Kepler Cheuvreux TRANSITION RESEARCH

360 Report

Climate change scenarios

Risks and opportunities

30 July 2018

Project funded by the EUROPEAN UNION

Transition risks in the steel sector

CLIMATE XCELLENCE

THE-CO-FIRM

What's it all about?

Since the FSB's Task Force on Climate-related Financial Disclosures (TCFD) published its recommendations in 2017, scenario analysis has been a vital tool for assessing the risks and opportunities for companies from measures taken to mitigate climate change. This study analyses the degree to which the valuation of steel companies could differ between two climate change scenarios and a market "consensus baseline", with a specific focus on European companies, such as ArcelorMittal, thyssenkrupp and voestalpine. This report also analyses how company valuations can vary due to two different strategic decisions they could take to adapt to the low-carbon transition. We provide insights for equity analysis and company engagement, taking into account regional and technological sensitivities.

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Energy Transition Risk Project
Project details at the end of the report and under www.et-risk.eu

Please refer to the last page of this report for "Important disclosures"

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360 in 1 minute

Climate change scenario analysis for crude steel production

This report is the fourth in a series of six, as part of the Energy Transition Risks project. It investigates the potential financial impact of climate change scenarios on companies in the steel sector, focusing on ArcelorMittal, thyssenkrupp, and voestalpine's crude steel business.

Macro climate change scenarios and company trajectories

We use The CO-Firm's climateXcellence model to assess two climate change scenarios and, overlaid onto them, two pathways illustrating the different ways a company might adapt to the changing crude steel market.

- Macro climate change scenarios: From the International Energy Agency's 2017 Energy Technology Perspectives: 1) the **Limited Climate Transition** scenario (LCT) (c. 2.7°C temperature increase by 2100); and 2) the **Ambitious Climate Transition** scenario (ACT) (c. 2°C).
- **Company adaptation pathways: "MARKET"**, expects companies' asset development and growth to be fully in line with the market developments outlined in the IEA's scenarios, relative to their market share by region, with the constraint of being tied to their current operating markets. The market share is determined through forecast data until 2020 based on VDEh's PLANTFACTS. **"MARKET-EBIT"** acknowledges that financially strong companies (higher EBIT) can capture a larger share of profitable growth.

Based on these scenario inputs, the model produces earnings, cash flows, depreciation, etc. Results are at the company level to 2050.

Key findings: tools for engagement and further research

Kepler Cheuvreux (KECH) analyses how to integrate the earnings outputs from the scenario modelling into equity valuations by altering the company's growth profile in DCF models. While our findings suggest that some companies could profit more under the ACT compared to the LCT scenario, we caution that this should not be seen as an investment recommendation or forecast. Instead, our analysis illustrates, through one set of many plausible climate change scenarios, that there will be winners and losers in the low-carbon transition. KECH and The CO-Firm's conclusions should benefit both equity analysts in their integration of transition risks into their investment cases, and asset managers in their engagements with companies.

This analysis was produced independently from Kepler's Steel team and does not reflect their views or ratings of any company mentioned.

Contents

The Energy Transition (ET) Risk Project

The ET Risk consortium, funded by the European Commission, is developing the key analytical building blocks needed for energy transition risk assessment and is bringing them to market.

1. **Transition scenarios:** The consortium has developed and made public two climate change scenarios, the first (LCT) represents a limited transition that extends current and planned policies and technological trends (e.g. the IEA ETP RTS trajectory). While the second (ACT) represents an ambitious scenario that expands on the data from the IEA ETP 2DS.
2. **Company data:** The Oxford Smith School and 2° Investing Initiative have jointly consolidated and analysed asset level information across six energy-relevant sectors (power, automotive, steel, cement, aircraft, and shipping), including an assessment of committed emissions and the ability to potentially "unlock" such emissions (e.g. by reducing load factors).
3. **Valuation and risk models:**
    - climateXcellence model: The CO-Firm's scenario risk model covers physical assets and products and determines climate transition risks at the levels of asset, company, country, and sector, along with opportunities under a variety of climate change scenarios. Effects on margins, EBITDA, and capital expenditure are illustrated under different adaptive capacity assumptions.
    - Valuation models – Kepler Cheuvreux. The above impact on climate- and energy-related changes to company margins, cash flows, and capex can be used in discounted cash flows and other valuation models for financial analysts.
    - Credit risk rating models – S&P Global. The results of the project will be used by S&P Global to determine if there is a material impact on a company's creditworthiness.
    - Assumptions on necessary sector-level technology portfolio changes are aligned with the Sustainable Energy Investment (SEI) Metrics project (link), which has developed a technology exposure-based climate performance framework, and associated investment products, that measure financial portfolio alignment.

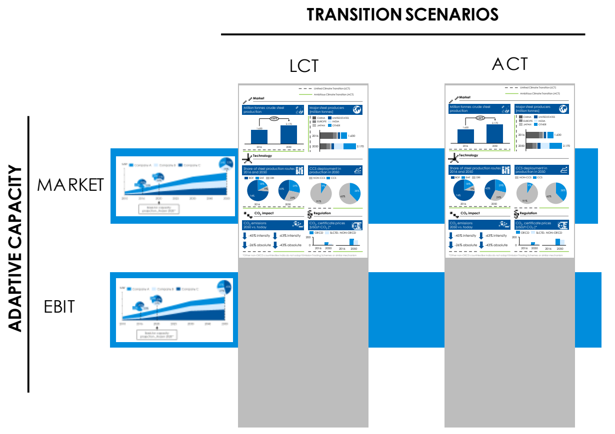
See seimetrics.org for more information on the "sister" project on companies' technological exposure

Acknowledgements

For sharing his insights, and providing feedback in the writing of this report, we wish to thank Mark Fulton. Mark is an advisor to the Carbon Tracker Initiative and the 2° Investing Initiative; a Senior Fellow at CERES; and Special Advisor to the Climate Bond Initiative.

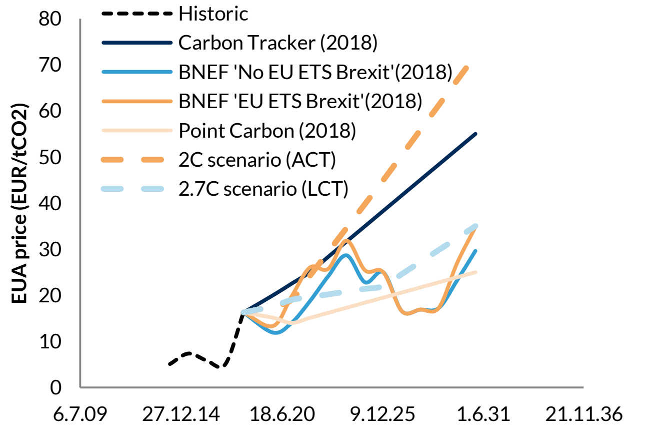
Executive summary: results in six charts

Chart 1: Two climate change scenarios overlaid with two adaptive capacity pathways



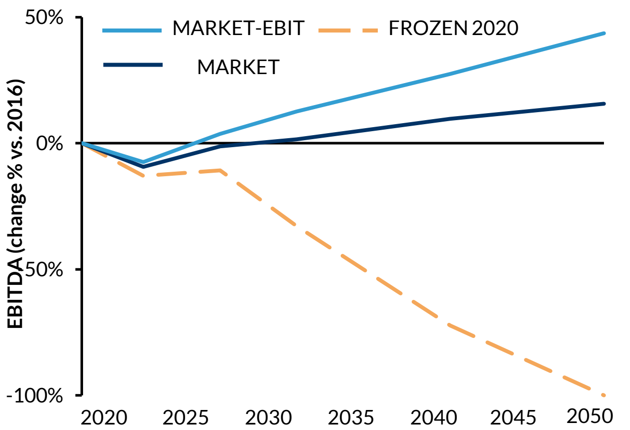
Source: The CO-Firm

Chart 2: Regional regulatory and technological factors drive the low-carbon transition in our scenarios – the EU ETS is one measure likely to become material to steel producers



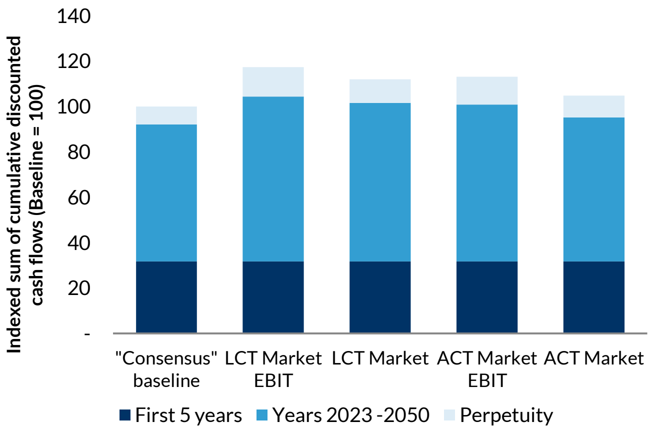
Source: Kepler Cheuvreux

Chart 3: Steel company earnings in each climate scenario – ArcelorMittal sees strong EBITDA growth to 2050



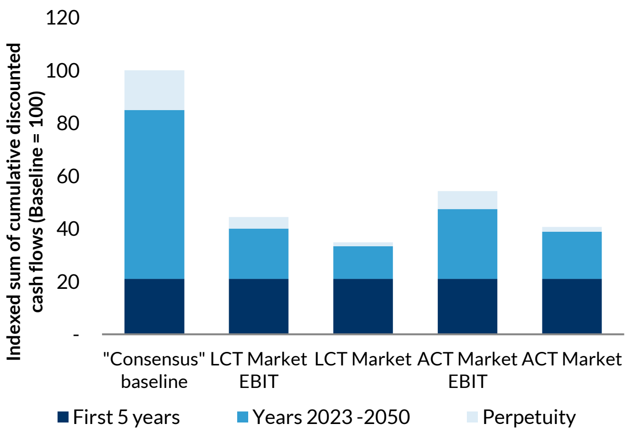
Source: The CO-Firm

Chart 4: ArcelorMittal's valuation under different climate change scenarios



Source: Kepler Cheuvreux

Chart 5: Thyssenkrupp's valuation could fall in our climate change scenarios compared to a consensus baseline



Source: Kepler Cheuvreux and The CO-Firm

Chart 6: Investors should question the impact on steel companies' valuation from transition risks

Engagement questions for investors

What is ArcelorMittal's strategy for growing the relative share of EAF- and DRI-based steel production methods?

Does thyssenkrupp consider CCS an option for its Duisburg mill, as well as CCU? If not, what solutions do you see for BOF steelmaking?

What plans are in place to diversify voestalpine's steel production asset base in the medium-term?

Source: Kepler Cheuvreux and The CO-Firm

Executive summary: the results in context

The steel sector needs a transformation

The steel industry is very energy intensive and, therefore, emissions intensive; the sector contributes 6-7% of global anthropogenic greenhouse gases (GHGs), which drive global warming. The energy intensity of the sector is improving, but this rate of efficiency gain must accelerate if governments are to deliver on their commitments under the 2015 Paris Agreement.

The price of carbon is becoming significant

Low-carbon steel production methods currently have relatively high capital and operating costs. Therefore, producers will need to be incentivised to make the transition from coal/gas-based processes. A price on carbon emissions is arguably the most effective way to do this and, in the EU, the emissions trading scheme (ETS) is quickly becoming significant for steel producers.

A perfect storm of factors could lead to an "existential threat"

In 2017, iron and steel emissions under the ETS rose. Simultaneously, the ETS price has also risen, by over 200%, to c. EUR15/tCO2 over the past 12 months to date. Many expect the price to rise to EUR20-50/tCO2 by 2030 as a result of recent reforms to correct the market balance. The amount of emissions allowances that steel producers are allocated for free in Phase 4 (2021-30) of the ETS will determine the extent of the financial incentives placed upon them to transition to lower-carbon production. According to KECH's mining equity analyst (February 2016), a price of EUR30/tCO2 could create *"an existential threat for the viability of many [steel] producers"*.

A price of EUR30/tCO2 could create "an existential threat for the viability of many [steel] producers"

Ours is a story of regional and technological diversification

Putting a price on carbon in OECD, and some non-OECD countries, is a key driver of the low-carbon transition in steel in the two climate change scenarios applied in this study: LCT (+2.7°C by 2100) and the ACT scenario (+2°C by 2100). These scenarios are based on pathways in the IEA's 2017 Energy Technology Perspectives report.

Simply put, these scenarios see the greatest steel production growth in non-OECD countries, which offer competitive advantages to companies based there from the later implementation of CO2 pricing (if they are implemented at all). At the technological level, non-coal based, direct reduced iron (DRI) steel production is the low-carbon method that grows most rapidly, as the electric arc furnace (EAF) method suffers from increasing electricity and scrap prices. CCS is economically viable from 2040 onwards due to a sufficiently high CO2 price. CCU (carbon capture and utilisation) is not addressed in these scenarios. Against this backdrop of future market demand, The CO-Firm is able to estimate company cash flows and earnings from crude steel production for ArcelorMittal, thyssenkrupp and voestalpine.

Searching for mispriced assets

KECH runs these company cash flows through a DCF model under its equity analysts' discount and terminal growth rate assumptions in order to estimate company valuations under our climate change scenarios. To answer the question, "*what could the valuation of a company be under different climate change scenarios*?" this report then compares the valuation of each company under these scenarios with that of a market "consensus" baseline.

One set of assumptions leads to one set of valuations

This analysis suggests that ArcelorMittal and voestalpine could be valued more highly in either of the climate change scenarios compared to the baseline, while thyssenkrupp[1] could be valued lower, when based on their crude steel operations. This reflects the specific technological and regional assumptions of the LCT/ACT scenarios, and the valuation assumptions (terminal growth rate and discount rate) used in the DCF model.

In this study, we apply the valuation assumptions used by KECH's mining equity analysts. This sees different discount rates being applied to each of the three companies, reflecting differing perceptions of the risks posed to each company's future cash flows. Other analysts or studies may have different views on any of these modelling inputs, resulting in different conclusions to those of this study.

Adaptive capacity can determine if a company is future-proof

Adaptive capacity is the result of dynamic capabilities (e.g. opportunity recognition, partnering etc.), that enable existing resources (financial strength, intellectual property etc.) to be put to good future use, by means of a strategy. It forms an implicit part of an equity analysts' everyday evaluation of a stock.

Adaptive capacity becomes all the more critical for companies exposed to transitioning sectors

Adaptive capacity becomes all the more critical for companies exposed to transitioning sectors, such as the steel sector, because it can determine the degree to which a company is able to foresee, align and adapt to market shifts. This report acknowledges the importance of adaptive capacity by running two pathways (MARKET and MARKET-EBIT), within each climate change scenario, that vary one aspect of a company's resource base, i.e. its financial strength. Of course, in reality, adaptive capacity is comprised of many more factors.

We also include a "standstill" pathway ("FROZEN") in which companies' expected product portfolio is frozen from 2020. This demonstrates the potential cost to companies of inaction in a sector that is undergoing a low-carbon transition.

Scenarios are critical to minimise risks and maximise opportunities

In the face of a host of unknown low-carbon transition factors, including: regional CO2 prices; cost reductions in EAF, DRI and carbon capture and storage (CCS); coal and gas prices etc., scenario analysis emerges as a vital tool to:

- Illustrate a range of, potentially extreme, market outcomes.
- Identify key drivers of change within each scenario.
- Understand how a company might be able to adapt to the changing market, given its current and potential future resources.

[1] Note, the impact of thyssenkrupp's current steel production on the group's future steel earnings and valuation will likely be less than when these scenarios were run as a result of its joint venture with Tata Steel Europe (June 2018).

The stakes are high for the steel sector when it comes to the low-carbon transition. Scenario analysis helps enhance the management of uncertainty and inform any decisions taken.

Objectives and readers' guide

This report aims to illustrate how climate change scenario analysis can be integrated into mainstream company earnings and valuation analysis, using the example of the steel sector.

Our findings illustrate a scenario analysis, not investment advice; none of the comments or data included in this report should be seen as informing or relating to Kepler Cheuvreux's equity analysts' ratings or views on any company mentioned in this report

This is the fourth in a series of six reports. The first report, "Investor primer to transition risk analysis", discussed the methodological and conceptual underpinnings of our endeavour. The second report focused on the potential impact of climate change scenarios on the valuations of specific companies in the utilities sector (EDF, Enel, Engie), while the third did the same for the automotive sector. This report tests the previously developed financial risk analysis methods on the steel sector with a focus on ArcelorMittal, thyssenkrupp and voestalpine. An upcoming report will apply the same approach to the cement sector. The final report in the project will bring together the results and lessons from each of the previous reports.

This report is primarily aimed at financial analysts who wish to understand the scale of transition risks for company performance and valuations, and the more technical aspects of scenario analysis. We also hope to inform investors as to which steel companies could be winners (and losers) in the transition to low-carbon production as a means to inform their engagements with companies.

The CO-Firm lays out its methods for determining financial risk based on climate change scenarios. Kepler Cheuvreux then investigates how to integrate these results into traditional equity valuation models. The results should not be considered investment recommendations, financial forecasts or a judgement of the accuracy of the equity models, but rather the result of a number of plausible assumptions around the low-carbon transition. They constitute an outside-in analysis for providing guidance on company engagement.

The report builds on the following previous reports:

- The Transition Risk-o-Meter: Reference Scenarios for Financial Analysis (2°C Investing Initiative, The CO-Firm, June 2017, link).
- Technical supplement: The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities, TCFD (June 2017, link).
- Changing Colours: Adaptive capacity of companies in the context of the transition to a low carbon economy (2°C Investing Initiative, The CO-Firm, Allianz, Allianz Global Investors, August 2017, link).
- Climate scenario compass: Investor primer to transition risk analysis (Kepler Cheuvreux, The CO-Firm, January 2018, link).
- Climate scenario compass: Transition risks for electric utilities (The CO-Firm, Kepler Cheuvreux, January 2018, link).

- Climate scenario compass: Transition risks for the automotive sector (Kepler Cheuvreux, The CO-Firm, forthcoming).
- Climate scenario analysis: Cement's financial performance under 2° C and 2.7° C - A how-to guide for the sector, and three companies across six countries (The CO-Firm, forthcoming).
- Climate scenario scenarios: Transition risks: How to move ahead. (The CO-Firm, Kepler Cheuvreux, forthcoming).

How to interpret and integrate the results

This section outlines how our target audiences can interpret and use the results of our analysis.

What are our research themes?

Looking at the crude steel production segment, this report comments on:

- **The scale of business risks and opportunities under long-term climate change scenarios** by looking at the relative change in company EBITDA.
- **The speed at which transition risks and opportunities manifest themselves, which are** revealed by changes in company and sector financial performance over time.
- **Drivers of change** supporting the low-carbon transition.
- **Company readiness and capacity for transition,** factors which are central to determining future winners and losers.

What can we learn about company-level analysis?

What can we learn about company-level analysis?

This research aims to help the reader understand:

- What the **key determinants** of company growth and profitability in climate change scenarios are.
- **Which mechanisms (volumes, prices, costs, etc.)** can impact company performance in each climate change scenario**.**
- Whether, and how, the structural setup of companies today provides a perspective on their **future performance potential** in a transitioning market.

What relevance does adaptive capacity have in climate change scenarios?

We test different assumptions of a company's adaptive capacity in order to judge its importance when sectors are transitioning. One should consider:

- The **scenario readiness** of the resource base: How is a company positioned for a changing market scenario, e.g. its potential to participate in relative growth, in specific technologies, or in regional markets?
- **Winner propensity**: How is the company positioned relative to others, regarding its types of physical and intellectual assets and its regional market presence?
- The **cost of inaction:** What are the financial implications for a company that stands still in a changing market?

How does our approach to climate change scenario analysis relate to current equity analysis?

Similarities:

- Both are financial assessments.
- Both are data-driven.
- Both reflect specific company strengths and weaknesses (current asset base).
- Both reflect the current corporate strategy (to 2020).
- Both incorporate industry and competitive dynamics, though with different timelines.

Differences:

- The scenario analysis timeline extends to 2050, beyond the currently available consensus data (to 2020).
- The climate change scenarios are designed to limit global emissions to below a pre-determined level of average temperature increases until the year 2100. Almost all company forecasts and expectations will not be from the climate angle, although some assumptions might take climate change into consideration.
- The fundamental driver of the assessment is the physical asset/product portfolio of the company, not its past financial performance.
- The analysis is more far-sighted than near-term outlooks, which tend to leverage historical data and performance.
- The focus is on a general propensity to change the asset portfolio, not on specific point-in-time strategic decisions as soon as these are announced.
- The company is only considered in terms of its most risk-prone or opportunity-laden business segments.

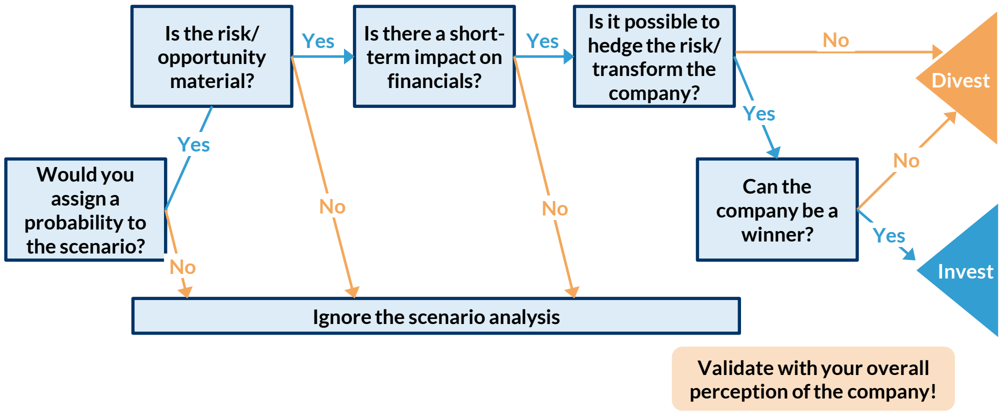
As an equity analyst, ask yourself the following:

As an equity analyst, ask yourself the following

1. To what degree do you **believe the scenario**? Do you assign a probability to it?
2. Do you consider **climate risk/opportunity to be material** for your sector(s) and company(ies)?
3. Does the risk/opportunity **materialise soon enough** for you to integrate it into your investment case? Or does managing the risks and capturing the opportunities already require preparation on the side of company(ies) that impacts their financial performance within your time horizon?

The schematic below introduces an example decision-tree that an equity analyst might follow when first interpreting the results of a climate change scenario analysis (Chart 7).

Chart 7: How an analyst can interpret their climate change scenario analysis



Source: The CO-Firm

As an asset manager, ask yourself the following

As an asset manager, ask yourself the following:

1. Do you want to **foster the low-carbon transition** by investing in it strategically? For example, by supporting companies that drive the transition.
2. Confronted by transition risk(s), **can the company credibly transform?** If so, do you need to engage with the company to either transition within its current business segments, or more fundamentally shift to other business segments?
3. In the case that the company can transform, do you agree that it will **be a winner in the market?**
4. If the company cannot align with the transition, can the risk be **ignored or hedged** outside the business segment/sector concerned?
5. Do you need to **divest** your holdings from the company due to unacceptable financial risks from the low-carbon transition?

As a portfolio manager, ask yourself the following

As a portfolio manager, ask yourself the following:

1. What are the **risk and opportunity drivers** of the underlying scenario?
2. How might transition risks impact the sectors' relative **risk-return** profiles?
3. How large is the **gap** between the traditional valuation and longer-term scenario dynamics, and what are the **main drivers**?
4. After performing a scenario analysis, **transparency** should have increased and you could ask whether you have identified the **characteristics that define companies' structural resilience**?
5. To what extent can stock picking impact **average sector risk**?

As a risk manager, ask yourself the following

As a risk manager, ask yourself the following:

1. What are the **drivers and early warning indicators** for climate risks in a 2°C scenario in TCFD-relevant sectors?
2. Do I want to assign the scenario a **probability weighting**? If so, what?
3. Can I identify a **structural component to the opportunities and risks** that exist for companies?
4. Would a change in the **significance of risk factors** or new risk factors imply changes to general risk management?

Scope of the study

This report focuses on the possible impact of the low-carbon transition on companies in the steel sector, which is one of the focus sectors of the TCFD's reporting recommendations due to its high business risks (and opportunities). We focus on ArcelorMittal, thyssenkrupp (prior to the JV with Tata Steel Europe) and voestalpine to give an indication of the factors that could determine the sector's winners and losers.

In this study, The CO-Firm and Kepler Cheuvreux compare the potential future earnings and valuations of these organisations. We also analyse the respective adaptive capacity of each organisation, i.e. their capacity to adapt to, and profit in, a transitioning sector.

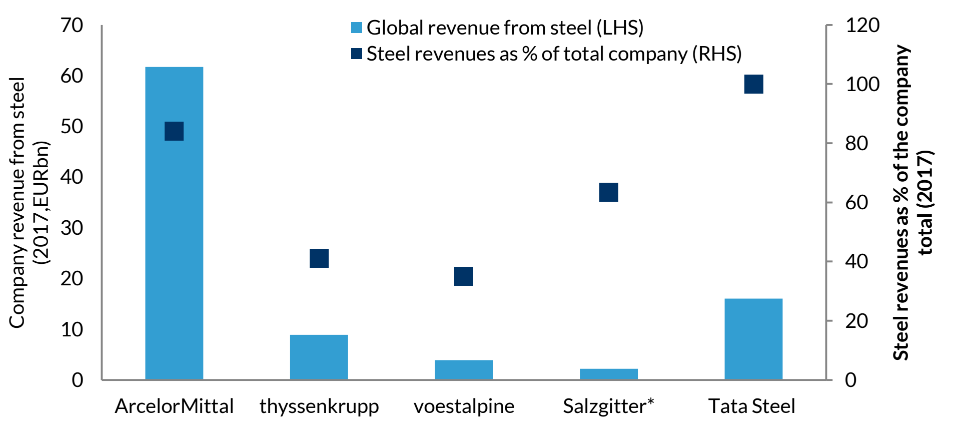
Although these organisations are within the same peer group, as determined by Bloomberg, they of course possess different financial structures and market exposures. For example, thyssenkrupp and voestalpine are diversified companies, while ArcelorMittal is more of a pure steel play. Understanding this is vital to making more accurate comparisons between the earnings and valuation results of this analysis.

thyssenkrupp and voestalpine are diversified companies, while ArcelorMittal is more of a pure steel play

Revenue base in focus

Chart 8 shows the total company revenues in 2017 from crude steel production, and what percentage this constitutes of the companies' total revenues for that year.

Chart 8: Understanding the importance of steel revenues to each company in 2017



Source: Bloomberg, Kepler Cheuvreux analysis

Chart 8 shows that thyssenkrupp and voestalpine are diversified companies for whom steel revenues made up just 35-40% of total revenues in 2017.[2] Therefore, a significant proportion of the earnings valuation of these two companies will be based on financials outside of the crude steel sector. Where possible, we pro rata down certain financial metrics in this study to reflect this diversification and allow

[2] This figure will now have changed for thyssenkrupp as a result of its recent joint venture with Tata Steel Europe (June 2018).

more accurate comparisons to be made between the crude steel segments only of these corporations. When we do this we make it clear. However, this is not possible for our company earnings and valuation analysis which scales up the results from the crude steel segment only to the company as a whole.

The analyst view: steel sector in transition

The steel industry is very energy intensive and, therefore, emissions intensive. The sector contributes 6-7% of global anthropogenic greenhouse gases (GHGs), which drive global warming. Carbon dioxide (CO2) emissions from the steel sector are yet to be decoupled from production, which is trending upwards.

However, efficiency gains are being made in the sector. The energy intensity of crude steel production fell by 1% in 2016, a significant acceleration compared to past years. According to the International Energy Agency (IEA), this rate of efficiency gain must accelerate further to 1.2% between 2016 and 2030 to align with the 2°C pathway.

Consequently, the global steel sector faces a technological transformation if governments are going to deliver on the internationally agreed target of limiting global warming to "well below" 2°C.

The global steel sector faces a technological transformation

Some of the technologies that will likely be required to deliver the low-carbon transition in the steel sector are available to manufacturers today, but have high capital and operating costs for incumbents and high barriers to entry for potential new market entrants. As such, government regulations and standards will be critical to driving technological innovation, lowering carbon abatement costs and speeding up steel production capacity turnover in the industry.

Manufacturers must make the necessary technological investments and strategic decisions today if they are to mitigate the long-term financial impact of these regulatory risks and outperform competitors.

This section delves into some of the most pressing regulatory and technological transition factors affecting the steel sector, and analyses the relative exposure to them of ArcelorMittal, thyssenkrupp and voestalpine.

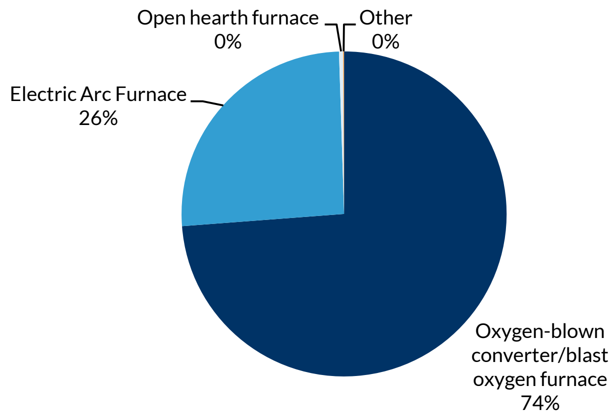
The technological options to transition the steel sector

At present, few alternatives to steel exist. Therefore, global steel demand is strongly linked to a number of macroeconomic factors, such as GDP per capita growth, the rate of urbanisation, the rate of population growth, etc. These factors drive demand for steel, principally, from the automotive, infrastructure and construction sectors.

At present, few alternatives to steel exist

In 2016, this demand was largely met by blast furnace-basic oxygen furnace (BF-BOF) production plants (74%), with electric arc furnace (EAF) plants making up the remaining quarter (Chart 9). In Europe, EAF plants make up a greater share of total production than the global average, but still remain the minority (Chart 10).

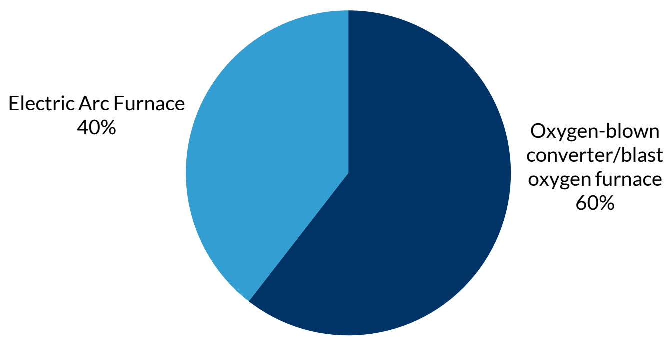
Chart 9: Global steel production by process in 2016



Source: World Steel Association

BOF steelmaking from iron ore is more CO2-intensive than EAFs

Chart 10: Steel production in EU28 by process in 2016



Source: World Steel Association

The CO2-intensity spectrum of steel production

These two main steel production processes have different levels of CO2 intensity per tonne of steel produced (Chart 11):

- **BF-BOF:** Iron ore and coke (coal) produce hot metal in a blast furnace before being conveyed to the basic oxygen furnace where its conversion to crude steel takes place. The CO2 intensity for energy usage (during iron making) can vary depending on whether coal, oil or natural gas is used as the fuel for under-firing the blast furnace, coal being the most CO2-intensive of the three fossil fuels. Additionally, the CO2 intensity for process relating activities is high for BOF because coke is used as a reduction agent, an alternative but significantly more expensive option would be to use electricity instead of coke.
- **EAF**: Steel is produced by the smelting of scrap steel in an EAF. The main inputs to the process are recycled steel and electricity. Other sources of metallic iron, such as direct-reduced iron (DRI) or hot metal can also be used in conjunction with recycled steel feeds in the EAF method to make up for lower grade scraps. It is estimated that EAF steel is almost 75% less CO2-intensive than the BF-BOF method, although this is dependent on the fuel

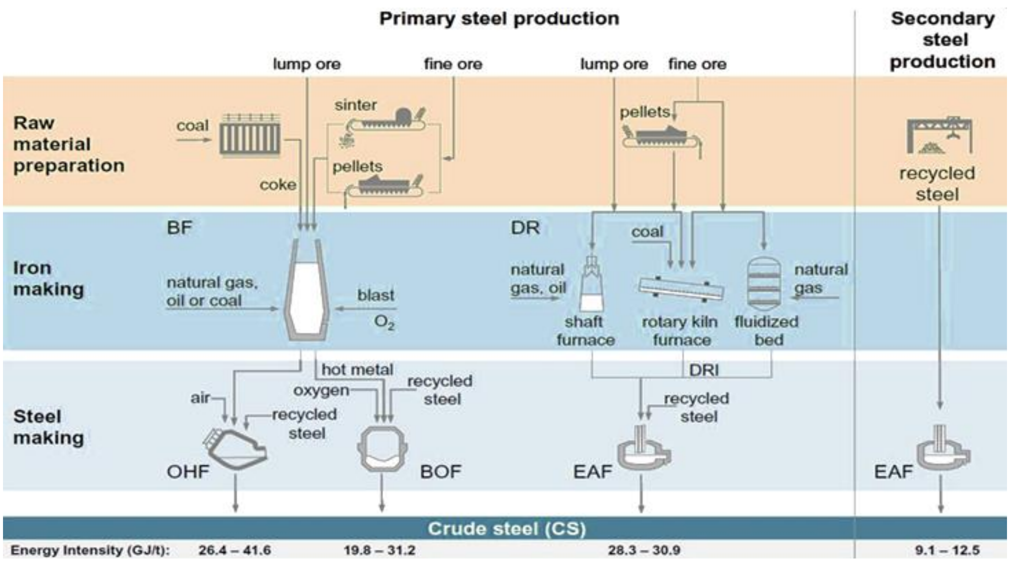
It is estimated that scrap based EAF steel is almost 75% less CO2-intensive than the BF-BOF method supplying the electricity. The availability of scrap steel can limit the growth of EAF production methods.

In addition to these two main steel production methods, two more factors are relevant in determining the CO2 intensity of steel production.

- **Direct Reduced Iron (DRI)**: The direct reduction of iron ore to iron for use in steelmaking by a reducing agent, either gas-based or coal-based. DRI is most commonly made into steel using EAFs which take advantage of the heat produced by the DRI product. DRI-based steel production using natural gas as the reducing agent is significantly less CO2-intensive than BF-BOF. This is due to it being more energy efficient than the blast furnace (BF) because it uses significantly less fuel than having to melt iron ore at up to 1,200 degrees centigrade. In this study, we assume that all DRI-based steel production uses natural gas as its reducing agent and therefore is a "low-carbon" method to produce steel.

We assume that all DRI-based steel production uses natural gas as its reducing agent and therefore is a "low-carbon" method to produce steel

Chart 11: A schematic of the different steel making processes



Source: Global CCS Institute

Overall, the degree to which the global steel sector is able to transition to a low-carbon structure is largely dependent on the growth and substitution of EAF and DRI-based processes for BF-BOF. According to the IEA, one final factor can alter this simple overview: carbon capture and storage (CCS).

CCS in steelmaking

It is estimated that 2.3t of CO2 are emitted per tonne of crude steel produced via the BF-BOF process, when coal is the main reductant of iron ore. In theory, this could be drastically reduced with CCS. Specifically, CO2 would need to be captured from the blast furnace gases and the cogeneration plant flue gases. A number of initiatives and pilot processes are up and running to find the technological solutions required and to bring costs down, e.g. Ultra-Low CO2 Steelmaking (ULCOS).

Steel companies are mostly unwilling to invest and bear liability for the transportation and storage costs incurred by CCS

At present, steel companies are largely unwilling to invest and bear liability for the transportation and storage costs incurred by CCS in the context of a competitive global steel market. Therefore, it may be up to the public sector to both finance CCS R&D and implement policies to incentivise R&D of the technology from within the steel sector.

An alternative to CCS could be carbon capture and utilisation (CCU), which can transform carbon into chemicals or fertilizers, for example, for usage in other industries, hereby, avoiding the drawbacks of storage and transportation and potentially providing another revenue stream. It is considered a niche market with limited growth potential globally by the IEA and is therefore not addressed further in this study.

The financial impact of regulatory risks

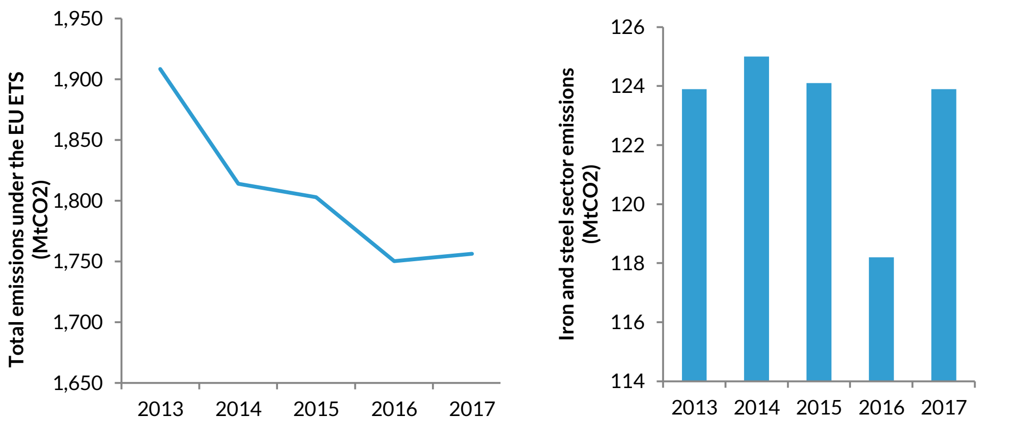
It is estimated that in 2017, 70% of global steel production faced a price on carbon, a measure intended to penalise excess CO2 emissions and drive efficiency gains and breakthrough low-carbon technologies in the sector. Over the past 12-18 months, the price of emissions under the EU Emissions Trading Scheme (ETS) has risen sharply. With the price expected by many to rise in the future, the EU ETS could become significant for steel producers in the short term.

The EU ETS: a significant price on carbon

The EU ETS is a tool for reducing the EU's greenhouse gas emissions in a cost-effective manner. It operates on the basis of setting a "cap" on GHG emissions from the 11,000+ heavy energy-using installations (power plants and industrial plants) covered by the system. Companies then receive or buy emissions allowances (EUAs) which must cover all of their emissions, otherwise fines are imposed.

CO2 is the most abundant GHG in the atmosphere. CO2 emissions under the EU ETS (which covers 45% of the EU's GHGs) rose in 2017, the first increase observed in seven years. This was in large part due to rising industrial sector emissions, and rising emissions from the iron and steel sector within that (Chart 12).

Chart 12: The iron and steel sector was a major factor in the rise in EU ETS emissions in 2017



Source: Kepler Cheuvreux

The ETS has not been costly to European steel companies to date

The ETS has not been punitive enough on carbon emitters to date

CO_2 emissions in the iron and steel sector, and the ETS more broadly, may have risen because the ETS has not been punitive enough on carbon emitters to date. According to responses to CDP's 2017 Climate Change Questionnaire (CDP is a not-for-profit that focuses on climate change), ArcelorMittal did not pay for any of its emissions allowances in 2016, while thyssenkrupp had to purchase only 16% of the allowances it required (Table 1). Given that the average EUA price was EUR5.35 that year, thyssenkrupp would not have incurred a significant cost penalty. Finally, voestalpine states that it is a net payer of ETS certificates, although the full extent of this cost is not disclosed.

Table 1: thyssenkrupp and ArcelorMittal's allowances in 2016[3]

thyssenkrupp			ArcelorMittal	
Allowances allocated (m)	Allowances purchased (m)	% purchased	Allowances allocated (m)	Allowances purchased (m)
17.9	2.8	16%	59.9	0

Source: CDP, Kepler Cheuvreux

Converging trends could hit steel makers with "existential threats"

The price per tonne of CO_2 emitted under the ETS has risen over 300%

As CO_2 emissions from the steel sector have risen over the past year, so has the price of emissions allowances. In fact, over 12 months (May 2017-May 2018) the price per tonne of CO_2 emitted (1 EUA) under the ETS has risen over 300% to EUR16. The two trends are related.

As a result of the emissions rise observed in 2017: 1) some companies have been short on emissions certificates, thereby increasing demand; and 2) those companies with surplus allowances have been incentivised to hold on to them, rather than make them available to sell, on the expectation of further increases in demand and price.

Why might the EU carbon price rise further?

The EU is preparing to tighten the market balance of the EU ETS for 2021-30

On 9 November 2017, negotiators from the European Parliament, Council and Commission agreed on how the ETS rules will change post-2020. This included an agreement to tighten the market balance of the ETS for 2021-30. Specifically:

- The cap on the total volume of GHG emissions will be reduced annually by 2.2% (known as the linear reduction factor).
- 24% of allowances in circulation will be removed from the marketplace and put in the Market Stability Reserve (MSR) by 2023.
- From 2023, allowances in the MSR above the total number of allowances auctioned during the previous year will be retired.

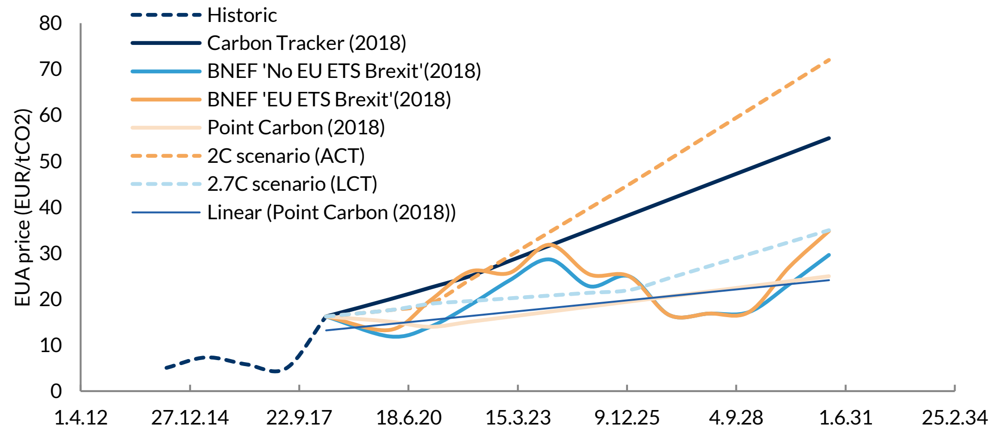
The EU's price of carbon has risen over the past 12 months because the market is beginning to price in the effect of this decision. It is likely that the price of each EUA will rise further after 2020 when these revisions are implemented, particularly if emissions covered by the ETS rise any further.

[3] Voestalpine did not disclose in its public documents and its CDP climate change questionnaire is not available publicly.

Chart 13 collates a number of projections for the EUA price until 2030 from industry experts. Note that the price in each forecast rises on recent levels (as of 25 May 2018). The European Commission estimates that a price of at least EUR30/tCO2 is required by 2030 for the EU to deliver on its CO2 reduction targets and incentivise the switch from coal to natural gas/renewables in the power sector. This price would be broadly consistent with our 2.7°C climate scenario, LCT, which is a median scenario of those projections included in Chart 13.

The EU ETS price is expected to rise until 2030, but to remain below the levels required in a 2°C scenario

Chart 13: The EU ETS price is expected to rise to 2030, but remain below the levels required in a 2°C scenario (DD.MM.YY)



Source: Kepler Cheuvreux

The very high carbon price assumed across all 'advanced economies', including the EU, in our ACT scenario illustrates that the EU ETS price will likely have to rise above these industry forecasts if the region is to be aligned with limiting global warming to 2°C.

A high future ETS price will require steel companies to transform their business strategies

A study by Ecofys consultancy, commissioned by the European Steel Association, modelled the impact of an EU ETS price of EUR20.1/tCO2 in 2020 and EUR40.7/tCO2 in 2030 on the steel industry. Including indirect costs, it concluded that the resulting net carbon costs could translate to EUR10/t in 2021E, rising to EUR28/t of crude steel production in 2030E.

Net carbon costs could translate into EUR10/t in 2021 rising to EUR28/t of crude steel production in 2030

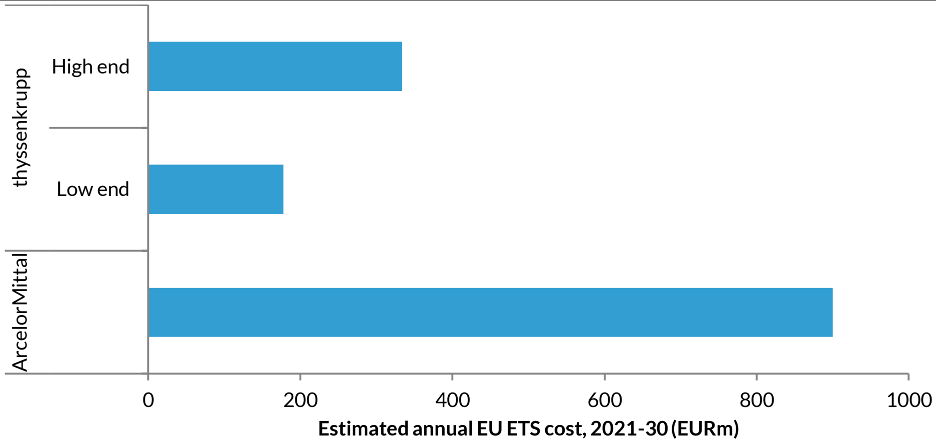
To put these figures into perspective, it is estimated that industry profit margins have oscillated around EUR35/t of crude steel in recent years, according to KECH's head of steel Rochus Brauneiser CEFA (although this varies by company, country etc.). The industry claims, therefore, that a rising CO2 price, which looks increasingly likely in light of recent reforms to the ETS, could erode the majority of European steel producers' profit margins. Of course, this would also depend on: 1) the extent to which steel producers are allocated allowances for free; 2) their ability to pass the cost on to consumers; and 3) international steel price dynamics.

According to Brauneiser (February 2016), having to purchase allowances at or above EUR30/tCO2 for a significant portion of total steel production would create *"an existential threat for the viability of many producers"*. It seems clear that a rising EU ETS price could serve as a strong incentive for steel companies operating in the region to embark on a transition to low-carbon production methods.

What does our sample of steel companies say about the ETS?

This risk has not gone unnoticed by the steel industry. ArcelorMittal and thyssenkrupp estimate that annual costs due to the ETS could be as high as EUR900m from 2021-30E (Chart 14). ArcelorMittal assumes a EUR30/tCO_2 ETS price by 2030 in its estimate (thyssenkrupp does not disclose its assumption). ArcelorMittal claims that this ETS price, and subsequent costs, would be *"an unsustainable level of cost increase to bear for any company"*.

Chart 14: The European steel industry predicts "unsustainable" ETS costs post-2020[4]



Source: Kepler Cheuvreux

The recent ETS reforms and price rises of the last 6-12 months have only made even higher CO2 prices more likely

Without doubt, a higher CO2 price presents a risk to the European steel industry in the future. The recent ETS reforms and price rises of the last 6-12 months have only made this more likely. Companies should conduct comprehensive reviews of their business strategies and consider large-scale investments in low-carbon solutions.

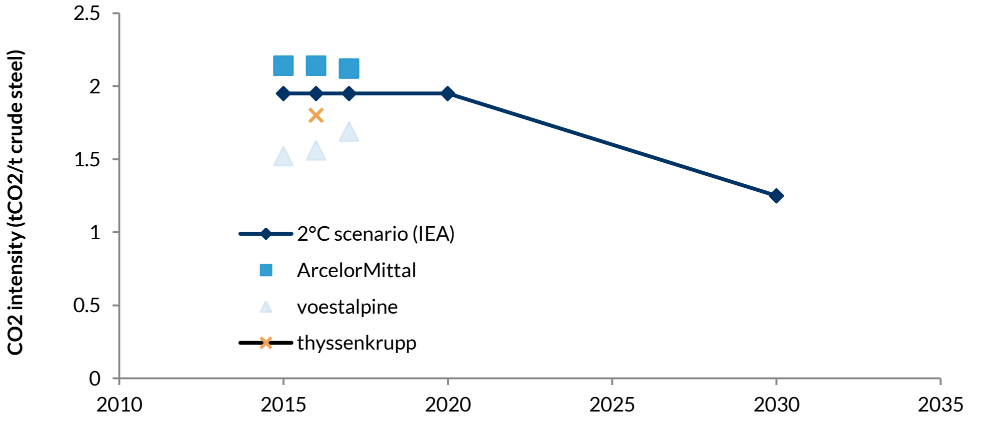
How prepared are thyssenkrupp, voestalpine and ArcelorMittal for carbon constraints in line with a 2°C scenario?

The ETS will be an integral tool for the European Commission to deliver the CO2 reductions outlined in its 2030 Climate and Energy Framework. These targets, however, are not ambitious enough to align the EU's emissions with the 2°C pathway and the 2015 Paris Agreement. This will likely be the next wave of regulations to hit European steelmakers. This was evidenced on 22 March 2018 when the European Council called on the commission to present, by Q1 2019, its long-term GHG emissions reduction strategy on aligning with the Paris Agreement.

Chart 15 shows how the relative CO2 intensities of steel production from thyssenkrupp, voestalpine and ArcelorMittal compare to the 2°C pathway set out for the steel sector by the International Energy Agency (IEA).

[4] Calculated from thyssenkrupp's projection that 2021-30 ETS costs will range from EUR1.6-3bn.

Chart 15: EU regulations are threatening to align steel production with a 2°C pathway[5]



Source: Kepler Cheuvreux, CDP

The degree to which steel production must reduce CO2 emissions per unit of steel produced accelerates dramatically post-2020

This shows that:

1. ArcelorMittal's current steel production exceeds the CO2 intensity required by a 2°C scenario.
2. Voestalpine's steel production appears to be becoming more CO2-intensive.
3. The degree to which steelmakers must reduce their CO2 emissions per unit of steel produced accelerates dramatically post-2020.

The European steel industry says that its steel production is at the lowest CO2 intensity possible with currently available technologies. This might be overstating the case. Lower carbon alternatives do exist – e.g. EAF and DRI-based steel production, or CCS and CCU – although at present incumbent producers are put off by high capital and operating costs for these technologies, and high barriers to entry for potential new entrants.

Choosing to wait for transformative breakthrough technologies or beneficial government intervention could very well be a high-risk strategy for companies. The winners and losers in the steel sector could be determined by those who choose to follow the lead of other sectors and proactively invest in driving the low-carbon transition, e.g. OEMs backing electric vehicles in the car sector.

[5] Quoting ArcelorMittal figures from page 41 of its 2017 Fact Book. However, the company reported its 2015 figure to CDP to be 1.974tCO2/t, so we note that there is room for discrepancy.

The scenarios: climate change and adaptive capacity

Building blocks: the climate change scenarios

The building blocks of the analysis are two climate change scenarios, within which are two company adaptation pathways. The two climate change scenarios are:

The building blocks of the analysis are two climate change scenarios and two adaptation pathways

1. The Limited Climate Transition (LCT), which corresponds to the International Energy Agency's (IEA) Reference Technology Perspective (RTS), a scenario consistent with +2.7°C by 2100.
2. The Ambitious Climate Transition (ACT), which corresponds to the IEA Energy Technology Perspectives' 2°C scenario (2DS).

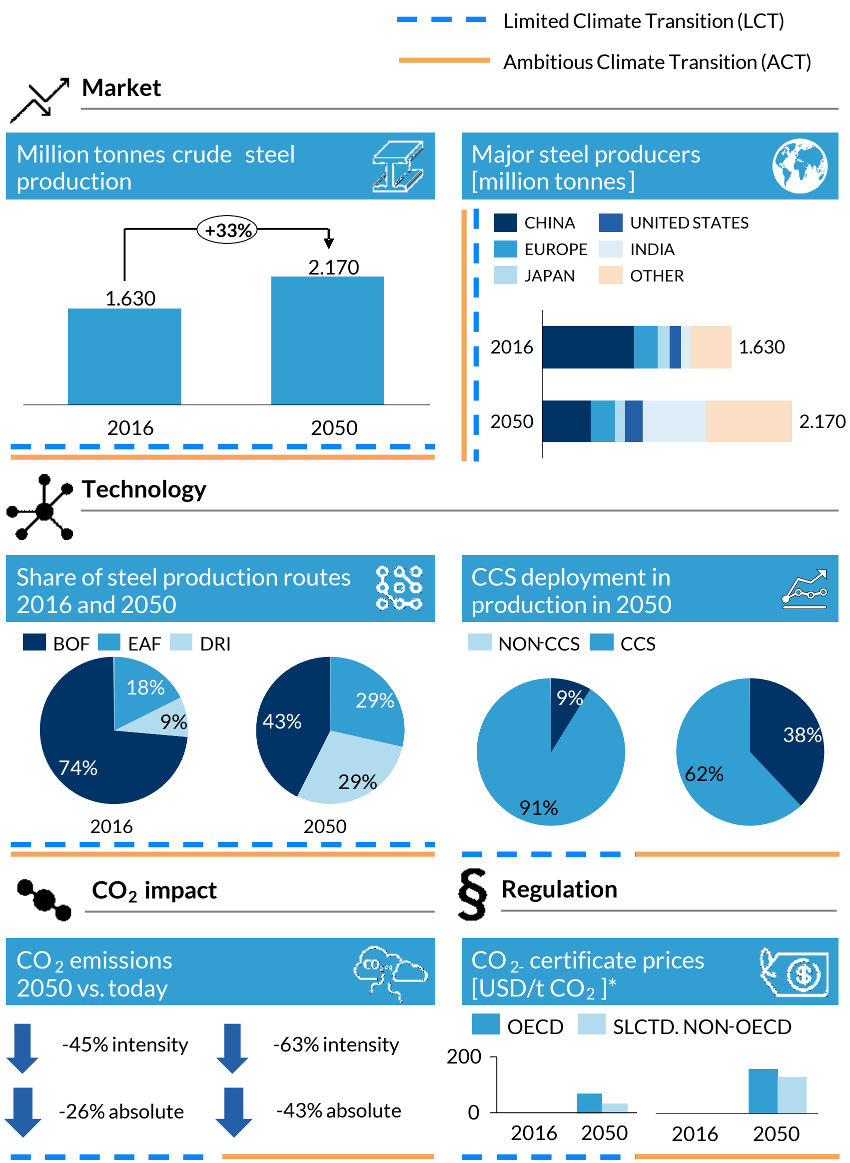
At present, the pledges that national governments have made to limit global warming, known as Nationally Determined Contributions (NDCs), are estimated to deliver an average global temperature rise of 2.7°C by 2100 above pre-industrial levels. As such, the LCT scenario should be perceived as a "business as usual" outcome.

In the 2015 Paris Agreement, all 197 parties to the UN Framework Convention on Climate Change (UNFCCC) pledged to limit global warming to 2°C by 2100, with ambitions to keep temperature rises to "well below" 2°C. The ACT, with its 2°C global warming ambition, falls short therefore of what governments have committed to transition their economies towards. To deliver the Paris Agreement, a much more ambitious transition plan than ACT is needed.

Key market drivers and trends

Our two scenarios make up a narrative on regulatory, technology and market-related changes that is consistent with the underlying IEA scenarios. This narrative forms the foundation for our company-level scenario analysis. Those market drivers and shifts that are most significant in determining the company earnings results of each scenario are shown in Chart 16.

Chart 16: Key characteristics of our two climate change scenarios that determine the earnings results of the steel companies



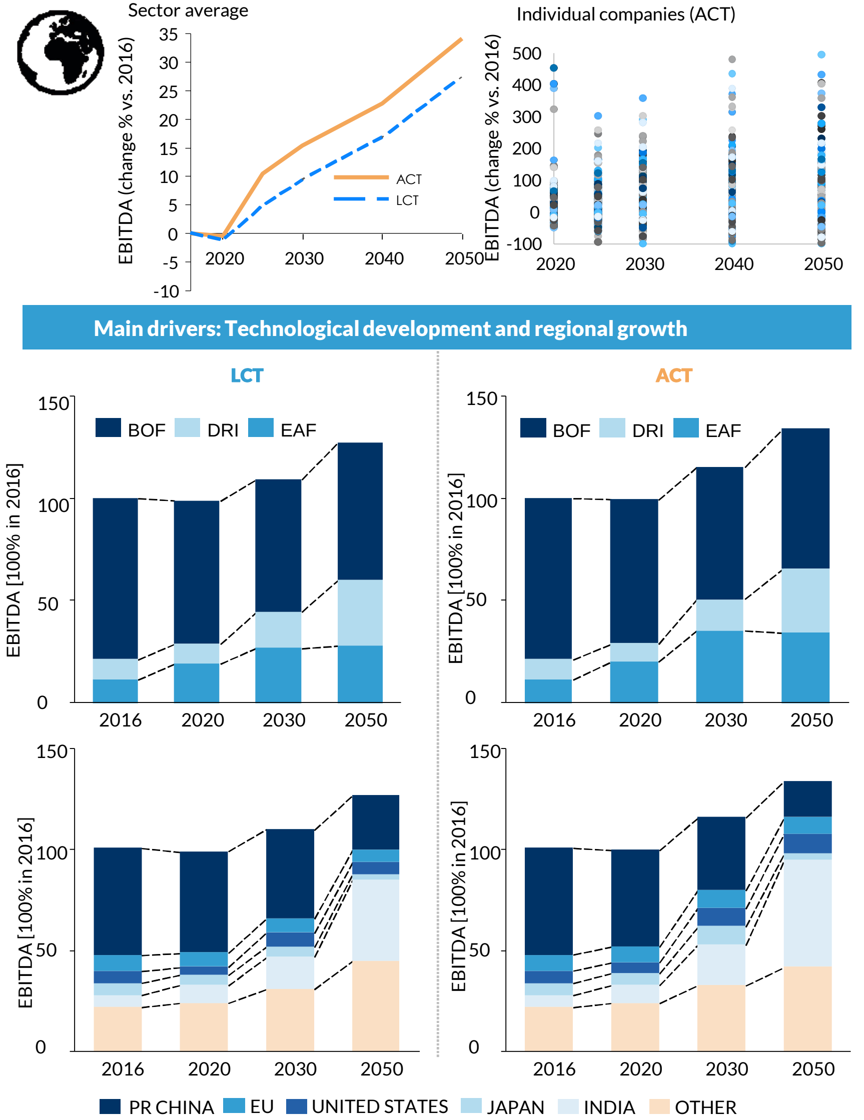
*Other non -OECD countries like India do not adopt Emission Trading Schemes or similar mechanism

Source: The CO-Firm

- Growth in population and GDP result in rising crude steel production globally (+33% by 2050E). The drivers of changes in production type go beyond climate-related action (e.g. scrap and ore prices), and thus remain the same across both climate change scenarios.
- India and other emerging countries will likely become major steel producers by 2050E. China is set to reduce its capacity but should remain the world's largest producer.
- The way steel is produced will change. The BOF method (43% of market share, iron ore and coal-based) remains the primary production method, but is partially replaced by the lower-carbon EAF (29% of market share, scrap and electricity-based) and DRI (29% of market share, iron ore and natural gas-based) methods by 2050 in both scenarios.
- One significant difference between the scenarios is that the 2°C ACT scenario assumes significant deployment of CCS. In this scenario, 38% of steel production capacity in 2050 is fitted with CCS, compared to 9% in the LCT (2.7°C). CCS investment comes with higher capital expenditures, however, which are economically justified in ACT in the face of CO2 prices that rise up to USD165/t of CO2 by 2050 in OECD countries. In both scenarios, CO2 prices are heterogeneous across countries, with some countries, like India, not having any CO2 pricing at all.
- Note, in the underlying IEA scenarios, carbon capture and utilization (CCU) is considered a niche technology with limited growth potential globally. Therefore, it does not feature in ACT and LCT. The economic viability of CCU, as for CCS, largely depends on the CO2 price. However, some expect CCU to be economically viable sooner than CCS because the use of the captured gas can offset some of the capital costs, and it avoids the complex challenge of storage. Therefore, strategic decisions by companies on CCU projects need to be analysed separately.

Determinants of company EBITDA performance

Chart 17: Winners and losers are largely determined by regional and technological exposure



Source: The CO-Firm

On a global level, EBITDA increases are in line with steel production in both climate change scenarios, ACT and LCT, due to GDP and population growth, particularly in emerging economies. EBITDA growth in the ACT scenario is higher than in the LCT scenario, despite higher CO2 prices. This is due to:

- More countries adopting carbon pricing or equivalent schemes, resulting in a lower relative difference of CO2 prices between countries. In 2050, under ACT, carbon prices in OECD and selected non-OECD countries have risen to USD165/tCO2 and USD135/tCO2 respectively, whereas they reach only USD68/tCO2 and USD35/tCO2 under the LCT scenario. This results in fewer competitive disadvantages, and fewer negative impacts on company profit margins, across the global steel sector as a whole.

The main drivers that determine sectoral winners and losers are:

- The competitiveness of the DRI method in both scenarios, due to increasing CO2 prices and lower natural gas prices.
- The BOF method's performance, which is impacted by the higher CO2 prices in the ACT scenario, despite lower coal prices.
- The EAF method's competitive advantage of relatively low direct CO2 emissions (Scope 1) disappears in the long run, due to:
  - Increasing wholesale electricity prices (driven by the energy system transformation and CO2 price increases, see "Transition Risks for Electric Utilities" report (link)).
  - Increasing scrap prices (driven by the increasing demand for scrap).
- In the LCT scenario, emerging countries that do not implement pricing on CO2 profit from the high, in relative terms, CO2 prices of OECD competitors.
- For example, we assume that India does not apply a carbon price in either scenario and so has a competitive advantage over developed countries.

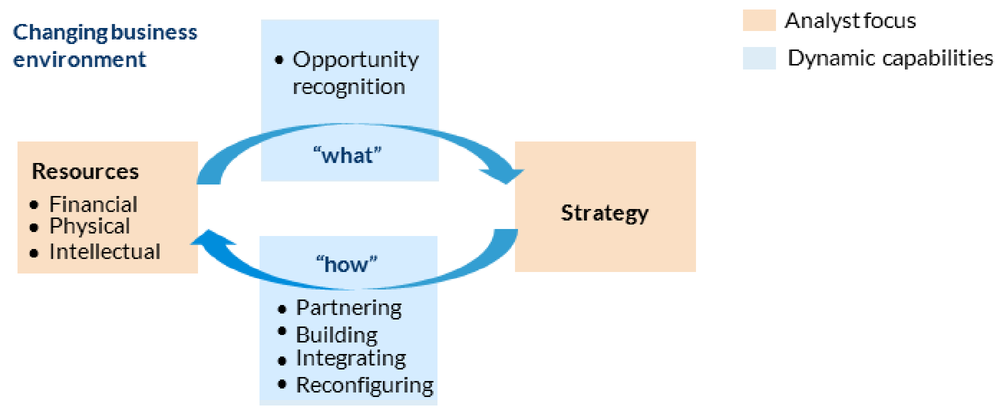
Building blocks: the market adaptation pathways

Alongside their technological and regional portfolios, the financial performance of steel companies in the future is also largely determined by the "strategic approaches" they can take to counter changes in their markets, i.e. their adaptive capacity.

Adaptive capacity is the degree to which a company is able to "*integrate, build, and reconfigure internal and external competencies to address rapidly changing environments*". It is the result of dynamic capabilities (partnering, integrating, building, etc.), which allow for putting existing resources (assets, financial pockets, intellectual property), to good future use, via a strategy (Chart 18).

A company's resources, its strategies, and capabilities determine whether it is future-proof

Chart 18: Explicit and implicit factors in an equity analyst's assessment of a company's adaptive capacity



Source: The CO-Firm

In this report, The CO-Firm distinguishes between two ways a company might adapt to market shifts, and maps them on top of the two climate change scenarios.

The "MARKET" pathway

If the market grows, the individual companies are also likely to grow

'MARKET' assesses the **scenario readiness** of individual companies. Here, earnings depend on the company's regional diversity as well as the levels of cost efficiency of its technology portfolio. A company's investment decisions until 2020 are determined by VDEh's PLANTFACTS database. The MARKET pathway assumes that companies are semi-flexible with technologies, but are not flexible in choosing to enter new countries. Each company's production increases to the same extent as the regional market, therefore, it is crucial for companies to be positioned in growth markets.

For instance, a 20% increase in steel production in one country corresponds to a 20% increase in capacity across all steel companies producing in this country. If a market stagnates or decreases, overcapacity first hits the least advanced company, by technology, as supply and demand are matched using a merit order.

The second factor, cost efficiency of technology, determines how profitable an additional unit of production will be. Here, the assumption is made that a company cannot switch its steel production method from the more carbon intensive BOF method to EAF or DRI due to the capital intensiveness of BOF plants; potentially the regional market situation, e.g. comparatively high natural gas prices; or limited scrap availability. A relatively new technology portfolio, thus, creates a competitive advantage for the company.

The “MARKET-EBIT” scenario

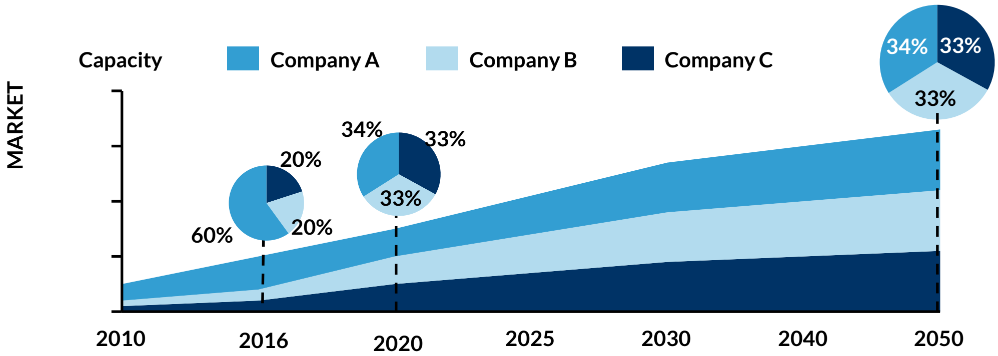
The general dynamics of MARKET-EBIT compare to the MARKET pathway, with the additional assumption being that better financial endowment (higher EBIT) allows companies to capture a larger share of growth. It assumes that financially strong companies can invest more in growing technologies, although only when replacement or growth options become positive for the business case.

A company’s overall EBIT serves as an indication of its financial strength. This is put into a non-linear function versus average total EBIT across all companies. This function ensures that the company with the strongest EBIT is able to gain a higher share of new investments than companies with average EBIT, which in turn gain more market share than companies with low EBIT.

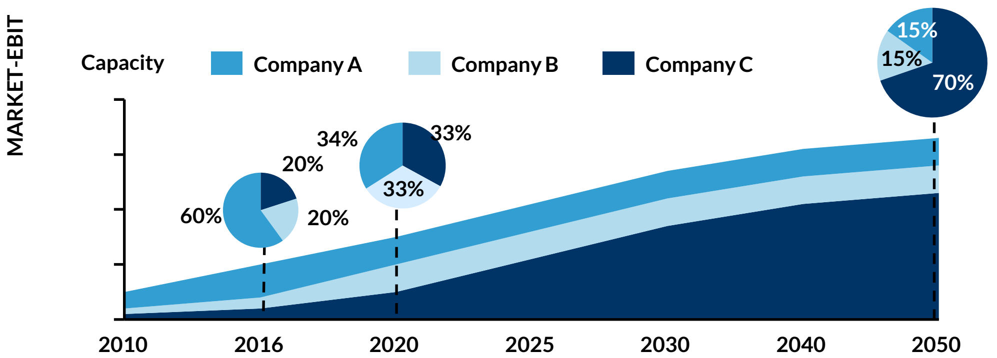
Finally, FROZEN illustrates the opportunity cost of inaction, i.e. of not seeing the required change or not being able to act upon it. It assumes that a company does not adjust to the changing environment from 2020 onwards. This means that a company only produces the existing technology in the existing regions. FROZEN illustrates the financial extent and speed of the transition that is required for the individual company. Also, it illustrates the speed and strength of the market change, along with the timing of the impact and its extent. This is not a proxy for the cost of transitioning, but, in comparison to the MARKET or MARKET-EBIT pathways, for the cost of inaction.

Chart 19: Three variations of a company's adaptation strategies in the ACT scenario (company and market shares are illustrative)

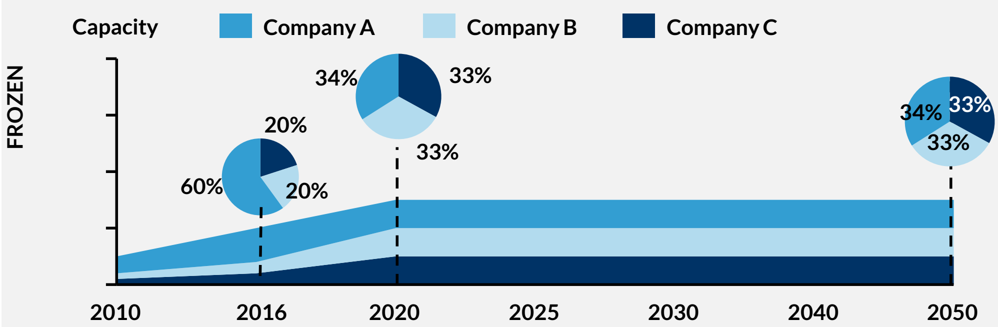
MARKET describes asset development that is fully in line with the market developments outlined in the scenario. For instance, a 20% steel production increase in one country corresponds to a 20% increase in capacity across all steel companies producing in this country. The country portfolio per company is fixed.



MARKET-EBIT builds on the market scenario but also includes companies' financial strength over time, assuming that financially strong companies can invest more in growing technologies. A company's overall EBIT serves as an indication of its financial strength. This is put into a non-linear function versus average total EBIT across all companies. This function ensures that the company with the strongest EBIT is able to gain a higher share of new investments than companies with average EBIT, which in turn gain more market share than companies with poor EBIT. The country portfolio per company is fixed.



Asset structure in 2020 is frozen until 2050. This considers new projects plans and shutdowns until 2020, as announced by the company until 2017. It should be noted that freezing technologies leads to inconsistency with the scenarios outlined, thus a frozen development serves only as an indication. The country portfolio per company is fixed.



Source: The CO-Firm

Key results: company earnings

Sectoral findings:

- All of the three companies show EBITDA growth to 2050E in both of The CO-Firm's scenario analyses.
- Earnings growth is stronger for each company along the MARKET-EBIT adaptive capacity pathway.
- ArcelorMittal displays the strongest earnings growth of the three companies in both climate change scenarios analysed.

All of the three companies show EBITDA growth to 2050E

The earnings charts presented in this chapter focus solely on the ACT scenario and the MARKET-EBIT pathway, so as not to overburden the reader with information. A full breakdown of the results from all scenario combinations can be found in the accompanying online tool, which can be accessed at www.et-risk.eu or by writing to climateXcellence@co-firm.com.

ArcelorMittal is climate change resilient

- Highlight 1: The company's earnings grow in a 2°C scenario, under both adaptive capacity pathways.
- Highlight 2: ArcelorMittal is transitioning to a regionally and technologically diverse asset base that makes it resilient to climate change scenarios.
- Highlight 3: BOF steel production in Europe will incur losses until CCS becomes cost viable.

ArcelorMittal

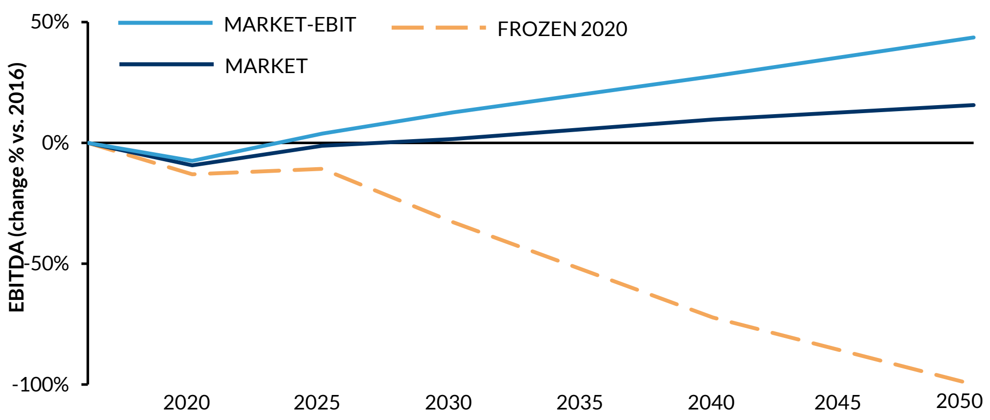
Fact book 2017 (link)

Analyst guidance: The results and charts below exclusively highlight findings from a climate risk scenario analysis. As such, they neither contain nor provide any assessment of probabilities. They illustrate relative changes in financial parameters over time. Results are subject to scope (steel production only), applied operationalised scenarios, corporate adaptation (technology portfolio development: FROZEN-2020, MARKET, MARKET-EBIT in the current countries and technologies), and modeling limitations. Companies' portfolio data are based on VDEh's PLANTFACTS database from December 2016. Any significant, interim changes in corporate strategies are likely to have an impact on these results. They do not constitute a financial forecast or investment advice. See Appendix for more information.

Steady EBITDA growth in the 2°C scenario due to adaptive capacity

ArcelorMittal is the world's largest steel producer and, according to The CO-Firm's modelling, is set to profit should the industry align with the 2°C target due to its regional and technological diversity (see Chart 20).

Chart 20: ArcelorMittal profits from its regional and technological diversity. Its EBITDA could increase after 2025E under both adaptive capacity pathways (ACT scenario)



Source: The CO-Firm

ArcelorMittal profits from a regionally and technologically diverse asset base, particularly from 2025E

The introduction of CO2 certificates and increasing CO2 prices in advanced economies in 2020 would reduce ArcelorMittal's competitiveness and profit margins. This could lead to a total EBITDA reduction of around 10% compared to today. After 2020E, ArcelorMittal is forecast to increase its EBITDA by more than 40% compared to today, surpassing both thyssenkrupp and voestalpine in this regard.

ArcelorMittal's earnings grow more strongly in the MARKET-EBIT pathway than MARKET, in which it uses its financial strength to gain market share in developing steel markets such as Mexico.

Earnings potential of DRI production realised in North America

ArcelorMittal's physical asset portfolio today comprises all three major steel production methods, BOF, EAF and DRI, with levels of distribution that are comparable to the global average. In the MARKET-EBIT pathway, ArcelorMittal adapts its portfolio to maximise earnings in the following ways (see Chart 21):

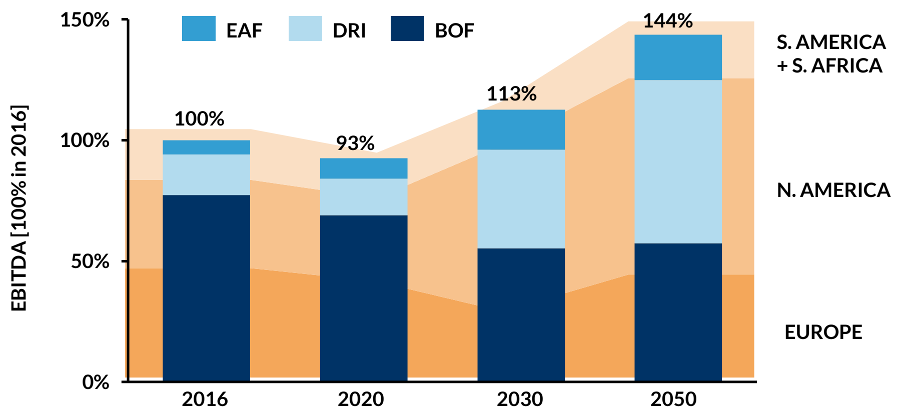
- By reducing its primary steel production (BOF) and investing strongly in the less carbon-intensive DRI and EAF production methods.
- BOF steel production is carbon-intensive and thus plant margins turn negative when CO2 prices increase, resulting in EBITDA losses till 2030E. After 2030E, high CO2 prices in conjunction with the availability of CCS render BOF-based steel production profitable again. This helps keep company EBITDA from BOF stable between 2030 and 2050, in the face of falling capacity.
- ArcelorMittal's DRI production capacity is set to increase by more than four times until 2050, compared to 2016. The DRI method's profitability peaks in 2030, due to a combination of low natural gas prices, high CO2 prices, and a lack of CCS technologies.
- Like the DRI method, the competitiveness of EAF steel production peaks between 2025 and 2030, though for different reasons. Having hardly any direct CO2 emissions (Scope 1), EAF's relative competitiveness benefits from rising CO2 prices and a lack of CCS technologies in the short-term.

BOF steel production is carbon-intensive and its margins turn negative with rising CO2 prices

Post-2030E, the transformation of the global power system and higher CO2 prices result in rising wholesale electricity prices which are likely to significantly increase the production costs of EAF steel.

EAF's relative competitiveness benefits from rising CO2 prices and a lack of CCS technologies until 2030E

Chart 21: Earnings in North America (Mexico in particular) increase steadily, surpassing Europe after 2020. Europe steel production is less profitable for ArcelorMittal.



Source: The CO-Fi

Low-carbon production methods compensate for lack of profitability in the OECD

ArcelorMittal's physical asset portfolio is located primarily in advanced economies, which will adopt the highest CO2 certificate prices in both the ACT and LCT scenarios. As steel is a globally traded commodity, the resulting gap in relative CO2 prices places many advanced economies at a competitive disadvantage relative to countries with lower, or no, CO2 pricing in place.

North America, and, in particular, Mexico, has a high DRI share in ArcelorMittal's production portfolio today. Increasing investment in DRI in North America compensates for the EBITDA losses from BOF in this region through to 2030. After 2030, the BOF retrofit with CCS renders it more competitive, boosting ArcelorMittal's EBITDA growth in North America, along with EAF and DRI.

In contrast to North America, DRI and EAF technology cannot compensate for the BOF method's losses in Europe

ArcelorMittal's production technology mix in Europe consists of all three production methods, with BOF being today's main production method in terms of EBITDA - France, Poland, and Ukraine are currently the company's leading earners. In contrast to North America, DRI and EAF technology cannot compensate for the BOF method's losses in Europe, resulting in a total EBITDA decrease until 2030E. After 2030E, CCS retrofits should stabilise earnings in Europe.

Engagement questions:

- How do you intend to mitigate the impact of increasing CO2 prices on earnings and profits in the OECD?
- Do you have strategies in place for growing the relative share of EAF- and DRI-based steel production?

Thyssenkrupp's earnings from its steel division might not be climate change resilient

- **Highlight 1:** thyssenkrupp's earnings from its steel division could fall until 2030E, when the CO2 price in Europe is high enough to render CCS a cost viable option for BOF-based production.
- **Highlight 2:** The company's steel earnings are under pressure due to a lack of regional and technological diversity.
- **Highlight 3:** thyssenkrupp is able to bring economies of scale to retrofitting BOF with CCS, rendering it among the most cost-competitive production methods between 2030 and 2050.

thyssenkrupp AG is a German multinational conglomerate with a focus on industrial engineering, materials trading, components, elevators and steel production. The company is the sixteenth largest steel producer worldwide, and the second largest steel producer based in Europe.

It is important to note that while thyssenkrupp produces a range of industrial products, the following section applies only to the company's iron and crude steel production earnings, modelled in this study to the company as a whole. This analysis does not cover the implications of thyssenkrupp and Tata Steel Europe's joint venture. Also, the VDEh's asset-level data, which underpins much of this analysis, does not take into account the recent development of thyssenkrupp's Carbon2Chem CCU project.

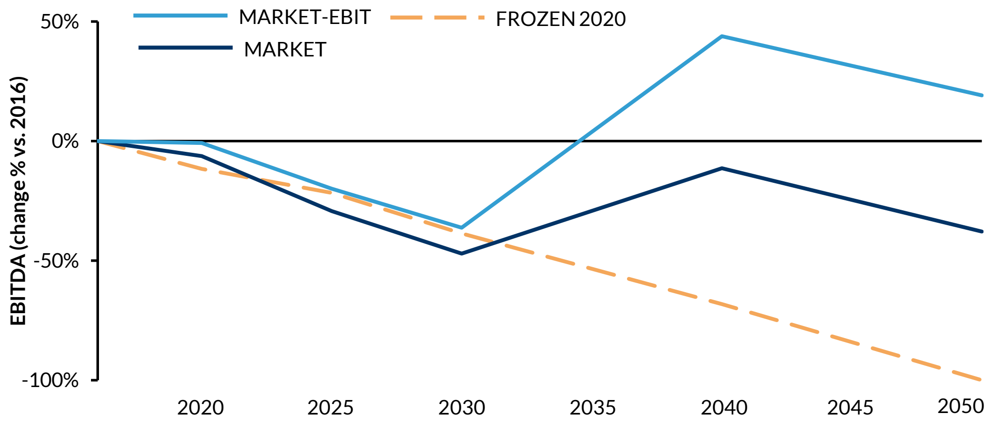
Analyst guidance: The results and charts below exclusively highlight findings from a climate risk scenario analysis. As such, they neither contain nor provide any assessment of probabilities. They illustrate relative changes in financial parameters over time. Results are subject to scope (steel production only), applied operationalised scenarios, corporate adaptation (technology portfolio development: FROZEN-2020, MARKET, MARKET-EBIT in the current countries and technologies), and the modeling limitations. Companies' portfolio data are based on VDEh's PLANTFACTS database from December 2016. Any significant, interim changes in corporate strategies are likely to have an impact on these results. They do not constitute a financial forecast or investment advice. See *Appendix* for more information.

thyssenkrupp's earnings between 2016 and 2050E are significantly impacted by both climate change scenarios. Although EBITDA falls starkly through to 2030E, it recovers in the long-term following strategic investments (Chart 22).

thyssenkrupp

2017 CDP climate change questionnaire ***(link)***

Chart 22: Due to its focus on the carbon-intensive BOF steel production method, thyssenkrupp is challenged by rapidly increasing CO2 prices (ACT scenario).



Note, the impact of thyssenkrupp's current steel production on the overall group's future steel earnings and valuation will likely be less than when these scenarios were run as a result of its joint venture with Tata Steel Europe (June 2018).

Source: The CO-Firm

Without CCS technology, thyssenkrupp steel production will almost certainly not be competitive until 2030

2°C scenario: steady EBITDA reduction until 2030E

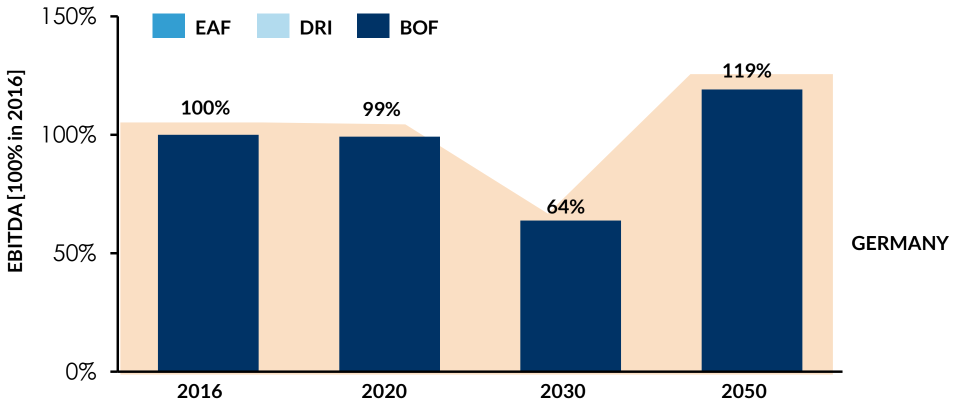
In 2017, thyssenkrupp sold its loss-making steel producing business in Brazil[6], leaving Duisburg, Germany, thyssenkrupp's only remaining steel production site. Under ACT, in 2020, the policy-based introduction of measures to increase CO2 prices, and the loss of all CO2 certificate exemptions, increases thyssenkrupp's steel production costs relative to countries that do not have CO2 price schemes. This reduces profit margins and earnings in MARKET and MARKET-EBIT.

Thyssenkrupp's negative earnings continue till 2030E, in spite of small technological improvements to its BOF asset base. Only with the availability of CCS after 2030E, made cost viable by rising CO2 prices, can thyssenkrupp retrofit (MARKET) and invest in new capacities (MARKET-EBIT), to bring profit margins back to, and above, previous levels.

Increasing overall adoption rates for CCS (including DRI with CCS) reduces EBITDA between 2040E and 2050E.

[6] It is important to note that we excluded Brazilian steel production from 2016 figures.

Chart 23: thyssenkrupp sticks to BOF steel production in Germany, which incurs losses until CCS becomes a viable financial option (ACT/MARKET-EBIT scenario)



Note, the impact of thyssenkrupp's current steel production on the overall group's future steel earnings and valuation will likely be less than when these scenarios were run as a result of its joint venture with Tata Steel Europe (June 2018).

Source: The CO-Firm

Thyssenkrupp stays loyal to BOF steel production in Germany

Having sold its Brazilian steel production business in 2017, BOF in Germany remains thyssenkrupp's only steel production method. The steel mill in Duisburg is one of the world's largest, integrated steel mills.

With one of the largest BOF production sites in the world, thyssenkrupp benefits from economies of scale when adopting CCS

As it is exclusively invested in the carbon-intensive BOF method today, we assume that thyssenkrupp will not shift its production in Germany to less carbon-intensive steel methods, like EAF or DRI, in either adaptive capacity pathways (MARKET and MARKET-EBIT). Barriers to this shift include technological lock-in effects, as capital-intensive BOF plants cannot be used in EAF and DRI steel production, comparatively high natural gas prices in Germany for the DRI method, and limited scrap availability for the EAF method.

Instead of shifting the production method, thyssenkrupp is improving the efficiency of its current BOF asset base. Improvements could include integrating Top Gas Recovery Blast Furnaces and gradually supplementing coke with hydrogen between 2020 and 2030. In spite of this, it is only with the CCS-retrofitting of BOF plants from 2030 that thyssenkrupp's steel production becomes profitable again.

Still, having one the largest BOF production sites in the world means that thyssenkrupp benefits from economies of scale when adopting CCS, increasing total EBITDA by 19% in 2050E relative to today (ACT/MARKET-EBIT).

Engagement questions:

- Do you see significant market barriers impeding thyssenkrupp's ability to diversify its portfolio of steel production methods to lower carbon alternatives?
- Would you consider engaging in steel production in countries outside of Europe?
- Does thyssenkrupp consider CCS an option for its Duisburg mill, as well as CCU? If not, what solutions do you see for BOF steelmaking?

Voestalpine can grow earnings in climate change scenarios

voestalpine

2017 Environmental Report (link)

- **Highlight 1:** voestalpine's earnings could rise by 33% to 2050 (relative to 2016 levels) as a result of a long-term BOF divestment strategy, towards DRI-based steel production (ACT).
- **Highlight 2:** voestalpine's OECD-based production could suffer to 2030.
- **Highlight 3:** CCS with DRI steel production can turn highly profitable for voestalpine.

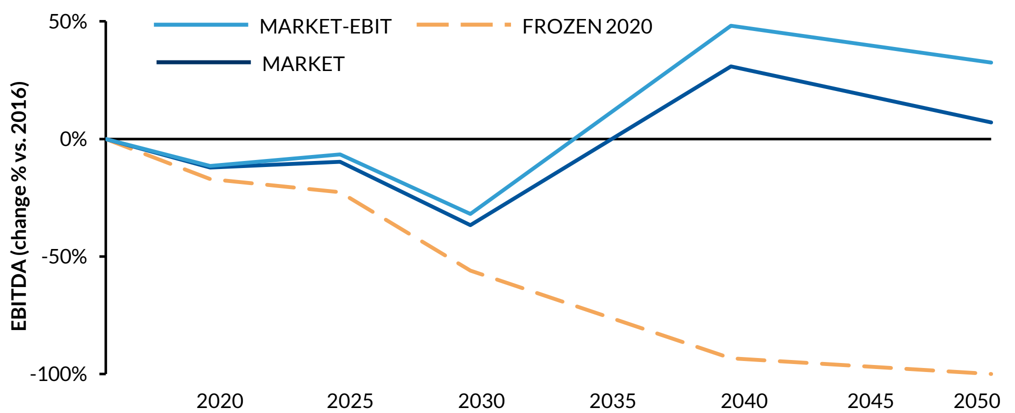
Voestalpine is a steel-based technology and capital goods producer based in Austria. The company is the 48th largest steel producer world-wide and one of the largest privately-owned steel producers in Europe. Note that while voestalpine produces a range of steel products, this report focuses on the earnings from the iron and crude steel production segment of the company only.

Analyst guidance: The results and charts below exclusively highlight findings from a climate risk scenario analysis. As such, they neither contain nor provide any assessment of probabilities. They illustrate relative changes in financial parameters over time. Results are subject to the scope (steel production only), the applied operationalized scenarios, corporate adaptation (technology portfolio development: FROZEN_2020, MARKET, MARKET-EBIT in the current countries and technologies), and the modeling limitations. Companies' portfolio data are based on VDEh's PLANTFACTS database from December 2016. Any significant, interim changes in corporate strategies are likely to have an impact on these results. They do not constitute a financial forecast nor investment advice. See Appendix for more information.

voestalpine's earnings follow a similar path to that of thyssenkrupp in the climate change scenarios, albeit for different reasons (Chart 24). In the 2°C-consistent scenario (ACT), company EBITDA drops to 2030, but can recover afterwards, based on strategic investments.

Voestalpine's low-carbon investments pay off in the long-term

Chart 24: Continuing investments in low carbon steel production limit EBITDA losses to 2030 and drive positive company earnings to 2050



Source: The CO-Firm

2°C scenario: EBITDA decline to 2030 followed by strong growth

In the ACT scenario, voestalpine continues to invest in low-carbon steel production technologies from now until 2050. To 2030, the relative divestment from BOF cannot drive a positive earnings development for the company. EBITDA losses occur in this period as a result of rising CO2 prices, in both adaptive capacity pathways.

Between 2030 and 2050, voestalpine's long-term divestment strategy from BOF plants to the DRI method pays dividends, resulting in positive earnings for the company. EBITDA peaks in 2040 with an increase of around 50% relative to today.

Between 2030 and 2050, voestalpine's long-term divestment strategy from BOF plants to the DRI method pays dividends

Voestalpine has uncompetitive BOF steel production

Voestalpine currently produces steel via the carbon-intensive BOF method in Austria. The company also invested in a large DRI plant in the US, which started production in September 2016. To compare its performance over time, we adjusted 2016 figures so that the DRI plant produced for a full year in 2016. We assume that the production from the US plant is traded at the US market, even though it is currently shipped to Austria as a pre-material.

The competitiveness of BOF steel production in Austria is affected by the increase in CO2 prices in the ACT scenario. These result in higher specific production costs relative to global competition without emission trading schemes.

Due to ongoing divestments, voestalpine's BOF steel production equates to less than 20% of thyssenkrupp's BOF capacity between 2030 and 2050. Adopting CCS in this period is assumed to have higher capex requirements for voestalpine compared with thyssenkrupp, due to lower economies of scale.

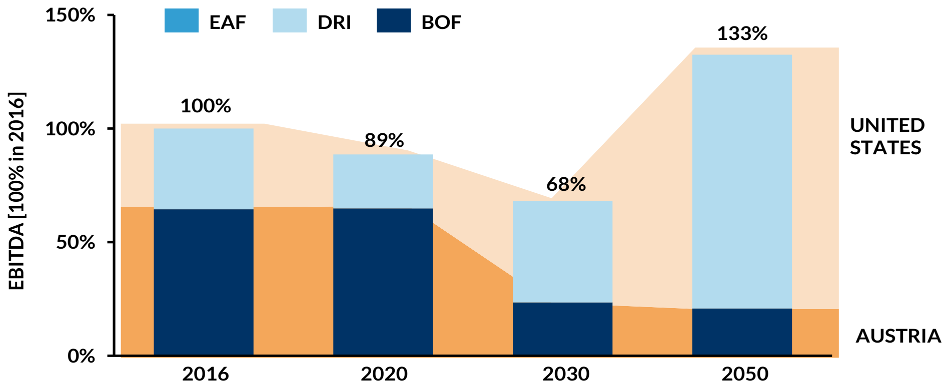
A long-term DRI-led strategy pays off

The investment in US-based DRI production pays off in the long run and can offset EBITDA losses in BOF production. In ACT, DRI's lower carbon intensity results in positive earnings, once CO2 prices increase enough.

Voestalpine's ongoing investment in US-based DRI production pays off and can compensate for EBITDA losses in BOF production in the long run

Furthermore, after 2030, EBITDA for DRI-based production increases with CCS-retrofits to DRI methods. High CO2 prices in the US render DRI with CCS more competitive than BOF with CCS. Increasing investment in DRI production and growing profit margins result in total EBITDA increase of 33% in 2050 compared to today (ACT/MARKET-EBIT).

Chart 25: In the long run, the ongoing investments in US-based DRI steel production can outweigh voestalpine's short-run BOF's EBITDA losses (ACT/MARKET-EBIT scenario)[7]



Source: The CO-Firm

Engagement questions:

- What plans are in place to diversify voestalpine's steel production asset base in the medium-term?
- Does voestalpine have a long-term capex strategy for the low-carbon transition?

[7] For voestalpine the production in the US counts as a pre-material and revenues occur in Europe. In our model the revenue is accounted for in the country of production, thus in the US.

Embedding the results within valuations

Analysts and investors are concerned about mispriced assets and subsequent value destruction. Climate change scenarios, such as the LCT and ACT, represent one lens through which potentially mispriced assets can be identified because:

1. The low-carbon transition is typically considered a long-term issue by mainstream equity analysis and subsequently overlooked.
2. These scenarios often present sector, country, and macro level futures that are materially different to the consensus view, hereby challenging conventional assumptions.

Climate change scenarios represent one lens through which potentially mispriced assets can be identified

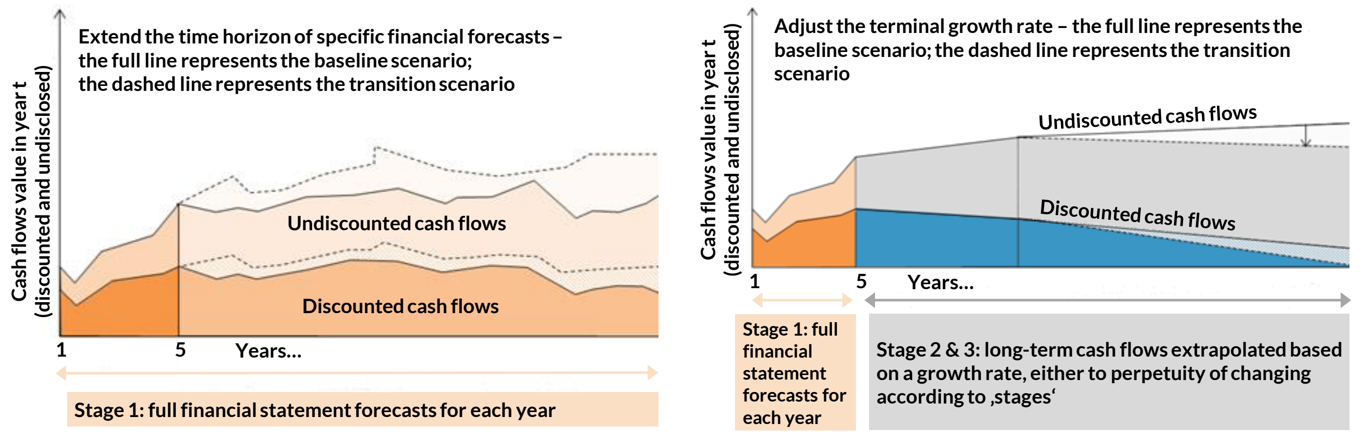
In this section, Kepler Cheuvreux investigates whether the result of transition risk modelling, such as that completed by our partner The CO-Firm, can be used in bottom-up stock valuation, and if so, how?

Integrating transition risk into valuation modelling

The integration of climate change scenarios into financial modelling can be done via either the **growth potential** and/or **risk profile** of specific stocks.

1. The energy transition can affect the **long-term growth potential** of a specific company, sector or country. In the context of scenario analysis, analysts can integrate this consideration by extending the time period over which **specific cash flows** are modelled year-on-year, i.e. extend stage 1 and test for different scenarios - Chart 26. Alternatively, an analyst can change the **growth** rate used in the second-stage of a stock valuation or the perpetuity rate in stage 3.

Chart 26: Either extend specific cash flows or adjust stage 2 and terminal growth rate



Source: Kepler Cheuvreux

2. Transition pathways, as captured by scenarios, can also affect the **risk profile, or variability of cash flows,** of an asset. Note that the notion of risk in finance refers to the variability from an expected outcome, either positive or negative, even if in practice investors are more concerned about downside risks. This is captured in the **discount rate**, which can be varied to reflect an analyst's perception of risk to the stock's future cash flow.

The CO-Firm model provides extended cash flows to 2050 and is therefore more amenable to the first option (growth). Our results apply this methodology for integrating climate change scenarios into equity valuations, before highlighting what could potentially be done on the risk side of the story, if preferred by an analyst.

Identifying potentially mispriced assets

Investors are increasingly asking the question: **What could the valuation of a company be under a climate change scenario?** This question hints at the potential gap between current company valuations and what they could be under a climate change scenario – thereby informing on the potential mispricing of a stock. This is the approach taken in this study, focusing on a climate scenario with global mean temperature increase of 2°C in 2100.

The 'consensus' baseline valuation

We compare the valuation estimates from our climate change scenarios with a market 'consensus' baseline. This baseline is comprised of:

- Bloomberg consensus data from 2018-2023 on company EBITDA, depreciation and capex from the crude steel segment.
- Over 2024-50, the baseline assumes that company cash flows from crude steel grow in line with the terminal growth rate for the company that is applied by KECH's own equity analysts.
- We model the company cash flows to perpetuity (post-2050) by applying KECH analysts' terminal growth rate (TGR) and discount rate (DR) to the company's average annual cash flows between 2040 and 2050.

Any difference between the baseline valuation and that in our scenarios gives an insight into a potential mispricing of the stock

Any difference between the consensus baseline valuation and that of the LCT scenario provides insight into the current potential mispricing of the stock due to the short-term nature of valuation models.

Any difference between the consensus baseline valuation and that of the ACT scenario highlights the current potential mispricing of a stock compared to a world which limits global warming to 2°C above pre-industrial limits.

Limitations of consensus valuations

According to research by 2 Degree Investing Initiative and Generation Investment, more than 90% of company value comes from cash flows accrued more than five years in the future. Over 60% of the net present value is derived from cash flows occurring more than 20 years in the future on average, even after discounting.

And yet, these cash flows are traditionally estimated using a perpetuity formula, usually based on economic growth. This is unlikely to be company-specific and will rarely consider the impact of the low-carbon transition on economy-wide growth.

Cash flows in any period in which the company is able to maintain a competitive advantage should be modelled YOY

In theory, cash flows in any period in which the company is able to maintain a competitive advantage should be modelled year-on-year. The terminal growth rate often reflects just the average growth rate of the industry in which the company's operate, or even more broadly, economic growth or inflation.

Not only could the low-carbon transition change the steel industry's growth rate forecasts, but also a company's positioning in a specific market, or ability to adapt and maintain higher returns than its industry. In that context, can we use climate change scenarios to derive a growth profile for each company that is more specific to the risks and opportunities of the low-carbon transition?

Altering the growth profile: Our valuation method

Our approach to valuation modelling of the three steel companies selected for this study consists of:

- The same Bloomberg consensus data on company EBITDA, depreciation and capex for the crude steel segment from 2018-23. This reflects our assumption that the consensus adequately reflects financially-relevant shorter-term transition risks.
- Extend the modelling of specific cash flows from 2024 to 2050, by using the CO-Firm climateXcellence model (see *Appendix*), reflecting our view that consensus data does not adequately evaluate and price in longer-term transition risks. This is also necessary to perform scenario analysis that deviates from forecasted trends (e.g. under a 2°C scenario).
- The same method for calculating cash flows to perpetuity as in the consensus baseline.

As a result, the bulk of the discrepancy between company valuations in the climate change scenarios and the consensus baseline is attributable to the difference in company cash flows in 2024-50E.

Valuation results: winners and losers

Under the assumptions made in the methodology highlighted above, we find that:

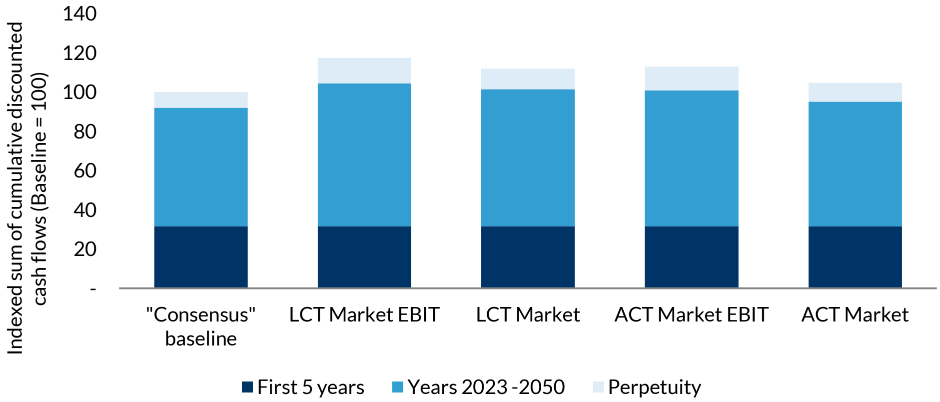
- ArcelorMittal and voestalpine could be undervalued in the consensus baseline compared to their valuation in the climate change scenarios.
- thyssenkrupp's has a lower company valuation in the climate change scenarios than the consensus baseline.[8]
- All three companies tend to value higher in the LCT scenario than the ACT, reflecting the challenges the industry will face in a high CO2 price, 2°C future.

In our valuation estimates, we apply the performance of the crude steel division of thyssenkrupp and voestalpine to the company as a whole. However, note that crude steel made up just 41% and 35% of each company's 2017 total revenue. In reality, therefore, the future valuation of these companies will also largely depend on the prospects for their non-steel segments.

[8] Note, the impact of thyssenkrupp's current steel production on the group's future steel earnings and valuation will likely be less than when these scenarios were run as a result of its joint venture with Tata Steel Europe (June 2018).

Results in focus

Chart 27: ArcelorMittal's valuation is higher in both climate change scenarios compared to a consensus baseline



Source: Kepler Cheuvreux; "Consensus baseline" represents current 5 year cash flow estimates per Bloomberg valuation Excel tools and our analysts' discount and terminal growth rates. It is therefore not the consensus of all analysts' current forecasts. Other data based on The CO-Firm climateXcellence mode

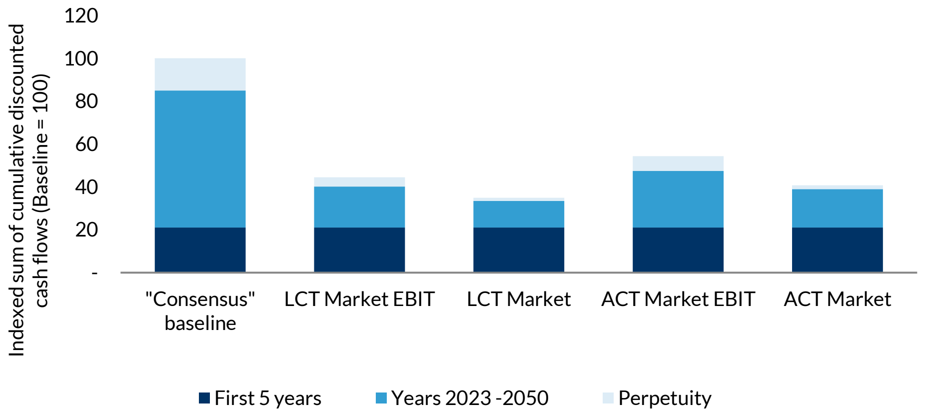
ArcelorMittal's valuation is higher in both climate change scenarios compared to a consensus baseline

Our analysis suggests that ArcelorMittal would be the most undervalued of the three steel producing companies in the consensus baseline. Interestingly, Chart 27 suggests that in spite of ArcelorMittal's apparent resilience to climate change scenarios, the company's cumulative discounted cash flows are largest in the LCT scenario rather than the 2°C scenario (ACT).

ArcelorMittal's valuation is stronger in the MARKET-EBIT adaptive capacity pathway than MARKET, in both climate change scenarios. Under the MARKET assumption, ArcelorMittal transitions its technology portfolio towards a stronger usage of recycled steels.

By comparison, MARKET-EBIT assumes that the company utilises its financial strength and proactively invests more in lower-carbon steel production technologies, such as natural gas based DRI, and adopts CO2 abatement measures earlier, such as CCS.

Chart 28: Thyssenkrupp's valuation is lower in all climate change scenarios than the consensus baseline



Note, the impact of thyssenkrupp's current steel production on the overall group's future steel earnings and valuation will likely be less than when these scenarios were run as a result of its joint venture with Tata Steel Europe (June 2018).

Source: Kepler Cheuvreux; "Consensus baseline" represents current 5 year cash flow estimates per Bloomberg valuation Excel tools and our analysts' discount and terminal growth rates. It is therefore not the consensus of all analysts' current forecasts. Other data based on The CO-Firm climateXcellence model

To a degree, the low valuation results shown in Chart 27 are to be expected because the weak earnings results from thyssenkrupp's BOF steel producing assets are applied to the group as a whole. In fact, thyssenkrupp's crude steel sales only make up around 40% of thyssenkrupp's overall revenue, so the performance of thyssenkrupp's non-steel segments will bear a large influence on the company's overall valuation.

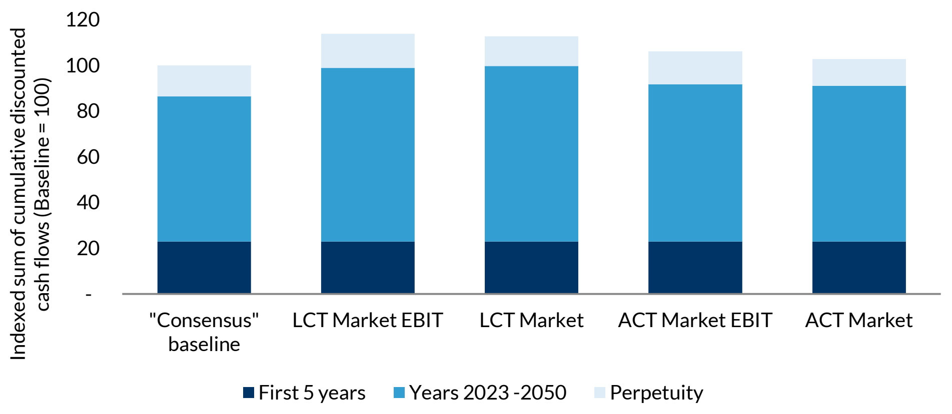
Maintaining an OECD based, BOF production portfolio will negatively affect company valuations

Nevertheless, it is clear from Chart 28 that maintaining an OECD-based, BOF production portfolio will negatively affect thyssenkrupp's valuation in any form of low-carbon transition, whether it is LCT or ACT. As explained, this is largely due to forthcoming and increasing CO2 prices.

Chart 28 also reveals an interesting nuance that thyssenkrupp is the only of the three steel companies whose valuation is higher in ACT than LCT. This is a result of a more widespread rollout of CO2 prices globally as opposed to just in the most advanced economies, and thyssenkrupp's economies of scale for the BOF-CCS technology combination

For thyssenkrupp's Germany-based steel production, adaptation options are limited in the short- to medium-term. Its technological lock-in and weak financial performance reduces its adaptive capacity so that the MARKET-EBIT assumption shows only marginal improvement of cumulative discounted cash flows compared to the MARKET scenario.

Chart 29: Our analysis suggests that voestalpine would be valued more highly in a low-carbon future compared to in the consensus baseline



Source: Kepler Cheuvreux; "Consensus baseline" represents current five-year cash flow estimates per Bloomberg valuation Excel tools and our analysts' discount and terminal growth rates. It is therefore not the consensus of all analysts' current forecasts. Other data based on The CO-Firm climateXcellence model

Although the results of our analysis, presented in Chart 29, are favourable for voestalpine, it is nevertheless important to note that, like thyssenkrupp, we apply discounted cash flows from voestalpine's steel division to reflect the company's valuation as a whole, even though it has diversified operations.

The drivers of voestalpine's upside valuation are similar to those affecting the results for our other two steel companies. Higher CO2 prices negatively impact the steel sector in the ACT scenario relative to the LCT scenario, and hurt the company's BOF production in Austria.

One might notice that the valuation of voestalpine in our climate change scenarios appears to be almost as high as that of ArcelorMittal in spite of the fact that its crude steel earnings were clearly more volatile and lower on average across 2016-50. This is partly a result of KECH's equity analysts assuming a lower discount rate for voestalpine (7%) than ArcelorMittal (8.5%).

KECH's equity analysts assume a lower discount rate for voestalpine (7%) than ArcelorMittal (8.5%)

In essence, a lower applied discount rate reflects an analyst's perception of lower risk to the company and will thus lead to less discounted future cash flows. Altering the risk profiles of different companies is discussed in more detail in the following section.

A reflection of one future and one valuation

We temper the results presented above with the fact that they represent only one pathway for the steel sector to be consistent with each pre-determined temperature target, without any probability attached. In fact, the pathways to deliver these temperature outcomes are numerous. The technological and regional structure of the scenario chosen for analysis has significant implications for the company valuations that result.

Perpetuity assumption: a further limitation

This analysis assumes that these companies will not cease operations, be delisted, or bought. This takes its root directly in how DCF models are built but is highly unlikely.

Indeed, the average age of an S&P company was 90 years in the 1930s, 61 years in 1958, and down to 18 years in 2012 (link) – mostly due to changes in size and M&A activities. By understanding the percentage of discounted cash flows arising from different time periods, analysts can understand the impact of different events on the total company valuation.

Company risk profiles: The other side of the coin

Our approach for embedding transition risks into company valuations has been to alter the growth profile. As highlighted earlier, another approach would be to alter the risk profile of the company. A company is considered to have high financial risk if the likelihood that investors could receive a return that is different from what was expected is high. In this context, a company more exposed to, or less prepared for, transition risks would have riskier/less certain future cash flows than a company with opposite qualities.

A company is considered to have high financial risk if the likelihood that investors could receive a return that is different from what was expected is high

This is usually captured through the discount rate. One way to calculate the discount rate (also known as the cost of capital) is through the Capital Asset Pricing Model (CAPM) (Chart 30).

Chart 30: The Capital Asset Pricing Model (CAPM) formula to determine the discount rate

$$E(R_i) = R_f + \beta_i\left[E(R_m) - R_f\right]$$

$\boldsymbol{E(R_i)}$ = **cost of equity**
R_f = risk–free rate
$\boldsymbol{\beta_i}$ = **beta of asset i; a measure of systematic risk**
$E(R_m)$ = return of equity
$[\mathbf{E(R_m) - R_f}]$ = **equity market risk premium, a measure of the excess return of the market portfolio over the risk-free rate**

$E(R_i)$ feeds into the "weighted average cost of capital", used as the **discount rate** in DCF models

Source: Kepler Cheuvreux

There are two sides to the CAPM equation: the equity risk premium and the beta. Deciding which variable is most appropriate to vary depends on the story that one wants to tell, i.e. whether we want to investigate the historical sensitivity of companies' share prices to transition-related shocks or how this sensitivity is changing as their strategy and exposure evolves. While this is beyond the requirements of this study, it gives an insight into the variables and methodology that go into calculating the appropriate discount rate for each stock.

Sensitivity analysis

KECH's sector equity analysts apply the same terminal growth rate (1%) across our three selected steel companies, but different discount rates; 8.5% for ArcelorMittal, 6.75% for thyssenkrupp and 7% for voestalpine. Typically, a higher discount rate reflects an analyst's view that there are higher risks to the future cash flows of that

A high discount rate reflects high risks to future cash flows, according to the analyst

company, and thus they are discounted more heavily. Again, the fact that two of our companies are diversified and do not focus principally on steel production like ArcelorMittal is hugely significant when thinking about the discount rates applied.

As a result of variable discount rates being attributed to our company sample, it is all the more important to conduct a sensitivity analysis to get a greater sense of the significance the discount rate, and the risk profile of the stock, plays in the overall company valuation (Tables 2-4).

Our analysis shows that varying the discount rate along with the terminal growth rate by ±1% around KECH's equity analysts' base assumption can affect the valuation of our selected steel companies by 15-25%.

Table 2: ArcelorMittal % difference between the consensus baseline and ACT/REVENUE-EBIT (blue text indicates scenarios in which ArcelorMittal's valuation is higher than the consensus baseline)

		Terminal growth rate				
		0.0%	0.5%	1.0%	1.5%	2.0%
Discount rate	7.50%	25%	20%	15%	10%	5%
	8.00%	23%	19%	14%	9%	5%
	8.50%	21%	17%	13%	9%	4%
	9.00%	20%	16%	12%	8%	4%
	9.50%	19%	15%	11%	8%	4%

Source: Kepler Cheuvreux

Table 3: thyssenkrupp's valuation is the least sensitive of the three companies to varying TGR and DRs (ACT/REVENUE-EBIT) (orange text indicates scenarios in which thyssenkrupp's valuation is lower than the consensus baseline)

		Terminal growth rate				
		0.0%	0.5%	1.0%	1.5%	2.0%
Discount rate	5.75%	-40%	-44%	-47%	-50%	-54%
	6.25%	-40%	-43%	-46%	-49%	-53%
	6.75%	-40%	-43%	-46%	-49%	-52%
	7.25%	-40%	-42%	-45%	-48%	-51%
	7.75%	-39%	-42%	-44%	-47%	-50%

Note, the impact of thyssenkrupp's current steel production on the group's future steel earnings and valuation will likely be less than when these scenarios were run as a result of its joint venture with Tata Steel Europe (June 2018).

Source: Kepler Cheuvreux

Table 4: TGR and DR assumptions are the difference between over- and under-valuation in the baseline compared to climate change scenarios for voestalpine (blue text indicates scenarios in which voestalpine's valuation is higher than the consensus baseline, orange = under)

		Terminal growth rate				
		0.0%	0.5%	1.0%	1.5%	2.0%
Discount rate	6.00%	19%	13%	7%	1%	-6%
	6.50%	18%	12%	6%	1%	-6%
	7.00%	17%	11%	6%	1%	-5%
	7.50%	16%	11%	6%	1%	-4%
	8.00%	15%	10%	6%	1%	-4%

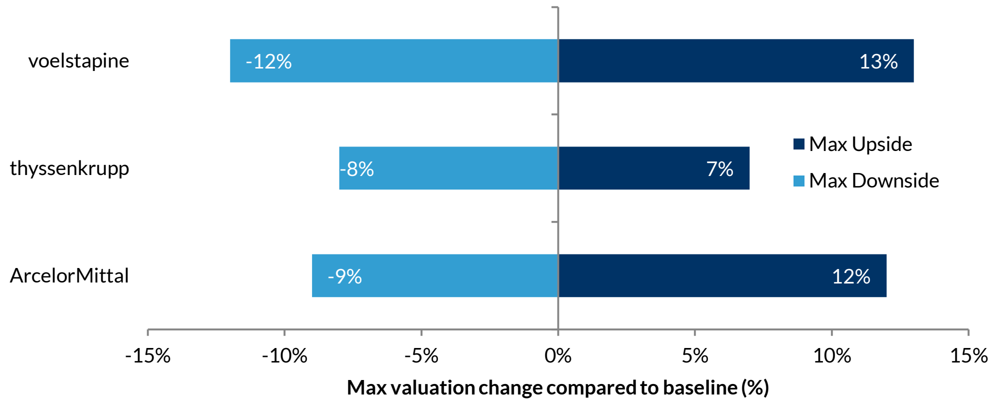
Source: Kepler Cheuvreux

Valuation model inputs reflect the beliefs of the analyst. Conducting sensitivity analyses such as Tables 2-4 is a useful exercise to understand how resilient or volatile a company valuation estimate is to alterations to these inputs.

Chart 31 summarises the results of the sensitivity analysis. It suggests that voestalpine is most volatile to its valuation model inputs, while thyssenkrupp is the least volatile. It also suggests that ArcelorMittal has more upside potential than downside risk in terms of its valuation in climate change scenarios compared to the baseline.

Voestalpine is most volatile to its valuation model inputs

Chart 31: A summary of the results from the sensitivity analysis



Source: Kepler Cheuvreux

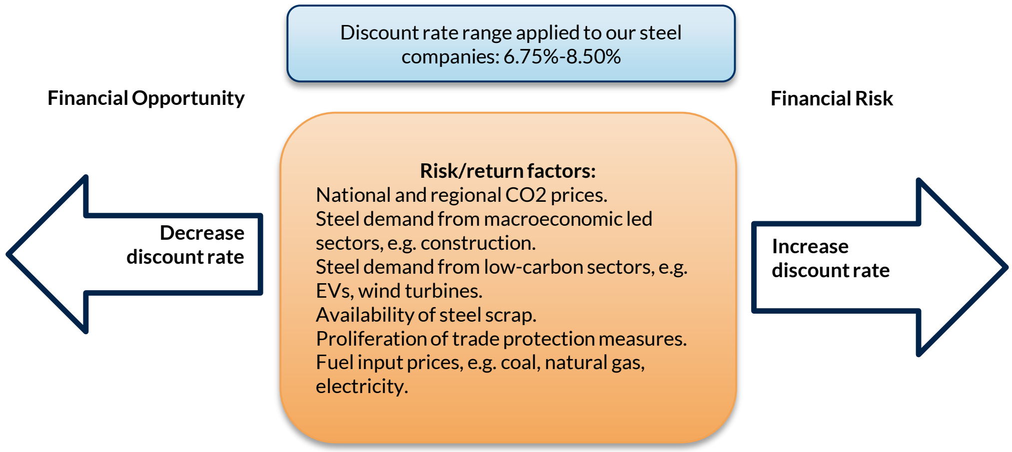
Why change the discount rate?

One might want to amend either the DR or TGR of a company if they hold a different view to that of the equity analyst. The TGR typically reflects the expected growth rate for the industry in question or sometimes simply future economic growth. The discount rate reflects the rate at which future cash flows are discounted. It is used to internalise risk into the valuation calculation; the more risk there is perceived to be to future company cash flows, the higher the discount rate, and vice versa.

The more risk there is perceived to be to future company cash flows, the higher the discount rate

Throughout this report, we have highlighted a number of different regulatory and technological factors that could impact the earnings and valuations of steel companies in a low-carbon transition. If one's view differs from that of our analyst, a different discount rate could be applied to the stock valuation to reflect whether that difference will have upside (opportunity) or downside (risk) has an impact on the company in question. Chart 32 illustrates how changing the discount rate can be used to analyse companies in the steel sector.

Chart 32: A discount rate should reflect an analyst's perception of risks/returns from key criteria in the sector



Source: Kepler Cheuvreux

Assessing company adaptive capacity

Adaptive capacity is a result of dynamic capabilities, which allow existing resources (assets, financial pockets, intellectual property) to be put to good future use, via a strategy

Adaptive capacity is the result of dynamic capabilities (partnering, integrating, building, etc.), which allow existing resources (assets, financial pockets, intellectual property) to be put to good future use, by means of a strategy (Chart 18). These dynamic capabilities comprise, for example, the ability to perceive external market changes, engage in alliances, reconfigure internal resources for future use, etc.

These need to be analysed closely when assessing whether an individual company is future-proof, especially in transitioning sectors. In this comprehensive scenario analysis across the crude steel segment globally, The CO-Firm assumes that all companies have the same dynamic capabilities at their disposal. Therefore, their adaptive capacity is determined by their current resources (physical, intellectual and financial assets) and their fit with future market requirements under the scenario. This assumption creates a data-driven, reproducible basis for comparing companies.

Traditionally, adaptive capacity forms part of an analyst's judgement in an implicit fashion, for example, when judging the credibility of strategic announcements or financial forecasts ("can the company really do it?"), and/or under the label "management quality".

By comparison, explicit consideration is given by the analyst to the company's current resource base (EBITDA, current model mix, etc.), the implementation of strategies in the transformation process (R&D expenditures), and strategic targets (model strategy).

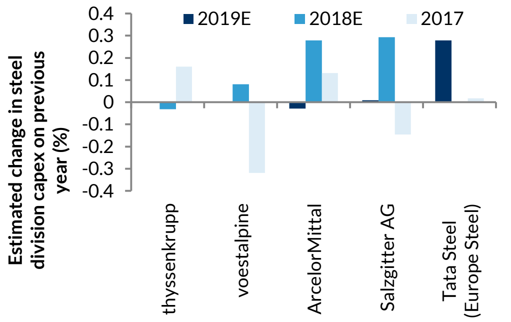
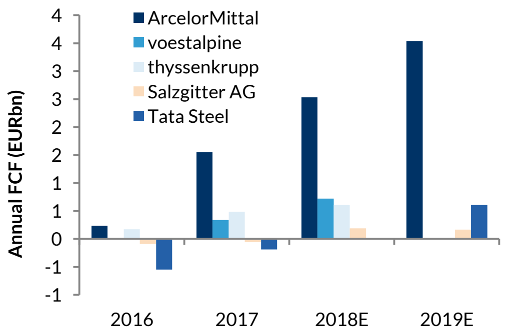
An example of bottom-up adaptive capacity assessment

Table 5 shows an example assessment of a company's adaptive capacity to transition risks and opportunities. It is not exhaustive; for example the 'partnering', 'integrating' and 'reconfiguring' adaptive capacity criteria are not addressed. Furthermore, The CO-Firm and Kepler Cheuvreux comment only on the crude steel segment. Thus, the potential to offset weaker growth or losses through other business units is not analysed. Also, a change in the business model is not captured, e.g. cross-industry earnings generated through CCU.

However, this assessment maps: 1) Kepler Cheuvreux's bottom-up assessment framework and criteria; with 2) The CO-Firm's conceptual framework for adaptive capacity of resources, strategies and dynamic capabilities.

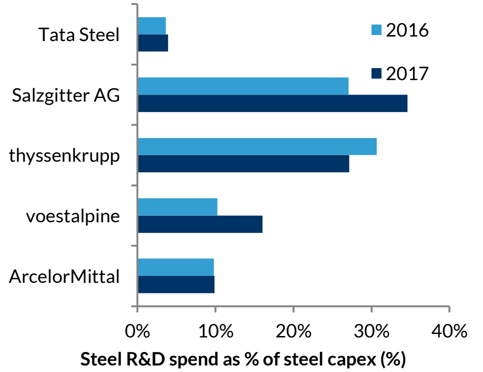
Our multicriteria adaptive capacity assessment confirms the strength of ArcelorMittal's balance sheet and profit and loss (P&L) statement relative to its peer group. It is also best-in-class with regards to climate change acknowledgements, risk analysis, and expertise, although thyssenkrupp and voestalpine also display clear awareness that transition risks could be material to their businesses in the medium term.

Table 5: An illustrative (not exhaustive) multi-criteria adaptive capacity assessment of ArcelorMittal, thyssenkrupp and voestalpine against their peers (as determined by Bloomberg)…**continues on next page**

Conceptual embedding	Criteria	Metric	Data analysis	Estimated impact on adaptive capacity	Description
	P&L				
Resources	Capital allocation ; investments	Capex	 Source : Bloomberg Chart estimates use 'steel factors' outlined at bottom of table. Tata Steel Europe's figure is % change from 2017-19 (2018 data missing)	ArcelorMittal : Positive thyssenkrupp : Negative voestalpine : Neutral	With mounting regulatory risks threatening compliance costs and fines, particularly in Europe via the ETS, steel companies need to invest heavily today to make the big jump to low-carbon alignment. • ArcelorMittal will increase 2018 steel capex sharply in 2018, following a similar trend to the annual change from 2016-17. Much of the annual capex spend will focus on restoration, upgrades and production capacity increases. • Voestalpine took the biggest cut to capex of any of this peer group in 2017. Initial signs suggest a reversal of this trend to resume growth of its steel division. • Thyssenkrupp's year-on-year capex 2016-18 is flat to downward trending.
Resources, Strategy	Revenues, earnings and cash flows	Free cash flow (FCF)	 Source : Bloomberg	ArcelorMittal : Positive thyssenkrupp : Neutral voestalpine : Neutral	Low steel prices due to oversupply in the market hit producers' earnings (2014-16) until the recent upturn. • ArcelorMittal is expected to post strong FCF figures that give it flexibility to wait and see re: low-carbon factors, such as the ETS price. • Thyssenkrupp and voestalpine are expected to be cash flow positive in 2018 also, but to a lesser extent than ArcelorMittal. Also, any available cash may not be directed towards the steel division.

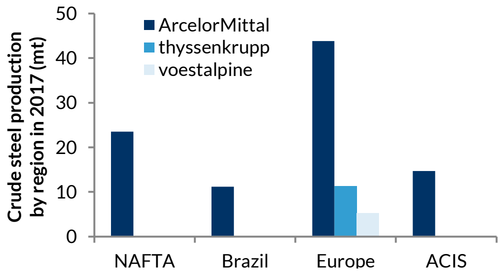
Source: Kepler Cheuvreux

An illustrative (not exhaustive) multi-criteria adaptive capacity assessment of ArcelorMittal, thyssenkrupp and voestalpine against their peers (as determined by Bloomberg)...continues on next page

Conceptual embedding	Criteria	Metric	Data analysis	Estimated impact on adaptive capacity	Description
	Intangible assets				
Resources, (Building)	Technological expertise and innovation	Steel division R&D spend	Source : Bloomberg Chart estimates use 'steel factors' outlined at bottom of table.	ArcelorMittal : Neutral thyssenkrupp : Neutral voestalpine : Neutral	• Voestalpine has increased R&D spend significantly in 2017 (4.3%) suggesting it is a priority for the company. This should benefit its steel division also. • Our estimates show thyssenkrupp invests a peer group leading proportion of its capex spend on R&D, developing products like steel for EVs. • Question marks remain across the peer group regarding the degree to which R&D spend is focused on low-carbon steel solutions.
	Disclosure of metrics and targets				
Resources	Production emissions targets	CO_2 targets	• ArcelorMittal has a target to reduce CO_2-intensity of steel production by 8% by 2020 (against 2007 levels). • Thyssenkrupp does not have a CO_2-intensity target in place but an energy efficiency target to 2020. • Voestalpine has numerous energy efficiency related targets, but no CO_2 specific target.	ArcelorMittal : Neutral thyssenkrupp : Negative voestalpine : Negative	Thyssenkrupp states it is developing a long-term CO_2 target which will take into account the Paris Agreement. Overall, the companies in the sector should be expected to make CO_2-intensity production targets and would be best in class if it is in the context of the Paris Agreement.
	Governance				
Resources (Expertise) **Opportunity Recognition** (Quality, Oversight)	Expertise, quality and oversight	Climate change expertise	N/A	ArcelorMittal : Neutral thyssenkrupp : Negative voestalpine : Negative	One board member of ArcelorMittal is part of World Business Council on Sustainable Development (WBCSD). The other two companies have no discernible climate change expertise on the board of directors.

Source: Kepler Cheuvreux

An illustrative (not exhaustive) multi-criteria adaptive capacity assessment of ArcelorMittal, thyssenkrupp and voestalpine against their peers (as determined by Bloomberg)

Conceptual embedding	Criteria	Metric	Data analysis	Estimated impact on adaptive capacity	Description
	Tangible assets				
Strategy	Capacity	Production capacity and diversity	 Source : company documents	ArcelorMittal : Positive thyssenkrupp : Negative voestalpine : Negative	ArcelorMittal has a far greater geographical diversity of steel production than our other two companies, reducing its exposure to regional transition risks such as the EU ETS. Thyssenkrupp's steel production assets are based in Germany, while voestalpine's are in Austria.
	Strategy				
Strategy; resources	Alignment with structural trends	2°C scenarios and the Paris Agreement	• Clear acknowledgement of the Paris Agreement and a 2°C global warming limit by each company.	ArcelorMittal : Neutral thyssenkrupp : Neutral voestalpine : Neutral	ArcelorMittal has been contributing to IEA 2°C scenarios for the steel sector; thyssenkrupp highlights the opportunities, as well as risks, presented to the industry by the Paris Agreement; and voestalpine points to its H2FUTURE project on hydrogen solutions as efforts to align with the Paris Agreement. Each company claims that 'breakthrough technologies' are needed to align steel production with a 2°C pathway. The bottom line is that the development of the required technologies remains to be seen.
Opportunity Recognition	Risk management	Scenario analysis	• ArcelorMittal models the impact of four ETS prices, while thyssenkrupp started in 2017 the Innovation Foresight Process conducting scenario analysis on energy and climate change factors. • voestalpine highlighted in its 2015/16 corporate responsibility report that it runs scenarios on transition risks, so we assume this continues, without the company explicitly disclosing as such.	ArcelorMittal : Positive thyssenkrupp : Positive voestalpine : Positive	All three companies conduct forward-looking scenario analysis on energy and climate change factors. The results should be integrated into their respective business strategies.

For reference, steel sector revenues for 2017 were: ArcelorMittal EUR61.7bn, thyssenkrupp EUR8.9bn, voestalpine EUR3.6bn, Salzgitter AG EUR2.2, Tata Steel EUR16.0.

thyssenkrupp and voestalpine are diversified companies. To account for this, we pro-rata financial metrics in this table, where necessary, by the percentage of total company revenues derived from the crude steel segment in 2017. These **'steel factors'** are as follows : ArcelorMittal 84% ; voestalpine 35% ; thyssenkrupp 41% ; Salzgitter 63% ; Tata Steel Europe 100%..

Source: Kepler Cheuvreux

Appendix: climateXcellence model

This section builds on:

- Validation with a broad range of financial and ESG analysts, academia, and practitioners over the last five years.
- Model co-development and extensions with Allianz Global Investors, Allianz Climate Solutions, WWF Germany, and the Investment Leaders Group hosted by the University of Cambridge.

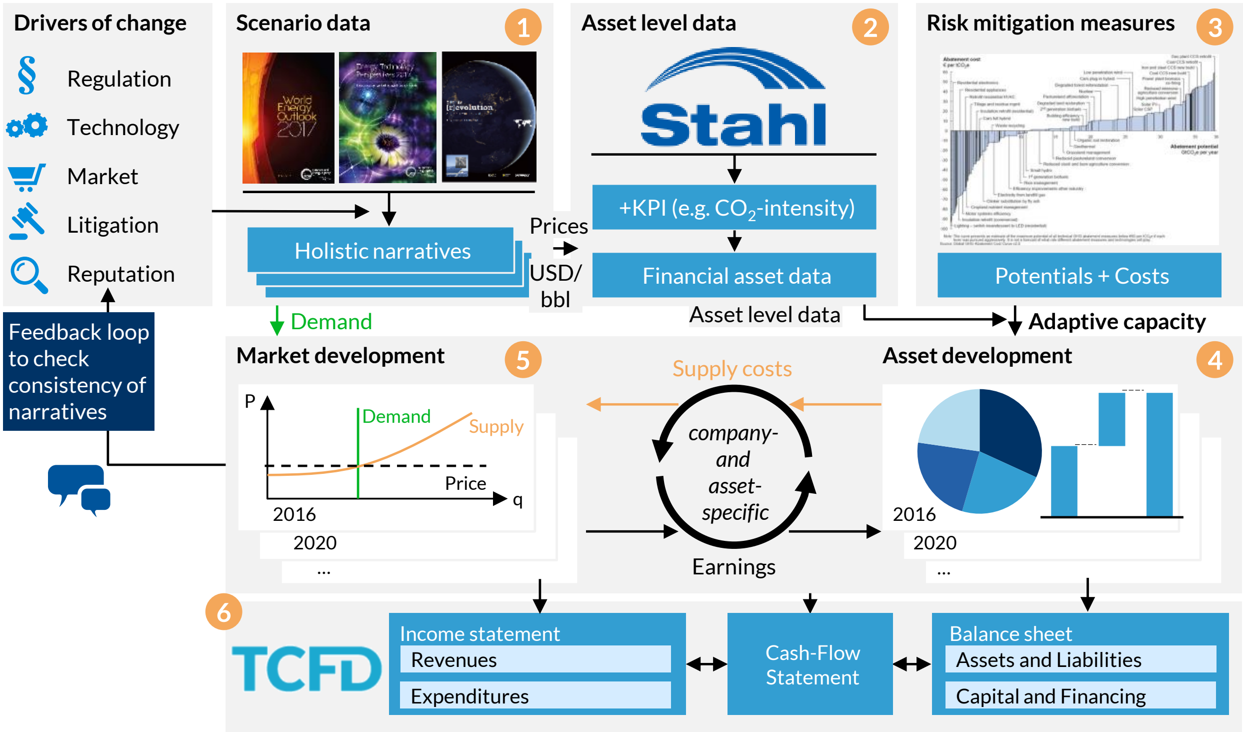
Research is published in the following documents:

- Feeling the heat, CISL, and CO-Firm (2016, *link*).
- Transition scenarios: the transition risk-o-meter. Reference scenarios for financial analysis (2dii, The CO-Firm, June 2017, *link*).
- Adaptive capacity: changing colors. Adaptive capacity of companies in the context of the transition to a low carbon economy (2dii, The CO-Firm, Allianz, Allianz Global Investors, August 2017, *link*).
- Investor primer to scenario analysis published by Kepler Cheuvreux and The CO-Firm (*link*)
- Transition risks for electric utilities sector (The CO-Firm and Kepler Cheuvreux, *link*)
- Climate scenario compass: Transition risks for the automotive sector (Kepler Cheuvreux, The CO-Firm, forthcoming).
- Climate scenario analysis: Cement's financial performance under 2° C and 2.7° C - A how-to guide for the sector, and three companies across six countries (The CO-Firm, forthcoming).
- Climate scenario scenarios: Transition risks: How to move ahead. (The CO-Firm, Kepler Cheuvreux, forthcoming).
- The way into an economy below 2 degrees (analysis paths - assessments - economic implications): Using the example of key economic sectors for Germany: automobile production and selected plastic goods (forthcoming)

This section illustrates the practical application of the Investor primer to scenario analysis published by Kepler Cheuvreux and The CO-Firm (*link*), with a focus on the steel industry which provides a higher-level discussion of the concepts and analysis steps described below.

Overview of the climateXcellence model

Chart 33: Overview of the method applied. How to derive the business impact of transition scenarios in the power sector



Source: The CO-Firm.

Financial modeling of the steel sector with respect to climate scenario analysis can be divided into six central steps (Chart 44; subsequent numbering is consistent with the chart; for more general information on each of the following steps, please refer to the "Investor primer to transition risk analysis" report).

Financial modeling of the steel sector only analyses financial impacts from iron and crude steel production. Other upstream (e.g. iron ore mining) or downstream activities (e.g. metal forming) or other typical business units associated with steel production (e.g. production of steel-based capital goods) are excluded from the analysis, as they are substantially less material with respect to climate change and energy transition impacts.

1. **Derive the key risk drivers to translate a scenario into a narrative.** First, develop a holistic transition narrative by extending scenario data with consistent transition drivers. For the steel sector, we conducted the following steps to derive a consistent scenario:

   a. Analysing, extrapolating, and breaking down available scenario data of the global and regional steel sector (i.a. IEA Energy Technology Perspektive 2017;2016; IEA World Energy Outlook 2017;2016) to country-specific technology pathways in terms of production and CO2 emissions (i.e. BOF, EAF, and DRI).

   b. Determining drivers of change including regulatory (e.g. CO2 prices), technological (e.g. specific capex, CO2 intensity) and market-based (i.e.

coal, coke, natural gas, iron ore and steel scrap prices) .by region and by scenario based on current and announced regulatory regime, climate targets, envisaged technology pathways (see point a), etc.

2. **Build an asset-level database with financial information on individual technology**. Since climate transition impacts technologies differently (even within the same sector), building a financially meaningful asset-level database is central to the modeling. For the steel sector, we build upon German Steel Association's (VDEh) PLANTFACTS database from December 2016. The database contains asset-level information on a global level such as technology type (e.g. BOF), installed capacity, ownership, start-up year, location, etc. We have complemented the available data (technology-specific) with the following information:

    a. Specific energy and raw material usage, CO2 intensity, marginal short-run and long-run production costs.

    b. Capex requirements and depreciation over time by scenario and by region.

    c. Expected year of decommissioning based on the age of the plant.

3. **Conduct a techno-economic assessment of risk mitigation measures ("adaptive capacity").** Financial modeling of climate risk must consider companies' ability to adapt to changing environments. With respect to the steel sector, analyzing risk mitigation has to take into account a variety of aspects such as:

    a. The scenario applied (e.g. ACT, LCT).

    b. The current technology (e.g. type, location, and age of technologies) and market base (e.g. access to cheap natural gas) of a company.

    c. The ratio between production costs benefits and capex requirements of the new technology.

4. **Assumptions for companies' physical asset portfolio development with and without adaptive capacities under different scenarios.** This step makes assumptions about how companies make use of the available options (see step 3) to adapt its physical asset base (see step 2) to the changing environment of the climate scenario (see step 1).). For the steel sector, we modeled three portfolio development pathways: FROZEN_2020, MARKET, and MARKET-EBIT (see Chart 3 for a detailed description of adaptive scenarios).

5. **Derive financial performance of individual assets in market models:** Crude steel is a globally traded commodity. The global steel market is modelled with an annual merit-order based approach. The merit order ranks the steel supply in ascending order based on the marginal production costs. The cross-section between supply costs and demand determines the annual average global steel price. The gap between the price and the production costs indicated the profit margins for an individual asset.

6. **Derive financial impacts on companies**. In the last step, the financial performance of the individual assets obtained in step 5 is aggregated together with the capital requirement of steps 3 and 4 at the company level. This step ensures the linkage to the TCFD recommendations by outlining the scenario-related impacts on the income, cash-flow statement and balance sheet.

Note: For an overview of how to develop scenario analysis and integrate this into company valuations and investment decision-making, please see the *Investor primer to transition risk analysis* published by Kepler Cheuvreux and The CO-Firm (link).

Limitation of method applied

Although the underlying method has been developed over years and reviewed by a range of stakeholders, it does have its limitations that need to be taken into account and tested for when incorporating results into financial modelling.

- **Scenarios are not associated with likelihoods:** The underlying scenarios are operationalised IEA scenarios (see the Investor primer to scenario analysis report). Although this is inherent to scenario analysis and not a limitation per se, it is important to note. For instance, the IEA has been criticised for continuously overestimating the deployment of CCS in its scenarios. While it is fair to say that the scenarios try to anticipate drivers such as technological improvements, it does not estimate the likelihood of these drivers. The strength of the scenario is the plausibility and consistency of the outlined parameters over time.
- **Companies' asset development assumptions:** The model assumes that companies will remain active in country-asset combinations they are invested in today or are planned to be invested in by 2020. To make data for companies' new investments until 2020 more reliable, we rely on VDEh's PLANTFACTS database (from December 2016). Furthermore, as no market entry of new players is assumed, capacity upgrades outlined by scenario are shared among existing companies.
- **Scenario analysis and alignment assessments**. It is important to understand that the ACT (2° C) scenario tests for the financial impact of the various parameters (e.g. CO2 prices) compatible with such a trajectory, but it does not assume that the companies are "aligned" in terms of their asset base, as understood under the science-based target approach (and more specifically the sectoral decarbonisation approach) or SEI Metrics' 2° C portfolio test (misalignment of activities based on future production by technology, and the technology portfolio requirements illustrated in the IEA's scenarios). In fact, while several of them can, the remaining BOF plants are too large to be equally distributed to allow for a linear ownership across steel companies. Thus, few companies will show higher emissions than aimed for, to ensure system stability. Also, note that alignment with science-based targets is not per se correlated with financial performance.

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Reduce	15%	10%
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Total	100%	100%

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