# *THE IMPACT OF DECARBONISNG THE IRON AND STEEL INDUSTRY ON THE $CO_2$ EMISSIONS OF THE EUROPEAN POWER SYSTEM*

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## Overview

The decarbonization of the European iron and steel industry (ISI) will play an important role in the European Union (EU)'s ambitions to become climate neutral by 2050 as the sector currently contributes to 6% of European $CO_2$ emissions. To meet the challenging $CO_2$ emission reduction targets, new technologies and production processes will transform the industry. These processes, at different development stage, often entail a higher degree of electrification. Furthermore, where hydrogen may be used as fuel and feedstock, electrolysis may contribute to an even larger demand for (clean) electricity.

The interest shown by major European steelmakers in deploying full-scale low-carbon iron and steel manufacturing technologies by 2030, in particular on the hydrogen-based direct reduction of iron technology (DRI-EAF-H2), intensifies electricity and hydrogen ($H_2$) demand already in the short-term. This poses additional strain on a transitioning power sector still focusing on increasing and integrating its share of renewable power production. The accelerated electrification of the ISI, if not appropriately supported by low-carbon power generation, risks to be counter effective. In fact, if on the one hand the emissions directly generated by the industry – i.e., direct emissions – will decrease with the deployment of low-carbon manufacturing technologies, on the other hand, there is a risk of incrementing power system emissions – i.e., indirect emissions – if the additional demand for electricity and electrolytic $H_2$ is supplied by fossil-based sources. Therefore, in this study we aim at assessing how the transition of the ISI will affect the European power system in 2030 by answering the following research question: *how does the short-term transition to a low-carbon ISI affects the European power system CO2 emissions?*

## Methods

To answer the research question, some scenarios are developed that reflect different rates of deployment of low-carbon steel making technologies by 2030. The 2030 steel production by country and technology is estimated based on specific assumptions on steel production levels, scrap availability for recycling and low-carbon technology deployment, building on announced projects by European steel makers, specific assumptions on relining of technologies, reinvestment cycles and avoidance of stranded assets. The steel scernarios derived – *Base*, *Pace* and *Accelerated* – are compared to a *Reference* scenario that reflect the development of the steel sector foreseen by the POTEnCIA[1] Central Scenario, which describes the evolution of the EU energy system with the assumption of no further policies introduced beyond 2017. Once defined the production levels, the corresponding energy demand per electricity and hydrogen are calculated using country and technology specific data retrieved from the IEA World Energy Balances.

The energy demand for each scenario is used as input to the model METIS. METIS is a linear programming model which has been used in policy-oriented studies on several energy system transition topics. The model focuses on the short term operations of energy systems and markets of each EU member states and relevant neighbouring countries under multi-years weather profiles. The scenarios for the European ISI in 2030 are applied in the context of the MIX-H2 scenario of the Fit-for-55 package of the European Commission. Two series of computations are performed: first, a serie simulating the unit commitment and economic dispatch problem with natural gas prices as foreseen by MIX-H2 – i.e., *low* – and with natural gas prices six times higher – i.e., *high* – so to encompass the uncertainties of the European energy crisis. Second, a serie simulating the unit commitment and economic dispatch problem while simultaneously allowing the expansion of renewable generators.

[1] The Policy-Oriented Tool for Energy and Climate change Impact Assessment (POTEnCIA).

## Results

The three scenarios developed forsee a reduction of production level by the highly polluting blast furnace-basic oxygen furnace (BF-BOF) route of 20%, 28% and 65% compared to current production, for *Base*, *Pace* and *Accelerated*, respectively. This reduction is partly compensated by an increased use of recycled steel in the scrap-EAF route, BF-BOF with carbon capture (CCUS). But production is mainly replaced by the DRI-EAF technology, which is, in *Base*, partly supplied by natural gas while in *Pace* and *Accelerated* is exclusively supplied by $H_2$. Compared to the *Reference* scenario, the high share of low-carbon steelmaking foreseen by *Base*, *Pace* and *Accelerated* rises yearly electricity consumption by 15%, 20% and 39%, respectively. Most importantly, $H_2$ yearly demand for the steel sector rises from 0 PJ in *Reference* to about 30 PJ, 145 PJ and 300 PJ in *Base*, *Pace* and *Accelerated*, respectively, which also contributes to an increase in electricity demand if this is supplied as electrolytic $H_2$.

Results of the first serie of computations performed with METIS show that an increase of electricity demand by the steel sector leads to increased $CO_2$ emissions by the European power system between 10 $Mt_{CO2}$ to 18 $Mt_{CO2}$ with *low* natural gas prices and 12 $Mt_{CO2}$ to 38 $Mt_{CO2}$ with *high* natural gas prices. In both cases, fossil-based generators provide most of the additional electricity demand, with natural gas being the largest supplier when prices are *low*, and coal and lignite contributing the most when natural gas prices are *high*. In *Pace* and *Accelerated*, the increase of indirect emission allocated to the ISI are justified by a larger decrease of direct emissions. In fact, in these scenarios the overall – i.e., direct and indirect – emissions reduction compared to *Reference* ranges from 4% to 40%. On the contrary, overall emissions increase in *Base* by up to 6% due to a more limited emission reduction potential of some of the technologies foreseen by this scenario – i.e., natural gas-based DRI-EAF. Results from the second serie of computations performed show that, by allowing the expansion of 20 GW to 100 GW of renewable generators, the increment of indirect emissions remains under 10 $Mt_{CO2}$ for all scenarios. All scenarios entail an overall $CO_2$ emissions reduction, with decrements from 2% in *Base* to 45% in *Accelerated*.

## Conclusions

This study assesses the impact of the European ISI transitioning towards low-carbon steelmaking on the indirect $CO_2$ emissions generated by the power system. In fact, the ISI low-carbon transition entails a large degree of electrification and, if on the one hand direct emissions from the sector can be strongly reduced, on the other hand the indirect emissions from power supply may increase. The research finds that a transition of the ISI in 2030 in the context of the MIX-H2 scenario of the Fit-for-55 package, increases power system emissions because it leads to a larger use of fossil-based power generators. In the one scenario foreseeing the deployment of the natural gas-based DRI-EAF technology, direct emissions reduction are lower than the increase of indirect emissions, leading to an overall increase in $CO_2$ emissions. The other scenarios, on the other hand, forsee a very large direct emissions reduction, resulting in an overall positive $CO_2$ emissions reduction. An expansion of renewable capacity allocated to the sector can further lessen indirect emissions. This study aims at emphasising the necessity of for the ISI and the power sector to align their decarbonisation targets during the trasnsition to a fully decarbonised system. A collaborative and integrated approach is key.