worldsteel
ASSOCIATION

Steel and CO_2 – a global perspective

Presentation to BHP Beijing Symposium, Beijing China

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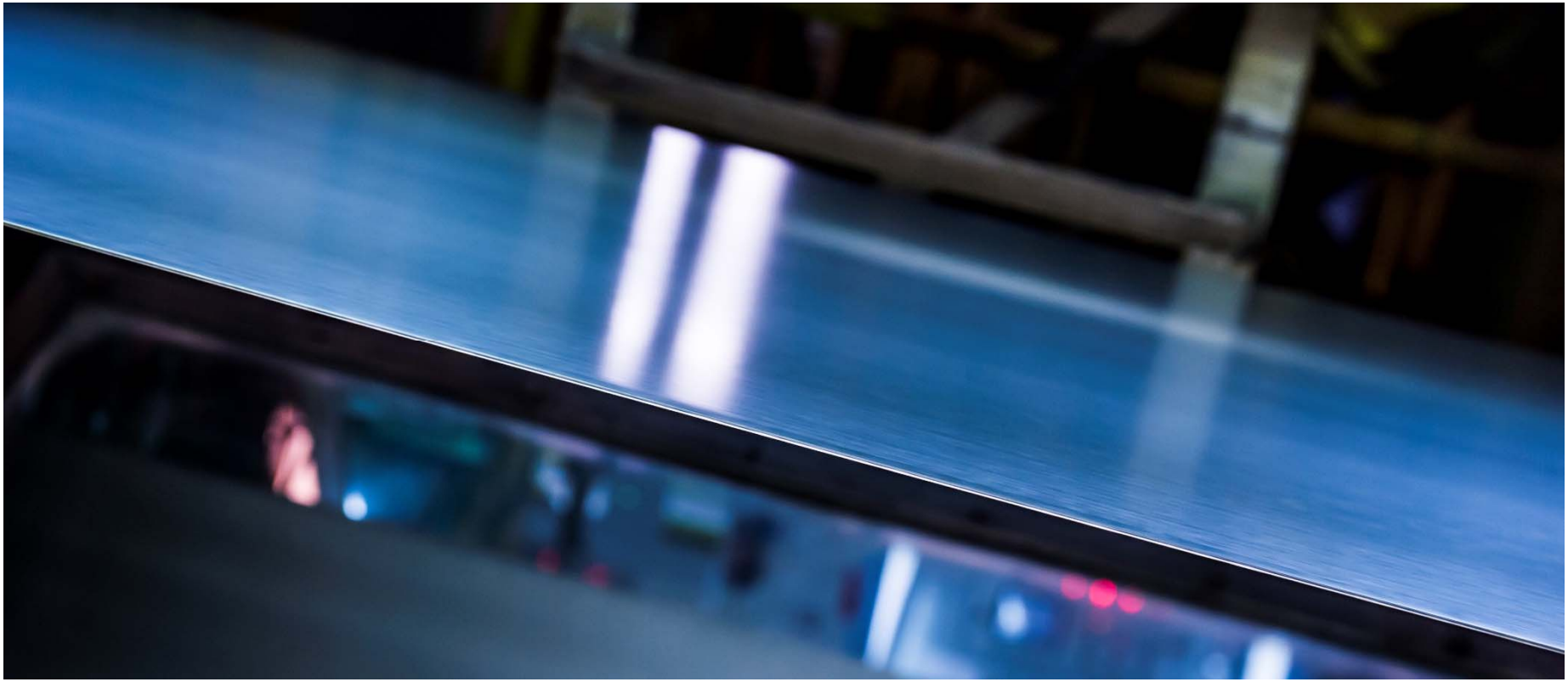
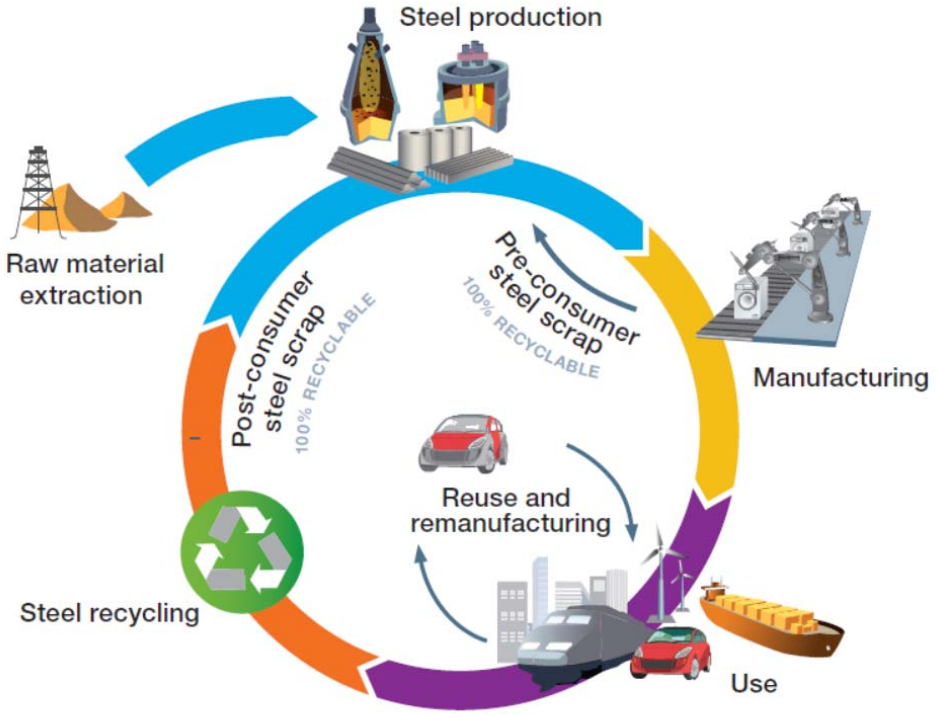


What are our key goals?

- Act as the focal point for the steel industry providing global leadership on all major strategic issues impacting the industry, particularly focusing on economic, environmental and social sustainability
- Deliver benchmarking analysis and drive global improvement initiatives in the areas of environmental protection, technology, safety and people development
- Promote global market development opportunities for steel and promote steel to the world at large
- Provide on a timely basis world-class economic data and analysis on the global steel industry and its value chain, as well as assessments on life cycle aspects of steel
- Increase awareness, understanding and support for the steel industry amongst all external stakeholders and key target audiences worldwide
- Promote market competition that is free of government interventions preventing fair trade.

Steel in use

- Steel is the worlds most recycled material and also uniquely positioned to contribute to the transition to the circular economy



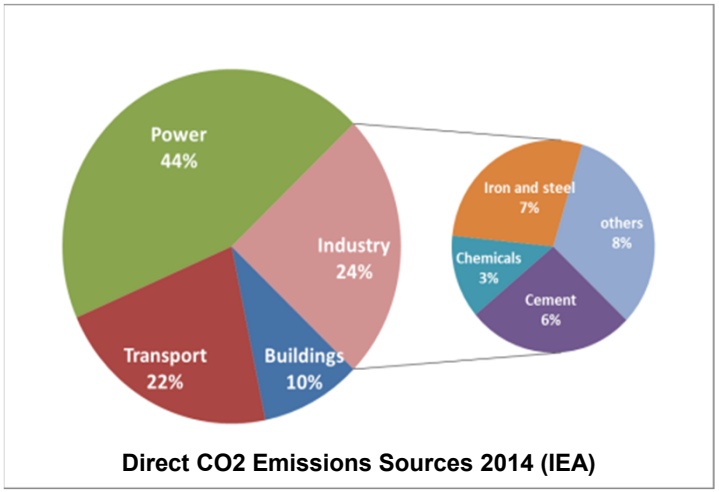
Steel enables mitigation

Almost every GHG mitigation technology **relies on steel**

Thermal and renewable energy, electrification, mass transport, smart cities, shipping, CCS, hydrogen…

The goals of the Paris agreement cannot be met without Steel

Ways of visualising steel's total CO_2 + others = GHG footprint



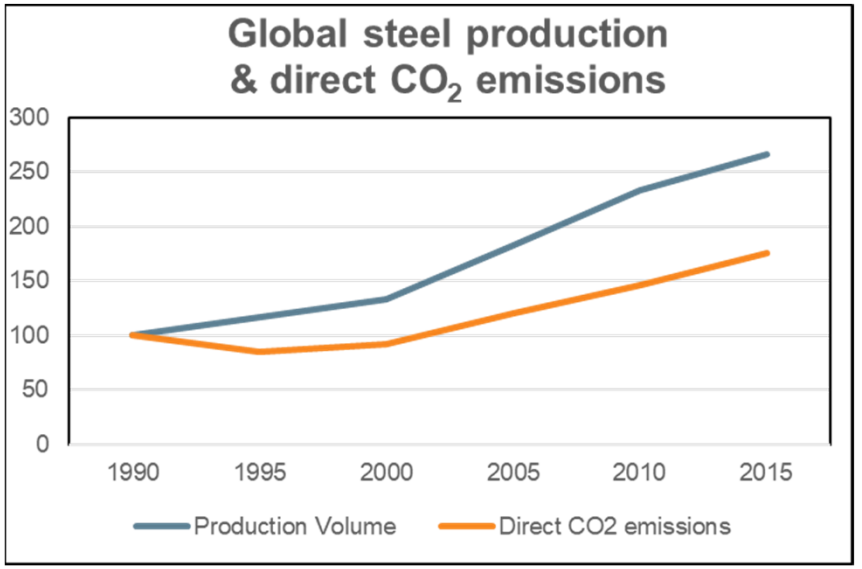
Direct CO2 Emissions Sources 2014 (IEA)

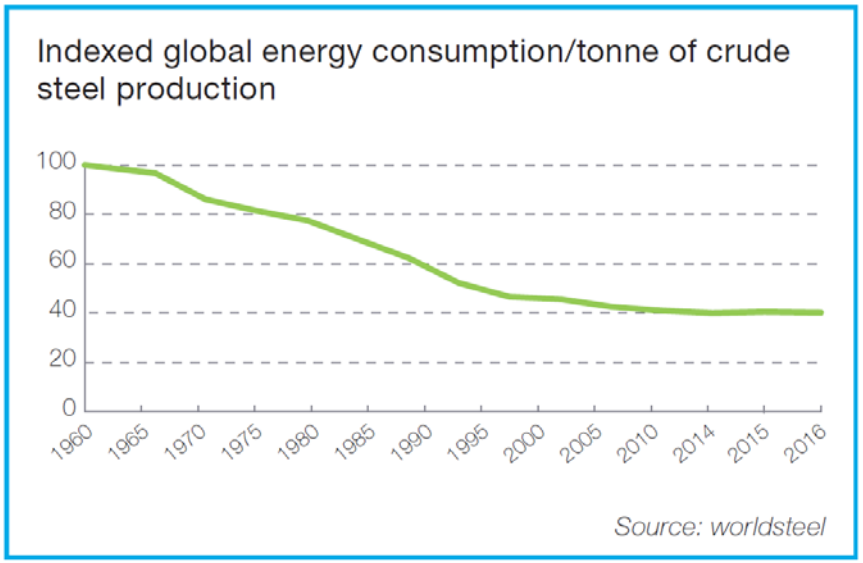
- In ore based steelmaking most emission are Scope 1 (direct). Scrap based steelmaking is mainly Scope 2 (electricity purchase and use).

- Direct emissions from our industry represent about 7% of the global total

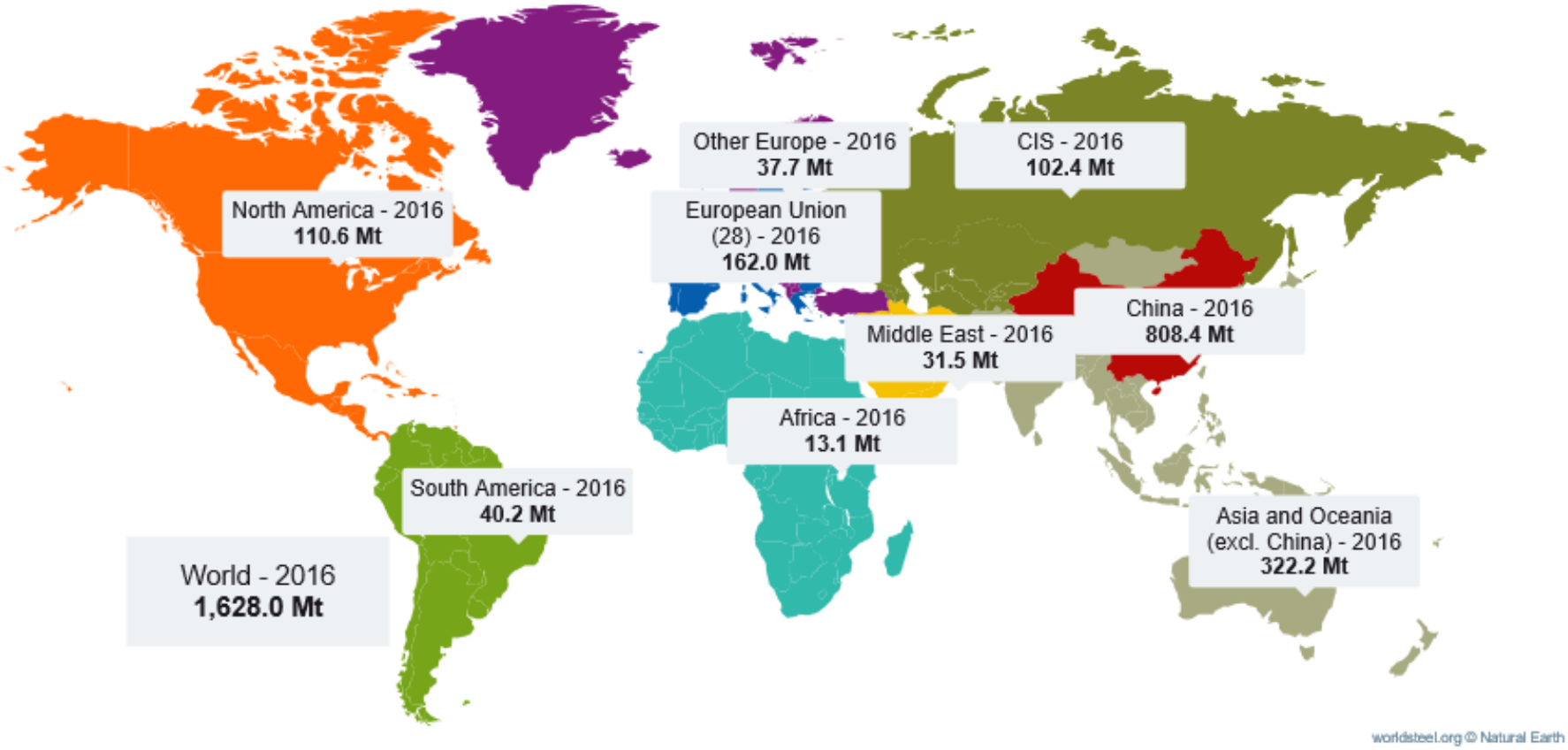
Steel industry has seen steady gains in GHG efficiency

- In ore based steelmaking carbon is primarily used as a reducing agent, not a source of thermal energy
- Energy constitutes a significant portion of the cost of steel production, from 20% to 40%
- 1990 - 2015 BOS/EAF Volume increased by 166%, emissions by 77%
- **Steel is now more CO_2 efficient than ever before.**

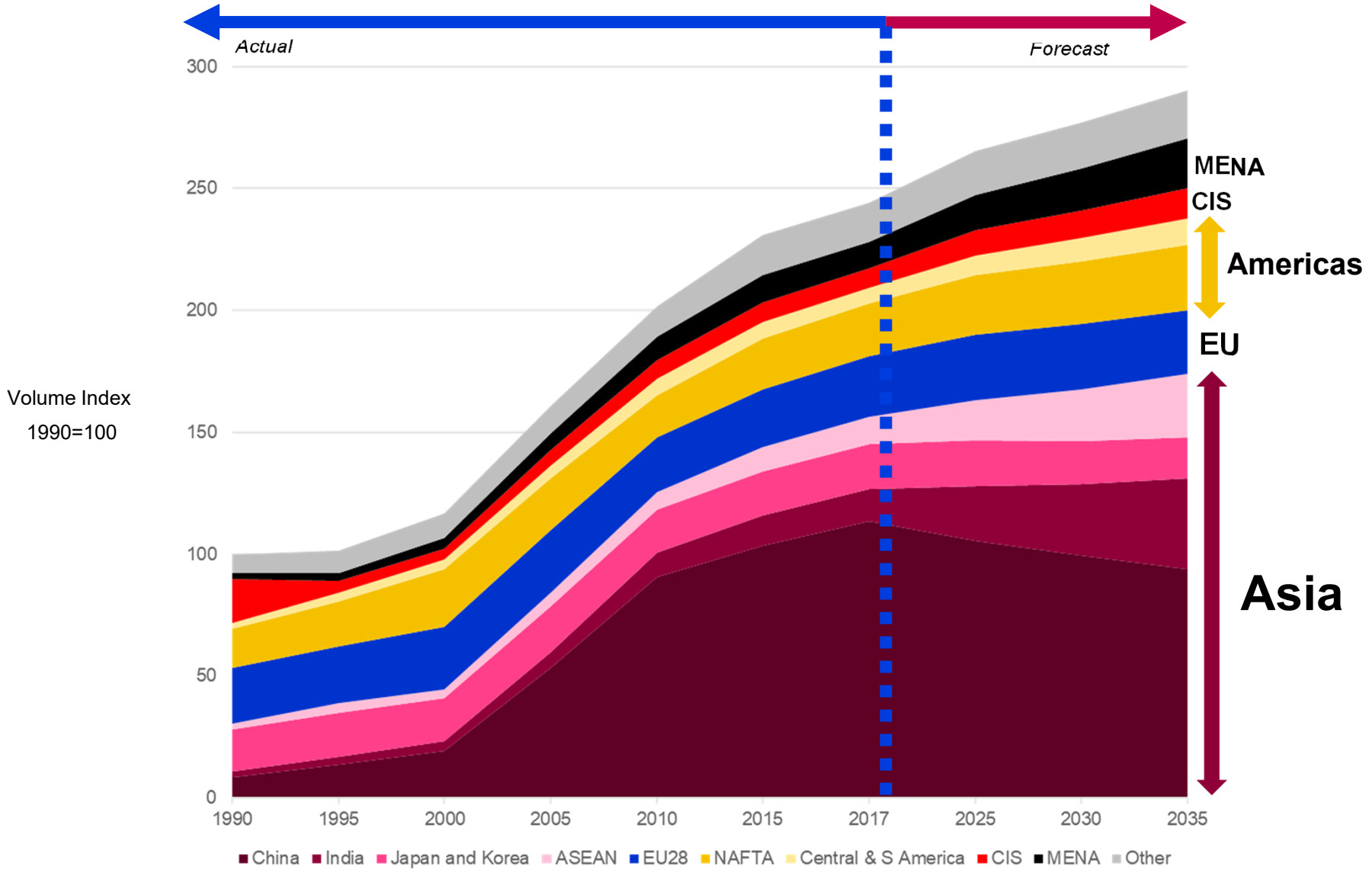




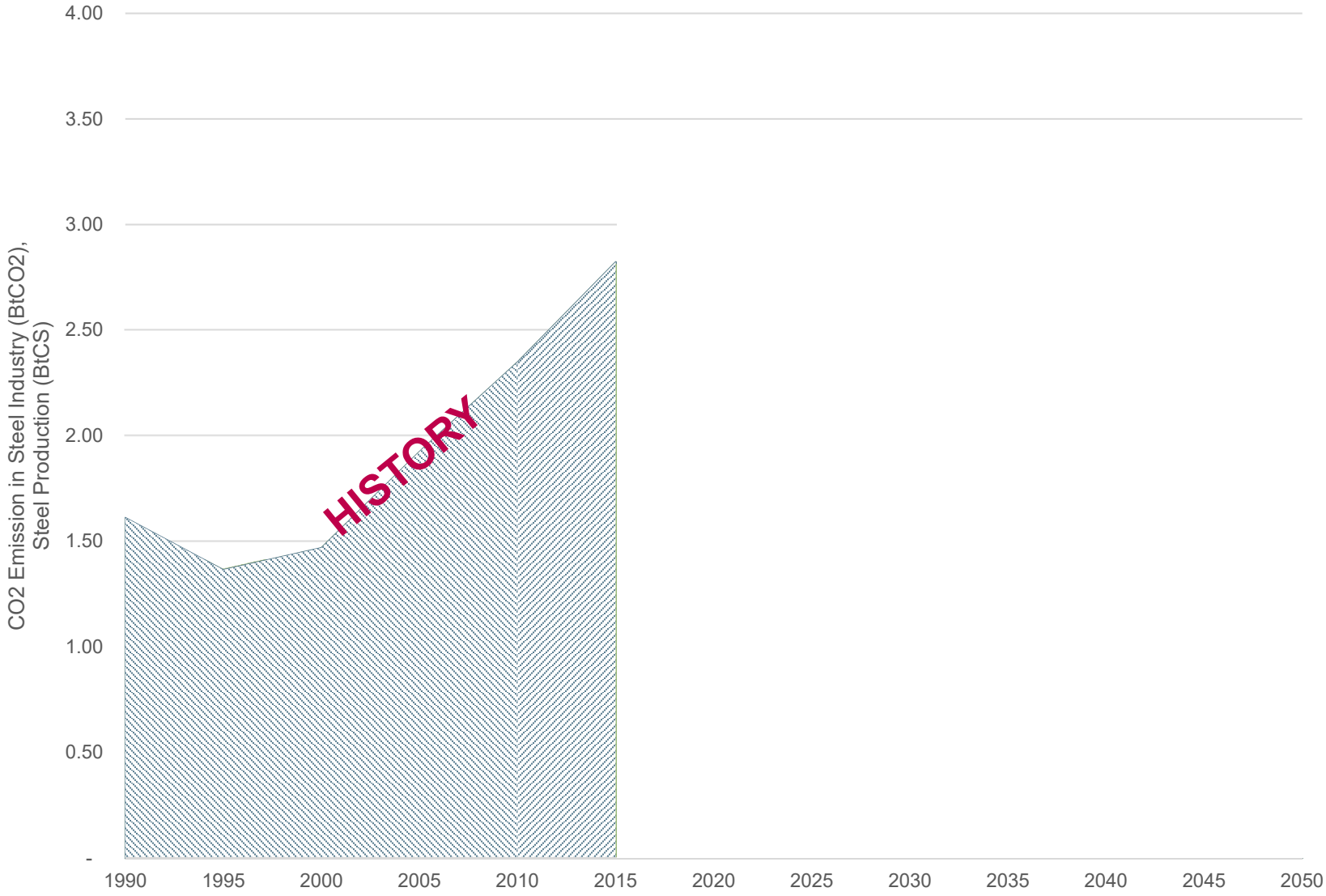
Crude steel production in million tonnes - 2016



Finished Steel Demand – regional trends



Improving performance levels



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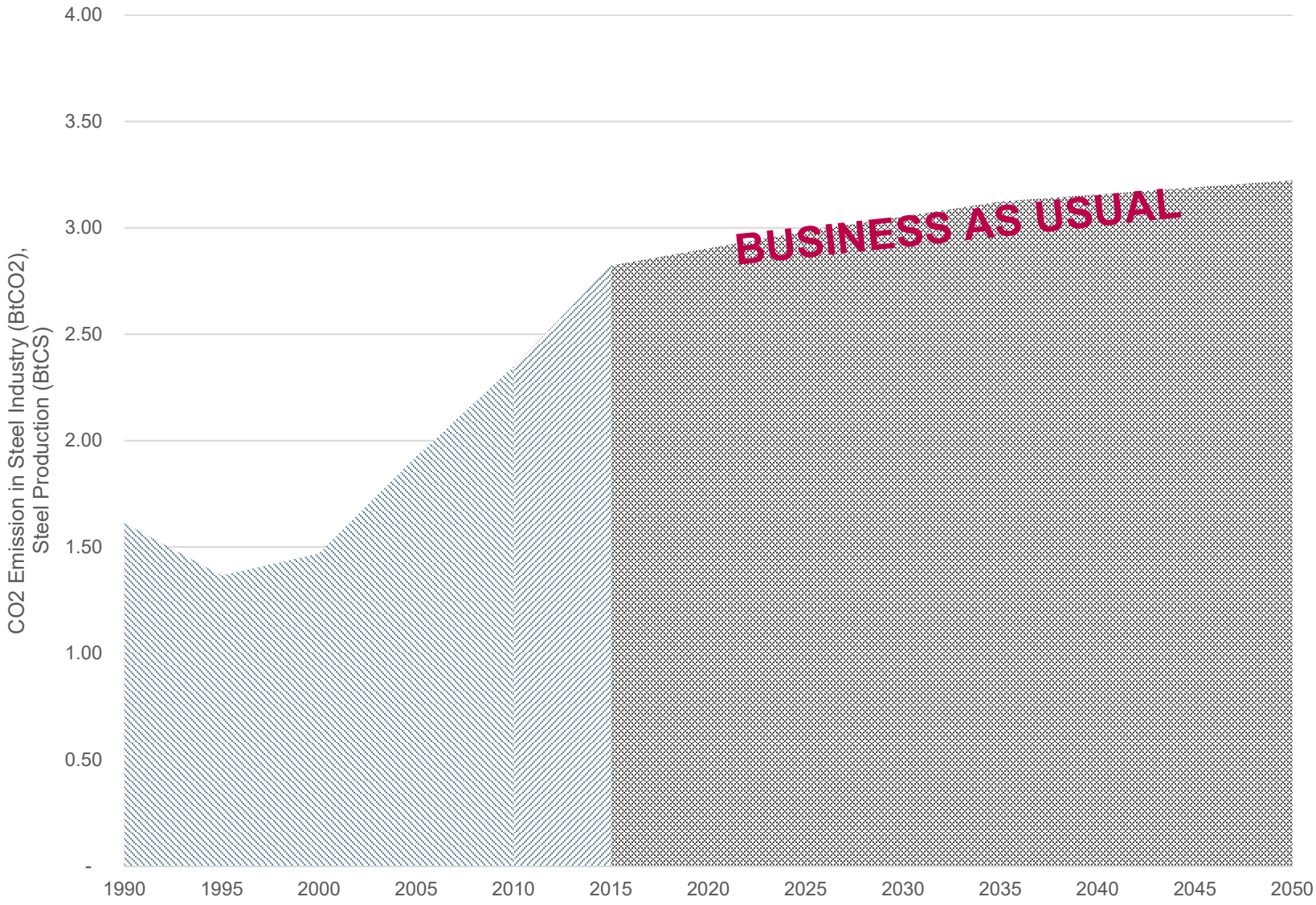

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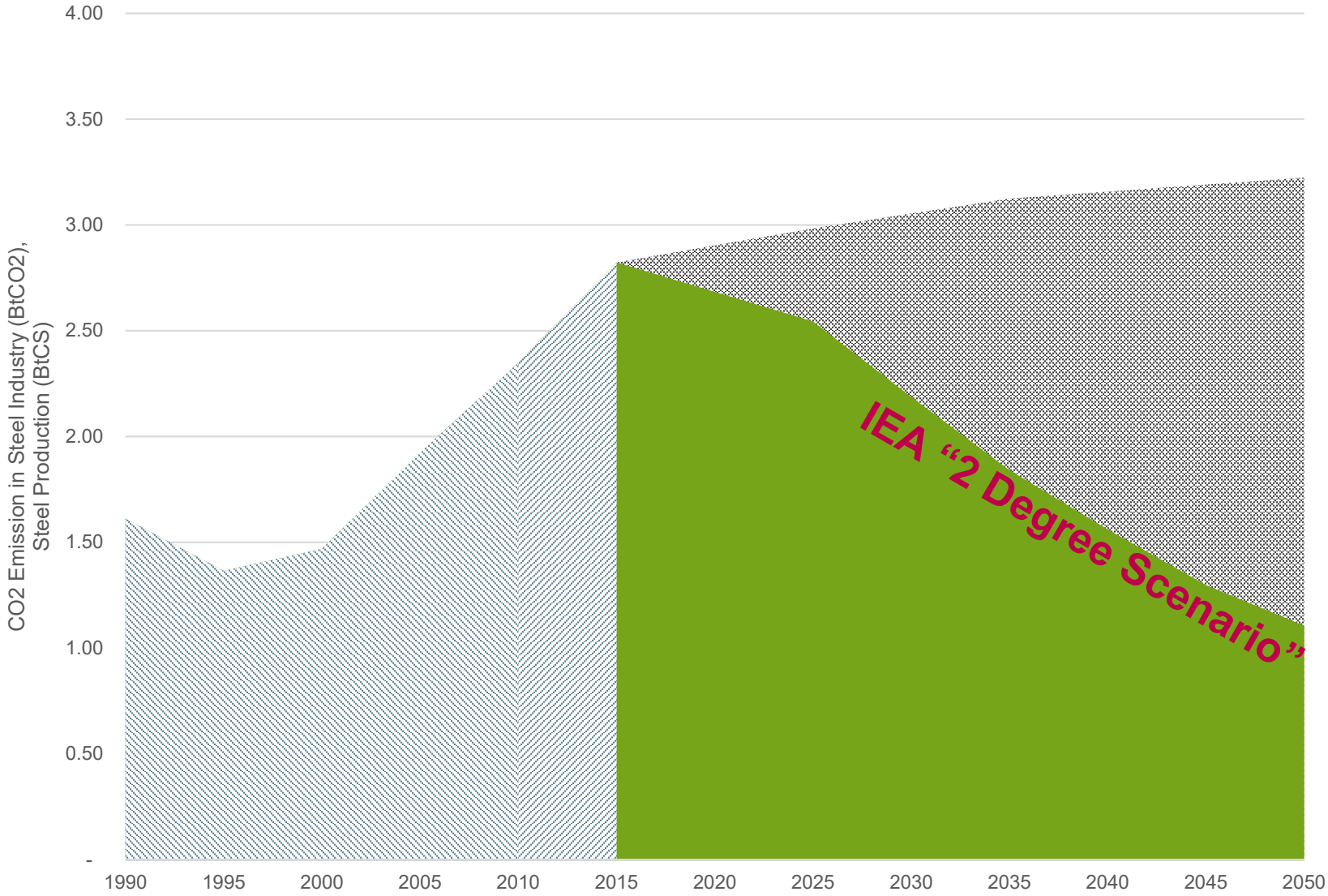

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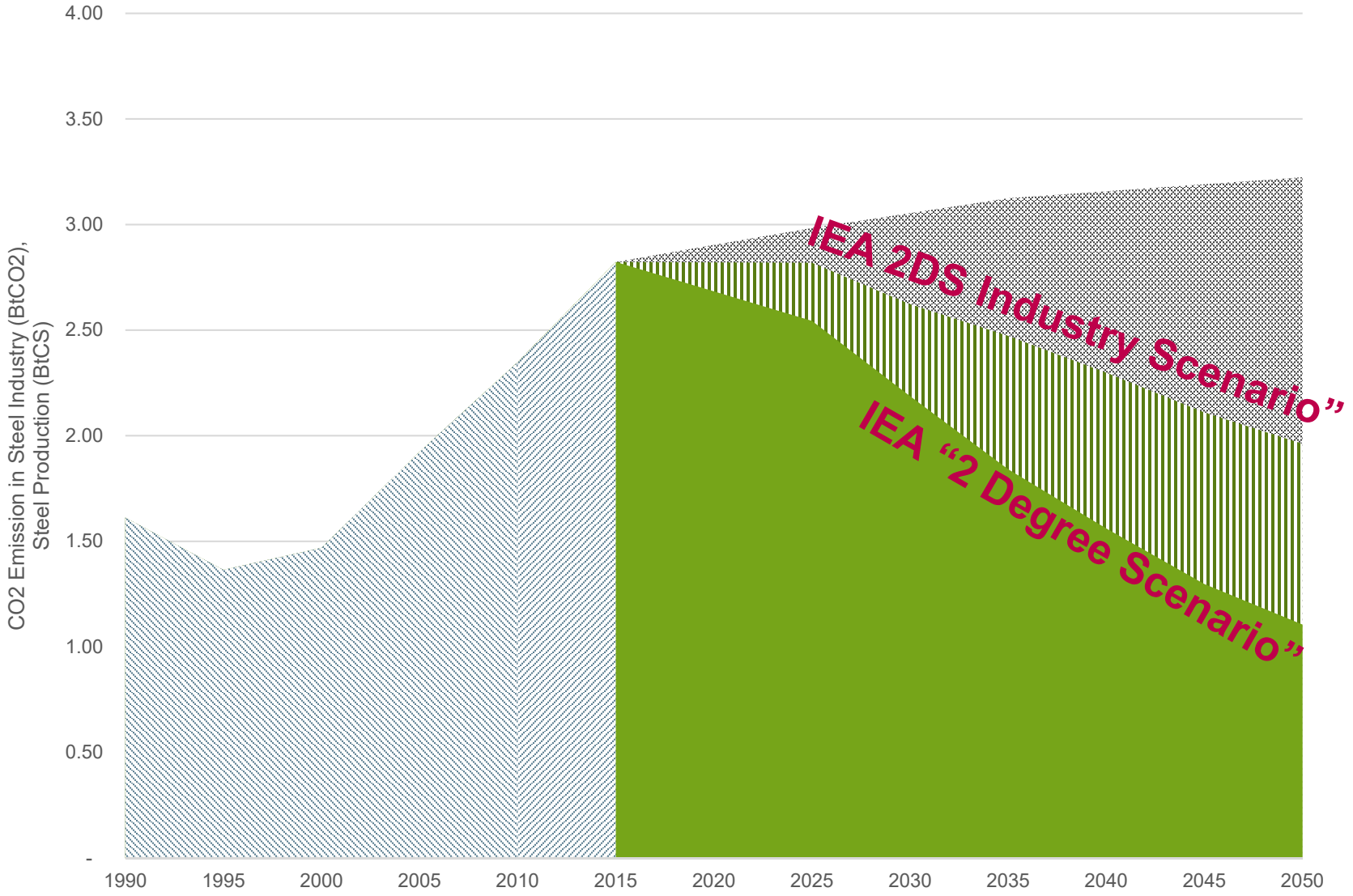

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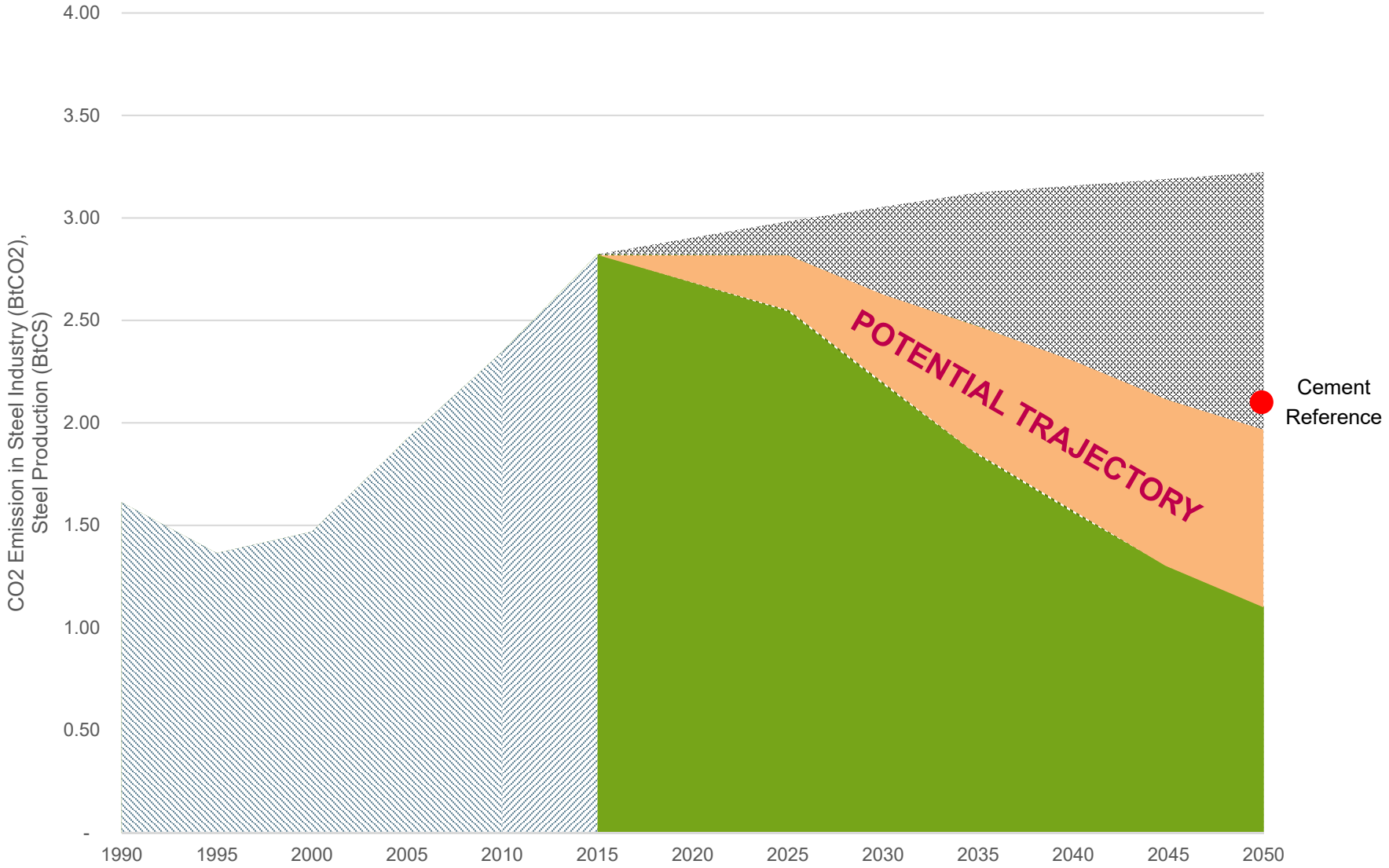

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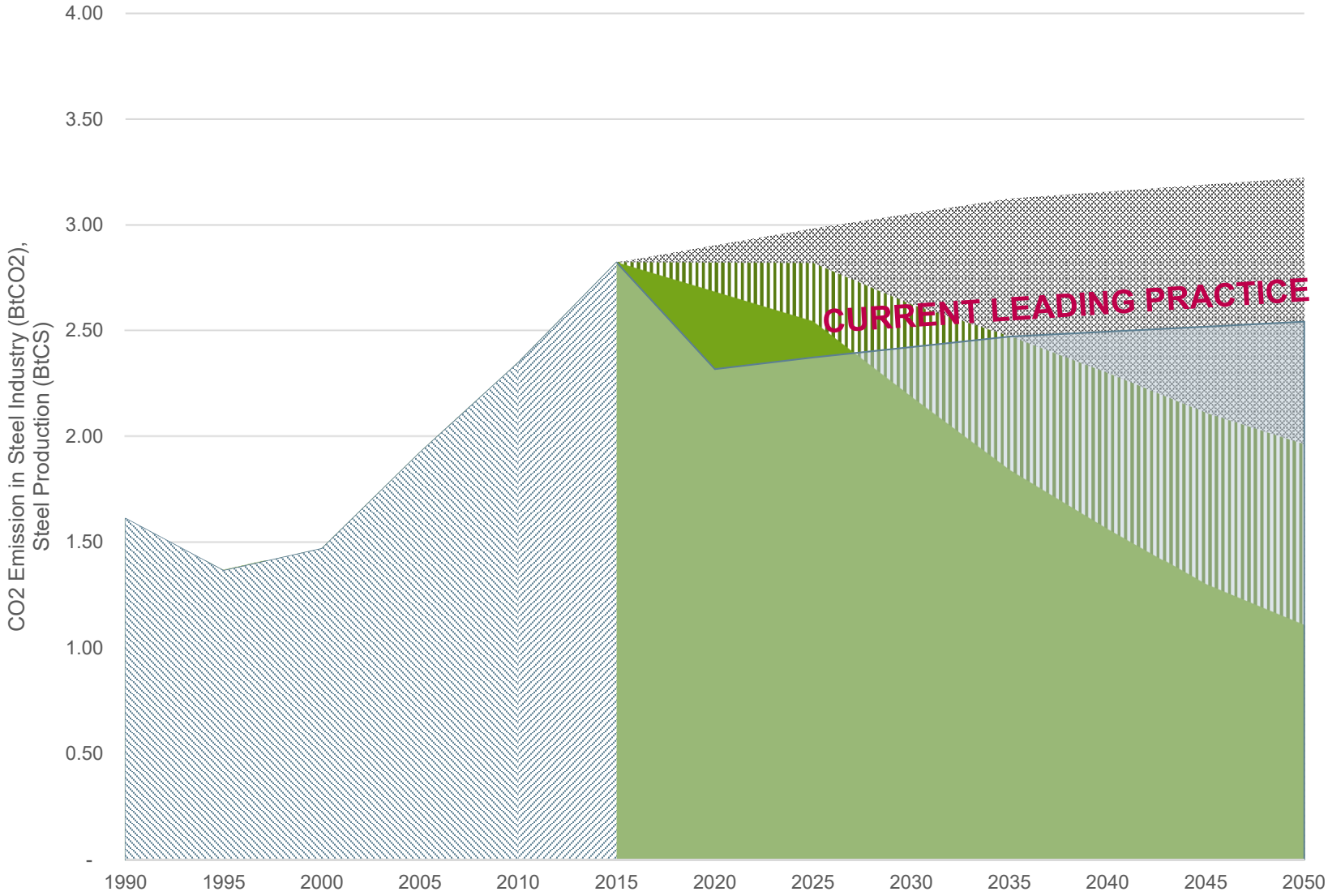

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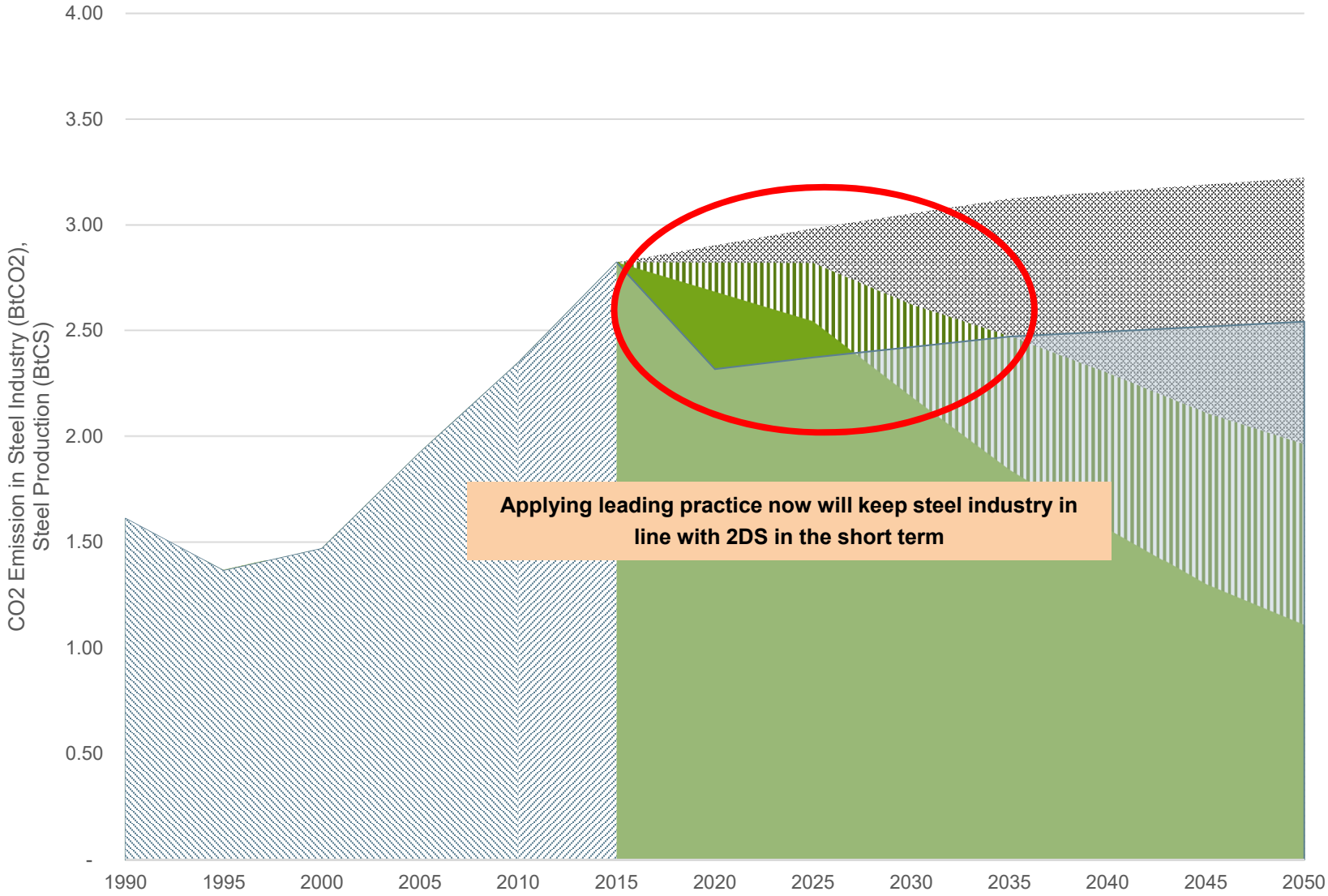
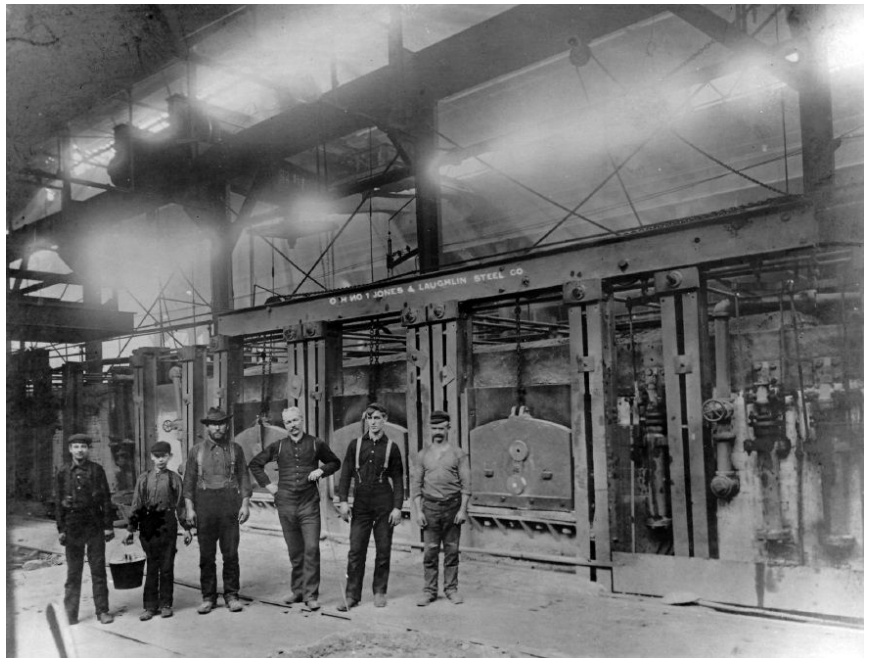


Breakthrough technology in Steelmaking



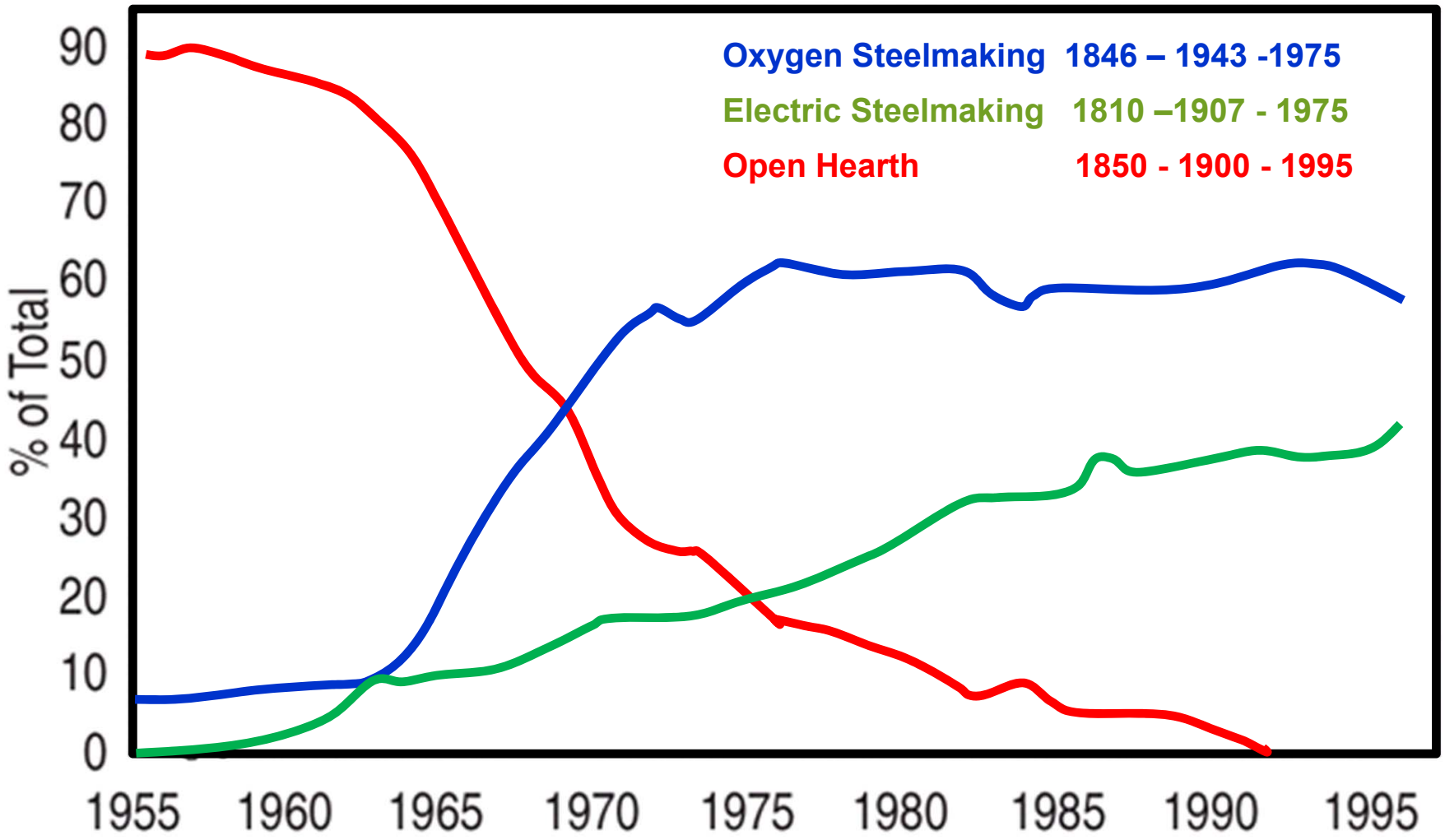
Open Hearth Steelmaking

c1900-1909

BOS Steelmaking

2015

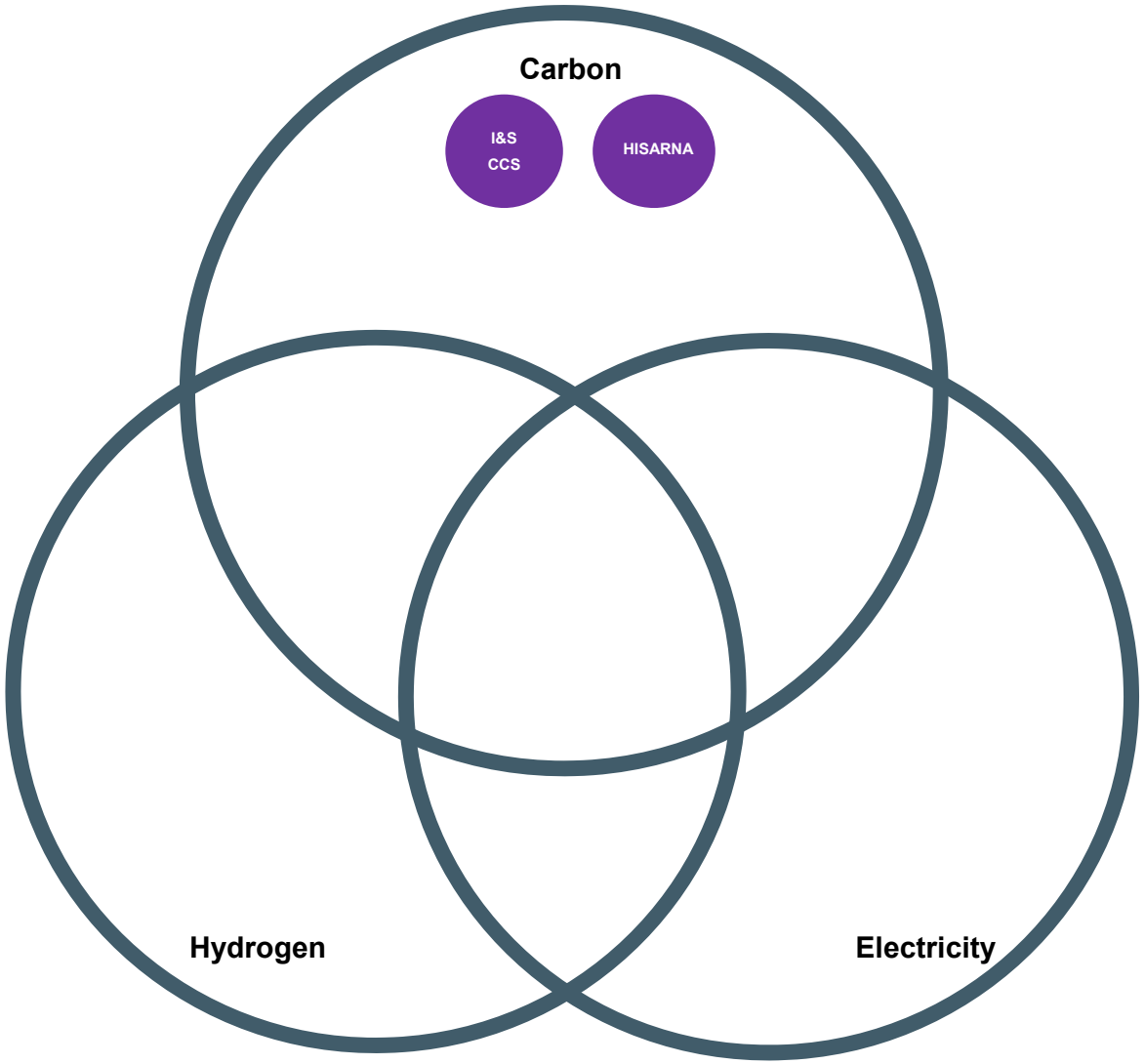
Steelmaking technology has always advanced




TKS BF8
Commissioned 2007
Euro 200 million
Replaced a 41 year old BF
Expected to last 20 years

What could steelmaking without CO_2 look like?

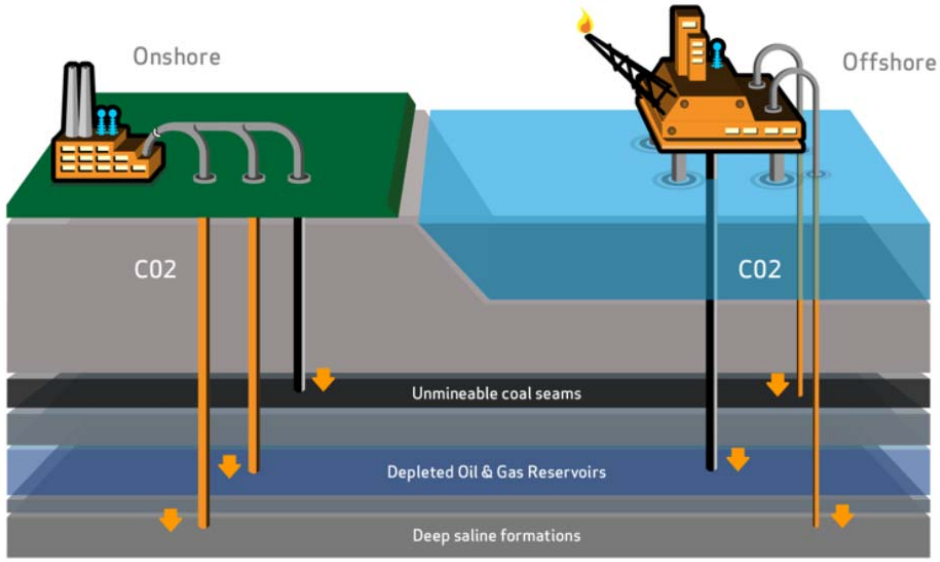
"CCS"



Carbon Capture and Storage (CCS)

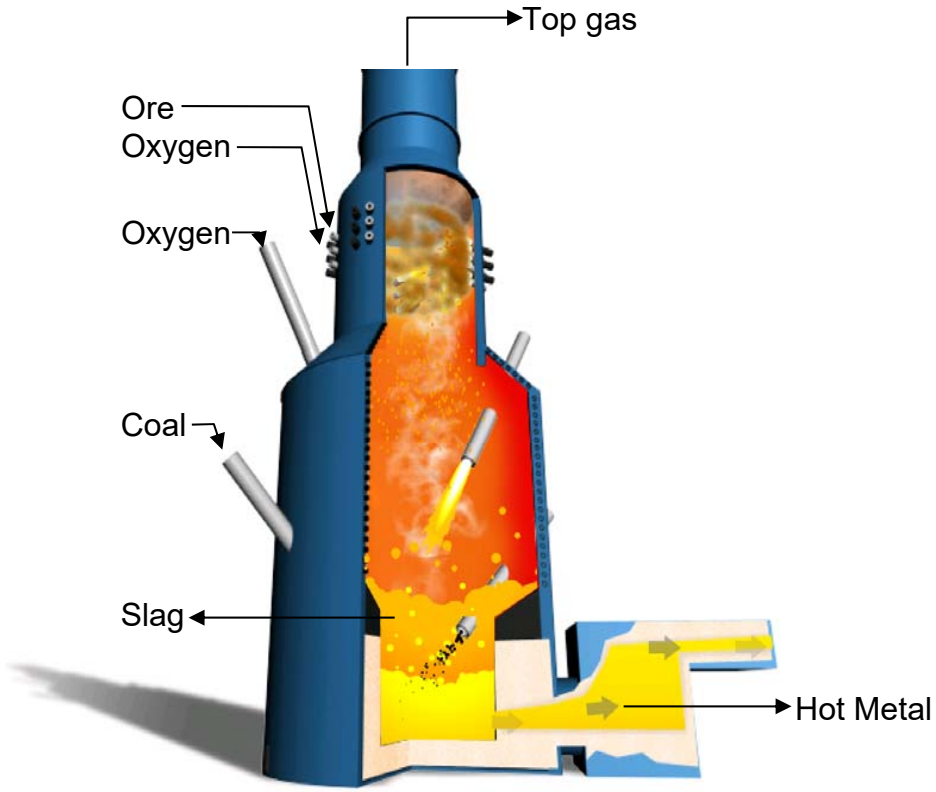
- BHP Billiton and Peking University study
- CCS looked in in other areas eg.
  - ULCOS-TGR BF
  - China Steel Corp
  - Posco
  - COURSE50 and others

- Issues to be resolved include
  - Cost and competitiveness
  - Reliable & risk free access to storage
  - Access to infrastructure
  - Acceptance

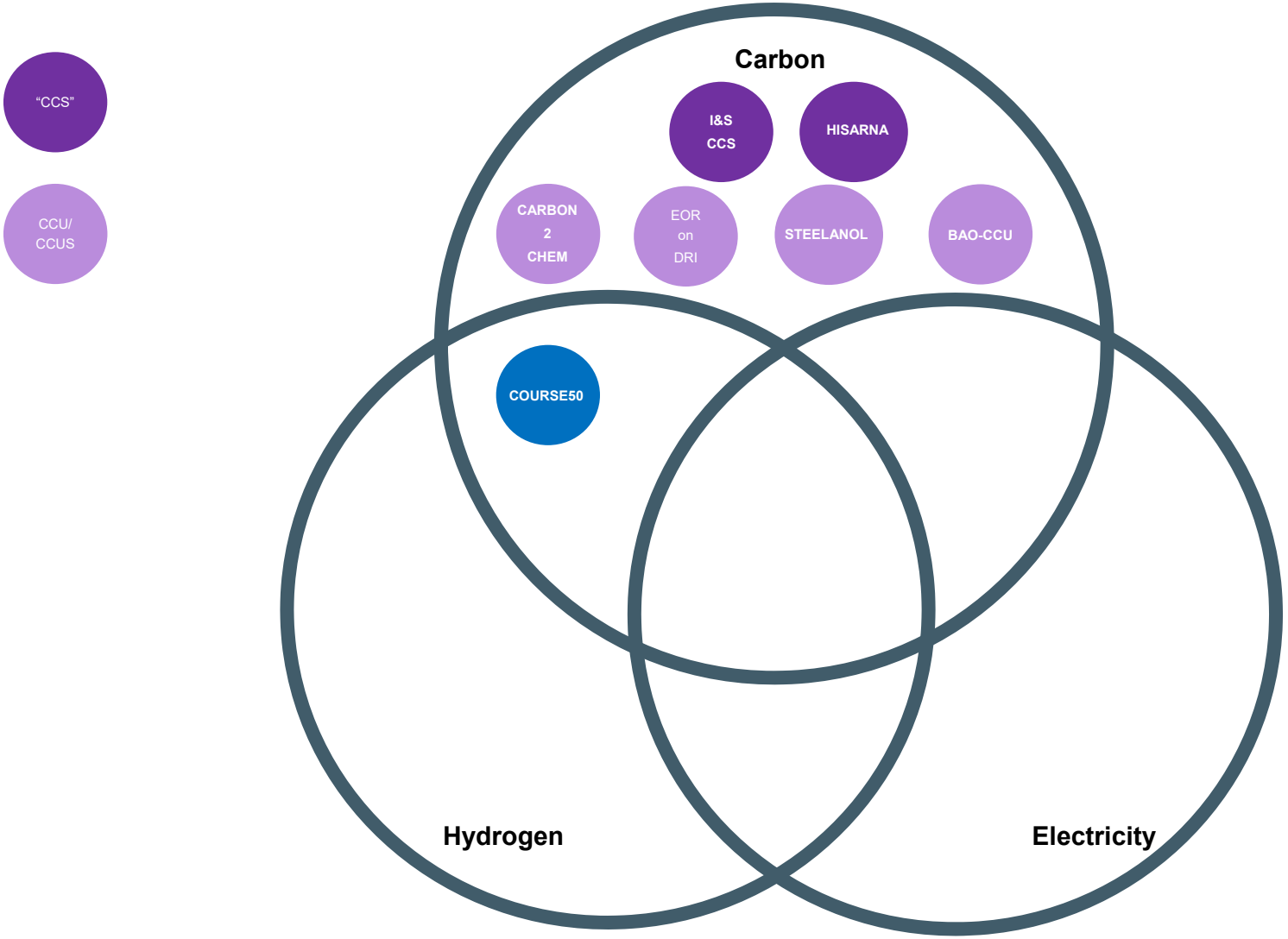


HIsarna

- A direct reduced iron process in which iron ore is processed almost directly into liquid iron
- The process combines two process units, the Cyclone Converter Furnace (CCF) for ore melting and pre-reduction and a Smelting Reduction Vessel (SRV) where the final reduction stage to liquid iron takes place
- The process does not require the manufacturing of iron ore agglomerates such as pellets and sinter, nor the production of coke
- The process is able to utilise lower grade iron ores and low cost coals and has a lower Capex
- HIsarna can achieve at least a 20% CO_2 reduction, 80% CO_2 reduction with CCS
- It also reduces emissions of dust, NOx and Sox
- Long-term trial since November 2017 running continuously using the hot metal in downstream processes
- Conceptual engineering for the first industrial scale plant, 0.5 to 1.0 M t/y, has started.



What could steelmaking without CO2 look like?



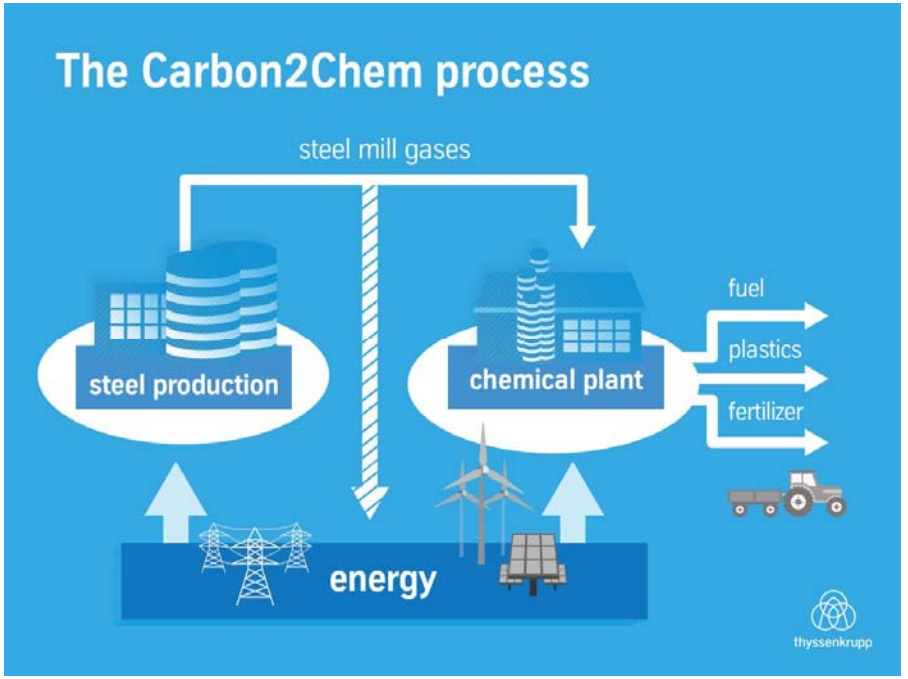
EOR on DRI

- Abu Dhabi CCS involves the capture of CO_2 from the Emirates Steel Factory in Abu Dhabi and its transportation to the ADNOC reservoirs for the purpose of enhanced oil recovery (EOR).
- The DRI process employed at ESI produces a pure stream of CO_2 (greater than 98 per cent)
- Launched in November 2016, the compression facility has a capture capacity of 0.8 Mtpa.

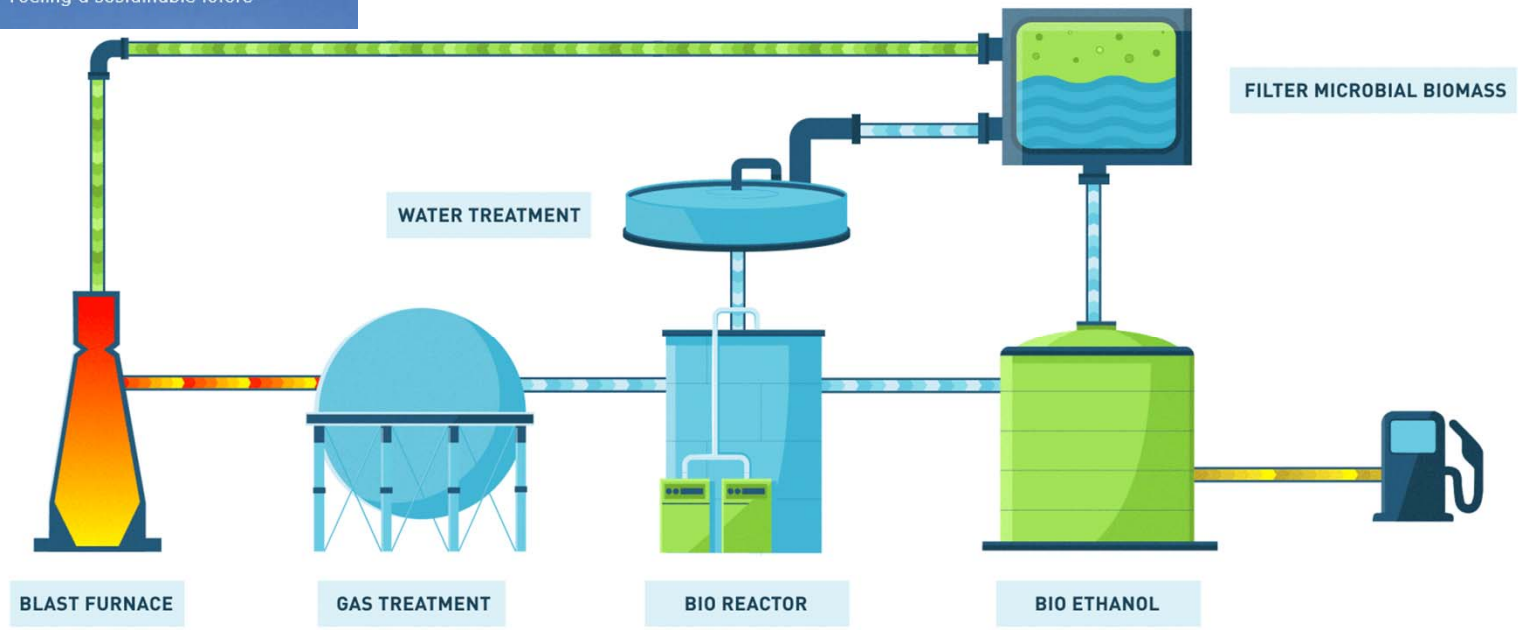
حديد الإمارات
emirates steel

Carbon2Chem

- Initiative by thyssenkrupp
- Using the gases from the steelmaking process as a raw material for the production of chemicals such as ammonia and methanol
- Additional hydrogen is needed for the chemical processes involved in ammonia and methanol production
- Produce hydrogen whenever there is a surplus of green electricity and the cost is particularly low using large-scale industrial facilities like steel mills and chemical plants as energy buffers
- One of the central development tasks for Carbon2Chem is to find catalysts for the production of chemicals which can cope with operating fluctuations without any impact on performance.



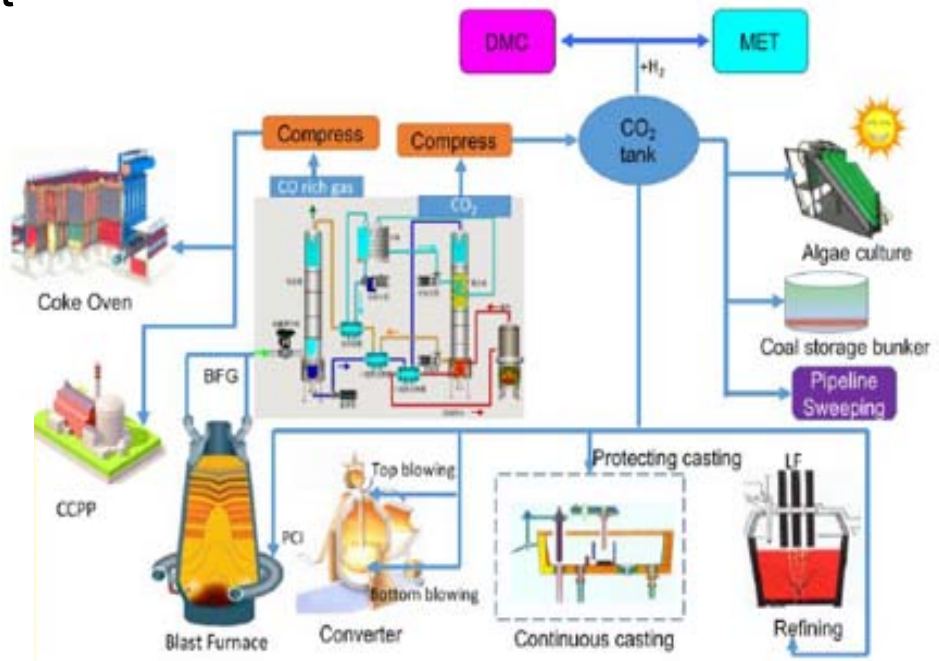
Steelanol
Fueling a sustainable future



- ArcelorMittal in partnership with Lanzatech and others
- Transforming carbon-rich industrial waste gases into advanced bio-ethanol for use in the transport sector by way of a novel gas-fermentation technology using microbes that secrete ethanol
- capture and reuse of a portion of carbon emitted by the steel industry without need to rebuild the steel plant
- The flagship pilot project involves a combined investment package of over €100 million from ArcelorMittal, EU Horizon 2020 and the European Investment Bank, and will start to yield results in 2019.
- The design of this first plant is larger than originally anticipated, and will produce 80,000 million litres of ethanol.

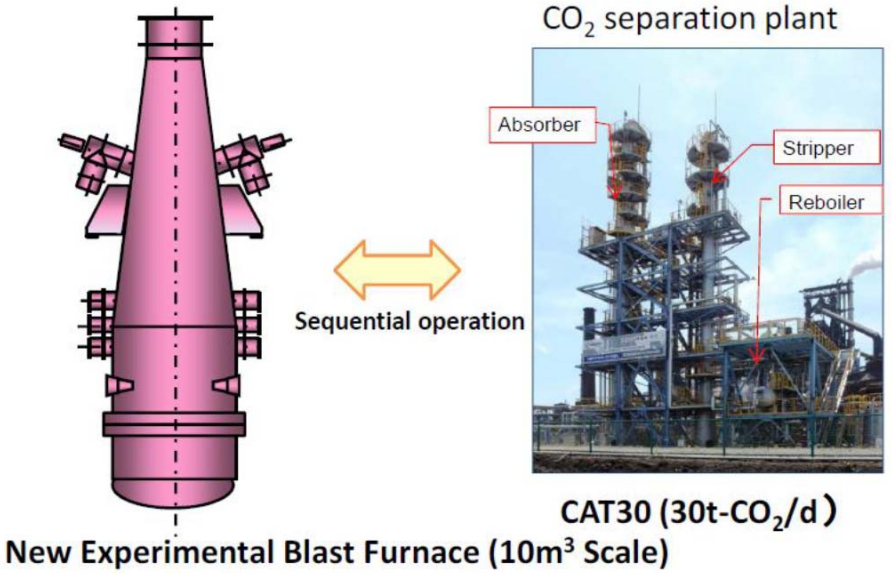
BAO-CCU

- Development of low energy cost CO2 separation and integrated gas utilisation technology
- Results:
  - Development of a new absorbent with desorption energy of 3.0GJ/tCO2
  - Integration of CO2 usage in the steel making process (converter, refining and continuous casting)
  - Proposal for a new CO rich fuel for coke ovens and CCPP

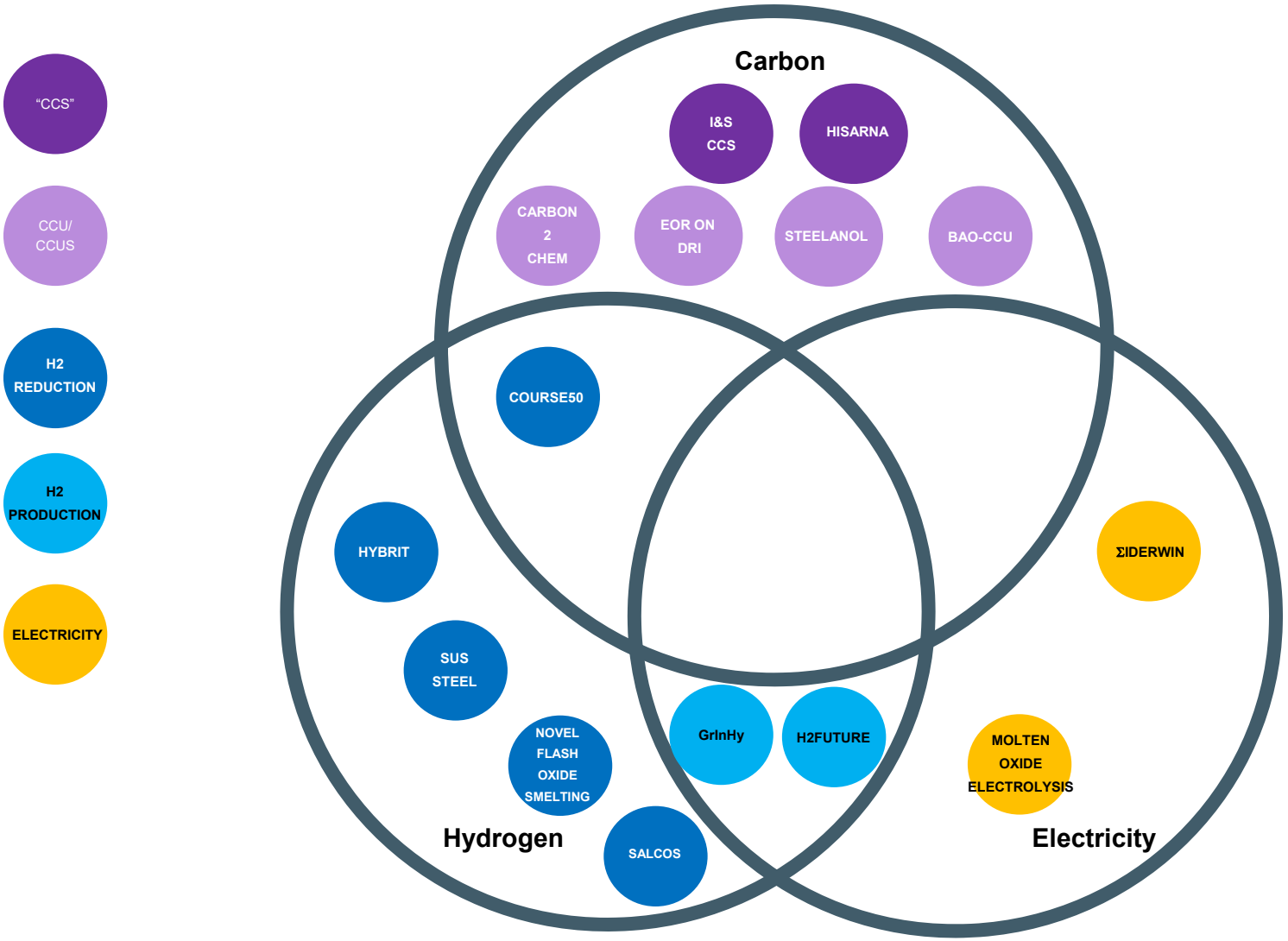


COURSE50

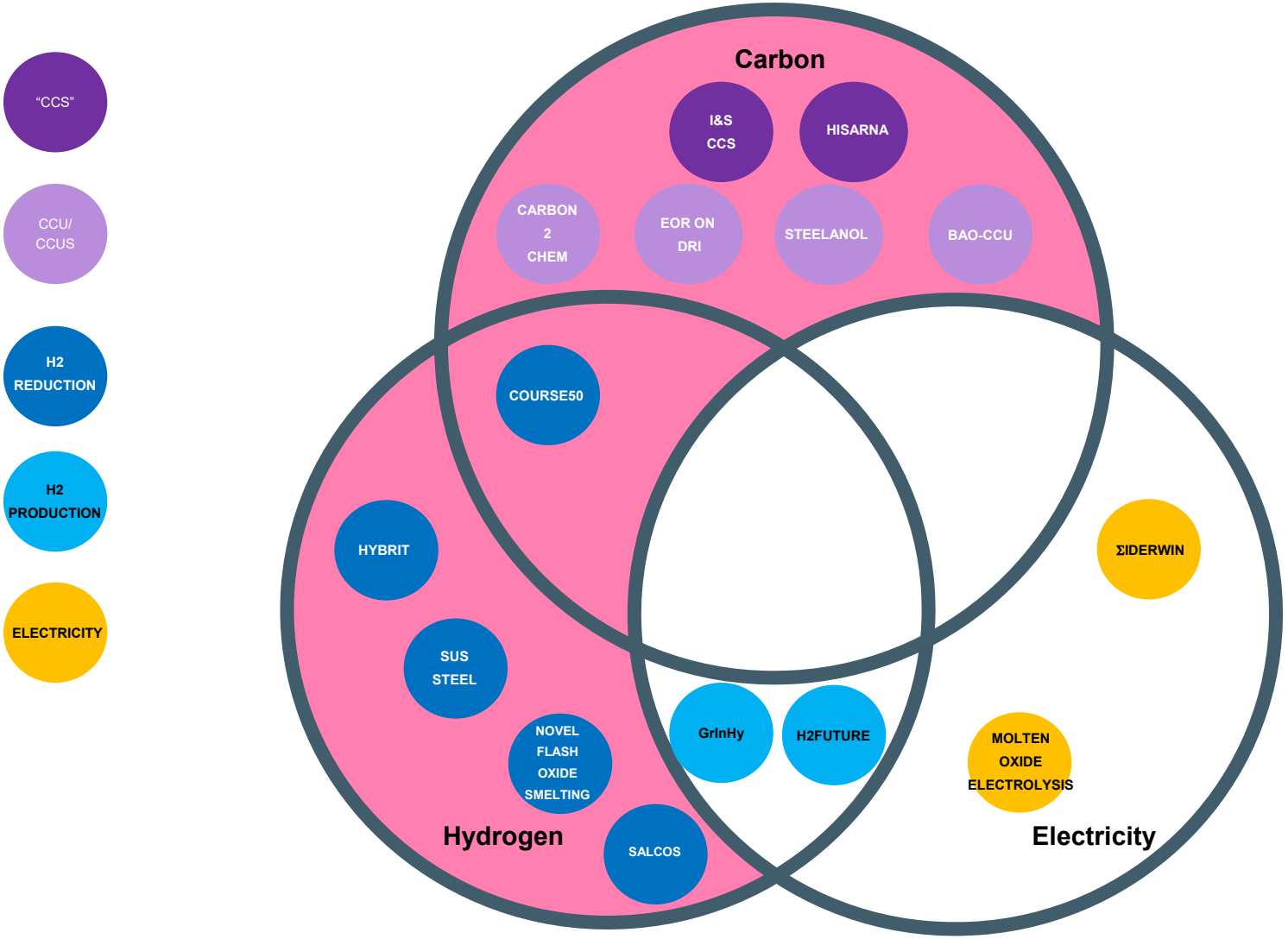
- Aims to reduce coal consumption in the Blast Furnace by 10% by using a H2 rich reductant and separate and capture CO2
- A 10m3 experimental blast furnace has been built and tests are ongoing showing results close to predictions
- A 30t/day CO2 chemical absorption test plant (CAT30) has been built simultaneously in preparation of phase2
- The final goal is a reduction of CO2 emissions by 30% (2030)



What could steelmaking without CO_2 look like?



Potential CCUS “zone of interest”



Steel and Climate

- Steel is an essential mitigator of emissions in all other sectors
- However producing steel does result in GHG emissions
- The Steel Industry must play its part in achieving the goals of the Paris Agreement
- Efficient, safe and well run plants are also environmentally efficient plants
- worldsteel member's are committed to achieving top 15% performance to gain the time to develop breakthrough technology
- We need to understand why the best plants do so well
- Longer term, there is need to develop breakthrough technology.

What could steelmaking without CO_2 look like?

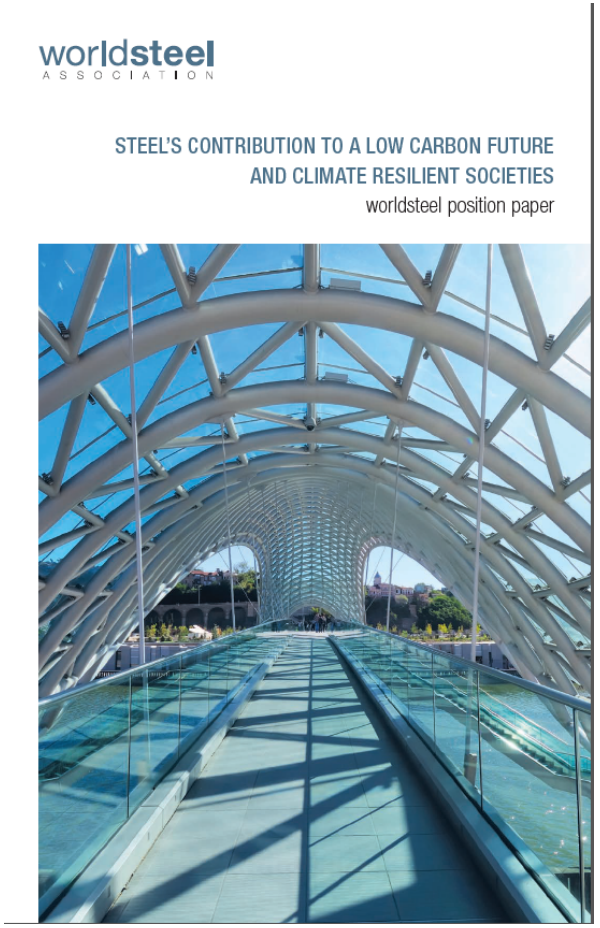
- For our industry there is no decarbonisation silver bullet
- Like in the power sector, all options will be needed, implementation will depend on local circumstances such as availability of electricity, CO_2 storage and policy support
- A portfolio of tools are being developed
  - CCUS is likely to play a role
  - Evidence of increased focus on the use of hydrogen – main focus currently on electrolysis
  - Integrated solutions involving other industries and utility companies

What could steelmaking without CO_2 look like?

- All options are dependent on huge amounts of carbon free electricity, hydrogen, or CO_2 infrastructure & storage
- Progress in breakthrough technology development in steelmaking and implementation must be maintained or accelerated requiring the financial burden to be shared.

Steel industry position

- Governments need to recognise and embrace the importance of a strong and healthy industrial base and engage with the industry when developing climate policy
- Steel is a CO_2 and energy intensive, but highly competitive industry that enables CO_2 mitigation in other sectors. Inequities introduced by carbon pricing mechanisms could jeopardise fair competition
- A life cycle approach is an important tool for future environmental policy
- Governments should promote and encourage a circular economy approach
- Progress in breakthrough technology development in steelmaking and implementation must be maintained or accelerated requiring the financial burden to be shared.



Thank you for your attention.

For further information contact:

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