The impact of decarbonising the iron and steel industry on the European power system and its CO_2 emissions in 2030

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An integrated system in transition

R.Q. How will the **increased electric load** of the steel industry impact **electricity generation** and the **CO_2 emissions** of the European power system in 2030?

- **Industrial decarbonization** is known that will have large impact on the power system due to the high potential for decarbonization through **direct or indirect electrification**.
- Many study perform **power system analysis** with low-carbon industries **in net-zero scenarios** 2050 – e.g., Lechtenböhmer et al. (2016), Göransson et al. (2019), Toktarova et al. (2022).
- Many steel companies have announced projects **operating by 2030**
- In 2030, the European power sector will still be undergoing transformations towards decarbonization. RED II and Fit-for-55 package of the EU foresees 40% renewable energy. Although the share will be higher for electricity generation, **fossil-based sources will still play a key role in 2030 power production**.

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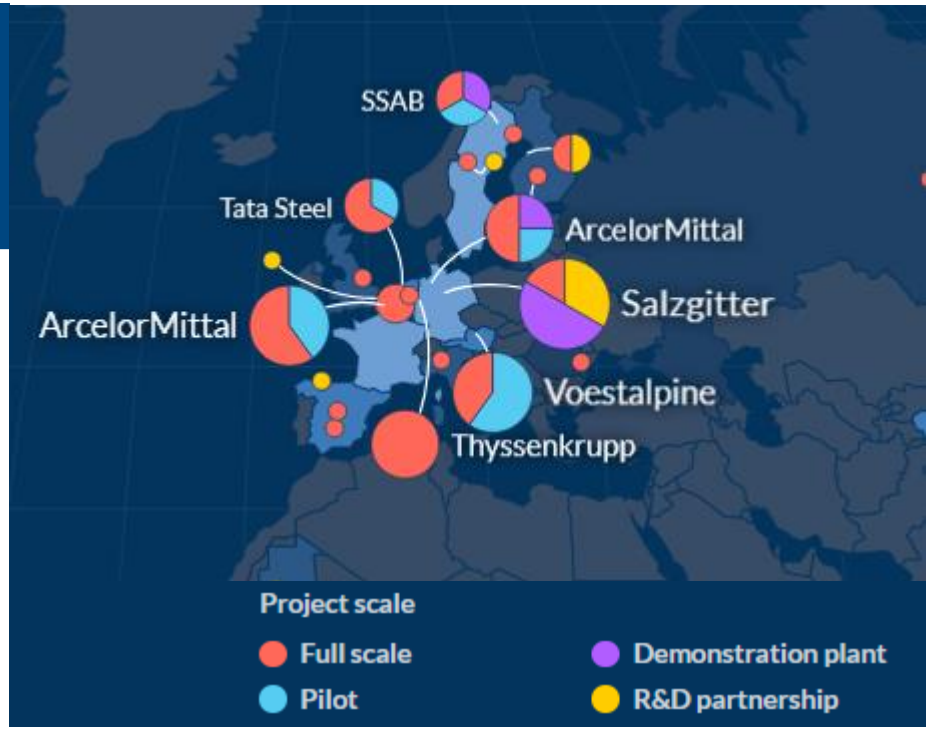
The decarbonisation of European steel

Green Steel Tracker.

Which low-carbon projects have been announced in the steel industry?

The Green Steel Tracker aims to support decision makers in policy and industry, academia as well as civil society, by tracking public announcements of low-carbon investments in the steel industry and presenting them transparently in one place.

Download the dataset



- Big hype for the hydrogen-based direct reduction of iron ore (H2-DRI-EAF)
  - 2 carbon capture projects
  - 18 hydrogen-based DRI projects

https://www.industrytransition.org/green-steel-tracker/

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Methodology

ANNUAL STEEL ENERGY DEMAND

- Development of three steel scenarios defining technology production portfolios in 2030
  - Brownfield investments
  - Country-specific assumptions
- Calculation of electricity and hydrogen demand per scenario
  - Own calculation of energy intensities per production route at country level taking into account import/export of intermediate products
- Direct CO_2 emission reduction
  - Same method as for energy intensities

POWER SYSTEM MODELLING

- Model METIS – European Commission
  - Unit commitment and economic dispatch (UCED) model
    - Country-nodes
    - No H2 transmission in 2030
  - Assessment of power and hydrogen generation, and CO_2 (indirect) emissions

CONTEXT

- MIX-H2 2030 (Fit-for-55) – calibration and modelling

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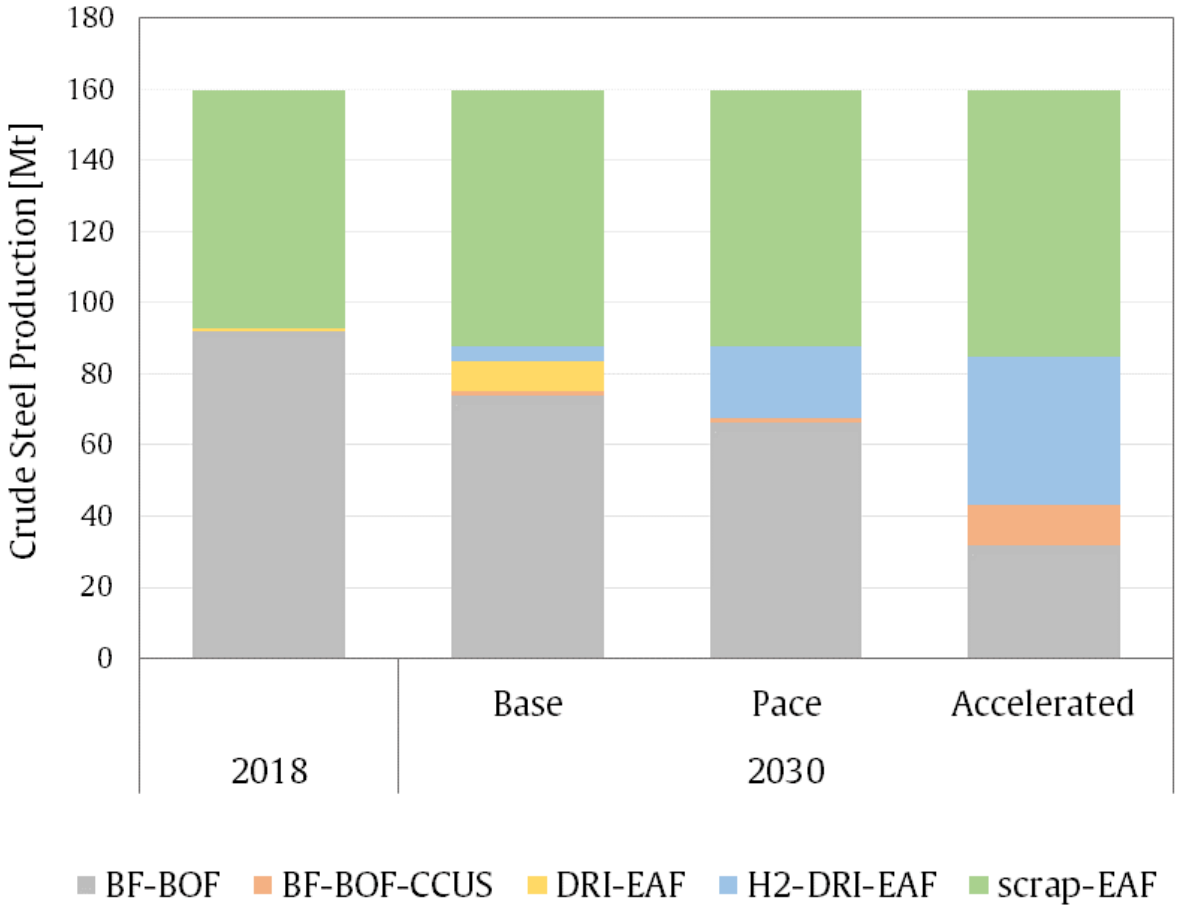
Steel production portfolios

ASSUMPTIONS

- *Base*: current pilots and approved decarbonisation projects are online by 2030
- *Pace*: All projects announced by steel manufacturers are online in 2030 using hydrogen as fuel
- *Accelerated*: all blast furnaces that require refurbishment before 2030 are replaced by low-carbon technologies



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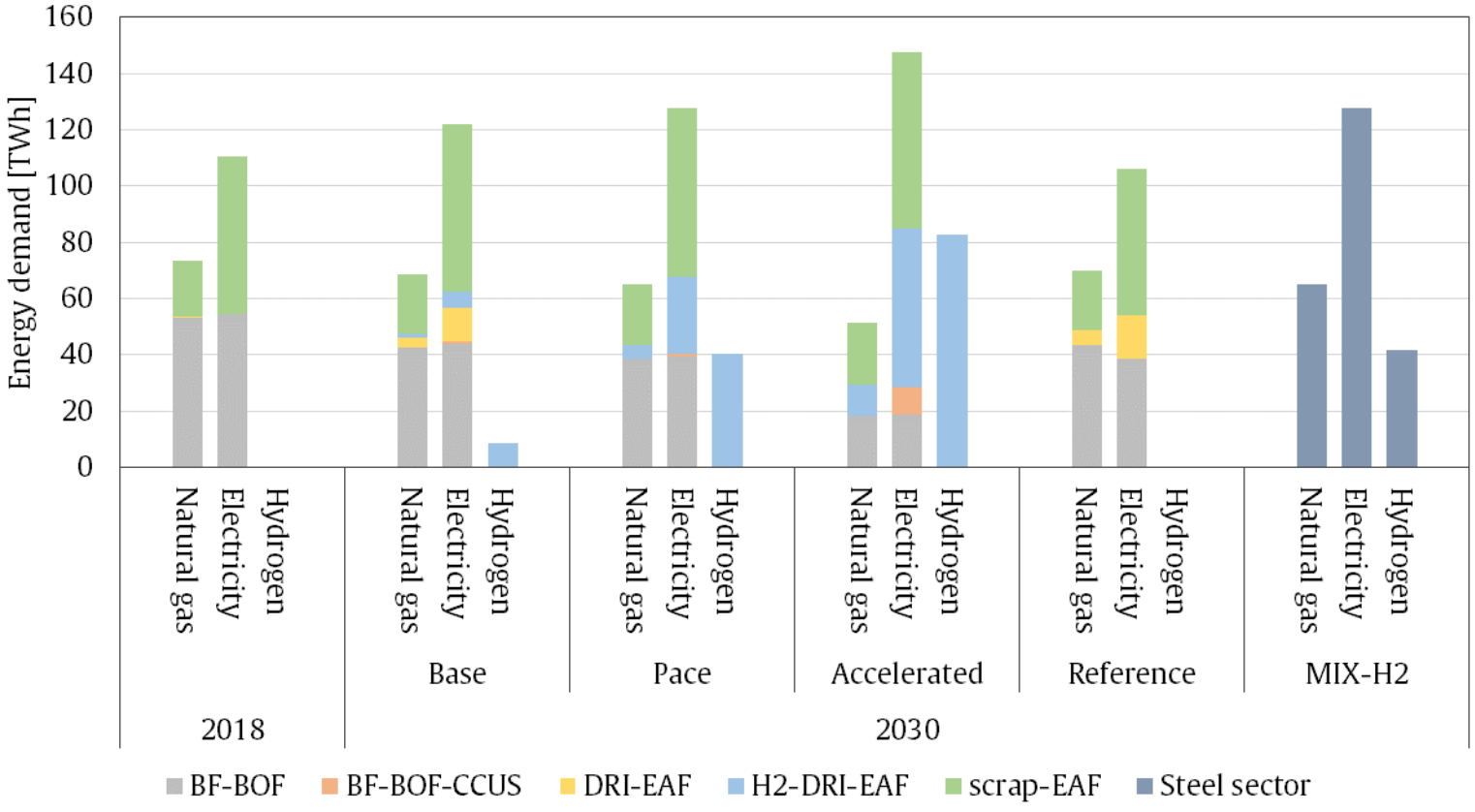
Steel energy demand



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Sub-scenarios and data input

2030 MIX-H2		(b)	
		Low prices	*High prices*
(a)	*UCED problem*	Reference Base Pace Accelerated	Reference_high Base_high Pace_high Accelerated_high
	UCED problem with capacity expansion	Reference_EXP Base_EXP Pace_EXP Accelerated_EXP	Reference_high_EXP Base_high_EXP Pace_high_EXP Accelerated_high_EXP

(b)

- *Low prices*: MIX-H2 prices

  Natural gas: 30 €/MWh_{HHV}

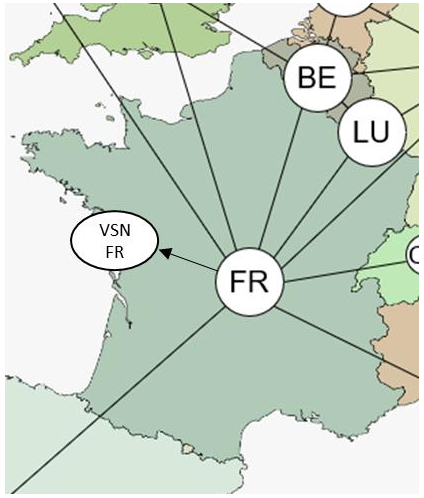
  H_2 other supply: 60 €/MWh_{HHV} (2.3 €/kg_{H2})

- *High prices:* price x6

  Natural gas: 180 €/MWh_{HHV}

  H_2 other supply: 260 €/MWh_{HHV} (10.4 €/kg_{H2})

(a)



- Capacity expansion of renewable and electrolyser in e.g., VSN FR (virtual steel node France)
- From VSN only electricity imports allowed, no export

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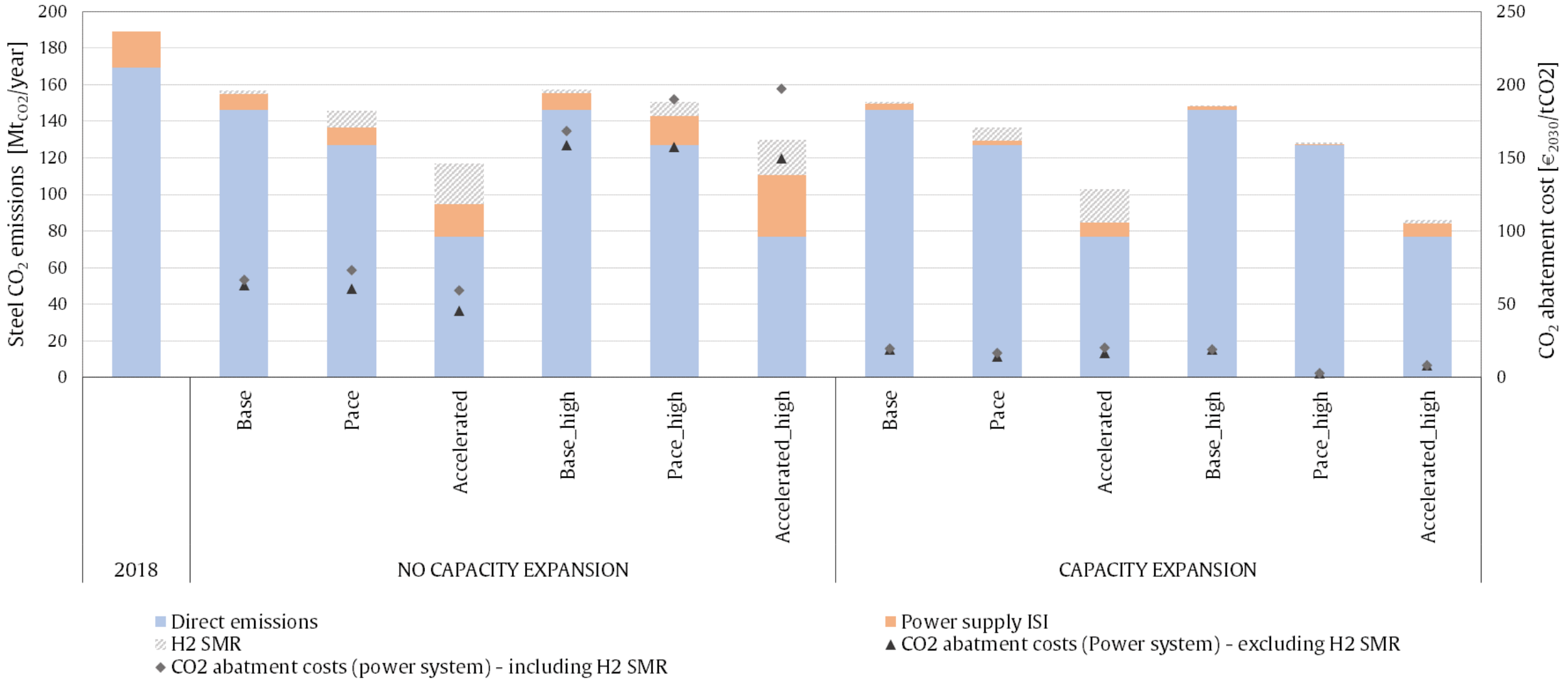
Total CO_2 emissions variation and CO_2 abatement cost



Uncertainties in future steel production and H_2 supply

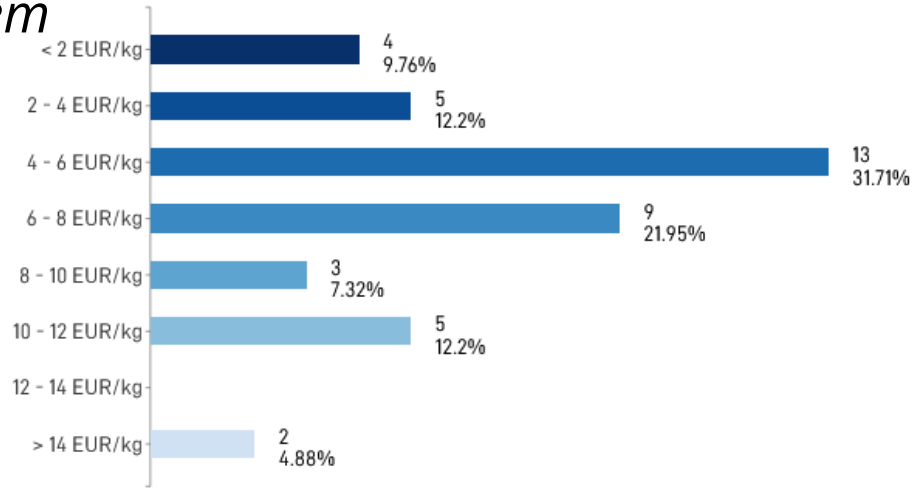
Steel making technological portfolio

- Future of the European iron and steel industry – production levels
- Green- vs. brownfield
- The advent of other technologies at commercial scale – e.g., electrowinning

Interaction of the industry with the power and hydrogen system

- H_2 other supply → 2 to 10 €/kg_{H2}

Average cost of green hydrogen (number (share) of Valleys)



https://h2v.eu/analysis/statistics/financing/hydrogen-cost-and-sales-prices

Key messages

1. **Steel decarbonization** is crucial to achieve the European Green Deal and it is **moving at a good pace**

2. **Alignment** of decarbonization **timelines** among sectors is key **to avoid CO_2 emissions spill-over**. Contract such as **PPAs** help ensuring the production green steel

3. **An integrated approach is needed**, which can lead to new opportunities – e.g., flexibility for the power system through **demand response** → future study!

Thanks for your attention!

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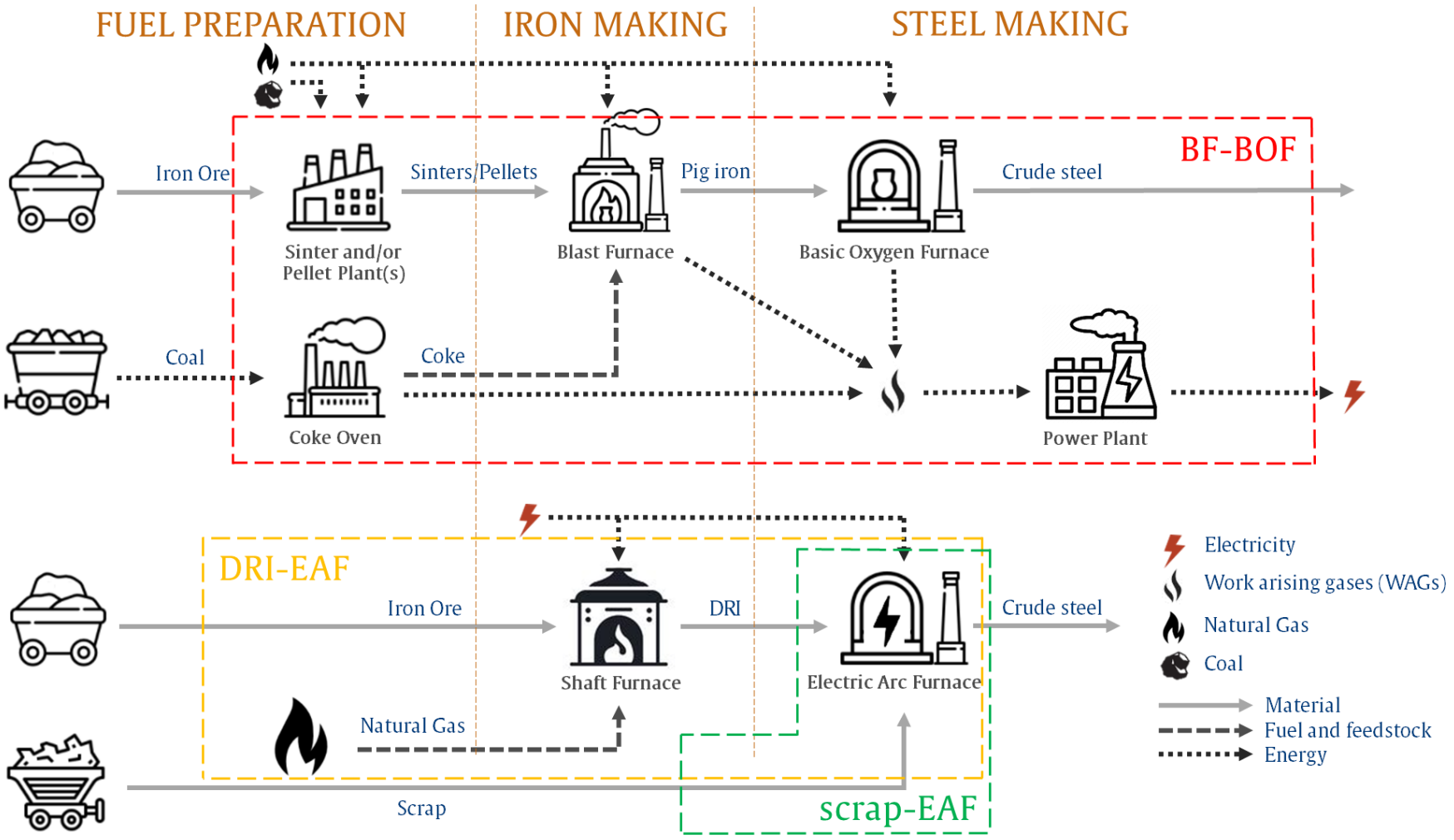
The European iron and steel industry today

Steel manufacturing contributes to **6%** of total European CO_2 emissions and **7%** of final energy consumption



BF-BOF
- 60% of production
- 2.1 $GJ_{electric}/t_{steel}$
- 1.9 t_{CO2}/t_{steel}

DRI-EAF
- <1% of production
- 4.9 $GJ_{electric}/t_{steel}$
- 0.9 t_{CO2}/t_{steel}

Scrap-EAF
- 40% of production
- 3.0 $GJ_{electric}/t_{steel}$
- 0.2 t_{CO2}/t_{steel}

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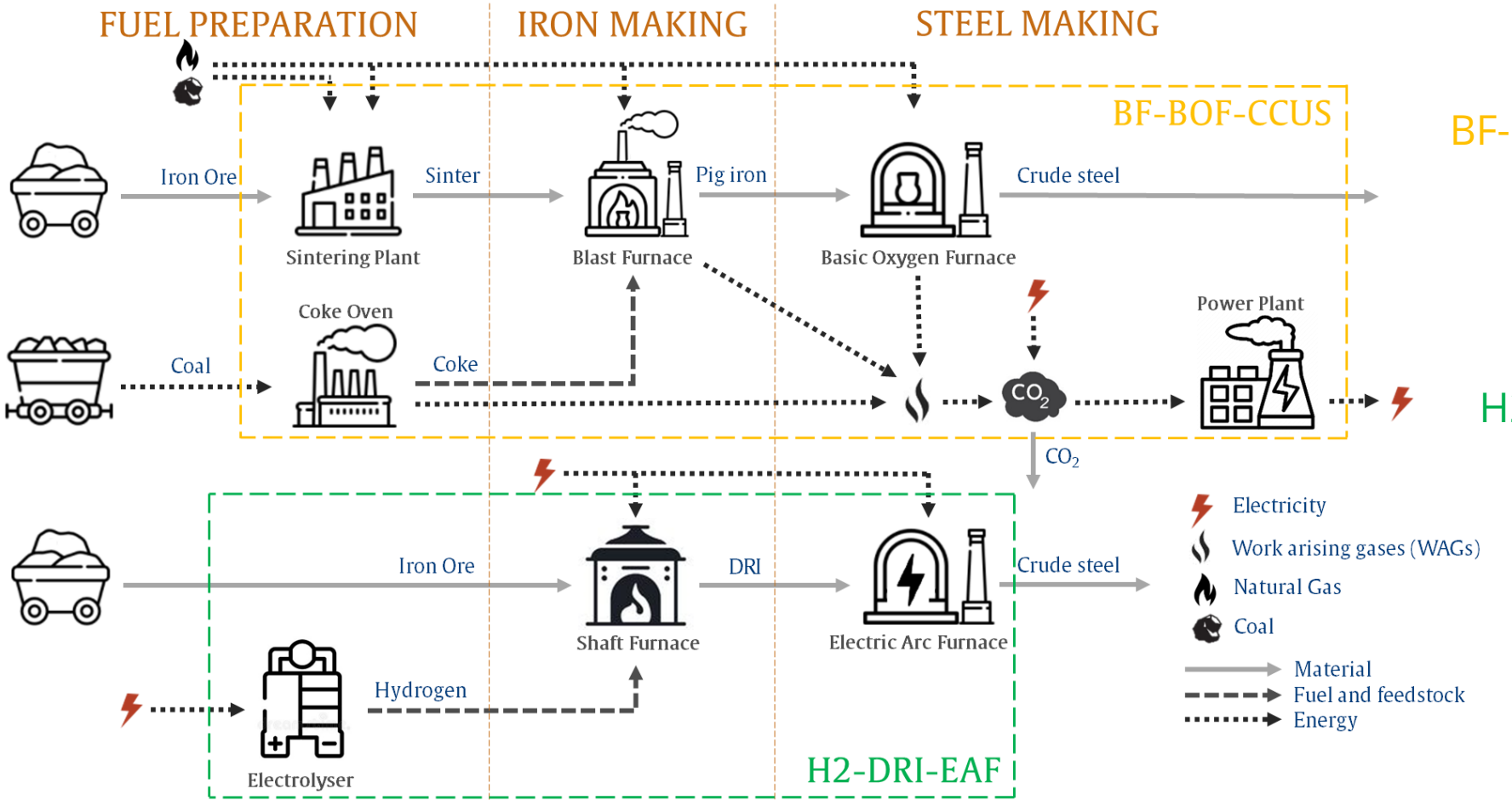
Low carbon iron and steel making routes



BF-BOF-CCUS

- 3.1 $GJ_{electric}/t_{steel}$
- 0.2-0.9 t_{CO2}/t_{steel}

H2-DRI-EAF

- 4.9 $GJ_{electric}/t_{steel}$
- 7.1 $GJ_{hydrogen}/t_{steel}$
- 0.05-0.30 t_{CO2}/t_{steel}

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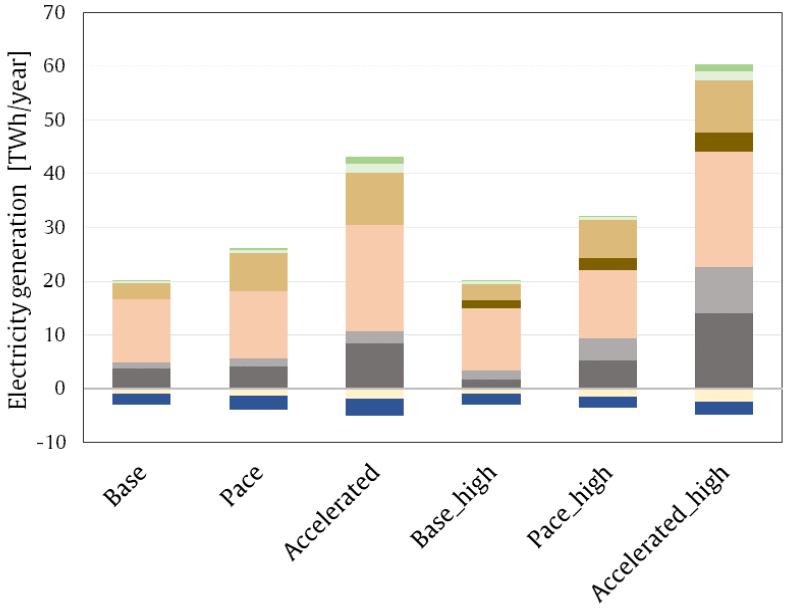
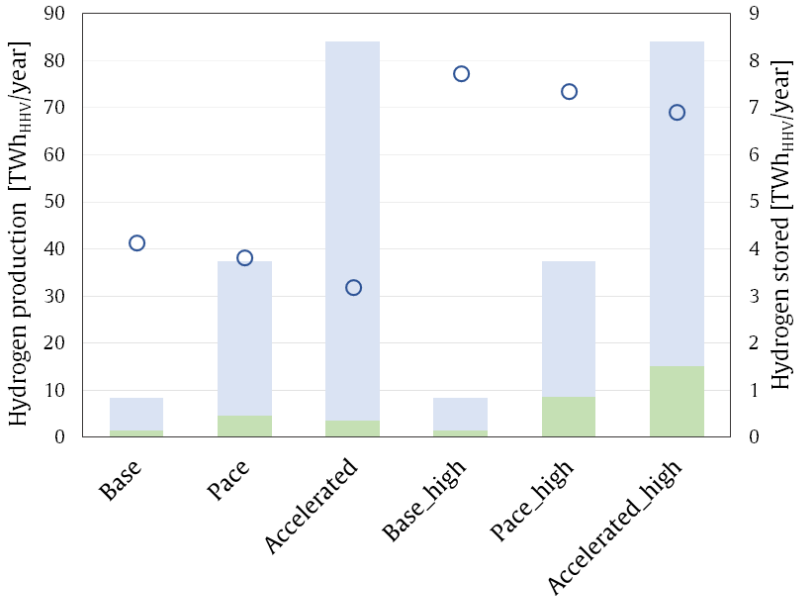
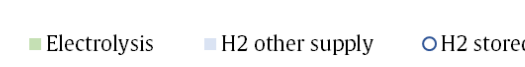
Results optimizations

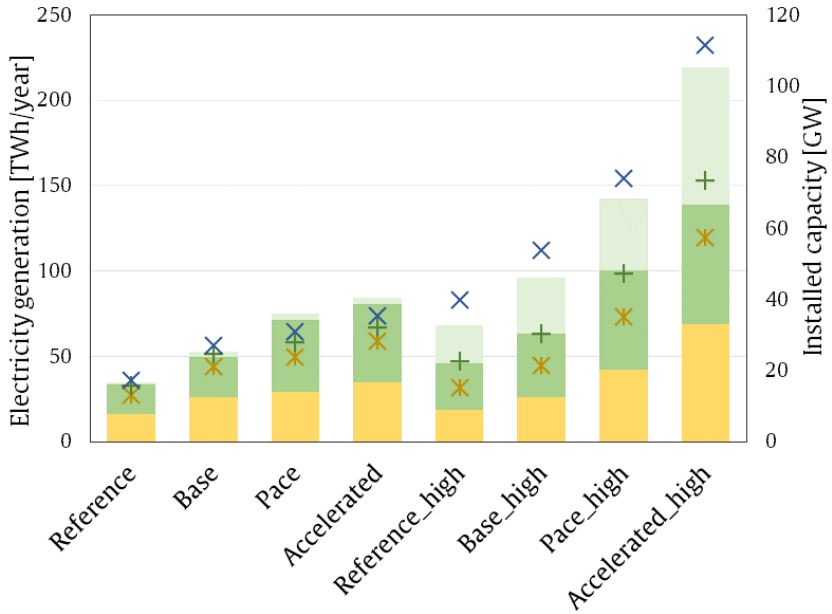
UCED problem

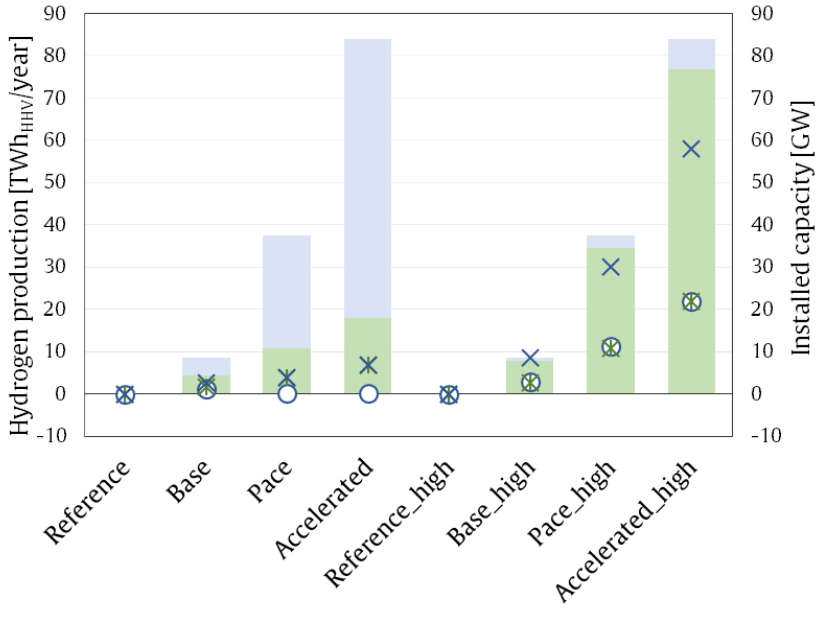






UCED with capacity expansion





Results optimizations