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topten

Framework paper life cycle costs

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In this report, all measurement units are defined metrically.

The 'comma' is used as decimal separator. The 'dot' is used as thousand separator.

Text is written following British English spelling rules.

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1 Introduction

Particularly innovative, resource-efficient products for example household appliances with low power consumption tend to have a higher purchase price than the equivalent conventional products. However, at the same time, operating costs, like costs for energy and other resources during the use phase, are lower than for conventional products. This means that the life cycle costs of innovative products are often equal or even lower than those of conventional products (Rüdenauer 2011).

For that reason, life cycle costs at the consumer level play an important role for the comparison of energy efficient products with conventional, inefficient products. However, previous work in Euro Topten Plus showed that the approaches used by the participating partners to determine the life cycle costs from the consumer's point of view differ from each other. They encounter several difficulties concerning methodological questions; the definition of how the products are used as well as the cost categories considered and type of data used in the different countries for e.g. purchase costs, costs for electricity and water. For not misleading the consumer but to benefit him/her and to have a consistent approach for calculating life cycle costs, this guideline at hand was developed.

1.1 Definition

Life cycle costing (LCC) is generally defined as the assessment of all costs which are connected to the entire life cycle of a certain product. The costs are directly covered by one or more actors within this life cycle (Hunkeler et al. 2008).

LCC includes for example costs of installation, operation, maintenance and decommission. By using this methodology consumers are able to compare and evaluate alternative products. Furthermore, they can assess their economic viability.

1.2 Types of LCC

According to Hunkeler et al. (2008), three different types of LCC can be distinguished: they are conventional LCC, environmental LCC and societal LCC. The main difference of the three types is the inclusion of external costs[1].

1.2.1 Conventional LCC

A conventional LCC is an economic instrument, taking into account only real, internal costs. In some cases it doesn't cover all life cycle phases. The perspective is mainly from one actor. It is used as a financial evaluation of various investment alternatives.

[1] External costs: not directly borne by an actor but which are expected to be internalized (e.g. when an environmental tax has been decided and will enter into force in the near future).
Internal costs: directly borne by an actor in supplying or consuming a product within its life cycle.

1.2.2 Environmental LCC

An environmental LCC covers all life cycle phases. In addition to internal costs, it also takes into account external costs that are expected to be internalised in the decision relevant future. For example subsidies or taxes are included in environmental LCC. The perspective is from one or more actors connected to the life cycle.

1.2.3 Societal LCC

A societal LCC includes all of environmental LCC. In addition to that, it also takes into account further external costs. This means that all external long-term and short-term costs (usually in monetary terms) are calculated. The perspective is from society overall and can be seen as an economic assessment of alternatives.

2 Approach and methodology of life cycle costing

2.1 Principles

2.1.1 Life cycle perspective

One of the main principles is the consideration of the entire life cycle of the specific product (from cradle to grave). In general the life cycle comprises production, use, disposal and transports.

In the guideline at hand, the conventional LCC is used. It is calculated from the consumer's point of view. That means that all costs which are connected to the life cycle of the product and which are beard by the consumer are taken into account. Production costs do only occur for manufacturers but not for consumers. In general the following cost elements are included:

- Purchase and installation costs,
- Costs during the use phase (also called operation costs):
  - Electricity,
  - Water,
  - Consumables (for example detergent),
  - Service and maintenance (including repair),
  - Taxes,
- Disposal costs.

Additional Note: Consumers often address the following two questions with relation to the life cycle perspective to Topten parterns:

- Is an early replacement of an inefficient appliance recommendable if the production phase is also considered?
- Where has the appliance been produced?

Both questions do not address the Life Cycle Costs from point of view of consumers meant in this paper but rather relate to the environmental impacts connected to them. Therefore they are not discussed further in this paper.

2.1.2 Functional unit

LCC usually compares different options; therefore the functional unit must be the same for these alternatives. The functional unit provides a reference to which all costs are related. It is based on common usage patterns, depending on the product category (e.g. washing machine: 220 washing cycles in the declaration programme per year over a time period of 10 years[2]).

2.1.3 System boundaries

To ensure comparability, the system boundaries must be the same for all products of a certain product group. In general they are purchase, use and disposal.

3 Modelling

3.1 Cost models

By carrying out a LCC analyses, different dimensions of costing can be used. It is important how the time value of money is considered, for example if taxes etc. are included in the analyses. Three different characteristics can be distinguished (Hunkeler et al. 2007).

3.1.1 Steady state model

The steady state model assumes that all technologies remain constant in time. The temporal accrual of revenues and expenses is not taken into account. This model is much easier to use than dynamic models.

3.1.2 Quasi dynamic model

The quasi-dynamic model assumes that most of the variables remain constant in time. However one or more of them vary. It is a combination of the steady state and the dynamic model.

[2] There are Gfk data on the average life time of different appliances (e.g. 13 years for washing machines; fridges: 14 years; freezers: 17 years). However there is no unique figure: Regarding one product group the life time of different brands and models may vary a lot. Also, the life time is not provided by the manufacturers with the product manual or as information on the point of sale. .

3.1.3 Dynamic model

Within the dynamic model the temporal accrual of revenues and expenses is taken into account. The variables develop over time. The evaluation of the revenues and expenses incurring at different times, is made by discounting.

3.2 Data collection

To calculate the LCC of products, it is important to identify the relevant cost data. On the one hand relevant costs have a significant share of the total costs; on the other hand if alternative products are compared, these are costs that are different for the alternatives.

Data of the specific appliance can be provided by the manufacturer, e.g. washing machine: energy and water demand, purchase price, etc. Besides, different data bases can be used to get statistical data (e.g. for energy prices).

3.2.1 Data concerning the purchase

Sometimes purchase costs are provided by the manufacturers in the form of recommended retail prices. But these retail prices are often not available. Also, typically they are 20 to 30 % higher than actually paid average prices in shops. They are good for orientation, but they do not represent average prices. Therefore it is rather recommended to use websites comparing purchase costs (e.g. amazon.com, idealo.de, etc.) as data source. Another solution, practised by some Topten parterns, is the use of data on average prices from GfK.

3.2.2 Data concerning the use phase

For calculating the LCC of a specific product, several assumptions concerning the use phase have to be made. For washing machines for example the washing cycles per year as well as the energy, water and detergent demand have to be known. Some of this data can be found on the EU energy label. Furthermore, the preparatory studies of the EuP/ErP process provide such data for several product groups. As these costs differ very much from country to country it is advisable to use the specific data of the relevant country instead of average data. The more specific the data the more accurate the results of the LCC.

Energy prices

Eurostat, the statistical office of the European Union provides statistics and data on Europe regarding energy prices. The data is freely accessible and can be used easily for calculating the life cycle costs of a product.

Link: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Electricity_and_natural_gas_price_statistics

Table 1 shows the electricity prices for domestic consumers, including all taxes, levies and VAT (exemplary for four countries and EU27). It is visible that the energy price varies from country to country. Therefore it should be taken into account for which country the LCC is conducted. The energy price is composed of a basic rate plus the price per kWh consumed. Energy savings refer to the price per kWh consumed.

Table 1 Electricity prices for domestic consumers in Euro/kWh (Eurostat 2012)

Country	Q1 2010	Q2 2010	Q1 2011	Q2 2011
EU 27	0,1676	0,1728	0,1795	0,1837
Germany	0,2375	0,2438	0,2528	0,2531
France	0,1283	0,1350	0,1383	0,1423
Finland	0,1325	0,1370	0,1540	0,1573
Denmark	0,2670	0,2708	0,2908	0,2975

Eurostat also offers statistical data regarding gas prices for domestic consumers.

Further costs

Depending on the analysed appliance, further costs can incur, like costs for water and detergent. The preparatory studies of the EuP/ErP process can be used as source for these costs. They provide scientific background information on individual products groups.

3.2.3 Data concerning the end of life

Disposal costs can be ignored, as no costs occur for consumers due to the WEEE directive 2002/96/EG (waste electrical and electronic equipment). In the EU this waste can be disposed free of charge[3] if it is similar in nature and quantity to that of private households.

4 Ideal proceeding for Topten

To support consumers in the comparison of energy efficient products to conventional, inefficient products, LCC is a suitable method. However, it can be calculated in a homogeneous way to make it easier for consumers a certain to understand it and to compare data. Therefore the following issues are recommended for the proceeding in Eco T Topten:

- Product life: 10 years for white goods and TVs (for other product groups, like printers shorter life times may be more appropriate)
- Steady state modelling (no dynamic effects to be on the conservative side)
- Optional: Inclusion of further operating costs, e.g. water and detergent costs.

Although the lifetime of products is very different, it is feasible to assume a life time of ten years for white goods ant TVs for the calculation. With it, consumers can easily assess the

[3] Actually the fee for the disposal is already included in the retail price. But from the consumer's point of view the disposal itself is free of charge.

annual total costs of the products and they can easily estimate the costs for their expected lifetime. In addition, it leads to a better comparability.

Further operating costs should be included into the LCC, as they can have a huge influence on the total costs of a product.

5 Calculation of life cycle costs / Product specific recommendations

In this chapter the analysis of the life cycle costs of efficient products is conducted for four product groups. Concerning the product groups, washing machines, dishwashers, coffee machines and led-lamps were selected. For each product group specific recommendations are worked out. Furthermore methodological questions and practical implications will be discussed.

The LCC analysis addresses the life cycle costs from the perspective of the consumer. Disposal costs can be ignored, as no costs occur for consumers due to the WEEE directive.

5.1 Washing machines

5.1.1 System boundaries

The life cycle analysis should include the following cost factors:

- Purchasing of washing machine: purchase price incl. VAT
- Use of the washing machine:
  - electricity costs
  - water costs
  - detergent costs
- Repair and maintenance costs can be neglected[4]
- End of life: can be neglected

5.1.2 Assumptions concerning the use phase

Regarding washing machines, important cost factors are energy costs, water costs and detergent costs. According to chapter 3.2 the following data bases can be used for the relevant (cost) data at the European level:

- Energy costs: Eurostat
- Water costs: 2,64 €/m³ (BIO 2011[5])

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[4] Reason: On the one hand no data on repair costs is available. On the other hand, repair and maintenance costs are often too high in relation to a new purchase. This depends on the country and the product group. As a consequence country specific data can be considered in the calculation, if available.

[5] The Water rate was extrapolated from the weighted average of the eight largest cities in Europe to the year 2010 based on the evolution of water price experienced in France over 15 years gives a water price of 2.64 €/m3 for the EU-27

- Detergent costs: 0,22 €/wash (ISIS 2007[6])
- Annual electricity consumption: EU energy label (input manufacturers)
- Annual water consumption: EU energy label (input manufacturers)

Table 2 shows an illustrative calculation of the life cycle costs of two washing machines. The results show in this example, that the life cycle costs of the A-class appliance are higher than the costs of the A+++ class appliance. Reasons for this are the higher operating costs (electricity and water costs) in comparison to the energy efficient A+++ appliance.

Table 2 Life cycle costs of two exemplary washing machines: comparison of an A+++ and A-class appliance (Topten 2012a / own calculation)

	unit	**Washing machine A+++**	**Washing machine A**
Capacity	kg	8	8
Life time	years	10	10
Washing cycles	Cycles/a	220	220
Purchase			
Purchase costs	Euro	749	635
Annual purchase costs	Euro/a	74,9	63,5
Use phase			
Energy demand	kWh/a	155	208
Water demand	l/a	9.750	11.800
Detergent demand	Euro/wash	0,22	0,22
Electricity costs (EU 27)	Euro/kWh	0,1837	0,1837
Water costs	Euro/m³	2,64	2,64
Life cycle costs			
Purchase costs	Euro/10 years	749	635
Electricity costs	Euro/10 years	284,73	382,10
Water costs	Euro/10 years	257,4	311,52
Detergent costs	Euro/10 years	484	484
Life cycle costs	**Euro/10 years**	**1.755,13 €/10 years**	**1.812,62 €/10 years**
Share purchase costs	Percent	42,7%	35,0%
Share electricity costs	Percent	16,2%	21,1%
Share water costs	Percent	14,7%	17,2%
Share detergent costs	Percent	27,6%	26,7%

6 The detergent costs are an estimate, as they are very country-specific.

5.1.3 Discussion

Regarding washing machines, energy and water costs are taken into account so far on most Topten websites. However, detergent costs also play an important part calculating the life cycle costs of washing machines. The share of water costs is about 15 % and of detergent costs about 27 % for the inefficient appliance.

The EU energy label shows the weighted annual energy consumption calculated on 220 washing cycles per year. It takes into consideration the energy consumption of the following programme shares:

- 43 % Standard 60 ^{0}C cotton programme at full load,
- 29 % Standard 60 ^{0}C cotton programme at half load,
- 29 % Standard 40 ^{0}C cotton programme at half load.

The figure of 220 washing cycles per year is quite high for small households. It should be kept in mind, that in real life, the number of washing cycles is rather various. Regional differences in the user behaviour can also occur, for example concerning the washing temperature, number of washing cycles, etc.

Concerning the capacity of washing machines there is a trend towards lager capacities. According to ISIS (2007) the average capacity in 2005 was 5.4 kg. Nowadays, there are also washing machines with a capacity of more than 8 kg. On the one hand the washing cycle of an 8 kg appliance needs more electricity than that of a 5 kg appliance. On the other hand more clothes can be washed in a bigger washing machine. So, a lower number of washing cycles could be expected. However in many countries the household sizes decrease (in Germany an average household is 2,1 persons). This leads to the result, that washing machines are often used with part load. According to ISIS (2007) the average load used is 3,2 kg.

Additional functions like noise emissions or water protection system can have an influence on the purchasing price but not on the use phase costs of the appliance; nevertheless these functions improve the quality of the appliance and are often used as additional purchase criterion.

5.2 Dishwashers

5.2.1 System boundaries

The life cycle analysis should include the following cost factors:

- Purchasing of dishwasher: purchase price incl. VAT
- Use of the dishwasher:
  - electricity costs
  - water costs

  - detergent costs
- Repair and maintenance costs can be neglected[4]
- End of life: can be neglected[3]

5.2.2 Assumptions concerning use phase and data base

Regarding dishwashers, important cost factors are energy costs, water costs and detergent costs. According to chapter 3.2 the following data bases can be used for the relevant (cost) data:

- Energy costs: Eurostat
- Water costs: 2,64 €/m³ (BIO 2011)
- Detergent costs: 0,076 €/washing cycle (including detergent, softener and rinsing agent) (ISIS 2007)
- Annual electricity consumption: EU energy label (input manufacturers)
- Annual water consumption: EU energy label (input manufacturers)

Besides the data, the capacity of the specific dishwasher should be considered, as it has an influence on the energy and water consumption of the appliance and as well on the purchase price.

Table 3 shows the comparison of the life cycle costs of an A+++ with an A-class dishwasher. The calculation is based on German data, as EU-wide average data of purchase are not available respectively difficult to obtain. That's why the price for electricity is different to the data used for the washing machine calculation.

The comparison shows, that the life cycle costs of the energy efficient dishwasher (A+++) are lower than those of the A appliance.

Table 3 Life cycle costs of two exemplary dishwashers: comparison of an A+++ and A appliance (Topten 2012b / own calculation)

	unit	**Dishwasher A+++**	**Dishwasher A**
Capacity	cm	60	60
Life time	years	10	10
Washing cycles	Cycles/a	280	280
Purchase			
Purchase costs	Euro	776	776
Annual purchase costs	Euro/a	77,6	77,6
Use phase			
Energy demand	kWh/a	195	311
Water demand	l/a	1.970	3.640
Detergent demand	Euro/cycle	0,076	0,076
Electricity costs (Germany)	Euro/kWh	0,2531	0,264
Water costs	Euro/m³	2,64	2,64
Life cycle costs			
Purchase costs	Euro/10 years	776	776
Electricity costs	Euro/10 years	493,55	787,14
Water costs	Euro/10 years	52,01	96,10
Detergent costs	Euro/10 years	212,80	212,80
Life cycle costs	**Euro/10 years**	**1.534,36 €/10 years**	**1.872,04 €/10 years**
Share purchase costs	Percent	50,6%	41,5%
Share electricity costs	Percent	32,2%	42,5%
Share water costs	Percent	3,4%	5,1%
Share detergent costs	Percent	13,9%	11,4%

5.2.3 Discussion

Analogue to washing machines, also for dishwashers water and energy costs are taken into account on most Topten websites but not detergent costs. As the example shows, detergent costs have a share of 11 respective 14 % of the total costs (see Table 3). Additional functions like noise emissions or water protection system have no influence on the use phase costs of the appliance; nevertheless these functions improve the quality of the appliance and are often used as additional purchase criterion and may increase the purchase price.

5.3 Coffee machines

The life cycle analysis should include the following cost factors:

- Purchasing of coffee machine: purchase price incl. VAT

- Use of the coffee machine:
  - electricity costs
  - coffee costs
- Repair and maintenance costs should be considered if data are available but see also[4]
- End of life: can be neglected[3]

5.3.1 Assumptions concerning use phase and data base

Important cost factors for coffee machines are costs for electricity and coffee. According to chapter 3.2 the following data bases can be used for the relevant (cost) data:

- Energy costs: Eurostat
- Costs for coffee (ground and beans): 12 €/kg (BIO 2011)
- Coffee filter: 0,03 €/filter (BIO 2011)
- Coffee pad: 0,15 €/pad (BIO 2011)
- Coffee capsule: 0,30 €/capsule (BIO 2011)
- Coffee consumption: 2190 cups/a (Topten.ch)
- Water costs: 2,64 €/m^3 (BIO 2011)
- Annual electricity consumption: input manufacturers

Table 4 shows an illustrative calculation of the life cycle costs of two automatic capsule coffee machines, an energy efficient appliance and an energy inefficient appliance. Due to the higher energy demand of the inefficient coffee machine, the life cycle costs of this appliance are higher than the life cycle costs of the energy efficient coffee machine.

Table 4 Life cycle costs of two exemplary automatic capsule coffee machines: comparison of an energy efficient and an energy inefficient appliance (Topten 2012c / own calculation)

	unit	**Energy efficient coffee machine**	**Energy inefficient coffee machine**
Life time	years	10	10
Coffee consumption	Cups/a	2.190	2.190
Purchase			
Purchase costs	Euro	90	1.174
Annual purchase costs	Euro/a	9	117,4
Use phase			
Energy demand	kWh/a	36	140
Water demand	l/a	1.642,5	1.642,5
Electricity costs (EU 27)	Euro/kWh	0,1837	0,1837
Water costs	Euro/m³	2,64	2,64
Capsule costs	Euro/piece	0,3	0, 3
Life cycle costs			
Purchase costs	Euro/10 years	90	1.174
Electricity costs	Euro/10 years	66,13	257,18
Water costs	Euro/10 years	43,36	43,36
Capsule costs	Euro/10 years	6.570	6.570
Life cycle costs	**Euro/10 years**	**6.769,49**	**8.044,54**
Share purchase costs	Percent	1,3%	14,6%
Share electricity costs	Percent	1,0%	3,2%
Share water costs	Percent	0,6%	0,5%
Share capsule costs	Percent	97,1%	81,7%

5.3.2 Discussion

Regarding coffee machines only energy costs are taken into account so far on Topten websites. However, research shows that the costs of coffee (especially coffee beans and coffee capsules) can be enormous. On the one hand there are huge differences regarding the countries where the coffee is sold, on the other hand coffee capsules are much more expensive as coffee ground or beans. As the coffee costs can exceed the purchase costs within a few years of using the coffee machine, they should be taken into account, calculating a LCC. According to the working document on possible Ecodesign and EU Energy label measures for domestic coffee machines, 90 % of the expenditures are related to coffee (inclusive filter). Expenditures for the appliance, energy use and maintenance play a secondary role.

Other important cost factors could be costs for maintenance and repair. Especially for high quality appliances like fully automatic coffee machines they might be non-negligible, as they need a regular maintenance. BIO (2011) assumes 20 % of the product price as repair and maintenance cost over the lifetime. For other coffee machines, e.g. filter coffee machines, repair and maintenance costs do not play such an important role. This information, if not included in a possible LCC line in the Topten Product tables, should be part of the related information page.

Further it can be discussed if costs for decalcification should be taken into account as well, calculating a LCC of coffee machines.

5.4 LED-lamps

5.4.1 System boundaries

The life cycle analysis should include the following cost factors:

- Purchasing of LED-lamp: purchase price incl. VAT
- Use of the LED-lamp:
  - electricity costs
  - repair and maintenance costs can be neglected
- End of life: can be neglected

5.4.2 Assumptions concerning use phase and data base

- Energy costs: Eurostat
- Life time: 25.000 hours
- Annual electricity consumption: calculation on base of power consumption (input manufacturers) and number of burning hours

LED-lamps are characterized by a high luminous efficacy and a long lifetime. As their purchase price is quite high they are especially for commercial businesses of interest. Regarding the efficiency of LED-lamps they are quite similar to energy saving lamps.

Table 5 shows an illustrative calculation of the life cycle costs of two led-lamps. Disregarding manufacturers' information, it was assumed that the average lifetime of LED-lamps is 25.000 hours. Furthermore, the calculation is based on the assumption that the LED-lamps are in use for 1.000 hours a year. This leads to a lifetime of 25 years.

Table 5 Life cycle costs of two exemplary LED-lamps (Topten 2012d / own calculation)

	unit	**LED-lamp 1**	**LED-lamp 2**
Life time	hours	25.000	25.000
Wattage	Watt	10	17
Luminous flux	Lumen	680	1.055
Luminous efficacy	Lumen/Watt	66	62
Colour temperature	Kelvin	2.883	2.700
Purchase			
Purchase costs	Euro	36	60
Annual purchase costs	Euro/a	3,6	6
Use phase			
Energy demand	kWh/a	1,837	3,12
Electricity costs (EU 27)	Euro/kWh	0,1837	0,1837
Life cycle costs			
Purchase costs	Euro/25 years	36	60
Electricity costs	Euro/25 years	8,44	14,33
Life cycle costs	**Euro/25 years**	**44,44**	**74,33**
Share purchase costs	Percent	81,0%	80,7%
Share electricity costs	Percent	19,0%	19,3%

5.4.3 Discussion

Concerning the life time of LED-lamps the information indicated by manufacturers is often too positive (up to 100 000 hours). Appliance tests showed that in many cases the actual life time is shorter than announced. This leads to an incorrect result of the LCC. Furthermore, they can lose part of their lumen value quite quickly, so the service varies in time.

There exists the EU energy labelling for non-directional lamps. The regulation for directional lamps is still in progress. LED-lamps are covered by the regulation of general lighting, but just in case if their power consumption is higher than 4 W. However there are a lot of LED-lamps with lower power consumption.

6 Conclusion

Life cycle costing is an important tool for consumers to compare energy efficient products most often with a high purchase price and low operating costs with inefficient products which are generally cheaper in the purchase but more expensive through their lifetime.

For the comparison of life cycle costs of different products it is important to use a coherent approach and a common methodology. The use of the specific product has to be defined clearly. This also applies to the cost categories that are considered and type of data. Differences between countries have to be taken into account.

To direct the attention to life cycle costs and not only to the purchasing costs, the determination of life cycle costs at the consumer level is very important. As Topten is a consumer-oriented portal, which presents the best appliances in different product categories, it is predestined to show the LCC of these appliances. On the one hand it enhances the importance of the Topten websites and on the other hand helps in achieving a faster market penetration for energy saving products.

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