

Life Cycle Inventory Database for Steel Industry Products

Frequently Asked Questions

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1. Background

1.1 What are LCI and LCA?

Life Cycle Inventory (LCI) is one of the phases of a Life Cycle Assessment (LCA).

LCA is a tool to assist with the quantification and evaluation of environmental burdens and impacts associated with product systems and activities, from the extraction of raw materials in the earth to end-of-life and waste disposal. The tool is increasingly used by industries, governments, and environmental groups to assist with decision-making for environment-related strategies and materials selection.

The initial phase of LCA includes defining the goals and scope of a study, and the collection and calculation of Life Cycle Inventory data. LCI data quantify the material, energy and emissions associated with a functional system (for example, the manufacture of 1kg of hot rolled coil). This phase precedes the Life Cycle Impact Assessment phase (LCIA) which involves the classification, characterisation and evaluation of these data in relation to ecological impacts. The fourth and last phase is the interpretation phase, where the data resulting from the LCI and LCIA phases are analysed in the context of the scope and study goals and the quality of any study conclusions assessed.

However, LCA is generally an iterative process where each phase has implications for the other phases.

Further related expressions included Life Cycle Costing (LCC) which looks at the economic life cycle impact, Social Life Cycle Assessment (SLCA) which covers the social aspects of an LCA and Life Cycle Sustainability Assessment (LCSA) which looks at the overall sustainability of a product or service over its full life cycle.

1.2 What are the main goals of the worldsteel LCI study?

The worldsteel Board of Directors initiated a global 'LCI on steel industry products' in the 1990s to help understand the environmental impact of steel products and to ensure consistency within the global steel industry on this topic. Since then, worldsteel has updated the data in 2000, 2010, 2017, 2018 and most recently in 2019. worldsteel publishes its new data annually, ensuring that no site data in the dataset is older than 5 years old.

One of the primary aims of the project was to build a database and develop a common worldwide methodology for cradle-to-gate steel product LCIs across a representative sample of member companies within worldsteel. This database can subsequently form the basis for full LCAs across broader boundaries and complete product life cycles.

The purposes of the project are to:

- Produce worldwide LCI data for steel industry products
- Understand the impact the steel industry has on the environment
- Assist industry benchmarking and environmental improvement programmes
- Provide a basis for carrying out impact assessments
- Obtain life cycle information requested by customers
- Support communication with industry stakeholders
- Support responses to environmental claims against steel
- Train industry people in the field of life cycle assessment

2. Methodology

2.1 Who conducted the study?

worldsteel has defined and run the six data collection projects: the original study was carried out in 1995 and subsequently updated in 1999/2000, 2010, 2017 and then in 2018. The most recent update was released in 2019 and currently includes 44 datasets.

The original study was undertaken by the independent consultancy firm Ecobilan (using their TEAM LCA software), selected as a world class company in the field of LCA, having carried out studies for many material industries, including plastics, paper and steel. The first update was also carried out in TEAM and then the four subsequent update studies were completed by worldsteel in the GaBi LCA software.

A critical review panel comprising of recognised independent experts was formed to review the methodology, data quality and data presentation aspects of the first three studies. For the fourth study released in 2017, a single external reviewer was used as the methodology used had not significantly changed since the previous version; however, the review was undertaken as the methodology and study reports were published as separate reports for the first time. Each of the critical reviews, from 1999 to 2017, helped improve the development of the methodology over time.

The 2018 and 2019 data releases follow the 2017 methodology report, which has not significantly changed during these two data collection processes and so no critical review has been conducted. A study report has been published for each of these data releases. The steel production data released each year is no older than 5 years old. During each annual update, sites older than 5 years will be removed from the dataset.

2.3 What products were included and how representative is the study?

The worldsteel LCI Study quantifies resource use, energy and environmental emissions associated with the processing of 17 steel industry products, from the extraction of raw materials in the ground through to the steel factory gate (“cradle-to-gate”) and produced via the blast furnace/basic oxygen furnace and the electric arc furnace routes. One of these products, UO pipe, actually contains data that is older than 5 years and was not updated in the 2019 update. The other 16 products that were included in the 2019 data release are: hot rolled coil; pickled hot rolled coil; cold rolled coil; finished cold rolled coil; tinned coil; tin-free steel; hot-dipped galvanised; electro-galvanised; organic coated flat; plate; rebar; wire rod; engineering steel; welded pipe; seamless pipe and sections. These products represent more than 80% of steel production by product category.

In total, 121 sites are currently participating in the most recent update, with more sites and companies joining the project. These sites represent most areas of the world and a range of operating configurations. These companies account for approximately 20% of global crude steel production.

2.4 worldsteel claims the study is technically rigorous - in what way?

The worldsteel LCI Study is one of the most comprehensive and rigorous LCI studies ever carried out for a material and was probably one of the first studies completed in accordance with the ISO standards on LCA (ISO 14040 series). It involved an exhaustive process to collate some twenty thousand items of data from the participating steel companies and the creation of various models and calculations for upstream processes. Therefore, it offers enormous scope for data analysis, trending, benchmarking and investigating environmental significance.

This approach has been repeated and improved for the update studies, to include key upstream processes. The data quality is excellent: data are recent, from reliable sources and, in general, their

range and variance are small. Every item of data is documented and verifiable. Measures were also taken to verify apparent inconsistencies and to ensure the consistent application of the study methodology, including training and technical support to ensure correct procedures for completion of the questionnaires.

The database includes information on whether data were measured, calculated or estimated. The process of generating LCI results is transparent and extensively documented, and therefore reproducible. Finally, each study underwent an independent critical review.

2.5 worldsteel has used system expansion to account for co-products. Why is this?

The treatment of co-products is one of the key methodological issues for most LCA studies and is especially true for the worldsteel LCI study because of the process gases, slags and many other co-products arising from the steelmaking processes. Therefore, how to account for these useful co-products and obtain the LCI of steel only is a critical issue.

There are essentially two main methods of accounting for co-products: allocation and system expansion.

'Allocation' consists of allocating the process in/outputs proportionally to the product and to the co-products, according to a parameter such as mass, feedstock energy or even monetary value.

For instance, if mass allocation were to be used: assuming the BOF generates 3 mass units of steel and 1 mass unit of recovered slags, three quarters of every BOF in/output is allocated to the steel and the remaining quarter to the slags.

'System expansion' assumes credits for co-products that render it unnecessary to produce functionally equivalent products by other means. For example, process gases that are exported and used to generate electricity are assumed to replace coal mining and combustion for electricity generation. The difference between the environmental burden associated with the coal and process gas combustion are then credited, or in some cases debited, to the steel LCI.

System expansion was applied in the worldsteel study primarily because ISO recommends the use of system expansion and the avoidance of allocation whenever possible. In addition, it is considered that there is no scientifically justifiable parameter to allocate in/outputs of the steelmaking process. In view of these and other relevant factors, worldsteel found the system expansion method to be the most scientific and fair way of accounting for most steel by-products.

Most importantly, it does not result in unfairly favourable or misrepresentative LCI results for the steel industry.

2.6 What was the source and quality of upstream inventories?

As the LCI is a cradle-to-gate study, the database includes upstream data (i.e. iron ore mining, electricity production, etc.). The majority of the upstream data has been obtained from the commercial database, GaBi. Where possible data was taken from other industry associations, such as the International Aluminium Institute and the International Zinc Association.

The steel LCI includes:

- All non-mass inputs (including electricity, steam, compressed air and water);
- More than 98% of steelworks material inputs (including raw materials, energy and consumables, as well as minor inputs which may have significant environmental burdens). For more than 98% of these inputs, upstream production was accounted for.

Transportation impacts have been taken into account for the major inputs to the steelworks and for on-site transport.

3. Results

The output of the worldsteel LCI Study is in the first instance a set of cradle-to-steel factory gate LCI data for steel products. Both worldwide and regional averages (currently Europe, Asia and Latin America) are available, provided that a minimum of three sites contributed data for that product. In addition, an LCI for steel scrap is available – this can be used to account for the burden of steel scrap used in the production process and the benefits of recycling steel from the product at the end of its life.

worldsteel makes these data available to its customers and other third parties undertaking LCA studies for steel-containing products.

3.1 What are the principal areas covered by the data?

The major material flows covered are quantified and categorised in terms of resource use, including energy and water; air emissions; water emissions; by-products and wastes. The range of data collected from different sites reflects different iron-making and steelmaking practices, energy efficiencies, national power mixes and efficiencies, raw material quality and the complexity of the finishing operations.

3.2 How reliable are the study results?

The quality of data input in the LCI Study is excellent (as outlined in Section 2.3). As transparency was a fundamental issue of the study, measures were taken to adopt fair assumptions and allocation rules in accordance with ISO standards. The methodological assumptions, boundaries and allocation principles that were made are transparent and fully documented.

In consequence, all results obtained are totally verifiable and reproducible.

The study was designed to represent the real interactions of steel production routes with the environment and avoid unsound theoretical scenarios. Most importantly, it does not result in unfairly favourable or misrepresentative LCI results for the steel industry. In addition, the software provides the flexibility to analyse and, if necessary, switch off specific scenarios and/or replace them with alternative functional systems. This facility allows sensitivity analysis of different scenarios and can be adapted to future data inputs or assumptions as required.

However, as for any LCA studies of this magnitude, there is still further scope to improve the database, including the improvement of upstream and co-product data, especially where generic databases have been used which do not represent relevant regional/local practices. Data for specific flow categories such as water usage, waterborne emissions, and air emissions of particulates can also be improved by extending and more clearly defining site data collection requirements. The database would also benefit from a larger number of participating sites for certain products, since this would provide more reliable averages and statistical confidence. A large programme of work is managed through the LCA Expert Group at worldsteel to continue improving and updating the database.

3.3 Does the study indicate the LCI benefits of recycling steel?

Whether used in the BOF (basic oxygen furnace) or EAF (electric arc furnace) route, there is no doubt that the recycling of steel is beneficial, saving raw materials and other resources. Scrap recycled via the BOF and the EAF effectively displaces the energy and emissions associated with primary iron production mainly from the blast furnace. In addition, all scrap used in the steelmaking process is assigned an environmental burden. In calculating the benefits of recycling therefore, only the net amount of steel scrap recycled at the end of the product's life is credited (amount of scrap recycled minus the amount of scrap used to make the product).

The benefits of recycling steel are also provided in the cradle to gate date, incorporating the end of life of the product.

3.4 Does steel recycling degrade the product quality; is there a limitation to steel recycling?

Steel is 100% recyclable. Approximately 35% of global steel production is made from scrap and the infrastructure for scrap recycling is well established. There is no limit to the level of steel that can be recycled and steel can be recycled repeatedly without downgrading to a lower quality product.

Scrap is used in both the BF-BOF and the EAF steelmaking routes. External or manufacturing scrap (as opposed to internally arising scrap) can contain some residual (tramp) elements such as copper and tin. Steelmakers are selective in their purchasing of scrap, manage the input of different quality scraps and use processes to eliminate or reduce the levels of tramp elements. Such treatment is a normal part of the steelmaking process and ensures that all steel recovered can be reused to make new steel.

3.5 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.

While the cradle-to-gate impacts to produce steel via the EAF route uses less energy and resources and produces fewer emissions than the BOF route, at current levels of demand, there is insufficient scrap supply to meet the demand for steel products. Therefore, there is a need to produce steel from virgin material. In life cycle terms, what is essential is that steel recycling is optimised so that the use of virgin material resources can be reduced to make the two routes complementary.

4. Use of results

4.1 Does the LCI signal any implications for global warming or energy use?

The LCI study is a cradle-to-gate study. The implications of the data collected should preferentially be assessed through full LCA studies, including the downstream activities (use and end-of-life), and LCIA (life cycle impact assessment), which can now be undertaken using the data provided by the study.

4.2 What is the industry doing to address the key issues?

As with other industrial processes and many human activities, there is no simple nor single remedy for fully avoiding environmental impacts, beyond striving for ever-improving energy efficiency, installing “clean” technologies and considering the scope for exploiting renewable energy. The global steel industry has invested heavily in measures to increase energy efficiency at its sites, resulting in an average reduction in energy consumption of 50% over the past 60 years. The steel industry has also introduced environmental management systems, and an increasing number of companies are certified or in the process of certification for ISO 14001.

Another key issue is the application of steel products in sustainable development. LCAs enable the industry to pursue a dialogue with customers to help improve the range of steel products available to them, thereby helping them to design steel-containing products that meet their environmental requirements.

On the road to the arrival of breakthrough technology, short and medium-term process efficiency gains will provide important climate change benefits. In 2019, worldsteel initiated a new industry wide programme named [step up](#). This multistep process covering raw materials, energy input, yield and maintenance can be used to support improvements in mill operations to efficiency levels commensurate with the steel industry's top performers. The programme will be tested across 5 mills and then rolled out much more widely through 2020-2025.

4.3 Are the data published?

The LCI Study has resulted in the creation of a database that contains a vast inventory of data, and the development of a method of analysis that is state-of-the-art in terms of data quality, rigour, broad coverage and adherence to the ISO Standards for LCA (ISO 14040 series). Data is made available to worldsteel member companies, but the full database is held by worldsteel, and will be regularly added to and updated on an annual basis.

However, one of the important aims of the study is to provide data to enable LCA studies of steel-containing products. To this end, third parties undertaking such studies can obtain data from the inventory free of charge from worldsteel or directly in the GaBi and SimaPro.

4.4 Does worldsteel intend to use the study to make comparisons with other materials?

The worldsteel LCA work is carried out according to the standards set out in the Policy Statement on LCA that was adopted by the worldsteel Board of Directors in 1995. This statement warns of the dangers of using LCI or LCA data in a simplified way for comparison between materials. The data will be used by worldsteel and its members to understand the impact of using steel in different product applications to see where the benefits lie and improvements can be made. The data will also be used by third parties to make comparisons and the steel industry therefore needs to support such studies and, where appropriate, respond to claims made about steel by other industries.

4.5 What if customers request steel LCI data but wish to use an alternative methodology?

One of the aims of the study is to produce worldwide LCI data for steel industry products, developing and using a common methodology, in order to enable benchmarking and valid comparison throughout the industry. However, the transparency and quality of the data mean that other methodologies could be used.

Nevertheless, expertise and care must be taken to ensure that the worldsteel methodology or any modifications are compatible with those of external studies. To this end, worldsteel is encouraging its member companies to participate in any third-party studies and to liaise with those undertaking them. The steel industry aims to encourage good LCA practices and, where appropriate, the use of the ISO 14040 series of international standards.

While worldsteel uses the end-of-life approach to account for steel recycling at the end of a product's life, the user of the data is not obliged to use this method. Data is provided as cradle-to-gate data and the net credits for recycling can be provided in addition, following the worldsteel recycling methodology as described in appendix 10 of the worldsteel methodology report.

4.6 Will steel companies with the ‘best’ LCIs claim advantage over other steelmakers?

The worldsteel LCI Study has been undertaken to further knowledge of life cycle issues within the industry, and to assist with benchmarking and environmental improvement programmes throughout the global steel industry. It is not intended to be used as a tool for competitive purposes.

4.7 Will the study be repeated or updated?

The LCI database is held by worldsteel, which has an on-going programme to both extend and update the data.

Specifically, additional worldsteel members will wish to collect LCI data for their operations and include them in the database. Participants are also working with suppliers to improve the quality of data for upstream operations. In addition, participants will repeat the study as appropriate to ensure continuing data quality, as well as to provide information on improvements over time. It is currently proposed to update the data on an annual basis.

The Head of Sustainability at worldsteel is responsible for this work.

4.8 What if worldsteel LCI results are used in a technically rigorous external study that concludes that steel is not the preferred material?

There will certainly be cases in which, based on specific criteria, steel is found not to be the preferred material for a particular application. In circumstances where steel might be found unsuitable on the grounds of environmental factors, LCA studies can give very clear guidance to the industry regarding the priorities for improvement in its environmental performance.

In practice, material selection by customers is based on a combination of a range of criteria such as technical performance, cost effectiveness, environmental and safety considerations. These complex issues cannot be reduced to a single answer, but rather prompt a continuing dialogue between customers and suppliers.

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For enquiries, please contact:

Head of Sustainability: Clare Broadbent – broadbent@worldsteel.org – Tel: +32 2 702 89 32