Environmental product declaration (EPD) report of fabricated steel products produced in the UK by Eco-Reinforcement members

FINAL REPORT

ROM Group

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Date of EPD: 20 March 2019 (5 year validity)

Anthesis

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1 Goal and scope

1.1 Background

Eco-Reinforcement are a consortium of reinforcing steel producers and fabricators who have developed a third-party certification scheme to access and recognise responsibly sourced reinforcing steel products.

Eco-Reinforcement are interested in better understanding the environmental profile of products manufactured by their member companies BRC Ltd, Express Reinforcements, ROM Group and Hy-Ten. To this end, life cycle assessment (LCA) can be used to generate quantitative environmental profiles for different products systems across their entire lifecycle. As Eco-Reinforcement were also very much interested in a study that allows a fair basis for comparison and communication results, an environmental product declaration (EPD) was performed using LCA as a basis for the underlying methodology.

Eco-Reinforcement members include the steel fabrications BRC Ltd, Express Reinforcements, ROM Group and Hy-Ten. This report is specific to ROM Group.

The following LCA practitioners from Anthesis were involved in this project:

- **Matt Fishwick** – Matt has over 10 years of experience in product carbon footprinting, LCA and waste. Past clients include E.ON, Land Securities, Lend Lease, HS2, Jotun and Masdar.
- **Alan Spray -** Alan leads the data analyst team at Anthesis. He has a PhD in engineering and a background in LCA, leading projects for EloPak, Reckitt Benckiser and Pepsico.

Life cycle assessment is a decision support tool that allows quantitative environmental profiles to be generated for different products systems. Environmental product declaration's and associated product category rules (PCRs) allow LCAs of similar products to be carried out using a consistent approach and communicated to interested stakeholders. This study and report has been performed in accordance with the requirements given in ISO 14025, EN 15804 and the International EPD programme's PCR for construction products and construction services (PCR 2012:01, v2.3, herein referred to as the construction products PCR). The methodology of this study is also underpinned by the international standards for LCA: ISO 14040:2006 and ISO 14044:2006. Comparison of products will only be possible if the comparative product LCA/EPD is carried out using EN 15804 and the construction products PCR.

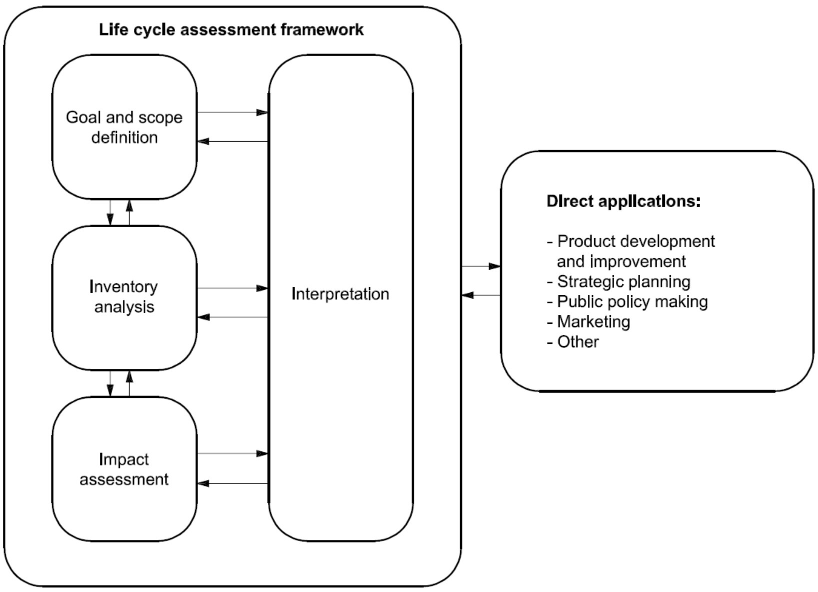

Figure 1 – The four stages of LCA as defined by ISO 14040.

The EPD followed a typical four-stage iterative process used in LCA: goal and scope definition, inventory analysis, impact assessment and interpretation (Figure 1). The whole process is usually iterative, with feedback loops between the interpretation and all other stages of the LCA, as was the case in this study. Following the definition of the goal and scope in this LCA project, the project involved the development of process flow diagrams (PFD) for each product system by both Anthesis and Eco-Reinforcement members jointly, in an iterative process. Then appropriate inventory data were gathered from both Eco-Reinforcement members and secondary sources to cover all unit processes within each product system. These inventory data were used to create a model, characterisation factors were applied, and results subsequently generated and interpreted.

1.2 Goal of the study

The goal of this study was to generate environmental profiles to be reported in an EPD of the following fabricated reinforcing steel products to better understand the associated lifecycle environmental impacts of each:

- **Cut and bent steel rebar product**;
- **Cut and bent steel mesh product;** and
- **Prefabricated reinforcement product**.

This LCA study will allow ROM Group and Eco-Reinforcement to identify the relative contribution to environmental impact of all processes in the product lifecycles. Therefore, it will allow members to identify the relative contribution to environmental impact of all processes of the product systems under investigation and help identify ‘hotspots’ where mitigation measures can be targeted. Results from this study will be used to communicate the environmental performance of these product systems to customers and other stakeholders, in the form of an EPD. In each case, the intended use of this EPD is business-to-business communication, not business-to-consumer communication.

The main objectives of the study were to:

- Generate EPDs to communicate the environmental impact of the product systems;
- Identify significant contributions to the environmental impacts (“hotspots”) across the product lifecycle; and
- Identify possible improvement areas of the studied systems that would be of interest for further analyses.

The intended applications are to:

- Understand the opportunities and risks of steel fabrication;
- Help inform opportunities for environmental impact reduction; and
- Inform ROM Group’s environmental policy.

1.3 System boundaries

The system boundary of this LCA study was “**cradle-to-gate**”, covering the following EN 15804 information modules: A1 raw material supply, A2 transport and A3 manufacturing (Figure 2). This includes the extraction and production of raw materials, manufacturing processes, all transportation stages and waste management through to the “gate” boundary. All other building life cycle stages are excluded.

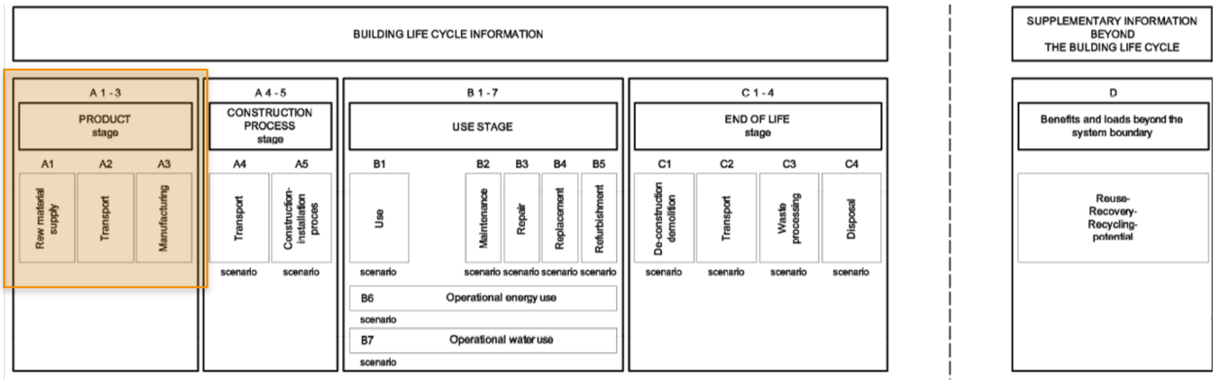

Figure 2 – EN 15804 building life cycle information modules

1.1 Declared unit

The general function of the product systems is, in each case, to provide reinforcement support for concrete used for a variety of purposes in buildings and infrastructure. However, the precise function of the product system at the building level is not stated here, due to the variety of possible uses of this construction product.

Instead, adeclared unit was applied for this EPD. The declared unit provides a reference to which material flows of the construction product are normalised and serves as a basis of comparison between systems, it is therefore an important factor. The declared unit for this study was defined as:

"1 tonne of fabricated reinforced steel product produced in the UK"

1.2 Manufacturing sites

Data were collected from the following ROM Group manufacturing sites for the cut and bent steel rebar product system:

- **ROM Witham**: 4 Wheaton Road, Witham, Essex, CM8 3BU;
- **ROM Sheffield**: 710 Brightside Lane, Sheffield, South Yorkshire, S9 2SR;
- **ROM Crumlin**: Rush Drive, Newport, NP11 3EJ;
- **ROM Brierley**: Brierley Park Close, Stanton Hill, Sutton in Ashfield, NG17 3FW;
- **ROM-TECH Whitburn**: Murrays gate Industrial estate, Whitburn, Bathgate, EH47 0LE; and
- **ROM-TECH Craigavon**: Unit 8 Silverwood Business Park, 70 Silverwood Road, Craigavon, Northern Ireland, BT66 6LN.

Data were collected from the following ROM Group manufacturing site for the cut and bent steel mesh product system:

- **ROM Lichfield**: Trent Valley Trading Estate, Eastern Ave, Lichfield, Staffordshire, WS13 6RN.

Data were collected from the following ROM Group manufacturing sites for the prefabricated reinforcement product system:

- **ROM Witham**: 4 Wheaton Road, Witham, Essex, CM8 3BU;
- **ROM Crumlin**: Rush Drive, Newport, NP11 3EJ;
- **ROM Brierley**: Brierley Park Close, Stanton Hill, Sutton in Ashfield, NG17 3FW;
- **ROM-TECH Whitburn**: Murrays gate Industrial estate, Whitburn, Bathgate, EH47 0LE; and

- **ROM-TECH Craigavon**: Unit 8 Silverwood Business Park, 70 Silverwood Road, Craigavon, Northern Ireland, BT66 6LN.

1.3 Material composition of product

The main material composition of the product is based on an EPD for rod/bar reinforcing steel published by one of ROM's main suppliers of this product (BREG EN EPD 000187; BRE, 2017). ROM's processes do not change the material composition of rod/bar reinforcing steel in any way.

- 95% iron; and
- 5% - FeSi, SiMn, CuSi, FeB, Al, FeV, C and other charge additives.

1.4 Product systems description

ROM Group produce cut and bent hot rolled ribbed steel reinforcement bar and mesh and prefabricated reinforcement product for use in the reinforcement of concrete. All three product systems have similar processes in their cradle-to-gate lifecycle, which is described below and presented in the PFD in Figure 3:

- **A1 raw materials supply:** scrap steel is added to an electric arc furnace to melt it and convert it into high quality steel before it is cast into billets. The production process for the first use of this scrap steel involved mining iron ore, extracting molten iron from the ore in a blast furnace and removing impurities to produce steel billets. Rod/bar reinforcing steel is produced by Celsa by heating steel billets, which are in turn pushed through a series of rolling stands with grooved cylindrical rolls, each with a smaller diameter than the previous. No other raw materials are considered in the bar and mesh product systems. In the case of prefab, welding wire and shielding gas raw materials were also considered. Packaging materials were excluded based on immateriality in all product systems.
- **A2 transport:** rod/bar reinforcing steel manufactured by Celsa in Cardiff and other raw materials manufactured at various sites are transported to ROM Group sites in the UK via road, rail and sea.
- **A3 manufacturing:** rod/bar reinforcing steel is cut to the desired length and bent to the desired shape at ROM Group site. In the case of prefab, the product is welded into shape using electric arc welding.

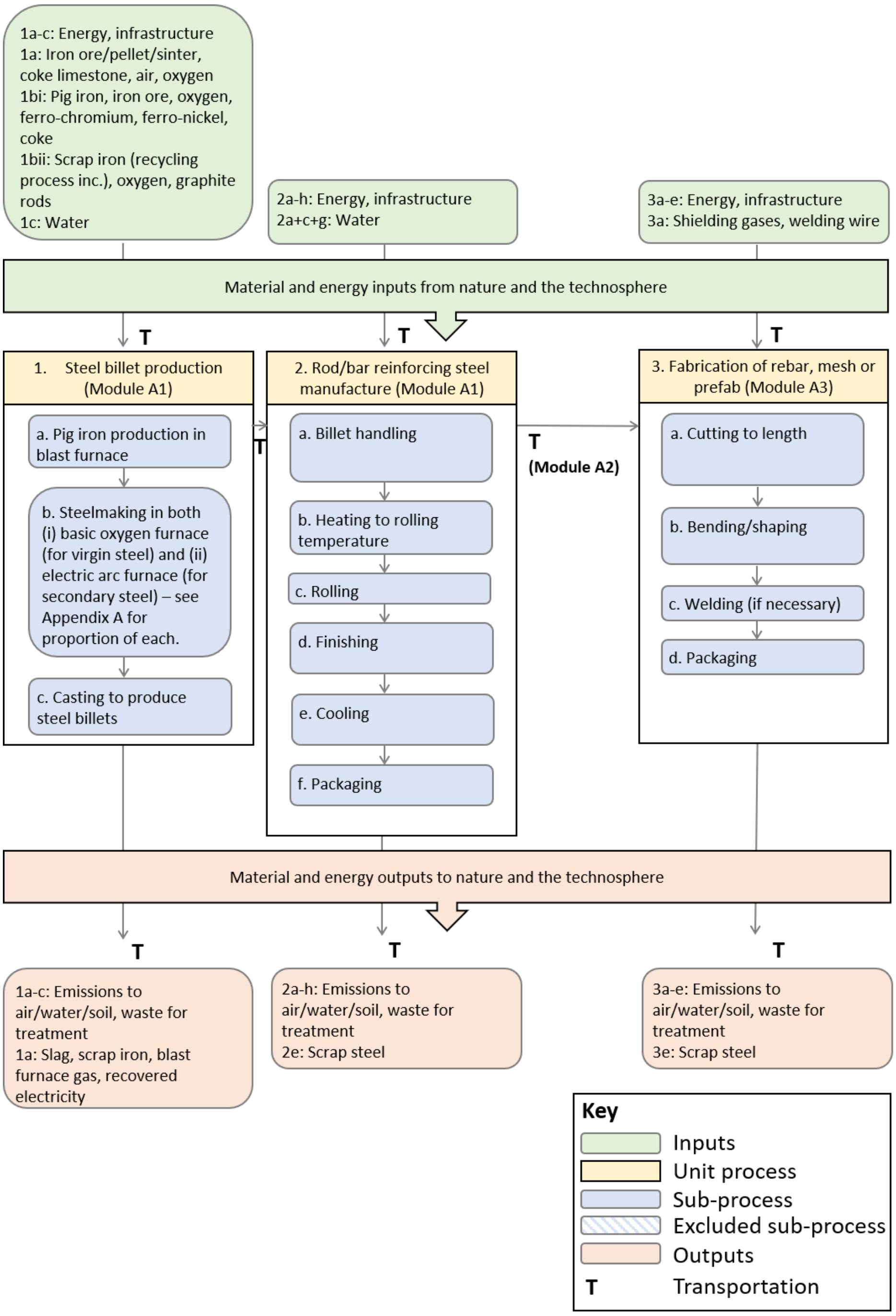

Figure 3 – Process flow diagram

1.5 Exclusions and cut-off criteria

In the process of building a life cycle inventory (LCI) it is typical to exclude items considered to have a negligible contribution to results. In order to do this in a consistent and robust manner there must be confidence that the exclusion is fair and reasonable. To this end, cut-off criteria are defined, which allow items to be neglected if they meet the criteria. In this study, exclusions could be made if they were expected to be within the below criteria:

- **Mass**: if a flow is anticipated to be less than 1% of the mass of the product it may be neglected;
- **Energy**: if a flow is anticipated to be less than 1% of the cumulative energy it may be neglected; and

- **Environmental significance**: if a flow is anticipated to be less than 1% of the key impact categories it may be excluded.

If an item meets one of the criteria but is expected to be significant for one of the other criteria it may not be neglected. For example, if a raw material is small in mass but is expected to have a notable contribution to the environmental results then it may not be excluded.

Lifecycle stages that have been omitted from the scope of the study include the following:

- Human energy inputs to processes;
- Production and disposal of the infrastructure (machines, transport vehicles, roads, etc.) and their maintenance;
- Environmental impacts related to storage phases;
- Losses of product at different points in the supply chain, for instance during handling and storage;
- Transport of employees to and from their normal place of work and business travel;
- Environmental impacts associated with support functions (e.g. R&D, marketing, finance, management etc.); and
- Primary, secondary and tertiary packaging of raw materials and finished products (estimated to be <0.1% of product by mass for finished products).

1.6 Data quality requirements

The general data quality requirements and characteristics that need to be addressed in this study are shown in **Error! Reference source not found.**.

Table 1 - Data quality requirements based on ISO 14044, EN 15804 or the construction products PCR

Aspect	Description	Requirement in this study
Time-related coverage	Desired age of data and the minimum length of time over which data should be collected	General data should represent the current situation of the date of study, or as close as possible. All data should be less than 10 years old and within the last 5 years for producer specific data. Producer specific data should be based on 1 year averaged data. Time period for inputs and outputs to and from the system should be 100 years. Long term emissions (> 100 years) should be excluded.
Geographical coverage	Area from which data for unit processes should be collected	Data should be representative of the physical reality for the declared product.
Technology coverage	Type of technology (specific or average mix)	Data should be representative of the physical reality for the declared product.
Completeness	Assessment of whether all relevant input and output data are included for each data set.	Simple validation checks (e.g. mass or energy balances) will be performed.

Aspect	Description	Requirement in this study
Representativeness	Degree to which the data set reflects the true population of interest	The data should fulfil the defined time-related, geographical and technological scope.
Precision	Measure of the variability of the data values	Data that is as representative as possible will be used.
Reproducibility	Assessment of the method and data, and whether an independent practitioner will be able to reproduce the results	Information about the method and data (reference source) should be provided.
Sources of the data	Assessment of the data sources used.	Data will be derived from credible sources, and references will be provided.

1.7 Data quality indicators (DQIs)

To ensure the quality of data was sufficient data quality checks were completed on key data parameters. This was completed through the use of data quality indicators (DQIs).

Data quality indicators are applied to key data parameters to ensure that the data is fit for purpose. Key data parameters are assessed against a data quality matrix and assigned scores between 1 (best) and 5 (worst). The data quality matrix used in this study was adapted from Weidema et al. (2013) and is shown in **Error! Reference source not found.**. Data quality indicator scores for inventory data are provided in Appendix B.

Table 2 - Data Quality Indicator Matrix

Aspect	1	2	3	4	5
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Representative	Representative data from sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years of	Less than six years of difference	Less than 10 years of difference	Less than 15 years of difference	Age of data unknown or more than 15 years of difference

Aspect	1	2	3	4	5
	difference to year of study				
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate

1.8 Data collection procedures

Quantitative and qualitative primary and secondary data were collected for all processes within the system boundary (with the exception of exclusions described in Section **Error! Reference source not found.**) and these data were used to compile the LCI.

In this study, primary data were collected for all process likely to be under the operational control of ROM over the period of 01/01/2016 to 31/12/2016 and most other processes were modelled using secondary data. Primary data were collected from ROM using data collection sheets via an iterative process and comprised general site information including annual production masses, annual raw materials used, annual energy and fuel use, annual fugitive and process emissions, annual solid and liquid waste treatment. Further primary data came in the form of an EPD from one of ROM's suppliers, Celsa Steel UK Ltd (BREG EN EPD No 000187). Secondary data were collected primarily from extended version of the ecoinvent v3.4 database (EuGeos'15804-IA v3.0). All data sources are described in Appendix A.

A mass balance of materials for each site was performed and is summarised below:

- ROM Witham: 1.017 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.017 tonnes per tonne of product left as waste.
- ROM Sheffield: 1.030 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.030 tonnes per tonne of product left as waste.
- ROM Crumlin: 1.027 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.027 tonnes per tonne of product left as waste.
- ROM Brierley: 1.022 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.022 tonnes per tonne of product left as waste.

- ROM-TECH Whitburn: 1.015 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.015 tonnes per tonne of product left as waste.
- ROM-TECH Craigavon: 1.025 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.025 tonnes per tonne of product left as waste.
- ROM Lichfied: 1.010 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.010 tonnes per tonne of product left as waste.

1.9 Life Cycle Impact assessment (LCIA) method

In LCA, the life cycle impact assessment (LCIA) stage is where characterisation factors are applied to life cycle inventory (LCI) data to generate environmental impact results. There are several LCIA methods that can be chosen, all with slightly different characterisation factors (both in terms of coverage and values) and different underlying characterisation models used to generate these factors. In this study, the LCIA methods prescribed in EN 15804 and the construction products PCR (CML-IA v4.1) were used.

The CML-IA impact assessment method transformed data gathered in the inventory phase to several indicator scores for various impact categories, giving a broad range coverage of environmental issues. These indicator scores express the relative severity on an environmental impact category and are represented here at the 'mid-point' stage. At the 'mid-point' stage, individual impact categories are shown, whereby a score is given for each in the appropriate reference unit.

A LCA model was built in Microsoft Excel for the product systems under investigation using primary and secondary inventory data. 'Mid-point' characterised results from the EuGeos EN 15804-IA database v2.1 were applied to LCI data in the LCA model. EuGeos EN 15804-IA is an extended version of ecoinvent v3.4 (cut-off) that allows for the calculation of all environmental indicators of CML-IA v4.1 in addition to other parameters required by EN 15804. Characterisation models and factors from CML-IA v4.1 were used unaltered and as provided and calculation of other EN 15804 parameters was carried out using EuGeos EN 15804-IA data and methods unaltered and as provided. Long term (> 100 years) emissions were excluded from this study. Note that estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

The CML-IA v4.1 mid-point environmental impact categories used in this study comprised the following:

- CML-IA v4.1, Global Warming Potential, GWP (kg CO_2 equivalent, eq);
- CML-IA v4.1, Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq);
- CML-IA v4.1, Acidification potential of soil and water, AP (kg SO_2 eq);
- CML-IA v4.1, Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq);
- CML-IA v4.1, Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq);
- CML-IA v4.1, Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq); and
- CML-IA v4.1, Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value).

Other EN 15804-IA parameters used in this study comprised the following:

- Parameters describing resource use, primary energy:
    - Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value);
    - Use of renewable primary energy resources used as raw materials (MJ, net calorific value);
    - Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value);

- Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (MJ, net calorific value);
- Use of non-renewable primary energy resources used as raw materials (MJ, net calorific value); and
- Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value).

- Parameters describing resource use, secondary materials and fuels and use of water:
  - Use of secondary material (kg);
  - Use of renewable secondary fuels (MJ, net calorific value);
  - Use of non-renewable secondary fuels (MJ, net calorific value); and
  - Net use of fresh water (m^3).
- Parameters describing waste categories:
  - Hazardous waste disposed (kg);
  - Non-hazardous waste disposed (kg); and
  - Radioactive waste disposed (kg).
- Parameters describing outputs flows at the end of life:
  - Components for re-use (kg);
  - Materials for recycling (kg);
  - Materials for energy recovery (kg); and
  - Exported energy (MJ, net calorific value).

Average LCIA results for the product system were generated using individual per declared unit LCIA results from each ROM site and weighting them based on the mass of production output from each site.

1.10 General allocation procedures

For cases where there is more than one product in the system being studied, ISO 14040/44 prescribes the following procedure for the allocation of material and energy flows and environmental emissions:

- In the first instance, allocation should be avoided, by process sub-division.
- Expanding the product system to include the additional functions related to the co-products.
- Where these methods are not applicable, the ISO 14040/44 requires that allocation reflects the physical relationships of the different products or functions. Allocation based on physical relationships such as mass or energy is a practical interpretation of this and an approach often used in LCA.
- For some processes, allocation based on mass is not considered appropriate and, in these cases economic allocation is used.

In this study, allocation procedures for multi-product processes followed the ISO approach above. Site level allocation of primary data at the A3 manufacturing stage was carried out on the basis of mass. In the case of secondary data, in most cases an extended version of the ecoinvent v3.4 database (EuGeos'15804-IA v3.0) was applied in this study. Where allocation of flows between multi-product processes was carried out in the EuGeos EN 15804-IA version of ecoinvent, an economic approach was used in most cases, with some mass-based allocation, where there was a direct physical relationship. The allocation approach of specific ecoinvent modules is documented on their website and method reports (see www.ecoinvent.org). See Appendix A for specific ecoinvent data used in this study.

1.11 End-of-life allocation procedures

In this study a cut-off method was applied to all cases of end-of-life allocation, including in the case of secondary data, where the EuGeos EN 15804-IA version of ecoinvent v3.4 with a cut-off by classification end of life allocation method was used. This was also used for the consumption of recycled materials at the start of life and for the sending of materials to recycling or material reuse at the end-of-life. In this approach the environmental burdens and benefits of recycled / reused materials are given to the product system consuming them, rather than the system providing them. This is known as the cut-off, recycled content or 100:0 approach. This is a common approach in LCA, follows the ISO standards on LCA and prescribed in EN 15804.

1.12 Demonstration of verification

CEN standard EN 15804 serves as the core product category rules
Independent verification of the declaration and data, according to EN ISO 14025:2010 ○ internal ○ **external**
Third party verifier: Jane Anderson, ConstructionLCA

1.13 Assumptions

During this LCA a number of assumptions were made, the most important of which are described below for transparency:

- Transportation of raw materials to ROM sites was based on the most logical route and transportation method from the supplier locations to Staines and Chatham. A small proportion of steel was known to be transported by rail and sea to some ROM sites, but detailed information on this was not available. Therefore, for simplicity all transport of steel from the supplier to ROM sites was modelled as being transported by road on the assumption that any difference in impact would be immaterial.
- Transportation of waste from ROM sites to materials recovery facilities was assumed to be a distance of 50 km by road.
- Average of refrigerant losses from other Eco-Reinforcement sites was used to estimate refrigerant losses from ROM sites.

2 Life cycle impact assessment (LCIA)

This section presents all LCIA results from this study for all product systems:

- **Cut and bent steel rebar product**;
- **Cut and bent steel mesh product**; and
- **Prefabricated reinforcement product.**

3 shows the cradle-to-gate LCIA results of 1 tonnes of ROM Group cut and bent steel rebar product. Results are broken down by life cycle information modules A1 raw materials, A2 transportation and A3 manufacturing and represented as a total of A1-3.

Table 3 – Cradle- to-gate LCIA results for 1 tonne of ROM Group cut and bent steel rebar product. For modules A4-5, B1-7, C1-4 and D, for all impact categories the notation Module Not Declared (MND) applies

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Global warming potential, GWP (kg CO_2 eq)	666.3	17.1	8.7	692.1	MND
Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq)	4.7E-05	3.5E-06	7.9E-07	5.1E-05	MND
Acidification potential of soil and water, AP (kg SO_2 eq)	3.20	0.04	0.04	3.28	MND
Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq)	0.81	0.01	0.01	0.82	MND
Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq)	0.29	0.00	0.00	0.29	MND
Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq)	9.5E-04	1.1E-04	3.4E-05	1.1E-03	MND
Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value)	8,795	280	126	9,201	MND
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value)	687.9	5.1	52.9	745.9	MND
Use of renewable primary energy resources used as raw materials (MJ, net calorific value)	1.1E-03	0.0E+00	3.3E-02	3.4E-02	MND
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	687.9	5.1	52.9	745.9	MND
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (MJ, net calorific value)	10,917	289	144	11,350	MND
Use of non renewable primary energy resources used as raw materials (MJ, net calorific value)	0	0	4.8	4.8	MND
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	10,917	289	149	11,354	MND
Use of secondary material (kg)	1,184	0	0	1,185	MND
Use of renewable secondary fuels (MJ, net calorific value)	0	- 0.45	- 0.07	- 0.53	MND
Use of non renewable secondary fuels (MJ, net calorific value)	0	0	0	0	MND

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Net use of fresh water (m^3)	17.92	0.06	0.05	18.03	MND
Hazardous waste disposed (kg)	16.79	0.01	0.11	16.90	MND
Non hazardous waste disposed (kg)	45.1	25.0	1.5	71.6	MND
Radioactive waste disposed (kg)	5.7E-04	2.0E-03	6.4E-04	3.3E-03	MND
Components for re-use (kg)	171	0	0	171	MND
Materials for recycling (kg)	38.5	0.0	24.4	62.9	MND
Materials for energy recovery (kg)	0.0E+00	5.6E-12	9.5E-13	6.6E-12	MND
Exported energy (MJ, net calorific value)	0	0	0	0	MND

Table 4 shows the cradle-to-gate LCIA results of 1 tonnes of ROM Group cut and bent steel mesh product. Results are broken down by life cycle information modules A1, A2 and A3 and represented as a total of A1-3.

Table 4 – Cradle- to-gate LCIA results for 1 tonne of ROM Group cut and bent steel mesh product

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Global warming potential, GWP (kg CO_2 eq)	653.5	16.8	26.9	697.1	MND
Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq)	4.6E-05	3.4E-06	2.8E-06	5.2E-05	MND
Acidification potential of soil and water, AP (kg SO_2 eq)	3.14	0.04	0.11	3.29	MND
Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq)	0.80	0.01	0.01	0.82	MND
Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq)	0.28	0.00	0.00	0.29	MND
Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq)	9.3E-04	1.1E-04	8.9E-05	1.1E-03	MND
Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value)	8,626	275	434	9,335	MND
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value)	674.7	5.0	136.9	816.6	MND
Use of renewable primary energy resources used as raw materials (MJ, net calorific value)	1.1E-03	0.0E+00	1.6E-01	1.6E-01	MND
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	674.7	5.0	137.1	816.8	MND
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (MJ, net calorific value)	10,707	283	470	11,460	MND
Use of non renewable primary energy resources used as raw materials (MJ, net calorific value)	0	0	23.2	23.2	MND
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	10,707	283	494	11,484	MND
Use of secondary material (kg)	1,162	0	0	1,162	MND
Use of renewable secondary fuels (MJ, net calorific value)	0	- 0.45	- 0.19	- 0.64	MND
Use of non renewable secondary fuels (MJ, net calorific value)	0	0	0	0	MND

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Net use of fresh water (m^3)	17.58	0.06	0.09	17.73	MND
Hazardous waste disposed (kg)	16.46	0.01	0.05	16.52	MND
Non hazardous waste disposed (kg)	44.2	24.5	1.3	70.1	MND
Radioactive waste disposed (kg)	5.6E-04	2.0E-03	1.8E-03	4.4E-03	MND
Components for re-use (kg)	168	0	0	168	MND
Materials for recycling (kg)	37.8	0.0	0.0	37.8	MND
Materials for energy recovery (kg)	0.0E+00	5.5E-12	3.1E-12	8.6E-12	MND
Exported energy (MJ, net calorific value)	0	0	0	0	MND

Table 5 shows the cradle-to-gate LCIA results of 1 tonnes of ROM Group prefabricated reinforcement product. Results are broken down by life cycle information modules A1, A2 and A3 and represented as a total of A1-3.

Table 5 – Cradle- to-gate LCIA results for 1 tonne of ROM Group prefabricated reinforcement product

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Global warming potential, GWP (kg CO_2 eq)	657.4	16.4	7.3	681.1	MND
Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq)	4.6E-05	3.4E-06	6.6E-07	5.0E-05	MND
Acidification potential of soil and water, AP (kg SO_2 eq)	3.14	0.04	0.03	3.22	MND
Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq)	0.79	0.01	0.01	0.80	MND
Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq)	0.28	0.00	0.00	0.29	MND
Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq)	1.2E-03	1.1E-04	3.3E-05	1.3E-03	MND
Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value)	8,673	269	110	9,052	MND
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value)	680.5	4.9	50.5	735.9	MND
Use of renewable primary energy resources used as raw materials (MJ, net calorific value)	1.0E-03	0.0E+00	1.9E-02	2.0E-02	MND
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	680.5	4.9	50.5	735.9	MND
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (MJ, net calorific value)	10,727	277	129	11,134	MND
Use of non renewable primary energy resources used as raw materials (MJ, net calorific value)	0	0	2.7	2.7	MND
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	10,727	277	132	11,136	MND
Use of secondary material (kg)	1,128	0	0	1,128	MND
Use of renewable secondary fuels (MJ, net calorific value)	- 8.87	- 0.44	- 0.08	- 9.38	MND
Use of non renewable secondary fuels (MJ, net calorific value)	0	0	0	0	MND
Net use of fresh water (m^3)	17.46	0.06	0.07	17.58	MND
Hazardous waste disposed (kg)	16.17	0.01	0.08	16.25	MND

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Non hazardous waste disposed (kg)	44.2	24.0	0.9	69.1	MND
Radioactive waste disposed (kg)	1.3E-03	2.0E-03	5.9E-04	3.8E-03	MND
Components for re-use (kg)	163	0	0	163	MND
Materials for recycling (kg)	36.7	0.0	23.7	60.3	MND
Materials for energy recovery (kg)	3.5E-10	5.4E-12	8.6E-13	3.6E-10	MND
Exported energy (MJ, net calorific value)	0	0	0	0	MND

3 Interpretation

Figure 4 shows the cradle-to-gate LCIA hotspots for ROM Group cut and bent steel rebar product. Results are broken down by life cycle information modules A1 raw materials, A2 transportation and A3 manufacturing and represented as a total of A1-3.

For all impact categories the major hotspot is the production of raw materials (A1) and within this hotspot the production of steel billets is the major contributor, with impacts from fuel use and emissions to air from rolling and cutting processes also contributing. In the manufacture of steel billets, electricity use is the major hotspot for all impact categories, although lime production is notable for global warming and photochemical ozone creation impact categories. Transportation (A2) is notable for depletion of abiotic resources and ozone depletion, due to exhaust emissions, but immaterial for other impact categories. Manufacturing cut and bent steel rebar product (A3) is immaterial for all impact categories.

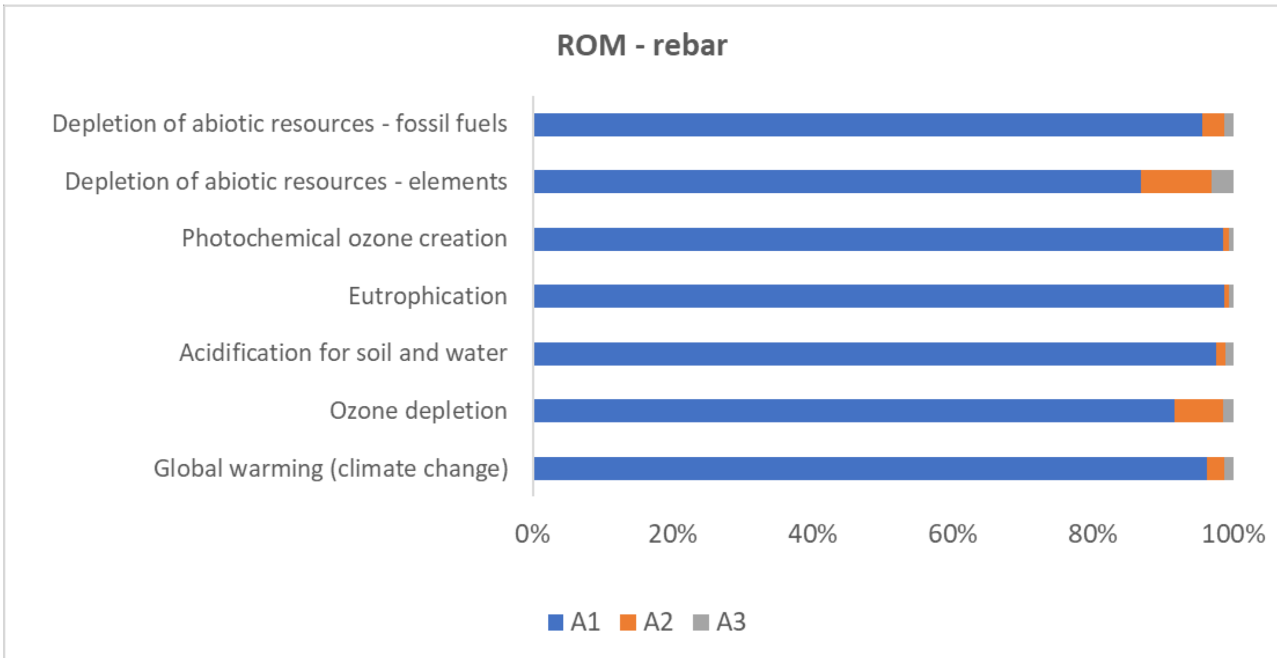

Figure 4 – Cradle- to-gate LCIA hotspots for ROM Group cut and bent steel rebar product

Figure 5 shows the cradle-to-gate LCIA hotspots for ROM Group cut and bent steel mesh product. Results are broken down by life cycle information modules A1, A2 and A3 and represented as a total of A1-3.

For all impact categories the major hotspot is the production of raw materials (A1) and within this hotspot the production of steel billets is the major contributor, with impacts from fuel use and emissions to air from rolling and cutting processes also contributing. Transportation (A2) is notable for depletion of abiotic resources and ozone depletion, due to exhaust emissions, but immaterial for other impact categories. Manufacturing cut and bent steel mesh product (A3) is immaterial for all impact categories except depletion of abiotic resources, where it is notable.

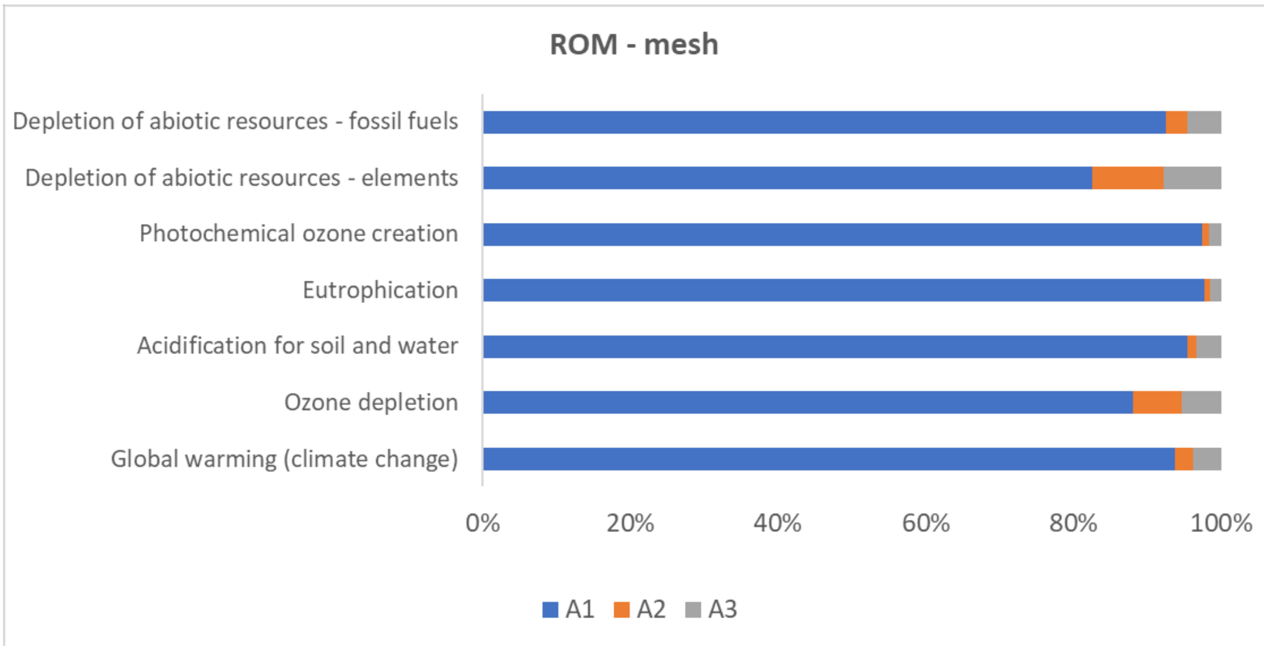

Figure 5 – Cradle- to-gate LCIA hotspots for ROM Group cut and bent steel mesh product

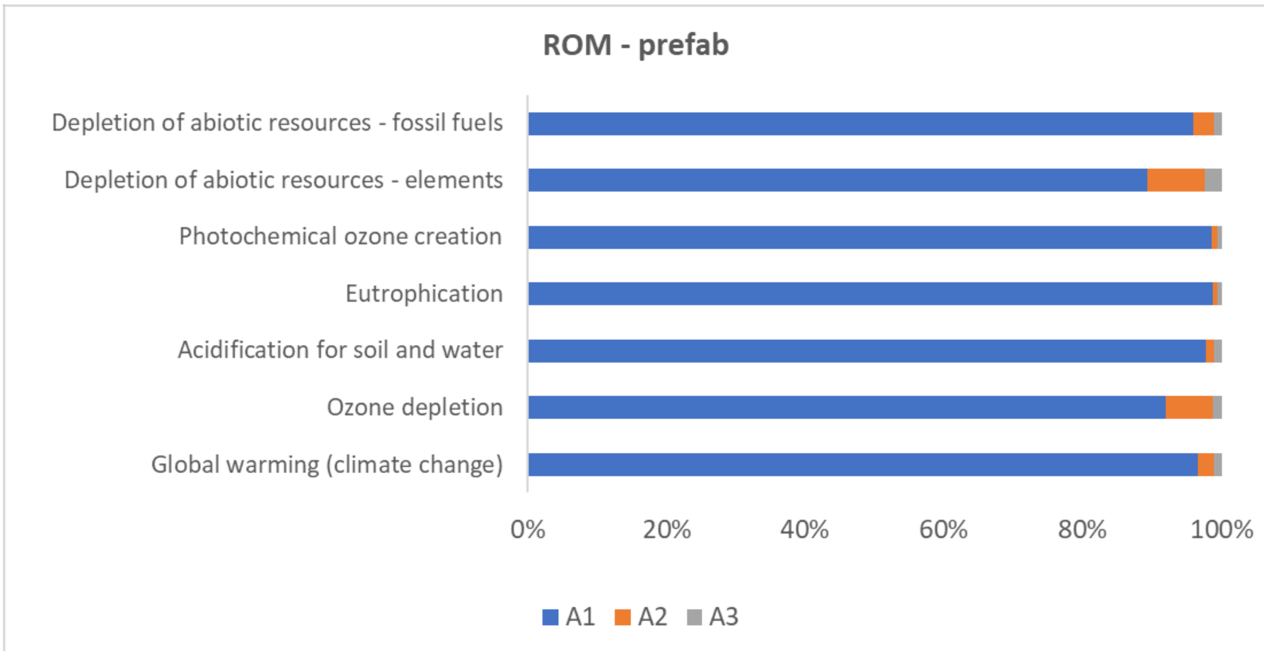

Figure 6 – Cradle- to-gate LCIA hotspots for ROM Group prefabricated reinforcement product

Figure 6 shows the cradle-to-gate LCIA hotspots for ROM Group prefabricated reinforcement product. Results are broken down by life cycle information modules A1, A2 and A3 and represented as a total of A1-3.

For all impact categories the major hotspot is the production of raw materials (A1) and within this hotspot the production of steel billets is the major contributor, with impacts from fuel use and emissions to air from rolling and cutting processes also contributing. Transportation (A2) is notable for depletion of abiotic resources and ozone depletion, due to exhaust emissions, but immaterial for other impact categories. Manufacturing prefabricated reinforcement product (A3) is immaterial for all impact categories.

4 References

BRE, 2017. BREG EN EPD 000187. London, BRE, 2017.

BSI, 2010. Environmental labels and declarations – Type III Environmental declarations – Principles and procedures. BS EN ISO 14025:2010. London, BSI, 2010.

BSI, 2011a. The Guide to PAS 2050:2011 How to carbon footprint your products, identify hotspots and reduce emissions in your supply chain. BSI, London.

BSI, 2011b. PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. BSI, London.

BSI, 2013. Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products. BS EN 15804:2012+A1:2013. London, BSI, 2013.

Ecoinvent, 2018. Ecoinvent v3.3 and v3.4, Swiss Centre for Life Cycle Inventories. Available from www.ecoinvent.ch.

International EPD Programme, 2012. Construction Products and Construction Services PCR 2012:01 v2.3. EPD International AB, Stockholm.

IPCC, 2007. Working Group I Contribution to the IPCC Fourth Assessment Report Climate Change 2007: The Physical Science Basis, Summary for Policymakers. Intergovernmental Panel on Climate Change, Geneva.

ISO, 2006. Environmental management – life cycle assessment – principles and framework. International Standards Organization, Second Edition, EN ISO 14040.

ISO, 2006. Environmental management – life cycle assessment – requirements and guidelines. International Standards Organization, EN ISO 14044.

JRC, 2011. ILCD Handbook: recommendations for life cycle impact assessment in the European context. European Commission Joint Research Centre Institute for Environment and Sustainability. http://eplca.jrc.ec.europa.eu/?page_id=86.

Pre Consultants, 2018. SimaPro 8.4 LCA Software. http://www.pre-sustainability.com

WRI/WBCSD, 2011. The Product Life Cycle Accounting and Reporting Standard. WRI/WBCSD, Geneva.

These pages (Appendix A - Raw Data Sources) have been intentionally removed for data sensitivity purposes.

6 Appendix B – data quality assessment

Table 8 – Data Quality Indicator Matrix (replication of Error! Reference source not found. **for convenience)**

Aspect	1	2	3	4	5
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Representative	Representative data from sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years of difference to year of study	Less than six years of difference	Less than 10 years of difference	Less than 15 years of difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate

Table 9 – Data Quality Indicator scores

Data	Reliability	Representative	Temporal correlation	Geographical correlation	Technological correlation
Annual mass of steel rod/bar from all suppliers used to produce cut and bent rebar	2	1	1	1	1
Annual mass of cut and bent steel mesh produced	2	1	1	1	1
Annual mass of steel rod/bar from all suppliers used to produce cut and bent prefab	2	1	1	1	1
Production of steel billets and rod/bar reinforcing steel by Celsa	2	1	1	1	1
Annual mass of cut and bent steel rebar produced	2	1	1	1	1
Annual mass of cut and bent steel mesh produced	2	1	1	1	1
Annual mass of cut and bent steel prefab produced	2	1	1	1	1
Annual grid electricity	2	1	1	1	1
Annual natural gas usage	2	1	1	1	1
Annual diesel usage	2	1	1	1	1
Annual fugitive emissions of refrigerants	4	5	1	1	1
Annual welding wire use	3	4	1	1	1
Annual shielding gases	3	4	1	1	1
Annual mass of general waste	2	1	1	1	1
Amount mass of scrap steel sent offsite	2	1	1	1	1
Annual mass of other waste sent for recycling	2	1	1	1	1
Annual mass of hazardous waste	2	1	1	1	1
Annual volumes of water use and treatment	2	1	1	1	1
Secondary data for transportation by road	2	2	1	2	2

Data	Reliability	Representative	Temporal correlation	Geographical correlation	Technological correlation
Secondary data for transportation by sea	2	2	1	4	2
Secondary data for imported grid electricity	2	2	1	1	2
Secondary data for natural gas	2	2	1	2	2
Secondary data for diesel use	2	2	1	2	2
Secondary data for refrigerant production and fugitive refrigerant emissions	2	2	1	2	3
Secondary data for water supply	2	2	1	2	2
Secondary data for welding wire	3	3	1	2	2
Secondary data for shielding gases	3	3	1	2	2
Secondary data for treatment of general waste	2	2	1	3	2
Secondary data for treatment of hazardous waste	2	2	1	2	2
Secondary data for treatment of waste water	2	2	1	2	2
Secondary data for waste transportation	2	2	1	3	2