**PROJECT REPORT:**
PR-Durus EasyFinish-EN

**MANUFACTURER:**
**Adfil**

**DATE:**
**27/05-2020**

# Index

# 1 General

This LCA study has been conducted according to the requirements in EN 15804:2012+A2:2019

## 1.1 MANUFACTURER

Adfil produces construction fibres such as their product Durus EasyFinish. Adfil has been working with development and application of synthetic fibres in concrete for over three decades. They serve the construction industry in more than 60 countries and have become one of the leading manufacturers of synthetic fibre concrete reinforcement.

## 1.2 LCA PRACTITIONER

The LCA has been conducted by Michael Reymann, Julie Rønholt and Linda Høibye at COWI Denmark in Lyngby.

## 1.3 DATE

This LCA has been conducted in February to May 2020 and is valid from 27 May, 2020.

# 2 Goal

The LCA study documented in this report has been carried out to support the development of a Type III declaration according to the requirements in EN15804, and thereby communicate scientifically based environmental information for the declared product. The LCA is performed to investigate the environmental impacts associated with the production of the construction reinforcement Durus EasyFinish produced by Adfil. The results are to be communicated through an EPD published at EPD Denmark's homepage.

The LCA is conducted to communicate at B2B level as the LCA allows environmental assessments of buildings containing Durus EasyFinish as reinforcement.

# 3 Scope

## 3.1 DECLARED/FUNCTIONAL UNIT

### 3.1.1 Definition

The products declared unit is 1 kg construction fibres, produced at the Adfil factory in Zele, Belgium. The amount of product needed to reinforce the concrete varies from 2-6 kg/m³ concrete depending on the final application of the concrete. The construction fibres are embedded in the concrete for the entire life time of the concrete structure.

**Table 1 - Declared unit**

| Name | Value | Unit |
|---|---|---|
| Declared unit | 1 | kg |
| Density | 912 | $kg/m^3$ |
| Conversion factor to 1 kg. | 1 | kg |

### 3.1.2 Technical specifications

The product is made up mainly of polypropylene. The remaining 4.5% of the total weight is additives increasing strength, speed up the manufacturing process and change the colour of the final product.

**Table 2 - Material composition**

| Material | Amount | Unit |
|---|---|---|
| Polypropylene granulate | 0.955 | kg |
| Calcium carbonate | 0.035 | kg |
| Nucleating agent (NC13PP) | 0.0045 | kg |
| Sorbitol | 0.0005 | kg |
| Carbon black | 0.00015 | kg |
| Water | 0.00485 | kg |

PP granulate and additives are gravimetrically dosed and mixed in the extruder feeder hopper. This composition is molten and blended in an extruder to a homogeneous polymer melt. After filtration and metering, the liquid polymers are extruded trough a die plate where the filaments are created. In order to increase the mechanical strength of the filaments, they are drawn and annealed in multiple steps. These high strength filaments undergo a surface deformation step in a consecutive step. In the next step the filaments are simultaneously wound into bundles, wrapped with water soluble film and cut to length to form pucks. Edge trim waste is regrinded and re-fed to the extruder. In the last process step, the pucks are stacked and packed in paper bags of 2-4 kg/ per piece. After pallet stacking of the bags, the pallet is wrapped with PE stretch film and provided with a cover.

Argunuc NC13PP is a nucleating agent used in the production of Durus EasyFinish, which consists mainly of polypropylene and sorbitol.

### 3.1.3 Calculation rules for averaging data

Only one product is included in this LCA, and data are specific for that one product. Therefore, the products are not formed as averages across multiple products.

## 3.2 SYSTEM BOUNDARIES

This study is cradle-to-grave and covers all the relevant life cycle sub modules.

The declared modules are shown in **Fout! Verwijzingsbron niet gevonden.**, which follows the modular approach in EN15804.

| System boundaries (X = included in LCA; MNR = Module not relevant) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Product | | | Construction process | | Use | | | | | | | End of life | | | | Beyond system boundary |
| Raw material supply | Transport | Manufacturing | Transport | Construction installation proces | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | De-construction demolition | Transport | Waste processing | Disposal | Reuse- recovery- recycling potential |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
| **X** | **X** | **X** | **X** | **X** | **MNR** | **MNR** | **MNR** | **MNR** | **MNR** | **MNR** | **MNR** | **X** | **X** | **X** | **X** | **X** |

**Figure 1 - System boundaries according to EN 15804.**

Figure 1 shows the relevant modules included in the LCA.

Figure 2 depicts the system boundaries for 1 kg of Durus EasyFinish. All relevant processes are included in the system boundary figure in accordance with EN 15804.

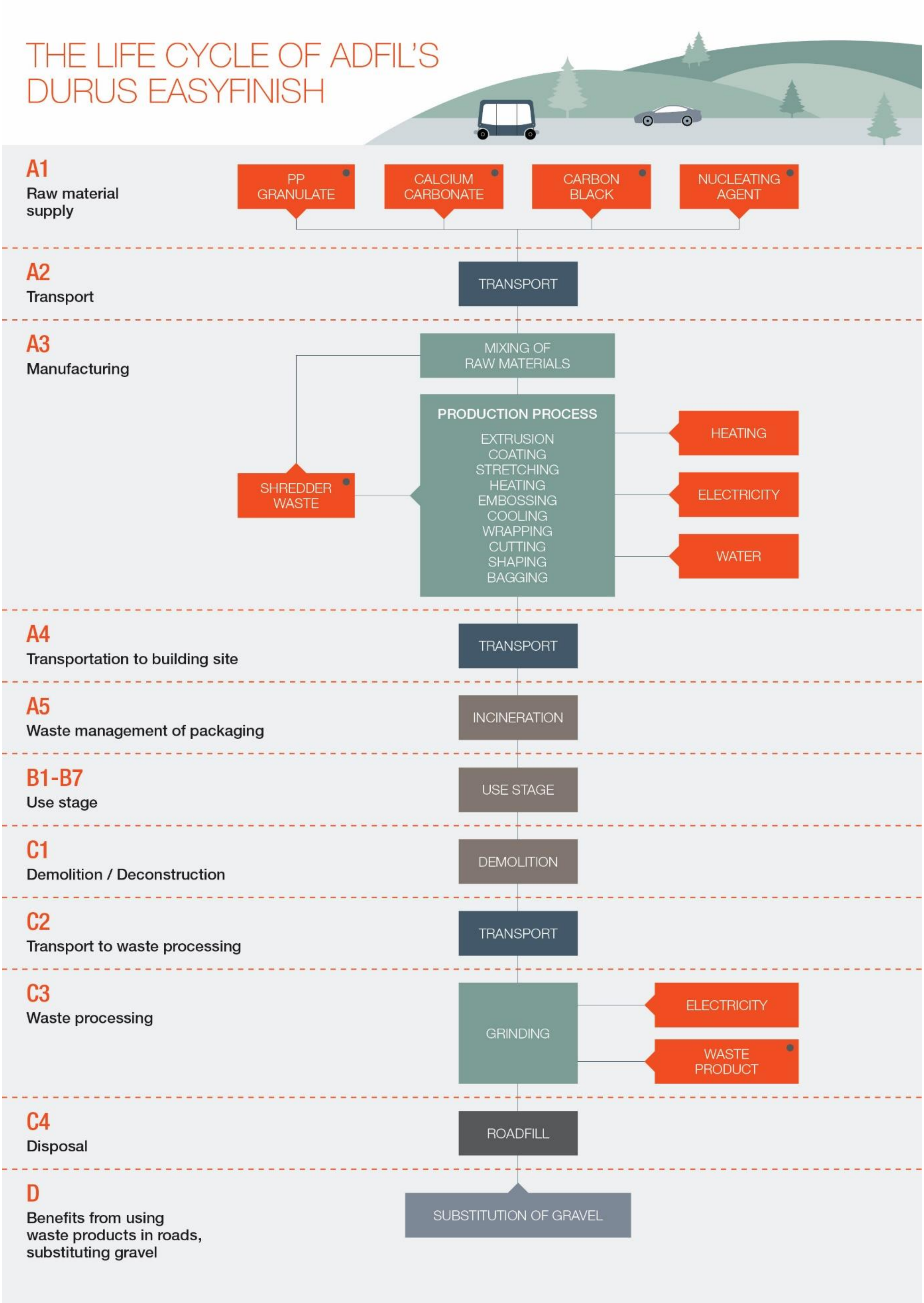



**Figure 2: System boundaries of the enitre life cycle of Durus EasyFinish divided into the relevant modules.**

Module A1 – The production of raw materials needed in the production, including extraction, treatment, processing, electricity and heat consumption.
The raw materials included are polypropylene granulate, calcium carbonate, Argunuc NC13PP, sorbitol, carbon black, water, PVA, paper, cardboard, LDPE-film, plastic bags and wooden pallets.
The polypropylene used in the production is produced by two suppliers one located in Belgium and one located in France. The amount of polypropylene from each of the suppliers is in average equally split at a 50/50 rate.

Module A2 – Transportation from the various manufactures and raw material extraction sites to the Adfil production factory in Belgium.

Module A3 – The manufacturing of Durus EasyFinish and packaging. The production of Durus EasyFinish is described in 3.1.2. The main inputs for the production process are raw materials and energy in form of heat and electricity. The production takes place in Belgium; hence the electricity and heat are based on a Belgian energy mix.

Module A4 – Transportation from the factory in Belgium to Denmark, simulating transportation to a construction site in Europe. This scenario uses an average truck, transporting goods at a distance of 1,000 km to simulate a truck with a load capacity of 50% to account for empty returns when the goods are delivered. Transportation of the packaging waste from the construction site to the municipal waste incinerator are also included.

Module A5 – Accounts for the environmental impacts associated with the disposal of waste packaging handled at the construction site, it is assumed incinerated at an incineration plant, as this is assumed to be the most likely and realistic situation. Construction installation process is considered not relevant.

Module B - The entire use phase is not included as the product has no impact during this phase and therefore has no associated environmental impacts. These modules are therefore stated as "Module Not Relevant" (MNR).

Module C1 – Demolition of a concrete structure using a demolition hammer. The most likely scenario for the concrete structure containing Durus EasyFinish is demolition.

Module C2 – Transportation of the demolished concrete containing Durus EasyFinish to a concrete crushing site. The grinded concrete containing Durus EasyFinish in module C3 is assumed to be transported 100 km to an industry concrete grinder.

Module C3 – Grinding and crushing of concrete blocks in a grinder. The concrete containing Durus EasyFinish is grinded to road fill together with the concrete. This scenario is modelled using the electricity consumption of an industry concrete grinder. This is further detailed in 6.2.

Module C4 – All disposal processes are handled in C1-C3, and no disposal emissions occur in this module, as the entire product is assumed recycled and used as road fill.

Module D – The gravel produced in Module C3 is used as road fill, and the system is credited the production of gravel, as it substitutes newly produced gravel as road fill. This disposal method was chosen, as it is the most used disposal method of crushed concrete in Europe.[1]

The system includes all known activities and all related emissions within the system boundaries.

### 3.2.1 Omissions of life cycle stages, processes or data needs

Omission of life cycle stages, processes and data has only occurred for products that fall below the cut off criteria set by EN 15804.

The following is not included in the LCA calculations:

[1] https://www2.mst.dk/Udgiv/publikationer/2018/08/978-87-93710-69-6.pdf

- Ink used for printing on the paper bags that Durus EasyFinish ships in.
- Ink and labels used for other packaging materials.
- Nails used in the pallet production.
- The glue used to seal the paper bag that Durus EasyFinish arrives in.

### 3.2.2 Quantification of energy and material inputs and outputs

Product specific data are based on average values collected in the period January 2019 to December 2019.

The electricity and heating are based on a one-year cycle. The energy inputs are then divided by the production output for one year to allocate the energy consumption per kg of the product.

The electricity and heat used to manufacture Durus EasyFinish is based on the Belgian electricity mix and thermal heat generated in Belgium using natural gas.

### 3.2.3 Assumptions about electricity production and other relevant background data

Electricity and heat consumed by Adfil is modelled according to the Belgian electricity grid mix and the use of Belgian natural gas for heating. The data for the Belgium electricity grid mix and heating by natural gas is based on the GaBi professional 2019 datasets. The dataset reference year for electricity is 2015 and for heating with natural gas is 2016. The electricity datasets in GaBi are updated each year and are based on the country specific electricity sources.

PVA-film is assumed produced in China and the Chinese electricity grid mix was used as electricity input to produce the PVA-film. The reference year for the Chinese electricity mix is 2015.

## 3.3 CUT-OFF CRITERIA

### 3.3.1 Application and assumptions

The general rules for exclusion of inputs and outputs in the LCA is in compliance with the rules in EN15804, 6.3.5, where the omission for input-flows pr. module must be maximum 5 % of energy usage and mass and at most 1 % for unit processes.

### 3.3.2 Excluded processes

Some processes and materials were omitted as described in 3.2.1. The omitted processes and materials falls way below the exclusion rule of 1 % per unit process, and are not relevant for the overall results and environmental impacts connected to Durus EasyFinish, All relevant processes and modules were included in the LCA calculations.

# 4 Life cycle inventory analysis (LCI)

## 4.1 UNIT PROCESSES

### 4.1.1 Manufacturing

The input materials and quantities for the manufacturing of Durus EasyFinish and the related packaging is shown in Table 3.

**Table 3 - Input**

| Input for the declared unit *(1 kg Durus EasyFinish)* | | | | |
|---|---|---|---|---|
| **Material/component** | **Amount** | **Unit** | **Remarks/explanation** | **Weight-%** |
| Durus EasyFinish product | | | | |
| Polypropylene | 0.955 | kg | Polypropylene in granulate form | 90% |
| Calcium Carbonate | 0.035 | kg | | 3.3% |
| NC13PP | 0.0045 | kg | Polypropylene | 0.42% |
| Sorbitol | 0.0005 | kg | Maize starch | 0.05% |
| Carbon Black | 0.00015 | kg | Carbon black powder solution | 0.01% |
| Water | 0.00485 | kg | Water in the black carbon solution | 0.46% |
| Packaging | | | | |
| PVA film | 0.006 | kg | | 0.57% |
| Paper bag | 0.0085 | kg | | 0.80% |
| Cardboard | 0.00544 | kg | | 0.51% |
| LDPE film | 0.00062 | kg | | 0.06% |
| Plastic bag | 0.00126 | kg | | 0.12% |
| Wooden pallet | 0.0396 | kg | | 3.70% |
| **Total with packaging** | **1.06** | **kg** | | **100%** |

The output materials and quantities for the manufacturing of Durus EasyFinish and the related packaging is shown in Table 4. The paper bag and PVA film is not modelled as a waste output, as these are mixed in the concrete together with Durus EasyFinish.

**Table 4 - Output**

| Output for the declared unit (1 kg Durus EasyFinish) | | | | |
|---|---|---|---|---|
| **Material/component** | **Amount** | **Unit** | **Remarks/explanation** | **Weight-%** |
| Durus EasyFinish | 1 | kg | | 94.2% |
| Pallet waste | 0.0396 | kg | | 3.7% |
| Cardboard waste | 0.00544 | kg | | 0.5% |
| LDPE film waste | 0.00062 | kg | | 0.1% |
| Plastic bag waste | 0.00126 | kg | | 0.1% |
| PVA film | 0.006 | kg | | 0.6% |
| Paper bag | 0.0085 | kg | | 0.8% |
| | | | | **100%** |

The energy inputs and quantities for the manufacturing of Durus EasyFinish and the related packaging is shown in Table 5.

**Table 5 - Energy inputs for the declared unit (1 kg)**

| Type | Total consumption |
|---|---|
| Electricity | 3.95 MJ/kg |
| Thermal heat | 0.314 MJ/kg |

## 4.2 SOURCES OF GENERIC DATA OR LITERATURE

Generic data and background data are based on the GaBi 2019 professional database and the EcoInvent 3.6 database.

## 4.3 VALIDATION OF DATA

### 4.3.1 Data quality assessment

The data quality of the applied generic data is assessed in accordance with the data quality method listed in Annex E in EN15804.

**Table 6. Data representativeness of the generic data included in the calculations to describe the production, transportation and disposal of Durus EasyFinish. The processes used and their respective reference years can be seen in Table 11.**

| Process | Geographical representativeness | Technological representativeness | Time representativeness |
|---|---|---|---|
| Polypropylene (PP) granulate France | Very good | Very good | Very good |
| Polypropylene (PP) granulate Belgium | Very good | Very good | Very good |
| Calcium Carbonate | Fair | Very good | Very good |
| Sorbitol | Good | Poor | Very poor |
| NC13PP | Good | Good | Very good |
| Carbon Black | Good | Very good | Very good |
| Tap water | Very good | Very good | Very good |
| PVA granulate | Very good | Very good | Very good |
| PVA extrusion | Good | Fair | Very good |
| Paper bags | Fair | Fair | Fair |
| Cardboard | Fair | Very good | Fair |
| Cardboard incineration | Good | Good | Poor |
| LDPE film | Very good | Good | Fair |
| Plastic bags made from polypropylene | Very good | Good | Fair |
| Wooden pallet | Very good | Good | Very good |
| Belgium electricity | Very good | Very good | Good |
| Chinese electricity | Very good | Very good | Good |
| Waste water | Good | Very good | Very good |
| Natural gas for heating | Very good | Very good | Good |
| Waste cardboard | Good | Very good | Poor |

| | | | |
|---|---|---|---|
| Concrete crushing | Very good | Very good | Good |
| Transport lorry | Very good | Very good | Very good |

### 4.3.2 Treatment of missing data

The nucleating agent Argunuc NC13PP was modelled by dividing it into its main material composition of polypropylene (90%) and sorbitol (10%). Data for sorbitol used to describe the nucleating agent Argunuc NC13PP were not available for this exact ingredient at the time of producing this EPD. Instead of neglecting the impacts from sorbitol, the production was substituted with the production of maize starch as sorbitol is produced by hydrogenation of glucose syrup, which is being derived from wheat starch and maize starch[2]. The data quality of this process is generally poor as stated in Table 6. However, the environmental impacts are of less importance when compared to the total environmental impacts of the product, as only 0.05% sorbitol are used in the manufacturing of Durus EasyFinish. The rest of the nucleating agent NC13PP consists of polypropylene and is modelled in accordance, using German produced polypropylene, as the nucleating agent is produced in Germany.

Transportation distances for processes with unknown transportation distances, such as the transportation to the disposal site, is modelled by a transportation distance of 100 km using a lorry.

As the conclusion of the LCA and the environmental impacts associated with the production of Durus EasyFinish, should be applicable for multiple European countries including Denmark, Norway, Sweden, England and other countries nearby, a transportation distance of 1,000 km was assumed from the production site.

Most PVA is produced in Asia[3] and PVA is assumed transported by sea from China Shanghai to Belgium and then transported by lorry from the harbour to Adfil.

## 4.4 ALLOCATION PRINCIPLES AND PROCEDURES

### 4.4.1 Documentation and justification of allocation procedures

No allocation has occurred at plant level as the plant only produces Durus EasyFinish.

Processes with energy recovery such as the incineration processes used in this LCA, uses allocation principles based on energy.

Concrete is often recycled into gravel used as road filler.[4] The same recycling is assumed for Durus EasyFinish, as it is encapsulating and separating the product and the concrete at disposal is highly energy demanding and time consuming. The same recycling process for the concrete is assumed for Durus EasyFinish. The product will be crushed and used as road fill instead of gravel. To estimate the amount of gravel being replaced by Durus EasyFinish as road fill a conversion must be made, as the two materials do not have the same density and therefore volume per kilo. The production of new gravel is credited the system at a 70% rate due to density differences, where densities of 0.92 g/cm$^3$ and 1.35 g/cm$^3$ are used for Durus EasyFinish[5] and gravel respectively.

The wooden pallets used for transportation of Durus EasyFinish are bought from a supplier that buys used pallets and recycles them to custom fit Adfil's pallet size. Since the pallets are reused pallets, not all environmental burdens are allocated to the pallet in the production stage of the pallet. An economic allocation is applied, hence 50% of

[2] Maize starch being used to produce sorbitol https://www.tereos-starchsweeteners.com/animal-nutrition/product-finder/starches-sweeteners/sorbitol

[3] Market share of PVA production https://www.marketwatch.com/press-release/polyvinyl-alcohol-pva-industry-global-production-analysis-demand-by-regions-segments-and-applications-2019-2026-2019-01-31

[4] https://www2.mst.dk/Udgiv/publikationer/2018/08/978-87-93710-69-6.pdf

[5] https://www.mlpolyolefins.com/en/pp_granulate/

the environmental impacts from the pallet are allocated to the declared unit. Since the pallets are custom made it is assumed that they are burned after being used for transportation of Durus EasyFinish to the construction sites.

#### 4.4.2 Uniform application of allocation procedures

Allocation based on mass has been applied throughout the LCA, except for the energy recovery processes which are based on energy allocation and the reused wooden pallet where an economic allocation was used.

# 5 Life cycle impact assessment (LCIA)

## 5.1 LCIA PROCEDURES AND CALCULATIONS

The LCIA results are calculated using the elementary flow list Environmental Footprint (EF) and impact methodology EF 3.0 for classification and characterisation of input and output flows. This is in accordance with EN15804:201+A2:2019. The following environmental impact categories are calculated:

- Global warming (GWP)
- Global warming fossil (GWPf)
- Global warming biogenic (GWPb)
- Global warming land use and land use change (GWPluluc)
- Ozone depletion (ODP)
- Acidification for soil and water (AP)
- Eutrophication (EP)
- Eutrophication marine
- Eutrophication terrestrial
- Photochemical ozone creation (POCP)
- Depletion of abiotic resources-elements (ADPe)
- Depletion of abiotic resources-fossil fuels (ADPf)
- Water use (WDP)
- Particulate matter (PM)
- Ionizing radiation (IRP)
- Eco toxicity freshwater (ETP-fw)
- Human toxicity cancer effect (HTP-c)
- Human toxicity non cancer effect (HTP-nc)
- Soil quality (SQP)

## 5.2 LCIA OG LCI RESULTATER

The estimated impact results of the LCIA are relative expressions and does not indicate the impacts endpoints, the exceeding of thresholds, safety margins or risks.

In Table 7, **Fout! Verwijzingsbron niet gevonden.** and Table 9 the LCIA and LCI results are shown divided into the modules A1-A4, C1-C4 and D for the product. The remaining modules are not relevant (see section 3.2).

In **Fout! Verwijzingsbron niet gevonden.** *Renewable primary energy resources used as raw materials* and *Non-renewable primary energy resources used as raw materials* are shown. The results have been calculated based on the heating values for the input materials.

### 5.2.1 Results

**Table 7 – LCIA results for the declared unit (1 kg Durus EasyFinish)**

| Environmental Impact | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Impact Category** | **Unit** | **A1** | **A2** | **A3** | **A4** | **A5** | **C1** | **C2** | **C3** | **C4** | **D** |
| Global warming (GWP) | kg CO2-Equiv. | 1.69E+00 | 1.57E-02 | 2.49E-01 | 8.54E-02 | 4.69E-02 | 7.89E-06 | 8.51E-03 | 2.53E-04 | 0 | 2.08E-02 |
| Global warming fossil | kg CO2-Equiv. | 1.76E+00 | 1.56E-02 | 2.50E-01 | 8.48E-02 | 3.88E-03 | 7.85E-06 | 8.46E-03 | 2.52E-04 | 0 | -1.85E-02 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Global warming biogenic | kg CO2-Equiv. | -7.19E-02 | -2.89E-05 | -1.73E-03 | -1.43E-04 | 4.30E-02 | 2.62E-08 | -1.42E-05 | 8.39E-07 | 0 | 3.92E-02 |
| Global warming luluc | kg CO2-Equiv. | 5.84E-04 | 1.36E-04 | 3.34E-04 | 6.88E-04 | 5.83E-07 | 1.14E-08 | 6.86E-05 | 3.65E-07 | 0 | -7.20E-06 |
| Ozone depletion (ODP) | kg R11-Equiv. | 1.12E-09 | 2.83E-18 | 1.11E-14 | 1.56E-17 | 6.69E-18 | 1.73E-19 | 1.56E-18 | 5.53E-18 | 0 | -1.47E-09 |
| Acidification for soil and water (AP) | kg mol H+-Equiv. | 3.72E-03 | 5.63E-05 | 3.32E-04 | 1.04E-04 | 7.73E-06 | 1.73E-08 | 1.04E-05 | 5.55E-07 | 0 | -1.45E-04 |
| Eutrophication freshwater (EP F) | kg Phosphate-Equiv. | 4.52E-06 | 6.10E-08 | 9.00E-07 | 2.59E-07 | 1.08E-09 | 2.10E-11 | 2.58E-08 | 6.72E-10 | 0 | -8.22E-09 |
| Eutrophication marine (EP M) | kg N Equiv. | 9.54E-04 | 1.58E-05 | 1.18E-04 | 3.30E-05 | 2.57E-06 | 3.85E-09 | 3.29E-06 | 1.23E-07 | 0 | -1.64E-05 |
| Eutrophication terrestrial (EP T) | mol N Equiv. | 1.02E-02 | 1.80E-04 | 1.21E-03 | 3.90E-04 | 3.59E-05 | 4.04E-08 | 3.89E-05 | 1.30E-06 | 0 | -1.70E-04 |
| Photochemical ozone creation (POCP) | kg NMVOC-Equiv. | 4.18E-03 | 4.28E-05 | 3.03E-04 | 8.69E-05 | 6.95E-06 | 1.05E-08 | 8.67E-06 | 3.38E-07 | 0 | -5.22E-05 |
| Depletion of abiotic resources-elements (ADPe) | kg Sb-Equiv. | e | 1.26E-09 | 1.20E-07 | 6.87E-09 | 1.05E-10 | 2.27E-12 | 6.86E-10 | 7.28E-11 | 0 | -2.56E-10 |
| Depletion of abiotic resources-fossil fuels (ADPf) | MJ | 6.93E+01 | 2.09E-01 | 8.21E+00 | 1.13E+00 | 1.14E-02 | 1.38E-04 | 1.13E-01 | 4.42E-03 | 0 | -3.12E-01 |
| Water use (WDP) | M³ | 3.29E-01 | 1.66E-04 | 1.50E-02 | 8.29E-04 | 5.00E-03 | 1.71E-06 | 8.27E-05 | 5.48E-05 | 0 | 3.46E-03 |
| Particulate matter (PM) | Disease incidence | 3.55E-08 | 7.58E-10 | 2.90E-09 | 6.68E-10 | 4.38E-11 | 1.45E-13 | 6.66E-11 | 4.66E-12 | 0 | -1.83E-09 |
| Ionizing radiation (IRP) | kBq. U235 equiv. | 2.72E-01 | 9.88E-05 | 1.66E-01 | 3.10E-04 | 9.62E-05 | 3.44E-06 | 3.09E-05 | 1.10E-04 | 0 | -6.18E-04 |
| Eco toxicity freshwater (ETP-fw) | CTUe | 3.69E+01 | 1.57E-01 | 3.04E+00 | 8.49E-01 | 5.41E-03 | 5.90E-05 | 8.46E-02 | 1.89E-03 | 0 | -6.96E-02 |
| Human toxicity cancer effect (HTP-c) | CTUe | 8.22E-10 | 3.29E-12 | 5.70E-11 | 1.75E-11 | 3.32E-13 | 1.63E-15 | 1.75E-12 | 5.23E-14 | 0 | -2.24E-12 |
| Human toxicity non cancer effect (HTP-nc) | CTUe | 3.46E-08 | 1.75E-10 | 2.00E-09 | 8.94E-10 | 1.56E-11 | 6.01E-14 | 8.91E-11 | 1.93E-12 | 0.00 | -1.48E-10 |
| Soil quality (SQP) | pt | e | 8.78E-02 | 2.75E+00 | 3.98E-01 | 3.10E-03 | 4.40E-05 | 3.97E-02 | 1.41E-03 | 0.00 | -6.05E-03 |

**Table 8 – Resource use (LCI) results for the declared unit (1 kg Durus EasyFinish)**

| Resource use | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category** | **Unit** | **A1** | **A2** | **A3** | **A4** | **A5** | **C1** | **C2** | **C3** | **C4** | **D** |
| Renewable primary energy resources used as energy carrier (PERE) | MJ | 2.41E+00 | 1.26E-02 | 2.31E+00 | 6.56E-02 | 2.13E-03 | 6.12E-05 | 6.54E-03 | 1.96E-03 | 0 | -3.32E-02 |
| Renewable primary energy resources used as raw materials (PERM) | MJ | 7.81E-01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total use of renewable primary energy resources (PERT) | MJ | 3.19E+00 | 1.26E-02 | 2.31E+00 | 6.56E-02 | 2.13E-03 | 6.12E-05 | 6.54E-03 | 1.96E-03 | 0 | -3.32E-02 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Non renewable primary energy resources used as energy carrier (PENRE) | MJ | 6.94E+01 | 2.10E-01 | 8.21E+00 | 1.14E+00 | 1.14E-02 | 1.38E-04 | 1.14E-01 | 4.42E-03 | 0 | -3.12E-01 |
| Non renewable primary energy resources used as raw materials (PENRM) | MJ | 4.32E+01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total use of non-renewable primary energy resources (PENRT) | MJ | 1.13E+02 | 2.10E-01 | 8.21E+00 | 1.14E+00 | 1.14E-02 | 1.38E-04 | 1.14E-01 | 4.42E-03 | 0 | -3.12E-01 |
| Use of secondary materials (SM) | kg | 1.98E-02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Use of renewable secondary fuels (RSF) | MJ | 0 | 0 | 0 | 0 | 4.83E-01 | 0 | 0 | 0 | 0 | 0 |
| Use of non renewable secondary fuels (NRSF) | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Use of net fresh water (FW) | $m^3$ | 9.41E-03 | 1.66E-05 | 2.04E-03 | 7.64E-05 | 1.18E-04 | 7.07E-08 | 7.62E-06 | 2.27E-06 | 0 | 7.76E-05 |

**Table 9 – End of life (LCI) results for the declared unit (1 kg Durus EasyFinish)**

| End of life – Waste and Output flow | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category** | **Unit** | **A1** | **A2** | **A3** | **A4** | **A5** | **C1** | **C2** | **C3** | **C4** | **D** |
| Hazardous waste disposed (HWD) | kg | 1.46E-08 | 1.33E-08 | 2.98E-09 | 5.27E-08 | 1.31E-11 | 5.71E-14 | 5.25E-09 | 1.83E-12 | 0 | -4.02E-10 |
| Non hazardous waste disposed (NHWD) | kg | 1.33E-02 | 3.45E-05 | 7.75E-03 | 1.81E-04 | 8.03E-04 | 9.79E-08 | 1.80E-05 | 3.14E-06 | 0 | -2.92E-02 |
| Radioactive waste disposed (RWD) | kg | 1.13E-03 | 5.24E-07 | 1.95E-03 | 2.10E-06 | 6.21E-07 | 2.09E-08 | 2.09E-07 | 6.71E-07 | 0 | -2.52E-05 |
| Components for re-use (CRU) | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Materials for recycling (MFR) | kg | 0 | 0 | 0 | 0 | 0 | 1.0E+00 | 0 | 0 | 0 | 0 |
| Materials for energy recovery (MER) | kg | 0 | 0 | 0 | 0 | 2.7E-02 | 0 | 0 | 0 | 0 | 0 |
| Exported electrical energy (EE) | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exported thermal energy (TE) | MJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| BIOGENIC CARBON CONTENT PER DECLARED UNIT (1 KG) | | |
|---|---|---|
| **Parameter** | **Unit** | **At the factory gate** |
| Biogenic carbon content in product | kg C | 0 |
| Biogenic carbon content in accompanying packaging | kg C | 0.17 |

## 5.3 RELATIONSHIP OF THE LCIA RESULTS TO THE LCI RESULTS

LCIA are relative expressions and do not predict impacts category endpoints, the exceeding of thresholds, safety margins or risks.

Table 10 shows the processes contributing the most to the specific impact categories, and how much they contribute to the given impact category.

**Table 10 - Maximum contribution to impact categories**

| Environmental Impact | | | | |
|---|---|---|---|---|
| **Impact Category** | **Unit** | **Contribution** | **Process** | **% of category** |
| Global warming | kg CO2-Equiv. | A1 | Polypropylene Granulate (PP) | 81% |
| Global warming fossil | kg CO2-Equiv. | A1 | Polypropylene Granulate (PP) | 81% |
| Global warming biogenic | kg CO2-Equiv. | C4 | EU-28: Wood (natural) in municipal waste incineration plant | 40% |
| Global warming luluc | kg CO2-Equiv. | A4 | Diesel mix at filling station | 38% |
| Ozone depletion | kg R11-Equiv. | A1 | CA-QC: paper production, woodfree, uncoated, at integrated mill | 42% |
| Acidification for soil and water | kg SO2-Equiv. | A1 | Polypropylene Granulate (PP) | 85% |
| Eutrophication freshwater | kg P-Equiv. | A1 | Polypropylene Granulate (PP) | 30% |
| Eutrophication marine | kg N Equiv. | A1 | Polypropylene Granulate (PP) | 78% |
| Eutrophication terrestrial | mole of N Equiv. | A1 | Polypropylene Granulate (PP) | 78% |
| Photochemical ozone creation | kg Ethene-Equiv. | A1 | Polypropylene Granulate (PP) | 86% |
| Depletion of abiotic resources-elements | kg Sb-Equiv. | A1 | CA-QC – paper production, wood free, uncoated, at integrated mill | 53% |
| Depletion of abiotic resources-fossil fuels | MJ | A1 | Polypropylene Granulate (PP) | 86% |
| Water scarcity | M³ | A1 | Polypropylene Granulate (PP) | 86% |
| Respiratory inorganics | Disease incidence | A1 | Polypropylene Granulate (PP) | 61% |
| Ionising radiation – human health | kBq U235 Equiv. | A1 | Polypropylene Granulate (PP) | 46% |
| Ecotoxicity freshwater | CTUe | A1 | Polypropylene Granulate (PP) | 87% |
| Cancer human health effect | CTUh | A1 | Polypropylene Granulate (PP) | 86% |
| Non-cancer human health effects | CTUh | A1 | Polypropylene Granulate (PP) | 86% |
| Soil Quality | Pt | A1 | Solid construction timber (softwood) | 70% |

## 5.4 CHARACTERISATION MODELS AND FACTORS

See 5.1.

# 6 Life cycle interpretation

## 6.1 THE RESULTS

Based on weight Durus EasyFinish consist of 95.5 percent polypropylene granulate, and the data environmental impacts highly reflects the environmental impacts of the production of polypropylene granulate. The quality and representativeness of the LCA-data for polypropylene must therefore be very high.

As seen in Table 10 the production of polypropylene alone accounts for approximately 80% of the environmental impacts in 11 of 19 impact categories. The most dominant module is therefore module A1, as this module includes the production of polypropylene.

Polypropylene is made of crude oil. The production of crude oil is carbon emission intensive. This is the reason why polypropylene has such a high contribution to the global warming impact category.

Durus EasyFinish is produced also by adding additives, electricity and heat at the Adfil factory site. The processes that occurs at the Adfil production site has only a minor effect on the total environmental impacts from Durus EasyFinish, as it is the production of polypropylene that has the highest contribution to most of the environmental impact categories as seen in Table 10. Due to the production of polypropylene module A1 has the highest environmental impacts for 17 out of 19 categories when compared to the environmental impacts from the remaining modules.

The main contribution to the environmental impacts in module A3 is the electricity and heat consumption for the manufacturing of Durus EasyFinish at the Adfil manufacturing site in Belgium. The process of melting, blending and extrusion the PP granulate and additives is energy intensive. In module A3 the highest environmental impacts are seen in the indicators ozone depletion and eutrophication freshwater.

The transportation to construction sites from Belgium occurring in module A4 has the highest impact on GWP land use and land use change. The dominant process in regard to GWP land use and land use change is Diesel mix at filling station.

The negative environmental impact for GWP biogenic is caused by timber used for the wooden pallets recycled in module A1. The $CO_2$ is then released again during incineration in module C4.

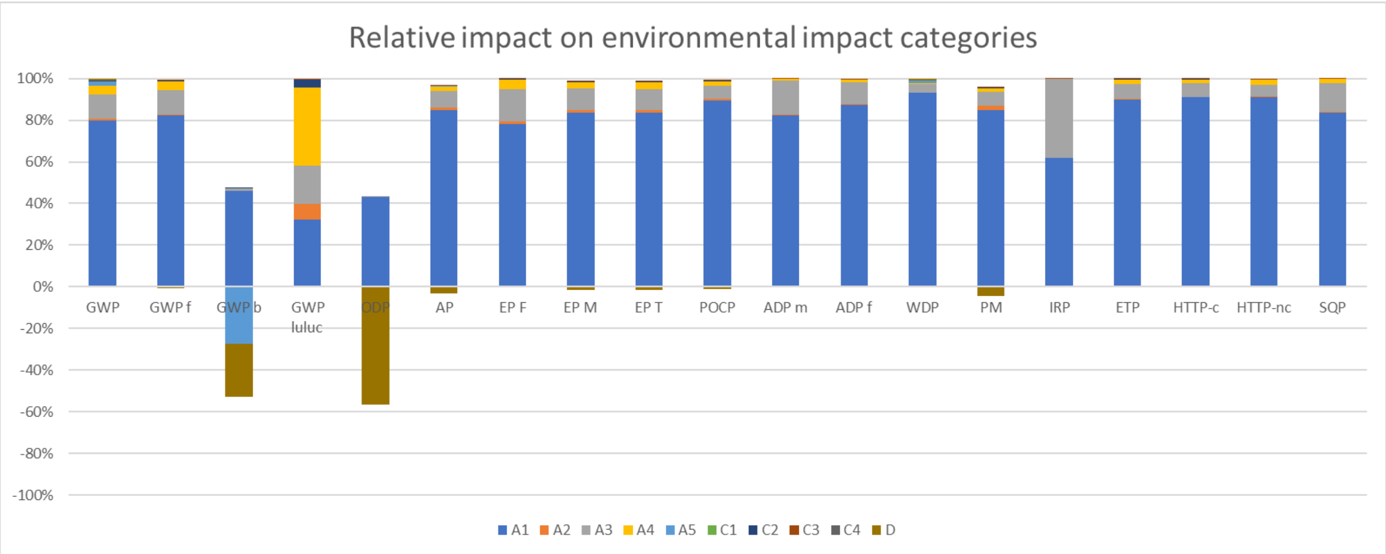



**Figure 3 – relative contribution on environmental impact categories for the LCA modules A1-A4, C1-C3 and D**

Conclusions based on the environmental impacts for ozone depletion should be done cautiously as the main contribution can be derived from the paper production alone. The negative environmental impacts for ODP occurs during the waste burning processes, and as these processes are 14 years old, and it should yet again be stated that conclusions drawn based on the ODP impact category should be drawn with caution.

## 6.2 ASSUMPTIONS AND LIMITATIONS

Carbon black
No supplier for carbon black was specified and generic data for German carbon black production was used.

Paper bag
The paper bag for packaging is assumed to be manufactured in the same way as kraft paper, as the texture and stiffness are similar compared to kraft paper. Kraft paper is chemically produced to remove the lignin in the paper. This type of paper is called wood free, and a generic process of wood free paper was used. A Canadian paper mill was used, as the data for the European papermill is 20 years old and are based on older heating methods causing non-justifiable impacts on particulate matter.

PVA film
The production of PVA film was modelled using PVA granulate and a film extrusion process. The film extrusion process used to produce PVA film from PVA granulate are based on a plastic film extrusion process. The extrusion process is estimated to be similar for PVA and plastic film.
PVA is mainly being produced in Asia, with China being a large manufacturer of PVA film and products. The PVA film is assumed transported from Shanghai harbour in China to Belgium, where it is then transported by truck to the Adfil manufacturing site.

LDPE film
Generic data for low density polyethylene film were not available, therefore, the same plastic film extrusion process used for PVA film was added to the LDPE granulate production.

Calcium carbonate
The calcium carbonate used by Adfil is produced in Spain, however, no generic data was available for calcium carbonate produced in Spain, hence generic production data from Germany has been applied. The transportation distance is set to the actual manufactures in Spain.

NC13PP
Is used in the nucleating adhesive batch. No specific data were available for NC13PP and the product were modelled by dividing it into its main components polypropylene (90%) and sorbitol (10%). The polypropylene was modelled using generic polypropylene granulate data. As described in 4.3.2 general data for sorbitol was not available. Thus an LCA-process was chosen to describe the production of sorbitol to not completely neglect the environmental impacts associated with the manufacturing of sorbitol. The data representativeness for the manufacturing process is poor at describing the manufacturing of sorbitol, as the process is modelled with the main component only. However, as only 0.05% of the total mass is sorbitol, the environmental burden associated with the differences from actual sorbitol manufacturing and the used process for maize starch production, will not affect the results significantly.

Waste modelling
The waste handling method used for the packaging is incineration.

Concrete demolition

The concrete demolition is modelled using an electric demolition hammer, which can deconstruct up to 47 m³/h[6] and has an electricity consumption of 2.2 kWh[7].

Concrete crushing
As concrete is often used as road fill the same recycling potential has been applied to Durus EasyFinish, as Durus EasyFinish is not separated from the concrete at the disposal stage.
Data for the concrete crushing machine were unavailable. Only the power consumption of the machine used for crushing has been applied and has been based on the power consumption and crushing rate of the machine CI5X1415[8]. The CI5X1415 crushes concrete at a rate of 350-550 t/h using 250 kWh. A European electricity grid mix is used, as the concrete crushing is assumed to occur in Europe.

## 6.3 VARIANCE FROM THE MEANS

The LCA report does not contain processes based on average LCIA means or processes declared from different sources.

## 6.4 DATA QUALITY ASSESSMENT

Specific data is used for processes were data have been provided and been available. However, estimates and alternative processes have been used as described in 4.3.2 and 6.2.

The generic datasets for the primary ingredients in Durus EasyFinish from GaBi and EcoInvent ar, , less than three years old.

Four of the datasets used are more than 10 years old, these are: *DE – Maize starch production, EU-28:- Waste incineration of paper, EU-28 – waste incineration of plastics* and *Wood (natural) in municipal waste incineration plant*. These datasets were used as newer datasets were unavailable, and they have only been used for low impact processes. The incineration processes do however greatly affect the environmental impact of ozone depletion.

Generally the data representativeness of both the geographical, temporal and time is good.

## 6.5 VALUE-CHOICES, RATIONALES AND EXPERT JUDGEMENTS

The choices and justifications for choices are described throughout the LCA in the relevant sections.

In section 3.2.2 the energy and material inputs and outputs are quantified.
In section 3.2.3 assumptions regarding energy and other background data are assessed.
In section 4.3.1 the data representativeness is assessed.
In section 4.3.2 the treatment of missing data is described.
In section 4.4.1 the allocation principles and procedures are described.
In section 6.2 the assumptions and limitations of the study, data and the datasets are described.

---

[6] As the concrete is not reinforced with steel, the average middle weighted non-reinforced demolition hammer is used, to model the demoltion of concrete structures containing Durus EasyFinish: https://www.methvin.org/construction-production-rates/demolition-renovation/demolishing-concrete
[7] Most demolition hammers found has an electricity consumption of 2.2 kWh which is the same as the electricity conumption applied for the demolition of the concrete structures in this EPD: https://primates2016.org/best-electric-jack-hammers-for-concrete-breakers-reviews/
[8] Data for the concrete crushing machine is based on data of the CI5X1415 machine: https://www.rebasilicotiburtina.it/37342_concrete+crusher+electricity+needs.html

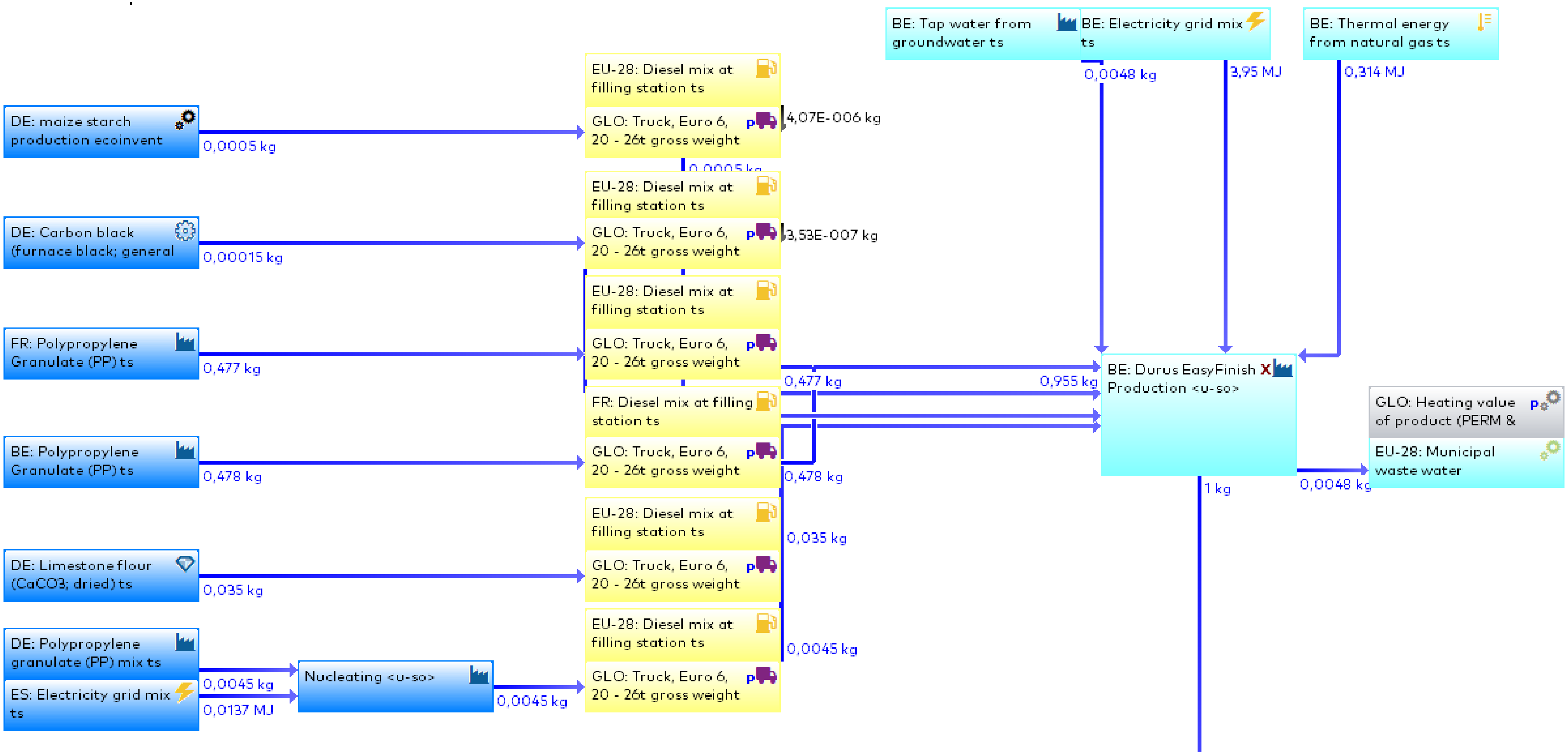
# 7 Documentation on additional information

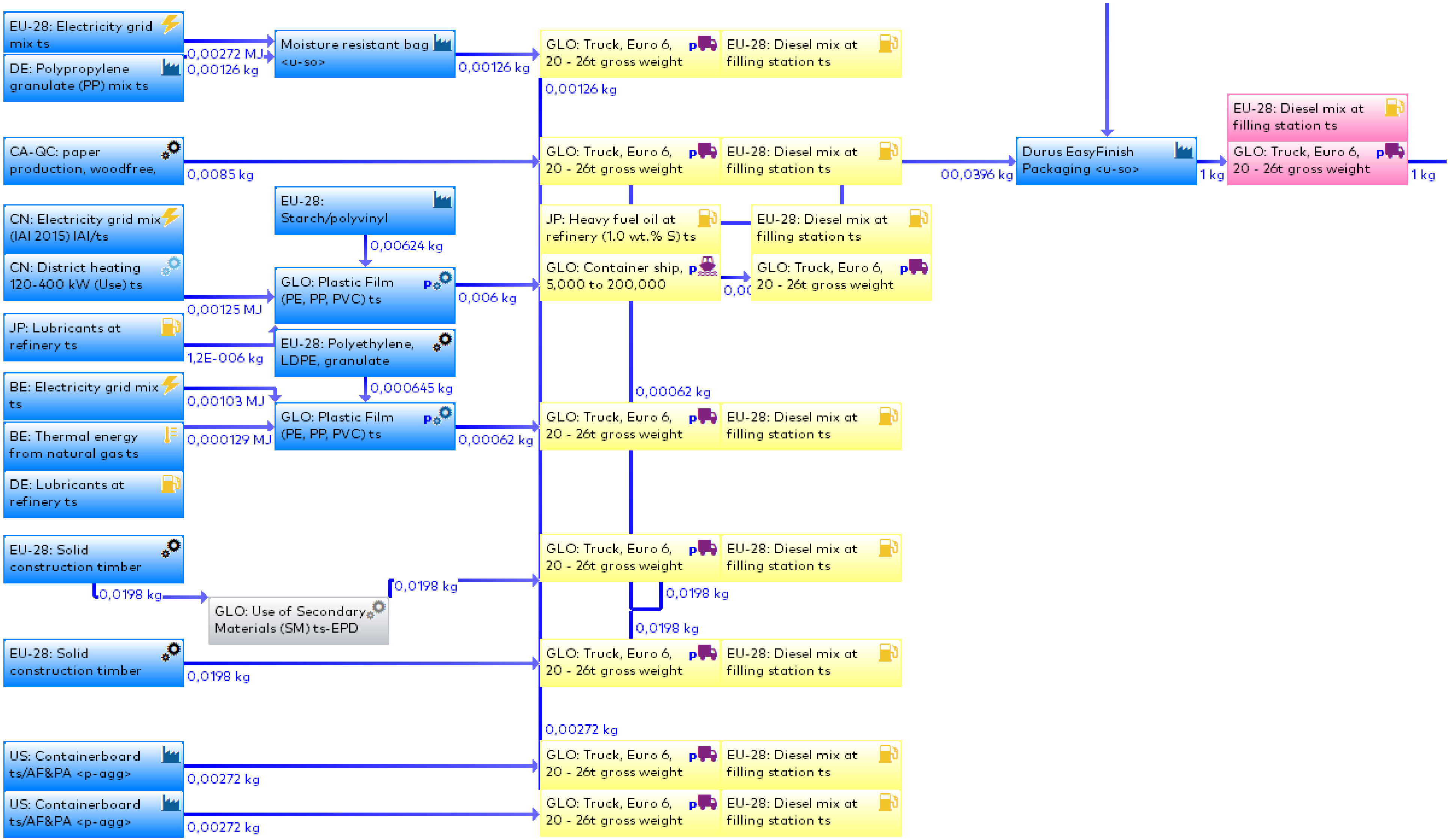
A description of Durus EasyFinish, can be found at their website:
https://www.adfil.com/media/3123/leaflet_adfil_durus_easyfinish-english.pdf

# 8 Data availability for verification

| Module | Process | LCA process | Database | Ref. year |
|---|---|---|---|---|
| A1 | Polypropylene France | FR – Polypropylene granulate (PP) | GaBi on demand | 2019 |
| A1 | Polypropylene Belgium | BE – Polypropylene granulate (PP) | GaBi on demand | 2019 |
| A1 | Calcium carbonate | DE - Limestone flour (CaCO3; dried) | GaBi Professional | 2019 |
| A1 | Nucleating (Sorbitol) | DE – Maize starch production | Ecoinvent 3.6 | 2002 |
| A1 | Nucleating NC13PP | DE - Polypropylene granulate (PP) mix, agg | GaBi Professional | 2019 |
| A1 | Carbon Black | DE - Carbon black (furnace black; general purpose) | GaBi Professional | 2019 |
| A1 | PVA granulate | EU-28 – Starch/polyvinyl alcohol (PVA) blend | GaBi on demand | 2019 |
| A1 | Extrusion of PVA film | GLO – Plastic film (PE, PP, PVC) | GaBi Professional | 2019 |
| A1 | Electricity PVA film extrusion | CN – Electricity grid mix (IAI 2015) | GaBi Professional | 2015 |
| A1 | Heat PVA film extrusion | CN – District heating 120 – 400 kW (Use) | GaBi Professional | 2019 |
| A1 | Lubricant oil PVA film extrusion | JP – Lubricants at refinery | GaBi Professional | 2016 |
| A1 | Papirpose | CA-QC – paper production, woodfree, uncoated, at integrated mill | Ecoinvent 3.6 | 2010 |
| A1 | Thin cardboard | US – Containerboard | GaBi Professional | 2012 |
| A1 | Heavy cardboard | US – Containerboard | GaBi Professional | 2012 |
| A1 | Paperboard incineration | EU-28: Waste incineration of paper | GaBi Professional | 2006 |
| A1 | LDPE film | EU-28 – polyethylene, LDPE, granulate | GaBi Professional | 2013 |
| A1 | Moisture resistant plastic bag | DE – Polypropylene, PP, granulate | GaBi Professional | 2019 |
| A1 | Pallet | EU-28 – Solid construction timber | GaBi Professional | 2019 |
| A2,A4,C2 | Transportation on land | GLO - Truck Euro 6, 20-26 t total weight, 17.3t max payload, | GaBi Professional | 2019 |
| A2 | Transportation by sea | GLO – Containership 5.000 to 2000 dwt payload capacity, ocean going ts | GaBi Professional | 2019 |
| A1 | Electricity Europe | EU-28 - Electricity grid mix, agg | GaBi Professional | 2016 |
| A3 | Electricity Belgium | BE - Electricity grid mix, agg | GaBi Professional | 2016 |
| A1 | Electricity China | CN – Electricity grid mix, agg | GaBi Professional | 2015 |
| A3 | Water | BE – Tap water from groundwater | GaBi Professional | 2019 |
| A5 | Waste water | EU-28 - Municipal waste water treatment (mix), agg | GaBi Professional | 2019 |
| A5 | Direct emissions from incineration of waste pallet | EU-28 – Wood (natural) in municipal waste incineration plant | GaBi Professional | 2019 |
| A5 | Direct emissions from incineration of waste plastic | EU-28 – Plastic packaging in municipal waste incineration plant | GaBi Professional | 2019 |
| A5 | Direct emissions from incineration of waste paper | EU-28 – Paper and board (water 0%) in waste incineration plant | GaBi Professional | 2019 |
| A3 | Gas for heating | BE - Thermal energy from natural gas, agg | GaBi Professional | 2016 |
| D | Credits from incineration of Waste pallet | EU-28 – Wood (natural) in municipal waste incineration plant | GaBi Professional | 2006 |
| D | Credits from incineration of waste plastic | EU-28 – Waste incineration of plastics (PE, PP,PS, PB) ELCD | GaBi Professional | 2006 |
| D | Credits from incineration of paper | EU28 – Incineration of paper fraction in municipal waste | GaBi Professional | 2019 |
| C3 | Concrete Crushing | EU-28 – Electricity grid mix, agg | GaBi Professional | 2016 |
| D | Substitution of gravel | EU-28 – Gravel 2/32 | GaBi Professional | 2019 |

**Table 11. The processes are categorised into modules and the processes used from the GaBi and EcoInvent databases is shown under LCA-process.**


BE: Tap water from groundwater ts
BE: Electricity grid mix ts
BE: Thermal energy from natural gas ts
0,0048 kg
3,95 MJ
0,314 MJ
EU-28: Diesel mix at filling station ts
DE: maize starch production ecoinvent
0,0005 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
4,07E-006 kg
EU-28: Diesel mix at filling station ts
DE: Carbon black (furnace black; general
0,00015 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
3,53E-007 kg
EU-28: Diesel mix at filling station ts
FR: Polypropylene Granulate (PP) ts
0,477 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
0,477 kg
0,955 kg
BE: Durus EasyFinish Production <u-so>
FR: Diesel mix at filling station ts
GLO: Heating value of product (PERM &
BE: Polypropylene Granulate (PP) ts
0,478 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
0,478 kg
EU-28: Municipal waste water
1 kg
0,0048 kg
EU-28: Diesel mix at filling station ts
0,035 kg
DE: Limestone flour (CaCO3; dried) ts
0,035 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
DE: Polypropylene granulate (PP) mix ts
0,0045 kg
Nucleating <u-so>
0,0045 kg
ES: Electricity grid mix ts
0,0137 MJ
0,0045 kg
GLO: Truck, Euro 6, 20 - 26t gross weight



EU-28: Electricity grid mix ts
DE: Polypropylene granulate (PP) mix ts
0,00272 MJ
0,00126 kg
Moisture resistant bag <u-so>
0,00126 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
0,00126 kg
CA-QC: paper production, woodfree,
0,0085 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
00,0396 kg
Durus EasyFinish Packaging <u-so>
1 kg
EU-28: Diesel mix at filling station ts
GLO: Truck, Euro 6, 20 - 26t gross weight
1 kg
EU-28: Starch/polyvinyl
0,00624 kg
CN: Electricity grid mix (IAI 2015) IAI/ts
CN: District heating 120-400 kW (Use) ts
0,00125 MJ
GLO: Plastic Film (PE, PP, PVC) ts
0,006 kg
JP: Heavy fuel oil at refinery (1.0 wt.% S) ts
GLO: Container ship, 5,000 to 200,000
EU-28: Diesel mix at filling station ts
GLO: Truck, Euro 6, 20 - 26t gross weight
JP: Lubricants at refinery ts
1,2E-006 kg
EU-28: Polyethylene, LDPE, granulate
0,000645 kg
0,00062 kg
BE: Electricity grid mix ts
0,00103 MJ
BE: Thermal energy from natural gas ts
0,000129 MJ
GLO: Plastic Film (PE, PP, PVC) ts
0,00062 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
DE: Lubricants at refinery ts
EU-28: Solid construction timber
0,0198 kg
GLO: Use of Secondary Materials (SM) ts-EPD
0,0198 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
0,0198 kg
0,0198 kg
EU-28: Solid construction timber
0,0198 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
0,00272 kg
US: Containerboard ts/AF&PA <p-agg>
0,00272 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts
US: Containerboard ts/AF&PA <p-agg>
0,00272 kg
GLO: Truck, Euro 6, 20 - 26t gross weight
EU-28: Diesel mix at filling station ts

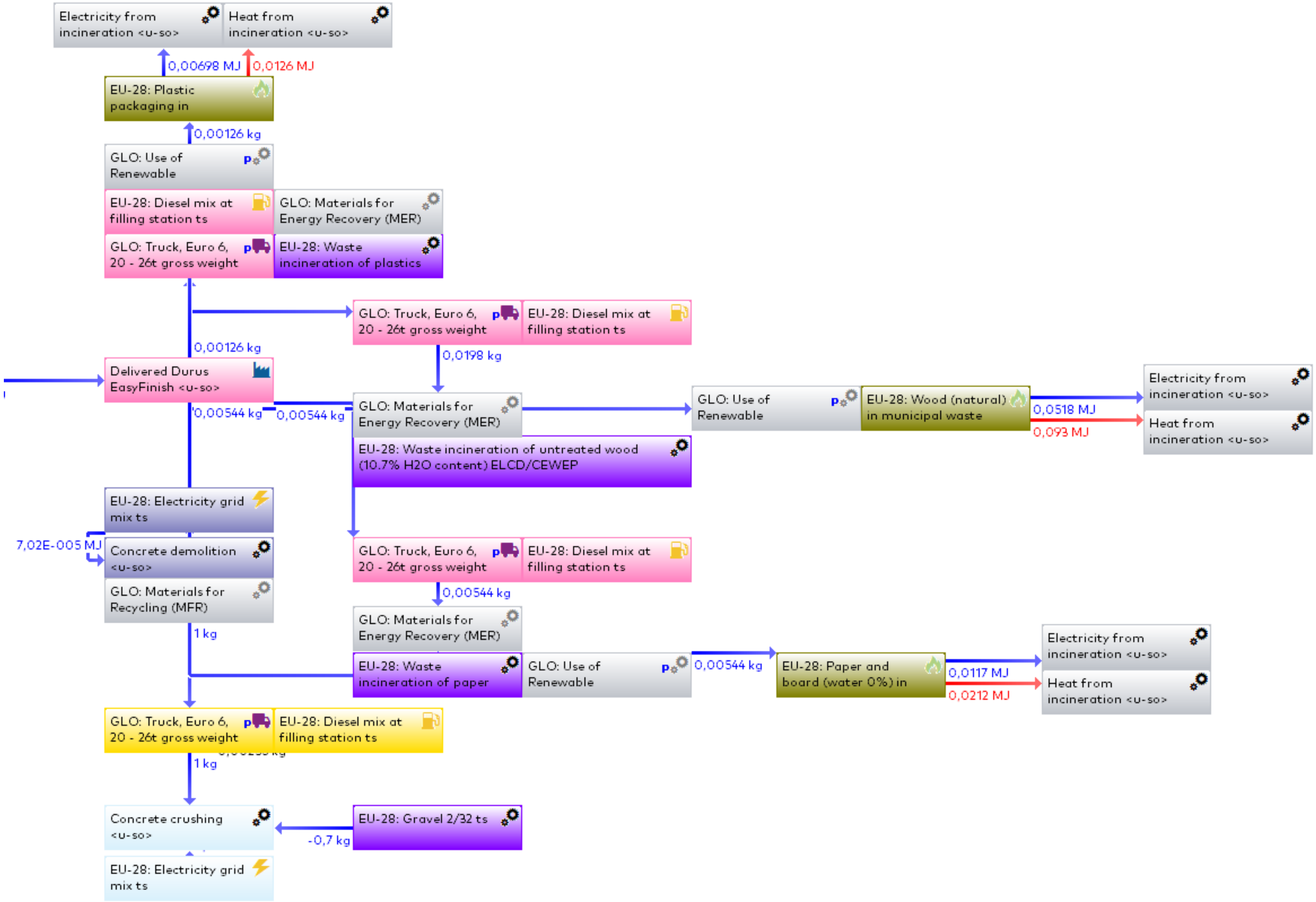



**Figure 4 Product system modelled in GaBi Professional, stating what specific LCA module (A1-A4, C1-C4, D) the single unit process is declared under. Colour coding: A1: Blue, A2: light yellow, A3: turquoise, A4: pink, C1: blue grey, C2: dark yellow, C3 light blue, C4: orange, D: purple.**

# 9 References


- GaBi 2019 Professional Database http://www.gabi-software.com/nw-eu-danish/databases/gabi-databases/professional/

- EN 15804
  DS/EN 15804 + A2:2019 - "Bæredygtighed inden for byggeri og anlæg - Miljøvaredeklarationer - Grundlæggende regler for produktkategorien byggevarer"

- EN 15942
  DS/EN 15942:2011 – "Bæredygtighed inden for byggeri og anlæg - Miljøvaredeklarationer (EPD) - Kommunikationsformat: business-to-business (B2B)"

- ISO 14025
  DS/EN ISO 14025:2010 – "Miljømærker og -deklarationer - Type III-miljøvaredeklarationer - Principper og procedurer

- ISO 14040
  DS/EN ISO 14040:2008 – "Miljøledelse – Livscyklusvurdering – Principper og struktur"

- ISO 14044
  DS/EN ISO 14044:2008 – "Miljøledelse – Livscyklusvurdering – Krav og vejledning"