ENVIRONMENTAL PRODUCT DECLARATION

LNP™ ELCRIN™ WF008NXPiQ COMPOUND

PLASTICS IN PRIMARY FORMS

The LNP ELCRIN iQ portfolio is based on upcycled iQ PBT resins, a SABIC patented technology that uses chemical de-polymerization to process recycled PET plastics into polybutylene terephthalate (PBT).

SABIC's Specialties business has developed the LNP ELCRIN iQ portfolio based on upcycled iQ PBT resins using a patented technology. This technology uses chemical de-polymerization to process recycled PET plastics into a polymer: polybutylene terephthalate (PBT) called iQ-PBT resin. The iQ-PBT resin is used to produce LNP ELCRIN iQ compounded products .

LNP ELCRIN WF008NXPiQ compound is an iQ PBT/glass fiber compound for various applications. Added features of this material include: >10% recycled content, high modulus, excellent metal bonding force, good surface quality, high impact, good adhesion and good color stability during anodizing process.

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

ENVIRONMENTAL PRODUCT DECLARATION

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LNP™ ELCRIN™ WF008NXPIQ
PLASTICS IN PRIMARY FORMS

According to ISO 14025, EN 15804 and ISO21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Environment 333 Pfingsten Rd., Northbrook, IL 606011 https://www.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	UL Environment Environmental Product Declaration Program, GENERAL PROGRAM INSTRUCTIONS, VERSION 2.5, MARCH 2020
MANUFACTURER NAME AND ADDRESS	SHPP Singapore Pte. Ltd. 23 Benoi Rd, Singapore 629895
DECLARATION NUMBER	4790717243.101.1
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	The functional unit is 1 kg of LNP ELCRIN WF008NXPiQ in the form of compounded resin pellets (solid), including its packaging.
REFERENCE PCR AND VERSION NUMBER	EPD International (2022). Plastics in primary forms, product category classification: UN CPC 347, 2010:16, version 3.0.2
DESCRIPTION OF PRODUCT APPLICATION/USE	LNP ELCRIN WF008NXPiQ is based on PBT resin utilized ELCRIN iQ upcycling technology and containing 40% glass fiber. Added features of this material include: minimum 10% PCR content, high modulus, good surface quality, high impact, excellent metal bonding force and good color stability targeted for various applications including electrical, electronics, automotives and others where nano-molding technology (NMT) may be applied.
PRODUCT RSL DESCRIPTION (IF APPL.)	N/A
MARKETS OF APPLICABILITY	Electronics – antenna split for mobile phone, tablet, laptop, and wearable device. Metal plastic hybrid, Nano-Molding Technology (NMT)
DATE OF ISSUE	May 1, 2023
PERIOD OF VALIDITY	5 years
EPD TYPE	Product specific
RANGE OF DATASET VARIABILITY	N/A
EPD SCOPE	Cradle to the grave of plastics in primary form
YEAR(S) OF REPORTED PRIMARY DATA	2022
LCA SOFTWARE & VERSION NUMBER	SimaPro LCA software (version V 9.4.0.2).
LCI DATABASE(S) & VERSION NUMBER	Ecoinvent 3.6
LCIA METHODOLOGY & VERSION NUMBER	EN 15804 +A2 Method V1.00/CED, LHV, V1.00, EDIP 2003 V1.07.

The PCR review was conducted by:	The International EPD® System Technical Committee Chair: Paola Borla info@environdec.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum Cooper McCollum, UL Envvironment
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	SABIC Specialties
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Lindita Bushi Lindita Bushi, PhD Athena Sustainable Materials Institute

LNP™ ELCRIN™ WF008NXPiQ
PLASTICS IN PRIMARY FORMS

According to ISO 14025, EN 15804 and ISO 21930:2017

LIMITATIONS

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc.

Accuracy of Results: EPDs regularly rely on estimations of impacts; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible". Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

Disclaimers:

- EPD owner has the sole ownership, liability and responsibility of the EPD,
- EPDs within the same product category but from different programmes may not be comparable.
- An EPD should provide current information, and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

1. Product Definition and Information

1.1. Description of Company/Organization

Owner of the EPD: The Specialties business of SABIC. https://www.sabic.com/en/products/specialties

Manufacturer name and Address: SHPP Singapore Pte. Ltd. 23 Benoi Rd, Singapore 629895

SABIC's Specialties business produces highly differentiated products which include specialty engineering thermoplastic resins and compounds, composites, thermosets & additives, and additive manufacturing solutions. Offering a distinct set of multi-function physical properties to serve a wide range of industries, the branded portfolio includes ULTEM™ resins and films, LNP™ compounds and Copolymers, NORYL™ resins and EXTEM™ resins. LNP ELCRIN iQ portfolio offers a drop in solution for conventional PBT applications such as electronics & electrical, consumer electronics, automotive and other markets.

1.2. Product Description

Product name: LNP ELCRIN WF008NXPiQ compound

Product Identification: Upcycled Poly (butylene terephthalate)/glass fiber compound for various applications including electrical, electronics, automotives and others where NMT may be applied.

Table-1. Product Specifications

GENERAL INFORMATION	
Features	Structural, Chemical resistance, High flow, High stiffness, Nano molding technology (NMT), Good metal adhesion, Impact modified, Sustainable (Advanced Recycling)
Fillers	Glass Fiber
Polymer types	Polybutylene terephthalate, PBT
Process techniques	Injection Molding

Table-2. Technical specifications for WF008NXPiQ

Characteristics	Units	Value	Test standard
Density	g/cm3	1.6	ISO 1183
Water absorption (23ºC/24 hrs)	%	0.03	ISO 62-1
Tensile stress, brk, type I, 5mm/min	MPa	145	ASTM D638
Tensile modulus, 50 mm/min	MPa	12800	ASTM D638
Flexural strength, 2mm/min	MPa	216	ISO 178
Flexural modulus	MPa	10800	ISO 178
Izod Impact, notched, 23ºC	J/m	135	ASTM D256
HDT, 0.45 MPa, 3.2 mm, unannealed	ºC	219	ASTM D648
CTE, -40 to 40 deg C, flow	1/ ºC	1.8E-05	ASTM E831

Flow Diagram: System Boundary

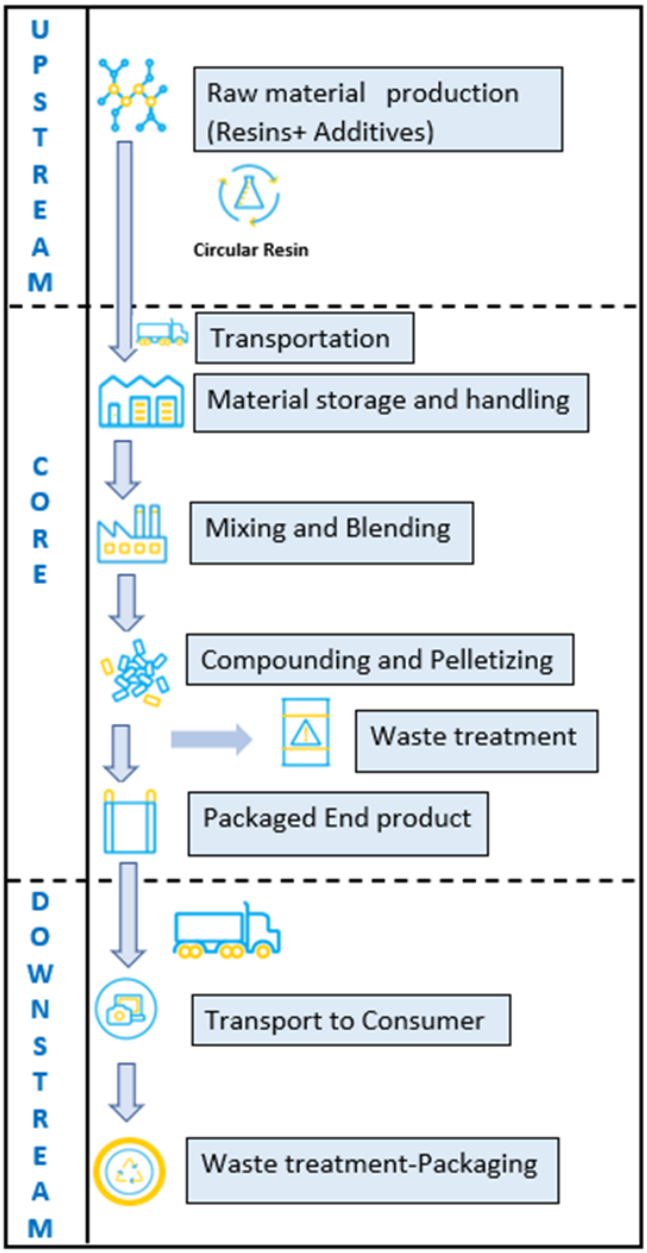

Figure 1. High level Process map for LNP ELCRIN WF008NXPiQ compound

Material composition

Key components in LNP ELCRIN WF008NXPiQ compound include Polybutylene terephthalate (PBT), sourced from fossil as well as recycled feedstocks and Glass Fiber. Detailed compositions are provided in Table-3.

Table 3. Material composition of LNP ELCRIN WF008NXPiQ compound

Chemical name	CAS No.	Content (wt. %)
PBT (Fossil)	26062-94-2	20-30
Recycled PBT	Proprietary	10-20
Glass Fibre+ others	65997-17-3	50-60

Recycled Resin

iQ PBT, the chemically upcycled polybutylene terephthalate (PBT) is the polymer derived from recycled polyethylene terephthalate (rPET), which in turn is primarily derived from post-consumer recycled (PCR) PET water bottles. LNP ELCRIN iQ compounds provide a circular solution which is a drop-in to virgin PBT and other conventional PBT materials with equivalent properties. LNP ELCRIN iQ compounds can offer consistent quality, colorable space and potentially used for food contact applications.

As per EPD (ISIC-CPC) guideline, the primary resin in scope belongs to the Class 3474, i.e., Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms.

HS 2017 Code:3905

CPV 2007 Code: 24550000-4.

1.2. Manufacturing

LNP ELCRIN WF008NXPiQ compound production process flow diagram is demonstrated in below Figure and consists of 10 steps as discussed below.

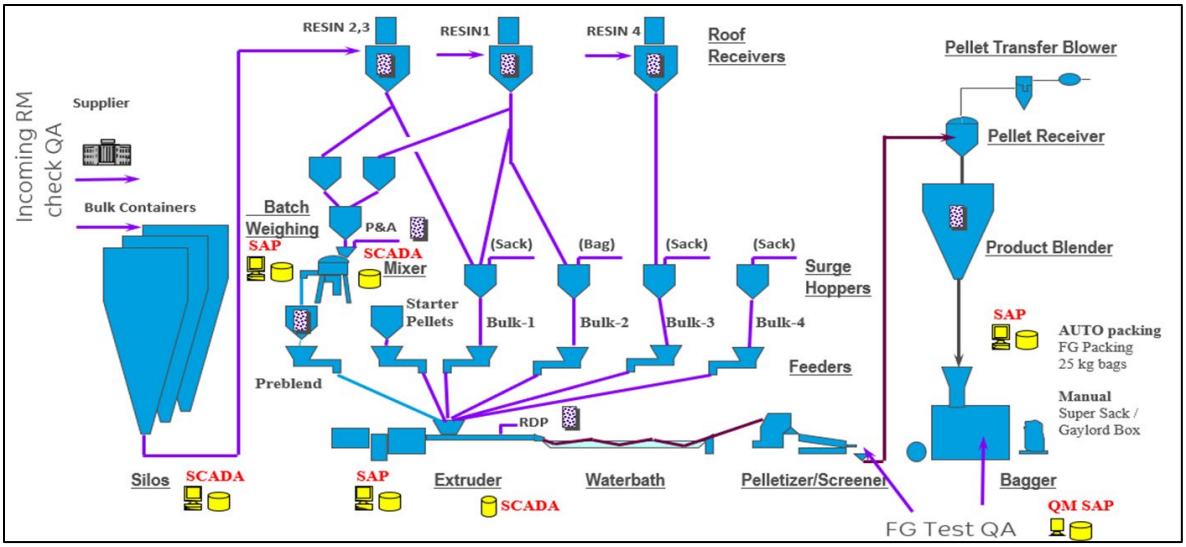

Figure 2. LNP ELCRIN WF008NXPiQ compound production flow diagram

Table-4. LNP ELCRIN WF008NXPiQ compound production process steps

No	Step	Description
1	Weighing	Weighing of additives and pigment package as per production batch
2	Blending	Mixing of raw materials with additives and pigment in mixer to form the pre-blend
3	Charging	Charging of raw materials and pre-blend to respective feeder hoppers
4	Extrusion	Melting and mixing of raw materials in the extruder
5	Cooling	Quenching of molten strands in the water bath
6	Drying	Lay cooled strands across strand dryer unit
7	Pelletizing	Cut strands into pellet
8	Screening	Screening of oversize and undersize pellets
9	Transfer/Storage	Transfer of product into post blender
10	Package	Packing a fixed quantity of products

Transportations

It is assumed that all raw materials are distributed using the shortest distance by truck and ship and products are delivered to customers as the shortest distance by ship and truck.

1.3. Properties of Declared Product as Delivered

Refer to Table-2. Technical specifications for LNP ELCRIN WF008NXPiQ compound

1.4. Material Composition

Refer to Table -3. Material composition of LNP ELCRIN WF008NXPiQ compound

1.5. Packaging

The packaging bags are considered to be made of low density polyethylene (LDPE).

2. Life Cycle Assessment Background Information

2.1. Functional or Declared Unit

The functional unit for this analysis is 1 kg of LNP ELCRIN WF008NXPiQ in the form of compounded pellets (solid) including its packaging. The weight of packaging is not included in this 1 kg.

2.2. System Boundary

The scope of the EPD is cradle to the grave of plastic in primary form.

The life cycle of LNP ELCRIN WF008NXPiQ compound is divided into three different life cycle stages:

- Upstream processes (from cradle-to-gate)
- Core processes (from gate-to-gate)
- Downstream processes (from gate-to-grave)

Upstream processes

The following attributional processes are part of the product system and classified as upstream processes:

- Resins production processes at SABIC site- Polybutylene terephthalate (fossil/recycled)
- Addtive production processes used in compounding
- All relevant transportations
- Treatment of waste and wastewater generated by resins production processes and key additives
- Impacts due to the production of electricity and fuels used in the upstream module
- Manufacturing of packaging

- All elementary flows at resource extraction is included

Core processes

The following attributional processes are part of the product system and classified as core processes:

- Resins and additives transportation to the plant site
- Compounding and pelletizing
- Transportation of waste generated in compounding to the waste management system
- Waste treatment of the waste generated during compounding
- Packaging film and associated transportations

Downstream processes

The following attributional processes are part of the product system and classified as downstream processes:

- Transport to customer site
- End of life processes of packaging waste

It is to be noted that the system boundary for the present LCA excludes the fabrication of the final part using plastics and use phase of the final product.

2.3. Estimates and Assumptions

Some of the key study assumptions and limitations are listed below for increased clarity and transparency:

- Data collection procedure- Primary data has been used for resin production as well as compounding processes based on actual process data including heat and mass balances, raw material, utility consumption figures, supply chain and transportation distances etc. Each response to the LCA data questionnaire is cross-checked for completeness and plausibility using mass balance, stoichiometry, as well as validation of key data using internal and/ or external reference values or benchmarking data. In case of gaps in data, LCA team engaged with the data provider to resolve any open issues. Most of the data used for this study beyond what is collected are based on industry average data from standard LCA databases.
- Time coverage- Primary data was collected from January to December 2022, data are conservatively extrapolated from 8 to 12 months by assuming the same average environmental profile for the rest of the four months.
- Geographical scope- The geographical resolution and coverage of this Gate-to-Gate LCA study is mostly at global level to keep it relevant. However, during consideration of transportation of raw materials and finished goods, transportation distances are calculated based on distances and hence resolution is at sub-national scale.
- Electricity usage- LNP ELCRIN WF008NXPiQ compound production and the electricity data are managed by SABIC Specialties.The total electricity usage at the compounding plant is allocated based on the total production of the plant and LNP ELCRIN WF008NXPiQ compound production.
- Waste- The total waste generated at the compounding plant is based on the total production of the plant and

LNP ELCRIN WF008NXPiQ compound production.

- Transport- Truck and Sea Transport at Global level is assumed to be with Euro 4 standard vehicles
- Upstream processes
  - Mostly developed with SABIC's Specialties primary data (PBT resin-fossil, recycled)
  - Used primary datasets for fossil sourced PBT while the resin is sourced from the supplier because of non-availability of secondary (Eco invent) dataset for this resin.
- Core processes
  - Developed with primary data from SABIC's Specialties business
  - Energy consumption from site mobile sources (vehicles, diesel generators, etc.) are not considered in this study.
- Downstream processes
  - Developed with primary data from SABIC's Specialties business as well as inputs from the customer
  - Polyethylene based packaging wastes are used and at their end of life they are incinerated at customers' end.

Impacts associated with manufacturing of vehicles and other transportations, packaging materials and use of the products are excluded from this study.

2.4. Cut-off Criteria

According to PCR 4.5, below are the cut-off criteria applied for the study.

- Life cycle inventory includes data that contributes to a minimum of 99% of the environmental impact on basic flows entering and exiting the product system.
- All the energy and fuels are included in the system
- According to the cut off criteria, excluded materials are pigments/colorants used in resin compounding (used <1 wt.%) with no effect on LCA major results.

2.5. Data Sources

The site specific primary data is used for the plant compounding operations.The secondary dataset is largely developed from Simapro (Ecoinvent 3.6).

2.5. Data Quality

Data quality considerations for this study aim to ensure that the LCI (life cycle inventory) data used by the study is as precise, complete, consistent, reproducible and representative as possible with regards to the goal and scope of the study.

Following are the key requirements considered.

- Time coverage- Primary data was collected from January to December 2022, data are conservatively extrapolated from 8 to 12 months by assuming the same average environmental profile for the rest of the four months.
- Geographical coverage- On site primary data was collected from manufacturing plant belonging to SABIC's Specialties business, located at Benoi, Singapore

- Technology coverage-Primary data flows are collected from the current process
- Data source- Product formulation data is obtained from SAP systems and supplier transport data is obtained from Procurement databases.

  Foreground and Background SimaPro LCI datasets are generated in compliance with ISO 14040/44 and 14025 standards. SimaPro datasets meet PCR criteria.
- The data quality parameters are assessed for the key foreground process (Core Process-Gate to Gate) modelled by the study. Ratings on technological, geographical and temporal relevance as well as precision is used to arrive at a numerical score for DQI using DQR formula.

2.6. Period under Review

Primary data was collected from January to December 2022, data are conservatively extrapolated from 8 to 12 months by assuming the same average environmental profile for the rest of the four months.

2.7. Allocation

The allocation for electricity, water and wastes are conducted based on the total production of the plant and the production mass of LNP ELCRIN WF008NXPiQ compound. Allocation of wastes are carried out according to the polluter pays principle.

2.9. Software and database

The LCA models are built using SimaPro LCA software (version V 9.4.0.2). The study mostly relies on primary data from SABIC's Specialties business with Ecoinvent background datasets (Ecoinvent v3.6). The study also has modelled key foreground processes based on data provided by SABIC technology partners.

3. Life Cycle Assessment Results

Figure 3 describes the material flows as part of Core processes. The study boundaries of this LCI include the Resin compounding process at Benoi plant and exclude the following elements: raw material production, fabrication of the final part using plastics as well as use phase of the final product.

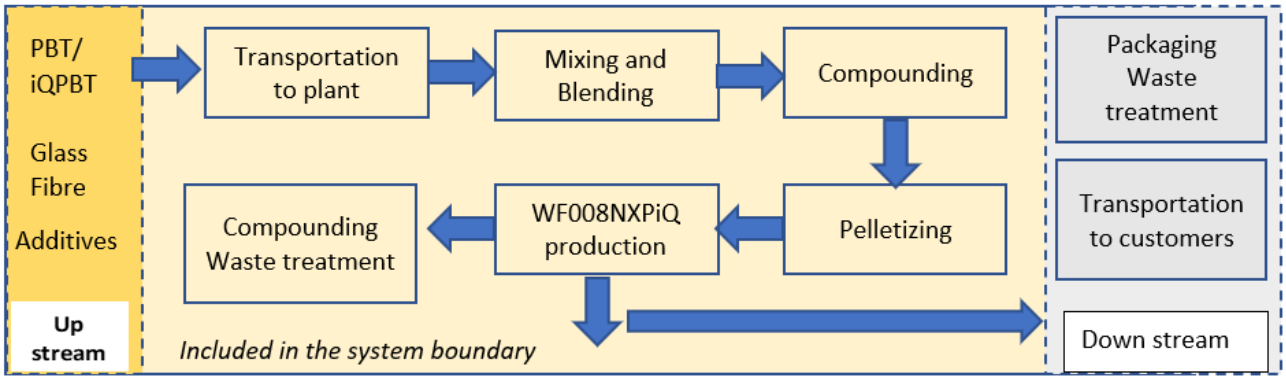

Figure 3. Core process product system for LNP ELCRIN WF008NXPiQ compound production

4.1. Life Cycle Impact Assessment Results

Table 8. Potential environmental impacts

Indicator	Unit	Upstream	Core	Downstream	Total
Global Warming Potential (GWP) total (GWP-total)	kg CO2 eq	3.50E+00	3.71E-01	3.45E-02	3.90E+00
Global Warming Potential fossil fuels (GWP-fossil)	kg CO2 eq	3.49E+00	3.67E-01	3.45E-02	3.89E+00
Global Warming Potential biogenic (GWP-biogenic)	kg CO2 eq	6.27E-03	3.62E-03	-5.62E-06	9.88E-03
Global Warming Potential land use and land use change (GWP-luluc)	kg CO2 eq	1.69E-03	6.65E-05	1.71E-05	1.77E-03
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC11 eq	2.67E-07	3.46E-08	5.33E-09	3.07E-07
Acidification potential, Accumulated Exceedance (AP)	mol H+ eq	1.97E-02	2.58E-03	7.70E-04	2.31E-02
Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg P eq	9.30E-04	1.40E-05	1.18E-06	9.45E-04
Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-marine)	kg N eq	3.97E-03	6.68E-04	1.91E-04	4.83E-03
Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq	4.06E-02	7.37E-03	2.12E-03	5.01E-02
Formation potential of tropospheric ozone (POCP)	kg NMVOC eq	1.36E-02	1.96E-03	5.51E-04	1.61E-02
Abiotic depletion potential for non fossil resources (ADP-minerals and metals)	kg Sb eq	1.14E-04	1.49E-06	2.56E-07	1.16E-04
Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, net calorific value	5.46E+01	5.90E+00	3.43E-01	6.08E+01
Water (user) deprivation potential, deprivation weighted water consumption (WDP)	m3 depriv.	3.59E+00	2.03E-02	5.93E-04	3.61E+00

Table 9. Use of resources

Parameter		Unit	Upstream	Core	Downstream	TOTAL
Primary energy sources, renewable	Use as energy carrier	MJ, net calorific value	0.00E+00	3.10E-02	0.00E+00	3.10E-02
	Used as raw materials	MJ, net calorific value	3.07E+00	2.36E-04	2.53E-03	3.08E+00
	TOTAL	MJ, net calorific value	3.07E+00	3.13E-02	2.53E-03	3.11E+00
Primary energy sources, non renewable	Use as energy carrier	MJ, net calorific value	0.00E+00	5.89E+00	0.00E+00	5.89E+00
	Used as raw materials	MJ, net calorific value	3.67E+01	1.58E-02	3.43E-01	3.71E+01
	TOTAL	MJ, net calorific value	3.67E+01	5.90E+00	3.43E-01	4.29E+01
Secondary material		Kg	4.68E-01	0.00E+00	3.20E-03	4.71E-01
Renewable secondary fuels		MJ, net calorific value	7.06E-01	0.00E+00	0.00E+00	7.06E-01
Non renewable secondary fuels		MJ, net calorific value	1.79E+01	0.00E+00	0.00E+00	1.79E+01
Net use of fresh water		m3	3.59E+00	2.03E-02	5.93E-04	3.61E+00

Table 10. Waste production

Parameter	Unit	Upstream	Core	Downstream	TOTAL
Hazardous waste disposed	kg	4.60E-05	7.21E-06	4.02E-07	5.36E-05
Non-hazardous waste disposed	kg	3.48E-01	3.18E-02	2.96E-03	3.82E-01
Radioactive waste	kg	6.52E-05	9.59E-06	2.36E-06	7.71E-05

Table 11. Output flows

Parameter	Unit	Upstream	Core	Downstream	TOTAL
Components for reuse	kg	1.95E-01	0.00E+00	0.00E+00	1.95E-01
Material for recycling	kg	0.00E+00	5.88E-02	0.00E+00	5.88E-02
Materials for energy recovery	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

4. LCA Interpretation

The underlying LCA, upon which this EPD is based considers the following key environmental impact categories- Global warming potential (GWP), Ozone depletion potential (ODP), Photochemical ozone creation potential (POCP), Water deprivation potential (WDP), Abiotic depletion potential (ADP), Acidification potential (AP) and Eutrophication potential (EP).

Global warming potential (GWP, total) associated with LNP ELCRIN WF008NXPiQ compound production is 3.90 Kg CO2 Eq. The impact of the upstream process accounts for 90% as 3.50 Kg CO2 eq. followed by core process as 9 % as 0.37 Kg CO2 eq. The downstream process accounts for 1% as 0.034 Kg CO2 eq. Among the 13 impact categories as mentioned in Table 3, the upstream processes account for > 85% of the overall scores for 9 cases. Long distance

transportation of raw materials is availed through trucks and hence leads to emissions into the air, which attributes to the terrestrial eutrophication score, associated with the upstream process.

Therefore, the impact assessment results indicate that the environmental performance of LNP ELCRIN WF008NXPiQ compound is dominated by upstream processes. Figure 4 provides the graphical representation of the summary.

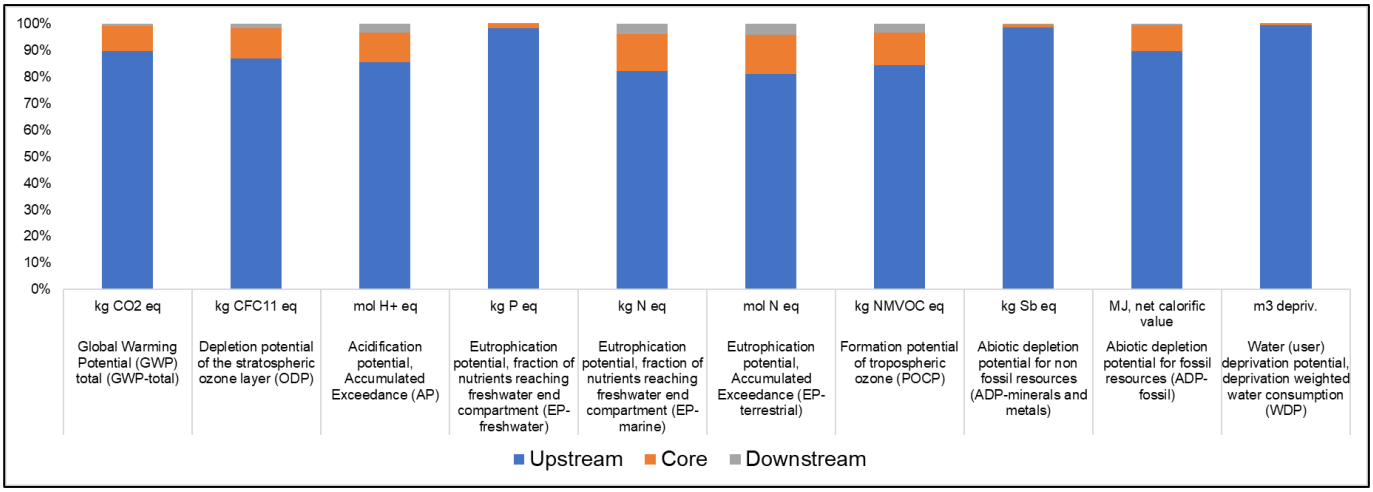

Figure 4. LNP ELCRIN WF008NXPiQ compound production environmental impacts.

5. Supporting Documentation

Detailed LCA Report with the SimaPro model screenshots and LCA workbooks.

6. References

1. UL Environment Environmental Product Declaration Program, GENERAL PROGRAM INSTRUCTIONS, VERSION 2.5, MARCH 2020
2. EPD International (2022). Plastics in primary forms, product category classification: UN CPC 347, 2010:16, version 3.0.2.
3. ISO 14040: 2006/Amd1: 2020 Environmental Management – Life cycle assessment – Principles and Framework
4. ISO-14044:2006/Amd1: 2017/Amd2:2020 Environmental management – Life Cycle Assessment – Requirements and guidelines
5. WBCSD (2020), Circular Transition Indicators V1.0 – Metrics for business, by business
6. Frischknecht R., Jungbluth N., Althaus H.-J., Doka G., Heck T., Hellweg S., Hischier R., Nemecek T., Rebitzer G., Spielmann M., Wernet G. (2007) Overview and Methodology. Eco invent report No. 1. Swiss Centre for Life Cycle Inventories, Dübendorf, 2007
7. Frischknecht R., Jungbluth N., et.al. (2003). Implementation of Life Cycle Impact Assessment Methods. Final report Eco invent 2000, Swiss Centre for LCI. Duebendorf, CH, www.ecoinvent.ch