

# Melting point

Which steel companies are ready for the low-carbon transition?

July 2019



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**Acknowledgements:**  
Dr Paul Griffin  
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# Linking climate metrics to earnings for steel companies

This report updates and expands CDP's research and League Table for steel companies, first published in October 2016. It ranks 20 of the largest and highest-impact publicly listed steel companies on business readiness for a low-carbon transition. The companies in aggregate represent 30% of global steel production.

The steel industry generates between 7% and 9% of global greenhouse gas emissions from fossil fuel use and industry. To align with the International Energy Agency's 2-Degrees Scenario (IEA 2DS), the sector will be required to reduce its emissions intensity by 65% by 2050, compared to 2014 levels.

The industry has historically achieved significant improvements in energy efficiency. However, modern steel plants are currently operating near optimal technological limits and around 70% of primary steel is still produced via the highly efficient but energy intensive BF-BOF route.<sup>1</sup>

To align with a transition to a low-carbon economy, the steel industry will require a step-change in emissions reductions through the deployment and commercialization of radical mitigation technologies and alternative steelmaking processes.

There are four key areas assessed in the League Table, which are aligned with the recommendations from the TCFD:

**Transition risks:** We assess companies' Scope 1+2 emissions intensities and energy performance, as well as data transparency and Scope 3 emissions reporting.

**Physical risks:** We analyse company exposure to localized water stress issues on a facility-by-facility basis across their entire operations. We compare this water stress exposure with companies' water consumption and governance frameworks.

**Transition opportunities:** We assess companies' involvement in low-carbon innovations in relation to steelmaking and circularity. We also analyse levels of R&D and investment in renewable energy.

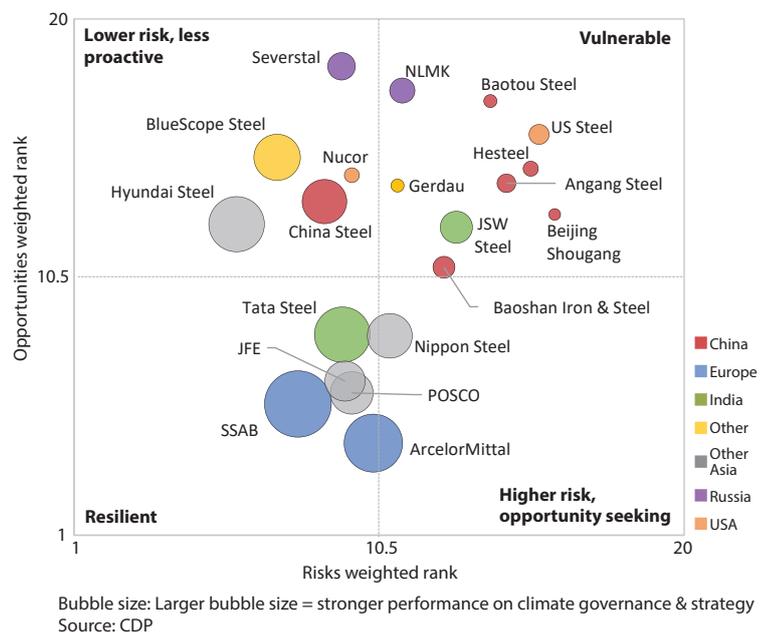
**Climate governance and strategy:** We analyse companies' governance frameworks including emissions reduction targets and the alignment of governance and remuneration structures with low-carbon objectives. We look at which companies are conducting scenario analysis and aligning with low-carbon initiatives.

## Key findings

- SSAB top the ranking, with ArcelorMittal, Hyundai Steel and Tata Steel closely ranked together in second, third and fourth respectively.
- Companies ranking in the bottom three are Inner Mongolia Baotou Steel, US Steel and Beijing Shougang.
- There is a significant geographical divide between the highest and lowest performing companies. Chinese, Russian and U.S. companies lag behind in terms of disclosure and performance in key areas.
- The analysis finds the weighted average Value at Risk for the companies to be 14% of net present value under a 2°C scenario, where global carbon prices rise to US\$100 per tonne CO<sub>2</sub> by 2040.<sup>2</sup>
- Reporting on emissions and energy consumption is inconsistent across the sample. Only four companies clearly disclose emissions intensity in line with worldsteel guidance.<sup>3</sup>
- Progress towards reducing Scope 1+2 emissions from steelmaking has been limited. Emissions intensities have been reduced at an average rate of 0.92% p.a. since 2013.
- Across the 20 companies, over 50% of inland steel capacity is located in areas of high water stress risk. Company operations located in China and India are most at risk.
- Only five companies have officially supported the TCFD.
- Seven of the 20 companies have set up Power Purchase Agreements to utilise renewable energy in their steelmaking operations.

- Six companies have delivered technologies, that we consider to be transformative. Innovations include the emergence of hydrogen steelmaking projects and a number of CCUS initiatives.
- 60% of companies have set emissions reduction targets, yet only two companies are aligned with a 2°C or below emissions pathway. SSAB has set a goal to reach carbon neutrality by 2045 across its entire operations.
- Companies are beginning to utilise scenario analysis to assess the impacts of climate change on their business. Seven companies use an internal carbon price.

Figure 1: Opportunity vs. risk for low-carbon transition



1. Blast Furnace-Basic Oxygen Furnace

2. Under our central 2°C scenario, the Value at Risk for individual companies ranges from 2.5% to 30% of net present value.

3. To calculate an emissions intensity that enables like-for-like comparison, worldsteel guidance is to include Scope 1, Scope 2 and upstream Scope 3 emissions relating to the procurement of pre-processed materials.

The summary League Table below presents headline company findings. It is based on detailed analysis across a range of carbon and transitional indicators which could have a significant impact on company performance. The League Table is designed to serve as a proxy for business readiness in an industry which will face increasing challenges as governments increase efforts to implement the Paris Agreement. Companies placed towards the bottom are deemed less prepared for a low-carbon transition.

**Figure 2: League Table summary**<sup>(i)</sup>

LT rank	Company <sup>(ii)</sup>	Country / region	Average market cap 2018 (US\$bn)	2018 steel production (million tonnes)	Weighted rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank	Production by process (%)		
										Open Hearth	BOF	EEAF
1	SSAB	Sweden	4.5	8.0	6.25	3	6	2	1			
2	ArcelorMittal	Luxembourg	31	93	7.34	10	10	1	2			
3	Hyundai Steel	South Korea	6.4	24	8.25	1	3	9	4			
4	Tata Steel	India	9.7	27	8.34	8	4	6	3			
5	POSCO	South Korea	26	43	8.72	6	8	3	8			
6	JFE Holdings	Japan	13	28	8.94	11	2	4	9			
7	Nippon Steel	Japan	20	48	9.67	13	5	5	6			
8	BlueScope Steel	Australia	6.5	6.0	10.13	2	7	16	5			
9	China Steel	Taiwan	13	15	10.37	9	1	11	7			
10	JSW Steel	India	12	17	12.59	14	14	8	10			
11	Baoshan Iron & Steel	China	28	47	12.71	15	11	7	13			
12	Nucor	USA	20	22	13.07	4	16	14	17			
13	Severstal	Russia	13	12	13.26	5	9	20	11			
14	Gerdau	Brazil	6.9	15	13.65	7	15	12	18			
15	Novolipetsk Steel (NLMK)	Russia	15	17	13.91	12	13	19	12			
16	Angang Steel	China	6.8	25	14.64	20	12	13	15			
17	Hesteel	China	5.3	27	15.35	17	17	15	16			
18	Beijing Shougang	China	3.6	16	15.38	19	20	10	20			
19	US Steel	USA	5.8	15	15.49	18	19	17	14			
20	Inner Mongolia Baotou Steel	China	13	15	15.74	16	18	18	19			

**Weighting**

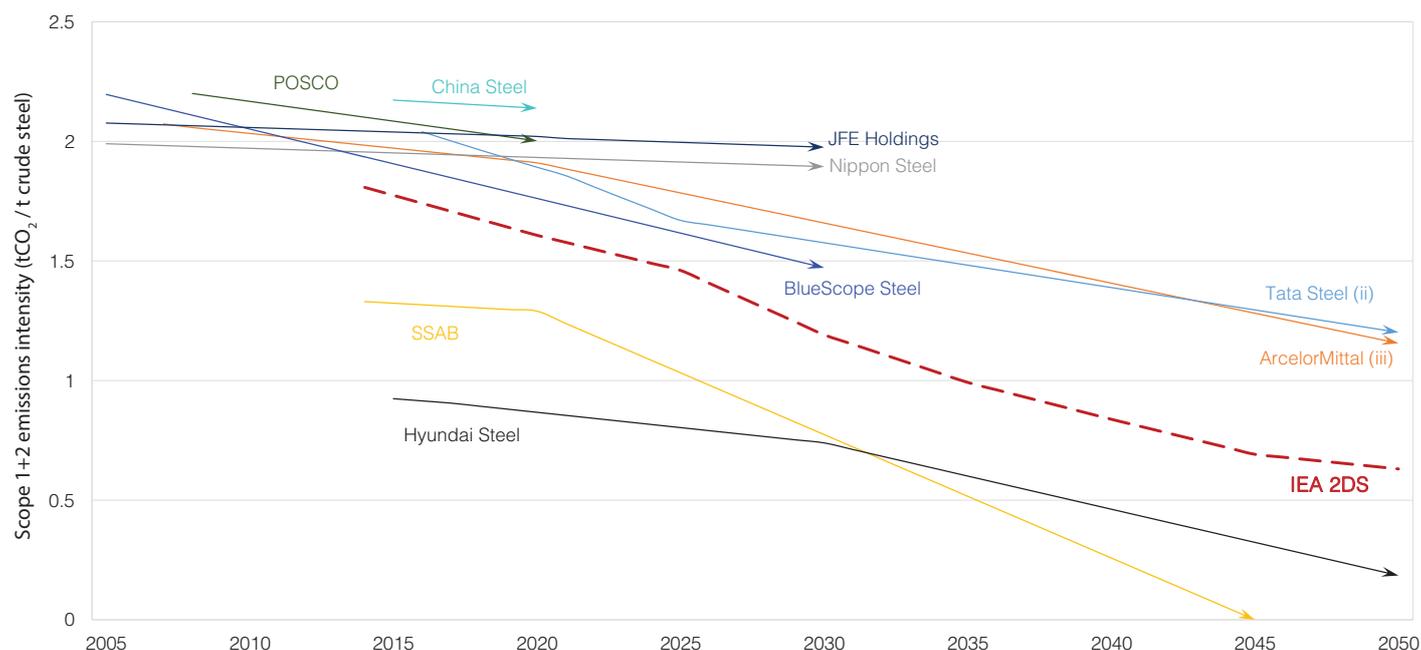
30% 10% 30% 30%

(i) Weighted ranks are calculated for each area. We display non-weighted ranks in this summary for simplicity only.

(ii) Angang Steel, Baoshan Iron & Steel, Beijing Shougang, BlueScope Steel, Gerdau, Inner Mongolia Baotou Steel, NLMK, Nucor and US steel are non-responders to CDP's 2018 climate change questionnaire. We encourage investors to raise this lack of transparency in discussions with company management.

Source: CDP

**Figure 3: Company emissions reduction targets and ambitions**<sup>(i)</sup>



(i) Target trajectories illustrate pathways from base year to target year emissions intensities. Therefore trajectories shown for companies to 2018 will differ from actual historical values, dependent on companies' performance relative to their targets.

(ii) Tata Steel's target pathway is calculated by combining Tata Steel's goal of <2 tCO<sub>2</sub>/tcs emissions intensity by 2025 for its Indian operations and Tata Steel Europe's ambition to be a carbon-neutral steelmaker by 2050.

(iii) ArcelorMittal's target pathway is calculated using its corporate target out to 2020 and then its ambition to achieve carbon neutrality in its European operations by 2050. We note that in 2020 the company is planning to set a 2030 reduction target.

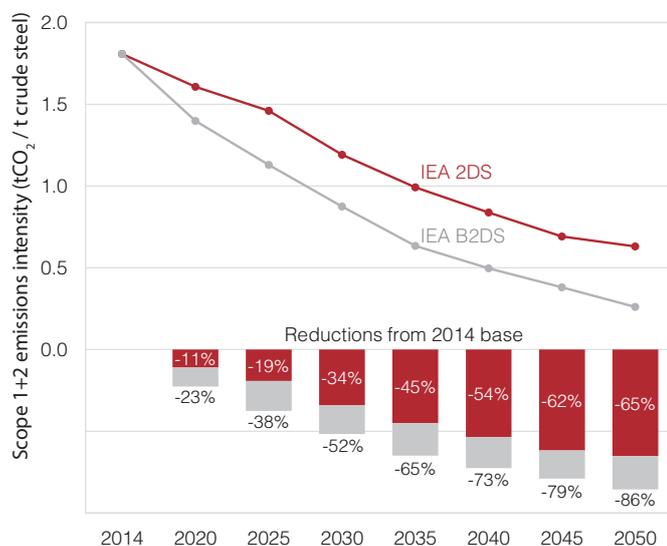
Source: CDP, company reports

## Overview

The steel industry generates between 7% and 9% of global greenhouse gas emissions from fossil fuel use and industry. To align with the International Energy Agency's 2-Degrees Scenario (IEA 2DS), which gives a 50% chance of limiting average global temperature increase to 2°C, the sector is required to reduce its emissions intensity by 65% by 2050, compared to 2014 levels (Figure 4).

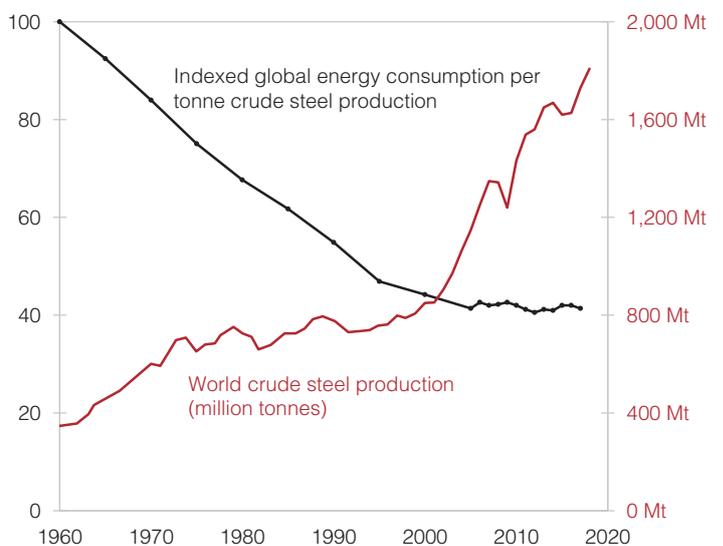
Over the past 60 years, the energy required to produce one tonne of steel has declined by over 60%, while steel production has increased almost fivefold during this period (Figure 5). However, since the early 2000s, energy efficiency has flatlined as predominant steelmaking routes have reached their technological limits. While the IEA states that short-term emissions reductions are achievable through further efficiency improvements, deployment of Best Available Techniques (BAT), and a greater uptake of scrap-based EAF production,<sup>4</sup> to align with the IEA 2DS or Beyond 2-Degrees Scenario (B2DS), the industry requires a step-change in emissions reductions through the deployment and commercialization of radical mitigation technologies and alternative steelmaking processes.

**Figure 4: Steel industry transition pathways**



Source: CDP, IEA ETP 2017

**Figure 5: Global steel production vs. energy efficiency**



Source: CDP, worldsteel

## Chronic overcapacity

The steel sector is cyclical by nature; however, while steel demand peaked in 2013, the cycle was disrupted by rapid investment in Chinese steelmaking facilities from 2004-2013, adding an additional 60 million tonnes of crude steel capacity (see Figure 6).<sup>5</sup> By the beginning of 2016 the steel industry had stagnated due to worldwide structural overcapacity, with plants unable to run at optimal capacity and an influx of cheap steel damaging company profits.

From 2017-2018, with the Chinese government implementing policies to address overcapacity in the steel industry<sup>6</sup> and steady demand growth in Europe and the U.S.,<sup>7</sup> metal and raw material prices began to rise from 2015 lows.<sup>8</sup> Though the steel industry continues to recover, with the World Steel Association forecasting demand growth of around 1% into 2020, surplus capacity is set to remain a long-term problem as it continues to outpace production and demand, while trade tensions and volatile currency movements create increasing uncertainty within the market.

## The importance of steel

More than 90% of all metal produced every year is steel,<sup>9</sup> and due to its favourable mechanical properties and affordability it is widely used in numerous industrial and consumer applications, many of which have limited substitutes (see Figure 7). Steel is the world's most recycled material; its durability means that steel components are well-suited to remanufacturing and reuse, and as such it has a central role to play in transitioning to a circular economy.

4. Energy-intensity improvements equivalent to 47% of cumulative CO<sub>2</sub> reductions by 2025. Shifts towards scrap-based EAF production equivalent to 26% of CO<sub>2</sub> reductions by 2025 - IEA ETP 2017.

5. McKinsey & Company 2018: The current capacity shake-up in steel and how the industry is adapting.

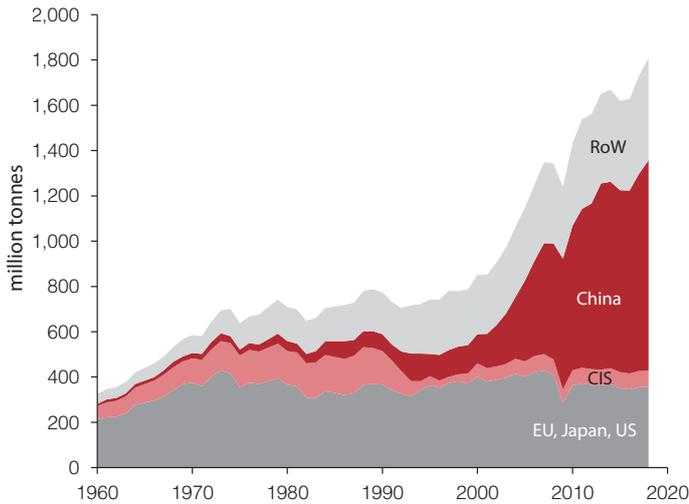
6. Policies to tackle overcapacity and energy prices include a target to close 100-150 million tonnes per year of capacity until 2020 and raise average energy efficiency to lower costs as well as environmental reforms - World Energy Investment 2018.

7. S&P Ratings: Industry Top Trends 2019 - Metals and Mining

8. OECD 2019: Steel Market Developments

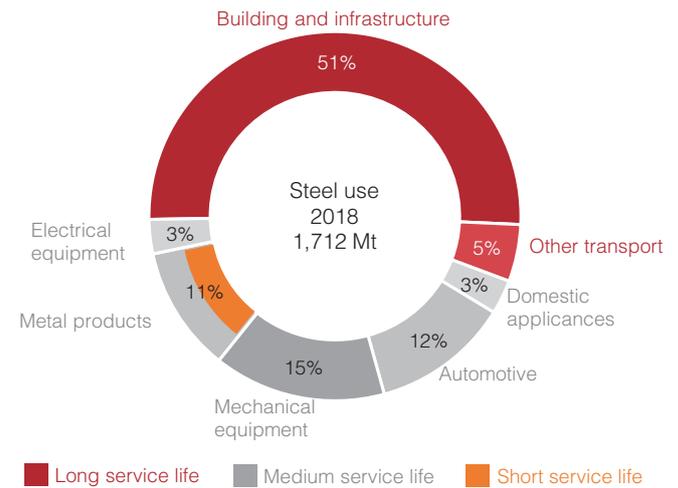
9. ResponsibleSteel™

**Figure 6: World crude steel production**



Source: CDP, worldsteel

**Figure 7: Steel consumption by sector**



Source: CDP, worldsteel

### The dominance of the Blast Furnace

Crude steel production continues to derive from two major steelmaking routes. Currently around 70% of global production derives from the Blast Furnace-Basic Oxygen Furnace (BF-BOF) route and 30% via the Electric Arc Furnace (EAF) route utilising Direct Reduced Iron (DRI-EAF) or scrap steel (scrap-EAF), see box on page 9 for further insight.

The predominant BF-BOF route is inherently emissions intensive and hard to abate. 45% of CO<sub>2</sub> emissions derive from the use of coal as a feedstock to produce coke, the main reducing agent used to convert iron ore into pig iron, while 35% of CO<sub>2</sub> emissions come from the use of coal and gas as fuels to generate high-temperature heat.<sup>10</sup> The replacement of fossil fuels with zero-emission alternatives is therefore problematic, as other sources of energy cannot reach the temperatures required to produce liquid steel. BF-BOF steel mills can also have life-spans of up to 60 years and are highly integrated, making it extremely difficult to isolate or retrofit existing components. Furthermore, without strong policy incentives, it will be problematic to write-off or prematurely shutdown existing plants in favour of new technologies.<sup>11</sup>

An increase in secondary steelmaking via the scrap-based EAF route is considered a crucial component in reducing emissions from the sector with potential emissions reduction of between 60% - 90% versus the BF-BOF route.<sup>12</sup> According to worldsteel, global scrap availability is expected to reach about 1 billion tonnes by 2030, allowing for a considerable increase in scrap-based steelmaking in the medium and long-term.<sup>13</sup> However, EAF steelmaking is currently constrained by scrap availability, quality issues when compared with primary steel,<sup>14</sup> and the cost competitiveness of electricity. As a result, there will always be a need for primary steelmaking to ensure supply.

### Challenges to decarbonization

Policy interventions will be crucial for the steel sector to transition towards a low-carbon economy. While carbon pricing schemes may expose companies reliant on BF-BOF steelmaking to additional costs; without strong policy incentives and financial support to invest in breakthrough steelmaking techniques, the net cost of upscaling and commercialising these technologies will be outweighed by a continued reliance on highly efficient and low cost steelmaking routes.

Differences in the complexity and ambition of national carbon pricing schemes (see box on page 18) will also impact on the competitiveness of steelmaking in regions exposed to higher prices on carbon, potentially leading to carbon leakage.<sup>15</sup> With approximately 30% of steel traded internationally, and against a backdrop of continued overcapacity in the global market, policies should look to promote a level playing field to ensure that steel companies in one region are not put at a disadvantage from an influx of cheap imported steel from regions with less ambitious carbon-pricing schemes.<sup>16</sup>

### Emerging technologies

In recent years, a number of emerging technologies with significant emissions-saving potential have been developed, demonstrating that deep decarbonization within the industry is feasible. In 2016 the world's first large-scale CCS project in the iron and steel industry went into operation in Abu Dhabi, with the capability of capturing up to 800,000 tonnes of CO<sub>2</sub> annually (see box on page 28 for further insight). Furthermore, the development of hydrogen steelmaking coupled with zero-emission electricity presents a tangible way of decoupling steelmaking from the use of carbon-rich feedstocks and fuel.

With the ratification of the Paris Agreement and the recommendations from the TCFD, companies are facing increasing pressure from investors to demonstrate their awareness and ability to adapt to the risks of climate change, which in turn, has led to the emergence of increasingly ambitious decarbonization targets from leading players within the sector.

10. McKinsey & Company: Challenges Decarbonization of industrial sectors: the next frontier

11. Energy Transitions Commission: Mission Possible – Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century

12. United Nations Environment Programme, 2019: Global Resources Outlook 2019: Natural Resources for the Future We Want

13. worldsteel: Potential game changers for the future of steelmaking

14. Some speciality steel requires high purity levels that can only be achieved via primary steelmaking routes.

15. The relocation of carbon-intensive production into an area not covered by CO<sub>2</sub> emission trading schemes or CO<sub>2</sub> taxes.

16. worldsteel position paper: Steel's contribution to a low-carbon future and climate resilient societies

# Key report findings

## Earnings risks

- With increasing public awareness and investor pressure to mitigate against the effects of climate change; **the steel industry is at a tipping point, and must look to innovate to support a transition to a low-carbon economy.**
- There is a significant geographical divide between the highest and lowest performing companies.** European and East Asian companies rank in the top half, while companies in China, Russia and the U.S. lag behind in terms of disclosure and performance in most key areas.
- For the 20 steel companies approximately **83% of their Scope 1+2 emissions are covered by existing or announced carbon pricing initiatives.**
- The analysis finds that under a 2°C scenario where global carbon prices rise to US\$100 per tonne CO<sub>2</sub> by 2040, **the weighted average Value at Risk for the company sample is 14% of net present value (NPV),** ranging from 2.5% to 30% for individual companies.
- Progress towards reducing Scope 1+2 emissions from steelmaking has been limited.** Across the 20 companies, emissions intensities have been reduced at an average rate of 0.92% p.a. since 2013.
- Reductions in energy intensities are restricted by the need to produce high temperature heat to make pig iron in the blast furnace. **Only 50% of the companies have demonstrated a reduction in energy consumption since 2013.**
- Companies with a higher proportion of EAF steelmaking have lower emissions intensities** and are less exposed to carbon pricing schemes. However, global steel demand cannot be met using this technology alone.
- Despite all 20 companies being members of worldsteel, **only four companies clearly disclose their emissions intensity in line with worldsteel guidance methodology.**<sup>17</sup>
- Reporting on emissions and energy consumption is inconsistent across the sample.** 70% of companies publicly disclose some aspect of their emissions performance, yet only 50% give a breakdown of Scope 1+2.
- Disclosure remains an issue for companies in the U.S., China and South America.** Without visibility across key environmental indicators such as emissions and energy reporting, investors are unable to benchmark company performance against peers.
- Government policy must incentivise companies to decouple emissions from steel production,** through financial support, consistent carbon pricing, materials policy and other means to facilitate long-term change in the steel industry.
- Companies with inland capacity located in China and India are most at risk from water stress. **Across the 20 companies, over 50% of inland steel capacity is currently located in areas of high water stress risk.**

## Opportunities

- Upscaling of several low-carbon innovations could enable the steel industry to achieve significant emissions reductions,** and align with below 2°C pathways. However, full commercialization of these technologies remains decades away.
- Six companies have delivered technologies that we consider to be transformative.** 7% of total low-carbon innovations are considered to be transformative and 11% radical. Six companies show little evidence of developing innovative low-carbon technology.
- The emergence of innovative technologies, including hydrogen for iron and steelmaking, presents significant opportunities for emissions reductions.** SSAB's HYBRIT project<sup>18</sup> and ArcelorMittal's SIDERWIN project have reduction potentials of 98% and 87% respectively compared to the conventional BF-BOF route.
- Nine companies are involved with innovations relating to Carbon Capture Utilization and Storage (CCUS).** Four companies have partnered with the carbon recycling company LanzaTech, which converts waste gases from the steelmaking process to produce bioethanol.
- All companies within the sample are demonstrating efficient utilisation of by-products** such as slag, dust and sludge from the steelmaking process.<sup>19</sup>
- Seven of the 20 companies have set up Power Purchase Agreements to attain renewable energy for steelmaking.** 55% of companies also operate or own renewable energy facilities.
- Average R&D as a percentage of sales is relatively low for a sector that needs to innovate, at 0.86%.** Patent analysis suggests companies based in Asia are filing the most high-quality patents.

## Governance & strategy

- 60% of companies have set emissions reduction targets,** yet only two companies are aligned with a 2°C or below emissions pathway. SSAB has set a goal to reach carbon neutrality by 2045 across its entire operations, while Hyundai steel have targeted an 80% reduction in emissions by 2050.<sup>20</sup>
- Companies are beginning to utilise scenario analysis** to assess the impact of climate change on their business strategies. However, only two companies have developed their own company scenarios in line with TCFD recommendations.
- Seven companies have incorporated a shadow carbon price into their decision-making.**
- Ten companies responded to the 2018 CDP Climate Change questionnaire** and six responded to the 2018 water questionnaire.
- Only five companies have officially supported the TCFD.**
- Eight companies have some form of climate-related remuneration** across short-term bonus programs and incentives at a broader corporate level. None of the companies show any evidence of long-term incentives.

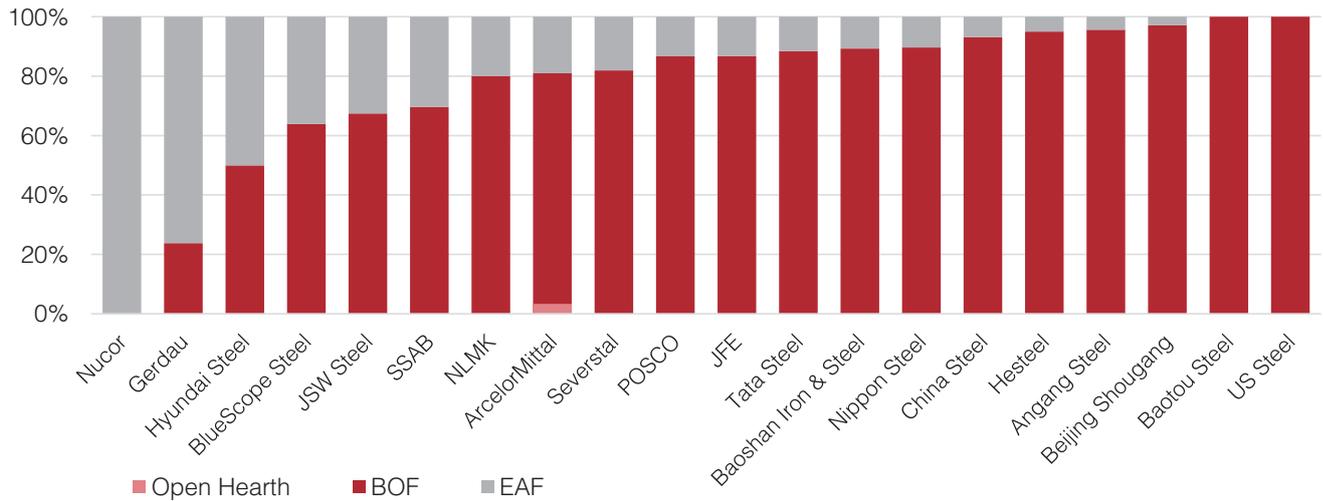
17. To calculate an emissions intensity that enables like-for-like comparison, worldsteel guidance is to include Scope 1, Scope 2 and upstream Scope 3 emissions relating to the procurement of pre-processed materials.

18. The HYBRIT project is a partnership project between the iron ore mining company LKAB, SSAB and the power utility company Vattenfall.

19. According to worldsteel the steel industry has a global material efficiency rate of 96.3%

20. We note that ArcelorMittal and Tata Steel have also set ambitions to become carbon neutral in their European operations by 2050.

**Figure 8: Steel production split by process type (2018)**



Source: CDP, company reports, PLANTFACTS

## Production process summary box

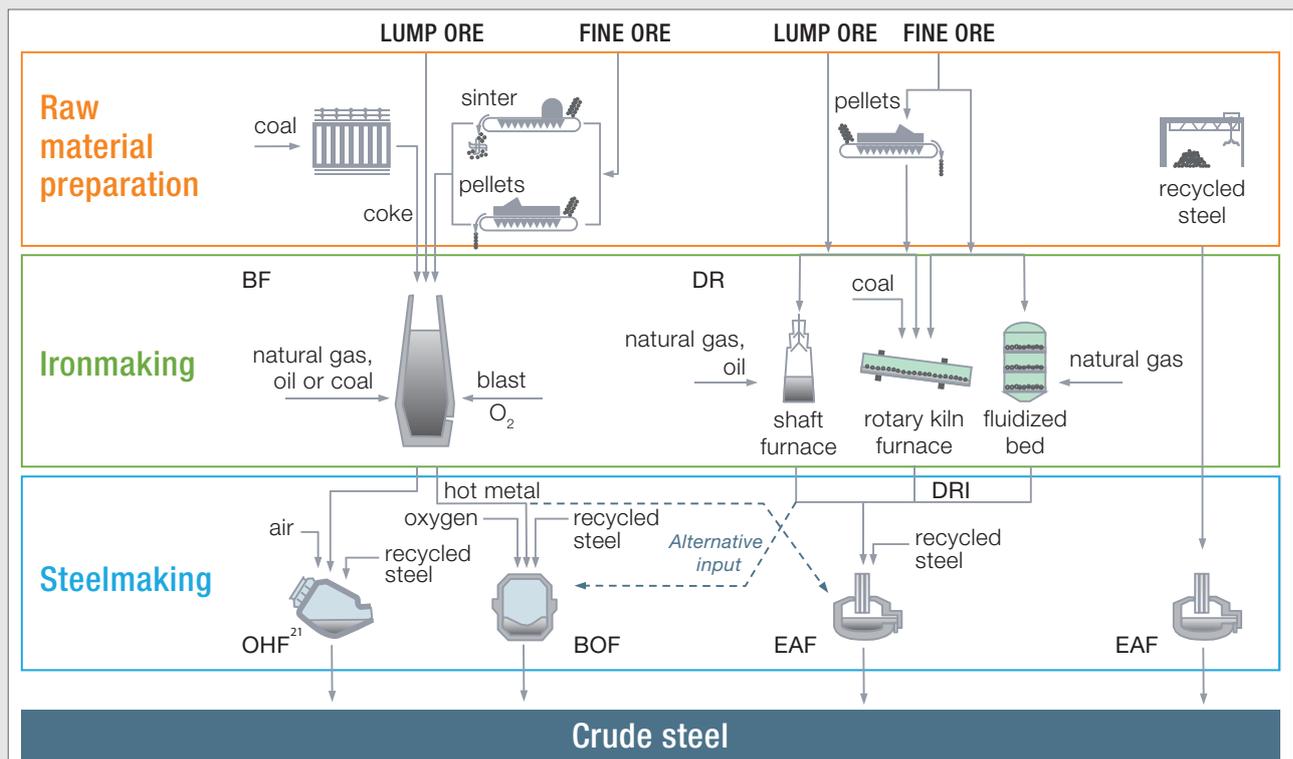
**Blast Furnace-Basic Oxygen Furnace (BF-BOF) route.** This entails first preparing coke by heating coal at high temperatures in a coke oven without oxygen and making iron ore sinter from fine ores and other materials in a sintering plant. In the blast furnace, coke reacts with the injected hot air to form CO, which reduces iron ore to iron. The molten iron produced is charged into the BOF and transformed into liquid steel. This process is also known as the integrated route and accounts for about 70% of steel produced globally.

**Scrap-based Electric Arc Furnace (scrap-EAF) route.** Recycled steel scrap is the primary raw material used in this route. The scrap metal is melted and converted into new steel in the high-power arc furnace using electricity.

**Direct reduction-Electric Arc Furnace (DRI-EAF) route.** This route allows removal of oxygen from iron ores using natural gas on a fluidized bed or coal in a rotary kiln to produce solid forms of iron, without going through a molten stage. Total EAF based production accounts for about 30% of steel produced worldwide.

Smelting reduction has been used as an alternative to blast furnaces. Molten iron is produced directly from iron ores and coal without coking and can be further processed in the BOF or EAF.

**Figure 9: Steel production process summary**



Source: worldsteel

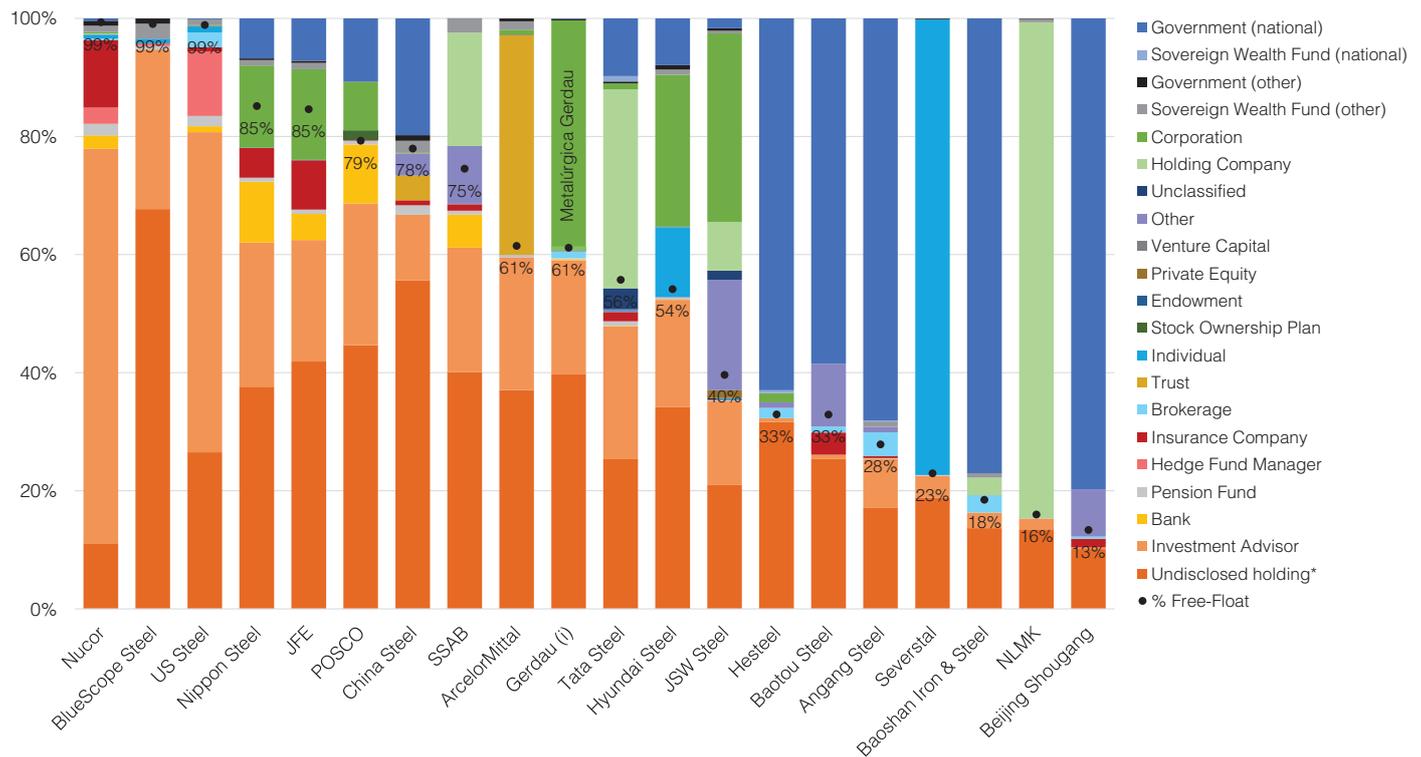
21. Open Hearth Furnace (OHF) converts molten iron or steel scrap to liquid steel using heated gaseous or liquid fuels. It is now generally replaced by BOF or EAF, accounting for less than 0.5% of world steel production.

## Company selection and classification

Companies were selected from the largest publicly listed steel companies. We reviewed a number of criteria, including production volumes, market capitalization, emissions, business activities, and shareholdings.

The chosen 20 companies represent approximately US\$259 billion in market capitalization and in aggregate represent 30% of global steel production. Eight of the 20 companies are featured in the Climate Action 100+ list and ten responded to CDP's 2018 climate change questionnaire.

**Figure 10: Company shares outstanding split by ownership type (Q1 2019)<sup>(ii)</sup>**



\*Shares not captured by publicly reported holdings, including Nominee accounts.

(i) Metalúrgica Gerdau S.A. holds 38.5% of Gerdau S.A. (The overall Free-Float for Gerdau increases from 61% to 89% if the Free-Float for Metalúrgica Gerdau is considered).

(ii) Listed arm of state-owned companies: Angang Steel for Ansteel Group, Baoshan Iron & Steel for China Baowu Steel Group, Inner Mongolia Baotou Steel for Baotou Iron and Steel Group, Beijing Shougang for Shougang Group, Hesteel for Hesteel Group.

Source: CDP, company reports, Bloomberg

## Linking our findings to investment choices

We recognize that investment decisions are based on a multitude of different factors and that some of these can be misaligned with emission-reduction efforts. Our League Table identifies company readiness for the transition to a low-carbon economy and the physical impacts of climate change, meaning that companies towards the bottom of our League Table are potentially higher risk investments from a climate change perspective than those towards the top.

## Methodology

We score each company based on a number of metrics which are ranked and then weighted within each key area (see Figure 11 for metric weightings within each key area). We then assign traffic light colours based on these weighted ranks. We calculate the overall League Table score by collating the weighted ranks for each key area. Each of the key areas has a separate chapter within this report.

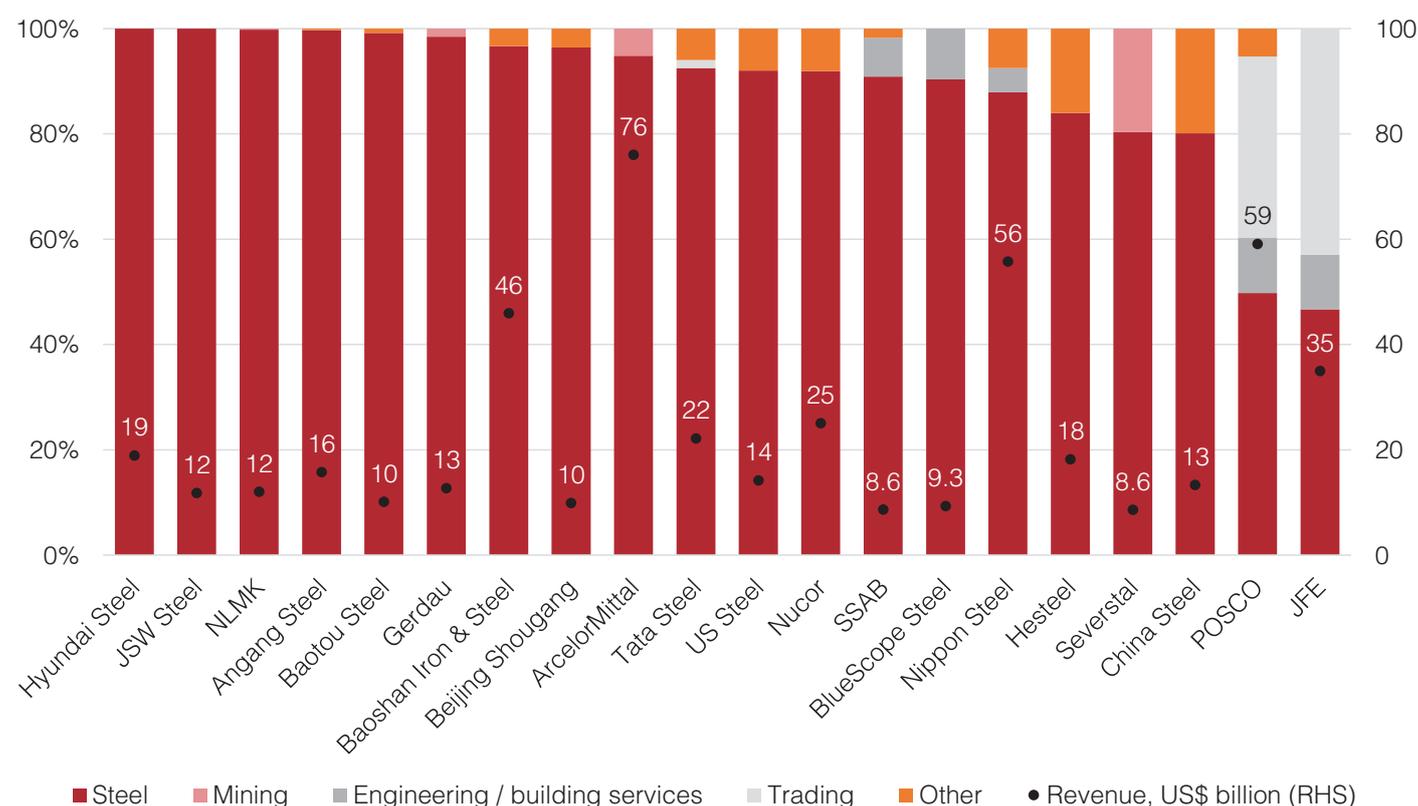
Data is compiled from multiple sources including: CDP questionnaire responses, company annual reports, CSR reports, websites, investor presentations and third party sources such as Bloomberg and the Steel Institutes' (VDEh) PLANTFACTS database.

**Figure 11: Summary of key areas, associated metrics and weights within the League Table**

Key area in League Table	Financial impact	Metrics	Metric weighting	Key area weighting
<b>Transition risks</b>	Companies face increasing costs from carbon pricing initiatives. Measures to reduce energy consumption and emissions can cut exposure to carbon costs and deliver cost benefits through improvements in operational efficiency, improving operational costs and delivering higher margins.	• Emissions intensity	35%	30%
		• Energy intensity	35%	
		• Data transparency	10%	
		• Scope 3 emissions reporting	10%	
		• Capital flexibility	10%	
<b>Physical risks</b>	Localised water issues at steel production sites can pose risks to operational continuity.	• Water stress exposure	50%	10%
		• Water consumption intensity	25%	
		• Water governance & policy	25%	
<b>Transition opportunities</b>	Parts of the steel industry operate close to maximum theoretical efficiency, and technological breakthroughs are required for significant emissions reductions. Companies that are investing in R&D, introducing low-emission technologies, and utilising renewable energy can gain a future competitive advantage over their peers.	• Low-carbon process innovation	60%	30%
		• Circular innovation	10%	
		• Patent analysis	10%	
		• Research & Development	10%	
		• Renewable energy use	10%	
<b>Climate governance &amp; strategy</b>	Ambition level of target setting and strength of climate governance provides insight into companies' strategies in adapting to a low-carbon economy and capitalising on climate-related opportunities.	• Targets & ambitions	50%	30%
		• Scenario analysis & internal carbon price	20%	
		• Climate-related remuneration	10%	
		• Board & executive climate management	10%	
		• TCFD and initiative support	5%	
		• CDP score	5%	

Source: CDP

**Figure 12: Revenue split by business (2018)**



Source: CDP, company reports

# Transition risks

- ▶ Limited progress in reducing emissions from steelmaking. Across the 20 companies, emissions intensities have been reduced at an average rate of 0.92% p.a. since 2013.
- ▶ Hyundai Steel, BlueScope Steel and SSAB rank in the top three. All three companies have emissions and energy intensities below the group average and have reduced their emissions intensity over time.
- ▶ US Steel, Beijing Shougang and Angang Steel rank in the bottom three.
- ▶ The analysis finds the weighted average Value at Risk for the companies to be 14% of net present value under a 2°C scenario.<sup>22</sup>

## Overview

The steel sector accounts for up to 25% of industrial energy demand<sup>23</sup> and is heavily reliant on the BF-BOF route for primary steelmaking.<sup>24</sup> Although this method is currently the most effective way of meeting global steel demand, it is an inherently carbon and emission intensive process, requiring significant amounts of heat to melt iron-ore and coking coal as a feedstock to reduce iron ore to steel.

BF-BOF steel plants are long-lived and highly integrated, requiring significant capital investment over time. Many plants are already operating at their technological limits of efficiency, yet others will need extensive retrofitting or complete rebuilds in order to implement more efficient processes, incurring additional costs and potential downtime in production.<sup>25</sup> EAF steelmaking utilising DRI or scrap steel offers companies with the opportunity to reduce emissions from steelmaking; however, global steel demand cannot be met using this technology alone.

With the majority of steel producers locked-in to the more intensive steelmaking route, companies will face increasing regulatory, technological, legal and reputational risks as national targets and policy initiatives to decarbonize intensify. Policy and legal risks are particularly pertinent with companies exposed to increasing costs of compliance from carbon pricing schemes such as the EU ETS (see Figure 13). Currently around 86% of global steel production occurs in regions that have existing or announced carbon pricing initiatives (see box on page 18 for further insight).

Technological risks will be twofold: Firstly, incremental energy saving technologies are difficult and costly to implement and secondly, breakthrough low-carbon technologies require significant capital investment and are at risk of being uncompetitive if a lack of policy incentives make commercialization too expensive in the long-term.

As public and investor awareness of the impacts of climate change increase, data transparency and reporting on key environmental indicators are vital for the stakeholders' perceptions of company progress towards a transition to a low-carbon economy.

In this chapter we assess company exposure and resilience to transition risks across the following key metrics:

Figure 13: EU ETS price has more than tripled since 2018



Source: CDP, Bloomberg

**Metric 1) Emissions intensity<sup>26</sup> (35%):** We identify the companies with the lowest current Scope 1+2 emissions intensity per tonne of crude steel production and the extent to which emissions have been reduced over the period 2013-2018. Where data was unavailable from company reporting, we employ a bottom-up method to model corporate emissions profiles (see box on page 15 for further detail).

**Metric 2) Energy intensity (35%):** We identify the companies with the lowest current energy intensity per tonne of crude steel production and the extent to which consumption has been reduced over the period 2013-2018. Energy data includes the use of coke and coal as feedstocks. As above, where data was unavailable from company reporting, we use bottom-up modelling.

**Metric 3) Data transparency (10%):** We assess company reporting of key environmental indicators including Scope 1+2 emissions and energy consumption. We assess companies' methodological approach to emissions accounting and the level of third-party verification. We also credit companies that are reporting emissions in accordance with worldsteel emission reporting guidance.

**Metric 4) Scope 3 emissions reporting (10%):** This metric evaluates companies' Scope 3 disclosure. The quality of disclosure is ranked on holistic reporting of the 15 categories under the GHG Protocol, including the justification for excluding certain categories. Companies are ranked on the total number of categories included. We present the total % calculated and the total % not calculated with a valid explanation provided.

**Metric 5): Capital flexibility (10%):** We assess companies EBITDA margins, and two measures of leverage: current level of gearing and net debt to EBITDA.

22. Under our central 2°C scenario, global carbon prices rise to US\$100 per tonne CO<sub>2</sub> by 2040. The Value at Risk for individual companies ranges from 2.5% to 30% of NPV.

23. United Nations Environment Programme, 2019: Global Resources Outlook 2019: Natural Resources for the Future We Want

24. BF-BOF process is used to make over 95 percent of the world's primary steel – McKinsey & Company 2018

25. McKinsey & Company 2018: Challenges Decarbonization of industrial sectors: the next frontier

26. Due to data limitations we are only able to compare Scope 1+2 emissions intensities, rather than intensities that also include upstream Scope 3 emissions.

**Figure 14: Transition risks summary**

Company	Emissions intensity	Energy intensity	Data transparency	Scope 3 reporting	Capital flexibility	Overall weighted rank	Transition risks rank
Hyundai Steel	1	2	4	8	16	6.51	1
BlueScope Steel	3	1	10	10	4	7.02	2
SSAB	5	3	9	6	11	7.95	3
Nucor	2	4	12	10	6	8.24	4
Severstal	6	6	10	10	2	9.48	5
POSCO	7	9	4	7	7	9.94	6
Gerdau	4	5	19	10	13	10.23	7
Tata Steel	8	14	3	2	12	10.43	8
China Steel	14	12	4	1	8	10.51	9
ArcelorMittal	10	15	1	3	9	10.76	10
JFE Holdings	11	11	4	4	20	11.07	11
NLMK	9	10	13	10	1	11.27	12
Nippon Steel	13	13	8	9	19	12.04	13
JSW Steel	18	19	1	5	3	13.35	14
Baoshan Iron & Steel	15	8	15	10	5	13.57	15
Baotou Steel	16	7	15	10	14	13.81	16
Hesteel	19	17	15	10	17	15.58	17
US Steel	12	20	14	10	15	15.60	18
Beijing Shougang	17	16	19	10	18	15.70	19
Angang Steel	20	18	18	10	10	15.86	20

**Weighting**                      **35%**                      **35%**                      **10%**                      **10%**                      **10%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

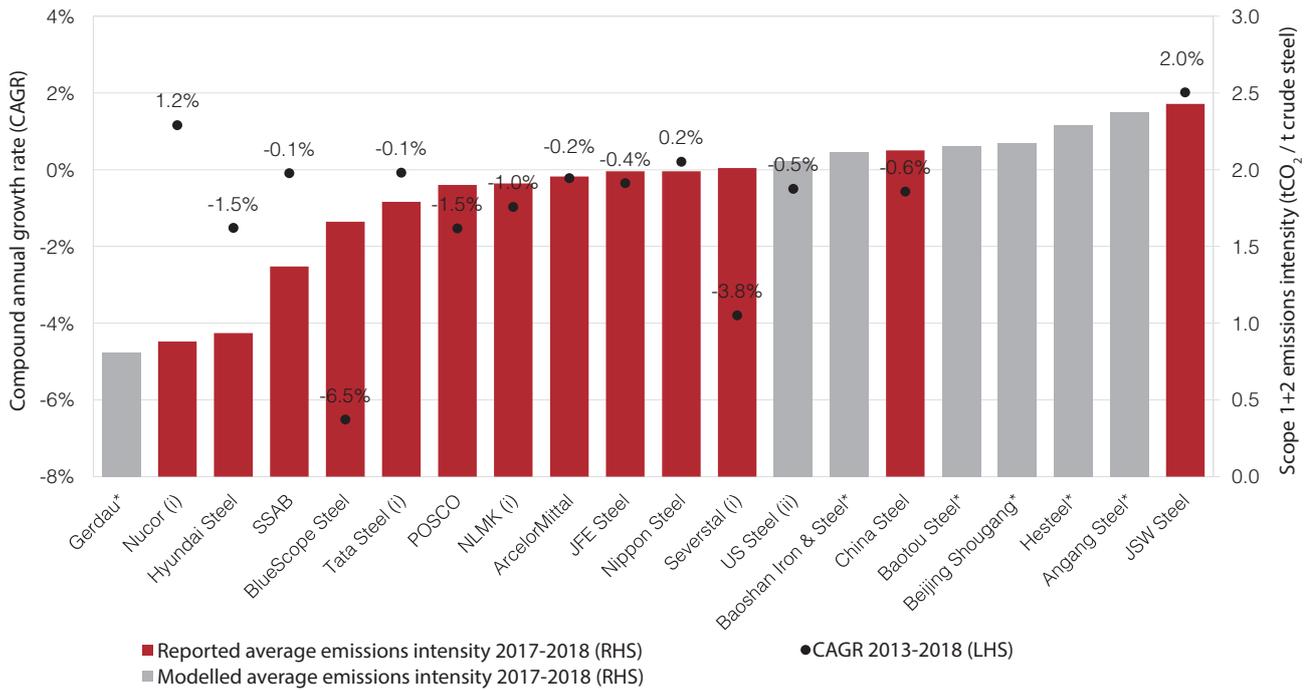
Source: CDP

## Emissions intensity highlights

Companies utilizing modern steelmaking facilities are able to operate at high levels of efficiency. When combined with greater integration of alternative fuels and renewable electricity, companies will be better placed to maximize emissions reductions from steelmaking, in addition to increasing resilience to regulatory, technology, and reputational risks associated with the transition to a low-carbon economy.

- ▼ Progress towards reducing Scope 1+2 emissions from steelmaking has been limited. Across the 20 companies, emissions intensities have been reduced at an average rate of 0.92% p.a. since 2013.
- ▼ Within our sample, 79% of company steel production derives from the BF-BOF steelmaking route, with two companies, US Steel and Beijing Shougang producing 100% of steel from this route.
- ▼ Companies with a greater percentage mix of EAF steelmaking have lower emissions intensities. Nucor, Gerdau and Hyundai have between 50-100% of production from the EAF route and emissions intensities that are 44% - 56% lower than the group average. While Nucor and Gerdau business models are predominately based on scrap-based steelmaking, they are more resilient to technology, market and regulatory risks such as carbon pricing schemes.
- ▼ Hyundai Steel and BlueScope Steel rank in the top two for emissions intensity performance. Hyundai steel has the second lowest emissions intensity, despite producing 50% of its steel from the BF-BOF route. It has also reduced its emissions intensity by an average rate of 1.5% p.a., the second largest reduction in the sample. BlueScope Steel has markedly reduced its emissions intensity at an average rate of 6.5% p.a. since 2013 with the removal of surplus export steelmaking capacity.
- ▼ Three companies have increased their emissions intensities from 2013-2018. The emissions intensity of JSW Steel and Nucor have grown at an average rate of over 1% p.a., while seven companies have shown marginal reduction rates of below 1% p.a. since 2013. Companies with insufficient data to calculate a trend were penalised in the ranking.
- ▼ All of the Chinese and Indian companies rank in the bottom eight. Emission intensities sit above 2 tonnes CO<sub>2</sub>/tonne crude steel, with over 90% of production deriving from the BF-BOF route. JSW has the highest emissions intensity of the group.

**Figure 15: Emissions intensity<sup>(iii)</sup>**



\* Insufficient data to calculate trend

(i) CAGR 2014-2018 for Tata Steel, CAGR 2015-2018 for NLMK and Severstal, CAGR 2015-2017 for Nucor.

(ii) For US Steel, trend is calculated from reported data for US only operations, CAGR 2014-2016.

(iii) Due to data limitations we are only able to compare Scope 1+2 emissions intensities, rather than intensities that also include upstream Scope 3 emissions. Companies which clearly report in line with the worldsteel guidance receive credit in the 'data transparency' metric (see page 16).

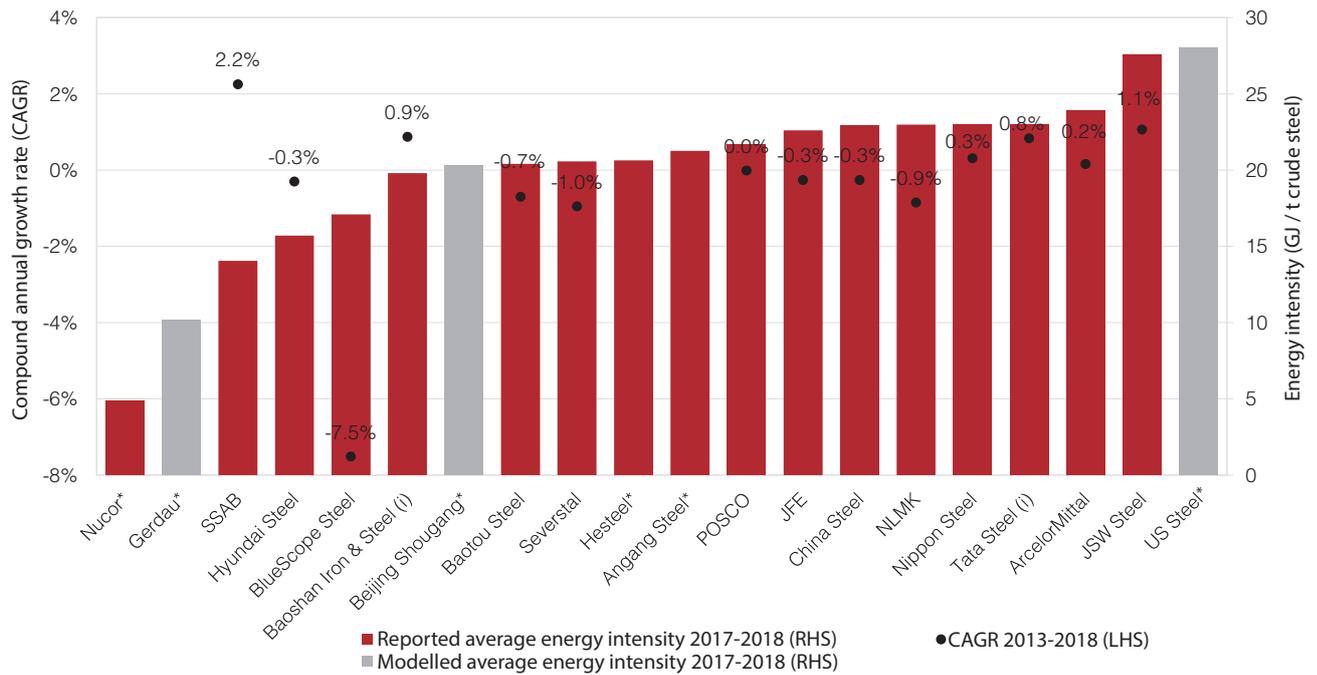
Source: CDP, company reports, PLANTFACTS

## Energy intensity highlights

Energy consumption intensity may be impacted by a number of different variables in the steelmaking process including the production route, fuel inputs, the quality of iron ore, scrap and coal and the grade of steel being produced. A reliance on coking coal as a reducing agent in the Blast Furnace also limits the ability of companies to improve the energy efficiency of operations. Companies that are able to maximise the value of inputs and optimize production processes with the use of Best Available Techniques (BAT) will be better positioned to reduce their energy consumption over time.

- ▼ Companies with a high percentage of EAF steelmaking in their production mix rank in the top five for energy consumption intensity. Nucor, Gerdau, SSAB and Hyundai Steel have energy consumption intensities that fall well below the group average.
- ▼ Only eight companies have demonstrated a reduction in energy consumption. Seven of those companies have made marginal reductions of less than 1% p.a. Only BlueScope Steel has substantially reduced its energy intensity, with an average reduction of 7.5% p.a. since 2013.
- ▼ Nucor's energy consumption is over five times lower than US Steel, demonstrating the stark contrast between energy consumption in primary and secondary steelmaking. It is important that investors understand the importance of both techniques and take into consideration the relative make-up of steel production routes when comparing the environmental performance of companies.
- ▼ Angang Steel, JSW Steel and US Steel rank in the bottom three. On average their energy intensities are 28% higher than the group average.

**Figure 16: Energy intensity**



\* Insufficient data to calculate trend  
 (i) CAGR 2014 - 2018 for Tata Steel, CAGR 2015-2017 for Baoshan Iron & Steel  
 Source: CDP, company reports, PLANTFACTS

## Bottom-up modelling with asset-level data

CDP employs a detailed bottom-up method to model corporate emissions from seven high impact sectors: coal mining, oil and gas extraction, petroleum refining, electric utilities, steel, cement, and automotive manufacturing.

These models are based on asset-level data which is supplemented by production and capacity data collected for the product and process level from company annual reports. Regarding the steel industry, CDP builds on the Steel Institutes' (VDEH) PLANTFACTS database and analyses over 13,000 process plants spanning 2,000 industrial sites and 1,550 companies. The asset dataset provides detailed information on process type and installed equipment, enabling the performance and structure of each company's steelmaking systems to be modelled.

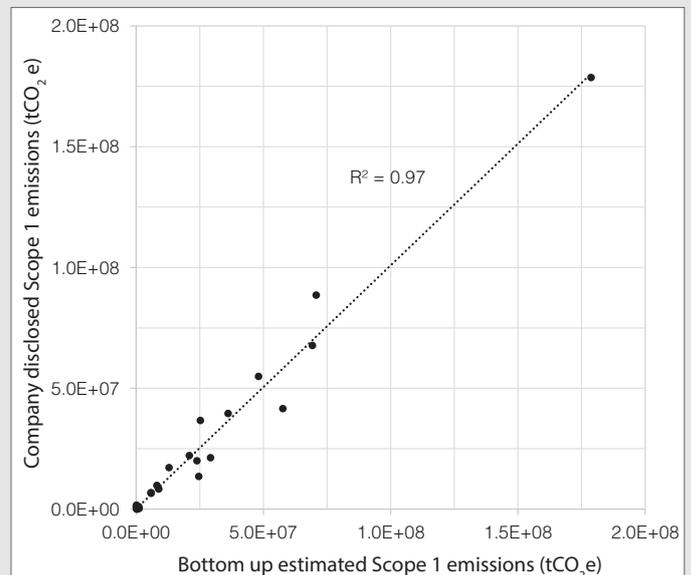
For each company, the average overall performance of each process plant type, e.g. blast furnace, is calculated and combined with the company's own production data from those plant, e.g. tonnes of pig iron, as reported in their filings. Where production data is not available, it is estimated for each process by aggregating asset capacities and applying regional-level crude steel load factors derived from statistical sources. Finally, hypothetical steelworks are constructed at the company level with all produced, consumed and lost energies accounted for and balanced.

The outputs of this complex analysis are estimates of Scope 1, Scope 2, and some Scope 3 categories of corporate emissions, along with estimates of net fuel consumption, water consumption, and purchased electricity use. As with the other six sectors mentioned, these bottom-up estimates are used to quality check corporate disclosure and account for non-disclosing companies in CDP's 'Full GHG Dataset', which is a clean and complete dataset of over 5500 companies worldwide.

Compared with the statistical regression approach to estimation, favoured by other data providers, the bottom-up method is more accurate and can provide reliable trends with time. Shown in Figure 17, bottom-up modelled estimates for the steel industry achieve an R<sup>2</sup> accuracy of 0.97 when compared with corporate disclosed emissions. For more information on the 'Full GHG Dataset' visit CDP's investor dashboard:

<https://www.cdp.net/en/dashboards/investor>

**Figure 17: Disclosed vs. estimated emissions**



Source: CDP

## Data transparency highlights

Data transparency is key for companies to inform stakeholders of their performance relative to peers. Within the steel sector heterogeneity exists not only from the different process types (e.g. BOF vs. EAF) but also from site design, where some steelplants import pre-processed materials whereas others have processing facilities onsite. Some steel companies also have integrated business models that can include largescale mining operations. To account for this, and enable like-for-like comparison of emissions intensities, worldsteel guidance is to include Scope 1, Scope 2 and upstream Scope 3 emissions relating to the procurement of pre-processed materials.

- ▼ Reporting on Scope 1+2 emissions is inconsistent across the sample. 70% of companies publicly disclose some aspect of their emissions performance, yet only 50% give a breakdown of Scope 1+2. 17 of the 20 companies report on energy consumption.
- ▼ Despite the fact that all companies are members of worldsteel, only four companies, ArcelorMittal, Tata Steel, JSW Steel and Severstal clearly disclose their emissions intensity in line with worldsteel guidance methodology. For consistent benchmarking of the emission profiles of companies with different business models, i.e. those that incorporate mining operations or those that import raw materials, it is important that companies incorporate this upstream Scope 3 aspect into their emissions reporting.
- ▼ ArcelorMittal and JSW Steel have the most comprehensive emissions and energy disclosure. Both companies report emissions according to worldsteel guidelines.
- ▼ Disclosure remains an issue for companies in the U.S., China and South America. US Steel only report Scope 1 emissions while Baoshan Iron & Steel, Hesteel, Inner Mongolia Baotou Steel and Angang Steel only publicly disclose their energy consumption figures. Beijing Shougang and Gerdau rank last with no public disclosure of emissions or energy data of any kind.

**Figure 18: Data transparency summary**

Company	Scope 1+2 emissions reporting	Clear emissions breakdown as per worldsteel guidelines	Energy data	Methodology: worldsteel / GHG Protocol / other appropriate method	Proportion of Scope 1 verified	Proportion of Scope 2 verified	Rank
ArcelorMittal	✓	✓	✓	✓	100%	100%	1
JSW Steel	✓	✓	✓	✓	100%	100%	1
Tata Steel	✓	✓	✓	✓	91%	84%	3
China Steel	✓	✗	✓	✓	100%	100%	4
Hyundai Steel	✓	✗	✓	✓	100%	100%	4
JFE Holdings	✓	✗	✓	✓	100%	100%	4
POSCO	✓	✗	✓	✓	100%	100%	4
Nippon Steel	✓	✗	✓	✓	91%	91%	8
SSAB	✓	✗	✓	✓	94%	✗	9
BlueScope Steel	✓	✗	✓	✓	✗	✗	10
Severstal	✓ <sup>(i)</sup>	✓	✓	✓	✗	✗	10
Nucor	✓ <sup>(i)</sup>	✗	✓	✓	✗	✗	12
NLMK	✓ <sup>(i)</sup>	✗	✓	✗	✗	✗	13
US Steel	✓ <sup>(i)</sup>	✗	✗	✗	✗	✗	14
Baoshan Iron & Steel	✗	✗	✓	✗	✗	✗	15
Hesteel	✗	✗	✓	✗	✗	✗	15
Baotou Steel	✗	✗	✓	✗	✗	✗	15
Angang Steel	✗	✗	✓	✗	✗	✗	18
Beijing Shougang	✗	✗	✗	✗	✗	✗	19
Gerdau	✗	✗	✗	✗	✗	✗	19

(i) Severstal report Scope 2 for one steel site only. Nucor and NLMK give no Scope 1+2 breakdown. US Steel report on Scope 1 emissions only. Source: CDP, company reports

## Scope 3 reporting highlights

While Scope 3 emissions reporting within the industry is in its infancy, an increased awareness of the interconnections between industries will lead to increased scrutiny of emissions reporting across the value chain.

- ▼ China Steel ranks first. It is the only company across the sample to provide Scope 3 emissions figures for every category. Tata Steel ranks second, providing data for 10 of the 11 reported categories and a valid explanation for not supplying data for the remaining category.
- ▼ Only nine companies within the sample report on some aspect of Scope 3. All companies not reporting on Scope 3 are also non-responders to CDP's Climate Change questionnaire. BlueScope Steel is the only non-responder to state that it intends to incorporate Scope 3 accounting into its future reporting.
- ▼ Scope 3 reporting varies across the sample. Currently there seems to be no clear consensus as to what aspects of Scope 3 reporting companies deem relevant for the steel sector, with companies reporting on a range of categories defined under the GHG Protocol and providing detailed explanations as to why certain categories are not considered material.

**Figure 19: Scope 3 reporting summary<sup>(ii)</sup>**

Company	Categories included <sup>(i)</sup>	Categories calculated		Verification / assurance	Rank
		■ Categories calculated	■ Not calculated but valid explanation		
China Steel	15	15	0	✓	1
Tata Steel	11	10	1	✓	2
ArcelorMittal	10	1	9	✓	3
JFE	9	9	0	✓	4
JSW Steel	7	7	0	✓	5
SSAB	11	7	4	✓	6
POSCO	8	8	0	✓	7
Hyundai Steel	12	4	8	✓	8
Nippon Steel	12	4	8	✗	9

(i) Upstream / downstream leased assets, Franchises and Fuel-and-energy-related activities included in Scope 1+2 calculations were excluded from the analysis.

(ii) Companies not listed above do not report on Scope 3 emissions.

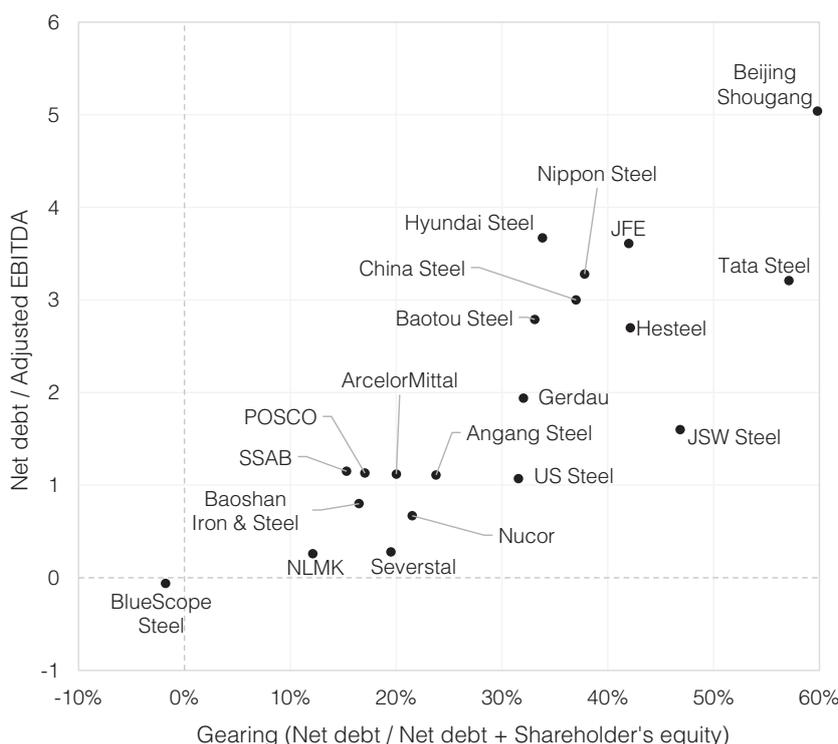
Source: CDP, company reports

## Capital flexibility

Companies that are able to maintain high margins and lower levels of gearing are better positioned to withstand fluctuations in raw material commodity prices and instability in global markets. With limited financial support or policy incentives to encourage investment in low-carbon technologies, companies with healthy balance sheets will have greater optionality to shape future investment decisions.

- ▼ NLMK and Severstal rank first and second respectively. Both companies have vertically-integrated business models with mining operations located close to steel production sites. The companies are near self-sufficient in iron ore and coal allowing them to keep costs down and providing them with a natural hedge against raw material price volatility.
- ▼ Figure 20 shows the relative leverage of companies. BlueScope Steel is well positioned and is currently cash positive, while Beijing Shougang is highly leveraged with gearing at 60%. Nippon Steel and JFE Holdings rank last overall with relatively high levels of gearing and adjusted EBITDA margins at 11%.
- ▼ Only five companies have net debt / EBITDA ratios below 1. Companies with significant levels of indebtedness are more at risk from downturns in the global steel market and may find it difficult to refinance maturing debt or flexibly transition their business strategies during periods of low profitability.
- ▼ Average adjusted EBITDA margins across the sample for 2017-2018 currently sit at 16%. Severstal have the highest adjusted EBITDA margin of the group at 35%, followed by NLMK at 28%.

**Figure 20: Financial flexibility**



Source: CDP, company reports

**Figure 21: Adjusted EBITDA margin**

Company	EBITDA margin (2017-2018)
Severstal	35%
NLMK	28%
JSW Steel	22%
Tata Steel	18%
China Steel	17%
Beijing Shougang	17%
Baoshan Iron & Steel	16%
Baotou Steel	15%
Nucor	15%
BlueScope Steel	14%
Hyundai Steel	14%
Gerdau	14%
POSCO	13%
Angang Steel	13%
ArcelorMittal	13%
Hesteel	13%
SSAB	12%
JFE	11%
Nippon Steel	11%
US Steel	10%

Source: CDP, company reports

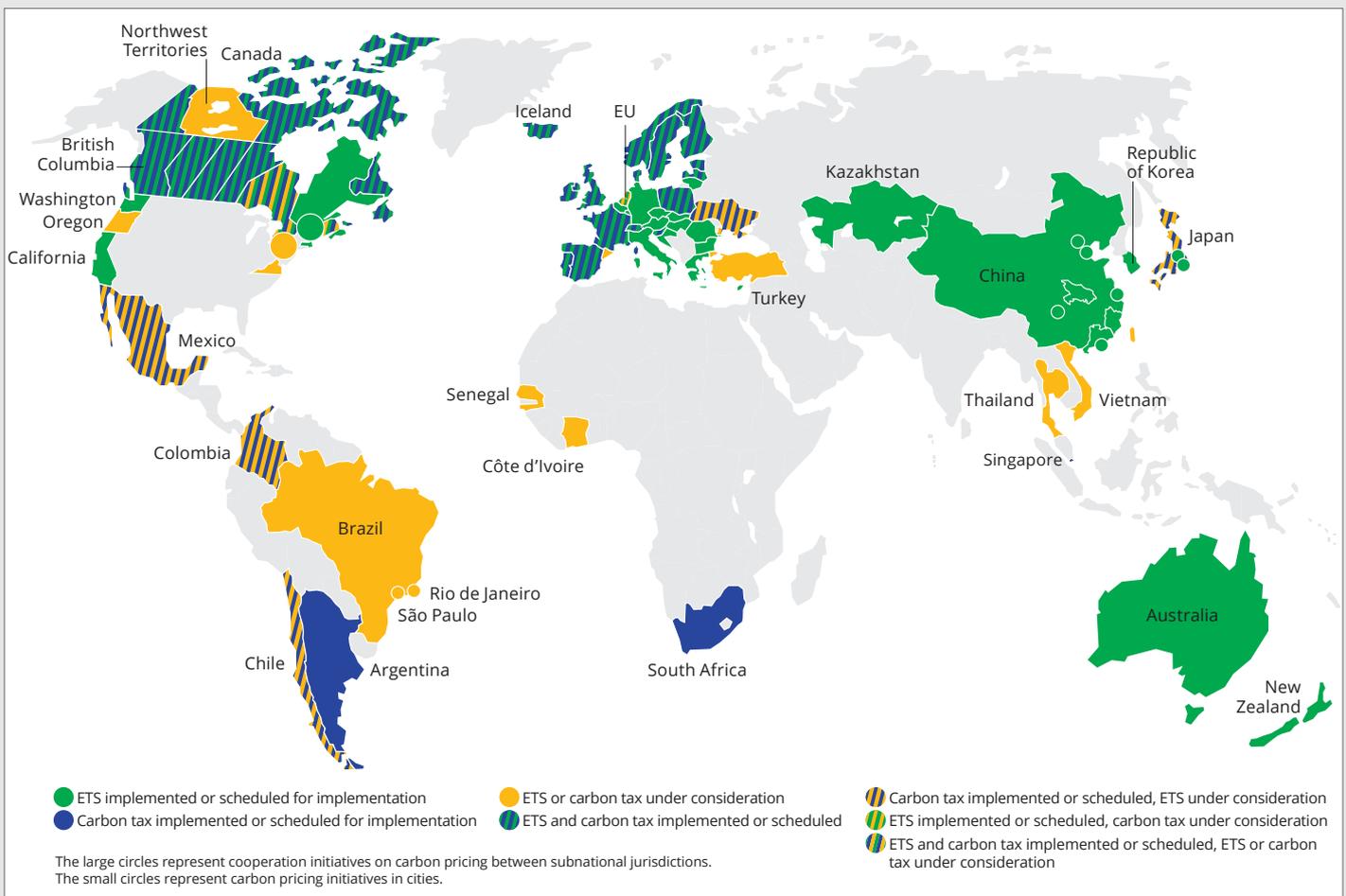
## Summary of carbon pricing initiatives

Carbon pricing is increasingly recognized as a key mechanism to cost-effectively deliver the transition to a low-carbon economy. Over the last year the World Bank, IMF, OECD and the IPCC have all reiterated the need to accelerate and strengthen carbon pricing.

A growing number of jurisdictions at the regional, national and sub-national level are implementing or planning to implement a carbon tax or emissions trading system (ETS). Globally there are currently 57 initiatives (28 emissions trading systems and 29 carbon taxes), as shown in Figure 22.

In total, these carbon pricing initiatives cover around 11 gigatonnes of CO<sub>2</sub>e, about 20% of global GHG emissions. However, according to the World Bank less than 5% of those emissions covered under carbon pricing are priced at a level consistent with achieving the goals of the Paris Agreement.<sup>27</sup>

**Figure 22: Map of regional, national and sub-national carbon pricing initiatives**



Source: World Bank

For the 20 steel companies in this report approximately 83% of their Scope 1+2 emissions are covered by existing or announced carbon pricing initiatives. However, pricing levels vary significantly which has led to discussions on possible border mechanisms to help level the playing field and avoid carbon leakage. These green border adjustments would impose tariffs on carbon contained in steel imports that do not face a comparable carbon price.

27. See Figure 62 on page 46 for detail of the current prices in implemented carbon pricing initiatives.

## Carbon cost pass through and carbon leakage

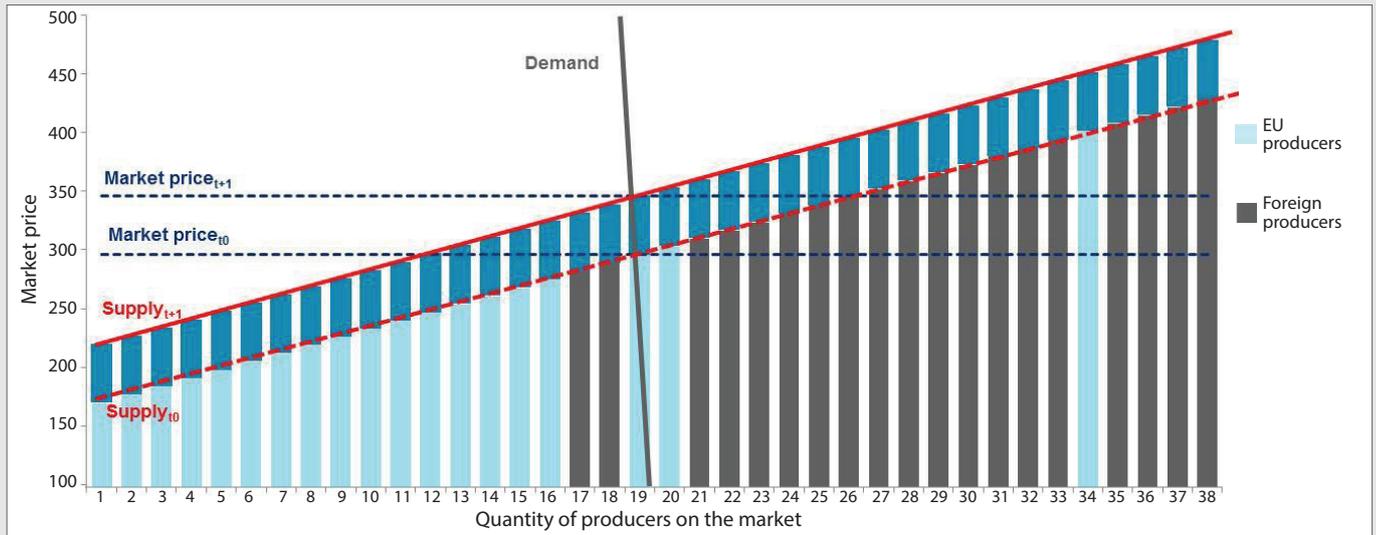
In July 2015 the European Commission published an Impact Assessment which, among other topics, looked at the ability of different industries (including steel) to pass through carbon costs. After conducting a literature review it estimated cost pass through rates of 60-100% for flat products and 66-80% for long products.<sup>28</sup>

However, this assessment has been criticised for not accounting for loss of market share.<sup>29</sup> A crucial feature of the EU ETS is that the carbon costs only affect EU producers, not foreign competitors. The cost increase is therefore asymmetric and any amount of cost pass-through must also be analysed in combination with loss of market share.

To illustrate this we present two examples below within a hypothetical EU steel market (which for illustration is assumed to be perfectly competitive and without product differentiation).

Figure 23 presents the case of a homogeneous cost increase, where all companies serving the EU market face the same carbon costs. In this scenario there is no loss of market share and carbon cost pass-through is close to 100%.

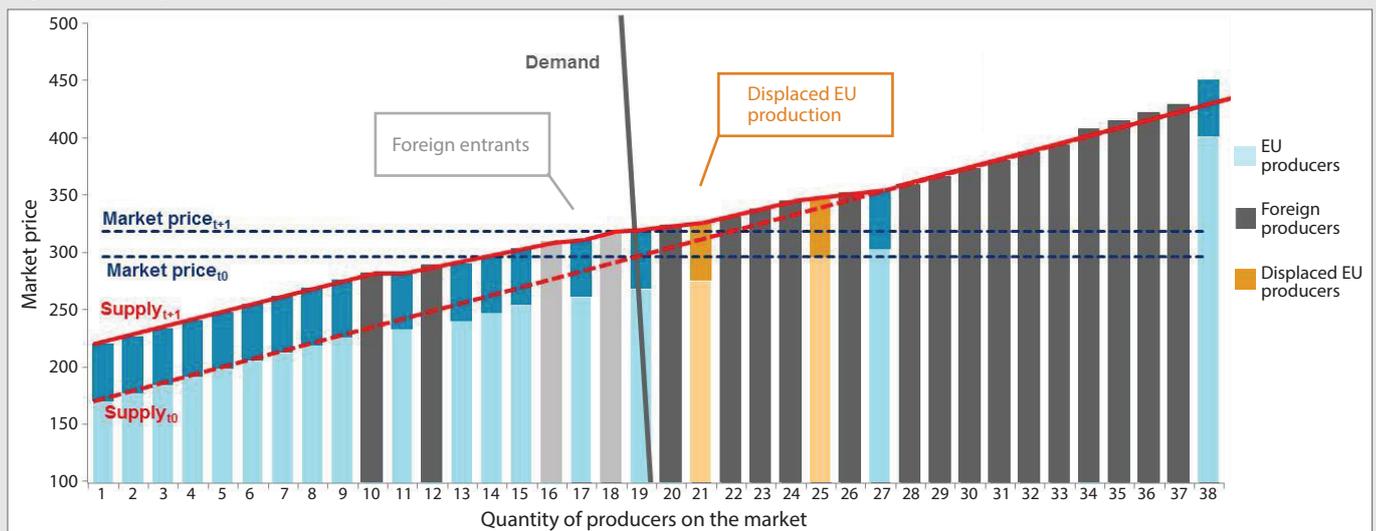
**Figure 23: Homogeneous cost scenario post ETS (t+1)**



Source: NERA Economic Consulting

In contrast, Figure 24 illustrates the case where only the European steel producers face a carbon cost. In this asymmetric cost scenario, cost pass through is much less than 100% and carbon leakage occurs (two European producers, illustrated by the two yellow bars are replaced by two foreign producers).

**Figure 24: Asymmetric cost scenario post ETS (t+1)**



Source: NERA Economic Consulting

As illustrated above, it is important to account for the substitutability between domestic and foreign products. One method is to use Armington elasticities to represent elasticity of substitution. Unlike price elasticity of demand, which for steel is often assumed to be relatively inelastic,<sup>30</sup> Armington elasticities for steel products are relatively high. This reflects the fact that steel is traded as a commodity adhering to global standards, meaning demand can be served by either domestic or foreign producers.

28. European Commission, 2015, "Impact Assessment Accompanying the document Proposal for a Directive of the European Parliament amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments"

29. NERA Economic Consulting, 2016, "Can the steel industry pass through carbon costs without losing market shares?"

30. Economic literature often states the steel industry exhibits relatively inelastic demand in the short run, between around -0.2 to -0.3 (Barnett and Crandall, 2002, "Commodities industries: Steel")

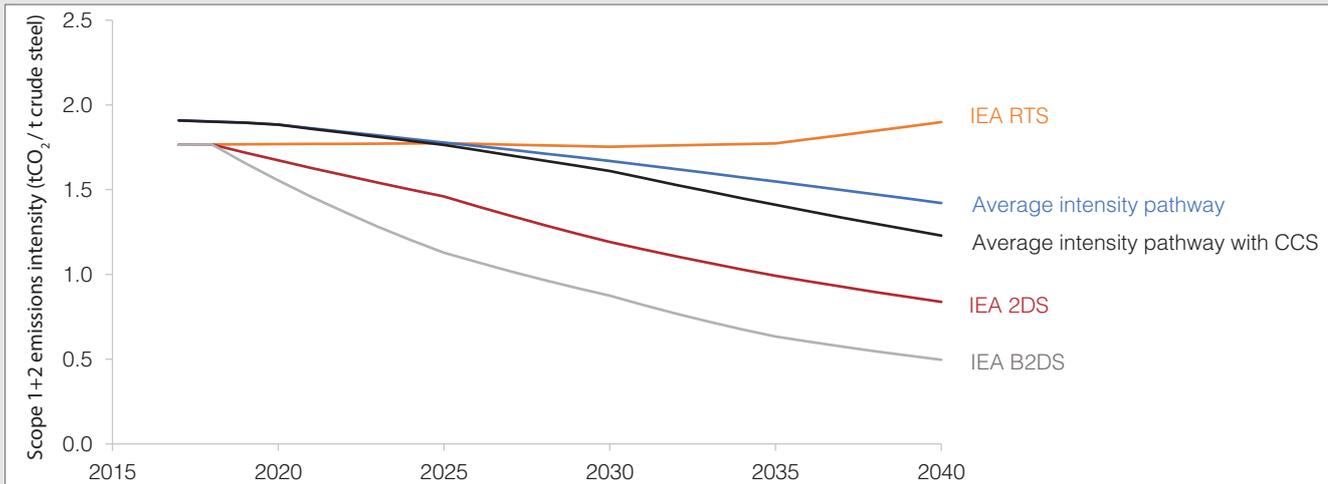
## Value at Risk

We conducted a Value at Risk (VaR) study across the 20 companies, assessing their potential earnings exposure to low-carbon scenarios. Asset level data is modelled using the Steel Institute VDEh's PLANTFACTS database. The approach combines scenario inputs with both top-down and bottom-up modelling to estimate the impact to future earnings.

Company emissions pathways are modelled out to 2040, accounting for company ambitions and targets, technology types (e.g. BOF), changes to asset portfolios, yield and efficiency improvements, regional exposure, use of scrap, carbon intensity of electricity, and likely adoption of low-emissions technologies / CCS.

Figure 25 illustrates the weighted average emissions intensity profile for the 20 companies under our central modelled scenario, with and without CCS, compared to the three scenarios in IEA's Energy Technology Perspectives 2017. It is evident that there is a significant gap between the company sample and the required trajectories for 2°C and below.

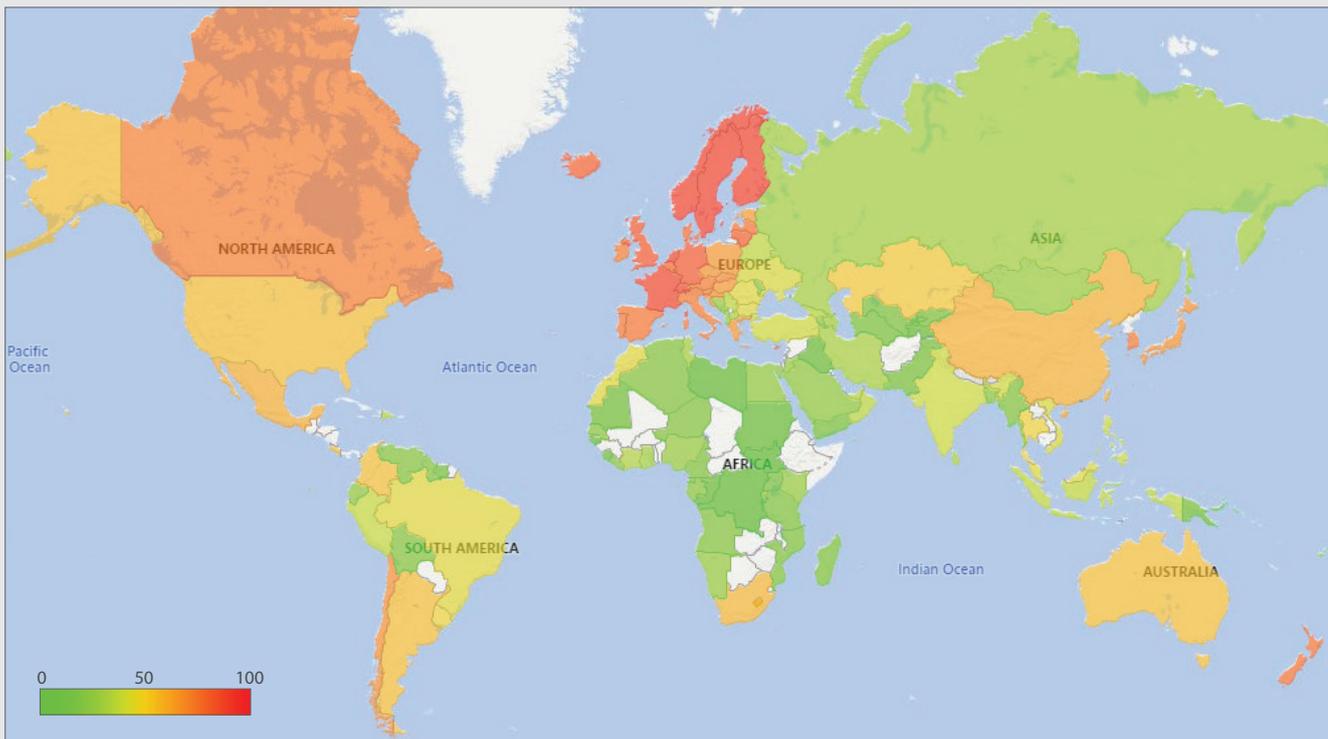
**Figure 25: Weighted average emissions intensity profile for company sample**



Source: CDP, IEA ETP 2017

To evaluate the potential liability associated with company emissions we apply an implicit global carbon price. The financial liability is then risked on a country-by-country basis using our 'climate regulation risk index'. The index assesses the strength and likely implementation of current and future climate policies across 130 countries (see Figure 26).

**Figure 26: Climate regulation risk index by country<sup>(i)(ii)</sup>**



(i) Example: A country index of 60 implies 60% risking i.e. 60% of the total carbon cost is recognised.

(ii) The index is constructed by considering various factors, including: country NDCs, ratification of Paris Agreement, regulation quality and legal strength, emissions performance and targets, governance and levels of corruption, implementation of carbon tax initiatives, and other key indicators.

Source: CDP

Companies can cut exposure to carbon costs by abating emissions, applying technologies such as CCS, re-locating production (carbon leakage), or by passing through costs to consumers.

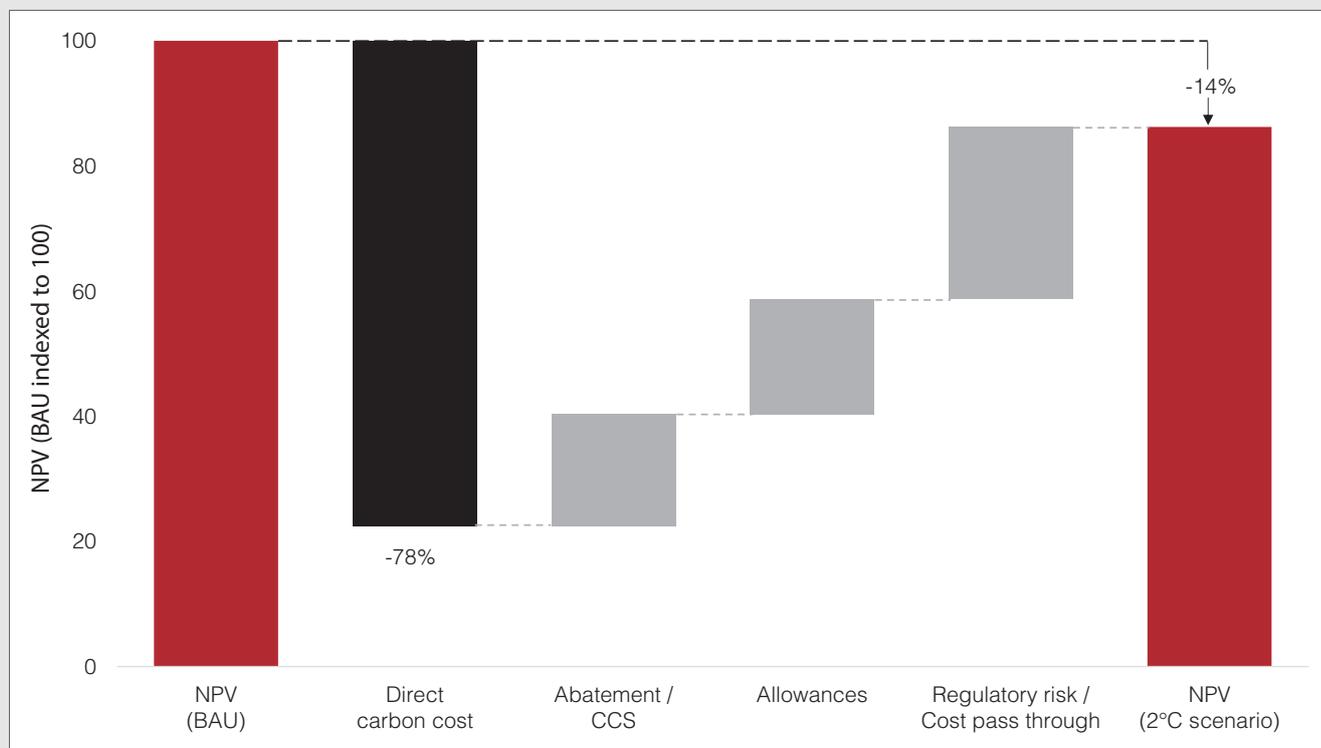
We model cost pass through rates as a function of demand effects (both price elasticity of demand and Armington elasticities)<sup>31</sup>, carbon costs for each company relative to competitors, and trade intensity of steel products by country.

Company EBITDA profiles under the chosen scenario are then compared to business-as-usual (BAU) profiles to provide a measure of the Value at Risk (VaR).

Figure 27 illustrates the aggregated impact to net present value (NPV) for the 20 companies under our central 2°C scenario, with cash flows of company earnings discounted at 5%.<sup>32</sup>

Under this scenario global carbon prices rise to US\$100 per tonne CO<sub>2</sub> by 2040, with free CO<sub>2</sub> allowances declining to zero by 2040. For the company sample the weighted average direct carbon costs reduce NPV by 78%. Accounting for abatement, CCS, allowances, regulation risk and cost pass through, the weighted average Value at Risk for the 20 companies is 14% of NPV (ranging from 2.5% to 30% for individual companies).

**Figure 27: Value at Risk for steel companies under a 2°C scenario**



Source: CDP

In our central 1.5°C scenario, carbon prices rise to US\$ 140 per tonne CO<sub>2</sub> by 2040, with free CO<sub>2</sub> allowances declining to zero by 2030. Under this scenario the weighted average Value at Risk for the 20 companies is 24% of NPV (ranging from 4.6% to 51% for individual companies).

This emphasises the importance of looking at options available to companies to mitigate the risks from carbon pricing, and companies need to evidence that strategies are being adopted to ensure resilience for the changes ahead.

31. Armington elasticities measure the extent to which domestic production can be substituted by imports in case of a price increase. See box on page 19 for further discussion.

32. For our central scenario we have chosen a discount rate of 5%, declining to 3.7% by 2040 (decline rate implied by Freeman et al. 2013). In the context of cost-benefit analysis of climate change mitigation we choose this rate rather than the average WACC for the company sample (8.7%) in order to place greater importance on future cash flows. For further insight, the reader is encouraged to look into the ongoing debate regarding social discount rates between Nicholas Stern and William Nordhaus.

# Physical risks: Water resilience

- ▼ Across the 20 companies, over 50% of inland steel capacity is located in areas of high water stress risk.
- ▼ China Steel ranks first overall, followed by JFE Holdings and Hyundai Steel. All three companies have a low water stress exposure with their production facilities primarily located in coastal areas.
- ▼ Beijing Shougang ranks last with approximately 77% of its production capacity located in high to extremely high water risk areas. US Steel ranks second last, with no disclosure of water consumption or evidence of water risk management.

## Overview

Water access and availability is crucial to the continuity of steel operations. Changes in the frequency and severity of acute weather events and chronic long-term changes to the climate will impact supply of freshwater, placing a greater emphasis on steel companies to consider the implications of its water use and management.

Water is used throughout the steelmaking process, predominately for cooling at the blast furnace and electric arc furnace, in coke quenching, dust scrubbing and cleaning. Steel companies use large quantities of water, but their impact on the watershed will vary depending on site location, access to water resources and facility configuration.

Steel mills located in coastal areas are able to withdraw large volumes of seawater for cooling, which can be discharged without any change in quality. In contrast, facilities with limited access to seawater are reliant on freshwater in their operations. Water intake by these facilities can be effectively reduced by water recirculation and closed-loop systems. However, reusing water involves treatments between each use, which requires additional energy consumption and can lead to greater water evaporation.

The nature of physical risks facing steel companies varies considerably across time and space. In its response to the CDP 2018 water questionnaire, ArcelorMittal identified the 2017 drought in the Western Cape as a severe threat to its Saldanha plant's continued operations. In response, ArcelorMittal has been working with the municipality to investigate alternative water sources as the plant's water reuse rate has already reached a theoretical maximum.

In comparison, China Steel identified the declining water quality during dry seasons as a major risk to its business in its 2018 water questionnaire response. The water quality usually deteriorates at higher evaporation rate, which requires the company to increase the water intake to dilute the chemical concentrations for cooling operations and water recycling.

In this chapter, we assess companies' water resilience and management using three key metrics:

**Metric 1) Water stress exposure (50%):** We assess localized water stress on a facility-by-facility basis using the World Resource Institute (WRI) Aqueduct global water-stress risk mapping tool. It assesses current water stress conditions based on physical water quantity and quality indicators as well as regulatory and reputational risks.<sup>33</sup> Only inland company assets were assessed, as it is highly likely that coastal sites will utilise seawater rather than freshwater.

**Metric 2) Water consumption intensity (25%):** Water consumption intensity is defined as the difference between water withdrawal and water discharge per tonne of crude steel produced. We use the current water consumption intensity and its five-year trend as an aggregate indicator to evaluate a company's net impact on the watershed or aquifer, control of evaporation loss in cooling and recirculation processes, and effectiveness in prevention of leaks.

**Metric 3) Water disclosure and governance (25%):** We form a ranking based on a range of indicators relating to companies' water risk disclosure, policies and governance frameworks based on responses to the 2018 CDP water questionnaire and public company disclosure. The scorecard includes disclosure to CDP, water risk assessment/management, water stress assessment, water accounting, water reduction target, scenario analysis and data verification.

33. Please note that the methodology for this metric has been changed from the last report. The index is now out of 5 to better reflect WRI's risk categorisation. Each company's water stress exposure is also scaled by capacity relative to total output to capture relative materiality within portfolios.

**Figure 28: Physical risks summary**

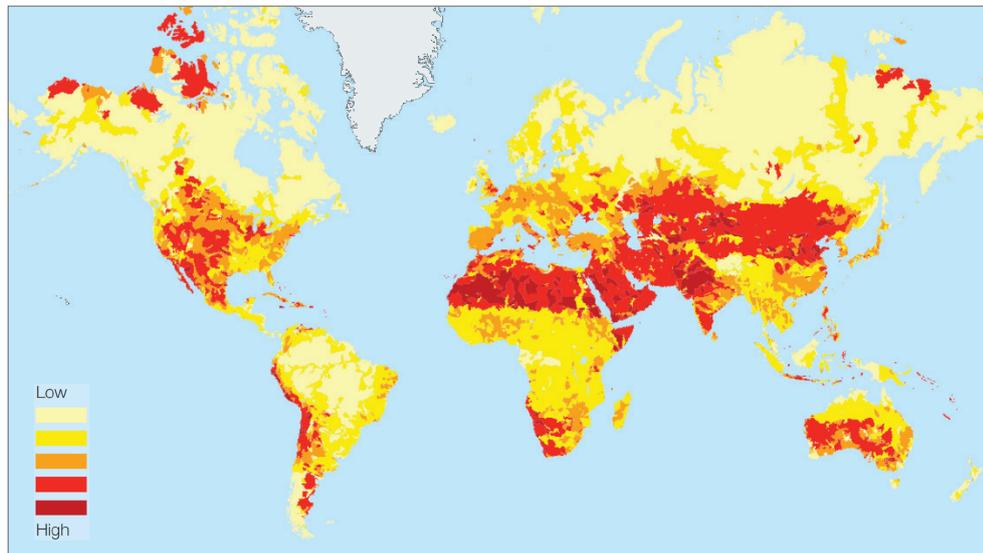
Company	Water stress exposure	Water consumption intensity	Water governance & policy	Overall weighted rank	Physical risks rank
China Steel	1	13	3	3.67	1
JFE Holdings	5	9	1	4.55	2
Hyundai Steel	1	4	8	4.72	3
Tata Steel	7	7	4	6.14	4
Nippon Steel	3	15	6	7.20	5
SSAB	4	15	8	8.03	6
BlueScope Steel	8	3	11	8.24	7
POSCO	13	10	2	8.79	8
Severstal	6	11	11	8.87	9
ArcelorMittal	10	14	5	8.99	10
Baoshan Iron & Steel	9	6	13	9.37	11
Angang Steel	16	1	13	10.28	12
NLMK	14	12	7	11.09	13
JSW Steel	17	8	8	11.58	14
Gerdau	11	15	18	13.60	15
Nucor	12	15	18	13.90	16
Hesteel	20	2	17	14.16	17
Baotou Steel	19	5	13	14.43	18
US Steel	15	15	20	15.14	19
Beijing Shougang	18	15	13	16.77	20

**Weighting**                      **50%**                      **25%**                      **25%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

**Figure 29: WRI Aqueduct water stress map**

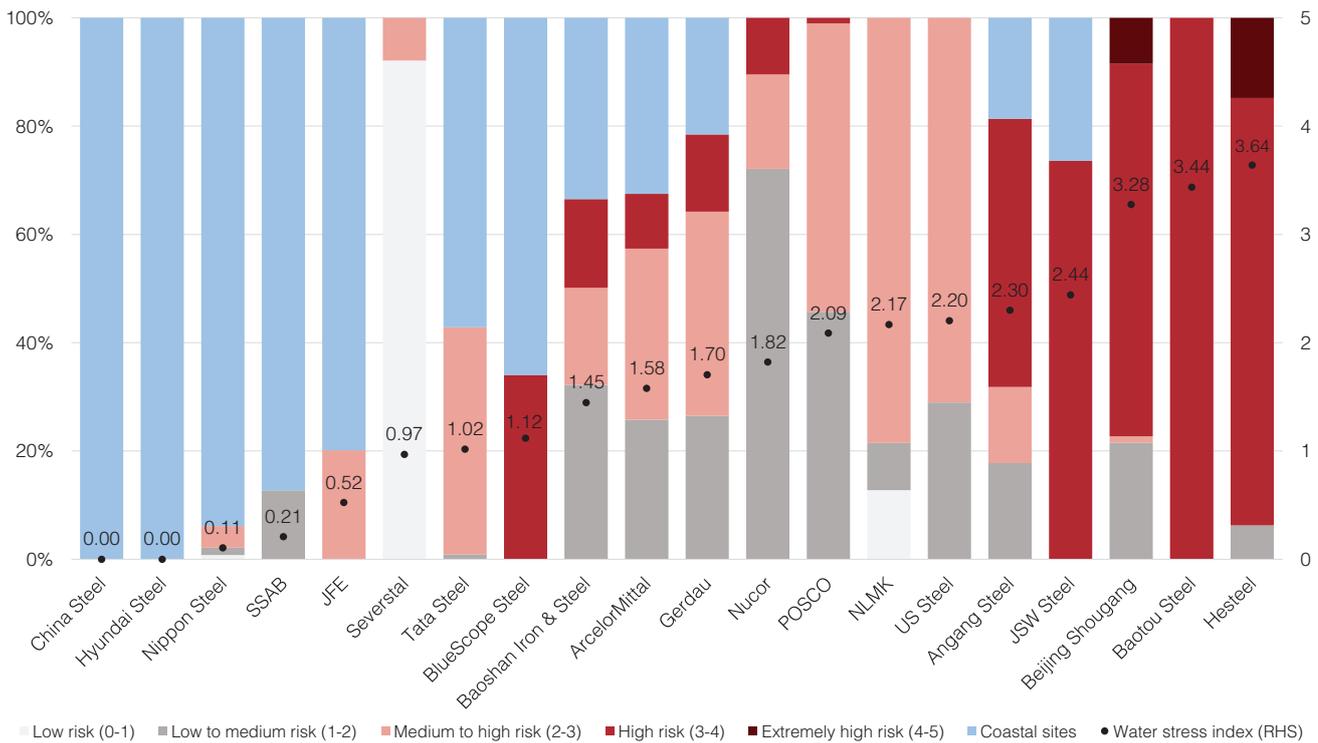


Source: WRI

## Water stress exposure

- Across the 20 companies, over 50% of inland steel capacity is located in areas of high water stress risk. Company operations located in China and India are most at risk.
- China Steel and Hyundai Steel rank in the top two, followed by Nippon Steel, SSAB and JFE Holdings. With only 4% of their collective capacity located inland, freshwater availability is less of a concern, as seawater can be withdrawn and discharged directly back to sea.
- Hesteel, Baotou Steel and Beijing Shougang rank in the bottom three. Approximately 88% of their aggregated capacity is located in high to extremely high water risk areas, predominately based in China.
- Over 70% of JSW Steel’s steelmaking capacity is located in high water stress risk areas in India. Severstal’s main steelmaking plant, accountable for 90% of its overall steelmaking capacity is located in a low risk region in Russia.

**Figure 30: Water stress exposure**



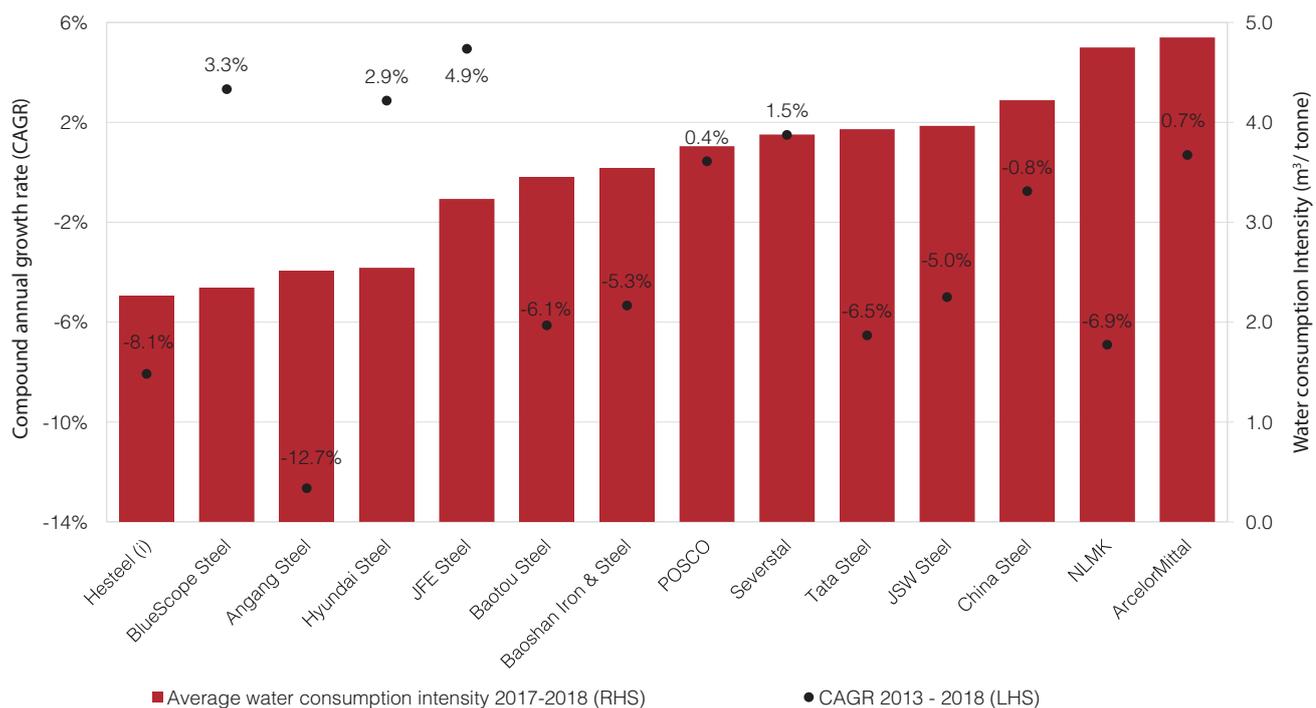
Source: CDP, WRI, PLANTFACTS

## Water consumption intensity

Across the 14 companies reporting on water consumption, eight companies have reduced their water consumption intensity in the past five years.

Angang Steel ranks first. It has the highest reduction rate at 12.7% p.a. since 2014 and the third lowest water consumption intensity across the companies. Hesteel ranks second with the lowest water consumption intensity of 2.3m<sup>3</sup>/t and a relatively high reduction rate at 8.1% p.a.

**Figure 31: Water consumption intensity<sup>(ii)</sup>**



(i) Hesteel: water consumption intensity 2016, CAGR 2013-2016  
 (ii) No data for Beijing Shougang, Gerdau, Nippon Steel, Nucor, SSAB, and US Steel  
 Source: CDP, company reports

## Water governance and policy

- Only six companies responded to CDP's 2018 water questionnaire, including ArcelorMittal, China Steel, JFE Holdings, Nippon Steel, POSCO and Tata Steel.
- JFE Holdings ranks first, followed by China Steel and POSCO. All three companies show clear evidence of water risk monitoring and management and have set a water reduction target.
- US Steel ranks last followed by Nucor and Gerdau. US Steel does not disclose on water risk monitoring or management, while Nucor and Gerdau only report the percentage of water recycled across all the indicators used in this metric.
- All five Chinese companies show evidence of some form of water risk assessment but are lacking evidence of water reduction targets and water accounting in details.

Figure 32: Water governance and policy summary

Company	CDP Score (2018)	Water data publicly disclosed	Water risk assessment / policy	Water stress assessment	Facility level water accounting	Water reduction target	Scenario analysis	Data verification	Rank
JFE Holdings	B	✓	✓	✓	✓	✓	✓	✓	1
POSCO	A-	✓	✓	✓	✓	✓	✓	✓	2
China Steel	B	✓	✓	✓	✓	✓	✓	✓	3
Tata Steel	B-	✓	✓	✓	✓	✓	✗ <sup>(iii)</sup>	✓	4
ArcelorMittal	B-	✓	✓	✓	✓ <sup>(ii)</sup>	✓ <sup>(ii)</sup>	✓	✗ <sup>(iii)</sup>	5
Nippon Steel	B-	✓	✓	✓	✗	✗	✗	✗	6
NLMK	n/a <sup>(i)</sup>	✓	✓	✓	✗	✓ <sup>(ii)</sup>	✗	✓ <sup>(ii)</sup>	7
SSAB	F	✓	✓	✓	✗	✗	✗	✓	8
Hyundai Steel	F	✓	✓	✗	✗	✓	✗	✓	8
JSW Steel	F	✓	✓	✓	✗	✗	✗	✓	8
BlueScope Steel	F	✓	✓	✗	✗	✓ <sup>(ii)</sup>	✗	✗	11
Severstal	F	✓	✓	✗	✗	✗	✗	✓ <sup>(ii)</sup>	11
Baoshan Iron & Steel	n/a <sup>(i)</sup>	✓	✓	✗	✗	✗	✗	✗	13
Angang Steel	n/a <sup>(i)</sup>	✓	✓	✗	✗	✗	✗	✗	13
Baotou Steel	n/a <sup>(i)</sup>	✓	✓	✗	✗	✗	✗	✗	13
Beijing Shougang	n/a <sup>(i)</sup>	✓ <sup>(ii)</sup>	✓	✗	✗	✗	✗	✓ <sup>(ii)</sup>	13
Hesteel	n/a <sup>(i)</sup>	✓ <sup>(ii)</sup>	✓	✗	✗	✗	✗	✗	17
Gerdau	F	✓ <sup>(ii)</sup>	✗	✗	✗	✗	✗	✗	18
Nucor	F	✓ <sup>(ii)</sup>	✗	✗	✗	✗	✗	✗	18
US Steel	F	✗	✗	✗	✗	✗	✗	✗	20

(i) "n/a" for companies that were not requested by CDP.

(ii) Partial disclosure.

(iii) Tata Steel anticipate doing scenario analysis within the next 2 years. ArcelorMittal are considering verifying data within the next 2 years.

Source: CDP, company reports

# Transition opportunities

- ▶ Upscaling of several low-carbon innovations could enable the steel industry to achieve significant emissions reductions, and align with below 2°C pathways. However, full commercialization of these technologies remains decades away.
- ▶ ArcelorMittal rank top overall followed by SSAB. Both companies are working on a number of pioneering technologies that could lead to a transition to zero-emission steelmaking.
- ▶ The two Russian companies Severstal and NLMK rank last and second last respectively. Neither company show evidence of developing any technologies deemed to be radical or transformative and rank in the bottom two in the majority of metrics.

## Overview

Against a backdrop of tightening emissions regulations and with modern steel plants operating at the limits of thermodynamic efficiency, a set of breakthrough technologies are needed to bring the steel industry in line with a 2°C or below emissions pathway.

Emissions reductions can be achieved through a variety of different means: Firstly, efficiency improvements of existing technologies can be achieved through the use of renewable electricity in EAFs, deployment of Best Available Techniques (BAT)<sup>34</sup> across existing plants and the use of biomass for heat production and biogas as a reducing agent in DRI steel production. Secondly, the industry can continue to improve circularity and reduce, reuse and recycle steel products and associated by-products, allowing for less demand in steel output. Finally, upscaling of Carbon Capture Utilization and Storage (CCUS) project and deployment of new decarbonization technologies will be crucial for the industry to shift from carbon-intensive fossil fuels and feedstocks.

The decarbonization of the industry must also go hand-in-hand with an accelerated build-up of zero-carbon electricity generation. The cost of renewable electricity compared to the cost of fossil fuel alternatives will heavily influence the attractiveness of decarbonization via electrification or hydrogen steelmaking, while electrification of heat production is only economical when electricity costs the same per unit of energy as the conventional fossil fuel alternatives.<sup>35</sup>

In recent years, the global portfolio of large-scale CCS projects continues to expand. The first steel plant CCS project began operation in 2016<sup>36</sup> while a number of existing CCUS projects are at varying stages of development. The emergence of hydrogen steelmaking, where hydrogen is used as a heat source and reducing agent, and produced via electrolysis presents a significant opportunity to reduce consumption of coke and coal.

Public-private-partnerships can be key to unlocking emissions reduction projects and accelerating timeframes for commercialization. ArcelorMittal currently has a number of R&D projects which are co-funded by EU Horizon 2020, while construction costs associated with SSAB's HYBRIT initiative were half financed by the Swedish Energy Agency. In Japan, COURSE50 represents a collaborative effort by the Japanese Government and the private sector to scale up low-carbon steel-making technologies by contracting out R&D tasks to private actors with public funds.

In this section we explore low-carbon process innovation to demonstrate where companies are investing in radical and transformative technologies associated with step changes in decarbonization. A bespoke innovation matrix was developed from de Beer (2000) and Weterings (1997) to assess efficiency improvements and low-carbon technologies that can be applied to crude steelmaking. Innovations over the past five years are scored on an exponential scale and defined as incremental, evolutionary, radical, and transformative, depending on their potential impact on decarbonizing the steel sector. Innovations are also assessed based on the relative stage in development, ranging from applied R&D through to full commercialization.

**Figure 33: Transformative change theory**

Innovation	Definition
Incremental	Incremental innovations occur continuously within the sector to provide marginal efficiency improvements in existing technologies.
Evolutionary	Evolutionary innovations refer to a logical continuation in an existing process improvement trend. Innovations can refer to the utilisation of Best Available Techniques, with moderate adaptations to existing processes, or the use of existing low-carbon technologies.
Radical	Radical innovations are discontinuous events that require changes to key process parameters and provide a leap forward in performance. Technologies will have a significant impact on the emissions performance of the industry and will be important means of decarbonizing the industry.
Transformative	Transformative innovations refer to far-reaching changes in technologies, that will require a fundamental change in processes and a step-change in emissions performance. Transformative technologies will lead to near zero emission steelmaking and can be utilised in a low-carbon economy.

Source: CDP, Weterings (1997), de Beer (2000)

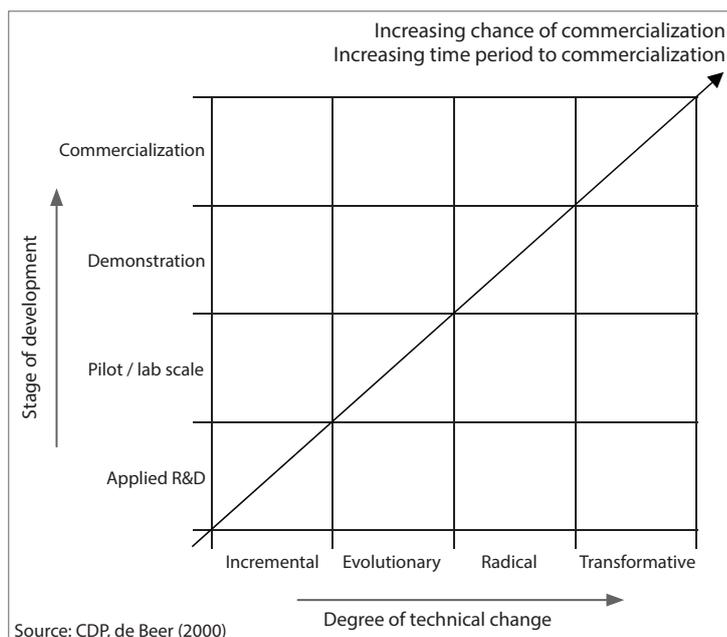
34. BAT include Top pressure gas recovery systems, Dry Coke Quenching in sinter plants, Pulverised coal injection in the Blast furnace and Preheating of EAF scrap – among others.

35. International Energy Agency, 2019: CCUS in industry and transformation: Tracking Clean Energy Progress

In this chapter we assess the extent to which companies are capturing these transition opportunities across the following metrics:

**Metric 1) Low-carbon process innovation (60%):** We compile a list of process innovations relating to steelmaking across the entire business operations of each company and assign each innovation two scores. The first assesses whether the innovation is incremental, evolutionary, radical or transformative as per the definitions in Figure 33. The second assigns the stage of development from R&D to full commercialization. We take the top 10 innovations for each company and combine the two scores to give a final innovation score out of 100.

**Figure 34: Innovation matrix**



**Metric 2) Circular economy innovation (10%):** We assess companies on innovations relating to the recycling and reuse of by-products from the steelmaking process. We use a scorecard approach, assessing companies across areas of slag, sludge and dust recycling, and heat and gas recovery.

**Metric 3) Patent analysis (10%):** This metric analyses the number of high-quality patent applications submitted by companies across the themes of energy efficiency, innovative steelmaking technologies, waste recovery and process control across various steelmaking routes.

**Metric 4) Research & Development (R&D) spend (10%):** We rank companies on their R&D expense to sales ratio over the period 2016-2018.

**Metric 5) Renewable energy use (10%):** We examine which companies currently operate or own renewable assets or have projects under development. We also identify companies that have set up Power Purchase Agreements to supply steelworks with renewable energy.

**Figure 35: Transition opportunities summary**

Company	Low-carbon innovation	Circular innovation	Patent analysis	R&D	Renewable energy use	Overall weighted rank	Transition opportunities rank
ArcelorMittal	1	3	15	13	1	4.39	1
SSAB	2	3	16	11	8	5.83	2
POSCO	5	3	1	8	4	6.24	3
JFE Holdings	4	1	3	7	6	6.67	4
Nippon Steel	6	2	5	6	10	8.34	5
Tata Steel	3	8	9	12	12	8.38	6
Baoshan Iron & Steel	8	6	8	2	3	10.86	7
JSW Steel	7	6	11	15	16	12.34	8
Hyundai Steel	9	14	2	9	16	12.45	9
Beijing Shougang	11	18	4	5	5	12.81	10
China Steel	10	18	6	10	7	13.28	11
Gerdau	11	8	16	16	2	13.87	12
Angang Steel	15	11	7	4	14	13.95	13
Nucor	11	10	10	16	13	14.25	14
Hesteel	17	14	12	1	15	14.49	15
BlueScope Steel	14	11	16	14	11	14.91	16
US Steel	16	13	16	16	8	15.75	17
Baotou Steel	19	18	14	3	16	16.98	18
NLMK	18	14	16	16	16	17.37	19
Severstal	19	14	13	16	16	18.26	20

**Weighting**                      **60%**                      **10%**                      **10%**                      **10%**                      **10%**

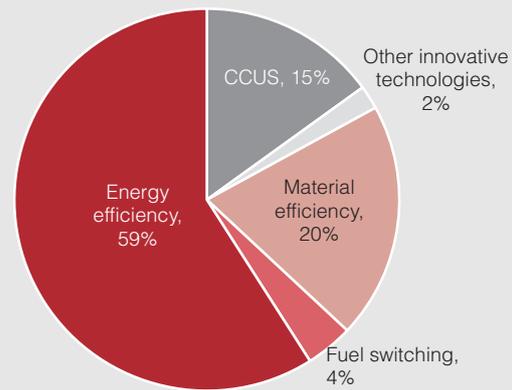
Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

# Carbon capture and storage: the solution to decarbonising steel?

Figure 36: Technology contributions to emissions reductions

Economic and technical challenges in redefining production processes mean carbon capture, utilization, and storage (CCUS) will be critical to decarbonise the steel sector. In the IEA's latest Clean Technology Scenario (CTS) – which sets out an energy system pathway consistent with the Paris Agreement aims – CCUS contributes up to 15% of emissions reductions in the iron and steel industry in the period to 2060 (see Figure 36). However, despite CCUS forming a principal component of emissions reduction scenarios, progress towards developing this technology in the steel sector has been slow.



Source: IEA, 2019: Transforming Industry through CCUS

## Pioneer large-scale CCUS project proves successful

Only one steel facility currently operates with large-scale CCUS. The Abu Dhabi-based project – developed as a joint venture by Abu Dhabi Future Energy Company (Masdar) and Abu Dhabi National Oil Company (ADNOC) – began operating in November 2016. The project has the capacity to capture up to 0.8Mt of CO<sub>2</sub> annually from the Emirates Steel facility in Mussafah using a combination of dehydration and compression processes. The captured CO<sub>2</sub> is then transported via a 43km pipeline to ADNOC operated onshore oil fields for use in Enhanced Oil Recovery (EOR).

The project's success where many CCUS developments have failed to take off is due to several factors. In particular, the project's location in the vicinity of oil fields ensures a guaranteed source of revenue where CO<sub>2</sub> can be used in EOR in place of natural gas, increasing the economic viability of the project. State ownership also means the commercial and technical risks are borne by the government, boosting the project's commercial viability.<sup>37</sup> Indeed, a lack of government financing and a weak policy context are principal deterrents to private investment and development of CCUS technologies.

## Early stage CCUS projects show promise, but the pace of development is slow

CCUS technologies are gaining traction among steelmakers, albeit on a smaller scale and largely at a pilot phase. One of the most promising options is coupling CCUS with alternative emission abatement technologies – particularly those which incorporate oxygen-rich conditions that produce off-gases with higher CO<sub>2</sub> concentrations, such as Hlsarna, Finex and top gas recycling (TGR), see Figure 40 on page 30. However, to date there has been little progress in combining these existing technologies with CCUS.

Several steel companies – including ArcelorMittal, China Baowu Steel Group, Shougang Group, and Baotou Steel – have also partnered with innovation company LanzaTech in pilot projects using a technology which converts carbon monoxide produced during steel production to ethanol. The process is becoming increasingly attractive to steelmakers for its potential both to abate CO<sub>2</sub> emissions and to create new revenue streams where the ethanol produced can be converted into transport fuel or potentially used in the production of plastics.<sup>38</sup>

## Can CCUS be scaled-up fast enough to achieve its envisioned emissions abatement potential?

Several technical and economic barriers exist to upscaling CCUS deployment, creating uncertainty over when the implementation of industrial CCUS will be commercially viable.

The steel industry generally operates at narrow profit margins, and in competitive international markets companies are reluctant to raise production costs by transitioning to low-carbon processes and technologies that could put them at an economic disadvantage. Deploying commercial-scale CCUS projects is highly capital-intensive; policy support and financial incentives such as capital grants, subsidies, or tax credits will therefore be required to encourage commercial investment. An effective carbon price could act as a lever to boost investment; however, the IEA anticipates the current pace of carbon market growth will be insufficient to facilitate CCUS development at the level required.<sup>39</sup>

In the case of CCS, the requirement for transport networks necessitates significant investment, while access to storage sites is a critical factor in development.<sup>40</sup> This poses challenges in countries where operations have a wide territorial coverage and which lack adequate geological conditions for storage. Industry collaboration on infrastructure development could help stimulate investment. However, heterogeneous production processes create challenges for standardising CCS across the industrial sector,<sup>41</sup> while the absence of consistent policies or regulatory frameworks for CCS adds further uncertainty.

Given the slow pace of large-scale CCUS deployment and existing hurdles in terms of technical and economic feasibility, upscaling CCUS technology to meet the emissions reductions envisaged under 2°C aligned scenarios will be challenging.

37. Element Energy Limited, 2018: Industrial carbon capture business models

38. ArcelorMittal, 2018: ArcelorMittal and LanzaTech break ground on €150million project to revolutionise blast furnace carbon emissions capture

39. IEA, 2017: Five keys to unlock CCS investment

40. World Steel Association, 2017: Steel's Contribution to A Low Carbon Future

41. Element Energy Limited and Vivid Economics Ltd, 2018: Policy Mechanisms to support the large-scale deployment of Carbon Capture and Storage (CCS)

# Beyond CCS: zero-emission steelmaking

## Hydrogen in steelmaking

Research and development into alternative technologies to eliminate process emissions, such as the use of hydrogen in place of coal and natural gas in iron ore reduction, will become crucial if the sector is to avoid risks of locking-in emissions and overshooting a 2°C trajectory.

There is a growing consensus that clean hydrogen will play a key role in the world's transition to a sustainable future with multiple applications across industry, transport and energy storage. However, the efficacy of using hydrogen in the steel sector will depend on industry's ability to not only upscale hydrogen production but also achieve a mass increase in the integration of renewable electricity in industrial processes. Achieving a net-zero CO<sub>2</sub> emissions economy will require an increase in global hydrogen production from 60 Mt per annum today to around 425–650 Mt by 2050. Similarly, electricity's share of total final energy demand will need to rise from today's 20% to over 60% by 2060, with a simultaneous switch from high-carbon to zero-carbon power sources.<sup>42</sup>

Hydrogen can be sourced in a variety of ways. "Grey hydrogen" is produced through steam reforming of natural gas. It is currently the most cost-effective method for producing hydrogen, but still generates CO<sub>2</sub> emissions. "Blue hydrogen", where emitted CO<sub>2</sub> emissions are captured and stored during production offers a cleaner alternative but is reliant on proven CCS technologies and large-scale CO<sub>2</sub> transport and storage infrastructure. "Green hydrogen" – hydrogen produced via electrolysis – is the most promising option for decarbonization within the steel sector.

DRI production is able to utilise hydrogen (H-DR) in place of natural gas as the reducing agent to produce sponge iron without the need for major retrofitting of DRI-EAF plants. If green hydrogen is utilised, H-DR plants coupled with an EAF facility powered by renewable electricity can therefore produce near zero-emission steel and enable a 98% reduction in CO<sub>2</sub> emissions compared to the conventional blast furnace route.<sup>43</sup>

### HYBRIT

The Hydrogen Breakthrough Ironmaking Technology (HYBRIT) project, developed as a joint venture between LKAB, SSAB and Vattenfall, uses hydrogen produced via electrolysis for the direct reduction of iron oxide/ore combined with an EAF run by renewable electricity to produce primary steel.

Renewable electricity is used to split water in an electrolyser, and the hydrogen produced is then used to convert the iron ore to sponge iron in a direct reduction shaft (Figure 37). Oxygen emerges as a by-product from electrolysis and water from the direct reduction shaft.

The pre-feasibility study, which ended in 2017, considered that fossil-free steel, given current electricity, coal and CO<sub>2</sub> emissions prices, would be 20-30% more expensive than conventional steel production. With declining prices in electricity and increasing costs for CO<sub>2</sub> through the EU ETS, the study concluded that the new concept could thus be competitive with the BF-BOF route with a carbon price between € 40-60/tonne CO<sub>2</sub>, assuming the H-DR process is completely CO<sub>2</sub>-free.<sup>44</sup>

### SIDERWIN

A further innovation relates to the direct use of electricity to reduce iron oxides. This electrolytic process will be flexible enough to be supplied by renewable energies and will transform iron oxides into steel with a significant reduction in energy use.

The development of new methodologies for industrial CO<sub>2</sub>-free steel production by electrowinning (SIDERWIN) project, led by ArcelorMittal and developed under the Horizon 2020 framework,<sup>45</sup> uses electricity to cause a reaction of iron oxides to produce iron.

When iron ore is introduced into an electrolytic bath (a bath with an electrical current running through two electrodes), the iron is attracted to one electrode and the oxygen to the other (Figure 38). Compared to the conventional BF-BOF route the SIDERWIN project is expected to yield an 87% reduction in direct CO<sub>2</sub> emissions and a reduction of 31% in direct energy use.<sup>46</sup>

ArcelorMittal have also conducted inhouse R&D and developed the first electrolytic cell prototype, proving the viability of iron electrolysis.<sup>47</sup>

Figure 37: Hydrogen direct reduction process

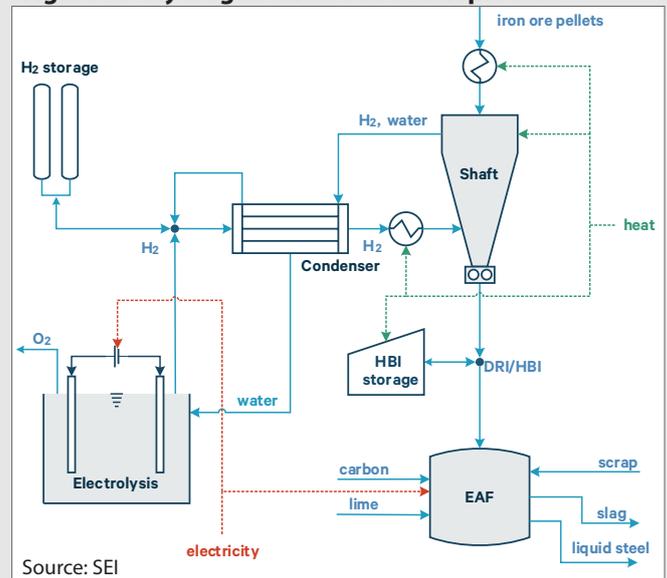
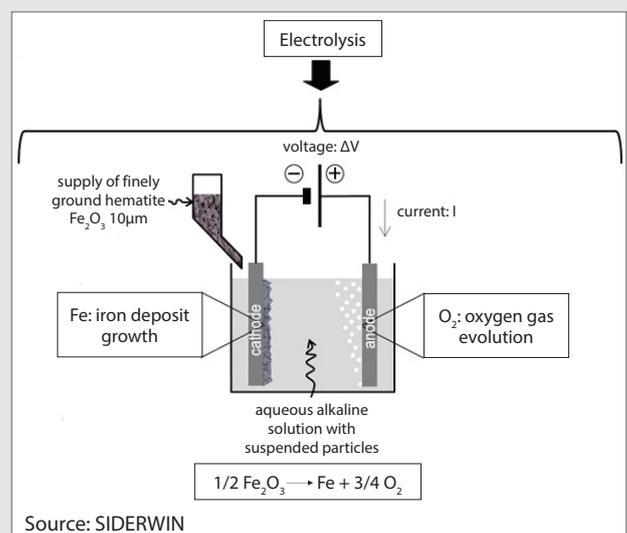


Figure 38: Direct use of electricity to reduce iron oxides



42. Energy Transitions Commission: Mission Possible – Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century

43. IEA: Tracking Clean Energy Progress – Iron and Steel

44. SEI: Hydrogen steelmaking for a low-carbon economy: A joint LU-SEI working paper for the HYBRIT project

45. Also known as ULCOWIN (Ultra Low CO<sub>2</sub> by electrowinning) under the ULCOS (Ultra Low CO<sub>2</sub> Steelmaking) EU programme.

46. SIDERWIN: <https://www.siderwin-spire.eu/>

47. ArcelorMittal Climate Action Report 2019

## Low-carbon process innovation

Having made significant advances in energy efficiency over the past five decades, further efficiency improvements alone will be insufficient to achieve the emissions reductions required to align with the Paris Agreement's temperature goals. While the industry must continue to upgrade plants, optimize processes and deploy BATs, the most progressive steel companies are those that are looking to develop breakthrough technologies that can radically reduce emissions.

Six companies have delivered technologies, that we consider to be transformative. 7% of total low-carbon innovations are considered to be transformative and 11% radical. Six companies show little evidence of developing innovative low-carbon technology (see Figure 39).

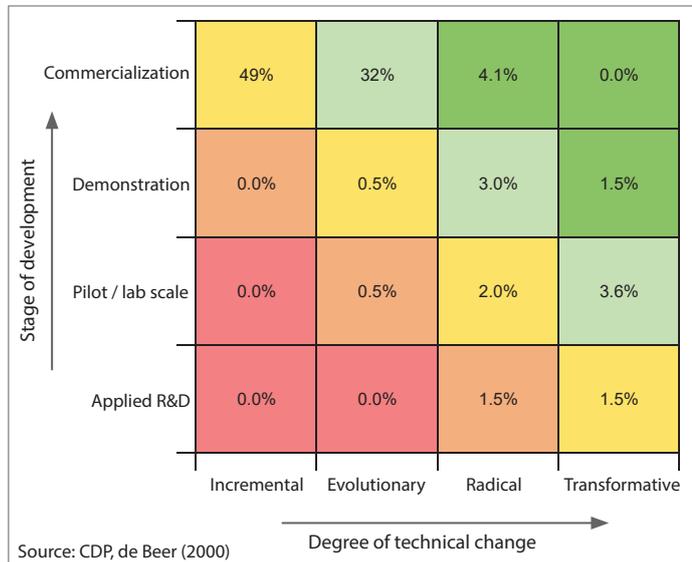
ArcelorMittal ranks first for low-carbon process innovation. The company is pioneering a number of breakthrough technologies such as the SIDERWIN project to produce iron ore via electrolysis (see box on page 29). The company is also investing \$65 million on an industrial scale DRI hydrogen based plant in Hamburg.

SSAB rank second. The company is focusing one two key strategies: Firstly the company is targeting fossil-free steelmaking via the HYBRIT project and secondly, it aims to decommission its operational BF's and replace them with EAFs. Its position in the Nordics, where clean power is abundant, gives it a unique advantage against its competitors.

Further innovations relate to the use of biomass as a fuel in the Blast Furnace and deploying BAT such as coke dry quenching, pulverised coal injection and top gas recovery.

Nine companies are involved with innovations relating to CCUS. Four companies have partnered with the carbon recycling company LanzaTech, which converts waste gases from the steelmaking process to produce bioethanol. ArcelorMittal predicts the use of bioethanol produced via its Steelanol project can achieve CO<sub>2</sub> emissions reduction of 87% compared with fossil transport fuels. Shougang Group's commercialized LanzaTech plant is capable of producing 16 million gallons of bioethanol per year.

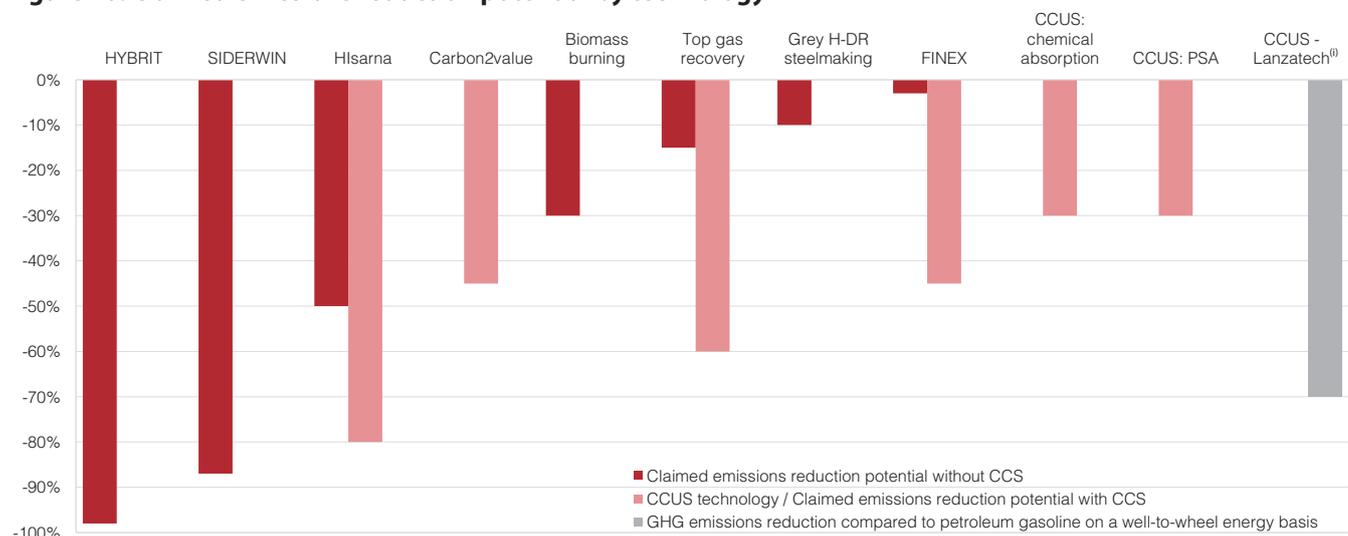
Figure 39: Innovation matrix company distribution



Ongoing innovative technologies such as Hlsarna (Tata Steel), and FINEX (POSCO) continue to provide emissions reduction compared to the BF-BOF route (see Figure 40). During its final testing campaign the Hlsarna project was shown to yield a CO<sub>2</sub> reduction of more than 50%. However, significant emissions reductions can only be achieved by combining these technologies with CCS and to date, there has been little progress in achieving this goal.

Six companies show little evidence of innovating beyond an evolutionary scale (i.e. the deployment of BAT). Baotou Steel and Severstal rank last. Baotou Steel show little evidence of innovation beyond the construction of a demonstration scale LanzaTech while 100% of Severstal's top 10 innovations were deemed to be incremental.

Figure 40: Claimed emissions reduction potential by technology



(i) LanzaTech state a GHG reduction of 50-70% over conventional gasoline. ArcelorMittal, in relation to its Steelanol - Carbalyt project, predict a CO<sub>2</sub> reduction of up to 87% compared with fossil transport fuels on a lifecycle analysis basis.

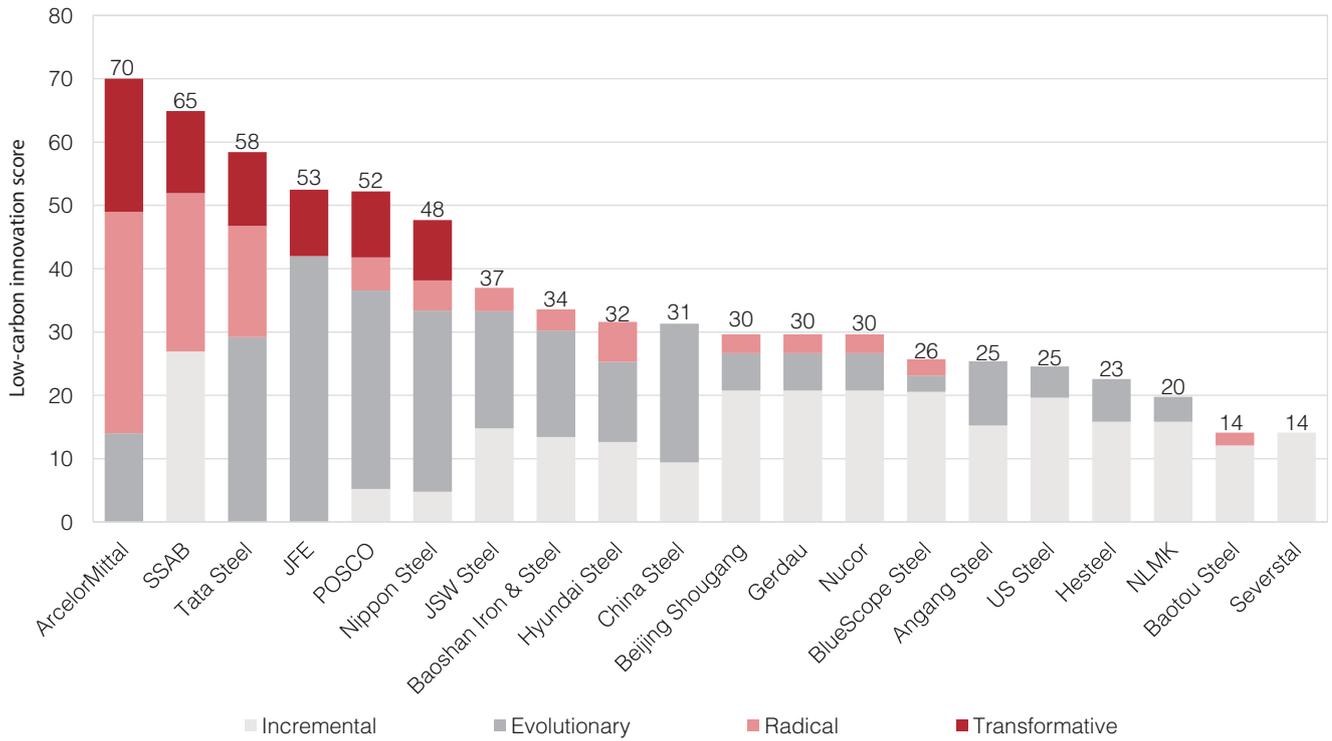
Source: CDP, company reports, SIDERWIN, IEA

**Figure 41: Low-carbon innovation highlights**

Company	Description	Score	Rank
ArcelorMittal	<ul style="list-style-type: none"> <li><b>SIDERWIN</b> – reducing iron ore via electrolysis. With sufficient affordable clean power, can lead to zero-emissions iron ore reduction.</li> <li><b>Carbon2Value:</b> Developing cost-effective technologies to capture and separate CO<sub>2</sub> from our waste gases</li> <li><b>Carbalyst® / Steelanol</b> – partnership with LanzaTech to construct a full-scale facility to produce ethanol from carbon-intensive waste gases.</li> <li><b>Hydrogen steelmaking</b> – Using green hydrogen for the direct reduction of iron ore. Pilot plant in coming years at Hamburg facility.</li> <li><b>Torero</b> – Processing waste wood to use as Pulverised Coal Injection substitute in the blast furnace.</li> <li><b>IGAR</b> – Capturing waste CO<sub>2</sub> from the blast furnace and converting into syngas that can be reinjected into the blast furnace in place of fossil fuels.</li> </ul>	70	1
SSAB	<ul style="list-style-type: none"> <li><b>HYBRIT</b> – Using hydrogen produced via electrolysis by use of renewables for the direct reduction of iron ore, combined with an EAF for steelmaking. In 2018 work started on construction of a pilot plant.</li> <li><b>Conversion of BF-BOF to EAF</b> – SSAB intends to decommission its blast furnaces at its Oxelösund by 2025 and its blast furnaces in Luleå, Sweden and Raahé, Finland between 2030-2040 and replace them with EAF powered by renewables.</li> <li><b>Guarantee of origin</b> - At least 50% of the electricity SSAB buys on the Nordic electricity market is derived from renewable energies.</li> <li><b>Biomass</b> – Testing of woodchips / biocoal in the blast furnace.</li> </ul>	65	2
Tata Steel	<ul style="list-style-type: none"> <li><b>Hilsarna</b> – Utilising iron ore and pulverized coal without having to pre-process the raw materials in separate coke, sinter or pellet factories. Produces high concentrations of CO<sub>2</sub> suitable for carbon capture.</li> <li><b>Green Hydrogen steelmaking partnership</b> - Exploring the feasibility of a water electrolysis facility to produce hydrogen and oxygen at Tata Steel's IJmuiden steelworks for use in steelmaking.</li> <li><b>CCU</b> - convert carbon monoxide – A pilot project which seeks to convert carbon monoxide – a by-product gas from blast furnaces – into naphtha.</li> <li><b>Solar plant</b> – Installation of an 80,000 solar panels on factory roofs at the IJmuiden steelworks.</li> </ul>	58	3
JFE Holdings	<ul style="list-style-type: none"> <li><b>COURSE50: CO<sub>2</sub> Separation &amp; Recovery System</b> – Verification tests for commercial application of CO<sub>2</sub> separation technology with a PSA (Pressure Swing Adsorption) process pilot plant.</li> <li><b>COURSE50: Hydrogen steelmaking combined with CCS</b> – First facility by 2030, followed by others in 2050.</li> </ul>	53	4
POSCO	<ul style="list-style-type: none"> <li><b>CCS</b> – Capture and absorption of CO<sub>2</sub> from the blast furnace gas using low concentration ammonia solution.</li> <li><b>Hydrogen-based steelmaking process</b> – Participating in the selection of element technologies for economic and technological feasibility review of hydrogen reduction steelmaking process led by the government.</li> <li><b>FINEX</b> – Combination of FINMET's Fluidized Bed and COREX's Melter Gasifier. Molten iron is produced directly using iron ore and non-coking coal rather than BF methods through sintering and reduction with coke.</li> </ul>	52	5
Nippon Steel	<ul style="list-style-type: none"> <li><b>COURSE50: ESCAP – energy efficient CCS</b> – Stack gas from blast furnaces or thermal power stations is separated and collected by use of a chemical absorption solution. Pilot plant built with capacity of 30 tonnes of CO<sub>2</sub> per day.</li> <li><b>COURSE50: Hydrogen steelmaking combined with CCS</b> – First facility by 2030, followed by others in 2050.</li> </ul>	48	6
JSW Steel	<ul style="list-style-type: none"> <li><b>COREX</b> – Smelting-reduction process that uses low grade coal directly for ore reduction and melting work, eliminating the need for coke making units. The use of lump ore or pellets also dispenses with the need for sinter plants.</li> <li><b>CONARC Technology</b> – Utilizes the benefits of both the conventional top blown converter steelmaking and EAF. Process is based on the use of hot metal in the EAF and optimizes energy recovery and productivity.</li> </ul>	37	7
Baoshan Iron & Steel	<ul style="list-style-type: none"> <li><b>CCUS: LanzaTech</b> – LanzaTech's first demonstration facility with partner China Baowu Steel Group in Shanghai capable of producing 100,000 gallons of bioethanol per annum.</li> <li><b>BAT deployment</b> – Coke dry quenching, organic rankine cycle (ORC) electricity generation from waste heat.</li> </ul>	34	8
Hyundai Steel	<ul style="list-style-type: none"> <li><b>CCS</b> – research into CO<sub>2</sub> absorption and separation technology.</li> <li><b>New Feedstock for Iron-making Process</b> – Technology to reuse cattle dung as a raw material for steelmaking either as fuel to replace coal or gas, to enhance efficiency in the melting pot or to produce iron nuggets.</li> </ul>	32	9
China Steel	<ul style="list-style-type: none"> <li><b>Bio-coal from biomass: EFB Torrefaction System</b> – Development of second-generation bio-coal low temperature carbonation system utilizing lignocellulosic pellets and oil palm empty fruit bunch (EFB) pellets.</li> <li><b>Biomass palletisation</b> – R&amp;D into more competitive and value added innovative bio-coal technology.</li> </ul>	31	10
Beijing Shougang	<ul style="list-style-type: none"> <li><b>CCUS: LanzaTech</b> – Shougang Group commercializing a gas-fired ethanol plant this year. The project converts gas into fuel ethanol through bio-fermentation technology and produces compressed natural gas.</li> </ul>	30	11
Gerdau	<ul style="list-style-type: none"> <li><b>EAF production</b> – Over 75% of steel produced from the more efficient EAF production route.</li> <li><b>Digitization</b> – Incorporation of a number of technologies such as AI and the Internet-of-things for efficiency gains in steelmaking, process control and logistics.</li> </ul>	30	11
Nucor	<ul style="list-style-type: none"> <li><b>EAF production</b> – 100% of steel produced from the more efficient EAF production route.</li> </ul>	30	11
BlueScope Steel	<ul style="list-style-type: none"> <li><b>PPA</b> – Landmark 7-year Power Purchase Agreement (PPA), where BlueScope Steel will offtake 66% of the 133MW of energy generated from ESCO Pacific's Finley Solar Farm.</li> <li><b>EAF</b> – New technology to upgrade the EAF transformer and high voltage system to create a smart furnace.</li> </ul>	26	14
Angang Steel	<ul style="list-style-type: none"> <li><b>BAT deployment</b> – Coke dry quenching, top gas recovery.</li> <li><b>Iron carbon ball processing system</b> – Iron materials are 100% reclaimed &amp; used in place of scrap.</li> </ul>	25	15
US Steel	<ul style="list-style-type: none"> <li><b>EAF construction</b> – Technologically advanced EAF facility with 1.6 Mt capacity, online in second half 2020.</li> </ul>	25	16
Hesteel	<ul style="list-style-type: none"> <li><b>BAT deployment</b> – Coke dry quenching, top gas recovery, pulverised coal injection.</li> </ul>	23	17
NLMK	<ul style="list-style-type: none"> <li><b>BAT deployment</b> – Top gas recovery, pulverised coal injection.</li> </ul>	20	18
Baotou Steel	<ul style="list-style-type: none"> <li><b>CCUS: LanzaTech</b> – Demonstration plant under construction.</li> </ul>	14	19
Severstal	<ul style="list-style-type: none"> <li>Waste utilization and recovery, digitization, energy conservation projects.</li> </ul>	14	19

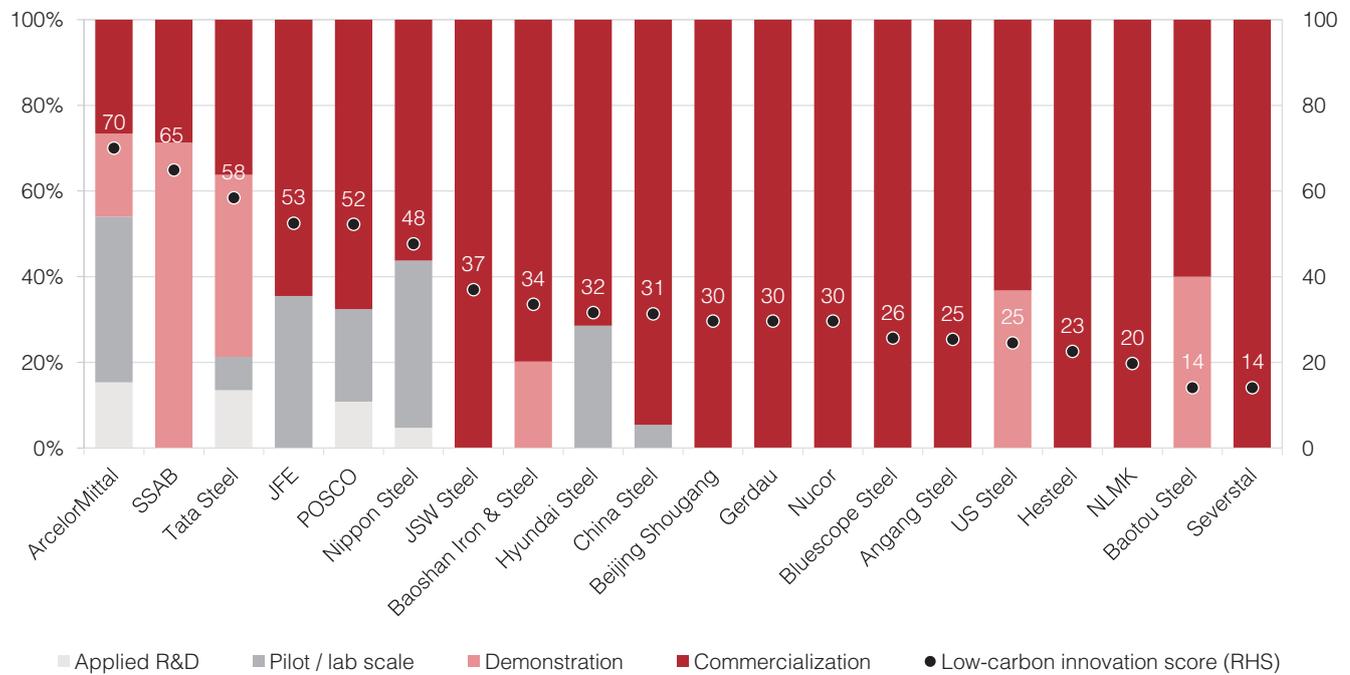
Source: CDP, company reports

**Figure 42: Low-carbon innovation score and degree of technical change**



Source: CDP, company reports

**Figure 43: Low-carbon innovation score and average stage of development**



Source: CDP, company reports

## Steel circularity

Companies that are able to maximize a circular economy approach to by-products and scrap steel will be better positioned to take advantage of the significant economic benefits of reducing and recycling waste from the steelmaking process (see box on page 34 for further insight).

- ▼ Circular activity is high across the sector where opportunities exist within company operations to drive down costs. For example, 18 out of the 20 companies have deployed some form of heat or gas recovery system within their operations to reduce energy costs, while 13 of the 20 companies are making use of recovered iron oxides for internal processes.
- ▼ Cross-sector circularity where companies sell on by-products as inputs into external industries is also prevalent. The sector most commonly referenced as a consumer of steel by-products is the cement and construction industry. 18 out of 20 companies disclose some kind of circular relationship with the cement and construction industry.
- ▼ More unique forms of circularity include the repurposing of slag for sea reforestation. Two Japanese companies, JFE Holdings and Nippon Steel are engaging in this kind of innovation.
- ▼ Disclosure of circularity is not consistent across the sector. While 11 companies disclose some percentage figure of by-products recycled, the material category of these by-products differs across the universe.
- ▼ Only three companies clearly disclose material efficiency as per worldsteel indicator guidelines.

Figure 44: Steel circularity summary

Company	Disclosure		Sludge & dust		Slag			Chemicals		Gas/heat	Rank
	Total waste recycled	% by-products recycled (public)	Extraction of iron oxides - internal processes	Extraction of iron oxides - external processes	Recycling of slag	Recycling of liming materials (agri.)	Recycling of slag for sea reforestation	Recycling of by-products for chemical industry	Recycling/reuse of plastic waste	Heat / gas recovery	
JFE Holdings	✓	✓	✓		✓		✓		✓	✓	1
Nippon Steel		✓	✓		✓		✓		✓	✓	2
ArcelorMittal	✓	✓	✓		✓					✓	3
POSCO	✓	✓	✓		✓					✓	3
SSAB	✓	✓	✓		✓					✓	3
Baoshan Iron & Steel		✓		✓	✓	✓				✓	6
JSW Steel	✓			✓	✓					✓	6
Tata Steel		✓	✓		✓					✓	8
Gerdau	✓	✓	✓		✓					✓	8
Nucor <sup>(i)</sup>		✓	✓								10
Angang Steel				✓	✓					✓	11
BlueScope Steel					✓	✓				✓	11
US Steel	✓	✓	✓		✓					✓	13
Hesteel		✓	✓		✓					✓	14
Hyundai Steel	✓				✓					✓	14
NLMK	✓				✓					✓	14
Severstal	✓				✓					✓	14
Beijing Shougang					✓		✓			✓	18
China Steel					✓					✓	18
Baotou Steel					✓					✓	18

(i) Categories relating to BF-BOF production route are n/a for Nucor (company production is 100% EAF). Ranking based on 'Disclosure' section only.

Source: CDP, company reports

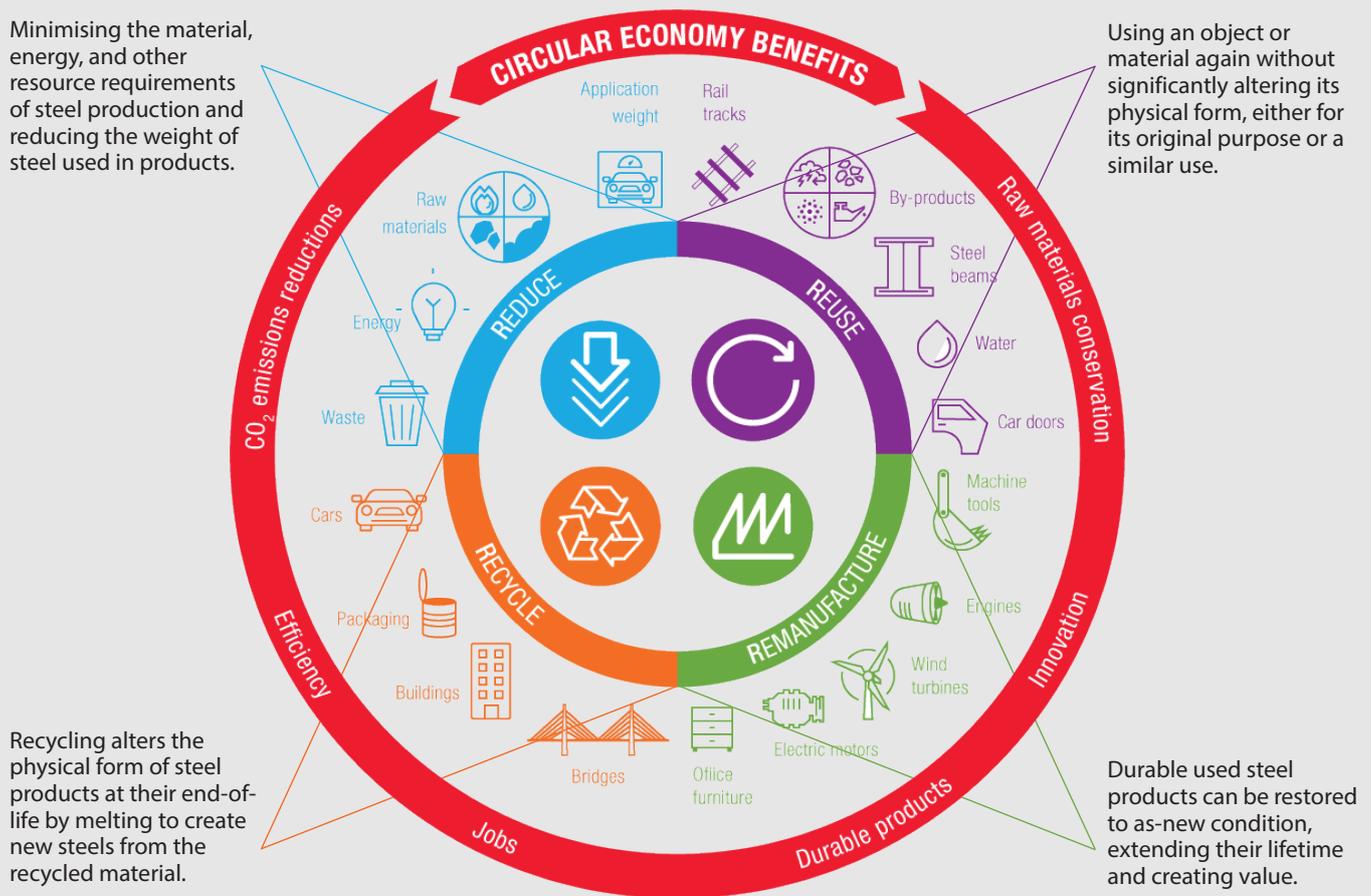
## Steel: a frontrunner in the circular economy transition

The current linear economic model of production and consumption is energy and resource intensive. Adopting a circular economy approach not only reduces resource use and waste, it generates significant economic benefits. With resource extraction and processing currently accounting for around half of global GHG emissions,<sup>48</sup> the circular economy framework is a key component of the transition to a low-carbon economy.

### Steel's circular economy opportunities

Steel's favourable mechanical properties and affordability mean it is the most widely used metal, largely as a construction and engineering material. The steel industry therefore has a central role to play in the circular economy transition. Four principal mechanisms are available to achieve circularity (see Figure 45), which also serve to significantly reduce the industry's carbon footprint.

**Figure 45: Circular economy opportunities in the steel sector**



Source: worldsteel<sup>49</sup>

The industry's efforts to reduce energy and resource intensity are already bearing fruit, with energy consumption in steel production having declined considerably since 1960. Meanwhile, increased use of high-strength steel over the past 50 years has led to a 25% - 40% reduction in the weight of many steel products, with associated advantages in terms of emissions reductions and reduced energy and raw material use.<sup>49</sup>

Steel has the advantage of being a durable material, meaning steel components are well-suited to remanufacturing and reuse. Considering remanufacturing and reuse early in the design phase of manufactured products is a key principle of the circular economy, ensuring that components can be easily disassembled and restored and that used products can be efficiently reprocessed for alternative uses at end-of-life.

By-products formed during steel production – primarily slags, dust, sludge, and process gases – can also be used in the manufacture of new products. On average, around 200kg and 400kg of by-products are typically produced per tonne of steel made via the electric arc furnace and blast furnace routes, respectively.<sup>50</sup> Primary uses for slag include cement and road construction (see Figure 46), while process gases can be used in heat and electricity production.

48. United Nations Environment Programme, 2019, Global Resources Outlook 2019: Natural Resources for the Future We Want

49. World Steel Association, 2016, Steel - The permanent material in the circular economy

50. World Steel Association, 2018, Steel industry co-products, position paper

Repurposing by-products has the advantages of minimising waste to landfill, reducing CO<sub>2</sub> emissions, and improving resource efficiency where by-products are used as a substitute for equivalent products. According to the World Steel Association, the steel industry has a global material efficiency rate of 96.3%, and is targeting the 100% efficient use of raw materials and zero waste.

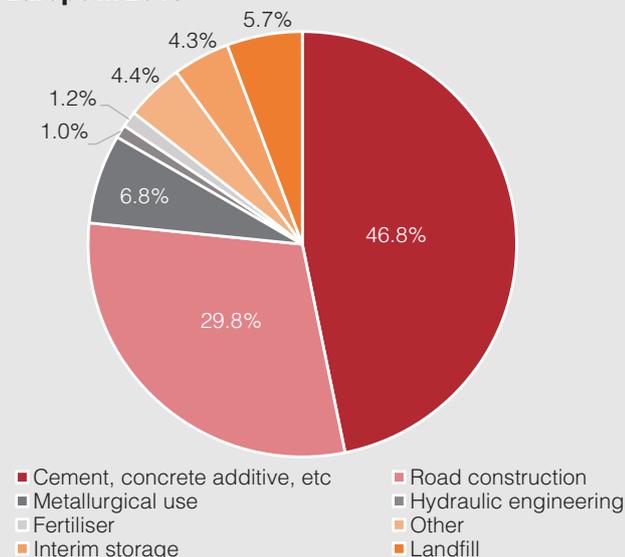
### Steel: the most recycled material globally

Steel can be repeatedly recycled while maintaining the intrinsic properties of the original steel, and its magnetism makes it easy and economically viable to recover from waste streams. These properties have led to steel being the world's most recycled material; each year around 650 million tonnes (Mt) are recycled, with an associated CO<sub>2</sub> emissions abatement of over 900 Mt.<sup>51</sup> Utilising secondary production circumvents the ore extraction and processing stages, meaning emissions associated with steel recycling are between 10% to 38% that of primary production.<sup>52</sup>

Globally, the steel industry has a recycling rate of 85%. The automotive and machinery sectors lead the way in terms of steel recovery, with rates estimated at 90% globally. These sectors are followed by construction (85%) and electrical and domestic appliances (50%).

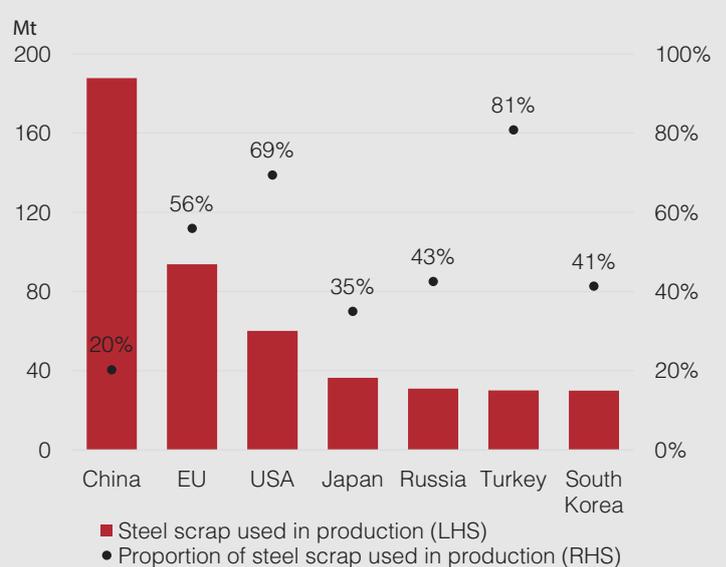
The use of scrap steel in production is on the rise. New steel products contain, on average, up to 37% recycled steel.<sup>53</sup> In 2018, steel scrap usage in countries and regions representing 81% of global steel production rose to 469 Mt – a 10% increase on 2017 – and accounted for almost 32% of annual steel production. As Figure 47 shows, Turkey had the highest proportion of scrap steel in total production – almost 70% of which was imported – followed by the USA and the EU.<sup>54</sup>

**Figure 46: Use of iron and steelmaking slags in Europe in 2016**



Source: The European Slag Association, 2017

**Figure 47: Steel scrap use for steelmaking by country**



Source: Bureau of International Recycling

### Not all plain sailing

Despite the range of opportunities available, the steel industry faces challenges in achieving a fully circular economy. Steel demand is expected to continue to rise over the next decade driven by population and economic growth, particularly in developing economies in Asia and Africa. Scrap-based recycled steel will be able to satisfy some of this demand growth. However, steel's use in applications with long lifetimes – the average lifetime for steel products is around 40 years – means the amount of scrap steel available will be insufficient to bridge the supply-demand gap.

Scrap availability is projected to reach around 1 billion tonnes globally in 2030.<sup>55</sup> But, with global steel production reaching 1.8 billion tonnes in 2018 and forecasts expecting this figure to rise in the medium term, steel manufacture from raw materials will continue to make a substantial contribution over the coming decades.

For the steel industry to fulfil its potential in advancing the circular economy and minimising its contribution to global emissions, scrap-based steel production will need to increasingly offset primary production. Achieving this goal will require improved collection and separation of steel products at end-of-life, while products must be designed to facilitate recycling into high-quality steel.<sup>56</sup> Currently, the mixing of alloys and other metals and materials, notably copper, during scrapping and collection results in high-quality steel being downgraded during the recycling process into lower quality products. Similarly, designing products for reuse, remanufacture and reducing resource requirements will need to become standard practice. Ultimately, collaboration throughout the whole value chain to maximise the value and lifetime of steel products will be crucial to achieve circularity.

51. World Steel Association, 2016, Steel - The permanent material in the circular economy

52. United Nations Environment Programme, 2019, Global Resources Outlook 2019: Natural Resources for the Future We Want

53. World Steel Association, 2018, Steel Facts

54. Bureau of International Recycling, 2019, World Steel Recycling in Figures 2014-2018

55. World Steel Association, 2018, The future of global scrap availability

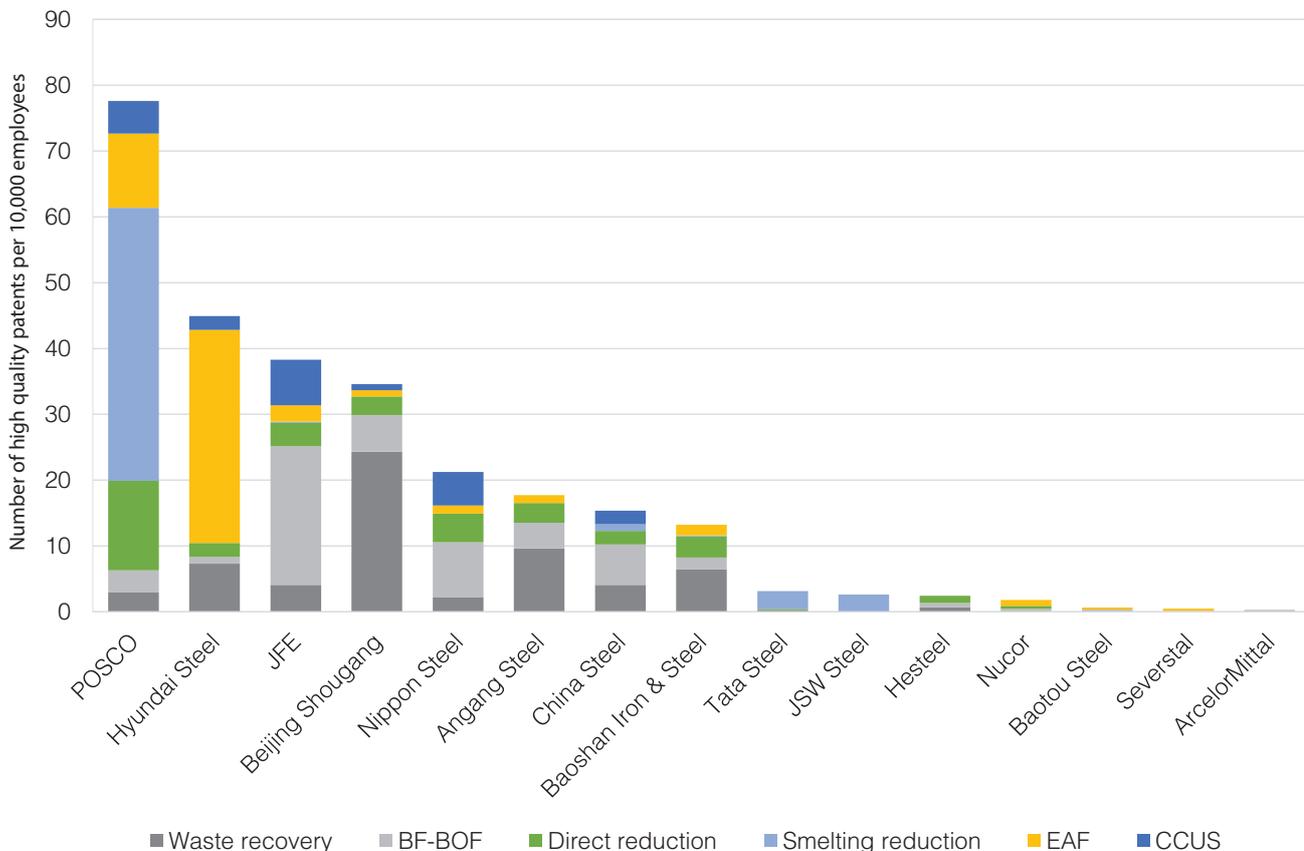
56. Energy Transitions Commission, 2018, Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century

## Patent analysis

We look at the number of high-quality patents filed between 2005 – Q2 2019, normalizing by average employee numbers during the timeframe and calculating a weighted score of the total patent count based on their carbon reduction potentials and jurisdictions in which patents are filed. We determine the quality of the patents based on the number of citations received in scholarly publications.

- ▼ POSCO is ranked first both before and after normalizing by employee numbers, with a large volume of patents filed for smelting reduction, especially the FINEX technology. POSCO also filed a significant number of patents for EAF facilities and CCS technologies. Hyundai Steel is ranked in second position overall with the majority of its patents relating to optimizing EAF processes.
- ▼ There is a regional disparity in the total number of patents filed by companies. Companies based in Asia, especially South Korea and Japan submitted a greater volume of patent applications than other companies over time.
- ▼ Five companies have patents filed in the CCUS category, including JFE Holdings, Nippon Steel, POSCO, Hyundai Steel and China Steel.
- ▼ JFE Holdings and Beijing Shougang rank third and fourth respectively. JFE Holdings has a good distribution of patents across the six categories, while Beijing Shougang has a large number of high-quality patents in waste recovery.

**Figure 48: High quality patents by technology theme (2005 - Q2 2019)**



Source: CDP, LENS.ORG

## Research and development

To measure the extent to which companies are investing in innovation we looked at R&D expenditures as a percentage of total sales.

- One of the TCFD recommendations is that companies should consider disclosing R&D expenditures for low-carbon alternatives and energy / water efficiencies. With new technologies emerging and increasing focus from companies on smart solutions to optimize production, companies should look to highlight the actions taken in these areas and present clear indicators of performance to investors.
- Across the sample, average R&D as a percentage of sales from 2016-2018 is relatively low for a sector that needs to innovate, at 0.86%.
- Five Chinese companies top the ranking in R&D expenditure. Hesteel ranks first with an R&D expenditure at 2.24%, followed by Baoshan Iron & Steel, Baotou Steel and Angang Steel.
- Five companies do not have any R&D expenditure.

**Figure 49: Research and development (R&D)**

Company	R&D / Net sales (2016-2018)
Hesteel	2.24%
Baoshan Iron & Steel	1.95%
Baotou Steel	1.71%
Angang Steel	1.54%
Beijing Shougang	1.49%
Nippon Steel	1.30%
JFE	1.00%
POSCO	0.89%
Hyundai Steel	0.69%
China Steel	0.62%
SSAB	0.49%
Tata Steel	0.42%
ArcelorMittal	0.40%
BlueScope Steel	0.23%
JSW Steel	0.05%

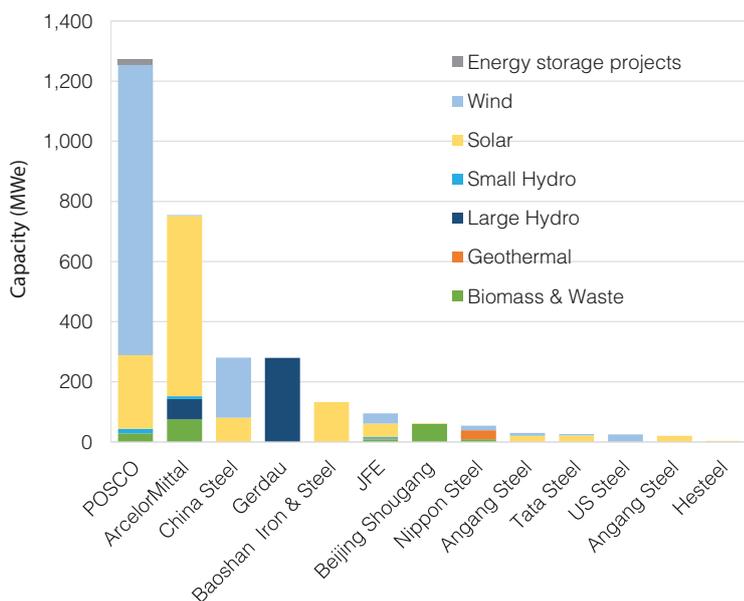
Source: CDP, company reports

## Renewable energy use

The integration and use of renewable energy into the steelmaking process provides companies with an opportunity to reduce emissions without significant changes to production process routes. We assess which companies currently operate or own renewable assets and identify companies that have set up Power Purchase Agreements to supply steelworks with renewable energy.

- Seven of the 20 companies have set up Power Purchase Agreements or Guarantees of Origin to attain renewable energy for steelmaking. 55% of companies also operate or own renewable energy facilities.
- The companies operate or own a combined renewable capacity of over 3000 MWe. POSCO is accountable for over 40% of all renewable capacity with a strong presence in wind and solar (see Figure 50).
- ArcelorMittal ranks first, with a number of renewable assets including 75MWe solar capacity. It has multiple PPAs to acquire solar and wind power and is actively exploring the potential for further PPAs to supply its steel plants.
- Five companies – Hyundai Steel, Baotou Steel, JSW Steel, NLMK and Severstal do not own or operate any renewable assets, or have a PPA to supply their steelworks with renewables.

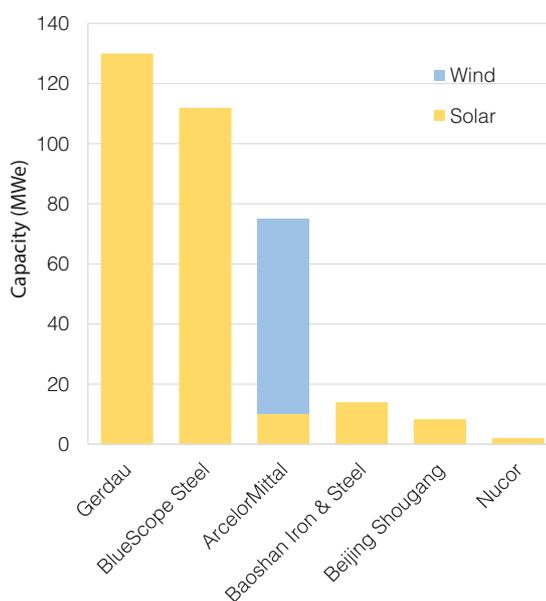
**Figure 50: Owned / operated renewable assets<sup>(i)</sup>**



(i) Only companies that operate or own renewable energy assets are shown. Capacities are shown on an absolute basis, but companies have been ranked relative to their steel production.

Source: CDP, company reports, BloombergNEF

**Figure 51: Power Purchase Agreements<sup>(i)</sup>**



(i) SSAB have Guarantees of Origin that mean at least 50% of the electricity it buys on the Nordic electricity market is derived from renewable energies.

Source: CDP, company reports, BloombergNEF

# Climate governance & strategy

- ▼ 60% of companies have set emissions reduction targets, yet only two companies are aligned with a 2°C or below emissions pathway.
- ▼ SSAB and ArcelorMittal rank first and second respectively. SSAB has set a long-term goal to reach carbon neutrality by 2045, while ArcelorMittal has set an ambition to reach carbon neutrality in its European operations by 2050.
- ▼ There is a significant geographical divide between the highest and lowest performing companies. European and East Asian companies rank in the top half, while companies in China, Russia and the U.S. perform poorly across all climate governance metrics.

## Overview

Post-Paris and following the recommendations from the Task Force on Climate-related Financial Disclosures (TCFD), the mandated disclosure on climate risks and opportunities is likely to become the business norm. There is a growing awareness of the need for all sectors to put in place climate-risk management strategies and enhanced disclosure for the benefit of investors and stakeholders.

The steel industry is increasingly subject to climate-related regulation and carbon prices across a number of jurisdictions. Therefore, companies that are strategically aligning themselves with low-carbon regulatory measures and incorporating the risks of climate change into their business strategies and long-term planning, are likely to be better positioned should regulations tighten.

In this section, we assess how companies are planning for a low-carbon future through aligning their governance structure with the associated risks and opportunities presented by the low-carbon transition. We rank companies on their mid to long-term emissions reduction targets and the utilisation of scenario analysis and internal carbon pricing. We also assess companies on the presence of climate experts on the board, the use of climate-related remuneration and those that have officially supported the TCFD and other climate-related organisations and initiatives.

In this chapter we assess companies on their climate governance and strategy using six key metrics:

**Metric 1) Targets and ambitions (50%):** We assess the strength of companies' emissions reduction targets and ambitions.

**Metric 2) Scenario analysis and internal carbon pricing (20%):** We look at which companies are conducting scenario analysis, using an internal carbon price and stress-testing their portfolios against a low-carbon energy transition.

**Metric 3) Climate-related remuneration (10%):** We assess alignment between climate-risk strategy performance and remuneration across long-term incentives and short-term annual bonus programs at the senior executive and board level as well as other practices at broader corporate levels.

**Metric 4) Board & executive climate management (10%):** Companies are assessed on a number of factors relating to board and executive climate responsibility performance including: the level of directors on the board with climate related experience, the presence of climate-related committees (at board and/or executive levels).

**Metric 5) TCFD and initiative support (5%):** We highlight the companies that have officially supported the TCFD, and which other climate-related organisations and initiatives companies are members of.

**Metric 6) CDP Score and disclosure (5%):** Companies are ranked based on their 2018 CDP Score. The CDP Score provides an aggregate measure of the quality of climate-related disclosure and management systems addressing climate risks.

**Figure 52: Climate governance & strategy summary**

Company	Targets & ambitions	Scenario analysis & internal carbon price	Climate-related remuneration	Board & executive climate management	TCFD & initiative support	CDP Score (2018)	Overall weighted rank	Transition risks rank
SSAB	1	5	1	16	7	C	4.37	1
ArcelorMittal	3	1	7	1	1	B	6.33	2
Tata Steel	3	2	3	4	2	B	6.94	3
Hyundai Steel	2	5	2	9	8	D	6.97	4
BlueScope Steel	5	2	10	2	3	F	9.09	5
Nippon Steel	6	2	7	14	4	B	9.46	6
China Steel	8	9	4	3	11	B	9.55	7
POSCO	8	5	4	12	6	B	9.95	8
JFE Holdings	6	8	6	16	4	D	10.53	9
JSW Steel	12	9	7	5	9	D	12.41	10
Severstal	10	11	10	10	9	Not scored	13.50	11
NLMK	11	11	10	8	17	F	14.04	12
Baoshan Iron & Steel	12	11	10	6	11	F	14.81	13
US Steel	12	11	10	12	16	F	15.23	14
Angang Steel	12	11	10	18	17	F	15.55	15
Hesteel	16	11	10	11	15	Not requested	16.38	16
Nucor	16	11	10	7	14	F	16.43	17
Gerdau	16	11	10	20	13	F	16.86	18
Baotou Steel	16	11	10	15	17	F	16.87	19
Beijing Shougang	16	11	10	18	20	F	17.18	20

**Weighting**                      **35%**                      **35%**                      **10%**                      **10%**                      **5%**                      **5%**

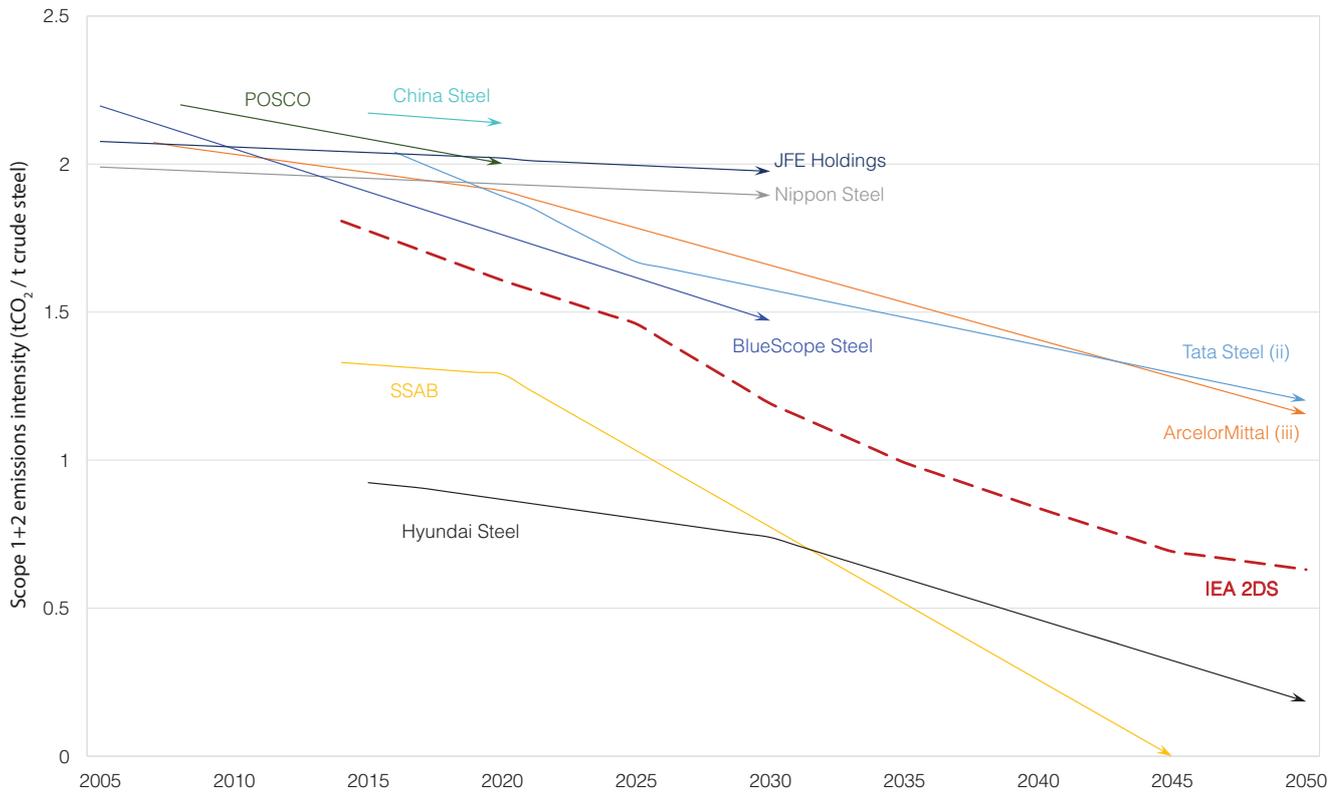
Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

## Targets and ambitions

- ▼ 60% of companies have set emissions reduction targets, yet only two companies are aligned with a 2°C or below emissions pathway.
- ▼ SSAB has set a goal to reach carbon neutrality by 2045 across its entire operations, while Hyundai Steel has targeted an 80% reduction in emissions by 2050.
- ▼ ArcelorMittal and Tata Steel have also set ambitions to become carbon neutral in their European operations by 2050.
- ▼ A number of company targets fall well below the levels required to align with the IEA 2DS (see Figure 53). POSCO and China Steel have set relatively unambitious short term targets out to 2020, while JSW Steel's emissions reduction target expired in 2018.
- ▼ Hesteel, Nucor, Gerdau, Baotou Steel and Beijing Shougang show no evidence of setting an emissions reduction target. US Steel intend to set an emissions reduction target before the end of 2019.

**Figure 53: Company emissions reduction targets and ambitions<sup>(i) (iv)</sup>**



(i) Target trajectories illustrate pathways from base year to target year emissions intensities. Therefore trajectories shown for companies to 2018 will differ from actual historical values, dependent on companies' performance relative to their targets.

(ii) Tata Steel's target pathway is calculated by combining Tata Steel's goal of <2 tCO<sub>2</sub>/tcs emissions intensity by 2025 for its Indian operations and Tata Steel Europe's ambition to be a carbon-neutral steelmaker by 2050.

(iii) ArcelorMittal's target pathway is calculated using its corporate target out to 2020 and then its ambition to achieve carbon neutrality in its European operations by 2050. We note that in 2020 the company is planning to set a 2030 reduction target.

(iv) NLMK says it will ensure that specific emissions remain below the industry average. Severstal target reducing emissions from 2.1 to 1.85 (tCO<sub>2</sub> / t molten steel) at its main Cherepovets Steel Mill, JSW Steel's target expired in 2018, US steel is looking to set a target by the end of 2019, Angang Steel has a target which is not publicly disclosed, and Baoshan Iron & Steel disclose that by the end of 2020 emissions levels will reach the ultra-low emission standards.

Companies that have not set a corporate emissions reduction target include: Beijing Shougang, Gerdau, Hesteel, Inner Mongolia Baotou Steel, and Nucor.

Source: CDP, company reports

## Scenario analysis and internal carbon pricing

- ▼ Ten companies are conducting scenario analysis to assess the impact of climate change on their business strategies. However, only two companies ArcelorMittal and BlueScope Steel, have developed their own company scenarios in line with TCFD recommendations.
- ▼ Seven companies have incorporated internal carbon pricing into their decision-making. Across the sample, carbon prices used range from \$10-45 per tonne.
- ▼ ArcelorMittal has developed four policy scenarios to understand financial implications of climate change and evaluated the impact of EU ETS Phase 4 against two different carbon price scenarios. BlueScope Steel has developed three company scenarios to assess the impact of climate change and is factoring a shadow carbon price into its decision-making for large scale investments in carbon-intensive assets or carbon reduction technologies.

**Figure 54: Scenario analysis summary**

Company	Low-carbon scenario(s) used	Company scenarios	Multiple carbon prices used	Carbon price(s) used (US\$/tonne CO <sub>2</sub> )	Rank
ArcelorMittal	Company - Accelerate Globally	Four policy scenarios are developed to understand financial implications and inform policy positions: Stagnate, Wait, Accelerate-regionally, Accelerate-globally	Yes. Evaluated the impact of EU ETS phase 4 against a carbon price of €15 per tonne of CO <sub>2</sub> and a forecast price of €25 per tonne of CO <sub>2</sub>	18 30	1
BlueScope Steel	Company - Global Cooperation IEA 2DS	Three company scenarios: Global Cooperation, Runaway Climate Change, Patchy Progress	No	Yes - Price not disclosed	2
Tata Steel	NDCs	No	Yes. Shadow price is fixed at US\$15 per tonnes of CO <sub>2</sub> e and variable prices are used for short-term (US\$10/tonne) and long-term (US\$34/tonne) planning	10 15 34	2
Nippon Steel	NDCs	No, but anticipate doing so in the next two years	No	45	2
Hyundai Steel	NDCs	No	No	20	5
POSCO	NDCs	No	No	20	5
SSAB	NDCs	No	No	18	5
JFE Holdings	NDCs	Data from the Meteorological Agency is used to evaluate risks of abnormal climate	Not disclosed	-	8
China Steel	NDCs	No	Not disclosed	-	9
JSW Steel	NDCs	No	Not disclosed	-	9
Severstal	Not disclosed	No	Not disclosed	-	11
Gerdau	Not disclosed	No	Not disclosed	-	11
Angang Steel	Not disclosed	No	Not disclosed	-	11
Baoshan Iron & Steel	Not disclosed	No	Not disclosed	-	11
Nucor	Not disclosed	No	Not disclosed	-	11
US Steel	Not disclosed	No	Not disclosed	-	11
Baotou Steel	Not disclosed	No	Not disclosed	-	11
Beijing Shougang	Not disclosed	No	Not disclosed	-	11
NLMK	Not disclosed	No	Not disclosed	-	11
Hesteel	Not disclosed	No	Not disclosed	-	11

Source: CDP, company reports

## Climate-related remuneration

- Only nine companies show evidence of some form of climate-related remuneration across short-term bonus programs and incentives at broader corporate-level. None of the companies have long-term climate-related incentives (see Figure 55).
- SSAB is ranked in first position with short-term incentives related to environmental targets for relevant senior executives and bonuses linked to climate KPIs for selected employees. Hyundai Steel ranks second and provides a short-term incentive linked to GHG emission and energy reduction targets for the CEO. Tata Steel, China Steel and

POSCO are ranked third, fourth and fifth respectively with selected sub-executive managers' annual bonuses linked to GHG and energy reduction targets.

- ArcelorMittal, JFE Holdings, Nippon Steel and JSW Steel all have company-wide programs to reward individuals or groups who contribute to enhancing the companies' environmental performances, including GHG emissions reduction and energy efficiency improvements. Rankings mainly depend on levels of relevance of the program to climate risk mitigation.

**Figure 55: Climate related remuneration<sup>(i)</sup>**

Company	Short-term incentive	Long-term incentive	Corporate-level incentive	Description	Rank
SSAB	✓	✗	✓	Selected senior executives have environmental targets linked to their STIs. The company also links sustainability and climate KPIs to remuneration for selected employees.	1
Hyundai Steel	✓	✗	✗	CEO is rewarded with a monetary bonus of a 2% reduction in GHG emissions compared to base year (2015) is achieved each year. The remuneration varies according to the achievement level of the GHG emission reduction each year.	2
Tata Steel	✗	✗	✓	The Vice President of Safety, Health & Sustainability is driving the CO <sub>2</sub> reduction agenda on behalf of CEO & MD. The VP's individual compensation is linked to the performance of achieving the Business Objectives including achieving "benchmark in CO <sub>2</sub> emission". Climate-related target covers 25% of the performance KPIs.	3
China Steel	✗	✗	✓	Managers receive a monetary bonus if they successfully complete a large-scale emission reduction project or develop energy saving technologies. Employees are rewarded with a monetary bonus if they propose emission reduction projects which can create carbon credits and get approved by the Taiwan EPA.	4
POSCO	✗	✗	✓	Head of Energy and Environment Business Department is rewarded with an increase in annual salary if the GHG emission reduction target is achieved. POSCO Family Environment Management Award is given to departments and individuals who have made significant contributions towards POSCO's environmental mission, vision and goals such as reducing greenhouse gas emissions and improving energy efficiency.	4
JFE Holdings	✗	✗	✓	"JFE Steel President's Award" is given to an organisation or a team who successfully contributes to the company's technology development or process improvement including reducing GHG emissions and developing climate change-related businesses and services.	6
ArcelorMittal	✗	✗	✓	"Performance Excellence Awards" are given to the "best in class" individuals or departments across several categories including Environment and Corporate Responsibility. ArcelorMittal also recognizes the impact of carbon emissions on EBITDA, FCF and EPS as the company will have to purchase EU ETS credits to cover shortfalls in carbon emission reductions. These three KPIs are directly linked to CEO and CFO's STI and LTI.	7
Nippon Steel	✗	✗	✓	"Invention Improvement Achievement Award" is given to an individual or group who significantly improves the energy efficiency of the iron-making process or at the time of using the products.	7
JSW Steel	✗	✗	✓	Employees are rewarded for contributing to JSW Steel's environmental management, including resource saving, water saving, pollution control and waste management.	7

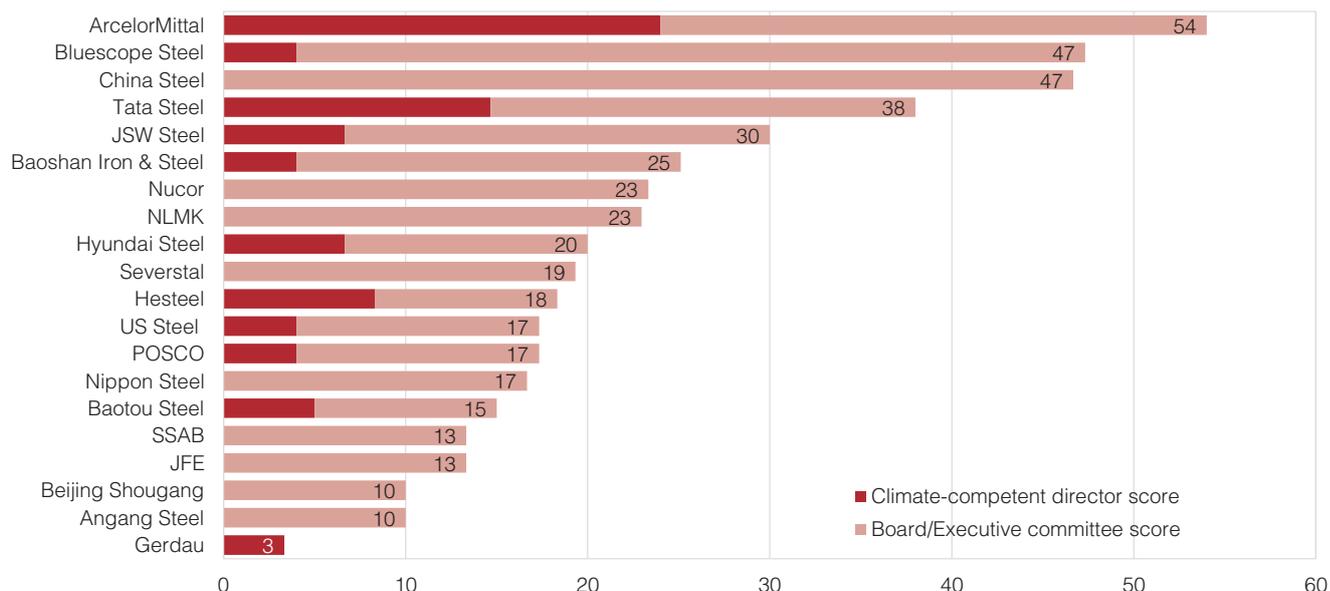
(i) Angang Steel, Baoshan Iron & Steel, Beijing Shougang, BlueScope Steel, Gerdau, Hesteel, Inner Mongolia Baotou Steel, NLMK, Nucor, Severstal and US Steel do not disclose any information suggesting that climate-risk management is linked to executive or sub-executive pay.

Source: CDP, company reports

## Board and executive climate management

- ▾ ArcelorMittal is ranked first with three individuals on the board judged to have climate related experience (see Figure 56). In addition, ArcelorMittal has a sustainability committee at board level overseeing the company's sustainability issues and low-carbon transition strategies with 100% of committee members being independent directors.
- ▾ Gerdau is ranked last. It is the only company not to have a climate-related committee at either board- or executive-level.
- ▾ BlueScope Steel and China Steel are ranked second and third overall and are the two of only four companies which have climate- or sustainability related committees on both board- and executive-level.
- ▾ The two India-based companies, Tata Steel and JSW Steel are ranked fourth and fifth with a number of individuals at board-level judged to have climate related experience and a Corporate Responsibility & Sustainability committee at board level in each company.

**Figure 56: Board & executive climate management<sup>(i)</sup>**



(i) Scored out of 100 where companies with higher scores receive higher rankings.  
Source: CDP, company reports

## TCFD and climate initiative support

▼ ArcelorMittal, Tata Steel and BlueScope Steel rank in the top three. All three officially support the TCFD and both ArcelorMittal and BlueScope Steel are members of ResponsibleSteel™ (see box on page 44 for further detail).

- ▼ All companies within the sample are members of worldsteel, with 14 companies also part of worldsteel’s Climate Action Programme.
- ▼ Only five companies have officially supported the TCFD and seven companies are participants in the United Nations Global Compact.

**Figure 57: TCFD and climate initiative support summary**

Company	TCFD	worldsteel	worldsteel Climate Action Programme <sup>(i)</sup>	ResponsibleSteel™	United Nations Global Compact	Membership of other organisations / initiatives <sup>(ii)</sup>	Rank
ArcelorMittal	✓	✓	✓**	✓	✓	✓	1
Tata Steel	✓	✓	✓**	✗	✓	✓	2
BlueScope Steel	✓	✓	✓**	✓	✗	✓	3
JFE Holdings	✓	✓	✓**	✗	✗	✗	4
Nippon Steel	✓	✓	✓**	✗	✗	✗	4
POSCO	✗	✓	✓**	✗	✓	✓	6
SSAB	✗	✓	✓**	✗	✓	✓	7
Hyundai Steel	✗	✓	✓*	✗	✓	✗	8
JSW Steel	✗	✓	✓	✗	✗	✗	9
Severstal	✗	✓	✓	✗	✓	✗	9
Baoshan Iron & Steel	✗	✓	✗	✗	✓	✗	11
China Steel	✗	✓	✓**	✗	✗	✓	11
Gerdau	✗	✓	✓*	✗	✗	✗	13
Nucor	✗	✓	✓**	✗	✗	✗	14
Hesteel	✗	✓	✗	✗	✗	✗	15
US Steel	✗	✓	✓	✗	✗	✗	16
Angang Steel	✗	✓	✗	✗	✗	✗	17
Baotou Steel	✗	✓	✗	✗	✗	✗	17
NLMK	✗	✓	✗	✗	✗	✗	17
Beijing Shougang	✗	✓	✗	✗	✗	✗	20

(i) Companies with two asterisks (\*\*) have contributed to the CO<sub>2</sub> data collection programme for at least 10 consecutive years. Those with one asterisk (\*) have contributed for at least 5 consecutive years.

(ii) Other organisations / initiatives include: Low Carbon Technology Partnerships, Carbon Pricing Leadership coalition, Responsible Minerals Initiative, IRMA, 2050 Pathways, ULCOS, BAFWAC, Responsible Corporate Engagement in Climate Policy, worldsteel Sustainable Development Charter and others.

Source: CDP, company reports

## Introduction to ResponsibleSteel™

ResponsibleSteel™ is a global, multi-stakeholder, not-for-profit standard and certification initiative for the responsible sourcing and production of steel.

Its vision is that steel's contribution to a sustainable society is maximised. Its mission is to enhance the responsible sourcing, production, use and recycling of steel by:

- ▼ Providing a multi-stakeholder forum to build trust and achieve consensus;
- ▼ Developing standards, certification and related tools;
- ▼ Driving positive change through the recognition and use of responsible steel.

More than 90% of all the metal produced every year is steel. In addition, 20% of all tin and tungsten, 60% of all nickel and zinc, 75% of chromium and 85% of manganese and vanadium are used for steel coatings and alloys. More than 600 million tons of metallurgical coal is mined every year for steelmaking.

The ResponsibleSteel™ standards system will cover both the sourcing of raw materials used for steelmaking including iron ore, metallurgical coal, scrap metal and charcoal, and the production of steel. ResponsibleSteel™ will not certify raw material suppliers itself, but will recognise materials assured under existing initiatives such as those of the Initiative for Responsible Mining Assurance (IRMA), and the Mining Association of Canada's Towards Sustainable Mining programme.

The ResponsibleSteel™ standard, currently under development, addresses: Corporate Leadership; Social, Environmental and Governance Management Systems; Occupational and Community Health and Safety; Labour Rights; Human Rights; Local Communities; Stakeholder Engagement and Communication; Climate Change and Greenhouse Gas Emissions; Noise, Emissions, Effluents and Waste; Water Stewardship; Biodiversity; Decommissioning and Closure.

The draft standard requires that companies that wish to benefit from ResponsibleSteel™ certification of their sites must be committed, at the corporate level, to the goals of the Paris Agreement. In line with the agreement's reference to financial flows, the standard requires that such companies implement the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD).

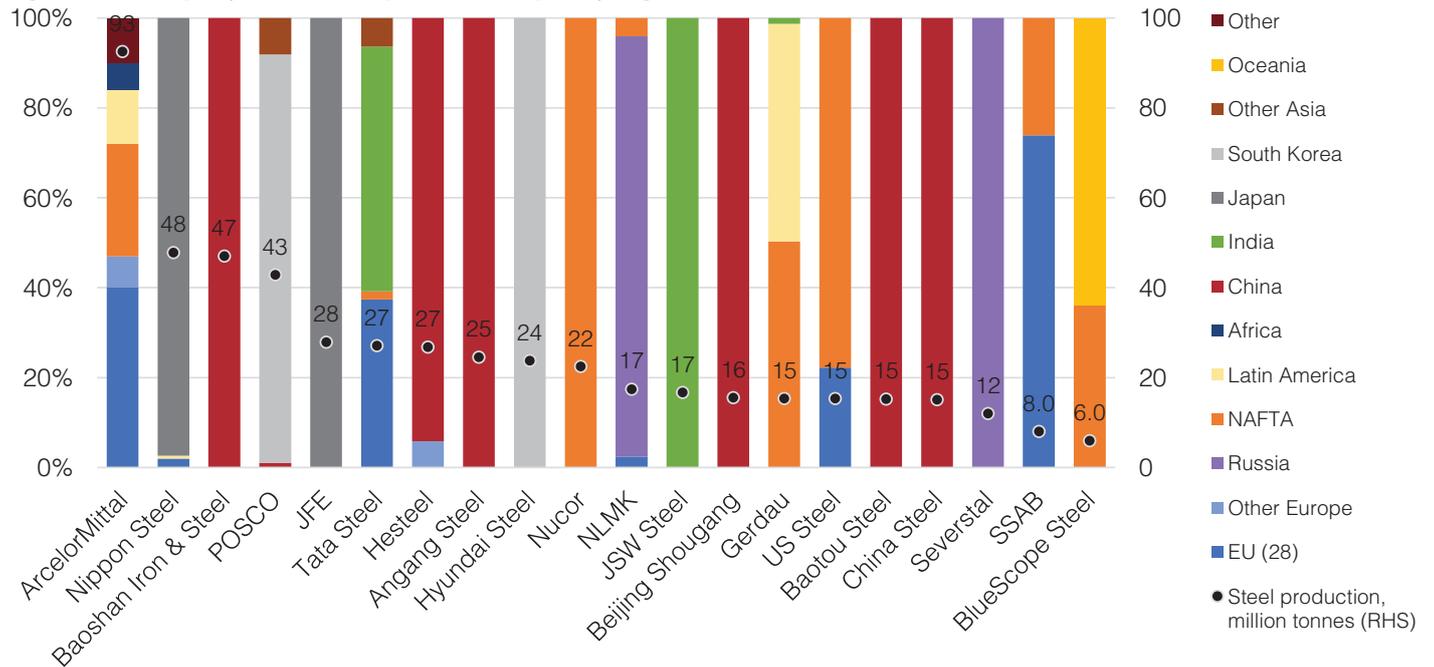
At the site level, the standard specific to 'Climate Change and Greenhouse Gas Emissions' focusses first on the consistent measurement, reporting, and disclosure of greenhouse gas emissions, following the applicable ISO standard 14404 developed with the support of the World Steel Association for application to the steel sector. It then requires that sites set their own internal goals to reduce greenhouse gas emissions, and have credible plans in place to achieve these goals. Finally, it provides the basis for markets to recognise and reward sites that achieve low emissions, by requiring that their emissions data are made available to customers on a clear and consistent basis, allowing meaningful comparisons and choices to be made between steel produced at different sites. By doing so, the standard aims to create market advantage for steelmakers who show leadership at the corporate and site levels in addressing the critical issue of climate change.

ResponsibleSteel's current membership includes: ArcelorMittal, BlueScope Steel, voestalpine, Aperam, BMW, Daimler and HSBC on the business side, and IndustriALL, IUCN, Fauna and Flora International, CDP, Mighty Earth, The Climate Group and the We Mean Business Coalition on the civil society side.

It expects to finalise and submit its standard for membership approval in October 2019, and operationalise its assurance programme for steelmaking site certification by the end of the year.

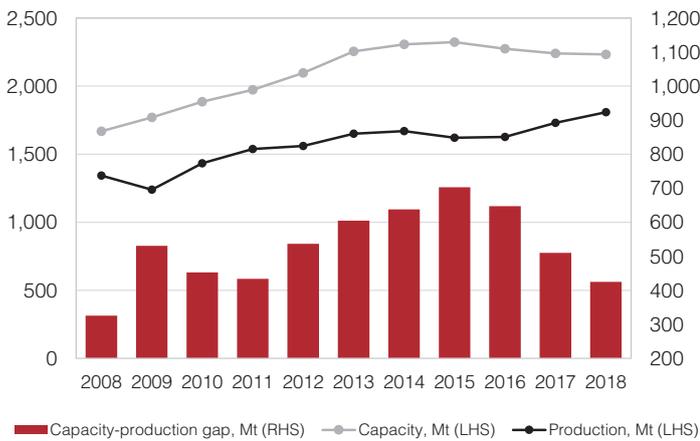
# Supplementary figures

**Figure 58: Company crude steel production split by region (2018)**



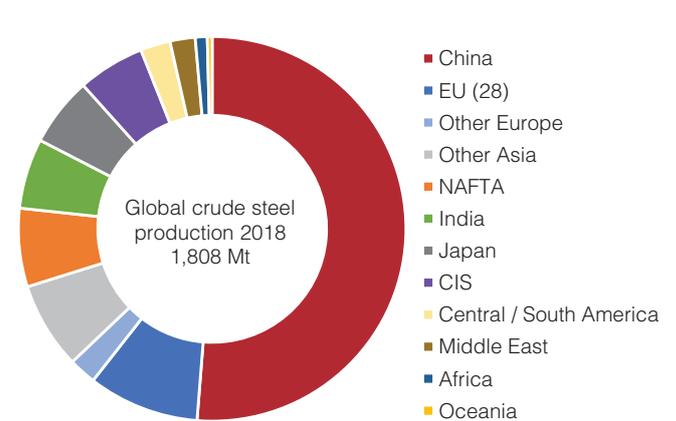
Source: CDP, company reports, PLANTFACTS

**Figure 59: Global crude steel capacity vs. production**



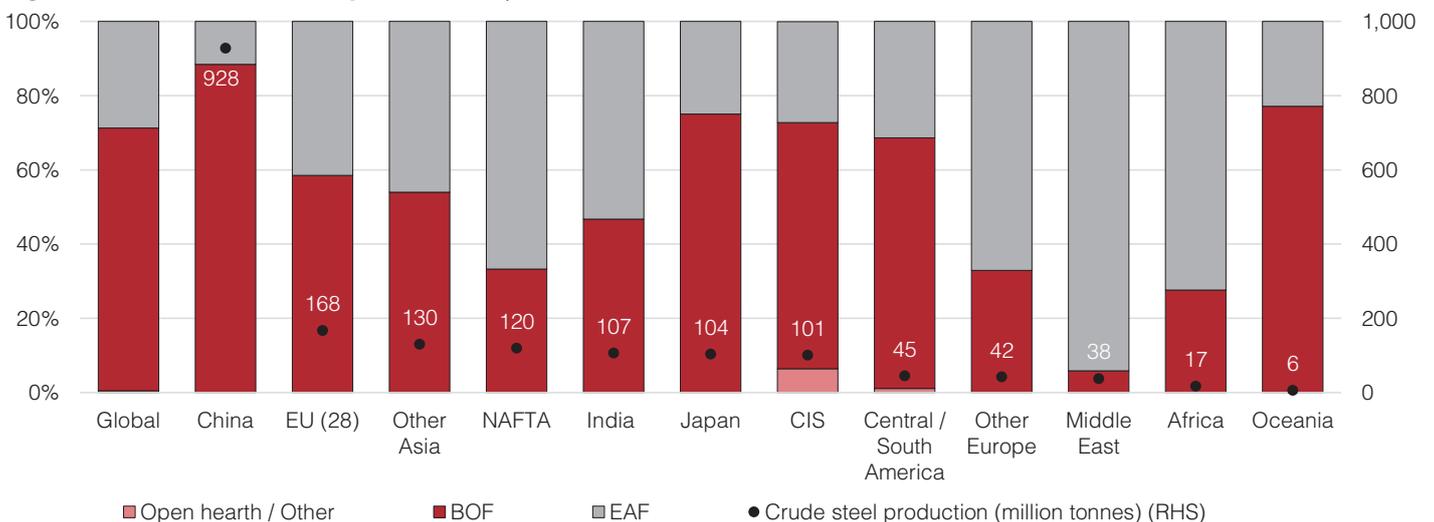
Source: CDP, OECD

**Figure 60: Global crude steel production by region**



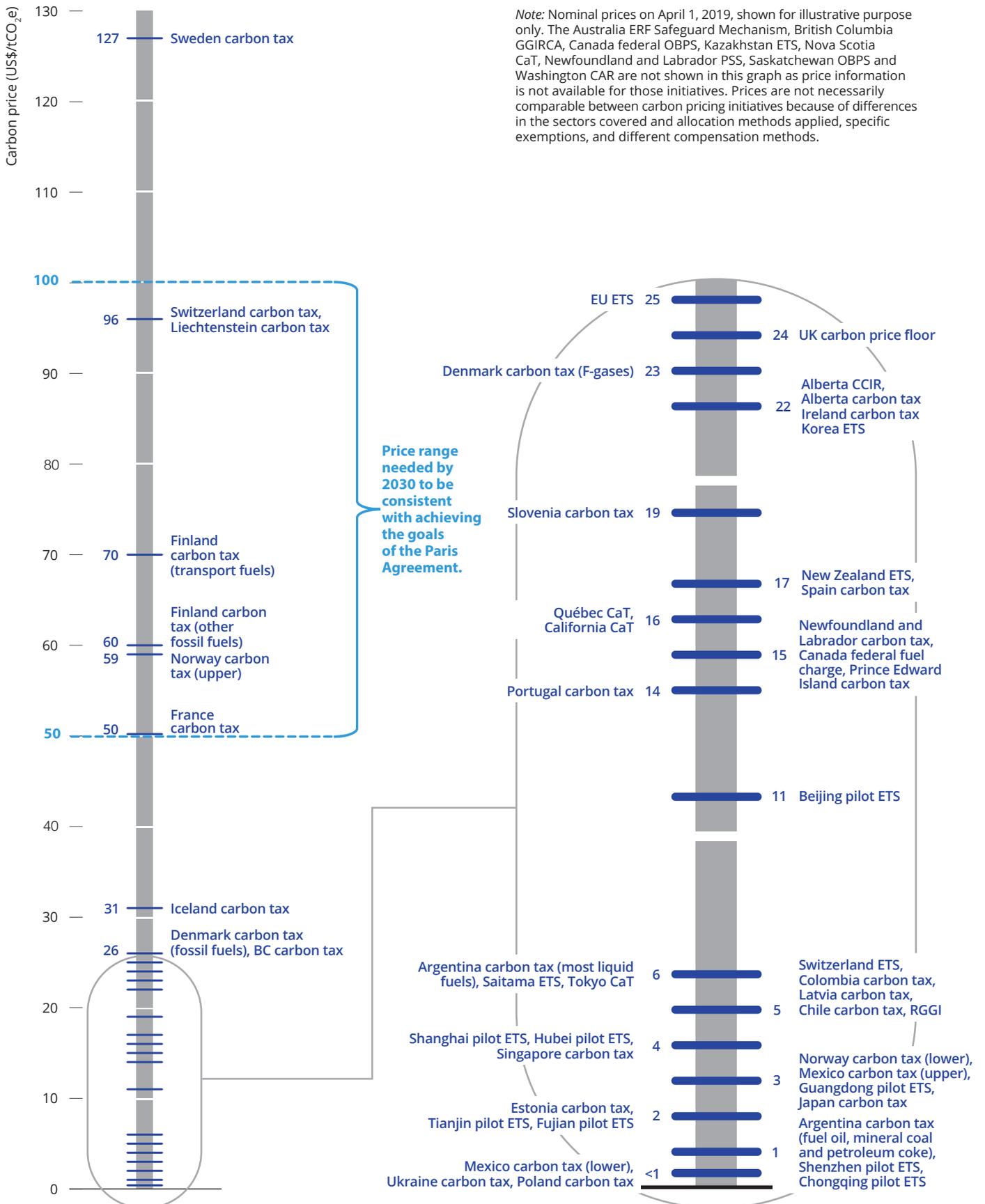
Source: CDP, worldsteel

**Figure 61: Global crude steel production by route (2018)**



Source: CDP, worldsteel

**Figure 62: Prices in implemented carbon pricing initiatives**



Source: World Bank, "States and Trends of Carbon Pricing 2019"

# Appendix I: Company engagement traffic light system

League Table rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Weighting
Companies	SSAB	ArcelorMittal	Hyundai Steel	Tata Steel	POSCO	JFE Holdings	Nippon Steel	BlueScope Steel	China Steel	JSW Steel	Beaohan Iron & Steel	Nucor	Severstal	Gerdau	NLMK	Angang Steel	Hesteel	Bailing Shougang	US Steel	Baoou Steel	Metric Area
<b>Transition risks rank</b>																					30%
Emissions intensity	3	10	1	8	6	11	13	2	9	14	15	4	5	7	12	20	17	19	18	16	35%
Energy intensity	5	10	1	8	7	11	13	3	14	18	15	2	6	4	9	20	19	17	12	16	35%
Data transparency	3	15	2	14	9	11	13	1	12	19	8	4	6	5	10	18	17	16	20	7	10%
Scope 3 reporting	9	1	4	3	4	4	8	10	4	1	15	12	10	19	13	18	15	19	14	15	10%
Capital flexibility	6	3	8	2	7	4	9	10	1	5	10	10	10	10	10	10	10	10	10	10	10%
	11	9	16	12	7	20	19	4	8	3	5	6	2	13	1	10	17	18	15	14	10%
<b>Physical risks rank</b>																					10%
Water stress exposure	6	10	3	4	8	2	5	7	1	14	11	16	9	15	13	12	17	20	19	18	50%
Water consumption intensity	4	10	1	7	13	5	3	8	1	17	9	12	6	11	14	16	20	18	15	19	25%
Water governance & policy	15	14	4	7	10	9	15	3	13	8	6	15	11	15	12	1	2	15	15	5	25%
	8	5	8	4	2	1	6	11	3	8	13	18	11	18	7	13	17	13	20	13	25%
<b>Transition opportunities rank</b>																					30%
Low-carbon innovation	2	1	9	6	3	4	5	16	11	8	7	14	20	12	19	13	15	10	17	18	60%
Circular innovation	2	1	9	3	5	4	6	14	10	7	8	11	19	11	18	15	17	11	16	19	10%
Patent analysis	3	3	14	8	3	1	2	11	18	6	6	10	14	8	14	11	14	18	13	18	10%
R&D	16	15	2	9	1	3	5	16	6	11	8	10	13	16	16	7	12	4	16	14	10%
Renewable energy use	11	13	9	12	8	7	6	14	10	15	2	16	16	16	15	4	1	5	16	3	10%
	8	1	16	12	4	6	10	11	7	16	3	13	16	2	16	14	15	5	8	16	10%
<b>Climate governance &amp; strategy rank</b>																					30%
Targets & ambitions	1	2	4	3	8	9	6	5	7	10	13	17	11	18	12	15	16	20	14	19	50%
Scenario analysis & internal carbon price	1	3	2	3	8	6	6	5	8	12	12	16	10	16	11	12	16	16	12	16	20%
Climate-related remuneration	5	1	5	2	5	8	2	2	9	9	11	11	11	11	11	11	11	11	11	11	10%
Board & executive climate management	1	7	2	3	4	6	7	10	4	7	10	10	10	10	10	10	10	10	10	10	10%
TCFD & initiative support	16	1	9	4	12	16	14	2	3	5	6	7	10	20	8	18	11	18	12	15	10%
CDP Score (2018)	7	1	8	2	6	4	4	3	11	9	11	14	9	13	17	17	15	20	16	17	5%
	6	2	7	3	4	7	5	13	1	9	13	13	10	12	13	13	11	13	13	13	5%
<b>Total</b>																					
Green	7	8	7	7	5	4	5	5	6	1	2	2	2	3	1	1	2	0	0	1	
Yellow	4	4	5	7	9	10	5	5	3	5	7	4	4	2	2	2	0	3	0	2	
Orange	6	7	5	5	5	4	7	4	9	9	5	5	7	3	7	7	8	3	7	5	
Red	2	0	2	0	0	1	2	5	1	4	5	8	6	11	9	9	9	13	12	11	

Note: weighted ranks are calculated for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

This heat map is designed to help investors pinpoint priority areas for engagement.

Green = good performance  
 Yellow = reasonable performance  
 Orange = monitor performance, possible concern  
 Red = area of concern, engage with company

We have not assigned a uniform number of green, yellow, orange and red colours across the metrics according to rank. Instead, we have reviewed the results of each metric in detail and assigned the above colours according to the underlying values for each metric.

# Appendix II: Company summaries

## Baotou Steel<sup>(i)</sup>

Average market cap 2018: US\$ 13 bn  
 Free-Float: 32.9 %  
 Steel production 2018: 15 million tonnes  
 Revenue 2018: US\$ 10 bn

Revenue split by business area (%)



Country: China

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
600010 CH	20 / 20	16	18	18	19

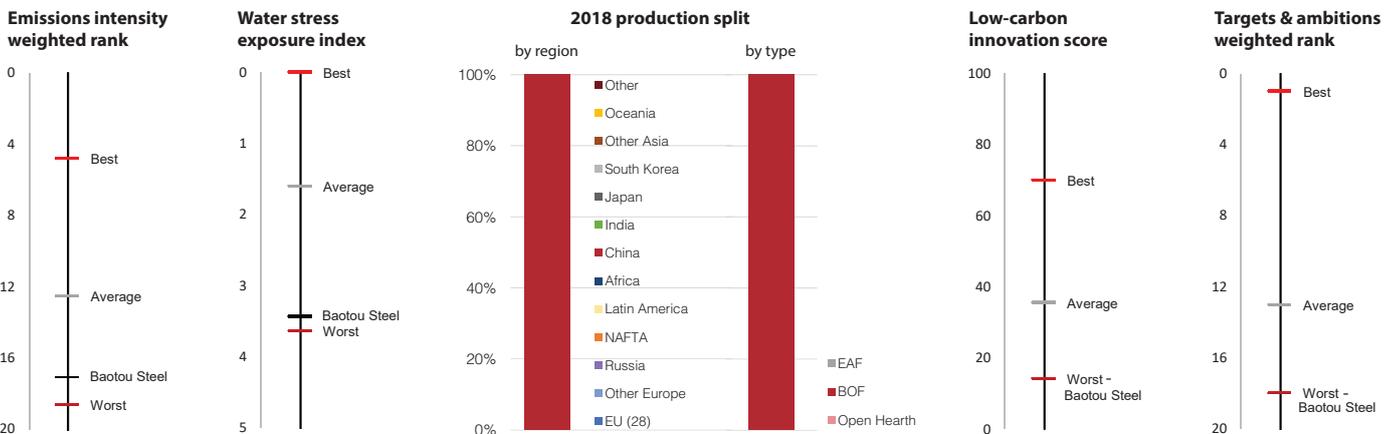
### Company strengths

- ▼ The company ranks seventh in energy consumption, reducing its energy intensity by 0.7% p.a. since 2013.
- ▼ Ranks fifth in water consumption, with an intensity below the group average and a reduction rate at 6.1% p.a. since 2013.
- ▼ Ranks third in R&D with an average R&D spend of 1.71%. It also signed a contract with Shougang Group in 2017 to build a demonstration LanzaTech plant with a capacity of 45,000 tonnes of ethanol per year.

### Company Weaknesses

- ▼ Disclosure of data remains an issue for the company. It does not disclose on Scopes 1-3 emissions and has limited disclosure of water related issues.
- ▼ 100% of its steelmaking capacity is located in high water stressed areas in China.
- ▼ Ranks third last for transition opportunities. The company shows little evidence of low-carbon innovation beyond LanzaTech and does not have any installed renewable energy capacity.
- ▼ Ranks second last for climate governance. It has not set a corporate emissions reduction target and shows no evidence of using scenario analysis, an internal carbon price or climate-related remuneration.

(i) Inner Mongolia Baotou Steel is the listed arm of state-owned Baotou Iron and Steel Group.



## US Steel

Average market cap 2018: US\$ 5.8 bn  
 Free-Float: 98.9 %  
 Steel production 2018: 15 million tonnes  
 Revenue 2018: US\$ 14 bn

Revenue split by business area (%)



Country: USA

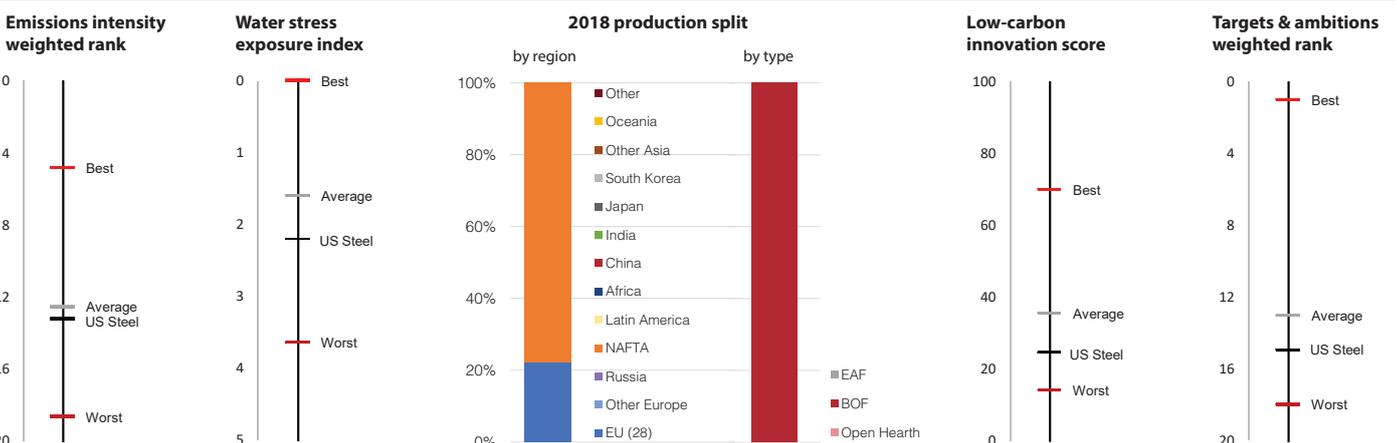
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
X US	19 / 20	18	19	17	14

### Company strengths

- ▼ In February 2019, US Steel restarted the construction of a technologically advanced EAF steelmaking facility at its Fairfield plant in Alabama. The EAF will have an annual capacity of 1.6 Mt, with production expected in the second half of 2020.
- ▼ The company has a board-level climate-related committee and a board member considered to have some climate expertise, ranking joint 12th for board-level climate expertise.
- ▼ None of US Steel's onshore facilities are considered to be located in areas of high water stress risk.

### Company Weaknesses

- ▼ Ranks third last in transition risks. Has the highest energy intensity of the group at 28 GJ/tonne. Only reports on Scope 1 emissions and has an above average emissions intensity.
- ▼ Rank 17th in transition opportunities. This reflects the limited implementation of innovative technologies, with the majority of initiatives providing only marginal decarbonization impacts. It does not publish an R&D figure and has no patents filed in low-carbon innovations.
- ▼ Shows no evidence of using scenario analysis, an internal carbon price or climate-related remuneration, though is committed to introducing a GHG emissions reduction goal by the end of 2019.



# Beijing Shougang<sup>(i)</sup>

Average market cap 2018: US\$ 3.6 bn  
 Free-Float: 13.4 %  
 Steel production 2018: 16 million tonnes  
 Revenue 2018: US\$ 10 bn

Revenue split by business area (%)



Country: China

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
000959 CH	18 / 20	19	20	10	20

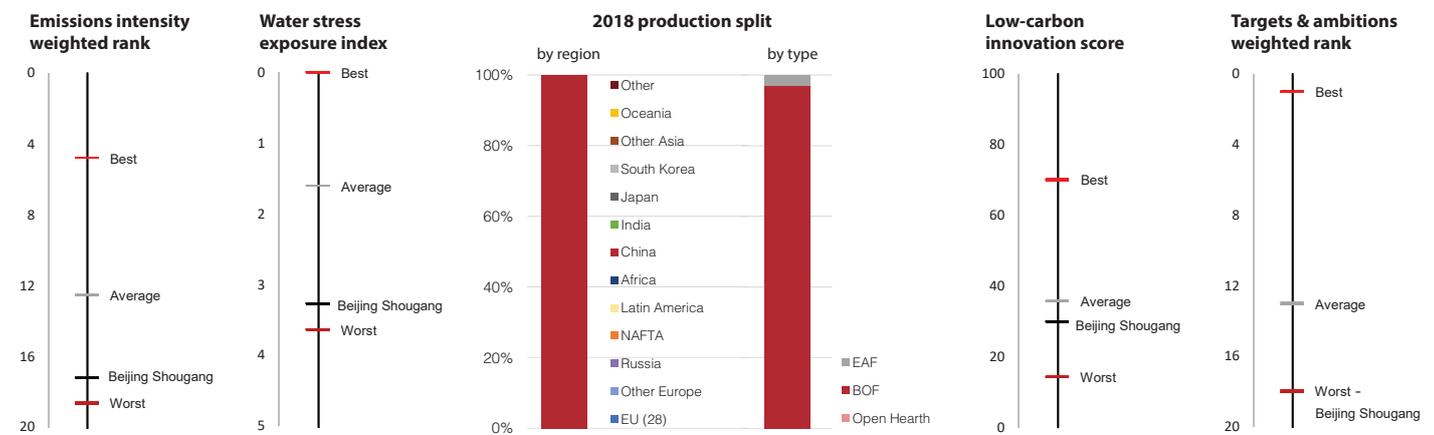
## Company strengths

- Shougang has the world's first commercial LanzaTech facility, producing 16 million gallons of bioethanol per year.
- The company ranks fourth in the patent analysis with patents filed in waste recovery and circularity and fifth in R&D with an average R&D spend of 1.49%.
- Ranks fifth in renewable energy, reflecting its ownership and operation of a relatively large biofuel capacity, as well as a PPA with solar power providers.

## Company Weaknesses

- Data disclosure is a major issue for the company. It does not disclose any emissions or energy data and has the fourth largest emissions intensity.
- Shougang ranks last in physical risks. The company is exposed to high water stress with all its steelmaking capacity located in inland areas in China and approximately 78% of the capacity at high to extremely high water risk. It does not disclose any water consumption data.
- The company ranks last for climate governance & strategy. It has not set a corporate emissions reduction target and shows no evidence of using scenario analysis, an internal carbon price or climate-related remuneration.

(i) Beijing Shougang is the listed arm of state-owned Shougang Group.



# Hesteel<sup>(i)</sup>

Average market cap 2018: US\$ 5.3 bn  
 Free-Float: 32.9 %  
 Steel production 2018: 27 million tonnes  
 Revenue 2018: US\$ 18 bn

Revenue split by business area (%)



Country: China

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
000709 CH	17 / 20	17	17	15	16

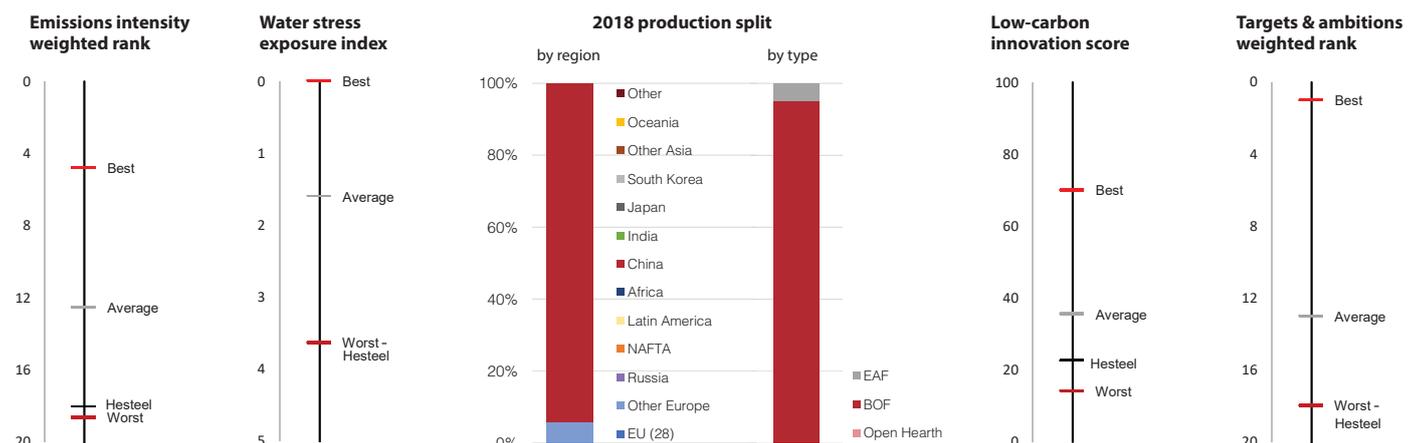
## Company strengths

- Ranks first in R&D with an average R&D spend of 2.24%.
- Ranks second in water consumption. It has the lowest water consumption intensity (2.3 m<sup>3</sup>/tonne) and the second highest reduction rate at 8.1% p.a. over the 2013-2016 period.
- Ranks 12th in patent analysis and 14th in circular innovation, indicating the company's effort in reducing environmental impacts and improving process efficiency.

## Company Weaknesses

- Disclosure of data remains an issue for the company. It does not disclose on Scope 1-3 emissions and its modelled emissions intensity is the third highest.
- Hesteel has the highest water stress exposure with 94% of its steelmaking capacity located at high to extremely high water risk areas.
- The company ranks fifth last for climate governance & strategy. It has not set a corporate emissions reduction target and shows no evidence of using scenario analysis, an internal carbon price or climate-related remuneration. However, one of the board members is judged to have high-level climate-related experience.

(i) Hesteel is the listed arm of state-owned Hesteel Group.



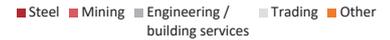
# Angang Steel<sup>(i)</sup>

Country: China

Average market cap 2018: US\$ 6.8 bn  
 Steel production 2018: 25 million tonnes  
 Revenue 2018: US\$ 16 bn

Free-Float: 27.8 %

Revenue split by business area (%)



Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
000898 CH / 347 HK	16 / 20	20	12	13	15

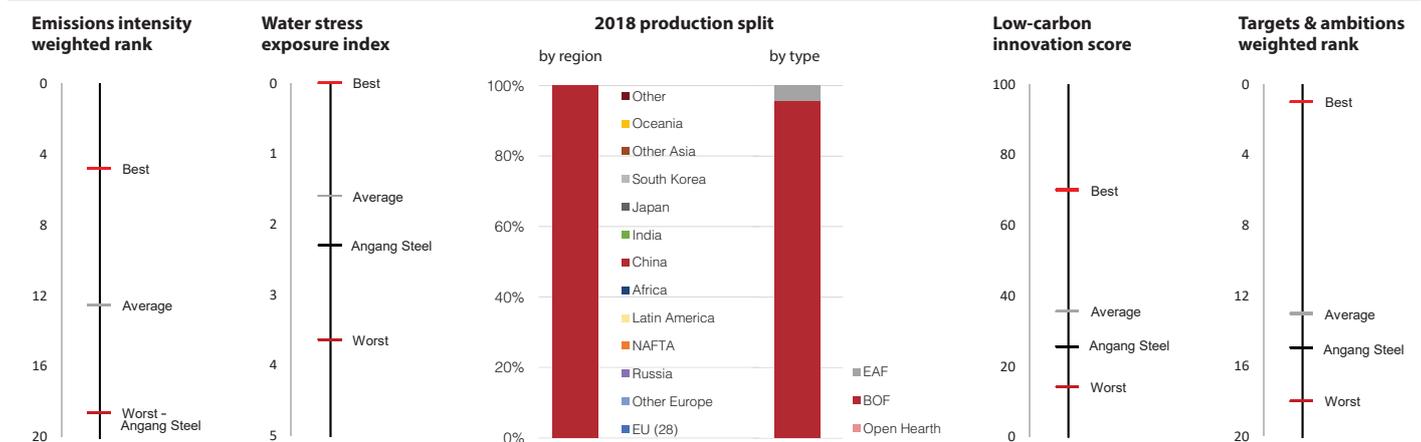
## Company strengths

- Angang Steel ranks first for water consumption intensity. It has the highest reduction rate at 12.7% p.a. since 2014 and the third lowest water consumption intensity (2.5 m<sup>3</sup>/tonne).
- It ranks fourth in R&D with an average R&D spend of 1.54% and seventh in patent analysis.
- Angang Steel ranks tenth in terms of capital flexibility. It has a relatively low financial gearing ratio (24%) and a net debt/EBITDA ratio close to 1.

## Company Weaknesses

- Angang Steel ranks last for transition risks, with the second highest emissions intensity. It ranks third last in energy intensity with limited data disclosure.
- It does not disclose any emissions data.
- The company has the fifth highest water stress exposure score with approximately 64% of its steelmaking capacity located at medium-to-high risk.
- It ranks 15th in climate governance & strategy. It shows no evidence of using scenario analysis, an internal carbon price or climate-related remuneration. However, one of the board members is judged to have high-level climate-related experience.

(i) Angang Steel is the listed arm of state-owned Ansteel Group.



# NLMK

Country: Russia

Average market cap 2018: US\$ 15 bn  
 Steel production 2018: 17 million tonnes  
 Revenue 2018: US\$ 12 bn

Free-Float: 16.0 %

Revenue split by business area (%)



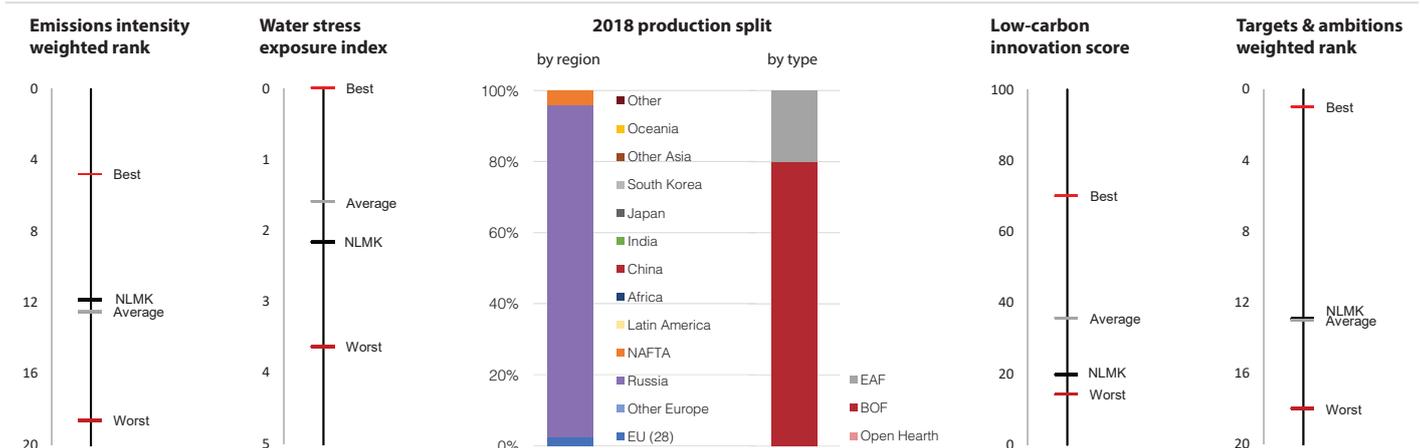
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
NLMK RM	15 / 20	12	13	19	12

## Company strengths

- NLMK ranks first in capital flexibility. It has a vertically integrated business model providing a high degree of flexibility, with high adjusted EBITDA margins (28%) and low levels of gearing (12%).
- Angang Steel ranks ninth for emissions intensity. It has reduced its emissions intensity at an average rate of 1.0% p.a. from 2015-2018.
- Angang Steel ranks in the top half in terms of board & executive climate management, due to climate committees at both the board and executive levels.

## Company Weaknesses

- NLMK ranks second last for transition opportunities. This reflects the company's limited implementation of low-carbon technologies considered to be transformative or radical and a low uptake of renewable energy.
- Angang Steel ranks 12th in water consumption. Despite a reduction in intensity from 2014-2018 of 6.9% p.a., water consumption remains high relative to its peers at 4.8 m<sup>3</sup>/t.
- The company lacks engagement with climate initiatives including the TCFD. It shows limited ambition in target setting, only stating to keep emissions below the industry average and shows no evidence of using low-carbon scenario analysis or an internal carbon price.



# Gerdau

Country: Brazil

Average market cap 2018: US\$ 6.9 bn  
 Steel production 2018: 15 million tonnes  
 Revenue 2018: US\$ 13 bn

Free-Float: 61.1 %

Revenue split by business area (%)



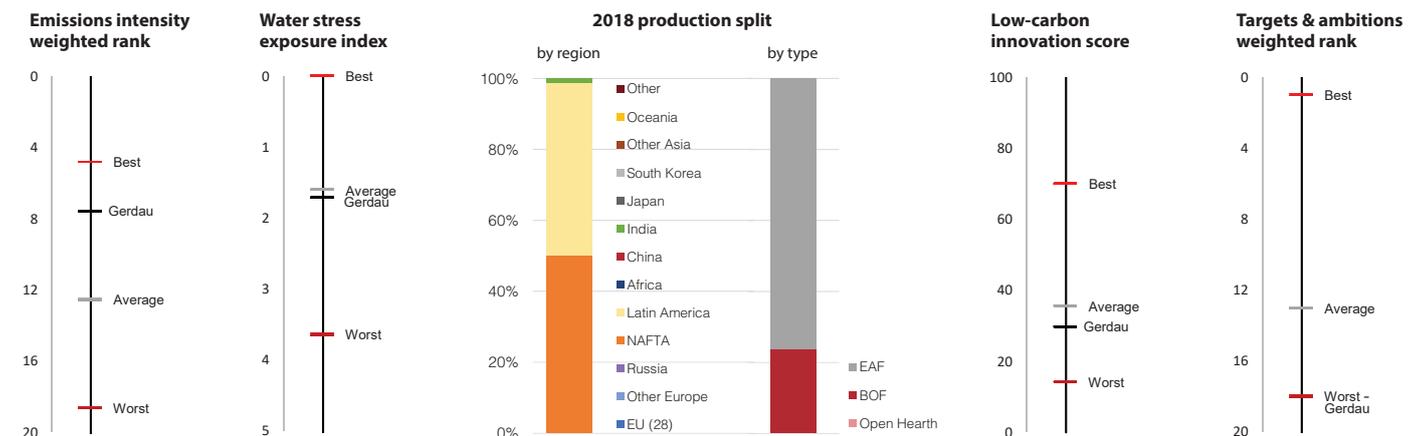
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
GGBR4 BZ / GGBR3 BZ	14 / 20	7	15	12	18

## Company strengths

- Ranks fourth overall for in emissions intensity. It produces over 70% of steel via the EAF route and has a low emissions intensity compared to its peers, at 0.8 tCO<sub>2</sub>/tonne.
- Operates around 280MWe of hydropower assets and purchases the largest amount of renewable energy via PPAs, ranking second in renewable energy.
- Ranks in the top half for circular innovation and 11th in low-carbon innovation, with a number of innovations relating to digitization and process control.

## Company Weaknesses

- Gerdau has poor disclosure across most metrics. It does not report emissions or energy data, ranking last in data transparency.
- One of five companies that has not set a corporate emissions reduction target and does not have a climate-related committee at the board or executive level.
- Ranks second last in the water disclosure and governance and does not disclose its water consumption intensity.



# Severstal

Country: Russia

Average market cap 2018: US\$ 13 bn  
 Steel production 2018: 12 million tonnes  
 Revenue 2018: US\$ 8.6 bn

Free-Float: 23.0 %

Revenue split by business area (%)



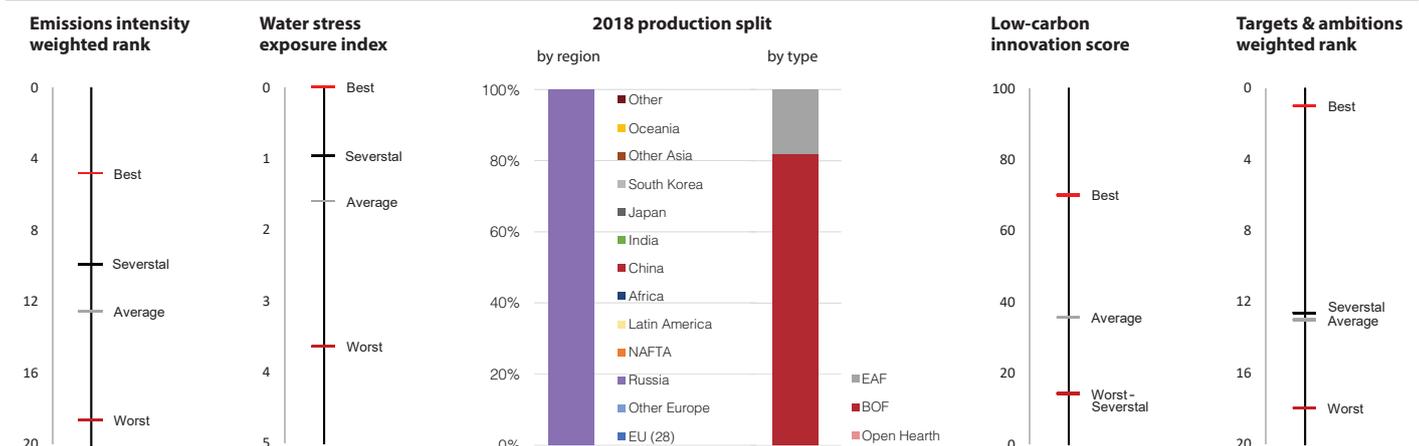
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
CHMF RM	13 / 20	5	9	20	11

## Company strengths

- Ranks fifth overall in transition risks with relatively low emissions and energy intensities. It has reduced its emissions intensity at an average rate of 3.8% p.a. since 2015. One of only four companies to report emissions according to the worldsteel methodology.
- Ranks second in capital flexibility. Its vertically integrated business model providing a high degree of flexibility and the highest adjusted EBITDA margin of the group at 35%.
- Ranks sixth in water stress risk with over 90% of its steelmaking capacity located in a low water stress region of Russia.

## Company Weaknesses

- Ranks last in transition opportunities, with limited uptake of technologies with significant decarbonisation potential or evidence of innovation relating to recycling or reuse of by-products.
- Does not operate or own any renewable energy assets or have any renewable PPAs. Does not disclose an R&D figure.
- Has not conducted low-carbon scenario analysis nor introduced an internal carbon price, ranking joint last in this metric.



# Nucor

Country: USA

Average market cap 2018: US\$ 20 bn  
 Steel production 2018: 22 million tonnes  
 Revenue 2018: US\$ 25 bn

Free-Float: 99.4 %



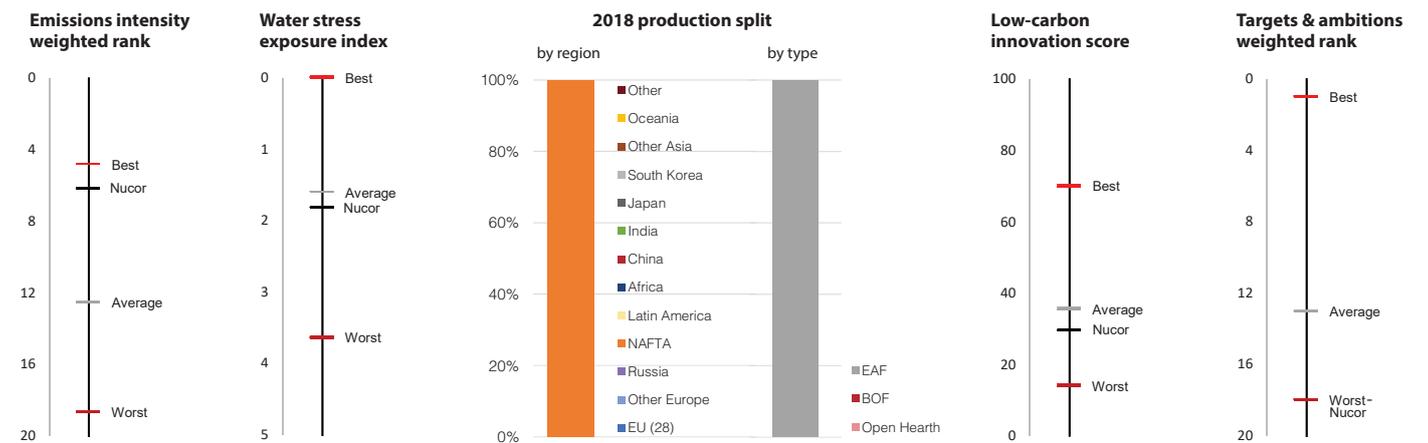
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
NUE US	12 / 20	4	16	14	17

## Company strengths

- Rank second in emissions intensity and fourth in energy intensity. Produces 100% of steel from the EAF route with a business model predominantly based on scrap-based steelmaking.
- The company rank sixth in capital flexibility, reflecting its relatively high adjusted EBITDA margin and reasonably low levels of indebtedness.
- Ranks seventh in the board & executive climate management metric, having a board-level committee chaired by an independent director to oversee the company's environmental risks.

## Company Weaknesses

- Nucor is one of five companies that have not set a corporate emissions reduction target.
- The company rank second last in water disclosure. Across all indicators evaluated in this metric, the company only reports on the percentage of water recycled.
- Nucor has no R&D spend and has limited renewable energy assets. Although the company produces 100% of steel via the less emissions intensive route, it displays little innovation beyond this.



# Baoshan Iron & Steel (i)

Country: China

Average market cap 2018: US\$ 28 bn  
 Steel production 2018: 47 million tonnes  
 Revenue 2018: US\$ 46 bn

Free-Float: 18.5 %



Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
600019 CH	11 / 20	15	11	7	13

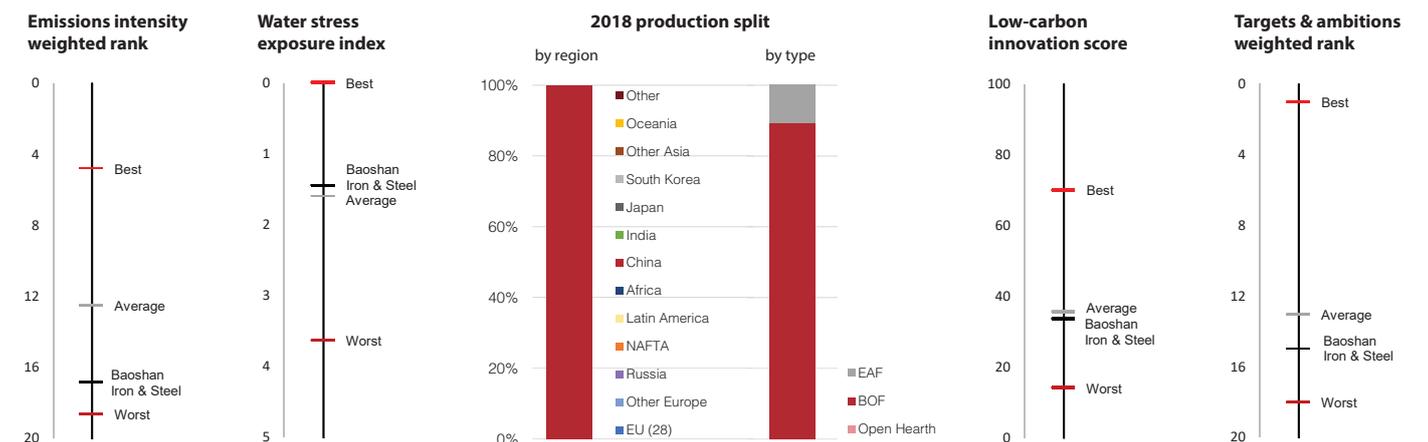
## Company strengths

- The company ranks seventh in transition opportunities. It has the second highest R&D (1.95%) and ranks third in the utilization of renewable energy.
- Has deployed multiple BATs and partnered with LanzaTech to build the first demonstration facility.
- Ranks fifth in capital flexibility with gearing at 17% and a net debt/EBITDA ratio at 0.8.
- The company ranks sixth in water consumption intensity with a relatively low water consumption intensity of 3.5 m<sup>3</sup>/tonne and a reduction rate at 5.3% p.a. since 2013.

## Company Weaknesses

- Disclosure of data remains an issue for the company. It does not disclose any emissions data and has the seventh highest emissions intensity across the companies.
- Ranks in the bottom five for water governance & disclosure.
- Ranks 13th for climate governance & strategy. It provides no evidence of using scenario analysis or an internal carbon price to inform business decision-making. It does not have any climate-related remuneration for managers and employees.

(i) Baoshan Iron & Steel is the listed arm of state-owned China Baowu Steel Group.



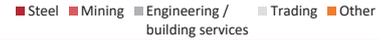
# JSW Steel

Average market cap 2018: US\$ 12 bn  
 Steel production 2018: 17 million tonnes  
 Revenue 2018: US\$ 12 bn

Country: India

Free-Float: 39.6 %

Revenue split by business area (%)



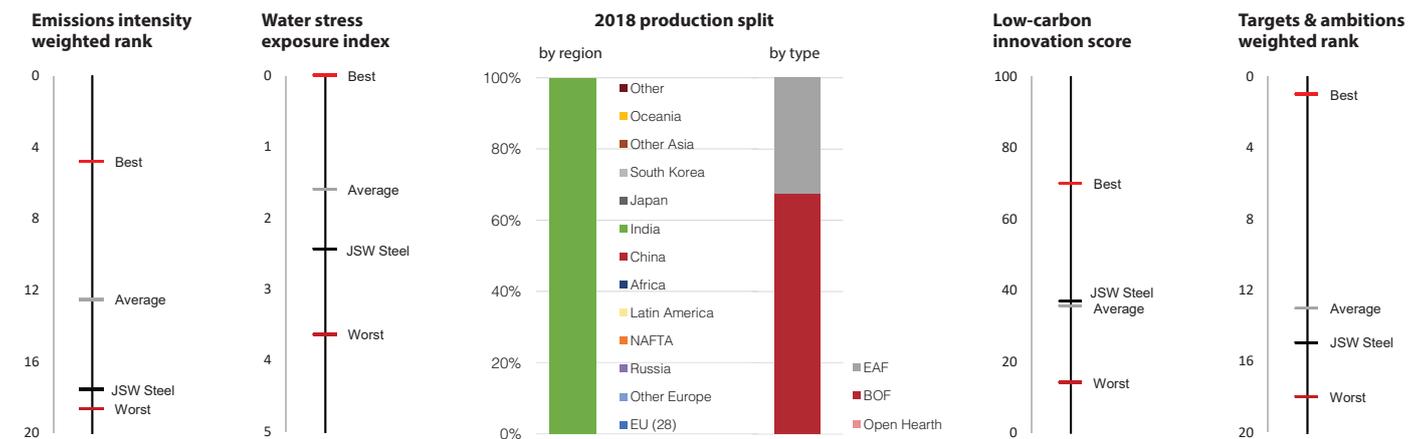
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
JSTL IN	10 / 20	14	14	8	10

## Company strengths

- JSW Steel rank joint first for data transparency. It is one of only four companies that clearly discloses their emissions intensity in line with worldsteel guidance, while also having 100% of Scope 1+2 emissions verified by a third party.
- Its ranks third for capital flexibility with an adjusted EBITDA margin of 22%.
- Ranks in the top half for transition opportunities. Its COREX and CONARC technologies remain important to improving efficiency.
- Ranks fifth in board & executive climate management, with an independently chaired climate-related committee at board level and a board member judged to have climate expertise.

## Company Weaknesses

- JSW has the highest emissions intensity at 2.43 tCO<sub>2</sub>/tonne, while its emissions intensity has grown at an average rate of 2.0% p.a since 2013.
- It also has the second highest energy consumption intensity at 27.6 GJ/tonne, while its energy consumption grew at a rate of 1.1% p.a. between 2013-2017.
- Ranks fourth last in the water stress metric, with over 70% of its steelmaking capacity located in high water stress risk areas in India.
- The company does not own or operate any renewable assets and has the lowest R&D spend (0.05%) compared with companies disclosing an R&D figure.



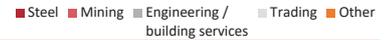
# China Steel

Average market cap 2018: US\$ 13 bn  
 Steel production 2018: 15 million tonnes  
 Revenue 2018: US\$ 13 bn

Region: Taiwan

Free-Float: 78.0 %

Revenue split by business area (%)



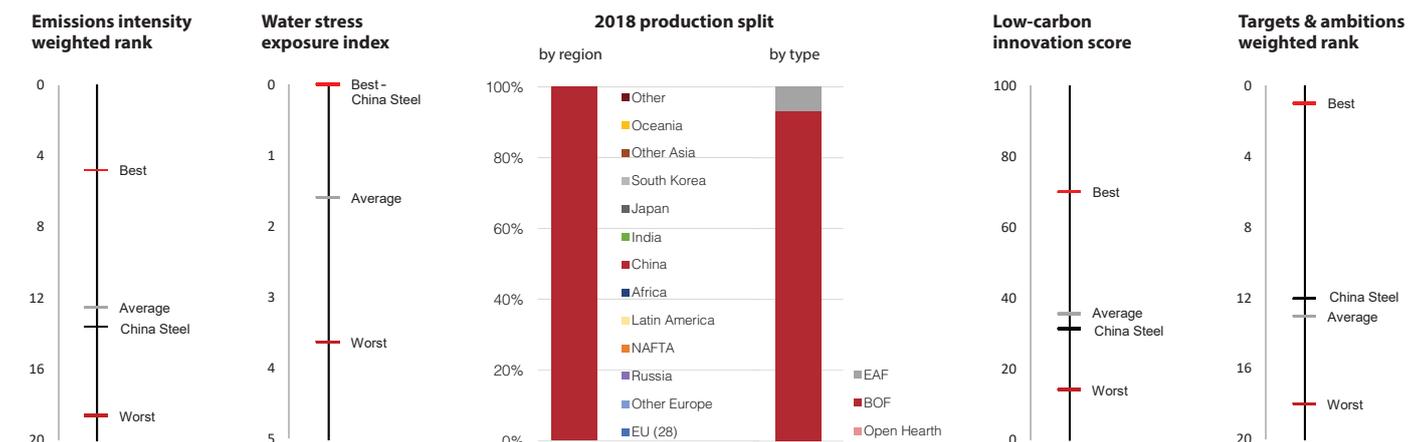
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
2002 TT	9 / 20	9	1	11	7

## Company strengths

- China Steel ranks first in Scope 3 emissions disclosure. It has reporting on all 15 Scope 3 categories in its operations and good overall transparency.
- Ranks first in physical risk. It has the lowest water stress exposure with all capacity located in coastal areas and ranks third in water disclosure & governance.
- Ranks sixth in the patent analysis and seventh for renewable energy operations & PPAs with electricity generators.
- Ranks in top half for climate governance & strategy. It is one of the only four companies with climate/sustainability-related committees at both board- and executive-level.

## Company Weaknesses

- Ranks in the bottom half in energy intensity and emissions. It has the seventh highest energy intensity and sixth highest emissions intensity across the 20 companies.
- It has a higher water consumption intensity figure than many peers but shows a reduction at 0.76% p.a. since 2013.
- Ranks last in circular innovation and has no innovations deemed to be either radical or transformative.



# BlueScope Steel

Country: Australia

Average market cap 2018: US\$ 6.5 bn

Steel production 2018: 6.0 million tonnes

Revenue 2018: US\$ 9.3 bn

US\$ 6.5 bn

6.0 million tonnes

US\$ 9.3 bn

Free-Float: 99.0 %

Revenue split by business area (%)



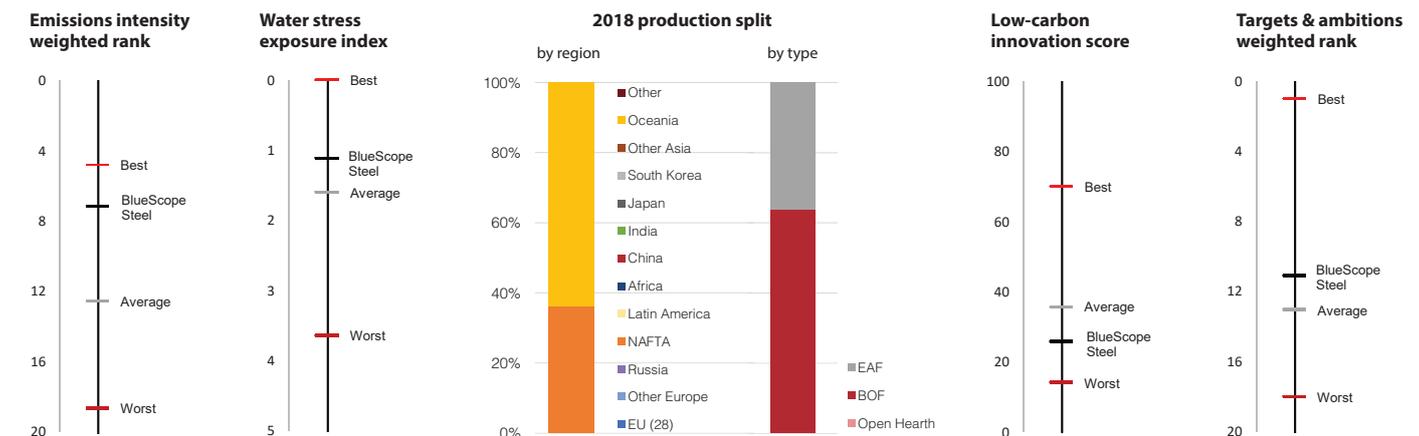
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
BSL AU	8 / 20	2	7	16	5

## Company strengths

- BlueScope rank second in transition risks. It has among the lowest emissions intensities and has significantly reduced its emissions and energy intensities at an average rate of 6.5% and 7.5% p.a since 2013, respectively.
- It has the lowest level of indebtedness of its peer group and a relatively high adjusted EBITDA margin of 14%, ranking fourth overall in the capital flexibility metric.
- It has a climate-related committee at both the board and executive levels, has introduced an emissions reduction target, has developed three company scenarios to evaluate climate risks, and officially supports the TCFD and other climate initiatives in the industry.

## Company Weaknesses

- Rank in bottom half for low-carbon innovation with limited investment in radical and transformative technologies.
- Its low R&D expense to sales ratio over the 2016-2018 period (0.23%) and a lack of high-quality patent applications also contribute to its overall ranking of sixteenth for transition opportunities.
- Does not publicly report a breakdown of Scope 1-2 emissions in alignment with worldsteel guidelines and has not obtained third-party verification of its emissions data. It does not report on Scope 3 emissions but states that it intends to incorporate Scope 3 accounting into its future reporting.



# Nippon Steel

Country: Japan

Average market cap 2018: US\$ 20 bn

Steel production 2018: 48 million tonnes

Revenue 2018: US\$ 56 bn

US\$ 20 bn

48 million tonnes

US\$ 56 bn

Free-Float: 85.2 %

Revenue split by business area (%)



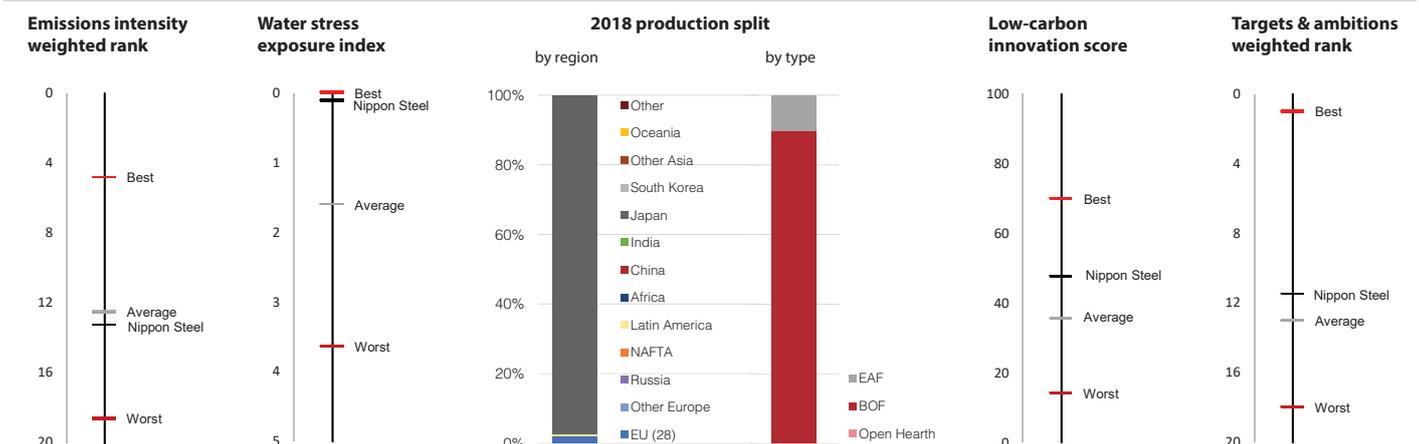
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
5401 JP	7 / 20	13	5	5	6

## Company strengths

- One of six companies that responded to CDP's 2018 water questionnaire. Ranks fifth for physical risks with low water stress exposure and evidence of water risk management.
- Nippon Steel has introduced several transformative and radical technologies as part of COURSE50 in relation to CCUS and hydrogen steelmaking.
- Ranks second in circular innovation, with widespread recycling and reuse of by-products.
- Ranks sixth in climate governance and strategy reflecting its use of scenario analysis, presence of a climate target, and its official support of the TCFD and other climate-related industry initiatives.

## Company Weaknesses

- Ranks second last in capital flexibility reflecting a high level of gearing at 38%, elevated net debt / EBITDA ratio of 3.28, and a low adjusted EBITDA margin at 10.9%.
- It has a climate-related committee at executive level only and no directors on the board deemed to have climate-related experience, ranking 14th in the board & executive climate management.
- The company's emissions and energy intensities are above the group averages at 1.99 tCO<sub>2</sub>/tonne and 23.0 GJ/tonne, respectively, while its intensities have increased by 0.2% p.a. and 0.3% p.a. between 2013 and 2017.



# JFE Holdings

Country: Japan

Average market cap 2018: US\$ 13 bn  
 Steel production 2018: 28 million tonnes  
 Revenue 2018: US\$ 35 bn

Free-Float: 84.6 %

Revenue split by business area (%)



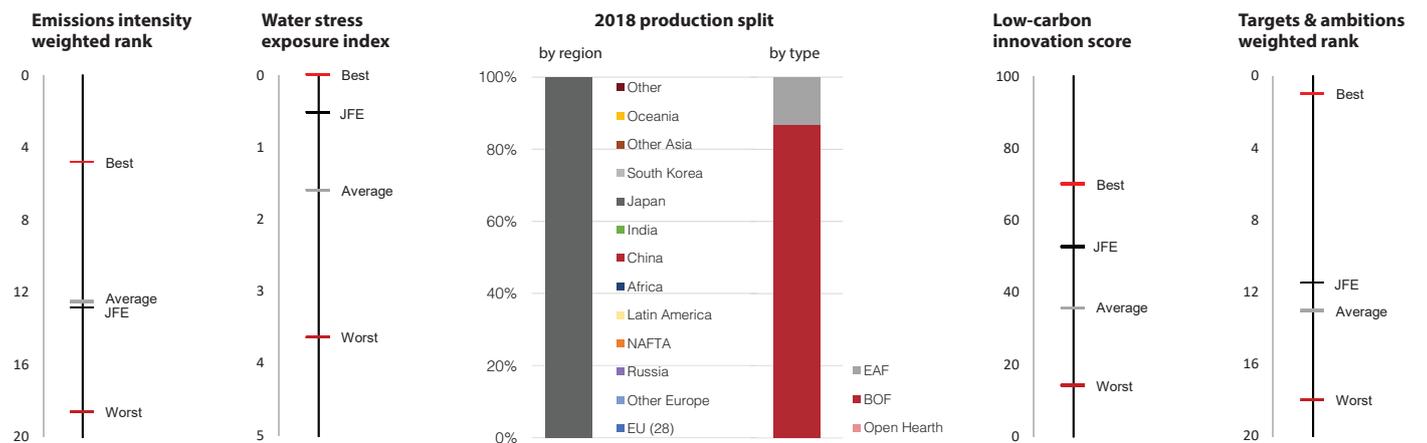
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
5411 JP	6 / 20	11	2	4	9

## Company strengths

- Ranks second in physical risks, driven by relatively low water stress exposure and strong performance in water governance and policy.
- Ranks fourth overall in transition opportunities, with good performance across all five sub-metrics.
- Ranks first in circular innovation with widespread recycling and reuse of by-products and fourth in low-carbon innovation with innovations relating to CCS and hydrogen steelmaking.
- Ranks third in patent analysis with patents distributed across the six categories and in the top half for renewable energy use and R&D.

## Company Weaknesses

- Ranks last in capital flexibility with a high level of gearing (42%), elevated net debt / EBITDA ratio (3.61) and low adjusted EBITDA margin (11.3%).
- The presence of a climate-related committee at executive level only and the lack of any directors on the board deemed to have climate-related experience results in the company ranking sixteenth in the board & executive climate management metric.
- Its emissions and energy intensities are above the group averages at 1.99 tCO<sub>2</sub>/tonne and 22.6 GJ/tonne, respectively, while it achieved only minor intensity reductions of 0.4% p.a. and 0.3% p.a. between 2013-2017.



# POSCO

Country: South Korea

Average market cap 2018: US\$ 26 bn  
 Steel production 2018: 43 million tonnes  
 Revenue 2018: US\$ 59 bn

Free-Float: 79.3 %

Revenue split by business area (%)



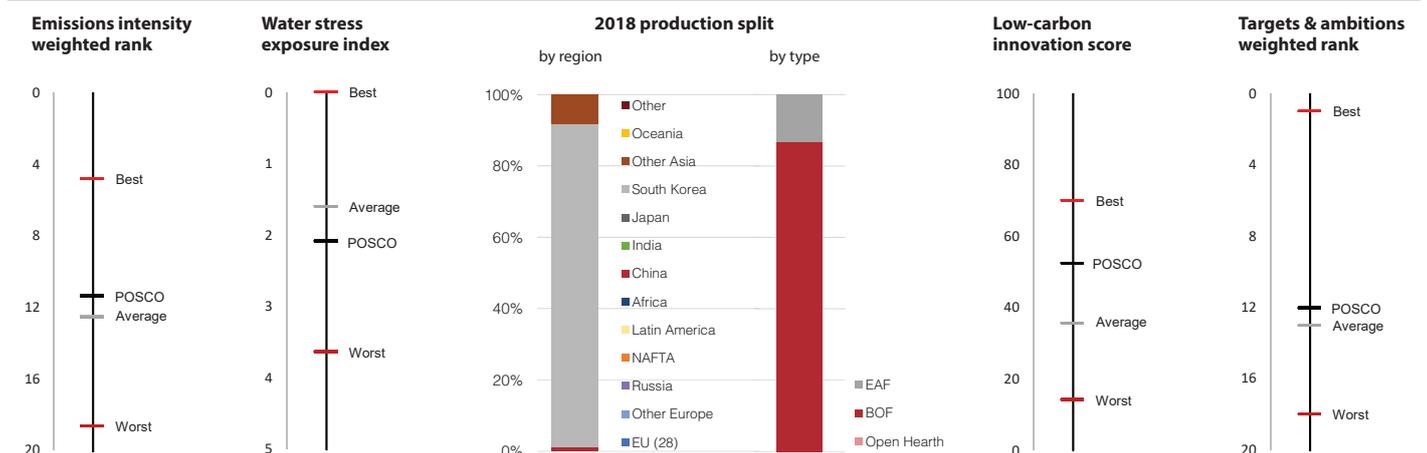
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
005490 KS	5 / 20	6	8	3	8

## Company strengths

- The company ranks sixth in transition risks, ranking in the top half across all metrics.
- Ranks third in transition opportunities. It ranks first in the patent analysis with patents filed in relation to its FINEX technology and CCS.
- Company also accounts for over 40% of all renewable capacity within the sample, with a strong presence in wind and solar.
- Achieved the highest score out of the six companies that responded to CDP's 2018 water questionnaire and ranks second in water governance and policy.

## Company Weaknesses

- POSCO has set a relatively unambitious short term target out to 2020, ranking joint eighth in the targets and ambitions metric.
- POSCO's energy intensity falls above the group average at 21.7 GJ/tonne.
- Its water consumption intensity is above the average of the 14 companies reporting on water consumption at 3.8 m<sup>3</sup>/tonne, while its water consumption rate has increased by 0.44% p.a. since 2013; the company rank tenth for this metric.



# Tata Steel

Average market cap 2018: US\$ 9.7 bn  
 Steel production 2018: 27 million tonnes  
 Revenue 2018: US\$ 22 bn

Country: India

Free-Float: 55.7 %

Revenue split by business area (%)



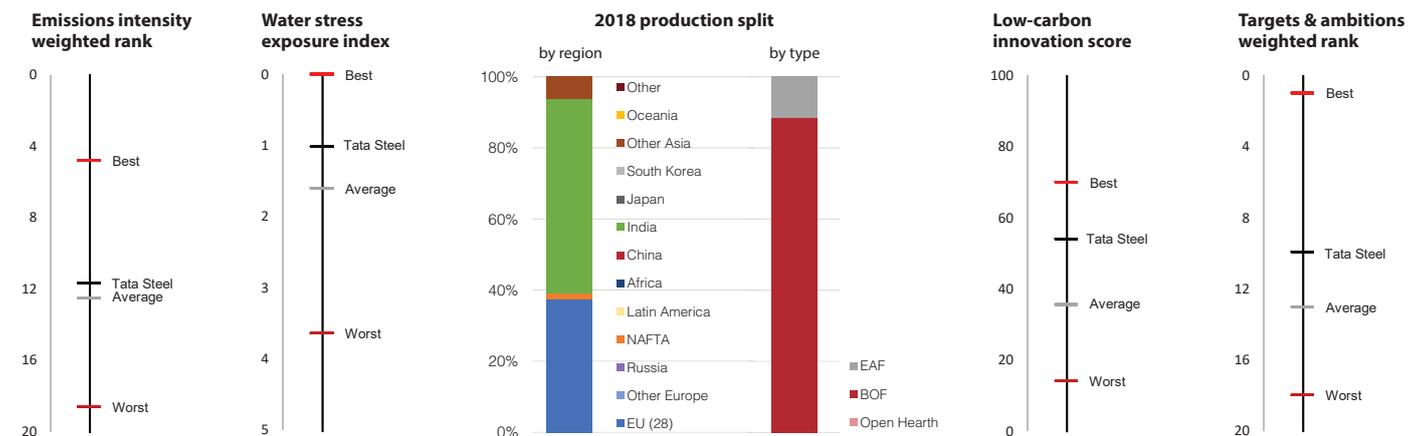
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
TATA IN	4 / 20	8	4	6	3

## Company strengths

- Has among the most comprehensive emissions and energy disclosures. Reports emissions according to worldsteel guidelines and provides Scope 3 emissions data for 10 of the 11 reported categories.
- Rank fourth for physical risks. It has reduced water intensity by 6.5% p.a from 2014-2018.
- The company is highly innovative. As well as the Hlsarna it is involved in a number of CCUS and hydrogen-based projects.
- Ranks third for climate governance and strategy. Has an ambition to reach carbon neutrality in its European operations by 2050.

## Company Weaknesses

- Ranks 14th in energy intensity with an above average intensity (23GJ/tonne) that has slightly increased since 2013.
- Has the second highest level of gearing at 57% and an elevated net debt / EBITDA ratio of 3.21.
- Ranks in the bottom half for renewable energy and R&D spend.



# Hyundai Steel

Average market cap 2018: US\$ 6.4 bn  
 Steel production 2018: 24 million tonnes  
 Revenue 2018: US\$ 19 bn

Country: South Korea

Free-Float: 54.1 %

Revenue split by business area (%)



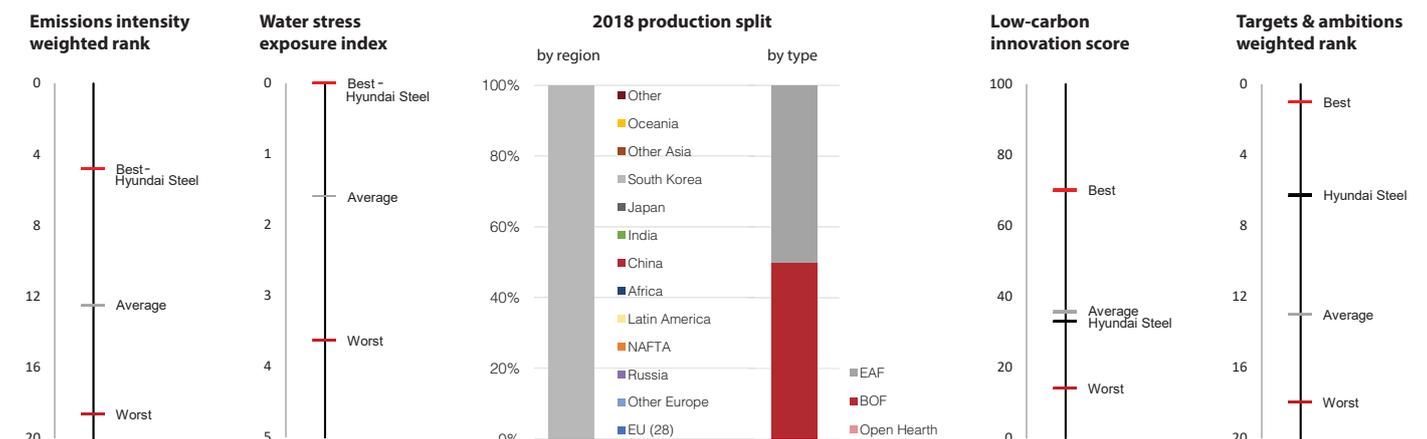
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
004020 KS	3 / 20	1	3	9	4

## Company strengths

- Tops the ranking for transition risks. It has the third lowest emissions intensity and an energy intensity below the group average at 15.7 GJ/tonne. Intensity has declined by 1.5% p.a. and 0.3% respectively since 2013.
- Risks are mitigated with a near 50/50 production split between BF-BOF and EAF steelmaking routes.
- Hyundai Steel is targeting an 80% reduction in emissions by 2050, conducts scenario analysis using an internal carbon price.
- Ranks second in patent analysis, with patents relating to optimizing EAF processes, CCS and by-product recovery.

## Company Weaknesses

- Ranks 16th in capital flexibility with a relatively high level of gearing (34%), high net debt / EBITDA ratio (3.7), and low adjusted EBITDA margin of 13.8%
- Lags behind competitors in terms of radical and transformative innovations and ranks 14th in circular innovation.
- It does not own or operate any renewable assets nor have a PPA to supply its steelworks with renewables.



# ArcelorMittal

Average market cap 2018: US\$ 31 bn  
 Steel production 2018: 93 million tonnes  
 Revenue 2018: US\$ 76 bn

Country: Luxembourg

Free-Float: 61.5 %

Revenue split by business area (%)



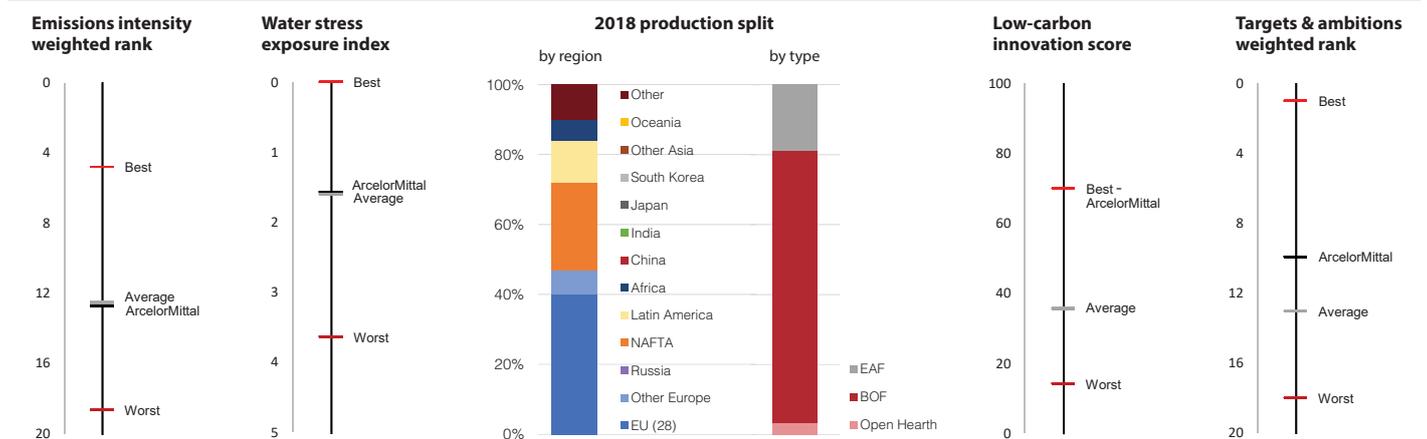
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
MT NA	2 / 20	10	10	1	2

## Company strengths

- Rank first in transition opportunities. It is invested in a suite of radical and transformative technologies including Carbon2value, SIDERWIN, IGAR, and Torero with significant decarbonization potential.
- It has among the most comprehensive emissions and energy disclosures of its peer group, reporting emissions according to worldsteel's guidelines and ranks first in data transparency.
- Rank second for climate governance & strategy. It has an ambition to be carbon neutral in its Europe operations by 2050 and officially supports the TCFD and other climate initiatives in the industry.

## Company Weaknesses

- Its energy consumption is among the highest compared to its peers at 23.9 GJ/tonne, while its energy intensity increased by 0.15% p.a. from 2013-2018.
- Its emissions intensity has decreased by just 0.2% p.a. over this period, and its emissions intensity is above the group average at 1.96 tCO<sub>2</sub>/tonne.
- Of the companies for which consumption data is available ArcelorMittal has the highest water consumption intensity, which increased by 0.7% p.a. from 2014-2018. It ranks 14th for this metric.



# SSAB

Average market cap 2018: US\$ 4.5 bn  
 Steel production 2018: 8.0 million tonnes  
 Revenue 2018: US\$ 8.6 bn

Country: Sweden

Free-Float: 74.5 %

Revenue split by business area (%)



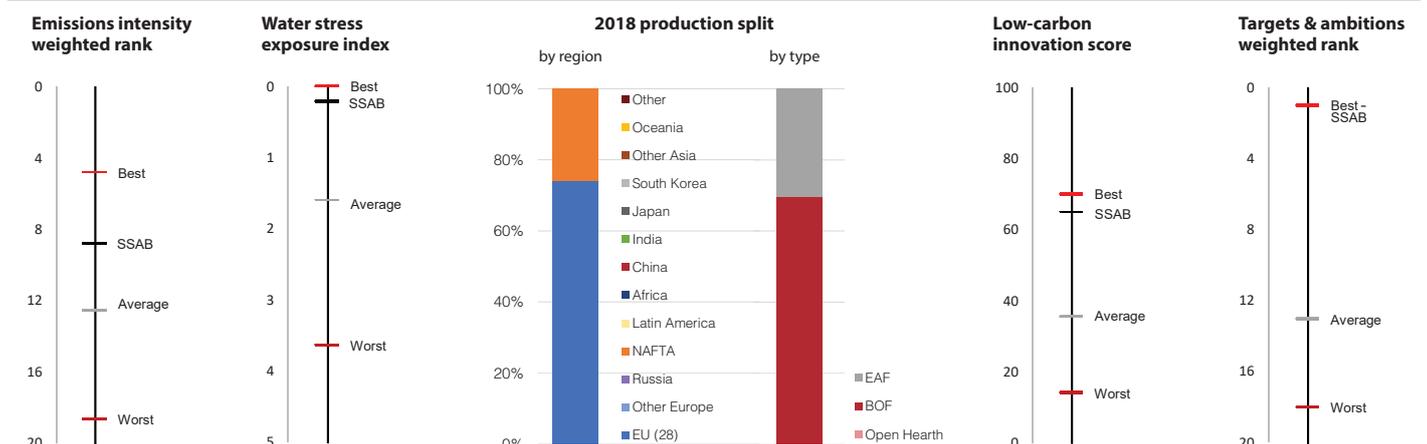
Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
SSABA SS / SSABB SS	1 / 20	3	6	2	1

## Company strengths

- SSAB has the most ambitious emissions reduction goal. It is targeting reaching carbon neutrality by 2045 across its entire operations.
- Rank third in transition risks. Has an energy consumption intensity well below the group average at 14.1 GJ/tonne and has among the lowest emissions intensities of its peers, at 1.4 tCO<sub>2</sub>/tonne.
- Rank a close second in transition opportunities. It is focusing on two clearly defined innovation strategies: targeting fossil-free steelmaking via the HYBRIT project and replacing its existing BFs with EAFs.
- Has a Guarantee of Origin to supply 50% of its electricity from renewable sources.

## Company Weaknesses

- Despite relatively low levels of indebtedness, its adjusted EBITDA margin of 12% is below the group average.
- It did not submit any high-quality patent applications between 2005 and Q2 2019 and its R&D spend is below the group average at 0.49%.
- With a climate-related committee at board level only and no individuals on board judged to have climate-related experience, SSAB rank joint sixteenth in the board & executive climate management metric.







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