly advised to look into them for a deep understanding of LCC concepts and GPP in general.

### *Directives*

- ***Directive 2014/24/EU of The European Parliament And Of The Council on public procurement and directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors.*** This directive was developed in order to improve several aspects of previous directive on public procurement (2004/18/EC). Along with Utilities Directive (2014/25/EU) they came to force on 17 April 2014, and provided 2 years to the member states to integrate them to national law (April 2016). The directives include changes on procurement procedures, contract award rules, corruption safeguards etc. In relation to LCC, the directive integrates completely the LCC approach in determining the most economically advantageous tender allowing the contracting authorities to adopt sustainable, long term purchasing strategies. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0024&from=EN>  
<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0025&from=EN>
- ***“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”*** enables consideration of power consumption and environmental aspects prior to road vehicles purchase or leasing. The target group are both public purchasers and private companies that offer public transport services. This Directive addresses the need to provide support for Member States through facilitating and structuring the exchange of knowledge and best practices for promoting the purchase of clean and energy-efficient vehicles, on the basis that vehicle procurement for public transport services can make a significant impact on the market if harmonized criteria are applied at Community level. The Directive should provide a comprehensive set of opinions

that take under consideration energy and environmental impacts, enabling authorities and operators that already have developed according methods to continue applying them. It defines ranges for the costs of energy consumptions, CO<sub>2</sub> and pollutant emissions, allowing flexibility for contracting authorities and operators and ensuring an equivalent degree of harmonization. If sufficient demand for clean and energy-efficient vehicles is created, even though these types of innovative vehicles initially cost more than conventional ones, it could be ensured that the automobile economy would see cost reductions for such vehicles. The aforementioned Directive can be found in the following link: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0033>

### *LCC Tools*

- **Generic luminaire by the European Commission (Outdoors and indoors applications)**

The LCC Calculation tool for generic luminaire has been developed by the European Commission (EC) in order to be used for the tender evaluation. The main feature of this tool is the evaluation of direct costs for both indoor and outdoor lighting throughout the product life cycle in support of public procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs) and has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products. You can find the LCC tool, alongside with additional information here: [ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm](https://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)  
[ec.europa.eu/environment/gpp/pdf/LCC tool user guide final.pdf](https://ec.europa.eu/environment/gpp/pdf/LCC_tool_user_guide_final.pdf)  
[ec.europa.eu/environment/gpp/pdf/LCC tool technical specifications.pdf](https://ec.europa.eu/environment/gpp/pdf/LCC_tool_technical_specifications.pdf)

- **Lighting System by the National Agency for Public Procurement (Indoor Applications)**

The following tool, developed by the National Agency for Public Procurement, is designed especially for the procurement of indoor lighting and thus, it can be used when choosing criteria or in the evaluation of tenders. It also allows to the user to efficiently calculate the climate impact, heavily based on the power consumption coming from the lighting system currently operating. More specifically, the tool can provide an approximation of the costs correlated to the system. As for the tenders' evaluation, the LCC cost will be included as a parameter in order for the most cost-efficient tender to be evaluated. Quality criteria for the lighting system, such as light quality, are not included in the tool and must be specified

separately in the tender documents. The LCC tool is based on present value method to be able to calculate future cost to present value, an equation that is included in the tool. Other parameters such as discount rate, electricity pricing and economic periods are just some of the criteria that are expected to affect the result and should be decided upon consulting the Contracting Authority (CA). You may find the LCC tool by clicking on the link below: <https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>

- **Lighting System by the National Agency for Public Procurement (Outdoor Applications)**

As with the Indoor Lighting System from the National Agency for Public procurement, the following tool applies to outdoor lighting and is designed especially for the procurement of outdoor lighting. It can be used when choosing criteria or in the evaluation of tenders, while also allowing the user to efficiently calculate the climate impact, based on the energy consumed in the operation of the lighting system (as also described with the indoor lighting system). More specifically, the tool can provide an approximation of the costs correlated to the system. Yet, one thing to consider using an LCC-tool is to only include the large cost items, or costs that is expected to differ between different suppliers, whereas externality costs for environmental parameters can be included and calculated only if their monetary value can be determined and verified in a way that is standardised. As for the tenders' evaluation, the LCC cost will be included as a parameter in order for the most cost-efficient tender to be evaluated. Quality criteria for the lighting system, such as light quality, is not included in the tool and must be specified separately in the tender documents. The LCC tool is based on present value method to be able to calculate future cost to present value, an equation that is included in the tool. Other parameters such as discount rate, electricity pricing and economic periods are just some of the criteria that are expected to affect the result and should be decided upon consulting the Contracting Authority (CA). You can find the LCC tool by clicking on the following link: <https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>

- **SEAD by the Clean Energy Ministerial (Outdoor Applications)**

The Super-efficient Equipment and Appliance Deployment (SEAD) Street Lighting tool is an Excel-based tool that calculates expected energy use, light performance and LCC costs for outdoor lighting upgrades from the most common road infrastructures. It is an initiative of the Clean Energy Ministerial and a task within the International Partnership for Energy Efficiency Cooperation and gives the opportunity to quickly and with ease evaluate the efficiency, the quality, the technical compatibility and the lifetime costs of different street

lighting products, targeted for government procurement officials. As a result, it may help municipal officials in making more informed procurement selection to mitigate the complexity that buying new street lighting products involves. The SEAD street lighting tool identifies the optimal lighting product for any circumstances, allowing users to evaluate without much complexity lighting products e.g. LEDs and conventional fixtures, based on technical specification, lighting quality, costs and energy savings. You can find the aforementioned LCC tool on this link: <https://superefficient.org/tools/street-lighting-tool>

- ***Generic Clean Fleets by the European Commission***

This tool allows a comparison of the Life Cycle Costs (LCC) and Total Costs of Ownership (TCO) for different vehicles and bids within a procurement process. The developed tool is quite easy to use and fully complies with the Clean Vehicles Directive (CVD). It also allows the user to apply the Operational Lifetime Costing (OLC) methodology as described in the ***Directive 2009/33/EC***, a methodology which provides accurate costings of the environmental impacts of fuel consumptions and tailpipe emissions. The LCC calculation is divided on different sub-categories, such as General Conditions, Acquisition Costs, Operating Costs, Maintenance Costs, Taxes and Other Costs, OLC costs (optional) and End-of-life Costs. The LCC calculation result reveals the Total LCC per unit and in overall and also creates diagrams concerning total costs per product and costs during the life cycle of each vehicle tested in the tool. A series of valuable resources derived from the Clean Fleets Project, including the Clean Fleets Life Cycle Cost Calculator, can be found at the homepage of the project's website. The LCC tool of the Clean Fleets Project can be found here: <http://www.clean-fleets.eu/home/>

- **LCC tool for Computers and Monitors from the European Commission**

This has been developed for procurement practitioners in public organizations in the EU and was designed for procurement both below and above the thresholds for application of the **EU 2014/24/EU directive** on public procurement, yet it can also be used in private sector purchasers and even the general public. The tool may be used for desktop computers (e.g. Integrated Desktop Computers and Thin Clients), Portable Computers (e.g. Notebooks, Tablets) and Computer monitors. Its purpose is to encourage and facilitate the wide application of LCC among public authorities in the EU, so that organizations can make more cost-effective decisions in the procurement processes for computers and monitors. The tool allows users to consider different cost categories and, at a preliminary stage, it is important to have the full costs picture for better planning. However, inclusion of all these categories in the tendering process is not needed, if there is a good reason to exclude them. Using the tool during tendering allows considerations related to initial acquisition costs, operating and



maintenance costs, other costs and costs of environmental externalities. You can find the aforementioned LCC tool on this link: [ec.europa.eu/environment/gpp/pdf/EC\\_LCC\\_Tool\\_Computers\\_final\\_updated\\_13Mai2019.xlsx](https://ec.europa.eu/environment/gpp/pdf/EC_LCC_Tool_Computers_final_updated_13Mai2019.xlsx)

- **Office IT LCC Tool by the European Commission**

The LCC Calculation tool for Office IT Equipment (includes both stationary computers, portable computers and display devices) has been developed by the European Commission (EC) in order to be used for the tender evaluation. The main feature of this tool is the evaluation of direct costs computers and monitor displays throughout the product life cycle in support of public procurement procedures. The tool provides, in addition to direct costs, complementary information on the evaluation of environmental externalities (indirect costs) and has been developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products; therefore, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products. You can find the LCC tool here: [ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm](https://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)

- **Vending Machines LCC tool by the National Agency for Public Procurement**

The LCC tool for vending machines is also developed by the National Agency for Public Procurement, is adapted to use in the tender evaluation in order to demonstrate the real cost that the CA will have to pay for the unit during the period of usage. The LCC tool aims to improve the planning phase before purchasing a product, alongside with a cost reduction estimation of what an environmentally-friendly alternative will cost as opposed to a conventional product. In the same manner with the other tools by the National Agency for Public Procurement, environmental externality costs are accepted by the tool only if the supplier, who is responsible for filling in the LCC data, can accurately determine and verify the product value in a standardized way. You can find the LCC tool by clicking on the following link: <https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>

- **Vending Machines LCC tool by the European Commission**

The LCC Calculation tool for vending machines has been developed by the European Commission (EC) in order to be used for the tender evaluation. The main feature of this tool is the evaluation of purchase and use & end-of-life costs throughout the product life cycle in support of public procurement procedures. The tool may also provide complementary information on the evaluation of environmental externalities (indirect costs) and has been

developed in line with Art. 68 of Directive 2014/24/EU. The evaluation of environmental externalities is limited to the use phase of products. As a result, the tool does not provide comprehensive and life-cycle based information on the environmental profile of such products. You can find the LCC tool here: [ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm](http://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)

- **LCC tools to be developed by the EC for Outdoor Lighting, Indoor Lighting, Vending Machines, Imaging equipment**

The European Commission is in the process of developing a series of sector specific LCC calculation tools which aim to facilitate the use of LCC amongst public procurers. At the time of finalization of this report (June 2019), EC had finalized and published the LCC tool for Computers and Monitors which has been described in Section 4.3. EC plans to publish LCC tools for four additional product categories in the next months. The original schedule is presented as shown below:

- Outdoor Lighting (summer 2019)
- Indoor Lighting (summer 2019)
- Vending Machines (autumn 2019)
- Imaging equipment (autumn 2019)

You can find any updates on these tools (and the tools themselves when they are published) in the EC dedicated page for LCC: <http://ec.europa.eu/environment/gpp/lcc.htm>

### *Guides and Reports*

- **SMART SPP – innovation through sustainable procurement. Driving energy efficient innovation through procurement. A practical guide for public authorities**

SMART SPP was a European project supported by the Intelligent Energy Europe funding programme, which promoted the introduction of new, innovative low carbon emission technologies and integrated solutions onto the European market. This was done by encouraging early market engagement between public authority procurers and suppliers and developers of new innovative products and services in the pre-procurement phase of public tenders. The project has developed a great guide that is aimed at assisting public authorities in becoming "innovation-friendly" - that is achieving the most innovative, energy efficient

solutions within their procurement actions, particularly through increased dialogue with suppliers and producers. The guide contains a comprehensive strategy in creating successful green tenders, describing each step on the way from identifying your needs to monitoring the contract's performance. This guide is a great first step for procurement officers in GPP in general.

[http://www.smart-spp.eu/fileadmin/template/projects/smart\\_spp/files/Guidance/Final\\_versions/SMART\\_SPP\\_Guide\\_2011\\_EN\\_FINAL\\_www.pdf](http://www.smart-spp.eu/fileadmin/template/projects/smart_spp/files/Guidance/Final_versions/SMART_SPP_Guide_2011_EN_FINAL_www.pdf)

- **The Procura+ Manual - A Guide to Implementing Sustainable Procurement**

The Procura+ Manual provides clear, easy-to-understand guidance for any European public authority on how to implement sustainable procurement. This publication was produced as part of the SPP Regions project and contains:

- a simple implementation model for ensuring the systematic inclusion of sustainability considerations in procurement
- a clear guidance on how to integrate sustainability criteria into the procurement process under the 2014 Directives – from preliminary market consultation to technical specifications, selection and award criteria, and contract clauses
- an introduction to the concept of life cycle costing (LCC), evidence regarding the costs of sustainable procurement and advice on how to keep costs down
- an overview of sustainable procurement approaches for six key products, works and services: construction, IT equipment, cleaning products, food, vehicles and electricity – including information on the available criteria

This guide can be very helpful to any European public authority and is available here:

[http://www.procuraplus.org/fileadmin/user\\_upload/Manual/Procuraplus\\_Manual\\_Third\\_Edition.pdf](http://www.procuraplus.org/fileadmin/user_upload/Manual/Procuraplus_Manual_Third_Edition.pdf)

- **Life Cycle Costing State of the art report. SPP Regions (Sustainable Public Procurement Regions) Project Consortium**

The SPP Regions project was aimed at promoting the creation and expansion of European regional networks of municipalities working together on sustainable public procurement (SPP) and public procurement of innovation (PPI). The project developed many reports on SPP. One of them focused on the Life Cycle Costing, presenting the state of the art on the subject. The report, published by ICLEI – Local Governments for Sustainability, European Secretariat, describes the challenges and solutions on applying LCC concepts in procurement, and mentions available tools and best practices. This report is a great introduction in LCC for every

procurement officer and can be accessed through the link below.  
[http://www.sppregions.eu/fileadmin/user\\_upload/Life\\_Cycle\\_Costing\\_SoA\\_Report.pdf](http://www.sppregions.eu/fileadmin/user_upload/Life_Cycle_Costing_SoA_Report.pdf)

- ***The Green Public Procurement and the EU Action Plan for the Circular Economy*** by the European Parliament is a study provided by Policy Department A at the request of the Committee on the Environment, Public Health and Food Safety (ENVI). The purpose of the study is an analysis of the current landscape regarding available tools and approaches for GPP and a discussion on possible improvements. The study also provides recommendations and measure for a better integration of CE into GPP procedures and provide decision makers with a pool of options for taking circularity to a higher level.  
[http://www.europarl.europa.eu/RegData/etudes/STUD/2017/602065/IPOL\\_STU\(2017\)602065\\_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/STUD/2017/602065/IPOL_STU(2017)602065_EN.pdf)
- **The EU GPP criteria**, promoted by the European Commission, 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, procuring authorities may choose, according to their needs and ambition level, to include all or only certain requirements in their tender documents. The product categories is constantly expanded and updated, currently including Cleaning products and services, Computer and monitors, Copying and graphic paper, Electrical and Electronic Equipment used in the Health Care Sector, Electricity, Food and Catering services, Furniture, Gardening products and services, Imaging Equipment, Office Building Design, Construction and Management, Paints, varnishes and road markings, Road Design, Construction and Maintenance, Sanitary Tapware, Road lighting and traffic signals, Textiles, Toilets and Urinals, Road Transport, Waste Water Infrastructure, Water-based Heaters.  
[http://ec.europa.eu/environment/gpp/eu\\_gpp\\_criteria\\_en.htm](http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm)
- ***Revision of the EU Green Public Procurement Criteria for Street Lighting and Traffic Signals.***

This report by the Joint Research Centre (JRC), the European Commission's science and knowledge service, presents a broad look at the road lighting sector from the perspectives of scope and definition, relevant legislation, market, technical and environmental analysis. Its findings will act as a basis for the ongoing EU GPP criteria revision process for the product group "Road lighting and traffic signals". Therefore, it may provide interesting insights to the

process of selecting GPP and lifecycle cost criteria and strategies in street lighting projects in the public sector.

[http://susproc.jrc.ec.europa.eu/Street\\_lighting\\_and\\_Traffic\\_signs/docs/PR\\_Final\\_25-08-2017\\_Sci4\\_Pol.pdf](http://susproc.jrc.ec.europa.eu/Street_lighting_and_Traffic_signs/docs/PR_Final_25-08-2017_Sci4_Pol.pdf)

- ***Procurement & Design Guidelines for LED Street Lighting and Guidelines for Indoor Lighting in the Public and Private Service Sector by Premium Light-Pro.***

The international initiative “Premium Light Pro” focusses on the implementation of next-level energy efficient LED lighting systems (indoor & outdoor lighting) in the private and public service sector. The main target of this initiative is to support the implementation of high quality and efficient LED-solutions by appropriate instruments and services. To this end, the initiative has developed several guidelines and tools to help procurement professionals, decision makers and contracting companies on selecting energy efficient lighting solutions. These tools include guides for both indoor and street lighting projects, procurement criteria and Life Cycle Costing tools.

<http://www.premiumlightpro.eu/indoor-lighting/guidelines-downloads/>

<http://www.premiumlightpro.eu/outdoor-lighting/guidelines-downloads/>

- **EU green public procurement criteria for road lighting and traffic signals.** This document provides the EU GPP criteria for the product group ‘road lighting and traffic signals’. The environmental aspects covered by EU GPP criteria for road lighting are split into three broad sections: energy consumption, light pollution and lifetime. The procurement of traffic signals is considered separately using criteria that are predominantly centred on life cycle costs. The criteria are made up of selection criteria, technical specifications, award criteria and contract performance clauses. They may be divided into two levels:
  - Core criteria — these are designed for easy application of GPP, focusing on the key area(s) of environmental performance of a product and aimed at keeping administrative costs for companies to a minimum.
  - Comprehensive criteria — which take into account more aspects or higher levels of environmental performance, for use by any authorities that want to go further in supporting environmental and innovation goals.

[http://ec.europa.eu/environment/gpp/pdf/toolkit/181210\\_EU\\_GPP\\_criteria\\_road\\_lighting.pdf](http://ec.europa.eu/environment/gpp/pdf/toolkit/181210_EU_GPP_criteria_road_lighting.pdf)

- **The Clean Fleets Guide**, currently under the name “*Procuring clean and efficient road vehicles – Clean Fleets Guide*”, acknowledges the need for alternatives to traditional petrol and diesel vehicles for their fleets, due to environmental factors concerning climate

changes, air quality, fuel security and alternatively-fueled vehicles. The guide is mainly targeted towards procurers and fleet managers, but also remains relevant in regard to policy makers and others currently involved in the transport sector. It presents a variety of options on how environmental criteria can be introduced into the different stages of procurement procedures, alongside with relevant LCC information. The Clean Fleets project – funded by the Intelligent Energy Europe Programme of the European Union – has developed an excel tool which assists public authorities and fleet operators with the procurement or leasing of clean and energy-efficient vehicles, implementing the Clean Vehicles Directive (CVD), which is **Directive 2009/33/EC**. A series of valuable resources derived from the Clean Fleets Project, including the Clean Fleets Guide, can be found at the homepage of the project’s website by visiting the following link: <http://www.clean-fleets.eu/home/>

- **EU green public procurement criteria for road transport.** This document provides EU green public procurement (GPP) criteria on road transport products and services (cars, light commercial vehicle, buses etc) that can be (partially or fully) integrated into the authority’s tender documents with minimal editing. The criteria are split into selection criteria, technical specifications, award criteria and contract performance clauses. The criteria are of two types:
  - Core criteria — which are designed to allow for easy application of GPP, focusing on the key area(s) of environmental performance of a product and aimed at keeping administrative costs for companies to a minimum.
  - Comprehensive criteria — which take into account more aspects or higher levels of environmental performance, for use by authorities that want to go further in supporting environmental and innovation goals.<http://ec.europa.eu/environment/gpp/pdf/criteria/transport.pdf>
- The “**User Guide to the Life Cycle Costing Tool for Green Public Procurement of Computers and Monitors**” document provides useful background information on the LCC tool that was developed for procurement practitioners in public organizations in the EU. This guide provides readers with the key aspects to consider when using LCC in public procurement, especially during the preparatory and tendering stages and introduces briefly the main sections and elements of the LCC tool for Computers and Monitors. More specifically, the guide describes in detail what steps should be followed if the tool is intended to be used before tendering. For example, the guide states that “it is important to know what your real IT needs are, what solutions exist to cover them and which have lower life cycle costs.” In overall, the ‘Prior to the tendering process’ section of the guide addresses the following issues:
  - a) Determine your needs, b) Identify solutions for those needs, c) Identify relevant cost

drivers and parameters and d) Consult with relevant parties. The second section of the document describes how to use LCC during the tendering process and suggests that if life cycle costs are intended to be used in the tendering process, they should be stated clearly in the tender documents, common parameters should be provided to ensure transparency, data that is needed for the LCC calculation should be asked for and last but not least, clear definitions and standards should be provided in order to ensure the comparability of offers. The guide's last section refers to the after the tendering process stage, where suggested actions can be summarized as: a) monitor compliance with the tender requirements and performance levels promised by the contractor, b) apply sanctions if needed, c) identify lessons for future tenders, d) communicate results to motivate internal acceptance and buy-in and e) promote replication by other stakeholders. The guide is available here: [ec.europa.eu/environment/gpp/pdf/EC\\_LCC\\_computers\\_guide\\_final\\_updated\\_Mar2019.pdf](http://ec.europa.eu/environment/gpp/pdf/EC_LCC_computers_guide_final_updated_Mar2019.pdf)

- The **Technical Background Report for Office IT Equipment** was released by the European Commission. Based on the GPP criteria presented by the European Commission, this report targets at providing relevant background information on the environmental impact of office IT equipment. It outlines the key relevant European Legislation affecting this product group and is accordance with the life cycle data. The report presents market availability of this product group, consideration and public procurement needs while also outlining core and comprehensive environmental criteria which are proposed within the report. Associated GPP Criteria discussed and analyzed at this technical background report contain both proposed purchasing criteria and further information for green tendering procedures. The technical report includes specifications on defining acceptable computer power consumptions and different options to consider for consumption mitigations. It also tackles externality issues such as hazardous materials found in computer parts in order to promote products with very low or none concentration of these hazardous materials, methods for product's lifetime extension through extended durability and increased upgradability and ways to improve end of life management. The Technical Background Report for Office IT Equipment can be found in EC's website by clicking [the following link:](http://ec.europa.eu/environment/gpp/pdf/tbr/office_it_equipment_tbr.pdf)
- The **"Revision of the EU Green Public Procurement (GPP) Criteria for Computers and Monitors"** Technical Report has been released by the European Commission and is intended to supply background information and evaluate and discuss whether current GPP criteria should be revised, restructured, removed or still kept due to their relevance. The equivalent study was performed by the Joint Research Centre's Institute for Prospective

Technological Studies (JRC-IPTS). The report also identifies new criteria areas to be taken under high consideration in order to efficiently address environmental impacts of office IT equipment. For each of the criteria areas, the report presents both current criteria and revised criteria. Criteria discussed in the technical report are Energy Consumption, Hazardous Substances, Product lifetime extension, end-of-life management and additional criteria. Product group discussed in the report includes the following categories: a) Personal Computers, b) Computer Displays, c) Keyboards, d) External Power Supplies, e) Notebook Computers and f) Discrete Graphics Processing Unit (GPU). The Revision of the EU GPP Criteria for Computer and Monitors can be found again in the EC's website by clicking the following link: [http://ec.europa.eu/environment/gpp/pdf/tbr/Computers\\_and\\_monitors\\_technical\\_background\\_and\\_proposals.pdf](http://ec.europa.eu/environment/gpp/pdf/tbr/Computers_and_monitors_technical_background_and_proposals.pdf)

- ***“EU GPP Criteria for Computers and Monitors”*** document of 2016 aims at facilitating public authorities the purchase of products, services and works with reduced environmental impacts. While using these criteria is of course voluntary, integration into the equivalent tender documents is highly applicable if the individual authority considers the criteria formulation as appropriate for the intended use. While the adopted EU GPP criteria aim to reach a good balance between environmental performance, cost considerations, market availability and ease of verification, procuring authorities may choose, according to their needs and ambition level, to include all or only certain requirements in their tender documents. This document presents the EU GPP Criteria for the product group of Office IT Equipment whereas further information can be provided by consulting the accompanying Technical Background Report (2016), which provides full rationales that support the selection of these GPP criteria and references for further information. The document organizes discussed criteria into Selection Criteria, Award Criteria, Technical Specifications and Contract Performance Clauses. Each of these categories are divided in two sub-categories: a) Core Criteria, designed for easy GPP application with a focus on key areas of a product's environmental performance, minimizing the company administrative costs and b) Comprehensive Criteria, designed to take into consideration more aspects of environmental performance, aimed for public authorities. One can retrieve the document by visiting the EU GPP criteria section of the EC's website and selecting the EG GPP criteria document on the category of Computer and Monitors, found here: [http://ec.europa.eu/environment/gpp/eu\\_gpp\\_criteria\\_en.htm](http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm)



## References

- [1] European Commission, “Buying Green! Handbook (third edition)”. This handbook is an indicative document of the Commission services and its content is subject to the evolution of the EU law, including the revision of the Procurement Directives and case-law of the Court of Justice,.URL: <http://ec.europa.eu/environment/gpp/lcc.htm>
- [2] Interreg Europe, “Good Practice: Procuring recycled paper”. URL: <https://www.interregeurope.eu/policylearning/good-practices/item/346/procuring-recycled-paper/>
- [3] Interreg Europe, “Good Practice: Environmentally Friendly vehicles for Police Service”. URL: <https://www.interregeurope.eu/policylearning/good-practices/item/552/environmentally-friendly-vehicles-for-police-service/>
- [4] Interreg Europe, “Good Practice: Energy Efficiency improvement measures (renovation) in apartments house Klaipeda street 88, Liepaja”. URL: <https://www.interregeurope.eu/policylearning/good-practices/item/427/energy-efficiency-improvement-measures-renovation-in-apartments-house-klaipeda-street-88-liepaja/>
- [5] SPP Regions (Sustainable Public Procurement Regions) Project Consortium, Life Cycle Costing State of the art report, . [http://www.sppregions.eu/fileadmin/user\\_upload/Life Cycle Costing SoA Report.pdf](http://www.sppregions.eu/fileadmin/user_upload/Life_Cycle_Costing_SoA_Report.pdf)
- [5] Premium Light Pro, “LED Street Lighting Procurement and Design Guidelines”. A comprehensive guide for procurers for installation of outdoor lighting under specific safety, quality, efficiency and lifetime measures, using the project’s Outdoor Lighting Procurement Criteria as high quality benchmarking standards, URL: <http://www.premiumlightpro.org.uk/outdoor-lighting/guidelines-downloads/>
- [6] Van Tichelen P., Geerken T., Jansen, B. Vanden Bosch M., van Hoof V., Vanhooydonck L., Vercalsteren A.,2007. EuP study lot 9, Ecodesign for public street lighting, Final report, 2007. VITO. Available from <http://www.eup4light.net>
- [7] MEEr, 2011. ‘Methodology for Ecodesign of Energy-related Products’, available on <http://www.eupnetwork.de/product-groups/preparatory-studies/> Narisada, 2004. Narisada K. & Schreuder D. (2004)
- [8] European Commission, “Life Cycle Costing (LCC) calculation tool”. A tool, distributed by the European Commission, deriving from the provisions made in the new Directive 2014/24/EU,

designed to perform life cycle costing for a specific range of products commonly featured in public tenders. URL: [ec.europa.eu/environment/gpp/pdf/SF\\_SSSUP\\_ELCC.xlsm](http://ec.europa.eu/environment/gpp/pdf/SF_SSSUP_ELCC.xlsm)

[9] National Agency for Public Procurement, “LCC calculation for procurement of indoor lighting systems”. This tool is designed especially for procuring indoor lighting systems by assisting in the need’s analysis, when choosing criteria or in the evaluation of tenders, while also calculating climate impacts based on the system’s energy consumptions, URL: <https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>

[10] National Agency for Public Procurement, “LCC-calculation for procurement of outdoor lighting systems”. This tool is designed especially for procuring indoor lighting systems by assisting in the need’s analysis, when choosing criteria or in the evaluation of tenders, while also calculating climate impacts based on the system’s energy consumptions, URL: <https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>

[11] Clean Energy Ministerial, “SEAD Street Lighting Tool (and reference manual)”. A SEAD Procurement Tool for energy efficient street lighting, assisting municipal officials in making more informed procurement choices by efficiently evaluating the quality, efficiency, compatibility and lifetime costs of various street lighting products, URL: <https://superefficient.org/tools/street-lighting-tool>

[12] Premium Light Pro, “Indoor Lighting in the Public and Private Service Sectors Guidelines”. A comprehensive guide for installation of indoor lighting in the non-domestic sector, using the project’s Indoor Lighting Procurement Criteria as high quality benchmarking standards, URL: <http://www.premiumlightpro.org.uk/indoor-lighting/guidelines-downloads/>

[13] Clean Fleets, “Procuring clean and efficient road vehicles – Clean Fleets Guide”. The Clean Fleets Guide is designed in order to help public authorities and transport operations to purchase clean and energy efficient vehicles in full compliance with European Legislation, currently referring to the Clean Vehicles Directive, URL: <http://www.clean-fleets.eu/home/>

[14] 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, URL: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0033>

[15] Traverso, M., Donatello, S., Moons, H., Rodriguez Quintero, R., Gama Caldas, M., Wolf, O., Van Tichelen, P., Van Hoof, V. and Geerken, T. Revision of the EU Green Public Procurement Criteria for Street Lighting and Traffic Signals - Preliminary Report: Final version. EUR 28622 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-69097-6, doi:10.2760/479108, JRC106647.

[http://susproc.jrc.ec.europa.eu/Street lighting and Traffic signs/docs/PR Final 25-08-2017 Sci4 Pol.pdf](http://susproc.jrc.ec.europa.eu/Street_lighting_and_Traffic_signs/docs/PR_Final_25-08-2017_Sci4_Pol.pdf)

[16] European Commission, “Green Public Procurement – Office IT equipment – Technical Background Report - 2011“. This report provides background information on the environmental impact of office IT equipment, based on the life cycle data and focuses on the key relevant European legislation affecting this product group, URL:

[http://ec.europa.eu/environment/gpp/pdf/tbr/office\\_it\\_equipment\\_tbr.pdf](http://ec.europa.eu/environment/gpp/pdf/tbr/office_it_equipment_tbr.pdf)

[17] European Commission, “Revision of the UE Green Public Procurement (GPP) Criteria for Computers and Monitors – Technical Report - 2016“. Publication targeting at helping public authorities to ensure that computers and monitors are procured in such a way that it delivers environmental improvements that contribute to European policy objectives for energy, chemical management and resource efficiency, while reducing life cycle costs, URL:

[http://ec.europa.eu/environment/gpp/pdf/tbr/Computers and monitors technical background and proposals.pdf](http://ec.europa.eu/environment/gpp/pdf/tbr/Computers_and_monitors_technical_background_and_proposals.pdf)

[18] European Commission, “LCC Calculation Tool – Technical Specifications“. This guide includes all necessary background technical specifications for the LCC calculation tool, commissioned by the European Commission and intended to help public authorities to green their purchasing decision under the light of the Public Procurement Directive 2014/24/EU, URL:

[http://ec.europa.eu/environment/gpp/pdf/LCC tool technical specifications.pdf](http://ec.europa.eu/environment/gpp/pdf/LCC_tool_technical_specifications.pdf)

[19] National Agency for Public Procurement, “LCC-calculation for procurement of coffee and other vending machines“. This tool is designed to be adapted in the tender evaluation and demonstrate the real cost that the CA will have to pay during usage period, URL:

<https://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/>

[20] Brannigan, et al. Ex-post Evaluation of Directive 2009/33/EC on the promotion of clean and energy efficient road transport vehicles. Final Report. European Commission – Directorate-General for Mobility and Transport (2015)