H2020-SC5-2018-2: PLASTICS TO BE CLEANED BY SORTING AND SEPARATION OF PLASTICS AND SUBSEQUENT RECYCLING OF POLYMERS, BROMINE FLAME RETARDANTS AND ANTIMONY TRIOXIDE

D5.1 – DEFINITION OF GOAL & SCOPE AND RECYCLING ROUTE AND REFERENCES

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1 SUMMARY

In accordance with the ISO framework, the LCA and LCC studies that are carried out contain 4 phases:

- Goal & Scope definition
- Inventory analysis
- Impact assessment
- Interpretation.

In this document, only the Goal & Scope is defined and described more in depth; the other phases will get more attention in the other deliverables.
Critical aspects of the "Goal" are: intended application, reasons for the assessment, intended audience and will a public communication take place.
Critical aspects of the "Scope" are: definition product system, system boundaries, impact assessment methodologies, data (quality) aspects, quality control.
These are described in text and graphs in the report. The confidential part of the methodology is described in this deliverable (D5.1 - Definition of goal & scope and recycling route and references - Annexes) and access is restricted to the consortium and the European Commission (EC).

Two perspectives are taken in the assessment, viz. the waste perspective and the product perspective:

- The waste perspective will give insight in the impacts and costs of processing WEEE plastics by the P2bC dissolution process route versus other existing process routes.
- The product perspective will give insight in the impacts and costs of using in a product recycled ABS versus virgin polymers.

A main aspect to carry out is the definition of the Functional unit.

The Functional unit from a waste perspective is:
"***The End-of-Life treatment of 1 tonne of WEEE plastics in a defined average composition and particle size, coming from a WEEE treatment plant***".
The composition of WEEE plastic waste has been assessed by Coolrec and is reported in this report.
The three following End-of-Life treatment routes will be assessed within the project:

1. Reference situation: Separation of a bromine free plastics fraction and a brominated plastics fraction by wet mechanical separation. Mechanical recycling of the bromine free fraction and incineration with energy recovery of the brominated plastics fraction.
2. CreaSolv® route: Sorting of the mixed plastics to bromine free and bromine containing plastics fractions. Mechanical recycling of the bromine free fraction and physical recycling by dissolution of the bromine containing fraction, including recycling of the polymers, antimony, bromine with the CreaSolv® process.
3. P2bC dissolution route: Sorting of the mixed plastics to bromine free and bromine containing plastics fractions. Mechanical recycling of the bromine free plastics and physical recycling by dissolution of the bromine containing fraction, including recycling of polymers, antimony, bromine with the P2bC process.

The Functional units from a product perspective are:

1. For the ABS part: ***"1 external door frame (made out of 0.495 kg ABS) of a washing machine with overall running time of 220 washing cycles per year and an expected lifespan of 10 years (7000 running hours)"***.

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2. For the HIPS part: "***1 inner liner (made out of 4.6 kg HIPS) of a household refrigerator's cabinet with overall running hours of 78840 hours and an expected lifespan of 9 years***".

It is assumed that the application of recycled ABS or recycled HIPS will not change the material properties significantly, so that the same weight amount of virgin materials will be substituted by the application of the recycled amounts.

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2 INTRODUCTION

PLAST2bCLEANED's aim is to develop a recycling process for WEEE plastics in a technically feasible, environmentally sound and economically viable manner. To fulfil this aim, PLAST2bCLEANED addresses the recycling of the most common WEEE plastics acrylonitrile butadiene styrene (ABS) and high impact polystyrene (HIPS) that contain up to 20wt% brominated flame retardants (BFR) and up to 5wt% of the synergist antimony trioxide (ATO). PLAST2bCLEANED will close three loops: (1) polymer, (2) bromine, and (3) ATO. This document is deliverable 5.1 within the PLAST2bCLEANED project (GA no. 821087) and defines the Goal and Scope of the Life Cycle Assessment (LCA) and Life Cycle Costing (LCC).

LCA addresses the environmental impacts of a product system along the entire life cycle in accordance with ISO 14040, from raw material extraction, through energy and material production and manufacturing, to use and end of life treatment and final disposal. Through such a systematic overview and perspective, potential for further optimization of new developments can be derived and shifting of environmental burden between life cycle stages and individual processes can be avoided. By integrating economic aspects using LCC in accordance with ISO 14045, the life cycle framework can be extended in order to analyse the contribution of new developments towards sustainability from a second dimension.

In accordance with the ISO framework, the LCA and LCC studies to be carried out contain 4 phases (See Figure 1):

- Goal & Scope definition
- Inventory analysis
- Impact assessment
- Interpretation

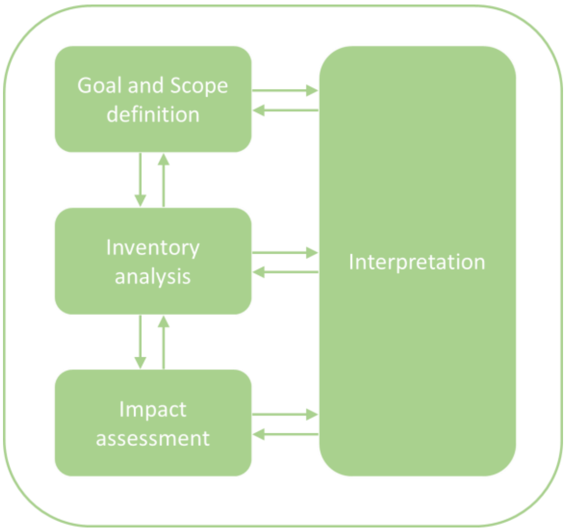

FIGURE 1 LIFE CYCLE ASSESSMENT FRAMEWORK ACCORDING TO ISO 14040

In this document, only the Goal & Scope is defined and described more in depth; the other phases will get more attention in the other deliverables. For the approach and definition of the Goal & Scope the ISO 14040 will be followed. In Chapter 3 aspects of the 'Goal' of the LCA and LCC will be described and the same approach will be formulated for the 'Scope' in Chapter 4.

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Crucial aspects for the 'Goal' are:

- Intended application of the assessment.
- Reasons for carrying out of the study.
- Intended audience (stakeholders); for whom are the results relevant and to whom will these results be communicated.
- Is the intention to discuss and to communicate the results to the public, for instance for comparisons or for real improvements to be implemented.

Crucial aspects for the 'Scope' are:

- Product system to be studied; the functions of the product system and the Functional unit.
- Boundaries for the systems to be studied and allocation procedures in the case of multi-input and/or multi-output systems.
- Selected impact assessment methodology, selected impact categories and used interpretation.
- Data requirements; assumptions, limitations, quality aspects.
- Critical review and quality control of the assessment.

In Chapter 4, the selected treatment, recycling routes are also described more in detail; both from the waste perspective (selected WEEE plastics) and the product perspective (proposed applications of the regenerated, purified WEEE plastics).

Finally, in Chapter 5, conclusions and recommendation are described in line with the planning of Work Package 5 and the foreseen follow-up activities.

The confidential part of the methodology is described in another deliverable (D5.1A - Definition of goal & scope and recycling route and references - Annexes) and access is restricted to the consortium and the European Commission (EC).

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3 GOAL

3.1 INTENDED APPLICATION

WEEE plastics containing brominated flame retardants (BFR) and antimony trioxide (ATO), sorted with LIBS and Raman MS sensors, which are recycled using the PLAST2bCLEANED superheated dissolution process. Separated HIPS and ABS fractions, including BFR and ATO, will be recycled. So three loops, polymers HIPS/ABS, bromine and antimony trioxide will be closed. The environmental and economic performance of this overall treatment will be compared with those of current, competitive options.

3.2 REASONS FOR CARRYING OUT LCA & LCC

Results of environmental and human health assessments, with the help of the LCA methodology, will ensure that the optional innovation will decrease the environmental and human health related impacts. Not only the innovation itself is accounted for, but also the avoidance of the winning of primary resources and materials is considered. This is because the loops are closed for the considered polymers, BFR and ATO.

For the proposed dissolution – recovery route, based on the application of one superheated solvent, real reductions of costs and more benefits are predicted;

- Mechanical pre-sorting results in high BFR/ATO concentrations
- Use of one solvent instead of two, looking at competitive options
- Less heat will be required by the application of less heat consuming process steps
- Relatively high prices for purified polymers for added value applications

Comparison of the results of the LCAs and LCCs with those of running and competitive routes will prove the attractiveness of the optional innovation. These LCA and LCC figures will support the acceleration of the implementation of the innovative route.

3.3 INTENDED AUDIENCE

This deliverable describes the LCA and LCC in more depth. The confidential part of the methodology is described in this deliverable (D5.1A - Definition of goal & scope and recycling route and references - Annexes) and access is restricted to the consortium and the European Commission (EC).

In principle, the intended audience of the LCA and LCC results are the project partners and the European Commission.

The results (at an aggregated and/or anonymised level) will be communicated outside the consortium. Especially the relevant stakeholders will be informed, who are involved in improvement and enlargement of the running WEEE structures, all over Europe, including the take back organisations. The attractive environmental and economic profiles of these developed superheated solvent routes will encourage them to support fast implementation.

3.4 PUBLIC

The detailed results of the assessment will be restricted to the consortium.

The results (at an aggregated and/or anonymised level) will be communicated to the public, with the aim to involve the European citizens to contribute to collection at source systems for WEEE articles. The message that sustainable and innovative WEEE processes will be introduced will help the citizens to change their knowledge and ideas on WEEE treatment. An enlarged contribution will reduce the losses of WEEE items in residual waste streams to be incinerated.

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4 SCOPE

4.1 FUNCTION AND FUNCTIONAL UNIT

To assess the environmental impacts and the economic costs of the dissolution route developed within the PLAST2bCLEANED project, two perspectives are selected: The waste perspective and the product perspective.

The waste perspective will give insight in the impacts and costs of processing WEEE plastics by the P2bC dissolution process route versus an existing, currently implemented process route and the CreaSolv® process route.

The product perspective will give insight in the impacts and costs of using recycled ABS in a door frame of a washing machine and recycled HIPS in the inner liner of a fridge versus the use of virgin polymers.

4.1.1 WASTE PERSPECTIVE

The Functional unit from a waste perspective is "***The End-of-Life treatment of 1 tonne of WEEE plastics in a defined average composition and particle size, coming from a WEEE treatment plant***".

For this situation, WEEE plastics is defined as a plastic concentrate produced after shredding WEEE and separating the metal fractions. The composition of WEEE plastics varies according to the process of the WEEE treatment plant because of the varying input of that plant (fridge, screens, ICT, …). It usually has a particle size in the range of 8 to 80 mm.

The WEEE plastics are the typical input of the plastics separation plant. This plant will further grind the WEEE fraction down to a grain size of 8 to 14 mm and separate them in recyclable pure plastics streams, as PP, HDPE, PS (in fact HIPS and GPPS) and ABS. These outputs of the plastics separation plant are free of Bromine, and usually sold to compounding or directly to end-users (injection moulders etc.)

The average composition of WEEE plastics for SDA (Small Domestic Appliances) and ICT, which comprises the majority of the volume, is given below.
The following impurities (non-hard plastics) are present (data from Coolrec); see Table 1:

TABLE 1 IMPURITIES IN WEEE PLASTIC MIX

Type of material	Mass %
Dust	8.0 %
Metals	2.6 %
Rubber	3.1 %
Wood	3.3 %
Other impurities (foam, foil, minerals)	2.0 %
Total impurities	19.0 %

The remaining plastic mix (81%) are hard plastics. The composition is (data from Coolrec); see Table 2:

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TABLE 2 COMPOSITION OF WEEE PLASTICS MIX

Type of polymer	Without additives or filler material	With (brominated) flame retardants or filler materials	Unknown if contains additives
HDPE	3.1 %	0.6 %	
PP	12.6 %	1.4 %	
GPPS or HIPS	13.9 %	3.8 %	
ABS	19.1 %	11.5 %	
PC or PC/ABS	4.4 %	9.1 %	
PBT			0.6 %
PA			0.6 %
Other hard plastics			0.3 %
Total	**53.1 %**	**26.4 %**	**1.5 %**

4.1.2 PRODUCT PERSPECTIVE

4.1.2.1 ABS product

The functional unit is: ***"1 external door frame (made out of 0.495 kg ABS) of a washing machine (See Figure 2) with overall running time of 220 washing cycles per year and an expected lifespan of 10 years (7000 running hours)"***.

FIGURE 2 ELECTROLUX WASHING MACHINE

The external door frame (see Figure 3) weighs around 495 g. Essentially, this component has structural as well as aesthetic function and is joined together with an inner frame. It supports the glass part of the door and all the mechanisms related to its functioning (opening, closing, blocking, etc.). The technical properties of the component are represented by the ABS material specifications and reported in Annex 1 (D5.1A). Among all the existing versions, this component is designed to be welded, painted and plated. The running hours of this product may vary according to users' habits, but on average it is expected to work for 220 washing cycles per year, i.e. about 7000 hours for an expected lifespan of 10 years.

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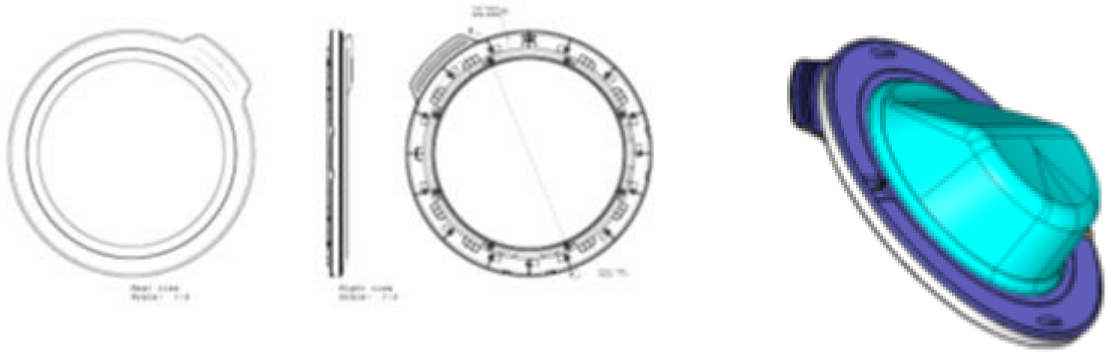

FIGURE 3 PICTURE AND DRAWING OF THE EXTERNAL WASHING MACHINE DOOR FRAME

4.1.2.2 HIPS product

The functional unit is: "***1 inner liner (made out of 4.6 kg HIPS) of a household refrigerator's cabinet (see Figure 4) with overall running hours of 78840 hours and an expected lifespan of 9 years***".

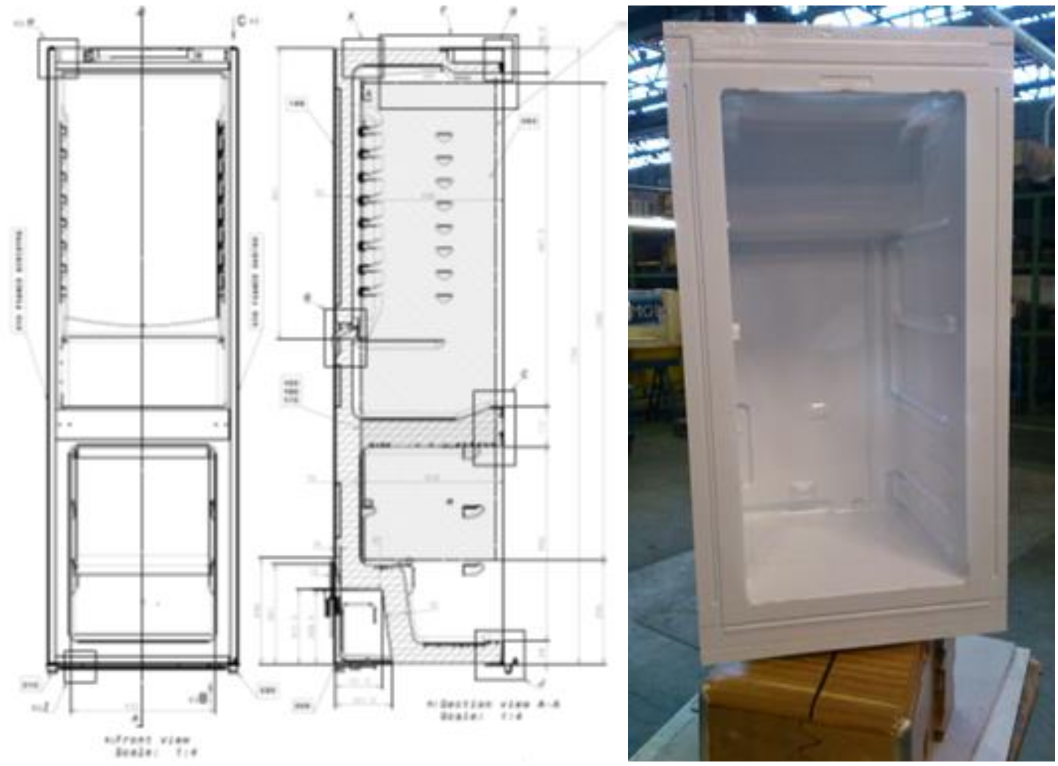

FIGURE 4 DRAWING AND PICTURE OF THE INNER LINER

A refrigerator normally runs 24 hours per day, i.e. 8760 hours per year. The expected life span of a refrigerator is 9 years, according to the Preparatory Studies for Eco-design Requirements of EuPs. Lot 12. (Bio Intelligence Service, 2007), that corresponds to 78840 hours. The inner liner weight is 4.6 kg and its technical specifications follow the HIPS material specifications reported in Annex 1 (D5.1A).

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4.2 SYSTEM BOUNDARY AND ALLOCATION

4.2.1 WASTE PERSPECTIVE

This perspective considers only the End-of-Life treatment of WEEE plastics. The production and the use phase are not taken into account. The system boundaries cover the

- Shredding, sorting and pre-treatment of the WEEE plastics.
- Various transportation steps.
- Various End-of-Life treatments.

The three following End-of-Life treatment routes will be assessed within the project:

1. Reference situation: Separation of a bromine free plastics fraction and a brominated plastics fraction by wet mechanical separation. Mechanical recycling of the bromine free fraction and incineration with energy recovery of the brominated plastics fraction.
2. CreaSolv® route: Sorting of the mixed plastics to bromine free and bromine containing plastics fractions. Mechanical recycling of the bromine free fraction and physical recycling by dissolution of the bromine containing fraction, including recycling of the polymers, antimony, bromine with the CreaSolv® process[1].
3. PLAST2bCLEANED (P2bC) dissolution route: Sorting of the mixed plastics to bromine free and bromine containing plastics fractions. Mechanical recycling of the bromine free plastics and physical recycling by dissolution of the bromine containing fraction, including recycling of polymers, antimony, bromine with the P2bC process.

1. Reference situation

The WEEE plastics mixture is treated in a plastics separation plant with wet separation techniques. In this plant, the mixture will be further ground to a grain size of 8 to 14 mm and will be separated in recyclable pure plastics streams as PP, PE, PS and ABS. These outputs of the plastics separation plant are free of bromine, and usually go to compounding or directly to end-users (injection moulders etc.). The remaining non-target plastics part, together with the non-metallic impurities, are incinerated. In total, this represents 47% of the WEEE plastics input to the separation plant. From incineration, energy will be recovered as electricity and heat (see Figure 5). This will be modelled as a benefit. This means that the prevented emissions from electricity production (European average) are modelled as negative emissions.

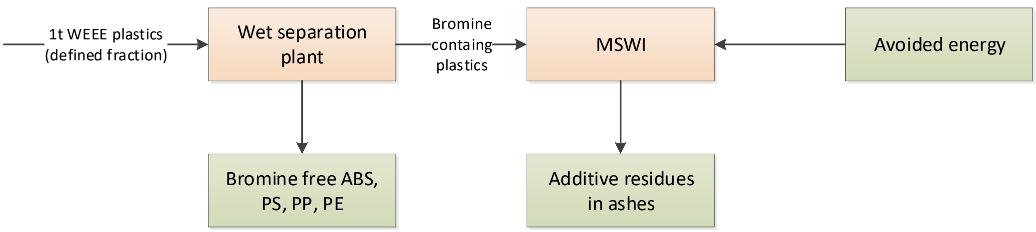

FIGURE 5 INCINERATION OF WEEE PLASTICS

2. CreaSolv® route

The WEEE plastics mixture is treated according to the CreaSolv® route, consisting of three main steps, viz. pre-sorting, mechanical recycling and the CreaSolv® process.

The sorting is done manually (with handheld XRF) or technical with XRT or LIBS. The non-flame retarded types of ABS, PS, PP and PE are processed in new products in the way of open-loop mechanical recycling. The BFR containing plastics are treated in the CreaSolv® process (see D5.1A, Annex 3).

[1] M. Schlummer et all ; Recovery of bromine and antimony from WEEE Plastics ; Fraunhofer Intitute IVV Germany ; Proceedings Electronics goes Green, Berlin, 2016

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3. P2bC dissolution route

The WEEE plastics mixture is treated according to the P2bC route, consisting of three main steps, viz. pre-sorting, mechanical recycling and the P2bC process.

First, the WEEE plastics are pre-treated by Coolrec using a combination of sensor-based LIBS and Raman spectroscopy and traditional sorting and separation technologies (density separation, magnetic separation, etc.). On top of the clean streams that are already produced in the existing process (PP, PE, PS and ABS without flame retardants), this process will produce new clean streams of the project target polymers (PS, HIPS and ABS with flame retardants, and PC/ABS). The non-flame retarded types of ABS, PS, PP and PE are processed in new products in the way of open-loop mechanical recycling. The BFR containing plastics ABS and HIPS are treated in the P2bC process (see D5.1A, Annex 3).

4.2.2 PRODUCT PERSPECTIVE

4.2.2.1 ABS washing machine door frame

ABS is a common grade plastic, widely used in household appliances. The polybutadiene in ABS has a rubbery consistency, which provides impact strength and durability. ABS is also resistant to many chemical substances and to electricity and it is easily machined, painted, welded or glued and even plated. Its low melting temperature (210°C-240°C) makes it ideal for injection moulding. The external door frame is manufactured by an injection moulding process (see Figure 6). The processing data of injection moulding are reported in the ABS specification. The use of recycled ABS from WEEE would lead neither to a significant change in material properties nor in manufacturing process parameters. The great advantage of using recycled ABS is the reduction of CO_2 emissions as a result of skipping the standard process for ABS production from fossil raw materials.

The product assessment will give insight in the impacts and costs of using recycled ABS in a door frame of a washing machine versus the use of virgin polymers.

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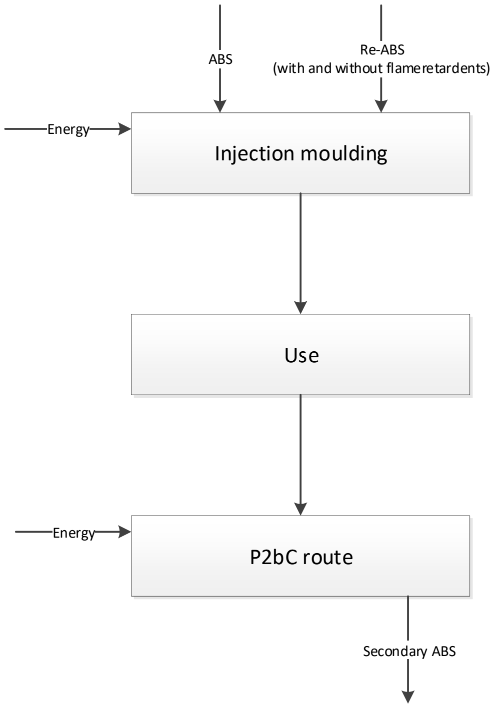

FIGURE 6 **VIRGIN OR RECYCLED ABS USED FOR PRODUCT MANUFACTURING, USE AND END-OF-LIFE**

4.2.2.2 HIPS inner liner fridge

HIPS is largely used to produce refrigerator inner and door liners, thanks to its good melt strength, which makes this plastic material particularly suitable for thermoforming. It is stable at the typical temperatures of fridges and freezers and can also be processed with other PS grades in multi-layered sheets. Its butadiene rubber content provides HIPS with good impact resistance and its surface requires minor or no treatments to achieve a good adhesion with foamed PUR, the insulation material that usually embeds the liner and must have a good adhesion to it to achieve good insulation performance. HIPS for refrigerators must usually have a good chemical resistance (ESCR) and must fulfil the international regulations concerning plastics in contact with food. The availability of recycled HIPS for WEEE would not change material properties and neither manufacturability process parameters. Also in this case, this is a great opportunity the reduce CO_2 emissions as a result of skipping the standard process for HIPS production from fossil raw materials. In Figure 7 the manufacturing of HIPS inner liners, including end-of life, is shown schematically.

The product perspective will give insight in the impacts and costs of using recycled HIPS in the inner liner of a fridge versus the use of virgin polymers.

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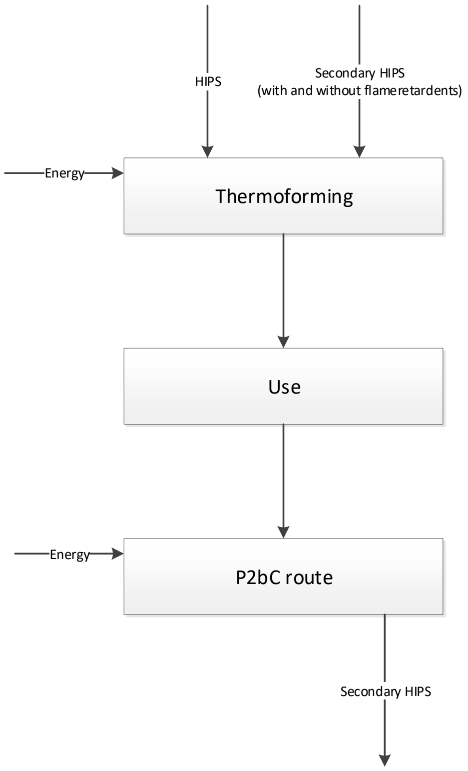

FIGURE 7 VIRGIN OR RECYCLED HIPS USED FOR PRODUCT MANUFACTURING, USE AND END-OF-LIFE

4.2.3 RULES FOR ALLOCATION

In some cases, processes can deliver more than a single product. In LCA, the question arises how the impacts of e.g. energy use or process emissions should be related to the production of the product and co-products, in this case ABS and PS polymers and bromine and antimony compounds. The approach is to first prevent allocation by system expansion, which is possible when the co-product data on the conventional production are available. One can then subtract the impacts of this process, hence only the impact of the product under study remains. In case this is not possible, a partitioning based on the physical relationships between the product and by-product is made. For instance, based on the mass balance in case different products are produced in different quantities and their prices per unit weight do not differ so much. In this case, this leads to unrealistic results, for instance when the main products have much more added value than the by-products, the approach for economic allocation is available. Therefore, the in- and outputs of the production process, for instance energy use and emissions, are allocated between the product and by-products in a way that reflects the economic values of the product and by-products.

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4.3 LCIA METHODOLOGY AND TYPES OF IMPACTS

4.3.1 ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impacts will be assessed using the following methods for impact assessment:

1. ReCiPe 2016[2] midpoint and shadow prices
2. ILCD[3] recommended indicators

ReCiPe 2016

Figure 8 shows an overview of the impact categories in the ReCiPe 2016 methodology and their relation to the areas of protection, human health, ecosystems and resource availability. The ReCiPe midpoint indicators will be used for the impact assessment. Shadow prices will be used to compare the various midpoint categories and to identify environmental hotspots in the considered process routes. A full set of shadow prices, updated to the ReCiPe 2016 methodology, might not be available at moment of the assessment. The missing shadow prices might need to be derived or estimated.

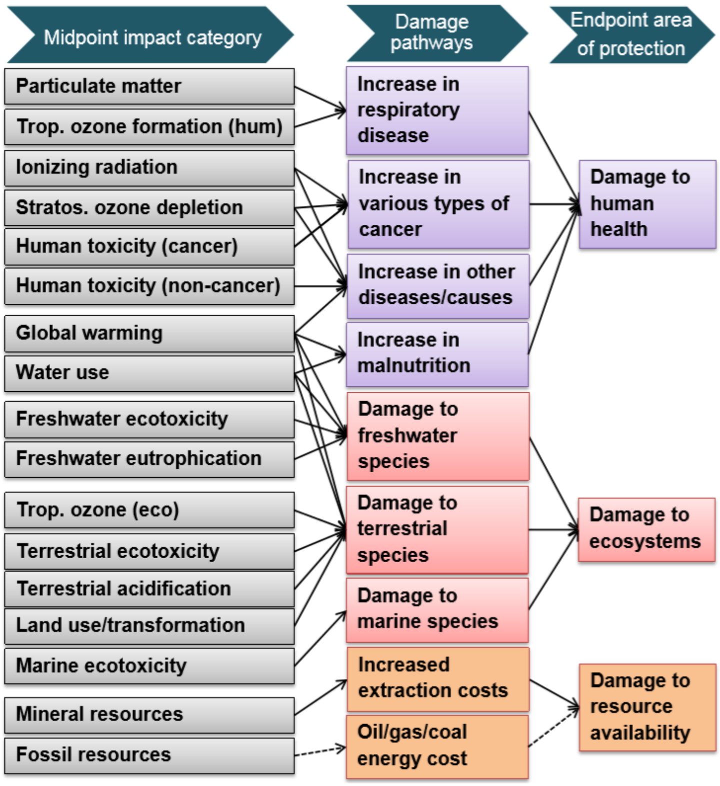

FIGURE 8 OVERVIEW OF THE IMPACT CATEGORIES THAT ARE COVERED IN THE RECIPE2016 METHODOLOGY AND THEIR RELATION TO THE AREAS OF PROTECTION

ILCD

The ILCD has a long list of recommended impact categories (see Annex 2, D5.1A). The list contains indicators from various methodologies. They are classified according to their quality into three levels: "Level I" (recommended and satisfactory), "Level II" (recommended but in need of some improvements) or "Level III" (recommended, but to be applied with caution).

[2] Huijbregts M, et al, ReCiPe 2016, A harmonized life cycle impact assessment method at midpoint and endpoint level Report I: Characterization (2016)

[3] European Commission, Joint Research Centre, Institute for Environment and Sustainability. Characterisation factors of the ILCD Recommended Life Cycle Impact Assessment methods. Database and Supporting Information. First edition. February 2012. EUR 25167. Luxembourg. Publications Office of the European Union; 2012.

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A selection of relevant indicators will be made. Table 3 includes a first example of a selection of impact categories which might be considered within the assessment, but this list can be modified and extended.

TABLE 3 EXAMPLE OF A SELECTION OF IMPACT CATEGORIES

Impact indicator	Unit	Methodology
Climate change (incl. biogenic carbon)	kg CO2 eq.	ILCD recommendations
Acidification (AP)	Mole of H+ eq.	ILCD recommendations
Freshwater eutrophication (EP)	kg P eq.	ReCiPe
Photochemical oxidant formation (POCP)	kg NMVOC eq.	ReCiPe
Abiotic depletion (ADP fossil)	MJ	CML 2015
Water use	m^3 water eq. of deprived water	ILCD recommendations

Based on findings and recommendations from the product environmental footprint (PEF) pilot studies of the European Commission (EC 2017), the standardized methods for normalization (Benini et al. 2014) and weighting (Sala, Cerutti & Pant 2018) of the characterized results can be applied optionally in order to support decision makers by calculating single score results (avoid potentially conflicting results in different impact categories). The final single score indicator is referred to as the environmental footprint (EF) and is expressed by the endpoint unit [Pt]. Table 4 includes the normalization and weighting factors based on the selection of impact categories (see Table 3).

TABLE 4 SELECTION OF NORMALIZATION AND WEIGHTING FACTORS

Impact indicator	Normalization factors	Weighting factors
Climate change (incl. biogenic carbon)	8 043	21.1
Acidification (AP)	55.6	6.2
Freshwater eutrophication (EP)	1.61	2.8
Photochemical oxidant formation (POCP)	40.7	4.78
Abiotic depletion (ADP fossil)	65 004	8.32
Water use	11 469	8.51

4.3.2 ECONOMIC COST ASSESSMENT

Life Cycle Costing according to VDI 2884 and ISO 14045 (functional value expressed in terms of total internal costs and revenues) will be integrated in order to address the economic dimension of sustainability. LCC compares the cost-effectiveness of alternative recovering

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processes and products developed during the project in EUROs depending on the defined functional unit and the product system (€/t from a waste perspective and €/piece from a product perspective).

In order to carry out the economic assessment, the following monetary values of the developed PLAST2bCLEANED recycling processes will be addressed:

- **Fixed costs**
  - Capital investment costs for the technical equipment and infrastructure of the new developed recycling processes
  - Costs for linear depreciation and amortization of the recycling processes over a physical lifetime of 10 years (assumed)
  - Expected costs for maintenance and repair of the technical equipment for the recycling processes
  - Expected costs after utilisation for dismantling and recycling of the developed technology

- **Variable costs**
  - Costs for acquisition of raw materials, energy (electric, steam, natural gas, and other fuels) and auxiliaries
  - Transportation costs
  - Personnel expenses (labour costs) to run the recycling processes
  - Internalization of real costs that occur (e.g. by taxes) having an ecological aspect, such as the costs involved to treat wastewater or costs for greenhouse gas emissions (carbon pricing) generated during the recycling process

- **Revenues after recycling**
  - Income corresponding to the market value of the recycled materials (such as ABS, Bromine and Antimony), depending on their quality and quantity.

The cost analysis will be calculated based on static methods of investment analysis (fictional average period with a physical lifetime of 10 years) without taking into account the time value of money (dynamic approaches such as the Net Present Value for investments). Hence, the discount rate in the calculation is set to 0%.
The cost analysis is limited in the point considering avoided or external costs on the environment in future. The conventional LCC (similar to Total Cost of Ownership - TCO) is only carried out for financial analysis, whilst LCA assessment focuses on the environmental impact. Additional weighting factors for costs and savings are not considered.

4.4 DATA QUALITY REQUIREMENTS

In order to carry out the LCA and LCC study, a distinction must be made between foreground (primary) and background (secondary) data. Foreground data refers to material or energy flows collected specifically for the product system. They are decisive for the quality of the study and must therefore be collected as completely as possible. Background data from LCA databases (such as GaBi and Ecoinvent) or literature will be considered in order to assess complex downstream processes, such as the provision of raw materials or energy. The data sets to be used for the quick scan and the full LCA will be reviewed by partners. These sets are defined as milestone M5.1 and 5.2 respectively. The following two subchapters focus on the requirements on data collection from a waste and product perspective.

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4.4.1 REQUIREMENT ON DATA FROM THE WASTE PERSPECTIVE

Primary data for the assessment from the waste perspective will be tracked by the consortium partners within end-of-life during the development of the PLAST2bCLEANED recycling process and will be completed by secondary data from LCA databases. Data of the CreaSolv® and incineration process will be extracted from public references; see Figure 9.

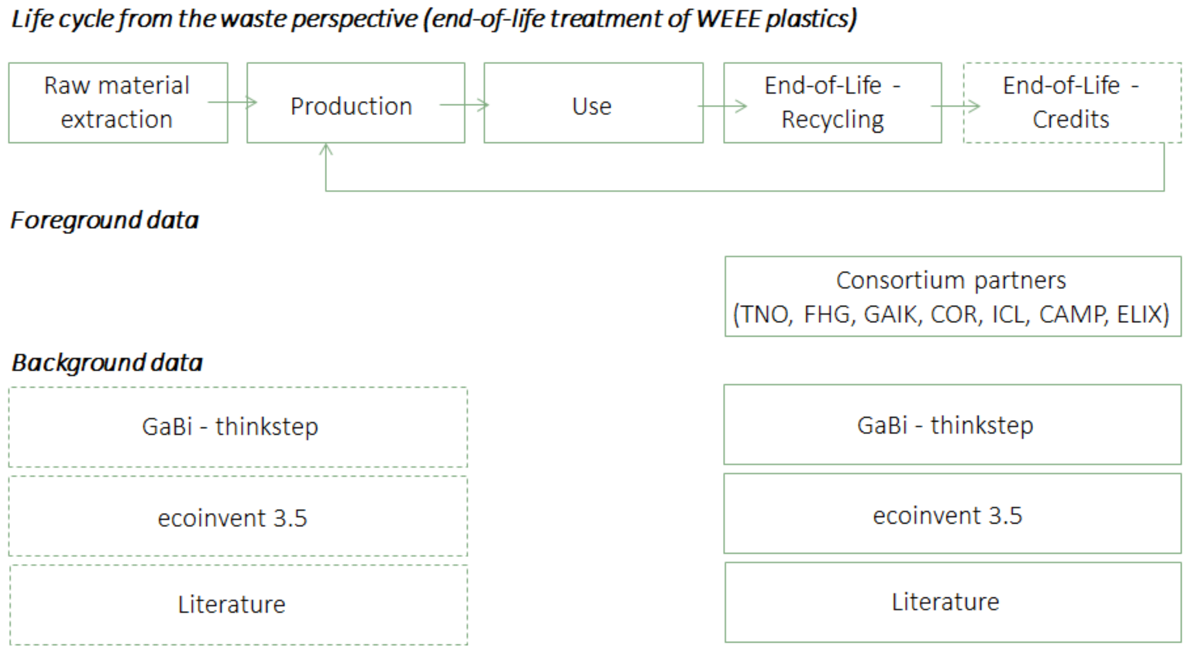

FIGURE 9 REQUIREMENT ON DATA COLLECTION FROM THE WASTE PERSPECTIVE

4.4.2 REQUIREMENT ON DATA FROM THE PRODUCT PERSPECTIVE

The assessment from the product perspective will consider the whole life cycle. Primary data for the production and the use phase will be provided by Electrolux. The other consortium partners will collect primary data during the development of the PLAST2bCLEANED recycling process. The inventory analysis of the study will be completed by secondary data from LCA databases; see Figure 10.

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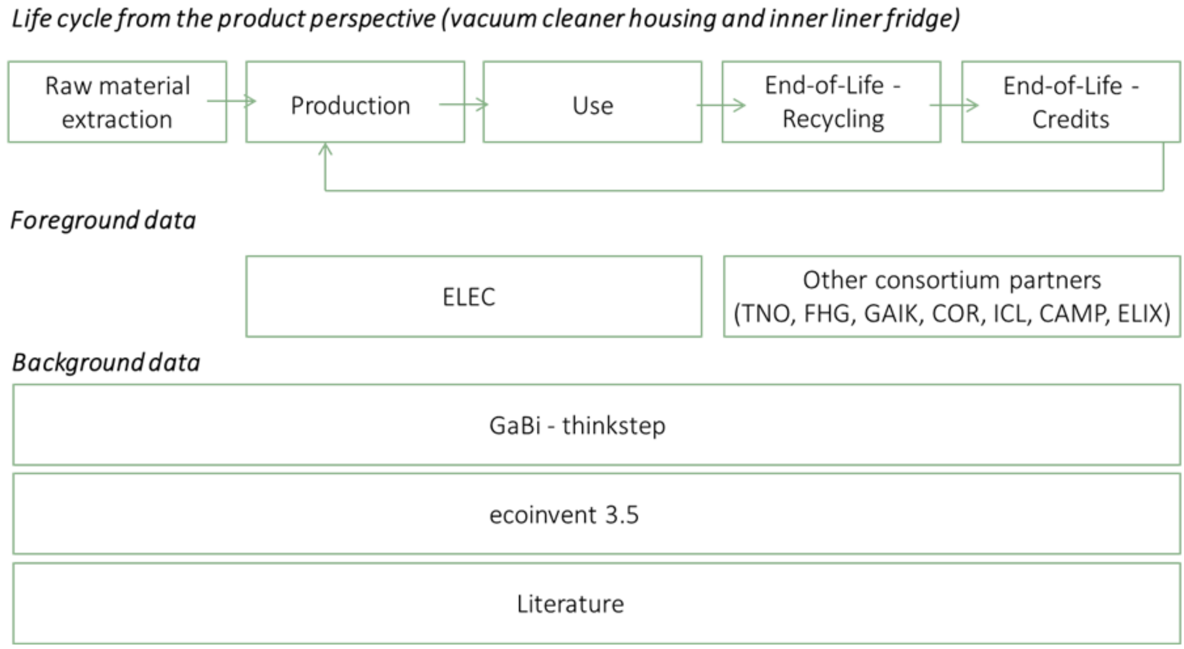

FIGURE 10 REQUIREMENT ON DATA COLLECTION FROM THE PRODUCT PERSPECTIVE

4.5 CRITICAL REVIEW

An external review is not planned within the project, but the assessment will be set up to be in compliance with the ISO guidelines for external review.

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5 CONCLUSIONS AND OUTLOOK

Assessing the sustainability of new recycling technologies requires a holistic life cycle perspective. Therefore, one of the main challenges is to avoid burden shifting in the case solutions, that close material cycles, unintentionally create other problems of ecological or economic nature. LCA and LCC are established instruments to provide a comprehensive environmental and economic assessment. Both tools will be used within the project PLAST2beCLEANED in order to assess the development of a new recycling technology for WEEE plastics (containing brominated flame retardants (BFR) and antimony trioxide (ATO)).

The goal and scope of the LCA and LCC study within PLAST2beCLEANED for the recycling of WEEE plastics (containing brominated flame retardants (BFR) and antimony trioxide (ATO)) was defined - including a detailed description of the product system and the functional unit from a waste and product perspective. According to ISO 14040/44, the next step (second phase) will be the collection of primary and secondary data during the inventory analysis of the study. The results of the inventory analysis will be summarized in Deliverable D5.2.

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ISO 14045 (2012). Environmental management – Eco-efficiency assessment of product systems – Principles, requirements and guidelines.

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7 ABBREVIATIONS

ABS	Acryl Butadiene Styrene
ATO	Antimony Tri Oxide
BFR	Bromine Flame Retardants
EF	Environmental Footprint
EoL	End-of-Life
ESCR	Environmental Stress Cracking Resistance
EuPs	Eco-Design of Energy Using Products
GPPS	General Purpose PolyStyrene
HDPE	High Density PolyEthylene
HIPS	High Impact PolyStyrene
ICT	Information and Communication Technology
ILCD	International Reference Life Cycle Database
ISO	International Standards Organisation
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LIBS	Laser-Induced Breakdown Spectroscopy
M	Month
MSWI	Municipal Solid Waste Incineration
P2bC	PLAST2bCLEANED
PA	PolyAmide
PBT	PolyButylene Terephthalate
PC	PolyCarbonate
PE	PolyEthylene
PEF	Product Environmental Footprint
PP	PolyPropylene
PS	PolyStyrene
Pt	Point
PUR	PolyURethane
PVC	PolyVinylChloride
SDA	Small Domestic Appliances
VDI	Verrein Deutsche Industrie
WEEE	Waste Electric and Electronic Equipment
WP	Work Package
XRF	X-Ray Fluorescence
XRT	X-Ray Transmission

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