3. Mapping life-cycle costing tools and practices

This chapter presents a mapping of available life-cycle costing (LCC) tools and methodologies, providing insights into the approaches EU and OECD countries and organisations have taken towards LCC, focusing on LCC calculation methodologies, cost parameters, and features of the tools. It also presents a deep-dive comparative analysis of selected tools and extract essential user-friendly features of common LCC tools to support the development process of LCC tools in Hungary. Finally, this chapter describes the uptake of LCC use based on practical experience from contracting authorities and policymakers, highlights the challenges and draws recommendations for a way forward to improve the uptake of this practice.

3.1. Mapping of available tools and methodologies to support the use of LCC

Calculating LCC is a complex endeavour, as it requires setting parameters based on realistic assumptions about potential future costs, such as energy prices, reparation and maintenance needs, or usage time. To support the uptake of LCC approaches in the procurement process, countries have developed so-called LCC tools. These tools provide a structured framework in which relevant costs of specific purchasing categories are pre-defined and can be assessed. With the support of these tools, practitioners can easily compare the LCC of various products.

Mapping available LCC tools provides insights into the approaches countries and organisations have taken with LCC, and allows building on the existing knowledge base for future development of LCC tools. In particular, the mapping exercise allows a structured comparison of LCC tools based on several dimensions, such as calculation methodologies, cost parameters, features of LCC tools, etc. As such, the analysis aims at systematically reviewing key characteristics of LCC tools, with a view to identifying elements and features that make tools most user-friendly and effective to use. The mapping exercise is complemented by input from fact-finding meetings with stakeholders that have been involved in the development process of LCC tools, or are currently responsible for advancing LCC use in procurement. While the mapping exercise focuses primarily on LCC tools, other relevant tools are also part of the analysis, as there are often links between various types of tools that broadly support GPP objectives (e.g. LCA tools or similar).

This chapter is structured as follows: first, a mapping of available LCC tools in EU and OECD countries based on desktop research is conducted; second, a deep-dive comparative analysis of selected tools is presented. Finally, the last section describes the uptake of LCC use based on practical experience from contracting authorities and policymakers.

3.1.1. Availability of LCC tools in the broader GPP policy context

To understand the development of LCC tools, it is important to consider the broader context of GPP policy. As such, the mapping exercise also takes into account several policy dimensions, in addition to identifying LCC tools. In particular, information was collected on whether countries have introduced a strategy dedicated to GPP or Sustainable Public Procurement (SPP), and whether guidance for SPP/GPP is available, as well as whether dedicated guidance for LCC has been developed in the countries analysed (Table 3.2).

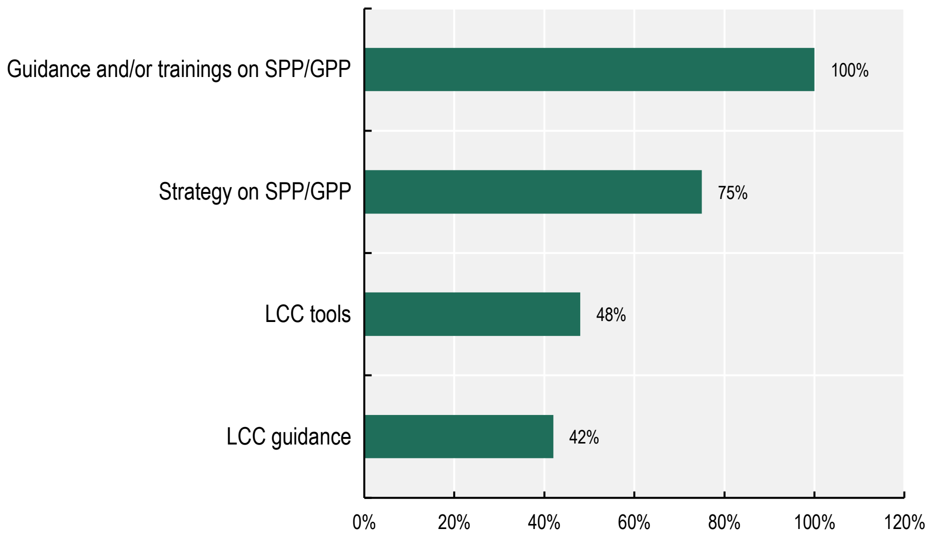
Based on a sample of 33 countries covering EU and OECD countries[1], it emerged that SPP/GPP is broadly anchored in the strategic policy framework of many countries with close to 75% of them having introduced a dedicated strategy on GPP/SPP. In the EU, as of December 2021, 85% of EU Member States have adopted a Green Public Procurement (GPP) National Action Plan (NAP) or an equivalent document[2]. Estonia, Luxembourg, Romania and Hungary are the four remaining States with no existing NAP.

Furthermore, it emerged that all countries (100%) have introduced guidance on SPP/GPP. For the purpose of this exercise, guidance has been defined broadly. Namely, it may include a vast array of support instruments for contracting authorities, such as GPP criteria, competence centre on sustainability and green procurement, guidance documents, etc.

Activities addressing GPP are present in every EU Member States, even when a National Action Plan is not yet adopted. For example, Luxembourg does not have a GPP NAP in place but it does have GPP guidelines for sustainable construction works and use of construction products, as well as procurement trainings including environmental aspects. Indeed, every EU Member States engaging in Green Public Procurement has developed some kind of capacity building activities such as trainings, conferences and seminars dedicated to contracting authorities, decision-makers, representatives of business and suppliers. None of them indicated having nothing in place. These activities can be organised periodically or permanently depending on the country, and focus on general information about GPP, on how to use GPP criteria, and offer practical guidance on green and sustainable public procurement. Some Member States are very proactive regarding GPP trainings: Malta has set up a permanent training programme for procurers and business entities, Croatia has held 60 specialised training programmes in 2015 attended by 1033 participants, and Latvia organised 29 seminars over five years to train over 1600 procurement professionals. Other Member States (44%) have also set up helpdesks and have specific websites on GPP through which requests can be handled, as well as dedicated webpage to “frequently asked questions”, while others focus on developing guidelines and manuals (51%). Special awards on GPP can also be granted for good practice in some countries, such as Germany and Cyprus[3] (European Commission, 2021[1]).

Furthermore, LCC-tools are also relatively wide-spread. In 42% of countries of out the sample (37% of EU Member States) have adopted LCC guidance, and 48% (40% in the EU) have developed general and/or products-specific LCC tools. For example, Denmark has developed LCC tools and guidance for 13 different products groups, which are being updated with a module calculating the end-of-use phase. It seems that indoor and outdoor lighting is the major area where specific LCC tools have been developed across EU Member States. While some Member States have developed LCC guidance and supporting tools, some of them have sometimes developed only LCC guidance without supporting tools, or LCC supporting tools without guidance. Croatia does not have LCC guidance on national level, but their GPP NAP contains an overview of several LCC tools and guides as well as a recommendation for the use of SMART SPP application. France does not have LCC tools but has settled a Joint task force aiming at establishing precise criteria for LCC (European Commission, 2021[6]).

Figure 3.1. Trends in GPP



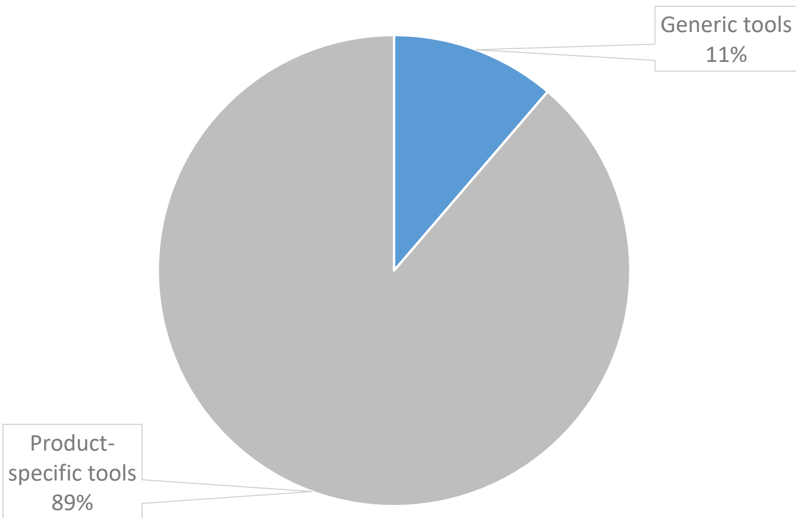
3.1.2. Approaches to LCC calculations

As highlighted by conversations with stakeholders and practitioners, the approach towards the LCC calculations varies notably among countries. A number of underlying assumptions are broadly shared among stakeholders. These include the need to educate public buyers on LCC and its use in public procurement, the relevance of private sector’s and research entities’ input in the development of ready-to-use tools or other solutions for practitioners, the importance of availability and reliability of data used in the available tools. However, the approaches towards incorporating LCC in public procurement practice diverge. Most countries choose to apply ‘ready-to-use’ LCC tools, usually in a form of a spreadsheet (Excel being the most common format), that contain the main costs categories, explanation of the methodology used, reference data, sometimes – the visualisations of the results for an easier comparison of the tenders. Such tools are typically developed either by the body responsible for public procurement or by the environmental protection body, and made available to procurers free of charge.

'Ready-to-use' LCC tools are typically designed to assess the life-cycle costs of a specific purchasing category. This allows to best tailor parameters with relevant cost categories (e.g. need for insurance, particular maintenance, etc.), and simplify the LCC calculation for procurement practitioners. Nevertheless, so-called 'generic' LCC-tools exist, too. These tools can be applied to any purchasing category, and contain the main parameters for LCC calculations, e.g. acquisition price, energy-consumption, installation, maintenance and repair, and disposal costs. When applying these tools, procurers need to adapt the main parameters to the specific purchase at hand. Based on the sample of tools analysed, product-specific tools account for 89% of tools, while generic tools account for 11% of the total (Figure 3.2). This indicates an overall strong preference for product-specific tools.

In some instances, 'ready-to-use' LCC tools may bring a specific environmental focus to the analysis, as it is the case for the tool developed by the Austrian federal railway company ÖBB (see Box 3.1).

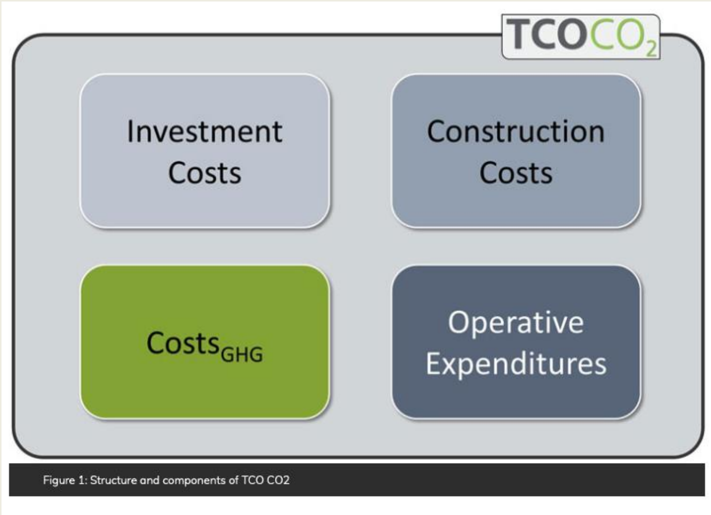
Figure 3.2. Generic vs. product-specific tools



Box 3.1. Austria: ÖBB TCO-LCC tool

The Austrian federal railway company, ÖBB, has recently developed an LCC tool: the TCO CO_2 calculator. ÖBB partnered with the Technical University of Graz to integrate externalities generated by CO2 emissions in its LCC calculation tool.

TCO CO2 calculator is Europe's first well-founded calculation model for the selection of the best bidder by Ecological, Sustainable TCO Evaluation. It is an extension of the Total Costs of Ownership (TCO) calculation already used by the company. It enables a product-specific calculation of the environmental impacts caused by the production, construction and use phase in the context of public procurement. These environmental impacts are monetised and integrated into the Total Costs of Ownership (TCO). This results in a direct inclusion in the tendering process. The aim of the TCO CO_2 project is to develop a model that calculates the offer-specific environmental impacts in production, construction and operation. The existing TCO methodology is thus extended to include the costs caused by environmental impacts ($Costs_{GHG}$).



Source: Austrian federal railway company, ÖBB

The TCO-CO2 calculator estimates the costs of GHG emissions, and requires the following data:

- Production: The bidder can either use data for energy consumption and GHG- emissions from an EPD or offer data on the energy consumption of production and the weight of the most relevant materials in the product (in terms of weight);
- Transport and construction: The bidder has to offer data on distances, means of transport and weight of the construction material as well as data on the transportation of construction workers;
- Use phase: The bidder has to offer data on energy consumption and maintenance.

The calculator adds the GHG-emissions from the different phases and multiplies them with a monetisation factor, which is currently 20 Euro/t CO2eq monetary value of the sum of GHG-emissions.

Source: (Landgraf and Schirmer, 2021[2])

Other countries opt for more sophisticated approaches, such as software-based solutions combined with underlying databases, and even supporting governance structures. These solutions typically focus on environmental impacts, as opposed to life-cycle costs. As an example, the Netherlands developed the so-called DuboCalc calculation tool that assesses environmental impacts of works in the civil engineering sector. Specifically, it produces an Environmental Cost Indicator (ECI) value based on project data, allowing contracting authorities to select the tender with the lowest environmental impact. The DuboCalc software builds on environmental impact data that is regularly included in the National Environmental Database (*Nationale Milieudatabase*[4]).

In Belgium, a similar approach was taken. In fact, a Life Cycle Impact Assessment (LCIA) enabled with the so-called Totem-building tool[5] is the closest to an LCC-approach used in procurement. This tool is developed, maintained and used by regional governments in Belgium, i.e. the Government of Flanders, Service Public de Wallonie and the Brussels Capital Region. The tool aggregates the environmental impacts of a building design during its entire life cycle. The tool calculates the impact of a building design per environmental indicator, such as climate change, eco-toxicity, depletion of abiotic resources, etc. It also calculates an aggregated score expressed in 'environmental millipoints per square meter Gross Floor area' of the building.

Beyond traditional LCC/LCA tools, other tools support green procurement more broadly, though strictly speaking they are not considered LCC tools, as they do not monetise environmental impacts. For instance, the CO2 Performance Ladder is a well-established tool in the Netherlands, whereby suppliers commit to reduce their CO2 emissions through an environmental management system. The CO2 Performance Ladder is often used in combination with DuboCalc by Dutch contracting authorities, such as the Department of Public Works of the Ministry of Infrastructure and the Environment (*Rijkswaterstaat*) (Box 3.2).

Box 3.2. Practices in the Netherlands: DuboCalc and the Co2 Performance Ladder

Use of DuboCalc by Rijkswaterstaat (LCA)

In the Netherlands, sustainable public procurement has been a longstanding policy goal, with the decision of the Dutch House of Commons to reach 100% sustainable public procurement by 2015. In response, the Department of Public Works of the Ministry of Infrastructure and the Environment (*Rijkswaterstaat*) introduced several approaches to make its procurements more sustainable, such as the calculation tool DuboCalc and the CO2 Performance Ladder.

To operationalise sustainable procurement, the software DuboCalc calculates the environmental impact of material use of infrastructure projects. The calculation is based on LCA of construction materials. It takes into account the embedded environmental impacts of materials during their lifecycle (e.g. material extraction, production, demolition and recycling). The energy consumed by the infrastructure is calculated, too.

DuboCalc calculates environmental impacts based on a system of shadow prices, which includes 17 different types of environmental impacts (e.g. CO2 emissions, land use, water use). The final result of the calculation is the Environmental Cost Indicator (ECI value). The tool is applied in works tenders that are typically based on the scheme 'Design-Build-Finance and Maintain'. Furthermore, tenders are based on functional requirements, thus giving suppliers the possibility to innovate and determine the most sustainable design. Namely, suppliers use the tool during the tender preparation and are able to test multiple designs to identify the most sustainable version, i.e. with the lowest ECI value.

DuboCalc tool is used in all major projects at *Rijkswaterstaat*, and has been progressively applied by large public entities in the Netherlands, too. Given the complexity of the tool, it is more difficult to apply by smaller entities such as municipalities. However, recently the so-called DuboCalc Light has been in used by smaller municipalities. It consists mainly of a list of materials that have a high negative environmental impacts, and are therefore excluded from the project. This simplified version of DuboCalc can be used for projects of EUR 10,000 or upwards.

An important foundation for the calculations is the underlying database, i.e. the National Environmental Database. This database includes the reference data for the environmental impacts of construction materials. It has a dedicated governance structure (National Environmental Database Foundation - NMD) that is tasked with maintaining and regularly updating the database.

CO2 Performance Ladder (GPP tool)

In the Netherlands, another important tool for including the sustainability dimension in public procurement is the CO2 Performance Ladder. The CO2 Performance Ladder is a certification system with which a tenderer can show the measures taken to limit CO2 emissions both within the company and in projects, as well as elsewhere in the supply chain. *Rijkswaterstaat* and other contracting authorities have used it in their procurements for more than a decade. Specifically, one in ten above threshold tenders in the Netherlands make use of the CO2 Performance Ladder.

Companies are certified by the CO2 Performance Ladder by an independent Certifying Institution on a scale of 1 to 5. When implementing a CO2 management system, certified companies are required to continuously measure and reduce the CO2 emissions of their operations. Level 4 and 5 certification also requires companies to take into account CO2 emissions throughout their supply chains.

The CO2 Performance Ladder can be used in the procurement process as an award criterion. That is, suppliers certified with the CO2 Performance Ladder receive a fictional discount on their tender price, giving them an advantage in the tendering process. The higher the level of certification, the greater advantage the supplier would receive. When applying for the tender, organisations do not need to be in possession of a CO2 Performance Ladder significant, but they make the commitment to obtain one at the indicated level within one year. Alternatively tenderers can choose to apply with an ambition level for the specific project. While it originated in the rail sector and is most widely used in the infrastructure sector, it can be implemented in any other sector, too. To date, over 1,200 certificates have been issued in the Netherlands and Belgium in the procurement context.

Research demonstrates that certified organisations reduce their CO2 emissions much faster compared to uncertified organisations. Furthermore, all investigated companies certified by the Ladder have implemented a fully-fledged energy management system, which highlights the reduction of CO2 as a key business strategy.

The CO2 Performance Ladder is managed by the independent Foundation for Climate Friendly Procurement and Business (SKAO) bringing together relevant stakeholders to promote the use of the instrument.

Source: (SKAO, n.d.[3]) (SKAO, n.d.[4]) (OECD, 2015[5])

In addition to LCC/LCA practices based on tools, there are also practices of applying the LCC approach without any type of individual tools used for the task. This is the case for instance in Italy, where the central purchasing body Consip developed its own approach to introducing LCC in certain tenders, such as ICT and vehicles. The detail of the practice is described below in Box 3.3.

Box 3.3. Consip’s integration of LCC in framework agreements

Italy’s central-level CPB Consip developed a simplified methodology to consider LCC in some of its framework agreements, such as ICT, vehicles, printing and public lighting. The methodology consists in taking into account energy consumption of the product category combined with green criteria. The methodology is adjusted on a case-by-case basis depending on the product group.

For instance, when procuring public lighting, Consip applied criteria, which allow for the reduction of cost during the duration of service. First, the Italian GPP criteria (criteria ambientali minimi - CAM) define the threshold consumption for lamps[6]. The efficiency of the lamps is also incentivised by the better lumen to watt (LM/W) result. Second qualitative criteria were applied. Namely, the design of the lighting systems has been awarded, which provides extra points for the decomposition of each component to facilitate repair or single component replacement instead of replacing the whole system. This approach favours the lengthening of the life cycle and a significant reduction in maintenance costs by applying strategic choice of ecodesign. In this approach, the quality of the tender is determined by technology that is easy to repair. In the health sector, the cost of service, maintenance and disposal was included for the purchase of radiation appliance and medical ultrasound machines.

Furthermore, a simplified, yet effective, LCC approach was chosen for the procurement of desktop computers and monitors. The award was based solely on the lowest cost, taking into account minimum environmental and social requirements, as well as energy consumption during the duration of the contract (3 years). Suppliers were requested to provide data on the energy performance based on specific ETEC (Calculated Typical Energy Consumption) parameters defined by IEC Standard (IEC 62301:2011). An independent entity certified the ETEC energy performance. The energy performance is multiplied by the reference price of electricity, as defined by the Authority for Energy Regulation and Environment. The full cost calculation formula is included in the tender documents to ensure transparency and clarity on the rules applied during the procedure.

Source: Consip

Each option has their strengths and shortcomings, as summarised in the Table 3.1.

Table 3.1. Overview of approaches to LCC/LCA

Approach to LCC	Strengths	Weaknesses	Countries
Application of LCC methodology without specific tools	• Consideration of acquisition cost and use cost (energy consumption) • Possibility to combine the LCC requirements with environmental [minimum] performance requirements • Data used for the LCC calculations is validated by a third party	• Does not provide ready-to-use solutions for the (average) procurement official • Requires significant investment in identifying and replicating good practices	Italy
“Ready to use” LCC tools	• Model that simplifies the calculation for the buyers. It is generally easily understandable by the (average) procurement official • Presented in a widely used Excel spreadsheet format • Do not require significant investment in technical solutions, hence fairly easy to maintain	• Tool application is limited in the cases of complex projects • Oftentimes the tools do not include the externalities	European Commission, Sweden, Germany, Denmark, Belgium, Austria, Germany, Norway, New Zealand, Australia, Poland, Lithuania, Latvia, US
LCC tool with specific environmental focus	• Combines the LCC data with environmental [CO2 emissions] data for the purchased goods, services or works • Data used for the LCC calculations is provided by	• Requires environmental data requires to be publicly available • Does not provide ready-to-use solutions for specific purchases in the beginning; these have to be added over time	ÖBB (Austria)

	verified third parties (e.g. environmental agencies) • Tool is widely flexible for future demands like evaluation environmental impact of water usage, particle emissions, NOx emissions, etc • Tool requires no investment other than the training of own personnel • Tool can easily be adapted for any kind of purchase		
Tools with an environmental focus (e.g. Dubocalc, Totem)	• Strong uptake of the tools due to inclusive approach to their development and maintenance • Mostly used in sectors that have a high impact on the environment (e.g. construction of buildings, roads)	• Higher level of sophistication in terms of technical implementation of the tools in comparison to the ready-to-use spreadsheets (e.g. software-based tools, creation of relevant databases) • Higher costs for the set up and maintenance of the tools (e.g. regular updates are required in order to maintain their relevance, inter-sectoral cooperation is required in order to create relevant databases, governance structures might be needed to ensure the tool's relevance)	Netherlands, Belgium

3.1.3. Economic methodology for LCC calculations

Despite the different approaches and practical implementations of LCC tools, the economic methodology at the core of LCC calculations, namely Present value (PV) calculation, is consistent in the LCC tools analysed in detail in the following sections. The dynamic approach of future costs is a fundamental concept in all areas of economic calculations, not just in LCC. By methodological definition, **life-cycle cost is the present value of all the costs throughout the whole life-cycle**. It can be calculated with the general formula for present value calculation:

$$LCC = PV = \sum_{n} \frac{C_n}{(1+i)^n}$$

Where:

- LCC = life-cycle cost
- PV = present value of the series of costs throughout n years
- C_n = value of costs in year n
- i = discount rate
- n = number of years analysed

All of the LCC tools analysed in the following section utilize Microsoft Excel, they apply a variety of mathematically equivalent, correct formulas provided by the software for present value calculation.

Most of the analysed LCC tools consider future prices in real terms, meaning on the fixed price level of a given year, to which the "present value" applies. Though nominal approach to future costs can be valid if applied correctly (i.e. with a nominal discount rate), **in LCC calculations the real approach is preferred** over nominal approach in order to avoid distortions and decrease uncertainty of future costs due to inflation. Certainly real price changes (which exceed general inflation) are considered in calculations applying real approach, in practice, most commonly real price increase of energy and personal costs are considered. In addition, the proper application of real approach to future costs requires a real discount rate (excluding inflation).

Determination of the appropriate level of the discount rate is a complex economic exercise, which is usually out of the scope of a single LCC calculation. Accordingly, the **LCC tools typically include the discount rate** or an official reference to its suggested value. However, a few tools (e.g. SE, BG) offer more flexibility in this regard, and allow the buyer to determine its own discount rate. This practice also can be methodologically correct, but it assumes a high level of economic background knowledge and sufficient capacities of the buyer. The application of a zero discount rate also can be justifiable in practical applications as a few of the tools allow this option, especially in case of products with shorter life span. This is simply due to the mathematics of present value calculation; on a short time period, it simply has no significant effect on the outcomes. As the formula above suggests, the smaller the discount rate and the shorter the time period considered, the less significance discounting has. In a generalised sense, discounting prefers the present over the future, which time preference is expressed by the discount rate. The impact of the discount rate on the outcomes can be explored in a sensitivity analysis, as included by the Austrian tool for computers, however in most cases this is not necessary due to the official recommendations for the value of the discount rate.

Best approaches to the methodological issues above are fundamentally dependent on the characteristics of the specific purchasing category and on the purchasing situation. Certainly, LCC calculations are also embedded in the relevant legal environment of public procurements, so methodological choices on handling inflation or on the level of discount rate should comply with these. Furthermore, special regulations applying for the buyer as a public organisation or specific requirements of public funding schemes can also influence these methodological choices in practical LCC tools.

3.1.4. Purchasing categories relevant for LCC

In addition to diverging approaches on the types of tools used for LCC assessment, not all purchasing categories are equally relevant for the consideration of LCC, and related tool development. In fact, a total of 29 different product groups have been identified, for which spread-sheet based LCC tools exist (Figure 3.3). These product groups cover several purchasing areas, ranging from ICT goods, consumer goods, building and construction as well as health-related goods.

Despite the breadth of available tools, several trends emerge regarding recurring purchasing categories, across the countries analysed. In fact, similar considerations are often shared by countries when selecting purchasing categories for the development of LCC tools. This includes purchasing categories that require high levels of energy consumption during the use time, goods/services that are quite easy to standardise and that are purchased frequently.

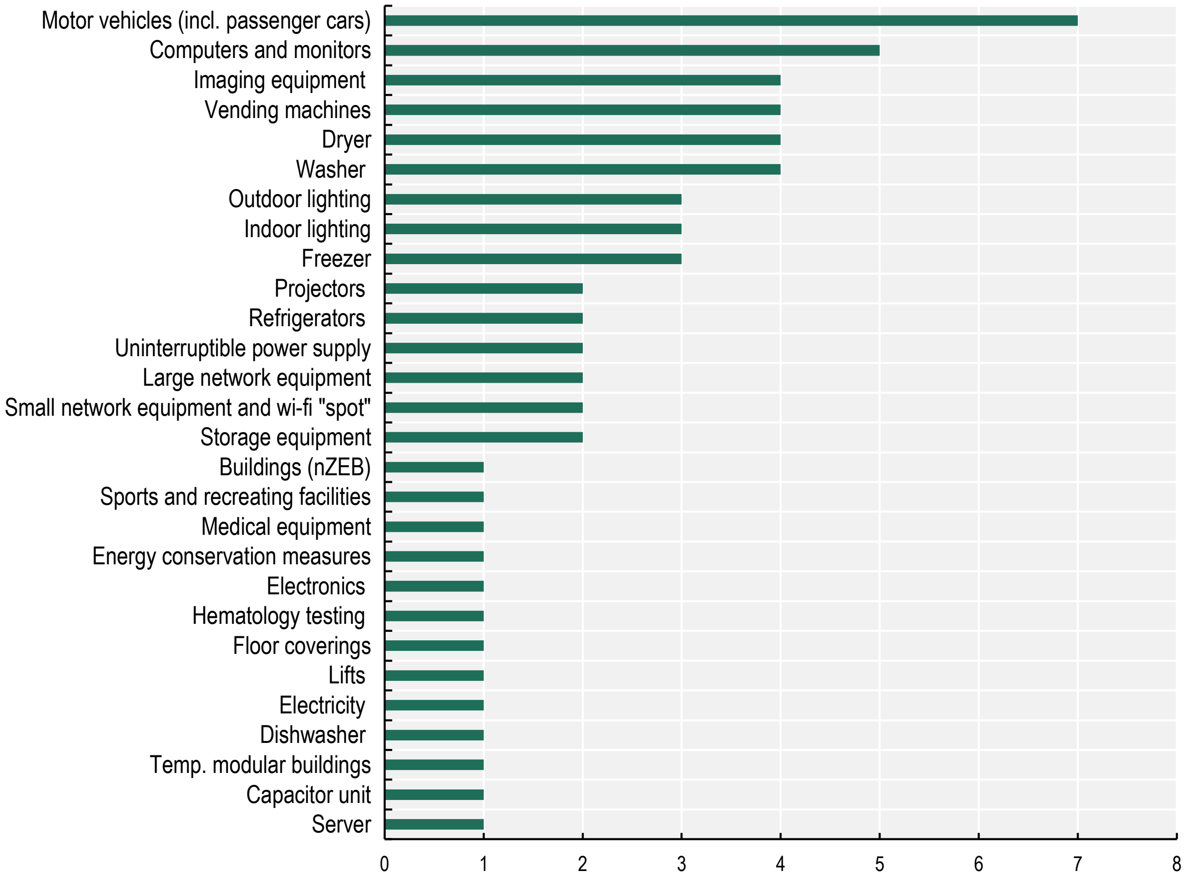
For instance, in Germany the focus for the choice of purchasing categories has been energy efficiency, as this reflected policy priorities at the time. As a starting point for LCC tool development, the German Federal Environment Agency (*Umweltbundesamt*) selected 10 products with the highest energy consumption during the use phase. A further selection was based on the frequency of purchase of these goods, as well as the purchasing volume. The final choice for LCC tool development includes computers, multi-functional machines, monitors, data centres, floor coverings, fridges, and dishwashers.

The European Commission focused its own LCC tool development on purchasing categories, for which green criteria already existed. The selection therefore includes vending machines, imaging equipment, computers and monitors, indoor lighting and outdoor lighting. The government of Flanders based its decision to develop an LCC-tool for indoor lighting on the fact that available tools did not take into account LED technologies. Finally, Denmark approaches the selection of LCC purchasing categories by consulting first with the central purchasing body SKI (*Statens og Kommunernes Indkøbsservice A/S*). This allows getting a first assessment about the level of demand for purchasing categories, and as well as getting technical product information necessary for later tool development.

Overall, the most frequent purchasing categories consist of the following:

- Office and ICT equipment;
- Outdoor lighting;
- Indoor lighting;
- Electric appliances;
- Computers and monitors;
- Imaging equipment;
- Vehicles.

Figure 3.3. Purchasing categories for LCC tools based on tool mapping



3.1.5. Mapping the climate dimension of LCC tools

The introduction of the Directive 2014/24/EU paved the way for the consideration of external environmental costs in procurement awards. As such, LCC calculations may be used as an instrument to monetise climate impacts, and thus promote goods and services with lower CO2 emissions. A series of requirements needs to apply for the calculation to comply with the EU Directives. Specifically:

- The calculation must be based on objectively verifiable and non-discriminatory criteria;
- The cost model must be accessible and free of charge for the bidder;
- Bidders must be able to provide the required data with reasonable effort (e.g. manufacturing data, data available to the bidders or subcontractors themselves);
- External data on which the bidder does not have any influence may also be used if it meets the above-listed criteria.

While several LCC tools take into account externalities related to CO2 emissions, the majority of tools focus on Total-Cost-of-Ownership, as opposed to full LCC (including externalities). As such, CO2 emissions are either not factored in the LCC tool, or they are not monetised. However, it should be noted that the TCO-CO2 developed by the ÖBB presents an exception in this regard (it does both). As reported by stakeholders, the greatest barrier to including CO2 emissions in the calculation is the lack of a consensus on an accurate CO2 price. However, once again, there is no unified approach, and countries have each taken several different approaches on whether to use LCC tools as an instrument for taking into account the climate dimension. For instance, in Italy, Consip opted for not considering CO2 emissions (except for vehicles, in which case the EU price was used) in their LCC calculations given the broad range of different estimates available, and the lack of a nationally accepted CO2 price.

In contrast, some countries have defined a price for CO2 emissions, and are making use of it in their LCC tools. This is the case for tools developed in Denmark, in Flanders (Belgium) and by the European Commission. In the Netherlands, a commonly agreed-on price for CO2 emissions applies in DuboCalc's calculation. The CO2 prices are, however, commonly considered low, or too low to actually have an impact in the calculation.

Taking into account the difficulties in determining a price for CO2, the National Agency for Public Procurement in Sweden opted for only including the quantification of CO2 emission in kg in its LCC tools, without assigning a specific price. An overly low CO2 emission price is considered potentially counterproductive, while transparency about the quantity of emission related to a procurement may be informative for buyers. Climate goals are achieved through other policy instruments, such as GPP criteria. In Austria, similar considerations applied in developing overall GPP policy (*naBe Aktionsplan*). Namely, Austrian policymakers considered that the maturity of methodologies for monetising CO2 is not advanced enough to be used on a broad scale. As such, TCO calculations are recommended for several product groups (with dedicated tools).

Conversely, Germany has introduced a new regulation ("AVV Klima") to reduce the climate impact of public procurement. Among other aspects of the regulation, federal buyers are mandated to consider a CO2-shadow price that takes into account the emissions embedded in the various lifecycle of the product learnt (e.g. production, transportation etc.). The Federal Environment Agency (*Umweltbundesamt*) is tasked with developing new LCC tools that address such embedded emissions.

The challenges of applying LCC including externalities have important repercussion in the calculations and ultimately the choice of climate-friendly procurements. In fact, the preparatory study to support the revision of the Clean Vehicles Directive highlighted that the proposed LCC calculation of Directive 2009/33/EC ('old' Clean Vehicles Directive) with the externalities did not achieve the expected result to drive cleaner vehicles in the market[7]. Hence, the approach taken in the new Clean Vehicles Directive was revised, and no longer mandates an LCC calculation. A similar experience was shared by the city of Niort in France. It used the LCC approach and cost factors for pollution when purchasing vehicles, but cleaner ones did not have a lower overall LCC, showing that the approach of including the externalities did not help to buy a cleaner vehicle.

3.1.6. Lessons learnt from the tool development process

The tool development process is important to ensure that the final product is aligned with the needs and expectations of users. As such, potential users should be involved from the beginning, and be given many opportunities to review and test the tools before their launch. Suppliers or industry representatives also need to be given opportunities to express their views during the development process, as their input is required during the use phase of the tool.

Broadly, the tool development process follows a similar pattern throughout the countries analysed. Typically, once the decision about which specific tools has been taken, a dedicated team (either internal or outsourced) develops a first version of the tool taking into account the relevant parameters. This is draft version of the tool is shared with a wider group of stakeholders for review and testing. An updated version is finalised and made available for use. The review process generally also includes industry stakeholders. Tools that are 'non-traditional' may have a more complex set-up process, as they may require the definition of a governance structure to maintain and operate the tools (e.g. DuboCalc and the CO2 Performance Ladder). In specific instances, such as the CO2 Performance Ladder that is managed by an independent foundation, the processes of setting up such structures is supported by civil society organisations, thereby facilitating the task for government.

Several common trends and good practices emerge from discussing the tool development process with stakeholders. Some countries and institutions have formed a permanent or semi-permanent stakeholder group that informs the policy process around sustainability in public procurement, including on LCC topics. These group help in guiding the overall sustainable procurement approach, and generating buy-in for policies related to GPP and LCC. In Austria, for instance, stakeholder management is considered an important aspect of GPP policy. Namely, since 2018 a stakeholder management process was initiated as part of the revision of Austria's GPP Action Plan (*naBe Aktionsplan*). This included the relevant federal ministries, the central purchasing body, experts, and representatives of *Länder*, among others. The goal was to generate wide buy-in of the goals of GPP policy across the country (Bundesministerium für Klimaschutz Umwelt Energie Mobilität Innovation und Technologie, 2021[11]). The European Commission also consults regularly the stakeholders on GPP with a dedicated Advisory Group, which represents all member states.

While forms of stakeholder representation are often focused on GPP policy at large, they can also be leveraged for discussing the implementation of LCC and specific LCC tools. In some instances, stakeholders have expressed specific needs, such as the creation of a dedicated LCC tool for indoor lighting in Flanders that would take into account the complexity of their projects. Similarly, the EC's Advisory Group on GPP has provided feedback on LCC tools and expressed demand for the development of tools in this area.

Testing of tools is another key step of the tool development process. In Flanders, a small working group of fifteen experienced users, which included public buyers and suppliers, was gathered to test the tool. This allowed ensuring the robustness of the tool. Importantly, engaging the right stakeholders requires their identification and targeted reach out early on in the process. In Denmark, a similar approach is taken to test LCC tools. Namely, a group composed of buyers and suppliers are tasked with reviewing the first approach of the tool, to ensure that there is a broad agreement on the parameters used and the tools offer a fair comparison between products. An iterative approach is taken to reach a satisfactory result for the stakeholders involved. LCC tools developed by the European Commission underwent similar testing. Namely, an external group was set up to test the first tool (for the structure, explanations, etc.), and the feedback was used to develop the additional tools. Internal testing was conducted, too.

Regarding the working methods of tool development, it is important to consider an agile approach, i.e. proceeding in iterations, and allowing for stakeholder feedback throughout the process. This is the approach taken in Norway by the DFØ (Norwegian Government Agency for Financial Management). However, DFØ also warns of 'engagement fatigue' if stakeholders are solicited too often. Another consideration applied in Norway is the engagement of users that are generally unfamiliar with the topic to ensure that the tools are understandable for a broad population.

An important consideration to make is the choice of interface and technical support on which LCC tools run. Spreadsheet-based tools based on Excel is the most commonly used format and presents several advantages, as reported by stakeholders. Namely, the Excel software is well known and commonly used by virtually any type of users, thus limiting the requirements for training on the software itself. Furthermore, Excel allows for transparency and potential adaptation of the calculation. This is an important factor to increase trust in the tool, as well as providing flexibility to users. While Excel is the format of choice of most LCC tool developers, it may not be the most suitable instrument in case the complexity of the calculation is very high (e.g. types calculations performed by DuboCalc).

Finally, stakeholders stressed that a consistent visual identity of LCC tools matters for recognition and ease of use.

3.2. Comparative analysis of selected spreadsheet-based LCC tools

The second part of the mapping of existing LCC tools consisted in a deep-dive comparative analysis on a selected number of product-specific LCC tools. The aim of this assessment is to extract essential user-friendly features of common LCC tools to support the development process of LCC tools in Hungary. As such, the analysis focused on two key elements:

1. first, elements pertinent to the LCC calculation as such (e.g. basic parameters, cost categories identified, reference data within the tools);
2. second, consideration of other features related to the "look and feel" of the tools (e.g. availability of guidance, user-friendliness, visualisation features).

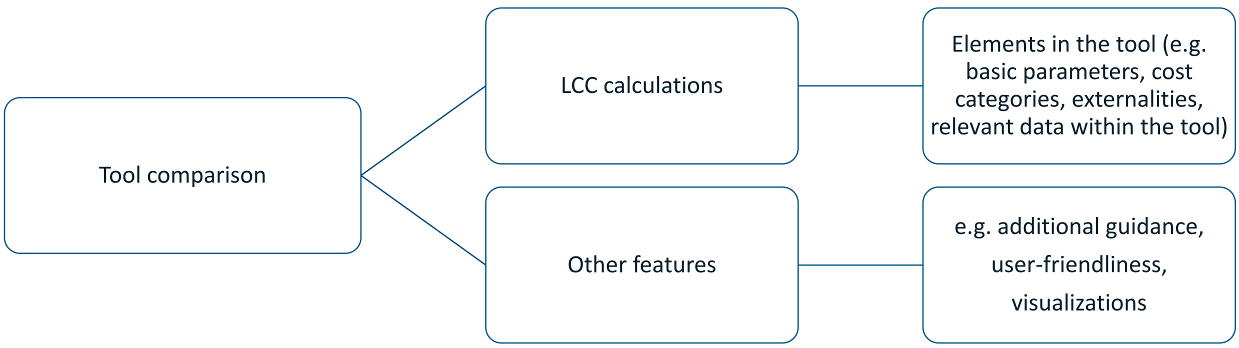
To extract comparable results, the analysis focused on a selected number of common purchasing categories, i.e. computers and monitors, indoor lighting, outdoor lighting, imaging equipment, vending machines and vehicles. This allowed to compare several tools for each of these categories, and analysing a variety of spreadsheet-based tools.

Table 3.2. Tools analysed

	European Commission	Denmark	Germany	Austria	Flanders	Sweden
Computers and monitors	√	√		√		
Indoor lighting	√				√	√
Outdoor lighting	√					√
Imaging equipment	√	√	√			
Vending machines	√	√				√
Vehicles	√	√				√

Note: Austria's tool for the TCO-calculation for computers and monitors was available on the old website of the naBe Aktionsplan (until the beginning of 2021). Since June 2021, there is a new website (www.nabe.gv.at) where tools are offered for those product groups where the naBe-Aktionsplan recommends the TCO-calculation. TCO-tools are made available from the SPP Smart project (https://www.smart-spp.eu/index.php?id=6988). The European Commission tool for vehicles is the Clean Fleets LCC Tool, https://clean-fleets.eu/home/

Figure 3.4. Elements of the analysis



3.2.1. Findings

Overall, findings suggest that there is a lack of homogeneity among tools, despite the fact that tools related to the same purchasing categories were compared. Namely, cost parameters that are taken into account may vary across different tool. The calculation of consumption patterns may also vary. For instance, maintenance for imaging equipment tools is calculated on the basis of estimated cost of spare parts in one tool, while it is estimated as the time and hourly wage for maintenance in a different tool.

Finding the balance between simplicity and accuracy

As an overarching observation, it is possible to distinguish amongst tools based on the level of sophistication. Some tools have a very simple interface and include only basic parameters for calculation, while other tools can be considered more elaborate. For instance, elaborate tools may include calculation parameters related to externalities (e.g. CO2 emissions) or allow for a more granular definition of operational costs, which may take into account customised consumption patterns. The possibility to customise consumption patterns could consist for instance in defining how long a computer is used in several types of modes (on, off, sleep) instead of using standardised assumptions.

Some of the tools analysed also provide users with reference data for some of the calculation parameters, such as e.g. a recommended discount rate. Not all tools include such reference data, and the type of available reference data also differs from tool to tool, as further detailed below. A number of tools also account for the evolution of parameters, such as the increase of electricity prices or similar. Typically, the user is able to select the estimated increase in percentage. In some cases, this is part of reference data.

In some instances, elaborate tools allow to choose the contract type (choice of acquisition of a product or a service) or further distinguish between the product categories within one tool. As an example, in the category of computers, some tools allow a more specific product choice, such as laptop or desktop. Modalities for visualisation of results can be more extensive in some tools compared to others.

The Figure 3.5 below provides an overview of features that are considered more sophisticated.

Figure 3.5. Increasing sophistication and complexity of LCC

Comparison of LCC tools based on elaborate features

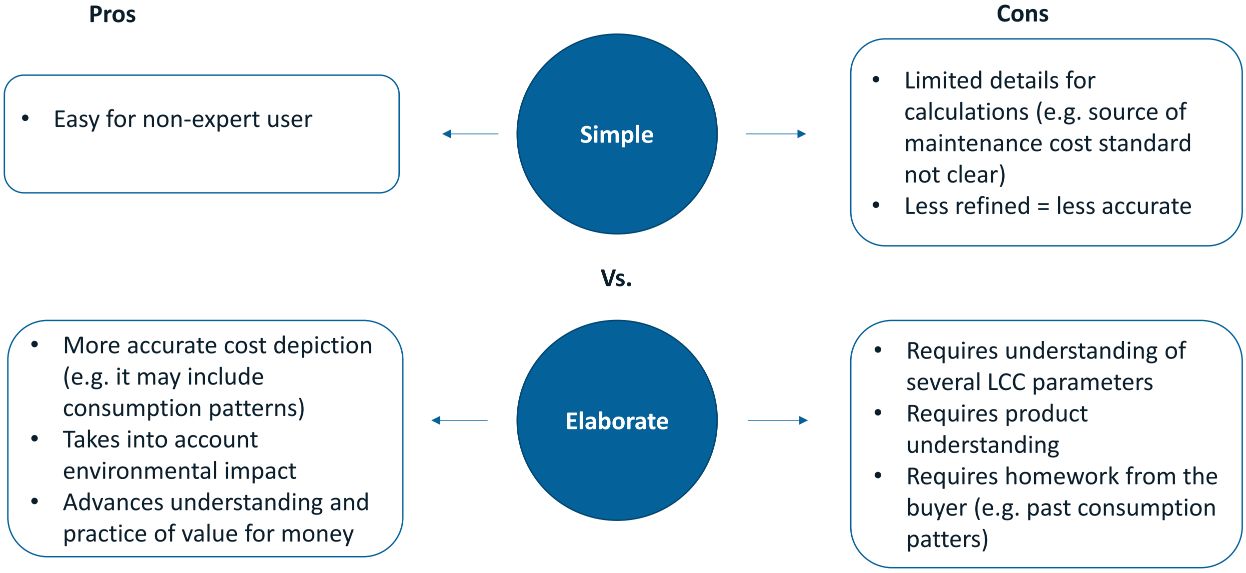
	DE LCC tools	AT LCC tools	SE LCC tools	BE LCC tools	European Commission LCC tools	DK LCC tools
Externalities	-	-	✓	✓	✓	✓
Reference data	-	-	✓	✓	✓	✓
Product / Contract choice	-	-	-	✓	✓	✓
Evolution of parameters	-	-	✓	✓	✓	✓
Customised consumption patterns	-	✓	-	✓	✓	✓
Multiple visualisations	-	✓	-	-	-	✓

Sophisticated features

Increasingly elaborate tools

While elaborate tools are considered more accurate in depicting LCC tools, there are advantages in keeping tools as simple as possible, notably to allow for use by non-expert users. In discussions with stakeholders, it generally emerges that LCC tools are sufficiently easy to be understood by procurement practitioners, albeit with some training requirements. However, the ease of use is often not the only obstacle to applying an LCC calculation tool. The barriers to LCC use are further discussed in the section on 'Key takeaways'.

Figure 3.6. Pros and cons of simple vs. elaborate tools



Externalities

The inclusion of externalities remains one of the most challenging elements in developing LCC tools. Whenever tools take into account externalities, these are for the most part indirect emissions generated by the electricity consumption of a certain product or service. Even when such costs are included, discussions with stakeholders underscored the difficulty in pricing relevant aspects. For instance, depending on studies, the monetisation of CO2 emission equivalents may range from EUR 20-30 to EUR 650.

Beyond indirect CO2 emissions related to electricity, only very few tools take into account other types of externalities such as embedded emissions or direct emissions from product use. Currently, such types of emissions are taken into account for the LCC tool dedicated to indoor lighting developed in Flanders. The table below summarises what types of externalities are taken into account in the tools analysed.

Table 3.3. Externalities considered in LCC tools

Product group	Externalities considered
Computers and monitors	Indirect CO2 emissions (electricity)
Indoor lighting	Embedded emissions from production stage, construction process, end-of-life stage Indirect CO2 emissions (electricity)
Outdoor lighting	Indirect CO2 emissions (electricity)
Imaging equipment	Indirect CO2 emissions (electricity)
Vending machines	Indirect CO2 emissions (electricity)
Vehicles	Direct emissions CO2 (fuel consumption) Direct pollutant emissions (NO_x, Particular Matter, NMHC)

Consumption patterns (operational costs)

Tools also differentiate themselves regarding how the contracting authority's consumption of resources is taken into account during the use phase of the product, i.e. the estimate of operational costs. The resources taken into account in the consumption patterns vary depending on the product group. While energy consumption is relevant for all product groups, other specific resources apply depending on the product categories, such as water consumptions in the case of vending machines, or toner for imaging equipment.

Estimating consumption typically requires the contracting authority to specify its needs, though the input required to define the needs (i.e. operational costs) may vary from tool to tool. For instance, in one of the LCC calculators for imaging equipment, the contracting authority is requested to specify the number of pages to be printed in black and in colour. In a similar tool for a printing machine, the calculation of operational costs is based on the average number of hours in 'ready', 'sleep' or 'off' mode and corresponding energy consumption per mode.

Similarly, to calculate the energy consumption of PCs and monitors, contracting authorities may be required to detail the number of hours in each power consumption mode (e.g. on, off, sleep). Alternatively, labels or standards provide pre-defined data for such consumption patterns. For computers, for instance, the Energy Star defines standard times in different power modes.

Table 3.4. Definition of consumption (operational costs)

	Tool 1	Tool 2	Tool 3
Computers and monitors	Energy consumption in: - 4 modes for computers (off, sleep, long-idle, short-idle) - 2 modes for monitors (on, off)	Power consumption in 3 modes (on, off, standby)	Power consumption in 3 modes (on, off, standby)
Indoor lighting	Energy consumption Area to be illuminated (sq/m) Operating hours (in different modes)	Operating hours (all attributed to calculation conditions) Area to be illuminated (sq/m)(attributed in basic description in the original tool) Power per lum (attributed to info from tenderer) Type of control Reduction (of operating time) factor	Building information (floor, room name, surface, number of lighting points, occupancy, function) Control system (Daylight entry detection, size area, presence detection, uniformity, maintenance factor, unified glare rating, level working surface, level lighting unit, reduction factor) Energy use: - Daily use (operating hours) - Number of days per year in use - Annual use (operating hours)
Outdoor lighting	Energy consumption: Area to be illuminated Operating hours (in different modes) Energy consumption in 2 modes (full/reduced power)	Operating time (h/year) Operating time in 2 modes (full effect, reduced (2 levels)) Power per lum Reduced power level (2 levels)	N/A
Imaging equipment	Estimated number of prints Estimated cost of toner	Consumption of units Length of service contract period (if applicable) Length of leasing period (if applicable)	Average number of hours in 'ready' mode Average number of hours in 'sleep' mode Average number of hours in 'off' mode Power consumption in operational state Power consumption in sleep state Power consumption in off state
Vending machines	Water price Water annual price increase Estimated use of products (that are sold, also cups) Estimated litres of drinks	Machine capacity (litres) Length of service contract period (if applicable) Length of leasing period (if applicable)	Annual use Annual energy price change (optional)

Vehicles	Annual fuel consumption (depending on fuel type, fuel price, possibility for dual fuel)	Annual mileage per motor vehicle For electric vehicles: Charging subscription	Annual mileage per vehicle

Reference data

The calculations of LCC may be simplified by the availability of so-called reference data. In most cases, reference data is suggested to procurers to simplify the task of applying LCC tools. Other reference data can be embedded in the calculations of the tool. The buyer is given the option to select the reference data available or pick a different parameter.

Table 3.5. Types of reference data available

	Tool 1 (EC)	Tool 2 (DK)	Tool 3 (SE)	Tool 4 (BE)
Computers and monitors	• Currency • LCC evaluation period (suggested) • Discount rate (suggested) • Electricity grid mix CO2eq emissions for EU countries • Cost of CO2 (suggested) • Time use profile in operation modes as defined by the Energy Star	• Evaluation period • Discount rate • Standard electricity price • Standard increase in electricity prices • Standard CO2 emission factor for electricity consumption	N/A	N/A
Indoor lighting	• Currency • Electricity grid mix CO2eq emissions for EU countries • Discount rate (suggested) • LCC evaluation period (suggested)	N/A	• Discount rate • Reference data for calculating the climate impact from electricity use - Swedish electricity mix - Nordic electricity mix - Electricity of unknown origin • EU (25) electricity	• LCC evaluation period (suggested) • Discount rate (suggested) • Table materials: - Rated wattage of lighting system - Rated lumen of lighting system - Useful lifetime - Useful lifetimeLx - Useful lifetimeBy - Driver type - Separate replacement of driver possible - Driver failure rate - Embedded emissions from production Stage (A1-A3) - Embedded emissions from construction process stage (A4-A5) - Embedded emissions from end-of-life stage (C1-C4) - User
Outdoor lighting	• Currency • Electricity grid mix CO2eq emissions	N/A	• Discount rate • Reference data for calculating the	N/A

	• CO2 externality cost • Provided AECI of the installation • Discount rate (suggested) • LCC evaluation period (suggested)		climate impact from electricity use - Swedish electricity mix - Nordic electricity mix - Electricity of unknown origin - EU (25) electricity	
Imaging equipment	• Currency • Electricity grid mix CO2-eq emissions • CO2 externality cost	• Evaluation period • Standard electricity price • Standard electricity price increase • Discount rate • Standard CO2 emissions factor • Standard cost of CO2 externality	N/A	N/A
Vending machines	• Currency • Electricity grid mix CO2-eq emissions • CO2 externality cost	• Standard CO2 emission factor for electricity consumption • CO2 externality cost • Evaluation period (suggested) • Standard electricity price • Standard increase in electricity prices (annually, in addition to inflation) • Discount rate	• Discount rate • Reference data for calculating the climate impact from electricity use - Swedish electricity mix - Nordic electricity mix - Electricity of unknown origin - EU (25) electricity	N/A
Vehicles	• Cost of emissions (NOx, PM, NMHC, CO2) • Fuel price increase (Default OECD FAO values)	• Evaluation period (suggested) • Discount rate (suggested) • Standard price increase rate for fuel • Standard price for fuel (Tax Council Rate) For hybrid plug-in: • Evaluation period (same as the service agreement period, cf. the requirements specification) • Electricity price • Electricity price increase (annually, in addition to inflation) • Discount rate • Life expectancy for charging stations (possibly charging boxes)	No reference data available	N/A

User-friendly features

The user-friendliness of tools is an essential aspect for their uptake and practical use. As discussed earlier in this chapter, user-friendliness often consists in finding a balance between a simple approach to the calculations, while maintaining sufficient accuracy. Beyond these elements, the structured comparison of LCC tools and conversations with stakeholders allowed identifying several features that contribute to user-friendliness of tools:

- **Clear distinction on the input to be provided by the buyer and the supplier**: If LCC tools are meant to be used in a procurement procedure, it should be very clear to the contracting authority, which data and input it needs to request from suppliers, and which input it has to provide itself. Some tools, such as LCC tools in Sweden, have been revised to take into account this aspect.
- **Transparency in the calculation**: It is essential that procurers trust the LCC calculation. This implies introducing transparency about the formulas used, and providing explanations about the methodology in the tool, including a definition of all parameters used.
- **Guidance on using the tool embedded in the tool itself**: A number of tools (e.g. Denmark, European Commission) have embedded guidance to simplify the use of LCC tools. This can take the form of comments that appear when hovering over a cell. Such feature is very practical, as it gives an immediate explanation of the parameter at hand. Reference data may also be embedded in this manner.
- **Availability of reference data:** As discussed in this chapter, reference data is a key element to simplify the use of LCC tools for public buyers, as it diminishes the work for contracting authorities.
- **Visualisation of results**: The visual representation of results provides a simple and effective modality of transmitting key information.
- **Appropriate support tools**: Spreadsheet-tools such as Excel provide several advantages as the format for LCC tools, such as transparency and adaptability. In case calculations are too heavy for an Excel-file, however, other software formats should be adopted to avoid overly slow processing times.
- **Basic explanations of investment calculations**: It is important to provide key explanation of the concepts that lie behind LCC calculations and related methodologies (e.g. LCA). A simple webpage with such explanations on economical calculation has proven to be very popular with users in Sweden.
- **Means of proof of input data**: When applicable, appropriate measurement methods of input data should be defined to prevent the risk of litigation and determine an unequivocal evaluation of the best offer.

3.3. Key takeaways

This section draws on the analysis of LCC tools, fact-finding discussions with stakeholders as well as the survey of Hungarian contracting authorities to draw conclusions about the current use of LCC, challenges and recommendations for a way forward to improve the uptake of this practice.

3.3.1. LCC adoption remains low across many countries, even when there is commitment to GPP

Overall, based on the evidence gathered, broad LCC uptake during the procurement process appears to be limited, in particular for goods and services. Importantly, the adoption of LCC remains low even when there is an overall policy commitment to GPP and sustainability at country level. In fact, most countries in the EU have adopted a national strategy or action plan to advance GPP practices and take several actions to move forward on this agenda.

Nordic countries traditionally have placed GPP high on their agendas, and made substantive commitments to the introduction of LCC in public procurement. In Denmark for instance, LCC (or TCO) is an explicit part of the GPP agenda. Namely, the Danish strategy *Green Procurement for a Green Future* launched in 2020 foresees the mandatory use of existing calculation tools for several purchasing categories, as well as the creation of a digital version of the currently available spreadsheet-based LCC tools (Finansministeriet, 2020[12]). Sweden has had longstanding work in the LCC area as well, with first LCC tools created in the 1990s and becoming an integral part of the current sustainability-oriented public procurement practices. Originally concerned with energy efficiency, after the adoption of the new public procurement directives in 2014, LCC tools have become a relevant means to promote the use of other criteria than price and cater to the goal of efficient and environmentally responsible public procurement (Government Offices of Sweden and Ministry of Finance, n.d.[13]).

Other countries have placed the focus explicitly on the application of TCO instead of LCC, given that the maturity of methodologies to monetise environmental impacts is not considered sufficient for broad adoption. This is the case in Austria, where the new strategy for GPP, the so-called *naBe-Aktionsplan*, places emphasis on applying TCO when procuring selected purchasing categories (i.e. lighting, electrical appliances, IT equipment, and vehicles) (Bundesministerium für Klimaschutz Umwelt Energie Mobilität Innovation und Technologie, 2021[11]).

Germany is another example where policy ambitions are high with regards to implementing LCC. Namely, since January 2021, federal contracting authorities must take into account monetised costs of GHG emissions over the lifecycle of a product (see Box 3.5). The German Federal Environment Agency is tasked with developing LCC tools that will support this exercise. Furthermore, in principle the German procurement law requires the use of LCC. In practices, however, most contracting authorities find exemptions to this rule.

Despite public procurement being susceptible to the use of the LCC, many policy initiatives and ambitions targeted at GPP or LCC (including the European Commission efforts to support the uptake of the practice), stakeholders overall consider that the use of LCC is relatively low, with the exception of the construction industry, where a higher level of advancement with LCC appears more common.

3.3.2. Limited availability of tools for specific product groups

The tool mapping exercise has demonstrated that the purchasing categories for which the LCC tools are available tend to recur, such as computers and monitors, imaging equipment, vending machines, kitchen equipment, vehicles. This might be explained by a relative ease in creating tools for standardised products which are also widely used, making it simpler to introduce a calculation that would be well understood by procurement officials and therefore easier to incorporate in procurement practices.

In some cases, availability of specific categories of LCC tools also depends on the background of the organisation that was appointed with the task to develop them. For example, in Germany LCC tools have been developed by the German Federal Environment Agency, meaning that the primary criterion for identifying relevant purchasing categories was based on the purchases that have an impact on energy efficiency. Considerations regarding procurement volume and frequency were secondary. Specific considerations apply whenever LCC tools have developed by agencies responsible for GPP. Such actors, too, typically focus on purchasing categories that consume energy, as taking these parameters into account is considered to lead to greener choices. However, this is not always the case in practice. As reported by practitioners, LCC use leads to environmental choices when purchasing categories have a long lifespan (e.g. indoor and outdoor lighting), while it is less effective for 'green' purposes for short-lived products, such as IT goods.

At the same time, it means a vast spectrum of products remains non-covered, so even if there is inclination from the procurement practitioners to expand the application of the LCC in their daily work, they simply have no tools to make it happen. Each purchase also requires a tailored approach, meaning the procurement officials choosing a product for which LCC tool is not available, would have to create a tool on their own or apply the LCC methodology. That consequently implies the need for specialised knowledge and the investment of time and human resources.

3.3.3. Development of LCC tools is a labour-intensive process

The creation of any LCC tool is also highly labour intensive. Even a relatively simple product requires extensive research on which specificities are the most relevant for the LCC calculations, the ability to select an appropriate and reliable methodology, and finding reliable sources for the reference data to be used in the tool. All the interviewed authorities confirmed the relevance of these elements.

Since all the relevant competencies are rarely found within one organisation, creation of LCC tools also requires to involve and manage a wide net of stakeholders (such as other public bodies, private sector (e.g. individual companies or associations of companies working in the relevant field), research bodies (e.g. universities), capable and willing to provide their knowledge and expertise in the process.

For example, the Danish Environment Protection Agency is working in cooperation with one of their central purchasing bodies – Statens og Kommunernes Indkøbsservice (SKI) – in order to define the needs of the public buyers and ascertain whether the chosen purchasing categories for which the tools are created, correspond to these needs. They also regularly engage not just with the company that is responsible for the physical development of the tools, but also with other stakeholders such as other public bodies, research bodies and infrastructure companies, and retain a pool of economic operators and public buyers and their associations willing to provide their input during the development process. What is more, the work is continuous since the relevant developments in other areas, for example, standards, requires modification of already existing tools that contain related elements.

The German Federal Environment Agency takes a similar approach, considering the volume of purchasing and public buyers’ needs, collaborating with the experts from different fields, utilising reviewed papers and conducting their own research on the relevant aspects and drawing lessons from their previous experiences in developing the tools and methodologies.

3.3.4. Difficulty in ensuring the methodological soundness of the tools

The final result of the LCC development process requires scrutiny of the potentially affected entities (i.e. contracting authorities, suppliers, academia) to ensure methodological soundness. The interviews have indicated that agreeing on specific aspects of the LCC calculations, such as, for example, monetisation of the CO2 emissions, can be a complicated process due to the need to ensure a wide acceptance of the relevant stakeholders and consider potential sensitivities.

Failure to address methodological soundness and acceptance of the tool may not only result in lack of trust in existing tools but also may mean legal implications for the public buyer if they decide to use them. For example, if the LCC tool was used in the contract award process and it becomes apparent that the metrics of the tool are scientifically incorrect, not only it may raise questions regarding the tool's compliance with the existing standards and regulations, but also regarding the potential consequences to the procurement procedure it was used in.

The articles of the Directive also do not provide enough assurance of avoiding legal issues. For example, as one of the conditions for the method used for the assessment of costs imputed to environmental externalities, the Directive states that “the data required can be provided with reasonable effort by normally diligent economic operators”, leaving to the discretion of the creator of the methodology to define the standard of “reasonable effort” and “normally diligent economic operator” in a particular case.

Stakeholders also list the reservations regarding the acceptance of the LCC on the auditors side as one of the reasons for the reluctance to embrace LCC more often. Reaching consensus on the soundness of the tool may assist in ensuring a greater certainty for the procurement practitioners that they will not be penalised by the supervising institutions in case they would choose to adopt LCC practices.

3.3.5. LCC and TCO practices and approaches are more advanced in the infrastructure/ construction sector

While LCC approaches are not widely adopted for many purchasing categories, the infrastructure and construction sectors stand out as areas, in which LCC practices are more developed. This applies for most countries interviewed during the fact-finding, e.g. Germany, Finland, Norway, the Netherlands and Belgium. In part, this is linked to the fact that LCC in the infrastructure and construction sectors are partially mandatory in some countries. In Austria, for instance, the *naBe-Aktionsplan*, which is mandatory at federal level, outlines that for constructions of new buildings, life cycle costs have to be calculated. Furthermore, the Austrian Standards Institute developed a specific standard, which defines lifecycle costs in buildings, i.e. the ÖNORM B 1801-4:2014. The standard defines the accepted principles for lifecycle cost calculations and provides recommendations on calculation methods and assumptions for calculation parameters.

Denmark, in addition to the aim of making available LCC tools mandatory in spring 2022, is also taking steps to go beyond the LCC frame and introduce the specific requirements in relation to the building and construction sector's climate footprint in a form of a voluntary sustainability standard. The purpose is to test a life-cycle assessment (LCA) requirement with an intention to make it a part of the building code as a requirement for all buildings by 2023 (Denmark, 2021[14]).

In other instances, countries have invested significantly to apply LCC calculations to the infrastructure sector, particularly given its impact both on the environment and on CO2 emissions. Well-established practices in the infrastructure and construction sector can go beyond the classic quantification of LCC but focus on environmental impacts of infrastructure projects. A clear example of this are practices developed in the Netherlands around introducing LCA/LCC calculations based on a national environmental database, and using the CO2 Performance Ladder tool (see Box 3.2)

Pilot initiatives also appear to be more common in the infrastructure sector, and are typically led by large public companies responsible for such public works investment. An example is the Austrian federal railway company, ÖBB, which has recently developed and applied an LCC tool suitable for any kind of purchase, including for large projects. To conduct the LCC calculation, ÖBB partnered with the Technical University of Graz to integrate externalities generated by CO2 emissions in the LCC calculation (see Box 3.1). While requiring an important effort, the application of LCC proved successful, and is registering increasing interest (including by companies in the USA).

Other contracting authorities that conduct big investment projects are well placed in taking the lead regarding LCC in their procurement operations. Given the significant budgets and environmental impacts at stake, these contracting authorities are often more invested in making use of LCC in their projects. For instance, the Swedish Road Authority realised the value of using LCC for a lighting installation, as LCC considerations allowed to halve electricity usage for a lifespan of the product of 25 years, compared to a design that did not consider such operational costs. In Norway, the Norwegian Public Roads Administration is also advanced when it comes to LCC, as it also monetises CO2 emissions as part of the LCC calculations (see Box 3.4). In addition, Norway has developed a tool for buildings aimed at facilitating a simple LCC analysis of various alternative buildings (not replacing a complete LCC analysis of the entire building). To support the uptake of LCC, authorities have been focusing on providing guidance of the public project owners purchasers with different tools like an online guide with advice how to integrate a LCC analysis in the different phases of a building project, as well as e-learning courses, films, and proposal of LCC criteria and requirements in the tender documents.

Box 3.4. Norway: Reducing CO2 emissions in asphalt contracts

In 2017, the Norwegian Public Road Administration set the goal of reducing CO2 by 50% in asphalt contracts by 2030. In 2021, the Administration used CO2 emissions as an award criteria in 7 out of 27 asphalt contracts. To document emissions, it uses Environmental Product Declarations, which must include all emissions from the production of asphalt until it is laid out. The price defined for CO2 emissions has been set at 1 kg CO2 for 5 Norwegian kroner.

This price is added to the difference between the tender and the tender with the lowest amount of CO2 emissions. All the tenders, except the one with the lowest amount of CO2 emissions, thus have a new total cost. The tender with the lowest total costs is awarded the contract. The supplier awarded the contract must provide a climate budget prior to the contract start and an account when the contract is finished. The difference between the climate budget and accounting triggers a bonus if CO2 emissions are lower, or a deduction if CO2 emissions are higher.

Source: Information provided by Norwegian stakeholders

3.3.6. Evidence and data on LCC use is scarcely available

The use of LCC is scarcely documented, with very limited availability of data on concrete uptake and use of LCC tools. In part, this is linked to the broader trend of limited monitoring of strategic public procurement policies, including GPP. Countries typically do not have monitoring systems that are built into their e-procurement system, thus allowing to simplify and automate the data collection process. Instead, measuring the uptake of LCC relies on dedicated data collection exercise, such as surveys, self-reporting or similar. Furthermore, visibility over the use of LCC in the pre-tendering phase is limited. Organisations may use LCC to support their decision-making about which solutions to purchase, but this is difficult to track as it is conducted prior to tendering.

Finland and Norway are two examples of countries that have recently estimated the uptake of LCC. Specifically, a procurement survey in 2018 conducted by Norwegian Agency for Public and Financial Management (DFØ) revealed that approximately one third of respondents make use of LCC in the construction and ICT sectors (Rambøll Management Consulting/Difi, 2018[15]). In Finland, KEINO, the Competence Centre for Sustainable and Innovative public procurement, used data analytics methodologies to analyse open tenders and their documentation. Based on a keyword search, it emerged that 5% of public tenders include LCC.

Information about LCC uptake relies otherwise on anecdotal evidence, or proxies. For instance, the number of downloads of LCC tools could give an indication of their use. However, since the introduction of General Data Protection Regulation (GDPR), some countries chose not to collect such statistical data.

Monitoring activities by the European Commission also cover LCC only to a limited extent. For instance, the Commission regularly gathers information about the member states' implementation of their GPP national action plans (European Commission, 2021[6]). While it collects also information about the availability of LCC tools in EU countries, data on uptake of LCC is not available. Nevertheless, the European Commission has published a study that analyses the implementation of LCA in the procurement context across the EU (European Commission, 2021[16]).

3.3.7. Standardisation gaps/lack of consensus on how to incorporate environmental costs

The mapping of LCC and conversations with stakeholders pointed to gaps and lack of consensus on how to address certain aspects of LCC calculations, notably using LCC tool to take into account environmental impacts. As discussed in this chapter, monetisation of CO2 remains one of the main challenges. As per EU Directives, costs related to external environmental effects (e.g. pollution, emissions, etc.) can only be taken into account to the extent the monetised value can be verified. Currently, this represents one of the key barriers to include environmental costs in LCC calculations (Schreiber et al., 2021[17]). As a result, approaches diverge among countries. Some do not pursue climate policies through LCC (e.g. Sweden, Austria), while others are working towards improving LCC tools to address environmental dimensions, and notably embedded emissions (e.g. Germany, Flanders).

Beyond the challenges related to the monetisation of CO2, the lack of specific sustainability standard also poses a barrier to the development coherent LCC tools, as reported by stakeholders. For instance, standards that would tackle maintenance, reparability or circularity are currently not available. These would provide a strong basis for suppliers to compete on, and would simplify the development of LCC tools. Countries also consider that the creation of such standards needs to be an international effort. A small economy may not be in a position to invest in a lengthy process of standard creation if it is not able to subsequently ensure its diffusion and adoption at international scale.

Similarly, stakeholders also pointed to limitations in the availability of information on environmental impacts, such as embedded emissions throughout the lifecycle of a product (including the production stage). Currently, information about environmental impacts can be gathered through Environmental Product Declarations (EPD), but these are not consistently available for all products. In case no EPD information is available, a significantly higher effort is needed to assess the environmental impacts, such as embedded emissions. From the perspective of the European Commission, the ongoing Sustainable Products Initiative represents an important step. This initiative foresees a revision of the Ecodesign Directive including an expansion of regulatory measures to increase the sustainability of products on the EU market. In fact, as of March 2022, the European Commission adopted a proposal for regulation on eco-design of sustainable products (European Commission, n.d.[18]).

In this context, collaboration between various entities that have competencies related to technical/environmental performance and the public procurement community is essential. As discussed in earlier in this chapter, collaborative efforts have been part of the tool development process, and are necessary to ensure robust tools. Beyond the tool development, it is important to ensure the knowledge transfer between public procurement and expertise related to sustainability and environmental impacts. In some countries, the development of LCC tools or GPP policy at large falls under the purview of environment ministry or agency. This is the case in Germany and in Denmark, where the Federal Environment Agency and the Ministry of the Environment have responsibility for LCC tools. Incidentally, these countries are advancing their thinking about LCC by pioneering new types of tools (see Box 3.5). In other cases, the development of LCC tools is led by the public procurement authority.

Collaboration is important to set some of the foundations that are needed for the advancement of LCC tools. This may include the development of a structured and regularly updated database compiling the information on the relevant aspects for the existing LCC methodologies. Once data is available, accessible and regularly maintained, the development of a calculation software becomes more of a technical task rather than a methodological challenge.

Box 3.5. New trends in LCC tools

DE – Developing LCC tools that capture GHG during full life-cycle

With the introduction of the “AVV Klima”, German lawmakers have identified public procurement as a key policy instrument to address climate change. Among several measures addressed by the regulation, federal buyers are mandated to take into account the monetised costs of GHG emissions over the lifecycle of goods and services. This approach goes beyond the current consideration of LCC tools developed by the German Federal Environment Agency, which focus on energy consumption during the life-cycle of various products. In fact, the AVV Klima requires that all embedded GHG shall be monetised and taken into account into the procurement decision, beyond emissions produced during the operations phase (i.e. GHG emissions from the production, transport of the products, or other emissions prior to use by the contracting authorities). The German Federal Environment Agency is tasked with developing tools that facilitate the calculation of such embedded GHG. The regulation went into effect as of January 2022.

DK – Developing LCC tools for products with low energy consumption during the life-cycle (textile)

The Danish Ministry of Environment has developed over 20 spread-sheet based LCC for several purchasing categories. Currently available LCC tools focus on products that generate significant energy consumption over their lifetime, e.g. computers, multifunctional machines, vehicles, etc. Thus, energy efficiency of is typically the main factor to determine the least costly option, when comparing several products. The next frontier in expanding LCC considerations lies in developing tools for products that have low energy consumption during their lifetime, such as textile. With such product categories, the main cost drivers will be longevity of the product, and considerations related to one-time use versus products that can be washed and re-used.

Source: Umweltbundesamt, Danish Ministry of Environment

3.3.8. Time pressure and capacity gaps pose key barriers to wider adoption

A common view held by stakeholders is that practitioners are short on time to introduce practices that require some learning and investment, such as LCC. In fact, LCC practices require having a more extensive knowledge on the matter which may not be easily attainable for an average public procurement official, especially if the practice is not widely used and examples of existing practices are not easily accessible. Furthermore, LCC use requires more time and investment than the usual methods applied in the daily work of public procurement practitioners. Among other activities, public buyers need to verify the accuracy of LCC calculations and input data from suppliers, which is considered a challenging and time-consuming task.

While many stakeholders during the fact-finding missions agreed that LCC methodologies are generally accessible to the average public buyers, there is a need to be trained in understanding the key concepts behind the tools, and applying them in practice. Despite being broadly familiar with methodologies related to LCC, only few buyers have used them in the past and are therefore at ease making use of them. Institutional knowledge of LCC practices is also often lacking.

Resistance may also come from the fact that procurers lack specific expertise related to some aspects of LCC/GPP strategies. In the case of the CO2 Performance Ladder for instance, buyers are not familiar with supply chain risks. Hence, they welcome tools or support that minimise or eliminate specific risks in their practice. Similarly, in the case of smaller infrastructure projects, public buyers are faced with the high effort of learning how to use specific tools, such as DuboCalc. As such, there is greater resistance to make use of such tools, and simplified versions are more accepted.

The organisational culture and approach may play a role, too. As reported by stakeholders, procurement officials often do not have many resources to invest in developing new approaches, and rather rely on tested strategies. The lack of a more comprehensive, organisational approach, however, hinders the uptake of LCC, as the application of LCC calculation often relies on the cooperation of various departments and entities within an organisation. For instance, buyers may need to interact with the controllers department to define and agree on some of the parameters of the LCC calculation (e.g. interest rate or discount rate).

3.3.9. Tools are necessary but not sufficient condition for success

Conversations with stakeholders confirmed the need for tools to simplify and make LCC accessible in every day operations of public buyers. However, it emerged that beyond the availability of user-friendly tools, an enabling environment that supports the uptake of LCC tools is necessary to ensure widespread use. This entails support and commitment both at the political and strategic level, but also within an organisation. Countries that have made GPP a priority are more likely to invest in awareness-raising activities, or mandate some of the actions linked to LCC uptake, such as mandatory use of tools (e.g. Denmark). Commitment at organisational level is also considered a key factor for the successful integration of LCC into daily practices. As discussed above, collaboration within an organisation is a pre-condition for the uptake of LCC tools, bringing together the necessary skills and knowledge. Beyond that, a mind-set change is also required from the organisational leadership. As reported by stakeholders, proactive project managers may want to include LCC considerations in the tenders, but they need the support from the leadership to move ahead.

It is also important to consider the incentive structure, in which public buyers operate. Namely, in some instances the budgetary process does not favour the use of LCC. This is the case when there is a separation between the budget for the procurement and the one for operation costs. In such arrangements, the procurement department may not have incentives to generate savings for different parts of the organisation, and therefore not invest in LCC practices. Stakeholders also emphasise the need to rethink how the public buyers budget is formed switching from annual to longer period planning that would enable them to make decisions based on long-term aims rather than the immediate benefits such as savings generated by the procurement. Governments need to ensure that the right incentive structure is place, so that public buyers procure long-term sustainable solutions.

Collaboration among institutions to develop and mainstream tools is another key factor to creating an enabling environment, in which LCC is widely used. This entails the cooperation between procurement agencies and stakeholders with knowledge and expertise in environmental matters. Such collaboration is necessary to tackle some of the gaps related to standardisation in the LCC calculations, and removing related barriers to LCC adoption. Not least, enhancing capacity at individual level is necessary to meet pre-conditions for tool use. This requires training users in developing basic understanding of relevant parameters, as well as sufficient knowledge of consumption patterns, or the ability to retrieve such information, in order to fill all aspects related to operational use in the LCC calculation.

In addition to an enabling environment that supports LCC, policymakers need to develop the right kinds of tools supporting LCC. In Norway for instance, public procurement authorities have moved away from traditional LCC calculation spread-sheets, and now focus on tools that illustrate certain environmental impacts from public procurement (e.g. purchasing electric vehicles versus fuel-powered vehicles). These include tools developed for cars, vans and construction machines that calculate the effect on Co2 emissions and costs related to fuel and electricity consumption. An additional Norwegian tool helps to calculate, plan, and follow up on the climate footprint from food. Danish authorities would like to upgrade their TCO tools to web-based tools to facilitate their use.

Others, for example, the Swedish Public Procurement Authority and Austrian Federal Railways (ÖBB) continue the use of the traditional Excel spread-sheets, emphasising the transparency provided by this type of calculation, since the methodology, reference data and other relevant aspects are openly shown on the tool, which may not always be the case with the software solutions (albeit the latter might look less complex and more appealing to the users). As per EU procurement Directives, the lack of transparent calculations may result in litigation and the ensuing delay of the procedure.

It is also important to keep in mind that the creation of the tool is just the first step of the journey and LCC tools require a certain level of maintenance to ensure that reference data and other parameters are up-to-date. As the relevant markets and approaches to the LCC evolve, the existing tools need a regular review in order to ensure that the calculation models and data used are still relevant and reflect the realities. Depending on the chosen product and the form of the LCC tool, the level of effort needed to sustain the relevance of the tool will differ. For example, Excel spreadsheets require less investment for subsequent updates. In contrast, software-based approaches mean higher initial financial investment and the need to ensure the funds for the further development and upgrade of the tool, and may even mean the need to establish governance structures to keep the tools up and running. On the other hand, the updates for software-based solutions are automatically shared with users, while an Excel update requires the user to re-download the tool. Thus, the pros and cons need to be carefully weighed.

Last but not least, the stakeholders emphasise that LCC tools are not a substitute for quality criteria and proper technical specifications, which reminds that LCC tools are not the goal *per se* but rather a means in achieving the benefits resulting from the application of LCC.

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Notes

1 The sample of countries analysed consists of 27 EU countries and 5 OECD countries (Australia, Norway, New Zealand, United Kingdom, USA, Switzerland)

2 European Commission, National GPP Actions Plans (policies and guidelines), December 2021

3 Note by the Republic of Türkiye

The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the “Cyprus issue”.

Note by all the European Union Member States of the OECD and the European Union

The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

4 https://milieudatabase.nl/an-introduction-to-the-nmd/

5 Tool to Optimise the Total Environmental impact of Materials

6 CAM, decree issued by the Ministry of Ecological Transition and mandatory for Italian public Authorities referring to art 34 of the Code of Contracts

7 European Commission, Commission Staff Working Document, Impact Assessment Proposal for A Directive of the European Parliament and of the Council amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles, https://eur-lex.europa.eu/resource.html?uri=cellar:fd4de3bc-c55d-11e7-9b01-01aa75ed71a1.0001.02/DOC_2&format=PDF

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