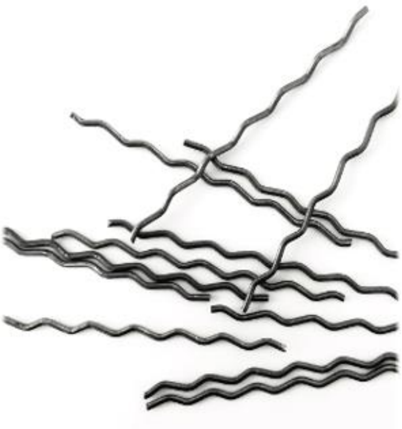
PRODUCT CARBON FOOTPRINT FOR STEEL FIBRES
SPAJIC DOO

CORRUGATED STEEL FIBRES ZSW/N, STEEL FIBRES WITH HOOKED ENDS ZS/N, HIGH PERFORMANCE STEEL FIBRES ZS5/N

SPAJIC doo



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Contents

1. GENERAL 3
1.1. Introduction 3
1.2. Company information 3
1.3. Calculation basis 3
2. PRODUCT AND SCOPE DESCRIPTION 4
2.1. Product description 4
2.2. Declared unit and reporting period 4
2.3. Scope of declaration 5
2.4. Reference service life 5
2.5. Data collection and quality 5
2.6. Cut-off criteria 5
2.7. Environmental data summary 6
3. PRODUCT LIFE CYCLE 6
3.1. Manufacturing process (A1-A3) 6
3.2. Transport and installation (A4-A5) 7
3.3. Product use and maintenance (B1-B7) 7
3.4. Product end of life (C1-C4, D) 7
4. IMPACT ASSESSMENT AND LIFE CYCLE INTERPRETATION 7
4.1. Complete life cycle per emission source 7
4.2. Limitations and assumptions 10
4.3. Allocation 10
5. REFERENCES 11

1. GENERAL

1.1. Introduction

SPAJIC doo has commissioned SGS Beograd to perform a LCA study (Cradle-to-gate (A1-A3) with end-of-life phases (C1-C4, D)) of their steel fibre products, in order to produce EPD declaration. Additionally, SPAJIC doo commissioned SGS Beograd to produce Product Carbon Footprint (PCF) for the same products.

The objective of this study is to present reliable and accurate quantitative environmental data about Spajic's three products through a PCF, according to climate change impact categories set out in the EN 15804+A2 standard. This PCF document is not subject to verification and cannot be communicated externally.

The purpose of this document is to obtain insights into Global Warming Potential (total, fossil, biogenic and LULUC) and CO2e emissions of the products under the study, as well as to identify hotspots throughout the product's lifecycle, on which further actions to reduce CO2 emissions can be taken.

1.2. Company information

Products:	Steel fibres (Steel fibres with hooked ends ZS/N, High performance steel fibres ZS5/N, Corrugated steel fibres ZSW/N)
Manufacturer:	SPAJIC doo
Address:	Koroglaska 13, Negotin, Serbia
Email:	info@spajic.com
Website:	www.spajic.com

1.3. Calculation basis

Reference standard:	EN 15804+A2, ISO 14040/44, EPD Hub Core PCR version 1.0
LCA Software:	OneClick LCA
LCA database profiles:	Ecoinvent version 3.8

2. PRODUCT AND SCOPE DESCRIPTION

2.1. Product description

Steel fibres covered by this study include steel fibres with hooked ends, corrugated steel fibres and high-performance steel fibres produced by SPAJIC doo. Fibre's diameter range is from 0,55 to 1.05 and length from 30mm to 60mm. Steel fibres are produced in SPAJIC doo's manufacturing plant in Negotin, Serbia.

SPAJIC steel fibres are used as concrete reinforcement, in combination with rebars or mesh, and can be used as a single structural component as well. By adding a certain quantity of fibres, the tensile and shear strength, impact strength and fatigue resistance of concrete is being increased.

Steel fibre reinforced concrete is an alternative to traditional reinforced concrete for certain application areas. Once they are mixed into the concrete, steel fibres become a discontinuous, 3-dimensionally oriented, isotropic reinforcement. Steel fibres bridge the crack at very small crack openings, transfer stresses and develop post crack strength in the concrete. Advantages of steel fibres in concrete are as follows:

- Provision of multi-dimensional reinforcement
- Improvement of impact resistance of concrete
- Enhancement of durability and toughness of concrete
- High resistance and good ductility
- Crack control.

All three types of fibres covered by this study are produced by cold drawing of steel wire, go through the same production process and use the same amount of raw materials, with the only difference being the final shape of the fibre.

Fibres included in this study:

Fibre and surface type	Length (mm)	Diameter(mm)	Nominal Tensile Strength (N/mm^2)
ZSW/N	30-60	0,55-1	1200-1350
ZS/N	30-60	0,55-1,05	1200-1350
ZS5/N	50-60	0,75-1	1200-1300

SPAJIC doo steel fibres are used all over the world and in various applications such as industrial flooring, shotcrete and tunnelling, foundation slabs, refractory concrete, hydro structures, precast elements, sprayed concrete linings, traffic areas and airport runways.

2.2. Declared unit and reporting period

Declared unit is set to be 1 kg of steel fibres. The declared unit comprises of Cradle-to-gate (A1-A3) with end-of-life phases (CI-C4, D) data for steel fibres produced by SPAJIC doo at production site in Negotin, Serbia. The reference flows considered are all materials, packaging and energy flows to produce and ttreat product at its end-of-life stage.

Table 1. - Declared unit

Product	Production site	Declared unit	Mass per declared unit	Reporting period
Steel fibres (Steel fibres with ends ZS/N, High performance steel fibres ZS5/N, Corrugated steel fibres ZSW/N)	Negotin, Serbia	1 kg	1 kg	2022 calendar year

2.3. Scope of declaration

The scope of this study is Cradle-to-gate (A1-A3) with end-of-life phases (C1-C4, D), as set out in the EN 15804+A2 reference standard and displayed in **Error! Reference source not found.**.

Table 2. - Declared phases

Product stage			Assembly stage		Use stage							End of life stage				Beyond the system boundaries		
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D		
x	x	x	MND	MND	MND	MND	MND	MND	MND	MND	MND	x	x	x	x	x		
Raw materials	Transport	Manufacturing	Transport	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstr./demol.	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling

MND = Module Not Declared

2.4. Reference service life

The reference service life is not applicable to be declared for this product.

2.5. Data collection and quality

Data is retrieved from Mass Balances supplied by SPAJIC doo. There are no inconsistencies found in the data and there is no reason to believe data is incomplete or not reliable. The total of calculated material flows was compared with the total outputs. No deviations were found. The reference year for data collected is 2022 calendar year.

Data from suppliers is modelled with Ecoinvent processes for the region where they operate and source their materials. In case no specific region was available, an average for a wider region or world average is used. The specific composition of materials is inventoried for the main materials and processes.

Background data is based on Ecoinvent processes, both the sourcing of raw materials and processes are carefully selected to meet the materials specific characteristics. Basic descriptions on the different materials are supplied by the commissioner of the study, SPAJIC doo.

For end-of-life scenarios, the corresponding information and default scenarios from the World Steel Association Report and EeBGuide were used.

2.6. Cut-off criteria

The study does not exclude any modules or processes which are stated mandatory in the reference standard and the applied PCR. The study does not exclude any hazardous materials or substances. The study includes all major raw material and energy consumption. All inputs and outputs of the unit processes, for which data is available for, are included in the calculation. There is no neglected unit process more than 1% of total mass or energy flows. The module specific total neglected input and output flows also do not exceed 5% of energy usage or mass.

The following processes have been **excluded** from the system boundary:

- Packaging of ancillary materials in the production phase. Quantities are negligible and therefore not included.

2.7. Environmental data summary

Declared unit: 1 kg
Declared unit mass: 1 kg
Global Warming Potential- fossil, A1-A3 (kgCO2e): 2,57
Global Warning Potential-total, A1-A3 (kgCO2e): 2,53
Secondary material, inputs (%): 21,6
Secondary material, outputs (%): 0
Total Energy use, A1-A3 (kWh): 8,32
Total Water use, A1-A3 (m3e): 0,02

Biogenic carbon content in product (kg C): 0
Biogenic carbon content in packaging (kg C): 0,0088

3. PRODUCT LIFE-CYCLE

3.1. Manufacturing process (A1-A3)

SPAJIC doo steel fibres production starts with procurement of basic raw materials- wire rods. Wire rods are the only raw material used in the production of steel fibres. For the production of steel fibres, SPAJIC doo company uses hot-rolled steel wire rods of 5.5 mm diameter and of following steel grades: SAE 1006, SAE 1006+B, C4D+B and Fe37+B. SPAJIC doo purchases steel wire rods from suppliers from Moldova, Italy, Turkiye and Bosnia and Herzegovina, which are then shipped to the production site. The transportation of most materials involves multiple transport modalities, where route involves both transport by truck and ship.

First step of the production process is rough wire drawing from diameter 5.5mm to 2.4 or 2.00mm. The wires of diameter 2.4mm and 2.0mm then go through the fine wire drawing process. Steel wires with a diameter of 2.4mm are reduced to diameters 1.0, 0.9 and 0.75mm, whereas steel wires with a diameter of 2.0 are reduced to the diameter 0.6 and 0.55mm. In the wire drawing process, steel wire rods are pulled through conical dies, with an opening in the centre, which has a conical and a cylindrical part. As wire rod is pulled through the dies, it undergoes plastic deformation and gradual reduction in its diameter. At the same time, the length is increased proportionally. Wire drawing is a cold process, there is no change in the chemical composition of the wire, but only change in the diameter. After the wire drawing process, the next step is production of steel fibres. A wire is placed on the platform of the machine and inserted into the machine. The inserted wire is first being shaped and then cut to a certain length. Three types of fibres under this EPD: Steel fibres with hooked ends ZS/N, Corrugated steel fibres ZSW/N and High performance steel fibres ZS5 all go through the same production process and are produced from the same raw materials and technology. The only difference is being achieved by the shape forming assembly, where steel fibre shape and length is being formed.

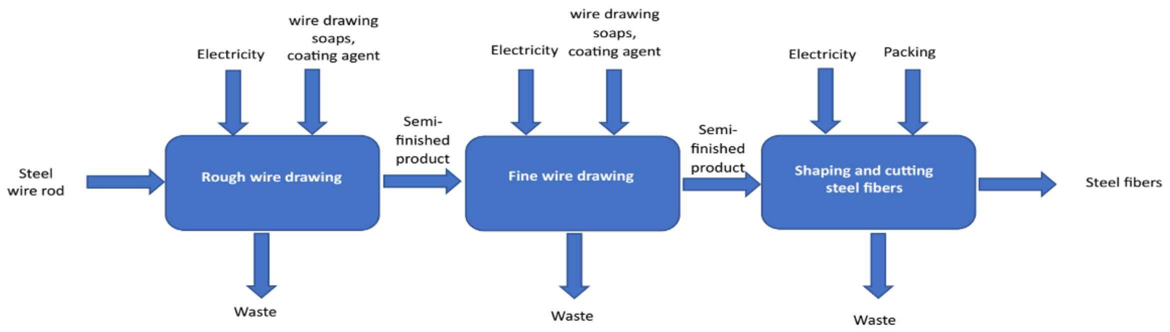

Figure 1. - Production process diagram

The production of packaging and ancillary materials is also modelled in this stage. Coating agent and wire drawing soaps are used in the manufacturing process in order to even out the wire drawing surface, make the wire drawing process more stable, enable higher drawing speed and reduce the friction between die and wire.

Production loss is 0,298% of declared unit and is modelled in A3. Steel wire rods that SPAJIC doo purchases are wrapped and packed with the hot-rolled steel wire rod that is considered as input packaging. Input packaging treatment is considered in A3. Treatment of packaging of ancillary materials contributes less than 1% to total mass, and according to cut-off criteria, is excluded from the study.

Steel fibres with hooked ends ZS/N, Corrugated steel fibres ZSW/N and High performance steel fibres ZS5 are packed in the same way. Pallets, paper sacks, cardboard, hook thread, stretch foil and PE foil are used for product packaging.

3.2. Transport and installation (A4-A5)

This PCF does not cover product distribution and installation.

3.3. Product use and maintenance (B1-B7)

This PCF does not cover the use phase.
Air, soil, and water impacts during the use phase have not been studied.

3.4. Product end of life (C1-C4, D)

End-of-life processes are confined to treatment and disposal of the steel fibres and packaging in which the product is supplied. Waste treatment is modelled up to the moment where the material reaches the end-of-waste status (C1-C4). Loads and benefits beyond the system boundary are declared separately (D).

Demolition is assumed to take 0,01 kWh/kg of product. The source of energy is diesel fuel used by construction machines (C1).

It is assumed that 100% of waste is collected. Transportation distance to recycling plant is assumed to be 250 km and to landfill is assumed to be 50 km. Transportation method is assumed to be lorry. Transport distances of waste to landfill and recycling facilities are retrieved from the EeBGuide (C2).
At the end of life, approximately 95% of steel fibres are assumed to be recycled based on World Steel Association, 2020 (C3). The remaining 5% of steel fibres is assumed to be taken to landfill for final disposal (C4).

Finished product is distributed and sold to clients all over the world. Since the packaging end-of-life is unknown, the conservative approach is taken. It is assumed that 100% of packaging pallet, plastic and paper is being sent to landfill.

Load and benefits beyond the system boundary include the processes that take place after the material reaches the end-of-waste state. In addition, avoided production of material due to reuse or recycling and avoided energy generation due to incineration are declared in this module. Due to recycling process, the end-of-life product is converted into recycled steel (D).

4. IMPACT ASSESMENT AND LIFE CYCLE INTERPRETATION

4.1. Complete life cycle per emission source

The carbon footprint (Cradle-to-gate with end-of-life options) of the steel fibres is described below. Results per emission source are included in the table 3, showing the total GHG emissions expressed in kg CO_2e per 1 kg of steel fibres produced by SPAJIC doo and per emission source, including Global Warming Potential, Global Warming Potential- biogenic, Global Warming Potential- land use and land use change (LULUC). Impact indicators are defined according to EN 15804+A2, climate change impact category requirements.

Table 3. - Steel fibres by carbon source in kg CO_2 e, EN 15804+A2

Impact category	A1	A2	A3	Total (A1-A3)	A4-A5	B1-B7	C1	C2	C3	C4	D
GWP-total1)	2,43E+00	1,27E-01	-2,75E-02	2,53E+00	MND	MND	3,31E-03	3,17E-02	2,09E-02	-2,77E-02	-1,80E+00
GWP-fossil	2,43E+00	1,27E-01	1,65E-02	2,57E+00	MND	MND	3,31E-03	3,16E-02	2,08E-02	6,90E-04	-1,81E+00
GWP-biogenic	2,57E-03	5,50E-05	-4,41E-02	-4,15E-02	MND	MND	0,00E+00	1,33E-05	9,22E-05	-2,84E-02	5,90E-03
GWP-LULUC	1,23E-03	7,51E-05	1,50E-04	1,46E-03	MND	MND	3,30E-07	1,29E-05	2,73E-05	6,50E-07	-3,53E-04

1)GWP- Global Warming Potential

The largest contribution in carbon footprint of steel fibres has raw material extraction and processing phase, which accounts for 92,4% of total CO_2 emissions. This is due to the manufacturing of steel wire rods that are used as the basic and only raw material for the production of SPAJIC doo steel fibres. Transport to the manufacturing site accounts for 4,8% of total CO_2 emissions. The stage of manufacturing of steel fibres at SPAJIC doo manufacturing plant in Negotin, Serbia, has low contribution to total GWP, only accounting for 0,6% of emissions. The rest of emissions are linked to the end-of-life phases (C1-C4), which are modelled according to the available literature (as set out in the section 3.4.). The emissions from the Loads and benefits beyond the system boundaries are considered external impacts and take place after the material reaches the end-of-waste state and are therefore excluded from the total result.

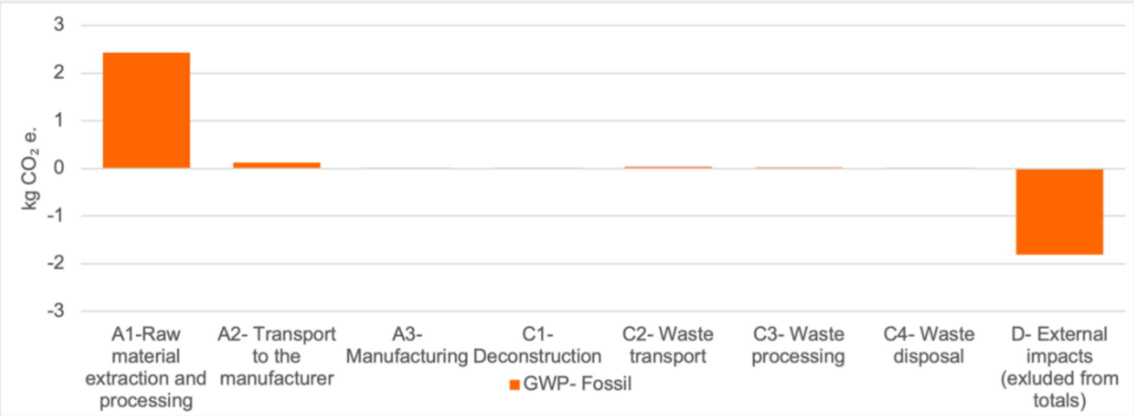

Figure 2. - GWP (Fossil) results per LCA stage (kgCO_2e)

Relative contribution of all stages in the system boundaries to the total results is shown in Figure 3.

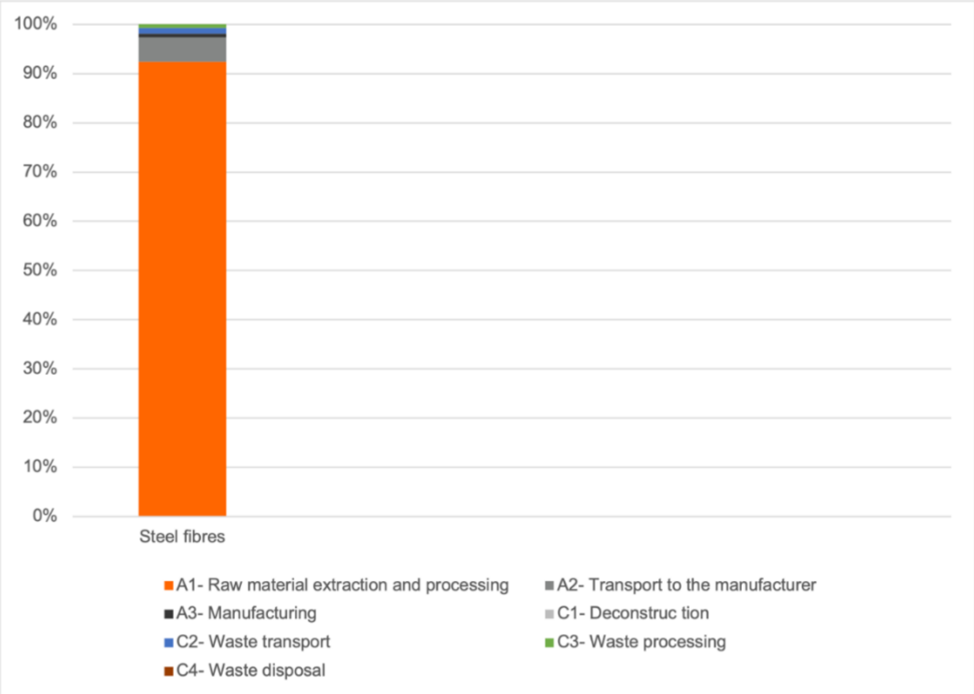

Figure 3. - Relative contribution to GWP (Fossil) results per LCA stage

In the Figure 4, results by emission source (GWP-total, fossil, biogenic and LULUC) required by EN 15804+A2 are shown.

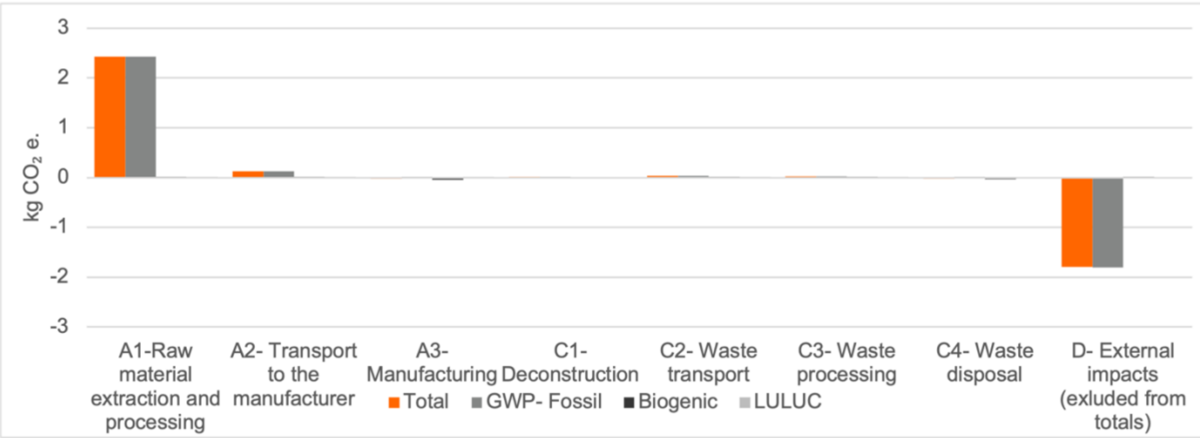

Figure 4. - Results per emission source (kgCO_2e)

Steel wire rods used for the production of steel fibres have the most significant contribution to the total GWP. Considering the highest amount of consumption of steel wire rod 5.5mm SAE 1006+B, this wire rod appears as the most contributing resource to the Global Warming Potential. However, per kg, all of the steel wire rods (SAE 1006+B, Fe37+B, C4D+B, SAE 1006) used as raw materials have the same Global Warming Potential. Materials for steel fibres packaging (pallet, paper sacks, cardboard, hook thread, PET tape, Stretch foil and PE foil) contribute with 0,4% to the total Global Warming Potential (fossil), per declared unit. Ancillary materials (wire dies, wire drawing soaps, water, coating agent and send belt), have contribution of 0,1% to the Global Warming Potential. Effects of electricity in the production process are negligible, due to the low electricity consumption per declared unit. Contribution of diesel used for internal transport is 0,1%.

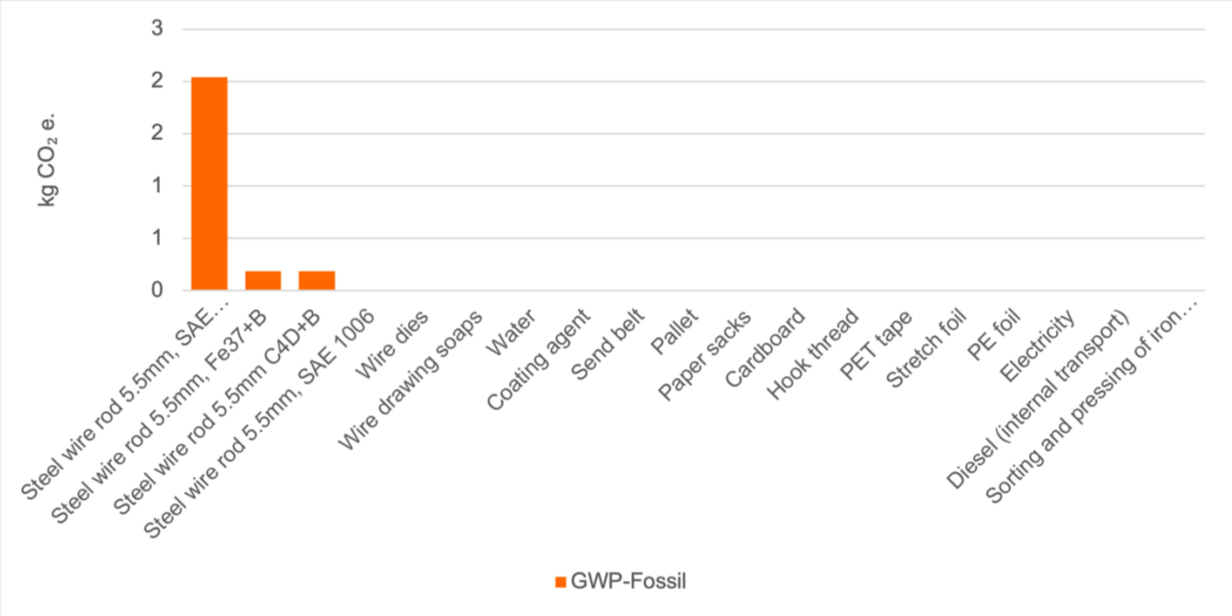

Figure 5. - Contribution analysis (A1-A3)

4.2. Limitations and assumptions

It is preferred to use third party reviewed LCA data from the suppliers of products and materials whereas possible or when data is available. Since no specific data from suppliers was available, background data from the Ecoinvent 3.8 database is used to model the production of raw materials.

4.3. Allocation

Allocation is required if some material, energy, and waste data cannot be measured separately for the product under investigation. No allocation for raw materials, packaging materials, ancillary materials and manufacturing energy and waste was used. Additionally, no averaging was used. Therefore, variation in GWP-fossil for A1-A3 is 0%.

5. REFERENCES

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[5] World Steel Association. (2017). Life cycle inventory methodology report for steel products. World Steel Association, Brussels.

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