TRANSrisk

TRANSITION PATHWAYS AND RISK ANALYSIS
FOR CLIMATE CHANGE POLICIES

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Understanding risks related to the decarbonisation of the European steel sector

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Key Points

- Policy packages for steel industry decarbonisation are well advised to address risks
- Market power, supply dependencies and competitiveness are main matters of concern for steel producers
- Input supply risks are high for hydrogen-based options of steel decarbonisation
- Effective management of risks is to work across sectors and governance levels

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1 LOW CARBON TECHNOLOGY OVERVIEW

Achieving long-term targets of climate change mitigation as defined by the Paris Agreement, supported by the recent release of the 2050 long-term strategy of the European Commission[1], includes the requirement of a substantial decarbonisation of primary steel production. In 2016, iron and steel production accounted for about 1.5% of total greenhouse gas emissions in the EU (UNFCCC, 2018). There is a range of technological options currently discussed and intensely explored in R&D projects. This policy brief, in line with the TRANSrisk[2] project focuses on understanding risks related to the implementation of different decarbonisation options, the relevance of these risks for innovation processes in the steel sector and ways to reduce and manage them.

The most relevant current technological options for steelmaking are (i) the primary (iron ore based) blast furnace/basic oxygen furnace (BF-BOF) route, (ii) the primary (iron ore based) direct reduced iron (DRI[3])/ electric arc furnace (EAF) route and (iii) the secondary (steel scrap based) electric arc furnace (EAF) route. The BF-BOF route, with a share of more than 60% currently prevailing in Europe (WSA, 2017), uses coking coal and other suitable reducing agents to remove oxygen molecules from iron ore oxides ('reduction'). This route typically leads to around 1.5-2.0 tons of carbon dioxide emissions per ton of steel (including coking and sinter plants). However, the emissions of greenhouse gases related to primary steelmaking can be reduced by a significant share, if DRI processes are applied for iron ore reduction, where coal is replaced by natural gas. Depending on the specific direct reduction technology (MIDREX, Energiron ZR, FinMet) and the specific emissions of the current electricity mix used for the downstream EAF, emissions per ton of steel amount to around 0.8-1.2 tons of carbon dioxide for the DRI-EAF route (Kirschen et al., 2011). In Europe, the production of DRI is already implemented in Germany (Arcelor Mittal Hamburg) and several steel producers in EU member states, such as the Austrian company voestalpine, import DRI (e.g. from a plant in Corpus Christi, TX/USA). DRI is used as pre-reduced feed for conventional blast furnaces, replacing a small part of the respective share of iron ore.

In secondary steel production, recycled scrap is melted in EAFs. If only recycled scrap is used (i.e. without adding 'virgin' iron), emissions from the reduction processing of iron ores is completely avoided. For being overall emission-neutral, (i) direct energetic emissions from using process-optimising machinery like oxy-fuel burners and injectors and (ii) indirect energetic emissions accruing in electricity generation have to be dealt with (Kirschen et al., 2009). However, recycling is expected to be restricted to 50-75% of products by 2050 due to impurities in scrap feedstock and the long economic lifetime of steel applications (Arens et al., 2017; Morfeldt et al., 2015, Pauliuk et al. 2013).

Major research and development projects – taking stock from the 'ULCOS'[4] project – currently investigate the steel sector's options for deep decarbonisation. The use of carbon containing gases as well as hydrogen from BF-BOF steel production to produce feedstock for the chemical industry (ThyssenKrupp within 'Carbon2Chem'[5] and ArcelorMittal within 'Steelanol'[6]) is an approach that demands the deployment of carbon capturing technologies (Carbon Capture and Usage, CCU). Some companies have different strategies (diverting from storing greenhouse gases in products) and, instead, focus on underground storage pathways (Carbon Capture and Storage, CCS), e.g. Tata Steel in the Netherlands[7]. In addition, incremental improvements such as more recycling of steel are discussed among steel producers.

There is a fundamentally different alternative leading to the avoidance of greenhouse gas emissions by more than 80% of current emissions when using BF-BOF technology. This includes a

1 www.ec.europa.eu/clima/policies/strategies/2050_en
2 www.transrisk-project.eu
3 In Direct Reduction Plants (DRPs), iron ore is reduced in its solid state – unlike in the BF process, where liquid hot metal is formed.
4 www.cordis.europa.eu/project/rcn/74430_en.html
5 www.circulary.eu/project/carbon2chem
6 www.steelanol.eu
7 www.co2-cato.org

gradual switch from mainly carbon (coal/coke) to mainly hydrogen (natural gas/hydrogen) based iron ore reduction, combined with EAF steelmaking. The approach is called 'Carbon Direct Avoidance' (CDA). Several steel producers and research consortia pursue such a pathway (e.g. SSAB in Sweden within 'HYBRIT' and Salzgitter in Germany within 'SALCOS'[8]) with hydrogen generated by means of electrolysis corresponding roughly to the "coking plant" of future iron and steel making. Clearly, electricity needs to be generated solely from renewables to avoid sectoral leakage and to achieve the maximum decarbonisation level of well above 80% for operation on 100% hydrogen basis.

We complement existing frameworks and proposed policy measures (Neuhoff et al., 2018) by going beyond traditional instrument discussion for decarbonisation actions (e.g. enhancing efficiency, repairing and recycling, etc.). Instead, we focus on the steel sector's perceived and stated risks accompanying the respectively chosen medium to long term mitigation options.[9] Investigation with steel producers and other companies in the value chain resulted in the identification of a diverse set of risks and risk clusters that highlight the need for integrated policy support.

2 DECARBONISATION OPTIONS AND RELATED RISKS

This section gives an overview of risks related to the different decarbonisation options. The core domains of risk we identified for an iron and steel transition are listed in Table 1 (right column). They are aimed to complement current proposals of more general policy packages for basic material decarbonisation (based on Neuhoff et al., 2018; left column). We differentiate between risks that have been identified at the company level, and those that are faced at a more aggregate level of the economy. The risk domains pertain to each decarbonisation option in varying strength and characterisation. The uncertainty on the right timing for low carbon investments was mentioned as a risk, with some companies possibly having more short term windows of opportunities (e.g. when production facilities need to be modernised anyway and when the relevant supply with renewable energy is secured in specific regions) than others.

Table 1: Current policy (packages) and risk domain of iron and steel transition.

Currently proposed policy (packages)	**Risk of iron and steel transition to be considered in future policy design**
Based on Neuhoff et al. (2018):	**Identified risks at the company level include:**
• Share, repair, and reuse (extended by 'steel leasing') • Material substitution • More and purer steel from scrap • Efficiency measures • Customer-tailored and material efficient manufacturing • Higher value steel • Technological change	• Input supply risk • Price risks • Market power risks • Technology risk • Long lifetime and overcapacities • Acceptance due to environmental risks **Broader/inter-sectoral dimension of risk include:** • Policy risks • New value chains entail new range of risks due to additional interdependencies • Low-carbon transition in other sectors

8 https://salcos.salzgitter-ag.com/en/

9 However, there are still substantial efficiency gains possible for existing steel mills in the short term. For instance, increased waste heat and gas recovery measures still have energy saving potentials of around 8% up until 2030 (ICF, 2015).

In the following section, we first describe company level risks currently perceived by European steel makers. We consider several decarbonisation strategies: (i) mainly hydrogen-based steel making (CDA); (ii) conventional steel making with end of the pipe carbon capture and storage (CCS); (iii) going beyond CCS by exploring carbon usage potentials (CCU); and (iv) scrap-based steel production. There is a range of possible incremental improvements that are in different stages of development and testing such as using biomass as low carbon inputs that we do not discuss in detail here.

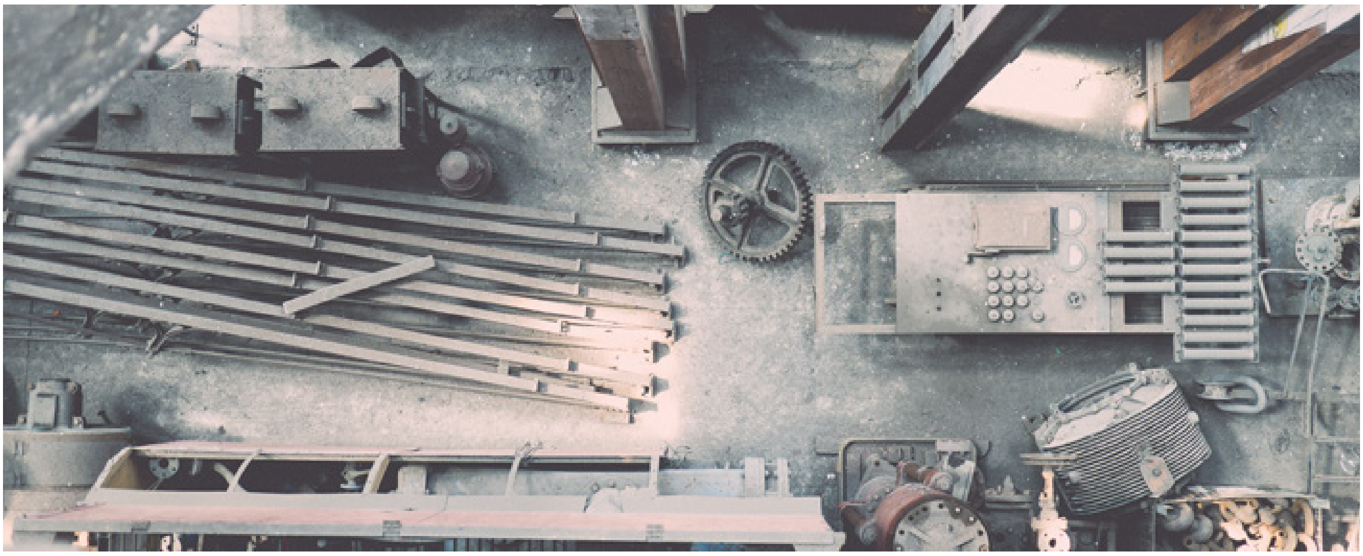
We discuss specific aspects of the selected strategies, setting the stage for a more nuanced picture of related risks and subsequent policy implications.

(Mainly) Hydrogen-based steel production (carbon direct avoidance, CDA)

Several steel companies (e.g. voestalpine in Austria, Salzgitter in Germany, SSAB in Sweden) are investigating almost completely carbon dioxide free steel production based on hydrogen generated by renewable electricity as long-term goal. However, a varying ratio between natural gas and hydrogen could be used in a transition phase. A few enterprises have already demonstration sites while others see this as long-term option. Yet, technology costs are not competitive to conventional blast furnace based steel production (cf. Mayer et al., 2019). There is a range of related risks and these are less on the technological side as our interviews revealed. The most relevant risks include supply risks and raises some of the following questions: Is there enough renewables potential available that can be easily used? More specifically, who is generating hydrogen (is it the iron and steel sector itself or a third supplier)? Which other sectors would compete with the steel sector either for renewable electricity or hydrogen? And what would the competition with other consumers mean for price formation and merit order? The Austrian iron and steel sector, for example, stresses that it would need about 33 TWh additional electricity supply to produce an amount of steel at equivalent to current levels, while total current Austrian electricity consumption is roughly 70 TWh today (E-Control, 2018).

Additionally, the break-even for hydrogen based steel has to be evaluated dependent on carbon dioxide pricing and the level of electricity cost as the relevant parameters (Fischedick et al., 2014; Mayer et al., 2019; Vogl et al., 2018). Particularly the iron and steel sectors' capability to pay for electricity may be at the lower end of the merit order curve. If market imperfections (externalities) diverge across the economic sectors demanding hydrogen and if these are not internalised, a mere market-based selection of the sector to which hydrogen is finally supplied will generally not correspond to an overall economic efficient outcome. In this case, policy intervention needs to be considered. Given that electricity demand remains relatively inelastic, price decline will materialise if penetration of low variable cost technologies like PV and wind power is stronger than rising total demand. Electricity demand is also influenced by technological progress as such (e.g. digitalisation) and mitigation efforts in other sectors, for instance, in e-mobility, and green hydrogen for other sectors. Consequentially, other consumers than iron and steel might have an advantage because competitiveness might be given with electricity prices above the iron and steel sector's capability to pay. At the same time, if the production of hydrogen could offer flexibility to the energy system, hydrogen can be stored and the production can be shifted to periods with high or excess renewable electricity generation. Offering this kind of flexibility could lead to new revenue streams for actors producing hydrogen. Large-scale hydrogen storage technologies are, however, still in their testing phase. Yet, while there are R&D efforts to make electrolyzers better suited to intermittency, they are currently best operated if the supply of electricity is constant.

In the current pilots, hydrogen is produced on-site at the steel facility; hence, new dependencies may occur, such as, from utilities that may exert market power affecting the price for renewable electricity. Hence, steel producers would face different supply side risks, particularly in comparison to conventional steel making where coal is purchased in a global market. If steel producers purchase hydrogen instead of electricity, new dependencies may occur because free market competition for hydrogen may be not realistic, particularly at a global scale. Long-distance transport of hydrogen as a gas in pipelines also has difficulties due to shifting market power to pipeline owners (which is a rather monopolistic market).



The risk profile for hydrogen-based steelmaking therefore strongly depends on the way the company currently is positioned in the market and on its access to renewable electricity and hydrogen. As interim solution, direct reduced iron can be produced with different shares of hydrogen and natural gas. The combination diversifies the input in the transition phase, which would help to better manage market dependencies.

Techno-economic and system-wide analysis of expected technology cost rates suggest a maximum electricity price of 0.05 EUR per kWh in order to achieve competitiveness for the DRI-EAF route (in operating expenditures compared to the conventional BF-BOF). This is conditional on a carbon price of around 140 EUR per ton of carbon dioxide (Fischedick et al., 2014; Mayer et al., 2019; Vogl et al., 2018). In a best-case scenario, further technological progress in hydrogen-based steelmaking (i.e. plasma-based processes) in combination with an electricity price at or below the current lowest industry prices of 0.03 EUR per kWh would require much lower carbon prices to reach break-even points (for a specific parameter constellation, e.g. Mayer et al. (2019) give a global price of about 25 EUR per ton of carbon dioxide). The low-carbon transition in the electricity market, and its associated design, plays a decisive role here. Large investment requirements may (temporarily) push up wholesale electricity prices. It is also conceivable that generation of electricity and/or hydrogen is organized in a much more decentralized manner such that a more competitive and possibly geographically closer generation of 'green hydrogen', for example, decreases the upstream dependence of the iron and steel sector. On-site electrolysis would be the 'coking plant' of future steel production. However, this on-site generation possibility is location-specific and some steel companies experience better opportunities than others do because e.g. of their vicinity to areas where large-scale renewables production can be established. This creates unequal framework conditions for steel companies following the hydrogen route, in case they produce the hydrogen themselves, in particular in absence of a harmonized European energy policy.

Hydrogen production from dedicated power generation, such as the emerging offshore wind parks in the North Sea, is currently considered as important option if the main hydrogen demand develops from industrial users. However there is the risk that industry is relocating to a small number of 'hydrogen-focused' clusters avoiding the transport of hydrogen. A relocation of larger steel production, however, is unlikely as interviews revealed.

Supply risks may be reduced if steel producers due to respective ownership structures or long-term collaborations can guarantee the supply of renewable electricity to them. For instance, in the case of the German steel producer Salzgitter, the regional government co-owns steel plants and at the same time fosters renewables. In Sweden, the steel producer SSAB, the mining company LKAB and Vattenfall, an energy provider owned be the Swedish state, have set up the joint venture company HYBRIT to implement hydrogen based steel production.

Another two pivotal risks for hydrogen-based steelmaking are (i) global steel demand and corresponding capacities and (ii) the long lifetime of blast furnaces (with an operational period of up to 60 years) compared to lifetime of investments in other sectors. Both are important barriers for implementing new technologies. Without niche specialization, steel producers currently face large uncertainties due to price deterioration given the strong competition to manage underutilization of existing capacities. In this surrounding, incentives for investing in new plants are low regardless of technological choice. Likewise, 'greenfield' investments are enormous projects that require considerable assessments prior to switching technologies. For blast furnaces, experience has shown that regular retrofitting measures can extend its economic lifetime significantly, adding uncertainty to when plants are really outdated and need to be replaced by new equipment e.g. hydrogen-based steelmaking. If the switch occurs too early, this would unnecessarily create stranded assets for existing infrastructure. Thus, injection of capital by public authorities (e.g. direct finance or co-finance by public investment banks) is a precondition for such investments. While some companies call for industrial price guarantees others see this as too risky. A number of steel company representatives, for example, argue that as long as technological competitiveness of a new technology is not achieved, they are reluctant to switch (i.e. operating expenditures net of any distortions are not in a comparable range to incumbent technologies). Subsidies would not change this position, given the extraordinary lifetime of iron and steel facilities compared to political cycles.

Least to say, many new promising technologies have entered the stage in iron and steel production in recent decades but the vast majority never reached maturity. There is a poor track record for significant technological turnovers because productivity gains in conventional blast furnaces have been large and are not foreseeably bound. However, minimum greenhouse gas emissions of the blast furnace route are stoichiometric determined (1.3-1.6 tons of carbon dioxide per ton of steel produced; Kirschen et al., 2011) limiting complete avoidance. The technological options described in the two following subsections illustrate how continuing with blast furnaces may comply with strict mitigation targets but requires dealing with end of pipe carbon dioxide emissions.

Carbon Capture and Storage

Retrofitting blast furnaces with carbon capturing applications might be a cost-efficient approach from a technical point of view. However, this is also linked to a set of risks. There is the possibility of a global market for carbon dioxide storage and transport as it can be kept liquid and long-distance shipping by trucks and ships enables storage anywhere. However, industry fears that due to limited suitable sites, the operators of underground storage facilities can exert market power. This raises the question whether it can be guaranteed that storage is provided at operating expenditures. Despite this possible dominant position, storage providers (i.e. mostly companies in the fossil fuel industry) face the trade-off between paying certificate prices or investing heavily in pipeline and storage infrastructure. However, storage providers can benefit from accredited emissions abatement and have a secure long- term revenue source. Public authorities could play a significant role here, first, in incentivizing such investments and second, in controlling competition and antitrust.

Underground storage also comes along with a significant environmental risk accompanied by a lack of societal acceptance. Besides managing leakage risks, induced seismic activities triggered by (near-) onshore reservoirs is heavily at odds with acceptance by affected societies. Some steelmakers going for CCS admit that this environmental risk can only be socialized; no individual private actor can mitigate this risk on his or her own.

Carbon Capture and Usage

An alternative possibility is to store carbon dioxide not underground but in products. The usage of carbon dioxide for industrial applications may be an important step in accelerating the deployment of carbon capturing which is the focus of the subsequent subsection. In many CCU applications, the carbon dioxide is not bound permanently, but later released again. This makes it distinctly different from CCS, which is presumed to be permanent.

Customer-tailored iron and steel products represents the core business area of European steel producers. The extension of this traditional activity towards capturing and using waste gases could be a promising avenue supplying by-products to the chemical sector. For instance, the chemical sector is using at large scale gas conversion processes deriving ethylene, propylene, styrene, hydrogen and fertilizers. New bio-chemical processes even aim at transforming industrial waste gases into liquid fuels ('steelanol'). However, this new avenue also involves risks that incumbent steel firms have previously neither encountered nor engaged in. A few steel makers see CCU as 'intermediate' solution between complete avoidance of emissions (i.e. hydrogen-based steelmaking) and underground storage bypassing some of the major risks as described above for example market power risks. Currently, the market for carbon dioxide is comparably small. About two thirds of carbon dioxide is used in 'Enhanced Oil Recovery' processes, with the remaining share devoted to beverage carbonation and food industry purposes (Global CCS Institute, 2011).

Given the low costs of producing carbon dioxide (e.g. utilizing natural wells or by-product of natural gas processing) estimated to be around 9-26 EUR per ton of carbon dioxide (Global CCS Institute, 2011), companies that use capturing technologies are confronted with 100 EUR per ton of carbon dioxide avoided (Porter et al., 2017). The usage route, therefore, has a possible demand risk. It remains to be seen whether (i) a shadow price for carbon dioxide fills this gap or (ii) new markets can be established such that the excess supply of carbon dioxide can be utilized and absorbed by market forces alone. For the second avenue to happen, incentives have to be sufficiently high such that the value of avoided carbon dioxide emission can be shared between the steel industry and carbon dioxide using industries (e.g. using 'steelanol' in the transport sector).

In addition, the usage of the carbon dioxide flow by chemical processing inevitably entails the consumption of energy and hydrogen, which need to be supplied accordingly. Hence, CCU approaches have to face and manage a supply risk, which may be in a similar order of magnitude as in the case of the hydrogen-based steel production.

Scrap-based steel production

Primary steel production and associated process emissions, which make up the largest share of the sectors' emissions, would be nearly obsolete with deploying secondary steelmaking only (i.e. recycling scrap). This incremental option is a legitimate decarbonisation strategy, however not suitable to rapid change necessary to comply with objectives of the Paris Agreement, as already outlined in the introduction. The accumulation of steel and scrap is subject to a long time lag and, since global steel demand is expected to rise until mid-century, scrap availability in quantity terms is insufficient. Additionally, steel products increasingly involve special purity as well as alloying requirements leading to quality problems of the scrap feedstock (Arens et al., 2017; Morfeldt, 2015; Pauliuk et al. 2013); thus scrap-based steel may not be suitable for all production processes needed for specialized high quality steel products.

However, the entire transformation of current production towards climate-neutrality requires steel in various qualities, for instance piles of wind power plants, or rails for train services. Hence, incremental improvements in conventional steel making (e.g. customer-tailored manufacturing) are still highly important in the medium term in order to support the transformation of other sectors. Moreover, recycling efforts have to increase because they are in many cases economically and ecologically meaningful.

Synthesis of company-level related risks

We summarize the most relevant company level risks of iron and steel decarbonisation in a European context. We differentiate between three main pathways beyond the conventional BF-BOF derived steel making. For hydrogen-based steelmaking, the main strengths are clearly that carbon dioxide emissions of primary steelmaking can be reduced by more than 80% and there seems to be less societal caveats against deploying renewables-based electrolysis. On the downside, security of supply and the related price risk is comparably high with this option. In comparison, technological issues reflect only intermediate risks, most issues concern upscaling of hydrogen generation by means of polymer electrolyte water electrolysis because direct reduction of iron oxides and steel processing with electric arc furnaces are already mature technologies. Various designs of how and who is generating electricity and hydrogen renders the level of market power risk ambiguous. The application of natural gas as an intermediate "bridge" technology may help to mitigate the above risks.

With carbon capturing, the prevailing input structure of steelmaking does not change, thus steel producers' relations with upstream suppliers can be maintained. Contrary, carbon storage providers are in a strong market position relative to steelmakers with leakage and societal acceptance risks adding to the adverse company-level risk rating of CCS. For CCU, even if there are various opportunities to store carbon dioxide in industrial products, bulk demand for some of the products needed for CCU are still lacking (e.g. ethanol). Moreover, carbon storage in products (i.e. CCU) may imply other sectors generating GHG emissions when using these products (e.g. steelanol, bio-kerosin), and in this case hinder the decarbonisation of those sectors and thus emission-neutrality of the overall economy.

For recycling (i.e. scrap-based steel production), we mainly identify quantity and quality issues translating to input supply and price risks. Neuhoff et al. (2018) suggest various instruments and measures for overcoming them. However, this option alone is insufficient for meeting the 'well below 2° C' target.

Broader/inter-sectoral dimension of risk

An essential aspect in recent debates has been how cost/risks and benefits/opportunities of socio-economic development spread across actors. Given the fact that some risks are not bearable by single private actors (e.g. basic research and demonstration activities), the main concern is that a small group benefits from risky undertakings while potential costs are socialized (e.g. seismic activity induced by underground storage). An integrated perspective of new value chains that may include the steel sector, other industrial sectors as well as the energy sector may enable viable business models but necessitates dealing with new risks appropriately. Keeping an eye on plausible unintended consequences and possible synergies and opportunities is key. Otherwise, the value chain will either not materialize or be ineffective from a system perspective. An exemplary case for such ineffectiveness is the mere shift of emissions to the electricity supply sector as long as the electricity mix, if devoted to hydrogen-based steelmaking, remains fossil fuel based. Industrial cooperation and symbiosis can thus potentially help clearing supply-demand chain needs, in the end being supportive in managing transition risks.

In addition, policymaking has to mirror this integrated perspective as well. A very recent negative example has been the price zone split of German and Austrian day ahead electricity markets. The resulting artificial shortages may prevent industry decarbonisation via electrifying production at least costs. This counterproductive development within sectors covered by the EU ETS deteriorates the effectiveness of climate mitigation even further if aspects of the non-ETS area (e.g. transport), dealt with by national member states, are not anticipated and accounted for at the EU level and vice versa. In general, the division into ETS and non-ETS had led to a split of responsibilities that may hinder the establishment of value chains that cross these boundaries. This is clearly visible for a green hydrogen-based value chain for the steel sector. Integrated National Energy and Climate plans, as provided for in the EU governance regulation may address this coordination problem.

3 CONCLUSIONS AND IMPLICATIONS FOR FUTURE POLICIES

Investigating distinct risk domains of a low-carbon transition in iron and steel production, as we do here, aims to complement existing and currently discussed policies. These include ETS reform, more recycling or supporting the establishment of a risk-reducing framework for a steel transition. According to our interviews with various steel company representatives across Europe, we find that several see hydrogen-based steel production as viable long-term vision. Opinions strongly differ as to what extent less fundamental options need to be considered in the transition phase. Additionally, the different planned approaches depend on the companies, their products, their possible windows to innovate and many other factors determining the specific risk profile of each company. Larger companies with several production sites, for example, seem to contemplate more than one decarbonisation option, by doing so cautiously diversifying the risk of choosing an inadequate strategy.

Each decarbonisation strategy involves other or new dependencies and market power constellations, which is why we find that steel producers thoroughly evaluate value chain risks before they take investment decisions. This applies for companies that strive for hydrogen-based steelmaking but also for other options such as CCS. Public and private decision makers need to understand new or re-organized value chains for medium and long-term iron and steel production. These cross-sectoral value chains require the installation of infrastructure, e.g. electrolysis plants, or the establishment and connection of distribution networks (power grids and pipelines for methane, carbon dioxide, biogas, etc.).

Cross-sectoral cooperation such as between the steel sector, other industry sectors and the energy sector could lead to economic and decarbonisation synergies; however, these are not yet sufficiently understood and will not be available at every site to the same extent and conditions, thus, possibly leading to competitive inequalities.

The effectiveness of policies enabling such cross-sectoral cooperation hinges upon risk mitigation frameworks that account for the fragmentation of political competences. For instance, national governments do not have the main responsibility regarding decarbonisation of ETS sectors apart from calling for changes to the ETS design itself. Coordination, coherence and transparency of political processes are prerequisites for enabling low-carbon transition and interventions could start by means of public-private partnerships. Governments will need to play a more active role in the management and reduction of related risks in steel industry decarbonisation. The timeframe in which risks are managed across other sector transformations will also contribute to determining the timing and costs of the transition in the steel sector.

As important element of governmental measures, industry representatives strongly advocate for stronger harmonization and integration of the European Electricity market in order to provide equal market conditions for electricity consuming industry. Also regarding storage options public authorities could play a significant role in enabling competition. Another starting point to establish a more equal framework across the EU for the steel sector would be that each single sector in EU member states (ETS and non-ETS area) creates its own low-carbon pathway incentivized by company strategies, political commitment or even legal obligation.

A subsequent comparison of the requirements of single sectors could provide a clearer picture where main bottlenecks but also synergies exist at the national scale. This aggregated picture then serves as basis for a stronger European perspective on the ultimate renewable energy or hydrogen provision requirements. This approach reflects single sector needs at the national level in a case-by-case manner that could be a good basis for a more harmonised European policy framework for a steel transition.

MORE INFORMATION

There is more information on this work, and on TRANSrisk as a whole, on our website

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About TRANSrisk

TRANSrisk is studying the **risks and uncertainties** within **low carbon transition pathways**, and how transitions can be implemented in ways that are **technically, economically** and **sociably** feasible. The project's objective is to produce a new assessment framework, and an accompanying **toolbox, for policy makers**.

TRANSrisk's unique approach sees us combining **economic computer models** with **input from people working in the area of study ("stakeholders")**. Models provide a useful means of predicting the future impacts of decisions we take now, but **factors such as political opinion and public acceptability** are very difficult to predict via a purely numerical approach. TRANSrisk is using **stakeholder input** to feed our models, and is presenting the results **back to stakeholders** to see how this affects their views.

14 country case studies lie at the core of TRANSrisk's work. To fully understand the range of transition pathways our **case studies encompass the globe**, as presented in the adjoining map. In alphabetical order they are: **Austria, Canada, Chile, China, Greece, India, Indonesia, Kenya, the Netherlands, Poland, Spain, Sweden, Switzerland and the United Kingdom.**

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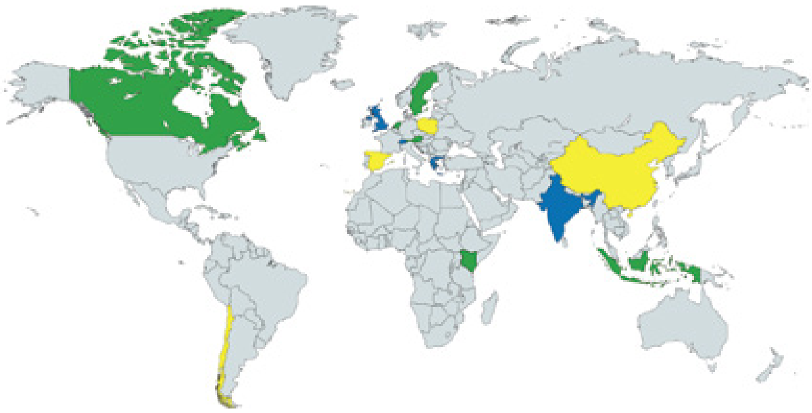

The team behind TRANSrisk is a knit partnership of 12 leading universities / research institutions, based in the EU, Switzerland, and Chile.