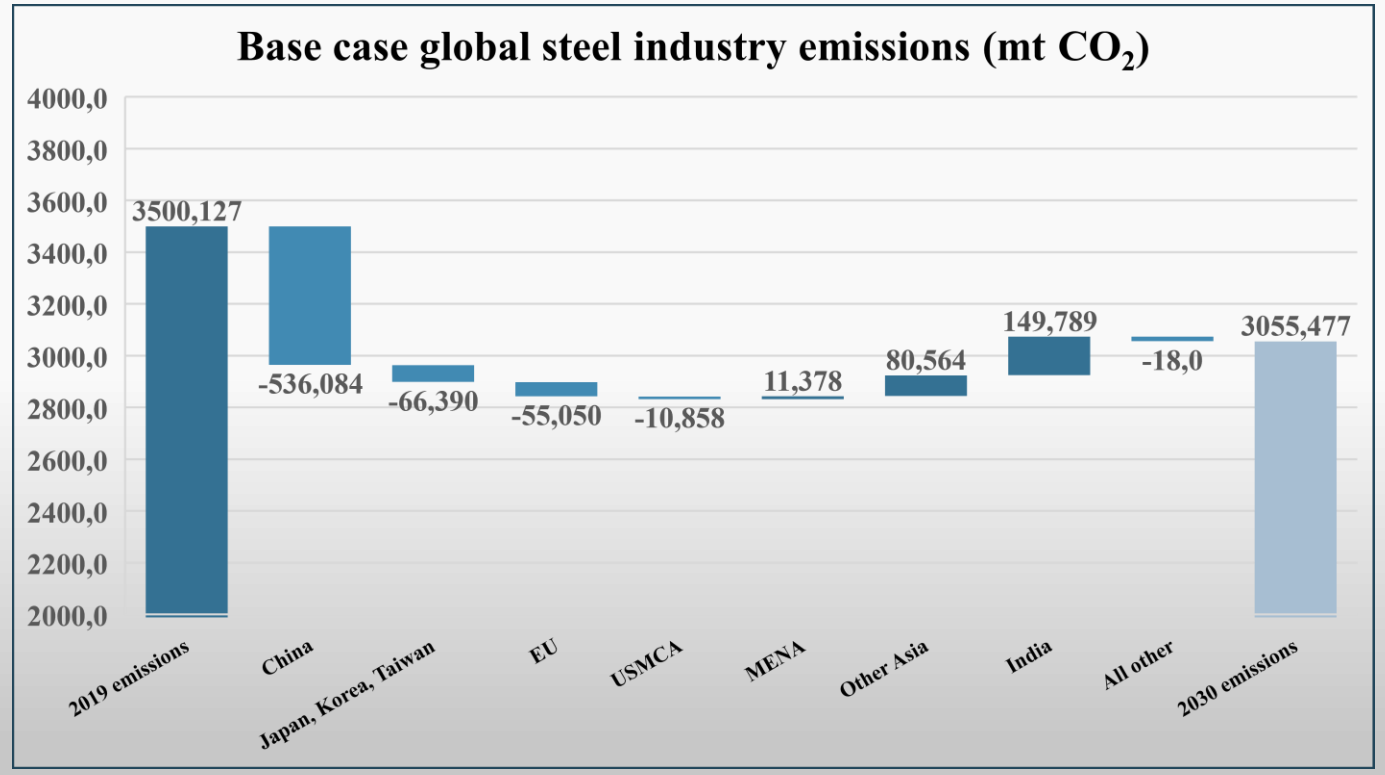
Global steel industry decarbonization

Report #1: the race to the 2030 starting line

WSD WORLD STEEL DYNAMICS®

2030 global steel industry CO_2 emissions

WSD expects global steel production to increase from 1,875 mt in 2019 to 1,920mt in 2030, but global industry CO_2 emissions to decrease 13% from ~3,500mt to 3,055mt, led by a massive reduction in China.



	Change	% change
China	-536mt	-24%
Developed countries	-138mt	-22%
Developing countries	+230mt	+34%
World	- 445mt	-13%

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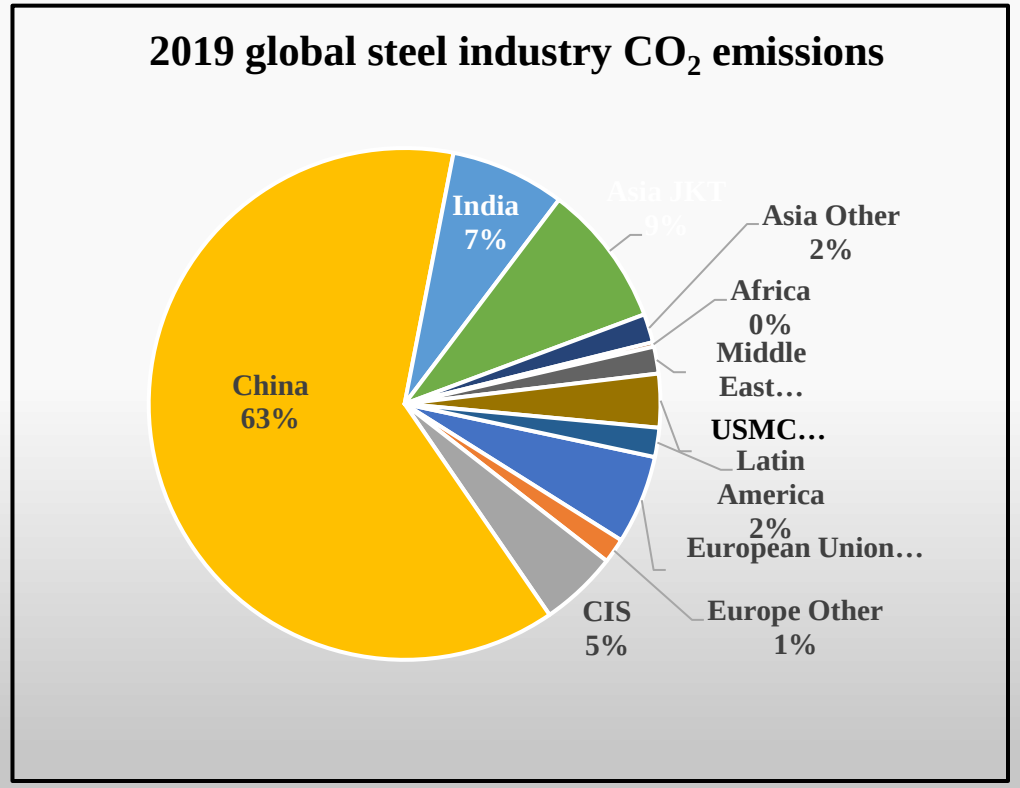
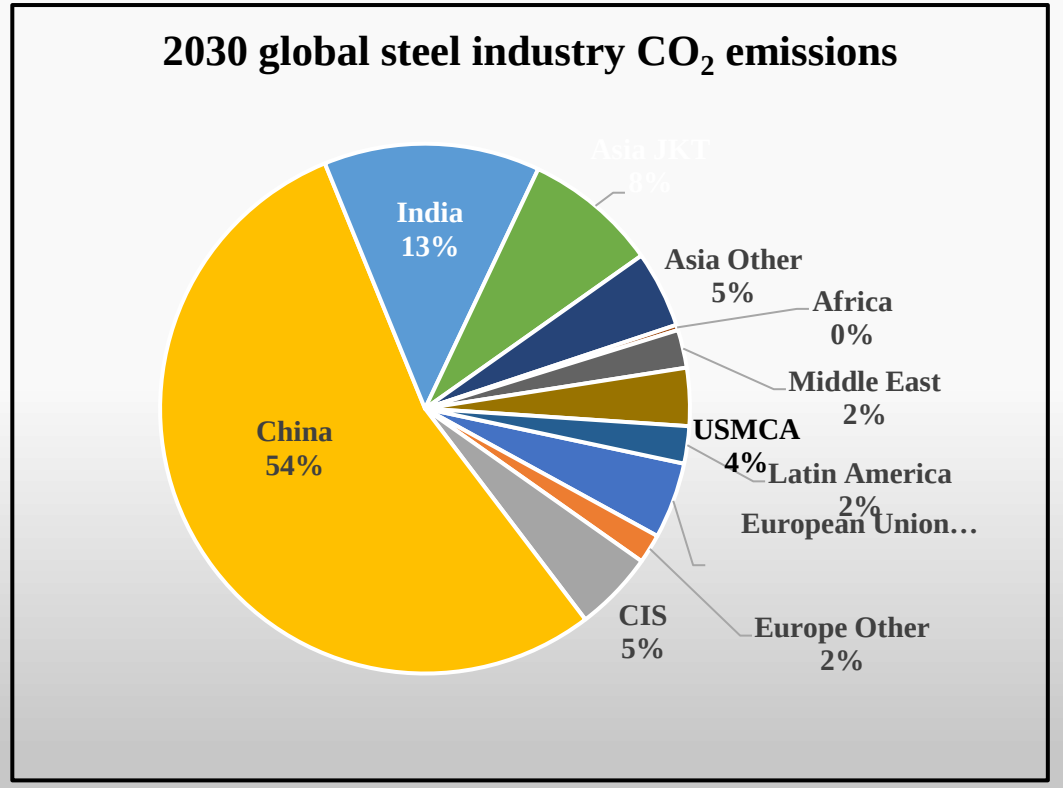
Source: WSD analysis

2030 region share of steel industry emissions

WSD expects China's share of global steel industry emissions to decline from 63% to 54%, India's share to grow from 7% to 13%, and Other Asia's to grow from 2% to 5%.

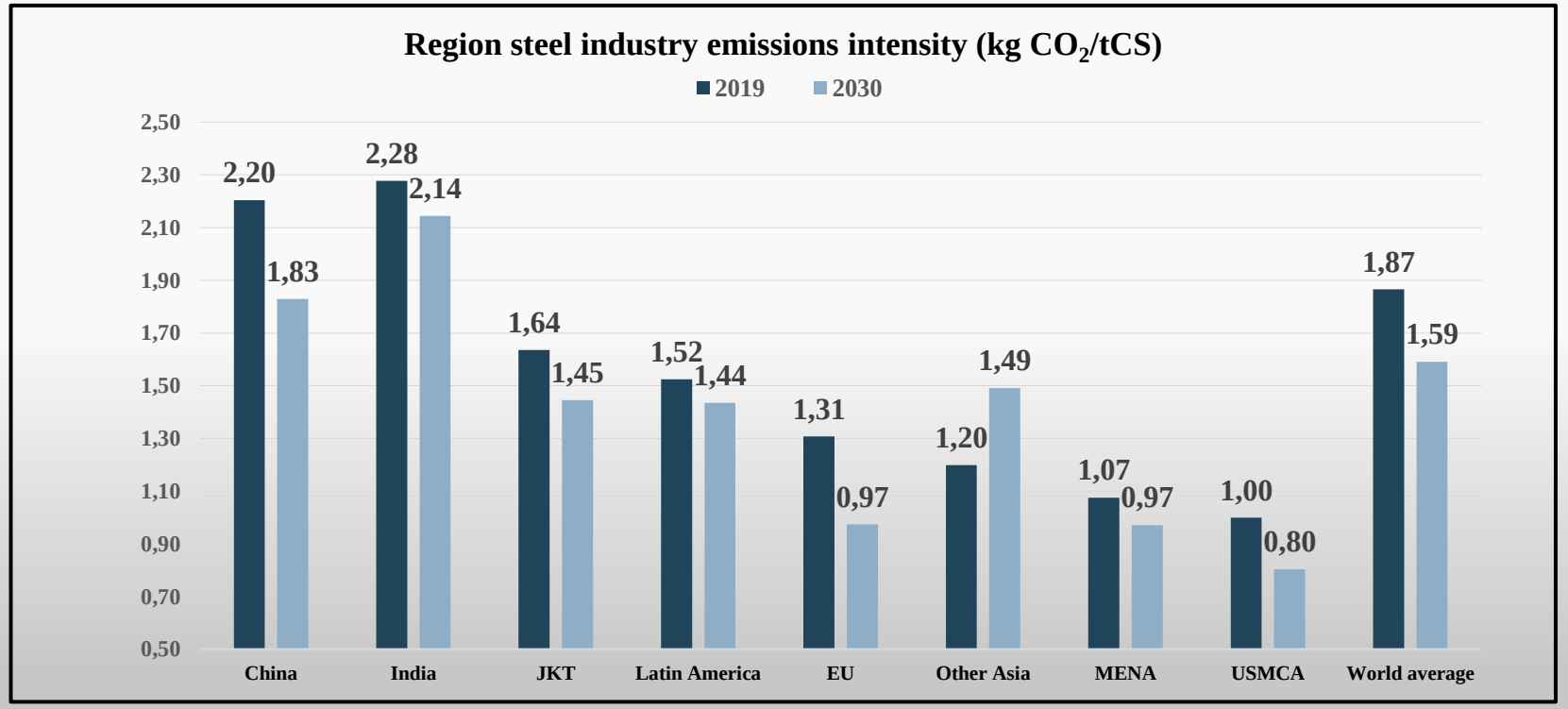




Source: WSD analysis

2030 steel industry emissions intensity

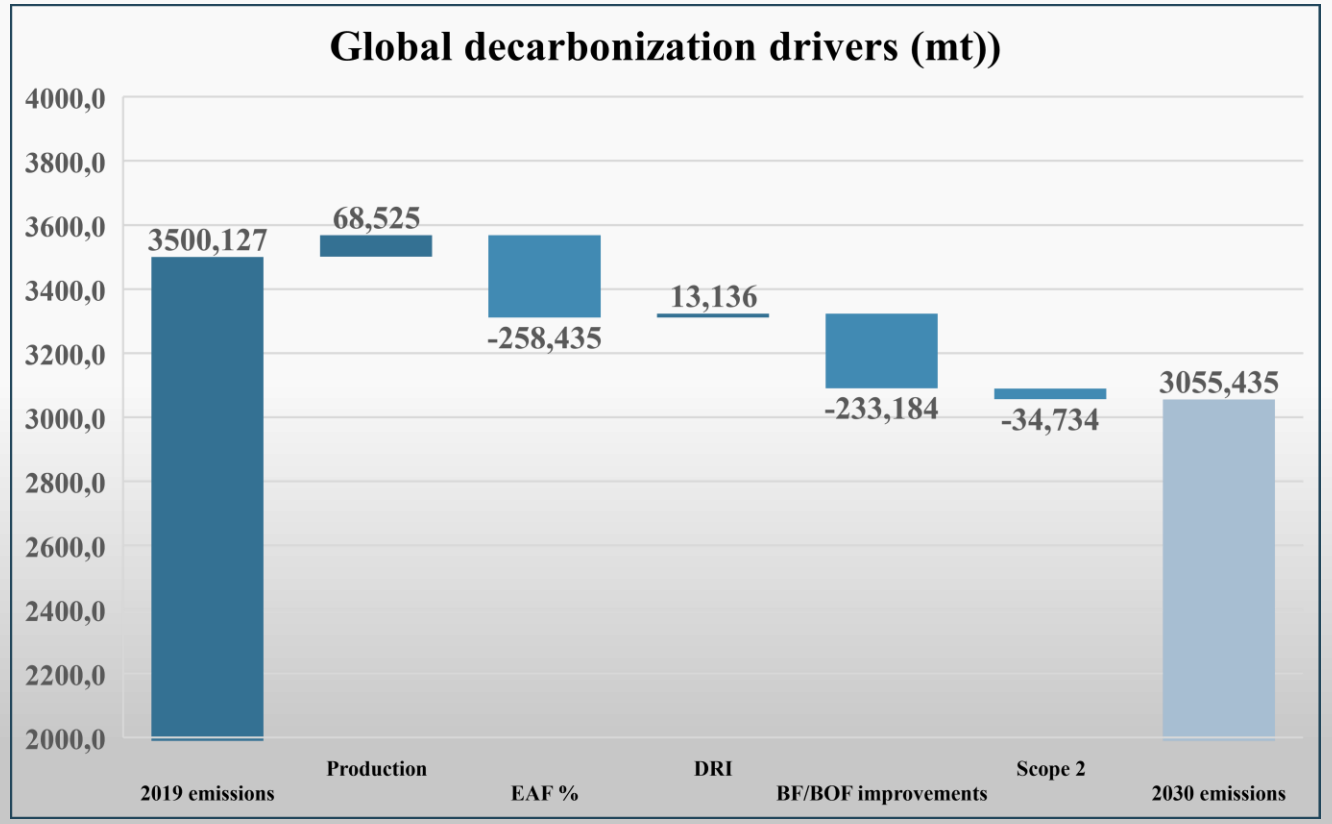
WSD expects the industry average CO_2 intensity to decline from 1.87 to 1.59 kg CO_2/tCS with the EU showing the the greatest percentage improvement.



Source: WSD analysis

Decarbonization drivers: global

WSD has quantified five main categories of decarbonization drivers which generate the expected 445mt reduction in emissions between 2019 and 2030.

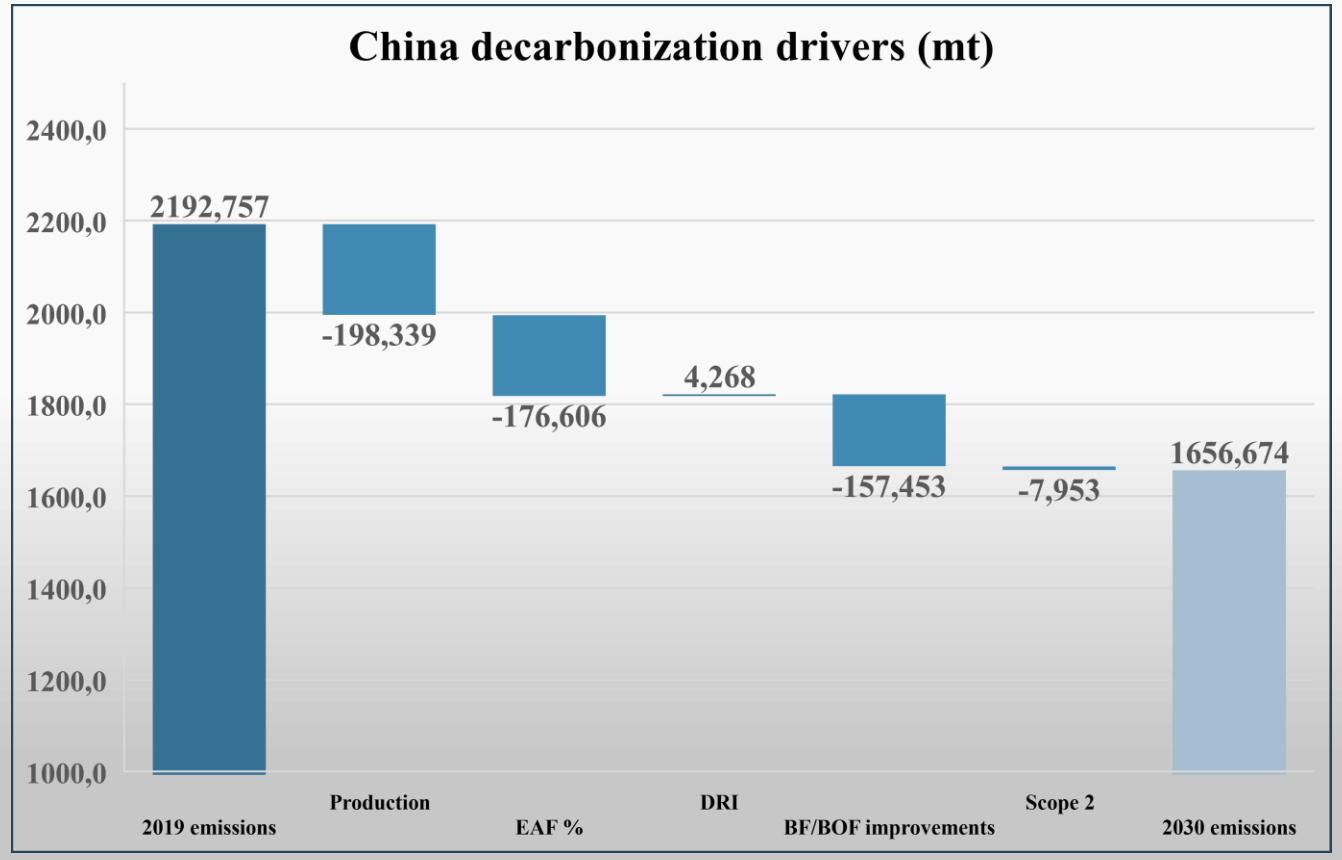


1. **Production** measures the emissions impact of changes in total country steel production levels with everything else held constant.
2. **EAF %** indicates the impact of increased EAF production and production share.
3. **DRI production** measures the impact of increased DRI production which increases emissions based on the assumption that natural gas will be the predominant DRI reductant through 2030.[9]
4. **BF/BOF improvements** measure the impacts of decarbonization technologies and operating practices involving BF fuel rates, BF fuel sources, BF burden, BOF hot metal ratio and BOF yield.[10]
5. **Scope 2** measures the impacts of changes in the emissions intensity of purchased electricity.

9. In WSD's base case, low emissions hydrogen for steelmaking accounts for <10% of global DRI reduction, 18%% in the EU,. (Section V).
10. WSD does not expect BF/BOF CCUS to make a measurable contribution to BF/BOF decarbonization this decade. (Section IV).
Source: WSD analysis

Decarbonization drivers: China

Reduced steel production, EAF conversion, and BF/BOF operating improvements are all major contributors to the expected reduction in Chinese steel industry emissions.



- China's expected 90mt **production decline** is the largest single factor in its emissions reduction .
- China's **EAF production share** is expected to increase from 10% to 22% adding >95mt.
- **DRI production** is not expected to be a major factor in the base case China's 2030 industry landscape.
- **BF/BOF improvements** deliver a large reduction as average BF coke rates decline.
- China's **Scope 2** impact is expected to be small because the proportion of coal-fired electricity generation in the grid is likely to decline only slightly by 2030.

Source: WSD analysis

Decarbonization drivers: summary BF/BOF operating metrics

The global average BF/BOF emissions intensity is expected to decline from 2.24 to 2.05 kg CO_2/tCS as steel producers in all regions reduce coke rates by deploying various improvement levers.[13]

Global	2019	2030
BF fuel rate (kg/tHM)	529	507
BF coke rate (kg/tHM)	410	358
BOF hot metal ratio (charge %)	86.3%	83.4%
BF/BOF emissions intensity (kg/tCS)	2.24	2.05

China	2019	2030
BF fuel rate (kg/tHM)	540	518
BF coke rate (kg/tHM)	421	363
BOF hot metal ratio (charge %)	88%	84.1%
BF/BOF emissions intensity (kg/tCS)	2.34	2.12

Developed regions	2019	2030
BF fuel rate (kg/tHM)	498	482
BF coke rate (kg/tHM)	361	323
BOF hot metal ratio (charge %)	82.7%	81.1%
BF/BOF emissions intensity (kg/tCS)	1.98	1.83

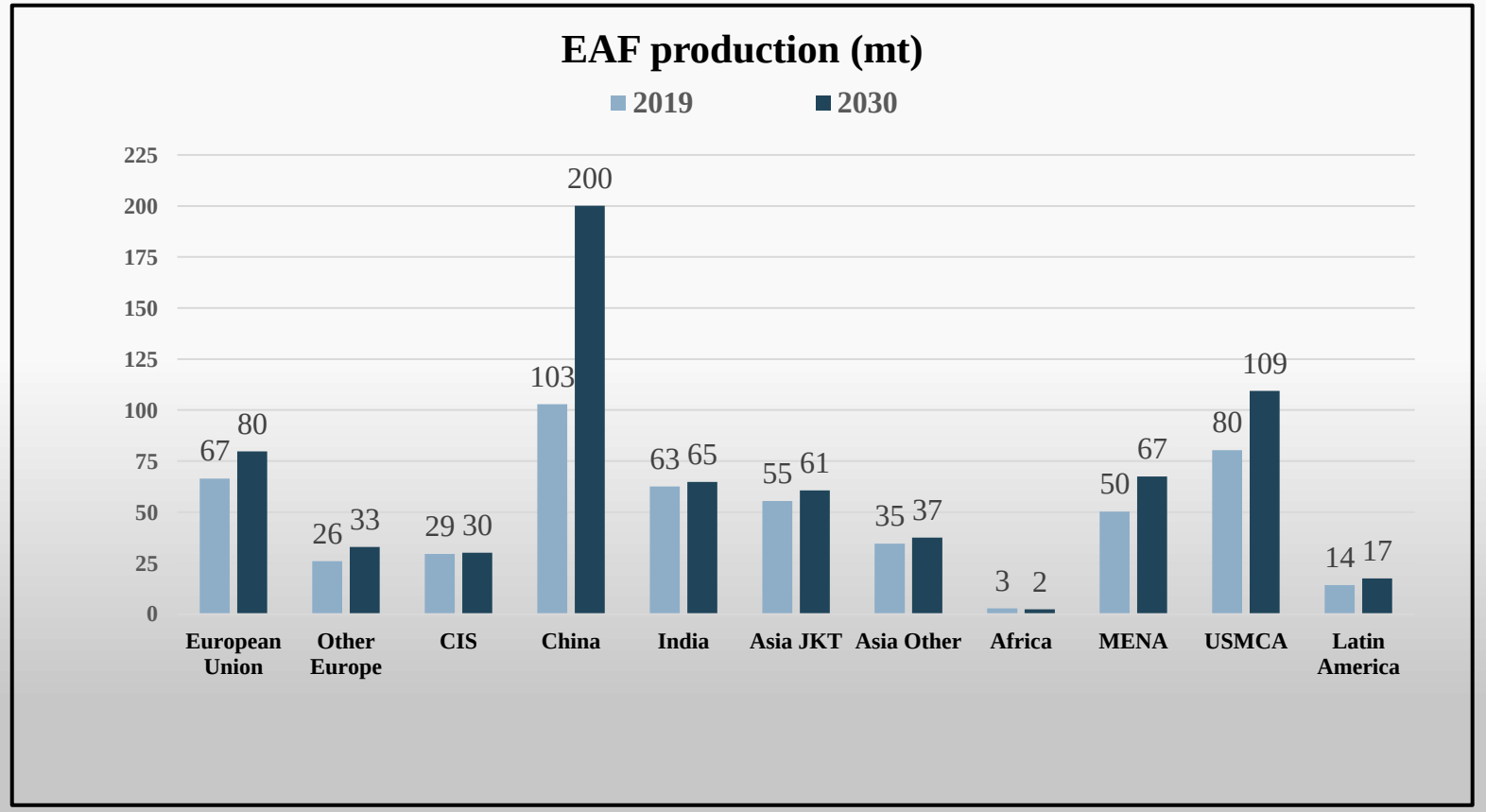
Developing regions	2019	2030
BF fuel rate (kg/tHM)	515	497
BF coke rate (kg/tHM)	420	366
BOF hot metal ratio (charge %)	83.2%	86.4%
BF/BOF emissions intensity (kg/tCS)	2.14	2.02

13. Section IV provides details behind this summaries

Source: WSD analysis

Decarbonatization drivers: EAF production

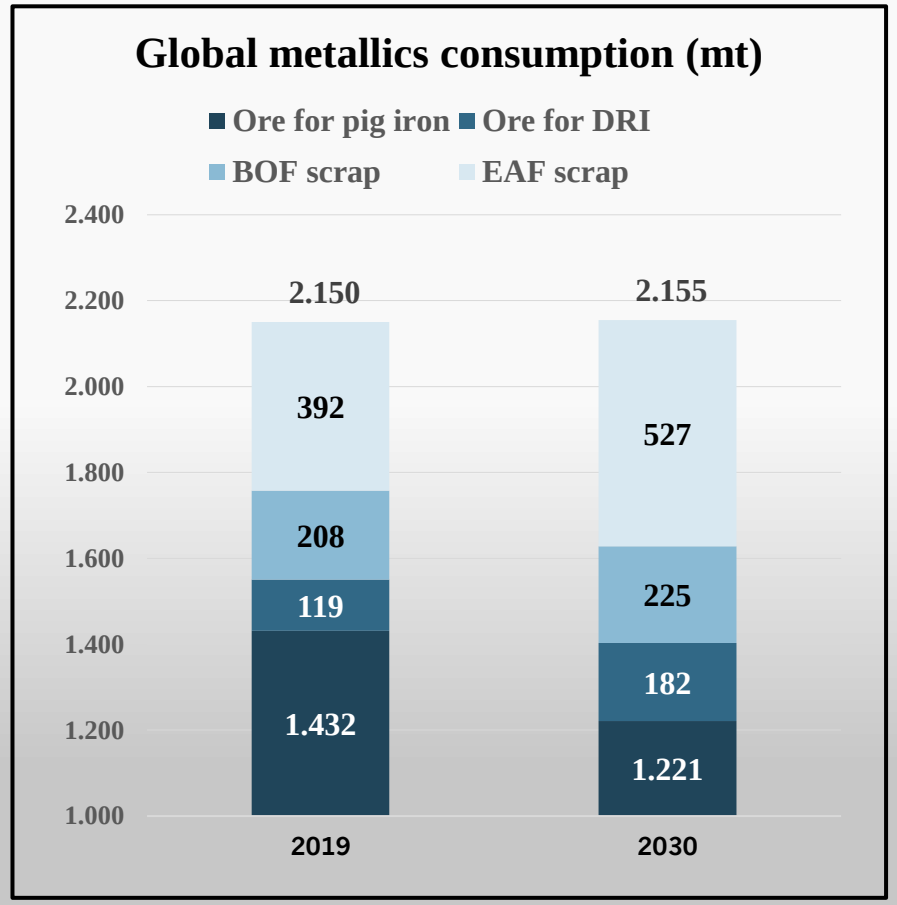
WSD expects global EAF production to grow from 530mt to 710mt and from 28% to 37% of total steel output; the EAF share in developed regions increases from 41% to 55% but decreases from 56% to 47% in developing regions.

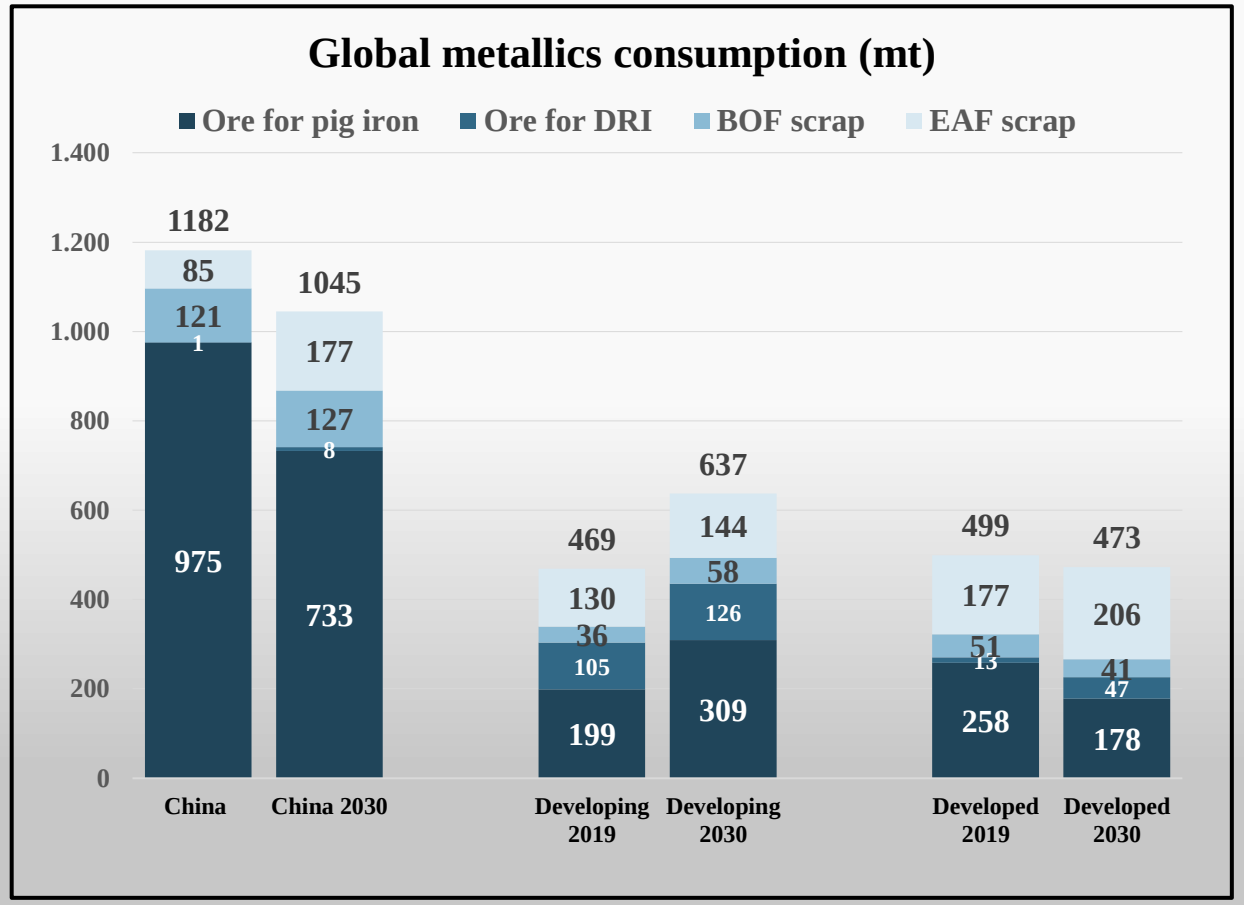


Source: WSD analysis

Global scrap and iron ore consumption

WSD expects a 5mt increase in total scrap and iron ore consumption between 2019 and 2030 despite a 45mt increase in steel production.[13]



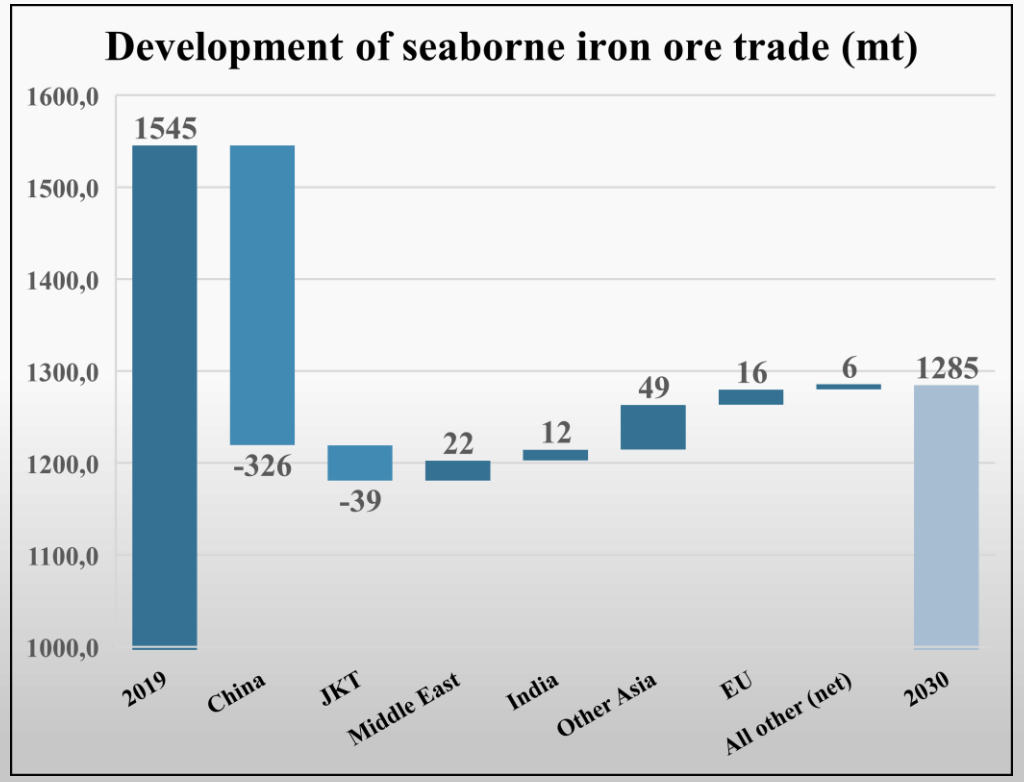


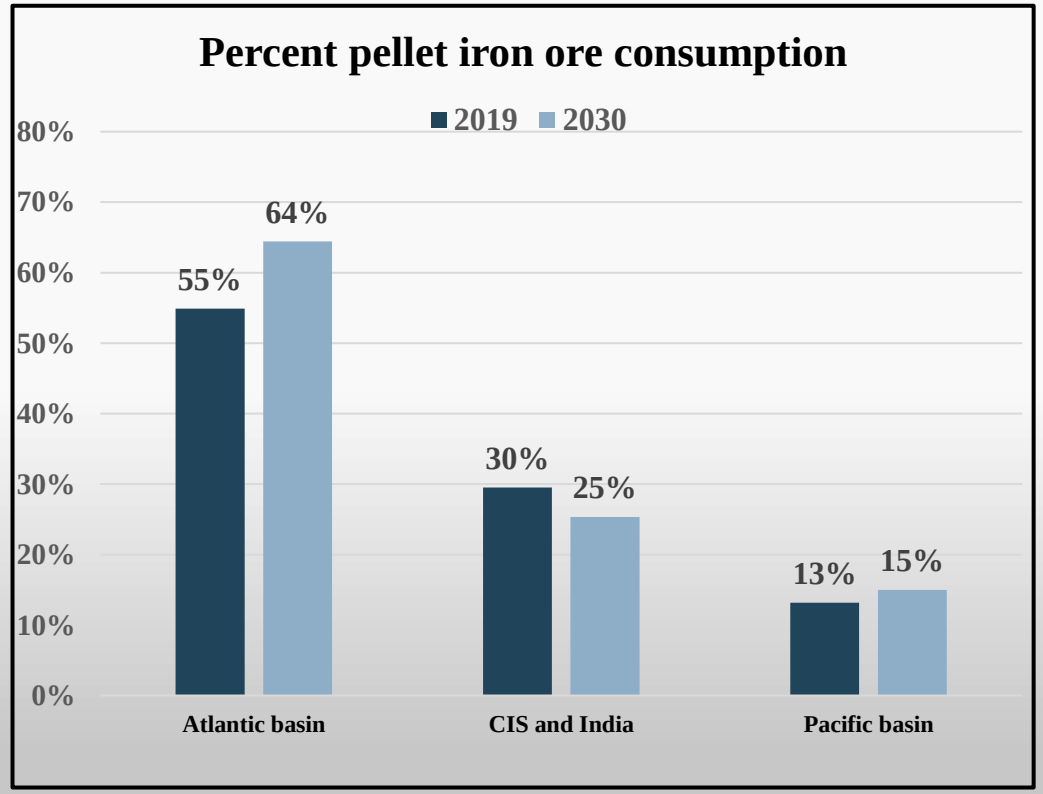
13. The change in metallics requirements is less than the increase in steel production due to the increase in EAF production share which a) uses more scrap than the BOF route and b) has higher yields than the BOF route.; iron ore yielded to useable Fe at 1.45/1.0.

Source: WSD analysis

2030 iron ore market

WSD expects the seaborne iron ore market to decline by around 260mt (17%), driven by the expected reduction in China's consumption.

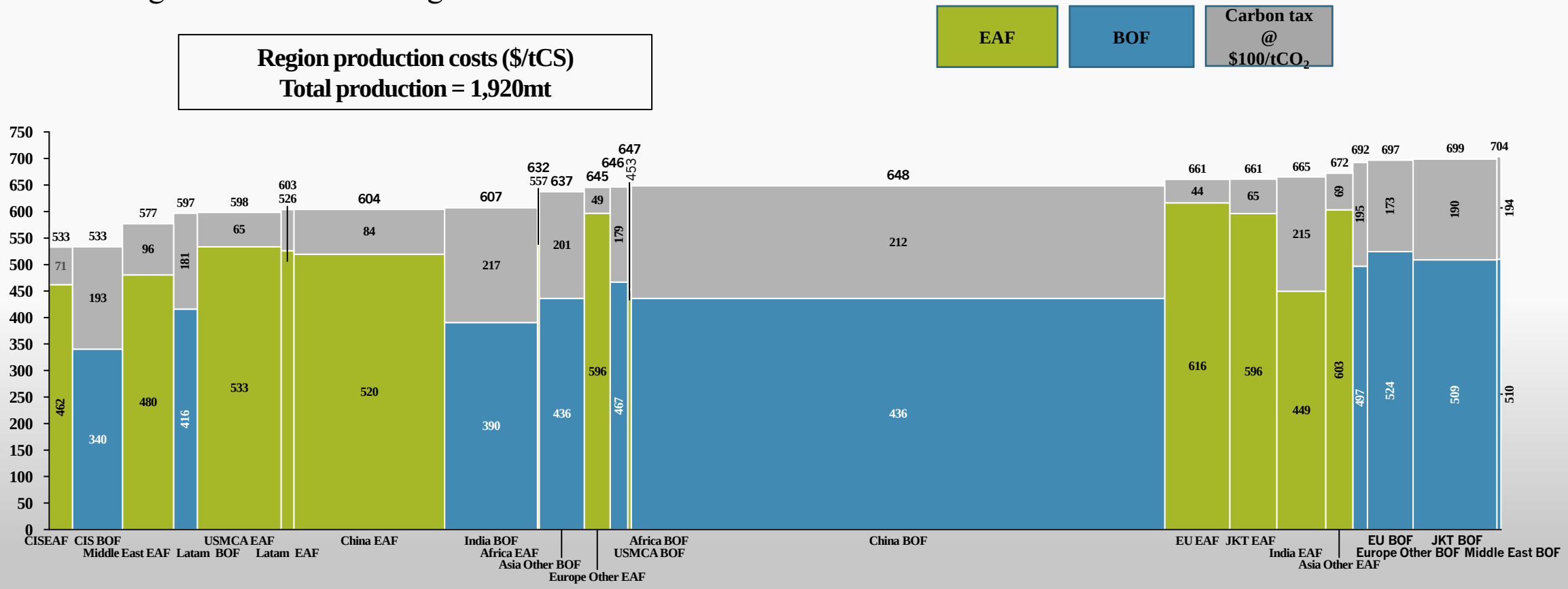




Source: WSD analysis

2030 pro forma industry cost curve

A $100/t carbon tax applied universally would result in a flatter industry cost curve, but with EAF configurations in some regions "stuck" at the higher end of the curve.

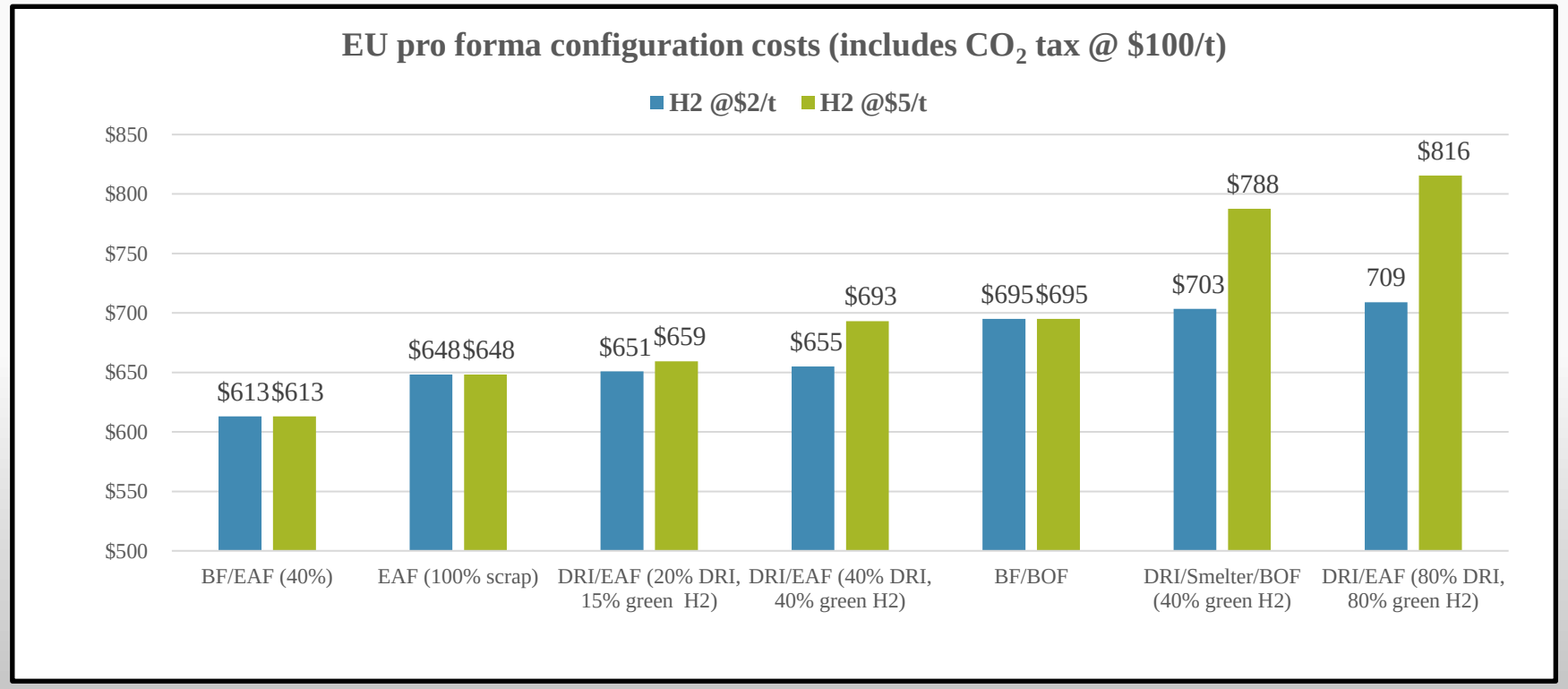


Costs are pro forma 2030 crude steel cash costs/ton reflecting each region's average metallics mix and input prices for each configuration. Carbon tax calculated on country/region specific emissions intensity estimates, weighted by long/flat mix.

Source: WSD analysis

2030 EU pro forma configuration H_2 cost scenarios

The BF/EAF configuration with a 40% hot metal charge is the lowest cost configuration; EAF operations with high percentages of green DRI have higher costs at $2/t H_2 and are extremely uncompetitive at $5/t.

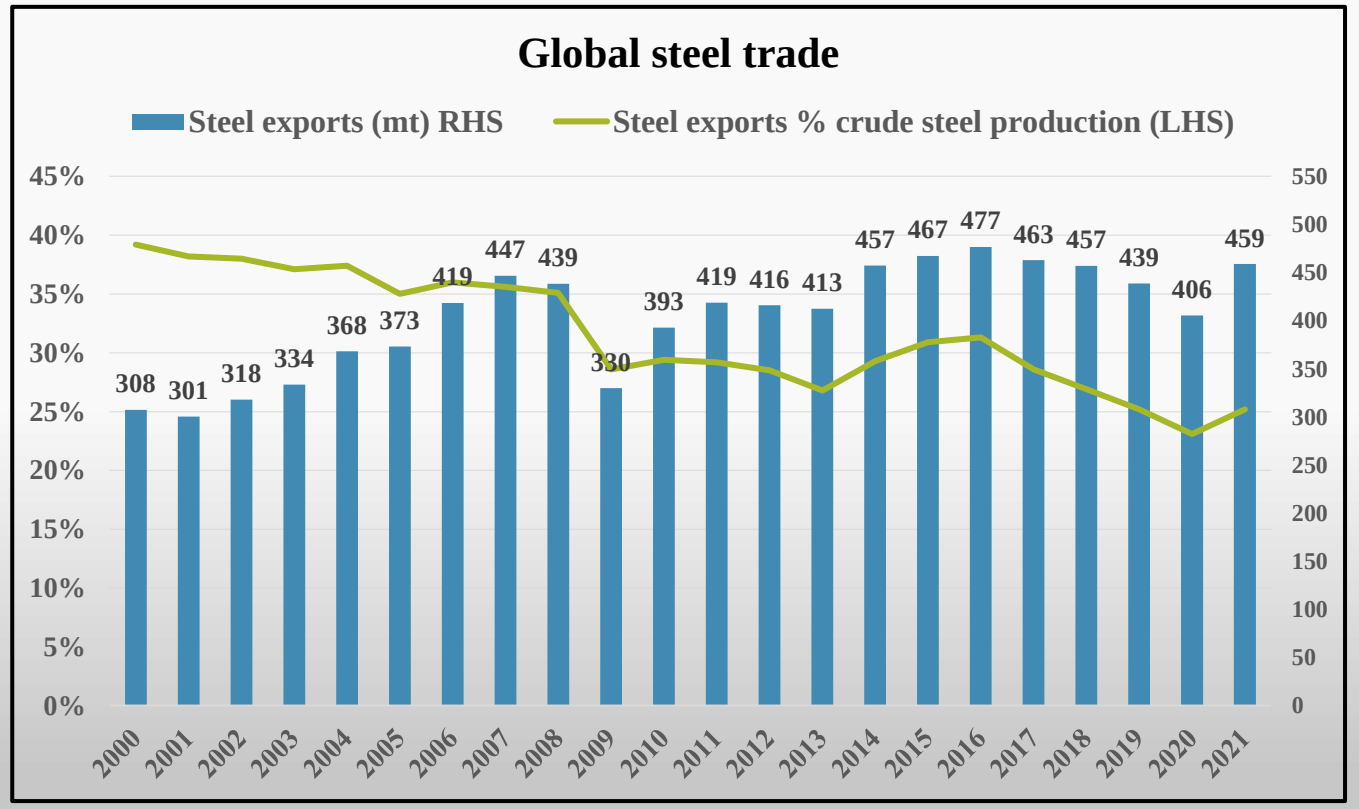


The hydrogen price is assumed to be either a fully-loaded (with capital return) production cost or a purchased price based on a supply contract; assumes 0 free allowances although they will not be fully phased out until 2034; the configuration D with 100% scrap will not be able to produce the same high quality flat roll steels as the others; -included for illustrative purposes

Source: WSD analysis

Direct steel trade

WSD expects that global steel trade will continue to decline over the rest of this decade due in part to the impacts of industry decarbonization actions.

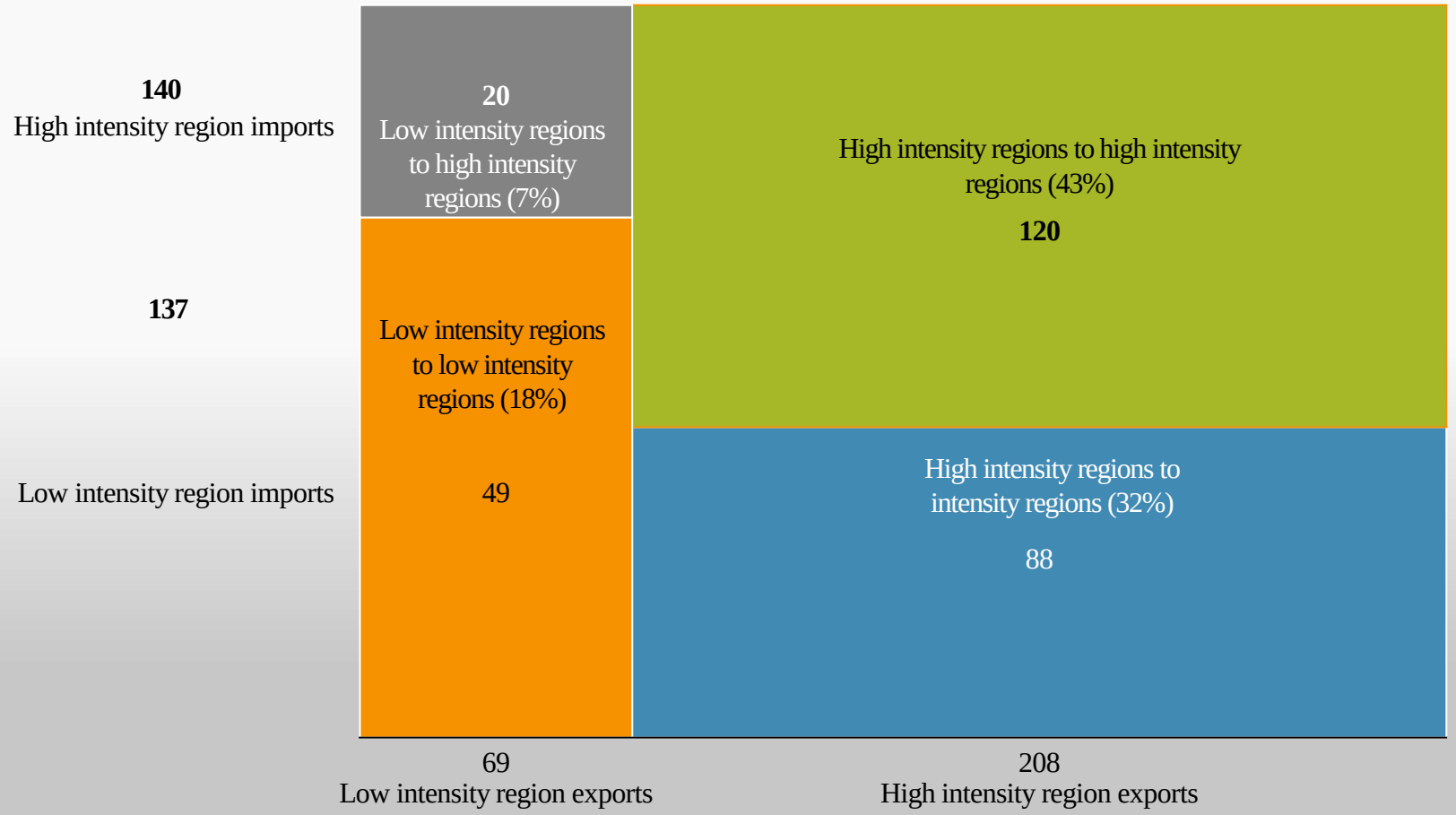


- Increased self-sufficiency of net importing regions: USMCA, Southeast Asia, MENA
- CBAMs and other CO_2-tied trade restrictions will proliferate, constraining opportunities for high emissions exporters
- Countervailing trade cases will also proliferate due to government subsidies for EAF conversions, green hydrogen, CCUS and other forms of support.
- Increased awareness of the carbon footprint of ocean steel trade
- Geo-political fault lines will further reduce export opportunities for "pariah" countries
  - Semi-finished steel shipments from Russian mills to captive rolling mills in the EU and the USMCA are assumed to end

Source: WSA 2022 Steel Statistical Yearbook

Extra-regional steel trade

Exports from high steel emissions intensity (>1.5 kg CO_2/tCS) regions accounted for 75% of the total 278mt extra-regional exports in 2021 of which 88mt (32%) were to low emissions intensity regions.

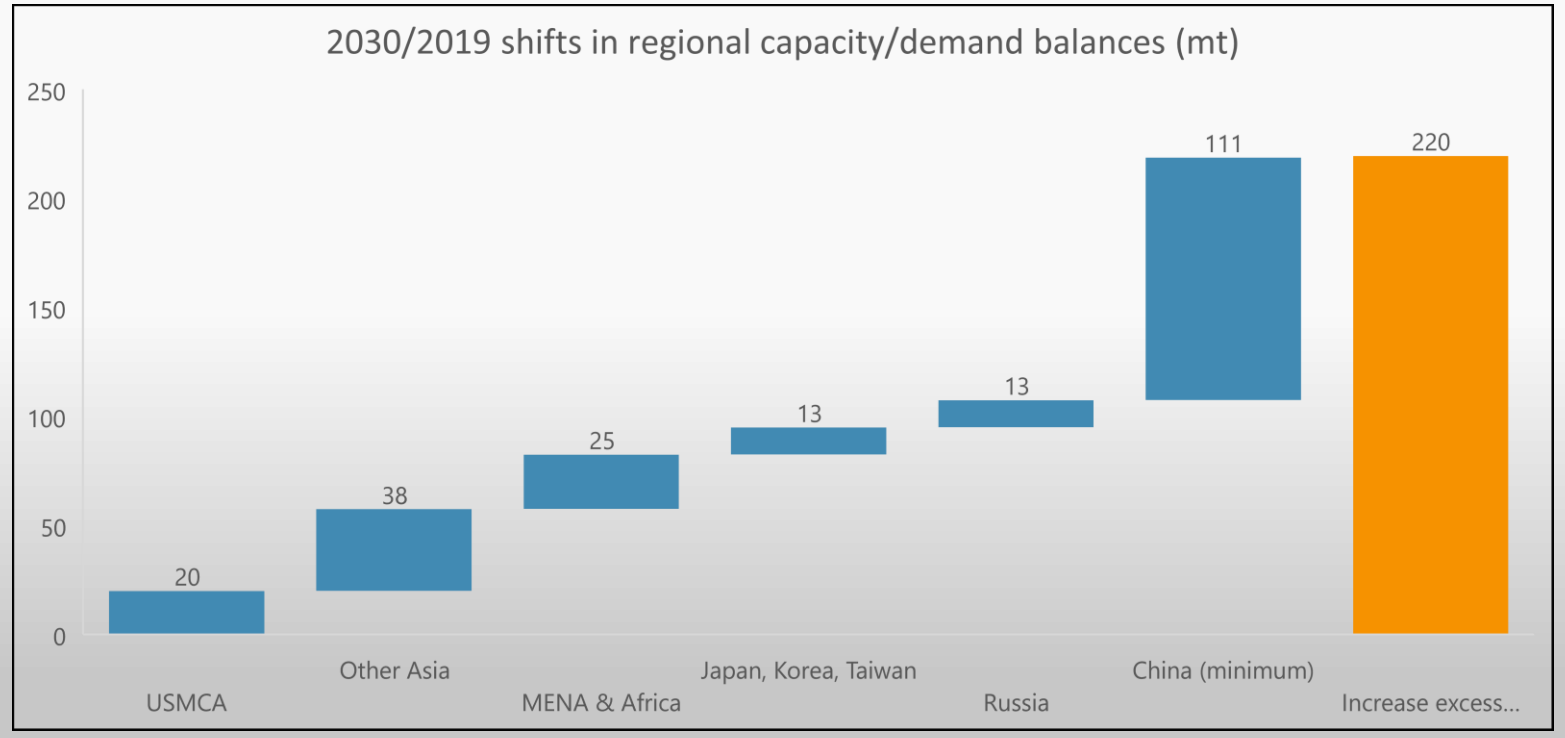


CO_2 figures are based on WSA region averages, weighted between BF/BOF and EAF. High CO_2 regions per WSA categories are: Russia/CIS/Ukraine, China, Japan, Other Asia, Latin America; low CO_2 regions are: USMCA, EU, Other Europe and Middle East/Africa .

Source: WSA *World Steel in Figures 2022;* WSD analysis

Global excess capacity

WSD expects global excess capacity will increase by at least 220mt by 2030 as capacity growth outpaces demand in most regions

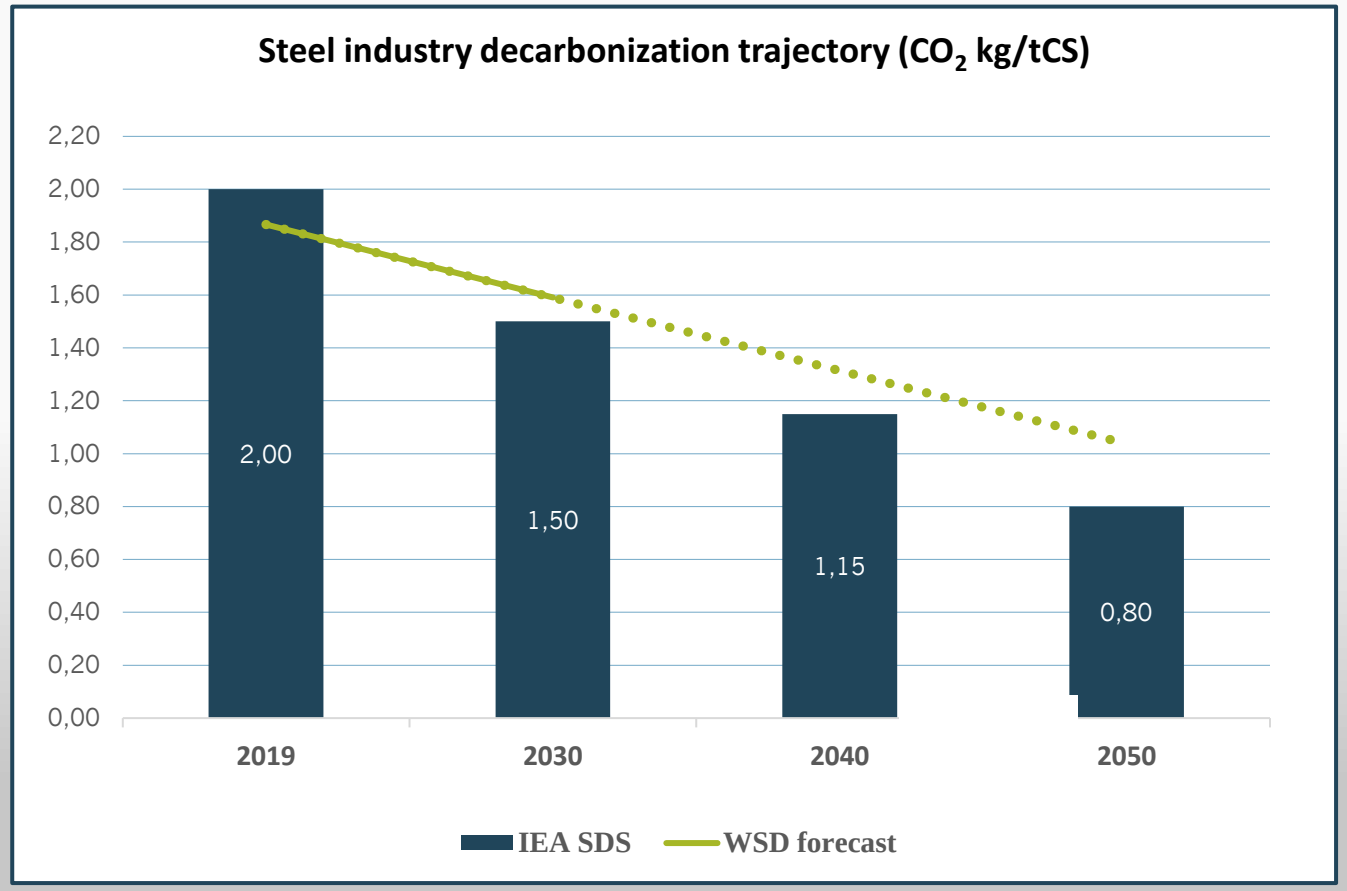


Source: WSD analysis

Utilization of 80% assumed for new capacity. China minimum assumes closure of around 90mt of BF/BOF capacity.

After 2030: the challenge ahead

Based on the trajectory of the decarbonization progress forecast for 2030, global steel intensity will decrease to around 1.10 kg/tCS by 2050 - above the IEA's Sustainable Development Scenario (SDS) target of 0.8 kg/tCS and far above the Net Zero target.



- There is a risk that without a further steep drop in China steel production, the pace of industry decarbonization will slow in the decade to 2040
- BF/BOF production growth in India and Southeast Asia may outpace the deployment of alternative and mitigating technologies.
  - Rapid growth in DRI production may outpace growth in the availability of green hydrogen resulting in continued high levels of natural gas usage in many regions.
  - The rapid scaling and adoption of BF CCUS is the most important lever for the continued reduction in the global steel industry's emissions after 2030.

Source: *IEA Iron and Steel Technology Roadmap* 2020 and updates; WSD analysis