Paris compatible steel capacity

Contraction and replacement for zero emissions

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Policy brief

Paris-compatible steel capacity:

Contraction and replacement for zero emissions

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Key points

- Decarbonisation will have major implications for global excess steel capacity. The steel industry today is dominated by carbon intensive capacities, but to reach net-zero – as set out in the Paris agreement – we need zero-emission capacities. We need to phase-out all current carbon-intensive capacities to meet Paris commitments. To meet future steel demand, we need to phase-in zero-emission capacities. These are two distinct, but related processes.
- Decarbonising steel will require a multitude of strategies, including increased material efficiency, reining in steel demand, and deploying new zero-emission production techniques. We thus must *contract demand and replace carbon intensive capacity* on a short time scale, given by carbon budgets. Phasing-out carbon intensive capacities as they reach the point of reinvestment will incentivise material efficiency and demand for zero-emission production.
- In a Paris-compatible steel transition pathway, global steel demand will stagnate but relocate, secondary production will increase, and market shares of new technologies have to grow in a stagnating market. Phase-out of *Paris-incompatible capacity* and phase-in of *Paris-compatible capacity* will therefore require international coordination. Something like a *Global Steel Club* should coordinate trade, steel capacities and transition support for decarbonisation.

1. Decarbonisation and steel excess capacity

The Paris Agreement implies a sea change for global climate policy. Parties to the Agreement set out a target maximum temperature increase of 2 degrees Celsius and agreed to pursue efforts for 1.5 degrees. In order to avoid temperature increases beyond that goal, anthropogenic greenhouse gas-emissions have to remain within a very limited global carbon budget and reach net-zero by mid-century (IPCC, 2018). All sectors and all countries thus have to reach net-zero within a few decades.

For the steel industries in the countries that have committed to the Paris Agreement, this is a profound challenge. In total, the steel sector is responsible for about 10 percent of annual global CO2-emissions today (Vogl et al., 2021). The carbon intensity of steel is due to the production technologies used. Primary steel production constitutes 70% of total production and is based on iron ore and coal as the main inputs. 90 percent of primary steel is produced via a blast furnace (BF). This route produces between 1.8 and 2.8 tonnes of CO2 per tonne of steel in the major steelmaking countries (Hasanbeigi & Springer, 2019). Secondary steel production constitutes 30 percent of steel production today and is based on scrap in an Electric Arc Furnace (EAF) (IEA, 2019). If the electricity used in the EAF is from emission-free sources, the steel has near-zero emissions.

Reaching net-zero emissions as agreed to by the Parties to the Paris Agreement, will require a combination of strategies (I.A. Bashmakov et al., 2022). These include lower steel demand though increased material efficiency via design for longer life and reuse and recycling of products, increased secondary steelmaking via EAFs as more scrap becomes available, and shift away from emissions intensive primary production processes, to processes based on renewables (e.g. hydrogen or direct electricity) or coal but with very high capture rate CCS (BF-CCS or HIsarna with CCS) (Pathak et al., 2022).

Decarbonisation relates to the problem of excess steel capacity in two ways: on the aggregate level of steel demand, which has to be reined in as much as possible (Pathak et al., 2022) (IEA, 2023), and on the supply side, where carbon-intensive steelmaking technologies have to be replaced with new zero-emission steelmaking (Vogl, 2023) (I.A. Bashmakov et al., 2022). **The decarbonisation formula for the steel sector can thus be summed up as *contract demand and replace carbon-intensive capacity*.**

Decarbonisation therefore has major implications for how we should understand strategies to reduce excess steel capacity. Not only do we need to rein in demand, but we also have to phase out obsolete carbon-intensive steel capacity, and phase in zero-emission capacity. In contrast to the diffusion of steelmaking technology in history (e.g., the shift from open hearth furnaces to blast furnaces) zero-emission steelmaking technology will thus have to diffuse under stagnating demand – a historically unique challenge.

The steel decarbonisation process is shown in the schematic illustration below.

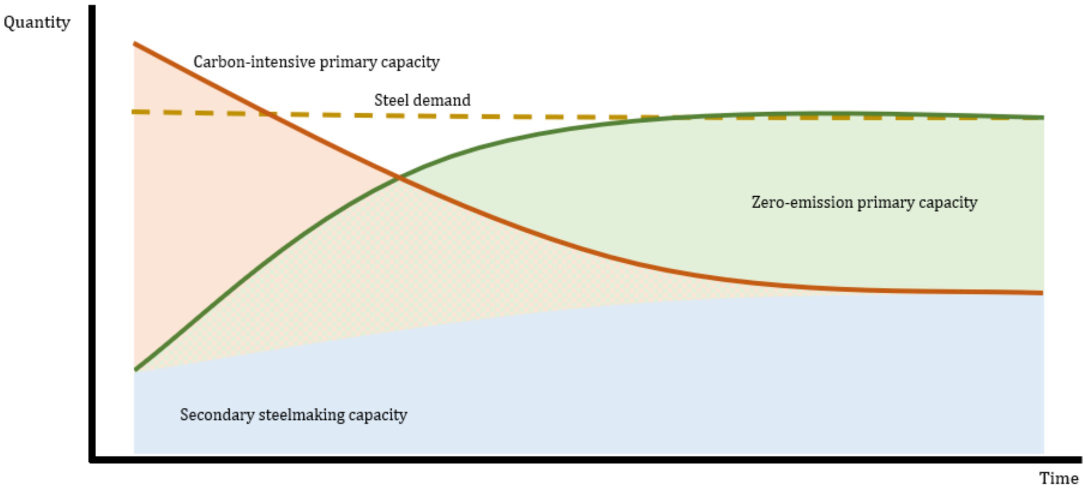

Figure 1. Schematic illustration of the phase-in of Paris-compatible steel capacity and the phase-out of Paris-incompatible steel capacity relative to steel demand over time.

For signatories to the Paris Agreement, excess steel capacity in the long term includes all capacity that is not viable in a net-zero world, or what can be denominated as *Paris-incompatible capacity*. But to meet future steel demand, there is also a lack of what can be denominated as *Paris-compatible capacity*. Therefore, we have three capacity-related challenges over the coming decades: 1) how to rapidly phase-out all Paris-incompatible capacity, 2) how to phase in Paris-compatible capacity to meet future steel demand, and 3) how to coordinate the pace and scale of both changes and minimise market turbulence.

2. Opportunities for phase-out

Steel excess capacity in the conventional sense is a testimony to how difficult it is for the steel sector to adjust capacity downwards. Governments, firms, and communities are reluctant to close plants for a number of reasons. Since steel is an input used in a wide variety of sectors, governments tend to see steel production as strategically important, and therefore support the construction of plants and keep uncompetitive plants alive to reduce reliance on steel imports and to support industrialisation (OECD, 2018) (Åhman et al., 2017) (Rimini et al., 2020). Firms on their side invest in steel plants with the intention of running them for a long time, and therefore face sunk costs that have to be recouped over long time horizons. They may also face "legacy costs" associated with retirement, or environmental clean-up costs if a plant is closed (Rimini et al., 2020). Finally, plants are usually large employers and taxpayers in the surrounding communities. These communities thus become highly dependent on the plant, and understandably oppose closures out of fear for the survival of the community (Unruh, 2000) (Moore, 1996). Together, such issues imply large *barriers to exit* in the steel sector, keeping steel plants running, despite a lack of demand (Rimini et al., 2020).

Steel plants are therefore slow to phase out, and over the last few decades, only 25 percent of steel plants have left the market after 40 years of operation (Rimini et al., 2020). This is a problem for decarbonisation, since the global blast furnace and NG-DRI fleet is young as seen in figure 2 below and will not reach end-of-life on a Paris-compatible timeline. Colours represent different global regions.

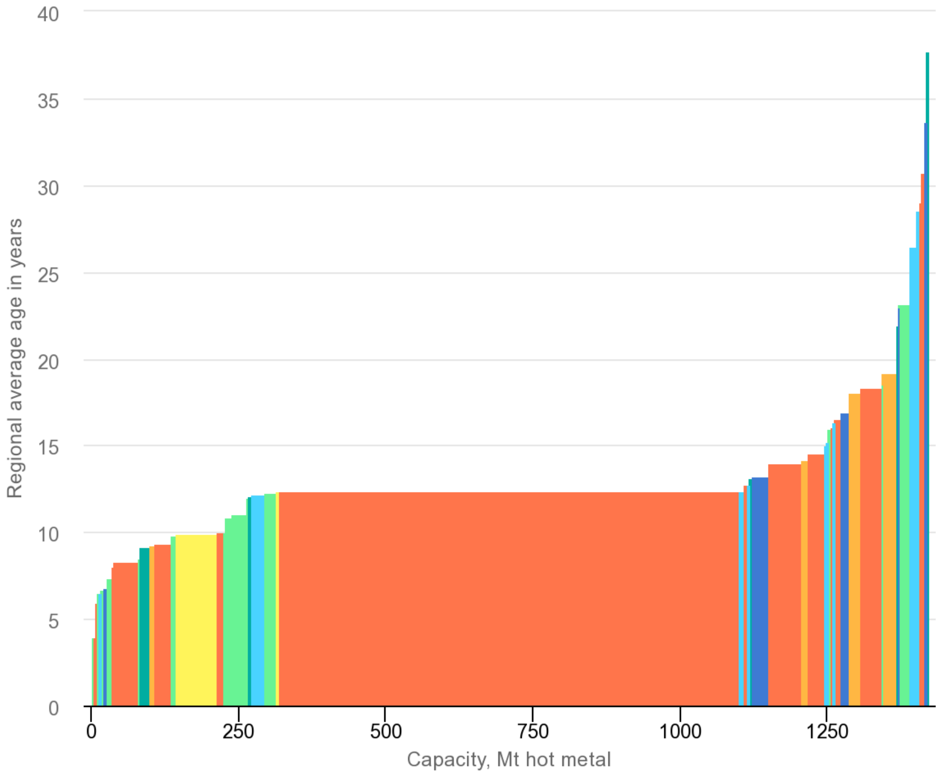

Figure 2. Age profile of global production capacity for the steel sector (blast furnaces and DRI furnaces), IEA, Paris. https://www.iea.org/data-and-statistics/charts/age-profile-of-global-production-capacity-for-the-steel-sector-blast-furnaces-and-dri-furnaces. Licence: CC BY 4.0.

However, an opportunity for phase-out of carbon-intensive blast furnaces arises when they have to be relined (Vogl et al., 2021) (Agora Industry et al., 2021). Relining implies reinvestment of several hundred million USD where the furnace is out of service for about three months foregoing revenue, incurring costs of approximately a third of the cost for a new blast furnace (Vogl et al., 2021). This is ca 50 percent of capital investment needed for an H-DR plant (Vogl et al., 2018). While the blast furnace can run for decades, its lifetime can be divided in campaign lives in between relining, of about 17 years. 70 percent of the global blast furnace fleet will require such reinvestment before 2030 (Agora Industry et al., 2021). Relining for another investment cycle will incur sunk costs until mid-century. A globally coordinated phased ban on relining would force a phaseout of obsolete capacity and super-charge demand for net-zero compatible capacity.

Phasing out obsolete capacity on Paris-compatible timelines will require lowering of barriers to exit though managing asset-related debt, social aspects through reemployment of the labour force and community support, and environmental clean-ups. Many steel plants are recently built in developing countries which may struggle to afford phase outs of Paris-incompatible capacity. Sharing the burden of early scrapping costs will be important for meeting the principle of common but differentiated responsibilities and respective capabilities within the United Nations Framework Convention on Climate Change (UNFCCC), and to ensure public and political support for a steel transition with minimal political upheaval and resistance, and social unrest (Nilsson et al., 2021) (IPCC, 2022).

3. Phase-in and new comparative advantages

The second challenge regards the phase-in of Paris-compatible capacity to meet future steel demand. The IEA expects that demand for steel will remain stable but stagnant at about 2000 Mtpa in a net-zero scenario (IEA, 2023). But today there is only a small number of primary steel projects with low enough emissions to meet this future steel demand. Hydrogen direct reduction appear to be the most promising technology (Vogl, 2023) (Vogl et al., 2018), although there are other options. Such Paris-compatible capacity would produce steel at costs about 30-50 percent[1] higher than blast furnaces without carbon pricing (Delasalle et al., 2022). But the price increase of the final good would be small, at about 0.3 to 2.1 percent.

While the cost increases for final goods are small, other obstacles remain for a rapid phase-in of Paris-compatible capacity. These are access to large amounts of low cost zero-emission electricity for the supply of hydrogen, technology-related risks in the early development phase, as well as demand for Paris-compatible steel with, initially, a price premium. That is why many green steel projects have been supported by governments through subsidies, credit guarantees, and development bank investments.[2] Such support may be crucial in the initial development phase of Paris-compatible steel, though countries have very different financial ability to support such projects. Today most green steel projects announced are in financially stronger countries with ambitious climate policies such as the EU and it´s member states. In the future, changes from fossil to renewable energy will lead to new comparative advantages across the globe, potentially undermining existing iron and steel production in some countries and enabling production elsewhere. It is likely that access to inexpensive renewable energy in regions that are endowed with rich wind and solar resources will attract investments in new and green iron- or steelmaking capacity. In this scenario, sponge iron or hot briquetted iron may be exported for alloying and steelmaking in EAF:s closer to steel markets.

However, for the long-term diffusion of Paris-compatible capacity beyond the initial development of green steel technology, it is key that there is demand for green steel. For firms to take investment risks, they must see demand for their products. This shift to green steel may

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[1] Green steel costs will be highly dependent on electricity prices, and therefore cost estimates are subject to a high degree of uncertainty. With low electricity prices, high carbon prices and high prices for metallurgical coking coal, hydrogen direct reduction may well be cost competitive with the traditional route.

[2] Government support for green steel projects is analysed in a forthcoming paper by Jonas Algers, Max Åhman and Lars J Nilsson.

be hampered if there is excess obsolete steel capacity. Therefore, a key policy supporting the diffusion of Paris-compatible steel capacity will be the phase-out of Paris-incompatible capacity, which would provide clear directionality for the steel industry and shape the steel market towards rapid decarbonisation (Nilsson et al., 2021).

4. Coordination

The third challenge regards the coordination of decarbonisation through the phase-out/phase-in of capacities. This issue regards both the aggregate level of demand and production, as well as the geographical location of production capacity and demand.

It is important to ensure that there is not a shock to global steel markets though a sudden phase-out of capacity without new capacity being ready for production. Such turbulence could be detrimental to decarbonisation, as it may entail a political backlash or that individual countries choose to expand capacity and cause friction in the steel market. But at the same time, we need to ensure that firms are not discouraged from investing in Paris-compatible capacity, due to saturation in the market. How to balance these two risks?

As mentioned above, overcapacity is a testament to the difficulty for the steel sector to downwardly adjust capacity (Rimini et al., 2020). Despite a lack of demand, plants are kept online at low capacity utilisation, causing financial harm to all participants in the market. If policymakers are able to increase the exit-rate of Paris-incompatible capacity and there is a lack of capacity to meet production, this should both incentivise increased material efficiency and the construction of Paris-compatible capacity and innovation in green steel (Kivimaa & Kern, 2016). Therefore, permanent overcapacity is a greater risk than transitory *undercapacity* as the steel sector decarbonises.

The geographical coordination of steel decarbonisation is likely to be a contested political issue. While incumbent steelmaking nations may want to retain their steel industry for reasons such as self-sufficiency, tax income and employment, nations with access to renewable energy resources probably want to enter the market, arguing for cost efficiency. Such political issues may have to be negotiated and coordinated internationally through a green steel club (Åhman et al., 2022) (Grubb et al., 2022) (Hermwille et al., 2022). A green steel club could work on common rules and regulations for trade, to ensure that carbon leakage does not undermine steel decarbonisation in a certain region or country, but that green iron and steel can outcompete conventional iron or steel elsewhere. Carbon borders but green free trade. The club could also work on international access to relevant technology and engineering competences, to ensure as rapid a transition as possible. Early scrapping costs incurred by scrapping Paris-incompatible capacity before plants reaching end-of-life could also be managed by the club. If not, it is probable that nations that have recently built large amounts of carbon-intensive capacity will be reluctant to decarbonise on necessary timelines. Finally, managing social aspects such as unemployment, foregone tax revenue and environmental degradation will be important for realising a rapid global steel decarbonisation deal. How to minimise the burden of adjustment placed on workers and communities will be important to discuss and recognise by the green steel club.

5. Conclusion

To decarbonise in line with the Paris Agreement, countries have to adjust all steelmaking capacity to net-zero compatibility. This implies that all capacity which is not net-zero compatible – what we call Paris-incompatible capacity – is obsolete and has to be phased out by mid-century. Managing steel excess capacity after the Paris Agreement therefore requires phasing out Paris-incompatible capacity, phasing-in Paris-compatible capacity, and coordinating the two processes. Phasing out blast furnaces – which constitute the main source of steel-related emissions – could be done at the end of campaign lives instead of relining the blast furnace. Since 70 percent of blast furnaces have to be relined before 2030, such a phase-out of conventional steelmaking would imply rapid decarbonisation of the steel sector, while relining a blast furnace implies continued 15-20 year carbon lock-in. At the same time Paris-compatible steelmaking capacity has to be phased-in to meet future demand for steel. Primary green steel is expected to be 30-50 percent more expensive than conventional steel, though the price increases for final goods are small, at about 0.3 to 2.1 percent. Phasing out Paris-incompatible steel and phasing in Paris-compatible steel are two distinct processes that must be coordinated to minimise turbulence in the global steel market. Therefore, a green steel club could be set up to internationally coordinate the steel transition, and ensure that political issues are negotiated, and rivalrous competition between countries that could create overcapacity, trade wars or other disturbances to the steel sector are avoided.

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