LIFE CYCLE ASSESSMENT REPORT

WOODEN WINDOWS:

- ARBOR 68s
- ARBOR 68f

ARBOR FENEX Wood Windows

Made for	ARBOR
Made by	BUREAU VERITAS CODDE

CODDE – Subsidiary of Bureau Veritas
170 rue de Chatagnon – ZI Centr'Alp
F-38430 Moirans

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Abbreviations and acronyms

AA	Air Acidification, EIME impact indicator
AE	Environmental Aspect
AT	Air Toxicity, EIME impact indicator
BOM	Bill of Materials
CODDE	Design, Sustainable Development, Environment
DHUP	Direction de l'Habitat, de l'Urbanisme et des Paysages
EIME	Environmental Improvement Made Easy
ED	Energy Depletion, EIME flow indicator
ErP	Directive 2009/125/EC Energy related Product (formerly Energy using Product, EuP)
FDES	Fiche de Déclaration Environnementale et Sanitaire, standing for Environmental and Health Declaration Formats
FIEEC	Federation of Electric and Electronic Industries and Communication
GW	Global Warming, EIME impact indicator
HWP	Hazardous Waste Production, EIME flow indicator
LCA	Lifecycle Analysis
LCI	Lifecycle Inventory
OD	Ozone Destruction, EIME impact indicator
EPD	Environmental Product Declaration
POC	Photochemical Ozone Creation, EIME impact indicator
RMD	Raw Material Depletion, EIME impact indicator
SEA	Significant Environmental Aspect
SME	Environmental Management System
WE	Water Eutrophication, EIME impact indicator
WD	Water Depletion, EIME flow indicator
WEEE	Waste Electrical and Electronic Equipment
WT	Water Toxicity, EIME impact indicator

Reading guide

The following writing conventions are used in this study:

- ✓ Scientific notation: 4.32E-3 = 4.32 x 10-3
- ✓ Percentage values are rounded to whole numbers.
- ✓ Absolute values and scientific notations are rounded to two decimal places.
- ✓ Very low relative values of less than 1% have been noted: <1%.
- ✓ The values of the inventories listed in the tables are given for the entire life of the product.

1. CONTEXT AND OBJECTIVES OF THE STUDY

1.1. GENERAL CONTEXT

ARBOR started from a corporate philosophy: “Nature, with the help of advanced technology, is sufficient in meeting all our needs. In the foundations of this principle, lies our trust in nature.”

There have been great developments in natural raw materials and the technology in processing them. The use of "natural architectural elements" in houses carries a special importance when considered from the point of family and individual health. By using up-to-date production technology and the new generation natural raw materials, ARBOR aims at spreading its state-of-the-art windows and doors throughout the whole world.
In order to value this innovating process and evaluate the environmental benefits, ARBOR wishes to conduct the Environmental Product Declarations (FDES format) for two of its wooden products.

To do so, Bureau Veritas CODDE, the eco-environment centre of expertise of the Bureau Veritas Group since 2008, has been mandated. Our task consists in conducting the evaluation of the ecological footprint of products and assist companies in their ecodesign approach.

Modelling was conducted with EIME version 5.5, from primary data collected by ARBOR for all life cycle phases.
The database version used for this study is the 2015 version of EIME V5 (updated April 2015).
It should be noted that the study was conducted on the basis of the technological knowledge of the time.

1.2. OBJECTIVES OF THE STUDY

This study will allow ARBOR:

- ✓ **Understanding** the environmental impacts of its products
- ✓ **Highlighting** the eco-friendly behavior of its products
- ✓ **Being able** to answer its clients regarding the environmental impacts of its products
- ✓ **Having access** to a clear and reliable environmental communication.

1.3. AUDIENCE

The results of this study are intended to a BtoB market (retailers, installers, site supervisors…).
Environmental Product declarations are to be communicated to building professionals through INIES database.

1.4. VALIDITY OF RESULTS AND CRITICAL REVIEW

1.4.1. Validity of results

The results are valid only for the situation defined by the assumptions described in this report. The findings may change if the conditions differ. Therefore, the relevance and reliability of use by third parties or for purposes other than those mentioned in this report cannot be guaranteed by Bureau Veritas CODDE. Such utilisation is therefore the sole responsibility of the user.

1.4.2. Critical review

This study is aimed at critical review. The external verifier is Frédéric ROSSI from C4CI company.

1.5. REFERENCES

The main references supporting this study are:

- ✓ ISO 14040 : Environmental management -- Life cycle assessment -- Principles and framework (2006)
- ✓ ISO 14025 : Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures (2006)
- ✓ NF P 01-010 : Qualité environnementale des produits de construction - Déclaration environnementale et sanitaire des produits de construction (2004)
- ✓ NF EN 15804 + CN : Contribution des ouvrages de construction au développement durable - Déclarations environnementales sur les produits - Règles régissant les catégories de produits de construction (2014)
- ✓ NF EN 16485 : Bois ronds et sciages – Déclarations environnementales de produits – Règles de définition des catégories de produits en bois et à base de bois pour l'utilisation en construction
- ✓ EN 15942 : Sustainability of construction works - Environmental product declarations - Communication format business-to-business (2011)
- ✓ XP P01-064/CN : Contribution des ouvrages de construction au développement durable - Déclarations environnementales sur les produits - Règles régissant les catégories de produits de construction - Complément national à la NF EN 15804+A1 (2014)
- ✓ Décret relatif à la déclaration environnementale des produits de construction, de décoration et des équipements électriques, électroniques et de génie climatique destinés à un usage dans les ouvrages de bâtiment, Direction de l'Habitat, de l'Urbanisme et des Paysages (2013)
- ✓ ISO 19011 : Guidelines for auditing management systems (2011)
- ✓ ISO/TS 14071 : Environmental management -- Life cycle assessment -- Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006 (2014)
- ✓ EIME v5 guides[1] [2] for the modelling of the different processes.

[1] Guide méthodologique de la base de données EIME – April 2013 - Bureau Veritas CODDE
[2] Protocole de création de module interne – April 2013 - Bureau Veritas CODDE

2. SCOPE OF THE STUDY

2.1. PRODUCT, FUNCTION, FUNCTIONAL UNIT AND REFERENCE FLOW

2.1.1. Description of the products

This study covers the following commercial references:

- ✓ ARBOR 68s
- ✓ ARBOR 68f.

Figure 1: Illustration of ARBOR products (68s on the left, 68f on the right)

Both windows are made of glued laminated timber (from pine wood). It is then cut, profiled before adding the glass. It is then assembled and painted so it can be transported to the installation site.

The Reference Service Life of the product is set to 25 years, as considered in the DHUP proposition from October, 25th 2010.

The thermal performance of both windows is 1,3 W/(m².K), considering a 1,230 mm x 1,480 mm window and a 1,150 mm x 1,385 mm frame and a 962 mm x 1,217 mm glass surface.

The complete list of thermal, acoustic and use performance test reports are given in annex to this report.

No test report has been issued concerning:

- **The dangerous substances content**
- **The air, water and soil emissions**

2.1.2. Functional unit

The main function of the windows is to let the light enter the room and provide decent room ventilation.

According to the standard ISO 14040:2006, the functional unit (FU) consists of the "quantified performance of a system of products for use as a reference unit in a lifecycle analysis. Thus, the functional unit is made from the main technical characteristics of a product. This makes it possible to compare several products with one another and thus to evaluate the best practices for the ecodesign of each product.

Based on the information regarding the functions of the product under study, the functional unit chosen for both products will be:

« To allow the light to enter through a 1m² wall surface with a light transmission factor of 80%, while ensuring a 1.3W/(m².X) thermal insulation, a 29 dB acoustic reduction, and allowing to open for ventilation during 25 years»

This functional unit is in compliance with NF EN 15804 + CN standard for the environmental evaluation of building products (A1-D steps).

The windows dimensions are:

- 1,230 mm x 1,480 mm window (1.820 m²)
- 1,150 mm x 1,385 mm frame (1.598 m²)
- 962 mm x 1,217 mm glass surface (1.171 m²)

Values have been adapted to a window surface of 1m² (ratio of 1.82).

2.1.3. Description of the reference flow

The reference flow is the measure of process deliverables, in a given system of products, to perform the function as expressed by the functional unit. It should include:

- ✓ The reference product allowing the realization of the function describing the service given to customers
- ✓ The packaging of the reference product
- ✓ Elements necessary for installation
- ✓ Elements necessary for the use of the product
- ✓ Process losses.

In this study, the reference flow is expressed in kg/FU. To answer this functional unit, the reference flow will answer the function for the installation of 1 m² of window.

2.1.3.1. Description of the reference flow answering the functional unit of 68s

Quantity of product, packaging, complementary products contained in the reference product: 45.94 kg + 6.37 kg manufacturing losses + 1.187 kg evaporation

- ✓ Product without packaging: 24.92 kg + 6.37 kg manufacturing losses + 0.66 kg evaporation
  - o Glued laminated timber: 9.18 kg + 6.14 kg manufacturing losses
  - o Glue: 0.16 kg
  - o Double-glazing: 12.38 kg
  - o Steel for structure: 1.65 kg
  - o Varnish: 0.00817 kg + 0.132 kg evaporation
  - o Paint: 0.442 kg + 0.0946 kg manufacturing losses + 0.577 kg evaporation
  - o Primer: 0.0888 kg + 0.138 kg manufacturing losses + 0.0836 kg evaporation
  - o Screws: 0.0277 kg
  - o Silicone: 0.181 kg
  - o Nails: 0.00478 kg

- Seals: 0.795 kg

✓ Packaging: The packaging considered in this study are the ones for the upstream transport of raw materials as well as primary and secondary packaging of the product: 20.70 kg

  ✓ Upstream packaging:
    - Polyethylene film: 0.0437 kg
    - Pallet (wood): 0.122 kg
    - Expanded polystyrene: 0.000277 kg
    - Cardboard: 0.0823 kg
    - Bucket: 0.120 kg

  ✓ Primary and secondary packaging:
    - Bubble pack: 1.10 kg
    - OSB box: 10.99 kg
    - Pallet 2 (wood): 8.24 kg

✓ Process losses during installation: 0%

✓ Installation materials: This study includes the material used to install the product in the building. Three different processes are considered. The reference flow below considers the weighted average: 0.295 kg
  - Screws: 0.0437 kg
  - Set square: 0.0528 kg
  - Silicone: 0.0824 kg
  - Compribande: 0.0277 kg
  - EPDM band: 0.00579 kg
  - Packaging (cardboard): 0.0547 kg
  - Packaging (polyethylene film): 0.0277 kg

✓ Complementary products for use: 0.0225 kg + 0.527 kg evaporation

  - Varnish: 0.00563 kg + 0.132 kg evaporation per application, 4 applications over the life cycle (one every 5 years)

2.1.3.2. Description of the reference flow answering the functional unit of 68f

Quantity of product, packaging, complementary products contained in the reference product: 46.17 kg + 7.10 kg manufacturing losses + 1.319 kg evaporation

✓ Product without packaging: 25.15 kg + 7.10 kg manufacturing losses + 0.797 kg evaporation
  - Glued laminated timber: 7.86 kg + 6.81 kg manufacturing losses
  - Glue: 0.165 kg
  - Aluminium: 1.63 kg + 0.0624 kg manufacturing losses
  - Double-glazing: 12.38 kg
  - Steel for structure: 1.65 kg
  - Varnish: 0.00817 kg + 0.132 kg evaporation
  - Paint: 0.442 kg + 0.0946 kg manufacturing losses + 0.577 kg evaporation
  - Primer: 0.0888 kg + 0.138 kg manufacturing losses + 0.0836 kg evaporation
  - Screws: 0.0277 kg
  - Silicone: 0.181 kg
  - Nails: 0.00476 kg
  - Corner connection parts: 0.110 kg
  - Plastic clips: 0.110 kg
  - Seals: 0.495 kg

✓ Packaging: The packaging considered in this study are the ones for the upstream transport of raw materials as well as primary and secondary packaging of the product: 20.70 kg

- ✓ Upstream packaging:
    - Polyethylene film: 0.0437 kg
    - Pallet (wood): 0.122 kg
    - Expanded polystyrene: 0.000277 kg
    - Cardboard: 0.082 kg
    - Bucket: 0.120 kg
- ✓ Primary and secondary packaging:
    - Bubble pack: 1.10 kg
    - OSB box: 10.99 kg
    - Pallet 2 (wood): 8.24 kg

✓ <u>Process losses during installation</u>: 0%

✓ <u>Installation materials:</u> This study includes the material used to install the product in the building. Three different processes are considered. The reference flow below considers the weighted average: 0.295 kg

- Screws: 0.0437 kg
- Set square: 0.0528 kg
- Silicone: 0.0823 kg
- Compribande: 0.0277 kg
- EPDM band: 0.00579 kg
- Packaging (cardboard): 0.0547 kg
- Packaging (polyethylene film): 0.0277 kg

✓ <u>Complementary products for use:</u> 0.0225 kg + 0.522 kg evaporation

- Varnish: 0.00563 kg + 0.132 kg evaporation per application, 4 applications over the life cycle (one every 5 years)

2.2. SYSTEM BOUNDARIES

2.2.1. Modules as in NF EN 15804 +CN

The environmental comparison is based on the module description as depicted in NF EN 15804 +CN. All modules were chosen in agreement with ARBOR in order to ensure a cradle-to-grave assessment.

Building assessment information																
Building life-cycle information																Supplementary information beyond the building life-cycle
Product stage			Construction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport	Construction - installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction - demolition	Transport	Waste processing	Disposal	Reuse - Recovery - Recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X			X	X	X	X	X	X	X	X	X	X	X	X	X	

Table 1: Modules included for the evaluation of the three processes

- **Product stage:**
  - A1-A3 :
    - Raw material extraction and processing
    - Production of aggregates from raw materials and their transformation, including water and energy supply
    - Upstream transport of raw materials
    - Management and treatment of production waste until the end-of-life status of waste.
    - All eventual co-products are treated as wastes, 100% allocated to the studied products.
- **Construction process stage, information modules:**
  - A4: transport to the building site
  - A5: installation into the building
- **Use stage, information modules related to the building fabric:**
  - B1: use or application of the installed product
  - B2: maintenance
  - B3: repair
  - B4: replacement
  - B5: refurbishment

- **Use stage, information modules related to the operation of the building:**
  - B6: operational energy use (e.g. operation of heating system and other building related installed services)
  - B7: operational water use
- **End-of-life stage, information modules:**
  - C1: de-construction, demolition
  - C2: transport to waste processing
  - C3: waste processing for reuse, recovery and/or recycling
  - C4: disposal
- **Benefits and loads beyond the system boundary:**
  - D: Loads of incineration emissions (other than the ones emitted by the incineration for the current scenario).

2.2.2. Phases and flows taken into account

The life-cycle step taken into account in this study is the manufacturing (from cradle-to-gate).

Please find below a scheme of the life-cycle steps considered in this study:

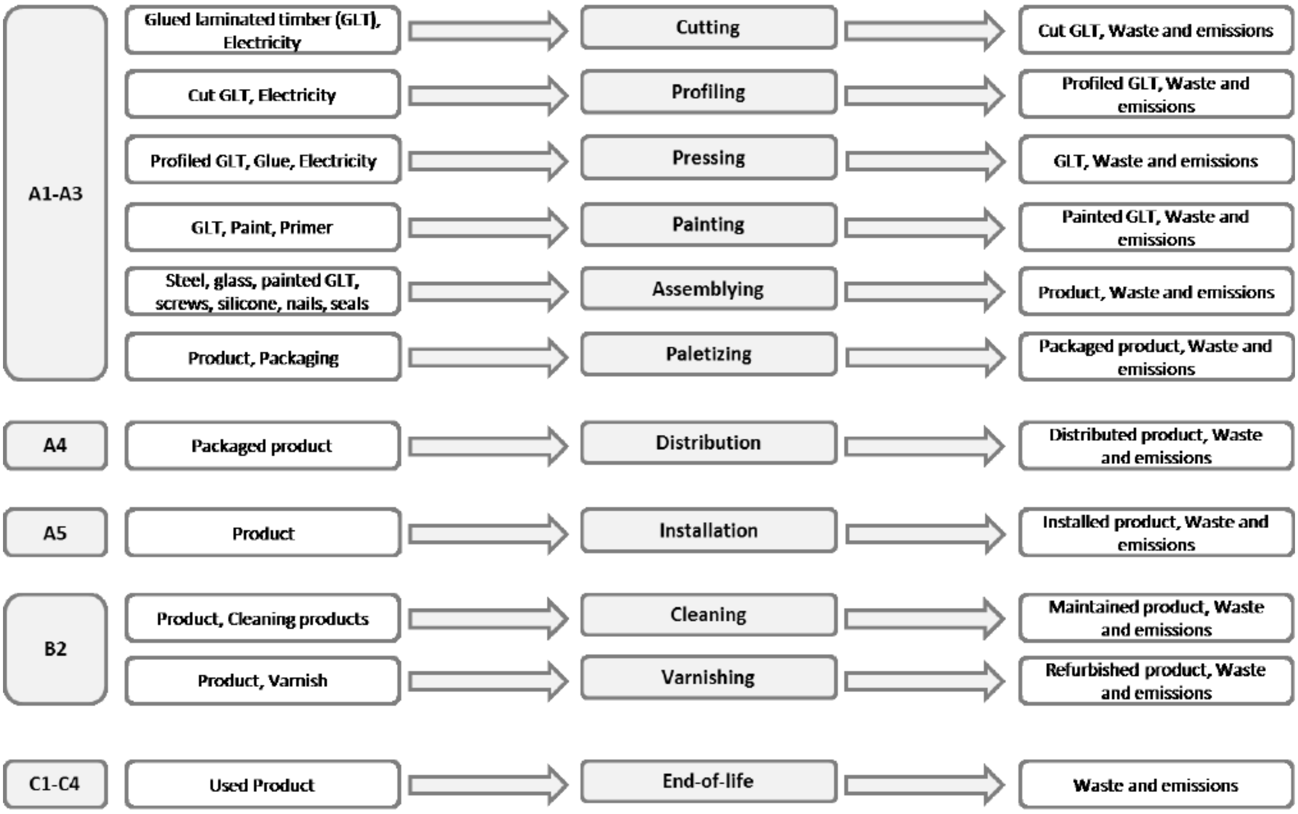

Figure 1 - Synopsis of the life-cycle steps considered in this study

2.2.3. Exclusions

Flows that can be excluded from the study because of the difficulty of attributing them to a particular reference flow are conventionally the following:

- The lighting, heating, sanitation and cleaning of facilities
- The transportation of employees
- The manufacture and maintenance of production tools
- The construction and maintenance of infrastructures
- The systems and infrastructures
- The flows from administrative, management, and R&D departments

- The product marketing
- The staff catering facilities

Specifically for this study, and due to their low environmental relevance, we excluded:

- The upstream packaging (packaging of the materials and components bought)

2.2.4. Cut-off rules

It is possible to identify a cut-off rule:

- A rule is linked to a flow category. Ex: weight rule.
- Each rule is associated with a cut-off criterion, giving the threshold to respect. Ex: 1% of the total weight of the reference flow.

Each cut-off criterion must be respected in the life-cycle inventory. The objective is to prevent the results from a too high incertitude. It is thus necessary to assess the compliance with each cut-off criterion.

The following procedure shall be followed for the exclusion of inputs and outputs:

- In case of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1 % of renewable and non-renewable primary energy usage and 1 % of the total mass input of that unit process. The total of neglected input flows per module, e.g. per module A1-A3 and module D shall be a maximum of 5 % of energy usage and mass.

Life-cycle stages	Real weight for the FU (kg)	Modelled weight for the FU (kg)	Variation (%)
Product stage	51.99	51.99	0%
Construction process stage	0.295	0.295	0%
Use stage	0.0225	0.0225	0%
End-of-life stage	0	0	0%
Total	52.307	52.307	0%

Table 2 – Verification of the weight cut-off rule for 68s

Life-cycle stages	Real energy for the FU (kg)			Modelled energy for the FU (kg)	Variation (%)
	Evaluated with EIME	Known	Total		
Product stage	1.67E3	0	1.67E3	1.67E3	0%
Construction process stage	1.33E2	0	1.33E2	1.33E2	0%
Use stage	2.14E2	0	2.14E2	2.14E2	0%
End-of-life stage	4.02E1	0	4.02E1	4.02E1	0%
Total	1.83E3	0	1.83E3	1.83E3	0%

Table 3 – Verification of the energy cut-off rule for 68s

Life-cycle stages	Real weight for the FU (kg)	Modelled weight for the FU (kg)	Variation (%)
Product stage	52.95	52.95	0%
Construction process stage	0.295	0.295	0%
Use stage	0.0225	0.0225	0%
End-of-life stage	0	0	0%
Total	53.2675	53.2675	0%

Table 4 – Verification of the weight cut-off rule for 68f

Life-cycle stages	Real energy for the FU (kg)			Modelled energy for the FU (kg)	Variation (%)
	Evaluated with EIME	Known	Total		
Product stage	2.02E3	0	2.02E3	2.02E3	0%
Construction process stage	1.34E2	0	1.34E2	1.34E2	0%
Use stage	2.14E2	0	2.14E2	2.14E2	0%
End-of-life stage	4.44E0	0	4.44E0	4.44E0	0%
Total	2.37E3	0	2.37E3	2.37E3	0%

Table 5 – Verification of the energy cut-off rule for 68f

Energy flows cannot be measured on the total life-cycle. In this way, the reference flow in energy was completed by the energy flows of the product modelled in EIME.

The proportion of non-modelled elements is in compliance with the 1%-in-weight cut-off rule and the 5%-in-energy cut-off rule, over the life-cycle considered.

2.2.5. Bill of Materials (BOM)

The Bills of Materials of the products are described as below:

	Metals		Plastics		Others	
Constituent materials	Stainless steel	3.91%	Polyethylene low density	2.48%	Glass	27.26%
			Styrene butadiene rubber	1.09%	Oriented strand board	24.18%
			Silicone rubber	0.58%	Pine wood	20.18%
			Flexible polyurethane foam	0.06%	Wood for pallet	18.11%
			Ethylene propylene diene	0.01%	Unspecified raw materials (paint components)	0.83%
					Polyvinyl acetate (glue)	0.62%
					Titanium dioxide	0.55%
					Corrugated cardboard	0.12%

Table 6 – Bill of Materials of 68s

	Metals		Plastics		Others	
Constituent materials	Stainless steel	3.87%	Polyethylene low density	2.46%	Glass	26.95%
	Aluminium	3.78%	Styrene butadiene rubber	1.08%	Oriented strand board	23.90%
			Silicone rubber	0.57%	Wood for pallet	17.91%
			Polyamide	0.24%	Pine wood	17.08%
			Flexible polyurethane foam	0.06%	Unspecified raw materials (paint components)	0.82%
			Ethylene propylene diene	0.01%	Polyvinyl acetate (glue)	0.61%
					Titanium dioxide	0.55%
					Corrugated cardboard	0.12%

Table 7 – Bill of Materials of 68f

2.3. ORIGIN OF THE DATA USED FOR THE STUDY

2.3.1. Source and type of data

Data collection was performed by ARBOR from information collected in France and Turkey.

For non-available data, Bureau Veritas CODDE has set hypotheses and collected information from sources close to the sector.

Collected data are available in the following file:

- ARBOR_Data collection_20160810.

This table sums up the origin of data used in this study for both 68s and 68f products.

Environmental aspects	Parameter	Method of data production	Type of data
Material production	Mass and material	Manufacturer data	Primary data
Processes	Nature and quantity	Manufacturer data	Primary data
Packaging	Mass and material	Manufacturer data	Primary data
Upstream transport	Distances and transport means	Manufacturer data	Primary data
Distribution	Distances and transport means	Manufacturer data	Primary data
Installation	Installation mode, mass and nature of materials	Data based on experience	Secondary data
Use	Mass, material and distances	Manufacturer data	Primary data
End-of-life	Nature and end of life potentials	Literature data	Secondary data

Table 8 - General information on collected data on aggregate production processes

Note

Primary data / Secondary data

Data from which LCA are based on can come from primary and secondary sources:

- Primary data: data collected on the field specific to the studied system
- Secondary data: generic data issued from literature review and researches.

The choice of a type of data is made depending of their availability and the level of quality necessary for this study.

2.3.1. ARBOR specific data quality evaluation - Representativeness

Data were collected from December 2015 to April 2016 and are representative of 2015 manufacturing technologies.

The data is representative of one year of production (no seasonal variation).

The data collection has been led by Fatih Bagli, from ARBOR.

The manufacturing stage takes place in Turkey for an installation and use in France.

The reference life time of the product is 25 years, but emissions and impacts have been considered over a period of 100 years (mainly concerning the landfill of wastes).

2.3.2. Generic inventory database used

The database in use is BDD CODDE-2015-04 (updated in April 2015). The different inventories are available in Excel format in EIME case studies.

This database has been chosen as it contains data from the most recognized sources, including:

- ELCD database for the electricity and transport,
- Worldsteel for the steel
- EAA for the aluminium.

This database is managed directly by Bureau Veritas CODDE, providing this study with a good control and transparency over the data used.

The data from the INIES database have not been used, as they are LCIA data instead of LCI data.

2.3.3. Traceability

Life Cycle Inventory was realized by Bureau Veritas CODDE in 2016 and the compilation of data results from the calculations made by EIME (Environmental Improvement Made Easy) v5.5 LCA software.

The data quality information can be found in part 3.7 Life-cycle Inventory and data quality for both products.

2.4. Management of uncertainties and interpretation of results

One objective of this study is to identify the significant environmental aspects (SEA) of the product studied. To achieve this, we need to define a relevant threshold to state clearly that an environmental aspect is significant.

To that end, we must consider the various sources of uncertainties:

- **Lifecycle inventory database:**

The uncertainty inherent to the inventory data of the EIME database is assessed qualitatively. A completeness indicator and a reliability indicator are associated to each data element. For each of these indicators, three levels of quality are integrated (high/medium/low).

These notions make possible to ensure the reliability of the results of the study.

Data reliability	
High	Inventory data taken from primary data from at least 3 industrial sites
Medium	Inventory data taken from primary data from 1 to 2 industrial sites, combined with explicit documentation regarding the scope of the study.
Low	Bibliographic data or data from poorly documented databases.
Completeness of data	
High	The scope of the inventory is complete. All the significant stages of the manufacturing process are covered by the scope of the inventory and the knowledge of the input flows is established at 98% of the weight.
Medium	The scope of the inventory is not complete. Certain significant stages of the process have not been studied, or the knowledge of the input flows is less than 98% of the weight.
Low	Only the composition of the material is indicated.

Table 9 - Management of uncertainties in EIME database

In addition, when creating the life-cycle inventories in the EIME database, if more data is available, the sensitivity threshold determining the aggregation of the source data is the following:

- If the differences between the assessment results per data source are less than 20%[3] for each of the 11 indicators, then the data is considered representative of the same technology.
- If a difference of more than 20% is observed for at least one indicator, then several LCI datasets will be created.

Thus, one can consider that the uncertainty of the generic data used through the EIME database is 20% or less.

- **Collection of primary data:**

Each technical data element is collected with an accuracy of a few per cents related to the method of measurement (accuracy of the measurement instruments, for example human parameter).

When data is collected by the organisation requesting the study, or when the data is derived from secondary sources that do not disclose the level of uncertainty of the measurement, then the accuracy is not known. Uncertainty in the measurement of data is therefore not taken into account and is beyond the scope of responsibility of Bureau Veritas CODDE.

When Bureau Veritas CODDE is appointed to conduct direct data collection, then, when the measurement tools permit, the uncertainty in the accuracy of the instruments is taken into account.

- **Reference flow and functional unit:**

The comparison between systems is provided using the same functional unit and an equivalent scope (same boundaries, same technological, geographical and temporal representativeness of the inventory data, same collection methodology, and same methodologies for characterizing impacts).

The material flows included in the functional unit are taken into account and any failure or approximation is recorded in the inventory phase.

- **Modelling assumptions:**

Finally, the variability of the results of the assessment based on approximate or generic parameters is studied through sensitivity analyses.

[3] The 20% value is commonly admitted among LCA practitionners as the gap below which it is not possible to conclude on differences between two solutions (EeBGuide Project – Aspect G-37 (Buildings) / G-35 (Products) Uncertainty analysis for comparative assertion).

To take into account the uncertainties related to the study, we consider that an impact variation below 20% may be due to a methodological bias. **We then speak of significant change when it is greater than or equal to 20%.**

Sensitivity analyses can also test the robustness of the results and their reliance on the modelling assumptions and uncertainties.

2.5. ENVIRONMENTAL INDICATORS AND CHARACTERISATION MODELS

The aim of this paragraph is to present the environmental indicators.

2.5.1. Flow indicators

The 17 flow indicators assessed in the life cycle impact assessment in EIME v5.3 are established in compliance with EN 15804 and are classified in several categories:

- Describing resource use:
  - ERP: Use of renewable primary energy excluding renewable primary energy resources used as raw materials (in MJ)
  - ERM: Use of renewable primary energy resources used as raw materials (in MJ)
  - ER: Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (in MJ)
  - ENRP: Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (in MJ)
  - ENRM: Use of non renewable primary energy resources used as raw materials (in MJ)
  - ENR: Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (in MJ)
  - USM: Use of secondary material (in kg)
  - URSF: Use of renewable secondary fuels (in MJ)
  - UNRSF: Use of non renewable secondary fuels (in MJ)
  - NUFW: Net use of fresh water (in m3)
- Describing waste categories:
  - HWD: Hazardous waste disposed (in kg)
  - NHWD: Non hazardous waste disposed (in kg)
  - RWD: Radioactive waste disposed (in kg)
- Describing output flows:
  - CRU: Components for re-use (in kg)
  - MRE: Materials for recycling (in kg)
  - MER: Materials for energy recovery (in kg)
  - EE: Exported energy (in MJ).

2.5.2. Impact indicators

The 9 impact indicators assessed in the life cycle impact assessment in EIME v5.3 are established in compliance with EN 15804 and DHUP:

- GWP: global warming (in kg CO2-eq)
- ODP: ozone depletion (in kg CFC11-eq)
- AP: acidification of soil and water (in kg SO2-eq)
- EP: eutrophication (in kg PO43- -eq)
- POCP: photochemical ozone creation (in kg C2H4-eq)
- ADPe: depletion of abiotic resources (elements) (in kg Sb-eq)
- ADPf: depletion of abiotic resources (fossil) (in MJ)
- WP: water pollution (in m^3)
- AP: air pollution (in m^3).

2.5.3. Methodology

EIME methodology integrates a weighting of 1 for each indicator, so to consider all indicators as a whole, as critical as the others. An ecodesign approach demands, when possible, to reduce all of them.

Each entity can prefer one or several indicators depending on its location and activity sector.

3. ASSUMPTIONS USED FOR MODELLING IN EIME

Chapter 3 sums up all hypotheses taken into account for the modelling of both products in EIME. EIME models are stored in EIME software. Excel files in Appendix give the description of the modelling.

The values below are expressed for a complete window. For a 1m² functional unit, multiply all relevant values by a 1/1.171 ratio.

3.1. ALLOCATION RULES

All data have been collected directly relatively to a product (ex: production machine consumption), and not at a site level. Therefore, no allocation rule is required.

Moreover, eventual coproducts that would be generated during the life cycle of the product have been taken into account as wastes, and 100% allocated to the studied product.

3.2. BIOGENIC CARBON ACCOUNTING

This part is based on the NF EN 16485.

The wood extraction is performed in Europe. Therefore, we consider the carbon neutrality.

In that regard, for every kg of wood extracted, we consider the resource extraction of 1.12kg of CO2.

This resource extraction has been accounted as a negative emission flow in the model, due to the non-consideration of CO2 resource extraction in the impact indicator model.

This carbon is emitted to the atmosphere during the discarded product and the process losses landfill. After 100 years, only 15% has been emitted as methane[4].

As the molecular weight is different for the methane and the carbon dioxide, the weight ratio can be calculated with the molecular weight ratio:

- Weight ratio = (12+4*1) / (12+16*2) = 16 / 44

Example: product 68s

Step 3 – Profiling / sizing wood wastes: 7.3 kg

Associated CO2 resource extraction: 7.3 x 1.12 = 8.176 kg

Landfill emissions: CH4: 8.176 x 15% x 16 / 44 = 0.446 kg

[4] « L'Analyse de Cycle de Vie (ACV) appliquée aux produits bois : bilan énergétique et prise en compte du carbone biomasse », Claire Cornillier, Estelle Vial, FCBA, 2008

3.3. PRODUCT STAGE (A1-A3)

3.3.1. General assumptions

- Transports: the formula used in the FD P01-015 has been used. It considers a 24T capacity truck, 100% loaded, with a 30% empty return rate. The amount of diesel combusted is calculated with the following formula:

38/100*km*(1/3*Cr/24+2/3+(2/3)*0,3)*N

Where:

km: transport distance
Cr (kg): truck load (24T in case of a 100% load)
Q (kg) mass of the transported goods
N=Q/Cr: number of trucks necessary to transport the quantity Q.

- Energy mix: The Turkish energy mix from 2005 has been used, as the product is manufactured in Turkey. It has the following characteristics: Coal: 28.58% - Fuel Oil: 2.47% - Natural Gas: 49.33% - Biofuels: 0.13% - Waste incineration: 0.05% - Hydro: 18.46% - Wind: 0.22% - Import: 0.42% - Distribution losses: 14.88% - Efficiencies: Coal: 35%/Oil: 35.3%/Natural Gas: 54.6%/Hydro: 90%.

- Packaging wastes: the upstream packaging wastes have been considered as being landfilled, as no information is available concerning Turkish end of life ratio of packaging wastes. The downstream packaging wastes have been assessed based on French end of life potentials. The transport of wastes is based on the FD P01-015 (30 km by truck for non-hazardous wastes, and 100 km by truck for hazardous wastes).

- Based on the modularity principle, all impacts are allocated to the module where they are generated. It is mainly the case concerning process wastes where the production, transport and end of life impacts are allocated at the step when the wastes are generated. Example concerning the 68s: the transport and production of 2.7kg of wood is considered in the “cutting” step, and 7.3kg is considered in the “profiling/sizing” step.

- Due to their low environmental significance, and the difficulty to trace their impact, the transformation processes of small elements (screws, seals, etc.) have been neglected. The material productions, transports and wastes have been taken into account.

3.3.2. Glued laminated timber supplying

- Conservative hypothesis: The glue is water based polyvinyl acetate. As the water/polyvinyl acetate ratio is unknown, it has been considered to be entirely polyvinyl acetate.

- Hypothesis: no polyvinyl acetate dataset was available. The vinyl acetate dataset has been used. Vinyl acetate is a precursor of polyvinyl acetate.

3.3.3. Cutting

- No specific hypothesis.

3.3.4. Profiling

- No specific hypothesis.

3.3.5. Pressing

- Conservative hypothesis: The glue is water based polyvinyl acetate. As the water/polyvinyl acetate ratio is unknown, it has been considered to be entirely polyvinyl acetate.
- Hypothesis: no polyvinyl acetate dataset was available. The vinyl acetate dataset has been used. Vinyl acetate is a precursor of polyvinyl acetate.

3.3.6. Aluminium supplying *(68f only)*

- Conservative hypothesis: Due to the lack of data, the upstream transport distance of the aluminium has been considered as being a continental transport (3,500 km by truck)

3.3.7. Cutting *(68f only)*

- No specific hypothesis.

3.3.8. Glass supplying

- No specific hypothesis.

3.3.9. Mechanical parts supplying

- No specific hypothesis.

3.3.10. Paint/varnish supplying

- The material composition of the materials has been assessed as follow:
  - Organic polymer is assessed with the "Unspecified organic chemicals" data due to the lack of specific data
  - Biocide is assessed with the "Unspecified organic chemicals" data due to the lack of specific data
  - Inorganic compound is assessed with the "Unspecified inorganic chemicals" data due to the lack of specific data
  - Organic compound is assessed with the "Unspecified organic chemicals" data due to the lack of specific data
  - Volatile organic compound is assessed with the "Unspecified organic chemicals" data due to the lack of specific data
  - Water is assessed with the "Water consumption; for process" data
  - Mineral is assessed with the "Titanium dioxide" data as titanium dioxide is the most common pigment for white paint

- The wastes are considered to be steel buckets. The bucket production and transport have been added.

3.3.11. Painting/varnishing

- The process losses are considered for the primer and the paint, respectively 20% (0.043 kg) and 8.5% (0.095 kg). Losses wastes are considered dangerous and treated accordingly.

- The remaining water and VOC (after process losses) are considered as being evaporated during and after the painting phase. VOC and water have been considered as process losses and corresponding VOC emissions have been accounted for. The quantity of water and VOC is as follow, for both products:

- TEKNOS AQUA 1410-01 Colorless
  - Water: 0.130 kg
  - VOC: 1.236E-3 kg
- ANTISTAIN AQUA 2901-52
  - Water: 0.104 kg
  - VOC: 5.05E-4 kg
- AQUATOP 2600-82 RAL 9010
  - Water: 0.605 kg
  - VOC: 0.0254 kg

3.3.12. Assemblying

- The gear and hinge screwing have been neglected due to the lack of information regarding the amount of compressed air or the related energy consumption. It is considered to have little environmental significance.

3.3.13. Paletizing

- We consider that the packaging is used to transport only one window (conservative hypothesis).

3.3.14. Storage

- No specific hypothesis.

3.4. CONSTRUCTION PROCESS STAGE (A4-A5)

3.4.1. Distribution

The distribution is separated in two phases: from plant to distribution center, and from distribution center to construction site. Both phases have been assessed

- Concerning the first step, 5 different destinations are filled out: France, Germany, UK, Belgium and Algeria. Within this study, we considered that the window is distributed to France as the environmental declaration is targeting a French audience. It implies that only the French distribution has been taken into account, at a 100% rate.

- Concerning the second steps, all destinations have been taken into account based on their sales ratio.

3.4.2. Installation

Three different installation processes are possible. All three have been considered in this study, based on their application rate.

- Hypothesis: all three processes imply the use of a 5kg wood pallet. Considering the amount of material to be transported, this pallet is most likely either reused, or used to transport more products at the same time. For that reason, it has been decided not to take it into account.

- Hypothesis: addition of a French electricity consumption corresponding to the drill : 150Wh (considering a 900W drill for 10 minutes)

3.5. USE STAGE (B1-B7)

3.5.1. Cleaning

- Hypothesis: we consider that the cleaning process varies deeply depending on the installation configuration and final client wishes. Therefore it has not been taken into account in this study.

3.5.2. Varnishing

- Hypothesis: it is considered that the windows have to be varnished once during their life span. It has been considered one varnish every 5 years, based on the BRONNER documentation (2012)
- Hypothesis: the truck is considered to have an 8L/100km consumption of diesel[5].
- Hypothesis: we consider that the whole truck is dedicated to the varnishing of one window.
- Hypothesis: we consider the same varnish as in the product stage (TEKNOS AQUA 1410-01 Colorless). No losses, water and VOC evaporates (1.236E-3 kg VOC and 1.236E-1 kg water per varnishing).

3.6. END-OF-LIFE STAGE (C1-C4)

3.6.1. Deconstruction

- The deconstruction operation is considered to not generate any environmental impact.

3.6.2. Transport

- 30 km by truck, based on FD P 01-015 for non-hazardous wastes

3.6.3. Waste processing for reuse, recovery and recycling & Disposal

- End of life has been considered to be 100% landfill of non-hazardous wastes, considering elimination in France, with actual technologies.

3.7. LIFE-CYCLE INVENTORY AND DATA QUALITY FOR BOTH PRODUCTS

The representativity ranking is from 1 to 5, 1 being the best and 5 the worst. NE stands for non-evaluated, and implies a note of 5 by default.
Overall, the geographical representativities have bad marks as few data are available for Turkish production.

3.7.1. A1-A3

Collected data	LCI data in EIME 5.5	Source	Representativity		
			Technical	Geographical	Temporal
Wood	Pine wood; timber; production mix, at saw mill; 40% water content; DE	ELCD	1	2	2
Glue	Vinyl Acetate; at plant; CN	CODDE	4	5	4
PE film	Polyethylene low density (PE-LD) film; production mix, at plant; RER	CODDE	1	5	3
Wood pallet	Plain wood; for pallet; to manufacturing site; 42% maritime pine, 32% poplar and 26% scot pine; FR	CODDE	1	5	5

[5] Source: http://www.developpement-durable.gouv.fr/IMG/pdf/CS310.pdf

Transport by truck	Diesel oil combustion; in engine, including diesel oil production; consumption mix, at consumer; 42 MJ/kg net calorific value; RER	CODDE	1	5	5
Landfill of plastic	Landfill of plastic waste; landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	5	3
Landfill of wood pallet	Landfill of untreated wood; landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	5	3
Electricity - Turkey	Electricity mix; AC; consumption mix, at consumer; 230V; TR	CODDE	1	1	3
Landfill of wood	Landfill of wood products (OSB, particle board); landfill including landfill gas utilisation 3and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	5	
Aluminium	Aluminium; primary production; production mix, at plant; RER	CODDE	1	5	2
Landfill of aluminium	Landfill of ferro metals; landfill including leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	3	5	3
Glass	Glass; for windows; 18,7% recycled; production mix, at plant; RER	CODDE	1	5	5
Expandable plastic	Polystyrene (PS); in expandable form; production mix, at plant; RER	CODDE	1	5	3
Steel	Stainless steel; primary production; 15% Cr; RER	CODDE	1	5	3
Cardboard	Corrugated cardboard; 5 layers; production mix, at plant; 85% recycled; RER	CODDE	1	5	2
Landfill of cardboard	Landfill of packaging cardboard (19.6% water content); landfill including air, water emissions, flue gas cleaning and leachate treatment; technology mix, at landfill site; RER	CODDE	1	5	5
TEKNOS AQUA 1410-01 Colorless - Organic polymer	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
TEKNOS AQUA 1410-01 Colorless - Biocide	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
TEKNOS AQUA 1410-01 Colorless - Inorganic compound	Unspecified inorganic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
TEKNOS AQUA 1410-01 Colorless - Organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
TEKNOS AQUA 1410-01 Colorless - Volatile organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
TEKNOS AQUA 1410-01 Colorless - water	Water consumption; for process; consumption mix, at consumer; 1L; TR	CODDE	1	1	
ANTISTAIN AQUA 2901-52 - Organic	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4

polymer					
ANTISTAIN AQUA 2901-52 - Biocide	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
ANTISTAIN AQUA 2901-52 - Mineral	Titanium dioxide (TiO2) powder; chlorine process, from ilmenite; production mix, at plant; RER	CODDE	2	5	5
ANTISTAIN AQUA 2901-52 - Organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
ANTISTAIN AQUA 2901-52 - Volatile organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
ANTISTAIN AQUA 2901-52 - Water	Water consumption; for process; consumption mix, at consumer; 1L; TR	CODDE	1	1	4
AQUATOP 2600-82 RAL 9010 - Organic polymer	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
AQUATOP 2600-82 RAL 9010 - Inorganic compound	Unspecified inorganic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
AQUATOP 2600-82 RAL 9010 - Organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
AQUATOP 2600-82 RAL 9010 - Volatile Organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
AQUATOP 2600-82 RAL 9010 - Mineral	Titanium dioxide (TiO2) powder; chlorine process, from ilmenite; production mix, at plant; RER	CODDE	2	5	5
AQUATOP 2600-82 RAL 9010 - Water	Water consumption; for process; consumption mix, at consumer; 1L; TR	CODDE	1	1	4
AQUATOP 2600-82 RAL 9010 - Biocide	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	5	4
Bucket	Stainless steel; primary production; 15% Cr; RER	CODDE	1	5	3
Landfill of paint	Landfill of paint waste (0% water content); landfill including air, water emissions, flue gas cleaning and leachate treatment; technology mix, at landfill site; RER	CODDE	1	5	5
Incineration of paint	Waste incineration of paint waste (0% water content); incineration including air, water emissions and flue gas cleaning; technology mix, at incineration site; RER	CODDE	1	5	5
Recycling	Waste recycling; in compliance with stock method; GLO	CODDE	1	1	1
VOC emissions	Elementary flow / Emissions / Emissions to air / Emissions to air, unspecified / volatile organic compound	ELCD	1	1	1
Screws	Stainless steel; primary production; 15% Cr; RER	CODDE	1	5	3
Silicone	Silicone rubber; catalyzed polymerisation; production mix, at plant; US	CODDE	2	5	5
Nails	Stainless steel; primary production; 15% Cr; RER	CODDE	1	5	3

Seals	Styrene Butadiene Rubber (SBR); production mix, at plant; RER	CODDE	1	5	5
Corner protection parts	Aluminium; 48% recycled from clean scrap; production mix, at plant; RER	CODDE	1	5	2
Plastic clips	Polyamide resin 6.6 (PA 6.6); production mix, at plant; without additives; RER	CODDE	2	5	3
Bubble pack	Polyethylene low density (PE-LD) film; production mix, at plant; RER	CODDE	1	5	3
OSB box	Oriented Strand Board; OSB III; production mix, at plant; 4,8% water content; EU-27	CODDE	1	5	3
Wooden support	Plain wood; for pallet; to manufacturing site; 42% maritime pine, 32% poplar and 26% scot pine; FR	CODDE	1	5	5

Table 10 – Life-cycle inventories – A1-A3

3.7.1. A4

Collected data	LCI data in EIME 5.5	Source	Representativity		
			Technical	Geographical	Temporal
Transport by truck	Diesel oil combustion; in engine, including diesel oil production; consumption mix, at consumer; 42 MJ/kg net calorific value; RER	CODDE	1	3	5

Table 11 – Life-cycle inventories – A4

3.7.1. A5

Collected data	LCI data in EIME 5.5	Source	Representativity		
			Technical	Geographical	Temporal
Compribande	Polyurethane (PU) flexible foam; production mix, at plant; RER	CODDE	1	2	3
Shelf bracket	Stainless steel; primary production; 15% Cr; RER	CODDE	1	2	3
Silicone	Silicone rubber; catalyzed polymerisation; production mix, at plant; US	CODDE	2	5	5
Screw	Stainless steel; primary production; 15% Cr; RER	CODDE	1	2	3
EPDM strip	Ethylene Propylene Diene copolymer (EPDM); from ethylene, propylene and ethylidene norbornene; production mix, at plant; US	CODDE	1	5	5
Cardboard	Corrugated cardboard; 5 layers; production mix, at plant; 85% recycled; RER	CODDE	1	2	2
PE film	Polyethylene low density (PE-LD) film; production mix, at plant; RER	CODDE	1	2	3
Recycling	Waste recycling; in compliance with stock method; GLO	CODDE	1	1	1
Incineration of cardboard	Waste incineration of packaging cardboard (19.6% water content); incineration including air, water emissions and flue gas cleaning; technology mix, at incineration site; RER Waste incineration with energy recovery; in compliance with stock method; GLO	ELCD CODDE	1	2	5
Incineration of PE film	Waste incineration of plastics (PE, PP, PS, PB); average European waste-to-energy plant, without collection, transport and pre-treatment; at plant; EU-27 Waste incineration with energy recovery; in compliance with stock method; GLO	ELCD CODDE	1	2	3
Transport by truck	Diesel oil combustion; in engine, including diesel oil production; consumption mix, at consumer; 42 MJ/kg net calorific value; RER	CODDE	1	2	5
Drill electricity	Electricity Mix; AC; consumption mix, at consumer; 230V; FR	ELCD	1	1	3
Incineration of wood product	Waste incineration of untreated wood (10,7% water content); average European waste-to-	ELCD	1	2	3

	energy plant, without collection, transport and pre-treatment; at plant; EU-27 Waste incineration with energy recovery; in compliance with stock method; GLO	CODDE			

Table 12 – Life-cycle inventories – A5

3.7.1. B3

Collected data	LCI data in EIME 5.5	Source	Representativity		
			Technical	Geographical	Temporal
Transport	Diesel oil combustion; in engine, including diesel oil production; consumption mix, at consumer; 42 MJ/kg net calorific value; RER	CODDE	1	2	5
Varnish - Organic polymer	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	2	4
Varnish - Biocide	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	2	4
Varnish - Inorganic compound	Unspecified inorganic chemicals; average production; production mix, at plant; RER	CODDE	4	2	4
Varnish - Organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	2	4
Varnish - Volatile organic compound	Unspecified organic chemicals; average production; production mix, at plant; RER	CODDE	4	2	4
Varnish - water	Water consumption; for process; consumption mix, at consumer; 1L; FR	CODDE	1	1	3
VOC emissions	Elementary flow / Emissions / Emissions to air / Emissions to air, unspecified / volatile organic compound	ELCD	1	1	1

Table 13 – Life-cycle inventories – B3

3.7.1. C2

Collected data	LCI data in EIME 5.5	Source	Representativity		
			Technical	Geographical	Temporal
Transport by truck	Diesel oil combustion; in engine, including diesel oil production; consumption mix, at consumer; 42 MJ/kg net calorific value; RER	CODDE	1	2	5

Table 14 – Life-cycle inventories – C2

3.7.1. C4

Collected data	LCI data in EIME 5.5	Source	Representativity		
			Technical	Geographical	Temporal
Painted wood - Landfill	Landfill of wood products (OSB, particle board); landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3
Glass – Landfill	Landfill of glass/inert waste; landfill including leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3
Steel – Landfill	Landfill of ferro metals; landfill including leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3
Silicone – Landfill	Landfill of plastic waste; landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3
Compribande –	Landfill of plastic waste; landfill including landfill	ELCD	1	2	3

Landfill	gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27				
Seal – Landfill	Landfill of plastic waste; landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3
Aluminium – Landfill	Landfill of ferro metals; landfill including leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3
Polyamide - Landfill	Landfill of plastic waste; landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site; EU-27	ELCD	1	2	3

Table 15 – Life-cycle inventories – C4

4. ENVIRONMENTAL ANALYSIS OF THE PRODUCTION PROCESSES OF THE WINDOWS

Note: LCIA results are relative expressions and do not predict final category impacts, threshold level compliance and security margins.

The impact results have been calculated thanks to the NF EN 15804+A1 and the NF EN 15804+CN characterisation factor lists, with the addition of specific contributing flows to take into account additional substances that were not taken into account by the standard. Those additions have been audited by the CSTB during the CaSIE² project.

4.1. Analysis of 68s

Impact and flow indicators are calculated in compliance with NF EN 15804 +CN and DHUP decree. The environmental impacts of 68s wooden window are presented in the tables below:

4.1.1. Environmental impacts

Indicator	Global warming	Ozone depletion	Acidification of soil and water	Eutrophication	Photochemical ozone creation	Depletion of abiotic resources - elements	Depletion of abiotic resources - fossil fuels	Air pollution	Water pollution
	kg CO2-eq	kg CFC11-eq	kg SO2-eq	kg PO43- -eq	kg C2H4-eq	kg Sb-eq	MJ	m3	m3
Product stage	3.18E+01	1.10E-05	7.03E-02	1.73E-02	8.29E-03	1.21E-03	5.67E+02	6.98E+03	4.00E+03
Construction stage	1.21E+01	6.61E-06	5.39E-02	1.38E-02	1.81E-03	6.59E-05	1.26E+02	1.46E+03	1.66E+03
Use stage	1.63E+01	1.19E-05	9.90E-02	2.61E-02	2.90E-03	9.86E-09	2.13E+02	2.60E+03	2.48E+03
End-of-life stage	1.42E+01	3.78E-08	1.53E-03	4.58E-03	3.47E-03	1.45E-08	3.64E+00	9.09E+01	2.99E+01
Total	**7.44E+01**	**2.95E-05**	**2.25E-01**	**6.19E-02**	**1.65E-02**	**1.28E-03**	**9.11E+02**	**1.11E+04**	**8.17E+03**

Table 16 - Environmental impacts of 68s

4.1.2. Resource use impacts

Indicator	Use of renewable primary energy excluding renewable primary energy resources used as raw materials	Use of renewable primary energy resources used as raw materials	Total use of renewable primary energy resources	Use of non renewable primary energy excluding renewable primary energy resources used as raw materials	Use of non renewable primary energy resources used as raw materials	Total use of non renewable primary energy resources	Use of seconday material	Use of renewable secondary fuel	Use of non renewable secondary fuel	Net use of fresh water
	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m3
Product stage	5.03E+02	4.66E+02	9.69E+02	6.00E+02	9.91E+01	6.99E+02	2.31E+00	1.26E+00	0.00E+00	2.39E-01
Construction stage	3.79E-01	1.48E-01	5.27E-01	1.29E+02	3.69E+00	1.32E+02	4.67E-02	0.00E+00	0.00E+00	8.96E-01
Use stage	3.32E-03	0.00E+00	3.32E-03	2.13E+02	1.47E+00	2.14E+02	0.00E+00	0.00E+00	0.00E+00	2.09E-02
End-of-life stage	1.40E-01	0.00E+00	1.40E-01	3.88E+00	0.00E+00	3.88E+00	0.00E+00	0.00E+00	0.00E+00	3.38E-04
Total	**5.04E+02**	**4.66E+02**	**9.70E+02**	**9.45E+02**	**1.04E+02**	**1.05E+03**	**2.36E+00**	**1.26E+00**	**0.00E+00**	**1.16E+00**

Table 17 - Energetic and resource impacts of 68s

4.1.3. Other environmental information describing waste categories

Indicator	Hazardous waste disposed	Non hazardous waste disposed	Radioactive waste disposed	Components for re-use	Materials for recycling	Materials for energy recovery	Exported energy
	kg	kg	kg	kg	kg	kg	MJ
Product stage	8.86E+01	9.84E+00	5.62E-03	0.00E+00	4.95E-03	0.00E+00	1.07E-01
Construction stage	4.87E+00	1.61E+01	2.65E-03	0.00E+00	5.88E+00	0.00E+00	0.00E+00
Use stage	1.58E-02	1.26E-01	3.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
End-of-life stage	3.36E-03	1.54E+01	9.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	**9.35E+01**	**4.15E+01**	**1.17E-02**	**0.00E+00**	**5.88E+00**	**0.00E+00**	**1.07E-01**

Table 18 - Waste and output impacts of 68s

4.1.4. Breakdown of impacts

The following contribution analysis aims at identifying the sub-elements the most contributing to the manufacturing stage of the product:

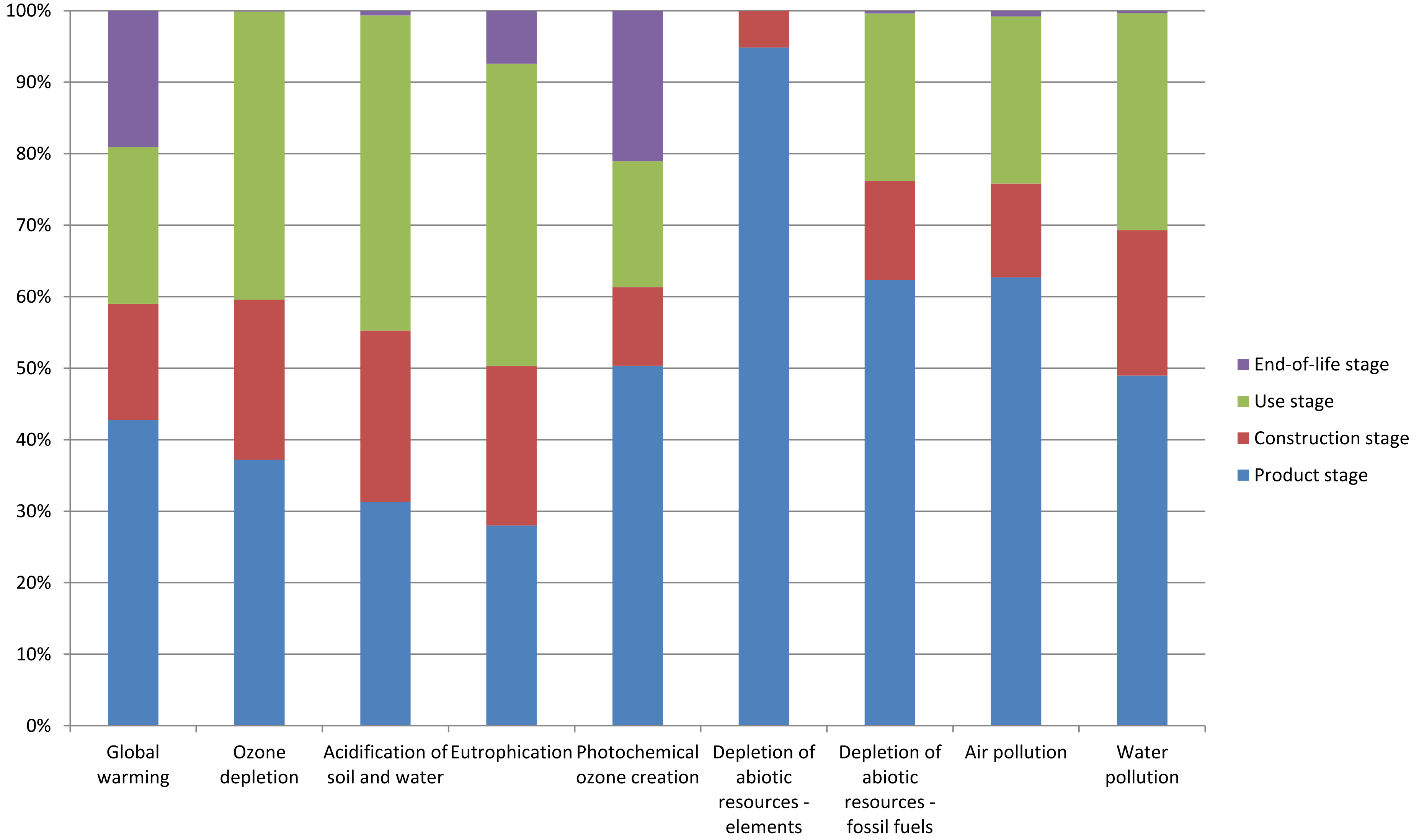

Figure 2 - Contributing elements to the impacts of the manufacturing stage of 68s

This first-level detail shows the importance related to the production phase, but also that other phases are not negligible. In order to identify the causes of the environmental impacts, it is necessary to detail this assessment, as presented in the table below.

Indicator			Global warming	Ozone depletion	Acidification of soil and water	Eutrophication	Photochemical ozone creation	Depletion of abiotic resources - elements	Depletion of abiotic resources - fossil fuels	Air pollution	Water pollution
			kg CO_2-eq	kg CFC11-eq	kg SO_2-eq	kg PO_4^{3-} -eq	kg C_2H_4-eq	kg Sb-eq	MJ	m3	m3
Production phase	A1-A3	Glued laminated timber supplying	-8.59E+00	9.07E-07	7.57E-03	2.00E-03	4.50E-04	2.81E-08	2.61E+01	2.21E+02	2.11E+02
		Cutting	8.50E-01	1.26E-07	1.20E-03	3.05E-04	5.96E-04	2.38E-09	3.32E+00	3.34E+01	3.04E+01
		Profiling	4.12E+00	4.01E-07	4.75E-03	1.23E-03	1.92E-03	2.34E-08	3.85E+01	2.20E+02	1.46E+02
		Pressing/sizing	1.20E-01	3.71E-08	1.09E-04	3.74E-05	4.69E-05	1.11E-09	2.79E+00	1.09E+01	1.06E+01
		Glass supplying	1.08E+01	4.98E-06	1.87E-02	4.99E-03	1.40E-03	5.50E-07	1.39E+02	2.21E+03	2.27E+03
		Mechanical parts supplying	8.18E+00	2.20E-06	1.52E-02	2.48E-03	1.58E-03	1.14E-03	9.66E+01	1.85E+03	2.66E+02
		Paint/varnish supply	2.39E+00	3.75E-07	2.80E-03	9.63E-04	4.19E-04	4.85E-05	3.23E+01	1.31E+03	1.31E+02
		Painting/varnishing	5.51E-01	3.69E-08	4.49E-04	6.82E-04	9.55E-05	1.17E-08	9.08E+00	4.15E+02	3.19E+01
		Assemblying	1.88E+00	1.29E-06	2.21E-03	5.50E-04	2.90E-04	2.25E-05	4.72E+01	1.46E+02	3.39E+02
		Paletizing	1.15E+01	6.21E-07	1.73E-02	4.11E-03	1.50E-03	8.18E-07	1.73E+02	5.67E+02	5.62E+02
		Storage	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Construction phase	A4	Transport	6.60E+00	4.83E-06	4.03E-02	1.06E-02	1.18E-03	1.25E-09	8.61E+01	1.04E+03	1.01E+03
	A5	Installation process	5.46E+00	1.78E-06	1.36E-02	3.20E-03	6.34E-04	6.59E-05	4.01E+01	4.15E+02	6.47E+02
Use phase	B3	Repair	1.63E+01	1.19E-05	9.90E-02	2.61E-02	2.90E-03	9.86E-09	2.13E+02	2.60E+03	2.48E+03
End of life phase	C2	Transport	4.22E-02	3.09E-08	2.58E-04	6.80E-05	7.53E-06	7.98E-12	5.51E-01	6.64E+00	6.44E+00
	C4	Elimination	1.42E+01	6.88E-09	1.27E-03	4.51E-03	3.46E-03	1.45E-08	3.09E+00	8.43E+01	2.35E+01
		Total	**7.44E+01**	**2.95E-05**	**2.25E-01**	**6.19E-02**	**1.65E-02**	**1.28E-03**	**9.11E+02**	**1.11E+04**	**8.17E+03**

Table 19 - Detailed contribution of the life cycle impacts of 68s

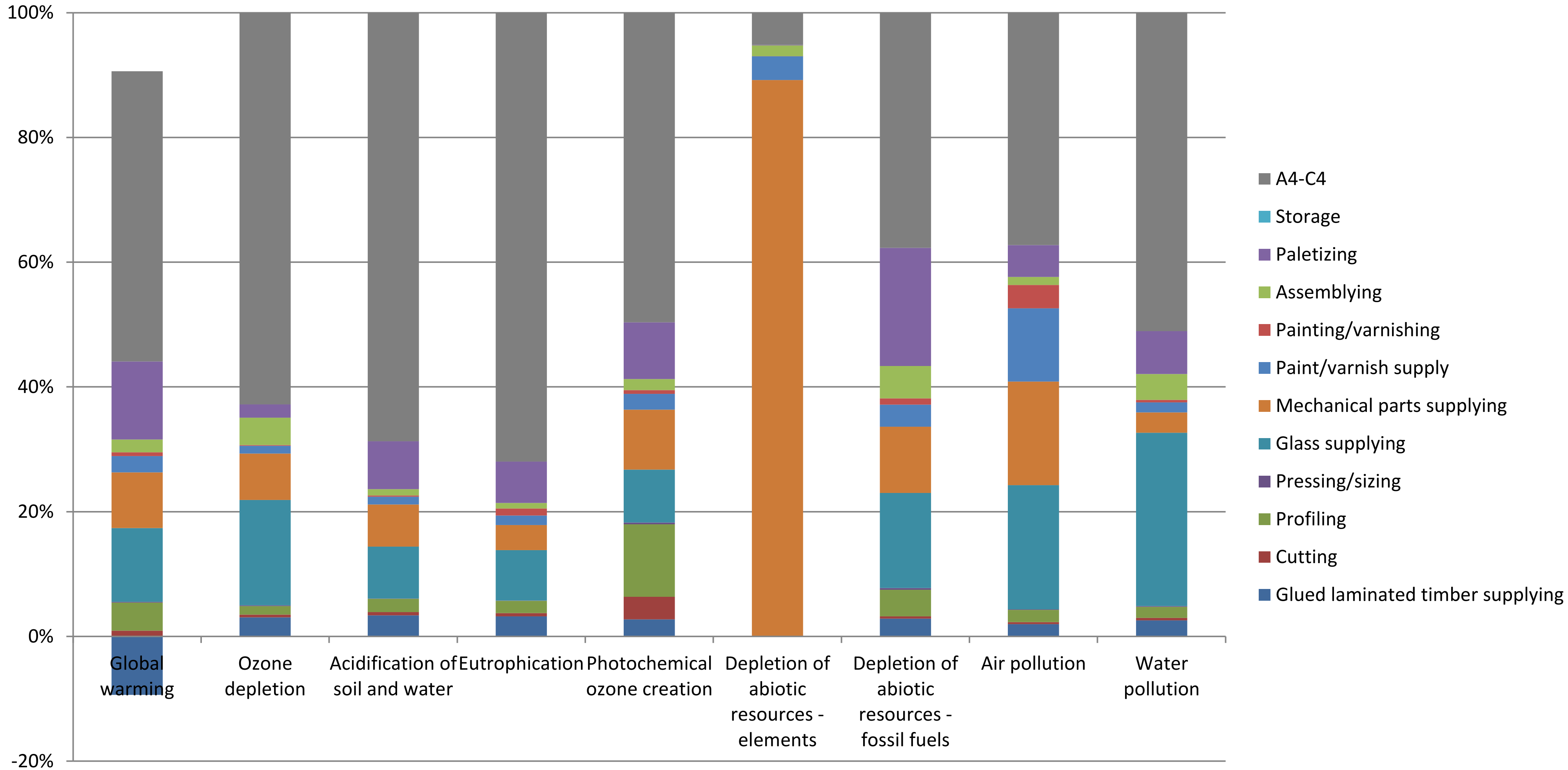

Figure 3 - Detailed contribution of the life cycle impacts of 68s – Production phase

This contribution analysis shows that most elements have a non-negligible environmental impact. Globally, the material supplying causes the most impact due to the material production processes.

In details, the mechanical parts supplying causes most of the impacts on the abiotic depletion. This is caused by the rare materials used in the stainless steel alloy, such as molybdenum.

Furthermore, the material supplying generates more impacts than the processes.

The wood, despite being the most used material in terms of mass, generates little impact as its production necessitates few materials and little energy.

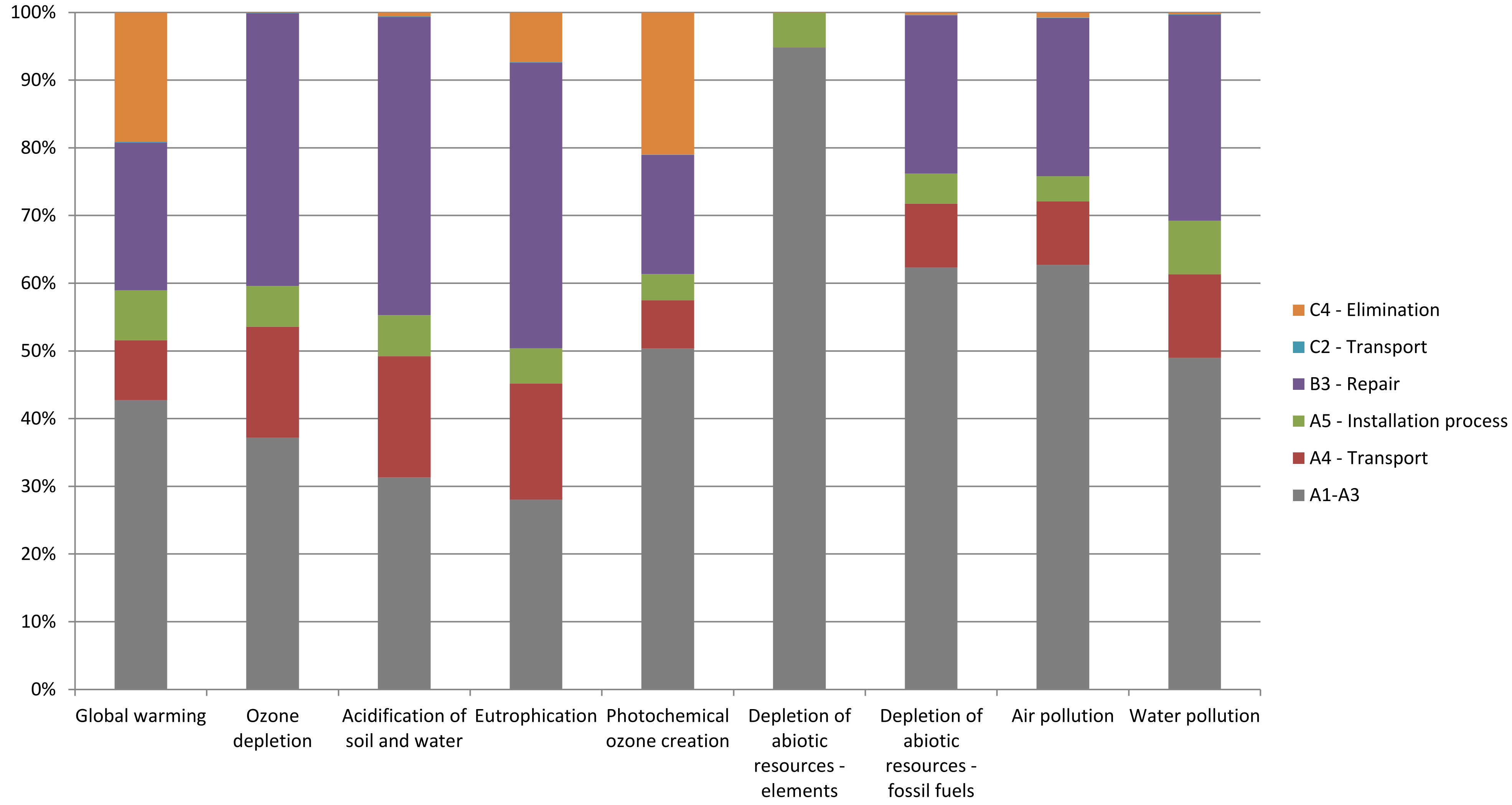

Figure 4 - Detailed contribution of the life cycle impacts of 68s – Other phases

Concerning the other phases, even though the global impacts are lower, they are not negligible.
We can notice that the transports phases have overall a significant impact. The following part focusses on that.
The table and graph below separate the impacts coming from the different transports (upstream, intermediary and downstream transports as well as waste transports) from other impacts.

Indicator			Global warming	Ozone depletion	Acidification of soil and water	Eutrophication	Photochemical ozone creation	Depletion of abiotic resources - elements	Depletion of abiotic resources - fossil fuels	Air pollution	Water pollution
			kg CO_2-eq	kg CFC11-eq	kg SO_2-eq	kg PO_4^{3-} -eq	kg C_2H_4-eq	kg Sb-eq	MJ	m3	m3
Production phase	A1-A3	Transport	1,99E+00	1,46E-06	1,22E-02	3,21E-03	3,55E-04	3,77E-10	2,60E+01	3,14E+02	3,04E+02
		Other	2,98E+01	9,51E-06	5,82E-02	1,41E-02	7,93E-03	1,21E-03	5,41E+02	6,67E+03	3,69E+03
Construction phase	A4-A5	Transport	7,99E+00	5,85E-06	4,87E-02	1,29E-02	1,42E-03	1,51E-09	1,04E+02	1,26E+03	1,22E+03
		Other	4,08E+00	7,65E-07	5,17E-03	9,64E-04	3,86E-04	6,59E-05	2,20E+01	1,97E+02	4,35E+02
Use phase	B3	Transport	1,62E+01	1,19E-05	9,89E-02	2,61E-02	2,89E-03	3,07E-09	2,11E+02	2,55E+03	2,47E+03
		Other	6,96E-02	6,70E-09	7,74E-05	2,13E-05	1,22E-05	6,80E-09	2,01E+00	4,96E+01	9,58E+00
End of life phase	C2-C4	Transport	4,22E-02	3,09E-08	2,58E-04	6,80E-05	7,53E-06	7,98E-12	5,51E-01	6,64E+00	6,44E+00
		Other	1,42E+01	6,88E-09	1,27E-03	4,51E-03	3,46E-03	1,45E-08	3,09E+00	8,43E+01	2,35E+01

Table 20 - Detailed contribution of the transport steps of 68s

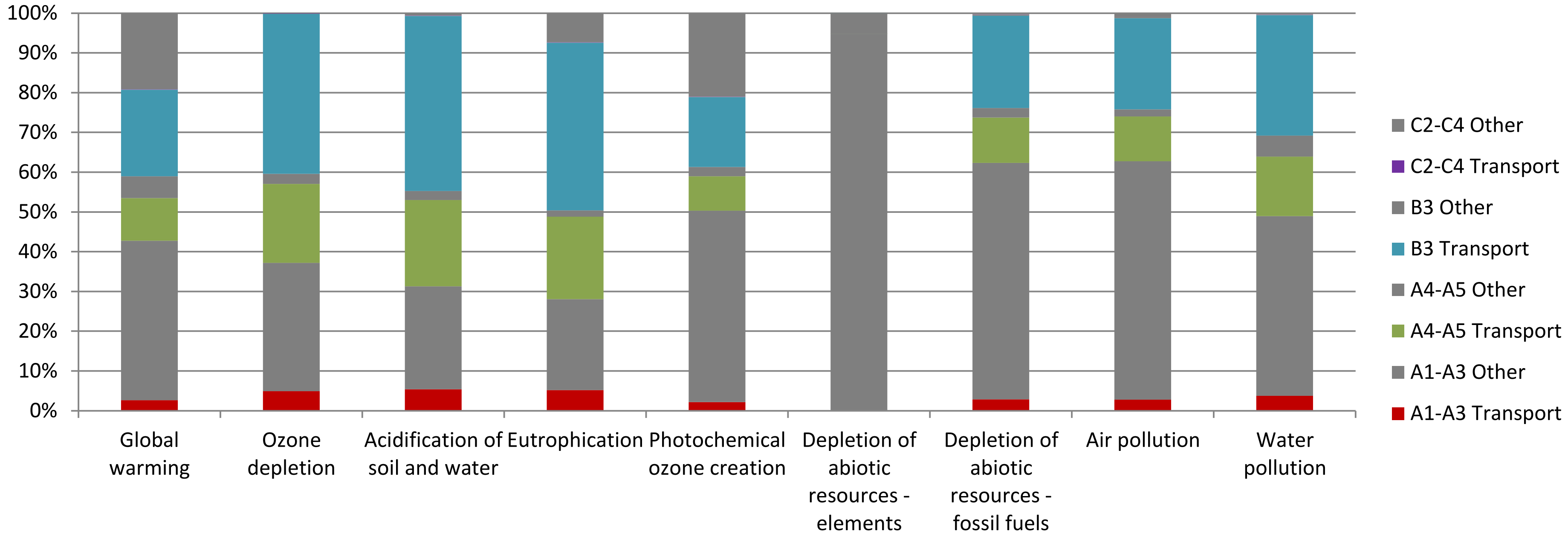

Figure 5 - Detailed contribution of the life cycle impacts of 68s – Focus on the transports

We can see that the overall transport is significant, up to 73% of impacts. It mainly concerns 2 steps: the use phase and the construction phase transports. The use phase transport is high due to the conservative hypothesis and is likely to be much below in reality, but the production phase transport is based on primary data and therefore is accurate.

4.2. ANALYSIS OF 68F

Impact and flow indicators are calculated in compliance with NF EN 15804 +CN and DHUP decree. The environmental impacts of 68f wooden window are presented in the tables below:

4.2.1. Environmental impacts

Indicator	Global warming	Ozone depletion	Acidification of soil and water	Eutrophication	Photochemical ozone creation	Depletion of abiotic resources - elements	Depletion of abiotic resources - fossil fuels	Air pollution	Water pollution
	kg CO2-eq	kg CFC11-eq	kg SO2-eq	kg PO43- -eq	kg C2H4-eq	kg Sb-eq	MJ	m3	m3
Product stage	5.22E+01	1.52E-05	1.86E-01	2.46E-02	1.46E-02	1.21E-03	7.97E+02	8.88E+03	5.19E+03
Construction stage	1.21E+01	6.66E-06	5.43E-02	1.39E-02	1.82E-03	6.59E-05	1.27E+02	1.47E+03	1.67E+03
Use stage	1.63E+01	1.19E-05	9.90E-02	2.61E-02	2.90E-03	9.86E-09	2.13E+02	2.60E+03	2.48E+03
End-of-life stage	1.23E+01	3.95E-08	1.65E-03	5.34E-03	2.99E-03	1.64E-08	4.02E+00	9.52E+01	3.25E+01
Total	**9.29E+01**	**3.38E-05**	**3.41E-01**	**7.00E-02**	**2.24E-02**	**1.28E-03**	**1.14E+03**	**1.30E+04**	**9.37E+03**

Table 21 - Environmental impacts of 68f

4.2.2. Resource use impacts

Indicator	Use of renewable primary energy excluding renewable primary energy resources used as raw materials	Use of renewable primary energy resources used as raw materials	Total use of renewable primary energy resources	Use of non renewable primary energy excluding renewable primary energy resources used as raw materials	Use of non renewable primary energy resources used as raw materials	Total use of non renewable primary energy resources	Use of seconday material	Use of renewable secondary fuel	Use of non renewable secondary fuel	Net use of fresh water
	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m3
Product stage	5.40E+02	4.46E+02	9.86E+02	9.32E+02	1.02E+02	1.03E+03	2.37E+00	1.16E+00	0.00E+00	3.47E-01
Construction stage	3.79E-01	1.48E-01	5.27E-01	1.29E+02	3.69E+00	1.33E+02	4.37E-02	0.00E+00	0.00E+00	8.40E-02
Use stage	3.32E-03	0.00E+00	3.32E-03	2.13E+02	1.47E+00	2.14E+02	0.00E+00	0.00E+00	0.00E+00	2.09E-02
End-of-life stage	1.50E-01	0.00E+00	1.50E-01	4.29E+00	0.00E+00	4.29E+00	0.00E+00	0.00E+00	0.00E+00	3.72E-04
Total	**5.41E+02**	**4.46E+02**	**9.87E+02**	**1.28E+03**	**1.07E+02**	**1.39E+03**	**2.41E+00**	**1.16E+00**	**0.00E+00**	**4.52E-01**

Table 22 - Energetic and resource impacts of 68f

4.2.3. Other environmental information describing waste categories

Indicator	Hazardous waste disposed	Non hazardous waste disposed	Radioactive waste disposed	Components for re-use	Materials for recycling	Materials for energy recovery	Exported energy
	kg	kg	kg	kg	kg	kg	MJ
Product stage	9.05E+01	5.34E+01	4.07E-02	0.00E+00	7.69E-03	0.00E+00	1.07E-01
Construction stage	4.87E+00	1.61E+01	2.66E-03	0.00E+00	5.88E+00	0.00E+00	0.00E+00
Use stage	1.58E-02	1.26E-01	3.39E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
End-of-life stage	3.45E-03	1.73E+01	1.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	**9.54E+01**	**8.70E+01**	**4.69E-02**	**0.00E+00**	**5.88E+00**	**0.00E+00**	**1.07E-01**

Table 23 - Waste and output impacts of 68f

4.2.4. Breakdown of impacts

The following contribution analysis aims at identifying the sub-elements the most contributing to the manufacturing stage of the product:

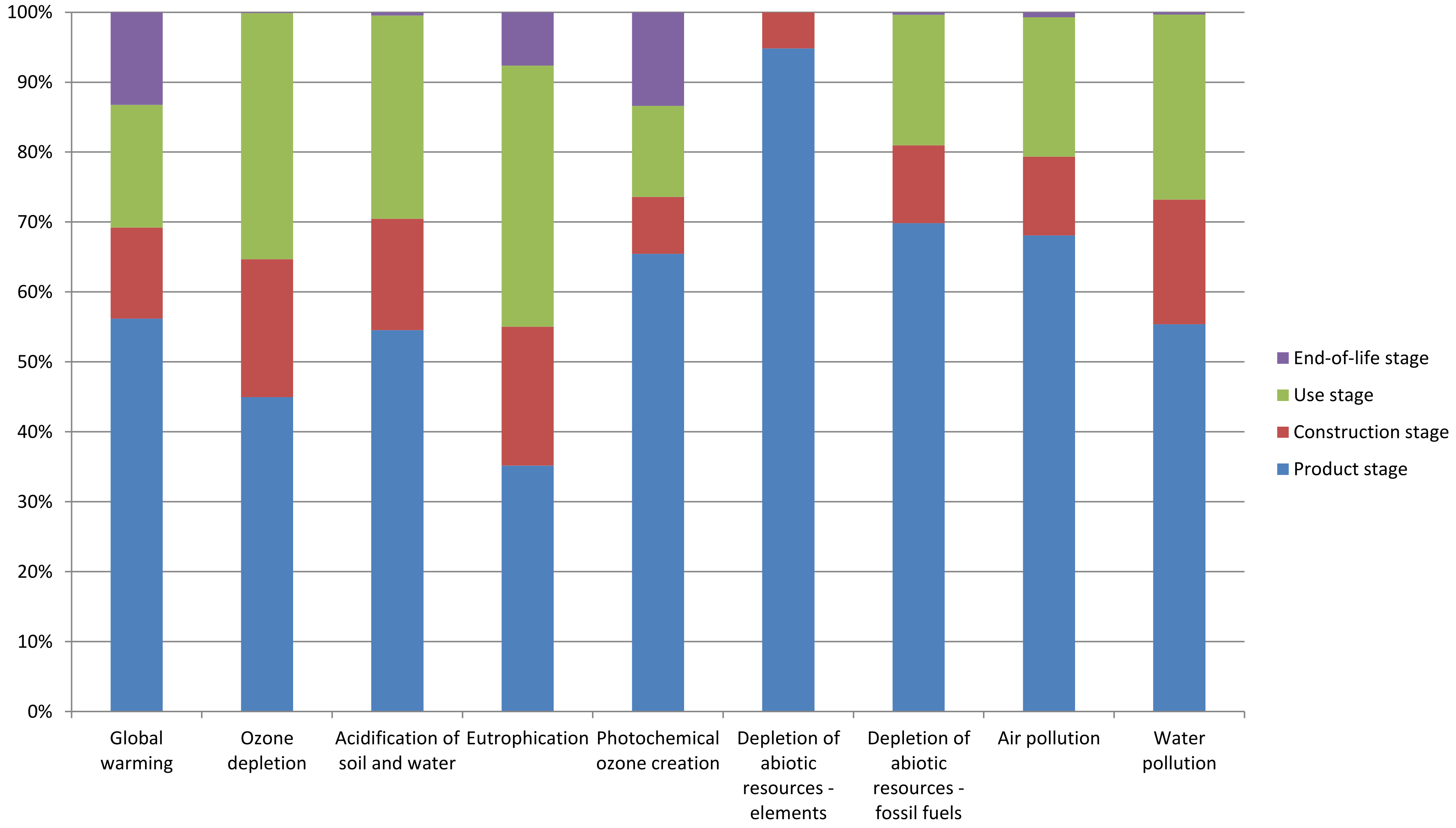

Figure 6 - Contributing elements to the impacts of the manufacturing stage of 68f

This first-level detail shows the importance related to the production phase, but also that other phases are not negligible. In order to identify the causes of the environmental impacts, it is necessary to detail this assessment, as presented in the table below.

Indicator			Global warming	Ozone depletion	Acidification of soil and water	Eutrophication	Photochemical ozone creation	Depletion of abiotic resources - elements	Depletion of abiotic resources - fossil fuels	Air pollution	Water pollution
			kg CO_2-eq	kg CFC11-eq	kg SO_2-eq	kg PO_4^{3-} -eq	kg C_2H_4-eq	kg Sb-eq	MJ	m3	m3
Production phase	A1-A3	Glued laminated timber supplying	-7.29E+00	8.05E-07	6.62E-03	1.75E-03	4.12E-04	2.63E-08	2.39E+01	1.96E+02	1.87E+02
		Cutting	8.47E-01	1.26E-07	1.19E-03	3.05E-04	5.94E-04	2.37E-09	3.32E+00	3.33E+01	3.04E+01
		Profiling	4.74E+00	4.41E-07	5.19E-03	1.33E-03	2.42E-03	2.51E-08	3.96E+01	2.31E+02	1.57E+02
		Pressing/sizing	1.20E-01	3.71E-08	1.09E-04	3.74E-05	4.69E-05	1.11E-09	2.79E+00	1.09E+01	1.06E+01
		Aluminium supplying	1.58E+01	3.77E-06	1.05E-01	5.64E-03	5.32E-03	1.62E-06	1.93E+02	1.69E+03	1.06E+03
		Cutting	1.27E+00	4.03E-07	6.38E-03	8.59E-04	3.20E-04	6.54E-08	1.71E+01	1.41E+02	1.04E+02
		Glass supplying	1.08E+01	4.98E-06	1.87E-02	4.99E-03	1.40E-03	5.50E-07	1.39E+02	2.21E+03	2.27E+03
		Mechanical parts supplying	8.18E+00	2.20E-06	1.52E-02	2.48E-03	1.58E-03	1.14E-03	9.66E+01	1.85E+03	2.66E+02
		Paint/varnish supply	2.39E+00	3.75E-07	2.80E-03	9.63E-04	4.19E-04	4.85E-05	3.23E+01	1.31E+03	1.31E+02
		Painting/varnishing	5.51E-01	3.69E-08	4.49E-04	6.82E-04	9.55E-05	1.17E-08	9.08E+00	4.15E+02	3.19E+01
		Assemblying	3.32E+00	1.42E-06	6.75E-03	1.40E-03	5.36E-04	2.25E-05	6.69E+01	2.36E+02	3.78E+02
		Paletizing	1.15E+01	6.21E-07	1.73E-02	4.11E-03	1.50E-03	8.18E-07	1.73E+02	5.67E+02	5.62E+02
		Storage	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Construction phase	A4	Transport	6.66E+00	4.88E-06	4.07E-02	1.07E-02	1.19E-03	1.26E-09	8.69E+01	1.05E+03	1.02E+03
	A5	Installation process	5.46E+00	1.78E-06	1.36E-02	3.20E-03	6.34E-04	6.59E-05	4.01E+01	4.15E+02	6.47E+02
Use phase	B3	Repair	1.63E+01	1.19E-05	9.90E-02	2.61E-02	2.90E-03	9.86E-09	2.13E+02	2.60E+03	2.48E+03
End of life phase	C2	Transport	4.34E-02	3.18E-08	2.65E-04	6.99E-05	7.74E-06	8.21E-12	5.66E-01	6.83E+00	6.62E+00
	C4	Elimination	1.23E+01	7.74E-09	1.38E-03	5.27E-03	2.98E-03	1.64E-08	3.45E+00	8.84E+01	2.59E+01
		Total	**9.29E+01**	**3.38E-05**	**3.41E-01**	**7.00E-02**	**2.24E-02**	**1.28E-03**	**1.14E+03**	**1.30E+04**	**9.37E+03**

Table 24 - Detailed contribution of the life cycle impacts of 68f

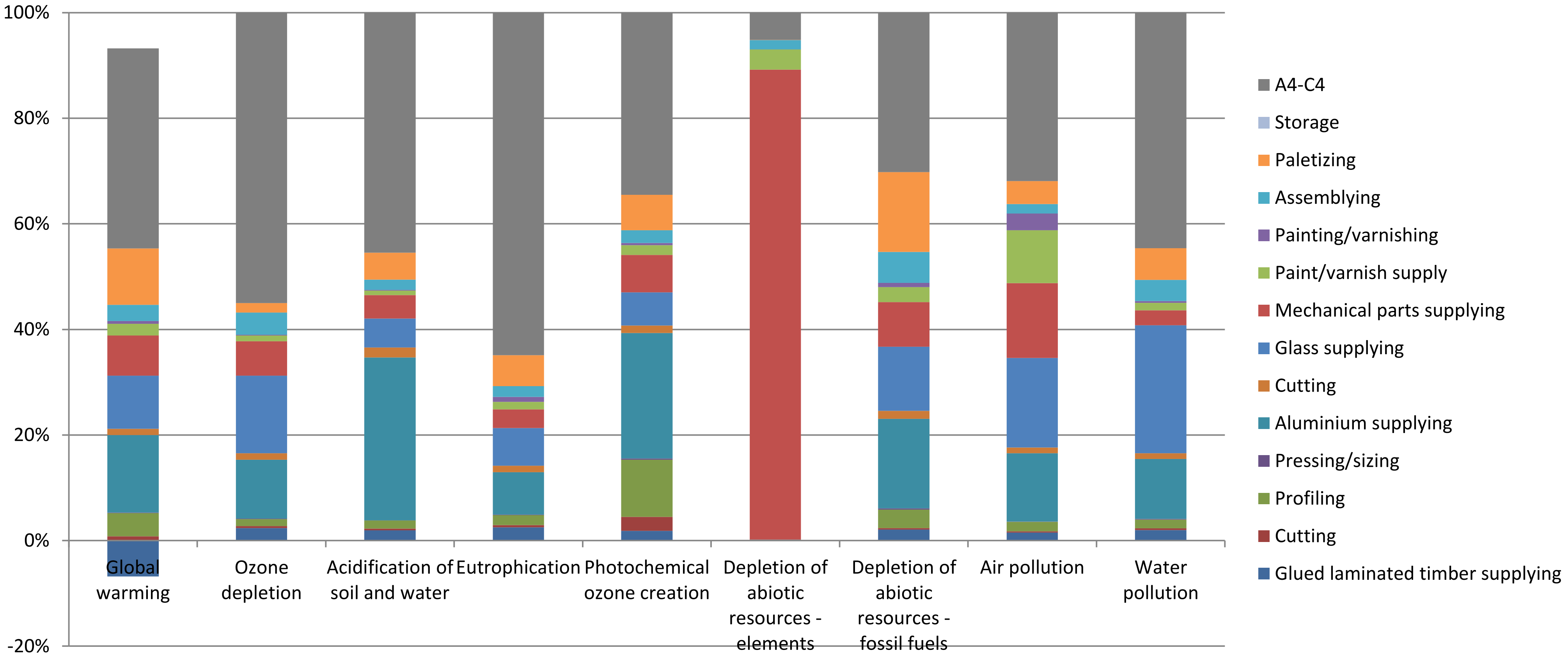

Figure 7 - Detailed contribution of the life cycle impacts of 68f – Production phase

This contribution analysis shows that most elements have a non-negligible environmental impact. Globally, the material supplying causes the most impact due to the material production processes.
In details, the mechanical parts supplying causes most of the impacts on the abiotic depletion. This is caused by the rare materials used in the stainless steel alloy, such as molybdenum.
In addition to the 68s, the aluminium has significant impacts over most categories, despite its relatively low mass. Indeed, the aluminium manufacturing process requires a high amount of energy and creates dangerous bauxite wastes.
Furthermore, the material supplying generates more impacts than the processes.
The wood, despite being the most used material in terms of mass, generates little impact as its production necessitates few materials and little energy.

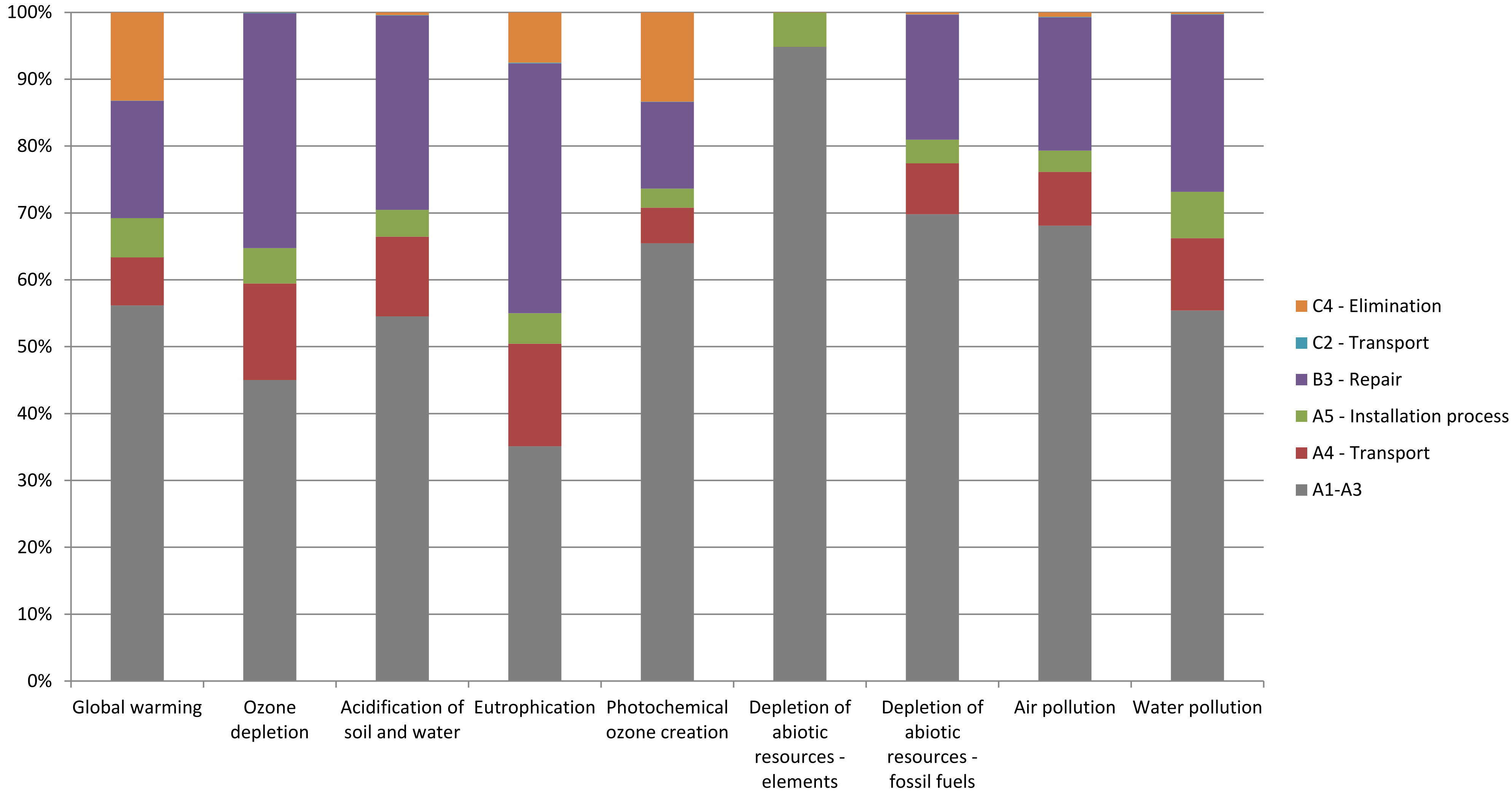

Figure 8 - Detailed contribution of the life cycle impacts of 68f – Other phases

Concerning the other phases, even though the global impacts are lower, they are not negligible.
We can notice that the transports phases have overall a significant impact. The following part focusses on that.
The table and graph below separate the impacts coming from the different transports (upstream, intermediary and downstream transports as well as waste transports) from other impacts.

Indicator			Global warming	Ozone depletion	Acidification of soil and water	Eutrophication	Photochemical ozone creation	Depletion of abiotic resources - elements	Depletion of abiotic resources - fossil fuels	Air pollution	Water pollution
			kg CO_2-eq	kg CFC11-eq	kg SO_2-eq	kg PO_4^{3-} -eq	kg C_2H_4-eq	kg Sb-eq	MJ	m3	m3
Production phase	A1-A3	Transport	2,60E+00	1,90E-06	1,58E-02	4,18E-03	4,63E-04	4,91E-10	3,39E+01	4,09E+02	3,96E+02
		Other	4,96E+01	1,33E-05	1,70E-01	2,04E-02	1,42E-02	1,21E-03	7,63E+02	8,47E+03	4,79E+03
Construction phase	A4-A5	Transport	8,05E+00	5,90E-06	4,92E-02	1,30E-02	1,44E-03	1,52E-09	1,05E+02	1,27E+03	1,23E+03
		Other	4,07E+00	7,61E-07	5,14E-03	9,57E-04	3,85E-04	6,59E-05	2,20E+01	1,96E+02	4,34E+02
Use phase	B3	Transport	1,62E+01	1,19E-05	9,89E-02	2,61E-02	2,89E-03	3,07E-09	2,11E+02	2,55E+03	2,47E+03
		Other	6,96E-02	6,70E-09	7,74E-05	2,13E-05	1,22E-05	6,80E-09	2,01E+00	4,96E+01	9,58E+00
End of life phase	C2-C4	Transport	4,34E-02	3,18E-08	2,65E-04	6,99E-05	7,74E-06	8,21E-12	5,66E-01	6,83E+00	6,62E+00
		Other	1,23E+01	7,74E-09	1,38E-03	5,27E-03	2,98E-03	1,64E-08	3,45E+00	8,84E+01	2,59E+01

Table 25 - Detailed contribution of the transport steps of 68f

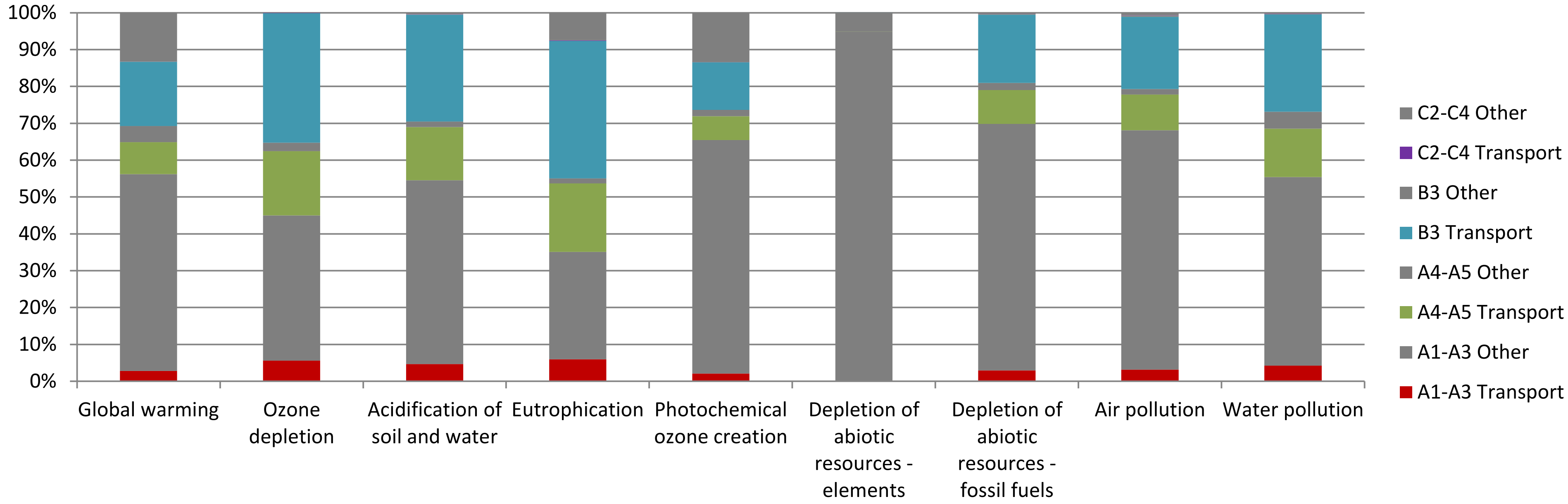

Figure 9 - Detailed contribution of the life cycle impacts of 68f – Focus on the transports

We can see that the overall transport is significant, up to 65% of impacts. It mainly concerns 2 steps: the use phase and the construction phase transports. The use phase transport is high due to the conservative hypothesis and is likely to be much below in reality, but the production phase transport is based on primary data and therefore is accurate.

5. CONCLUSION

Bureau Veritas CODDE supported ARBOR in the realization of the environmental assessment of its wooden windows, using the Life Cycle Assessment method and a « cradle to grave » approach.
ARBOR wanted to provide its clients with reliable information on the environmental impacts of its products.

The study identified several significant environmental aspects (SEA) for both products:

- SEA 1: material supplying
- SEA 2: transport steps

An ecodesign approach should focus on those aspects and try and reduce them while keeping a consistent functionality.

This report will be used as a base to provide environmental declaration (FDES format) for both products, based on French DHUP regulation.

6. Index of figures and tables

7. Appendices

7.1. Appendix 1: Sourcing and type of data

Collected data are available in this file:

- ARBOR_Data collection_20160810

7.2. Appendix 2: EIME modelling

Modelling is available in Excel format the following files:

- 68s v3_design
- 68f v3_design