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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.

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Upgraded tools with updated user manuals for GRASPINNO pilots and workshops – Life Cycle Cost Tool User Manual

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1. INTRODUCTION

The following document is a relation of the various uses and explanations of the Life Cycle Cost (LCC) tool. The purpose of this instrument is to help the user to understand how to interpret correctly the results of a green tender under an economic and sustainable point of view.

A large part of the manual is based on cases, already studied in the GRASP project that analyzes GPP procedures for 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 working life of the product), the overall greener alternative may well prove to be cheaper over time.

If contracting authorities wish to ascertain which products are most cost effective for them, 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 are 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 typology of product the 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 signify consider this cost twice. As in the previous GRASP project the waste treatment cost remains an "open" issues: when the data are available, will be used.

2. GENERAL EXPLANATION

The LCC tool is contained within a Microsoft Excel document with six sheets. The first sheet ("LCC") is the tool itself. This is a semiautomatic tool that helps in the calculation of Life Cycle Costs (LCC), and its use will be explained in the next section. The second sheet ("Assessment") contains the relative costs based on the price of the products and then on their LCC to show the difference between making a decision based solely on price as opposed to a decision made based on more complete criteria. The price difference is the simple difference between prices, taking into account the number of products to be purchased, with red and negative numbers meaning the green product (column E of the first sheet) costs more than the other product. The LCC difference is the discrepancy between the LCC of the two products, red and negative numbers again meaning that the LCC of the green product is higher than the LCC of the other product. This page is used to show that, often (but not always) the product with the lowest price will cost more over its lifetime than the product with better green criteria. The third sheet ("CO2 – Countries") contains a list of countries and the amount of CO_2 emitted for each kWh of energy created. This is used in the assessment on first sheet which will be explained in the paragraph 4. The fourth sheet ("Conversion tables") is a support tool to calculate LCC in presence of goods or services that consume thermal energy using a specific fuel (energy efficiency operations).

3. USES

For the LCC tool, there are three main uses that help the user 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 cost of keeping an existing product instead of replacing 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 would split the different aspects of the renovation 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, a simple but less precise calculation is preferred: 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 vast variety of circumstances.

4. GUIDELINES FOR USE

The following list is the explanation of each cell that will be modified according to the products being compared. In column C, there are 10 yellow cells to be modified, and in column E there are 5.

- Cell C5/E5: Purchase price per product – the cost of each individual unit
- Cell C6/E6: Lifetime – the projected lifetime of the product
- Cell C11: Average yearly time usage – how much time (the number of hours) the product will be used throughout the year (a light bulb, for example, might be used for 8 hours a day for 260 days per year for 2080 hours per year)
- Cell C13: Number of purchases – the amount of the product to be purchased
- Cell C17/E17: Number of units per year – this number is based on how the maintenance for the product is measured (for example, work hours for lighting, kWp for a photovoltaic plant, number of pages used in a printer, etc.)
- Cell C18/E18: Cost per unit – the cost for each maintenance unit used in C17 (€5/hour or €3/kWp, €0.50/page, etc.)
- Cell C21: Price of energy – the price of energy in the area of interest (kWhe or kWht)
- Cell C22/E22: Energy consumption/production – how much energy each individual unit consumes or produces (such as renewable sources, and in which case if it produces energy, this value must be negative)
- Cell C26: kg CO 2 /kWh – a quantity taken from the table given on sheet 5 of the tool of how much CO 2 is emitted to generate one kWh (varies by country)

- Cell C28: Economic value of CO_2 – economic value (in €) of one ton of CO_2 as found at **http://www.sendeco2.com/index-uk.asp**

Guidelines by case

Absolute cost – Calculating the absolute cost of a product can be done with either for two products or one product. If using two products, fill in the columns C and E according to the guidelines set out above using these products' specifications. When this has been done, set the economic value of CO_2 to 0 in the first column (cell C28). The absolute price for the green product will be the number shown next to "Total life cycle costs" at the bottom of the table in the second column (cell E30). To find the absolute LCC of the lowest price product, fill in both columns C and E with its same specifications and set the economic value of CO_2 to 0. The absolute cost of the lowest price product will be always the "Total life cycle costs" on the table (cell E30).

Evaluation of a substitute – The evaluation of a substitute is largely a matter of examining the savings produced by the new product. To do this, fill in column C with the specifications of the existing product and column E with the possible substitute. To examine the savings, set the prices of each product to zero (cells C5 and E5). The prices, as previously noted, are not useful in this case because they come from two different time periods. Due to inflation and other cost fluctuations, the price comparison is not helpful and may lead to unrealistic conclusions. Instead, we can examine the energy savings of the new product with respect to the old one, which is the more valuable evaluation. Understanding this calculation, it is simple to examine the effects of making a substitution.

Comparison between two products – The case that the tool was built for is a comparison between two similar products: one with a lowest price and the other with a sustainable price. To complete this assessment, fill in the Lowest Price column (column C) and the Sustainable Price column (column E) with the specifications of the two products. Once these specifications have been entered, the LCC are seen at the bottom of the table and the relative costs (for both price and LCC) are shown on the "Assessments" sheet (sheet 2). Having completed the evaluation, the winning product can be compared to others, thus choosing the best option based on the LCC. This is designed also to show that the misunderstanding that green products are more expensive is often false, especially in long-term projects.

Working with different partners' specific cases, some minor difficulties have arisen, but they have been overcome and resolved. As a result of this, the tool has become more generalized and the partners now have a better instrument to use for their evaluations. Section 4 provides a list of these cases.

5. EXAMINATION OF SPECIFIC CASES

The following tables list the involved partners as well as the foreseen tests or pilots they had to conduct in GRASP. 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 it involved. The second table gives a few details about each test done by the involved partners. As can be seen, there was a wide range of cases submitted with an equally wide range of results. Following the tables is an evaluation of some of these cases. In the present document the description is focused only on tenders concerning EE/RES for buildings, even if the tables include all the cases analyzed in GRASP.

Table 1: Pilots and Tests

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 2: Tender Characteristics

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
Hortiatis-Pilea	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

5.1 Case: Terrassa

	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	6	y
Units per year [work hour, kwp, page...]	24,56	n	4,91	n
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	0,430	kg
Total of CO2 avoided [ton]	0,000	t	3,913	t
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**	**€**

The Terrassa case tested indoor (office) lighting; and 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; and the cost of labor depends on the country. In the period of GRASP project, the cost was €20.99/hour in Spain, €35.47/hour in France, €28.44/hour and in Italy.

5.2 Case: PABBC/Atlantis

	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 CO2/kWh	0,430	kg	0,430	kg
Total of CO2 avoided [ton]	0,000	t	0,000	t
Economic value of CO2 [€/ton]	7,29	€	7,29	€
Total economic value of avoided CO2 [€]	0,0	€	0,0	€
Total life cycle costs	**-1.795.792,60**	**€**	**-1.883.997,10**	**€**

This joint case verified the effectiveness of a green tender with 10 different bids of photovoltaic plants to having some power. For this test, the lowest-price product is not as efficient as the sustainable-price. This case is interesting 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. Particularly here the sustainable-price product has a lower maintenance cost which makes it the more efficient and economical decision.

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

5.3 Case: Spata-Artemis A

	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**	**€**

The case of Spata-Artemis dealt again with the 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 economic and environmental benefits as a result of choosing the environment-friendly product.

5.4 Case: Spata-Artemis B

	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**	**€**

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 30year period. Within this experiment it is considered the real work hours of each product which both consume the same amount of energy. The efficiency of the boilers which contributed to the increase in hours to reach the target energy consumption, was also considered. 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

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 CO_2 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 CO_2 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

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 CO_2 over 30 years make the environment-friendly product the better choice.

5.5 Case: Castellón

	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]	0,00	kWh e/t	0,00	kWh e/t
Total energy cost [€]	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**	**€**

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 duet of products. Thus, when deciding between several green products such as these, this tool is still helpful.

5.6 Case: RAIS (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**	**€**

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

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exterior walls of the building. Nevertheless, 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.

As previously written it is very 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, 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 the 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 CO_2 emissions.

5.7 Case: RAIS (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**	**€**

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.

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5.8 Case RAIS (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**	**€**

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.

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6. 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. 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 use 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 expected outcomes of the GRASPINNO project can be reached.

Numerical Summary:

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	-1123,057

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 (CO_2 emissions or GHG equivalent). With a quick glance, observing the numbers in red color, which indicates 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, there was none red number in the LCC column;

- have the best environmental choice for the Public Administration; if it was so, there was none red number in the "avoided CO_2" column. It means that this LCC tool could be very useful in the preparation phase of the tender as well.

The cases studied with GRASP 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:

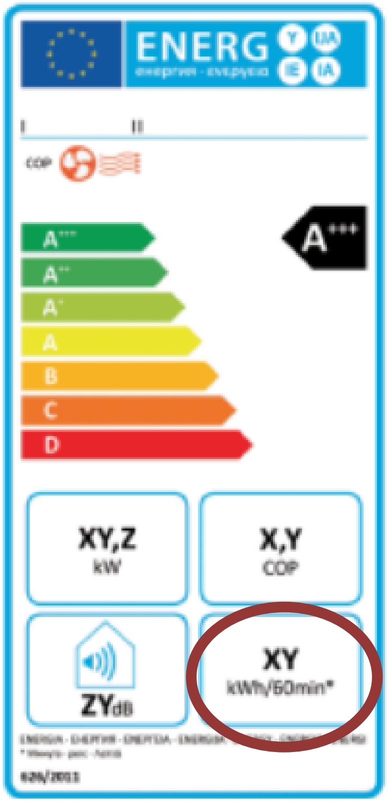
	Lowest Price		Environment-friendly Price	
Price				
Price per product [Euro/product]	0,00	€	66521,00	€
Lifetime [years]	10,00	y	10,00	y
Comparable number of replacements	1,00	n	1,00	n
Total Cost [€]	0,00	€	66.521,00	€
Duration				
Lifetime [years]	10	y	10	y
Average yearly time usage [hours/year]	1	h/y	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**	**€**

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 CO2 emissions): if they are lower after the introduction of this product, then 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 products 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 calculating the LCC and CO_2 emissions.

- Air conditioning plants; obtaining the LCC is similar to any other electrical and 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.


ENERG
COP
A+++
A+++
A++
A+
A
B
C
D
XY,Z
kW
X,Y
COP
ZYdB
XY
kWh/60min*
626/2011