OVAKO

CRADLE-TO-GATE — UNDERSTANDING CO_2 FOOTPRINT OF HOT-ROLLED BAR STEEL PRODUCTS

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Executive overview

Ovako is a leading European producer of engineering steel for customers in the bearing, transportation and manufacturing industries. Its production comprises primarily bar, tube, ring and pre-components in low-alloy steels. Typically, they are used in demanding applications such as vehicle powertrains, hydraulic cylinders and rock drills.

Steel products play a vital role in building smart flexible cities, cost-effective and reliable infrastructure and energy-efficient transportation systems. They are vital to the world economy and as it grows, then so does the demand for steel. And this demand is increasing fastest in emerging areas of the world.

However, while steel can offer solutions to many of the world's climate challenges, steel manufacturing processes present their own environmental challenge. In fact, the steel industry accounts for just over eight percent of the world's carbon dioxide CO_2 emissions directly, and even more when the inputs to the steel industry are fully taken into account. The environmental impact of steel is an important and complex issue.

Thanks to steel production based on scrap as the main raw material, combined with close control of upstream consumables and efficient and low-fossil energy usage during production and transportation, the CO_2 footprint of Ovako hot-rolled bar steel products is approximately one sixth of the world average.

This offers opportunities to significantly reduce the carbon dioxide footprint of finished products based on steel.

In this white paper, Ovako explains how a detailed Life Cycle Assessment (LCA) has established the full carbon dioxide footprint of its steel products.

Ovako takes responsibility for conducting its business in a sustainable manner. This covers every aspect of its operations from suppliers, to employees to customers. It also means acting responsibly in the communities where it operates. Sustainability is an integral component of the company's long-term strategy. The aim is not only to meet increasingly stringent legislation but also to build the social capital that creates goodwill, interests investors and helps attract and retain talented employees.

1 — Introduction

Steel is a highly versatile material, and a cost-efficient solution to many challenges facing society.

Steel can also be recycled an infinite number of times. In contrast with other materials, such as concrete, this makes steel suitable for a more circular society.

The majority of the steel in the world is made by an integrated steelmaking route that uses iron ore and coking coal in basic oxygen steel-making furnaces (BOF). Some steel is however made using the more flexible electric arc furnace (EAF) route that is based on ferrous scrap as the primary raw material.

70–75 percent of all steel in the world is produced by the BOF process and the remainder by the EAF route. The use of the EAF or BOF process varies between different regions. For example >90 percent of China's steel is produced by BOF, while the USA produces the majority of its steel by EAF.

Ovako produces its own steel by the EAF route. This offers the advantages of operational flexibility and sustainable production as the EAFs use recycled scrap and are powered by electricity that is sourced from predominantly non-fossil electric power, in Sweden and Finland.

The global production of crude steel, according to the World Steel Association, amounted in 2017 to 1,689 million tonnes, with China, the largest producer accounting for 49 percent of this total. Out of this, Ovako manufactured less than 1 million tonnes of crude steel.

2 — Life Cycle Assessment builds an understanding of steel´s environmental footprint

Ovako engaged RISE IVF to carry out a Life Cycle Assessment (LCA) of its steel. The LCA is a technique developed to assess the environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, and end of life disposal or recycling.

When all life cycle phases are included in an LCA study, it is referred to as a cradle-to-grave study – see Figure 1. Studies that focus on raw material production and a company'sown production are referred to as cradle-to-gate studies.

The cradle-to-gate approach offers key stakeholders, especially customers, the opportunity to add on their own emissions to create Environmental Product Declarations.

The Ovako LCA was carried out in accordance with ISO 14044 [ISO, 2006] and the ILCD Handbook (Wolf & Pant, 2012). Site specific data from Ovako's own manufacturing was used which encompassed a large part of the life cycle environmental impact since the production is largely based on scrap steel. The remaining data is generic, i.e. taken from existing databases for LCA and generally represents global or European averages. In particular, data was taken from the commercial database Ecoinvent 3. For the calculations SimaPro 8.3.0.0, has been used.

By careful selection of low-impact suppliers of products and services, Ovako can influence the value chain, deliver even more climate-smart products and lower overall emissions. Taking a more holistic view of the whole value chain helps to inform decision making, ensuring that priority is given to actions that deliver the greatest environmental benefit.

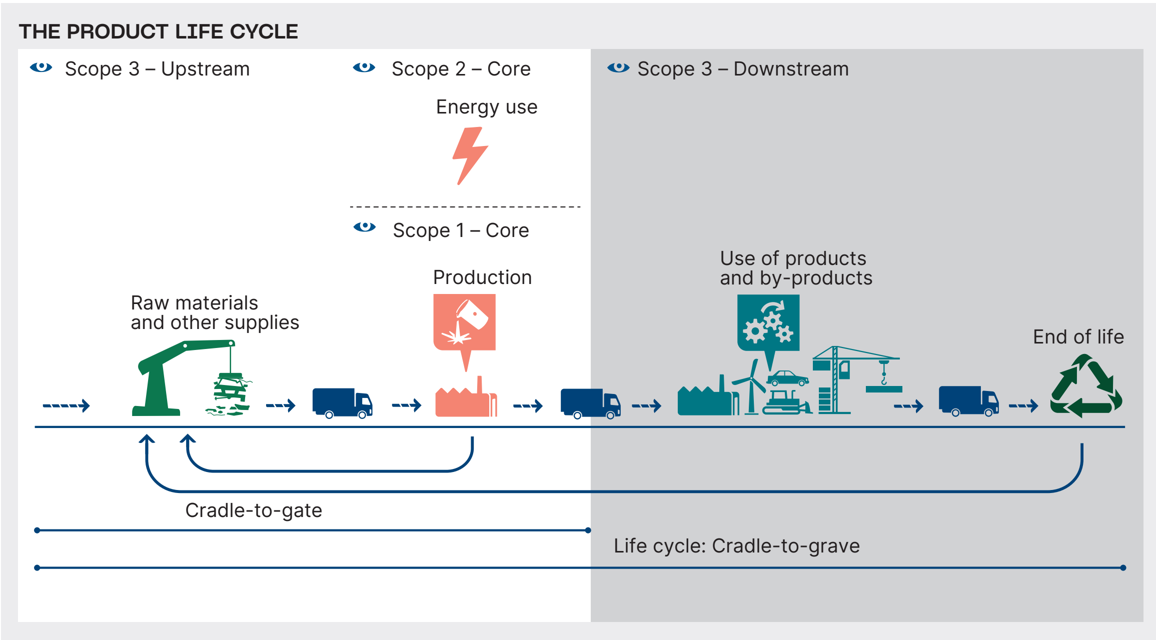

Figure 1 – The product life cycle.

The functional (or declared) unit in Ovako's LCA is 1 tonne (1000 kg) of hot-rolled bar steel product at the factory gates at three sites – Hofors, Smedjebacken/Boxholm and Imatra. With respect to finishing, the products are hot-rolled, ground and blasted.

The system boundary for Ovako's LCA is shown in Figure 2. Upstream represents raw material production and Core is Ovako's own production.

The system boundary for the life cycle assessment is based on the product category rules for Basic iron or steel products & special steels, except for construction steel products 2015:03 in the EPD® system (PCR2015:03, 2015) as well as the general program Instructions for the EPD system (EPD System, 2015). Upstream is in principal the same as Scope 3 emissions according to the Greenhouse Gas protocol (Schmitz et al., 2004), while Core includes Scope 1 and Scope 2 according to this protocol.

Concerning the allocation of waste burdens and benefits, the EPD system stipulates how to separate the product systems at the point where the waste products have their lowest value.

This type of system boundary delimitation is often called the cut-off approach since there is a clear cut-off point between the product systems. It enables addition of consecutive product life cycles without double counting emissions and resources.

The aim was to include all materials and energy used to manufacture the hot-rolled bar steel product. The modeling is based on production processes in the Ovako plants in Hofors, Smedjebacken including Boxholm and Imatra in 2017, as described in their environmental reports.

All data in the report concerning raw materials, energy use, water use, emissions to air, emissions to water and wastes is included in the model. In addition, data about chemical use and transportation of goods is added. PCR 2015:03 stipulates that 99 percent of inflows to the core module should be included. However, data about job commuting, R&D, business travelling etc was not collected nor included since PCR 2015:03 specifically excludes these activities. Raw material flows of less than 1 tonne, i.e. less than 0.0003 percent of the output flow were disregarded, unless there were reasons to suspect problems in an environmental sense.

This Life Cycle Assessment report was verified and approved by a certified auditor.

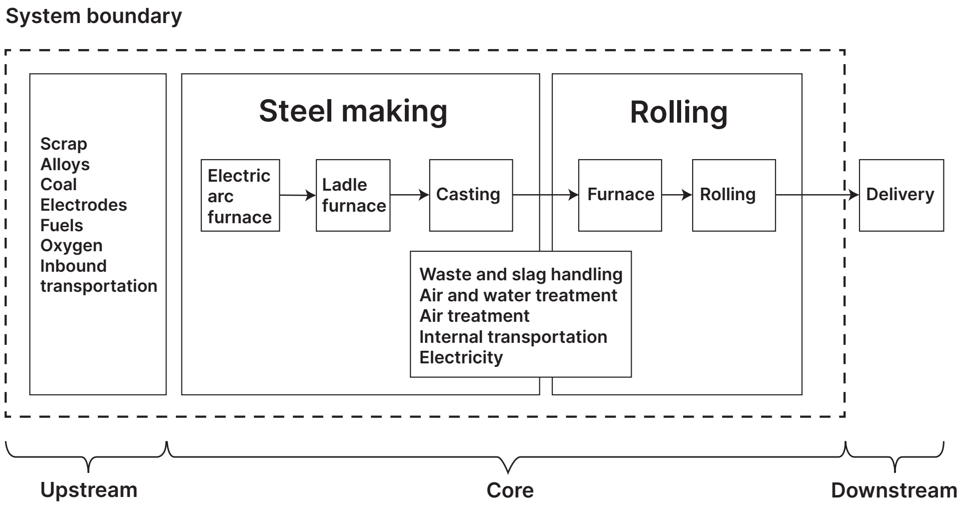

Figure 2 – System boundary for the LCA, example from Smedjebacken and Boxholm.

3 — Support is provided by the Environmental Product Declaration system

As environmental impact becomes increasingly important and the requirements for complete transparency increase, Ovako has made declarations for its products according to PCR 2015: 03, which is based on a comprehensive life cycle assessment according to ISO 14044 in the context of environmental product declarations according to ISO 14025.

In these declarations, Ovako considers what it buys for its own production, as well as the impact of its own processes. An Environmental Product Declaration (EPD) is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products.

Ovako views these declarations as giving its customers an important competitive edge, especially when comparing products with competing products or global averages.

Ovako has Climate Declarations for hot-rolled bar steel products from Hofors, Smedjebacken/Boxholm and Imatra and full EPD with all environmental data for hot-rolled bar steel products from Imatra. A full EPD will also be made for products from Hofors and Smedjebacken/Boxholm. All environmental data are already available in the Life cycle assessment report.

These declarations enable customers to make well-informed purchasing decisions based on carbon footprint. It also gives them the opportunity to produce climate declarations for their own products.

By promoting this approach, Ovako and its customers can create far-reaching environmental benefits by enabling a more informed choice.

All EPDs registered in the International EPD® System are available to the public and free to download through www.environdec.com

Figure 3 – Environmental product declaration for Imatra.

4 — The LCA result in detail

Figure 4 shows that the carbon dioxide impact of the functional unit of 1 tonne (1000 kg) of hot-rolled bar steel product from Ovako's plants in Hofors was 453 kg CO_2, Smedjebacken/Boxholm 426 kg CO_2 and Imatra 445 kg CO_2/tonne.

The life cycle assessment indicates that the carbon dioxide impact of steel products from Hofors, Imatra and Smedjebacken/Boxholm mainly derives from, in order of size:

1. Resource related CO_2 emissions in the EAFs
2. Natural gas, LPG or fuel oil used in the rolling mills
3. Quicklime
4. Mining, refining and transporting various metal alloys
5. Scrap sorting and transporting
6. Electricity

A climate declaration has to be based on a full LCA, i.e. not only carbon dioxide impact but also the impact categories i.e. acidification, eutrophication, photochemical oxidation, ozone depletion and primary energy. More information about these categories are available in the LCA document.

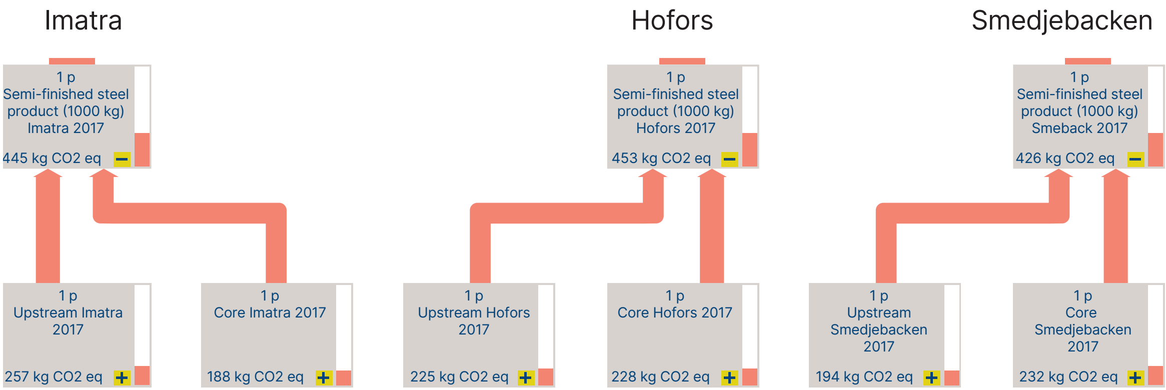

Figure 4 – Carbon dioxide impact for average hot-rolled bar steel products from Ovako.

5 — How ovako works with process improvement to reduce environmental impact

Ovako has worked hard to reduce the emissions from its own processes. For many years the company has operated an energy saving program as well as trying to optimize scrap use in relation to alloying. All Ovako's steel manufacturing is scrap based, making it the largest steel scrap recycling company in the Nordic region. It also selects its suppliers carefully and uses electricity from Nordic electricity producers which have some of the lowest carbon dioxide emissions in the world.

The EAF process, which has been used for many years, has been continually developed and improved and residual energy is recovered. A variety of useful by-products are also produced, such as slag products used in high wear-resistant and noise-dampening asphalt.

Ovako's production processes create by-products that are used for various purposes. More than 90 percent of all residuals from production are either reused or recycled and can therefore reduce CO_2 emissions in other sectors.

Ovako contributes to research projects together with other companies to find new areas where waste products can be used as raw materials, thereby minimizing waste from steel production.

The Ovako CO_2 efficiency program aims at reducing the CO_2 emissions and the use of fossil fuel. The program has recently been launched and is taking Ovako to the next level in CO_2 reduction.

Here are some examples of investments and improvements made in the time period 2015–2019

- New flue gas filters have been installed that significantly reduce the emissions of dust and metals
- Optimization and reconstruction of control systems, furnaces and heat treatment has lowered CO_2 emissions and energy use. For example reconstruction of a Rolling Mill Furnace has lowered CO_2 emission by 10%
- Conversion to Oxyfuel in pit furnaces, chamber furnaces and rolling mill furnaces has significantly reduced energy consumption and lowered the emissions of CO_2 and NOx. For example conversion in 2 pit furnaces has lowered the CO_2 emissions by 15% and the conversion in a rolling mill furnace has lowered the CO_2 emission by 20%
- Excess heat from hot processes are utilized in the district heating systems.
- The heat from water used for cooling in processes is recovered in several locations. As a result, net usage of district heating to heat these buildings has essentially been reduced to zero
- Systematic work to convert furnaces from oil to either LPG or electricity has reduced emissions including CO_2
- Modernization of a water pumping station has reduced energy consumption by more than 1700 MWh
- Modernization of Imatra's vacuum system will reduce energy consumption 22 000 MWh yearly and lower Imatra's total CO_2 emissions with 8%

6 — A global comparison

To understand how Ovako's hot-rolled bar steel compares with other steels made around the world, a survey of several sources was carried out. There is no uniform methodology applied globally, which makes comparisons between different sources more difficult. However, some conclusions can be drawn by looking at data from the same source for different routes and geographic locations.

In relation to the climate footprint of Ovako hot-rolled bar steel, the following basic observations are important

- Presently there is only one climate declaration, reinforcement steel from Mo i Rana in Norway, that is lower than Ovako with regards to carbon dioxide impact.
- Ore-based production, which today is pre-dominant, has on average four times more carbon dioxide impact than scrap-based production.
- The combination of scrap-based production in electric arc furnace and access to carbon lean electricity minimizes the carbon footprint.

The World Steel Association (worldsteel) represents over 160 steel producers (including 9 of the world's 10 largest steel companies), national and regional steel industry associations, and steel research institutes. World-steel members represent around 85% of world steel production. Worldsteel presents aggregated production data from the whole world on the climate footprint of crude steel. No less than 193 sites have submitted data for 2015; however no sites from the largest producer China participated 2015. It should be noted that mining and transportation of iron ore and coal are not included in the production data from World Steel.

The following conclusions can be drawn from the worldsteel data

- The difference between scrap-based steel and ore based is around 1700 kg CO_2/tonne on average. Ore based gives around four times more carbon dioxide impact than scrap based. This is however before including the carbon footprint of mining and transportation of iron ore and coal.
- The current world average is 75% ore based and 25% scrap based (EAF based).
- No data was delivered from Chinese sites 2015
- Since the EAF (scrap based) carbon dioxide impact is largely driven by electricity and China's electricity is very coal-rich, EAF based production in China would most likely be in the upper span for EAF production, i.e. closer to 2100 kg CO_2/tonne.
- The ore-based route is the most common in China but for BF-BOF electricity is less dominant so it is hard to place Chinese steel in the span 1600-3600 kg CO_2/tonne for BF-BOF production. This is before including the carbon footprint of mining and transportation of iron ore and coal.

The LCA database Ecoinvent presents numerous data sets for steel. The following conclusions can be drawn from them

- The difference between Steel, low-alloyed and Steel, low-alloyed, hot-rolled implies 300 kg CO_2/tonne steel for hot rolling.
- Crude steel global average is 1710 kg CO_2/tonne for 58% ore|42% scrap based which compares well with worldsteel´s 1870 kg CO_2/tonne for 75% ore|25% scrap
- Mining and transportation of iron ore has a carbon dioxide impact, on average, of 188 kg CO_2/tonne crude steel, most of which stems from transportation.
- The carbon dioxide impact of mining and concentration of iron ore in Ecoinvent compares well with academic studies (Ferreira & Leite, 2015; Haque & Norgate, 2015)
- Ecoinvent data on carbon dioxide impact of mining and transportation of coal suggests an "add-on" of 346 kg CO_2/tonne crude steel.

Academic studies indicate that

- Both (Hao et al, 2017) and (Hasanbeigi et al, 2016) stress that the EAF rate and the carbon intensity of the electricity are very significant for the carbon dioxide impact.
- Open pit iron ore mining has a small impact, 12-13 kg CO_2/tonne iron ore. This compares well with the global average 28 kg CO_2/tonne ore suggested by Ecoinvent since many mines are not open pit.

Crude steel is defined by worldsteel as steel in the first solid state after the melting/refining process as it comes out of the casting process suitable for further processing. Crude steel has to be further refined/rolled before it becomes a semi-finished steel product. Rolling and refining processes contain many losses of internal scrap. In this study we have used a yield factor that creates a 20% difference between distributing burdens on crude steel output or rolled output.

To enable a comparison between Ovako average steel carbon dioxide impact and world-steel average values, the carbon dioxide impact for iron ore and coal mining and transportation should be added to worldsteel values. In addition worldsteel figures should be increased by 20% due to distribution of impacts on crude steel, see above.

Data presented above suggest that 150+346=496 kg CO_2 should be added to world steel data per tonne of crude steel for iron ore mining and transportation and coal mining and transportation respectively, so 2300+496=2796 kg CO_2/tonne steel for BF/BOF route.

In addition, worldsteel figures should be increased by 20% due to distribution of impacts on crude steel, thus 2796*1.2=3350 kg CO_2/tonne steel BF-BOF route.

Since little mining is involved in the EAF route for this type of steel, this will only increase by 20% to 696 kg CO_2/ tonne steel, thus a global steel average comparable to Ovako average steel would be 0.75*3350+0.25*696= 2690.

So Ovako average hot-rolled bar steel product is approximately 445/3350=1/8 of the global steel average (excluding Chinese sites) for the predominant ore based route and 445/2690=1/6 of the global steel average (excluding Chinese sites).

In summary, the following observations are important

- The combination of scrap-based production in electric arc furnace and access to carbon lean electricity minimizes the carbon footprint
- Ore-based production, which today is predominant, has on average four times more carbon dioxide impact than scrap-based production. Compared to Ovako´s crap-based hot-rolled bar steel product, ore-based production gives eight times more carbon dioxide impact.
- Presently there is only one climate declaration within the EPD®system, reinforcement steel from Mo i Rana, that has a lower carbon dioxide impact than the Ovako hot rolled bar steel product.
- In relation to the current global steel average, which is estimated from worldsteel figures (75% BF/BOF and 25% EAF route) to 2690 kg CO_2/tonne hot-rolled steel product, the Ovako hot-rolled bar steel gives only 1/6 of the carbon dioxide impact.

Simply put, Ovako’s customers save around two tonnes of carbon dioxide per tonne of steel they buy, compared to the global average.

7 — The environmental impact of quality steel in its user phase

Steel differs, not only in its production methods, but also in cleanness, performance and the level of environmental impact. Ovako's low CO_2 footprint, compared to other steel, differentiates it from other suppliers of steel products.

For every kg of steel used in the manufacture of a passenger vehicle, using Ovako steel cansave 2 kg of CO_2. Figures produced by the Lightweight Forging Initiative show that atypical passenger vehicle has 399 kg of forged parts for the powertrain and 285kg for the chassis. The sum of the finished components in engineering steel (684 kg) requires approximately 1000 kg of hot-rolled steel bar.

It is possible therefore to make an immediate saving of 2 tonnes of CO_2, simply by selecting a low-emission steel producer. According to the new EU agreement, an average passenger vehicle by 2021 should emit about 95 g of CO_2 per km, so the saving in production equals the emissions over some 21,000 km – or one to two years of daily driving.

The savings do not stop at the factory gate, steel selection can play a vital role in helping optimize power-train weight and efficiency.

'Clean' steel has a lower level of impurities than competing conventional steel, in line with vacuum-smelted steel – see Figure 5. This high level of cleanness enhances fatigue strength, and Ovako's high-grade steel, such as IQ-Steel and BQ-Steel, enables new design solutions that, in turn, allow for lighter, stronger and more durable components. This helps Ovako's customers to reduce CO_2 emissions in their products and applications.

As an example, using Ovako steel in the gearbox can improve the power density of a vehicle, boosting energy efficiency and helping to reduce its CO_2 emissions.

Volvo Penta put the isotropic properties of Ovako's IQ-Steel to use when developing its IPS marine 'pod-drive' system with counter-rotating forward-facing propellers. The steel has enabled the powertrain performance to be optimized. The result is a 30 percent reduction in CO_2 emissions.

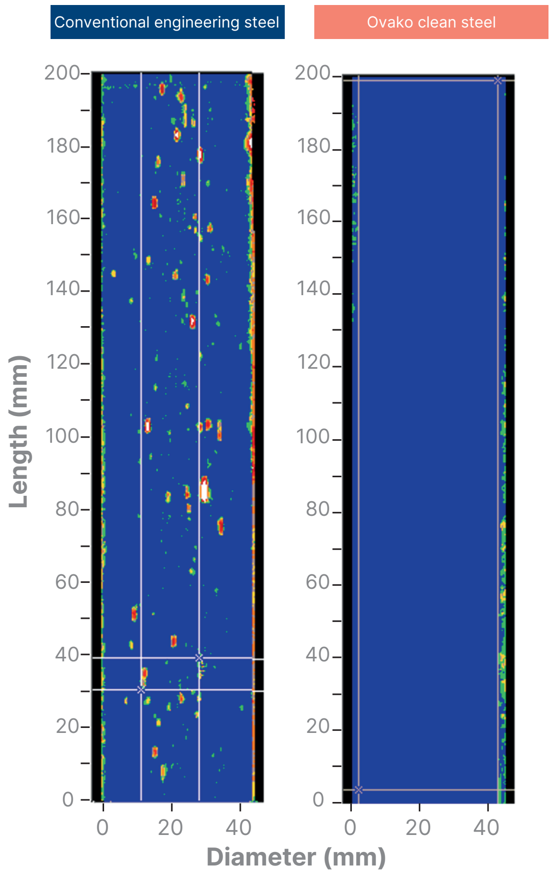

Figure 5 – Clean steel has a lower level of impurities

8 — Summary

The Life Cycle Assessment (LCA) of Ovako steel shows that its CO_2 emissions are significantly lower than the global average for companies that produce rolled steel products. In relation to the current global average, estimated from worldsteel figures to be 2 690 kg CO_2/tonne steel product, Ovako hot-rolled bar steel at 420–450 kg CO_2/tonne has only one sixth of the carbon dioxide impact.

Compared to the predominant BF/BOF route, Ovako hot-rolled bar steel has only one eighth of the carbon dioxide impact.

This low CO_2 footprint is something that differentiates Ovako from other suppliers of steel products. In addition, high-performance steels, such as IQ-Steel and BQ-Steel, enable new design solutions that, in turn, allow for lighter, stronger and more durable components.

Ovako has several types of steel in its program that provide particularly strong customer benefits in terms of enhanced end products. This places the company in a strong position to enable its customers to minimize their carbon footprint.

By careful selection of products and services from low-impact suppliers, Ovako and its customers can influence the value chain, deliver even more climate-smart products and lower overall emissions.

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