Transformation Paths for the Steel Industry in Germany

Non-technical version of the study

Source: iStock – Petmal

prognos
Wir geben Orientierung.

Transformation Paths for the Steel Industry in Germany

Non-technical version of the study

By
Jan Limbers
Dr. Michael Böhmer
On behalf of
German Steel Federation
(Wirtschaftsvereinigung Stahl)
Date of completion
February 2022

About us

Prognos – providing orientation.

For over 60 years, Prognos has provided clients from enterprises, political institutions, and civil society with a sound foundation for decision making. This is achieved by independent research, consulting, and diagnosis. With our robust research, dependable reports, and competent expert opinions, we at Prognos support clients from the public and private sectors in developing future-proof strategies.
Our inter-disciplinary project teams comprised of dedicated economists, geographers, engineers, mathematicians, sociologists, and logistic researchers work in unison which ensures a constant ongoing exchange between our seven consulting fields: Economy & Labour, Society & State, Location & Region, Technology & Innovation, Energy & Climate Protection, Infrastructure & Transportation, and Management Consulting.

CEO
Christian Böllhoff

President of the Board
Dr. Jan Giller

Commercial Register Number
Berlin HRB 87447 B

VAT-ID
DE 122787052

Legal form
Joint stock company (AG) under Swiss law

Founding year
1959

Working languages
English, German, French

Headquarter

Prognos AG
St. Alban-Vorstadt 24
4052 Basel | Switzerland
Tel.: +41 61 3273-310
Fax: +41 61 3273-300

Further locations

Prognos AG
Goethestr. 85
10623 Berlin | Germany
Tel.: +49 30 5200 59-210
Fax: +49 30 5200 59-201

Prognos AG
Domshof 21
28195 Bremen | Germany
Tel.: +49 421 845 16-410
Fax: +49 421 845 16-428

Prognos AG
Résidence Palace, Block C
Rue de la Loi 155
1040 BrusselsI | Belgium
Tel: +32 280 89-947

Prognos AG
Werdener Straße 4
40227 Düsseldorf | Germany
Tel.: +49 211 913 16-110
Fax: +49 211 913 16-141

Prognos AG
Heinrich-von-Stephan-Str. 17
79100 Freiburg | Germany
Tel.: +49 761 766 1164-810
Fax: +49 761 766 1164-820

Prognos AG
Hermannstraße 13
(C/O WeWork)
20095 Hamburg | Germany
Tel.: +49 40 554 37 00-28

Prognos AG
Nymphenburger Str. 14
80335 Munich | Germany
Tel.: +49 89 954 1586-710
Fax: +49 89 954 1586-719

Prognos AG
Eberhardstr. 12
70173 Stuttgart | Germany
Tel.: +49 711 3209-610
Fax: +49 711 3209-609

info@prognos.com | www.prognos.com | www.twitter.com/prognos_ag

Table of contents

List of figures

1 Climate policy challenges of the steel industry

As a basic industry at the beginning of value chains, the steel industry is one of the core sectors of the German economy. Its products are used as intermediate inputs in many other sectors such as vehicle construction or mechanical engineering, but also in the construction industry.

With the technology used so far, the blast furnace-converter route, the production of primary steel is associated with the emission of considerable amounts of carbon dioxide (CO2). Both the German federal government and the European Union have set themselves the goal of gradually reducing greenhouse gas emissions (GHG emissions) in all sectors of the economy and of causing no further net GHG emissions from the year 2045 (Germany) or 2050 (EU). This means that the steel industry in Germany is also faced with the task of transformation to GHG neutrality.

In the year 2021, climate policy goals were tightened at both national and European level and corresponding packages of measures were specified or expanded. At the national level, for example, the German Federal Government decided to reduce GHG emissions more quickly: By 2030, a reduction of emissions by 65 percent compared to 1990 is planned (previously 55 percent), and by 2045, Germany is to be climate neutral (previously 2050). On July 15th, 2021, the European Commission presented a legislative package with proposals to successfully transform the European economy towards climate neutrality ("Fit for 55"). Although the legislative package is currently still at the consultation stage, the main cornerstones of the EU's future climate action policy are nevertheless becoming clear.

From the steel industry's point of view, central components of the "Fit For 55" package are, on the one hand, the revision of the EU Emissions Trading System Directive. This provides for an increasing reduction in the previously free allocation of emission certificates for the steel industry and their complete abolition by the year 2035. On the other hand, the introduction of a Carbon Border Adjustment Mechanism (CBAM) on imports from third countries is intended to ensure cost parity for emission-intensive products on the European domestic market.

Steel companies in Germany have been planning for several years to implement the climate targets. To this end, the primary steel production is to be converted to low-CO2 and, in the future, CO2-free production processes based on hydrogen, the so-called hydrogen direct reduction process (H2-DRI).[1] The steel action concept formulates the goal of converting one third of production capacity to hydrogen direct reduction by 2030 (cf. BMWi 2020).

In this study, scenario calculations are used to examine under which climate policy conditions the transformation of the steel industry in Germany can succeed. Successful transformation is understood to mean that the production of primary steel is completely GHG-neutral at the end of the transition phase, without any transformation-related losses in production volumes and employment.

[1] The electric steel route, in which steel scrap is melted down in the arc and recycled, produces largely emission-free. However, the possible production quantities are limited by the availability of steel scrap. In the previous study, the consequences of the climate policy framework conditions for the electric steel route are discussed in more detail (see Prognos 2020).

The study shows that investments in climate-neutral production facilities and their operation are associated with additional costs and that transformative processes, such as in the steel industry, take place gradually and in international competition. This poses special challenges for companies and for the design of a suitable regulatory framework. The study thus complements the study already carried out in 2020 on the climate challenges of the steel industry, in which transformation paths to climate neutrality were not explicitly modelled, but rather the burdens of a purely nationally oriented climate action policy were examined in comparison to a business-as- usual scenario (cf. Prognos 2020).

2 Procedure and central assumptions for the simulation calculations

The outcome of the transformation process of the steel industry towards climate neutrality depends on market developments, the political framework conditions and the tangible corporate decisions of the individual steel producers. We assume that the general market developments (supply and demand on the global steel markets) will not change fundamentally compared to a hypothetical reference without transformation.[2] The various political framework conditions are mapped in detail in the individual scenarios. Of course, we cannot anticipate the tangible entrepreneurial decisions within the scope of this study. For this reason, we model typical companies in the steel industry. A modelled plant and the decision on its transformation, therefore, do not correspond exactly to a real plant and decision-making process. The great value of modelling lies in the fact that influencing variables on typical and economically rational decisions can be reproduced in a comprehensible way.

i

Agent-based model simulations with LABS (Large Agent Based Simulation)

The scenarios are created using the agent-based simulation model LABS from Prog- nos. LABS models the real economy in which a large number of heterogeneous agents (i.e. companies, private households, banks, the state) pursue their respective goals autonomously and depending on their individual states.

The steel industry is represented here by strongly typified companies that have similar characteristics to the statistically available average of the steel industry in Germany. We would like to point out that the modelled companies have no tangible equivalent in the "real" world. This type of modelling allows the transformation to be implemented at the level of individual plants, explicitly taking into account functional relationships at the business and economic level.

[2] For the development of the steel industry in the hypothetical reference, see detailed Prognos 2020.

The simulation calculations are based on a series of assumptions for the period under consideration. These are plausibly derived from available data and policy assessments, but do not constitute forecasts in themselves. The central assumptions are in detail:

- Non-European countries pursue less ambitious climate action policies than the EU. As a result, European and non-European companies face different GHG emission costs.

- The prices for the allowances in EU Emissions Trading System are 50 euros per tonne of CO2 in 2020, the starting year of the simulation, and increase by 5 euros per year until 2045. In non-European countries, it is assumed that emission costs for the steel industry are first introduced in 2031 and will increase by 2 euros per tonne per year.

- The energy carrier prices approximately follow the assumptions made by Agora et al. 2021: The coal price is stable at 140 euros per tonne, the hydrogen price starts at 170 euros per MWh in 2020 and drops to 120 euros per MWh by 2045. The electricity price is 60 euros per MWh in the starting year and declines slightly to just over 57 euros per MWh by 2045. The price for natural gas is 12 euros per MWh in 2020, rising significantly to 24 euros per MWh by 2045.

- The change in technology to low-emission processes on the part of domestic producers will be carried out in any case. Conventional deliveries (with one exception in 2025) will no longer be made. If the changeover is not economically viable, withdrawal from the market is the only alternative.

- With regard to alternative low-emission processes, we only consider hydrogen direct reduction (H2-DRI) in this study. We assume that the new H2-DRI plants to be built will initially be operated predominantly with natural gas. In 2026, when the first installation is converted in our scenario, the share of natural gas is 70 percent and decreases by 5 percentage points p.a. in the following years.
- For the simulation calculations, we assume that there is sufficient availability of hydrogen and that no energy industry or other restrictions stand in the way of a transformation of the steel industry.

- According to Agora et al. 2021, the specific capital costs for conventional primary steel production amount to 16 euros per tonne of steel, while those for alternative production in the H2-DRI process are almost five times as high at 79 euros per tonne of steel. The capital costs of both production processes are constant over the course of the simulation and are identical in Germany and abroad.

3 How can the transformation succeed?

The goal of GHG-neutral production in the steel industry by 2045/2050 presents companies with a double challenge under the current and planned climate protection policy framework:

1. The expiry of the free allocation planned by the European Commission, coupled with rising prices for allowances in the future, will significantly increase the emission costs of steel companies in Europe. If conventional and emission-intensive production processes are maintained, European steel producers will be at a cost disadvantage compared to their international competitors. Although the CBAM envisaged in the "Fit for 55" package of measures is intended to ensure (emission) cost parity in the European domestic market, support for steel exports to third countries is not envisaged. Moreover, its effectiveness in avoiding various circumvention strategies is also uncertain.

2. From an economic point of view, low-emission production processes do not offer a way out, as these processes currently have higher production costs than conventional ones (including emission costs) and will continue to do so for the foreseeable future.

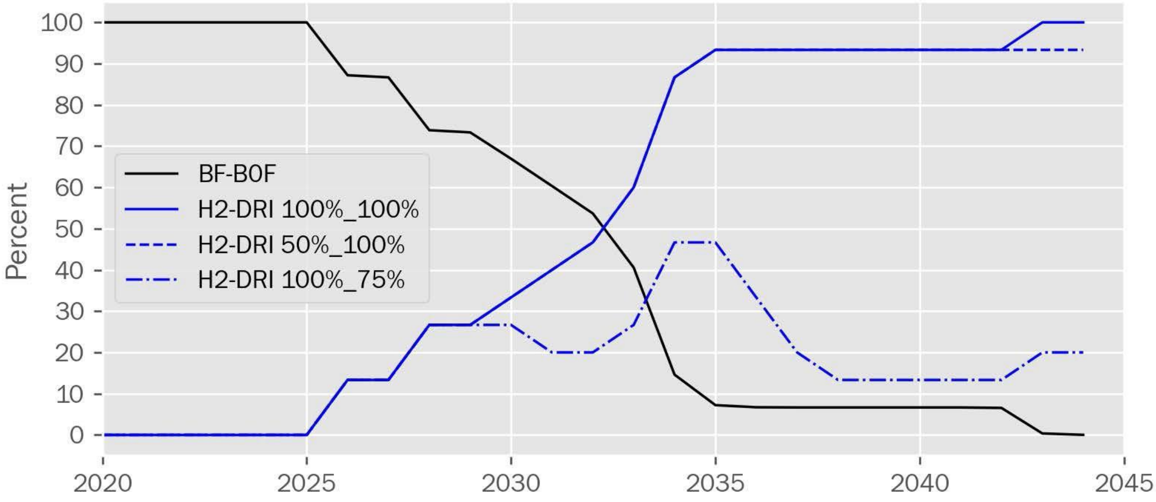
The transformation scenario addresses these challenges. First of all, it is important to understand that the transition to GHG-neutral production cannot take place overnight. Existing investments in the blast furnace-converter route have an average lifespan of about 18 years. Only then, a plant will be renewed ("relined") or replaced by a plant with a different technology. According to these investment cycles, the conversion to GHG-neutral plants can only take place gradually.

In this transition phase, the companies in the transformation scenario will continue to receive free allowances for their conventional plants to an extent that ensures parity with non-European countries in terms of emission costs ("level playing field"). The conversion of the plants to direct hydrogen reduction takes place gradually according to the usual investment cycles. For this purpose, the steel manufacturers receive financial grants in the transformation scenario that compensate for the differential costs between the (cheaper) conventional and the (more expensive) GHG-neutral technology. The financial grants are modelled in such a way that they compensate for both the higher investment costs (capex) and the higher operating costs (opex).

The calculation of the additional investment costs follows the assumptions of Agora (2021). If the Capex grants for an H2-DRI plant (annual production capacity two million tonnes) are granted in full, they amount to 1.2 billion euros. The maximum possible grants for ongoing operating costs corresponds to the difference in production costs at the time and depends in particular on the development of the costs for "green" hydrogen and its share in the operation of the plant. Since the plants are initially operated primarily with natural gas, the values initially amount to 150 euros per tonne of steel (2026) and rise to a maximum of 242 euros per tonne of steel when the plants are almost completely operated with "green" hydrogen at the end of the 2030s.

Under this condition, the conventional production capacity in the initial year 2020 will be completely converted to hydrogen direct reduction by the year 2045. The previous production capacity will be maintained without any losses.

Figure 1: Production capacity of the primary steel production in Germany in the transformation scenario, as a percentage of initial capacity (2020 = 100%)3



Source: own calculations, average over 200 simulation runs
BF-BOF: blast furnace converter technology, H2-DRI: hydrogen direct reduction First percentage figure for capex grant, second figure for opex grant

The question arises as to whether full compensation of the additional costs is necessary for the transformation to succeed, or whether proportional compensation would be sufficient. The simulation calculations arrive at the following results:

- If the capex grant is only 50 percent, this still leaves around 93 percent of the initial capacity until 2045 in the market. With reduced support companies have to raise more equity and debt capital to finance the investment, resulting in a slightly hhiigher risk of insolvency.

- A reduction of the opex grant to 75 percent, on the other hand, leads to low profit margins and falling sales. In such a scenario, a cost-covering operation of the H2-DRI plants at competitive prices is hardly possible, the financial reserves of the individual companies/ plants from the time before the conversion are reduced and the risk of market exits increases massively. As a consequence, about 80 percent of the initial capacity exits the market by the end of the simulation period in 2045. If the simulation period is extended beyond 2045, the remaining plants would also exit the market.

An important finding from these simulation runs is that a complete closure of the profitability gap in additional operating costs is crucial for a successful transformation. This is explained above all by the high intensity of competition on the international steel markets and the associated low profit margins. Based on the ramp-up of H2-DRI plants realized in this transformation scenario, a complete coverage of the economic efficiency gap results in an average annual subsidy requirement of 4.6 billion euros in the period 2026 to 2045. In the first decade of the ramp-up (until 2035), this amounts to a cumulative 27.5 billion euros. In addition, there are investment grants,

[3] In the case of an optimal transformation, the H2-DRI production capacity corresponds exactly to the mirrored conventional (residual) capacity: the BF-BOF plants are converted according to the blast furnace's last year of delivery in the simulation period, i.e. taken from the stock of conventional plants and assigned to the stock of H2-DRI plants. In the case of incomplete extraction, the stock of converted H2-DRI plants is reduced accordingly.

which, if fully granted, amount to a total of 18 billion euros in the entire simulation period (2026 to 2045). The vast majority of this will be incurred in the first decade of the ramp-up.

About one third of the greenhouse gases emitted in primary steel production (approx. 55 million tonnes per year (average 2016-2018) can be saved in the transformation scenario by 2030, and by 2035 it is higher than 90 percent.

In the long term, the additional operating costs can be earned on the market. The establishment of "green" lead markets will first create sales niches for the transformed plants, while in the longer term the profitability gap can also be permanently closed for the subsequently transformed plants. The need for financial support can also be reduced if the ramp-up of the hydrogen economy and the associated expected cost degressions take place more quickly than assumed here.

As the decarbonisation of the steel industry is plant-specific and thus takes place in individual steps, it is crucial for the success of this process in summary that not only the new H2-DRI plants can be operated in a cost-covering manner. The existing blast furnaces must also be able to continue producing economically, because once existing plants have been eliminated from the market, they can no longer be transformed afterwards.

4 What does the "Fit for 55" package mean for the steel industry?

The plans of the European Commission's "Fit for 55" package mean additional burdens for the steel industry in Germany and Europe compared to the transformation scenario. In order to model the effects, the two central aspects of the package are implemented in the simulation model:

- According to calculations by the German Steel Federation (Wirtschaftsvereinigung Stahl), the steel industry in Germany currently receives free allowances amounting to 83 percentage of the actual emissions. With the tightening of regulations in the European emissions trading system from 2026, we assume in the calculations a gradual decrease in the proportion of free allocation. From 2035, no more free allowances will be allocated.

- In order to prevent the European steel industry from losing international competitiveness due to the reduction of the cost-free allocation of emission certificates, the "Fit for 55" package provides for an emission-based border adjustment mechanism (CBAM). This is intended to effectively ensure emissions-based cost parity between domestic and foreign conventional steel production on the domestic market. The amount of the CBAM tax, which domestic customers have to pay on foreign steel products, corresponds to the difference in the certificate prices to be paid between domestic and foreign markets.

In order to take into account the current uncertainties about the actual introduction as well as the effectiveness of the CBAM - both of which are equivalent from a methodological point of view - two different load scenarios are modelled:

- Load scenario 1: Expiry of free allowances and ineffective CBAM
- Load scenario 2: Expiry of free allowances and fully effective CBAM

Thus, the spectrum of different degrees of effectiveness of the CBAM - especially against the background of still open trade law and trade policy questions - is fully covered.

4.1 Load scenario 1: Expiry of free allowances and ineffective CBAM

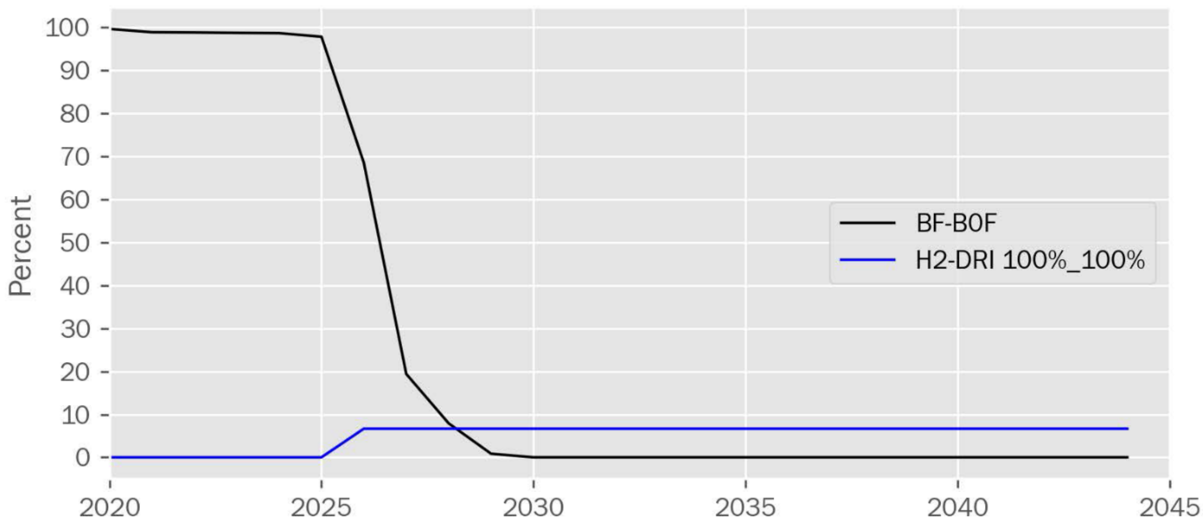
Due to the expiry of the free certificates, the difference in production costs between Germany and abroad is steadily increasing and amounts to approx. 248 euros per tonne of steel in 2045. Assuming an ineffective CBAM is available here, the emission-related cost differences with other countries are not compensated.

Our simulation calculations show that under these conditions the domestic blast furnace- converter route collapses before a switch to the low-emission H2-DRI technology can take place. The insufficient coverage by free allowances puts the companies of the conventional route under pressure from the beginning of the simulation calculation. As a result, they are only insufficiently able to raise the necessary financing for delivery or conversion. In 2026, when the share of free allocation drops significantly, the steel companies concerned are no longer able to produce competitively in terms of price. The consequence will be market exits before the blast furnaces reach the end of their operating life. The transformation would thus have failed before it had begun. Any capex or opex grants for the conversion would no longer apply.

Even an early technology change offers no way out: an opex grant for newly installed H2-DRI plants is measured by the differential costs compared to domestic conventional steel production. Without an effective CBAM, however, the financial support would not be sufficient to compensate for the cost disadvantage compared to conventional generation abroad. In this variant, too, the transformation would not take place.

Even if the hydrogen direct reduction were subsidised in full, the decarbonisation of the steel industry in Germany would have failed. The steel formerly produced in Germany would now be produced abroad and the greenhouse gases emitted in the process would also be emitted abroad in at least the same amount ("carbon leakage").

Figure 2: Production capacity of the primary steel production in Germany in the load scenario without CBAM, as a percentage of initial capacity (2020 = 100%)



Source: own calculations, average over 200 simulation runs BF-BOF: blast furnace converter technology, H2-DRI: hydrogen direct reduction First percentage figure for capex grant, second figure for opex grant

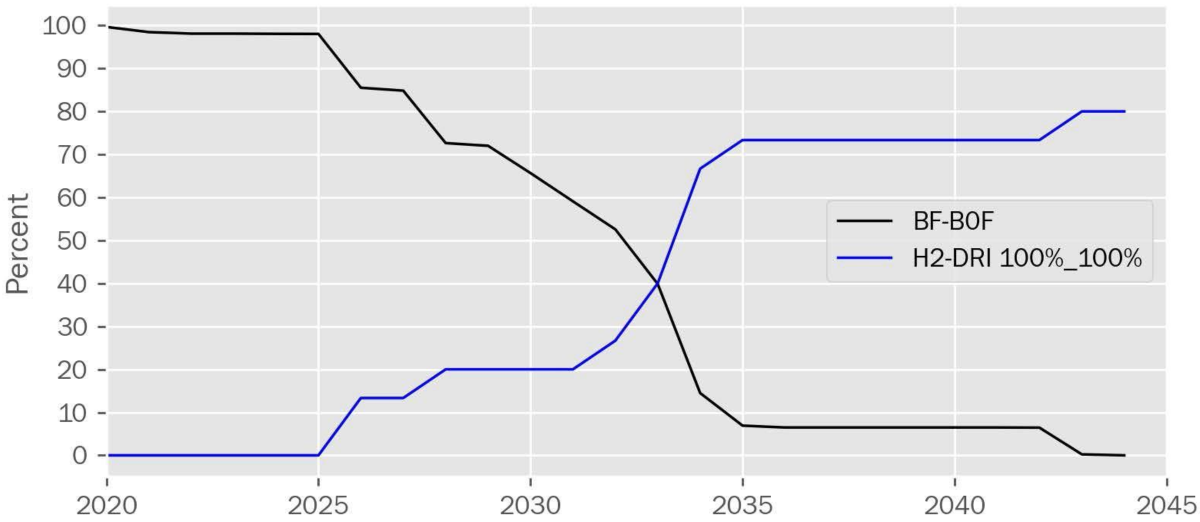
4.2 Load scenario 2: Expiry of free allowances and fully effective CBAM

The second load scenario differs from the previous one in that the CBAM introduces an emissions-based tax on domestic steel imports and is fully effective. In line with the European Commission's proposal, this is not associated with any relief on exports. For the simulation, we assume that the specific GHG emissions of the domestic and foreign blast furnace-converter routes are identical. Under these conditions, the companies on the conventional route are already under increased competitive pressure at the beginning of the simulation period, analogous to the first burden scenario, but increased market exits are effectively prevented by the CBAM.

The construction of the H2-DRI route does not fully succeed even with full support: Exports by domestic steel producers are not protected by the CBAM and are not price-competitive on the foreign market. The share of turnover with non-European countries in the total turnover of the steel industry is statistically under 20 percent. In this order of magnitude, the corresponding production capacities are also "missing" in the simulation calculations towards the end of the period. And this despite an assumed complete promotion of the new H2-DRI plants.

Production in Europe is now only for the domestic market, and "green" steel would also have no export prospects.

Figure 3: Production capacity of the primary steel production in Germany in the load scenario with CBAM, as a percentage of initial capacity (2020 = 100%)



Source: own calculations, average over 200 simulation runs BF-BOF: blast furnace converter technology, H2-DRI: hydrogen direct reduction First percentage figure for capex grant, second figure for opex grant.

An effective CBAM is in principle suitable to effectively support the transformation of the European steel industry. However, the lack of a level playing field in foreign markets remains a major shortcoming of this instrument. Measured against the capacity level of the transformation scenario, the steel industry would have a capacity level of around 80 percent at the end of the transition.

5 Macroeconomic consequences and conclusion

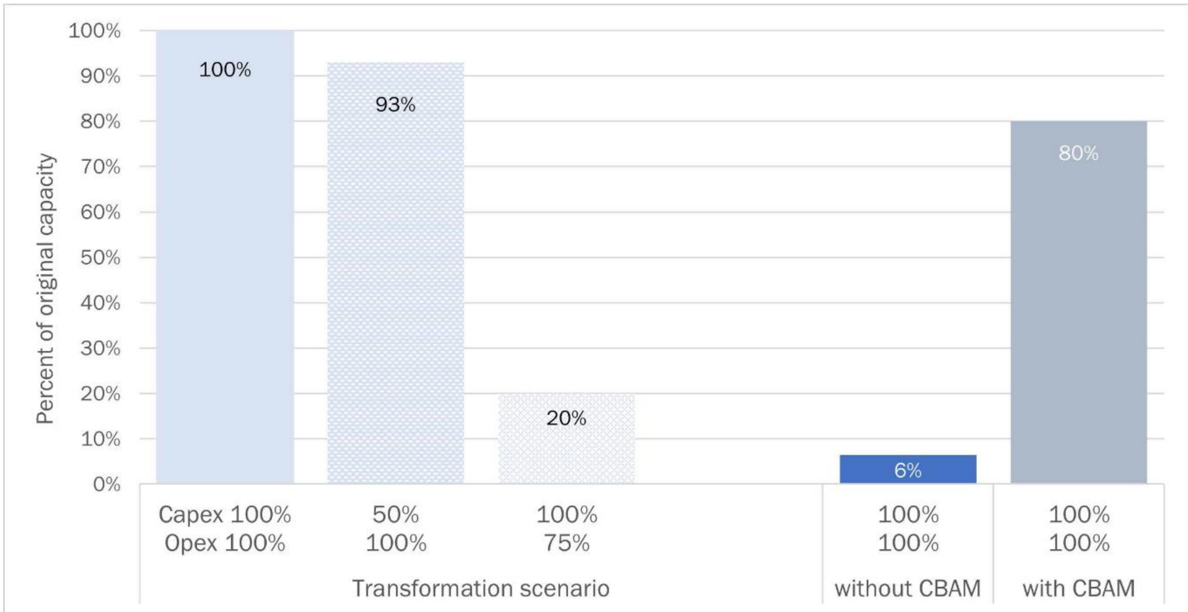
The simulation calculations show that decarbonisation of the steel industry in Europe and Germany is not feasible for the companies concerned on their own, as the production costs of low-emission generation processes in the primary steel production are currently and in the medium term significantly higher than those of conventional processes.

If the transformation were to fail, the economic costs would have an impact beyond the steel industry itself (updated on the basis of Prognos 2020): In Germany, the industry has a relatively high value-added multiplier. If the value added in the steel industry falls by one euro, 2.7 euros of value added are "missing" in the economy as a whole. In addition, there are negative circular effects resulting from the reduction in investment spending by the affected companies as well as the consumption expenditure of their former employees and the additional demand for steel imports. The overall effect on value creation in Germany is greater by a factor of 4 than the value creation losses of the steel industry itself.

Based on this ratio, each lost percentage point of production capacity in the primary steel production is approximately associated with a loss of macroeconomic value added amounting to 200 million euros. In the first adverse scenario, the "worst case", the total economic value added loss, taking direct steel processing into account, amounts to almost 19 billion euros. Around 200 thousand jobs would be lost directly and indirectly as a result.

From this, the overall economic emission avoidance costs - defined as the loss of gross value added per tonne of greenhouse gases avoided - can be derived, which are around 600 euros per tonne. These costs clearly exceed the differential costs between low-emission and conventional production processes (maximum 242 euros per tonne of steel in 2039). Moreover, in the case of carbon leakage - i.e. a displacement of domestic production by additional imports from abroad - the emissions are not avoided, but at least the same amount is produced abroad. It is therefore advantageous, not only from an economic but also from a climate policy perspective, to support the steel industry in its decarbonisation.

Figure 4: Hydrogen-based production capacity of the primary steel production in Germany in 2045, in percent of (conventional) initial capacity 2020



Source: own calculations, average over 200 simulation runs Capex/Opex: grant amount as a percentage of differential costs

If there is (emission) cost parity between domestic and foreign conventional production (e.g. through free allowances in the transformation scenario), then according to the results of the simulation calculations for the conversion to the H2-DRI process, a (state) grant for the investment expenditure (capex) of fifty percent is approximately sufficient.

For current operating costs, on the other hand, a financial grant in the full amount is necessary if the companies in question are to remain in the market permanently. In the longer term, emission costs will also be introduced in non-European countries and a decarbonisation of the steel industry will take place, so that support for the steel industry in Europe may have a temporary character.

A significant increase in allowance prices within the framework of the European emissions trading system and a reduction in freely allocated allowances - as envisaged by the European Commission iin its "Fit for 55" plan - reduce the relative costs of alternative processes. However, these measures have the consequence that steel-producing companies in Europe will leave the market before a changeover to low-emission processes can succeed. The introduction of an effective emission-based border adjustment (CBAM) creates (emission) cost parity on the (European) domestic market vis-à-vis suppliers from third countries, but leads to the loss of non-European export business and a corresponding reduction in production capacities. The two load scenarios take the two possible extreme positions with regard to the effectiveness of the border adjustment mechanism. If the CBAM is not effective, the effects of the climate policy framework conditions will lie between the two shown here.

Glossary

Agora Energiewende, FutureCamp, Wuppertal Institut und Ecologic Institut (2021): Klima-schutz-verträge für die Industrietransformation. Analyse zur Stahlbranche

Eurofer (2020): European Steel in Figures, The European Steel Association, 2020

BMWi (2020): Für eine starke Stahlindustrie in Deutschland und Europa (Handlungskonzept Stahl), Bundesministerium für Wirtschaft und Energie, 2020

Prognos (2020): Klimapolitische Herausforderungen der Stahlindustrie in Deutschland, 2020

Imprint / Disclaimer

Transformation Paths for the Steel Industry in Germany - Non-technical version of the study

Published by

Prognos AG
Nymphenburger Straße 14
80335 München
Telephone: +49 89 954 1586-710
Fax: +49 89 954 1586-719
E-Mail: info@prognos.com
www.prognos.com
twitter.com/prognos_aG

Authors

Jan Limbers
Dr. Michael Böhmer

Contact

Jan Limbers (Projektleitung)
E-Mail: jan.limbers@prognos.com

Composition and layout: Prognos AG
Picture credit(s):

Status: February 2022

Quotes according to § 51 UrhG ought to be equipped with the following citation: Prognos AG (2021): Transformation Paths for the Steel Industry in Germany.