Emission reporting boundaries and requirements

From raw material extraction to the product leaving the steel factory gate: how GHG emissions should be accounted for.

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Dashed boxes indicate that additional information, other than quantitative data, should be provided.

Steel Standards Principles (SSP):
https://steelstandardsprinciples.org/transparency-criteria-in-ghg-emissions-reporting

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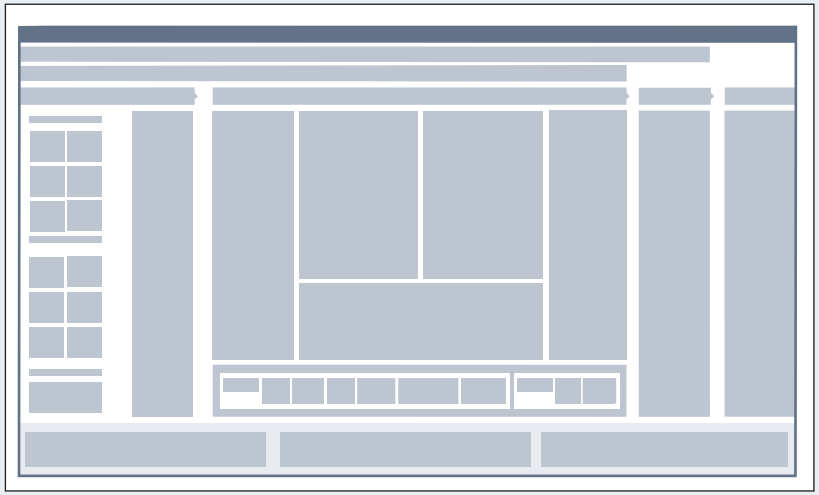

Extended Boundary 2

The extended boundary 2 includes the minimum reporting boundary (cradle to crude steel) as well as extended boundary 1 (hot rolling).

If extended boundary 2 (“from cradle to finished product”) is included or defined as a GHG emissions accounting and reporting boundary, whether voluntary or mandatory, this should be explicitly declared and the purpose for which it is being calculated, should be specified:

- For LCA studies
- For site level reporting
- For corporate reporting
- Not included
- Not relevant
- Other

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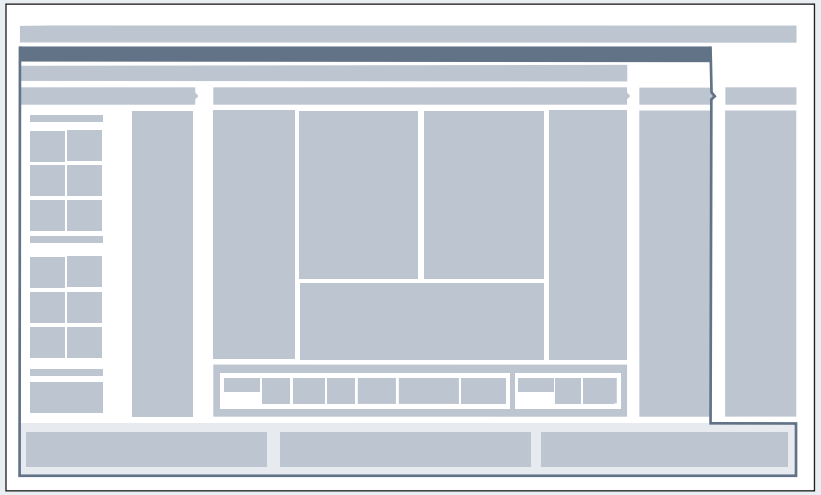

Extended Boundary 1

The extended boundary 1 includes the minimum reporting boundary (cradle to crude steel).

If extended boundary 1 (“from cradle to hot rolling”) is included or defined as a GHG emissions accounting and reporting boundary, whether voluntary or mandatory, this should be explicitly declared.

The method or standard by which imported crude steel (and any associated upstream emissions) is accounted for must also be declared. If excluded, this must also be declared.

Whether or not this boundary is used as a level to set thresholds for low carbon emissions steel should also be reported.

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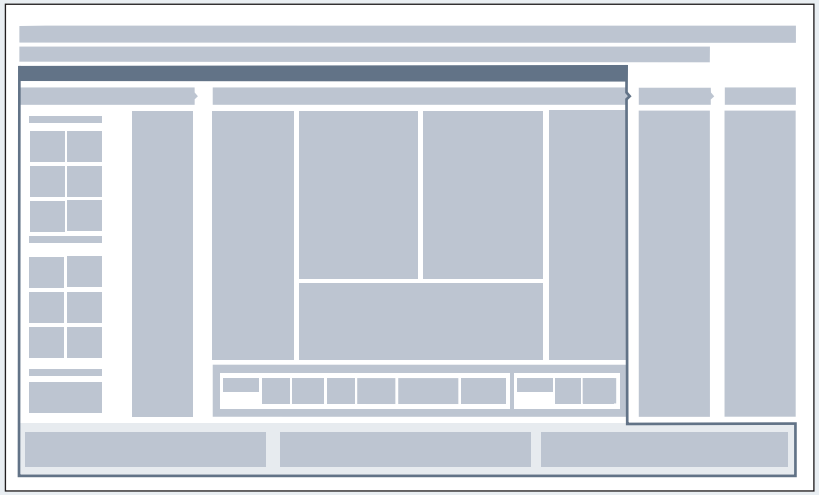

Minimum Boundary / Cradle to Crude Steel

For GHG emissions accounting and reporting, the cradle-to-gate GHG emissions from mining to crude steel should be used as a minimum boundary (direct and indirect emissions), reported per tonne of crude steel. Other boundaries can be reported in addition to the minimum boundary as specified in a referenced standard.

Whether or not this boundary is used as a level to set thresholds for low carbon emissions steel should also be reported.

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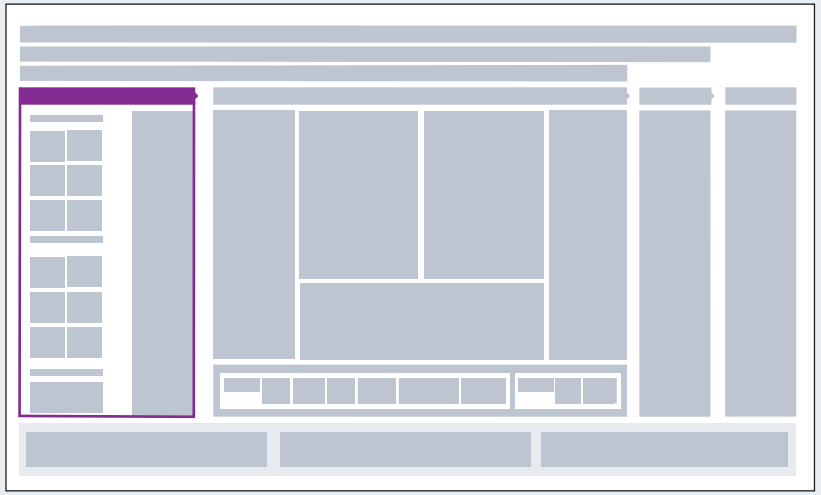

Upstream processes

All raw material inputs, energy and purchased intermediate products should be included in the minimum boundary. In case any of these have been excluded from the GHG accounting boundary (while still being used within the minimum boundary), this should be clearly stated and justified.

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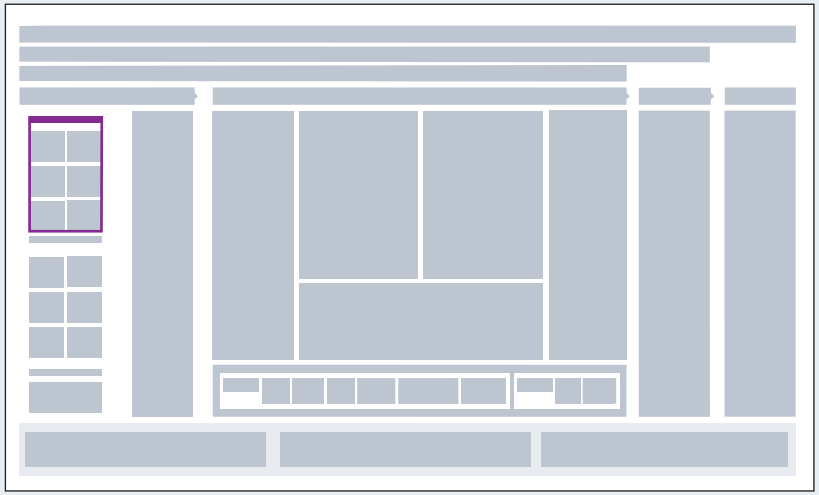

Mining and extraction

The upstream GHG emissions impact of mining and extraction of the raw materials should be included.

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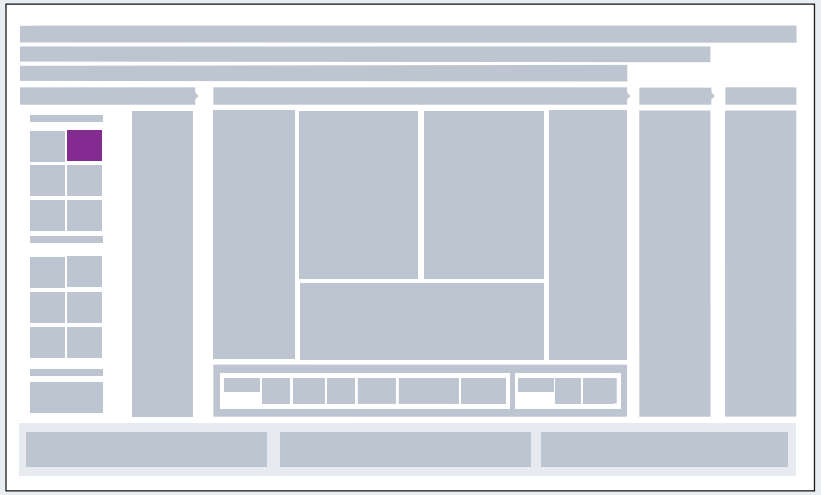

Coal

Coal

This includes both thermal coal and metallurgical coal. One of the largest sources of GHG emissions during the coal mining process are fugitive methane emissions - these should be included in the accounting boundary. In addition, emissions also arise as a result of the use of fuel and electricity for machinery and internal transport.

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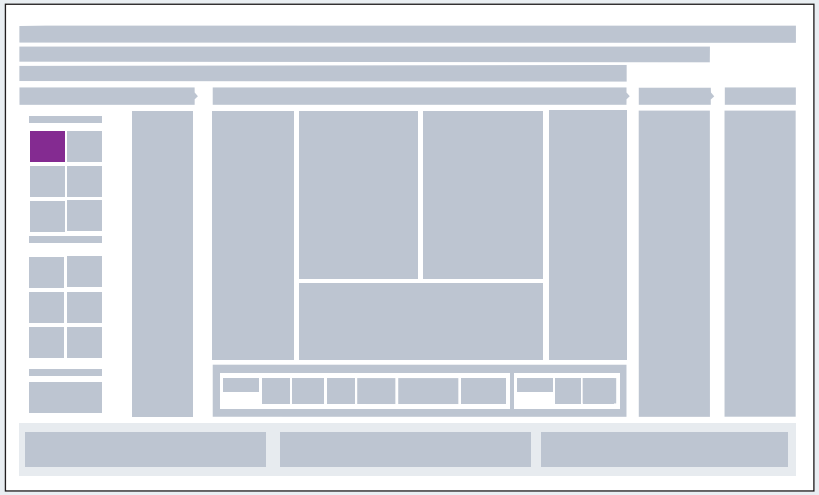

Limestone

Limestone

This includes emissions from mining (from machinery use and internal transport). Steel facilities may purchase limestone ($CaCO_3$) and process it internally, or purchase calcined lime (CaO) directly. In the case where lime is purchased, upstream emissions from the calcination process must be included.

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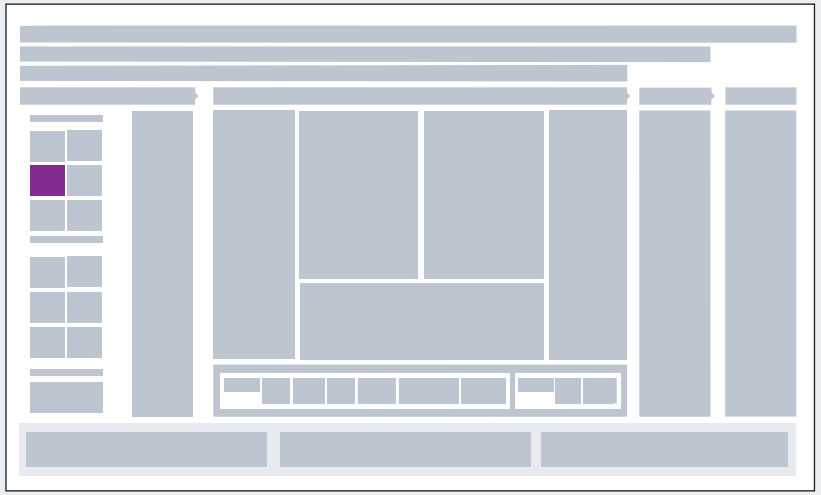

Iron ore

Iron ore

This includes emissions from mining (from machinery use and internal transport). Steel facilities may own the mines themselves or may purchase iron ore and process it internally, or purchase it in the form of pellets.

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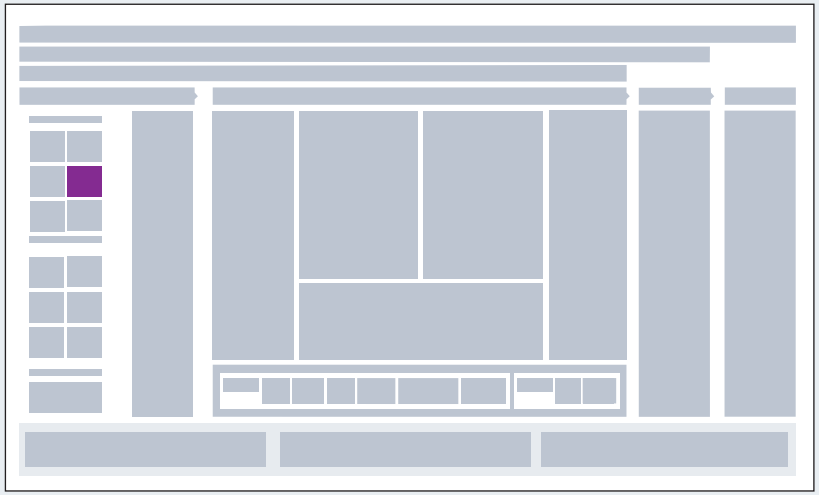

Alloying materials

Alloying Materials

This includes emissions from mining (from machinery use and internal transport). Steel facilities may own the mines themselves or may purchase alloying materials from third party producers.

Alloys can contribute significantly to the upstream GHG emissions, especially for high alloyed steels, and should therefore be included.

The alloys required for steel production are a function of the desired properties and application for the final product. Therefore, it's important to consider that, while a high alloy steel will most likely carry a significant upstream burden due to its alloy consumption, its function cannot be fulfilled by a low alloy carbon steel.

This is why LCA approaches advocate for the use of the Functional Unit as the basis for comparison between products.

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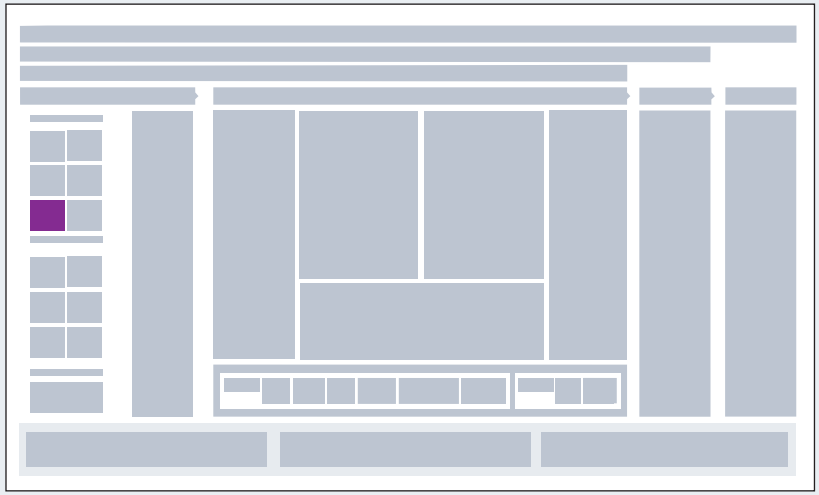

Natural gas

Natural gas

This includes upstream emissions from the extraction of Natural Gas from a number of extraction technologies, mainly resulting from unintentional fugitive methane leaks from pipelines, valves, storage tank, and flaring. It should also include operational emissions from the use of fuels and energy when operating machinery such as compressors and drilling rigs.

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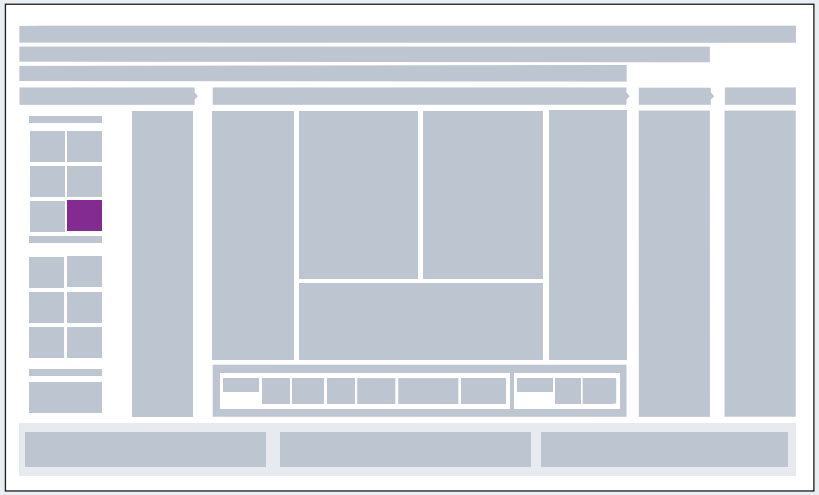

Oil

Oil and other liquid fuels are used as an auxiliary source of thermal energy in steel making processes and in the operation of machinery and transports on-site. Upstream operational emissions come from the use of fuels and energy when operating machinery such as compressors and drilling rigs, as well as conversion from crude oil to useful oil products such as heavy fuel oil, or light fuel oil.

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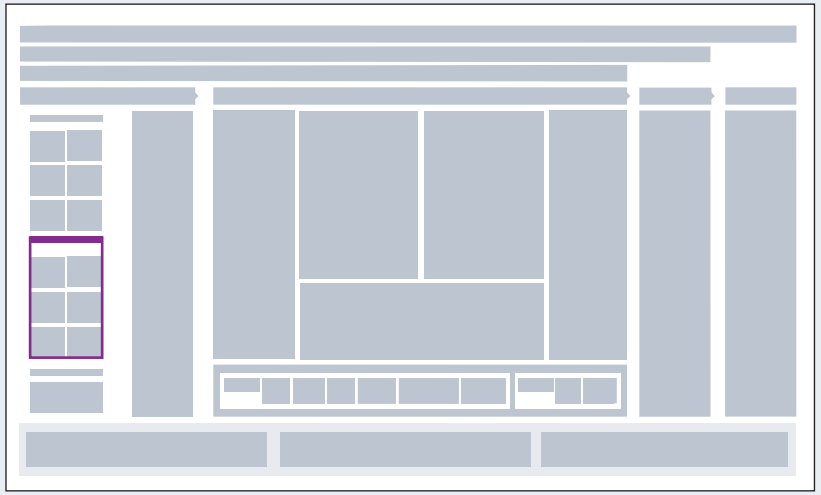

Other Inputs

While the emissions associated with the inputs below should generally be incorporated within the minimum reporting boundary, each of them come with additional reporting requirements which are described in further detail below.

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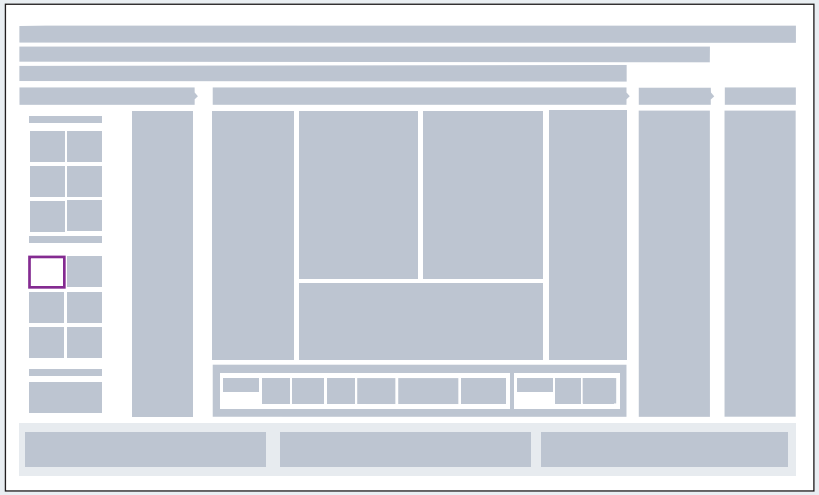

Electricity

Electricity

Emissions associated with electricity should be included as part of the minimum system boundary. In addition, the approach defined by the methodology for accounting for these emissions should be included – this relates to location-based electricity or market-based electricity. Methodologies can either specify whether one or both of these approaches must be reported. In some cases the approach is not specified.

Steel sites are often also net producers of Electricity, exporting the surplus electricity back to the grid or other local users.

Location-based electricity

Location-based electricity represents emissions calculated using the average electricity grid factor for the physical location (country or region) where the electricity is consumed. Imports and transmission losses should be included when material.

Market-based electricity

Market-based electricity represents emissions calculated using a supplier-specific contract, renewable certificate, power purchase agreement, or other market instrument.
In case, market-based approach is used, a residual grid mix should be used to represent any additional electricity being purchased. It's important to consider that when market-based reporting is used, the entire supply chain should use the same methodology for the reporting and use of certificates and calculation of a residual grid mix. Mixing of methodologies incurs a risk of double counting.

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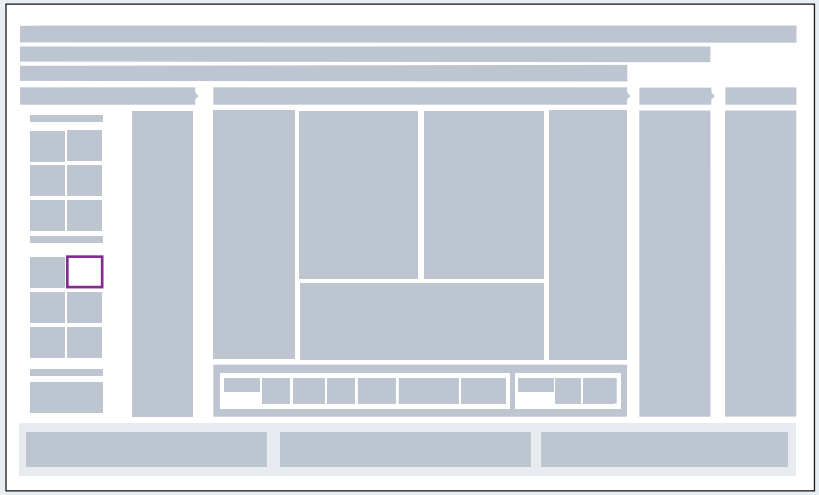


Hydrogen

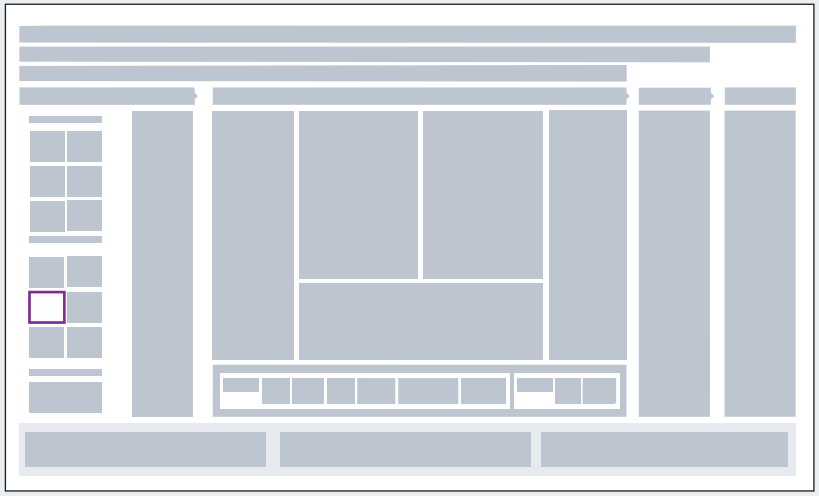
Hydrogen

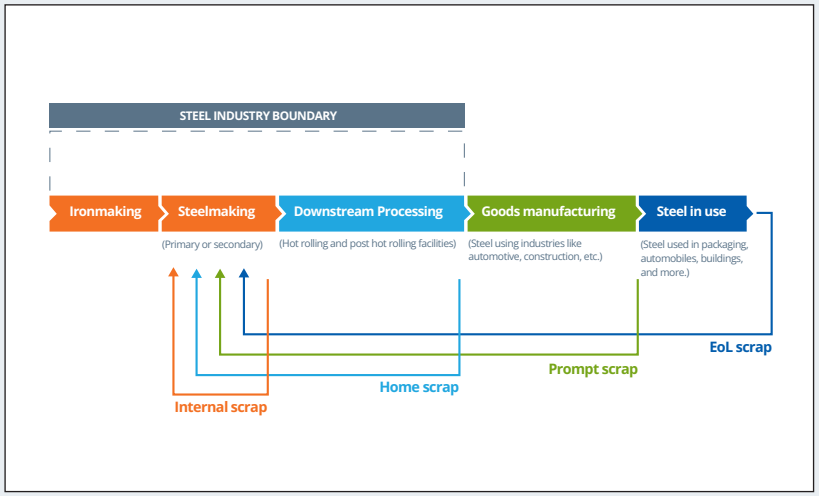
Hydrogen is regarded as one of the most promising alternative sources of energy as well as a reducing agent for iron ore, as a substitute to widely used carbon. When reducing iron ore using hydrogen instead of carbon, the waste gas produced is water, instead of CO2.

However there are more potentials pathways to generate hydrogen, with significantly different GHG emissions profiles.

According to IEA (2023): "At present, several different terminologies are used to categorise hydrogen based on how it is produced, including "sustainable" or "clean". Even more common is the use of colours, such as "grey", "blue", "pink", or "green" hydrogen. However, there are no agreed definitions for these terms, and they can obscure many different levels of potential emissions."

The method through which hydrogen was produced and procured should be specified and represented by an appropriate upstream burden factor.





Scrap types across the steel value chain.

Scrap

Scrap

The amount of ferrous scrap or recycled steel entering into the steel production process will have an impact on the overall carbon footprint. Recycling scrap (often known as secondary production) does not entail the same energy and chemical requirements than producing steel from raw iron ore (primary steel production). While the quantity used varies, scrap is used in all steel production routes.

The amount of scrap entering the production process per tonne of output (described as crude steel, hot rolled steel, or finished steel product, depending on the boundary adopted) should be specified. The type(s) of scrap included in the calculation should be specified (multiple options possible), for example:

- Pre-consumer scrap
- Internal scrap
- Home scrap
- Manufacturing or Prompt scrap
- Post-consumer scrap, i.e. end-of-life (EoL) scrap

The denominator should also be specified:

- Per tonne crude steel, hot rolled, or finished steel
- Per tonnes metallic input

While scrap is considered to be a recycled material, methodologies may consider net burden/credits for its use due to the avoidance of the use of raw materials. Scrap must also be gathered and processed before use in steel production processes, by steelmakers themselves or by third party processers. During reporting, it must be specified how these upstream processes' burdens are handled:

- No upstream burden applied
- Applied to the scrap input separately
- Applied as net burden/credits when considering full LCA

Through the Steel Standards Principles, a proposal on scrap input definition is under development.

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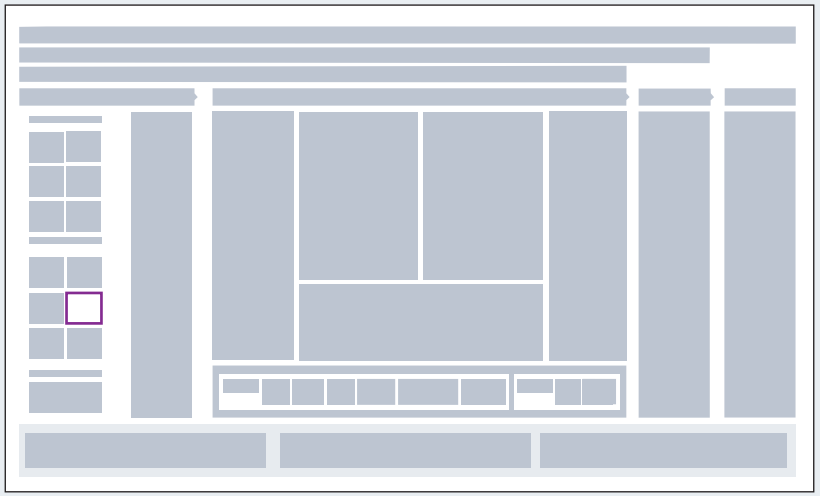
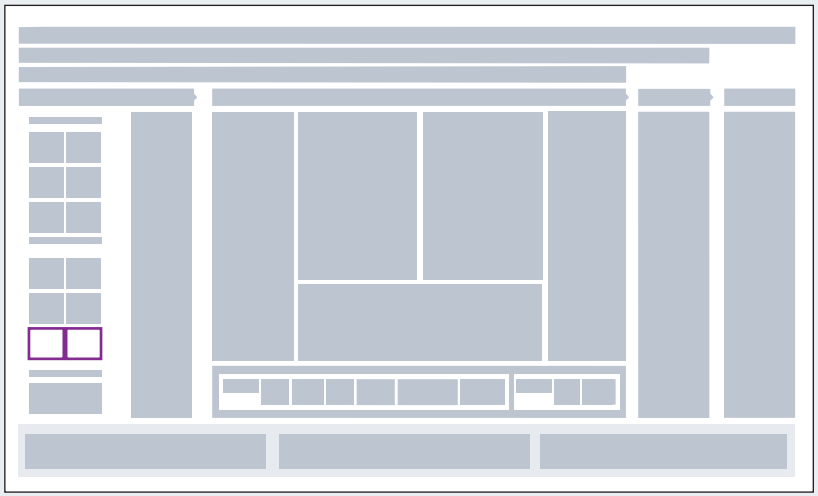


Waste plastics

Waste plastics

Plastic waste can be used up to a limited amount in steelmaking facilities such as Coke Ovens and Blast Furnaces as an alternative source of energy and reducing agent. Methodologies generally consider the input of the waste plastic as zero embodied GHG emissions. However, it is important to consider the emissions associated with their use and/or combustion. This is particularly important as other material sectors do not necessarily account for these combustion emissions. Waste plastics must also be gathered and processed before use in steel production processes. During reporting, it must be specified whether emissions related to the processing of and combustion of these waste plastics have been included.



Biomass in the steel industry

Biofuels Biogas | Charcoal Biochar

Under the right circumstances, biomass can be considered to be a carbon-free resource; therefore, it can be an attractive option to reduce emissions from iron and steel production.

The International Energy Agency's (IEA) bioenergy programme notes that "within the biospheric carbon cycle, bioenergy can be carbon neutral because the carbon that is released during combustion has previously been sequestered from the atmosphere and will be sequestered again as the plants regrow, i.e. if sustainably produced."

However, the whole supply chain must be considered, and all emissions associated with the production, processing, transport and use of bioenergy need to be included. Particularly, harvesting, transport, and processing generally involve fossil energy use.

Nevertheless, analysis shows that the fossil energy used in the supply chain is generally a small fraction of the energy content of the bioenergy product, even for woody biomass transported over long distances, e.g. between North America and Europe.

During reporting, it must be specified which type of biomass has been used how these upstream processes' burdens are handled, either:

- The material is assumed to have zero embodied GHG emissions.
- Emissions are accounted for and reported separately as biogenic GHG emissions.
- Net burden/credits are reported when considering the full LCA of the material.

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Biofuels Biogas

Biofuel/Biogas generated from sustainable sources or waste streams can be considered a carbon-free resource and be used as a substitute to fuels and Natural Gas.

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Charcoal Biochar

While some blast furnaces do currently operate entirely using biomass, the relative strength of charcoal compared to coke means that this is only possible in smaller furnaces, reducing its scalability. Charcoal is currently used commercially to substitute a proportion of the coal used in blast furnaces, primarily in Brazil.

Biochar can potentially be substituted for pulverised coal, which is currently injected directly into blast furnaces.

Usually produced through a pyrolysis process, CH_4 emissions can be a significant aspect in charcoal making that need to be appropriately managed. Since methane has a higher GWP impact than CO_2, its uncontrolled emission may hinder the carbon neutrality of its use.

Work was undertaken to this end under the Australian CO_2 breakthrough programme, which focused on substituting coal used in pulverised coal injection (PCI) in the blast furnace with sustainable biochar.

Some developments continue to optimise charcoal production further to improve its product specifications for steel production.

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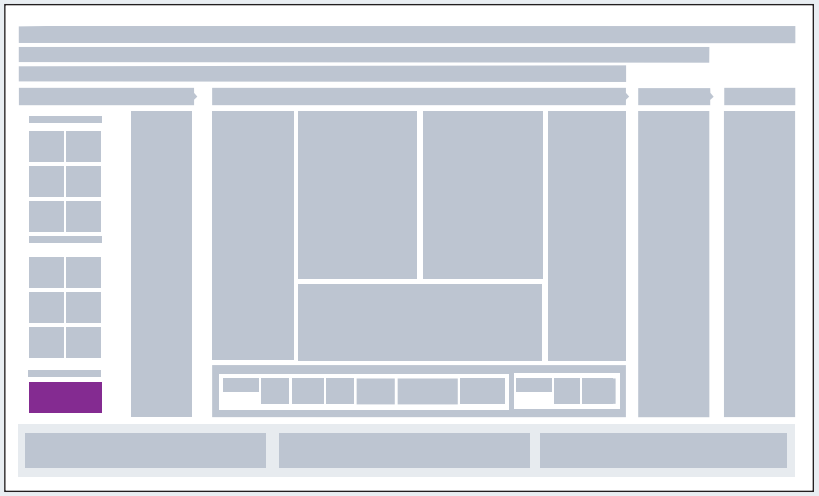

Intermediate products

Pellets, coke, sinter, pig iron, DRI, HBI

While these products are often produced on a steel making site, some companies will purchase these intermediate products, or transfer them from one of their own production sites – for example pellets, coke, sinter, pig iron, hot metal, DRI, HBI etc. The cradle to gate GHG emissions associated with the production of these products should be included in the minimum system boundary. Go to intermediate product exports.

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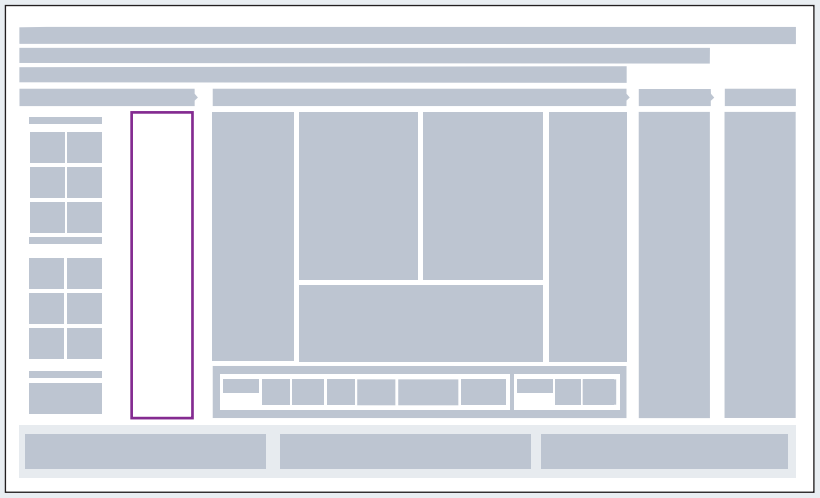

Fuel and material transportation

Steel is a truly global commodity and more than 30% of steel crosses international borders before being utilised. Not only that, the most significant raw materials in volume (iron ore, coal, and scrap) are also significantly traded. Emissions arising from such transport refer to the amount of fuel and energy that is used to power ships, trains, and trucks to bring raw materials to the steel making facility.

When compared to primary emissions in steelmaking processes, transport-related emissions tend to be a small fraction of the total carbon footprint of steelmaking and can be considered to be not material.

Another concern regarding quantifying these emissions is regarding the commercial sensitiveness of this information, since via the distances travelled, suppliers and commercial routes can be tracked and derived.

The inclusion or exclusion of transport of raw materials should be specified.

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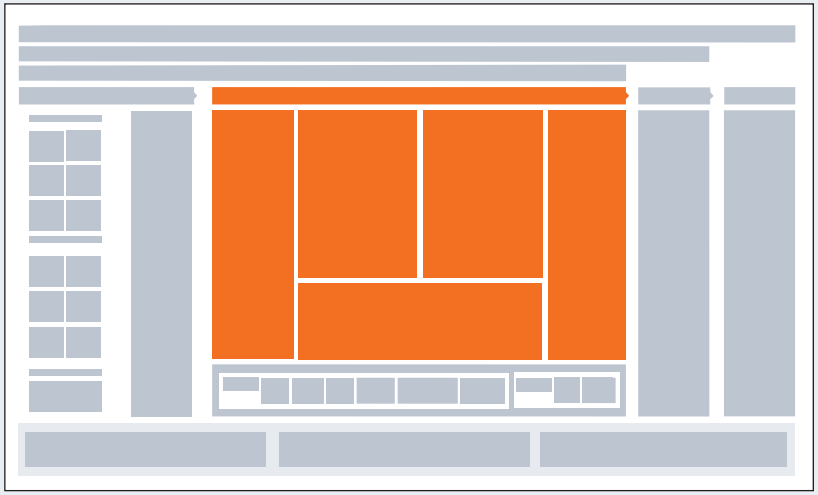

Steel production

This section includes all main processes operated in steel producing facilities up to the crude steel stage, i.e. the first solid form of steel and includes products such as slab, blooms and billets. Combined, these activities are what we normally refer to as “steel industry”, although it is common for many steel companies to also operate outside of these boundaries, for example, by owning and operating its own mine facilities, electricity generation and/or downstream steel product making.

For the steelmaking processes, when operated by the reporting organisation, direct emissions should be calculated and reported. Most emissions result from process emissions, from iron ore reduction, and stationary combustion. Often energetic inputs perform simultaneously the role of providing thermal heat and being used in the chemical reduction transformation.

Direct emissions can be measured through Continuous Emissions Monitoring System (CEMS) Methods or most commonly calculated through accounting for the mass or volume of material inputs and outputs (fuels and other materials) and using emission factors per mass or volume unit. For most fuels, emission factors are determined by their carbon content.

The method used to determine direct emissions must be specified, as well as the materiality criteria used and any notable exclusions.

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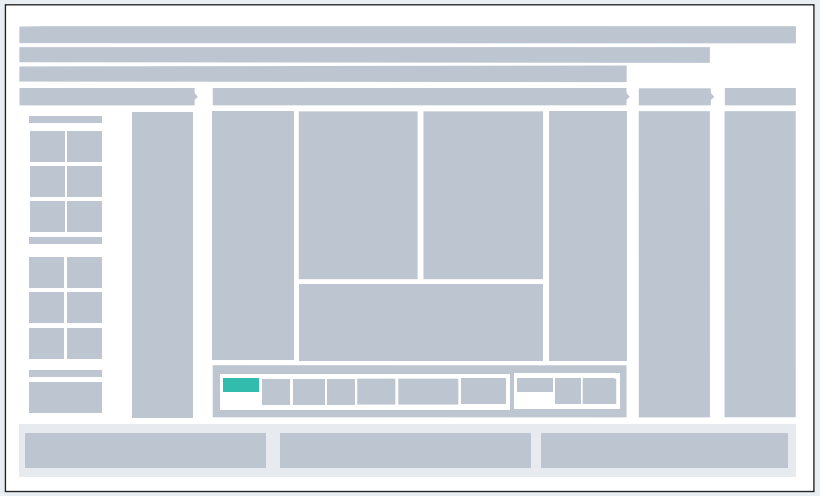

Co-products and exports

Due to the nature of the steel production process, a number of co-products (or by-products) are generated which can be sold as a useful input to another industrial system. Additionally, intermediate products can be sold to other steel companies as their raw material input for steel production.

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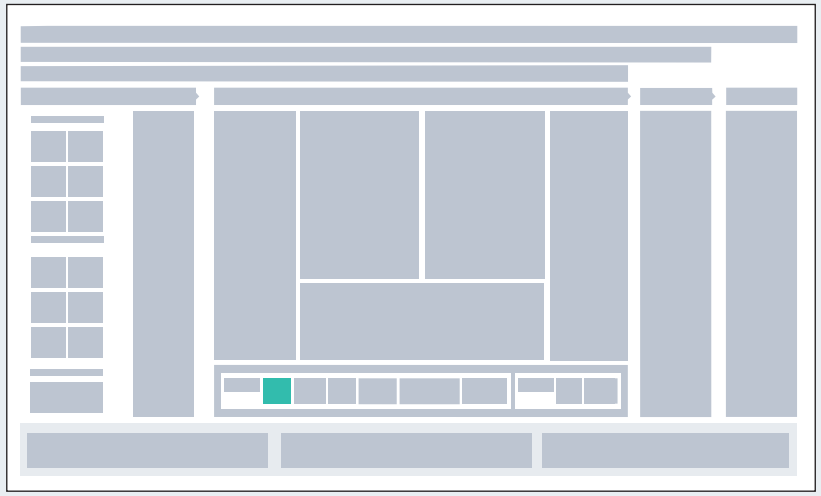

Slags

Useful slags are generated in the blast furnace, BOF and electric arc furnace. These are sold and can be used to replace clinker, as a fertiliser or as roadstone. The methodology for how each of the slags should be handled needs to be defined. This can include:

- System expansion
- Economic allocation
- Physical partitioning
- Mass allocation
- Other
- No allocation
- Not specified

Where slags are not sold, but become waste, the impact of waste disposal should be associated with the steel product. Any other treatment of such material should be disclosed.

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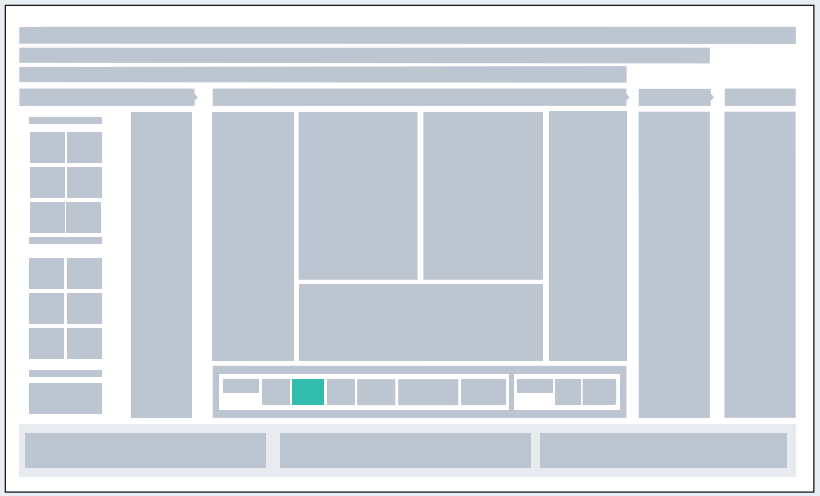

Exported electricity

Electricity

Electricity can be exported from the steelmaking production site. This electricity is commonly generated in Power Plants that use processes gases produced on the site.

This surplus electricity has the effect of avoiding emissions from the additional amount of electricity substituted that would have had to be generated in the local grid in its absence.

The method through which emissions are assigned to exported electricity and how the amount of avoided emissions is calculated should be specified.

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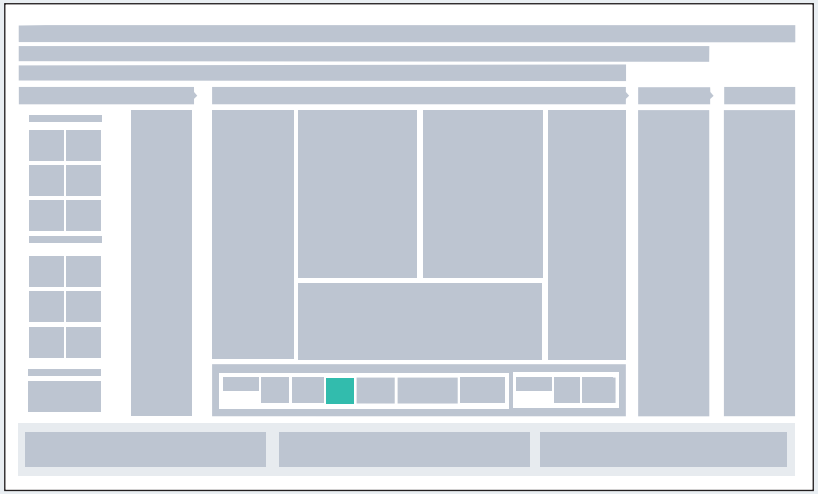

Process gases

Process gases

Steelmaking facilities such as coke ovens, blast furnaces, alternative iron making (e.g. DRI), and basic oxygen furnaces produce gases with significant energy potential. These are often utilised internally in Power Plants, generating electricity for use on the steelmaking facility itself or exported to the grid and other users. These gases can also be captured and processed for Carbon Capture and Use and Carbon Capture and Storage operations.

In some cases, the gases are exported directly to third party power plants and users. These surplus gases and the energy they contain also have the effect of avoiding emissions from the additional amount of energy inputs substituted that would have had to be used in their absence. These can be calculated when adopting a system expansion approach, accepted in some methodologies.

The methodology for how the process gases should be handled needs to be defined.

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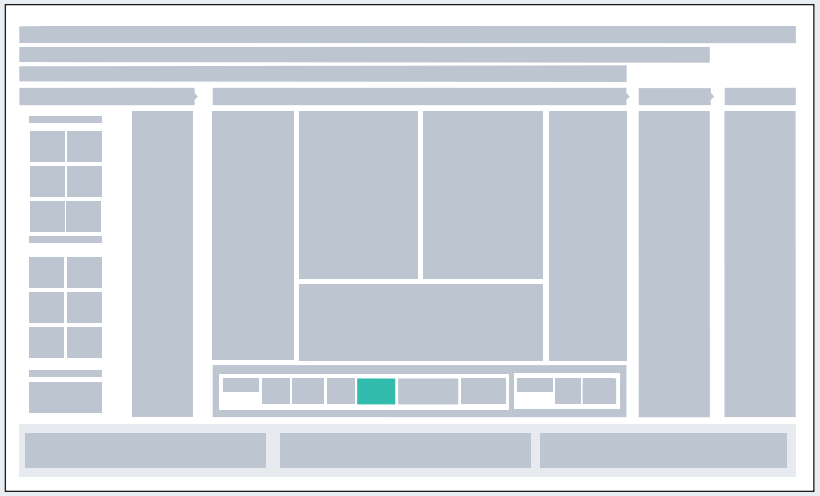

Other co-products

Other co-products can leave the site for use in other value chains. The methodology for handling these co-products should be defined.

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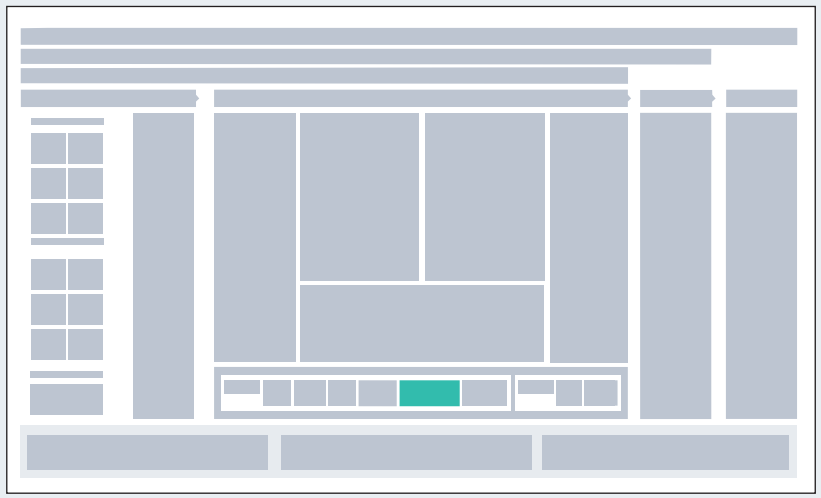

Intermediate product exports

Pellets, coke, sinter, pig iron, DRI, HBI

When intermediate steel products are sold, they are in most cases utilised in another steel making facility. Thus, the associated emissions with the use of this material are downstream of the producing site and upstream to the site purchasing them, creating the possibility of double counting, depending on the boundary considered.

To avoid such occurrences, any crediting or assumptions used when handling the export/import of intermediate products needs to be specified, according to the boundary being used for reporting.

Go to intermediate products as an input material.

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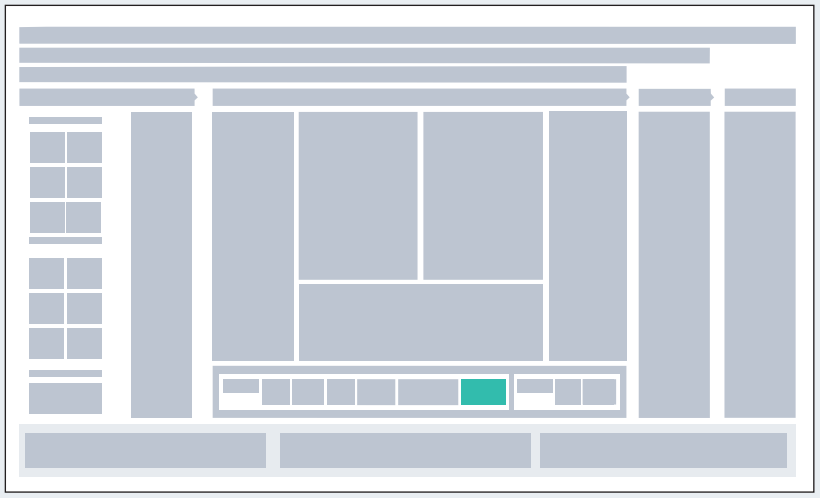

Carbon capture utilisation and storage

Carbon capture utilisation and storage

CCS: Carbon capture and storage (CCS) refers to a suite of technologies that capture waste CO2, typically from large point sources, transport it to a storage site, and deposit it in a location where it will not enter the atmosphere.

Stored CO2 is injected into an underground geological formation; this could be a depleted oil and gas reservoir or other suitable geological formation. CO2 can also be injected into mature oil fields, driving out additional oil from the rock before being permanently stored. This is known as enhanced oil recovery (EOR) and is a form of carbon capture use and storage (CCUS).

The modality of storage and assumptions used must be specified when reporting GHG emissions.

CCU: As is the case with carbon capture and storage (CCS), CCUS technologies separate and capture the CO2 generated during the iron and steelmaking process. The difference is that when using CCS, the CO2 is stored permanently.

Using CCUS technologies, the CO2 can be chemically converted into other products such as plastics, concrete or biofuel, or used in enhanced oil recovery (EOR). Food grade CO2 can also be sold as a raw material input to other industries. CCUS may result in emissions at a later stage, but often displacing requirement of other raw materials. The assumptions and criteria to represent such processes need to be specified.

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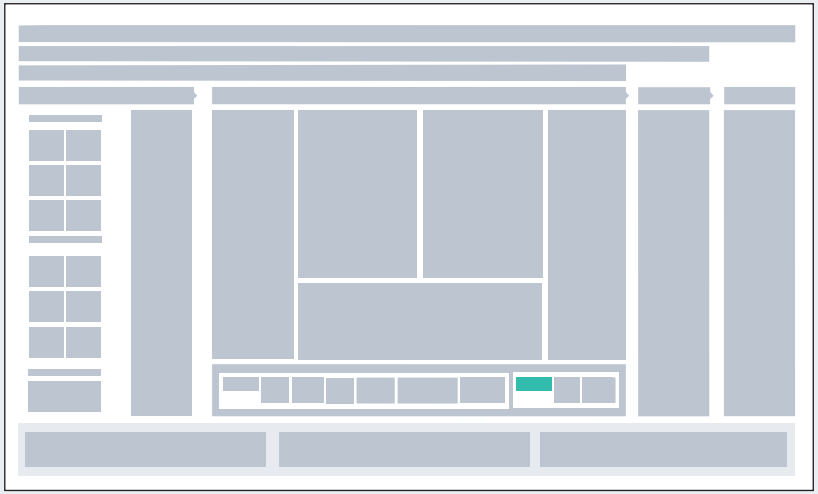

Additional measures

Additional measures can include credits, carbon insets, carbon offsets and also approaches such as the use of chain of custody models. These approaches are evolving and there is not always a consistent way of implementing them within the methodologies. It is therefore important to specify if such an approach is allowed within the methodology framework, and in such cases, how this should be applied.

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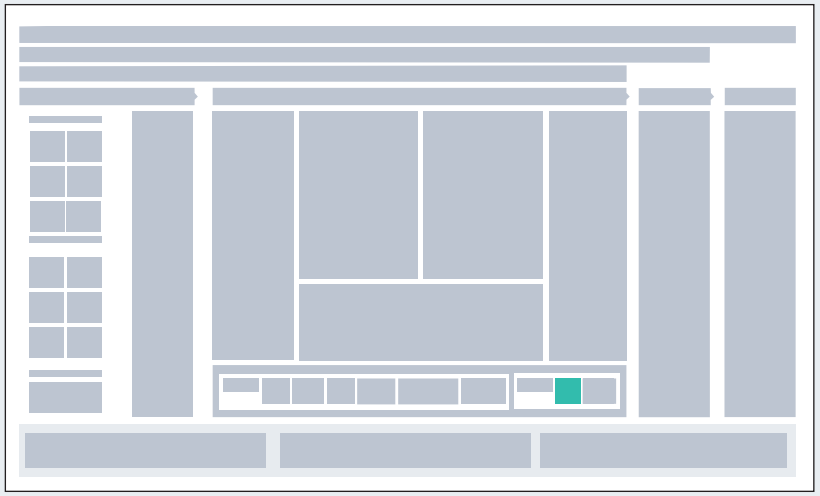

Credits

Credits

Credits are usually calculated in relation to avoided emissions from the displacement of raw materials and other energy inputs against a realistic baseline, in most cases, the absence of a particular export of a by-product of energy carrier by the steel plant.

While this type of accounting requires care when establishing baselines, it is an important accounting step to appropriately assign value to efforts towards industrial integration and circular approaches.

Any crediting approaches adopted must be specified.

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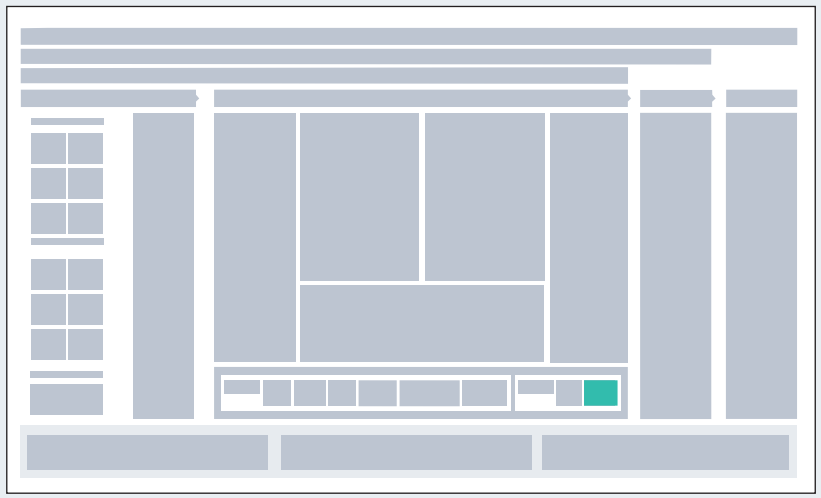

Carbon insets and offsets

Carbon insets and offsets

Insets in this context refer to GHG emission reduction projects performed inside an organisation, without a link to the steel production value chain in this organisation. If carbon insets are used in the accounting methodology and reporting, the assumptions and criteria used must be specified.

Offsets in this context refer to GHG emission reduction projects performed outside an organisation, without a link to the steel production value chain in this organisation. If carbon offsets are used in the accounting methodology and reporting, the assumptions and criteria used must be specified.

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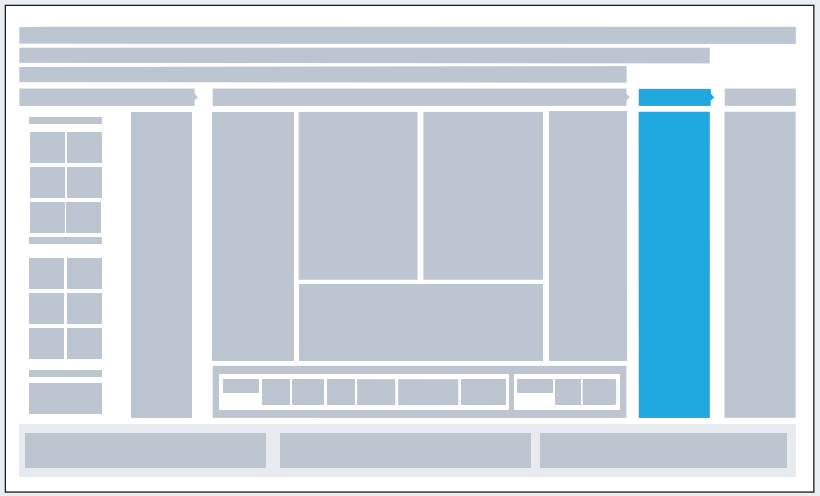

Hot rolling

Often operated in the same facility that produced the crude steel, hot rolling mills are facilities where solidified steel is preheated to a high temperature and then is continuously rolled between consecutive sets of two rotating cylinders, improving physical properties, until it reaches a standardised semi-finished product form, such as hot rolled coil.

In most cases, crude steel is cooled in slab, billet, or ingot form before proceeding to hot rolling facilities, on the same site or in a different location. In these cases, they must be heated in reheating furnaces. Most direct GHG emissions arising from these processes are a result of the fuel input needed to operate these furnaces. In integrated sites, process gases are often utilised, optimising the site's energy balance. Electricity is also a significant source of (indirect) emissions in this process, used to operate the equipment.

There are facilities that allow for crude steel to proceed directly from casting to hot rolling, removing the need to reheat it and greatly reducing GHG emissions, however such installations require significant area availability and stable operation conditions.

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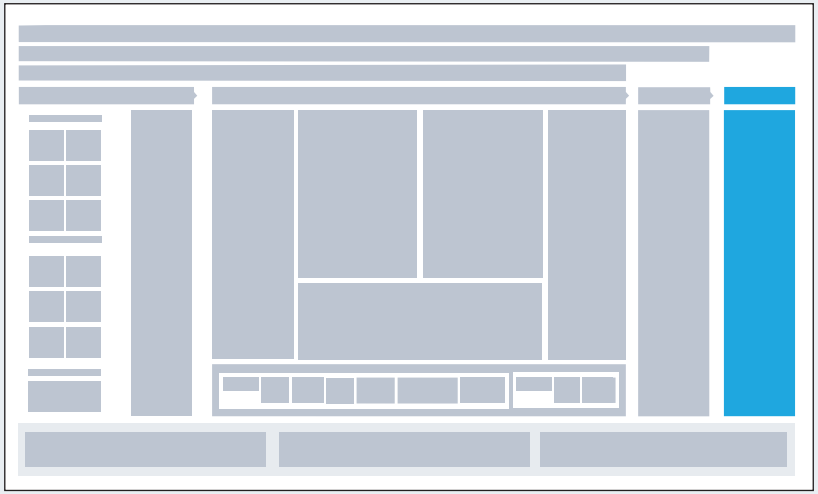

Finishing operations

Finishing operations include a wide range of steel post-processing units used to enhance properties or characteristics of steel in preparation for its final use. They may aim to improve surface cleanliness and aesthetic appeal, corrosion resistance, durability, among other. Key methods include cold rolling, annealing and tempering, coating (galvanizing, painting, powder coating), cleaning (pickling, sandblasting), and smoothing (grinding, polishing).

Due to how varied the processes are, key inputs for GHG emission accounting can also vary significantly and the materiality of each process is often assessed case-by-case. However, fuel and electricity consumption often remain the most significant sources of emissions.

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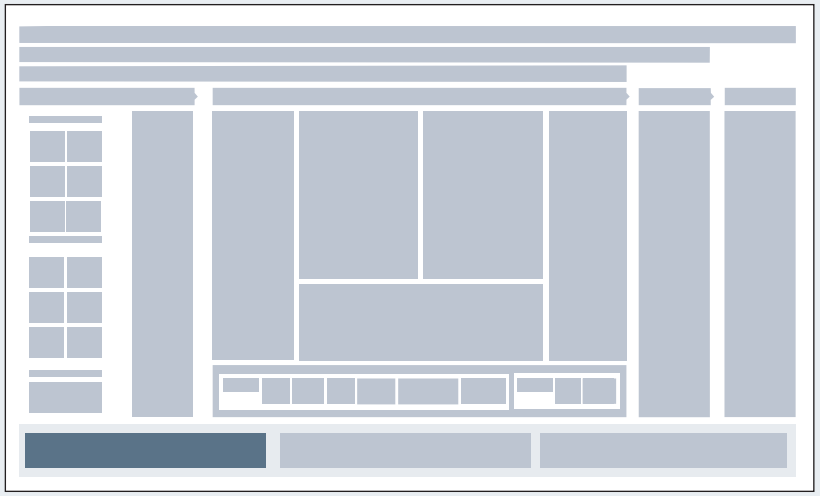

Global warming potential (GWP) impact assessment method

Global Warming Potential (GWP) methods are categorized by time horizons, primarily GWP100 (100-year) and GWP20 (20-year), which determine how long greenhouse gas impacts are calculated relative to carbon dioxide. Users can select standard GWP factors derived from different scientific updates, such as the latest IPCC Sixth Assessment Report (AR6). As there are multiple methods available, the selected method should be documented.

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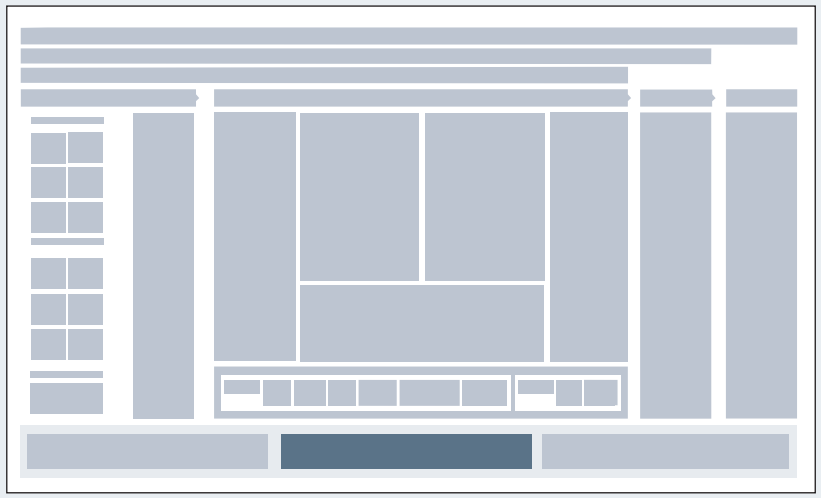

Included GHGs

All main 7 GHGs should be accounted for, when possible. When applying the concept of materiality for steel operations, 3 key GHGs (CO_2, methane and N_2O) represent 99.9% of cradle-to-gate emissions, thus should be considered as the minimum requirement.

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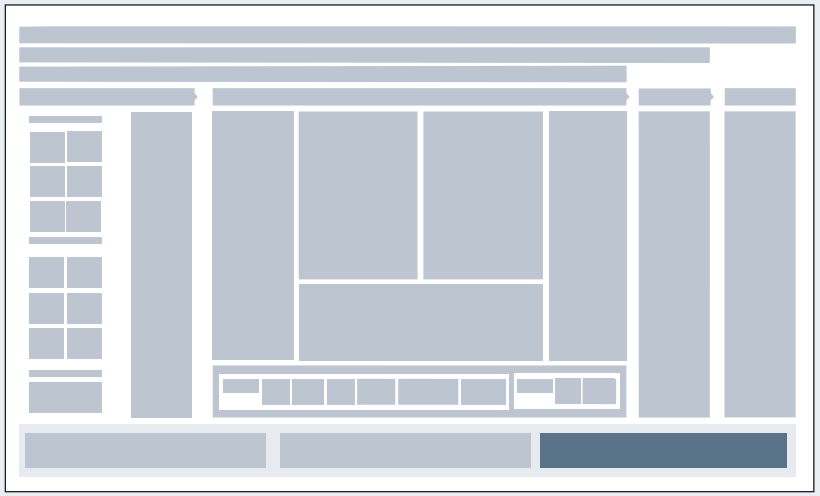

Data sources and data quality

Often operated in the same facility that produced the crude steel, hot rolling mills are facilities where solidified steel is preheated to a high temperature and then is continuously rolled between consecutive sets of two rotating cylinders, improving physical properties, until it reaches a standardised semi-finished product form, such as hot rolled coil.

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Data sources: In most steel facilities, GHG emissions are accounted for using activity data (i.e. consumption of a material or energy source) multiplied by a direct and/or an upstream emission factor per input unit. Activity data is usually monitored physically via stock management and/or measuring equipment and is considered to be part of the site's routine operation. Emission factors however can be more challenging.

Direct emission factors are often obtained through empirical testing of combustion processes or laboratory measurement of the carbon content of physical inputs.

Upstream emission factors should represent the cradle-to-gate emissions generated in the preparation of the raw or processed material or energy input arriving on the steel facility for use.

In both cases, the source of data should be communicated: primary, i.e. obtained by the steel facility itself through empirical testing of its materials and by direct contact with its suppliers, or secondary, when they are obtained from third party reference lists, both official (from government sources) and private sources (commercial databases, industry associations, standard setting organisations).

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Data quality: Data quality refers to a measure of the reliability and accuracy of the data being used. It's often assumed that primary data (i.e. measured or obtained by the site itself in direct contact with its suppliers) is preferred to secondary data.

However, aspects such as cost of monitoring technique and frequency and variability found between samples may make primary data use unfeasible, so that secondary data is considered to be the best available information. Secondary data can also vary in terms of its specificity geographically and temporally.

An indicator of data quality should be reported.

Through the Steel Standards Principles, a proposal on data quality criteria is under development.

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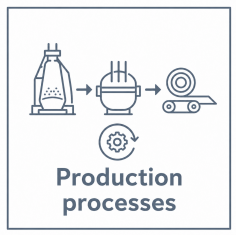

Steel production routes: Steel production routes: Details about the steel production facilities and technology route should be provided, specifying the main production processes for ironmaking and steelmaking.