LCA background report

Recycled PVC products

Report according to EN-15804

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Mediator

Denmark

1. Introduction

This LCA assessment has been commissioned by **LHI PVC recycled** product and is authored by Morten Carlsen. The report is dated 17-03-23 and complies to the requirements set in the ISO 14040 [1], ISO 14044 [2], ISO 14025 [3] and, in case of construction materials, the EN-15804 + A2:2019 [4]. The report can be verified by a qualified independent verifier, experienced in Life Cycle Assessment (LCA). Ecochain version 3.2.12 has been used in the preparation of this report [5]. This report is valid until five years after initial publication. The results of the product assessments and resulting 'Environmental Product Declarations' in this report are only comparable to others, if these others also comply with the norms and standards used in this report, and as set out above.

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1.1. Goal and target group of the LCA study

The purpose of the life cycle analysis (LCA) is to provide quantitative environmental figures on products and resources for market information, environmental optimization, and as part of a company's corporate responsibility program. An LCA assessment delivers an increased understanding of the sources of pollution, priority setting for sustainable business practices and aids the commercialization of sustainable products. This LCA study has been carried out in order to:

- Create an Environmental Product Declaration (EPD) that complies to internationally harmonized standards.
- Communicate reliable and accurate quantitative environmental data to users downstream within the building supply chain.
- Apply environmental data in LCA calculations for sustainable construction works. This is essential to enable valid and verifiable comparability of environmental data.

In addition, this assessment allows the comparison of the environmental performance of LHI PVC recycled against other products with similar functions. This comparison is, however, only valid for product assessments that comply with similar norms and standards.

The outcomes of this study will be used for both business-to-business communication. The intended company internal audience of this study consists of stakeholders such as marketers, product innovators, purchasers and process managers. External stakeholders could be clients and suppliers with an interest in environmental profiling, governments and environmental NGO's.

2. Scope

The following sections describe the general scope of this assessment. This includes, but is not limited to, the identification of specific product systems to be assessed, the product function(s), reference unit, the system boundaries, allocation procedures, and cut-off criteria of the study.

2.1. Reference unit

The reference unit for an LCA study can be presented in two ways: either as a functional unit or as a declared unit. A functional unit is a product unit that fulfils a specific function, e.g., a window, concrete beam, staircase, etc. For the product unit a precise product function or specific scenarios at the building level are known. A declared unit is a product unit where a specific function has not been indicated, e.g., a cubic metre of concrete, a square metre of wall panelling.

In this assessment all phases in the life cycle of the product are covered and quantified. The declared unit / functional unit has been defined as follows: the production, construction, maintenance, and waste processing of 1 kg LHI PVC recycled.
The service life of LHI PVC recycled is 50 years.

2.2. Product Description

LHI PVC recycled products is based on 100% recycled PVC waste.

2.3. Process Description

The process consists of all processes that cause environmental impacts, for example material extraction and the transportation of these resources to the production facility. The quantified impact flows of **LHI PVC recycled**. The processes and life cycle modules that are included in this study are defined by the system boundaries. In this LCA of **LHI PVC recycled** the following stages are covered:

- Raw material supply, transport and manufacturing (A1-A3)
- De-construction, transport, waste processing and disposal (C1-C4)

2.4. System boundaries and cut-off criteria

All relevant inputs and outputs - like emissions, energy and materials - have been taken into account in this LCA. And in accordance with EN15804+A2:2019 the total neglected input flows per module do not exceed 5% of energy usage and mass.
In this LCA, the waste processes are allocated in the relevant module. In the case of the use of secondary materials or energy recovered from secondary fuels, the system boundary between the system under study and the previous system (providing the secondary materials) is set where outputs of the previous system, e.g., materials, products, building elements or energy, reach the end-of-waste state.

X = Included
MND = Module Not Declared
MNR = Module Not Relevant

	Stage; Prodcution			Stage; Construction		Stage; Use							Stage; End of life				Stage; Ressource recovery
	Material supply	Transport	Manufacturing	Transport	Construction / Installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse/Recovery/Recycling Potential
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Modules declared	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	MND	MND
Geography	EU	EU	DK	-	-	-	-	-	-	-	-	-	-	-	DK	-	-
Specific data use	<10%	<10%	>90%	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3. Life Cycle Inventory Analysis

The life cycle inventory comprises data gathering and calculation procedures to quantify all relevant environmental impacts (inputs and outputs) of the product system. In this analysis all environmental inputs - such as resources, energy and waste - were qualified, quantified and translated to environmental impacts through the use of LCA background data from Ecoinvent.

3.1. Data collection procedures

All relevant suppliers of **LHI PVC recycled** product have been requested to send LCA related product information for this assessment. However, no data has been received. As suppliers could not provide any relevant data, public references, industry statistics and literature has been used instead. Based on this information, representative background data have been selected. The explanation of this selection is further elaborated upon in paragraph 4.3.

3.1.1. Suppliers involved

Suppliers has not been contact.

3.1.2. Data sources

The data of products, by-products and the waste in this report were derived from energy and resource administrations at the production site. Primary production data from the year 2022 has been used. Emissions to air, water and soil and other environmental impacts associated with the production of **LHI PVC recycled** were derived from emission registrations.

3.2. Inventory and allocation

In this section the quantity, quality and allocation of various materials, energy streams and emissions by processes and products are outlined. The system boundaries that have been adopted are in accordance with modular approach of EN 15804.

3.2.1. Materials (Module A1)

All relevant resources, materials and services in production phase A1 have been included in this study. The composition of LHI PVC recycled per kg is given in the table below. The compositions are based on the Bills of Materials supplied by **LHI** products manufactured in 2022.

Table 1: The composition of the product per declared unit.

	LHI PVC recycled
Recycled PVC	1kg

3.2.2. Transport (Module A2)

All relevant transport to LHI products production plant has been included in this study. The references for transport are according to EN15804+A2:2019and are presented in table 4 (paragraph 4.3). These LCA database references calculate with an average load factor of 50%, in other words: fully loaded transport towards the customer with empty returns.

Table 2: Transport distance from suppliers towards the production facility in kilometers.

Material	Supplier	Truck
Ethanol	-	428 km
Isopropyl alcohol	-	428 km

3.2.3. Production (Module A3)

The production processes are modelled using specific values from primary data collection at the production site. All relevant production processes in module A3, like packaging materials and production losses, have been included in this assessment. Table 2 illustrates which processes are present at the production site of **LHI** products. In addition, it is illustrated how the total energy usage on the site is distributed over the individual production processes.

Table 3: Energy usage of the processes at **LHI** products.

Processes	Electricity mix medium voltage Poland
	kWh/lkg
producing	0.205

Processes	Wastewater treatment (kg)	Solid waste, incineration
	kg	Kg
Mixing & Filling liquid	0.005585	0

The production site does not have any dangerous waste streams.
All other substances and emissions that are released during the production process are included in this assessment.

4. Data validation

4.1. Data quality

In this study the data flows have been modelled as realistic as possible within the practical feasibility of the LCA practitioner. The data quality is based on the principle that the primary data used for processes, occurring at the production site, must be of higher quality than background data of other processes.

4.1.1. Data representation

In this LCA the data relating to the manufacturing of **LHI PVC recycled** and the background processes for environmental impacts are relatively recent (2-5 years) and deviate less than 5% from reality.

The processes used in the production of **LHI PVC recycled** is geographically representative, meaning that the production location of **LHI PVC recycled** lies within the region for which the relevant Ecoinvent environmental records have been selected.

The dataset is up-to-date and representative for the current technology used in the processes of manufacturing the product.

4.1.2. Completeness of environmental impacts and economic flows

All environmental impacts and economic flows – from sources such as resources, energy, emissions and waste – were quantified and qualified in environmental effects. There is no presumption that relevant inputs or outputs have been omitted.

All identified environmental impacts have been translated into environmental impact categories. Direct emissions from the inventory have been characterized by the characterization factors of CML. The used LCA references were derived from accepted databases such as Ecoinvent, which ensures that all relevant environmental impacts were characterized.

4.1.3. Consistency and reproducibility

The process descriptions and quantities in this study are entirely quantitatively reproducible in accordance to the reference standards that have been used. The references of all sources, both primary and public sources and literature, have been documented in the chapter “References”. Additionally, in order to guarantee the reproducibility, a project dossier has been composed which can be consulted via the Ecochain tool. This project dossier contains a summary of all the data used in the LHI products Ecochain account, and in this LCA.

4.2. Energy and mass balance

4.2.1. Energy balance

In accordance with the Ecochain methodology, the energy usage of the production facility has been allocated to all processes and products at the production location of **LHI** products. Therefore, the energy balance is by definition 100% closed. In other words, the total energy consumption at the production site is allocated to all produced products.

4.2.2. Mass balance

The mass balance checks whether the provided (theoretical) composition of **LHI PVC recycled** correlates to the actual purchased resources for this product. The LCA calculations have been performed based on the actual amount of materials used.

4.3. Description of LCA references, scenarios and databases

In this paragraph the used background processes and databases from which these processes derive are discussed. In the table below these processes are presented, accompanied by a motivation for each specific background process. The table furthermore provides a complete record of all materials and means of transportation used in this study.
The data for the upstream supply chain derives from Ecoinvent (version 3.8) and, when possible, are modelled according to the EN15804+A2:2019in the Ecochain application. According to the Ecoinvent standards, the background process data ("LCA references") includes infrastructure and capital goods.

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Table 4: LCA references for emission sources, materials and transport.

Emission source	Reference	Database	Motivation
Electricity mix medium voltage Poland	market for electricity, medium voltage | electricity, medium voltage | Denmark	Ecoinvent v 3.8 Cut-off	Factory are in Poland
Truck		Ecoinvent v3.8 Cut-off	The transport process sheet has been selected because the mode of transport corresponds with the real situation. Transport distances have been calculated from the supplier.

5. Life Cycle Impact Assessment

5.1. Results

In this chapter the results of the LCA calculations of **LHI PVC recycled** are presented and discussed. The environmental profile consists of 7 impact categories and a number of parameters. Both groups differ from each other. Use of energy, for example, is an input to the parameter 'Energy' (primary) and contributes to the score of (among others) the impact categories ‘depletion of abiotic resources (fossil)’ and ‘global warming'.

The LCA profile of **LHI PVC recycled** is presented in the table below. The values of the impact categories are calculated in the following manner: all environmental emissions from the inventory are multiplied by the characterisation factors from the CML-VLCA impact assessment method, after which these values are added up to provide the total environmental impact per impact category. These LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Impact category name	Unit	A1	A2	A3	C4	Total
Climate change (GWP)	kg CO2 eq	0,00E+00	1,10E-01	5,75E-02	0,00E+00	1,67E-01
Climate change - Fossil	kg CO2 eq	0,00E+00	1,10E-01	5,73E-02	0,00E+00	1,67E-01
Climate change - Biogenic	kg CO2 eq	0,00E+00	2,94E-04	2,07E-04	0,00E+00	5,01E-04
Climate change - Land use	kg CO2 eq	0,00E+00	4,46E-05	1,33E-05	0,00E+00	5,79E-05
Ozone depletion	kg CFC11 eq	0,00E+00	2,57E-08	8,70E-10	0,00E+00	2,66E-08
Acidification	mol H+ eq	0,00E+00	6,21E-04	4,15E-04	0,00E+00	1,04E-03
Eutrophication, freshwater	kg P eq	0,00E+00	8,06E-07	7,89E-06	0,00E+00	8,70E-06
Eutrophication, terrestrial	mol N eq	0,00E+00	2,46E-03	5,15E-04	0,00E+00	2,97E-03
Eutrophication, marine	kg N eq	0,00E+00	2,23E-04	4,46E-05	0,00E+00	2,68E-04
Photochemical ozone formation	kg NMVOC eq	0,00E+00	7,03E-04	1,42E-04	0,00E+00	8,45E-04
Resource use, minerals & metals	kg Sb eq	0,00E+00	3,67E-07	1,07E-07	0,00E+00	4,75E-07
Resource use, fossils	MJ	0,00E+00	1,69E+00	6,25E-01	0,00E+00	2,31E+00
Particulate matter	disease inc.	0,00E+00	9,86E-09	6,34E-10	0,00E+00	1,05E-08
Ionising radiation	kBq U-235 eq	0,00E+00	7,32E-03	6,08E-04	0,00E+00	7,93E-03
Ecotoxicity, freshwater	CTUe	0,00E+00	1,34E+00	7,51E-01	0,00E+00	2,09E+00
Human toxicity, cancer	CTUh	0,00E+00	5,33E-11	2,03E-11	0,00E+00	7,36E-11
Human toxicity, non-cancer	CTUh	0,00E+00	1,54E-09	8,62E-10	0,00E+00	2,40E-09
Land use	Pt	0,00E+00	1,41E+00	2,16E-01	0,00E+00	1,62E+00

Table 5: Environmental profile of 1 kg **LHI PVC recycled**.

6. Life Cycle Interpretation

In chapter 5 the environmental profiles of **LHI PVC recycled** have been presented. In this chapter the results of the LCA are reviewed in more detail. In section 6.1 the environmental impact of **LHI PVC recycled** is analysed more in-depth, followed by a sensitivity analysis in section 6.2.

6.1. Contribution Analysis

This paragraph provides the contribution analysis of **LHI PVC recycled**. The contribution analysis indicates which parts (specifically: materials, production, transport, construction, or end-of-life) are associated with the highest influence on the total global warming potential (GWP) of **LHI PVC recycled**. In this way the results from the life cycle inventory of this LCA are related to the outcomes of the impact assessment.

Transport of the material contribute to 64,7% of the GWP impact. Remaining 35,3% comes from the electricity used for production of the elements.

6.2. Sensitivity analysis

In this paragraph the results of the sensitivity analysis are presented. Of the input parameters which contribute the most to the global warming potential (paragraph 6.1), the extent of uncertainty is first described. Then it is investigated whether other relevant data has been used with a relative high uncertainty. Based on the former, the input parameters are selected for which a sensitivity analysis is most relevant. For these parameters new calculations are made on the basis of the expected minimum and maximum values. As such, it is analysed to what extent the results change when these input parameters change. The sensitivity analysis is performed in order to identify which data and assumptions have the highest influence on the results.

If the transportation of the elements where only handled by EURO6 lorry/trucks the GWP could be reduced with 0,04kg GWP to 0.13kg GWP per 1kg material. Which is equal to a 36,4% reduction.
If there instead were selected green energy, such as wind power or sun power the reducing of GWP would be reduced with 100%. The GWP impact would be 0.11 kg GWP per 1kg material

7. References

[1] 'ISO 14040: Environmental management - Life cycle assessment – Principles and Framework', International Organization for Standardization, ISO14040:2006.

[2] 'ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines', International Organization for Standardization, ISO14044:2006.

[3] 'ISO 14025: Environmental labels and declarations -- Type III environmental declarations -- Prin-ciples and procedures', International Organization for Standardization, ISO14025:2006.

[4] 'NEN-EN 15804+A2: Duurzaamheid van bouwwerken - Milieuverklaringen van producten - Basisregels voor de productgroep bouwproducten', NEN-EN 15804:2012+A2:2019.

[5] Ecochain 3.2.12, 2021, web: http://app.Ecochain.com.