

Deliverable 29 - Life Cycle Flow Diagram (LCFD) for each alternative supply chain configuration considered

- 19/07/2016 -



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1 Introduction

1.1 Project summary

The project LIFE13 ENV/IT/000559 Autoplast aims at recovering waste plastic materials from the automotive sector, adopting an innovative production process which enables an improvement of the quality of the finished product. The implementation of a micro-collection system in the local area allows to recover plastic material that, otherwise, would have been sent to disposal. This project complies with the philosophy of Company Social Responsibility and Sustainability, considering its strong environmental, social and economic value [1].

The project aims at developing a system for the recovery of special plastic waste from the automotive sector through the realization of a pilot recycling plant, as well as the development of a network for a selective waste collection, to be carried out in the Province of Brescia.

The specific objectives of the project are [1]:

- Construction and start-up of an industrial plant for transformation of the collected plastic waste in reusable material.
- Development and organization of a supply chain in the Province of Brescia.
- Active involvement of a social cooperative in the activities of recovery, selection and separation of decommissioned components.
- Use of the regenerated granules in percentages higher than the current situation and with a reduction in the use of virgin raw materials and a reduction of CO₂ emissions into the environment.

1.2 Partners

Valsir: is a leading company in the plumbing and heating sector. Valsir has always been interested both in the development of sustainable solutions for its made in Italy range of products, and in the implementation of energetically efficient industrial processes. Valsir is the coordinating beneficiary of the Autoplast consortium [1]. (<http://www.valsir.it/>)

Cauto: is a cooperative founded in 1995 (l.381/91) to combine social inclusion and respect for the environment. The activities and services offered by the cooperative allow to promote employment, social and economic life and to take care of the environment [1]. (<http://www.cauto.it/>)

CSMT - Cento Servizi Multisetoriale e Tecnologico: the mission of CSMT is to translate innovation into applications, combining the most qualified and international university competences and the concreteness traditionally typical to the industrial area of Brescia. CSMT provides companies with consultancy and training services, in order to increase and improve their competences, so that they can be able to face new competitive challenges with an adequate know-how [1]. (<http://www.csmt.it/>)

1.3 LCA methodology

Life Cycle Assessment is a well-known analytical tool, standardised in ISO 14040-14044 [2-3], employed to assess potential environmental impacts of the entire life-cycle of a product, process or service.

Key characteristics of LCA are the “cradle to grave” approach, analysing each stage of the life cycle of a product, from raw materials, transports, production, distribution, use phase to recycling or final disposal; the assessment of a broad range of environmental burdens, including extraction of different types of resources, emissions of potentially hazardous substances, different types of land use, etc.; and the quantification of the environmental burden in relation to a functional unit of a product system.

The LCA methodology consists of four phases [2-3]:

1. Goal and scope: the first phase of an LCA, establishing the aim of the intended study, the functional unit, the reference flow, the product system(s) under study and the breadth and depth of the study in relation to this aim;
2. Life Cycle Inventory (LCI): the second phase of an LCA, in which the relevant inputs and outputs of the product system(s) under study throughout the life cycle are, as far as possible, compiled and quantified;
3. Life Cycle Impact Assessment (LCIA): the third phase of an LCA, concerned with understanding and evaluating the magnitude and significance of the potential environmental impacts of the product system(s) under study;
4. Interpretation: the fourth phase of an LCA, in which the results of the Inventory analysis and/or Impact assessment are interpreted in the light of the Goal and scope definition (e.g. by means of contribution, perturbation and uncertainty analysis, comparison with other studies) in order to draw up conclusions and recommendations [4].

The LCA methodology as defined and standardised by ISO 14040-14044 [2-3], is illustrated in Figure 1.

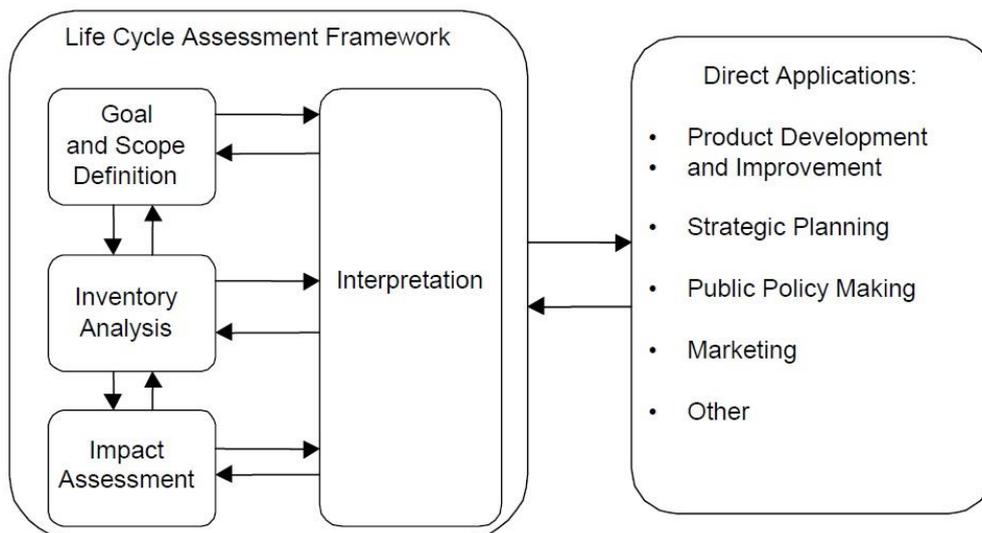


Figure 1: LCA methodology [2-3]

In the Autoplast project, LCA is applied to quantify and evaluate the environmental impacts associated with the novel recycling technologies developed during the project and with the new micro-collection system for automotive waste. The new recycled plastic granulate obtained in the

project will be compared with a conventional recycled granulate and with a virgin plastic granulate. Moreover, recycling will be compared with disposal in landfill and incineration.

2 Goal and scope definition

2.1 Goal definition

2.1.1 *Intended application and reasons for carrying out the study*

The main intended application for the LCA study is eco-design. An eco-design focused approach supports the development of new products and processes with reduced environmental impacts, through the analysis of their life cycles. The LCA will provide useful feedback, allowing to identify critical issues, environmental hot spots and improvement options.

2.1.2 *Decision context*

The decision context is the “micro-level decision support”, as defined in the ILCD manual [5]. This decision context implies that the LCA study will be employed for decision support, but with only small scale, non structural consequences in background systems or other systems of the economy. “Micro-level decision support” is usually applied, for instance, for decision support related to product comparison, product development and design, weak point analysis, product benchmarking, etc.

2.1.3 *Limitations of the study*

The limitations of the study can concern methodological approaches, assumption and calculated impacts. Impact limitations are not significant due to the selection of a wide range of environmental indicators. Other limitations may derive from data availability and possible need for assumptions; these kind of limitations, if present, will be reported in the final LCA report describing data collection and modelling.

2.1.4 *Intended audience and commissioner*

The target audience for the LCA results is the project consortium (internal audience), that will profit from the eco-design feedback obtained through LCA. The results will be also communicated to stakeholders, as car body shops, car scrapyards and final users of recycled plastic granulates. The eventual target audience is the European Commission, that, through the Life Programme, is the commissioner of the LCA studies to be conducted during the project.

2.1.5 *Comparisons and critical review*

Comparative assessment with established processes (landfill, incineration, conventional recycling) and products (virgin plastic granulate, conventional recycled plastic granulate), will be made for eco-design purposes. Comparisons will be used to provide ecodesign feedback to the involved stakeholders. At the moment, a critical review is not yet foreseen.

2.2 Scope definition

2.2.1 Product systems to be studied and their functions

Two separate comparative LCAs will be conducted. The first one will be focussed on recycling as waste disposal service, in comparison with incineration and landfill disposal, and will also focus on the novel micro-collection system for automotive waste developed during the project. This first LCA will include the collection and treatment of waste car bumpers, as shown in Figure 2. In this case, the plastic waste considered is polypropylene (PP).

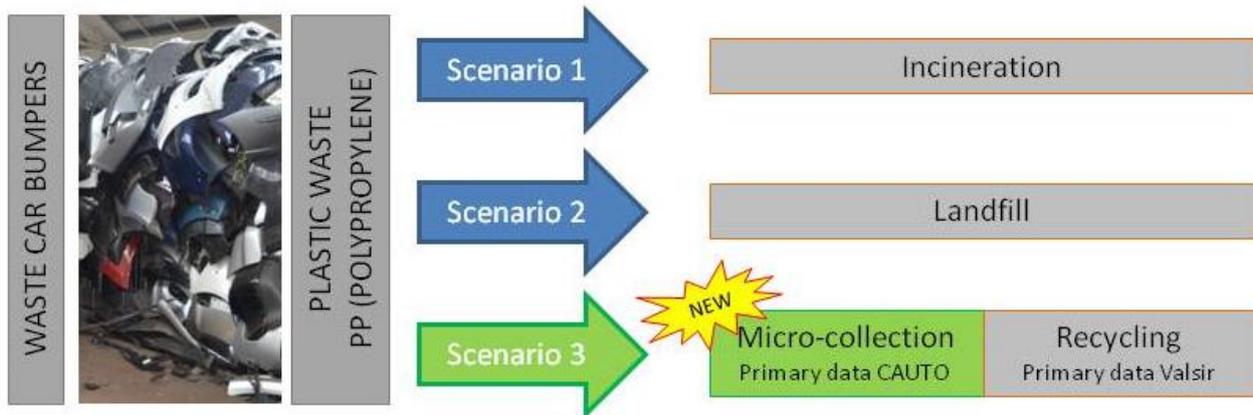


Figure 2: System under study, collection and disposal or recycling of waste PP car bumpers

The second comparative LCA focuses on the production of partially recycled HDPE granulate from waste car tanks. During its lifetime, this particular type of waste absorbs a certain quantity of hydrocarbons, making the activities of recovering and re-using of the recycled material problematic, for these reasons [6]:

- Superficial flaws on the finished product;
- Permanence of the hydrocarbons odour.

Together with Cauto and CSMT and supported by the municipality of Vobarno and the Faculty of Engineering of the University of Brescia, Valsir has created a specific patented treatment able to facilitate the reusing of the material and to limit the abovementioned problems [6].

The innovative process developed during the Autoplast project uses spent coffee drags to improve the properties of the recycled HDPE, thus allowing to produce a HDPE granulate containing 30% recycled material, compared to the 10% content that can be achieved if waste car tanks are recycled with the conventional process. The two partially recycled HDPE granulates will be compared with 100% virgin HDPE. Conversion of plastic granulates into plastic goods is currently excluded, but it may be included at a later stage of the project. The final use of recycled plastic granulates shall take into account the technical properties and possible limitations of the recycled materials.

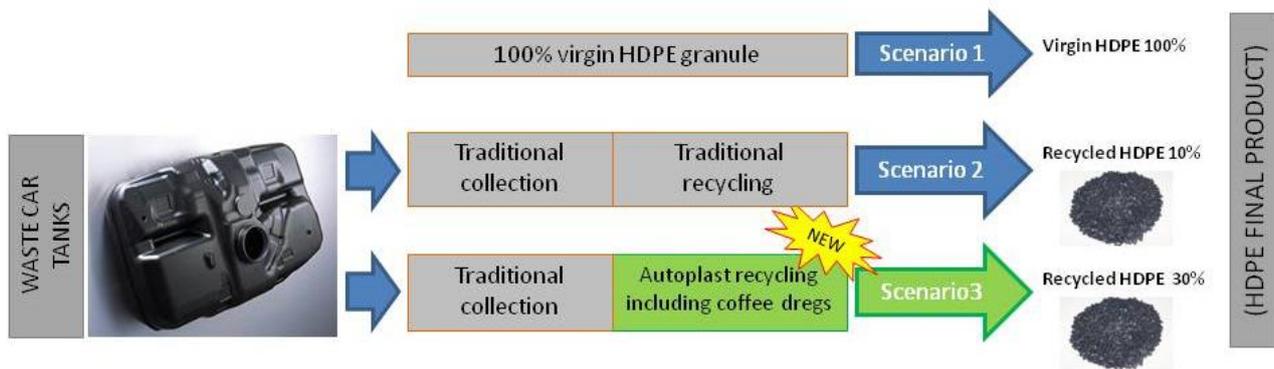


Figure 3: System under study, virgin and recycled plastic granulates.

2.2.2 Modelling approach

The attributional modelling approach has been adopted, since the main objectives of the analysis are identification of environmental hotspots and process or product optimization (ecodesign).

The attributional life cycle model of a product depicts its actual or forecasted specific or average supply-chain plus its use and end-of-life value chain. The existing or forecasted system is embedded into a static technosphere [5].

2.2.3 Allocation criteria

Allocation is the partitioning of the input or output flows of a process or a product system between the product system under study and one or more other product systems [3]. According to the ILCD handbook [5], when attributional modelling is applied, the correct way to proceed is to subdivide the system into specific sub-processes as far as possible, and to solve remaining multifunctionality through allocation. Allocation between products and co-products will be based on physical relationships; where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationships between them (e.g. economic).

When a recycling process is involved, a choice need to be made regarding the allocation of the environmental burden of the recycling process (i.e. to which life cycle the environmental burden will be allocated). In this LCA study, the “cut-off” approach will be applied as default. With this approach, outputs subject to recycling will be considered as inputs to the next life cycle, and no environmental burdens nor environmental gains deriving from the recycling process will be allocated to the system that produces the waste to be recycled. Waste collection and transport to the recycling facility will be included. At the same time, the environmental impact of the recycling process will be accounted for in the life cycle of the recycled granulate.

For the first comparison, sensitivity analysis will be applied, to provide an alternative evaluation to the cut-off approach. In the sensitivity analysis, the environmental impact of the recycling process will be included in the overall environmental impact of scenario 3 (micro-collection + recycling, Figure 3), as well as the environmental gain associated with the production of the recycled material.

When disposal processes are considered, as is the case in these LCAs, the environmental impact of the activities that produce the waste (car bumpers, car tanks and spent coffee drags) are not included.

2.2.4 Functional unit

Two functional units have been selected:

- The disposal of 1 kg of waste PP car bumpers, whether through recycling, incineration or in landfills;
- 1 kg of HDPE granulate

2.2.5 System boundaries

- Technical system boundaries:

For the first comparison, waste collection, transports, input materials and energy for incineration and disposal in landfill will be included, as well as all direct emissions associated with the disposal processes. The recycling process itself will be excluded from the study, according to the “cut-off” approach. The recycling process will be included in the sensitivity analysis, where a different allocation approach for recycling will be applied. The avoided production of virgin PP granulate will be also included in the sensitivity analysis.

For the second comparison, waste collection, transports, input materials and energy for the recycling processes will be included for the recycled HDPE granulate. For virgin HDPE, raw materials, their transports and manufacturing processes will be included. Conversion of plastic granulates into plastic goods and their end of life is currently excluded, but they may be included at a later stage of the project.

- Geographical and time boundaries: the collection and recycling of used car bumpers and car tanks takes place in the province of Brescia. Database processes will be chosen in order to reflect the Italian or European situation. The reference year for primary data collection is 2016.

2.2.6 Data and data quality requirements

Primary (specific) data will be used to model the main activities of interest for the project:

- Micro-collection of waste car bumpers: primary data will be provided by Cauto
- Recycling of waste car bumpers: primary data will be provided by Valsir
- Autoplast recycling of waste car tanks, including the use of coffee drags: primary data will be provided by Valsir

For the other activities under study (e.g. conventional waste collection, conventional recycling, incineration, landfill, virgin HDPE) secondary data from established LCA databases or other sources (e.g. literature, data available to project partners, etc.) will be used.

Background data used to model input materials, energy consumption mixes, means of transportation, etc. derive from the ecoinvent database v3.2, released in 2015 [7] (version “recycled content”)¹.

2.2.7 Selection of impact categories and impact assessment methods

Two impact assessment methods have been selected for the quantification of the environmental impact of the processes and products under study.

The first method is ILCD 2011 midpoint. This method consists of 16 midpoint categories recommended by the European Commission [8], namely: climate change; ozone depletion; human toxicity, cancer effects; human toxicity, non-cancer effects; particulate matter; ionizing radiation HH (human health); ionizing radiation E (ecosystems), interim; photochemical ozone formation; acidification; terrestrial eutrophication; freshwater eutrophication; marine eutrophication; freshwater ecotoxicity; land use; water resource depletion; mineral, fossil and renewable resource depletion. The method enables the normalisation of the outputs with respect to the European situation (EU27).

In addition, the ReCiPe method (endpoint H/A) [9] will be used to integrate the evaluation of the environmental performance of the products and processes of interest. This method comprises 17 environmental indicators that can be aggregated in 3 damage categories (human health, ecosystem and resources) and one single value (in ecopoints), and allows the normalisation and weighting of the outputs.

2.2.8 Tools

The LCI modelling and impact assessment calculations will be performed with the state-of-the-art LCA software SimaPro8 [10], that contains the ecoinvent [7] database and the impact assessment methods and indicators selected for the study.

2.2.9 Reporting format

The reporting style will follow the main steps of LCA and will include, at least, the following sections:

1. Goal and scope
2. Inventory
3. Impact assessment
4. Interpretation

The report shall include all the relevant information needed for a clear understanding of the results, thus guaranteeing transparency on the methodology and results; e.g. objectives, functional unit, system boundaries, allocation choice, assumptions and simplifications, impact assessment methods, etc.

¹ For the sensitivity analysis on the allocation approach to be used for the recycling process, the ecoinvent database v3.2 “allocation default” will be used.

3 References

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