Expanding Integrated Assessment Modelling: Comprehensive and Comprehensible Science for Sustainable, Co-Created Climate Action

Decarbonising EU Steel:
Impact of Trade and Industrial Policy

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1 Introduction

IAM COMPACT is a European Union project, funded under the Horizon Europe Research and Innovation programme, with the objective to support the assessment of global climate goals, the collective progress towards them, and the feasibility space in delivering on those goals. The project aims to involve relevant stakeholders in the process to help promote acceptable, robust, and sustainable transitions, as well as to enhance trust on both ends, yielding outputs intelligible in terms of real-world implications and actionable in terms of concrete policy recommendations.

Participatory approaches have been argued to bring a more diverse range of views into the integrated assessment and the energy system modelling process, by building a better understanding of the social context and supporting more inclusive decision-making. In IAM COMPACT, we have designed a Policy Response Mechanism (PRM), a co-creation process that facilitates collaboration among modelling teams and with stakeholders. The PRM dynamically responds to changing policy priorities, aiming for policy relevance, knowledge exchange, and enhanced trust, by providing different layers of inputs and making modelling socially/politically realistic.

Stakeholder engagement in IAM COMPACT is organised into themes (for stakeholders within the European Union (EU)) and regions (for stakeholders outside the EU). The themes and regions were collaboratively determined within the project, with Bruegel coordinating the process. As part of the second PRM cycle, our project team received 46 research questions from stakeholders forming the Policy Steering Groups (PSGs), which were then grouped into seven new modelling studies. After internal discussion among modelling teams, an initial scenario design for each study was agreed and then presented to our Core Working Groups (CWGs), a broader policy audience selected on geographical and sectoral criteria, for discussion and co-design in three separate workshops.

This policy brief is part of the theme "**Modelling Clean Industrial Deal**[1]", which focused on infrastructure investments and steel sector decarbonisation, and produced two modelling studies. The study presented here focuses on steel, both because it is a key sector and because of the availability of modelling tools.

1.1 Motivation

Steel production accounts for 7% of global and 5% of the EU's energy and industrial GHG emissions. In the EU, primary steel production mainly relies on the blast furnace / basic oxygen furnace (BF/BOF) method, which produces 57% of all crude steel[2] and releases about 2.1 tonnes of CO_2 per tonne of finished steel[3]. Meanwhile, 43% of crude steel is created from scrap using electric arc furnaces (EAF)—the secondary steel process—which generates significantly less CO_2 than the BF/BOF method, at only 0.22 tonnes of CO_2 per tonne of finished steel. Less CO_2-intensive primary steel production technologies than the BF/BOF route exist or are on the verge of market introduction. As CO_2 certificate prices in the EU rise and the free allocation of these certificates to the steel industry ends, the financial incentives for investing in low-CO_2 steel production grow. However, the risk of carbon leakage, that is, emission-intensive production being shifted to regions with lower CO_2 prices, increases as well. Additionally, low-CO_2 steel production technologies rely on alternative energy sources such as (green) electricity and (green) hydrogen rather than traditional primary steel production. This shift influences the comparative attractiveness of different locations for steel manufacturing.

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[1] https://iam-compact.eu/news-events/core-working-group-workshop-modelling-clean-industrial-deal.
[2] WV Stahl, Statistisches Jahrbuch der Stahlindustrie 2023 | 2024.
[3] Own calculation based on Zelt et al. (2025).

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Regions with strong renewables potential might gain an advantage, attracting future investments from steel companies ("renewables pull"). Both carbon leakage and the renewables pull effect could cause industrial production to relocate from the EU to other parts of the world. The renewables pull effect may also prompt the movement of iron and steel production within the EU. A key question for policymakers at both the EU and national levels is whether measures to counter carbon leakage and renewables pull should be implemented through industrial and trade policies.

2 Scenario design

2.1 Study outline

We analysed the impacts of different policy measures aiming at the protection or support of the EU steel industry on the EU and regional levels. We conducted a multi-model scenario study that includes various policy measures and analysed their impacts on steel transformation pathways in the EU with associated final energy demand, CO_2 emissions and costs.

Two models were used in this study, which are briefly described in **Box 1**: the global Integrated Assessment Model (IAM), GCAM, and the bottom-up EU steel model, ITOM.

BOX 1: MODEL DESCRIPTIONS

GCAM (Global Change Analysis Model) is a global, partial equilibrium IAM that represents human-Earth dynamics by exploring the behaviour and interactions between the energy system, agriculture and land use, the economy and climate to model GHG emissions, energy use, energy prices, and trade patterns (Calvin et al. 2019). It operates by looking for cost-efficient energy system solutions in a specific period and then moves on to the next time period to repeat the optimisation exercise. GCAM represents supply and demand for one "iron and steel" commodity in each of its 32 regions. In this study, we used GCAM version 7.0, which includes global iron and steel trade, with modifications to socioeconomic pathways and by extending the iron and steel production technologies to 20 technology options. Technology choice in each year is modelled with a logit function based on price and historically calibrated technology preferences. This logit competition allows all available technologies to take some share of the market, preventing winner-take-all behaviour. Demand for iron and steel can be met through a combination of domestic production and imports from a global trade pool.

ITOM (Industry Transformation Optimisation Model) builds on site-specific information of production processes (e.g. capacity and age of assets) and cost-optimises European production networks over several steps of a value chain (i.e., from iron reduction to steel making and steel finishing), considering the spatial layout of the production network and various transport options for intermediary products. Investments are made to meet externally given production levels (differentiated for 13 finished steel products) while considering energy and CO_2 prices as well as a range of constraints (e.g. on scrap availability) (Bilici et al. (2025). The model version used for this exercise differentiates five technologies for iron reduction (BF, BF_CCS, DRI with/without reformer, electrolysis), three technologies for steelmaking (BOF, EAF, SAF_BOF) and 12 technologies for steel finishing. The technologies can be combined to different steel making routes across the production steps. Scrap qualities and steel qualities that result from using scrap of different quality are differentiated in five different categories that are linked to finished steel demand types (i.e. some types of demand require a minimum level of steel quality).

Figure 1 shows that GCAM is used to model steel demand per world region and steel trade between world regions. The main outcome for this study is steel production levels of the EU, depending on the trade scenario (see below). ITOM is used to model the technology mix of steel transformation pathways within the EU and associated CO_2 emissions, energy demand, costs and intra-EU relocation of production. ITOM adopts the EU steel production levels from GCAM as an exogenous driver and, in addition, uses electricity, hydrogen, biomass, natural gas, coal and CO_2 costs resulting from GCAM.

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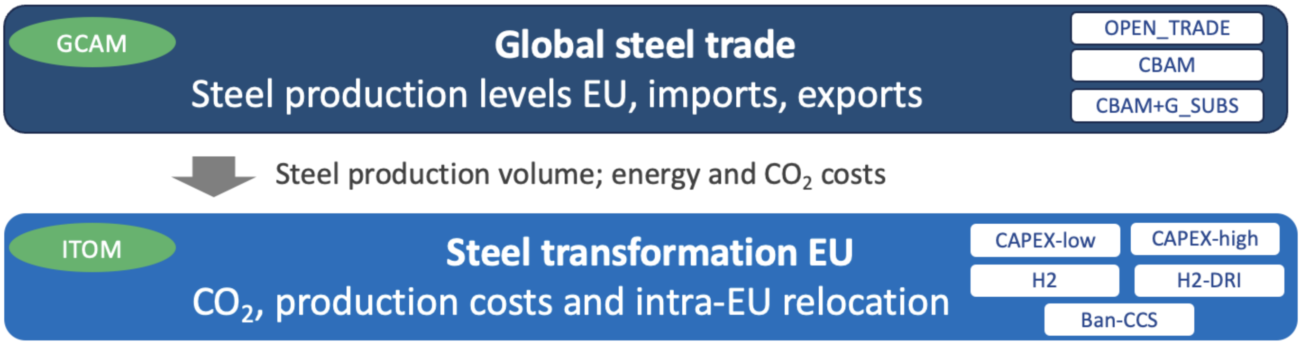

Figure 1: Workflow of the study, including scenarios and models used at each stage**.**

For the analysis of steel production levels of the EU with GCAM, we analysed three scenarios. All of these scenarios are based on the same context scenario, which describes a world in which all countries implement all the current climate policies and achieve the GHG emissions reduction targets aimed at in their respective NDCs up to 2030. After 2030, the long-term targets of countries, including net-zero strategies of major economies, are included as a linear pathway from the 2030 NDC target. The context scenario leads to a temperature increase of 1.7-1.8 °C above pre-industrial levels in 2100 (van de Ven et al. 2023).

2.2 Scenario design

Against this background scenario, three scenarios are defined that differ with respect to the protection or support of the EU steel industry. These scenarios were modelled using GCAM:

- **OPEN-TRADE** scenario: includes no specific steel-related (or energy-intensive industry-related) policy interventions. All countries interact in a global market, setting boundary conditions and implementing policies that enable them to achieve climate goals as defined in the context scenario. The countries leave it to the market to decide where steel is produced and with which technologies. The regionally different CO_2 and energy prices affect the steel industry, which leads to the global relocation of steel production.
- **CBAM** scenario: identical to the OPEN-TRADE scenario except that the EU introduces a Carbon Border Adjustment Mechanism (CBAM) with the aim to create a level playing field for its steel industry, which faces comparably high CO_2 costs compared to other world regions, on the European market and to prevent carbon leakage. Technically speaking, the CBAM is represented by introducing three steel categories: low-carbon, medium-carbon, or high-carbon[4]. High- and medium-carbon steel imports have to pay CO_2 prices based on the CO_2 prices in the EU's Emissions Trading System (ETS), the status of the CBAM phase-in and the average CO_2 footprint of steel in the respective steel category. Low-carbon imports do not receive any CBAM pricing.
- **CBAM+G_SUBS** scenario: the same as the CBAM scenario, except that the EU offers subsidies for low-carbon primary steel production. In this scenario, this is achieved by reducing CAPEX for low-carbon primary steel, with a 30% decrease before 2030, 20% in 2035, and 10% in 2040.

[4] Technologies with emissions greater than 1.37 tCO_2/t steel are classified as high-carbon, those with emissions between 0.59 and 0.79 tCO_2/t steel are classified as medium-carbon, and all other technologies (having emissions below 0.37 tCO_2/t steel) are low-carbon.

3 Results

3.1 Energy and CO_2 prices (GCAM)

GCAM endogenously calculates EU averages of energy costs and CO_2 prices for the EU steel industry, which greatly influence the scenario and are also used as exogenous data inputs by ITOM. Table 1 displays the main cost factors for the CBAM+G_Subs scenario[5]. For those energy carrier prices required by ITOM at the member state level, the table also includes minimum and maximum values across member states. These member state prices are derived from EU average values (from GCAM) and additional considerations explained in Holtz et al. (2025)[6]. Note that the prices shown for CO_2 certificates are the effective (average) CO_2 prices for steel producers, considering the phase-out of free allowances during CBAM phase-in and a shift in the baseline used for granting free allowances[7].

Table 1: Energy and CO_2 prices.

	2020	2025	2030	2035	2040	2045	2050
Elect. (€/MWh) (Min / Max in MS)	115 (51/233)	104 (66/170)	83 (55/106)	92 (61/137)	85 (57/127)	73 (49/109)	60 (40/89)
Natural gas (€/GJ) (Min / Max in MS)	7.7 (5.7/14.6)	9.4 (7.1/18)	8.6 (6.5/16.4)	9.4 (7.1/18)	9.1 (6.8/17.4)	8.7 (6.5/16.6)	8.5 (6.4/16.2)
Coal (€/GJ)	2.5	3.4	2.4	3.0	3.0	3.2	3.2
Hydrogen (€/GJ) (Min / Max in MS)	-	-	32.7 (24.5/40.9)	22.6 (19.2/26)	22.0 (19.8/24.2)	19.4 (17.4/21.3)	16.6 (14.9/18.2)
CO_2 effective avg. costs (€/t CO_2)	2.6	17.3	105	234	240	273	311

3.2 Steel production levels of the EU27 (GCAM)

From 2020 to 2030, EU steel production in the EU drops significantly, by 19% in the OPEN-TRADE scenario and by 7-8% in the scenarios with CBAM (**Figure 2**). Exports decrease in all scenarios by 20-32%, which can be explained by EU steel producers being affected by rising (effective) CO_2 costs while steel producers in other world regions do not face such additional costs. The difference in production levels between scenarios, however, results mostly from different levels of production for the domestic EU market. In the OPEN-TRADE scenario, imports replace about 17 Mt of domestic production of finished steel, while in the scenarios with CBAM, the reduction in

[5] The values are very similar for the other two scenarios.

[6] Electricity prices are based on the average prices from GCAM but varied per country based on a pattern of differences between marginal electricity costs of EU member state. The latter was derived from data from ACER (2020) for 2019 in combination with analyses conducted with the EXPANSE model for three scenarios on the energy crisis conducted in IAM COMPACT, each run by three IAMs (D4.5 "National, regional, global mitigation pathways"; Sasse & Trutnevyte 2023). The results of the EXPANSE model were used for 2035 onwards while 2025 and 2030 have been linearly interpolated between 2020 and 2035, for each country. Hydrogen prices for ITOM are derived based on average hydrogen prices of the EU as calculated by GCAM and varied between countries according to the same pattern as electricity prices. However, deviations from the EU average hydrogen price are capped by a maximum deviation of 25% in 2030, 15% in 2035 and 10% from 2040 onwards, assuming that a growing hydrogen infrastructure provides possibilities for hydrogen imports and exports and an according reduction of price spreads. The spread of prices for natural gas around the EU average is taken from Eurostat data (average for the years 2023 and 2024) and kept constant over time. The years 2023 and 2024 are chosen to reflect the changed pattern of EU gas purchases since the Russian war on Ukraine.

[7] Based on announcements for DRI plants according to the Green steel tracker (https://www.industrytransition.org/green-steel-tracker/) and the rule that the amount of allowances is calculated from the best-performing 10% of plants in the EU it has been estimated that free allowances cover 55% of CO_2 emissions in 2025 and 40% of CO_2 emissions of the steel industry in 2030. From 2035 onwards no free allowances are provided.

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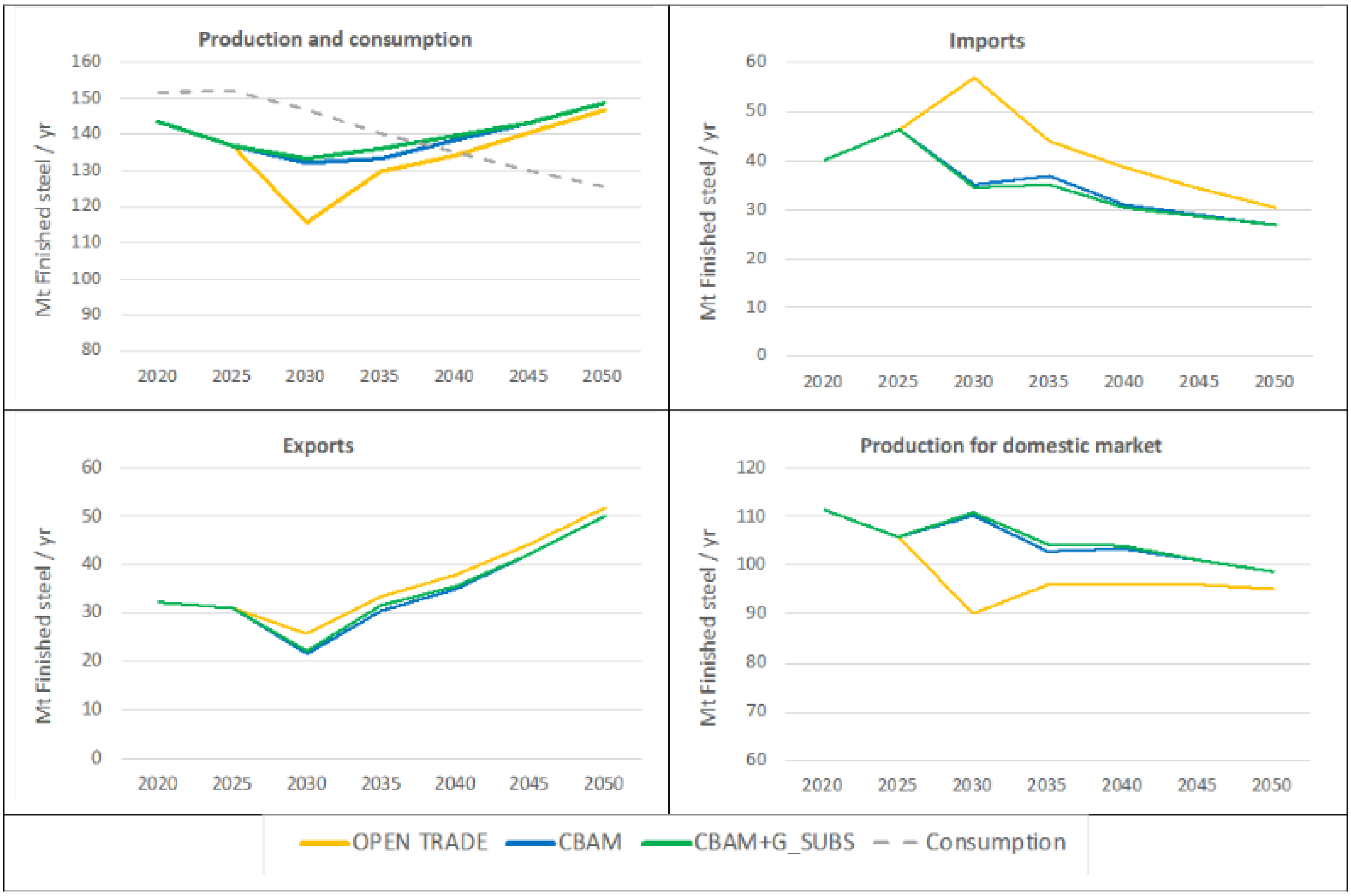
production for the domestic market is in line with overall consumption decline. In all scenarios, exports increase again from 2030 onwards, when CO_2 prices in other world regions become effective. After 2040, the EU even becomes a net exporter of steel (i.e. steel production exceeds consumption). The competitiveness of the EU steel industry in the long term is mainly achieved by making use of (domestic) scrap and low-cost electricity for the cost-competitive production of secondary steel, which by 2050 covers around 70% of EU steel production, according to GCAM.



(Note: production for domestic market = Production – Exports)

Figure 2: EU27 steel production, consumption, exports, imports and production for domestic markets, according to GCAM.

3.3 Steel transformation pathways in the EU

The scenario work used steel production volumes as well as energy and CO_2 prices of the *CBAM+G_SUBS* scenario (see above) as inputs to ITOM and analyses the technological transformation pathway on the EU-level, relocation of iron and steel production between EU regions, CO_2 emissions, and average crude steel production costs. Some additional constraints were defined, as outlined in **Box 2**. Then, various model experiments are conducted to explore additional policy measures for steering the steel transformation and to analyse their effects.

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BOX 2: Constraints applied in ITOM modelling

DRI-bio+CCS: Negative emissions from the use of biomass in shaft furnaces for DRI production in combination with CCS are remunerated at the level of CO_2 certificate costs (see table 1). As a result, this route is very competitive. To assure that biomass use does not exceed biomass availability, total biomass use in ITOM was harmonized with biomass use of the steel industry according to GCAM.

Electrolysis: Techno-economic parameters of electrolysis as they are available today suggest that this technology is very competitive – in particular for molten oxide electrolysis (MOE). Because the technology has a comparably low TRL and uncertainties about its future performance remain, the upscaling of this technology has been limited manually.

HBI imports: Costs for the import of hot-briquetted iron (HBI) from global markets are highly uncertain from today's perspective. In the scenarios modelled with ITOM, the imports of HBI were limited to green HBI with prices based on expected H_2-costs in Australia and Brazil and the amount was manually limited.

Scrap: Available scrap per quality is limited based on a material-flow scenario. Scrap is allocated endogenously by ITOM between scrap use in primary routes and for secondary steel production.

3.3.1 Iron and steel transformation pathway: CO_2 emissions and production costs (ITOM)

Figure 3 shows the resulting transformation of crude steel and iron production in the EU27. It can be observed that primary steel production is primarily done via the DRI-route and electrolysis from 2035 onwards. The share of secondary steel increases significantly from 51% in the year 2020 to 66% in the year 2050, with an intermediate peak of 70% in the year 2035 (top left). Iron production drops until 2035 to about 60% of the 2020 level and remains on this lower level even when steel production recovers in the long term to 2020 levels (top right). The scenario thus suggests that future steel demand can be met with a significantly smaller amount of reduced iron. The key element to achieve this is making use of (domestic) scrap. The upscaling of electrolysis-based primary production, which does not involve iron production as an intermediate step, supports this decoupling. From 2035 onwards, iron is mainly provided by the DRI routes, with around 60% of the domestic iron production using natural gas as reducing gas, while bio-syngas has a share of around 25%. The import of HBI starts in 2035 and complements domestic production of iron. Blast furnaces equipped with CCS play some role until 2045 and are then replaced by hydrogen-based DRI and higher imports (top right). The CO_2 emissions drop significantly in the period from 2025 to 2035, due to the swift shift to secondary steel and low-carbon primary routes. The bio-based DRI-route in combination with CCS creates negative emissions and as a result the EU steel industry is almost CO_2-neutral by 2035, already. When the energy provision for hot-rolling from natural gas is gradually replaced by hydrogen and electricity after 2035 and the associated CO_2 emissions of hot-rolling are avoided, the net emissions of the EU27 steel industry even become net-negative around 2045 (bottom left). The average costs of the production of finished steel in the EU27 increase from 524 €$_{2020}$ / t finished steel to around 620 €$_{2020}$/t in the long-term, with an intermediate peak of 674 €$_{2020}$/t in the year 2035. The main part of the long-term increase results from higher energy costs. In the medium term around the year 2030 CO_2 certificate costs play a significant role, before the steel industry switches to low-carbon production routes and negative emissions generate some revenues. Material costs remain comparably stable in the scenario, but CAPEX and OPEX increase in the mid-term when new plants are built while existing plants have not yet reached the end of their lifetime (bottom right).

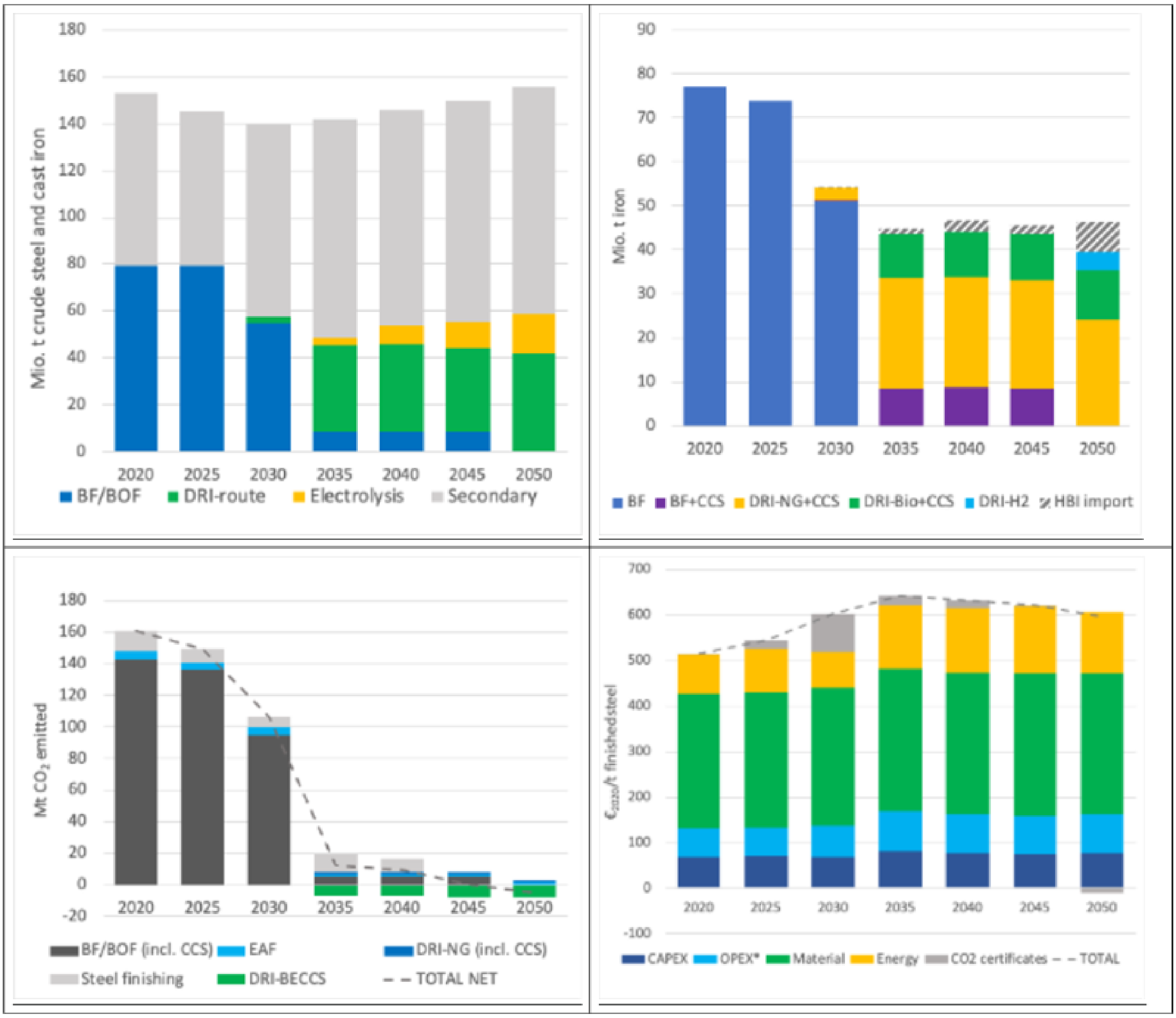

Figure 3: EU27 crude steel production (top left), iron provision (top right), CO_2 emissions (bottom, left) and specific steel production costs (bottom right) for the baseline scenario modelled with ITOM

3.3.2 Relocation of iron and steel production (ITOM)

While the transformation unfolds, iron and steel production partly re-locate within the EU27 (**Figure 4**). With regards to iron production (**Figure 4** top), most blast furnaces in established steel regions such as Germany (DE), BeNeLux and EU_East are shut down, while DRI production is being build-up where local energy (electricity, natural gas, hydrogen) prices make this most competitive, in particular in Northern Europe and Southern Europe. The picture is similar but less pronounced for crude steel production (**Figure 4** bottom)[8]. The difference between iron and steel results from regions with decreasing iron production increasing their secondary steel production, importing HBI, or establishing MOE steel production (which does not require pig iron production as an upstream production step).

[8] While ITOM covers techno-economic aspects that are in favour of established iron and steel production sites – such as energetic synergies between iron making, steel making and steel finishing as well as transport costs to markets in central Europe – it should be noted that the model does not cover "soft" factors such as established business relationships and trust that may counteract relocation tendencies.

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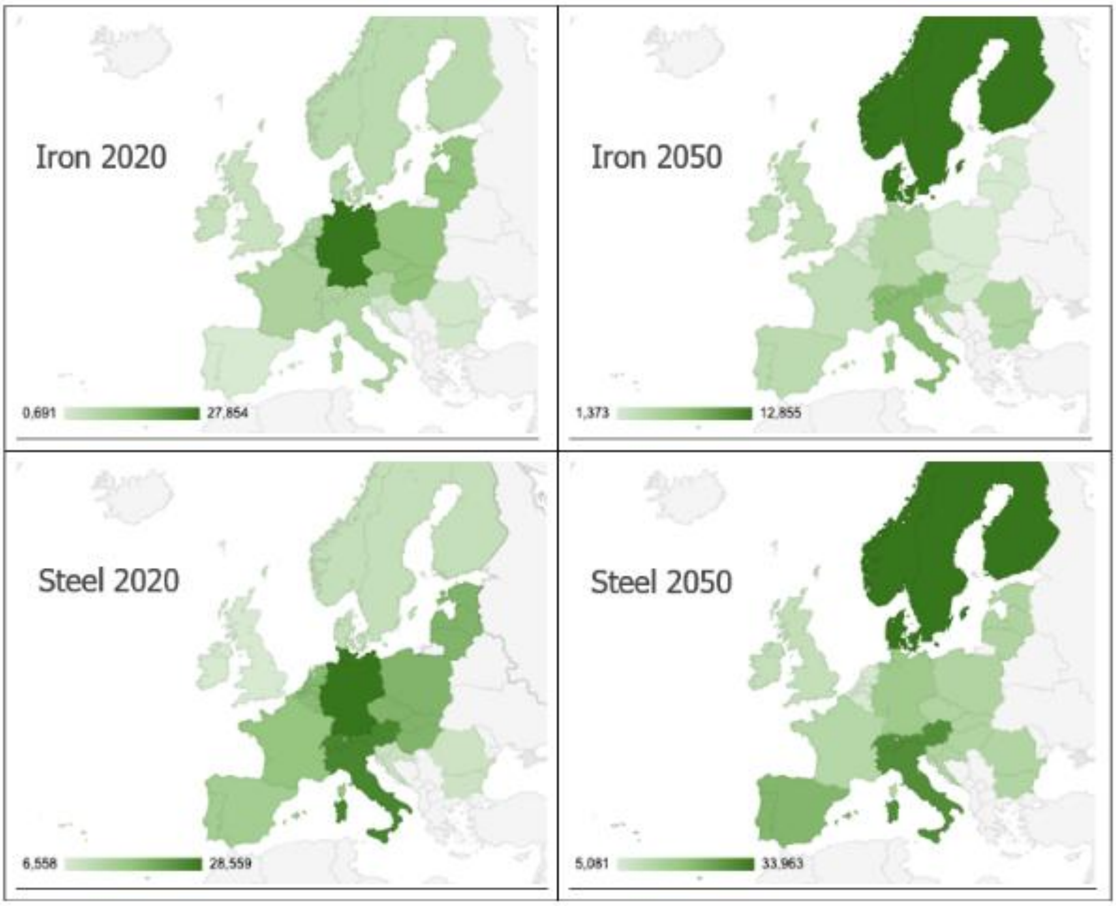

Figure 4: Iron production (top) and crude steel production (below) per region for the years 2020 (left) and 2050 (right).

4. Additional policy measures

On top of that scenario, five policy measures were modelled and compared with each other. First, the measures aim to accelerate the transformation towards low-carbon steel further. Second, the strong reliance of the baseline scenario on the capture and storage of fossil CO_2 for a production process for which renewables-based alternatives exist (bio-/hydrogen-based DRI and electrolysis) may be questioned for reasons of unaccounted upstream emissions associated with the use of coal and natural gas (e.g. methane leakage) and the use of CO_2 storage and injection capacities which may be needed for carbon dioxide removal from the atmosphere (through BECCS) or so-called unavoidable[9] emissions from processes for which there are currently no renewable alternatives. A second objective, therefore, is a shift from fossil-CCS to renewables-based steel production.

The policy measures are as follows:

1. **GSUBS_Capex-low:** This scenario examines the impact of CAPEX subsidies for DRI plants, offering a phased reduction of investment costs from 30% in 2030 to 10% in 2040 to stimulate early adoption. Subsidies are focused on DRI plants, as these are the most competitive in the long term (Table 2) and, in the case of H2-DRI and NG-DRI+CCS, have lower residual CO_2 emissions compared to BF/BOF+CCS.
2. **GSUBS_Capex-high:** This ambitious scenario investigates the effects of substantially higher CAPEX subsidies for DRI plants (90%) around 2030, designed to provide a stronger, more immediate financial incentive for early transformation.
3. **GSUBS_H2:** Here, the focus shifts to reducing operational burdens for new technologies through the provision of low-cost green hydrogen to the steel industry. 134 PJ/year of hydrogen are provided to the EU27+UK steel industry at low costs in the time periods 2030 to 2040 (2030: 15€/GJ, 2035: 12€/GJ, 2040: 11€/GJ). The subsidised amount of hydrogen is (in principle) sufficient for producing 20 Mt of H2-DRI per year.
4. **GSUBS_H2-DRI:** This variant refines the hydrogen subsidy by restricting its application exclusively to the production of DRI, ensuring targeted support for a key decarbonisation pathway.
5. **BanOf_FossilCCS:** In this measure, the capture and storage of fossil CO_2 is not permitted.

These measures were compared with each other as shown in **Table 2**, using the following indicators:

- **Direct CO_2 emissions avoided:** Reduction of direct CO_2 emissions in the period 2020 – 2050, compared to the baseline case described above.
- **Upstream emissions avoided:** Reduction of upstream emissions from the use of coal and natural gas, which are outside the system boundary, such as from mining and transport.
- **CO_2 storage capacity saved**: Reduction of the storage of fossil CO_2 in the period 2020 to 2050, compared to the baseline described above.
- **CO_2 avoidance costs**: the sum of subsidies provided in the period 2020 to 2050 divided by the direct CO_2 emissions avoided.
- **Costs of steel**: average decrease or increase of specific finished steel production costs in the period 2020 to 2050, compared to the baseline scenario.
- **Subsidies in EU27**: The amount of subsidies provided through additional policy measures.
- **Iron relocation**: percentage of iron production in the year 2050 that has been relocated to another EU region. This is calculated by comparison to the year 2020, taking into account reduced production volumes of the EU 27 steel industry (the overall reduction on the EU level is not included in the calculation of intra-EU relocation). For comparison: the intra-EU relocation in the baseline scenario (**Figure 4**) is 29%.

[9] The definition of "unavoidable" is not completely sharp but typically refers to emissions from cement and lime production and to emissions from waste incineration plants.

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- **Steel relocation**: Similar to iron relocation but focusing on crude steel. For comparison: the intra-EU relocation in the baseline scenario (**Figure 4**) is 23%.

Table 2: Comparison of effects of policy measures.

	Direct CO2 Emissions avoided (Mt CO2)	Upstream Emissions avoided (Mt CO2eq)	CO2 storage capacity saved (Mt CO2)	CO2 avoidance costs (€/t CO2)	Costs of steel (relative to baseline)	Subsidies in EU 27 (Mio €)	Iron relocation (% of production)	Steel relocation (% of production)
GSUBS_Capex-low	40	2.6	45	83	-0.7%	3'316	25%	24%
GSUBS_Capex-high	116	7.1	72	145	-1.0%	16'773	26%	23%
GSUBS_H2	67	10.9	34	226	-0.6%	15'115	27%	23%
GSUBS_H2-DRI	47	24.4	159	115	0.5%	5'843	37%	24%
GSUBS_BanOfFossilCCS	41	12.3	350	0	2.7%	0	51%	25%

The most effective policy instrument is the provision of high CAPEX[10] subsidies in the 2030 time period, but this instrument involves comparably high CO_2 avoidance costs of 145€/t CO_2 and the highest amount of public spending for support measures (16.7 billion €). According to the modelling results, the provision of lower CAPEX subsidies over a more extensive time period is among the most efficient instruments, in terms of CO_2 avoidance costs (€83€/t CO_2) and public spending (3.3 billion €). At the same time, it is the least effective option for CO_2 reduction, resulting in only 40 Mt of direct CO_2 emissions avoided.

Untargeted hydrogen support in the period 2030-2040 has the highest CO_2 avoidance costs and includes high volumes of subsidies but does not stand out as being most effective in terms of emissions avoidance or saving CO_2 storage capacities. Under this measure, subsidised hydrogen is used by the EU27 steel industry almost entirely for hot-rolling. This was not anticipated during scenario design but is understandable from a comparison of cost savings achieved when using 1 GJ of subsidised hydrogen for H2-DRI, compared to using it for hot-rolling: cost savings from using hydrogen for hot-rolling include avoided costs for natural gas (5 to 18 €/GJ) and associated CO_2 certificate costs (13 to 18 €/$GJ_{\text{natural gas}}$ in the period 2035 to 2050). Cost savings when using hydrogen for H2-DRI can be defined as the cost difference to the otherwise cheapest route normalised to 1 GJ hydrogen used – which is 7 €/GJ_{hydrogen}, at maximum. Subsidies for hydrogen use targeted to the DRI route feature moderate CO_2 avoidance costs (115 €/t CO_2) and public spending (5.8 billion €) and achieve a strong effect on saving CO_2 storage capacity and on avoiding upstream emissions.

The scenario with a ban on fossil CCS (by design) has the by far strongest influence on saving CO_2 storage capacity. It features no additional costs for public authorities but comes with significantly increased production costs of steel. The effects on avoided direct emissions are small in the period 2020 to 2050, with highly divergent effects over time: while CO_2 emissions are higher compared to the baseline around 2030 (because hydrogen-based steel production is not competitive yet, and therefore unabated fossil production is prolonged), it favours hydrogen-based production in the longer term and avoids residual emissions of CCS-based routes.

All scenarios feature a similar level of relocation of crude steel production between EU regions as in the base case (**Figure 4**). Regarding iron production, the ban on fossil CCS – and to a lesser extend hydrogen support targeted to DRI production – create a stronger tendency for relocation to regions with lower renewable costs, compared to the other scenarios.

[10] With regards to CAPEX subsidies it should be noted that ITOM assumes the same CAPEX in all modelled years. The costs and subsidies hence refer to "nth-of-a-kind" technologies. In reality, CAPEX subsidies are typically provided to reduce high costs of "first-of-a-kind" technologies. This case is not covered by the modelling exercise.

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5. Conclusion and Policy Implications

CBAM is an effective instrument to mitigate carbon leakage.

The analysis of GCAM scenarios shows that the divergent climate ambitions in global regions until 2030 reduce the competitiveness of the EU steel industry and lead to significantly reduced production levels in the time period around 2030, if no policy measures are implemented. The analysis furthermore shows that CBAM is an effective measure to soften these impacts on the EU steel industry and to limit imports of (high carbon) steel to the EU market. CBAM instead increases the EU production of (low carbon) steel for the domestic market. However, it has no effect on EU exports and thus cannot completely circumvent production losses.

Competitive renewable energy prices secure EU steel production in the long-term.

The analysis with GCAM also suggests that the EU steel industry becomes competitive (again) in the long term and production levels increase to 2020 levels, independent of policy support. This is facilitated by increasing CO_2 prices in other global regions and is achieved by producing low-carbon steel in the EU and exporting it to other global regions. It should be noted, however, that the competitiveness of low-carbon steel production in the EU is (in the scenario) mostly achieved through high levels of secondary steel production and competitive electricity prices due to support for renewable energy.

An increasing CO_2 price is the main instrument to foster the transition to low-carbon steel.

The analysis of EU transformation pathways with ITOM shows that the scenario induces a swift switch to low-carbon steel making even without additional policy instruments. The main driver is the effective CO_2 price, which combines the effects of increases in the EU ETS-1 price, the phase-out of free allowances during the phase-in of CBAM, and a shift in the baseline based on which free allowances are granted as a result of the implementation of the first low-carbon primary steel plants. This effective CO_2 costs increase steeply in the time period until 2035 and make unabated iron and steel production uncompetitive. In addition, electricity prices continuously drop from 2020 to 2050, which improves the competitiveness of production routes with high electricity demand such as the DRI-EAF routes and secondary steel.

Additional policy measures allow to steer the transformation according to preferences.

In such a context, the considered additional policy instruments have only small impact on (additional) CO_2 emissions reduction. The additional reduction of the cumulative emissions of the EU27 steel industry in the period from 2020 to 2050 vary from 2% to 6% between policy instruments, compared to the base case. But CO_2 avoidance costs, avoided upstream emissions, costs of steel, public spending, CO_2 storage saved and relocation (within Europe) vary strongly, dependent on the policy measure. Additional policy measures, hence, allow to shape the transformation according to policy preferences. For example, the ban of fossil CCS and the targeted support for H2-DRI are effective in avoiding fossil-CCS and in saving CO_2 storage and injection capacities for unavoidable emissions and negative emissions.

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The need for renewable energy can be reduced through making use of scrap.

The ITOM scenario also shows that steel production and iron production can be decoupled to some extent over time and that future steel demand can be met with a significantly lower amount of reduced iron. This implies a reduced demand for (renewable) energy. The key element for achieving this decoupling of steel production from iron reduction is making use of (domestic) scrap. This strategy mitigates the use scarce resources such as renewable energy and CO_2 storage capacities while it does not rely on imports of DRI for the strategically important steel production.

Relocation of iron and steel production within the EU is cost-effective.

Relocation of iron and steel production within the EU is a prominent feature in all scenarios developed with the (cost-optimising) ITOM. Iron production is relocated when coal-based blast furnaces are shut down and DRI capacity is built where the costs of energy carriers required for the DRI routes (hydrogen, natural gas, electricity) are favourable. The picture is similar but less pronounced for steel production, where closeness to target markets is more important.

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IAM COMPACT

Policy Brief

Decarbonising EU Steel: Impact of Trade and Industrial Policy

In a nutshell

IAM COMPACT supports the assessment of global climate goals, progress, and feasibility space, and the design of the next round of Nationally Determined Contributions (NDCs) and policy planning beyond 2030 for major emitters and non-high-income countries. It uses a diverse ensemble of models, tools, and insights from social and political sciences and operations research, integrating bodies of knowledge to co-create the research process and enhance transparency, robustness, and policy relevance. It explores the role of structural changes in major emitting sectors and of political, behaviour, and social aspects in mitigation, quantifies factors promoting or hindering climate neutrality, and accounts for extreme scenarios, to deliver a range of global and national pathways that are environmentally effective, viable, feasible, and desirable. In doing so, it aligns climate action with broader sustainability goals, while developing technical capacity and promoting ownership in non-high-income countries.

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