Value chain analysis

Rebars

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Version	C
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1. Introduction

N.V. BESIX S.A is part of BESIX Group, a multidisciplinary construction group specialized in the realization of buildings, infrastructure, sports & leisure, industry, environment and marine works, which are often distinguished by their complexity.

Through its wide range of projects BESIX acknowledges the significance of its carbon footprint within SCOPE 3. Yet, this scope is intricately linked to an entire supply & production chain and influenced by decisions made by both customers upstream as suppliers & subcontractors downstream.

Steel, a key material in BESIX's structural projects, is valued for its technical characteristics and reinforcement benefits. Despite its advantages, it stands out as one of the most carbon-intensive materials. In BESIX's project several types of steel are used, from rebars to structural steel, passing by sheet piles and thin steel sheets. This value chain analysis focuses on rebars. It is imperative to acknowledge that the calculations were conducted on the basis of products with the "rebar" or "netten" specification. The terms "rebar" means reinforcing bar and "netten" means rebar nets. The term REBAR throughout this document therefore includes reinforcing bar and rebar nets.

The pivotal question arises: How can BESIX tackle this environmental challenge and contribute in the effort to achieving global net zero by no later than 2050? This document aims to delve into this inquiry by conducting a comprehensive analysis of the value chain related to the use of rebar. This study highlights the stakeholders, life cycle stages and identifies the greenhouse gas emissions throughout the entire value chain related to the production of rebar and its application in our activities.

This value chain analysis is drawn up as part of the level 5 CO_2 performance ladder certification of N.V. BESIX S.A.

1.1 What is a value chain analysis?

A value chain analysis is a means of evaluating each of the activities in a company's value chain or life cycle of a product to understand where opportunities for improvement, in this case reduction of GHG emissions, lie.

The value chain analysis is structured as this document describes the following elements:

- Description of the value chain in question
- Determination which life cycle categories are relevant
- Identification of the value chain partners
- Quantification of the scope 3 emissions for each relevant life cycle category
- Description of measures which can be taken by BESIX to reduce the carbon footprint

1.2 Choice of this value chain analysis within BESIX

As part of the CO_2 performance ladder certification BESIX has reviewed in the second semester of 2024 its scope 3 analysis, both quantitative as qualitative, in order to redefine the most relevant scope 3 emission categories.

Considering the composition of the scope 3 category 'Purchased Goods & Services' over the last 5 years (see below extract from the CO_2 software application Smarttrackers), rebar is in absolute values a top 3 contributor amongst ready-mix concrete and MEP.

Considering the importance in the sector and the potential influence both the sector and BESIX can have on reducing the emissions, ready-mixed concrete and rebar are considered as the 2 most relevant scope 3 categories.

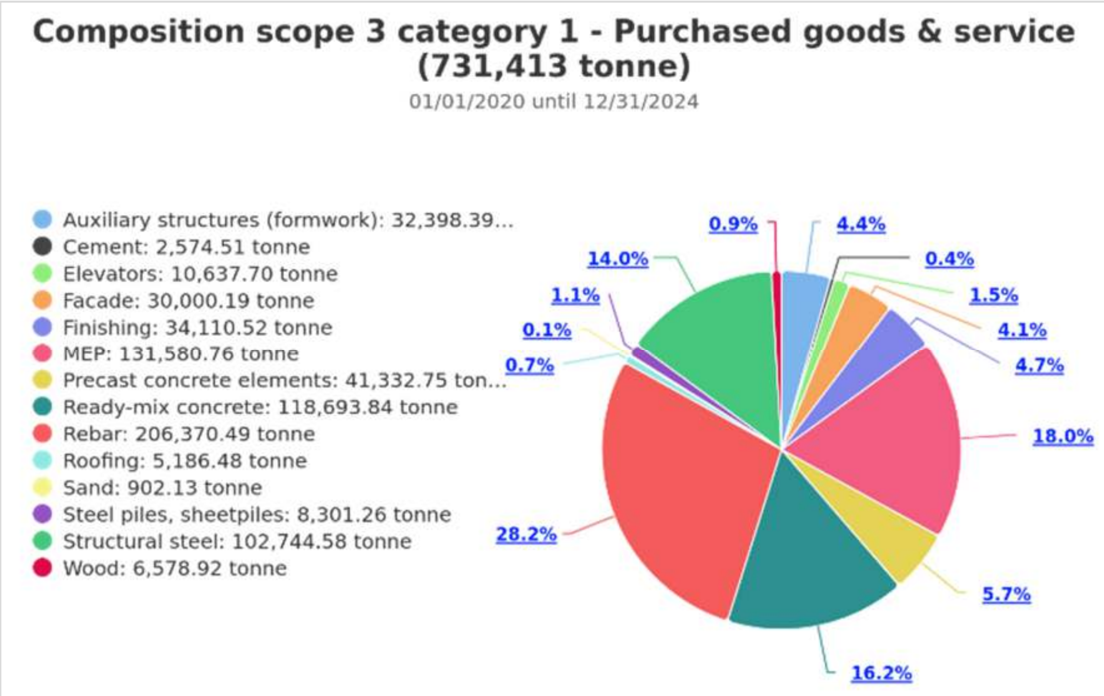

Figure 1

1.3 Goal of this value chain analysis

This value chain analysis must be seen as a continuation of previous document 'Rebars' written in March 2024 within BESIX NV/SA going more in depth and using more supplier specific data. The current value chain analysis concentrates on the projects in Belgium, France and Netherlands.

The goal of this analysis is to identify and analyze the value chain of rebar and determine how BESIX can have an impact in the value chain over the entire life cycle, both upstream as downstream. By understanding the entire production process of rebar, from raw materials acquisition over the application of the final product in construction projects to its end-of-life treatment, BESIX aims to determine the actions and opportunities it can take to reduce the carbon footprint of this product. It is also aims to define reduction targets and the process to monitor progress.

In this value chain analysis, specific data and information on rebar suppliers has been used. Suppliers included are from N.V. BESIX S.A., Franki Foundations, Franki Grondtechnieken and Atlas Fondations.

The value chain analysis has been performed on 2023 data.

2. Value chain identification

The steel value chain is a complex and interconnected system involving multiple stakeholders, including raw material suppliers, steel manufacturers, construction companies, transportation providers and regulatory bodies.

In addition to the life cycle of rebar—from raw material extraction to end-of-life processing—two other key processes significantly impact its overall footprint. The first is the tendering phase, where the client sets the project's sustainability ambitions. The second is the design phase, where optimization strategies are explored, and steel types are selected. While these processes are not included in the direct quantification of value chain emissions, they are addressed separately, as BESIX can play a crucial role in both.

This means that the value chain looks at follows:

Figure 2

The LCA boundaries from the extraction of raw materials to end-of-life processing is broken down in the picture bellow. The system which will be studied is the value chain of concrete from the raw materials supply who are needed to the end-of-life. The global warming potential is going to be analyzed for the different steps.

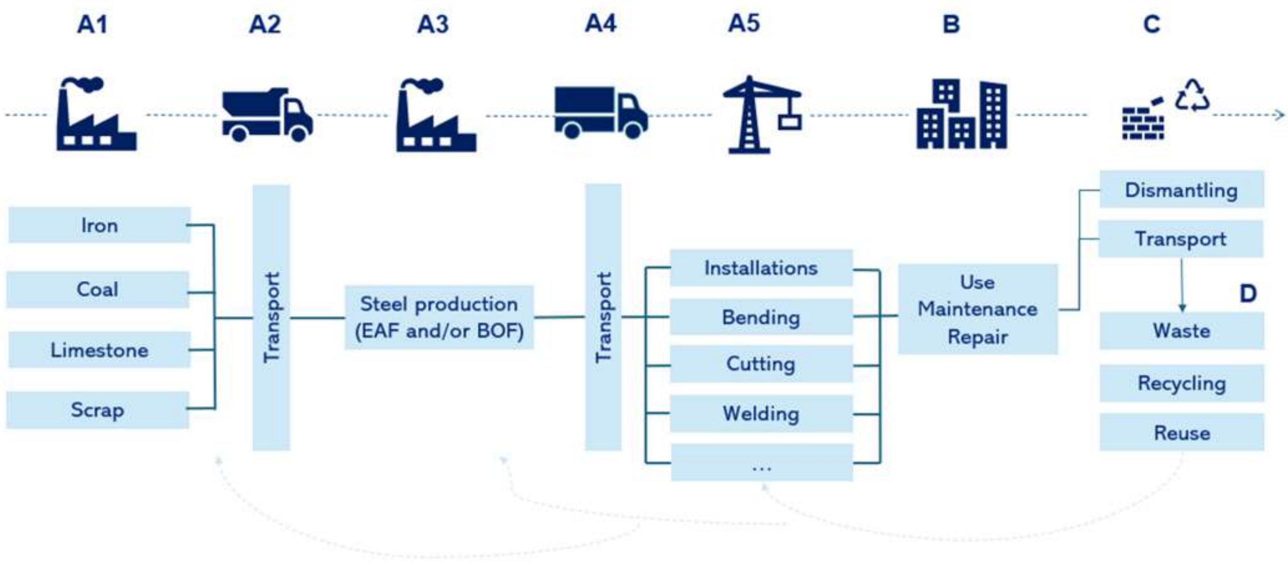

Figure 3

2.1 Value chain partners

In the steel value chain, there are different contributors at each step. This section describes the players in the chain. Collaboration between the stakeholders in the steel sector is the key to reduce the material's carbon footprint, by sharing knowledge, best practices and adopting innovative technologies.

- ✓ Policy makers (European Union, Governments (national/regional)

  Due to the regulatory nature (climate policy, energy policy, building regulations...) of both the European Union as well as the national and regional governments of the various member states, there is an active drive towards CO_2 reduction within the industry and thus also the construction sector.

  From the European Union, various measures have been taken within the European Green Deal to reduce the emissions within the construction sector. Examples include the Climate Act, ETS mechanisms for specific sectors and recently for road transport and buildings, the Energy Efficiency Directive...

  Member states and/or regions can also individually implement additional legislation which has a direct impact on making the construction sector more sustainable. Examples include the Steel Action Concept “For a strong steel industry in Germany and Europe” released by the Federal Ministry for Economic Affairs and Climate Action in Germany. This action outlines the key strategic points of Germany to reduce the environmental impact of steel. Another example comes from the European Steel Association EUROFER and introduce a plan of action called “Green Deal for Steel” defining the key strategic points to reach the CO_2 emissions target for 2025 in EU.

- ✓ Research, certification and standardization

  By drafting and updating product standards, accreditation organizations can facilitate CO_2 reduction within the construction sector. We are thinking here of adjusting product standards on steel in function of technological and innovative developments within the sector. Examples include the use of Electric Arc Furnace, the direct reduction with hydrogen as a reducing agent or the development of Green Steel in EU.

  Through participation in sector initiatives such as the European Green Deal, efforts are being made to adapt little by little existing standards in function of these innovative developments. The General Contractor, alongside the government, scrap and raw material suppliers have an important role to play here. The academic world, whether or not in cooperation with the construction industry, is actively looking for solutions to make rebar and/or its use further sustainable.
  Examples include initiatives around recycled steel (e.g. Mundo lab in Louvain-La-Neuve), the use of alternative reducing agents...

- ✓ Client

  By defining the sustainability ambition level of the project, the Client has a major impact in reducing the footprint of its building or structure. By choosing for more sustainable construction materials such as low-carbon steel and/or sustainable transportation methods the Client defines already in the tendering/early-design phase the footprint of its building or structure. Early Contractor Involvement with BESIX is therefore important and can help the Client in making sustainable choices and drive innovation.

- ✓ Internal/external Engineers and architects:

  They design the structures and specify the steel types. At the design stage, and the earlier they consider it, engineers and architects can reduce the project's carbon footprint. A number of techniques can be used, such as reducing the amount of required material by making the building slimmer, life cycle analysis, comparison of design concepts, optimization of steel types, etc.

- ✓ Raw materials suppliers:
  Providers of raw materials such as iron, coke and limestone. They have an impact on the chain in the extraction practices to minimize the environmental footprint of quarrying raw materials such as iron. The impact of the raw material supplier is determined by the location of the raw material extraction, transportation methodology of these raw materials and the energy used during the production phase. They can also reduce the need of new ore by opting for recycled materials such as scrap. (Scrap in the steel sector refers to recycled ferrous materials, such as discarded steel and iron, that are reprocessed to produce new steel products.)

- ✓ Scrap suppliers:
  In the steel industry, two types of raw materials are distinguished: ores and scrap. Scrap is steel that is recycled at the end of its life and then remelted to produce new steel. Scrap has an impact on the chain in terms of recycling and handling practices to minimize the environmental footprint of raw materials such as scrap. The environmental impact of scrap is determined by various factors including recycling, transportation from the construction sites and to the manufacturing factory and the energy consumption associated with handling scrap throughout the supply chain.

- ✓ Steel producers:
  As mentioned in figure 4 the Global Warming Potential of rebar is mainly determined by the type of furnace. The way in which iron is melted is crucial to steel production and therefore plays a significant role in determining the material's environmental footprint.
  They combine the raw materials to produce rebars according to specific project requirements. With knowledge of the sector and their materials, steel producers can work on a number of aspects to reduce environmental impact. Steel suppliers which are situated along water ways or near the railway can opt for transport over water or by train for their base materials such as iron, coke, limestone or scrap. They can also optimize designs by minimizing the amount of raw materials or by investing in the development of the use of alternative solutions (see 4.4.). They can also reduce the need of new ore by opting for recycled materials such as scrap.
  As product experts, they can distinguish themselves through innovation and advise their customers on how to move towards lower-carbon steel.
  Also in the transport of the end product to their clients, the steel suppliers can reduce their footprint by opting for alternative fuels (such as HVO, biogas, hydrogen...) or electrification of their fleet.
  Finally, communication is important, and providing EPDs of their products is a key point so that other stakeholders can make coherent choices at their level.

- ✓ Construction companies
  They use steel in the projects. Via the procurement phase they play a strategic role. By choosing products with a low carbon footprint, they can distinguish themselves from competitors. General Contractors with an internal engineering Department can optimize the design of the structure to be built and also reduce the amount of required tons of rebar and/or ready-mixed concrete. This is certainly the case in design & build projects.
  Emission during the handling of rebar on site is mainly due to the energy use related to vertical transport, cutting, welding... By opting for renewable energy and optimization of execution methods (transport outside rush hours, approach routes...) further optimization in CO_2 reduction is possible.

Finally, a point of attention that is also in their hands is the management of demolition and the flow of steel at the end of its life.

- ✓ End user (buildings)
  Although the influence of an end-user is limited on the choice of materials while constructing a building, an end-user has an influence by choosing more sustainable buildings.

- ✓ Demolition companies
  A demolition company plays a crucial role in the value chain of rebars, particularly through the recycling and repurposing of construction and demolition (C&D) waste. By integrating scrap into the production of rebars, demolition companies contribute to a circular economy. This process helps in reducing waste, conserving natural resources, and lowering carbon emissions associated with steel production.

- ✓ Recycling and waste management companies:
  They will handle the steel waste and find options for recycling. Finally, the last of the chain can foster the circular economy and therefore reduce the carbon footprint by facilitating the recycling and reuse of steel.

All the stakeholders have also a common challenge to optimize the **energy efficiency** of their process and to minimize the **transport impact** between the different steps.

3. Quantification of the emissions

Based on the description of the value chain as shown in chapter 2, the CO_2 emissions are determined for each step in the value chain.

3.1 Product stage : A1-A3

These stages of the LCA consist of material production. It is in the hands of the raw materials suppliers, the steel producer and the rebar producer. As BESIX is not a rebar producer, the analysis of the production phase (A1-A3) is limited to the rebar provided by the supplier. An internal analysis was carried out to determine the impact of steel purchased from BESIX's suppliers with a focus on the projects in Belgium, France and Netherlands.

3.1.1 Raw materials

Steel production begins with the extraction of iron ore from mines. Iron ore is a rock or mineral that contains a high concentration of iron. Once extracted, the iron ore is transported to steel mills and undergoes various handling processes to ensure quality and consistency. Coke is also needed to produce steel and is obtained by heating coal in the absence of air.

An important point to note is that the melting accounts for a significant portion of emissions. In steel production, there are two different routes to produce steel: the blast furnace and the electric arc furnace.

Figure 4 provides a global overview of the production of steel and the environmental benefits of the different routes. These values are average value taken from steel producer’s EPD present on the European steel market. It is important to note that the market is constantly evolving, as are the technologies within it. Consequently, it may be necessary to re-evaluate these figures in future analyses.

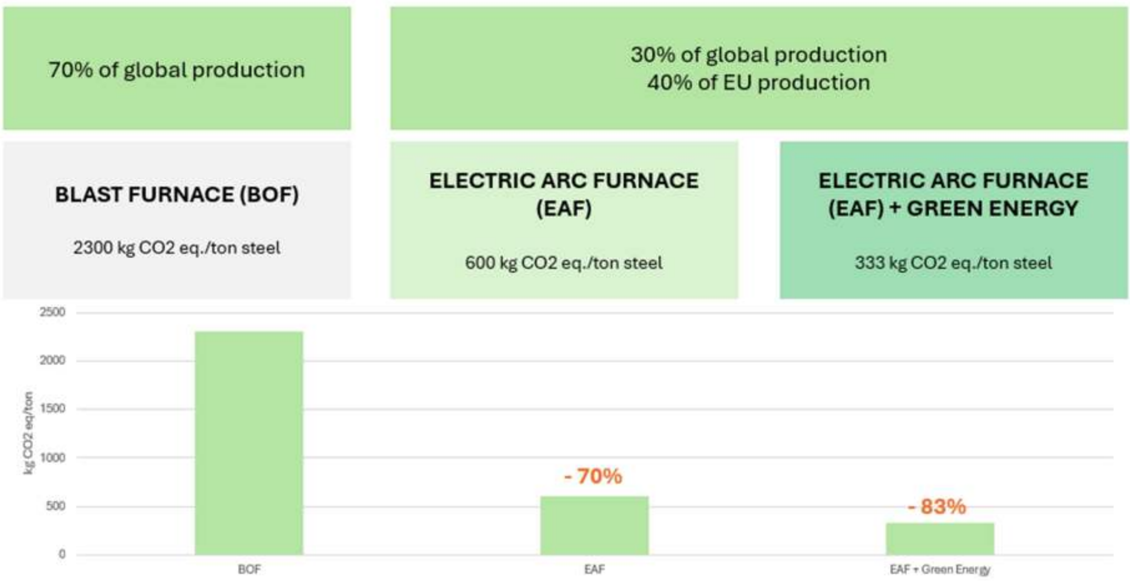

Figure 4

In every case, recycled steel called scrap can be used in the process. There is two types of scrap, steel that has reached the end of its useful life, is known as 'post-consumer scrap' and steel that has been generated during the manufacture of steel products, is known as 'pre-consumer scrap'. Both methods of steel production require a significant input of scrap steel. The primary route uses 15% scrap steel, and the secondary route uses 105% scrap steel.

The primary method for producing molten iron is through the blast furnace (BF) process. This process relies on a chemical process called reduction. The blast furnace process produces two by-products: carbon dioxide, and slag (a mixture of minerals). Carbon is necessary for reduction and this is why $C0_2$ emissions are unavoidable in this process. In the Basic oxygen furnace (BOF) or converter, oxygen is blown into the hot metal to remove impurities and control the composition.

Figure 5 below shows the blast furnace steelmaking process.

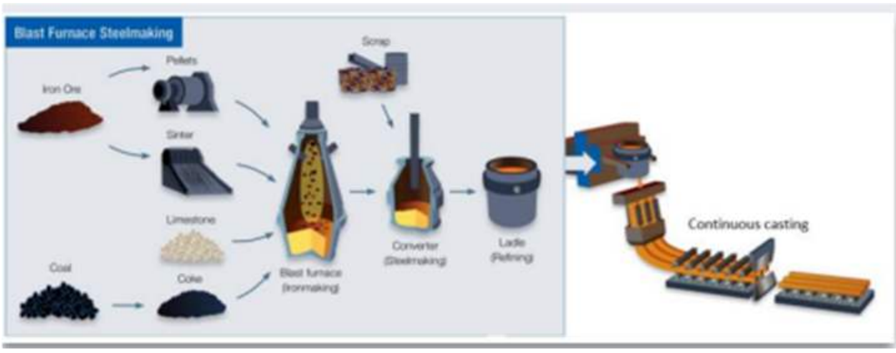

Figure 5

The secondary method for producing steel is through the electric arc furnace (EAF) process. The main feedstock is steel scrap, but they can also smelt solidified iron. EAF works thanks to graphite electrodes which produce heat from an electric arc that arises when the electrodes are in contact with the metal. The advantage of this process is that the energy used can come from renewable sources, which reduce significantly the carbon footprint of steel

Figure 6 below shows the electric arc furnace steelmaking process.

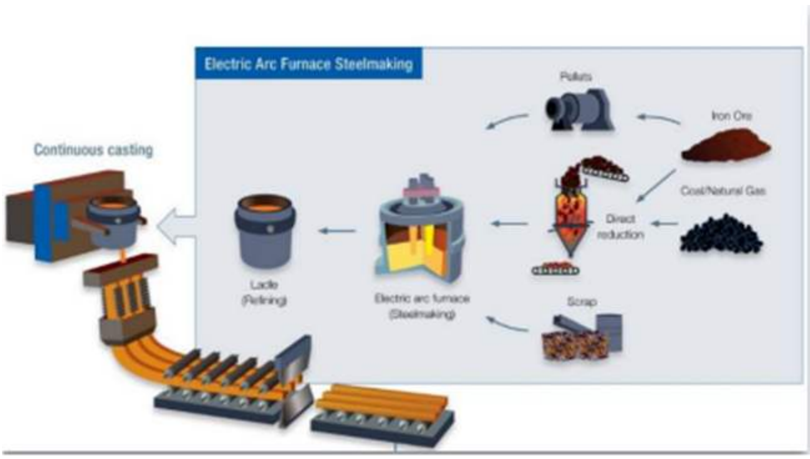

Figure 6

It is also important to note that the two routes can be combined, and that it's not just possible to have BOF or EAF. BOF can be combined with DRI (Direct Reduced Iron) and also with EAF. The University of Cambridge[1] provides the Figure 7 below which explains the different ways of combining production methods.

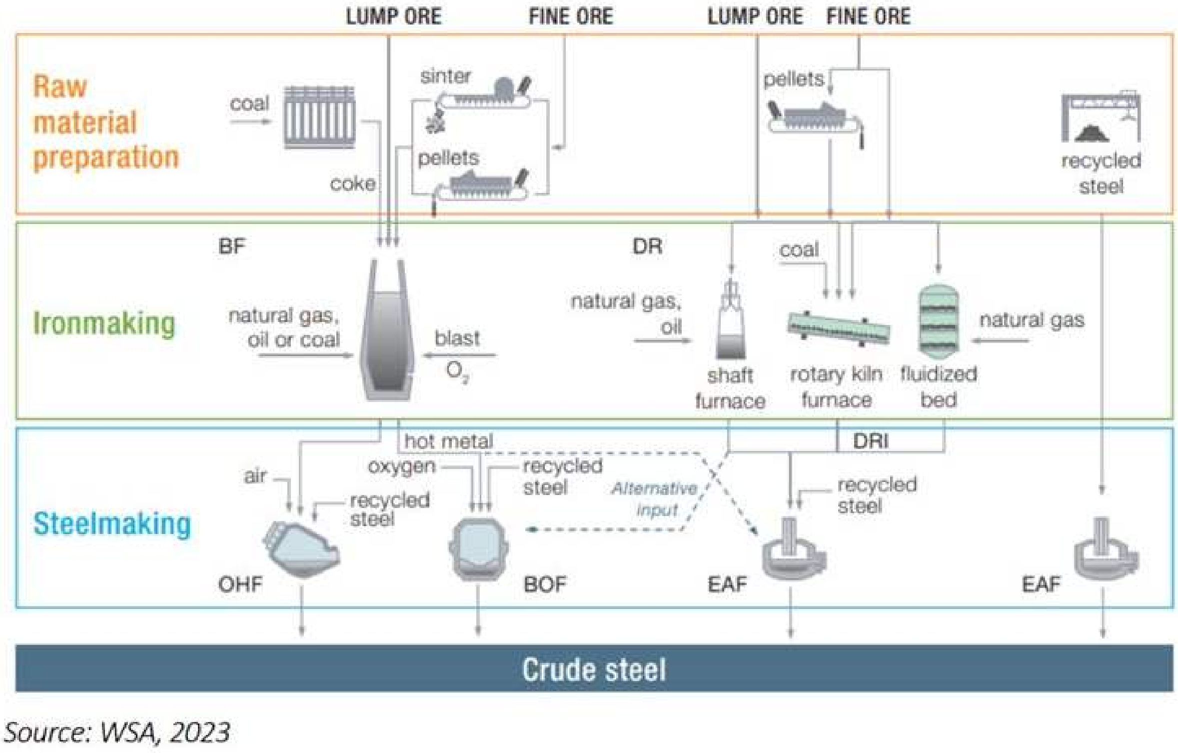

Figure 7

Figure 8 shows the percentage of procured rebar per production method (i.e. type of furnace) within NV BESIX SA. Indeed, our suppliers utilize a diverse range of furnaces, some of which may be more or less polluting than others. The graph categorizes these furnaces as Blast Oxygen Furnace (BOF), Electric Arc Furnace (EAF) and EAF/BOF when both furnaces are used in the production process. The Unknown category is the generic category when we do not have the information about the supplier's furnace.

[1] Devlin, A., Markkanen, S., & The University of Cambridge Institute for Sustainability Leadership. (2023). Steel sector deep dive: How could demand drive low carbon innovation in the steel industry. In *Cambridge Institute for Sustainability Leadership (CISL)*. Cambridge Institute for Sustainability Leadership (CISL). https://www.cisl.cam.ac.uk/files/sectoral_case_study_steel.pdf

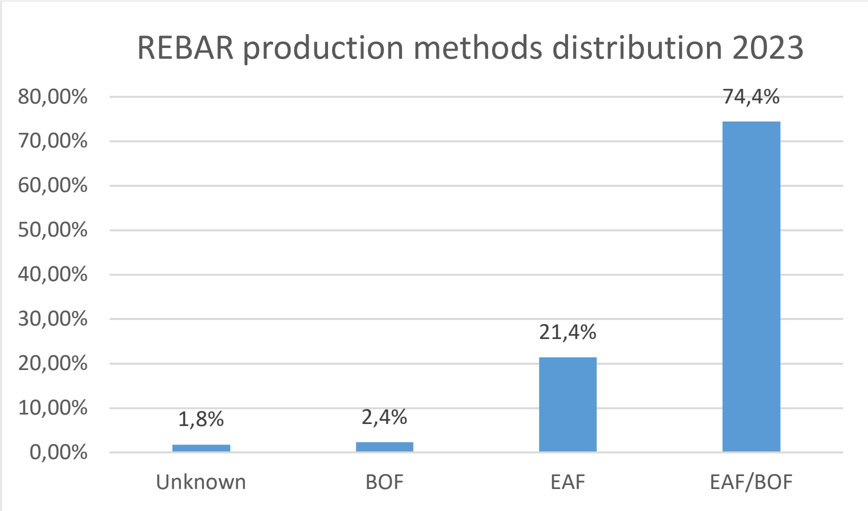

Figure 8

3.1.2 Assumptions of the carbon footprint

Our carbon footprint analysis is based on CO_2 data by type of furnaces. The calculations are derived from the Environmental Product Declaration (EPD) provided by each supplier. When supplier EPDs are available, values are calculated using the specific Emission Factor (EF) provided. When supplier EPDs are not available, a generic CO_2 value is assigned based on the furnace type : Basic Oxygen Furnace (BOF), Electric Arc Furnace (EAF) or Unknown (Average Value). Emission Factors for BOF and EAF are calculation assumptions based on the average value of the EPDs rounded up. The Average Value used comes from the VWN EPD.[2]

Table 1 provides the generic data (tons of CO_2 eq./ton) for each type of furnace.

Type of furnace	Emission Factor (A1-A3) (tons of CO_2 eq. /ton)
BOF	2
EAF	0.6
Unknown (Average Value)	1.02

Table 1

The methodology to define the emission factor used for calculation is very simple and the focus is mainly on the supplier's information. The Generic data above are used when we only have the type of furnace and no detailed EPD by the supplier. If the supplier provides its own EPD, the supplier's EPD has been used. Table 2 provides specifications on the production method used to produce the steel. Emission Factors for each company are provided in the Appendix 1.

[2] EPD VWN – Vereniging Wapeningsstaal. (2021). EPD reinforcing steel for use in reinforced concrete structures (MRPI® registratie 1.1.00236.2021). Stichting MRPI®.

Company	Type of furnace	Source
CH. STERNOTTE NV/SA	EAF	Supplier’s EPD
NV STAALBETON SA	EAF	Suppliers’ EPD
Intersig	EAF/BOF	Own EPD
Baustahlgewebe services GMBH	EAF	Own EPD
Metalurgia Galaica SA (MEGASA)	EAF	Own EPD
BRUHLER STAHLHANDEL GMBH	EAF	Own EPD
Besix Brühler Staalbeton	EAF/BOF	Suppliers’ EPD
Besix Steel	EAF/BOF	Own EPD
Diepstraten Wapeningstaal BV	EAF/BOF	Suppliers’ EPD
DUBAERE NV/SA	EAF/BOF	Suppliers’ EPD
BBC	EAF/BOF	Own EPD
BCS (Buig Centrale Steenbergen B.V)	EAF/BOF	Own EPD
ACCIAIERE DI VERONA SPA	EAF	Own EPD
B&G ARMATURES	EAF/BOF	Own FDES
Van Merksteijn Steel - Netherlands B.V.	EAF/BOF	Own EPD
Steelforce	BOF	Sustainability Report

Table 2

Figure 9 shows the source of data we have used for the calculation (either generic data or either EPD).

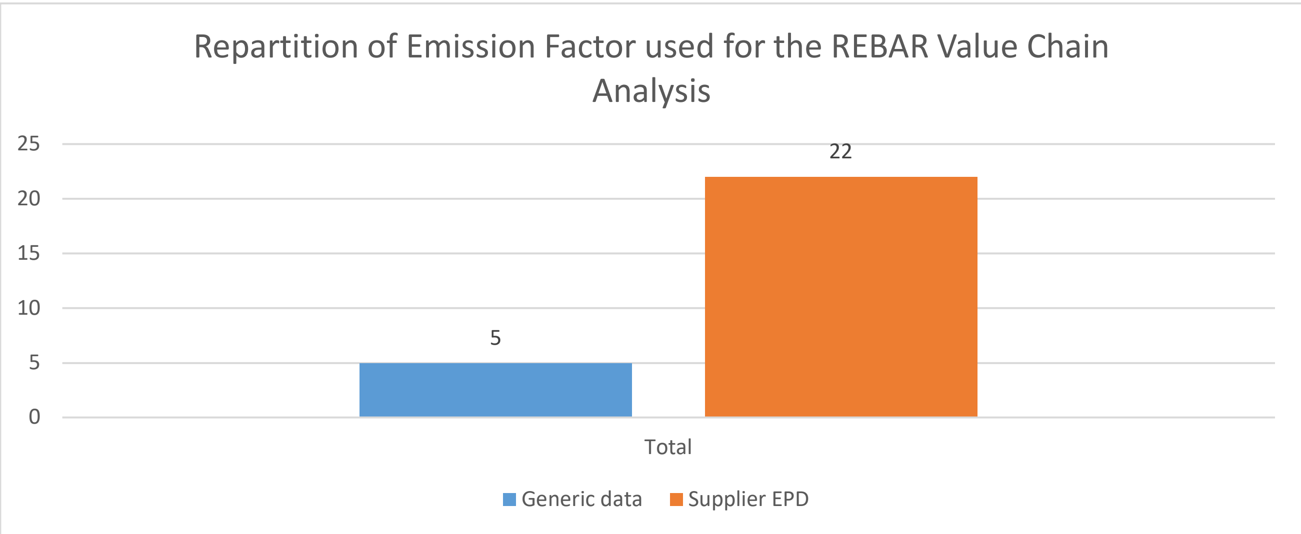

Figure 9

After determining the EF for each supplier, the total environmental impact must be calculated using the formula showed in the Figure 10:

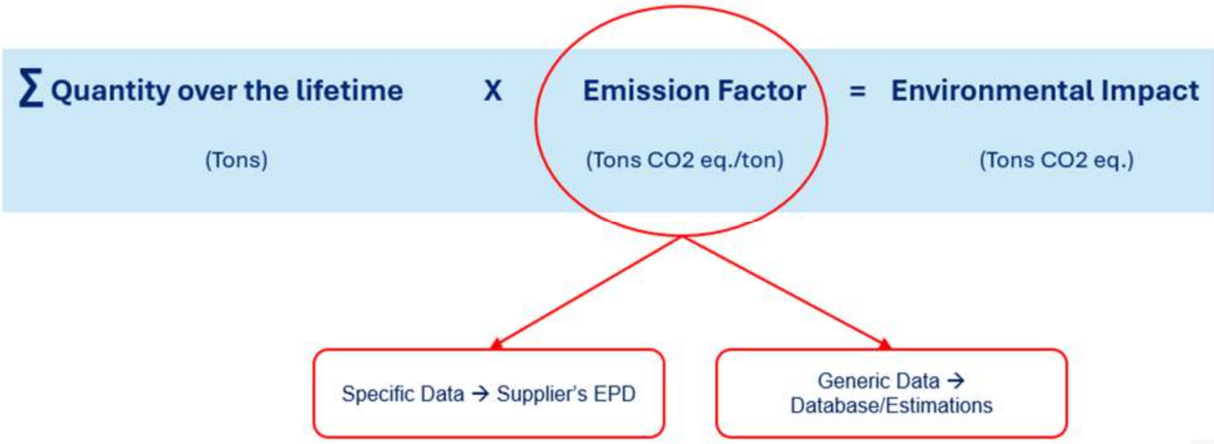

Figure 10

The calculation of quantity is based on financial spends incurred in 2023 by each supplier within the BESIX Group. The spends for 2023 are then divided by the price per kilogram, thereby yielding the total quantity.

The price per kilogram for each supplier has been determined through a meticulous examination of the invoices available in the BESIX database. In instances where reliable data is lacking, a calculated estimate has been employed to arrive at a reliable approximation. The approximation is derived from the Price Index, which is based on the average unit price of rebar (€/kg) across the four trimesters of the year. The mean price for 2023 (0.659€/kg) is utilized for the value chain analysis conducted for that year.

The table 3 below shows the average price from the Price Index between 2021 and 2025.

Year	Average Price (€/kg) (Price index)
2021	0.709
2022	0.945
2023	**0.659**
2024	0.604
2025	0.645

Table 3

3.1.3 Results & graphs of our A1-A3 analysis

This study provides a better understanding of the A1-A3 carbon footprint of the use of REBAR in our projects. The quantities collected are based on the Spends 2023. An overview of the main quantities by supplier can be found in the appendices.

The REBAR quantities are distributed within BESIX Group as shown in Figure 11.

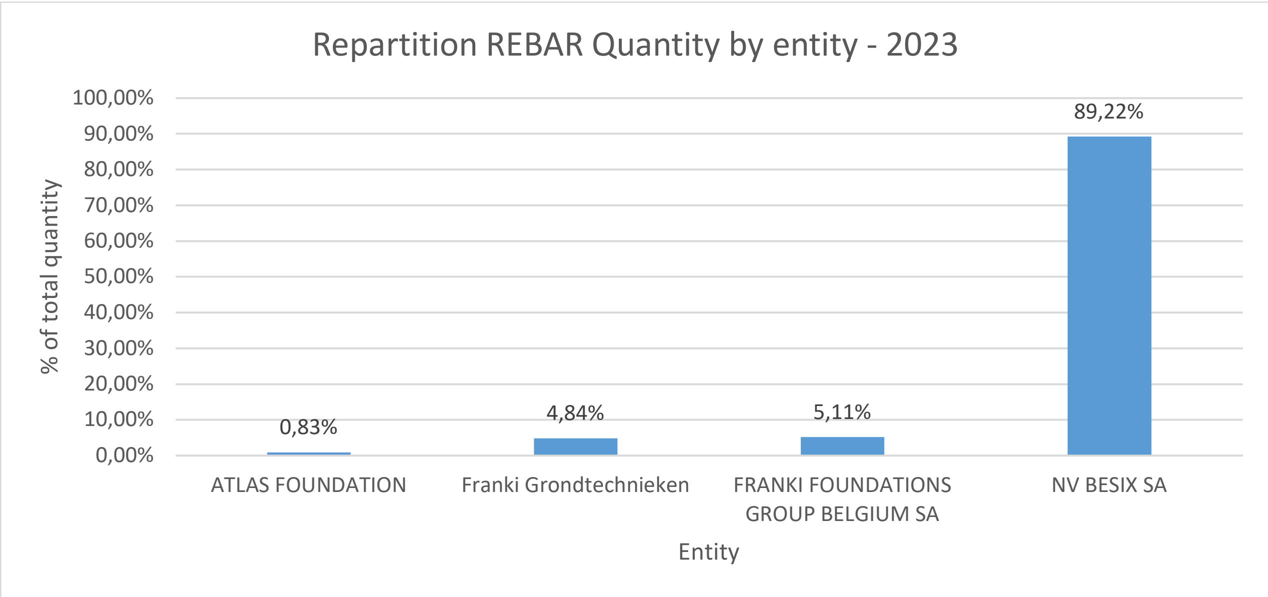

Figure 11

Figure 13 below outlines the total quantity and CO_2-emissions of REBAR by entity.

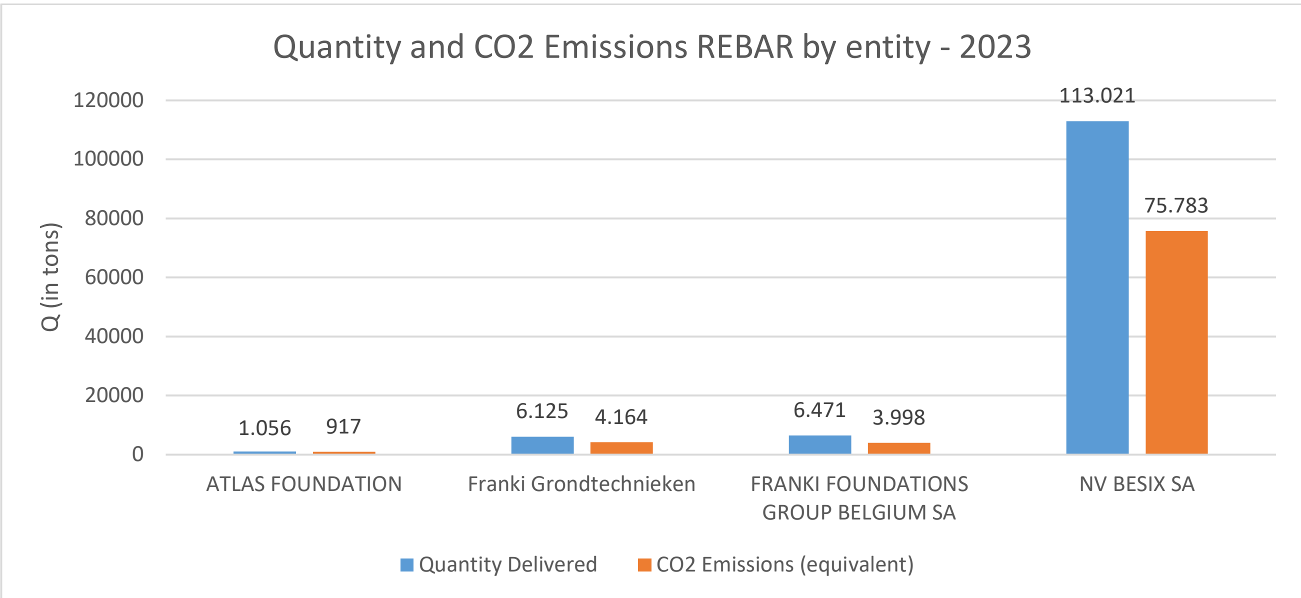

Figure 12

Figure 13 below outlines the total quantity and CO_2-emissions of REBAR by production method.

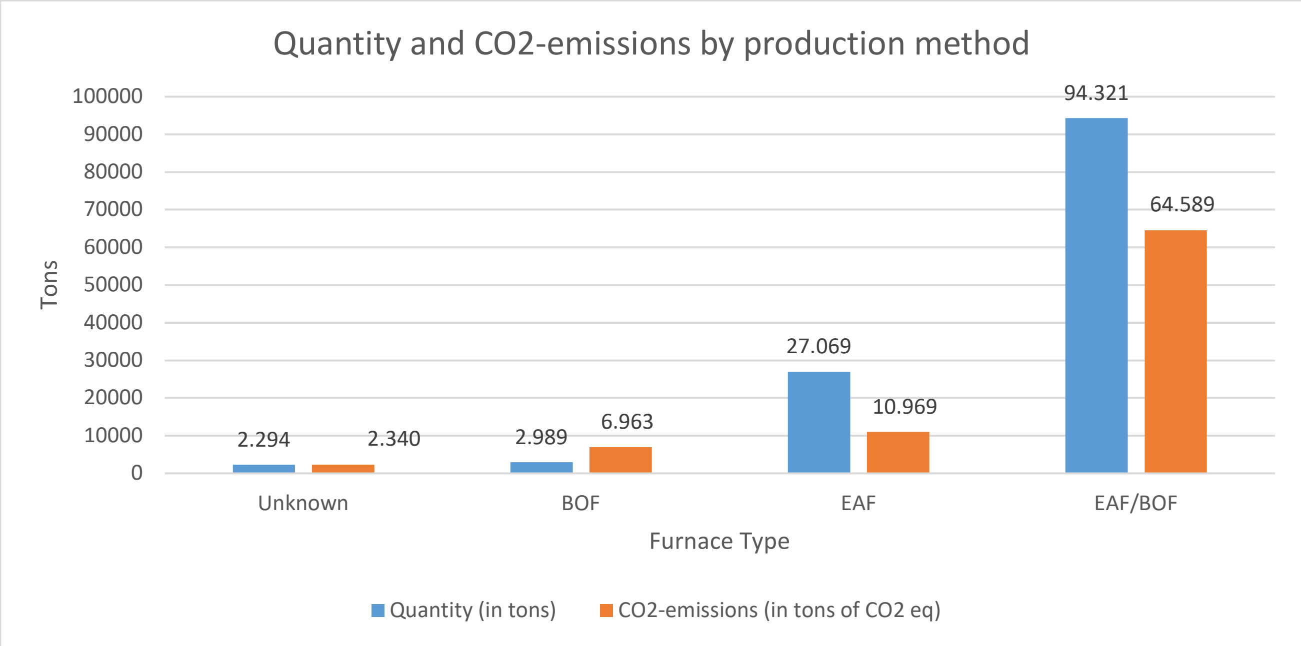

Figure 13

Figure 14 shows the repartition of the quantity ordered by entity by productions methods.

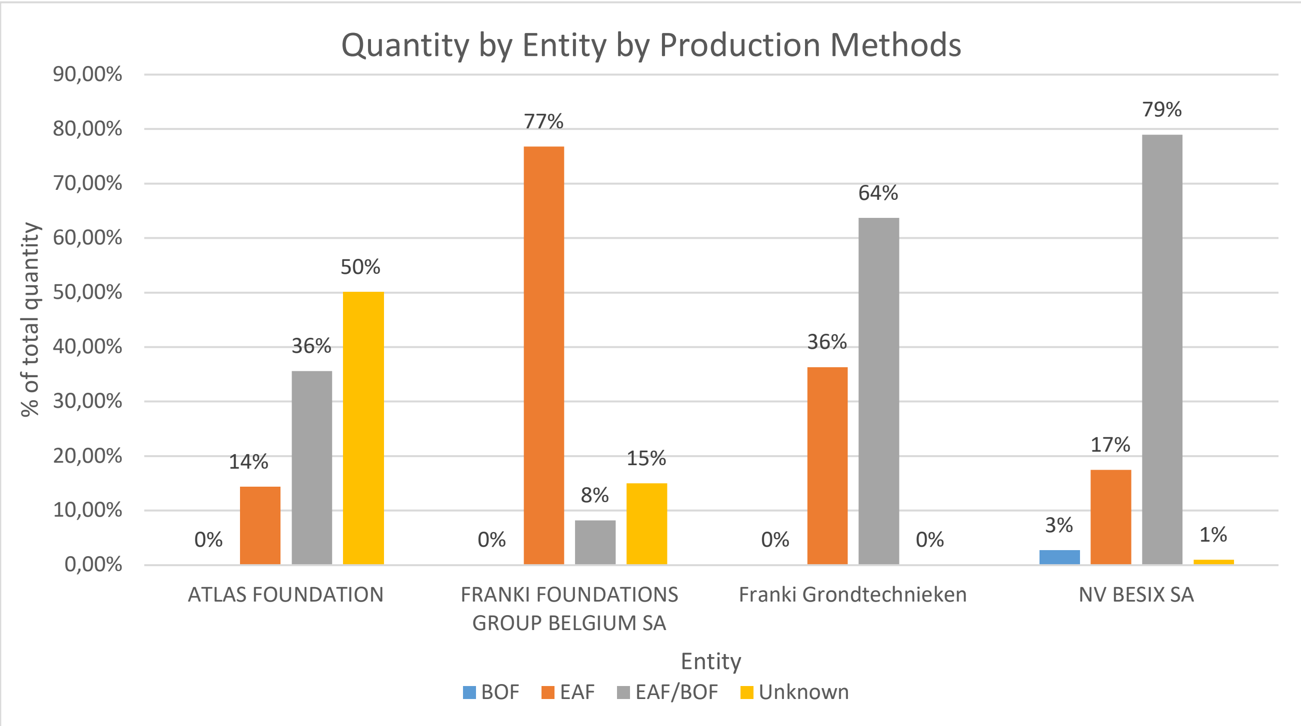

Figure 14

Table 4 is a summary of the executed analysis and gives the carbon footprint (phase A1-A3) for 2023:

		QUANTITY	UNIT	SOURCE
N.V. BESIX S.A.	Total CO_2 quantity ordered during 2023	126 672.5	[ton]	Spends 2023
	Total carbon footprint (A1-A3) estimated for REBAR	84 861 834	[$KgCO_2$ eq.]	Computation
	Average carbon footprint (A1-A3) per ton of REBAR	669.93	[Kg CO_2 eq./ton]	Computation
Average GWP (A1-A3) Buildwise[3]		2063.31	[Kg CO_2 eq./ton]	Buildwise
Average GWP (A1-A3) VWN EPD[4]		1020	[Kg CO_2 eq./ton]	VWN EPD

Table 4

3.2 Transport: A4

BuildWise gives a value of 190 kg CO2 eq./ton of rebar, but this value seems too high compared with other databases, suppliers' EPD and other companies' value chain analysis. This is why we have decided to base our transport calculations on a different emission factor database. CO2 emissiefactoren[5] gives the emissions factor for reinforcing steel. For the transport to construction site, we assume a truck with a loading capacity of over 20 tons and an average distance of 80 km.

This means that per ton of rebar the emissions related to transport from plant to the construction site were computed as follow: 0.105kg CO2 eq./tonkm * 80 km = 8.4 kg CO_2 eq./ton of rebar.

3.3 Construction process stage: A5

After transport to site, the rebar needs to must be processed on the construction site. Just as stages A4 (transport) is stage A5 (construction) specific to each project.

During the processing of rebar on site, the following equipment is normally used:

- A crane for transporting rebar to the processing location which is often powered by fuel.
- Rebar cutting/welding machine to make the rebar in the right shape.

On-site energy consumed by the above mentioned equipment also has a footprint that needs to be monitored. To obtain data for these LCA stages, on-site monitoring is necessary but complex. However, an estimate of 120 kg CO_2 eq. per ton of rebar is used based on the A5 data from the Buildwise emissions factors.

[3] BuildWise – List of emissions factor for construction materials - Scope 3-berekeningen maken in het kader van de CSRD en de CO_2-prestatieladder

[4] EPD VWN – Vereniging Wapeningsstaal. (2021). EPD reinforcing steel for use in reinforced concrete structures (MRPI® registratie 1.1.00236.2021). Stichting MRPI®.

[5] Home | CO_2-emissiefactoren

A second point during construction is the production of waste, which also needs to be monitored in order to better control and limit the quantity of waste. As this is expected to be minimal, this is not taken into account in the value chain analysis.

3.4 Use stage: B

As the life expectancy of rebar is 100 years, it is assumed that there is no maintenance, repair or upkeep of the steel. This stage therefore has no influence on CO_2 emissions. The lifespan of the reinforcement steel will depend on the quality of the design (whether cracks appear and the ingress of water into the concrete), the lifespan of the project, and the environmental conditions (such as exposure to moisture, chemicals, and temperature fluctuations).

3.5 End-of-life: C

At the end-of-life, rebar structures undergo a demolition process facilitated by machinery such as cranes and crushers. The environmental repercussions of this process are contingent upon the quantity and composition of structures, as well as the specific machinery employed. Following demolition, the residual materials include concrete granulate and old rebar, both of which are potential candidates for recycling.

The rebar can undergo recycling processes infinitely to be transformed into fresh steel, promoting the circular economy. Simultaneously, concrete, once extracted, can be repurposed as a substitute for traditional gravel in foundation material.

The scrap is transported to recycling facilities where it is melted again. In this way, the old rebar can be reused to make new steel indefinitely.

According to the Buildwise emissions factors, 130 kg CO_2 eq per ton can be used for calculating the C-LCA phase. This value is the sum of:

- C1 deconstruction / demolition = 70 kg CO_2 eq. per ton
- C2 transport after demolition = 60 kg CO_2 eq. per ton
- C3 waste processing after demolition = 0 kg CO_2 eq. per ton
- C4 disposal = 0 kg CO2 eq. per ton

3.6 Benefits and loads beyond the system boundary: D

Steel, once used and no longer suitable for its original purpose, can be recycled indefinitely. This material is called scrap. Scrap comes in two forms: "post-consumer scrap," which is steel that has completed its lifecycle in products, and "pre-consumer scrap," which is steel waste generated during the manufacturing process. Both types of steel production rely heavily on scrap. The primary production method incorporates 15% scrap, while the secondary method uses up to 105% scrap. The Buildwise data does not provide figures for the stage D. Since stage D is rarely computed in the LCA, we used an average value of 31.88 kg CO_2 eq./ton computing from our suppliers when the stage is calculated. The computation can be found in the Table 5.

Company	Stage D (kg of CO_2 eq./ton of rebar)
Diepstraten Wapeningstaal BV	No computation
Steelforce	No computation
Besix Steel	0
CH. STERNOTTE NV/SA	-85.8
BCS (Buig Centrale Steenbergen B.V)	No computation
Metalurgia Galaica SA (MEGASA)	-141
Baustahlgewebe services GMBH	349
NV STAALBETON SA	131.6
BRUHLER STAHLHANDEL GMBH	49.1
Intersig	70.8
Van Merksteijn Steel - Netherlands B.V.	No computation
B&G ARMATURES	-84.8
ACCIAIERE DI VERONA SPA	-1.94
Besix Brülher StaalBeton	60.23
AVERAGE STAGE D :	**34.72**

Table 5

3.7 Total amount of emissions in the value chain

The table 6 below summarizes the emissions per life cycle and consolidated over all LCA phases for 2023:

Phase	Data Source	2023 emissions in kg CO_2 eq. per ton	%
A1-A3 - Production incl. raw materials	Besix Average CO_2-emissions per ton of rebar	669.93	72.2%
A4 - Transport (upstream)	CO_2 emissiefactoren NL	8.4	0.9%
A5 - Processing on site	Buildwise Emission Factor	120	12.9%
C - Demolition & disposal	Buildwise Emission Factor	130	14%
Total emissions per ton rebar		928.33	

Table 6

4. Reduction measures

As outlined in chapter 3.1.1, the highest potential for reducing the environmental footprint of rebar lies in the melting of raw materials and particularly in the type of furnace in which the raw materials are processed.

BESIX is committed to minimizing the environmental impact of rebar through various measures, both already implemented and under development.

The following sections outline key areas of focus:

4.1 Sector initiatives

BESIX is conscious that transitioning the rebar and steel sector to a more sustainable production process is something that BESIX can't do alone. Only a collaborative approach between client, steel manufacturers and contractors will achieve this ambition.

It is therefore that BESIX joined and/or is participating in a number of initiatives:

- EUROFER (European Steel Association) wants to make a success of the EU Green Deal with the launching of EUROFER's 'A Green Deal on Steel'.
  - → The European Steel Association (EUROFER) has committed to reducing carbon emissions by 30% per ton of steel produced by 2030, using 2018 as the baseline year. This target aligns with the broader goal of achieving a 55% reduction in emissions by 2030 compared to 1990 levels.
  - → EUROFER would like the European steel industry to be fully committed to the EU's climate objectives and sustainable growth. This would permit the sector to reduce their CO_2 emissions by 80% to 95% by 2050.
  - → An action plan has been put in place by EUROFER and could tackle the various policies put in place by Europe as part of the Green Deal. This action plan aims to shape the markets for green steel, the circular economy around steel (reuse of steel and recycling) and a global level playing field.
  - → Sixty key low-CO_2 projects in EU will almost all start before 2030 and might lead to a reduction of 81.5 million tons of CO_2 equivalent per year by 2030. The map in Figure 15 below shows the project locations.

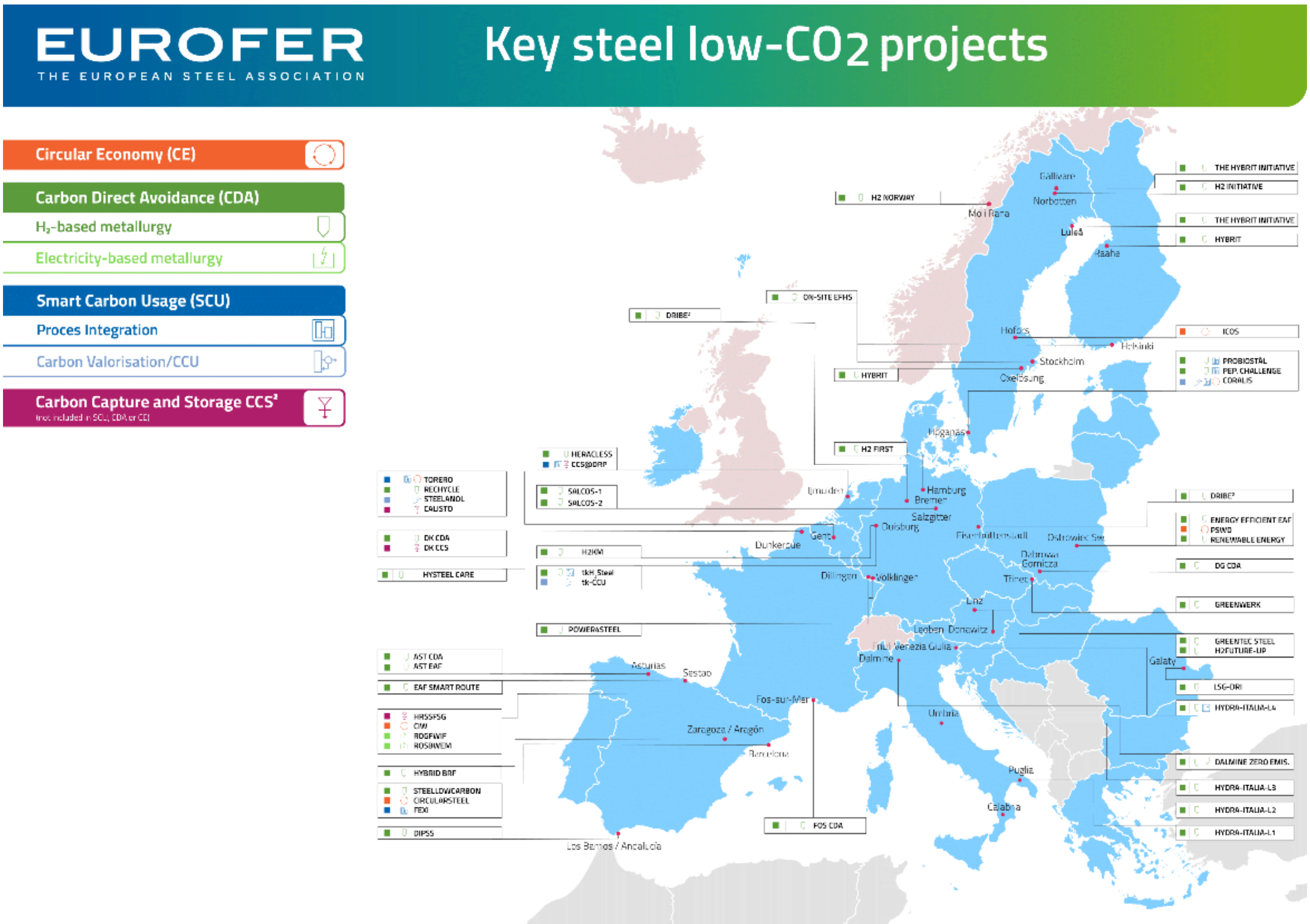

Figure 15

Source: [eurofer-low-carbon-projects-map-18022025.pdf]()

- The future of green steel begins in Europe and will become a global reality if we support our own industrial ecosystems throughout this green transition. 5 pillars are essential to focus on for this green transition:

  - → Drive a joint industrial policy & spur investments: European joint green industrial policy enhancing investments and providing enough resources to make access to the green transition easier and clearer.
  - → Promote access to affordable fossil-free energy: deliver international competitive prices and prioritize the use of clean electricity and hydrogen all across Europe.
  - → Give EU trade policy renewed impetus: establish an effective EU-US Global Arrangement on Sustainable Steel to tackle global emissions.
  - → Secure access to critical raw materials: champion the use of scrap to align with EU's circular economy goals.

→ Inspire, attract and retain steelmakers: provide adequate training and academic opportunities in green steelmaking to support the sector's transition to ensure a qualified workforce.

- According to the Bouwakkoord Staal roadmap (version 7 dd. May 2023) we can state that the targeted footprint for rebar in 2030 is 0,8 ton CO_2 eq. per ton of steel for the stages A1-C4.

4.2 Working with and sensitizing the Client / Customer

Beyond the role of steel manufacturers, as mentioned in chapter 2.1, the client's sustainability ambitions play a crucial role in shaping project outcomes.

Through early contractor involvement BESIX can influence the choices made by the client and/or by the client contracted engineering companies, not only in the design phase but also during construction. By discussing environmental performance criteria early in the tendering phase in all transparency, BESIX can guide clients toward lower-carbon solutions and influence material selection, mix designs, and construction methodologies. A choice for green steel can for example have a negative influence on the planning. It is then up to the Client to make choices.

BESIX actively engages with (possible) clients to discuss upfront decarbonization strategies. A detailed PPT has been developed within BESIX and serves as guideline during meetings with (possible) clients.

By setting up (sector) initiatives and/or development projects in cooperation with (regional) authorities / private clients, BESIX can stimulate the transition to a more sustainable construction sector.

4.3 Design optimization

BESIX Engineering Department applies value engineering to optimize structural designs, focusing on reducing material quantities without compromising performance. This ensures cost efficiency and resource efficiency in every project and therefore helps to decrease the carbon footprint. This approach is supported by a dedicated sustainability team specializing in life cycle assessment (LCA). By conducting project-specific analyses, they pinpoint carbon hotspots and determine the most impactful CO_2 reduction strategies.

For steel-related optimizations, BESIX relies on its in-house steel experts, who closely follow the latest industry developments and integrate the most sustainable solutions available. These specialists work proactively to ensure that low-carbon alternatives are considered as soon as they become viable for project implementation.

BESIX combines the expertise of its engineering, sustainability, and steel teams to apply the most feasible and effective low-carbon solution for each project.

4.4 Use of Electric Arc Furnace and alternatives

4.4.1 Alternative solutions

Over the past decade, the steel industry has transitioned from melting in blast furnace (BOF) to electric arc furnace (EAF), significantly reducing emissions.

However, this is not enough, and there are still ways to reduce the emissions associated with steelmaking. We are following new developments such as use of recycled steel, hydrogen as a reducing agent, use of green energy for EAF, carbon capture solutions... (Figure 16)

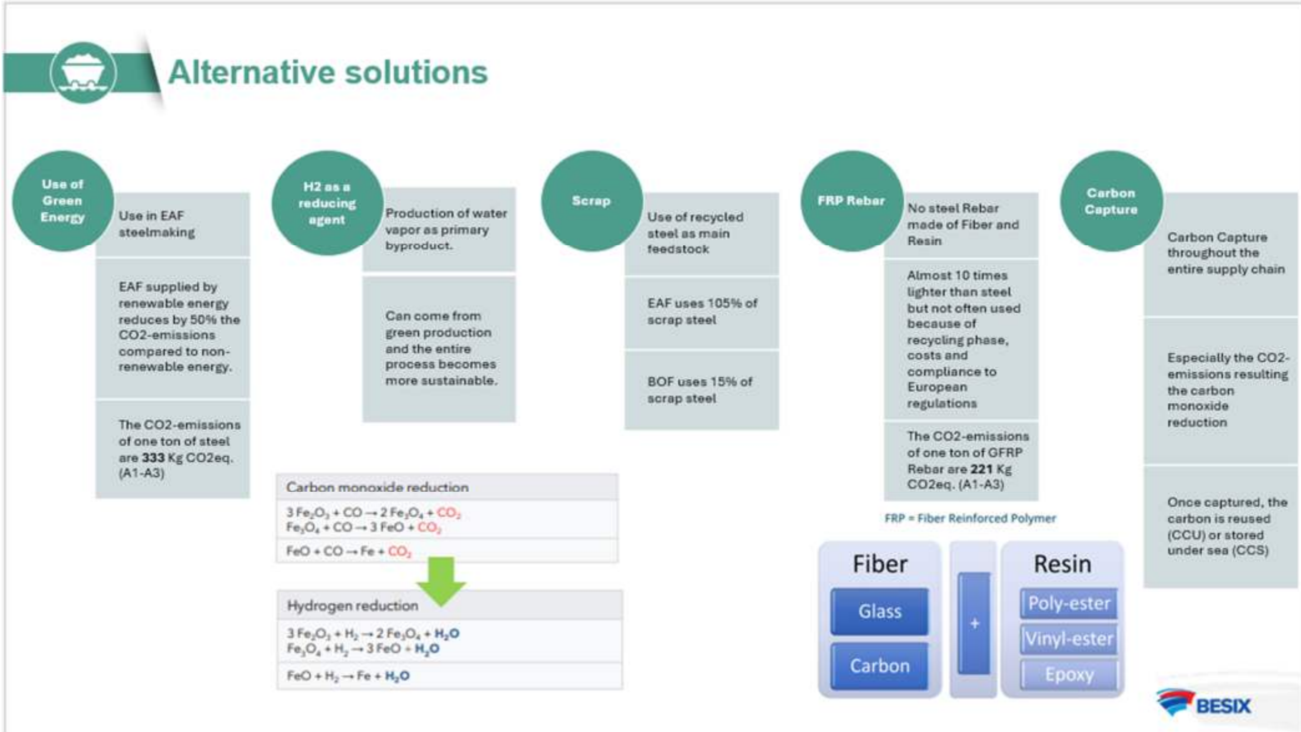

Figure 16

There is already a well-known melting alternative**, Electric arc furnace** (EAF), where the raw materials are melted in a furnace **using electricity instead of fossil fuel** such as coke and natural gas which emits lot of CO_2 during the chemical reaction. Moreover, the amount of **recycled steel (scrap steel)** used in an EAF is significatively bigger than in a BOF (105% of scrap steel against only 15%). Using an EAF is definitely more sustainable than a BOF but there are alternatives that can reduce emissions even more.

The re-use of structural steel elements is also a solution for reducing the carbon footprint. This increases the longevity of the material without having to re-melt it at high temperatures. However, this methodology is complex because we often have very limited information about the beam/column. We don't know what it has been through, or the type and quality of steel used.

Switching from traditional blast furnace (BF) steelmaking to using hydrogen as a reducing agent offers several sustainability advantages. This process is often referred to as "direct reduction with hydrogen". Hydrogen-based steelmaking, replacing coke in blast furnaces, drastically cuts carbon emissions by producing water vapor as the primary byproduct, offering a significantly lower carbon footprint compared to traditional methods. If the hydrogen used in steelmaking is produced using renewable energy sources (green hydrogen), the entire process becomes even more sustainable. One significant technical challenge of hydrogen steelmaking is the need for the development and optimization of large-scale hydrogen production methods, as well as addressing the associated infrastructure requirements, such as storage, transportation, and delivery systems, to ensure a reliable and cost-effective supply of hydrogen to the steelmaking process.

Carbon capture is also a solution, given the emissions from BOFs. The carbon is captured as soon as it is emitted and then stored (often in liquid form) before being transported via pipeline and reinjected into the ocean floor. There are also solutions where the carbon is re-used for other industrial purposes. This is very expensive and reinjecting CO_2 into the ocean floor may not be a viable long-term solution.

More recently, the use of renewable energy in the manufacture of steel in EAFs has also made it possible to move from less polluting steel to even less polluting steel by supplying furnaces with energy from renewable sources. This is often referred to as green steel. Some suppliers, such as Megasa and the major ArcelorMittal group, are already using these methods.

There is also a non-steel alternative known as FRP rebar, which stands for Fiber Reinforced Polymer. Made from carbon or glass fibers combined with polyester, vinyl ester, or epoxy resin, FRP rebar offers several advantages. However, its adoption in the construction industry remains limited, primarily because it is not yet incorporated into established design standards like the Eurocode. Additionally, the recyclability of FRP rebar has been a concern, and it tends to be more expensive than traditional steel rebar. Concrete reinforced with FRP rebar also does not currently meet European standards.

On the other hand, FRP rebar can significantly reduce transportation costs and footprint, as it is nearly ten times lighter than steel rebar.

Recent advancements, such as the development of Elium Resin— the first liquid thermoplastic resin—have made it possible to recycle FRP rebar, which could further encourage its use in construction.

A key benefit of FRP rebar is its resistance to corrosion, particularly in aggressive environments like marine settings. This property allows for more efficient designs, using less concrete and ultimately reducing the overall carbon footprint of the structure.

A more recent technology has been introduced, allowing reinforcing steel fibers to be injected directly into the concrete. This technology significantly reduces the amount of concrete compared to regular rebar. However, there are doubts about the strength of this new technology, and the question of recycling arises as it is far less straightforward to recover the steel for recycling.

All these alternative solutions are a good way of reducing the rebar's CO_2 emissions, but for the moment they are not predominant in practice, as they remain solutions that can be expensive.

4.4.2 Use of EAF at BESIX

Within BESIX Group, the steel used in the buildings sector comes mainly from EAF but there are still suppliers using BOF. Based on the volumes purchased from BESIX Group, the complete replacement of BOF to EAF could lead to an estimated reduction of 20% of CO_2 and the replacement to EAF using green energy could lead to a reduction of 51% of CO_2 emissions in the stages A1-A3. Figure 17 below shows the simulation if all the furnaces from suppliers were 100% EAF and 100% EAF with the use of Green Energy.

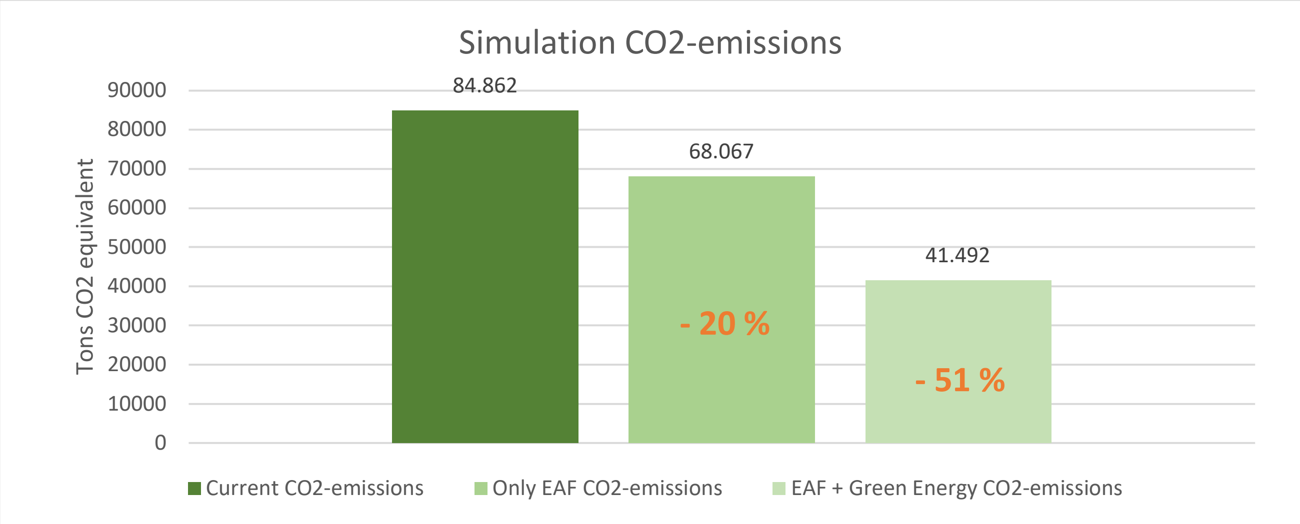

Figure 17

4.5 Transport

Transporting steel involves the use of vehicles, leading to energy consumption and emissions. The type of fuel used in transportation significantly influences the environmental impact. Optimizing transport routes and using fuel-efficient vehicles can help to reduce energy consumption and related emissions. Moreover, transitioning to alternative fuels, such as HVO or shifting to electric or hybrid vehicles, can mitigate the impact of steel transport. During contract negotiation with the rebar supplier, a dialogue to opt for more sustainable transport (use of HVO, electrification, hydrogen...) can be held.

For larger projects a feasibility study will be made for the use of on-site batching plants. This becomes even more interesting when the project is situated near waterways. Additionally, if the project is spread over a long distance opting for two batching plants, each covering a part of the project, can reduce the amount of transport.

Finally, planning large pours outside rush hour has a direct impact on the emissions.

4.6 Collaboration and supply chain engagement

Collaboration with the rebar suppliers is key! The Procurement and Engineering Departments of BESIX actively engage with suppliers through dedicated workshops, including the Supplier Sustainability Forum and low-carbon product presentation meetings. These initiatives foster collaboration, promote sustainable innovations, and encourage the adoption of lower-carbon materials across the supply chain.

BESIX is clearly committed to reducing the carbon footprint of rebar throughout its entire supply chain, thanks in particular to its BESIX Steel reinforcement plant, which is one of the main distributors of rebar to construction sites in Belgium, France and the Netherlands. The plant has even invested in an EPD (Environmental Product Declaration) assessment to determine the carbon footprint of every ton of rebar leaving the plant. The furnaces used by its suppliers are mainly electric arc furnaces. The EPD assessment yielded a global warming potential of 728 kg/ton of rebar output. This clearly shows an initiative within the BESIX group to reduce carbon emissions as much as possible, and is just the beginning of the decarbonization of REBAR within the group.

4.7 Internal training

One of the key factors in reducing our carbon footprint is ensuring that everyone joins the transition. To make sure no one is left behind, we prioritize communication and knowledge-sharing through training sessions (such as BDA...) and newsletters, as illustrated in the figure 18 below.

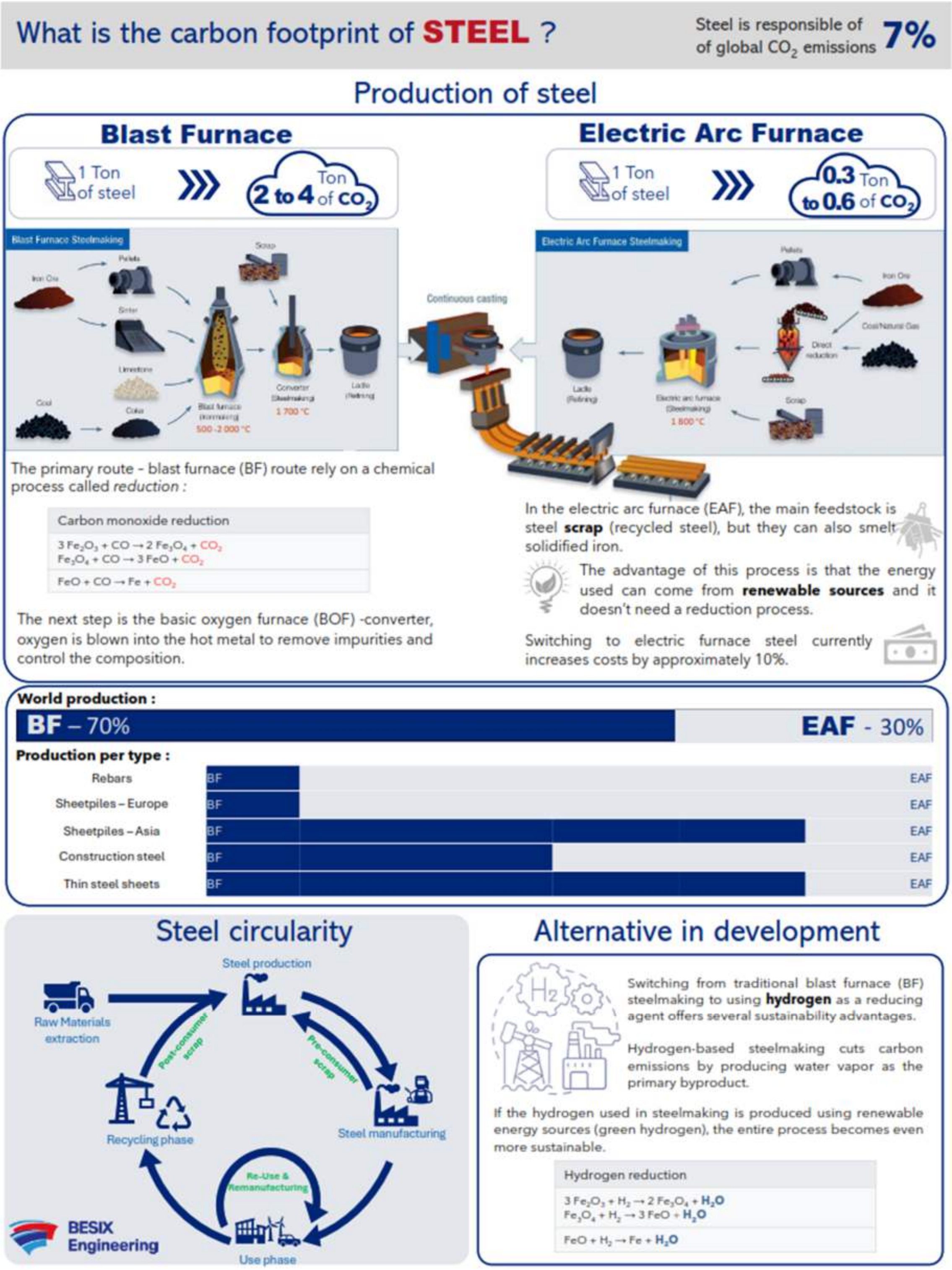
What is the carbon footprint of STEEL ?
Steel is responsible of 7% of global CO2 emissions
Production of steel
Blast Furnace
1 Ton of steel
2 to 4 Ton of CO2
Electric Arc Furnace
1 Ton of steel
0.3 to 0.6 Ton of CO2
Blast Furnace Steelmaking
Electric Arc Furnace Steelmaking
Continuous casting
The primary route - blast furnace (BF) route rely on a chemical process called reduction :
Carbon monoxide reduction
3 Fe2O3 + CO → 2 Fe3O4 + CO2
Fe3O4 + CO → 3 FeO + CO2
FeO + CO → Fe + CO2
The next step is the basic oxygen furnace (BOF) -converter, oxygen is blown into the hot metal to remove impurities and control the composition.
In the electric arc furnace (EAF), the main feedstock is steel scrap (recycled steel), but they can also smelt solidified iron.
The advantage of this process is that the energy used can come from renewable sources and it doesn't need a reduction process.
Switching to electric furnace steel currently increases costs by approximately 10%.
World production :
BF – 70%
EAF - 30%
Production per type :
Rebars
Sheetpiles – Europe
Sheetpiles – Asia
Construction steel
Thin steel sheets
BF
EAF
Steel circularity
Steel production
Raw Materials extraction
Post-consumer scrap
Pre-consumer scrap
Steel manufacturing
Recycling phase
Re-Use & Remanufacturing
Use phase
BESIX Engineering
Alternative in development
Switching from traditional blast furnace (BF) steelmaking to using hydrogen as a reducing agent offers several sustainability advantages.
Hydrogen-based steelmaking cuts carbon emissions by producing water vapor as the primary byproduct.
If the hydrogen used in steelmaking is produced using renewable energy sources (green hydrogen), the entire process becomes even more sustainable.
Hydrogen reduction
3 Fe2O3 + H2 → 2 Fe3O4 + H2O
Fe3O4 + H2 → 3 FeO + H2O
FeO + H2 → Fe + H2O

Figure 18

4.8 Research & development

BESIX has a highly qualified internal engineering department with multiple steel specialists. By participating in master thesis and research & development projects in collaboration with the Academic world BESIX actively supports the search to sustainable alternatives for the current rebar steelmaking.

Through BESIX Technology, BESIX Group continuously monitors the market evolution with the objective of supporting and investing in start-ups. At the same time, BESIX acts as an industrial partner for testing new and innovative products and materials.

In the engineering department, an R&D project (R&D flooring systems) is ongoing, the goal is to optimize the amount of materials used for slabs based on their dimensions and load cases. The goal is to parametrize our calculations, allowing us to determine the optimal flooring system in just a few clicks at the start of a project, considering both carbon footprint and cost. For more details, please refer to the BESIX initiatives document.

5. Ambition and targets

The United States Steel (USS) has defined a roadmap to net-zero for their sector indicating the different initiatives which can be implemented to decarbonize the steel production to achieve net-zero in 2050.

Figure 19 below shows the initiatives over the years to be implemented in order to reach the carbon neutral steel industry.

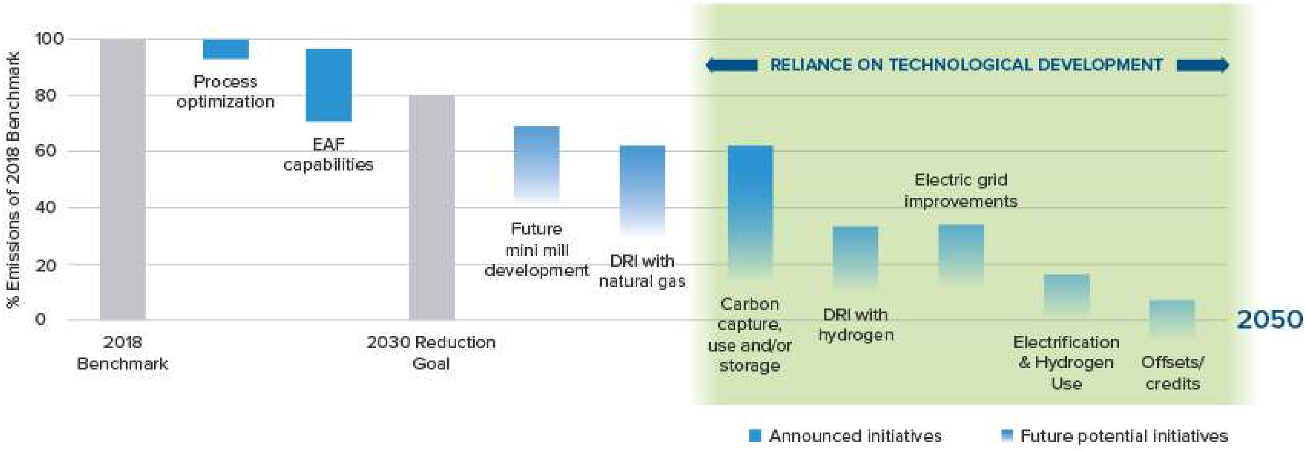

Figure 19

Source: Sustainability - Roadmap to 2050 - www.ussteel.com

At BESIX Group, the targeted footprint for rebar in 2030 is 0,8 ton CO_2 eq per ton of steel for the stage A1-C4. This target has been taken according to the actual status within BESIX and the roadmap aiming at reducing the CO_2 emissions (see Figure 20 below) released by Bouwakkoord Staal in mei 2023 . We are currently complying the 60% reduction target (compared to 1990 value) established by the Bouwakkoord Staal. However, we have decided to strengthen our focus by setting a new target of 0.8, aligning with the Bouwakkoord Staal's zero growth scenario. This target has been made taken into account that our suppliers are currently investing to make their process more sustainable and the contracts for 2030's projects are being signed in the 2 coming years. Then the current EPDs do not reflect the future reality.

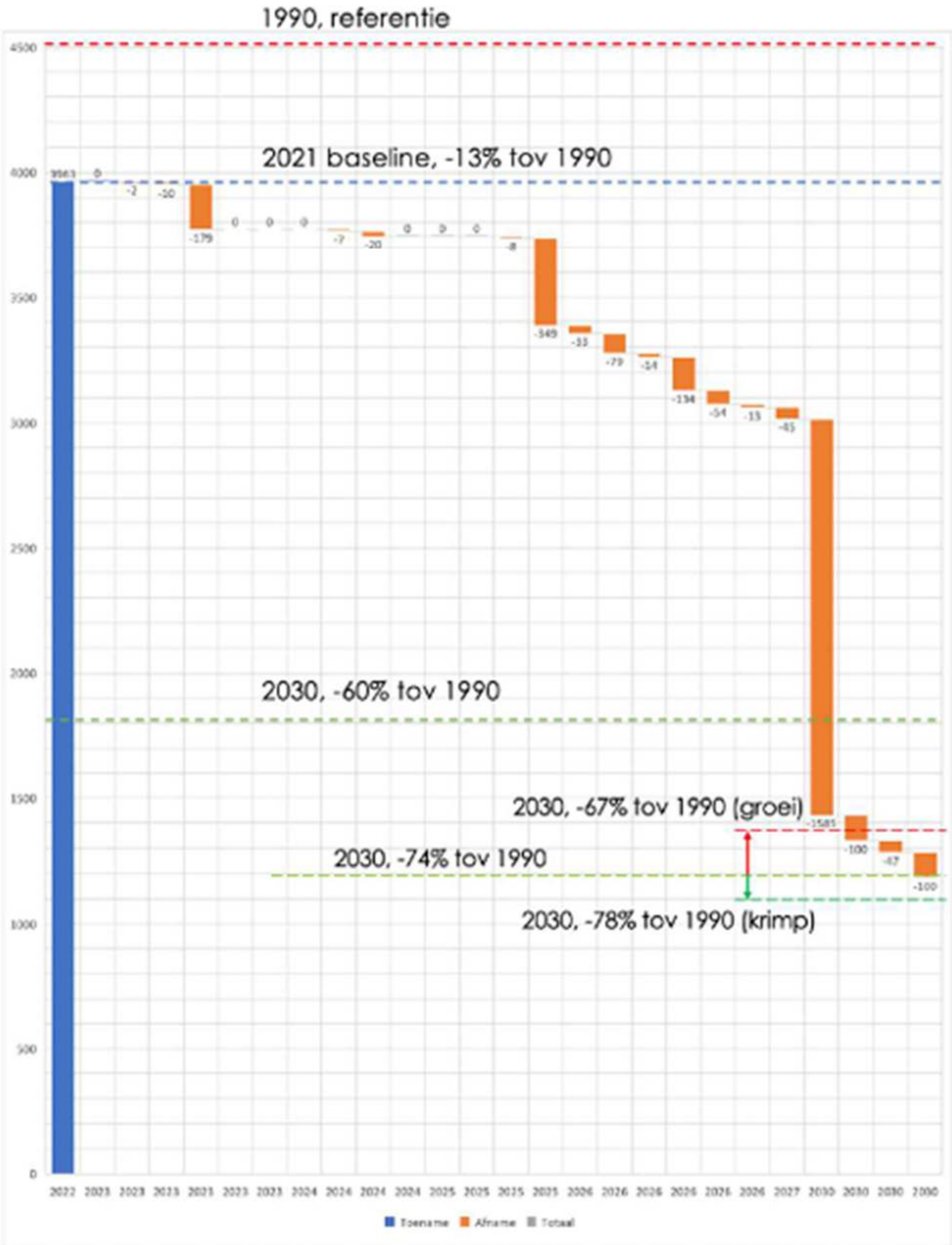
1990, referentie
2021 baseline, -13% tov 1990
2030, -60% tov 1990
2030, -67% tov 1990 (groei)
2030, -74% tov 1990
2030, -78% tov 1990 (krimp)
Toename
Afname
Totaal

Figure 20

As BESIX is not a rebar supplier itself and that often steel strength and designs are prescribed in the technical specification, BESIX focuses on four areas:

- reducing at the source through:
  - awareness creation amongst private and public clients and going in dialogue with them on applying design alternatives/optimizations and more sustainable materials which means often to allow the General Contractors to opt for innovation by less prescribing strict technical requirements during tender phase. BESIX continues to invest in workshops and dialogue sessions with clients to increase awareness and create partnerships.
  - optimizing the design (reducing dimensions, optimization of mix design) where possible (this is one of the areas in which BESIX distinguishes itself from its competitors). We are promoting EAF and trying to use renewable energy to reduce emissions.
  - partnerships with rebar suppliers to engage and encourage collaboration towards innovative and more sustainable solutions. BESIX continues to go in dialogue with these suppliers during visits, workshops, supplier forums...
  - going in dialogue with standardization bodies for reviewing current standards which is holding back innovation today (for example increasing the % of allowed recycled aggregates). To be successful this will be taken up at sector level.

- stimulating innovation and research & development through:
  - collaborating with the academic world as an industrial partner in master theses.
  - searching for alternative and more sustainable solutions through research & development, market screening and monitoring of innovations and start-ups. BESIX Group has created a dedicated department, BESIX Technology, to facilitate innovation and supporting start-ups.

- reducing the emission during the handling of rebar on site by going in dialogue with rebar suppliers on their production process, transportation methods to the site and data availability.

- internal & external awareness creation through:
  - newsletter, posters and training
  - creating a knowledge of alternative or low carbon solutions (reuse of steel, hydrogen as a reducing agent, use of renewable energy for EAF, Carbon Capture solutions...)

As mentioned above BESIX has defined a 70% reduction target related to the 1990 value by 2030. To track progress a detailed analysis was initiated in 2024 in order to define an average carbon emission per ton for the rebar. This average value is calculated for the life cycle phase A1 to C4 and serve as a baseline for monitoring progress in reducing carbon emissions for this type of material. As from 2025 this is now monitored on a half-yearly basis. Targets and Ambitions are summarized in the BESIX' Scope 3 Strategy.

6. References

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