Project co-financed by the European Regional Development Fund

GRASPINNO

Transnational model, strategies and decision support for innovative clusters and business networks towards green growth, focusing on green e-procurement in EE/RES for energy refurbishment of public buildings.

Deliverable: 4.3.1

Training material for

GRASPINNO Living Labs

MODULE 2

A PROPER USE OF ELECTRONIC GREEN PUBLIC PROCUREMENT FOR THE ENERGY EFFICIENCY OF

Prepared by TERRE DI SIENA LAB (PP02)

Date: 29/06/2018

Table of contents

List of tables

List of figures

1. Executive summary

Aim of this module is to give useful information and a methodology for a **proper use of electronic Green Procurement** for the energy efficiency of Public Building.

The training materials include a **preliminary analysis of the Italian regulatory framework** (Italy case study) but the application of the Green Public Procurement (GPP) in each country is a transposition of the European legislation in the national context based on the same concepts of GPP criteria (Italian CAM, Criteri Ambientali Minimi) and MEAT (Most Economically Advantageous Tender).

This process should give a complete compatibility between environmental criteria and economic issues. In other words, the methodology should allow a situation in which the **introduction of GPP criteria implies also a lower Life Cycle Cost of the product/intervention**.

This results in benefits for Public Administrations and SMEs; on one hand, Public Administrations can be sure of real savings and in a higher environmental compatibility, on the other hand, SMEs improve their competitivness by offering best solutions at a right price.

2. Case study: Italian regulatory framework for Green Public Procurement

BACKGROUND

The European Commission (Communication 2003/302 on Integrated Product Policy – Building on "Environmental Life-Cycle" Thinking) have set the target of encouraging "*….the Member States to draw up publicly available* ***action plans for greening their public procurement"****.*

Such plans:

"…..should contain an assessment of the existing situation and ambitious targets for the situation in three years' time. The action plans should also state clearly what measures will be taken to achieve this. They should be drawn up for the first time by the end of 2006 and then revised every three years. The action plans will not be legally binding but will provide political impetus to the process of implementing and raising awareness of greener public procurement. They will allow Member States to choose the options that best suit their political framework and the level they have reached, while at the same time enabling an exchange of best practice."

The European Commission has thereafter issued specific Guidelines for setting up National Action Plans on Green Public Procurement (GPP). Law 296 of 27 December 2006 (Finance Act 2007) states, in Article 1(1126):

> " *…the implementation and monitoring of an 'Action Plan for the environmental sustainability of consumption by public authorities' drawn up by the Ministry of the Environment and the Protection of Natural Resources, in concert with the Ministers for the Economy and Finance and for Economic Development …"*

In Article 1(1127) and (1128) the Act goes on to indicate the commodity categories and the Ministerial Committee set up to monitor the environmental sustainability targets.

2.1 Italian law

Article 95, paragraph 2 of the Code states that, in compliance with the principles of transparency, non-discrimination and equal treatment, **contracting authorities award contracts on the basis of the MEAT criteria** identified on the basis of the best quality/price ratio, or based on the price or cost element, following a cost/effectiveness comparison criterion such as the cost of the life cycle.

Paragraph 4, of the art. 95, establishes that it can - and should not - be used the criterion of lower price:

a) for works of an amount equal to or less than 1,000,000 euros, taking into account that compliance with the quality requirements is guaranteed by the obligation that the tender procedure will take place on the basis of the executive project;

b) for services and supplies with standardized features or whose conditions are defined by the market;

c) for services and supplies of an amount less than the community threshold, characterized by high repetitiveness, except for those of considerable technological content or which have an innovative character.

For services and supplies "*with standardized features or whose conditions are defined by the market*" they must be understood as those services or supplies which, even with reference to the production practice developed in the reference market, cannot be modified at the request of the contracting authority or which comply with certain national, European or international standards.

The services and supplies "*characterized by high repetitiveness*" meet generic and recurring needs and are connected to the normal operation of the contracted stations, requiring frequent supplies in order to ensure continuity of the service.

In essence, the mentioned law **allows contracting authorities** (and economic operators) **to avoid costs**, in terms of time and costs, of a competitive comparison based on the best value for money, when the benefits deriving from such comparison are null or reduced (in relation to the amount of the contract).

Since it is an exception to the general principle of the most economically advantageous tender, the contracting authorities wishing to proceed with the award using the criterion of lower price, pursuant to art. 95, paragraph 5, must give **adequate reasons for the choice made** and specify in the call for proposals the criteria used to select the best offer (think of the use of effectiveness criteria in the case of cost/effectiveness approach also with reference to the life cycle cost).

In the explanatory statement, the contracting authorities, in addition to justifying the use of the elements at the basis of the exemption, must demonstrate that a particular

supplier has not benefited by using the lowest price, for example the **characteristics of the product** offered by the individual are considered standardized.
Tenders must always be awarded on the basis of the best value for money, pursuant to the art. 95, paragraph 3, the contracts relating to:

a) social services and hospital catering, assistance and education;
b) labor-intensive services (ie those in which the cost of labor is at least 50 per cent of the total contract amount - Article 50, paragraph 2);
c) engineering and architectural services as well as other technical and intellectual services for amounts exceeding € 40,000.

The **choice of the award criterion**, the definition of the evaluation criteria, the methods and the formulas for the assignment of the scores, the determination of the scores themselves and the method for the **formation of the final ranking** develop during the initial life of the contract, from the programming to the preparation of the documentation of the tender.
It is recommended:

a) in the planning phase: to define the characteristics of the assignment that allow to verify the existence of the conditions for which the Code and these guidelines prescribe or allow the use of a particular award criterion;
b) in the planning phase: to start the definition of the evaluation criteria and the relative scores;
c) in the adoption of the decision: to contract and process the tender documentation, proceed to complete definition of the additional elements.

2.2 Evaluation criterion

The underlying idea of the new criterion of the most economically advantageous offer is that the public administration when tendering works, services or supplies should not only consider cost savings but must also consider the quality of what is purchased. In essence, a trade-off between cost and quality is usually created and the tender is considered the most suitable way to guarantee the best balance between these two. In the design phase of the tender the contracting authority (qualified) must concretely **identify its objectives** (usually multiple), assign a relative weight to each of them, define the methods by which the degree of adequacy of each offer is assessed with respect to the individual objective, as well as summarizing the information relating to each offer in a single final numerical value. None of these choices has a neutral impact on the results of the tender. These guidelines are intended to provide operational indications that can help the contracting authorities in adopting the most economically advantageous bid criterion.

The first problem that the contracting authority must face in the preparation of the tender documents is the **definition of the objectives** it intends to pursue and the importance it intends to attribute to each of them. **This translates into the identification of the elements (or criteria) that one intends to evaluate and the relative weight or ponderation factor.** Evaluation criteria may include price or cost of product life cycle, technical characteristics, social and environmental impact, etc. Each of these objectives must be measurable in order to be taken into consideration for the most economically advantageous bid. The definition of objectives or evaluation criteria differs in each assignment, and therefore cannot be dealt with in detail in general guidelines.

In general, when defining the **criteria for evaluating offers**, the contracting authorities must take into account the structure of the product sector to which the object of the contract relates, the technical characteristics of the works / goods / services that meet the requirements of the contracting authority and those that the reference market is able to express.

Article. 95, paragraph 6 of the Code provides that the evaluation criteria of the **best quality / price ratio** must be objective and connected to the object of the contract, in order to ensure compliance with the principles of transparency, non-discrimination and equal treatment. The following criteria are considered connected to the object of the contract:

- relate to works, supplies or services to be provided in the context of the assignment under any aspect and at any stage of the life cycle (including factors involved in the specific process of production, supply or exchange or in a specific process for a subsequent phase of the cycle of life, even if they are not part of their substantial content);
- respect the characteristics of the works, goods or services considered the most relevant by the contracting authority for the purpose of satisfying their needs and enhancing the additional profiles indicated by the code

Also in art. 95, paragraph 6, of the Code are indicated, by way of example, the following criteria:

a) quality (technical merit, aesthetic and functional characteristics, accessibility, certifications and certifications regarding worker’s safety and health, social and environmental characteristics, containment of energy consumption, innovative features, marketing and related conditions);
b) holding of an EU eco-label in relation to the goods or services covered by the contract, equal to or higher than 30 per cent of the value of the supplies or services covered by the contract;
c) cost of use and maintenance, «also regarding the consumption of energy and natural resources, polluting emissions and overall costs, including external ones and mitigation of the impacts of climate change, referring to the entire life cycle of the work, good or service, with strategic objective of a more efficient use of resources and a circular economy that promotes environment and employment»;
d) compensation of greenhouse effect gas emissions associated with the company's activities calculated according to the methods established on the basis of recommendation no. 2013/179/EU of 9 April 2013 on the use of common methodologies for measuring and communicating environmental performance over the life cycle of products and organizations;
e) organization, qualifications and experience of the staff actually used in the contract, if the quality of the personnel in charge can have a significant influence on the level of performance of the contract;
f) after-sales service and technical assistance;
g) conditions of delivery or execution of the service.

The evaluation criteria defined by the contracting authority also take into account the minimum environmental criteria (CAM) adopted by decree of the Ministry of the Environment and of the protection of the territory and the sea; to this end, the evaluation criteria provide for the attribution of specific scores if conditions higher than the minimum ones provided by the CAM are proposed with reference to the basic specifications and the contractual clauses/conditions of execution or are proposed the conditions foreseen, within the aforementioned CAM, from the specific awarding

techniques (specially designed for the procedures awarded on the basis of the best quality / price ratio).
In general, the contracting authorities must identify **evaluation criteria that are concretely suitable for highlighting the characteristics of the tenders** presented by the competitors and to differentiate them according to the requirements of the contracting authority. The mentioned criteria must therefore allow an effective competitive comparison on the technical profiles of the offer, avoiding situations of flattening the same on the same values, negating the **application of the criterion of the best quality/price ratio**. In other words, the participation requirements which, by definition, are held by all the competitors, or the minimum conditions - including the price - with which the works, services or supplies must be realized, should not be assessed; a positive score should be given only to actual improvements compared to what is expected from the tender.
It must also be considered that with the list referred to in art. 95, the rigid separation between participation requirements and evaluation criteria that had characterized the **subject of public contracts** was definitively overcome. In evaluating offers, subjective profiles can be assessed if they allow a better appreciation of the content and reliability of the offer or enhance the characteristics of the offer considered to be particularly deserving; in any case, they must concern aspects, such as those indicated in the Code, which directly affect the quality of the performance. Naturally the evaluation of the offer concerns, as a rule, only the part exceeding the threshold required for participation in the tender, provided that this does not result in a ploy to introduce dimensional criteria.
In paragraph 13 of the art. 95 it is also established that, compatibly with the respect of the **principles governing public procurement**, the contracting authorities can include in the evaluation of the offer criteria related to the legality rating, the impact on the safety and health of workers, to that on the environment and to facilitate the participation of micro-enterprises and small and medium-sized enterprises, young professionals and newly established companies. Please note that the **legality rating may be required by companies operating in Italy**, registered in the company register for at least two years and with a minimum turnover of at least two million euro. Unless the contracting authority already knows, in the preparation of the tenders or the letter of invitation, that only eligible companies may participate in the procedure, it is appropriate that, for its use, compensations are introduced to avoid penalizing foreign and/or newly established companies and/or those lacking the expected turnover, allowing

these companies to prove otherwise the existence of the conditions or the use of the measures envisaged for the assignment of the rating. In particular, for those who can not access the legality rating, the contracting authority could indicate the elements present in the legality rating, (pursuant to the Resolution of the Antitrust Authority no. 24075 of 14 November 2012 - Legality Rating Regulation "Regulation for the implementation of Article 5-ter of Legislative Decree 1/2012, as amended by Article 1, paragraph 1-quinquies, of Decree Law No. 29/2012, converted with amendments by law 62/2012 "and subsequent updates), different from those already considered for qualification purposes, for which it is necessary to provide a reward score and consider the presence verified.

In order to facilitate the participation of micro-enterprises and small and medium-sized enterprises, young professionals and newly established companies, it is suggested that the contracting authorities provide evaluation criteria that enhance the innovative elements of the offers.

Finally, it should be noted that, pursuant to paragraph 14, in the award criteria based on the best quality/price ratio, the call for tenders may provide for the request for variants, according to the procedures described there. These variants must have a level of definition equal to that of the project put forward and be consistent with the same without distorting it. The evaluation criteria of these variants must take into account the results of the various planning phases and be aimed at stimulating the improvement of the good or service.

With specific reference to the evaluation of the economic aspects, taking into account the formulation of art. 95, paragraph 7, it is considered that, whatever the chosen award criterion, (therefore also in the case in which the identification of the MEAT takes place on the basis of the best quality/price ratio), the economic element can be assessed in terms of price or cost.
It should be noted that the Code, incorporating the indications contained in Directive 2014/24 / EU, provides that the cost element within the MEAT must be assessed using a lifecycle cost-based approach.
This concept includes all the costs that emerge during the **life cycle of the works, supplies or services**. Pursuant to Recital 96 of the aforementioned Directive, "*the concept covers internal costs, such as research to be carried out, development,*

production, transport, use and maintenance and final disposal costs but it can also include costs attributable to environmental externalities such as pollution caused by the extraction of raw materials used in the product or caused by the product itself or its manufacture, provided that they can be monetized and controlled ". Among the costs that would be useful for consideration are the social costs of the life cycle indicated without any further specification.

The cost criterion, as a cost of the life cycle, therefore allows to appreciate the costs connected to the various phases of the life cycle of the works / goods / services and to proceed with an overall assessment of the economic impact of the same as well as an assessment of the costs that most directly fall on the contracting authority (ultimately summarizable in a "price"); the price criterion makes it possible to appreciate the consideration provided within the offer, as a concise and direct index of the economic profiles of the offer;

While with the **Directive 2004/18 / EC and Legislative Decree 163/2006** it was not possible to assign a particularly low (or zero) score or to provide a calculation method that would effectively cancel the price component, currently this possibility it is admitted by the art. 95, paragraph 7, of the Code, according to which it is possible to compete exclusively on quality.

However, the rule leaves open the definition of the cases for which it is possible to exclude the cost element in the MEAT. Indeed, the aforementioned paragraph 7, refers to art. 95, paragraph 2, for the identification of cases in which the fixed price can be used: the cases in which there are "*laws, regulations or administrative provisions concerning the price of certain supplies or the remuneration of specific services*". This casuistry, however, is not exhaustive, in consideration of the phrase "also" used for the aforementioned reference.

The indeterminacy contained in the Code seems to be present also in Directive 2014/24 / EU, where art. 67, paragraph 2, generically indicates that "the cost element can also take the form of a fixed price or cost on the basis of which the economic operators will compete only on the basis of qualitative criteria". Indeed, in Recital 92 it is stated that "the award decision should not be based only on criteria that do not depend on costs" and on the following Recital 93 that in cases where national rules determine the remuneration of a service or the price of a supply the contracting authorities **must evaluate the quality/price ratio to award a contract**.

Under a different profile, where the contracting authorities decide to determine the price of assignment for cases other than those for which there is a provision of law providing for it, the same must take particular precautions in this regard, carefully evaluating the modalities of calculation or estimate of the price or fixed cost. This is to avoid that the price is too low to allow the participation of companies, "correct" or too high, producing damage to the contracting authority.

2.3 Integration of economic and environmental sustainability considerations in the procurement cycle

According to the **ANAC Guidelines** n. 2, Legislative Decree 18 April 2016, n. 50, "Most economically advantageous tender" and, in particular, the 95, paragraph 2 of the Procurement Code the choice of the winner has to be carried out through the criterion of "the Most Economically Advantageous Tender" (MEAT). As described in the previous paragraph to apply the MEAT criterion there are 2 options:

1. a system based on the best quality/price ratio;
2. following a cost/effectiveness comparison criterion such as the life cycle cost (LCC).

It means that by **applying the CAM as minimum criteria** (threshold) to have a Green Public Procurement the MEAT criterion can be respected by using the LCC.

LCC is a powerful instrument because, in addition to a possible selection criterion for the tender (MEAT to be used with GPP criteria), it is also a quite complete economic and environmental assessment tool.

To understand this assertion a linguistic approach can be very useful; the French definition of "Sustainable Development" is "développement durable" a term more suitable than English one to explain:

- a higher replicability of productive processes and factors (more duration)
- Indication of the maximum level of the Anthropic pressure for a chosen technology (performance)

These elements are 2 fundamental cost items of the LCC. All the elements of the LCC can be described in the following list:

- purchase price,
- product lifespan,
- performance,
- maintenance costs,
- disposal costs/resale value,
- externalities (emissions, in particular GHG but also other emissions)

In other words, by **using the LCC as a MEAT criterion**, we are introducing very detailed and **precise economic and environmental considerations** on the procurement cycle. By using these tools, the Public Administration can improve the quality of its expenditure under an economics and environmental point of view. A systematic use of the tools means to make sustainable the local economy. **The LCC tools measure the Life Cycle Cost of products or services offered in a tender**. There are 2 versions of the tool: an old version to assess the winning choice carried out after the tender publication; a new one to be used before the tender publication in order to implement it correctly. An ex-post use is related to an already concluded and therefore unchangeable tender, while with an ex-ante use the aim is to prevent a possible economic and environmental damage with the execution of the intervention.

3. Main barriers and opportunities for a sustainability

3.1 Introduction to the LCC tool

Following paragraphs explain various uses of the **Life Cycle Cost (LCC)** tool. The purpose of this instrument is helping the user to understand how to correctly interpret the results of a green tender from an economic and sustainable point of view.

A large part of the manual is based on cases, already studied in the previous GRASP project, analysing **GPP procedures for Energy Eefficiency/Renewable Energy Sources (EE/RES) in buildings**. This part has been integrated with other possible products that could be the subject of a GPP tender in the energy refurbishment of buildings.

Although in many cases the greener alternative may have a higher purchase price, if we **analyze all the costs** (throughout the life span of the product), the greener alternative may well prove to be cheaper over time.

If contracting authorities wish to ascertain which products are most cost effective they need to apply LCC approaches in their procurement decisions. This means comparing not only the initial purchase price of a product, but all future costs as well. A complete LCC would include:

- ✓ Price
- ✓ Usage costs (in our specific case energy consumption or fuel)
- ✓ Maintenance costs
- ✓ GHG emissions
- ✓ Disposal costs (or recycle and reuse)

For the disposal costs, the data is not always available and an estimation of the costs may not be easy. For instance, in presence of material homogeneity, a disposal cost per weight unit can be found but it is harder when the materials are heterogeneous. Moreover, in some cases, like electronic waste, the **European directive 2012/19 on Waste Electrical and Electronic Equipment (WEEE)** constrains vendors with a quite big store to collect all the old electronic goods brought by citizens in ratio of one to one, or one to zero for devices with larger side less than 25 cm, even if the products haven't been sold by the same vendors. For this types of products calculation of the disposal cost would be erroneous; in fact, this modality implies a disposal contribution in the purchase price and, thus, calculating the disposal cost would lead to double calculation of disposal costs. As in the previous GRASP project, the waste treatment costs remain an "open" issues: when the data is available, it should be used.

3.2 General explanation

The available LCC tool **helps the users to make specific evaluations of different products**. First, the user can easily see the absolute value of the LCC of the green product. This can be seen whether there are two products or a single product. Second, the **user can evaluate the difference between the costs of keeping an existing product versus substituting it with a new product**. In this case, price doesn't need to be considered because it is a comparison of two products from different time periods with **different performances** whose prices depend on the circumstantial and temporary nature of the market. In such cases, examining price is not useful. Third, the user can evaluate the LCC of two similar products with comparable performance. This allows for a more informed decision to be made and is the main purpose of this tool. This use shows easily the differences between a lowest price evaluation and a Life Cycle Cost evaluation.

As with any similar tool, there are some limitations that must be noted. One of these is that this tool can **only compare two products at a time**. This may prove tedious if comparing multiple products, but it maintains its simplicity. If we take the example of retrofitting buildings, this tool could be used to compare the different windows that might be used, then the type of walls that would be constructed, and in this way different aspects of the renovation would be split into different areas and thus into different comparisons. This may become less suitable if, in a general refurbishment of a building, there are many different areas of a project without homogeneous products to test. In this case, more simple but less precise calculation is preferable: the whole retrofitting may be considered as a single product with its own energy and maintenance specifications. Doing an analysis of this type would give an overall perspective of the project without comparing each individual product/work.

Considering the many uses of this tool, it seems clear that the benefits outweigh the limitations. This tool is helpful in the cited situations and can be used in a large variety of situations.

3.3 Examination of specific cases

In following tables involved partners are listed as well tests or pilots conducted in GRASP. GRASP was the previous Med programme project, precursor of GRASPINNO in which a first version of GPP support tool and LCC tool was developed. In particular, the first table deals with the partner (with the pilots highlighted in red), the public administration that did the test, and the sector that was involved. The second table gives a few details about each test done by the involved partners.

As can be seen, there were a wide range of cases submitted with an equally wide range of results. An evaluation of some of these cases follows. In the present document the description is focused only on tenders concerning EE/RES for buildings even if the tables includes all the cases analyzed in GRASP.

Partner (Pilots in red)	PA	Number/kind of SMEs
PP2 Province of Perugia	Province of Perugia	10 SMEs/IT sector
PP3 IRISS	Malta Government	10 SMEs/IT sector, server
PP10 SIEEP	Municipality of Saint-Florent	10 Companies/P. Lighting
PP4 CC I Terrassa	Municipality of Rubi	10 SMEs/RES
PP5 PABBC (with Atlantis)	Municipalities of Trivigno, Vaglio di Basilicata; Brindisi di Montagna	✓
PP6 Municipality of Spata-Artemis	Municipality of Spata	10 SMEs En. Ef. Build
PP8 Atlantis (with PABBC)	✓	10 SMEs Renewable Energy
PP9 CCI of Castellon	CCI of Castellon	10 SMEs/Solar Panels' sector
PP11 Hortiatis-Pilea	Municipality of H-P	10 SMEs/IT sector
PP12 UniVlora	University of Vlora	5 SMEs/IT sector
PP13 RAIS	City of East Sarajevo	10 SMEs En. Ef. Build

Table 1: Pilots and Tests

PP	Kind of Tender	Procedures	Award Criteria	N of SME	Subject	Total/Unit Cost
Perugia A	Secret bid	Open	Lowest P	172	7 Desktop PCs	4060/580
Perugia B	Secret bid	Open	Lowest P	172	6 LCD Monitors	498/83
IRISS	Secret bid	Reserved	Lowest P satisfying the administrative & technical criteria	3	Supply & Delivery of IT equipment	5940/1485
SIEEP	Secret bid	Reserved	Lowest P + technical specifications	2	Public Lighting	18.200/650
Terrassa	Secret bid	Open	Lowest P + technical specifications	10	Fluorescents LED	1960/70
PABBC	Auction	Open	Lowest P + technical specifications	10	Photovoltaic	1.492.272/1.492.272
Spata-Artemis A	Secret bid	Open	Lowest P + technical specifications	10	Replacement of conventional Municipal Street Lamps with new LED bulbs	290/10
Spata-Artemis B	Secret bid	Open	Lowest P + technical specifications	2	Replacement of the existing boiler with a new one	5.675/5675
Atlantis	Auction	Open	Lowest P + technical specifications	10	Photovoltaic	1.492.272/1.492.272
Castellon	Auction	Open	Lowest P + technical specifications	10	Thermal solar plant	4.975/995
HortiatisPilea	Secret bid	Open	Lowest P + technical specifications	10	Printers	3.000/600
UniVlora	Auction	Reserved	Lowest P + technical specifications	5	7 Projectors	2.920/365
RAIS	Secret bid	Open	Lowest P + technical specifications	10	Facade	412.410,51/412.410,51

Table 2: Tender Characteristics

3.4 Terrassa Case

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	15,95	€	70,00	€
Lifetime [years]	1,14	y	5,70	y
Comparable number of replacements [n]	5,00	n	1,00	n
Total Cost [€]	2.233,00	€	1.960,00	€
Duration				
Lifetime [years]	6	y	6	y
Average yearly time usage [hours/year]	3.168	h/y	3.168	h/y
Total usage time [hours]	18058	h	18058	h
Number of purchases [n]	28	n	28	n
Total [hours]	505613	h	505613	h
Maintenance				
Number of years [years]	6	y n	6	y n
Units per year [work hour, kwp, page…]	24,56		4,91	
Cost per unit [€]	20,99	€	20,99	€
Total [€]	2939	€	588	€
Energy costs				
Price of energy [€/Kwhe €/Kwht]	0,12	€	0,12	€
Energy consumption [Watt e/t]	36	W	18	W
Lifetime energy consumption [kWh e/t]	18.202,06	kWh e/t	9.101,03	kWh e/t
Total energy cost [€]	2.184,25	€	1.092,12	€
Emissions				
Kg of CO2/kWh	0,430	kg t	0,430	kg t
Total of CO2 avoided [ton]	0,000		3,913	
Economic value of CO2 [€/ton]	7,29	€	7,29	€
Total economic value of avoided CO2 [€]	0,0	€	28,5	€
Total life cycle costs	**7.355,82**	**€**	**3.611,10**	**€**

Table 3: Terrassa case

In the Terrassa case indoor (office) lighting was tested; the sustainable product was a fluorescent LED. This test is a good example of the usefulness of the LCC tool. The lowest-price product was clearly less expensive considering the initial purchase price (less than a quarter of the cost), but in the end, the sustainable LCC was less than half the LCC of the lowest-price option. There is not always such a dramatic difference as seen in this test, but it is typical that the lowest-price option will be more expensive in the end than the sustainable price.

The maintenance considers hourly wage, the cost of labor depends on the country. In the period of GRASP project (2013-2015), the cost was €20.99/hour in Spain, €35.47/hour in France, €28.44/hour and in Italy.

3.5 PABBC/Atlantis case

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	1475076,40	€	1492271,90	€
Lifetime [years]	20,00	y	20,00	y
Comparable number of replacements [n]	1,00	n	1,00	n
Total Cost [€]	1.475.076,40	€	1.492.271,90	€
Duration				
Lifetime [years]	20	y	20	y
Average yearly time usage [hours/year]	1.301	h/y	1.301	h/y
Total usage time [hours]	26020	h	26020	h
Number of purchases [n]	1	n	1	n
Total [hours]	26020	h	26020	h
Maintenance				
Number of years [years]	20	y	20	y
Units per year [work hour, kwp, page…]	338,00	n	331,00	n
Cost per unit [€]	280,00	€	270,00	€
Total [€]	1892800	€	1787400	€
Energy costs				
Price of energy [€/Kwhe €/Kwht]	0,20	€	0,20	€
Energy consumption [Watt e/t]	-992250	W	-992250	W
Lifetime energy consumption [kWh e/t]	-25.818.345,00	kWh e/t	-25.818.345,00	kWh e/t
Total energy cost [€]	-5.163.669,00	€	-5.163.669,00	€
Emissions				
Kg of CO_2/kWh	0,430	kg	0,430	kg
Total of CO_2 avoided [ton]	0,000	t	0,000	t
Economic value of CO_2 [€/ton]	7,29	€	7,29	€
Total economic value of avoided CO_2 [€]	0,0	€	0,0	€
Total life cycle costs	**-1.795.792,60**	**€**	**-1.883.997,10**	**€**

Table 4: PABBC/Atlantis case

This joint case verified the effectiveness of a green tender with 10 different bids of photovoltaic plants with same power. For this test, the lowest-price product is not as efficient as the sustainable-price. This case is interesting though for the fact that it produces energy (which is the cause of the negative value under energy consumption/production in the tool) instead of consuming it. The final result of this experiment is a negative value for the LCC which indicates that both products have the possibility of not only saving money for the organizations if the energy is completely used where it is produced (as assumed in this case), but also making money for them if there is an excess, which can be a complicated calculation and very case specific.

Since both products are renewable energy sources, the tool in this case takes into account the efficiency and maintenance of each to choose which product will provide more savings. In particular the sustainable-price product has a lower maintenance cost which makes it the more efficient and economical.

This is a good example of the fact that green products can be an economically-friendly investment. Not only are energy costs avoided, but the excess energy produced can also be distributed or sold to other places to avoid using energy created by greenhouse gas-emitting sources.

3.6 Spata-Artemis A case

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	3,00	€	10,00	€
Lifetime [years]	1,00	y	7,00	y
Comparable number of replacements [n]	7,00	n	1,00	n
Total Cost [€]	609,00	€	290,00	€
Duration				
Lifetime [years]	7	y	7	y
Average yearly time usage [hours/year]	4.015	h/y	4.015	h/y
Total usage time [hours]	28105	h	28105	h
Number of purchases [n]	29	n	29	n
Total [hours]	815045	h	815045	h
Maintenance				
Number of years [years]	7	y	7	y
Units per year [work hour, kwp, page…]	0,00	n	0,00	n
Cost per unit [€]	0,00	€	0,00	€
Total [€]	0	€	0	€
Energy costs				
Price of energy [€/Kwhe €/Kwht]	0,14	€	0,14	€
Energy consumption [Watt e/t]	125	W	57	W
Lifetime energy consumption [kWh e/t]	101.880,63	kWh e/t	46.457,57	kWh e/t
Total energy cost [€]	13.753,88	€	6.271,77	€
Emissions				
Kg of CO2/kWh	0,904	kg	0,904	kg
Total of CO2 avoided [ton]	0,000	t	50,102	t
Economic value of CO2 [€/ton]	7,02	€	7,02	€
Total economic value of avoided CO2 [€]	0,0	€	351,7	€
Total life cycle costs	**14.362,88**	**€**	**6.210,05**	**€**

Table 5: Spata-Artemis A case

The case of Spata-Artemis dealt again with replacement of conventional light bulbs with LEDs. This is another typical case of an environment-friendly priced product having a lower LCC, and this is also a good example of the amount of CO_2 that can be avoided by choosing a green product. Compared to the conventional bulb, the LED avoids 50,102 tons of CO_2. A decrease of this proportion in every municipality would be a large drop in overall emissions for any territory. This experiment shows that when these green characteristics are taken into account, there are many economical and environmental benefits as a result of choosing the environment-friendly product.

3.7 Spata-Artemis B case

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	4500,00	€	5675,00	€
Lifetime [years]	30,00	y	30,00	y
Comparable number of replacements	1,00	n	1,00	n
Total Cost [€]	4.500,00	€	5.675,00	€
Duration				
Lifetime [years]	30	y	30	y
Average yearly time usage [hours/year]	489	h/y	462	h/y
Total usage time [hours]	14659	h	13871	h
Number of purchases	1	n	1	n
Total [hours]	14659	h	13871	h
Maintenance				
Number of years [years]	30	y	30	y
Units per year [work hour, kwp, page…]	0,00	n	0,00	n
Cost per unit [€]	0,00	€	0,00	€
Total [€]	0	€	0	€
Energy costs				
Price of energy [€/Kwhe €/Kwht]	0,10	€	0,10	€
Energy consumption [Watt e/t]	160000	W	160000	W
Lifetime energy consumption [kWh e/t]	2.345.454,55	kWh e/t	2.219.354,84	kWh e/t
Total energy cost [€]	232.223,22	€	219.738,10	€
Emissions				
Kg of CO2/kWh	0,265	kg	0,265	kg
Total of CO2 avoided [ton]	0,000	t	33,416	t
Economic value of CO2 [€/ton]	0	€	0	€
Total economic value of avoided CO2	0,0	€	0,0	€
Total life cycle costs	**236.723,22**	**€**	**225.413,10**	**€**

Table 6: Spata-Artemis B case

In Spata-Artemis case B, a few modifications have been introduced to test operations concerning the energy efficiency of the buildings. This experiment explains the differences between the lowest cost item and the environment-friendly item over a 30 year span. Within this experiment, the real work hours of each product is considered, which both consume the same amount of energy. The efficiency of the boilers was considered, which contributed to the increase in hours to reach the target energy consumption. The following table, sheet "Conversion tables", has to be used to foresee the real work hours needed to correct the difference between the two products' energy efficiency.

	Theoretical Work Hours	Efficiency	Real Work Hours
Lowest Price	430	88,00%	488,64
Sustainable Price	430	93,00%	462,37

Table 7: Theoretical and real boiler work

Differently from previous cases, the fields named "Average yearly time usage" of the LCC sheet has to be filled in with the values obtained from the column "Real Work Hours". In addition to considering the real work hours of each product, several types of fuel were considered. Because all types of fuel are converted into comparable terms, the LCC tool can also be used to assess the operations concerning the energy efficiency of the buildings. The price per kWh was used for all kinds of available fuels and CO2 avoided was calculated according to the official conventions as reported in the following table (second table of the sheet "Conversion tables"). Data of the used specific fuel, obtained from the columns "Price" and "KgCO2/kwh," have to be entered into the fields "Price of energy" and "Kg of CO2/kWh" from the LCC sheet. It is particularly important to emphasize the biomass in the following table; the initial fuel contains carbon and then generates CO2, but that carbon is the very same biomass that is subtracted from the atmosphere. Therefore, in the case of wood and pellet, it is considered a recycling circle of equal amounts of CO2 produced and eliminated. Due to these particular cases, the CO2 factor is conventionally set at zero.

Fuel	Kw/mc, kw/kg, kw/l	Price	€/kwh	Kg CO2/kwh
Natural Gas	9,40		0,0000	0,200
Diesel	10,10	1,000	0,0990	0,265
Fuel Oil	10,52		0,0000	0,275
Lpg	7,00		0,0000	0,234
Wood	3,80		0,0000	0
Pellet	4,50		0,0000	0

Table 8: Fuel typology transformations

In conclusion, factoring the real work hours due to the difference in energy efficiency and converting all fuel into comparable terms, the environment-friendly product was more cost efficient in regards to the total life cost. Therefore, the savings over the total life of the product and the 33,416 tons of avoided CO2 over 30 years make the environment-friendly product the better choice.

3.8 Castellón case

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	585,00	€	995,00	€
Lifetime [years]	18,00	y	25,00	y
Comparable number of replacements [n]	1,39	n	1,00	n
Total Cost [€]	4.062,50	€	4.975,00	€
Duration				
Lifetime [years]	25	y	25	y
Average yearly time usage [hours/year]	3.650	h/y	3.650	h/y
Total usage time [hours]	91250	h	91250	h
Number of purchases [n]	5	n	5	n
Total [hours]	456250	h	456250	h
Maintenance				
Number of years [years]	25	y	25	y
Units per year [work hour, kwp, page…]	1,00	n	1,00	n
Cost per unit [€]	50,00	€	50,00	€
Total [€]	1250	€	1250	€
Energy costs				
Price of energy [€/Kwhe €/Kwht]	0,12	€	0,12	€
Energy consumption [Watt e/t]	0	W	0	W
Lifetime energy consumption [kWh e/t] Total energy cost [€]	0,00	kWh e/t	0,00	kWh e/t
	0,00	€	0,00	€
Emissions				
Kg of CO2/kWh	0,430	kg	0,430	kg
Total of CO2 avoided [ton]	0,000	t	0,000	t
Economic value of CO2 [€/ton]	7,02	€	7,02	€
Total economic value of avoided CO2 [€]	0,0	€	0,0	€
Total life cycle costs	**5.312,50**	**€**	**6.225,00**	**€**

Table 9: Castellón case

Castellón ran a test case for this experiment by comparing two different types of solar boilers with very similar specifications. The only two differences between the products were the lifetime and the price. Due to this, the only results that needed to be considered were the effects that they created. After this calculation, it was clear that the lowest price product was more economically beneficial. To solve this, the lifetime of the sustainable-price product would need to be increased (by about 6 years for this comparison), or its price would need to be decreased.

This case is interesting because it shows that there are times when the lowest-price product will be more economically beneficial than the green product, but it also shows that this tool is not limited to comparisons between products that are green and not green, but it can compare any two products. Thus when deciding between several green products such as these, this tool is still helpful.

3.9 RAIS case (EE - natural gas)

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	0,00	€	0,00	€
Lifetime [years]	1,00	y	25,00	y
Comparable number of replacements [n]	25,00	n	1,00	n
Total Cost [€]	0,00	€	0,00	€
Duration				
Lifetime [years]	25	y	25	y
Average yearly time usage [hours/year]	1.000	h/y	1.000	h/y
Total usage time [hours]	25000	h	25000	h
Number of purchases [n]	1	n	1	n
Total [hours]	25000	h	25000	h
Maintenance				
Number of years [years]	25	y	25	y
Units per year [work hour, kwp, page…]	0,00	n	0,00	n
Cost per unit [€]	0,00	€	0,00	€
Total [€]	0	€	0	€
Energy costs				
Price of energy [€/l]	0,57	€	0,57	€
Energy Consumption [KW or Watt e/t, m3 l...]	26741	W	10899	W
Lifetime energy consumption [kWh e/t, m3, l...]	668.534,50	kWh e/t	272.466,00	kWh e/t
Total energy costs [€]	383.070,27	€	156.123,02	€
Emissions				
Kg of CO2 per kWh, m3, l or kg	0,200	kg	0,200	kg
Total of CO2 avoided [ton]	0,000	t	79,214	t
Economic value of CO2 [€/ton]	7,02	€	7,02	€
Total economic value of avoided CO2 [€]	0,0	€	556,1	€
Total life cycle costs	**383.070,27**	**€**	**155.566,94**	**€**

Table 10: RAIS case (EE - natural gas)

RAIS case is a very problematic but interesting test. It is a building retrofitting operation that uses different forms of energy sources.

In particular, this is an improvement of the thermal efficiency of the exterior walls of the building but this example can apply also to a roof or other parts such as windows, doors, but it contains a change of the energy sources to warm the building up too. Because the energy performance of the existing building was improved, this case applies substitution, which is one of three different examples of usage; thus, the companies, participating in the tender, can be selected by the lowest price criterion.

The case is complicated because there are three different sources to be considered (natural gas, fuel oil, and electricity). This aspect implies three different LCC sheets to calculate the overall cost. Unfortunately, the previous format cannot be used because the data on installed power and the efficiency of the plants and an estimation of the time usage is missing. For this reason, the file was adapted to allow the study of this case. If the aforementioned data had been provided, then the experiment could have been formatted with the previous format used for the other tests and its tables conversion sheet. Including these last modifications we should be able to deal with energy efficiency operation as well.

The first table describes the changes in the consumption of natural gas. Passing from the unaltered to improved building in regards to the energy consumption, the use of natural gas is less than half for the improved building. Beyond the energy saving due to the reduction of fuel consumption, the operation allows to reduce CO2 emissions.

3.10 RAIS case (EE – electricity)

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	0,00	€	0,00	€
Lifetime [years]	25,00	y	25,00	y
Comparable number of replacements [n]	1,00	n	1,00	n
Total Cost [€]	0,00	€	0,00	€
Duration				
Lifetime [years]	25	y	25	y
Average yearly time usage [hours/year]	1.000	h/y	1.000	h/y
Total usage time [hours]	25000	h	25000	h
Number of purchases [n]	1	n	1	n
Total [hours]	25000	h	25000	h
Maintenance				
Number of years [years]	25	y	25	y
Units per year [work hour, kwp, page…]	0,00	n	0,00	n
Cost per unit [€]	0,00	€	0,00	€
Total [€]	0	€	0	€
Energy costs				
Price of energy [€/l]	0,04	€	0,04	€
Energy Consumption [KW or Watt e/t, m3 l...]	166146	W	300514	W
Lifetime energy consumption [kWh e/t, m3, l...]	4.153.650,75	kWh e/t	7.512.846,50	kWh e/t
Total energy costs [€]	147.039,24	€	265.954,77	€
Emissions				
Kg of CO2 per kWh, m3, l or kg	0,386	kg	0,386	kg
Total of CO2 avoided [ton]	0,000	t	-1296,895	t
Economic value of CO2 [€/ton]	7,02	€	7,02	€
Total economic value of avoided CO2 [€]	0,0	€	-9.104,2	€
Total life cycle costs	**147.039,24**	**€**	**275.058,97**	**€**

Table 11: RAIS case (EE – electricity)

The second table shows the difference in electricity before and after the modification. In this case the consumption of energy is higher in the improved buildings.

3.11 RAIS case (fuel oil)

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	0,00	€	0,00	€
Lifetime [years]	25,00	y	25,00	y
Comparable number of replacements [n]	1,00	n	1,00	n
Total Cost [€]	0,00	€	0,00	€
Duration				
Lifetime [years]	25	y	25	y
Average yearly time usage [hours/year]	1.000	h/y	1.000	h/y
Total usage time [hours]	25000	h	25000	h
Number of purchases [n]	1	n	1	n
Total [hours]	25000	h	25000	h
Maintenance				
Number of years [years]	25	y	25	y
Units per year [work hour, kwp, page…]	0,00	n	0,00	n
Cost per unit [€]	0,00	€	0,00	€
Total [€]	0	€	0	€
Energy costs				
Price of energy [€/l]	1,04	€	1,04	€
Energy Consumption [KW or Watt e/t, m3 l...]	13764	W	0	W
Lifetime energy consumption [kWh e/t, m3, l...]	344.087,66	kWh e/t	0,00	kWh e/t
Total energy costs [€]	357.162,99	€	0,00	€
Emissions				
Kg of CO2 per kWh, m3, l or kg	0,275	kg	0,275	kg
Total of CO2 avoided [ton]	0,000	t	94,624	t
Economic value of CO2 [€/ton]	7,02	€	7,02	€
Total economic value of avoided CO2 [€]	0,0	€	664,3	€
Total life cycle costs	**357.162,99**	**€**	**-664,26**	**€**

Table 12: RAIS case (fuel and oil)

The third table describes the usage of fuel oil, which is the last source of energy. Energy consumption originated by this source of energy, is zero for the improved building, while before the consumption was substantially higher (13764 W).

The final assessment, found in the conclusion, is the sum of the total LCC of all three different energy sources.

3.12 Conclusion

This tool if very useful for the **comparison of a large variety of products**. With this tool, the users will be able to visualize in many cases the economic and environmental benefits of their choices. It is easy to use, but it is also **very powerful in its different operations**, and at this point the only missing component is waste disposal, but considering the many different methods of computing this (depending on materials, location, and other factors), it was not included in the tool. Public Administration staff can utilize this tool to simply reduce costs within the organization, or it can be used within a Sustainable Energy Action Plan (SEAP) as a way to reduce energy consumption and the emission of greenhouse gasses. In this way, the outcomes of the GRASPINNO project can be realized.

PP	Test/Pilot	Lowest Price	Environment-Friendly Price	Price Difference	LCC (Difference)	Avoided CO2 (ton)
Perugia A	P	0,00	0,00	0,00 EUR	1.581,56 EUR	4,187
Perugia B	P	0,00	0,00	0,00 EUR	918,81 EUR	4,187
IRISS	P	5940,00	5992,00	-52,00 EUR	-1.285,66 EUR	-6,66
SIEEP	P	663,00	91650,00	-90.987,00 EUR	123.688,83 EUR	763,26
Terassa	T	446,60	1960,00	-1.513,40 EUR	3.744,53 EUR	3,91
PABBC	T	1475076,40	1492271,90	-17.195,50 EUR	88.204,50 EUR	0,00
Spata-Art. A	T	87,00	290,00	-203,00 EUR	8.152,83 EUR	50,10
Spata-Art. B	P	4500,00	5675,00	-1.175,00 EUR	11.310,12 EUR	33,416
Atlantis	T	1475076,40	1492271,90	-17.195,50 EUR	88.204,50 EUR	0,00
Castellon	T	2.925,00	4.975,00	-2.050,00 EUR	-912,50 EUR	0,00
Hortiatis-Pilea	T	1940,00	3000,00	-1.060,00 EUR	1.319,34 EUR	6,60
UniVlora	T	2640,00	2920,00	-280,00 EUR	-240,69 EUR	0,129
RAIS	T	0,00	0,00	0,00 EUR	457.310,85 EUR	-1123,05

Table 13: Numerical Summary

The previous table is a summary of all the pilots and tests carried out in GRASP project; it gives indications in order to have a precise evaluation of a tender under an economic and environmental point of view. For each product, the table shows information on the tender (test/pilot), the price, a first evaluation considering only the price (Price difference), a second evaluation considering LCC and a third one based only on an environmental item

(CO2 emissions or GHG equivalent). With a rapid glance, observing the numbers in red color, indicating a relative negative evaluation, a clear picture may be defined:

- ✓ the price of the green product is often more expensive than the other;
- ✓ considering the lifetime (LCC), a sustainable product is often cheaper.

At the same time, with the same data we may guess that preparing a GPP tender does not give us the guarantee to:

- have the best economic choice for the Public Administration; if it was so, no red numbers would be in the LCC column;
- have the best environmental choice for the Public Administration.

The cases studied with the GRASP Project have been integrated with other EE/RES products for buildings. An interesting EE tool is the voltage transformer that reduces and stabilizes the potential difference in the electrical network allowing a reduction of the energy consumption around 15%. In the next page a feasibility study on a public building of the Province of Perugia is represented using a classical LCC table:

Perugia Province case

	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	0,00	€	66521,00	€
Lifetime [years]	10,00	y	10,00	y
Comparable number of replacements	1,00	n	1,00	n
Total Cost [€]	0,00	€	66.521,00	€
Duration				
Lifetime [years]	10	y	10	y
Average yearly time usage [hours/year]	1	h/y	1	h/y
Total usage time [hours]	10	h	10	h
Number of purchases	1	n	1	n
Total [hours]	10	h	10	h
Maintenance				
Number of years [years]	10	y	10	y
Units per year [work hour, kwp, page…]	0,00	n	0,00	n
Cost per unit [€]	0,00	€	0,00	€
Total [€]	0	€	0	€
Energy costs				
Price of energy [€/Kwhe €/Kwht]	0,16	€	0,16	€
Energy consumption/production [Watt e/t]	733804000	W	623733000	W
Lifetime energy consumption [kWh e/t]	7.338.040,00	kWh e/t	6.237.330,00	kWh e/t
Total energy cost [€]	1.176.283,72	€	999.840,52	€
Emissions				
Kg of CO2/kWh	0,405	kg	0,405	kg
Total of CO2 avoided [ton]	0,000	t	445,405	t
Economic value of CO2 [€/ton]	5,24	€	5,24	€
Total economic value of avoided CO2	0,0	€	2.333,9	€
Total life cycle costs	**1.176.283,72**	**€**	**1.064.027,61**	**€**

Table 14: Perugia Province case

To use the same LCC tool with this kind of product, with very small arrangements are needed. In the table is described the energy consumption of a public building in absence and in presence of a voltage transformer. Fixed the lifetime of the EE product, the same duration has to be considered for the condition without investment (for instance, if the product lifetime is 10 years, then you consider the same period simulating a consumption without investment for the same time-lapse). In this case, time usage will be equal to 1 and energy consumption is not referred to the power but to the yearly amount of consumption because the transformer is not applied to a specific device but to almost all electrical and electronic equipment used in the building. The assessment of the voltage transformer has the same characteristics of the other products (specific values for LCC and CO_2 emissions): if they, after the introduction of this product, are lower, the evaluation of the investment is completely positive.

Other possible application of LCC in the EE of building may be:

- the use of thermostats or other instruments to control the temperature; in this case the use of the LCC tool is simpler because it is usually applied to product already analyzed like boilers. The attainment of the established temperature reduces the number of working hours. When the yearly working hours of the boiler are known, an estimation of the reduction of the hours in which the boiler is turn on is enough to calculate the energy saving and, thus, LCC and CO_2 emissions.
- Air conditioning plants; obtaining the LCC is similar to any other electrical and

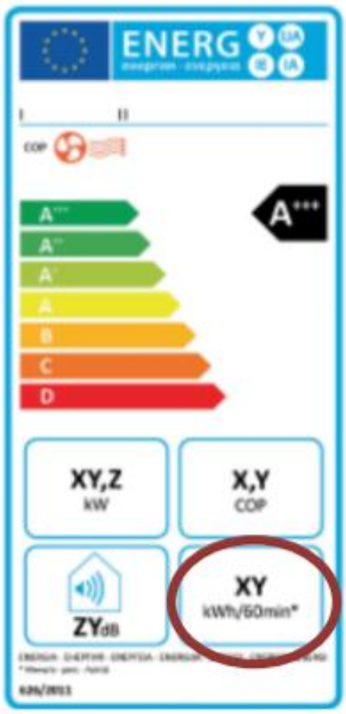

Figure 1: Air conditioning label

electronic equipment. The sole difference consists in use the value of electrical consumption that is located inside the red circle drawn on the product label (see below) instead of the declared value of real power. It represents the real consumption per hour both for the heating and cooling of the building.

The yearly energy consumption is obtained multiplying this value by the estimated number of working hours. Obviously, the assessment in economic and environmental terms has the same characteristics of the other products.

Project co-financed by the European
Regional Development Fund

4. Introduction to the ex ante LLC

The ex post LCC tool gives a correct evaluation of the tender in economic and environmental terms but the assessment arrives when the tender is already published and eventual corrections to it are not possible anymore. With an ex-post evaluation only the experience can help to formulate the tender with a correct setting and the verification is useful only in perspective. GRASPINNO testing phase has been exploited to introduce an ex-ante application to be used after the audit or like a pre-audit system. This usage allows the Public Administration to avoid, in absence of a prompt audit, to prepare a tender where the winning company has to prepare a refurbishment together with a planning. This kind of tender is a correct GPP procedure but it is generally considered unclear and dangerous by the small municipalities because the real costs and benefits are defined by the company that will refurbish the building. Small Public Bodies often are not able to control the real cost of this kind of operation not having at own disposal the right instruments and available human resources. A third part approach with an ex-ante application of LCC could help to guarantee an equal distribution of cost saving between company and Public Administration.

The Directive 2014/24/EU significantly innovates the process of tenders awarding, through assigning a relevant importance to LCC. New contract award criteria have been introduced in Article 67: "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 means that in any country in which there is a transposition of the Directive in the national legislation would be possible to adopt the same procedures.

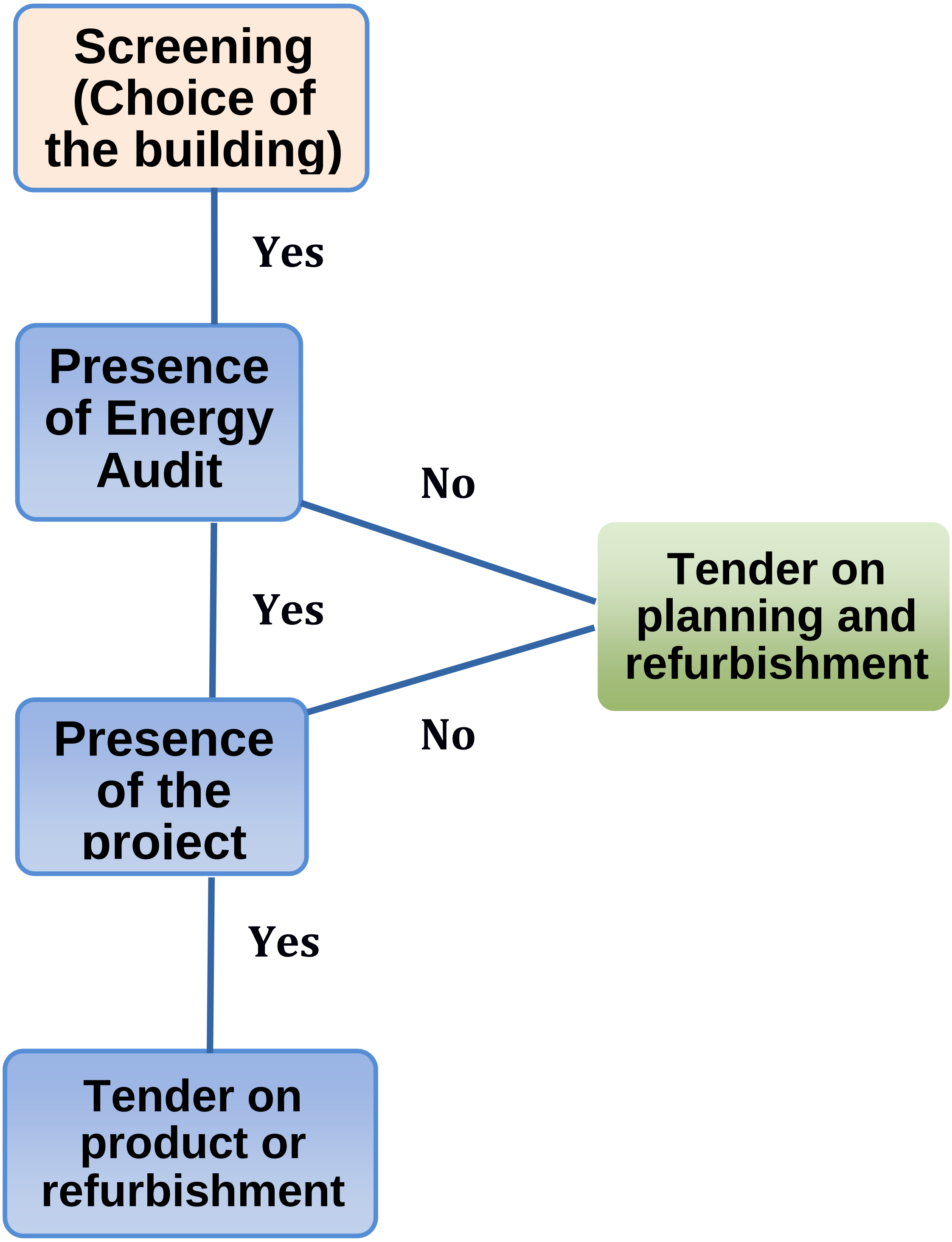

Figure 2: Ex-Ante Application

As showed in the previous figure (ex ante application) the new tool is very suitable for situations in which small municipalities or other public bodies with a scarce availability of financial resources aim to refurbish their buildings. The local experience originated by local pilots showed contexts in which the local body had no financial opportunities to prepare a specific audit or project. In these cases the tool seems somewhat effective in implementing the tender correctly and allowing the execution of the compulsory preliminary steps (energy audit and project) through a Public and Private Partnership (PPP) where the choices are carried out by selecting the intervention through a payback ranking in which products or services are chosen starting from those with the shortest payback. For other traditional (public) solutions the ex ante tool leave the opportunity to use the Life Cycle Cost of the interventions as a ranking criterion instead of the payback, by starting from those with the lowest cost.

Another interesting characteristic of the new tool is the use of real preliminary data to calculate the energy class of the building. EE tools often use theoretical estimations of the energy consumptions but this can give a relevant bias in the overall assessment because of a great difference between the estimation of the theoretical value and the real value of the energy index. The ex ante tool avoids this problem by uploading real data obtained in the GRASPINNO analysis through the collection of electricity and natural gas bills for a relevant number of buildings. The following figure shows this issue with a study **carried out by CasaClima / KlimaHaus Agency**, located in Alto Adige / Südtirol. **The image includes some contents in Italian, German and English language, but it easily represents the possible bias in calculating the energy class before (prebound) and after (rebound) the intervention.** Not always facing this problem is possible but, by uploading real data on energy consumption, **the "prebound" bias can be eliminated**.

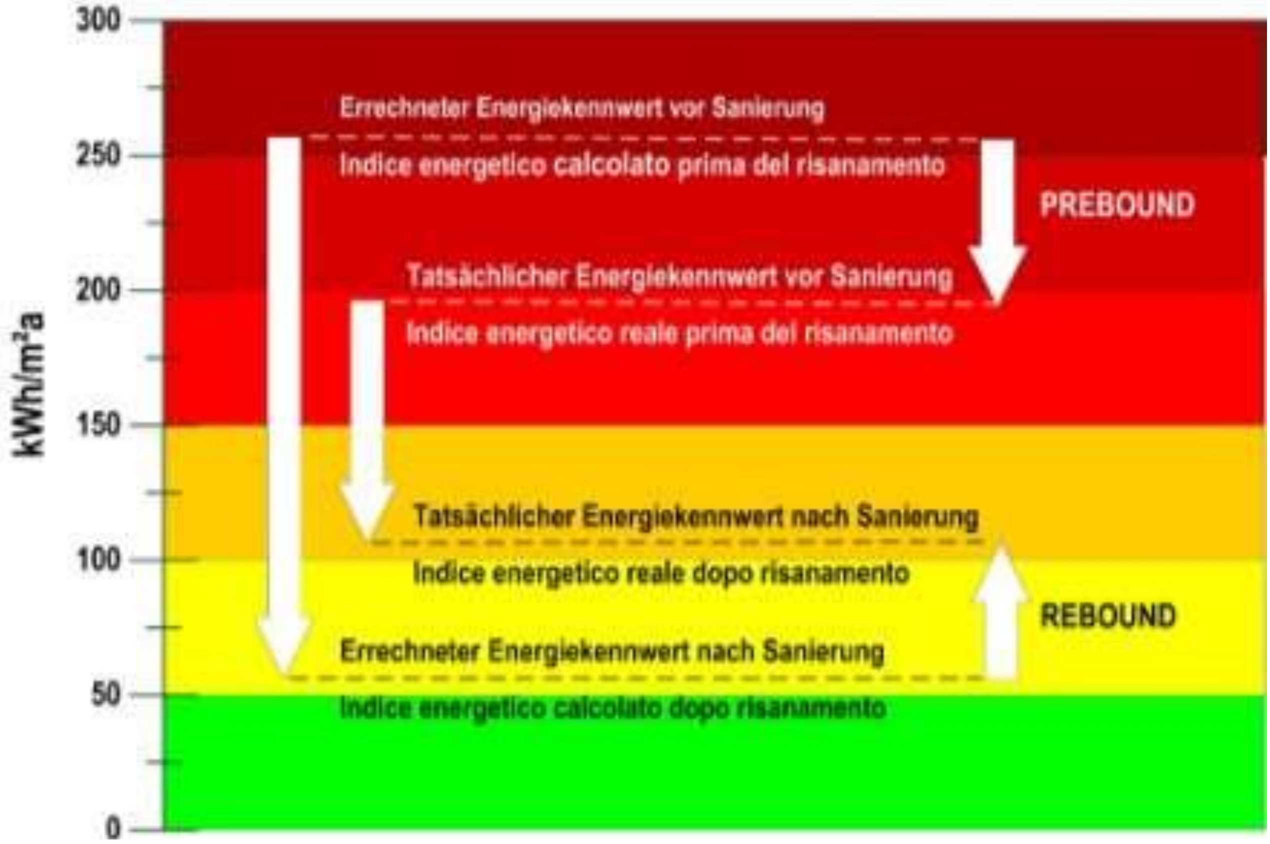

Figure 3: Prebound and rebound. Study carried out by CasaClima / KlimaHaus Agency. The image shows the real energy ratio before of the intervention (prebound) and after the intervention (rebound).

A series of possible interventions considers the main solutions used in the energy refurbishment of the buildings (building automation, lighting, solar heating, voltage transformer, boiler, insulation of roof and walls, insulation of windows and doors) but the greatest difference, in comparison with the ex post LCC tool, is the modality of use. In fact, the new instrument can be utilized **before the tender in order to implement it correctly** through some indications of cost that highlight the limit parameters to obtain a lower LCC. In other words, the tool works as a simulation of the refurbishment by giving indication on prices, quantities and typologies of products that allow to face a series of issues and guarantee good results in economic and environmental terms in a real tender.

A first step in using the tool is to set the **amount of energy savings by indicating the target percentage**. Automatically, as shown in the following image, the instrument, at the sheet number 3 named "Energy Class", is able to identify the thermal and electrical class. After this step, the user can choose the type of intervention to achieve the goal, with full awareness of following a specific strategy that can be a shortest payback or a lower LCC. The strategy is chosen by the Public Administration on the framework illustrated in figure n. 1: a traditional path that arrives at a tender on products or refurbishment or, alternatively, a PPP solution in which the subject of the tender can be the planning and restructuring phase.

The different path is important for defining the selection criteria. For a traditional path, the prevalence is the public interest and the strategy identified is LCC, while for the PPP the priority is the private financier and the chosen strategy is the shortest payback. Hybrid strategies that simultaneously take into account public and private interests are possible.

ENERGY CLASS	Inizial Index	
Index thermal (kWh/year/sm)	51,9	attuale
Index thermal (kWh/year/cm)	12,3	attesa
Electrical index (kWh/year/sm)	126,9	
Electrical index (kWh/year/cm)	30,1	

Target in terms of reduction of consumption through intervention of energy efficiency	Reduction	Final Index
Thermal	60%	20,8
Electrical	37%	80,0

Energy Class	Ex ANTE	Ex POST
Thermal	B	A+
Electrical	D	C+

Table 15: "Energy class" sheet of the ex ante LCC tool

A key representation of the payback approach and its possible results is contained in the sheet n.5 of the ex ante LCC tool named «target» and showed in the following figure 5. In the table is reported the current consumption and the expected typology of saving chosen in the previous «class» sheet and already showed in the figure 4. In addition, the thermal and electrical saving of a series of possible interventions are showed together with their sum, while in the column "Differences compared to the expected savings" there is the difference between the energy saving target and the value obtained by the sum of the chosen interventions. Practically, the values reported in the last column, -1,3%, for the thermal component, and -32,6%, for the electrical component, indicate that the energy saving targets haven't been reached.

	Current Consumption	Expected savings	1. Building Automation	2. Lighting	3. Solar heating	4. Transformer	5. Condensing boiler	6. Insulation (roof and external walls)	7. Windows and doors	Sum of the interventions	Differences compared to the expected savings
* tons TOE (thermal)	5,26	3,16	0,00	0,00	0,00	0,00	0,00	1,78	2,82	4,60	45,8%
* tons TOE (elettrici)	8,42	3,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-100,0%
* tons TOE	13,68	6,27	0,00	0,00	0,00	0,00	0,00	1,78	2,82	4,60	-26,6%
* CO2 (.000)	28,10	13,11	0,00	0,00	0,00	0,00	0,00	3,99	9,55	13,54	
* Euro	€ 13.966	€ 6.198	€ 0	€ 0	€ 0	€ 0	€ 0	€ 1.519	€ 3.633	€ 5.152	
* Yearly TEE - White certificates (Italy)	€ 4.104	€ 1.881	€ 0	€ 0	€ 0	€ 0	€ 0	€ 535	€ 846	€ 1.381	
* saved % of the total consumption	100,0%	45,8%	0,0%	0,0%	0,0%	0,0%	0,0%	13,0%	20,6%	33,7%	
Difference in yearly maintenance costs			0	0	0	0	0	0	0	0	
Payback (PB) – number of year			-	-	-	-	-	43,30	34,44	37,23	
Environment-friendly Product											
Price (€) *			0	0	0	0	0	88.913	154.296	243.210	
Maintenance (€)			0	0	0	0	1.800	0	0		
Energy costs (€)			334.249	0	0	189.678	39.922	59.884	59.884		
Emissions -Economic value of avoided CO2 (€)			0	0	0	0	0	-705	-645		
Life Cycle Cost (€)			334.249	0	0	189.678	41.722	148.092	213.535		
Lifetime (year)	30		30	6	20	20	20	30	30		
LCC difference (absolute value)			0	0	0	0	0	57.521	124.631		
LCC savings (period determined by the intervention with the longest lifetime)			0	0	0	0	0	57.521	124.631	182.151	
Lowest Price Product or Ex ante condition											
Price (€)			0	0	0	0	0	0	0		
Replacement (€)			0	0	0	0	0	0	0		
Maintenance (€)	2.700		0	0	0	0	1.800	0	0		
Energy costs (€)	418.982		334.249	0	0	189.678	39.922	90.571	88.905		
Life Cycle Cost (€)	421.682		334.249	0	0	189.678	41.722	90.571	88.905	603.833	

Table 16: "Target Payback" sheet of the ex ante LCC tool

Two typologies of corrections are possible to reach the targets; in case of a small difference between the saving target and that obtained by the sum of the single interventions, like the thermal component, a solution can consist in strengthening the chosen interventions starting from that with the shortest payback, while, in case of relevant difference, like the electrical component, could be more appropriated to reduce the energy saving target fixed in the «class» sheet Fig 4. In the lower part of the table is reported the LCC values of the interventions and their variations in absolute and relative (%) terms.

A similar representation for the LCC approach is reported in the figure 6. The framework of the table is a little different because the payback ranking doesn't matter. In this case, the ranking is defined through the standardized LCC in which the analysis of the costs is carried out considering the maximum lifetime of the foreseen interventions. The order obtained with the standardized LCC will be used in place of the payback to define the interventions with which the building will be refurbished. The further step will be to fill in the table in the sheet with the specific data for every chosen product.

	Current Consumption	1. Building Automation	2. Lighting	3. Solar heating	4. Transformer	5. Condensing boiler	6. Insulation (roof and external walls)	7. Windows and doors
* tons TOE (thermal)	5,26	0,00	0,00	0,00	0,00	0,00	1,78	4,27
* tons TOE (elettrici)	8,42	0,00	0,00	0,00	0,00	0,00	0,00	0,00
* tons TOE	13,68	0,00	0,00	0,00	0,00	0,00	1,78	4,27
* CO2 (.000)	28,10	0,00	0,00	0,00	0,00	0,00	3,99	9,55
* Euro	€ 13.966	€ 0	€ 0	€ 0	€ 0	€ 0	€ 1.519	€ 3.633
* Yearly TEE - White certificates (Italy)	€ 4.104	€ 0	€ 0	€ 0	€ 0	€ 0	€ 535	€ 1.280
* saved % of the total consumption	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	13,0%	31,2%
Difference in yearly maintenance costs		0	0	0	0	0	0	0
Payback (PB) – number of year		-	-	-	-	-	43,30	31,40
Environment-friendly Product								
Price (€) *	0	0	0	0	0	0	88.913	154.296
Maintenance (€)	2.700	2.700	540	2.700	2.700	2.700	2.700	2.700
Energy costs (€)	418.982	418.982	418.982	418.982	418.982	284.517	368.278	372.622
Emissions - Economic value of avoided CO2 (€)	0	0	0	0	0	0	-705	-645
Life Cycle Cost (€) - Standardized at the longest lifetime	421.682	421.682	419.522	421.682	421.682	287.217	459.187	528.974
Lifetime (year)	30	30	6	20	20	20	30	30
LCC difference (percentage)		0,0%	-0,5%	0,0%	0,0%	-31,9%	8,9%	25,4%

Table 17: "Target LCC" sheet of the ex ante LCC tool

5. Levels of efficiency

With the introduction of the ex ante LCC tool, a new technical evaluation was needed to measure the capability of the new and old tools to improve their effectiveness in reducing the LCC in the building refurbishment.

According to the European and national legislations, a tender is regular when it contains all the requested GPP criteria, but it still can present some negative environmental and economic impacts. The LCC tools (ex ante and ex post) try to verify these aspects. In other words, the tool gives the opportunity to avoid this bias through some Technical Performance Indicators (TPIs).

For the individuation of Technical Performance Indicators (TPIs) an evaluation table (see below) has been introduced with three levels of efficiency. Every tender can be assessed with this method.

A first level of efficiency is given by the timing of the use; in particular, an ex ante use of the LCC tool has a higher value of efficiency because it can avoid the generation a bad result after the implementation of the tender (a bad implementation means a generation of a higher value of LCC or CO2). In theory, this level would be enough for assessing the tender and the further levels wouldn't be needed because the ex ante application is able to avoid a bad result by modifying some specifications of the same tender before the publication. It means that if the LCC or GHG emissions value is higher than the previous situation, a Public Administration should change products for the energy refurbishment (increasing the performance) or reduce their price.

A second level of efficiency is given by a LCC value that can be obtained by comparing the results of the LCC as found through the the tool; if the value of the new product/service is higher than the old one, then the tender has had a bad result. This level is considered to be higher than the third one, because it can offset a higher emission value, the sole element measured by the third order level. In fact, LCC value contains also the emissions value, if the cost is lower than a previous situation it means that is able to offset the value of the emissions.

A third level of efficiency is given by the emission value obtained through the tool; if the value is higher than before the intervention, then the tender has had a bad result.

A clear representation of the scheme of the Technical Performance Indicators (TPIs) is available in the following table:

Level	Order	Presence (score)	Absence (score)
Ex ante LCC application	I	Yes (3)	No (0)
New product with lower LCC value	II	Yes (2)	No (0)
New product with lower CO2 emission value	III	Yes (1)	No (0)

Table 18: Measurement of the efficiency of the LCC tools

With this system of Technical Performance Indicators the partnership is able to classify the results of any tender on the basis of the table described in the table 1. The first level indicator would be already enough to establish that the tender procedure is correct.

Even if the presence of human errors cannot be excluded, in theory a technician has a powerful instrument (ex ante LCC tool) to avoid a bad result in the tender procedure. An unexpected results that could occur with the previous version of the tool (ex post LCC tool), can be corrected only changing the specifications of the future tenders that have the same characteristics; moreover, with the old tool the presence of errors doesn't mean that the tender is not valid; even if the procedure seems formally correct, the tender could be not set up well.

In the event of an ex post application, the second and the third levels should be verified. The second-level indicator has a higher importance than the third because it can offset a higher CO_2 emission value. However, the greenhouse gas negative effects cannot be excluded only by analyzing the second level.

The presence of the positive condition for each level (cells with “Yes” in green color) classifies the tender as best performer. If the positive condition is not present for each level, the first order is the most important and, on the contrary, the third one is the worst. The qualitative system of evaluation can be transformed in a quantitative assessment by using a different numerical value for every specific characteristic reported in the table 16: (3) for ex ante application, (2) for lower LCC value and (1) for lower emissions value). The absence of each of the above mentioned characteristics gives always a value equals to 0. This measurement, also reported in the table with the numbers in the brackets, allows to consider a minimum level of efficiency and productivity of the tool. A value of 3 (50% of the maximum amount obtainable by this evaluation) can be considered sufficient.

6. Final conclusions

The ex ante LCC tool has been created as a **dynamic and incremental system**. In other existing tool/software the data entered are often fixed and referable to a past period of time. The GRASPINNO tool is much more suitable if the aim is **setting the tender in a cost-effective way**. In simpler words: if the aim is setting an energy performance of the intervention, the new tool give the opportunity to choose new technologies or new materials with very high performance, also giving, as an additional characteristic, the opportunity to than update product price. This is a relevant advantage in comparison with other existing tool in which the values remains steady because the technology remain old and or not upgradeable in a simple way. **A full integration with a vast product database would make the ex ante LCC tool very powerful**.

The new ex ante LCC tool, by anticipating its use before the publication of the tender, should be able to contribute to a correct tender setting, **maximizing the economic and environmental positive effects**. The systematic use of the tool before the publication of tenders should strongly contribute to make sustainable the local economy.