BHP

Decarbonising steelmaking: technology options and regional pathways

Huw McKay Chief Economist
Ben Ellis Head of Marketing Strategy and Technical Marketing
Wenjun Bao Manager Steel and Nonferrous Analysis
Lee Levkowitz Manager Energy and Technology Research

11 November 2020

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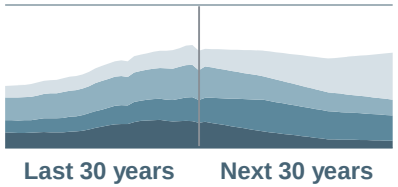
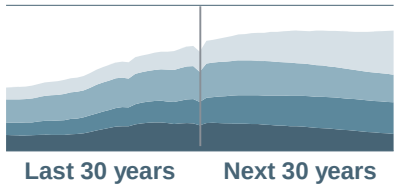
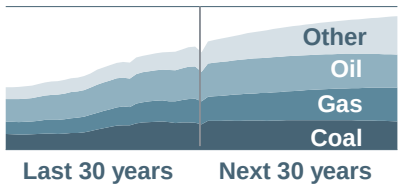
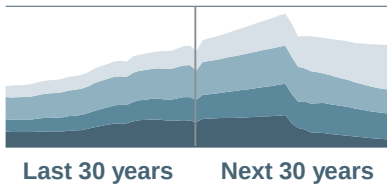
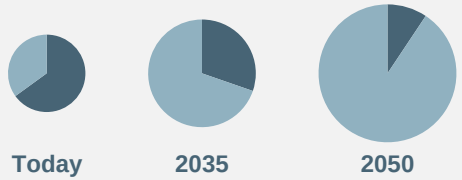
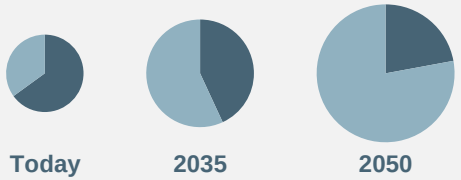
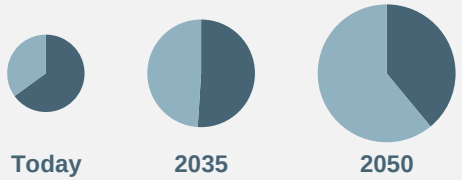
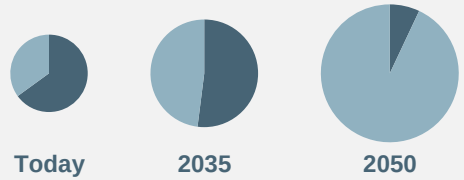
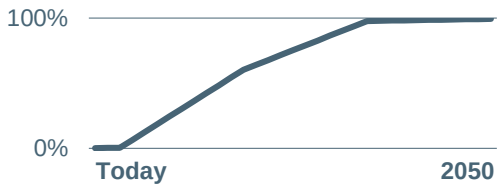
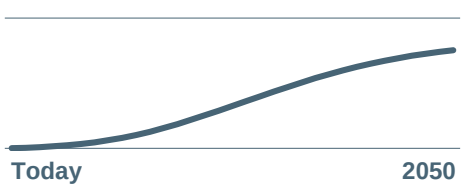
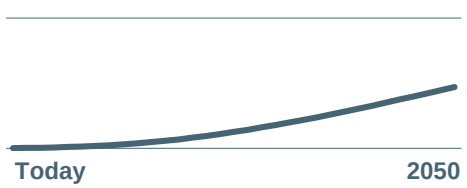
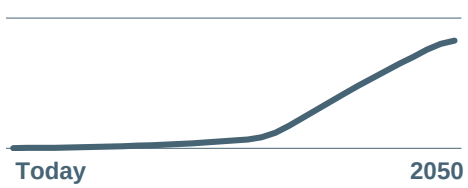
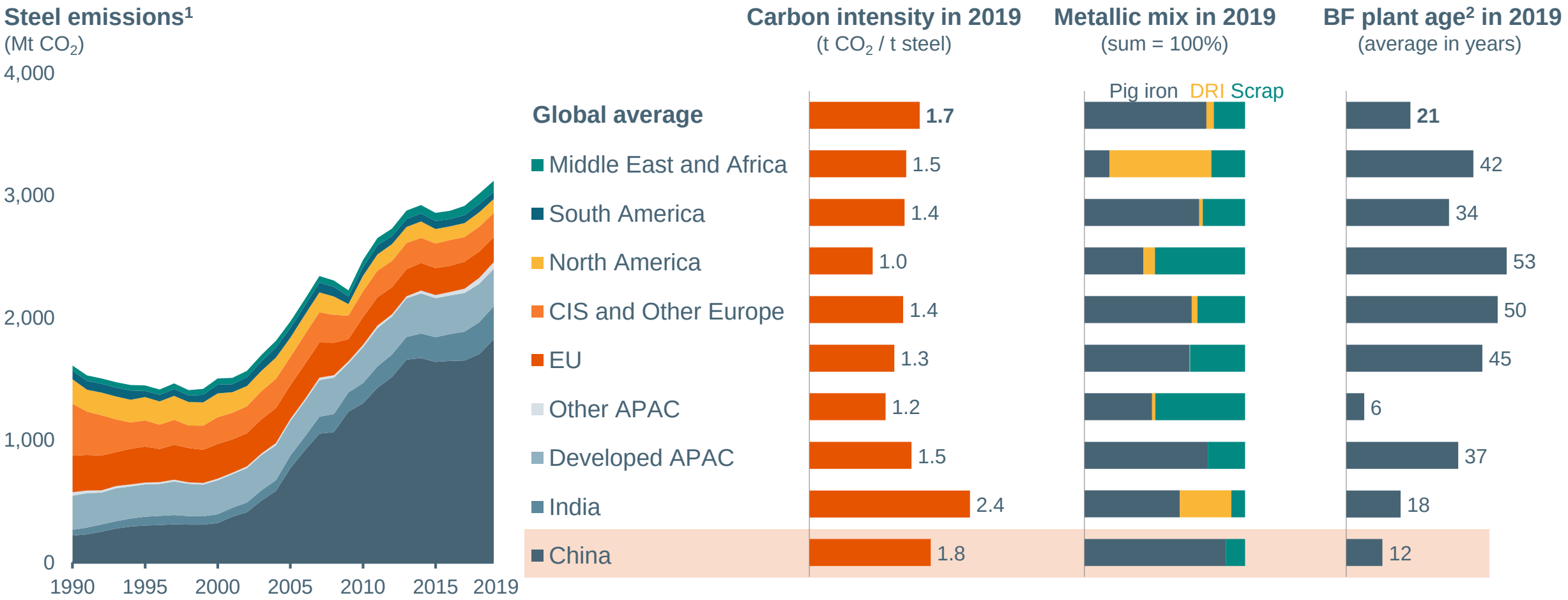
Climate change scenarios

Our portfolio is tested across a range of futures

	1.5 degrees	Lower Carbon View	Central Energy View	Climate Crisis
	Paris Agreement goals met through unprecedented large-scale changes to the global energy system	*Faster and deeper decarbonisation trends and policies, particularly in the easier to abate sectors*	*Reflects our view on the most likely pathway for policy, technology and consumer choice*	*A climate shock leads to turmoil and massive economic contraction and hands a mandate to governments to coordinate and enact wide-sweeping climate policies*
Total primary energy demand (Btoe)				
Fossil fuel share of power generation				
Electrified LDV fleet				
CCUS	• 10,000 CCUS facilities installed • 6 Bt of carbon captured by 2050	• CCUS is relegated to non-power “harder to abate” sectors • Technology constrained by high upfront capital costs and lack of storage availability		• ~1 Bt of CCUS captured by 2050 • Policy push enables CCUS in non-power sector post-crisis
Carbon Price	Effective global carbon price of US$160/t in 2030 and US$280/t in 2050	Regional carbon prices ranging from US$25-110 by 2030	Regional carbon prices ranging from US$10-40 by 2030	**Pre-crisis:** Regional carbon prices average <$10/t **Post-crisis:** Global carbon price increases to $160/t

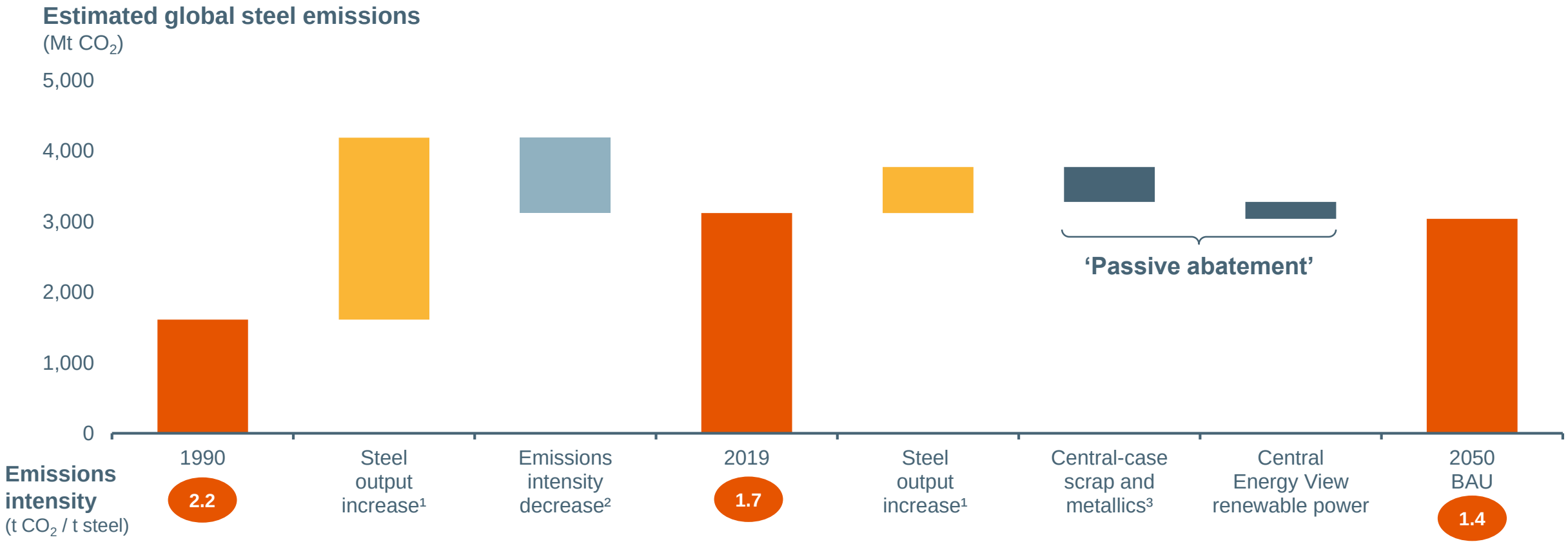
Steel emissions have roughly doubled in the last three decades, with rising demand dominating a major efficiency uplift



Source: Worldsteel; BHP analysis.

1. Estimated emissions from direct steelmaking process (captive sintering, pelletising, coking, ironmaking, steelmaking, casting and hot-rolling) and purchased power.
2. Regional capacity-weighted average age for the integrated steel plants. This is a sample estimate, not a census of all operations.

BAU passive abatement to barely offset demand growth to 2050



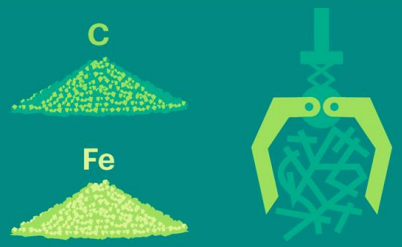
Source: BHP analysis; worldsteel.
1. Steel output increase multiplied with initial base year emissions intensity.
2. Includes technological shifts, efficiency gains and passive abatement levers such as steel metallic and power mix changes from 1990 to 2019.
3. Central-case scrap availability increase and business-as-usual natural-gas DRI development in gas-rich traditional markets.
Note: BAU means business-as-usual.

BHP's three stage steel decarbonisation framework

Each region will transit through these stages at its own pace, based on unique local conditions faced by steelmakers

Optimisation stage

20% CO_2 reduction vs. BAU



Energy Optimisation

- Waste heat recovery
- Blast furnace top gas recovery turbines
- Coke dry quenching

Technology Improvements

- Thin slab / strip casting

Raw Material Optimisation

- Higher quality iron ore
- Premium hard metallurgical coal
- Increased scrap-to-steel ratio

Transition stage

50-60% CO_2 reduction vs. BAU

Low Carbon Fuels

- Biomass
- BF hydrogen injection

Modified Blast Furnace

- Oxygen blast furnace
- Use of metallics

End of Pipe Solutions

- CCUS within integrated steelmaking
- CCUS with alternate technologies

Green end state

90% CO_2 reduction vs. BAU

Direct Reduction

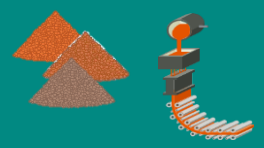
- Hydrogen based DRI

New Technologies

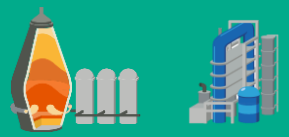
- Direct electrolysis
- Hydrogen flash smelting

Key regions in 2050 under Central and Lower Carbon cases

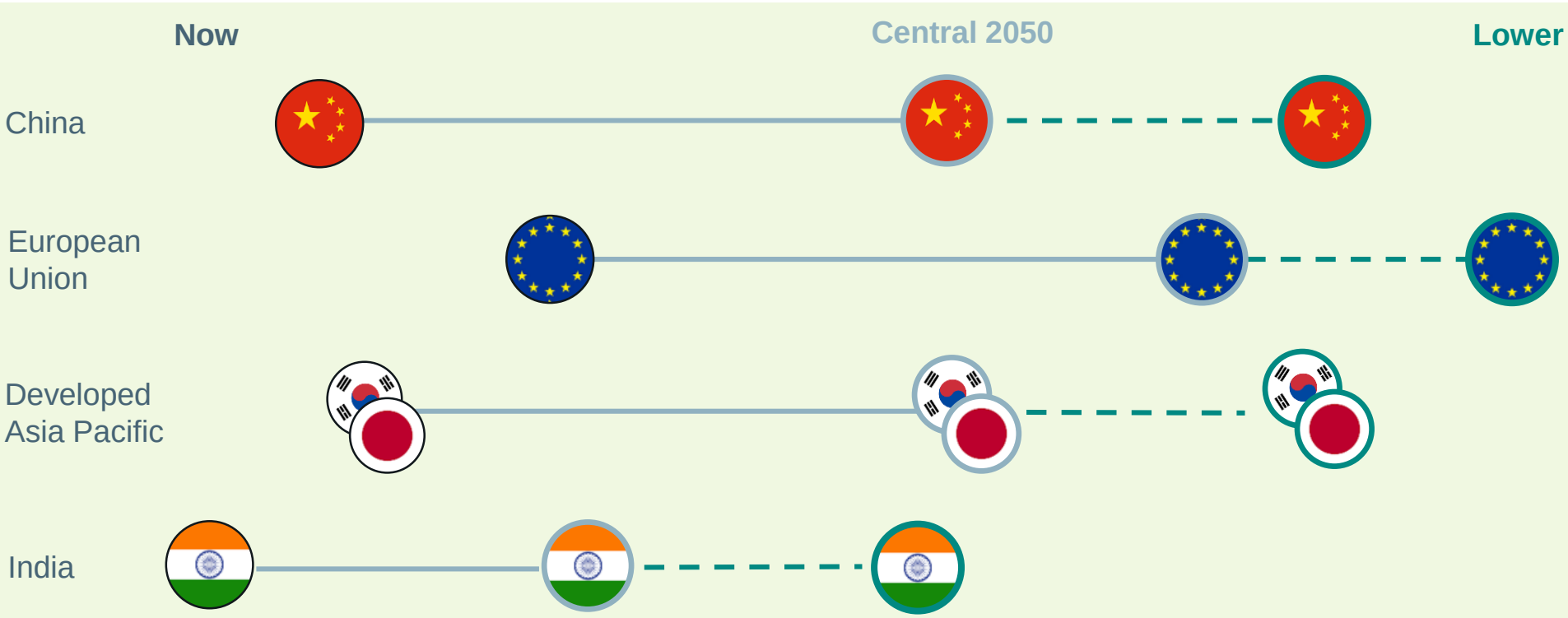
Optimisation stage
Energy optimisation
Raw material optimisation
Technology improvements



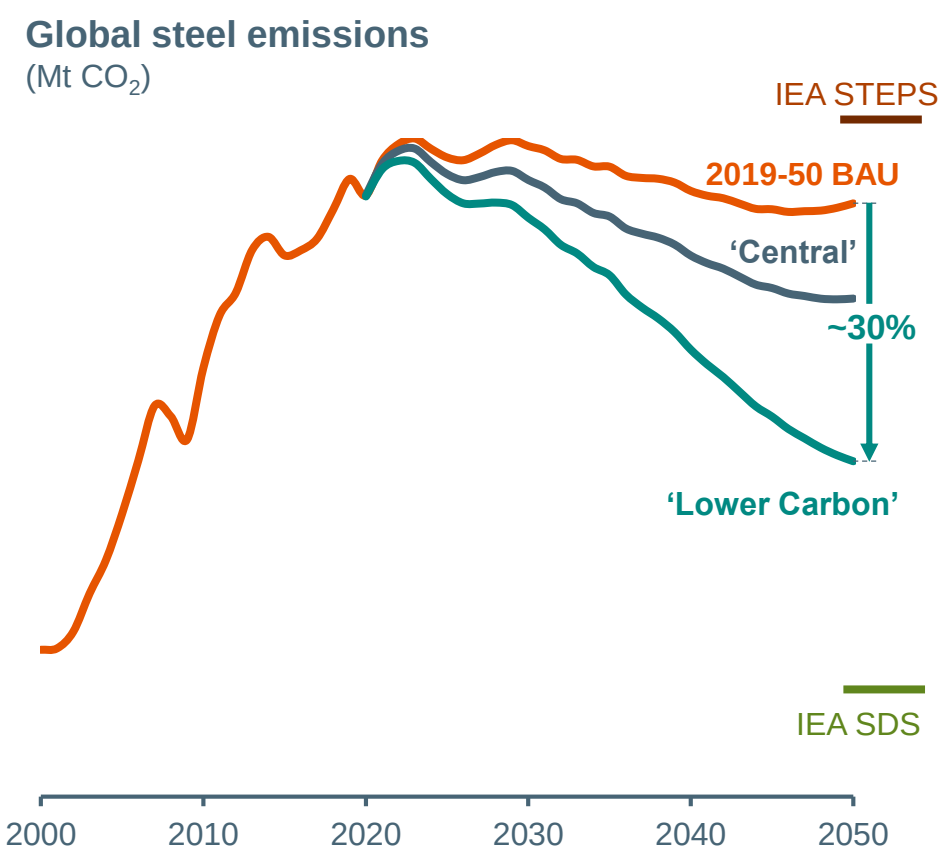
Transition stage
Low carbon fuels
Modified blast furnace
End of pipe CCUS

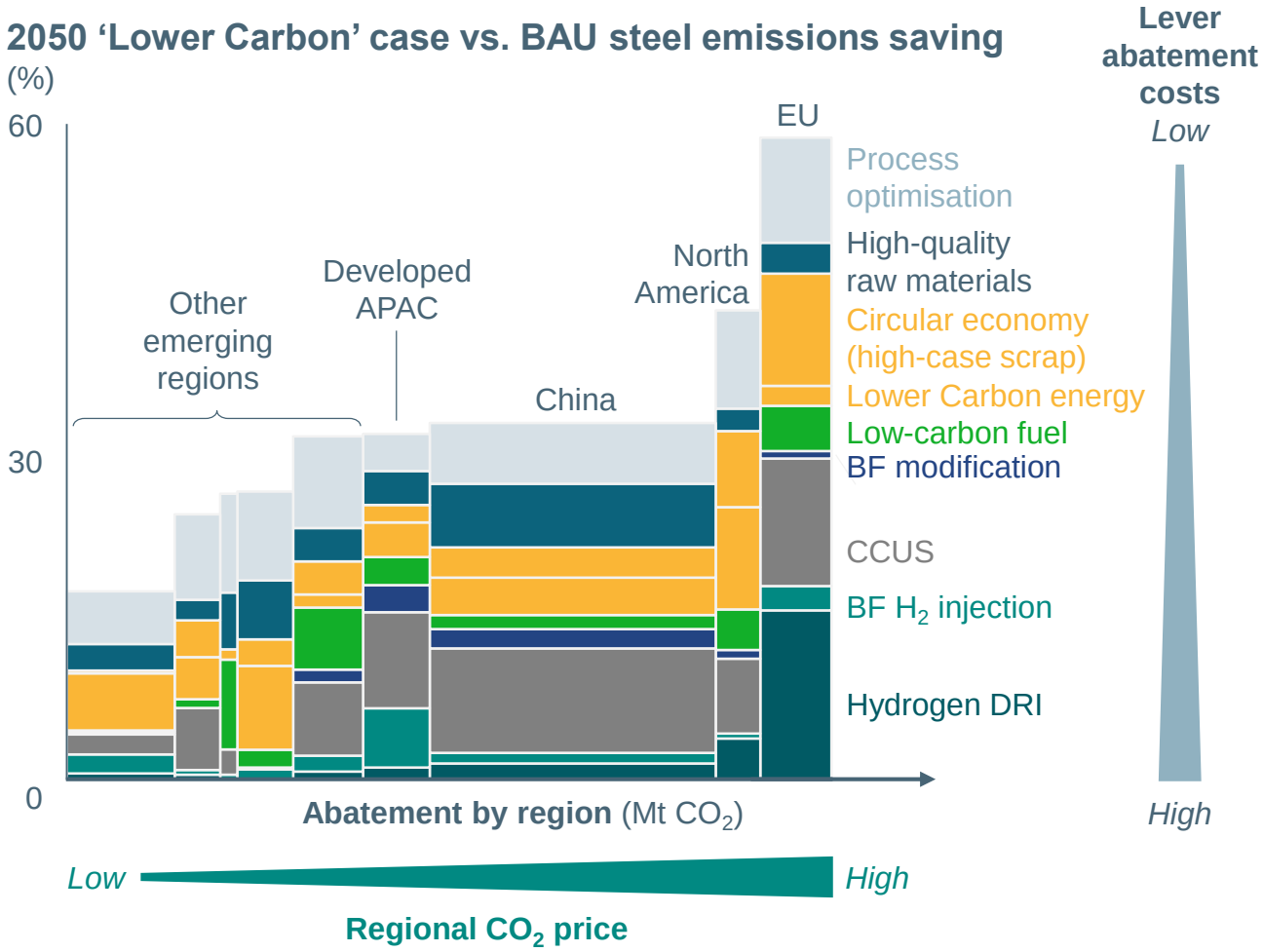


Green end state
Green hydrogen DRI
Electrolysis



Global scenarios and a bottom-up view of regional pathways





Source: BHP analysis; IEA.
Note: BHP Central Energy View (Central-case) tracks 3°C temperature increase above pre-industrial level. BHP Lower Carbon View tracks approximately 2.5°C increase. IEA State Policies Scenario (STEPS) is the baseline scenario in its Iron and Steel Technology Roadmap 2020. The IEA Sustainable Development Scenario (SDS) tracks 1.5~1.65°C temperature rise.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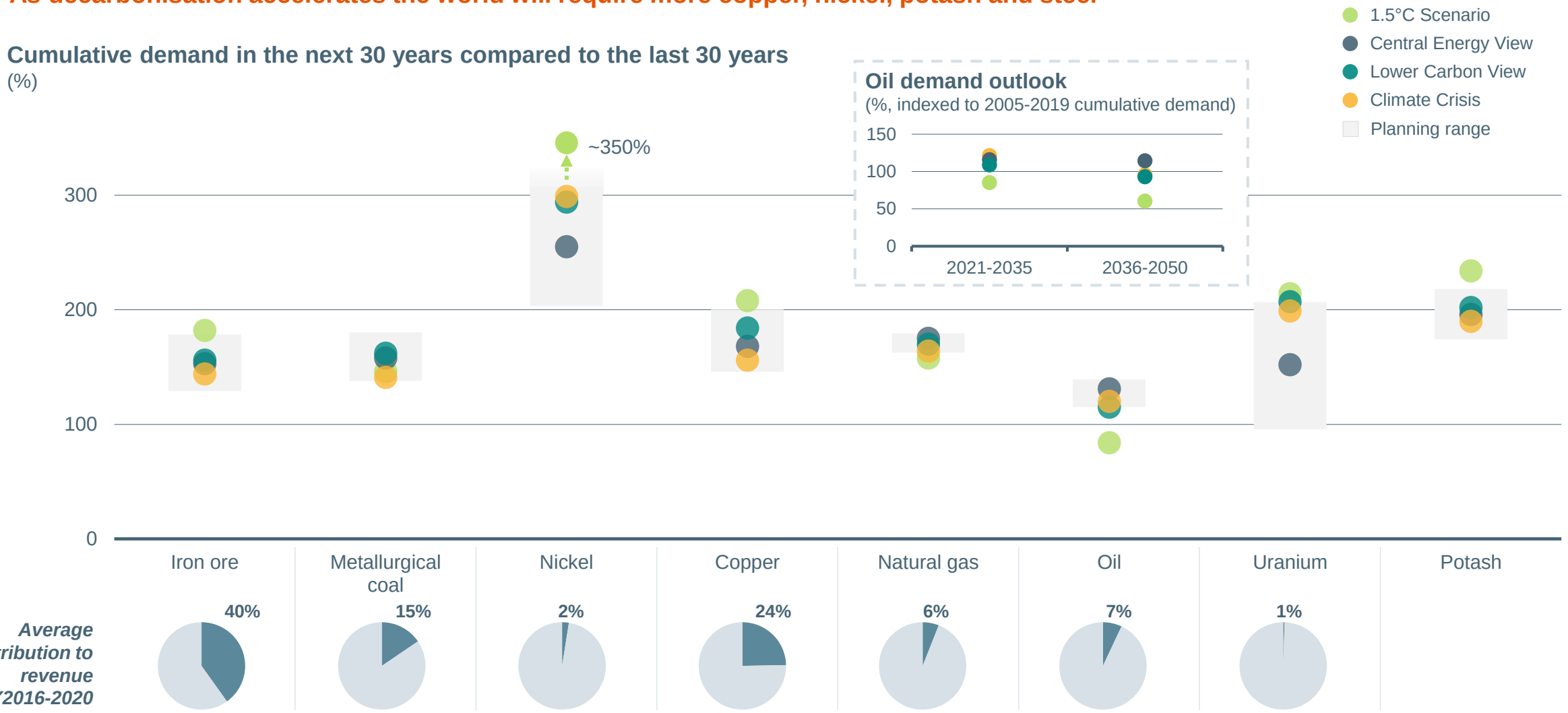
Appendix

Most of our commodities benefit in a decarbonising world

As decarbonisation accelerates the world will require more copper, nickel, potash and steel



Source: BHP; Vivid Economics.

Snapshot of global steelmaking as of 2019

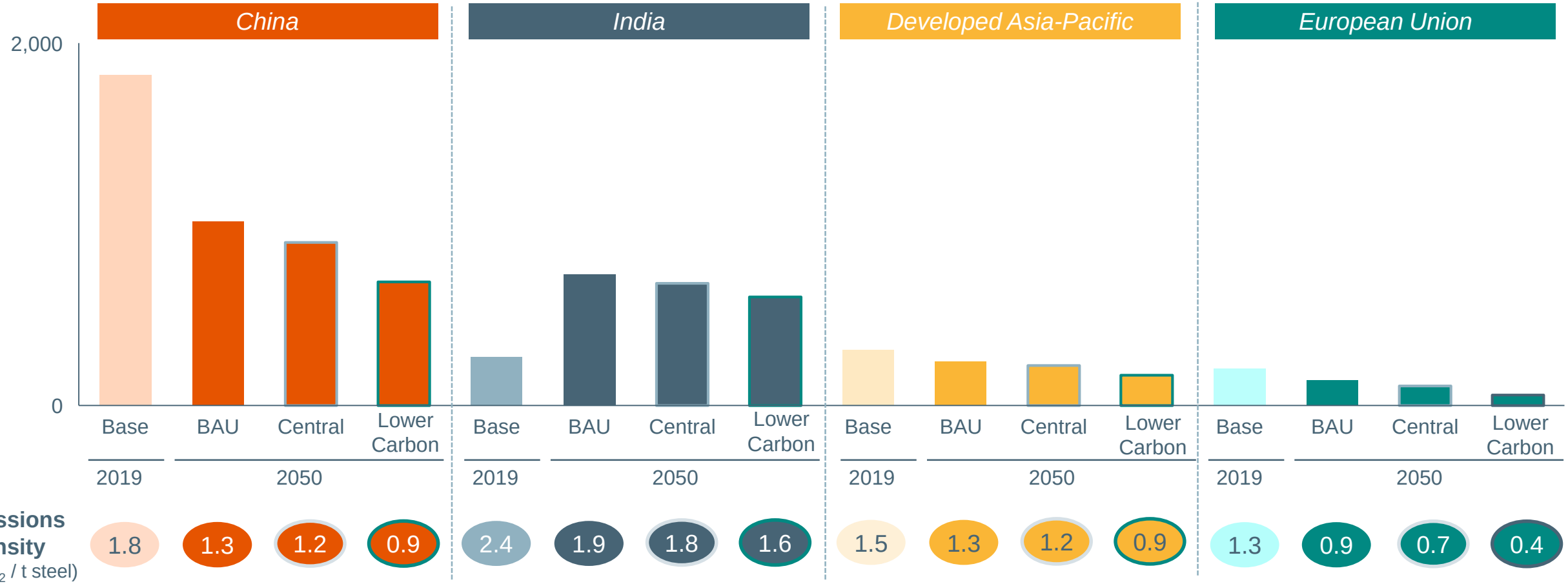
Country / Region	Crude steel (Mt)	Global share (%)	BOF / OHF share (%)	EAF / IF share (%)	DRI in EAF (%)[2]	BF plant age[3] (years)
China	996	53	90	10	1	12
India	111	6	44	56	57	18
Developed APAC	199	11	71	29	1	37
Other APAC	48[1]	3	31	69	5	6
European Union	159	8	59	41	6	45
CIS and Other Europe	140	7	61	39	9	50
North America	120	6	32	68	14	53
South America	41	2	67	33	7	34
Middle East and Africa	61	3	10	90	87	42
Global	**1,875**	**100**	**72**	**28**	**21**	**21**

Sources: worldsteel; BHP estimates.
BOF – basic oxygen furnace; OHF – open hearth furnace; EAF – electric arc furnace; IF – induction furnace.
1. With some adjustment with possible hidden induction furnace production in Other Asia to balance global steel production and demand.
2. Estimated direct reduced iron (DRI) consumption = (production + net import) / EAF production.
3. Regional capacity-weighted average age for the integrated steel plants. This is a sample estimate, not a census of all operations.

Steel emissions by 2050 for key regions

Regional steel emissions 2019 – 2050

(Mt CO_2)



Source: BHP analysis.

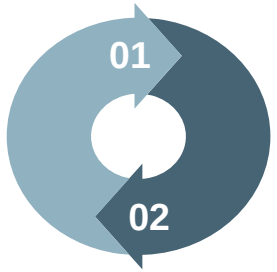
Partnering with China Baowu to address Scope 3 emissions

Supporting industry decarbonisation in line with our Scope 3 goals through partnership with one of the world's largest steel makers

Steel sector decarbonisation

- First major project under BHP's Climate Investment Program
- 5 year partnership with China Baowu focussing on:
  - ✓ Capturing emissions across the integrated steelmaking process; CCUS pilot at one of China Baowu's blast furnace facilities
  - ✓ R&D in hydrogen and oxygen enrichment in blast furnaces
  - ✓ Low carbon technologies with potential to reduce carbon emission intensity by up to 60%
  - ✓ Establishing a knowledge centre for industry stakeholders

01 Reduce
Reduce emission intensity at their source through process improvement and raw material optimisation



02 Capture
Capture emissions across the steel making process through application of CCUS technology

CCUS
- Use of BHP high quality raw materials
- Optimal capture location and technology
- Utilisation of captured carbon

Raw material optimisation
- Use of BHP premium coking coal
- High lump level in the burden
- Alternate agglomeration technologies

Blast furnace modification
- Hydrogen injection
- High level and pure Oxygen enrichment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