Extended Abstract
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PLATE
Product Lifetimes And The Environment

Coupling LCA and product lifetime modeling to support repair & reuse: a case study in the WEEE sector

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ecosystem & the WEEE scheme

Representing about 5,000 Electrical and Electronic Equipment (EEE) producers, ecosystem is a Producer Responsibility Organization (PRO), i.e., a non-profit organization accredited by the French Public Authorities to organize and manage the collection, the repair, the reuse and the recycling of household and professional Waste of Electrical and Electronic Equipment (WEEE). Each year about 700,000 tons of e-waste is collected by ecosystem with 2% reuse, a trend that is expected to grow in the coming years to reduce the environmental footprint of the EEE sector.

Repair & reuse in the WEEE sector

The "Anti-waste law for a circular economy" enacted in France in 2020 led to the creation of two financial funds aiming at supporting stakeholders of the reuse and repair sectors to extend appliances' lifetimes (French Code of Environment, Art. L541-10-4 / Art. L541-10-5). Handed with historical partners Emmaüs and Envie, about 1 million household appliances were reused in 2023.

On the repair side, more than 100,000 repairs were realized in 2023 with the funds.

To enhance and to give value to these activities, ecosystem enlarged its expertise to quantify the environmental benefits from repair/reuse.

LCA to support repair and reuse

An LCA was conducted based on a substitution approach (Tecchio et al., 2016; Ardente et al, 2018; Fangeat, ADEME et al, 2022).

It is assumed in this work that the used product was either defective or a waste at the time ecosystem took a responsibility of if for extending its lifetime. Therefore, the product's first life is excluded from the scope.

Then, the functional unit is defined as per the following:

"Extending the lifetime of an electrical / electronic household appliance during X years instead of replacing it with a new equivalent one to be used the same way over the same period X."

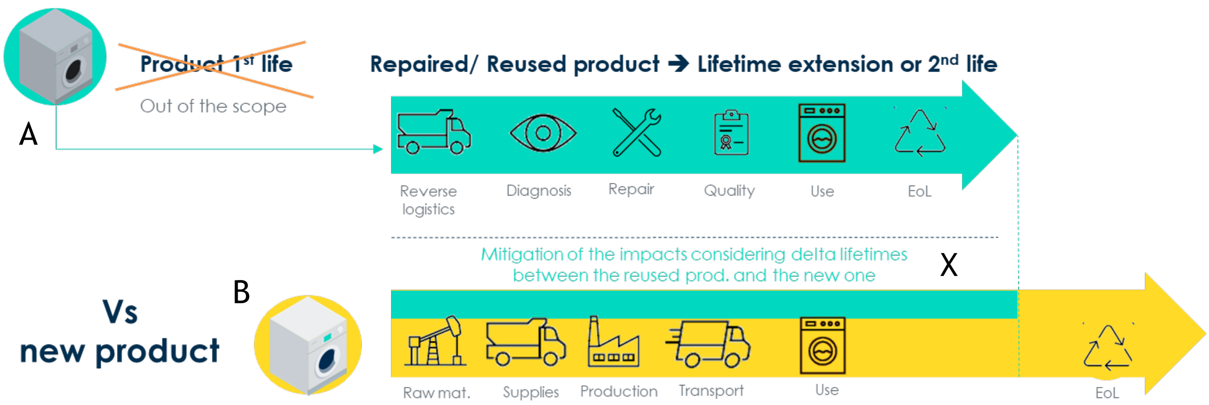


Figure 1. Visual approach of the environmental assessment of repair/reuse

The methodology remains identical for all household equipment, but a washing machine is chosen here as a study. A comparison is made between a first scenario considering a replacement of a washing machine (A) by a new one (B) and a second scenario where the washing machine (A) is extended by X years. A 10-year theoretical lifetime (TLT) is defined for the two scenarios, based on literature review and ecosystem's expertise on WEEE sampling.

Equation 1. Impact of 1st scenario (replace)

$$P_A + U_A \times LT_A + EoL_A + P_B \times \frac{X}{TLT} + U_B \times X + EoL_B \times \frac{X}{TLT}$$

Equation 2. Impacts of 2nd scenario (repair/reuse)

$$P_A + U_A \times (LT_A + X) + R_A + EoL_A$$

With:
P_A = Impacts of the production of appliance A
P_B = Impacts of the production of appliance B
U_A = Impacts of the use of appliance A
U_B = Impacts of the use of appliance B
EoL_A = Impacts of the end-of-life of appliance A
EoL_B = Impacts of the end-of-life of appliance B
TLT = Theoretical lifetime (assuming TLTA = TLTB)
LT_A = Lifetime of appliance A
X = Extended lifetime of appliance A

The assessment of the benefits is the difference between equation 1. and equation 2. described in equation 3.

Equation 3: Final assessment

$$\left[\frac{P_B}{TLT} + \frac{EoL_B}{TLT} + (U_B - U_A)\right] \times X - R_A$$

Two outcomes are possible:
1- The result is > 0, then it is relevant from an environmental standpoint to repair/reuse.
2- The result is < 0, then it is not relevant to repair/reuse. Another valorization shall be done by reusing spare parts and recycling.

This approach is relevant for setting an operational diagnosis to optimize the environmental benefits as part of an efficient circular economy strategy.

If the impacts modeling for repair can be different than reuse, both have shown that the assessment is very sensitive to the age of the washing machine, the need of spare parts for repair and reconditioning process and the lifetime extension as the key factor.

The delta of energy-consumption between the washing machine A and the new one B may also mitigate the benefits of repair/reuse particularly on fossil resources depletion.

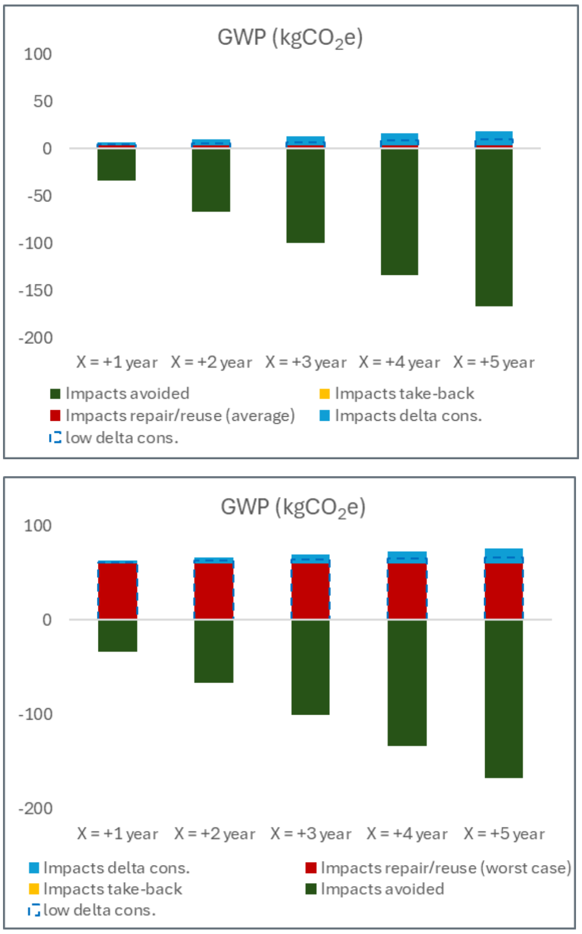
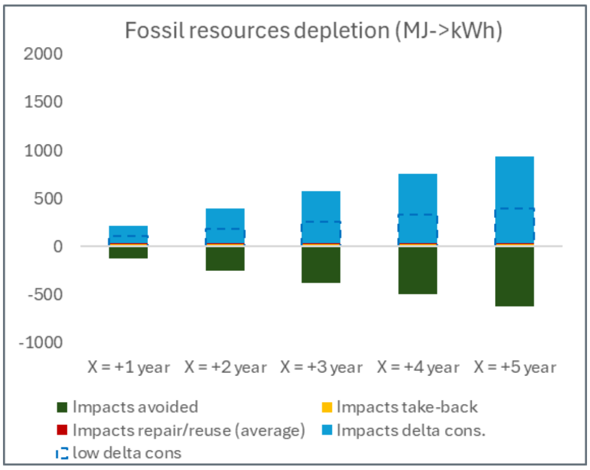


Figure 2. Results on climate change impact category (top = average scenario / bottom = spare part with high impact)

Overall, calculations have shown significant environmental benefits of repair / reuse, maximized with X.

Some isolated scenarios were considered when exploring the potential benefit of repair/reuse. As shown in Figure 2 the replacement of a spare with high impact will need to be compensated with more than two years' extension of product A. This emphasizes the need for secondary spare parts to minimize the impact.



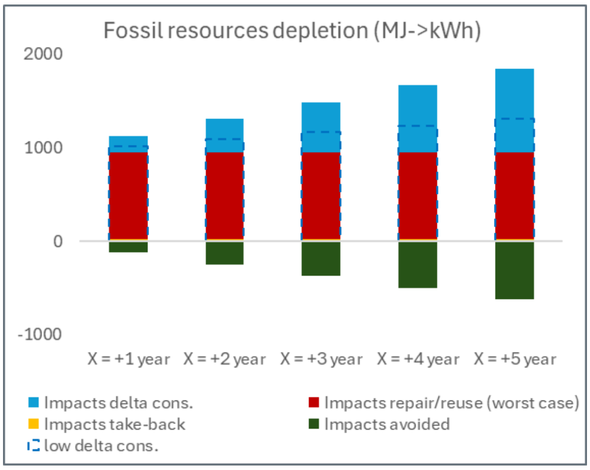


Figure 3. Results on fossil resources depletion impact category (top = average scenario / bottom = spare part with high impact)

The old washing machine may be less energy-efficient compared to the new one, and the environmental benefits from repair/reuse will also be limited as shown on Figure 3 looking at the fossil resources depletion impact category.

Using LCA to support a full diagnosis of the washing machine to repair/reuse considering its energy consumption linked to its age and its potential second life is key to deciding whether it is more viable to repair/reuse it or to send it to recycle.

Limits and perspectives

The environmental benefits of repair and reuse are mainly bonded to product lifetimes and particularly the lifetime extension as the major sensitive data and the first limit of the final assessment. This data remains in consumers' hands, which leads to high uncertainty about the results. To reduce this uncertainty, a refined data collection is currently carried out through several studies to address more the precisely the value of lifetime extension X**.**

A second limit is related to the TLT. If some assumptions can be made through literature and WEEE sampling, there is no consensus on the TLT value. Besides, using the number of years to define a product's lifespan may not reflect the same intensity usage from one consumer to another. This questions the functional unit when discussing the reuse of an electric drill used by a professional versus a non-professional user.

Finally, a third limit can be related to the 1st product's lifetime (ADEME, 2022). An allocation of the impact of the product A's 1st life can be considered when the repaired/reused product has not actually reached its TLT. Rebound effects of a second-hand market and product durability shall then be discussed.

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