ITOM-Steel | *Brief description*

Version: January 2026

Model purpose

The steel sector is a cornerstone of European industry. However, it is also responsible for approximately 5% of CO_2 emissions in the EU, largely due to its reliance on coal in primary production. While decarbonising steelmaking will be essential to achieve the EU's climate neutrality target, there are significant technological and economic challenges to overcome. ITOM-Steel covers the current landscape of EU steel production – including all primary and secondary production sites – and calculates detailed transformation pathways towards a climate-neutral, circular and competitive future. By evaluating various scenarios, the model identifies key technological shifts, infrastructure needs and policy impacts, enabling stakeholders to assess pathways for deep decarbonisation, resource efficiency and strategic resilience.

Model description

ITOM-Steel implements the ITOM[1] framework for the European iron and steel sector. The production chain represented in ITOM-Steel includes ironmaking (from ore and pellets), steelmaking (from iron and scrap) and finishing processes such as rolling and casting. The model covers all production sites in the EU27+3, with the EU27+3 further divided into five regions with regards to steel demand as well as other parameters (see tables below). While the model operates with flexible temporal resolution, scenariostypically use five-year steps. The main driver of the model is an externally given demand for finished steel, differentiated by 13 product types and four quality levels based on copper tolerance – a key factor for scrap recycling. ITOM-Steel optimises investment and production across sites, technologies and time, minimising total system costs while meeting material demand, resource constraints and emission limits.

Key features

- Spatially explicit representation of all existing EU production sites with a production capacity of more than 1 Mt crude steel per annum
- Site-specific energy and hydrogen costs, hence modelling of the "renewables pull" effect that arises from regional differences in hydrogen production costs
- Technology-rich representation of iron and steel production, including blast furnaces (with CCS), hydrogen-based direct reduction (DRI), electrolysis-based ironmaking, electric arc furnaces (EAFs) and flexible scrap/DRI blending
- Copper-sensitive scrap use based on the copper tolerance of final steel products

[1] ITOM stands for Industry transformation model – see supplementary information below

- Endogenous production network optimisation across the entire supply chain
- Integration of circular economy levers such as scrap use and imports of hydrogen-based iron (HBI/DRI)
- Detailed energy and emission accounting across all processes

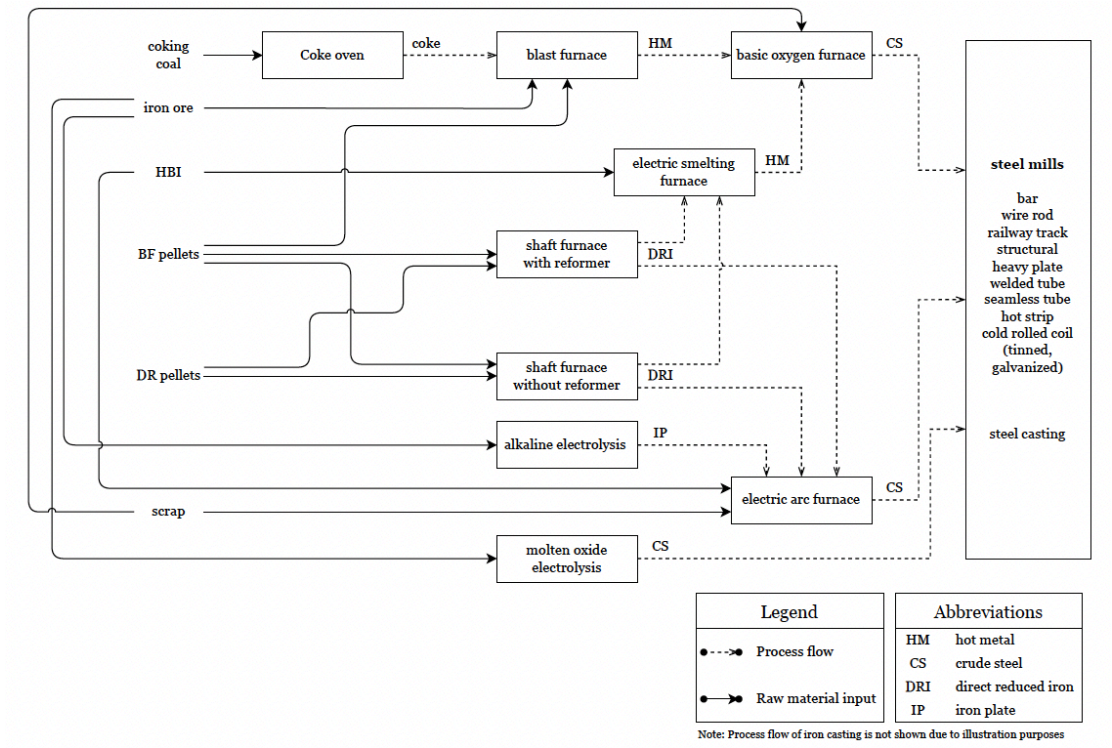

Figure 1: Material flows in ITOM-Steel

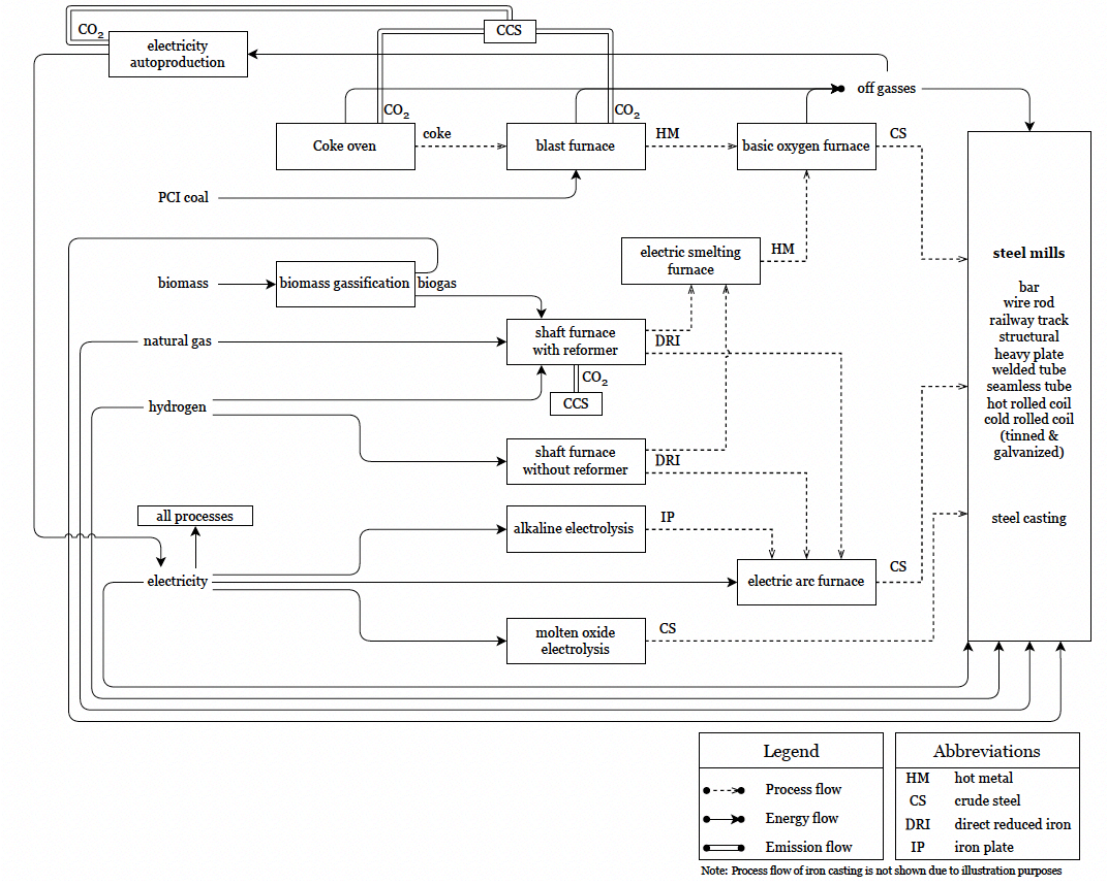

Figure 2: Energy and CO2 flows in ITOM-Steel

Key model inputs and outputs

Inputs

Parameter	Description
Finished steel demand	Yearly demand for finished steel products per region
Energy costs	Yearly and site-specific cost data for relevant energy carriers (e.g. electricity, hydrogen, natural gas)
ETS price	Yearly carbon price development
Material costs	Costs for iron ore, pellets, DRI/HBI imports, and other raw materials
Scrap availability	Yearly availability of scrap by quality (copper content)
CO_2 transport and storage costs	Yearly cost data differentiated by country and spatial storage zones (e.g. Onshore, Offshore)
Existing and planned production capacities	Capacity, age, and location of existing plants and announced projects
Green iron (HBI) import options	Cost and availability of imported hydrogen-based iron

Outputs

Parameter	Description
Production volume by technology / mode of operation	Per product (final or intermediate), and per region / location and year.
Material use (including scrap)	Per region and year
Installed capacity by technology	Per region / country / location and year. Can e.g., be used to examine intra-EU relocation/Renewables Pull effect.
Energy use	Per technology, and per region / country / location and year
CO_2 emissions	Per technology, and per region / country / location and year
CO_2 captured and stored	Per country / location and year
Trade flows (HBI, crude steel, finished steel)	Between regions and with non-EU sources

Selected Project References

TRANSItioning towards an Efficient, carbon-Neutral Circular European industry (TRANSIENCE)

Period: 01/2024 – 12/2027
Sponsor: European Commission, Horizon Europe

The project is developing a consistent, fully open-source model ecosystem for the transformation of European industry (MIC3 – Model for European Industry Circularity and Climate Change mitigation) to map and analyse the transition to a climate-neutral, sustainable and circular industry.
https://www.transience.eu/

hyBit – Hydrogen for Bremen's Industrial Transformation

Period: 09/2022 – 02/2026
Sponsor: Federal Ministry of Research, Technology and Space

In the hyBit project, researchers from the Wuppertal Institute and partner institutions are developing transformation pathways for the establishment of a hydrogen hub in Bremen and a North German hydrogen economy, with a focus on industrial applications such as steel production, mobility, logistics and heating. The project investigates how regional hydrogen hubs can be integrated into a supra-regional hydrogen economy, assesses the optimal use of hydrogen in the transformation process and examines the socio-technical and systemic interactions between hub development and the overall energy system.
https://wupperinst.org/p/wi/p/s/pd/2093/

EU Industry Pathways

Period: 08/2025 – 03/2026
Client: Agora Industry

In this project, researchers from Agora Industry, the Wuppertal Institute and the University of Kassel are developing and comparing three transformation scenarios

for the European steel, petrochemical and cement industries with regard to Europe's strategic sovereignty – as well as the potential advantages of a moderate relocation of energy-intensive production steps within Europe.
https://wupperinst.org/p/wi/p/s/pd/2521/

EU-CHINA BRIDGE

Runtime: 01/2024 – 12/2026
Sponsor: European Union, UK Research and Innovation

The EU-CHINA BRIDGE project aims to accelerate the transition toward climate neutrality by fostering collaborative research on industrial decarbonisation, co-developing advanced modelling frameworks for sustainable pathways, and establishing comprehensive emissions data through intensive stakeholder dialogue between Europe and China. In this project, the Wuppertal Institute is developing technology demonstrations, scaling-up paths and technology roadmaps for the European petrochemical and steel sector.
https://www.eu-china-bridge.eu/

KNDE-Update 2024 – Climate-Neutral Germany – From Target Setting to Implementation

Client: Agora Agriculture, Agora Energiewende, Agora Industry, Agora Verkehrswende, Prognos
Period: 01/2024 – 10/2024

Building on the 2021 KNDE – Climate Neutral Germany study, this project provided an updated roadmap for Germany to achieve its 2045 net-zero goals while accounting for recent economic shifts and delays in the transport and building sectors. The Wuppertal Institute used detailed bottom-up modelling to refine industrial scenarios to ensure robust decarbonisation strategies.
https://wupperinst.org/en/p/wi/p/s/pd/2384

Supplementary information

ITOM GitHub code repository: https://github.com/wupperinst/itom
ITOM code documentation: https://itom.readthedocs.io/en/latest/index.html
ITOM Steel model and full documentation: https://zenodo.org/records/15772720

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