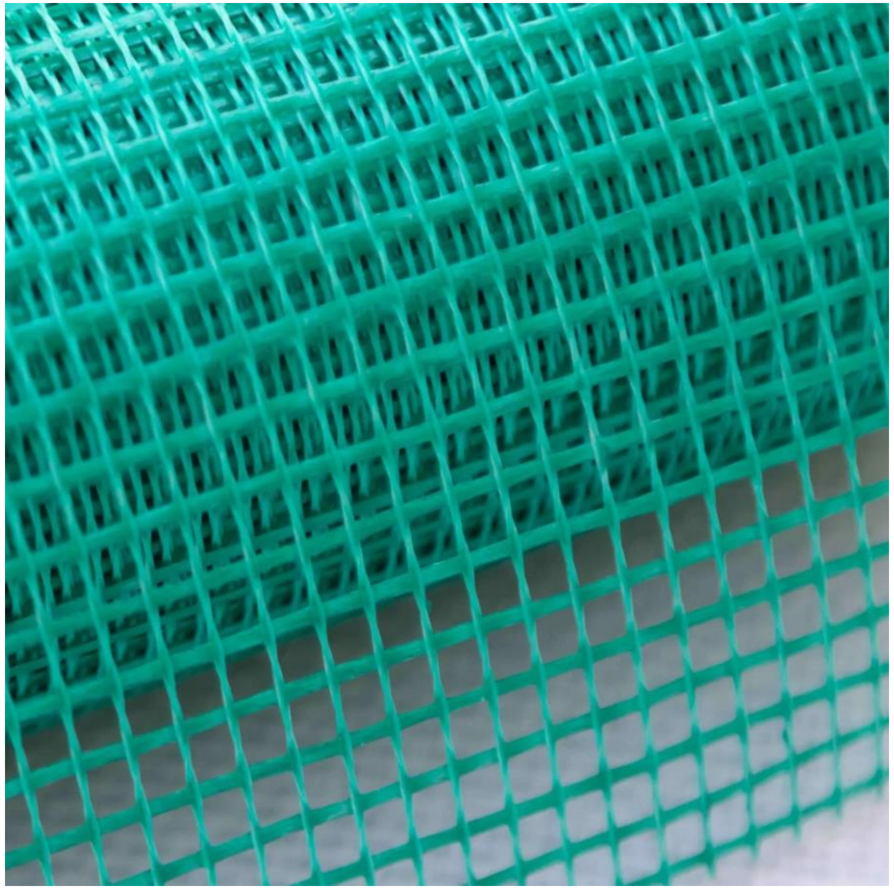
Tech-Fab Europe
Life cycle assessment of open mesh products

LCA report
January 2025



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Executive summary

Overview of the Study

Objective of the work completed

Tech-Fab Europe, the European Technical Textile Producers Association commissioned PwC to prepare the following report. The report presents the cradle-to-gate life-cycle impact assessment results of glass fibre fabric for composites and open mesh for thermal insulation, with the aim of informing product users and regulators of the environmental impacts of their production.

Participants

- **Glass fibre fabrics:** Chomarat, Dipex, GammaTensor, Metyx, Owens Corning, PD Oschatz, Saertex, Selcom, Tissa, Glasscom
- **Open mesh fabrics:** Asglatex, Bico, Gavazzi, Kelteks, Proxim, Saint-Gobain, Tolnatext, Valmiera, Vitrulan

Data contributors

Data was collected for the year 2023 in 10 plants from 9 companies.

- For the composite working group (glass fibre fabric), there were 6 sites and 5 contributors: Owens Corning, PD Oschatz, Saertex, Metyx and Chomarat.
- For the Open Mesh working group, there were 4 contributors: Gavazzi, Kast, Saint-Gobain and Valmiera.

Functional unit

- **Glass fibre fabric:** Production of 1kg of glass fibre fabric materials to be used in composite glass fibre products in applications such as wind blades, high-duty vehicles and sports and leisure applications.
- **Open mesh:** Production of 1kg of open mesh products

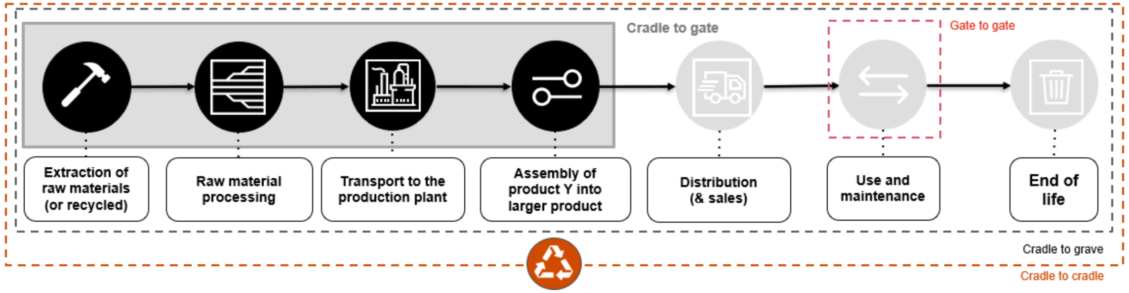
  Open mesh products mainly serves in the thermal insulation of buildings.

Tech-Fab result aggregation

The TechFab average environmental impacts are calculated by aggregating participants' data using a **weighted average based on each participating site annual production volume**.

Perimeter of the study

The perimeter for this study is cradle-to-gate: it includes the fabrication and transport of the raw materials to the site, and the production of glass fibre fabrics and open mesh materials. Transport to clients is not included.



Presentation of the data collection and modelling

Data collection

Each site participating in the study was addressed a data collection questionnaire. The data collection was split in three sections: raw material supply, production site energy and water consumption and packaging.

1. Raw materials extraction and processing and transport

Data collected

- Material
- Country of origin
- Quantity
- Mode of transportation
- Distance

Model

- **Glass Fibre raw materials**
  Data models originate from the Glass Fibre Europe (GFE) LCA study. For glass fibre supplied outside of the EU and the UK, the models from the GFE study were modified by switching the electricity mix from GFE to the one of the country-of-origin.
- **Other raw materials**
  Raw materials that are not derived from glass fibre are modelled using product lifecycle inventories from the Ecoinvent database.
- **Transportation**
  Transportation was modelled using data from the Ecoinvent database. The transportation of each raw material is modelled using the quantity of ton-kilometres of each transport mode at each site.

2. Production site

Data collected

- Energy consumption
- Water consumption
- Waste generation

Model

- **Energy**
  Energy consumptions were modelled using geography specific activities from Ecoinvent for natural gas supply and electricity. Europe or global model were used for diesel, propane and natural gas combustion.
- **Waste and water**
  Waste management is model using Ecoinvent activities. Water is included as an inventory flow without supply activities.

3. Packaging

Data collected

- Packaging materials
- Quantity

Model

- **Packaging**
  Packaging is modelled using Ecoinvent activities.

Impacts indicators measured

The following impact indicators have been calculated in the present study

AIR	**Climate change**	It represents all inputs and outputs that produce greenhouse gas emissions. Consequences include rising **global average temperatures** and sudden **regional climate events**. Climate change represents an impact on global scale.
	Photochemical ozone formation	It evaluates the effects of tropospheric ozone formation caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in presence of nitrogen oxides (NOx) and sunlight. High concentrations of **tropospheric ozone damage vegetation and the human respiratory tract**.
	Human toxicity (cancer)	It accounts for **adverse health effects on human beings caused by the intake of toxic substances through inhalation of air**, food/water ingestion, penetration through the skin insofar as they are related to cancer.
	Air Acidification	It identifies impacts due to acidifying substances present in the environment. NOx, NH3 and SOx emissions lead to releases of hydrogen ions (H+) that contribute **to soil and water acidification, with consequent damage to vegetation and acidification of lakes**.
WATER	**Water used**	It evaluates **water consumption** correlated to the life cycle of the product.
	Eutrophication	It identifies impacts due to nutrients (mainly nitrogen and phosphorus) from sewage and fertilized agricultural fields that accelerate the growth of **algae and other vegetation in the water (eutrophication)**, the degradation of which consequently causes **oxygen deficiency and, in some cases, fish death**.
SOIL	**Land use**	It is related to **use (occupation) and conversion (transformation) of land area** by activities such as agriculture, forestry, roads, housing, mining, etc. Land occupation considers the effects of the land use, the amount of area involved and the duration of its occupation (changes in quality multiplied by area and duration).
	Resource use (minerals and metals)	It addresses the use of **non-renewable abiotic natural resources** (minerals and metals).

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Life cycle impact assessment results

Data collection representativeness – Open mesh

TechFab Europe represents approximately >95% of the European production of glass fibre open mesh products

The collected data represents around 80% of total TechFab members Open Mesh production

- We gathered data from four facilities operated by four different companies.
- The average product density is **150 g/m^2**.

Lifecycle Assessment Results – Open mesh

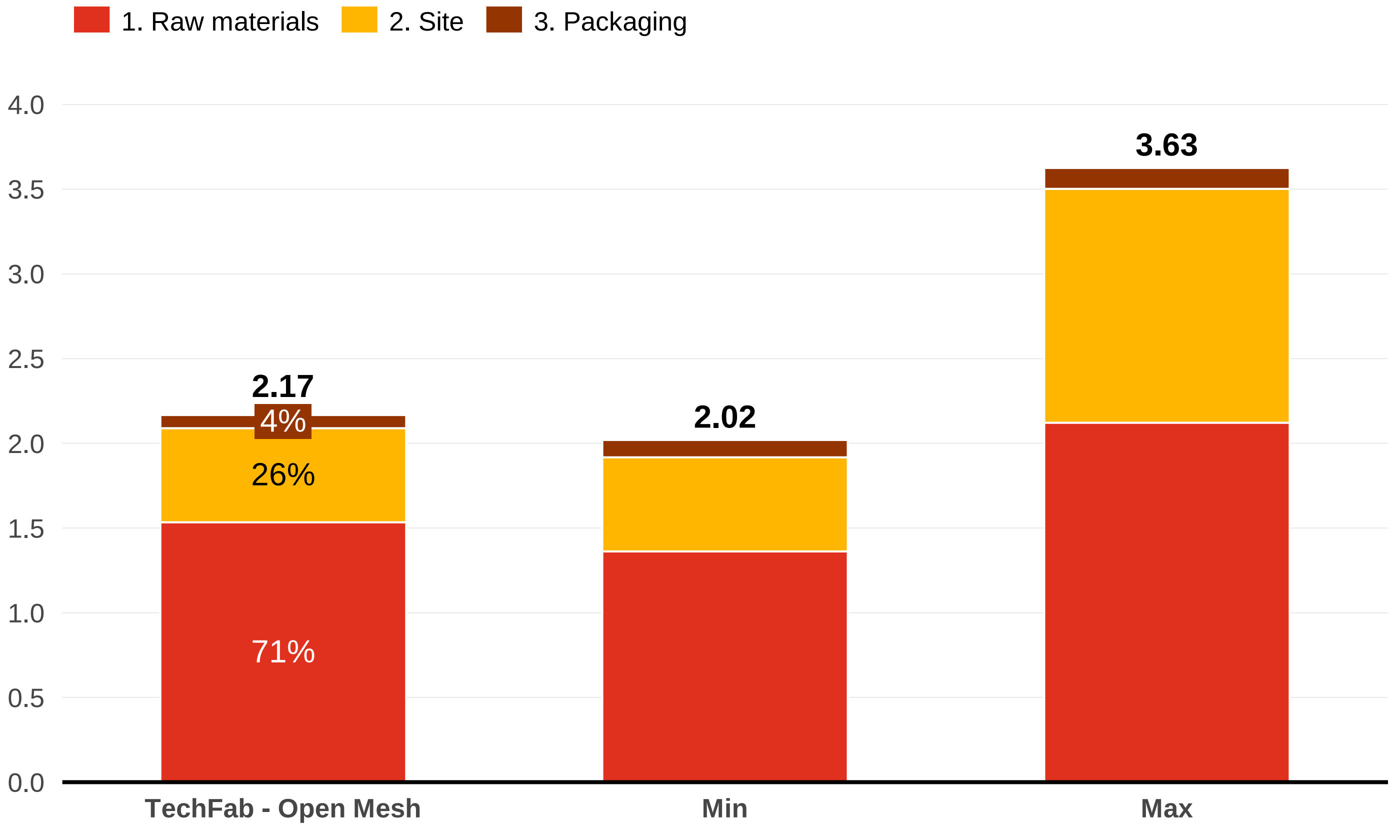
Functional unit
Results are presented for the production of one kg of open mesh product.

Interpretation
The supply of raw materials dominates all impact categories. The environmental impact of the open mesh is mainly determined by the impact of glass fibre and SBR production.

Impact method	Unit	TechFab – Open Mesh	Min	Max	Raw materials	Site	Packaging
Climate change	kg eq. CO2	2.17	2.02 (-7%)	3.63 (+67%)	71%	26%	4%
Primary Energy	MJ	48.10	44.36 (-8%)	69.34 (+44%)	74%	19%	10%
Acidification	mol eq. H+	1.01E-02	9.17E-03 (-8%)	1.52E-02 (+44%)	76%	19%	6%
Resource use, minerals and metals	kg eq. Sb	3.43E-06	3.16E-06 (-9%)	5.26E-06 (+51%)	70%	17%	20%
Eutrophication, terrestrial	mol eq. N	2.28E-02	2.08E-02 (-8%)	3.54E-02 (+54%)	78%	15%	9%
Eutrophication, freshwater	kg eq. P	8.75E-04	4.10E-04 (-9%)	1.22E-03 (+55%)	35%	56%	14%
Eutrophication, marine	kg eq. N	2.34E-03	2.19E-03 (-53%)	3.48E-03 (+39%)	74%	18%	11%
Photochemical ozone formation	kg eq. NMVOC	8.05E-03	7.25E-03 (-7%)	1.20E-02 (+49%)	82%	13%	7%
Human toxicity, cancer	CTUh	2.47E-09	2.41E-09 (-10%)	2.81E-09 (+49%)	68%	26%	10%
Water used	litre	24.64	22.17 (-10%)	27.24 (+11%)	73%	10%	25%
Waste	kg	0.57	0.5 (-11%)	1.09 (+93%)	59%	34%	10%

Raw material sourcing is the primary driver of GHG emissions

The production of 1 kg of open mesh fabric generates 2.17 kg CO_2 eq.

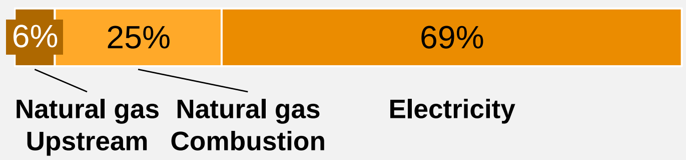


IPCC-Greenhouse effect 2013 (direct, 100 years) – kg CO_2 eq

Key takeaways

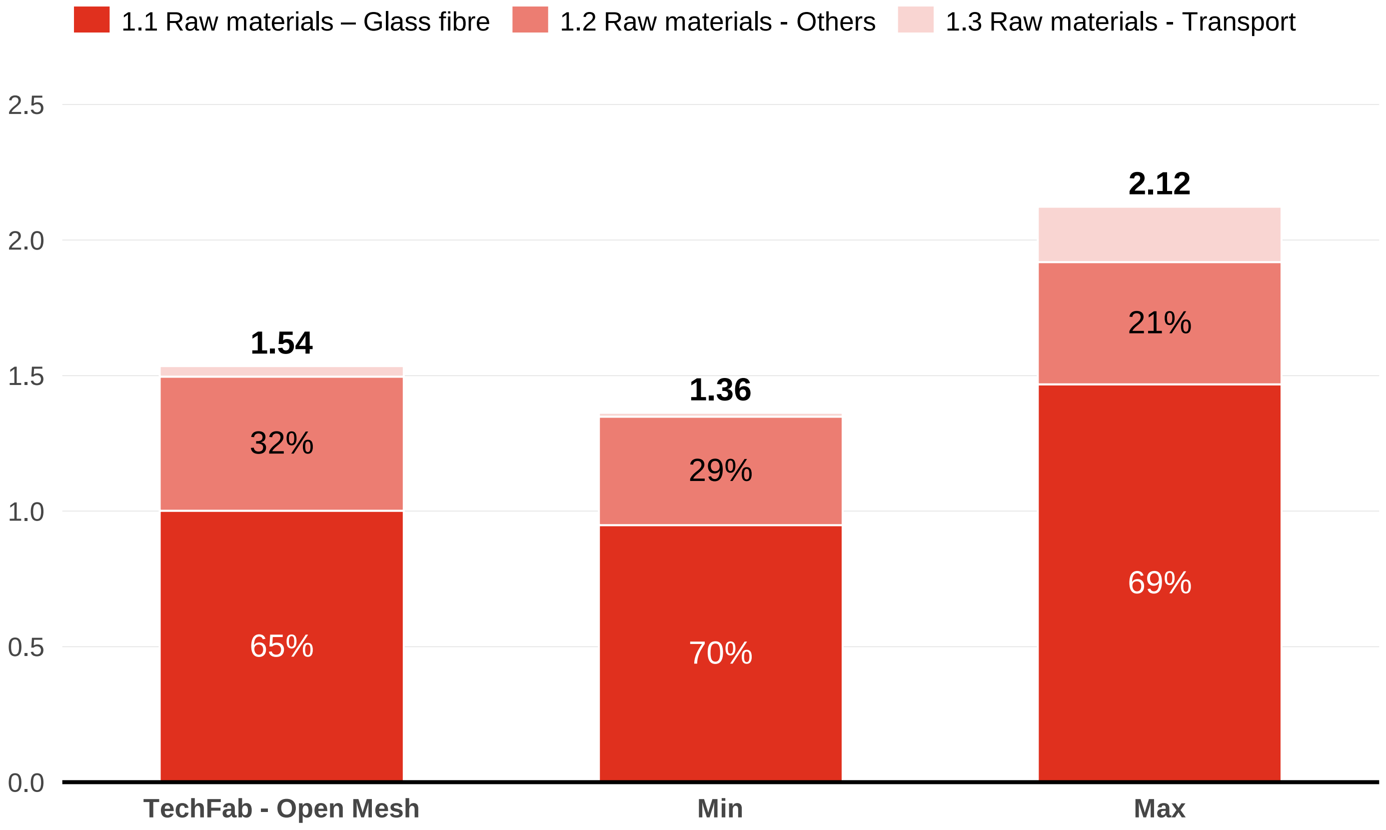
- Producing **1 kg of open mesh** results in an average GHG emissions of **2.17 kg CO_2 eq.**, with the highest-emitting site at 3.63 kg and the lowest at 2.02 kg.
- Emissions are predominantly driven by **raw material sourcing (71%)**, while on-site activities contributes 26% and packaging 4%.
- 93% of the "Site" GHG emission are linked to energy use and 7% to waste management.

Site energy GHG emissions split



Raw material emissions are driven first by the glass fibre and then by the styrene-butadiene rubber coating

GHG raw materials emissions to produce 1 kg of open mesh product



IPCC-Greenhouse effect 2013 (direct, 100 years) – kg CO_2 eq.

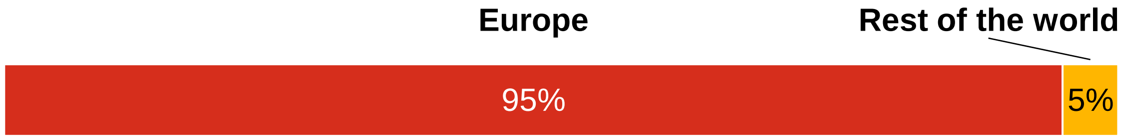
Key takeaways

- Across all sites, GHG emissions are primarily driven by **glass fibre raw materials**, which account for **65%** of emissions from raw materials.
- Other raw materials, mainly SBR for coating represents 32% of climate impacts.
- Transport of raw materials represents a small share of emissions linked to raw material supply, only 3% in the Tech Fab average.

Glass fibre provenance has the most impact on open mesh GHG emissions

1 95% of glass fibre for open mesh product is sourced in Europe*

*Split representative of the data contributors only



Europe: Belgium, Czechia, France, Germany, Italy, Latvia, Norway, Slovakia, United Kingdom
Rest of the world: Bahrain, Brazil, China, Egypt, India, Mexico, Russia, South Korea, Taiwan, Thailand, Turkey, United States

2 Provenance has a significant effect on greenhouse gas emissions

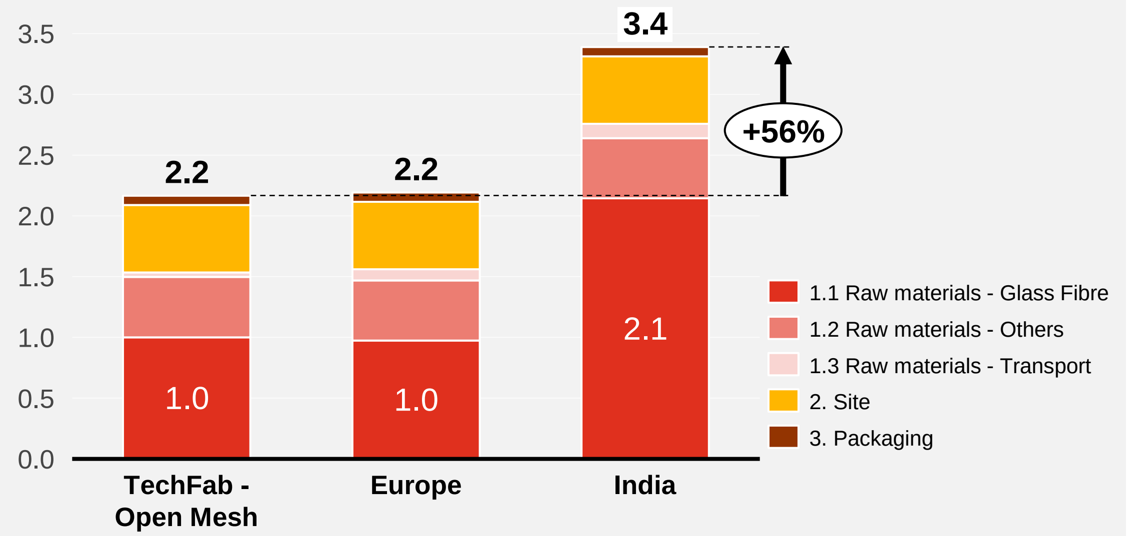
Geography	1 kg of Direct roving – Climate change impact *(transport not included)* kg CO2 eq.	Vs Europe
Europe	1.18	
India	2.61	+120%
China	2.26	+91%
Turkey	1.88	+59%
Egypt	1.86	+58%
Mexico	1.83	+55%
Bahrain	1.79	+51%

All glass fibre materials are modelled based on the Glass Fiber Europe study. The models for different countries are adapted by modifying the electricity mix to reflect the specific mix of each country, assuming the same energy efficiency (MJ/kg glass fibre) as in Europe.

3 Sensitivity analyses on glass fibre provenance

- We evaluated three scenarios: the baseline scenario (TechFab – Open Mesh), a scenario where all glass fibre is sourced from Europe, and another where all is sourced from India.
- The European scenario has the same emissions as the baseline. In contrast, in the Indian scenario emissions increase by 56% compared to the baseline.
- Compared to the European scenario, the Indian scenario more than doubles emissions from raw material production and increases emissions from transport by 29%.

GHG emissions in sensitivity analysis



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Appendix

3.1 Results

Result tables (1/3)

Impact	Process stage	Unit	TechFab - Open Mesh Value	Distribution	Min	Max
Climate change	1. Raw materials	kg eq. CO2	1.54E+00	71%	1.36E+00	2.12E+00
	1.1 Raw materials - Glass Fibre	kg eq. CO2	1.00E+00	46%	9.48E-01	1.47E+00
	1.2 Raw materials - Others	kg eq. CO2	4.96E-01	23%	4.01E-01	7.54E-01
	1.3 Raw materials - Transport	kg eq. CO2	3.88E-02	2%	1.34E-02	2.04E-01
	2. Site	kg eq. CO2	5.54E-01	26%	4.31E-01	1.38E+00
	3. Packaging	kg eq. CO2	7.73E-02	4%	2.10E-02	1.24E-01
	Total	kg eq. CO2	2.17E+00		2.02E+00	3.63E+00
Primary energy	1. Raw materials	MJ	3.55E+01	74%	3.15E+01	4.67E+01
	1.1 Raw materials - Glass Fibre	MJ	1.96E+01	41%	1.77E+01	2.59E+01
	1.2 Raw materials - Others	MJ	1.52E+01	32%	1.25E+01	2.32E+01
	1.3 Raw materials - Transport	MJ	5.93E-01	1%	2.09E-01	3.06E+00
	2. Site	MJ	9.11E+00	19%	7.65E+00	2.24E+01
	3. Packaging	MJ	3.53E+00	7%	6.57E-01	4.86E+00
	Total	MJ	4.81E+01		4.44E+01	6.93E+01
Acidification	1. Raw materials	mol eq. H+	7.70E-03	76%	6.75E-03	1.13E-02
	1.1 Raw materials - Glass Fibre	mol eq. H+	3.91E-03	39%	3.67E-03	5.89E-03
	1.2 Raw materials - Others	mol eq. H+	3.43E-03	34%	2.94E-03	4.87E-03
	1.3 Raw materials - Transport	mol eq. H+	3.53E-04	3%	7.67E-05	2.50E-03
	2. Site	mol eq. H+	1.93E-03	19%	1.56E-03	4.04E-03
	3. Packaging	mol eq. H+	4.81E-04	5%	9.87E-05	6.51E-04
	Total	mol eq. H+	1.01E-02		9.17E-03	1.52E-02
Resource use, minerals and metals	1. Raw materials	kg eq. Sb	2.41E-06	70%	2.06E-06	3.27E-06
	1.1 Raw materials - Glass Fibre	kg eq. Sb	1.63E-06	47%	1.42E-06	2.04E-06
	1.2 Raw materials - Others	kg eq. Sb	6.64E-07	19%	4.55E-07	1.33E-06
	1.3 Raw materials - Transport	kg eq. Sb	1.19E-07	3%	4.41E-08	5.84E-07
	2. Site	kg eq. Sb	5.72E-07	17%	4.38E-07	1.42E-06
	3. Packaging	kg eq. Sb	4.46E-07	13%	1.10E-07	6.78E-07
	Total	kg eq. Sb	3.43E-06		3.16E-06	5.26E-06

Result tables (2/3)

Impact	Process stage	Unit	TechFab - Open Mesh Value	Distribution	Min	Max
Eutrophication, terrestrial	1. Raw materials	mol eq. N	1.79E-02	78%	1.57E-02	2.71E-02
	1.1 Raw materials - Glass Fibre	mol eq. N	8.35E-03	37%	7.95E-03	1.24E-02
	1.2 Raw materials - Others	mol eq. N	8.31E-03	36%	7.15E-03	1.12E-02
	1.3 Raw materials - Transport	mol eq. N	1.20E-03	5%	3.03E-04	7.77E-03
	2. Site	mol eq. N	3.45E-03	15%	3.16E-03	6.43E-03
	3. Packaging	mol eq. N	1.46E-03	6%	2.33E-04	2.00E-03
	Total	mol eq. N	2.28E-02		2.08E-02	3.54E-02
Eutrophication, freshwater	1. Raw materials	kg eq. P	3.05E-04	35%	2.73E-04	4.75E-04
	1.1 Raw materials - Glass Fibre	kg eq. P	2.84E-04	32%	2.17E-04	4.47E-04
	1.2 Raw materials - Others	kg eq. P	1.90E-05	2%	1.08E-05	4.27E-05
	1.3 Raw materials - Transport	kg eq. P	2.61E-06	0%	9.02E-07	1.25E-05
	2. Site	kg eq. P	4.86E-04	56%	3.52E-05	9.30E-04
	3. Packaging	kg eq. P	8.35E-05	10%	6.33E-06	1.19E-04
	Total	kg eq. P	8.75E-04		4.10E-04	1.22E-03
Eutrophication, marine	1. Raw materials	kg eq. N	1.75E-03	74%	1.53E-03	2.63E-03
	1.1 Raw materials - Glass Fibre	kg eq. N	8.44E-04	36%	7.99E-04	1.24E-03
	1.2 Raw materials - Others	kg eq. N	7.92E-04	34%	6.98E-04	1.07E-03
	1.3 Raw materials - Transport	kg eq. N	1.10E-04	5%	2.77E-05	7.04E-04
	2. Site	kg eq. N	4.18E-04	18%	3.01E-04	7.77E-04
	3. Packaging	kg eq. N	1.80E-04	8%	2.66E-05	2.67E-04
	Total	kg eq. N	2.34E-03		2.19E-03	3.48E-03
Photochemical ozone formation	1. Raw materials	kg eq. NMVOC	6.61E-03	82%	5.76E-03	9.46E-03
	1.1 Raw materials - Glass Fibre	kg eq. NMVOC	3.78E-03	47%	3.35E-03	5.09E-03
	1.2 Raw materials - Others	kg eq. NMVOC	2.50E-03	31%	2.05E-03	3.75E-03
	1.3 Raw materials - Transport	kg eq. NMVOC	3.33E-04	4%	8.67E-05	2.09E-03
	2. Site	kg eq. NMVOC	1.02E-03	13%	9.29E-04	2.00E-03
	3. Packaging	kg eq. NMVOC	4.12E-04	5%	8.87E-05	5.59E-04
	Total	kg eq. NMVOC	8.05E-03		7.25E-03	1.20E-02

Result tables (3/3)

Impact	Process stage	Unit	TechFab - Open Mesh Value	Distribution	Min	Max
Human toxicity, cancer	1. Raw materials	CTUh	1.69E-09	68%	1.51E-09	2.15E-09
	1.1 Raw materials - Glass Fibre	CTUh	1.40E-09	57%	1.09E-09	1.76E-09
	1.2 Raw materials - Others	CTUh	2.65E-10	11%	1.94E-10	4.68E-10
	1.3 Raw materials - Transport	CTUh	2.78E-11	1%	9.41E-12	1.42E-10
	2. Site	CTUh	6.52E-10	26%	2.60E-10	1.10E-09
	3. Packaging	CTUh	1.26E-10	5%	1.99E-11	2.40E-10
	Total	CTUh	2.47E-09		2.41E-09	2.81E-09
Water used	1. Raw materials	litre	1.79E+01	73%	1.67E+01	2.24E+01
	1.1 Raw materials - Glass Fibre	litre	1.59E+01	64%	1.28E+01	1.92E+01
	1.2 Raw materials - Others	litre	1.87E+00	8%	1.43E+00	3.41E+00
	1.3 Raw materials - Transport	litre	1.14E-01	0%	4.19E-02	5.62E-01
	2. Site	litre	2.48E+00	10%	8.10E-01	5.95E+00
	3. Packaging	litre	4.29E+00	17%	1.74E-01	6.17E+00
	Total	litre	2.46E+01		2.22E+01	2.72E+01
Waste	1. Raw materials	kg	3.34E-01	59%	2.75E-01	7.77E-01
	1.1 Raw materials - Glass Fibre	kg	2.60E-01	46%	2.41E-01	5.45E-01
	1.2 Raw materials - Others	kg	3.49E-02	6%	1.88E-02	8.10E-02
	1.3 Raw materials - Transport	kg	3.88E-02	7%	1.52E-02	1.86E-01
	2. Site	kg	1.94E-01	34%	8.01E-02	2.90E-01
	3. Packaging	kg	3.87E-02	7%	8.72E-03	5.48E-02
	Total	kg	5.66E-01		5.05E-01	1.09E+00

3.2 Methodology

Data collection method and modelling

Three different types of data have been used to model the production of glass fibre.

1. **Glass Fibre Europe**

Glass fibre raw materials were modeled using life cycle assessment data provided by Glass Fibre Europe (GFE). Three different glass fibre products have been used in this study: direct rovings, assembled rovings and chopped strand mats. For participants sourcing their glass fibre materials outside of the European Union, GFE models were adapted by replacing the source electricity from the GFE mix with the country-of-origin mix and replacing the activity “air separation, cryogenic– RER” with “air separation, cryogenic – RoW”.

2. **Specific data collection**

Site-specific data has been collected by using individual questionnaires, in order to characterise the production processes and their related physical flows:

- raw materials consumption;
- raw materials supply distances;
- packaging material;
- energy consumption (electricity, natural gas, fuel, etc);
- water use;
- waste generation and their end-of-life;
- water discharged;
- annual production (total site and product-specific).

Data consistency checks were systematically implemented; sites were re-contacted whenever inconsistencies or outliers were detected. These checks included: data completeness, mass balance (consumption of raw materials vs glass production), consistency of values within the sites and consistency of values between sites. Finally, a general rule was applied for missing data: when site-specific data were not available from one or several sites, data from the sites where information was available were used to derive a weighted average. This average value was then applied to the sites where no data were available. Eventually, no outlier remained in the datasets collected for the project.

3. **Data consolidation**

All data have been analysed separately, to allocate physical flows to the studied products at the site level.

i. Results from each questionnaire were used to obtain product-specific datasets.
ii. Life cycle inventories (LCIs) have been calculated for each site and for each studied product, so that the calculations resulted in one inventory per product and per site.
iii. The European average has then been calculated from all LCIs referring to the same product, with a weighting for each contributing site corresponding to the annual production volume of the considered product.

Methodology and main hypothesis

Methodology
The present report was produced in accordance with the methodological guidelines developed in ISO standards 14 040 (Environmental Management – Life cycle assessment – Principles and Framework) and ISO 14 044 (Environmental Management – Life cycle assessment – Requirements and guidelines).

List of the life cycle steps excluded from the studied system
The studied system excludes the construction of the buildings of industrial sites as well as the manufacturing of machines and tools. This general assumption is justified from previous projects where construction of building sites proved to be negligible compared to the environmental impacts directly related to the manufacturing of industrial goods (e.g., raw materials and energy consumption).

Allocation methodology for the various products
The industrial system studied often manufactures several products on a same site. However, only the consumption of resources and the emissions related to the functional unit have to be taken into account.
Most sites produce several products for which some parameters cannot be differentiated or be specifically measured on an individual basis: energy consumption, water treatment, air emissions, waste etc.
Thus, when product-specific data were not available, the mass allocation was used for all sites. This consists in allocating a part of the impacts in proportion to the respective mass of the co-products.

Environmental flows
Direct environmental flows (direct emissions to water, soil or air) were not collected for the production sites in this study. According to interviews performed with TechFab Europe, due to the nature of the processes, direct emissions are non-existent or not material.

Water consumption
Water consumption was included in the model as an inventory flow, there is no upstream activity associated with water supply.

Glass fibre fabric
For glass fibre fabric, there are three different types of products : woven, non-crimp fabrics (NCF) and complex. The three products are aggregated in the glass fibre fabric results.

Modelisation of woven products used in complex
Woven are both a final product of the glass fibre fabric family and an intermediary product in the production of complex. Depending on sites, there are two scenarios for the production of complex:

1. Onsite production: In some sites, woven materials are produced onsite and then further transformed into complex.
2. External Supply: In other sites, woven materials are supplied directly as a semi-finished product and then transformed into complex.

The second scenario requires modeling the environmental impact of the woven material supply for the site. To address this, a specific model was developed for the woven products within the glass fibre fabric category, using the same methodology outlined in this document.

Environmental impacts and flows studied

Environmental impacts (1/2)

Indicator	Environmental category	Calculation method
Greenhouse gas emissions of fossil origin (direct, 100 years) Impacts on climate change over a 100-year time frame is assessed using the amount of greenhouse gas emissions, expressed in carbon dioxide equivalent. It specifically takes into account the "fossil" emissions CO2, N2O (these emissions are derived, for example, from the combustion of fuel and from natural gas) and CH4 emissions (for example from the fermentation of dumped waste) but does not take into account CO2 "biomass" emissions, resulting for example from the combustion of waste in incinerators. The greenhouse effect is expressed in kg eq. CO2.	AIR	IPCC, 2013
Emissions contributing to acidification The acidification impact category represents an increase of acid compounds such as nitrogen oxides and sulphur oxides in the atmosphere. The characterisation factor of a substance is calculated in moles of H+, which can be produced per kg, based on the production of H+ ions once solubilised in water.	AIR	EF 3.0
Photochemical ozone formation (Tropospheric ozone formation) Under certain climatic conditions, the atmospheric emissions from industries and transport can react in a complex way under the influence of solar rays and lead to the formation of photochemical smog. A succession of reactions implicating volatile organic compounds and NOx, lead to the formation of ozone, a super-oxidizing compound. The potential for the formation of photochemical oxidizers is expressed in kg eq. NMVOCs (non-methane volatile organic carbon).	AIR	EF 3.0
Eutrophication, freshwater, marine and terrestrial Eutrophication is defined as the enrichment in nutritive elements, as a consequence of human intervention. It is caused by nitrogen and phosphorous emissions mainly due to fertilizers, combustion, sewage systems. Oxygen depletion is the possible consequence of such enrichment.	WATER, SOIL	EF 3.0

Environmental impacts and flows studied

Environmental impacts (2/2)

Indicator	Environmental category	Calculation method
Depletion of abiotic resources (minerals and metals) This indicator quantifies the depletion of the environment in terms of its mineral resources. Living resources and their associated impacts such as the disappearance of species or the loss of biodiversity are excluded from this category. This indicator provides more information about the depletion of different subjects than on the impact caused by their extraction from the natural environment. The calculation is made in comparison with estimated remaining stocks and with the consumption rate of the current economy. This indicator is expressed in kg eq. antimony (antimony is a chemical element, atomic number 51). As an example, 1 kg platinum ore corresponds to 2.22 kg eq. antimony, and 1 kg of boron corresponds to 0.00043 kg eq. antimony (source: CML).	RESOURCES	EF 3.0
Human toxicity, cancer Toxicity is basically defined as the degree to which a substance can damage an organism. For these categories of environmental impacts, it is necessary to determine in detail the emissions then to analyse their impacts. Many of substances can have the potential to damage humans or ecosystems when released to the environment and should thus have characterization factors for the human and ecotoxicity categories of impact. The emission of some substances (such as heavy metals) can have specific impacts on human health. Assessments of effects related to the human toxicity impact category are focused on effects resulting from direct exposure to chemicals. Assessments of human toxicity are based on tolerable concentrations (or “safe doses”) in air, water, and on air quality guidelines, tolerable daily intake and acceptable daily intake. The USEtox method is based on a comprehensive comparison of existing Life Cycle Impact Assessment (LCIA) toxicity characterisation models aiming to identify specific sources of differences and the indispensable model components. It was developed to provide Characterisation Factors (CFs) for human toxicity and freshwater ecotoxicity in Life Cycle Assessment and gives recommended LCIA CFs for more than 1,000 chemicals for these both toxicity impacts. CFs for human toxicity and ecotoxicity account for the environmental persistence (fate), the accumulation (exposure), and the toxicity (effect) of a chemical in the human body or in the ecosystem. Characterization factors are used to obtain the potential impact associated with each contaminant emission. The quantities of contaminants released into the environment during the life cycle are multiplied by these CFs to obtain an impact score for human toxicity or ecotoxicity (Jolliet, et al., 2005). The CF for human toxicity is defined as human toxicity potential (HTP) and is expressed in comparative toxic units (CTUh in cases/kgemitted) providing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted.	HUMAN	EF 3.0 (USETOX 2.0)

Environmental impacts and flows studied

Environmental flows

Indicator
Water used The water used is calculated as the sum of water withdrawals from lakes, rivers and the ground. It does not include salted water, water used for cooling or to turn a turbine.
Primary energy The total primary energy is divided into non-renewable energy and renewable energy on the one hand; and into fuel energy and material energy on the other hand. The following equation illustrates this definition: Total primary energy = Non-renewable energy + Renewable energy = Primary energy used as fuel + Primary energy used as raw material Primary energy used as fuel is expended once and for all in production processes or transportation and is no longer available. Primary energy used as raw material is always available for material recycling or energy recovery.
Waste Waste is computed by adding the waste generated directly by the site and waste from other lifecycle stages. As waste quantities are not available in Ecoinvent modules, they are calculated using the factors presented in Annex N of the norm NF En 15804+A2/CN.

Data sources for modelling (1/3)

	Data source
Raw materials – Glass	
Chopped strands mat	Glass Fibre Europe[2] - Chopped strand mat
Continuous filament mat	Glass Fibre Europe[2] - Chopped strand mat
Direct roving and glass fibre yarn[1]	Glass Fibre Europe[2] - Direct roving
Multi-end roving	Glass Fibre Europe[2] - Assembled roving
Nonwoven (glass)[3]	Glass Fibre Europe[2] - Chopped strand mat
Raw materials – other raw materials and chemicals	
Acrylat	Ecoinvent 3.8 - butyl acrylate production, RER
Additiv	Ecoinvent 3.8 - chemical production, organic, GLO
Anti-foaming agent	Ecoinvent 3.8 - polydimethylsiloxane production, GLO
Calcium Carbonate powder	Ecoinvent 3.8 - calcium carbonate production, precipitated, RER
Chemical	Ecoinvent 3.8 - chemical production, organic, GLO
Coating - Styrene-Butadiene Rubber (SBR)[4]	Ecoinvent 3.8 - market for latex, RER
Epoxy powder	Ecoinvent 3.8 - epoxy resin production, liquid, RER
Nonwoven (polyester)	Ecoinvent 3.8 - polyester fibre production, finished, RoW
Polyester yarn	Ecoinvent 3.8 - polyester fibre production, finished, RoW
Starch	Ecoinvent 3.8 - maize starch production, RoW
Urea Formaldehyde resin	Ecoinvent 3.8 - urea formaldehyde resin production, RER

(1) When not specifically precised, glass fibre yarn were considered as direct roving material
(2) Adapted to geographies outside Europe by switching the electricity source from the original mix to the country-of-origin mix.
(3) Non-woven glass represents less than 0.1% of glass fibre raw materials quantities
(4) The water quantity in the SBR is not included in the study as it is not material to the environmental impacts

Data sources for modelling (2/3)

	Data source
Raw materials – packaging	
Cardboard	Ecoinvent 3.8 - market for corrugated board box, RER
Polypropylene fibre, wrapping foil	Ecoinvent 3.8 - textile production, nonwoven polypropylene, spunbond, RoW
Film PEBD	Ecoinvent 3.8 - packaging film production, low density polyethylene, RER
Labels	Ecoinvent 3.8 - market for kraft paper and market for polyurethane adhesive
Metallic	Ecoinvent 3.8 - market for steel, unalloyed, GLO
Paper, paper tube	Ecoinvent 3.8 - market for paper sack, RER
Pigments, Print color	Ecoinvent 3.8 - printing ink production, offset, product in 47.5% solution state, RER
Plastic (wraping foil, PET)	Ecoinvent 3.8 - market for packaging film, low density polyethylene, GLO
Plastic EPS	Ecoinvent 3.8 - market for polystyrene, expandable, GLO
PVC	Ecoinvent 3.8 - market for polyvinylfluoride, film, GLO
Tape	Ecoinvent 3.8 - market for polyurethane adhesive, GLO
Wood	Ecoinvent 3.8 - market for EUR-flat pallet, modified to be in kg - RER
Transport	
Fluvial	Ecoinvent 3.8 - market for transport, freight, inland waterways, barge, RER
Rail	Ecoinvent 3.8 - market for transport, freight train, Europe without Switzerland
Road	Ecoinvent 3.8 - market for transport, freight, lorry, unspecified, RER
Sea	Ecoinvent 3.8 - market for transport, freight, sea, container ship, GLO

(1) When not specifically precised, glass fibre yarn were considered as direct roving material
(2) Adapted to geographies outside Europe by switching the electricity source from the original mix to the country-of-origin mix.
(3) Non-woven glass represents less than 0.1% of glass fibre raw materials quantities

Data sources for modelling (3/3)

		Data source
Energy		
	Electricity	Ecoinvent 3.8 - market for electricity, medium voltage, country geography
	Natural gas – Upstream	Ecoinvent 3.8 – market for natural gas, high pressure, country geography
	Natural gas – Combustion	Ecoinvent 3.8 – heat production, natural gas, at boiler modulating >100kW, Europe without Switzerland
	Diesel	Ecoinvent 3.8 - market for diesel burned in building machine

(1) When not specifically precised, glass fibre yarn were considered as direct roving material
(2) Adapted to geographies outside Europe by switching the electricity source from the original mix to the country-of-origin mix.
(3) Non-woven glass represents less than 0.1% of glass fibre raw materials quantities

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