The relevance of Life Cycle Costing in Green Public Procurement

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1. Life Cycle Costing: an overview

Life Cycle Costing started to be used in the mid-'60, when it was applied by the US Department of Defence (Gluch and Baumann, 2004; Hunkeler et al., 2008) to acquire high cost military equipment (Guinée et al., 2011). One of the first definitions of Life Cycle Costing can be traced back to 1976, when White and Ostwald (1976) defined it as "[The life cycle cost of an item is] the sum of all funds expended in support of the item from its conception and fabrication through its operation to the end of its useful life".

As stated in this definition, LCC tracks and accumulates the costs and revenues attributable to the product over the full life-cycle, which may last for many years and that can be sustained by different entities, such as the manufacturer, the user (public or private) and the society (Asiedu and Gu, 1998).
The work of Hunkeler et al. (2008), was the starting point for a following Code of Practice published by the Society of Environmental Toxicology and Chemistry that considered the life cycle costing, together with the environmental and social components of sustainability, as part of the life cycle sustainability assessment (Swarr et al., 2011).
The three sustainability dimensions – environment, economy and society- are indeed taken into account within the framework of the sustainable development (Neugebauer et al., 2016). The Life Cycle Sustainability Assessment (LCSA) includes the three dimensions of the sustainability: Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Social Life Cycle Assessment (SLCA) (Finkbeiner, 2010; Klöpffer, 2008). Traditionally, LCC focuses on financial costs, expressed in monetary values (Hunkeler et al., 2008; Swarr et al., 2011), but in the framework of the LCSA, and taking into account that economic activities influence also the non-economic dimensions of sustainability, a different model of development and growth should be thought with respect to traditional ones (Sneddon at al., 2006). The inclusion of the sustainability dimensions within the LCC concept has determined that environmental and social issues have to be included in the LCC calculations. According to Hunkeler et al. (2008), LCC involves three different kinds of LCC assessments: the conventional, the societal and the environmental one. A conventional LCC deals with traditional financial assessment, where organizations take into account their costs. The environmental LCC include an LCA perspective and enables to include all costs incurred by all stakeholders. Finally, the societal LCC includes also externalities, by internalizing environmental and social costs (Martinez-Sanchez et al., 2015).

Taking into account firstly the "conventional approach", the reasons that can drive towards the application of LCC can be different: a complete list of these drivers has been discussed by Korpi and Ala-Risku (2008). Among the main motivations for the LCC adoption, there is the fact that manufactures may perceive it as an important element leading to competitiveness. Moreover, the motivations for using LCC obviously depend on the kind of sector that uses it (i.e. public or private).
According to the expectations and future possible use of the results, LCC can be performed from different perspectives:

- From the perspective of the manufacturer for pricing activities (Horngren et al., 2012), for estimating future costs (Woodward, 1997), for monitoring costs (Lindholm and Suomala, 2007), for design purposes (Asiedu and Gu, 1998) and for decision making (Lindholm and Suomala, 2004; Hasan, 1999);
- From the perspective of the user for procurement activities (Woodward, 1997, Robinson, 1996) and for pricing activities.
- From the perspective of society (Ogden et al., 2004).

If LCC is applied from the producer perspective, it focuses usually on those costs that are directly covered by the producer itself along the whole life of a product, from its invention and design, throughout its production and sale. There might be other costs incurred after a product is sold, such as warranty costs and plant decommissioning. Some examples of cost items that shall be included in a life cycle cost from the producer perspective are summarized in Table 2. In this case, according to the objective of the analysis, the costs covered by the users of the product can be disregarded. For example, if the LCC is performed to identify the main onerous phases in the life of a product, in order to reduce the cost of production for the producer, the costs covered by the user are obviously not of interest.
Moreover, the inclusion in the analysis of the cost items covered by the user can enable to employ these results also for pricing purposes. In fact, user-LCC focuses on the total costs incurred by a costumer to acquire, use, maintain and dispose of a product or service. User-LCC influences the price a company can charge for its products. For example, a product that guarantees lower operating and maintenance costs can be sold at a higher price if compared to a product with the same functionality that needs higher operating and maintenance costs, since this can lead to an overall decrease of costs associated with the product (Horngren et al., 2012; Iraldo et al., 2011).

Focusing on the producer perspective, Dowlatshahi (1992) and Lindholm and Suomala (2005) suggested that the design of the product influences between 70% and 85% of the total cost of a product. Designers are therefore in a position to reduce the life-cycle cost of the product they design (Asiedu and Gu, 1998).
Typically, by the end of the design phase, approximately 80% of costs are committed. This highlights the possibility for managers to influence the cost of manufacturing a product when it is still at the design stage of its lifecycle, since small changes to the product design may lead to significant savings in the cost of manufacturing. When LCC is applied from the user perspectives, all the cost items considered in the producer perspective can all be summed up in the "purchase price" of the product, which becomes the first cost item considered in the calculation. In user-LCC, all the costs connected with the life-cycle of the product -from the purchasing to the end of life- are also included, extending the scope of the analysis.

Table 1. Cost items from the producer perspective and from the user perspective.

Cost items - Producer perspective	***Cost items – User perspective***
R&D costs Raw materials procurement costs Manufacturing costs	Distribution costs (e.g.: costs of transport, wholesale, etc.) –if not included in the purchase price-

Labor costs Energy costs Water use Capital goods Maintenance costs (in pre-production and production phase) Management costs (in pre-production and production phase) Disposal/recycling costs (of pre-production and production scrap and waste) Share of administrative and general costs Share of commercial costs (e.g.: marketing) Share of logistic costs (e.g.: in-bound logistic)	Installation costs (if needed) - –if not included in the purchase price- Purchase cost Costs of functioning during the use phase (e.g.: energy, water, consumables, etc.) Repair and maintenance costs Costs of regulating (fees or tariffs to be paid to use the product, e.g.: taxes for a motor vehicle) Management costs Substitution costs Disposal / recycling costs (e.g.: costs of waste collection, costs of disassembling, etc.)

Considering the user perspective, life-cycle costs can be many times higher than the initial investment costs (Woodward, 1997). Just to give an example, reported by Asiedu and Gu in 1998, the LCC concept was initially applied for procurement purposes by the US Department of Defense that found operation and support costs for typical weapon systems accounted for as much as 75% of the total cost.

Although the relevance of the different cost items has been widely recognized, initial investment costs are still often used as the primary, and sometimes the only, criterion in purchasing decisions (Lindholm and Suomala, 2004; Woodward, 1997), in particular by public administrations (PAs).
As opposed to considering solely the "initial investment", the adoption of LCC implies considering a certain time horizon. Therefore, some key features need to be clearly defined and handled cautiously:

- Discount rate: Costs in the future are not "worth" as much as those incurred today, as capital is expected to accrue a certain amount of interest over time. A sum of €100 invested today at 5% interest would be worth €105 in one year's time. Therefore €105 spent in one year's time is only "worth" €100 at the present time. This factor needs to be taken into account when comparing the life-cycle costs. This is done through applying a social discount rate to future costs. Figures used will depend on the country but are usually between 3% and 8% (adjusted to eliminate the effects of inflation). This gives each cost a net present value (NPV), which allows a straight comparison of all present and future costs.
- Data availability and reliability: assessing life cycle costs inevitably includes an element of unpredictability regarding costs to be incurred in the future (for example, maintenance costs, energy consumption, as well as the product's actual lifespan). Requesting detailed supporting information for cost estimates provided by tendering companies is therefore important. In some cases, where future costs are within the control of the supplier (e.g. they are responsible for maintenance or disposal), purchasing authorities can build maximum future prices into their contract terms, giving higher certainty to the LCC calculations.

In light of these difficulties, in the last years many experiences and international projects have been developed to facilitate the adoption of the LCC concept by the PAs, mainly for procurement purposes. Examples of public authorities that have successfully launched 'green' tenders and have used life-cycle costing, since January 2010, can be found in a "GPP brochure of good practice examples" published by the European Commission.

2. The relevance of Life Cycle Costing for Public Administrations

2.1 The use of Life Cycle Costing in Green Public Procurement

As set out in the Commission Communication "Public Procurement for a Better Environment" (2008), the European Commission is encouraging public authorities to make their purchasing decisions greener. Achieving this goal is of paramount importance from the environmental policy standpoint, since the public sector has a very high purchasing power (i.e. 19,9% of the EU Gross Domestic Product on the purchase of goods and services in each year, according to: EC, 2011).
An approach that supports public authorities in such a task is Green Public Procurement (GPP). Green Public Procurement was 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" (EC, 2008). Particularly in the context of GPP practices, life cycle costing (LCC) is considered as a useful tool -applicable in green public purchase procedures- that can deliver economic savings as well as reductions in the environmental impact of purchases by public authorities.
The LCC use in GPP procedures can determine the lowest cost in evaluating offers. By using Life Cycle Costing in Green Public Procurement, in fact, Public Authorities are able to consider not only the acquisition costs of a product (they include the raw materials costs and manufacturing costs), but also others costs that usually have to be identified and calculated by the purchaser (e.g. distribution costs, running costs, maintenance costs, disposal recycling costs). These kinds of costs should be added to the selling price to have a comprehensive estimation of the life cycle cost of a product.
In addition, Life Cycle Costing can consider the environmental externalities of a product during its life cycle, when it is possible to determine a monetary value.
The new Directive 2014/24/EU on Public Procurement significantly innovates the process of tenders awarding, giving a relevant importance to LCC. In Article 67, new contract award criteria are introduced: "*The most economically advantageous tender from the point of view of the contracting authority shall be identified on the basis of the price or cost, using a cost-effectiveness approach, such as life cycle costing […]. It may include also the best price-quality ratio, which shall be assessed on the basis of criteria, including qualitative, environmental and/or social aspects, linked to the subject-matter of the public contract in question*".
The same Directive in the Article 68 gives a precise definition of LCC: "*Life Cycle Costing shall to the extent relevant cover parts or all 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".

According to art. 68, both direct costs and indirect costs shall be included in the LCC calculation; however, this can raise some methodological problems since direct costs can be calculated by applying LCC from the user perspectives, whereas externalities affect the entire humanity and can be assessed only if LCC is applied from the society perspective. In the "societal perspective" the costs that will be covered directly by the user are, in some way, undermined, but many other costs are included in the analysis, which are key from an environmental point of view. These costs are e.g.: all the costs induced by the consumption of the product related to the ecosystem conservation, to human health, to social aspects and so on. These impacts are commonly referred as externalities.

Although the Directive provides for a definition of LCC (together with a list of cost items to be included in the calculation), no clear explanation on how this calculation can be performed is given. The points that need to be clarified before an extensive application of the LCC by PAs can take place, include i.a.:

- How to avoid double counting of environmental externalities. The inclusion of externalities can lead to problems of double counting, for example when some externalities have been internalized by taxes (direct costs), but they are also accounted for by taking into consideration the effect on the society or on the environment.
- It has not been clarified if external costs should be summed to the direct costs or reported separately.
- There is no agreement on how externalities can be monetized.

With respect to the last point, in welfare economics an externality is defined as "external effect that occurs when the production or consumption decisions of one agent have an impact on the utility or profit of another agent in an unintended way, and when no compensation or payment is made by the generator of the impact to the affected party" (Perman et al., 2003). This definition excludes all the externalities that are internalized through taxes, because they are already included in the direct costs.

According to this definition, externalities arise from economic activities and they generate unaccounted costs and benefits that impact on a third party, who did not choose to incur those costs or benefits (Pearce and Barbier, 2000). Moreover, the agent who creates the externality has no incentive to take into account the costs or benefits that derive from the external effect.

2.2 Life Cycle Impact Assessment methods and Life Cycle Costing

In order to compute externalities within an LCC application, a monetary valuation of externalities should be carried out, for "converting measures of social and biophysical impacts into monetary units" (Pizzol et al., 2014). There are studies that include, among their goals, the identification of consistent Life Cycle Impact Assessment (LCIA) methods that could perform such tasks. For example, in a JRC report (EC, 2011) aimed to supply a consistent and comprehensive method for weighting environmental impacts, a review of the existing methods is proposed. Excluding single item methods (e.g. ecological footprint) and those non-monetized, the choice for a suitable method for the evaluation of the four classes of externalities is narrowed to a small group, which includes: EXIOPOL, ExternE/NEEDS, LIME, EPS and ReCiPe.

More specifically, ReCiPe allows calculating potential environmental impacts for all four environmental externalities. Within the International Reference Life Cycle Data System (ILCD) Handbook, which provides a background analysis of existing methods for LCIA, ReCiPe has been acknowledged by the European Commission as a valid and reliable method (EC, 2010). Moreover, the method has been referenced in the ILCD Handbook as a recommended method for LCIA, rated in the majority of the accounted categories, proving itself as being largely applicable under several circumstances, including the recently launched methodology on Product Environmental Footprint (EC, 2013).

Furthermore, ReCiPe can be considered one of the newest methods built on the experience of the first methodological approaches for the evaluations of environmental impacts. The European Commission

suggests giving priority to these up-to-date methods, thanks to the rapid development towards better and more complete techniques. ReCiPe calculates impacts at two different levels: Midpoint and Endpoint. Midpoint indicators are used to focus on specific environmental aspects (such as climate change and ozone depletion), while endpoint indicators provide a broader overview of the effects on the key areas of interest. Each endpoint category has an indicator to assess damages to: Human Health (Disability-adjusted loss of life years), Ecosystem (Loss of species during a year) and Resource availability (dollars). Damages to resources are converted directly in monetary value. Damages to Human Health and to Ecosystem can be monetized.

The following tables show some values provided by different methods to assess externalities. As can be noticed, whereas the values for the endpoint "Human Health" are quite similar (Table 2), the values for the endpoint "Ecosystem" differ a lot (Table 3**Errore. L'origine riferimento non è stata trovata.**). In addition, there is an issue related to inconsistent units of measurement.

Table 2 Monetization factors for Human Health impact category.

Endpoint	Reference	Unit	Value
Human Health	Heijungs (2008)	$/DALY[a]	60 000
	Weidema (2009)	€/QALY[b]	74 000
	ExterneE	€/QALY	74 627
	LIME – 1	€/DALY	73 720
	LIME - 2	€/DALY	111 720
	EPS 2000	€/YOLL[c]	85 000

a) DALY – Disability Adjusted Life Year.
b) QALY – Quality Adjusted Life Year.
c) YOLL – Years of Lost Life.

Table 3- Monetization factors for Ecosystem impact category.

Endpoint	Reference	Unit	Value
Ecosystem	Heijungs (2008)	$/PDF·Year[a]	175 000 000 000
	Weidema (2009)	€/BAHY[b]	1 400
		€/specie	30 800 000 000
	LIME – 1	€/BAHY	1 658
		€/specie	36 480 000 000
	LIME – 2	€/BAHY	4 905
		€/specie	107 920 000 000
	EPS 2000	€/specie	110 000 000 000

a) PDF – Potentially Disappeared Fraction of species.
b) BAHY - Biodiversity Adjusted Hectare Year

The methodological problems, uncertainties and heterogeneity of the monetisation factors used, connected with the application of LCC, described above, have been identified as the main barriers to its application by Public Administrations. In order to overcome the main methodological barriers concerning the externalities monetization, we have carried out an in depth analysis aiming to identify in detail the problems about methods, different units of measurement used and other aspects that cause differences in the externalities assessment. The analysis of methodological problems intends to shed light on issues about the monetization factors that can usually prevent a wider use of Life Cycle Costing by Public Authorities.

In the next paragraph, we report the results of a study carried out to verify this hypothesis.

3. A survey on the application of LCC by Public Administrations in Green Public Procurement

With the aim to explore the role that LCC has in green public procurement and the connected barriers to application, a survey among public administrations (PAs) of different countries has been carried out by the authors. The survey has been performed within the study "Development of a life cycle costing (LCC) calculation tool", on behalf of the European Commission – Directorate General Environment. The survey is part of a 18 months project aiming to realize a tool for public authorities for a easier use of the Life Cycle Costing approach. The electronic calculation tool will be referred to specific product categories, as: Office IT equipment, lighting, white goods, vending machines, medical electrical equipment. The survey has been carried out with the aim to:

1. Identify the needs of public authorities to implement the Life Cycle Costing approach and to promote the use of the tool;
2. collecting information to design an appropriate tool for the Life Cycle Costing analysis.

For the purpose of our study, we include in this paper only the results on some aspects investigated with the questionnaire.

3.1 The questionnaire.

The survey has been carried out by submitting a questionnaire to a sample of PAs. The structure of the questionnaire aimed to explore some key aspects, i.e.: the level of knowledge and implementation of the LCC approach by public administrations, the main barriers they encountered in LCC adoption, what direct and external costs are taken into account for assessing the indirect and external costs connected with public purchases and, finally, the main needs of PAs and their suggestions to improve the application of LCC. The questionnaire was composed by three main sections.

The first section of the questionnaire was focused on organization's details (number of employees, type of public administration, country). The second section was referred to Green Public Procurement (GPP). Here, questions were aimed to assess the level of GPP awareness among public organizations and their experiences and details on the real implementation of GPP criteria in their public tenders. The third section was the core of the questionnaire and it focused on Life-Cycle Costing. As in the case of GPP, the level of awareness on LCC was tested. Other investigated aspects concerned the kind of direct and external costs considered by PAs in procurement. The main barriers tackled by respondents in adopting LCC and suggestions on how to improve this approach were also explored.

In order to diffuse the questionnaire among the potential respondents, the on-line web platform "Survey Monkey" (http://www.surveymonkey.com) was used. To achieve the highest number of possible respondents, the questionnaire was translated in five languages: Italian, English, German, French, Spanish. The invitation to fill-in the questionnaire was sent by e-mail to all potential respondents identified. The e-mail included a brief text where the objective of the survey was explained. In addition to e-mails, one of the most important social networks for professional purposes was used to diffuse the survey: LinkedIn. The links to questionnaires were posted to several discussion groups on GPP practices, on EMAS and Ecolabel certifications, and on environmental management. The survey was available on-line from the 27th of March 2015 to the 14th of April 2015. Then, due to the high interest noticed in the respondents filling-in the questionnaire, it was agreed to keep the survey open until the 21th of April 2015.

3.2 Sample identification

The public administrations involved in the survey have been identified through different channels. The goal was to achieve the highest number of possible respondents. For this reason, a very wide population was defined. The sources we used to build the sample are the following:

a) EMAS register.
The list of all European Public Administrations that are EMAS registered according to Regulation EC 1221/2009 was selected. EMAS is one of the main relevant environmental management system scheme for organizations. To do this, the EMAS register was consulted (http://ec.europa.eu/environment/emas/registration/sites_en.htm) containing details on all EMAS organizations in Europe. 365 public administrations registered in EMAS were identified from the register.

b) Public administrations that participated in LIFE European funded projects on GPP.
Public administrations that in the last years participated as partners or lead partners in some LIFE European projects on the Green Public Procurement topic (http://ec.europa.eu/environment/life/project/Projects/index.cfm) were selected. These kind of administrations have had previous experience with GPP. 7 organizations were identified.

c) Public administrations of the mailing list of GPP Advisory Group.
The GPP Advisory Group is an expert group composed of representative of the European Member States and the following stakeholders: Business Europe, UEAPME (small and medium enterprises association), European Environment Bureau/BEUC (European Consumer Organization), ICLEI. The role of the Group is to provide advice to the European Commission on the development and implementation of GPP policies. Thanks to the support of the European Commission, 90 public administrations by this Group were contacted. However, most of these 90 contacts are also registered to the GPP News Alert.

d) Public administrations registered to the GPP News Alert.
Thanks to the support of the European Commission the links to the questionnaires were sent also to 1530 entities registered to the GPP News Alert. This News Alert is issued by the GPP Helpdesk. It provides for example articles, forthcoming GPP events, new initiatives and guides, updates on relevant legislation.

e) Public administrations that joined the Local Agenda 21 in Italy
Local Agenda 21 is a local-government-led, EU-wide, and participatory effort to establish a comprehensive action strategy for environmental protection, economic prosperity and community well-being in the local jurisdiction or area. Many of the Italian public administrations that have joined Local Agenda 21 were contacted.

The sample of public administrations, derived from the abovementioned sources, assured a wide geographical coverage of the EU and they allowed to include in the sample very different kinds of public administrations (e.g. central, or regional or local governments; universities or schools; health organizations; public agencies; public-owned companies; research centres; monitoring / auditing / inspection bodies; port authorities; public-owned companies).

3.3. Survey results

Many public organizations (119) participated in the on-line survey. Most organisations in the sample are Italian (26), Spanish (15) and Belgian (10). Other relevant countries in the sample are: Sweden (6), Germany (5), and Portugal and France with 4 respondents each. It is also interesting to point out that also some respondents from extra-European areas replied to the survey. Most respondents represent a central

government (31,9% of total respondents), followed by local governments or local institutions (22,4%) and regional ones (13,8%).

The first aspect explored by the survey was the level of Green Public Procurement (GPP) implementation by public organizations. Results show that most respondents implement GPP only to specific classes of products and/or services (42,9% of total answers). Approximately 22,7% of respondents implement GPP regularly, while 11% are planning to implement Green Public Procurement in the near future. Nearly a quarter of the respondents have never implemented GPP practices. This outcome of the study is rather surprising, because the sample, as we have seen in the previous paragraph, has been extracted from a set of different sources, all of which refer to "subsets" of Public Administrations that are supposed to be highly sensitive and sometimes even already acquainted with GPP. A first indication that can be drawn from our study is, therefore, that although many PAs are committed to pursue strategies and objectives in terms of environmental improvement (such as the PAs registered in EMAS) or are showing interest in GPP (by participating in different networks dealing with this topic), they are still not adopting GPP practices in a significant measure, and almost a fourth of them has never applied GPP criteria in their public procurement.

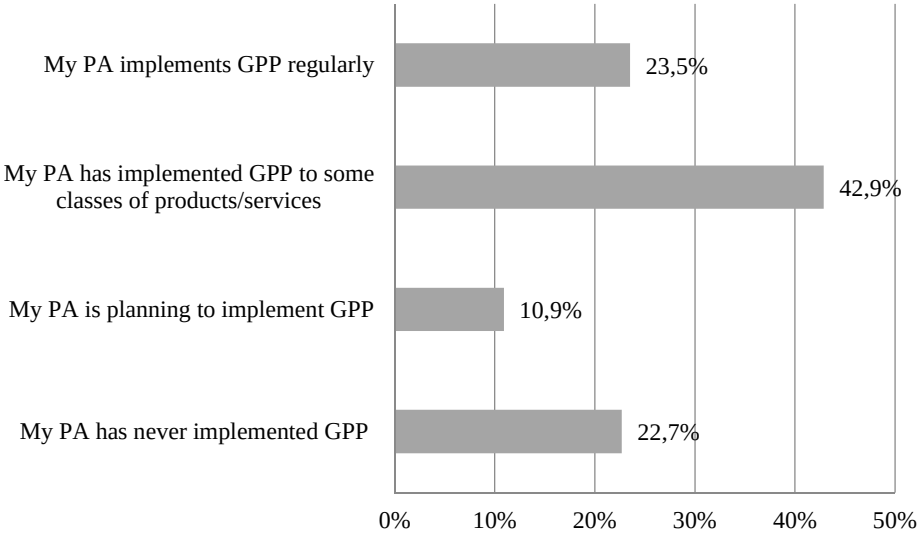

Figure 1. Level of GPP implementation.

Another aspect on GPP, investigated by the survey, was the "maturity" shown by the public organizations in implementing the Green Public Procurement practices. With the term "maturity" we mean the experience that respondents have in the adoption of GPP. 118 public organizations replied to this specific question.
Respondents show a very different "level of maturity" of GPP. Most organizations (33,1% of total answers) have a medium-term experience on GPP (4-8 years). About a quarter have only a quite recent experience (0-3 years). Only 15% of the respondents have a considerable experience on GPP, i.e. 9 years or more. Finally, a large percentage of respondents does not have any significant experience of GPP (about 27% of total answers).

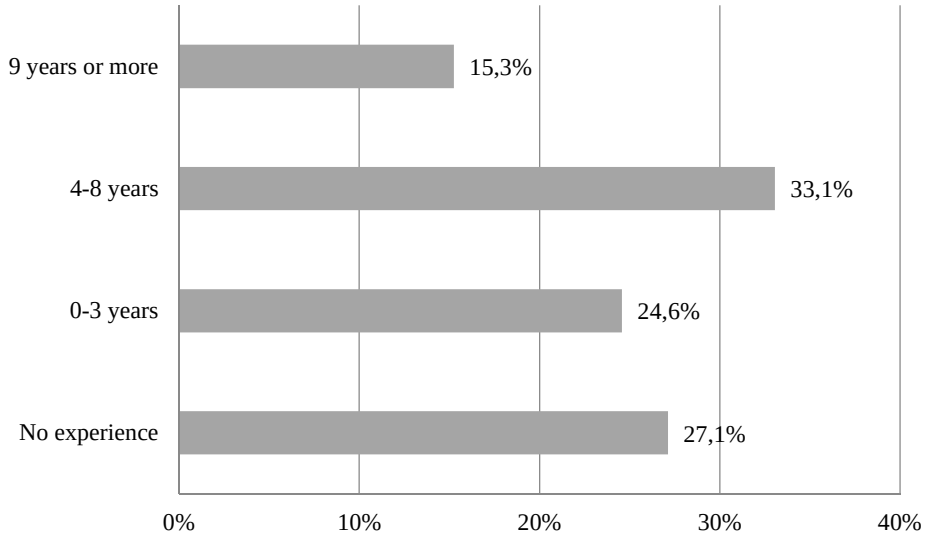

Figure 2. Respondent experience with GPP.

The third section of the questionnaire dealt specifically with Life-Cycle Costing (LCC) and its adoption and use by public administrations within their GPP practices. A first investigated aspect concerned the level of LCC implementation by the surveyed public organizations.

The number of respondents to this question was lower (81 in total) than the number of respondents to the previous similar question on GPP (119). Results clearly show that LCC is less implemented than GPP. Only 4,9% of the respondent organizations implements LCC regularly (compared to 24% of organizations that usually apply GPP).

More than a quarter of the respondents apply LCC only for some classes of purchased products and services. The great gap between the application of GPP by public administrations and their strategic decision to include criteria based on LCC, taken in very few cases, is clearly emphasizing that there is a weak relation between the two "tools". In spite of what many policy makers and researchers are today considering a strong link, the greening of the procurement practices by a public organization is still very far from being a stimulus to adopt LCC. The increasing diffusion of GPP is most likely starting to sensitize the procurers who operate within the public sector on the opportunity to consider the environmental costs and, therefore, on the possibility to use LCC as a supporting tool to correctly evaluate the externalities. The growing attention towards this opportunity is proved by the fact that 25% of the organizations state they are planning to implement LCC. But still it has to be acknowledged that a very wide part of the surveyed organizations have never implemented LCC (approximately 43% of total replies).

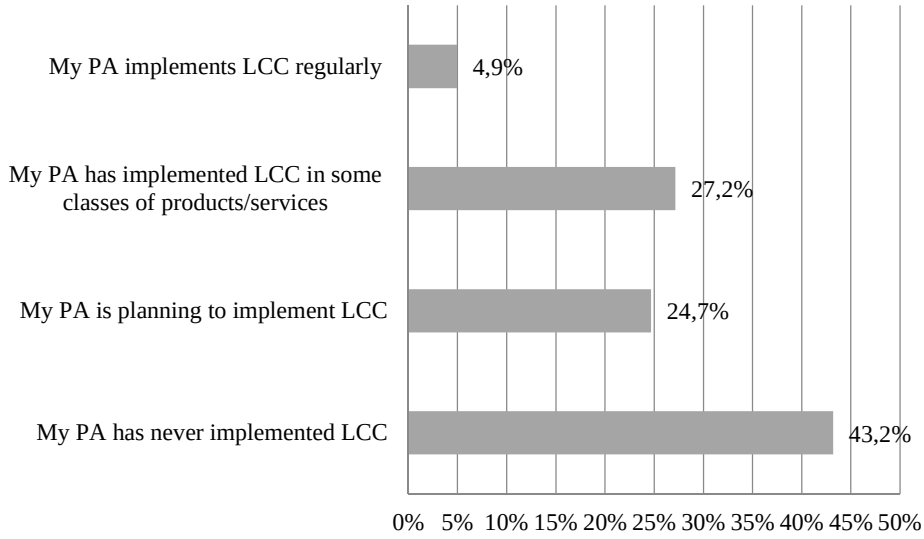

Figure 3. Level of LCC adoption.

In order to understand how LCC practices are currently applied by PAs, even though in few cases, the questionnaire specifically asked the respondents to identify what other "cost items", in addition to purchase price, they usually consider in procurement procedures. It is indeed true that the cost items that can be included in LCC, in addition to purchase price, can significantly vary according to the product to be purchased, however, some general trends can be identified. The respondents to this question were only 78. It has to be noted that each respondent had the possibility to choose more than one "cost item". The following figure shows that 65% of the PAs in the sample declares that "installation costs" are considered in addition to purchasing costs. Repair and maintenance costs, costs of transports and cost of energy during use are also taken in consideration in their procurement practices (in addition to the purchase price) by more than half of the respondents. The other cost items (among those investigated in the survey) are considered only by approximately one third of the respondents. In more details, the inclusion of end-of-life costs and management costs is generally very low.

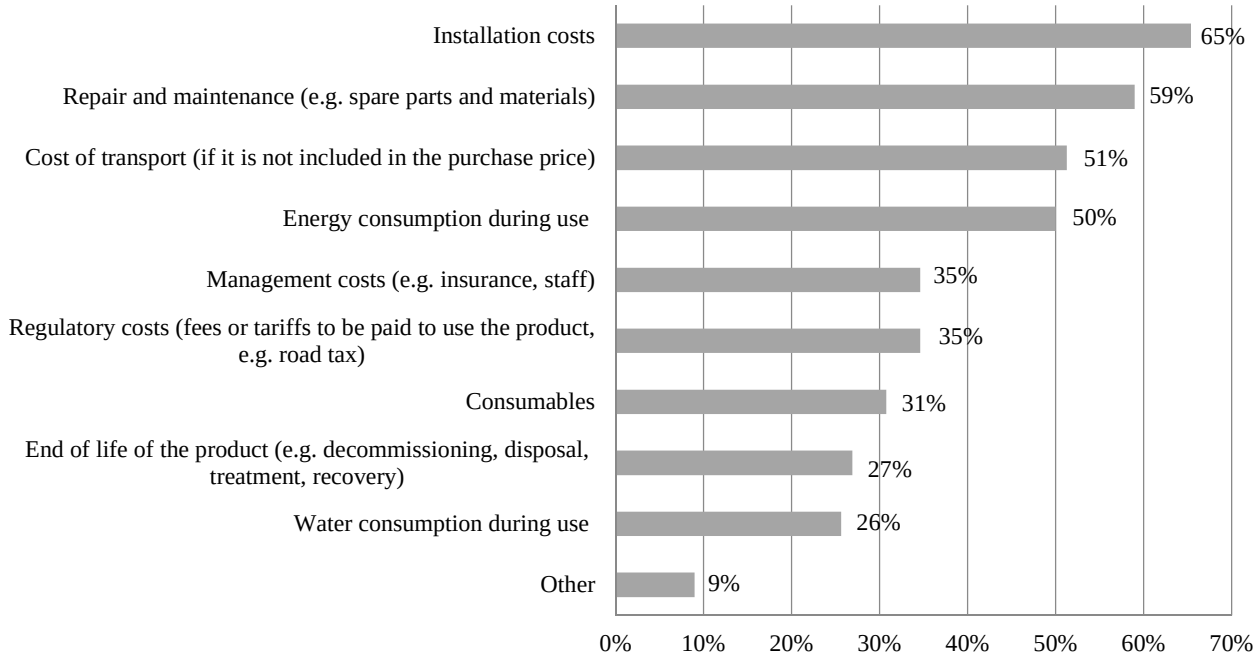

Figure 4. Which of the following direct costs (to be borne by your PA) does your PA generally consider in procurement in addition to the purchase price?

Finally, the survey explored the barriers that prevent the adoption of LCC by public entities. Respondents rated each barrier from 1 –strongly disagree- to 5 – strongly agree-.

On one hand, a very important barrier, according to respondents, is the lack of know-how and the corresponding gap of knowledge, which today is not filled by appropriate and effective tools and guidelines for LCC adoption. Moreover, even when methodological tools and guidelines exist, they are perceived as too complex by the potential "users", i.e. public authorities. Furthermore, public organizations also agree that the lack of human resources is a problem that hinders the full implementation of the LCC approach. Finally, the lack of information on costs is identified as another relevant limiting factor. In this case, a lesson can be learnt from the experience with GPP. The adoption of GPP by public organizations has been spurred and supported in the last years by way of a considerable effort in drafting and publishing guidelines and other tools that can help procurers understand and apply green criteria in their tenders. Recent studies (Testa et al., 2016) show that there is a significant correlation between the availability of these tools and the adoption of GPP in the public sector. The more public administrations are trained and supported by such initiatives as dissemination of these tools, training etc., the more they are keen to implement GPP in their purchasing choices. A further step could be taken to include in these tools clear indications and technical suggestions on how to include LCC in green procurement. This strategy can enable procurers to overcome the barriers they are facing in applying LCC.

On the other hand, also the lack of incentives coming from the institutional and policy framework to efficiently support public organizations in implementing LCC emerges as one of the most relevant barriers. The abovementioned Directive 2014/14/EU has provided a regulatory driver for the diffusion of LCC, but now proper incentives should be designed at the policy level to sustain the public organizations that are pioneering the adoption of this method. As our survey emphasizes, public institutions at different levels (national, regional and local) in Europe are asking for these incentives, especially in terms of financial resources to develop the organizational framework within the public body to face up to the challenge of applying LCC criteria in procurement, as well as to support the training actions that will be needed in order to acquire the technical know-how and competence for this ambitious task.

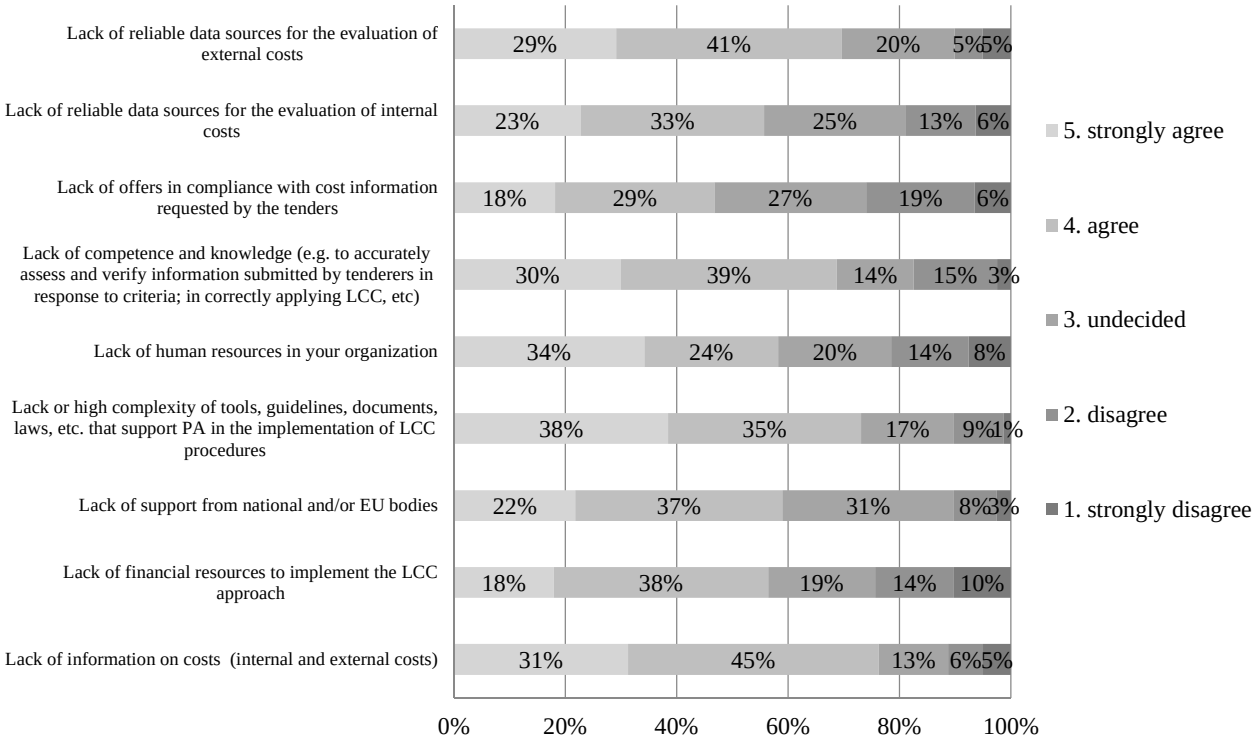

Figure 5. In your opinion, what are the main barriers to adopting LCC in your PA?

Taken into account the survey results, we can conclude that the use of LCC by Public Administrations is very limited with respect to GPP. Moreover, there is still a low practical use of Life Cycle Costing within the Green Public Procurement procedures. In other words, even if the European policies aim to better integrate LCC and GPP, currently we are very far from this objective. As highlighted by the survey results, there are a number of different barriers that limit a proper and wide use of LCC in Green Public Procurement procedures. To overcome the listed barriers, a number of actions have been suggested to respondents asking them to state their level of agreement. More than 49% of the respondents strongly agree on the need for additional guidelines and tools that support PAs in the implementation of LCC, for a specific training on LCC and the setting of a defined and recognized evaluation method for LCC.

3. Concluding remarks

Life Cycle Costing can be a powerful instrument to be used by companies and institutions for different purposes, such as procurement, design, cost monitoring and cost estimation. In particular, the use of LCC in procurement can help identify the most efficient alternative in a life cycle perspective, overcoming the need to rely only on the purchase price, which in some cases can be misleading. Despite the clear advantage for organizations, the use of LCC today is still very limited, particularly for public administrations.

The new Directive 2014/24/EU suggests the use of LCC in public tendering processes for the comparison of different offers; however the application of LCC is expected to remain quite difficult for public administrations, since there is no agreement on how to apply this kind of methodology and many barriers are emerging from this difficulty. Art 68 defines which cost items shall be included in the calculation of LCC, but this is not enough. One big issue is related to the inclusion of externalities in the LCC but, as we have seen, this will give rise to some problems, such as: the inclusion of externalities can lead to double-counting,

there is no agreement on how externalities can be monetized and if this external costs should be summed to the direct costs or reported separately.

The results of the survey we carried out on a sample of 119 public administrations from different countries, clearly show that GPP practices are commonly applied at least to a certain extent (e.g.: to some specific categories of products) by public administrations. As opposed to that, the application of LCC still remains very limited, and not effectively stimulated by (or even linked to) GPP, due to some barriers. The most relevant barriers public administrations must tackle consist in a poor availability of supporting tools and of incentives that could stimulate and support public organizations in the application of LCC. To overcome this barrier, the electronic calculation tool that will be carried out within the study "Development of a life cycle costing (LCC) calculation tool", on behalf of the European Commission – Directorate General Environment, can represent a valid support for Public Administrations and can stimulate a greater use of the LCC approach. Moreover, some examples exist of public authorities that have successfully launched 'green' tenders and used LCC in the last years. For example, the "GPP brochure of good practice examples" - published by the European Commission - includes some experiences of GPP and LCC approach (http://ec.europa.eu/environment/gpp/pdf/GPP_Good_Practices_Brochure.pdf). Moreover, in the official website of the European Commission, a list of GPP examples is available (http://ec.europa.eu/environment/gpp/case_group_en.htm), and some of them report cases of use of the LCC approach. For example, in 2011 the Kolding City Council of Denmark published a call for tenders for the supply of innovative, energy efficient LED replacement light bulbs. Life cycle costs were given a weighting of 55% (broken down into purchase price (35%), lifetime (35%) and operating costs (30%); energy-efficiency (lumen/watt) was given a weighting of 25%, and light quality, 20%. The reported examples can represent a valid support for Public Authorities with best practices for the application of LCC in public tenders.

Moreover, the lack of human resources within the public authorities today represents a constraint to the full adoption of LCC. The lack of human resources is a relevant constraint particularly due to the economic crisis of the last years. To overcome this issue, public authorities aiming to adopt LCC in public tenders, can for example train a specific task force identified among the internal staff to apply LCC. The trained staff could be shared among the different departments within the same public organization, in order to limit costs and to prevent the costs deriving from hiring new staff with LCC competences.

The comprehension and application of LCC in the public sector is thus still at a very early stage and a greater effort is needed to support the development and spreading of this tool in the European Union.

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