Environmental Product Declaration

as per ISO 14025 and EN 15804+A2

Owner of the declaration:	EEW Special Pipe Construction GmbH
Publisher:	Kiwa-Ecobility Experts
Programme operator:	Kiwa-Ecobility Experts
Registration number:	EPD-EEW-236-EN
Issue date:	03.08.2022
Valid to:	03.08.2027

Monopiles

Ready to install and individually prefabricated. Monopiles for offshore windstructures.

1. General information

EEW Special Pipe Construction GmbH

Programme operator
Kiwa-Ecobility Experts
Voltastr. 5
13355 Berlin
Germany

Registration number
EPD-EEW-236-EN

This declaration is based on the Product Category Rules
PCR B - Requirements on the Environmental Product Declarations for construction steel products (Edition 2020-03-13 (draft))

Issue date
03.08.2022

Valid to
03.08.2027

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(Head of Kiwa-Ecobility Experts)

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(Chairman of the independent expert committee – Kiwa-Ecobility Experts)

Monopiles

Owner of the declaration
EEW Special Pipe Construction GmbH
Am Eisenwerk 1
18147 Rostock
Deutschland

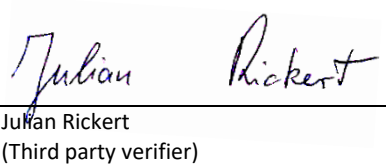
Declared product / declared unit
1 ton black steel construction product

Scope
The EPD is about a ready-to-install and individually prefabricated Monopiles (non coated), manufactured in Rostock, Germany. Monopiles are used as bottom fixed foundations in offshore wind farms. The owner of the declaration shall be liable for the underlying information and evidence. Kiwa – Ecobility Experts shall not be liable with respect to manufacturer information, life cycle assessment data and evidence.

Verification
The European standard EN15804:2012+A2:2019 serves as the core PCR.

Independent verification of the declaration and data according to ISO 14025:2006

☐internal ☒external



Julian Rickert
(Third party verifier)

2. Product

2.1 Product description and application

The monopiles from EEW are ready-to-install and individually prefabricated components for offshore wind farms.

2.2 Technical data

The possible technical data are listed in the table below. Specific values and value combinations depend on the individual design of the product. For this reason, only value ranges are given below.

Name	Value/Tolerance	Unit
Diameter range	1.800-12.000	mm
Length range	3.000-120.000	mm
Wall thickness range	20-170	mm
Steel grade DIN EN 10025 or DIN EN 10225	S275-S460	-
Weight Range	500-2.000.000	kg
Production route (EAF or BOF)	100% BOF	-
Tensile strength range	350-630	MPa
Yield strength range	275-460	MPa

2.3 Base materials / Ancillary materials

Raw material	Unit	Value
Heavy plate, base material S275-S460 according to EN 10225 or EN 10025 in various grades.	%	100

Other used Materials are Welding rod, welding powder (flux) and welding gases.
There is no biogenic carbon in the products. The product does not contain substances from the “Candidate list of substances of very high concern for authorisation” (SVHC).

2.4 Manufacturing

The production of Monopile is at EEW SPECIAL PIPE CONSTRUCTIONS GMBH, Am Eisenwerk 1, 18147 Rostock GERMANY and comprises the following process steps:

- Incoming goods - unload raw material plates, incoming goods inspection; plate storage
- Weld seam preparation
- Plate tacking: joining of two or three prepared plates
- Can rolling: bending of the prepared plates
- Welding inside longitudinal weld seam: SAW (submerged arc welding) welding of cans
- Milling: Milling of the outside longitudinal weld seam preparation
- Welding outside longitudinal weld seam: SAW welding of cans
- Calibration of cans: Calibration of the finished welded cans
- None destructive testing
- Assembly: assembly of cans to sections
- Welding inside circumferential weld seam: SAW welding of the sections

- Milling: Milling of the outside circumferential weld seam preparation
- Welding outside circumferential weld seam: SAW welding of the sections
- Final assembly of sections to complete monopile
- None destructive testing
- Final inspection
- Storage
- Loading for shipment

The manufacturing process is shown in the following figure:

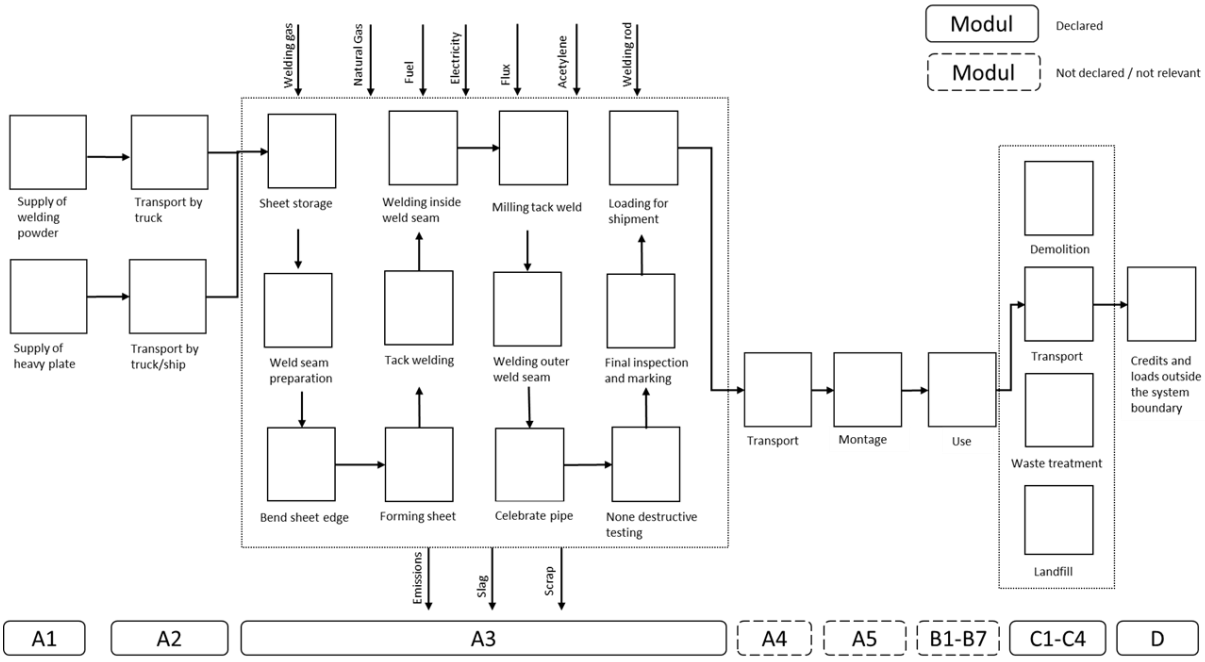


Figure 1: Simplified process flowchart of manufacturing (A3)

Monopiles can be coated according to customer requirements. This coating process is carried out externally by the neighbouring plant. This external processing is not considered in the LCA.

2.5 Packaging

There is no packaging in the process. Only securing methods are used in the storage.

2.6 Reference Service Life (RSL)

The lifetime of monopile will be limited by the service life of the construction (approx. 25 years, lifetime of monopile depends on lifetime of the installed wind turbine and other components.) Under these circumstances, no RSL according to the relevant ISO standards and EN 15804 can be declared.

3. LCA: Calculation rules

3.1 Declared unit

In accordance with the PCR B 1 ton of black steel is chosen as the declared unit.

Product	Unit	Value
Monopile	1 ton of black steel	1

3.2 System boundary

All inputs including raw materials, primary products, energy and auxiliary materials as well as the accumulated waste are considered in the assessment.
The following production steps are considered during the production phase:

- Raw material supply (A1)
- Transport of raw materials (A2)
- Energy supply for manufacturing (A3)
- Ancillary materials (A3)
- Production waste – transport and waste treatment (A3)
- De-Construction(C1)
- End-of-Life: Transport waste (C2)
- End-of-Life: Waste treatment (C3)
- End-of-Life: Disposal (C4)
- End-of-Life: Benefits and loads beyond the system boundary (D)

As described in section 2.4 and section 2.5, no coating and no packaging was considered in the LCA. Only securing methods are used in the storage. The products are handed over to the customer at the port edge of the factory and transported away via ships.
The manufacture of end products and the use of the final product is not within the manufacturer's sphere of influence. Therefore, the transport (A4) and (A5) installation are not declared.
No environmental impacts are expected in the use phase, therefore modules B1-B5 are declared as not relevant.
As hardly any offshore wind turbines have had to be dismantled so far, there is currently no data available for the evaluation of the pipes.
The production process generates production residues and waste. These include iron and steel drop-outs, slags, metal particles and emulsions. Depending on the material, these are either recycled or deposited.

3.3 Estimates and assumptions

The energy and material consumptions are average values and refer to the period 03/2020 to 02/2021.
To model the base material heavy plate in the LCA, a combination of two environmental profiles is used: “Steel, unalloyed, converter | production (EU)” and “Hot rolling, steel, | processing (EU)”. The transport routes of the raw materials are known.
Furthermore, the packaging of the supplied raw material is not considered.

Due to a high life expectancy and the fact that EEW is not responsible for this, there is no company data available on the material recovery of installed monopiles. There is also no literature data

available, as the construction of offshore wind farms is relatively new and no major wind farms have been dismantled yet. At present time, there is still discussion about what is the most sensible solution for the end-of-life, since deconstruction is costly and the damage may be less if, the plants remain in the sea. For this reason, the default scenario considers an empty waste scenario. This means that the built-in monopiles remain in place and there are no expenses for transport or treatment processes, and there are no credits for recycling and reuse. The dismantling is taken into account in an alternative scenario. The waste scenario "steel, heavy" from NMD 2022 is used for this. This scenario assumes that 51 percent will be recycled, and 49 percent reused. The electricity mix was chosen according to the current electricity provider and time reference (Electricity mix in detail: 22% natural gas; 78% EEG mix for time period 03/2020 -12/2020, 100 % renewable energy mix for time period 01/2021 – 02/2021).

3.4 Cut-off criteria

For the process modules A1 to A3, all process-specific data were collected. Potential environmental impacts were assigned to the material flows based on Ecoinvent V3.6. The mass sum of all inputs that were not considered in the life cycle inventory correspond to about 0,456 m-% of the declared unit. Therefore, these were also assumed to comply with the requirements for non-compliance according to EN 15804 (6.3.6).

3.5 Period under review

All process-specific data was collected for the period from March 2020 to February 2021.

3.6 Data quality

Overall, the quality of the data can be considered as good. In the operating data survey all relevant process-specific data could be collected. The data relating to the manufacturing phase of the construction steel are determined by EEW and refers to the production site in Rostock.
While for steel the background data from Worldsteel (a world industry association for the steel industry) was used, for all other inputs and outputs the data from Ecoinvent 3.6 was used.
The database is regularly checked and thus complies with the requirements of ISO 14040/44 (background data not older than 10 years). The background data meets the requirements of EN 15804. The quantities of raw materials, consumables and supplies used as well as the energy consumption have been recorded and averaged over the entire year of operation.
The general rule has been that specific data from specific production processes or average data derived from specific processes must be given priority when calculating an EPD or Life Cycle Assessment. Data for processes that the manufacturer cannot influence or choose, were backed up with generic data.

3.7 Allocation

There are no co-products in the raw material supply phase, so no allocation methods were used at this stage. There are no allocations during the manufacturing phase at the plant. The preparation of the construction product is an independent process.

3.8 Comparability

In principle, a comparison or assessment of the environmental impacts of different products is only possible if they have been prepared in accordance with EN 15804. For the evaluation of the comparability, the following aspects have to be considered in particular: PCR used , functional or declared unit, geographical reference, definition of the system boundary, declared modules, data selection (primary or secondary data, background database, data quality), scenarios used for use and disposal phases, and the life cycle inventory (data collection, calculation methods, allocations, validity period). PCRs

and general program instructions of different EPDs programs may differ. A comparability needs to be evaluated. For further guidance see EN 15804+A2 (5.3 Comparability of EPD for construction products) and ISO 14025 (6.7.2 Requirements for comparability). Reference Service Life (RSL)
The lifetime of monopiles will be limited by the service life of the construction. Under these circumstances, no RSL according to the relevant ISO standards and EN 15804 can be declared.

4. LCA: Results

The following tables show the results of the impact assessment indicators, resource use, waste and other output streams. The results presented here refer to the declared average product.

Disclaimer on ADP-e, ADP-f, WDP, ETP-fw, HTP-c, HTP-nc, SQP: The results of these environmental impact indicators must be used with caution, as the uncertainties in these results are high or as there is limited experience with the indicator.

Disclaimer on IR: This impact category mainly addresses the potential effect of low dose ionizing radiation on human health in the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents and occupational exposures, nor does it consider radioactive waste disposal in underground facilities. Potential ionizing radiation from soil, radon, and some building materials is also not measured by this indicator.

Description of the system boundary															
Product stage			Construction process stage		Use stage							End of life stage				Benefits and loads beyond the system boundaries
Raw material supply	Transport	Manu-facturing	Transport from manu-facturer to place of use	Construction -installation process	Use	Main-tenance	Repair	Replacement	Refur-bishmen	Operational energy use	Operational water use	De-construction / 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	MND	MND	MNR	MNR	MNR	MNR	MNR	MNR	MNR	X	X	X	X	X
X=Module declared | MND=Module not declared | MNR=Module not relevant																

Results of the LCA – Environmental impact: 1 ton Monopile (EN 15804+A2)										
Parameter	**Unit**	**A1**	**A2**	**A3**	**C1**	**C2**	**C3**	**C4**	**D**	**Total A1-A3**
Core environmental impact indicators										
GWP-total	kg CO2 eqv.	2,71E+03	1,20E+02	1,68E+02	0,00E+00	6,48E+00	0,00E+00	5,28E-02	-1,47E+03	3,00E+03
GWP-f	kg CO2 eqv.	2,71E+03	1,20E+02	1,67E+02	0,00E+00	6,48E+00	0,00E+00	5,27E-02	-1,48E+03	3,00E+03
GWP-b	kg CO2 eqv.	2,25E+00	2,56E-02	8,58E-01	0,00E+00	2,99E-03	0,00E+00	1,04E-04	6,02E+00	3,14E+00
ODP	kg CFC 11 eqv.	-9,86E-06	2,34E-05	1,14E-05	0,00E+00	1,43E-06	0,00E+00	2,17E-08	-7,11E-05	2,49E-05
GWP-luluc	kg CO2 eqv.	6,03E-01	1,20E-01	6,81E-02	0,00E+00	2,37E-03	0,00E+00	1,47E-05	-4,32E-01	7,92E-01
AP	mol H+ eqv.	7,86E+00	3,18E+00	5,70E-01	0,00E+00	3,76E-02	0,00E+00	5,00E-04	-6,49E+00	1,16E+01
EP-fw	kg P eqv.	1,65E-03	7,48E-04	4,94E-04	0,00E+00	6,53E-05	0,00E+00	5,90E-07	-6,54E-02	2,89E-03
EP-m	kg N eqv.	1,56E+00	8,39E-01	1,39E-01	0,00E+00	1,32E-02	0,00E+00	1,72E-04	-1,32E+00	2,53E+00
EP-T	mol N eqv.	1,69E+01	9,31E+00	1,56E+00	0,00E+00	1,46E-01	0,00E+00	1,90E-03	-1,44E+01	2,77E+01
POCP	kg NMVOC eqv.	4,35E+00	2,41E+00	3,32E-01	0,00E+00	4,17E-02	0,00E+00	5,51E-04	-7,39E+00	7,09E+00
ADP-mm	kg Sb-eqv.	1,93E-03	9,09E-04	1,24E-03	0,00E+00	1,64E-04	0,00E+00	4,82E-07	-6,78E-03	4,07E-03
ADP-f	MJ	2,74E+04	1,53E+03	2,56E+03	0,00E+00	9,77E+01	0,00E+00	1,47E+00	-1,43E+04	3,15E+04
WDP	m3 world eqv.	-1,57E+01	3,57E+00	1,87E+01	0,00E+00	3,50E-01	0,00E+00	6,60E-02	-2,53E+02	6,57E+00
Additional environmental impact indicators										
PM	disease incidence	1,26E-04	3,46E-06	5,54E-06	0,00E+00	5,83E-07	0,00E+00	9,72E-09	-1,25E-04	1,35E-04
IR	kBq U235 eqv.	9,93E+00	6,60E+00	3,10E+00	0,00E+00	4,09E-01	0,00E+00	6,04E-03	-1,99E+01	1,96E+01
ETP-fw	CTUe	3,84E+03	1,09E+03	2,55E+02	0,00E+00	8,71E+01	0,00E+00	9,55E-01	-4,42E+04	5,18E+03
HTP-c	CTUh	1,73E-07	6,51E-08	-8,64E-08	0,00E+00	2,83E-09	0,00E+00	2,21E-11	-7,27E-06	1,51E-07
HTP-nc	CTUh	6,64E-06	8,28E-07	2,04E-06	0,00E+00	9,53E-08	0,00E+00	6,79E-10	-4,99E-05	9,51E-06
SQP	Pt	-7,77E+03	4,68E+02	7,02E+02	0,00E+00	8,47E+01	0,00E+00	3,09E+00	-4,01E+03	-6,60E+03

ADP-mm= Abiotic depletion potential for non-fossil resources | **ADP-f**=Abiotic depletion for fossil resources potential | **AP**= Acidification potential, Accumulated Exceedance | **EP-fw** = Eutrophication potential, fraction of nutrients reaching freshwater end compartment | **EP-m**= Eutrophication potential, fraction of nutrients reaching marine end compartment| **EP-T**= Eutrophication potential, Accumulated Exceedance | **GWP-b**=Global Warming Potential biogenic | **GWP-f**=Global Warming Potential fossil fuels | **GWP-luluc**=Global Warming Potential land use and land use change |**GWP-total**=Global Warming Potential total| **ODP**=Depletion potential of the stratospheric ozone layer |**POCP**=Formation potential of tropospheric ozone | **WDP**=Water (user) deprivation potential, deprivation- weighted water consumption | **ETP-fw**=Potential Comparative Toxic Unit for ecosystems | **HTP-c**=Potential Toxic Unit for Humans toxicity, cancer | **HTP-nc**= Potential Toxic Unit for humans, non-cancer | **IRP**=Potential Human exposure efficiency relative to U235, human health | **PM**=Potential incidence of disease due to Particulate Matter emissions | **SQP**=Potential soil quality index

Results of the LCA – Resource and environmental information: 1 ton Monopile (EN 15804+A2)										
Parameter	**Unit**	**A1**	**A2**	**A3**	**C1**	**C2**	**C3**	**C4**	**D**	**Total A1-A3**
PERE	MJ	6,01E+02	1,72E+01	3,94E+02	0,00E+00	1,22E+00	0,00E+00	1,35E-01	-5,03E+02	1,01E+03
PERM	MJ	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
PERT	MJ	6,01E+02	1,72E+01	3,95E+02	0,00E+00	1,22E+00	0,00E+00	1,19E-02	-5,03E+02	1,01E+03
PENRE	MJ	2,73E+04	1,63E+03	2,75E+03	0,00E+00	1,04E+02	0,00E+00	2,55E+00	-1,51E+04	3,17E+04
PENRM	MJ	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
PENRT	MJ	2,73E+04	1,63E+03	2,71E+03	0,00E+00	1,04E+02	0,00E+00	1,56E+00	-1,51E+04	3,17E+04
SM	Kg	1,80E+02	0,00E+00	6,44E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,38E+02	1,86E+02
RSF	MJ	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
NRSF	MJ	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
FW	M3	2,18E+02	1,37E-01	8,93E+00	0,00E+00	1,19E-02	0,00E+00	1,57E-03	-6,94E+00	2,27E+02
HWD	Kg	0,00E+00	2,09E-03	-1,68E-03	0,00E+00	2,48E-04	0,00E+00	2,20E-06	-1,25E-01	4,16E-04
NHWD	Kg	6,60E+01	5,06E+00	6,84E+00	0,00E+00	6,20E+00	0,00E+00	1,00E+01	-2,60E+02	7,79E+01
RWD	Kg	0,00E+00	1,05E-02	2,93E-03	0,00E+00	6,42E-04	0,00E+00	9,67E-06	-2,33E-02	1,34E-02
CRU	Kg	0,00E+00	0,00E+00	8,31E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,31E+00
MFR	Kg	0,00E+00	0,00E+00	8,89E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,89E+00
MER	Kg	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
EE	MJ	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

PERE=Use of renewable primary energy excluding renewable primary energy resources used as raw materials | **PERM**= Use of renewable primary energy resources used as raw materials | **PERT**=Total use of renewable primary energy resources | **PENRE**= Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials | **PENRM**= Use of non-renewable primary energy resources used as raw materials | **PENRT**= Total use of non-renewable primary energy resources | **SM**=Use of secondary material | **RSF**=Use of renewable secondary fuels | **NRSF**=Use of non-renewable secondary fuels | **FW**=Use of fresh water | **HWD**=Hazardous waste disposed | **NHWD**=Non-hazardous waste disposed | **RWD**=Radioactive waste disposed | **CRU**=Components for re-use | **MFR**=Materials for recycling | **MER**=Materials for energy recovery | **EE**=Exported energy

5. LCA: Interpretation

5.1 Dominance analysis with environmental costs indicator

The aggregation of the environmental impact according to the calculation method of the "National Milieu Database" (NMD 2022) allows a comparison of absolute values and an analysis according to dominant drivers of the product system (Figure 2). In the interpretation, it must be taken into account that modules C1-C4 und D only apply if the corresponding scenario occurs (end-of-life: 94% recycling).

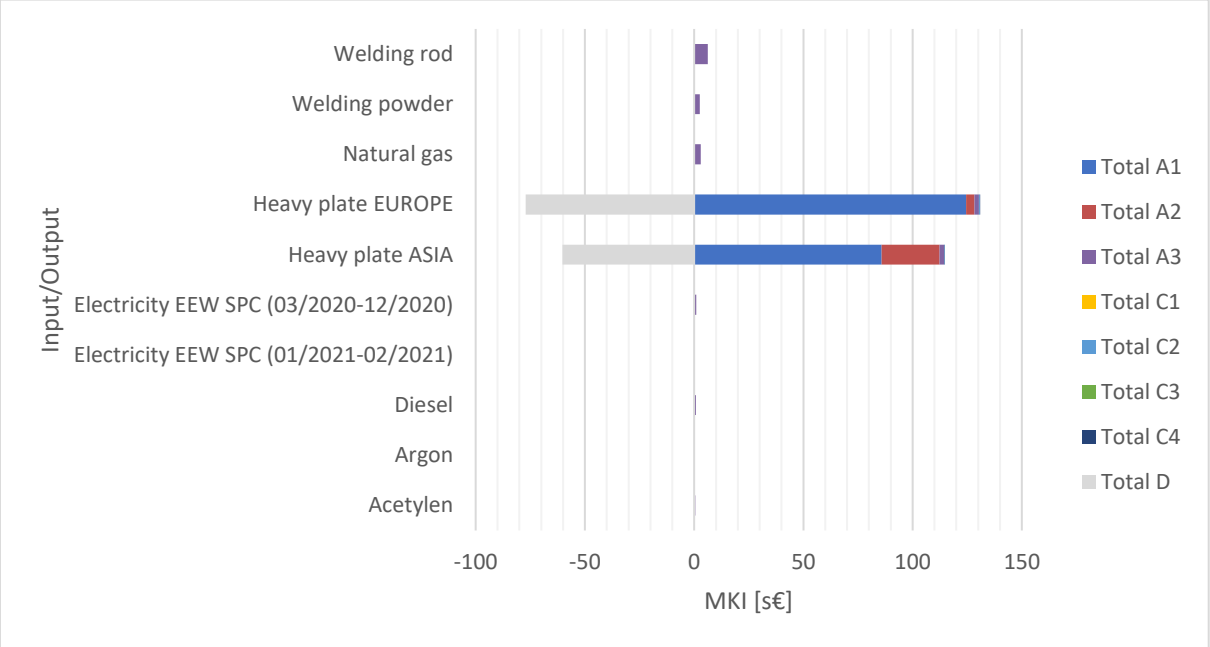


Figure 2: Environmental costs indicator [s€] per input / output flow

The comparison shows that the main raw material, heavy plate from Europe or Asia, has the greatest impact on the product's life cycle assessment. In- and Outputs in the production phase such as electricity, gas and fuel consumption as well as the use of welding wire and welding powder are insignificant. When comparing the heavy plates from Europe and Asia, it can be seen that the influence of transport (A2) on the total environmental impact (excluding D) is 19%, whereas for the European supplier it is only 3%. The weight-specific MKI value for the profiles is higher for the European steel (0,2219) than for the Asian steel (0,1954). It can be concluded from this that transport has a major influence on the environmental impact of the product. In general, structural steels have a high recycling potential. The waste scenario used assumes 94% recycling and 5% reuse (the rest is landfill). For this reason, there is a relatively high credit outside the product system in D.

The values in D are only meaningful to a limited extent. For some environmental categories, they are partly very high and higher than the impact from raw material extraction in A1. This can be explained by the fact that the raw material profile for A1 (heavy plate from the Worldsteel database) and the credit for recycling (Market steel, unalloyed from Ecoinvent 3.6) match due to different data origins. This can also be observed when comparing the impact of the modules per environmental indicator (see Figure 3).

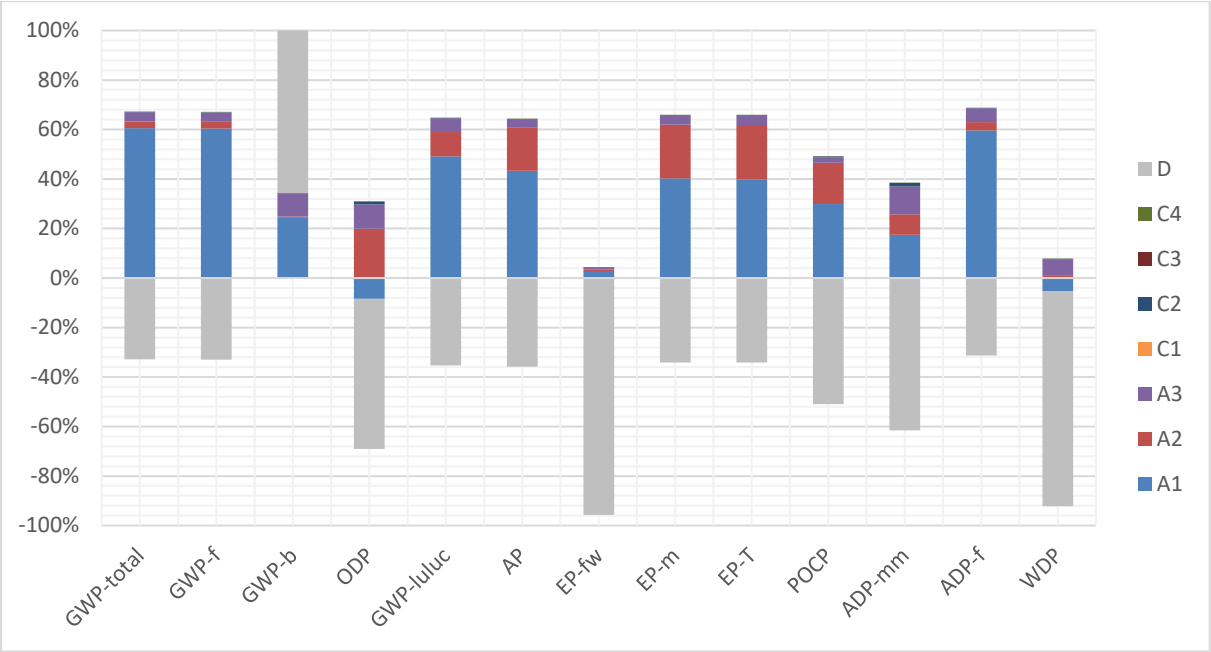


Figure 3: Impact of the LCA-modules on the environmental core-indicator

5.2 Data Quality

The data quality can be classified as good overall. All relevant process-specific data could be collected in the operational data collection. For the main input material heavy plate, site-specific environmental profiles of the background database Industrial Database (worldsteel) were used, for all other data Ecoinvent 3.6. was used as background database. Furthermore, the purchased electricity mix from EEW was used. The background data meet the requirements of EN 15804. The quantities of raw materials and supplies used as well as energy consumption were recorded for the entire operating year.

6. References

CML-IA April 2013 – Charakterisierungsfaktoren entwickelt durch Institut of Environmental Sciences (CML): Universität Leiden, Niederlande - http://www.cml.leiden.edu/software/data-cmlia.html

NMD STICHTING NATIONAL ENVIRONMENTAL DATABASE: Environmental Performance Assessment Method for Construction; 1.1 (March 2022); Rijswijk
Protocol EPD-online - 25011.16.03.015 - Protocol EPD online - NMD, version 1.2, November 2016, NIBE

SimaPro Software: Industry data LCA library; website: https://simapro.com/databases/industry-data-lca-library/

Standards and laws

ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework

ISO 14044:2006, Environmental management - Life cycle assessment - Requirements and guidelines

ISO 14025:2006: Environmental labels and declarations — Type III environmental declarations — Principles and procedures EN 13249

EN 15804:2012+A2:2019 Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

PCR A: General Program Category Rules for Construction Products from the EPD program Kiwa-Ecobility Experts, R.0_2021-07-16

PCR B: PCR B - Requirements on the Environmental Product Declarations for construction steel products (Edition 2020-03-13 (draft)

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