Fellowes

Life Cycle Assessment of Laminating Pouches

VERSION 4

JUNE 19, 2025

foresight

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Executive Summary

The following table identifies the relevant details of the Life Cycle Assessment (LCA) for use in various certification programs.

Manufacturer	Fellowes
Product(s)	Fellowes and Apex Laminating Pouches
Declared Unit	One cm^2 of Laminating Pouch
Reference Service Life (RSL)	N/A
Reference Standards	☒ ISO 14040 ☒ ISO 14044 ☐ ISO 21930:2017
Reference PCR	N/A
LCA Scope	Cradle-to-Grave
LCA Study Details	Complete: January 2025 LCA Practitioner: Sahil Akolawala, Foresight Management
LCA Review Details	Completed: 2 July, 2025 LCA Reviewer: Harshit Tyagi, Intertek Assuris Vijay Thakur, Intertek Assuris ☐ INTERNAL ☒ EXTERNAL
Program Operator	N/A
Year of Primary Data	January, 1 2023- December 31, 2023
LCA Software	openLCA 2.3.1
LCA Database(s)	EcoInvent 3.10
LCIA Methodology	EN15804+A2
Applicable Region(s)	Europe

1. Context

As the demand for product transparency increases, customers and manufacturers are beginning to inquire on the environmental impacts of products through their various stages of life. A Life Cycle Assessment (LCA) can be an invaluable tool that allows these impacts to be quantified, from raw material extraction to end of life. Quantifying environmental impacts allows manufacturers to respond to market pressures and optimize possible opportunities for the product's design and manufacturing. Fellowes wishes to provide customers with information on the environmental impacts of the product they are purchasing and provide transparency on the overall environmental impacts of their products.

1.1 GOAL OF THE STUDY

In accordance with the international standards that guide the LCA process (ISO 14040 and ISO 14044), the goal and scope of this study need to be clearly outlined. This LCA will be used to better understand the processes that cause the largest environmental impacts in the product's life and identify possible opportunities for improvement using study parameters such as Global Warming Potential (GWP) and Energy Intensities.

1.2 SCOPE DEFINED

In order to help normalize the results of Fellowes products, a declared unit of one cm^2 was chosen. Since the product comes in many options and configurations, the Fellowes 2 Layer Enhance product was chosen to represent the product lines and model numbers, and technical data was provided.

Key input streams that were included in the study were energy carriers (electricity, natural gas), transportation, raw materials, generated waste, auxiliary utilities, and end-of-life considerations. Transportation includes transportation of raw materials to the manufacturing site, distribution and use of the product, and waste transportation of generated waste and end-of-life. All packaging, sourcing and disposal is also included in the study.

1.3 LIST OF UNITS

The following units were used throughout this study:

- [kg] – Kilograms
- [cm^2] – Square Centimeters
- [m] – Meters
- [m^3] – Cubic Meters
- [km] – Kilometers
- [kWh] – Kilowatt Hours
- [MJ] – Megajoules
- [MJ, LHV] – Megajoules, Lower Heating Value

1.4 LCA FINDINGS

Table 1.1 shows the Life Cycle Impact Assessment (LCIA) results for a declared unit of 1 square centimeter of 2-Layer Enhance.

TABLE 1.1: LCIA RESULTS FOR DECLARED UNIT OF STUDIED PRODUCT.

	Upstream	Downstream	Core	Total
Impact Category	A	B	C	A-C
GWPT [kg CO2eq]	3.42E-05	2.86E-05	1.16E-05	7.45E-05
ODP [kg CFC 11-eq]	7.84E-11	1.44E-13	7.56E-14	7.86E-11
EPF [kg P-eq]	8.58E-09	7.41E-09	7.06E-10	1.67E-08
EPM [kg N-eq]	3.04E-08	3.35E-08	3.22E-08	9.61E-08
EPT [mol N-eq]	2.91E-07	3.49E-07	2.57E-07	8.97E-07
AP [mol H+-eq]	1.47E-07	1.96E-07	9.20E-08	4.35E-07
POCP [kg NMVOC-eq]	1.46E-07	9.92E-08	7.41E-08	3.19E-07

Raw material acquisition of plastic was by far the largest contributor to the product's environmental impact in Module A. Within the gate-to-gate (production) boundary, the electricity consumption at the Supplier's facility was the largest contributor.

For any process where data quality was in question or proxy data was used, a sensitivity analysis was conducted.

To reduce environmental impact associated with their products, Fellowes should increase the amount of recycled content in the plastic they source, partner with its suppliers to investigate energy efficiency and reduction projects and explore adding onsite renewable generation or source electricity from renewable sources.

2. General Objective and Description of the Investigated System

This LCA report represents a systematic and comprehensive summary of project documentation. Further, it shows all data and information important to the results required by the product category rules (PCR) listed below.

2.1 COMPANY PROFILE

Fellowes Brands is a global leader in innovative workspace solutions, specializing in office products, air purification, ergonomics, and business machines. Founded in 1917 and headquartered in Itasca, Illinois, the company has built a reputation for quality, durability, and cutting-edge design. With a diverse portfolio that includes shredders, laminators, sit-stand workstations, and air purifiers, Fellowes is committed to enhancing productivity, well-being, and security in workplaces worldwide.

With operations in over 100 countries, Fellowes Brands maintains a strong legacy of family ownership and customer-focused innovation. The company continues to evolve, integrating sustainability and advanced technology into its products to meet the demands of modern work environments. Its mission is to help people work better by providing high-performance solutions that support health, efficiency, and organization.

2.2 LCA COMMISSIONER AND PRACTITIONER

Fellowes has commissioned this LCA and report. Primary data was provided by Fellowes' Suppliers from two sites where the study was based. Foresight Management was contracted to develop the LCA model using openLCA software and prepare this report. Sahil Akolawala, Project Manager at Foresight Management served as the LCA Practitioner, and Thomas Cygan, Client Associate at Foresight Management, assisted in data collection and QA/QC of the model and report. Primary data validation was done in tandem with Fellowes and Foresight Management.

2.3 REPORTING DATE

This LCA project was initiated November 2024 and was concluded January 2025.

2.4 INTENDED APPLICATION AND REASONS FOR THE STUDY

This LCA was conducted for the intention of third-party review

2.5 TARGET GROUP AND AUDIENCE

The intended audience for this report includes Fellowes internal management and Fellowes Customers. The LCA is to be certified by an External Expert via a 3rd Party Certifying Body.

2.6 COMPARATIVE ASSERTIONS AND PUBLIC DISCLOSURE

This study was not completed with the intent for comparative assertions with external products or disclosures. The results of this report can be used for product optimization, and communication of potential environmental impacts of the product.

2.7 STANDARDS AND PCR CONFORMANCE

This LCA has been critically reviewed for conformance with ISO 14040, ISO 14044. As no PCR exists for this product category, this study is only conducted to conform with the ISO Standards. The critical review, conducted by Intertek Assuris, confirms that this LCA meets the requirements of these standards, and the verification statement and checklist is attached at the end of this document.

2.8 PRODUCT DESCRIPTION

2.8.1 Product Classification and Description

Laminating pouches play a crucial role in preserving and protecting important documents, photos, and artwork. Selecting the right laminating pouch is essential to ensure optimal results and durability. Fellowes has made available several resources to help users choose the correct laminating pouch: https://www.fellowes.com/uk/en/catalog/business-machines/resources/pg/choose-the-right-laminating-pouch

Fellowes Laminating Pouches are designed to deliver superior laminating results every time. These pouches are ideal for preserving notices, photos, instructions, catalogues, menus, teaching aids and frequently handled documents. The pouches are compatible with all popular brands of laminators and are available in different paper sizes. Additionally, the pouches come in various finishes, such as glossy or matt. Glossy pouches provide a shiny, vibrant look, while matt pouches offer a smooth, non-glare surface."

2.8.2 Applicability

The declared product is 1 cm^2 of laminating pouch.

2.8.3 Technical Data

Technical data for the product system can be found in Table 2.1

TABLE 2.1: PERFORMANCE AND TECHNICAL DATA FOR EACH PRODUCT SYSTEM INCLUDED.

Product System	Thickness (microns)	Area Coverage (cm^2)	Number of Declared Units	g/cm^2 Without Packaging	g/cm^2 With Packaging	Expected Life Span
Fellowes Enhance	75	1	1	0.009	0.012	N/A

Since multiple paper size options are available, e.g. A4, the study was conducted to 1 cm^2 to allow for scalability.

2.9 ADDITIONAL ENVIRONMENTAL INFORMATION

There is no additional environmental information to be included.

3. Scope of the Study

3.1 LCA METHODOLOGICAL FRAMEWORK

This LCA was conducted with an attributional approach.

3.2 DECLARED UNIT

The declared unit is 1 cm^2 of laminating pouch. Declared unit, performance characteristics, and RSL can be found in Section 2.8.3. Information for any future additional products included in this study at a later date will be found in Appendix B.

The product system is produced at two locations, one in Vietnam (Golden Champion Industrial Ltd.), and one in China (Yixing City Yulong Plastic Adhesive Packing Products Co., Ltd). From here on out, they will be referred as VN and CN, respectively.

3.3 SYSTEM BOUNDARY

This LCA includes a Cradle-to-Grave scope of study. An overview of these boundaries and module declaration can be seen below in Figure 3.1 and Table 3.1. All relative mass and energy flows from each process listed in the flow diagram were included in this study.

FIGURE 3.1: FLOW DIAGRAM OF MANUFACTURING OF LAMINATING POUCHES.

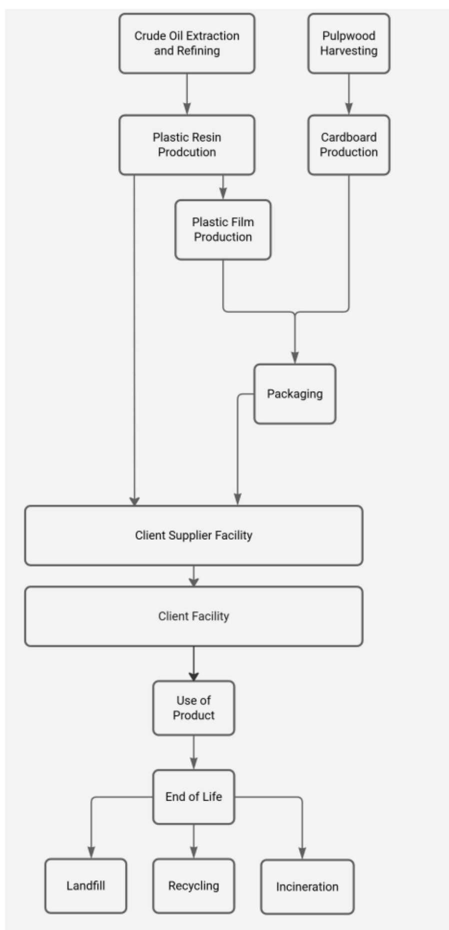


TABLE 3.1: MODULE DECLARATION FOR STAGES INCLUDED IN THIS STUDY.

Upstream	Core	Downstream
X	X	X

X = Module Included, MND = Module Not Declared

All primary and secondary data was modelled in OpenLCA using Ecoinvent datasets to calculate the potential environmental impacts during each stage of the product's life. For any processes that were not available in the Ecoinvent database, proxy data was used. Details for any proxy data used are outlined in Section 6.2.2.

This study follows the principles below:

- *Modularity Principle*: This study was done attributably, where all environmental aspects and potential impacts are attributed to each process and flow in the life cycle module that occur.
- *Polluter Pays Principle*: This study used the cut-off method regarding waste treatment, where the creator of the waste stream is responsible for all transportation and processing of all waste generated within the system boundary.

3.3.1 UPSTREAM - A

This stage includes all extraction, processing, and transportation of all the raw material. Table 3.2 shows more detail on what is included and excluded.

TABLE 3.2: INCLUSION AND EXCLUSION OF PROCESSES IN THE MATERIAL ACQUISITION STAGE.

Included	Excluded
Extraction and additional processing of all raw materials	Construction of all facilities.
Processing of any recycled feed streams from outside systems (Open Loop)	Manufacturing of operating equipment
Transportation of secondary processes included within A.	Production or any co-products leaving the system

A list of all raw materials for each product system is shown in Table 3.3. A list of the raw materials for each product system, exclusive of scrap, is shown in Table 3.4. The recycled content of each material used in this study is shown in Table 3.5. The product has an overall estimate material efficiency of 95%. The waste associated with Processing is included in the CORE Module.

TABLE 3.3: MATERIAL COMPOSITION PER DECLARED UNIT (INCLUSIVE OF SCRAP).

Material	Weight %	g/cm^2
Polyethylene Terephthalate (PET)	60%	0.005
Ethylene-Vinyl Acetate (EVA)	40%	0.004
Low Density Polyethylene (LDPE)	0%	0.000
Total	100%	0.009

TABLE 3.4: MATERIAL COMPOSITION PER DECLARED UNIT (EXCLUSIVE OF SCRAP).

Part	Weight %	g/cm^2
Polyethylene Terephthalate (PET)	60%	0.005
Ethylene-Vinyl Acetate (EVA)	40%	0.003
Low Density Polyethylene (LDPE)	0%	0.000
Total	100%	0.009

The study was conducted taking a conservative approach of no recycled content in the product.

TABLE 3.5: RECYCLED CONTENT OF MATERIALS USED IN THIS STUDY.

Material	PC Recycled Content	PI Recycled Content
PET	0%	0%
EVA	0%	0%
LDPE	0%	0%

All weights of raw materials needed are based on a bill of materials (BOM) and technical data supplied by Fellowes. More information regarding the datasets representing the raw materials used in the products can be found in Appendix A. Waste and scrap and its associated transportation from raw material acquisition and pre-processing is included in this secondary data.

All materials were modeled as delivered to customer's suppliers' facility via truck. The distance of inbound transportation was assumed to be 500 km

3.3.2 CORE - B

This stage includes all processes that occur at the facilities and production of any additional energy, utilities, or materials that are not considered raw materials. This also includes any intermediary transportation of these materials. See Table 3.6 for more specific information about what is included in this boundary. The finished product does not contain any materials that are required to be labelled as hazardous or dangerous substances in its Bill of Materials.

TABLE 3.6: INCLUSION AND EXCLUSION OF PROCESSES IN THE PRODUCTION STAGE.

Included	Excluded
All manufacturing processes occurring at suppliers' facilities.	Construction of all facilities.
Extraction and additional processing of raw materials for packaging	Manufacturing of operating equipment
Processing of any recycled feed streams from outside systems (Open Loop) for packaging.	Production or any co-products leaving the system
Transportation of intermediary materials and packaging to production facility	Manufacturing of transportation equipment
Inbound Transportation of all raw materials to the location of manufacturing.	--
Production of all fuels required for transportation	
Generation of any utilities, materials, and additional fuels.	
Transportation and treatment of any waste associated with production of product and packaging.	--

All energy resources used in the production process are accounted for in the model. Electricity is associated to the correct grid using the most recently available Ecoinvent dataset. All other energy and fuel sources can be seen in Appendix A. The suppliers' energy usage was normalized to one dollar of sale based on the production numbers from January 2023 – December 2023. Mass based input and output flows were not available, and obtaining this information was outside of the resources available for the project scope.

Raw data provided for facilities can be seen in Tables 3.7 and 3.8. The price was calculated by taking a representative unit price for a 100-pouch package (size A4) and dividing it amongst the total cm^2 of document being protected by the product. Results in section 5.2 are weighed by the percentage of sales coming from each respective facility. Unit processes include granulate extrusion, layering, seaming, cutting/forming, primary packaging, secondary packaging, and tertiary packaging. Note: discrepancy in flows attributable to the fact that VN produces other product types, while CN produces solely laminating pouches. Hazardous Waste generation was not reported at the CN Facility during the data collection phase.

TABLE 3.7 VN INPUTS/OUTPUTS PER YEAR

Input/Output Data Category	Units Per Year	Normalized Flows Per Dollar
Electricity [kwh]	3,797,720	7.17E-02
Natural Gas [MJ]	-	-
Process Water [m^3]	178,146	3.36E-03
Wastewater [m^3]	155,879	2.94E-03
Municipal Solid Waste [kg]	5,558	1.05E-04
Recycled Material [kg]	-	
Hazardous Waste [kg]	430	8.11E-06
Sales [$]	53,000,000	
Price [$/cm2]	0.0004	

TABLE 3.8: CN INPUTS/OUTPUTS PER YEAR

Input/Output Data Category	Units per year	Normalized Flows Per Dollar
Electricity [kWh]	2,785,000	1.27E-01
Natural Gas [MJ]	-	-
Process Water [m^3]	3,719	1.69E-04
Wastewater [m^3]	3,719	1.69E-04
Municipal Solid Waste [kg]	54,420	2.47E-03
Recycled Material [kg]	272,110	1.24E-02
Hazardous Waste [kg]	-	-
Sales [$]	22,000,000	
Price [$/cm2]	0.0004	

Packaging involves PP plastic sleeves, cardboard boxes for sets of products, corrugated cardboard, PE plastic wrapping (excluded due to being less than 1% of product weight per DU), and a wood pallet to support all parts during shipping. Packaging weights can be seen in Table 3.9

TABLE 3.9: FELLOWES PACKAGING PER DECLARED UNIT.

Material	g per 1 declared unit
Carboard	0.0021
Plastic	0.0002
Wood (Reusable Pallet)	0.0009

3.3.3 DOWNSTREAM - C

This stage includes all outbound shipping, additional warehousing, and use of the product. Table 3.10 shows more details on what is included and excluded. No products under study undergo any warehousing.

TABLE 3.10: INCLUSION AND EXCLUSION OF PROCESSES IN THE PRODUCTION STAGE.

Included	Excluded
Outbound Transportation of finished product to the location of warehousing or usage.	Replacement of Products to meet requirements of PCR (N/A)
Production of all fuels required for transportation	Production of the end-of-life facilities.
Generation and use of any energy or materials for usage or maintenance of the product.	--
Waste processing for reuse, recycling, energy recovery, and/or reclamation	--
Waste Disposal including all resource inputs and management activities of the disposal site	--
Transportation of the product and packaging to the end-of-life facility.	--

Type and distance of transportation was determined by developing a weighted average for all shipping data from January 2023 to December 2023 based on sales. Distances for each type of transportation can be seen in Table 3.11.

Table 3.11: Outbound Transportation Distances

	Truck [km]	Rail [km]	Ship [km]
Finished Product (VN)	246 Leg 1 526 Leg 2	-	24,326
Finished Product (CN)	419 Leg 1 526 Leg 2	-	25,485

TABLE 3.12: USE PHASE ASSUMPTIONS.

Energy/Material Flow	Unit	Amount
N/A	N/A	N/A

In the case of this study, the burden of use phase was assumed to fall under the use of the laminator itself, not the laminating pouches. Fellowes manufactures both laminators and laminating pouches and it has set a goal of conducting LCAs for the majority of the products in the portfolio. Fellowes' customers are intending to consider the carbon footprint in the shopping basket, and there is the risk that the use phase GHG emissions are double counted in both the laminator and the laminating pouches.

This stage includes shipment to waste treatment facilities and treatment of the waste. Table 3.13 shows more detail on what is included and excluded:

TABLE 3.13: INCLUSION AND EXCLUSION OF PROCESSES IN THE END-OF-LIFE STAGE.

Included	Excluded
Waste processing for reuse, recycling, energy recovery, and/or reclamation	Production of the end-of-life facilities.
Waste Disposal including all resource inputs and management activities of the disposal site	--
Transportation of the product and packaging to the end-of-life facility.	--

In lieu of readily available information stating otherwise, the distance to the final disposal location was determined to be 32 km as per the EPA WARM model. Since the product in its final form is not readily recyclable, a disposal pathway of 80% Landfill and 20% Incineration was utilized in this model. The fate of the packaging was determined based on market methods and values from Ecoinvent.

3.4 CUT-OFF CRITERIA

Any material present at or above 1 wt% of the final product was included within the scope of this study. Material inputs less than 1% were included if sufficient data was available to warrant inclusion and/or the material input was thought to have significant environmental impacts.

No energy inputs were excluded in this study. Excluded materials include felts and adhesives used in assembly of the product.

3.5 ALLOCATION PROCEDURE

General principles of allocation were based on ISO 14040/14044. This study is inclusive of products sold under the Fellowes and Apex Brand Names. Since there are no other co-products, no allocation based on co-products is required.

To derive a per-unit for manufacturing inputs and outputs such as electricity, thermal energy, and waste streams, allocation based on Total Sales by unit was adopted. This was the method used as Fellowes does not collect Bill of Lading Data for the products under study. Sensitivity to this allocation method can be found in section 6.2. As a default, secondary Ecoinvent datasets use a mass basis for allocation.

The method in which recycled materials were handled is relevant to the defined system boundary. Throughout the study, recycled materials were accounted for via the cut-off method. In this method, impacts and benefits associated with the previous life of raw material from recycled stock are excluded from the system boundary. Additionally, impacts and benefits associated with secondary functions of materials at the end of life are also excluded (i.e. production into a third life or energy generation from incineration). The study does include the impacts associated with reprocessing and preparation of recycled materials feed streams that are included in the studied product.

3.6 DATA QUALITY REQUIREMENTS

Secondary data sets used in the model are disclosed in Appendix A along with data quality indicators related to the geographical, time representation, and technological coverage of the datasets. If any proxy data was used, it is also included if applicable.

3.6.1 Geographical Coverage

The geographical scope of the production stage of this study production in Asia. All primary data was collected from the manufacturer; therefore, the geographical coverage of primary data is considered to be fully representative.

The geographical scope of all remaining stages is in Europe. In selecting secondary data from Ecoinvent, priority was given to technological representativeness of the data. Of the sets that were deemed high enough quality, then the most representative geographical data was used. This led to Global, European, and Rest of World being used when North American data was not available. The geographical coverage of all secondary datasets can be seen in Appendix A. Overall geographical data quality is considered partially representative.

3.6.2 Time Coverage

Primary data was provided by the manufacturer and represents all data for January 2023 to December 2024. Time coverage of primary data is considered fully representative.

Secondary dataset time coverage varies and is based on when the data was collected. Therefore, the most recent data set was chosen. Overall time coverage is considered to be completely representative and meets the PCR requirements of being no older than 10 years. More specific time coverage can be seen in Appendix A.

3.6.3 Technological Coverage

Primary data provided by the manufacturer is specific to the technology that they use in their processes and products. Given that this study is for products manufactured at the VN and CN facilities, the technological coverage is completely representative. All facility data was allocated to the product using economic allocation.

Secondary data was used to fill the gaps throughout the supply chain to address all inputs from Cradle-to-Grave. Technological coverage of these datasets is considered to be representative of the actual supply chain. Improving primary data in the supply chain would increase the technological coverage, but the use of secondary data sets for generic processes meets the goal and scope of the LCA.

3.6.4 Treatment of Missing Data

Primary data was used for the final manufacturing processes. Fellowes provided all inputs and outputs from their supplier's facility; it is considered to be a complete inventory. No supplier data was available for their manufacturing processes, therefore, secondary data for raw material production and component manufacturing were obtained using Ecoinvent databases, which are shown in Appendix A. Any proxies used for materials have also been documented in section 6.2.2 and a sensitivity analysis was done for any proxy materials.

3.6.5 Data Quality Assessment

Appendix A shows an assessment for the data quality of all secondary datasets used in the model. The following section shows details on the data quality of the model itself.

3.6.5.1 Precision

The precision of the data is considered good. The Fellowes facility team provided the data for a full year of operations. Their team provided a list of suppliers and a Bill of Materials for all products in the scope of the study. All inbound transportation data was estimated. All outbound transportation data is a weighted average of sales.

3.6.5.2 Completeness

The data included is considered complete. The LCA model included all known materials and energy flows except for specified materials outlined in Section 3.4. As stated, no known material flows above 1% were excluded and the sum of all exclusions is below 5% when evaluated against mass, energy, and environmental impact.

3.6.5.3 Representativeness

The data used in the assessment represent typical or average processes as currently reported from multiple data sources to Ecoinvent and are therefore generally representative of the actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis, though such a determination would require detailed data collection at each node upstream.

3.6.5.4 Consistency

The consistency of this model is considered high. Fellowes tracks all relevant inputs and outputs of their suppliers' processes over a year, any other primary data used was collected with similar methods and time frame. Modelling assumptions are consistent across the model.

3.6.5.5 Reproducibility

This study is considered to be reproducible. All assumptions and secondary datasets are described in this report and would allow an LCA practitioner to use an LCA tool to generate the results for the declared unit.

3.6.5.6 Uncertainty

Uncertainty of any primary data provided by [customer] is dependent on how the data was allocated to each product. This allocation came from the yearly totals of product produced and utility data. Sub metered processes would decrease the uncertainty of the primary data. For secondary data, all uncertainty is outlined and published by Ecoinvent for Ecoinvent 3.9.1 datasets.

3.6.5.7 Ecoinvent Data Quality System

Additionally, within openLCA, there is an Ecoinvent data quality system constructed to align with LCIA data quality assessments. The matrix is constructed as seen in Table 3.16.

TABLE 3.16 ECOINVENT DATA QUALITY ASSESSMENT SCORING TABLE.

Score	Reliability (R)	Completeness (C)	Temporal Correlation (T)	Geographical Correlation (G)	Further Technical Correlation (F)
1	Verified Data based on measurements	Representative data from all sites relevant for the market considered, over and adequate period to even out normal fluctuations	Less than 3 years of difference to the time period of the data set	Data from area under study	Data from enterprises, processes and materials under study
2	Verified data partly based on assumptions or non-verified data based on measurements	Representative data from > 50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Less than 6 years of difference to the time period of the data set	Average data from larger area in which the area under study is included	Data from processes and materials under study (i.e. identical technology) but from different enterprises
3	Non-verified data partly based on qualified estimates	Representative data from only some sites (<< 50%) relevant for the market considered or > 50% of sites but from shorter periods	Less than 10 years of difference to the time period of the data	Data from area with similar production conditions	Data from area with similar production conditions
4	Qualified estimate	Representative data from only one site relevant for the market considered or some sites but from shorter periods	Less than 15 years of difference to the time period of the data set	Data from area with slightly similar production conditions	Data on related processes or materials

Score	Reliability (R)	Completeness (C)	Temporal Correlation (T)	Geographical Correlation (G)	Further Technical Correlation (F)
5	Non-qualified Estimates	Representativeness unknown or data from a small number of sites and from shorter periods	Age of data unknown or more than 15 years of difference to the time period of the data set	Data from unknown or distinctly different area	Data on related process on laboratory scale or from different technology

Scores were assigned to datasets in the model, and an overall score was generated for the LCIA Indicators.

TABLE 3.17 ECOINVENT DATA QUALITY ASSESSMENT OF LCIA INDICATORS FROM TABLE 3.16.

Name	R	C	T	G	F	Average
Global Warming Potential	2	3	4	4	2	3
Ozone Depletion Potential	3	3	5	4	3	3.6
Eutrophication Potential Freshwater	1	1	5	1	1	1.8
Eutrophication Potential Marine	3	3	4	3	2	3
Smog Formation Potential Terrestrial	3	3	5	3	3	3.4
Photochemical Oxidant Creation Potential	3	3	5	3	2	3.2

4. Life Cycle Inventory Analysis

Primary data was collected from suppliers through Fellowes associates. All calculations adhere to the ISO 14044 standard. Collection and processing of the major data is described below. All primary data was collected over a period of 1 year.

- Electrical, Fuels, and Water Consumption
- Data was collected over the year January 2023 – December 2023. The totals over the collection period were divided by total sales during that period to derive a usage-per-sales unit for use in this model.
- Raw Materials and Purchasing
- Fellowes provided all bills of materials. Plastic and Cardboard comprise the raw materials. Inbound Shipping distances were assumed to be 500 km by truck.
- Waste Amounts
- Fellowes Suppliers tracks all waste streams associated with manufacturing of the product over the data collection period. All waste was characterized, disposed of, and treated appropriately as outlined in Section 3.3.
- Outbound Shipping Distance
- A weighted average of the distances to all states where Fellowes products are shipped was calculated based on sales shipped. It was found that on average, the shipping distance was as follows: 246 km from VN to Port, 24,326 km from VN Port to European Port, 419 km from CN to CN port, 25,485 km from CN Port to European Port, and 526 km to customer.
- End of Life (EoL) Scenarios
- No primary data for the fate of the product was available. Waste from products and packaging was disposed of based on assumptions detailed in section 3.3.3. No credits were taken for energy recovery from waste. Cut-off criteria for recycling were applied.

Data was reviewed for accuracy and completeness and any gaps were filled with primary or justifiable estimates. Secondary datasets were collected from EcoInvent for any processes that primary data was not collected for. All secondary datasets used can be seen in Annex A.

5. Life Cycle Impact Assessment (LCIA)

5.1 SELECTION OF IMPACT CATEGORIES

The following environmental impact categories and associated category indicators were used in this study as results reported in the LCA report for the declared unit. Quantities for each impact category were calculated for each stage of the product's life. The choice of impact categories is from International EPD System (IES) Environmental Performance Indicators. This program is internationally recognized and operated by EPD International AB. Please follow the link for details: Indicators of Environmental Impact | EPD International.

- GWPT- Global Warming Potential Total (GWP 100 years) [kg CO2-eq] – EN15804
- ODP - Ozone Depletion Air [kg CFC 11-eq] – EN15804
- EP-freshwater - Eutrophication potential (EPF) [kg P-eq] – EN15804
- EP-marine – Eutrophication Potential (EPM) [kg N-eq] – EN15804
- EP-terrestrial – Eutrophication Potential (EPT) [mol N-eq] – EN15804
- AP - Acidification Potential (AP) [mol H+-eq] – EN15804
- POCP – Photochemical Oxidant Creation Potential [kg NMVOC-eq] – EN15804

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

In addition to the environmental impacts described above, the following resource and waste categories are also disclosed in accordance with ISO 21930. Biogenic carbon was quantified by the EI Climate Change GWP biogenic indicator from EN15804+A2 (EF 3.1). All waste was classified based on the applicable North American Resource Conservation and Recovery Act (RCRA), Subtitle 3.

- RPR_E – Renewable primary resources used as an energy carrier (fuel) [MJ, LHV]
- RPR_M – Renewable primary resources with energy content used as a material [MJ, LHV]
- $NRPR_E$ – Non-renewable primary resources used as an energy carrier (fuel) [MJ, LHV]
- $NRPR_M$ – Non-renewable primary resources with energy content used as a material [MJ, LHV]
- FW – Net use of fresh water [m^3]
- HWD – Hazardous waste disposed [kg]
- NHWD – Non-Hazardous waste disposed [kg]

5.2 LCA RESULTS

All results are given per declared unit outlined in Section 3.2, which is 1 cm^2. Results are reported for each life cycle stage. The results can be seen in Tables 5.1-5.3.

The relevance of the LCIA results were not decreased due to any allocation methods used. No by-products were produced so the LCIA results reflect the impact of a declared unit.

EN15804 Life Cycle Impact Assessment results were calculated using the LCA software, OpenLCA, and are presented in Table 5.1. A brief description of each impact category can be found below. The definitions were taken from both the EPA website and "Indicators of environmental Impact" from the International EPD System Website.

- **Global Warming Potential (IPCC GWP 100)** is an index that attempts to integrate the overall climate impacts of a specific action (e.g., emissions of CH4, NOx or aerosols). It relates the impact of emissions of gas to that of emission of an equivalent mass of CO2. The duration of the perturbation is included by integrating radiative forcing over a time horizon (e.g., standard horizons for IPCC have been 20, 100, and 500 years). The time horizon thus includes cumulative climate change and the decay of perturbation.
- **Ozone Depletion (ODP):** Ozone within the stratosphere provides protection from radiation, which can lead to an increased frequency of skin cancers and cataracts in human populations. Additionally, ozone has been documented to have effects on crops, other plants, marine life, and human-built materials. Substances which have been reported and linked to decreasing the stratospheric ozone level are chlorofluorocarbons (CFCs) which are used as refrigerants, foam blowing agents, solvents, and halons which are used as fire extinguishing agents.
- **Eutrophication (EP)** is divided into multiple sub-impacts. Aquatic Eutrophication is the enrichment of an aquatic ecosystem with nutrients (nitrates, phosphates) that accelerate biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass. Terrestrial Eutrophication can be caused by emissions to air such as nitrogen oxides.
- **Acidification (AP)** is the increasing concentration of hydrogen ions (H+) within a local environment. This can be the result of the addition of acids (e.g., nitric acid and sulfuric acid) into the environment, or by the addition of other substances (e.g., ammonia) which increase the acidity of the environment due to various chemical reactions and/or biological activity, or by natural circumstances such as the change in soil concentrations because of the growth of local plant species.
- **Photochemical Oxidant Creation Potential (POCP):** Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities and industrial facilities.

TABLE 5.1: LCIA RESULTS FOR ONE DECLARED UNIT OF 2 LAYER ENHANCE

Impact Category	Unit	A	B	C	Total
GWPT	[kg CO2eq]	3.42E-05	2.86E-05	1.16E-05	7.45E-05
ODP	[kg CFC 11-eq]	7.84E-11	1.44E-13	7.56E-14	7.86E-11
EPF	[kg P-eq]	8.58E-09	7.41E-09	7.06E-10	1.67E-08
EPM	[kg N-eq]	3.04E-08	3.35E-08	3.22E-08	9.61E-08
EPT	[mol N-eq]	2.91E-07	3.49E-07	2.57E-07	8.97E-07
AP	[mol H+-eq]	1.47E-07	1.96E-07	9.20E-08	4.35E-07
POCP	[KG NMVOC-eq]	1.46E-07	9.92E-08	7.41E-08	3.19E-07

Tables 5.2 show life cycle indicators

TABLE 5.2: LCI RESULTS FOR DECLARED UNIT OF 2 LAYER ENHANCE

Parameter	Unit	A	B	C	Total
RPR_E	[MJ, LHV]	2.26E-05	3.36E-05	7.37E-07	5.70E-05
RPR_M	[MJ, LHV]	2.87E-05	2.56E-06	8.89E-08	3.14E-05
$NRPR_E$	[MJ, LHV]	6.89E-04	3.04E-04	5.39E-05	1.05E-03
$NRPR_M$	[MJ, LHV]	5.44E-05	4.98E-06	5.72E-06	6.51E-05
FW	[m^3]	2.26E-07	8.96E-07	-2.36E-08	1.10E-06
HWD	[kg]	1.21E-06	1.54E-06	1.30E-07	2.89E-06
NHWD	[kg]	2.54E-05	2.19E-05	4.30E-05	9.03E-05

RPR_E: Renewable Primary Energy Used as Energy Carrier (excluding raw materials). **RPR_M:** Renewable primary energy resources used as raw materials. **$NRPR_E$:** Non-renewable Primary Energy Used as Energy Carrier (excluding raw materials). **$NRPR_M$:** Non-renewable primary energy resources used as raw materials. **FW:** Use of net freshwater resources. **RE:** Recovered Energy. **HWD:** Hazardous waste disposed. **NHWD:** Non-hazardous waste disposed.

No additional substances required to be reported as hazardous, other than the classified hazardous waste, which is disposed of in accordance with local regulations, are associated with the production of this product. Hazardous waste was reported at the VN facility.

All other reported numbers for HWD are from auxiliary processes from secondary datasets. Fellowes does not produce any hazardous waste in any of their operations. All substances that may be considered dangerous or regulated are treated appropriately before they are released.

6. Interpretation

Within this section, the results of the Life Cycle Assessment were interpreted in accordance with the goal and scope of this study. This interpretation included a dominance analysis, a sensitivity analysis, a scenario analysis, and a data quality analysis. All of which help form the conclusion of the study.

6.1 DOMINANCE ANALYSIS

A dominance analysis was done to show which of the life cycle stages contributes to the majority of the environmental impacts. As seen in the previous section and in Figure 6.1, outside of the raw material acquisition, the highest contributor is electricity consumptions.

FIGURE 6.1: RELATIVE CONTRIBUTION OF EACH LIFE CYCLE STAGE

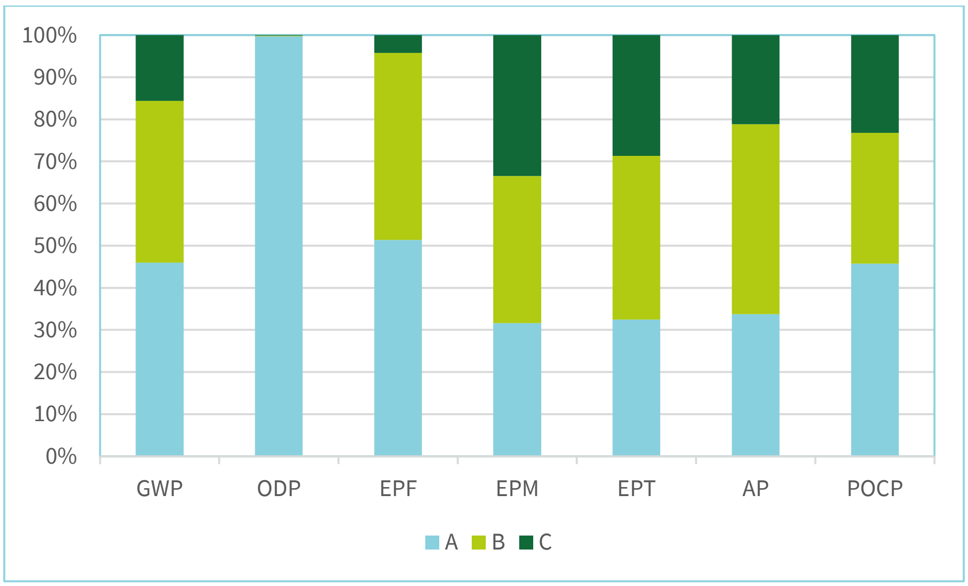
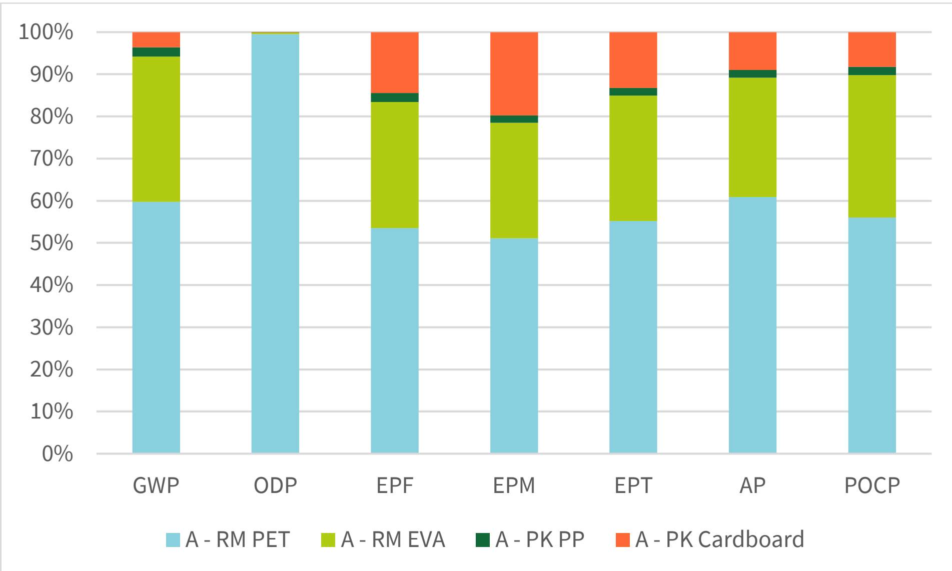


Figure 6.2 shows the relative contribution of raw material acquisition (Module A), which was more often than not the largest contributor. Module A is broken out by the processes that contribute to the impact within those stages. Of these PET is often the most dominant contributor. It is noteworthy that on a per kg basis, PET has a three (3) order of magnitude higher ODP than EVA, causing it to be the largest driver by far.

FIGURE 6.2: RELATIVE IMPACTS WITHIN THE TOP 4 PROCESSES IN MODULE A



6.2 SENSITIVITY ANALYSIS

A sensitivity analysis was done in the model to see how sensitive the results are to the assumptions that were made in the modelling process.

6.2.1 Manufacturing Input Allocation

To study how the decision of sales allocation of inputs per unit of finished product affected the results, all facility inputs other than raw materials were increased and decreased by +/- 50%. The results of this analysis can be seen in Table 6.1. Based on the below results, it can be determined that the model is sensitive to the allocation process. This follows, as the materials themselves have relatively low impact such that electricity, water, and waste flows have a larger effect on the results. It also illustrates the sensitivity of sales-weighted allocation across two different companies. ODP has limited sensitivity as the largest driver of impact was the raw material itself.

TABLE 6.1: VARIANCE OF IMPACT CATEGORIES BASED ON ALLOCATION SENSITIVITY ANALYSIS.

+/- 50% Change to all Allocated Manufacturing Flows	Change from Baseline
GWP	+/- 18.78%
ODP	+/- 0.08%
EPF	+/- 22.06%
EPM	+/- 17.08%
EPT	+/- 19.04%
AP	+/- 22.32%
POCP	+/- 15.04%

6.2.2 Proxy Data

Proxy Data was not utilized in this study.

6.3 SCENARIO ANALYSIS

Scenarios were run for all other products included in this study. Specific results can be seen in the sections below.

6.3.1 Recycled Content Specification

Scenarios were run in which 30% recycled content and 50% recycled content was specified for the 2-Layered Enhance products. Below are how the LCIA totals are affected by these modeling updates. The results suggest that specifying more recycled content would yield lower overall estimated environmental impacts during the life-cycle.

Impact Category	Unit	Original	30%	50%
GWPT	[kg CO2eq]	7.45E-05	6.81E-05	6.36E-05
ODP	[kg CFC 11-eq]	7.86E-11	3.96E-11	1.37E-11
EPF	[kg P-eq]	1.67E-08	1.55E-08	1.47E-08
EPM	[kg N-eq]	9.61E-08	9.17E-08	8.85E-08
EPT	[mol N-eq]	8.97E-07	8.45E-07	8.06E-07
AP	[mol H+-eq]	4.35E-07	4.02E-07	3.79E-07
POCP	[KG NMVOC-eq]	3.19E-07	2.89E-07	2.68E-07

6.3.2 Additional Products

Update paragraph: A total of 13 additional scenarios were run, as other products are available from Fellowes and Apex. They are described in table 6.3, below.

TABLE 6.3: ADDITIONAL PRODUCT SCENARIOS.

Family	Layers	Name	Thickness	g/cm^2	Wt% PET	Wt% EVA	Wt% LDPE
Fellowes (F)	2	Enhance	75	0.009	60%	40%	0%
F	2	Impress	100	0.011	59%	41%	0%
F	2	Capture	125	0.015	69%	31%	0%
F	2	Protect	175	0.020	66%	34%	0%
F	2	Preserve	250	0.029	59%	41%	0%
F	3	Enhance	75	0.009	60%	21%	19%
F	3	Impress	100	0.011	59%	20%	20%
F	3	Capture	125	0.015	69%	16%	16%
F	3	Protect	175	0.020	66%	17%	17%
F	3	Preserve	250	0.028	59%	21%	20%
Apex (A)	2	ULD	55	0.006	67%	33%	0%
A	2	LD	70	0.008	63%	37%	0%
A	2	SD	90	0.010	64%	36%	0%
A	2	MD	115	0.014	73%	27%	0%

TABLE 6.4 ADDITIONAL PRODUCT SCENARIOS LCIA RESULTS FELLOWES 2L POUCHES

Impact Category	Unit	Enhance	Impress	Capture	Protect	Preserve
GWPT	[kg CO2eq]	7.45E-05	8.92E-05	1.28E-04	1.85E-04	2.66E-04
ODP	[kg CFC 11-eq]	7.86E-11	1.03E-10	1.55E-10	2.06E-10	2.56E-10
EPF	[kg P-eq]	1.67E-08	1.94E-08	2.83E-08	4.11E-08	6.00E-08
EPM	[kg N-eq]	9.61E-08	1.14E-07	1.60E-07	2.28E-07	3.32E-07
EPT	[mol N-eq]	8.97E-07	1.05E-06	1.50E-06	2.15E-06	3.13E-06
AP	[mol H+-eq]	4.35E-07	6.69E-06	8.96E-06	1.28E-05	1.72E-05
POCP	[KG NMVOC-eq]	3.19E-07	8.24E-05	1.19E-04	1.72E-04	2.49E-04

TABLE 6.5 ADDITIONAL PRODUCT SCENARIOS LCIA RESULTS FELLOWES 3L POUCHES

Impact Category	Unit	Enhance	Impress	Capture	Protect	Preserve
GWPT	[kg CO2eq]	7.42E-05	8.83E-05	1.27E-04	1.84E-04	2.66E-04
ODP	[kg CFC 11-eq]	7.86E-11	1.03E-10	1.54E-10	2.05E-10	2.56E-10
EPF	[kg P-eq]	1.67E-08	1.94E-08	2.83E-08	4.10E-08	6.00E-08
EPM	[kg N-eq]	9.62E-08	1.14E-07	1.60E-07	2.27E-07	3.32E-07
EPT	[mol N-eq]	8.98E-07	1.05E-06	1.50E-06	2.14E-06	3.13E-06
AP	[mol H+-eq]	4.80E-06	6.65E-06	8.98E-06	1.28E-05	1.72E-05
POCP	[KG NMVOC-eq]	6.93E-05	8.16E-05	1.18E-04	1.71E-04	2.49E-04

TABLE 6.6 ADDITIONAL PRODUCT SCENARIOS LCIA RESULTS APEX 2L POUCHES

Impact Category	Unit	ULD	LD	SD	MD
GWPT	[kg CO2eq]	6.43E-05	7.24E-05	8.49E-05	1.24E-04
ODP	[kg CFC 11-eq]	6.63E-11	7.77E-11	1.02E-10	1.53E-10
EPF	[kg P-eq]	1.50E-08	1.65E-08	1.89E-08	2.81E-08
EPM	[kg N-eq]	8.48E-08	9.50E-08	1.11E-07	1.59E-07
EPT	[mol N-eq]	7.98E-07	8.87E-07	1.03E-06	1.49E-06
AP	[mol H+-eq]	3.22E-06	4.22E-06	5.68E-06	7.63E-06
POCP	[KG NMVOC-eq]	6.10E-05	6.81E-05	7.92E-05	1.16E-04

6.4 CONSISTENCY CHECK

A consistency check was conducted on this study. Consistency is considered to be great. All primary data was collected over the same time period and was allocated on a mass basis. All secondary data were chosen on the same assumptions based on geographic, technological, and time applicability as well as utilizing sales allocation. All flows are accounted for and treated appropriately. All Impact Assessment was done using EN15804+A2. Additional Consistency Check can be found in Section 3.6.

6.5 COMPLETENESS CHECK

The data that lead to the results in this section is considered complete. The LCA model included all known materials and energy flows except for specified materials outlined in Section 3.4. As stated, no known material flows above 1% were excluded and the sum of all exclusions is below 5% when evaluated against mass, energy, and environmental impact.

6.6 DATA QUALITY ASSESSMENT

Data Quality for each data point utilized in this study can be viewed in Section 3.6 of this report. Overall data quality is considered great. Improvements could be made to find more regional data sets or primary data for any Rest of World (RoW) or Global (GLO) data sets. Additionally, Suppliers could submeter specific processes and collect more supplier primary data to produce a more representative data set. However, the data quality is considered to be sufficient in relation to the goal, scope, and budget of the project.

Primary data from energy, fuel, and water consumption were normalized based on a per $ unit of production over the data collection window. The resulting energy and water per $ were used at all facilities where the Client's Suppliers have operational control. Overall, the primary data collected was considered satisfactory.

Fellowes also provided primary data regarding the materials used in their products as well as upstream data from their suppliers' locations. This data is considered satisfactory, it can be improved by collecting more primary facility data from their suppliers.

6.7 TRANSPARENCY DECISIONS THAT MAY HAVE AFFECTED THE MODEL

Throughout the report, choices and judgments that may have affected the LCA have been described. These decisions are summarized below:

Data Limitations/Assumptions

- All primary and secondary data was modelled in OpenLCA using Ecoinvent datasets to calculate the potential environmental impacts during each stage of the product's life. For any processes that were not available in the Ecoinvent database, proxy data was used. Details for any proxy data used are outlined in Section 6.2.2.
    - No proxy data was used for specific processes, see Section 6.2.2.
- Secondary data sets used in the model are disclosed in Appendix A along with data quality indicators related to the geographical, time representation, and technological coverage of the datasets. If any proxy data was used, it is also included if applicable.
    - The use and selection of secondary datasets from Ecoinvent to represent an aspect of the supply chain is a significant value choice. These datasets were chosen by the LCA Practitioner after discussions with Fellowes and review of the Ecoinvent datasets. It should be noted that no generic data is a perfect fit. Obtaining primary data from the supply chain data would improve the accuracy of results, however, budget and time constraints were considered.
    - Availability of more regionally appropriate data sets would improve accuracy; best choices were made for fit.
- Electrical, Fuels, and Water Consumption
    - Data was collected over the year January 2023 – December 2023. The totals over the collection period were divided by total sales during that period to derive a usage-per-sales unit for use in this model.
- Raw Materials and Purchasing
    - Fellowes provided all bills of materials. Plastic and Cardboard comprise raw materials. Inbound Shipping distances were assumed to be 500 km by truck.
    - All declared product systems were modelled using the same assumptions within this study and the results can be applied to all systems using the performance characteristics in Section 2.8.3. All systems are made from the same materials and processed identically. The only variations of the systems are the material composition of the systems.

- Waste Amounts
    - Fellowes Suppliers tracks all waste streams associated with manufacturing of the product over the data collection period. All waste was characterized, disposed of, and treated appropriately as outlined in Section 3.3.
    - The Client's Suppliers track all recycling and landfilled material over the data collection period.
    - Circular recycling of wood materials for pallets was considered in this study. It was assumed that all pallets were not disposed of upon installation.
- Outbound Shipping Distance
    - Type and distance of transportation was determined by developing a weighted average for all shipping data from January 2023-December 2023 based on sales.
    - A weighted average of the distances to all states where Fellowes products are shipped was calculated based on sales shipped. It was found that on average, the shipping distance was as follows: 246 km from VN to Port, 24,326 km from VN Port to European Port, 419 km from CN to CN port, 25,485 km from CN Port to European Port, and 526 km to customer.
- End of Life (EoL)
    - No primary data for the fate of the product was available. Wastes from products and packaging were disposed of based on assumptions detailed in section 3.3.3. No credits were taken for energy recovery from waste. Cut-off criteria for recycling were applied.
    - The fate of the product and packaging was determined using Ecoinvent Market Treatments.
    - Since this LCA uses the cut-off approach to model recycled material in the product, no credit is given to the end of the product system. Instead, the manufacturer realized reduced environmental impacts through the absence of the burden of virgin material.

Methodological Assumptions

- This LCA was conducted with an attributional approach.
- Suppliers' energy usage was normalized to one (1) USD based on the January 2023- December 2023 production data collected.
- To derive a per-unit for manufacturing inputs and outputs such as electricity, thermal energy, and waste streams, allocation based on total sales by unit was adopted. As a default, secondary Ecoinvent datasets use a mass basis for allocation.

System Boundary Exclusions

- The method in which recycled materials were handled is relevant to the defined system boundary. Throughout the study, recycled materials were accounted for via the cut-off method. In this method, impacts and benefits associated with the previous life of raw material from recycled stock are excluded from the system boundary.
- Any material present at or above 1 wt% of the final product was included within the scope of this study. Material inputs less than 1% were included if sufficient data was available to warrant inclusion and/or the material input was thought to have significant environmental impacts. No energy inputs were excluded in this study.
- Only known and quantifiable environmental impacts are considered.

Due to the assumptions and value choices listed above, these results do not reflect the real-life impact scenarios and hence, they cannot assess actual and exact impacts. Instead, it only represents potential environmental impacts.

6.8 CONCLUSION

In summary, raw material acquisition of plastic was by far the largest contributor to the product's environmental impact in Module A. Within the gate-to-gate (production) boundary, the electricity consumption at the Supplier's facility was the largest contributor.

To reduce environmental impact associated with their products, Fellowes should increase the amount of recycled content in the plastic they source, partner with its suppliers to investigate energy efficiency and reduction projects and explore adding onsite renewable generation or source electricity from renewable sources.

7. References

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Appendix A – Datasets

TABLE A1: LIST OF ALL SECONDARY DATASETS USED

Material	Data Set	Data Set No.	Stage	Source	Reference Year	Time Coverage	Location
Cardboard	market for corrugated board box | corrugated board box | EN15804GD, U	1	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW
Polypropylene	polypropylene production, granulate | polypropylene, granulate | EN15804GD, U	2	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW
Extrusion	extrusion, co-extrusion of plastic sheets | extrusion, co-extrusion | EN15804GD, U	3	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW
EVA	ethylene vinyl acetate copolymer production | ethylene vinyl acetate copolymer | EN15804GD, U	4	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW
LDPE	polyethylene production, low density, granulate | polyethylene, low density, granulate | EN15804GD, U	5	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW
PET	polyethylene terephthalate production, granulate, amorphous | polyethylene terephthalate, granulate, amorphous | EN15804GD, U	6	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW
rPET	polyethylene terephthalate production, granulate, amorphous, recycled | polyethylene terephthalate, granulate, amorphous, recycled | EN15804GD, U	7	A	Ecoinvent 3.10	2023	Within 10-year Period	RoW

Inbound Transport/Outbound Transport	transport, freight, lorry, all sizes, EURO5 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | EN15804GD, U	8	B/C	Ecoinvent 3.10	2023	Within 10-year Period	RER
CN Elec	market for electricity, medium voltage | electricity, medium voltage | EN15804GD, U	9	B	Ecoinvent 3.10	2023	Within 10-year Period	CN
VN Elec	market for electricity, medium voltage | electricity, medium voltage | EN15804GD, U	10	B	Ecoinvent 3.10	2023	Within 10-year Period	VN
Haz Waste	treatment of hazardous waste, hazardous waste incineration | hazardous waste, for incineration | EN15804GD, U	11	B	Ecoinvent 3.10	2023	Within 10-year Period	RoW
MSW	treatment of municipal solid waste, sanitary landfill | municipal solid waste | EN15804GD, U	12	B	Ecoinvent 3.10	2023	Within 10-year Period	RoW
Water	market for tap water | EN15804GD, U	13	B	Ecoinvent 3.10	2023	Within 10-year Period	RoW
Waste Water	market for wastewater, average | wastewater, average | EN15804GD, U	14	B	Ecoinvent 3.10	2023	Within 10-year Period	RoW
Outbound Transport	Transport, freight, sea, container ship | transport, freight, sea, container ship | EN15804GD, U	15	C	Ecoinvent 3.10	2023	Within 10-year Period	GLO
MSW	treatment of municipal solid waste, sanitary landfill | municipal solid waste | EN15804GD, U	16	C	Ecoinvent 3.10	2023	Within 10-year Period	CH
Incineration	treatment of municipal solid waste, municipal incineration | municipal solid waste | EN15804GD, U	17-21	C	Ecoinvent 3.10	2023	Within 10-year Period	NL, ES, IT, PL, GB

TABLE A2: LIST OF ALL SECONDARY DATASETS WITH DATA QUALITY VALUES

Data Set	Data Set No.	R	C	T	G	F
market for corrugated board box | EN15804GD, U	1	1	1	5	5	4
polypropylene production, granulate | polypropylene, granulate | EN15804GD, U	2	2, **3**	3	2, **5**	5	3
extrusion, co-extrusion of plastic sheets | extrusion, co-extrusion | EN15804GD, U	3	2, **3**	3	1, **4**	2	2
ethylene vinyl acetate copolymer production | ethylene vinyl acetate copolymer | EN15804GD, U	4	2, **5**	4, **5**	1, **5**	5	4
polyethylene production, low density, granulate | polyethylene, low density, granulate | EN15804GD, U	5	2, **3**	3	2, 3, **5**	5	3
polyethylene terephthalate production, granulate, amorphous | polyethylene terephthalate, granulate, amorphous | EN15804GD, U	6	2, **5**	2, 3, **5**	1, **5**	5	1, 4, **5**
polyethylene terephthalate production, granulate, amorphous, recycled | polyethylene terephthalate, granulate, amorphous, recycled | EN15804GD, U	7	1, 4, **5**	1, 3, **5**	2, 4, **5**	5	1, 2, **5**
transport, freight, lorry, all sizes, EURO5 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | EN15804GD, U	8	1	1	4	1	1
market for electricity, medium voltage | electricity, medium voltage | EN15804GD, U	9	1-**5**	1-**5**	1-**5**	1-**5**	1-**5**
market for electricity, medium voltage | electricity, medium voltage | EN15804GD, U	10	1-**5**	1-**5**	1-**5**	1-**5**	1-**5**
treatment of hazardous waste, hazardous waste incineration | hazardous waste, for incineration | EN15804GD, U	11	1, **5**	1, **5**	5	5	1
treatment of municipal solid waste, sanitary landfill | municipal solid waste | EN15804GD, U	12	1	1	4	1	1

market for tap water | EN15804GD, U	13	1-3, **5**	1, 4, **5**	4, **5**	1	1, 2, **5**
market for wastewater, average | wastewater, average | EN15804GD, U	14	1	1	2	1	1
transport, freight, sea, container ship | transport, freight, sea, container ship | EN15804GD, U	15	2-**4**	2, 4, **5**	4, **5**	1, 4, **5**	2-**4**
treatment of municipal solid waste, sanitary landfill | municipal solid waste | EN15804GD, U	16	1	1	4	1	1
treatment of municipal solid waste, municipal incineration | municipal solid waste | EN15804GD, U	17	1	1	1, **4**	1	1
treatment of municipal solid waste, sanitary landfill | municipal solid waste | EN15804GD, U	18	1	1	1, **4**	1	1
treatment of municipal solid waste, municipal incineration | municipal solid waste | EN15804GD, U	19	1	1	1, **4**	1	1
treatment of municipal solid waste, sanitary landfill | municipal solid waste | EN15804GD, U	20	1	1	1, **4**	1	1
treatment of municipal solid waste, municipal incineration | municipal solid waste | EN15804GD, U	21	1	1	1, **4**	1	1

*As a conservative approach, the highest number is bold. Lower numbers represent higher data quality. Multiple entries are for those datasets with mixed levels of data quality, depending on flows. Results in section 3.6.5 are an aggregate of all the data quality scores in the underlying processes in the secondary datasets used.

Appendix B – Additional Products

Hold for additional products to be added in the future. All methodology will be the same.

Appendix C – Model Graph

Figure C.1 Model Graph (Upstream, Core)

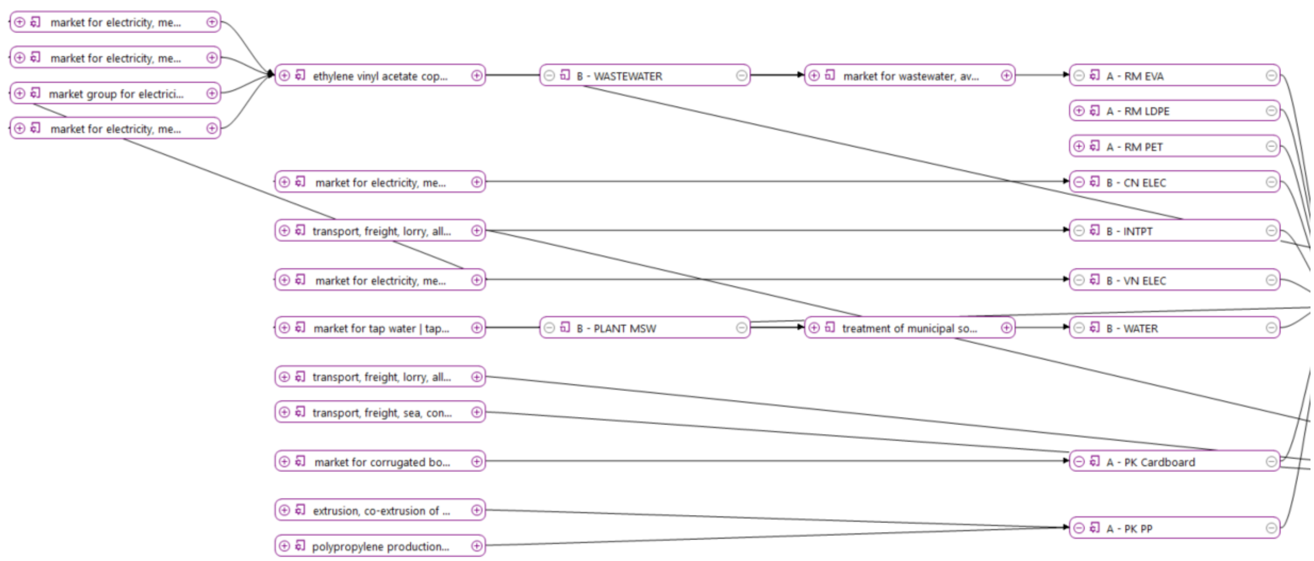
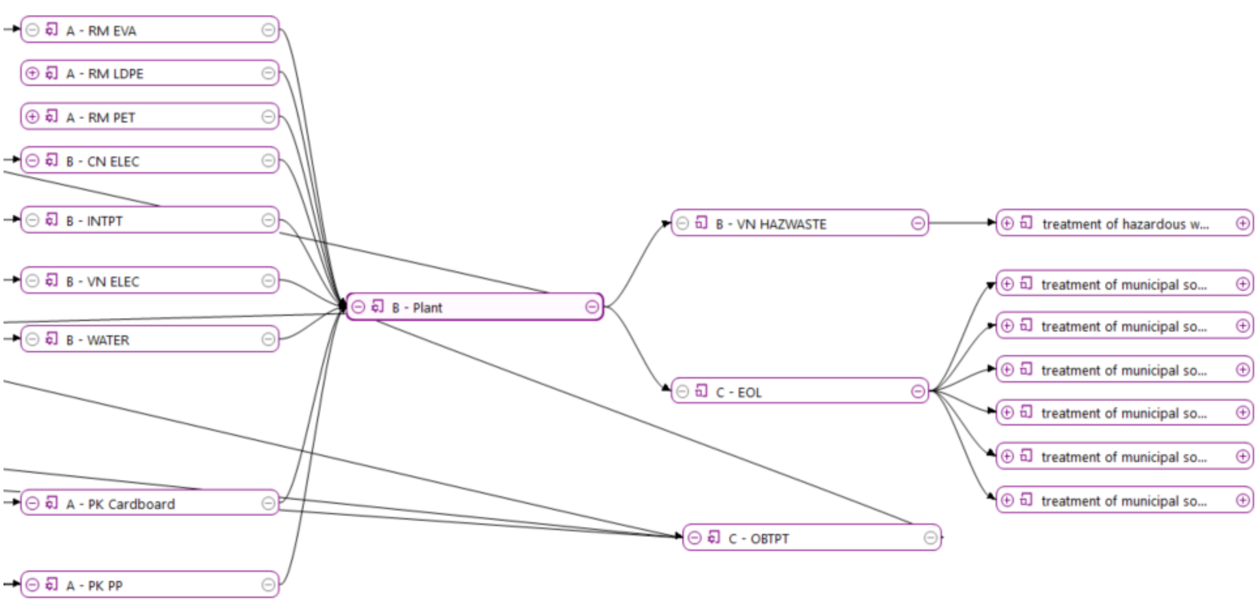


Figure C.2 Model Graph (Upstream, Core, Downstream)



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Thank you!

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