worldsteel ASSOCIATION

LCI DATA FOR STEEL PRODUCTS

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2019 LCI data release

worldsteel.org

1 Introduction

The following data is provided in this report: European average data for the manufacture of 1kg of Plate and Sections. Where recycling is considered, a recycling rate of 85% is used.

Chapter 4 shows the cradle to gate LCI.
Chapter 5 shows the cradle to gate including net credits for recycling.
Chapter 6 shows the net credits for recycling (i.e. the difference between chapters 4 and 5)

The data provided has been generated based on the worldsteel data collection and LCI methodology report, published in 2017. Full details are available in the World Steel Association Life Cycle Inventory for Steel Products report. This data was published in December 2019. The study report accompanying this data will be published shortly.

2 Data description

A description of the steel products provided in this report:

Product	Technical purpose of product or process
Plate	A flat steel sheet rolled on a hot rolling mill. It can be found on the market in sheets and is further processed into finished products by the manufacturers. Heavy plate is used in a large number of sectors: structural steels, shipbuilding, pipes, pressure vessels, boilers, heavy metal structures, offshore structures etc. Typical thickness between 2 to 20 mm. The maximum width is 1860 mm.
Sections	A steel section rolled on a hot rolling mill. Steel Sections include I-beams, H-beams, wide-flange beams, and sheet piling. It can be found on the market for direct use. This product is used in construction, multi-story buildings, industrial buildings, bridge trusses, vertical highway supports, and riverbank reinforcement.

The data provided is cradle to gate data. Data can also be provided to show the net benefits of recycling steel from the product at the end of its life, in other words it includes the benefits of recycling. This means that a burden is given for the steel scrap that is used as an input to the steel making process, and a credit for the end-of-life (EoL) steel that is recycled. More details about this are given in the section on methodology.

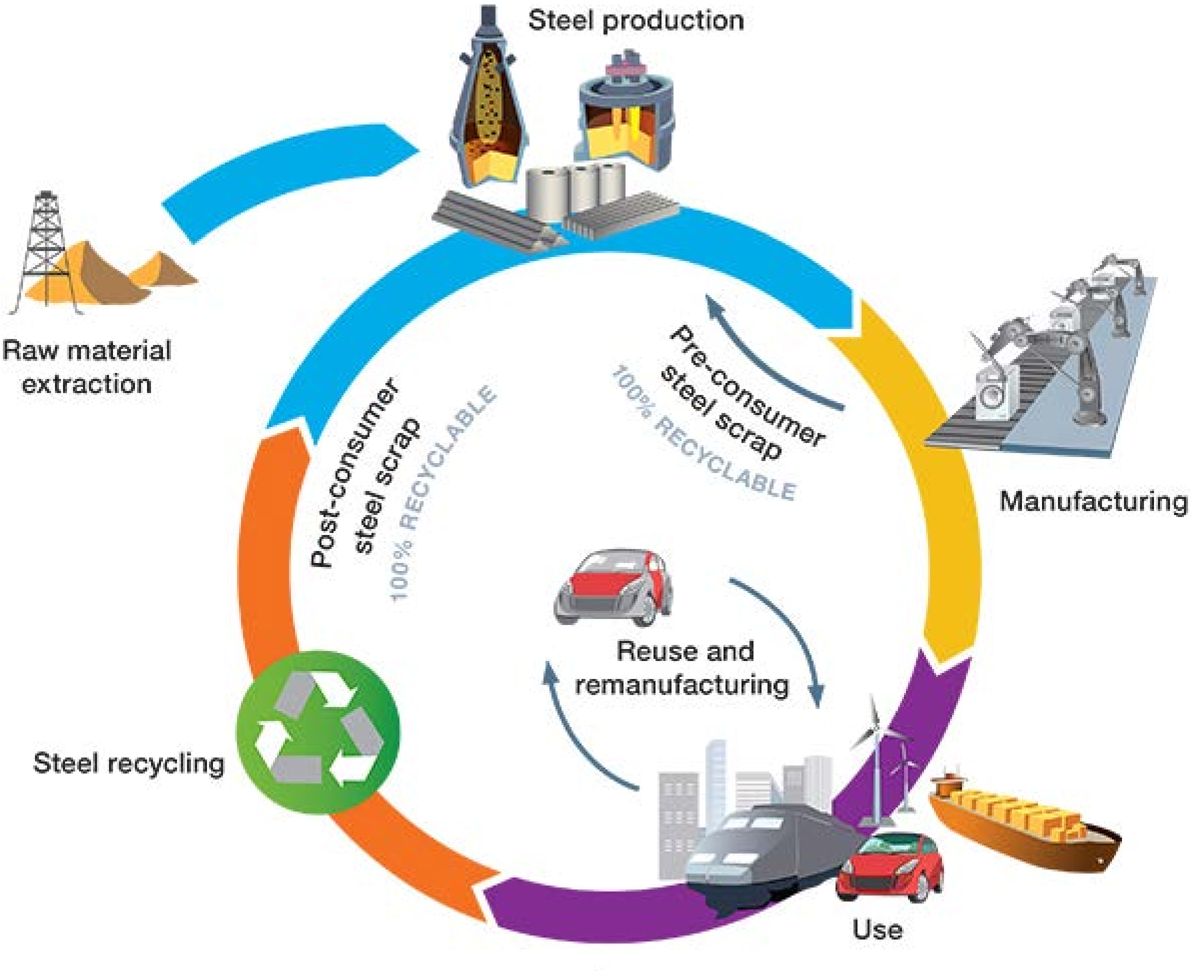
For each of the products given in this report, the recycling rates are specified with the data.

The data was published in 2019 and represents steel production from 2014 to 2018, with the majority being from 2015.

The flow list includes the main inputs and outputs of the steelmaking process. Please note that, when using the data, the inputs are expressed in **kg** and the outputs in **grams**.

3 Methodology

The methodology used to develop this data is detailed in worldsteel's World Steel Life Cycle Inventory report, 2017, which is provided with this data or can be requested via the worldsteel website www.worldsteel.org.



3.1 Summary of methodology

The quality and relevance of LCA/LCI results, and the extent to which they can be applied and interpreted, depends critically upon the methodology used. It is therefore important that methodology is transparent and well documented. ISO standards have been developed to provide guidance on methodological choices and to set down rules for transparency and reporting. The relevant ISO standards are:

- ISO 14040: 2006 - Environmental management – Life cycle assessment – Principles and framework
- ISO 14044: 2006 - Environmental management – Life cycle assessment – Requirements and guidelines

The goal of collecting and developing worldsteel LCI datasets is to facilitate the range of emerging impact assessment methods in future studies.

The worldsteel LCI study has been undertaken in accordance with ISO 14040 and ISO 14044. The previous three data collections and methodology reports underwent a critical review from an independent Critical Review Panel of LCA specialists. This approach improved the integrity of the study and can help guide methodology. The full CRP Report is included in the reports. The new data collection, released in December 2019, is based on the same methodology, except that now a weighted average approach is taken to determine product specific LCIs. This methodology has undergone a critical review by an external expert and is available from worldsteel.

The study is a cradle-to-gate LCI study, including recycling. That is, it covers all of the production steps from raw materials 'in the earth' (i.e. the cradle) to finished products ready to be shipped from the steelworks (i.e. the gate). It can also include the credits associated with recycling the steel from the product at the end of its life. It does not include the manufacture of downstream products or their use.

The steel product manufacturing system encompasses the activities of the steel sites and all major upstream processes, including the production and transportation of raw materials, energy sources and consumables used on the steelworks. In addition the recovery and use of steel industry by-products outside of the steelworks are taken into account using in most cases the method of system expansion.

The data includes steel production from both the integrated route (Blast Furnace / Basic Oxygen Furnace) and the Electric Arc Furnace route.

3.2 Recycling methodology

Steel is one of the most recyclable materials in the world and therefore it is important to consider recycling in life cycle assessment studies involving steel, namely the steel scrap that is recycled from a product at the end of its life. In addition, steel is a vital input to the steel making process, and this input of steel scrap should also be considered in LCA studies.

The worldsteel methodology therefore considers both of these factors in the methodology (full details available in the methodology report).

The general life cycle equation for the “closed material loop recycling methodology” is applied as shown by the equation below:

LCI for 1 kg of steel product including recycling = X – (RR – S) × Y(Xpr – Xre)

where:

X is the cradle to gate LCI of the product

(RR – S) is the net amount of scrap:
RR is the end of life recycling rate of the steel product
S is the scrap input to the steelmaking process

Y(Xpr - Xre) is the value of scrap:
Y is the process yield of the EAF (i.e. >1kg scrap is required to produce 1kg steel)
Xpr = the LCI for 100% primary metal production This is a theoretical value of steel slab made in the BF/BOF route, assuming 0% scrap input.
Xre = the LCI for 100% secondary metal production from scrap in the EAF (assuming scrap = 100%)

4 LCI Results: Cradle to Gate excluding Recycling for 1kg steel

The data does not consider a burden for scrap input or a credit for the EoL recycling.

Inputs (mass, kg)

	Plate	Section
Bauxite	0.009225	0.0017627
Crude oil (resource)	0.069134	0.01471
Dolomite	0.07408	0.03346
Hard coal (resource)	0.82777	0.43513
Lignite (resource)	0.01476	0.07136
Limestone (calcium carbonate)	-0.021938	0.046897
Natural gas (resource)	0.035398	0.056512
Uranium (resource)	1.2132E-006	2.1422E-006

	Plate	Section
Total freshwater consumption (including rainwater) 1 [kg]	0.13	4.48
Blue water consumption 2 [kg]	-1.81	0.67

[1] The total fresh water consumption is the net amount of freshwater, lake water, river water and rain water that is consumed. It excludes sea water.
[2] Blue water is Ground water + surface water. This is what is used for water footprint calculation. Please note the blue water is from the water footprint network and is for information only.

Inputs (mass, kg)

	Plate	Section
Chromium	0.0026264	0.00036433
Copper	4.793E-005	-0.0001039
Iron	0.93813	0.3651
Lead	3.1924E-007	-8.4379E-005
Nickel	0.00026739	1.6001E-005
Tin	-3.3399E-017	-1.35E-016
Titanium	4.0015E-008	-5.4397E-007
Vanadium	6.64E-005	0.00014866
Zinc	-8.4068E-006	-0.0046803

	Plate	Section
Steel and Iron scrap [kg]	0.099072	0.73114

Emissions to air (mass, g)

	Plate	Section
Carbon dioxide	2438	1398
Carbon monoxide	19.66	17.5
Hydrogen chloride	0.02716	0.03572
Hydrogen sulphide	0.00456	0.01826
Nitrogen dioxide	0.001341	-0.0005113
Nitrogen oxides	4.213	2.271
Nitrous oxide (laughing gas)	0.01456	0.01881
Sulphur dioxide	3.253	1.923
Dioxins (unspec.)	2.3E-009	4.52E-009
NMVOC (unspecified)	0.1431	0.1104
Methane	5.427	3.129
Particles to air	1.814	1.135

Emissions to fresh water (mass, g)

	Plate	Section
Biological oxygen demand (BOD)	0.007703	0.004992
Chemical oxygen demand (COD)	0.3671	0.4053
Nitrogenous Matter (unspecified, as N)	0.0294	0.008702
Solids (dissolved)	-0.0527	-0.0576
Iron	0.2158	0.1643
Phosphate	0.001382	0.002312
Phosphorus	0.0007732	0.0004456

Environmental Indicators – for information only

	Plate	Section
CML2001 - Jan. 2016, Acidification Potential (AP) [kg SO2 eq.]	0.00606	0.00352
CML2001 - Jan. 2016, Eutrophication Potential (EP) [kg Phosphate eq.]	0.000583	0.000333
CML2001 - Jan. 2016, Global Warming Potential (GWP 100 years) [kg CO2 eq.]	2.6	1.49
CML2001 - Jan. 2016, Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]	0.000883	0.000686
Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	28.1	18.4

5 LCI Results: Cradle to Gate including Recycling for 1kg steel

The data considers a burden for scrap input and a credit for the EoL recycling. These recycling rates are shown below.

Scenario parameters			
	Plate	**Section**	
Product	**Plate**	**Sections**	**Steel product**
Region	**Europe**	**Europe**	**Region**
RR	**85**	**85**	**EoL RR %**

Inputs (mass, kg)

	Plate	Section
Bauxite	0.0066593	0.0013566
Crude oil (resource)	0.09511	0.018821
Dolomite	0.028405	0.026231
Hard coal (resource)	0.28691	0.34952
Lignite (resource)	0.040939	0.075504
Limestone (calcium carbonate)	0.046628	0.05775
Natural gas (resource)	0.061619	0.060663
Uranium (resource)	2.2837E-006	2.3116E-006

	Plate	Section
Total freshwater consumption (including rainwater) 1 [kg]	-4.23	3.79
Blue water consumption 2 [kg]	-7.42	-0.22

[1] The total fresh water consumption is the net amount of freshwater, lake water, river water and rain water that is consumed. It excludes sea water.
[2] Blue water is Ground water + surface water. This is what is used for water footprint calculation. Please note the blue water is from the water footprint network and is for information only.

Inputs (mass, kg)

	Plate	Section
Chromium	0.0025735	0.00035597
Copper	-0.00012458	-0.0001312
Iron	0.20367	0.24885
Lead	-0.00010675	-0.00010133
Nickel	0.00025396	1.3874E-005
Tin	1.0417E-015	3.5169E-017
Titanium	-5.8446E-007	-6.4281E-007
Vanadium	0.00017529	0.00016589
Zinc	-0.0055904	-0.0055638

Emissions to air (mass, g)

	Plate	Section
Carbon dioxide	1297	1217
Carbon monoxide	0.6786	14.49
Hydrogen chloride	0.04259	0.03816
Hydrogen sulphide	0.01707	0.02024
Nitrogen dioxide	0.002481	-0.0003308
Nitrogen oxides	3.432	2.148
Nitrous oxide (laughing gas)	0.01672	0.01915
Sulphur dioxide	1.95	1.717
Dioxins (unspec.)	7.554E-010	4.276E-009
NMVOC (unspecified)	0.1623	0.1134
Methane	2.634	2.687
Particles to air	0.7104	0.9605

Emissions to fresh water (mass, g)

	Plate	Section
Biological oxygen demand (BOD)	0.0009099	0.003917
Chemical oxygen demand (COD)	0.5912	0.4408
Nitrogenous Matter (unspecified, as N)	0.000209	0.004082
Solids (dissolved)	2.43	0.3353
Iron	0.2022	0.1621
Phosphate	0.002325	0.002461
Phosphorus	0.0002103	0.0003565

Environmental Indicators – for information only

	Plate	Section
CML2001 - Jan. 2016, Acidification Potential (AP) [kg SO2 eq.]	0.00414	0.00322
CML2001 - Jan. 2016, Eutrophication Potential (EP) [kg Phosphate eq.]	0.000483	0.000317
CML2001 - Jan. 2016, Global Warming Potential (GWP 100 years) [kg CO2 eq.]	1.38	1.3
CML2001 - Jan. 2016, Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]	0.000276	0.00059
Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	18.1	16.8

6 LCI Results: Net credit of Recycling

The data show the net credit of recycling per product and per Recycling Rate selected.

Inputs (mass, kg)

	Plate	Section
Bauxite	-0.0025657	-0.0004061
Crude oil (resource)	0.025976	0.0041115
Dolomite	-0.045676	-0.0072296
Hard coal (resource)	-0.54086	-0.085607
Lignite (resource)	0.026179	0.0041436
Limestone (calcium carbonate)	0.068566	0.010853
Natural gas (resource)	0.026221	0.0041503
Uranium (resource)	1.0705E-006	1.6943E-007

	Plate	Section
Total freshwater consumption (including rainwater) 1 [kg]	-4.36	-0.69
Blue water consumption 2 [kg]	-5.61	-0.89

[1] The total fresh water consumption is the net amount of freshwater, lake water, river water and rain water that is consumed. It excludes sea water.

[2] Blue water is Ground water + surface water. This is what is used for water footprint calculation. Please note the blue water is from the water footprint network and is for information only.

Inputs (mass, kg)

	Plate	Section
Chromium	-5.2848E-005	-8.3648E-006
Copper	-0.00017251	-2.7306E-005
Iron	-0.73446	-0.11625
Lead	-0.00010707	-1.6947E-005
Nickel	-1.3438E-005	-2.1269E-006
Tin	1.0751E-015	1.7017E-016
Titanium	-6.2447E-007	-9.8842E-008
Vanadium	0.00010889	1.7236E-005
Zinc	-0.005582	-0.00088352

Emissions to air (mass, g)

	Plate	Section
Carbon dioxide	-1141	-180.6
Carbon monoxide	-18.98	-3.004
Hydrogen chloride	0.01542	0.002441
Hydrogen sulphide	0.01251	0.00198
Nitrogen dioxide	0.00114	0.0001805
Nitrogen oxides	-0.781	-0.1236
Nitrous oxide (laughing gas)	0.002159	0.0003417
Sulphur dioxide	-1.303	-0.2062
Dioxins (unspec.)	-1.545E-009	-2.445E-010
NMVOC (unspecified)	0.01921	0.003041
Methane	-2.793	-0.4421
Particles to air	-1.104	-0.1747

Emissions to fresh water (mass, g)

	Plate	Section
Biological oxygen demand (BOD)	-0.006793	-0.001075
Chemical oxygen demand (COD)	0.2241	0.03547
Nitrogenous Matter (unspecified, as N)	-0.02919	-0.004621
Solids (dissolved)	2.482	0.3929
Iron	-0.01361	-0.002155
Phosphate	0.0009429	0.0001492
Phosphorus	-0.0005629	-8.909E-005

Environmental Indicators – for information only

	Plate	Section
CML2001 - Jan. 2016, Acidification Potential (AP) [kg SO2 eq.]	-0.00192	-0.000304
CML2001 - Jan. 2016, Eutrophication Potential (EP) [kg Phosphate eq.]	-0.0001	-1.59E-005
CML2001 - Jan. 2016, Global Warming Potential (GWP 100 years) [kg CO2 eq.]	-1.22	-0.193
CML2001 - Jan. 2016, Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]	-0.000607	-9.6E-005
Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	-10.1	-1.59

7 Data usage

A life cycle inventory (LCI) study has been carried out by the World Steel Association (worldsteel) to quantify resource use, energy and environmental emissions associated with the processing of 16 steel industry products, from the extraction of raw materials in the ground through to the steel factory gate and including end-of-life recycling.

LCI data were calculated for products derived via the blast furnace/basic oxygen furnace route (based on iron ore and steel scrap) and the electric arc furnace route (mainly based on steel scrap).

The 16 products included in the study are the main finished products of the steel industry. They include hot rolled coil (with and without pickling), cold rolled coil (with and without finishing), hot dip and electrically galvanised sheet, painted sheet, tinplate and tin-free sheet, welded pipe, seamless tube, sections, plate, rebar, engineering steel and wire rod. The products are of general relevance to a wide range of downstream applications including those in the construction, automotive and packaging sectors.

A key goal of worldsteel is to provide support on the environmental credentials of steel to customers and users of steel, with the intention that those that specify and use materials in applications have access to relevant data to facilitate their own informed decision-making. In this regard, worldsteel is keen to support the implementation of this data in LCA software and LCA tools. It therefore currently has been made available to the GaBi software and SimaPro software.

worldsteel establishes agreement with LCA database vendors or consultants or advanced users to encourage broad use of the data in the interests of good LCA practice. The data is fully based on the worldsteel methodology.

By using the data, you agree with the following points:

- The worldsteel LCI data is provided free of charge and may not be sold to other parties.
- When the worldsteel data is included in a database for different products, it shall be supplied with the main database of the software (or tool), i.e. at no extra cost for the buyer, nor as an extra library.
- The data shall include a reference source (i.e. www.worldsteel.org)
- The worldsteel LCI Methodology Report shall be provided on request to users of the data.
- Version updates will be available following data improvements and extra LCI information supplied by companies around the world. Please accept these updates (e.g. version changes), and update the database system as required.
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- The data is supplied only for the purpose of the study for which it was requested. Should they be required for any another purpose, worldsteel must be contacted beforehand.
- The user shall not provide the data on public websites or communicate the full inventories externally without worldsteel agreement.
- The user shall not tamper with the worldsteel data in any way.
- worldsteel accepts no responsibility for the use or misuse of the data.

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8 FAQ

1. What is the system boundary of the data?

The data is cradle to gate data and is also provided including recycling at end-of-life. This can also be seen as cradle to grave, excluding the product manufacture (e.g. building, car etc.) and use phase. Upstream processes e.g. production of raw materials, are included. The net credits are also provided separately. The end of life recycling rate is determined by the user of the data.

2. Are you not double accounting by including a credit for the end-of-life recycling?

No. By considering the end of life of the product, we are taking a full life cycle approach: cradle to grave. We give a credit for the scrap that is recycled at the end of the products life, based on avoiding the production of steel from virgin material, but also a burden for any scrap that has been used to make that product: thus, each product has an overall net scrap credit or burden.

3. Is the EAF route better than the BOF route?

Both EAF and BOF routes provide essential capacity for scrap recycling and the impacts of converting scrap to steel are similar for each route. At current levels of demand, there is insufficient scrap supply. Therefore there is a need to produce steel from virgin material. In life cycle terms, the two production routes are equivalent: specifying EAF steel has no net benefit to the earth. What is essential is that steel recycling is optimised so that the use of virgin material resources can be reduced and this makes the two routes complementary.