Life cycle assessment aspects of reuse products

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Abstract Waste prevention including the possibility of reuse has highest priority in the waste hierarchy given by the waste framework directive (EU, 2008). Next to waste prevention "preparation for reuse" is of second highest priority. This step is only differing from reuse by fulfilling the definition of waste recommending a quality check or repair to leave the waste regime and become a product again. The market value of a product is influences by this change of status. This document is discussing the allocation of environmental impacts from production and credits from recycling (end of life) to the first and the second life of a washing machine taking into account the functionality and the market value as allocation indicators. Results are showing the allocation of impacts over the lifetime for both reuse possibilities including a suggestion for allocation based on consumer responsibility.

1   Introduction

After decades of focusing on the development of efficient and innovative waste recycling and disposal technologies to solve the problems of resource losses and emissions to water, air and soil in the last years the main focus was changed on waste prevention. Also the European Commission proclaims the goal of decoupling economic growth and increasing waste arising which can only be accomplished by strengthening waste prevention. Beside the prevention idea of reduced consumption one of the more consume friendly prevention possibilities is "reuse" which means that a product is donated or sold by its first user to a second user fulfilling the same function in its second life as in its first life.

Normally this type of trading is not covered by waste regulation e.g. by using well known web-based platform. But there is also a significant quantity of useable goods delivered to waste collection centres, for example in [1] 5-9% of the entire WEEE amount in Austria (3350-6000 tons/year) is estimated to be sellable reuse-products. These products are entering the waste regime with all related regulations e.g. the impossibility to sell it to consumers without waste treatment permits. To

motivate the responsible waste management authorities in the member countries to implement a system to enable a reuse of these goods instead of recycling, the European Commission introduced as second priority of the waste hierarchy given in the waste framework directive [2] the step "preparation for re-use". The implementation of this step shall facilitate the possibility that after a quality check, including repair if necessary, a useable good isn´t in the waste regime anymore and can be sold or donated to consumers. The new waste framework directive shall be implemented in the national law of the member states until December 2010 causing the development of new reuse programmes.

The underlying rationale for these activities is the expected environmental impact reduction of reused or reusable products compared to new products. Thus, also the quantification of these environmental advantages is assumed to be of higher interest in the near future. The quantification of the environmental impacts shall be life cycle based according to the waste framework directive bringing life cycle assessment (LCA) to one of the most applied methodologies for this estimation.

In course of the project TRANSWASTE funded by the CENTRAL EUROPE programme reuse of products from bulky waste and WEEE is one of the possibilities for reaching the project targets. The goal of the project is the development of formalisation strategies of the transhipment of informal collected goods and waste in Central European countries. Up to now these informal activities are mostly consisting of the collection of WEEE, bulky waste and metals in countries with "higher developed" waste management systems followed by transboundary shipment to a country with "less developed" systems where the products are repaired if necessary and sold [3]. Thus, the first life of the product takes place in e.g. Austria and the second (reuse) life in e.g. Hungary. Informal collection is done at households or at waste collection centres which cause the legal problem that informal collectors cannot fulfil the requirements for necessary permits based on waste regulations to collect or to tranship waste. One possibility of formalisation is the implementation of preparation for reuse at waste collection centres. After this step the former waste can be donated or sold to the informal collectors as product enabling a legal transboundary shipment without any permits. Part of the project is the environmental assessment of these activities using the LCA methodology to identify products which are environmentally favourable to reuse instead of recycling. Occurred methodological problems of the project are discussed in this paper, specifically the allocation of impacts between the first and the second use of a product. The allocation is necessary for a proper comparison between a formalised reuse scenario and a recycling scenario without any further use of the product. A first estimation on environmental impacts of this question was done in [4].

2 Methodology and problem definition

The methodology of life cycle assessment (LCA) is one of the most relevant approaches for the quantification of environmental impacts and will be the state of the art method for the evaluation of positive or negative influence of future reuse projects. DIN ISO 14040ff. gives the methodological basis which was overtaken and specified in the handbook of the International Life Cycle Data System (ILCD) [5]. In this paper only the ILCD handbook is taken as basis for further assumptions and for the case study calculations.

Following questions arose during assessment on reuse products in the TRANSWASTE project:

1) How to allocate the environmental impact of the production between the first and the second life of reuse products?
2) How to allocate the end of life impacts/credits between the first and the second life of the product?
3) Is there a difference in applying the LCA method for reuse under the waste hierarchy step "waste prevention" and under the step "preparation for reuse"?

These questions shall be answered by the case study of the global warming potential (GWP) of a washing machine given in [6]. As life cycle stages production, use and end of life (recycling) are considered. For both scenarios with identical duration of use impacts from use phase will be identical and not further addressed. Excluding the use phase from results enables a better focus on the discussed methodological issues. The total lifetime of the considered washing machine is assumed with 13 years which is given as average in [7] including one change of the owner of the appliance.

3 Case study - washing machine

For a reusable product without any need of repair the difference between reuse and preparation for reuse can be legally described by entering the waste regime [2]. This means that the first user decides to dispose of a product at a waste collection centre or a recycling centre including a market value of zero from first user´s point of view. The consequences on LCA due to this step are shown by the two scenarios.

1) Reuse: The first user sells the appliance to a second user using a web-based platform or directly sells it to a friend who is using the product until the end of its lifetime (13 years).
2) Preparation for reuse: The first user wants to dispose the product using the opportunistic of transport to a waste collection centre or a recycling centre as the direct selling of the product is to time expensive for the first user. As the appliance is in the same condition as in scenario 1 the step of "preparation of reuse" is done only by a quality check. Without any further steps of repairing the appliance can be taken by its second user at a flea market at the waste collection centre and be used until the end of the products lifetime (13 years).

3.1 Functionality vs. market value

The rules for allocation of environmental impacts to the first and second life of reuse products are described in the ILCD-handbook [1]. Before starting the allocation of impacts to the first and second life of a product the decision must be taken if the functionality or the market value is the basis of this calculation. These time-related functions can strongly vary and lead to completely different results.

For the specific case study it is assumed that the functionality of the washing machine after 13 years is equal to the start of its life. The market value was calculated over the lifetime with a discount rate of 20% per year which results in an exponential function. The same method is used for the allocation of impacts or credits from end of life after the second life of the product which is ca. 20% of GWP from the production [6].
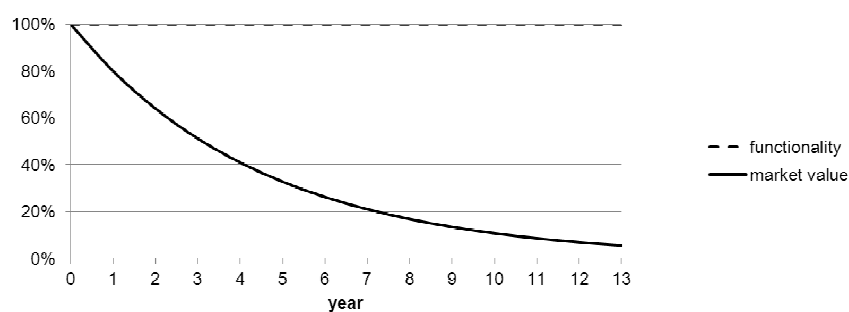

Fig.1:   Assumed lifetime functionality and market value of a washing machine

3.2 Scenario 1: Reuse

Taking into account the assumptions on functionality and market value for the reuse scenario the time-related discounting of environmental impacts of production and credits from recycling can be seen in Fig.2. This function is an adaption of the function in Fig.1 taking into account the fact that after the end of the assumed 13 years all environmental impacts of the production phase have to be allocated to the product.
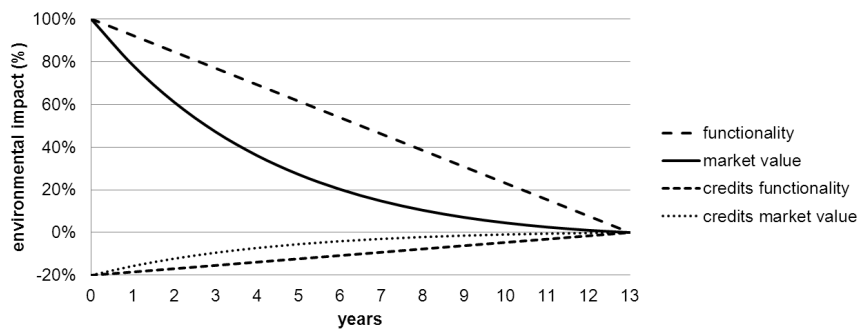

Fig.2:   Discounting of GWP over the lifetime of a reuse-washing machine

Fig.3 and Fig.4 show the environmental impact of production and credits from recycling for the two cases of functionality and market value based allocation. The results are showing the allocated burdens and credits to the first and second life/user for selling the product after different time periods.

Functionality based 46% of GWP from production and 9% of credits from recycling are allocated to the first life if the first user decides to sell the product after six years (see Fig.3).

The market value based allocation shown in Fig.4 results in 80% of GWP from production and 16% of credits from recycling allocated to first life taking into account the same time period for first and second user as above.

Comparing the two allocation approaches the results of environmental burdens and credits are varying strongly which shows the priority of this decision for LCA calculations. Considering the functionality only an underestimation of environmental responsibility for the first user is happening if market value based allocation is the more adequate approach.
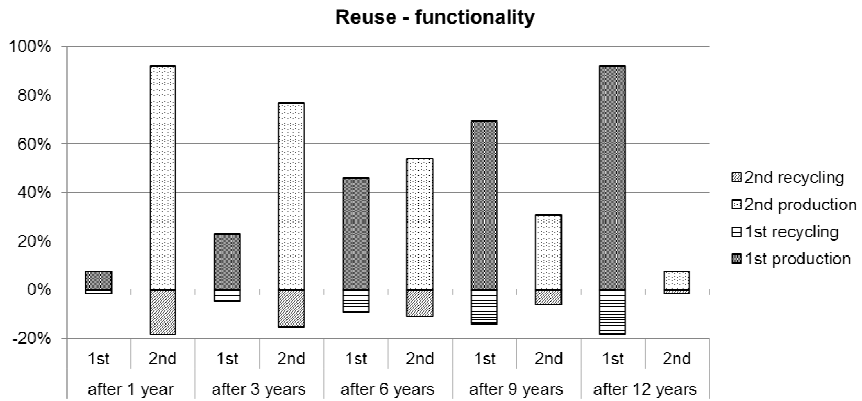
Fig.3: **Allocation of GWP to first and second life after different time-periods of a reuse-washing machine functionality based**
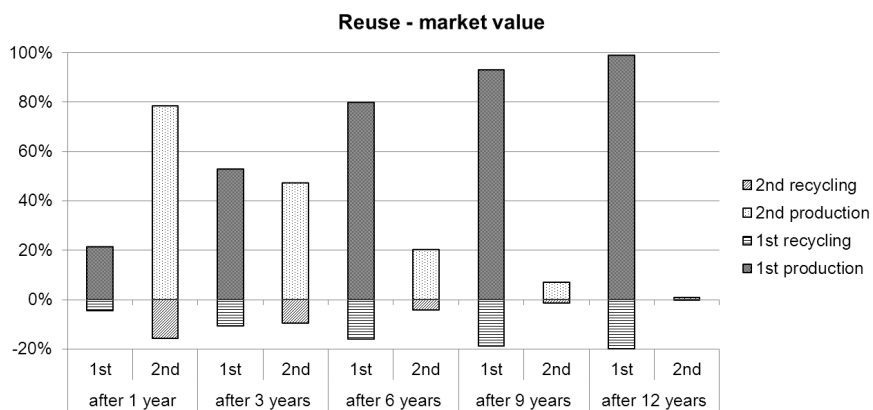

Fig.4: **Allocation of GWP to first and second life after different time-periods of a reuse-washing machine market value based**

3.3 Scenario 2: Preparation for Reuse

For the scenario "preparation for reuse" the same washing machine with the same functionality is assumed. Considering the market value, the scenario shows a significant difference to reuse, as it is assumed that the market value is zero from the point of view of the first owner when the product becomes waste. Fig.5 shows the market value and the functionality discounting over the life cycle of the washing machine. In this case the product is changing the user after six years by

the intermediate step of "preparation for reuse" at a waste collection centre without any repairing or remanufacturing.

Considering functionality exclusively no difference between reuse and preparation for reuse is assumed which is equal for the allocation of environmental burdens (see Fig.3).
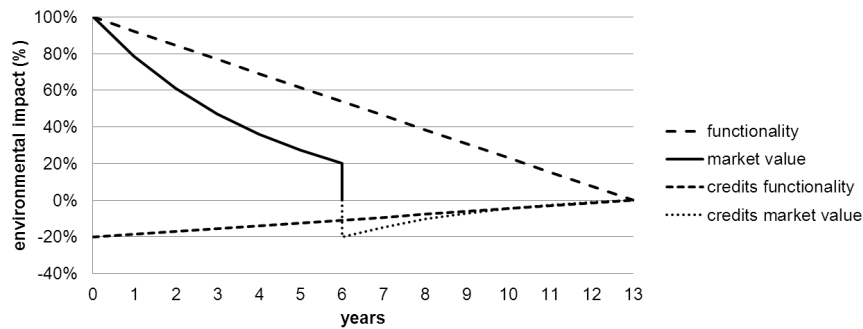

Fig.5: **Discounting of GWP over the lifetime of a "preparation of reuse"-washing machine (transported to waste collection centre in year 6)**

Applying market value allocation all environmental burdens until the point of a market value of zero are allocated to the first use of the product (=100% environmental burden from production phase) and the environmental impact after this step is allocated to the second use (=100% credits from end of life).

Being valid to the recyclability substitution approach [5] the result after a specific time-period must be the same for reuse and preparation for reuse as physical causality is equal and of higher priority than the market value.

The following suggestion of an allocation approach for "preparation for reuse" is combining the physical causality and the loss of market value to get equal results as in the reuse-scenario.

Therefore credits must be given to the first product life consisting of the environmental burden content of the second life and the appropriate recycling credits for the first life as in the reuse scenario. This method must also be applied for the second product life reciprocally by allocating the credits from first life as burdens in second life (e.g. Fig.6). The total results by adding burdens and credits for the time-period examples give equal results as the "reuse" scenario being compliant to the physical causality.

Regardless of getting equal results the involvement of the zero-value influence is clearly shown in Fig.6. The figure also points out the main responsibilities for the life cycle phase production (first user) and end of life (second user). These

crediting is also necessary to follow the idea of rewarding the first life of a product for enabling the possibility of a further use.
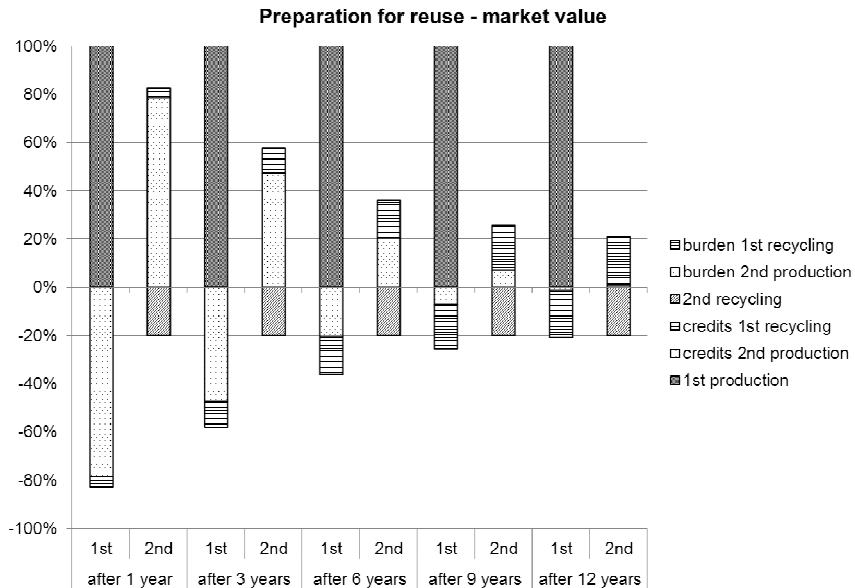
Preparation for reuse - market value

Fig.6: **Allocation of GWP to first and second user market value based after different time-periods for the scenario "preparation for reuse"**

4 Conclusions

The results of the case study of a washing machine in section 3 show the differences between allocations based on the functionality or on the market value of a product. As the loss of market value is normally higher than the loss of functionality, significantly higher environmental impacts are given to the first life of a product. For electrical appliances the market value can be seen as more appropriate than the functionality which does not involve the increasing risk of immediately breakdown within increasing age of a product. For future studies on the comparison between reuse and recycling especially this factor has to be intensively scrutinized.

The difference between a "reuse" and a "preparation for reuse" scenario is more methodological as physically driven. The results over the entire life cycle of a product are the same for both scenarios; only the way of allocating burdens and

credits can be adapted due to the reason of a market value of zero at the end of the first life for "preparation for reuse". The paper gives a suggestion for allocation of "preparation for reuse" to include the physical causality and the loss of market value. This suggestion also rewards the first owner for handing over a reusable electrical appliance to waste collection centre.

The results of the "preparation for reuse" scenario are also answering an additional question, namely the division of responsibilities between two use phases. The entire environmental impact of the production phase is allocated to the first life and recycling credits to the second life. A reduction of the environmental impact from production of a new appliance allocated to the first user is only possible by getting credits from proper end of life management. The impact allocation is equal to the responsibility of the first user as he is responsible for the production and for enabling the option of further use or recycling only. With the beginning of the reuse phase credits are given to the first life consisting of handed over production burdens to the second life and adequate time-related recycling credits. The second owner is responsible for a proper recycling after the end of the products life. Thus, all credits from recycling are allocated to the second user. If no recycling is applied the results for the second life are consisting of allocated production burdens and handed over recycling credits to the first life. This handing over of recycling credits is necessary even no recycling is done as the first owner has no influence on the end of life phase and must be credited as high as possible for enabling the reuse possibility.

These steps of responsibility are similar for the "reuse"-scenario. Thus, the steps of allocating burdens and credits between two users can also be applied for the reuse-scenario.

5   References

[1]   Spitzbart M., Thaler A., Stachura M.: Leitfaden für die Wiederverwendung von Elektroaltgeräten in Österreich, Ergebnis der reuse-Plattform, KERP-Kompetenzzentrum Elektronik und Umwelt, Wien, 2009

[2]   European Union, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, 2008

[3]   Obersteiner G., Linzner R., Pertl A., Scherhaufer S., Schmied E.: Formalisation of Informal Sector Activities in Collection and Transboundary Shipment of Waste in and to CEE – Introduction to the Project "TransWaste", In: International CARE Electronics Office (Ed.), Going Green. CARE INNOVATION 2010, 2010, Abstract Book p. 17; full paper on CD

[4]   Pertl A., Obersteiner G., Scherhaufer S., Den Boer J.: Ecological and economic informal waste management strategies - A case study, In: Gidarakos E., Cossu R., Stegmann R. (Eds.), Crete 2010 - 2nd International Conference on Hazardous and Industrial Waste Management, Executive Summaries, 2010, Abstract p.65-67, full paper on CD

[5]   European Union, ILCD handbook: General guide for Life Cycle Assessment - Detailed guidance, 2010

[6]   Rüdenauer I., Gensch C.-O., Quack, D.: Eco-Efficiency of washing machines - Life Cycle assessment and determination of optimal life span. Öko-Institut e.V., Freiburg, Germany, 2005

[7]   Rüdenauer I., Gensch C.-O.: Eco-Efficiency analysis of washing machines - Futher use versus substitution of washing machines in stock, Öko-Institut e.V., Freiburg, Germany, 2005