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Materials industry modelling in net-zero emissions scenarios: hydrogen contribution to low-carbon steel

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Plan

1. **The issue**
2. Methodology and setup
3. Projections: steelmaking
4. Projections: hydrogen
5. Case study: alternative for hydrogen in steelmaking
6. Conclusions

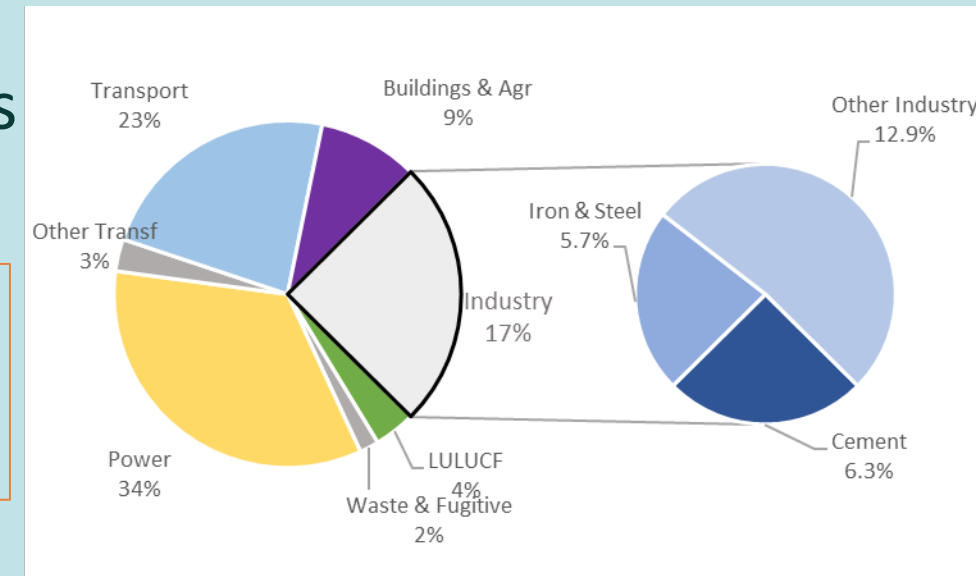
How to supply materials while meeting the net-zero emissions targets?

- Growing demand for CO₂-intensive base materials
- G20 climate change targets of net-zero emissions by 2050-2060

Is it possible to reconcile increase in well-being for all (and associated materials demand increase) with aspirations of decarbonization of the world economy?

- We propose to represent steel demand and production in an energy model
- We include hydrogen demand and production associated to emerging uses

World CO₂ emissions, 2018



Source: GECO 2020, JRC

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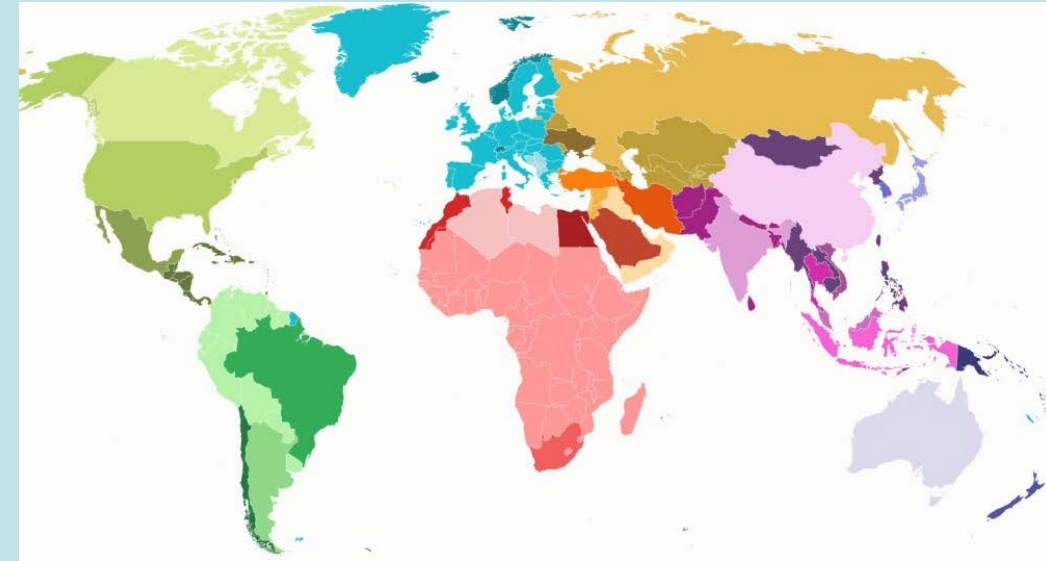
POLES: Prospective Outlook on Long-term Energy Systems

Projections of the evolution of the world energy system

- Long-term model (to 2050-2100)
- EU + 39 countries / regions (OECD, G20)
- Partial equilibrium, simulation

Output

- International energy prices & trade
- All energy sources and vectors
- All GHG emissions (linkage with specialist tools for non-energy)



Resources & production

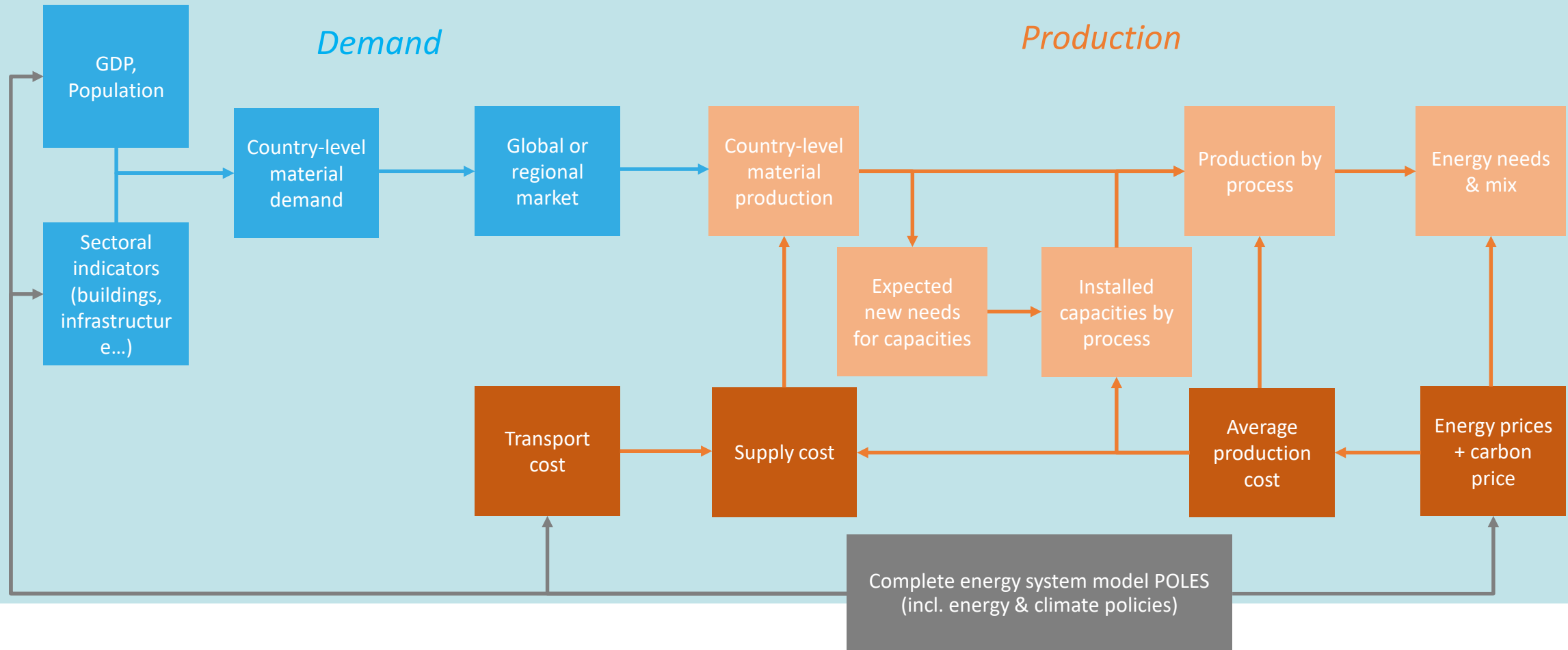
Trade

Transformation

Consumption

GHGs & other externalities

Materials Industry - POLES module: Methodology



Production processes: steel

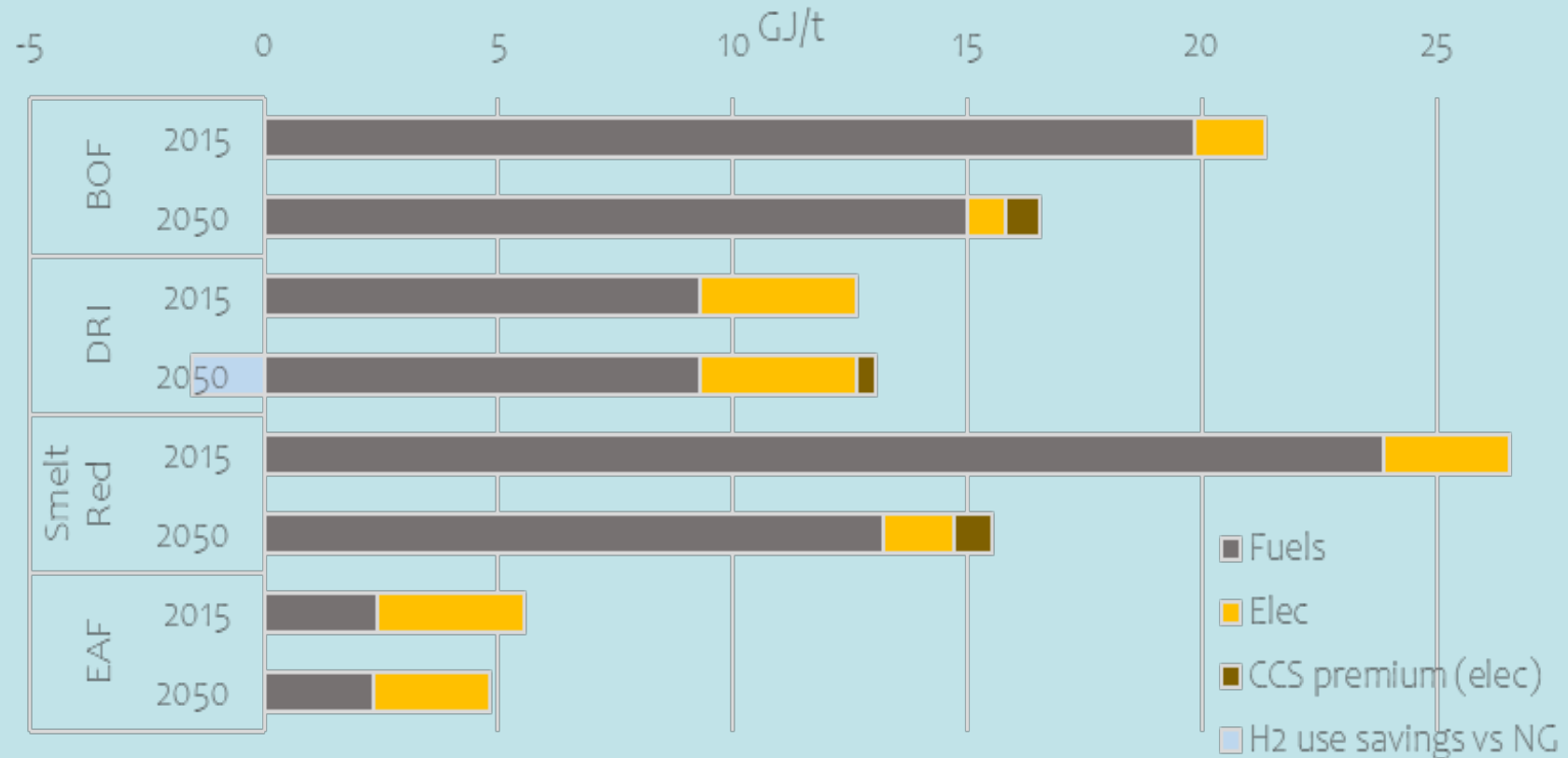
Processes:

- Ore reduction
- Scrap smelting

Decarbonisation options:

- Biomass
- CCS
- Smelting reduction
- Gas/Hydrogen reduction
- Recycling/electrification

Specific energy consumption, by steel production process



Hydrogen: production pathways

Electrolysis

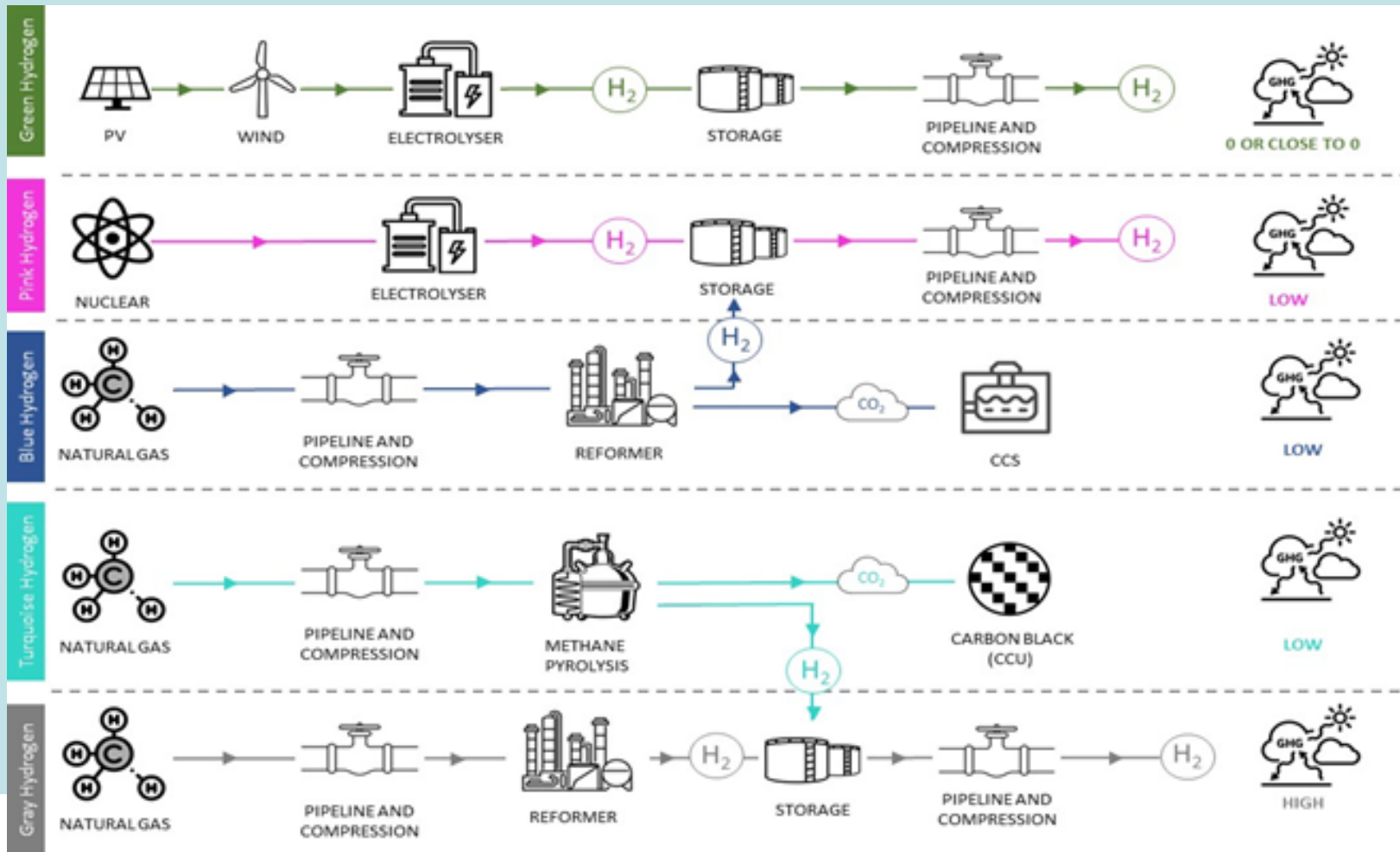
4 low-temp,
1 high-temp

Reforming
+CCS

Pyrolysis

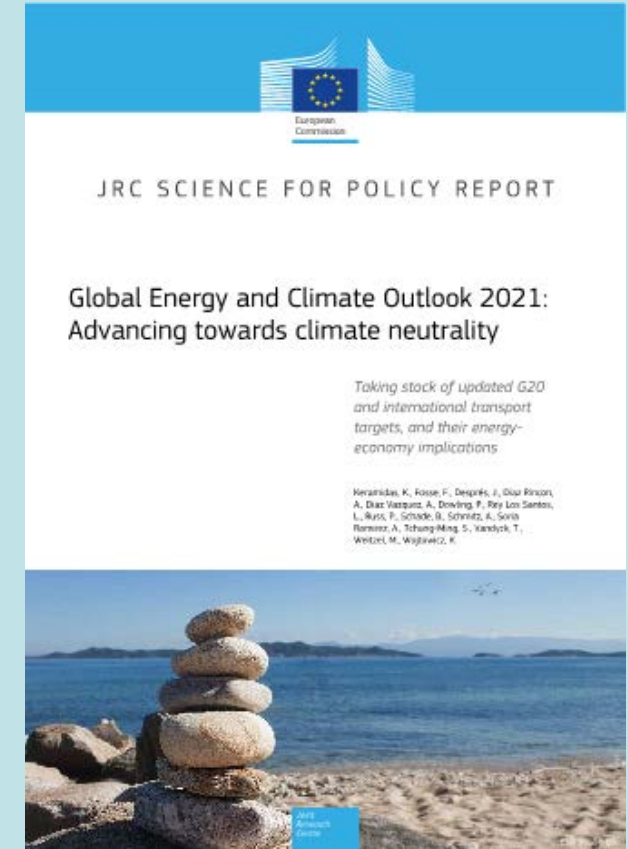
Reforming

+ Gasification



Scenarios

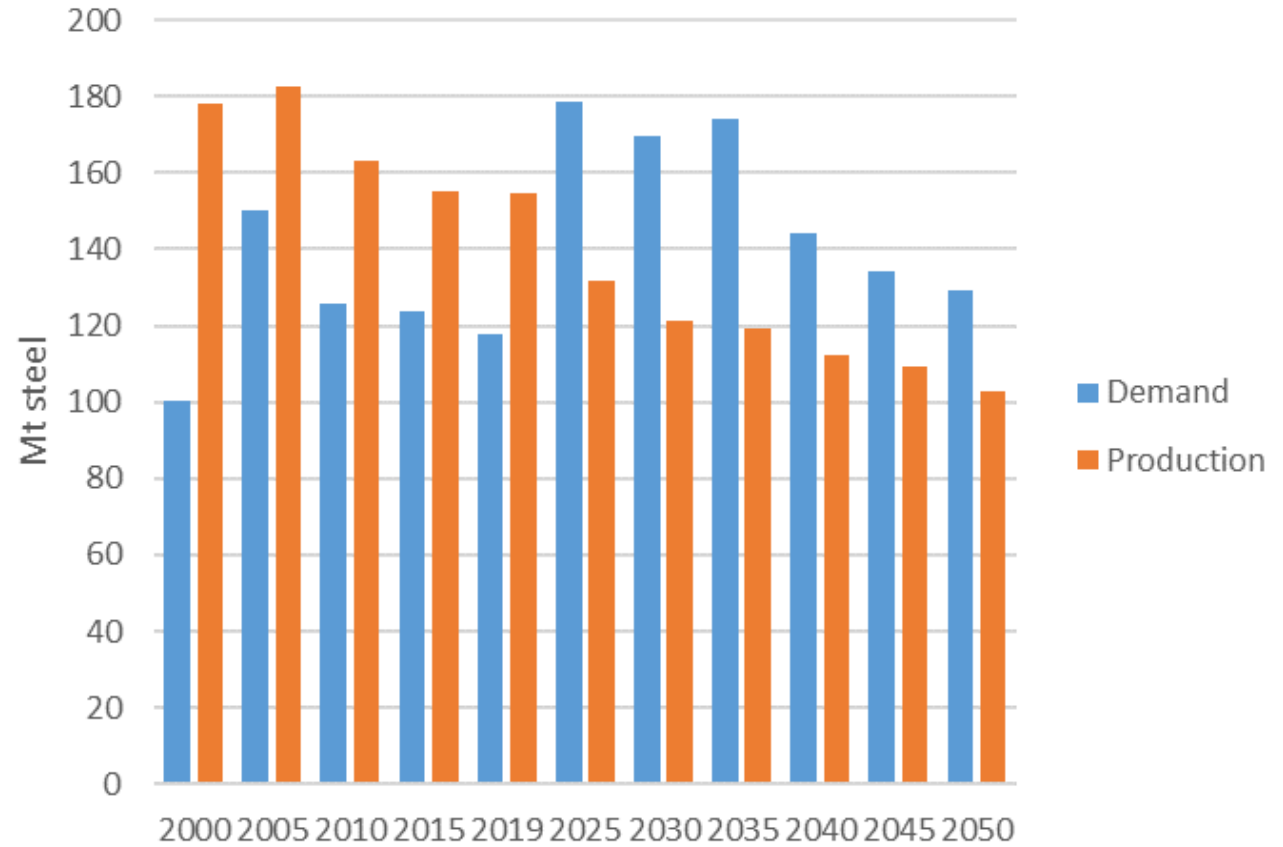
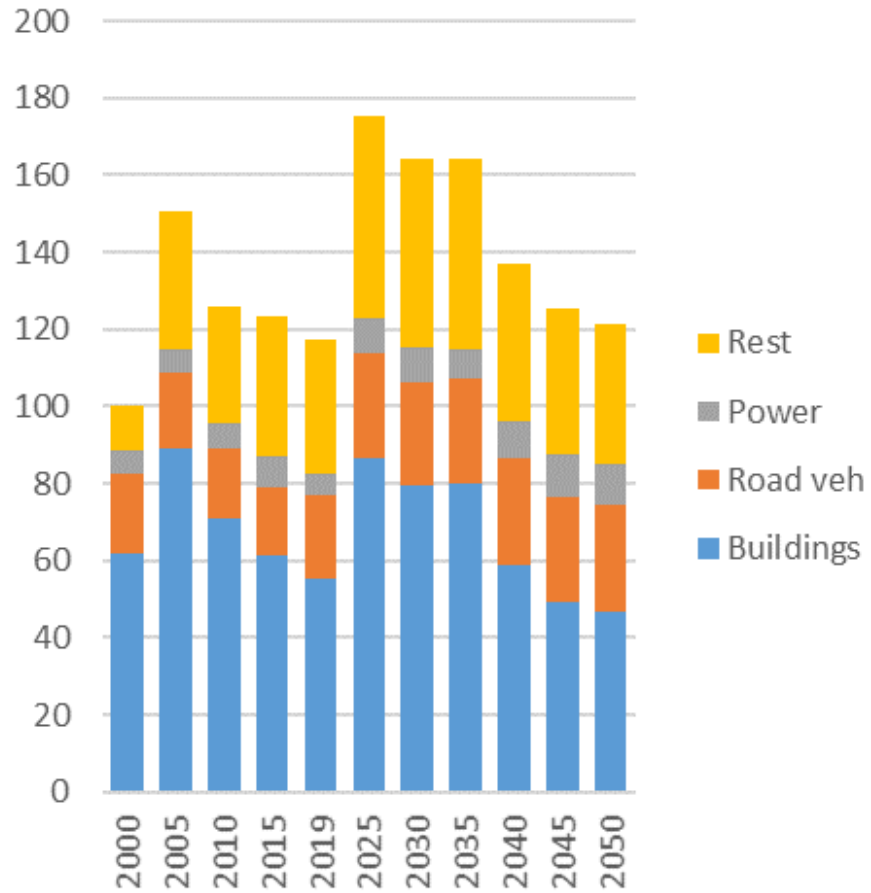
- Based on JRC Global Energy and Climate Outlook 2021
 - Common macro-economic assumptions (SSP2 + updates)
1. NoCP: no climate policies (~ current policies)
 2. CP: ambitious climate policies (global carbon price for 1.5°C)



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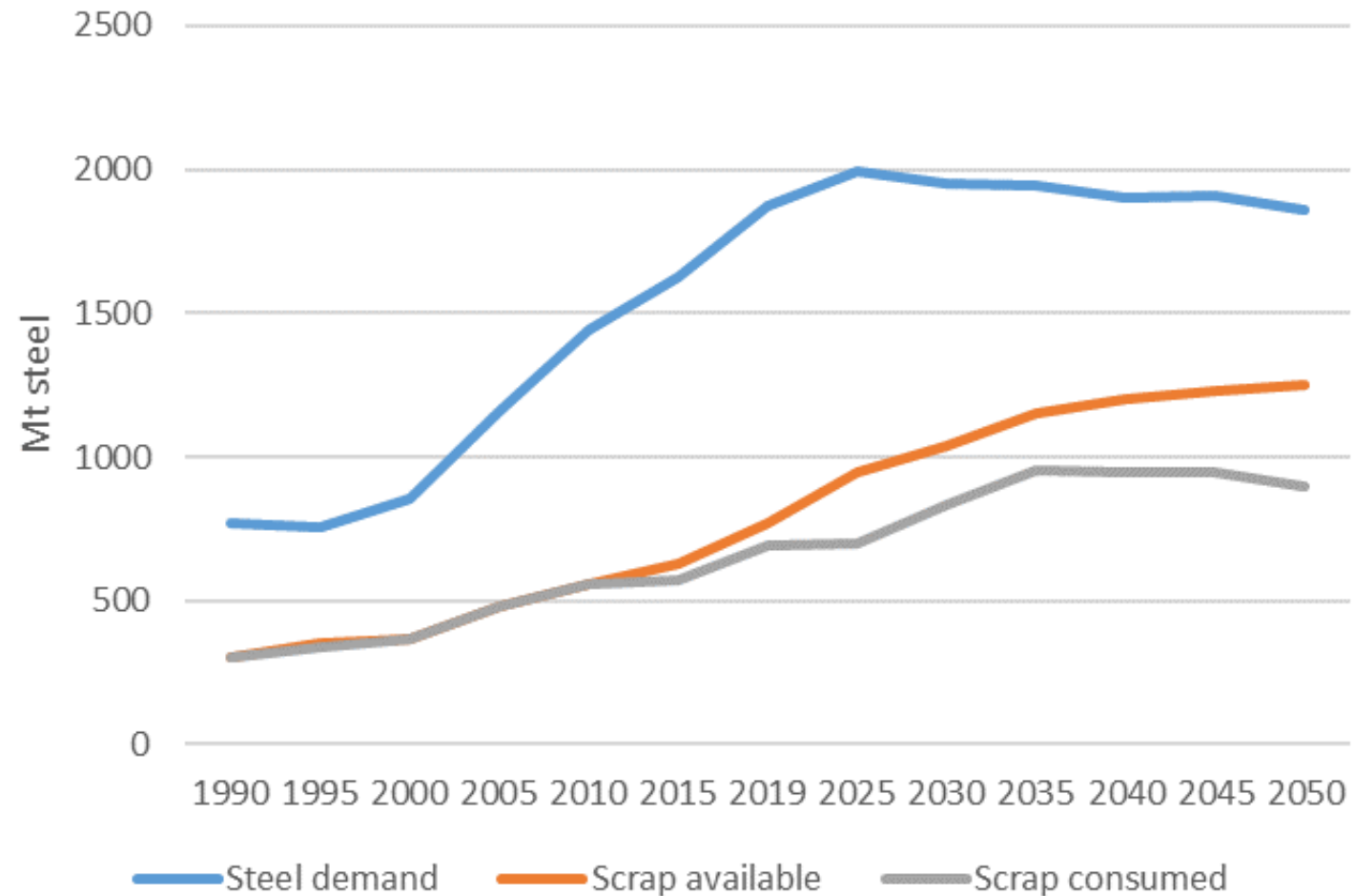
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Projections: EU steel demand and production

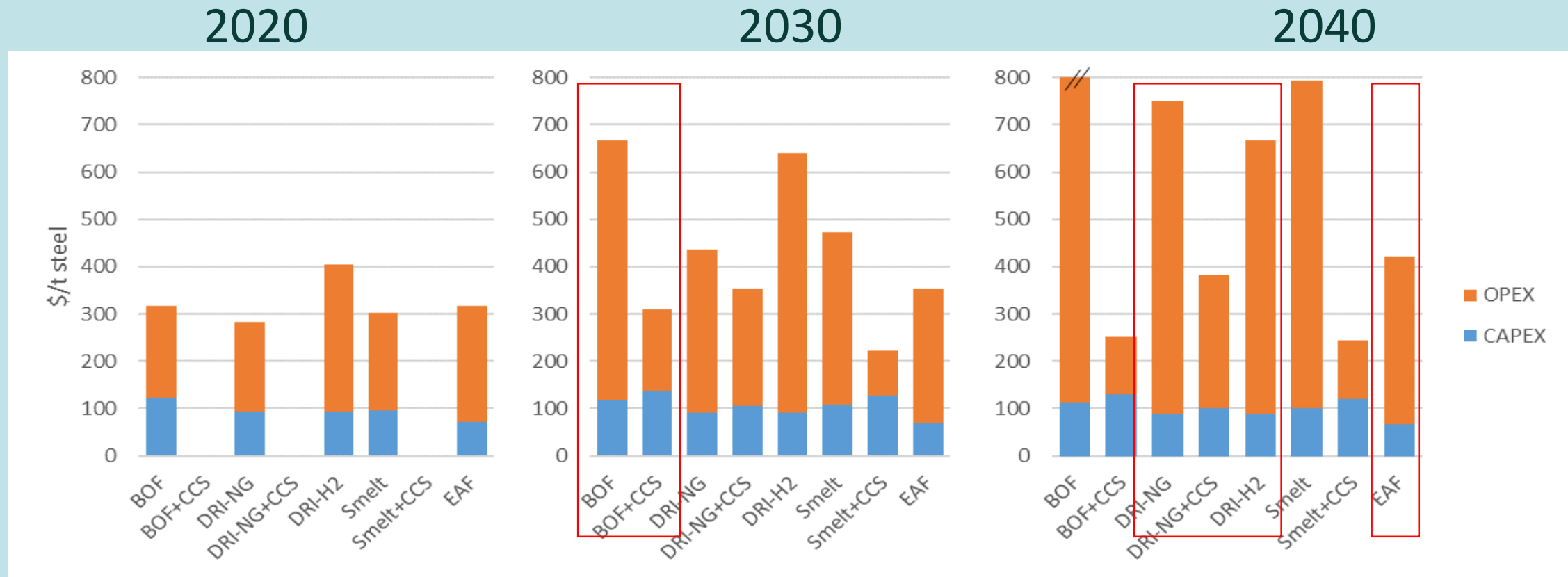


Projections: World availability of steel scrap

- Rising steel demand
→ increased future availability of scrap
- *Recovery gap*: recovery rate can be increased further
- *Economic gap*: EAF does not absorb all available scrap (scrap ~ half of production cost of EAF steel, electricity price could increase)

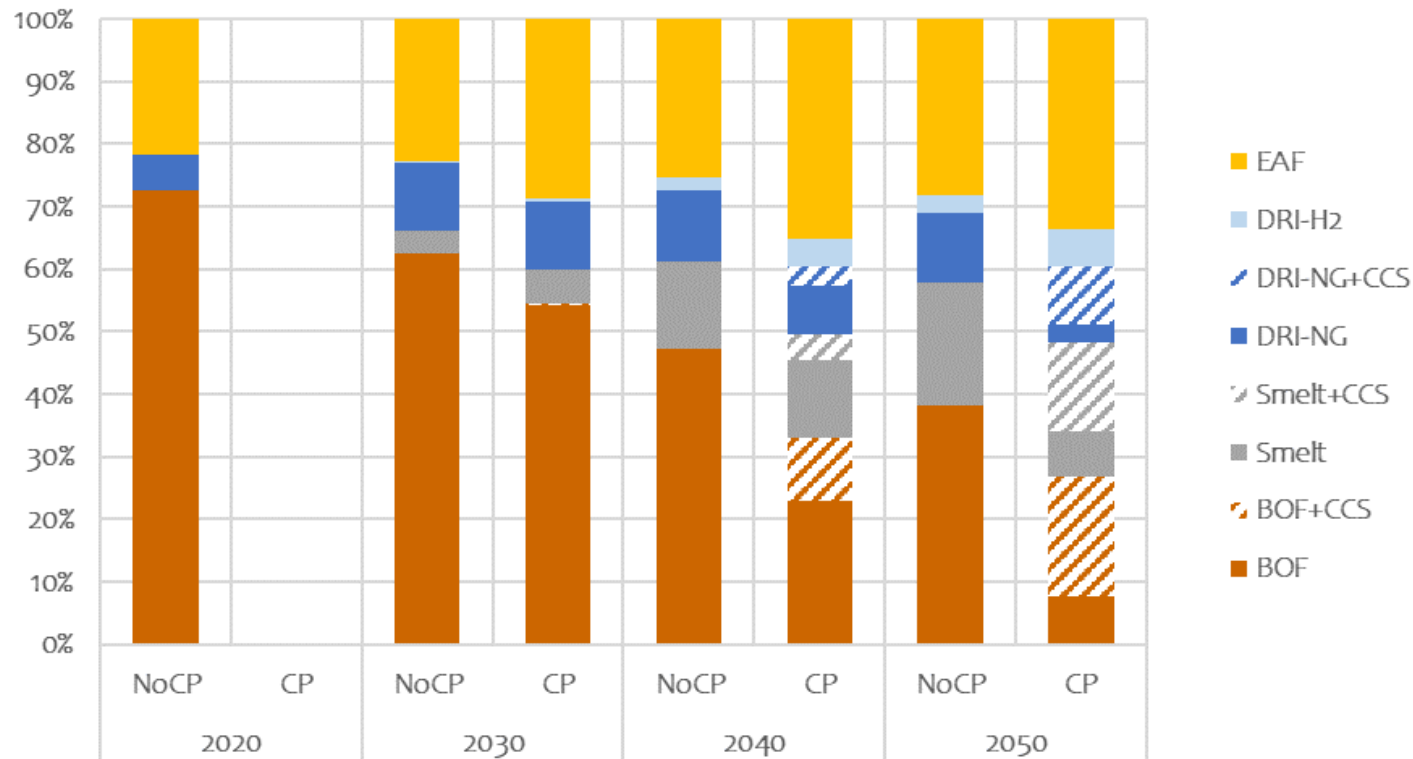


Projections: EU steel production costs

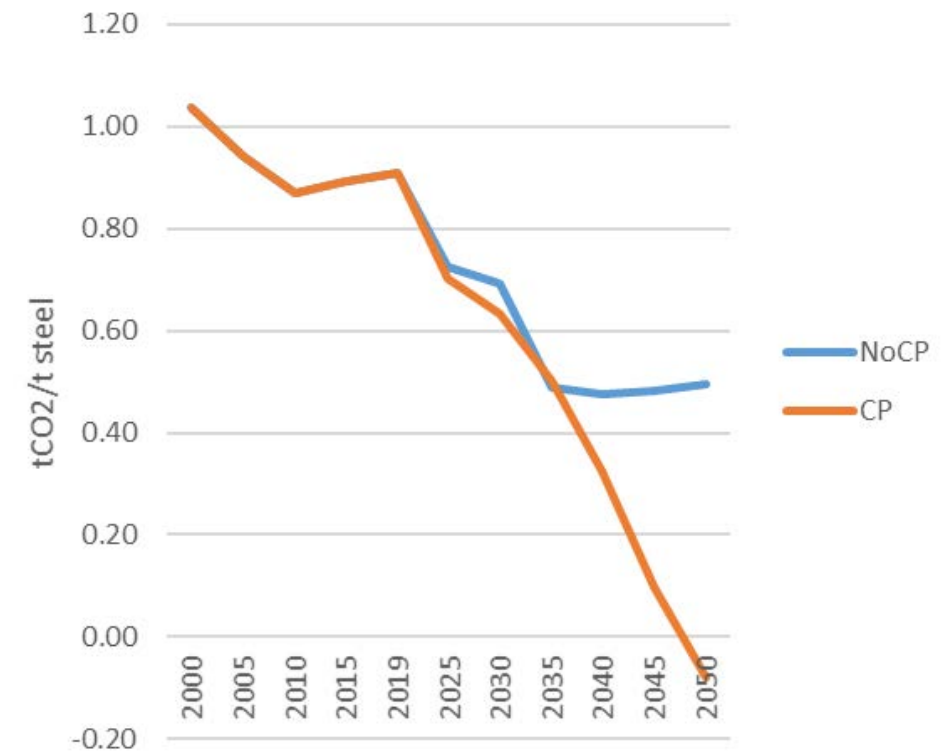


Projections: EU steel production and emissions

Steel production mix



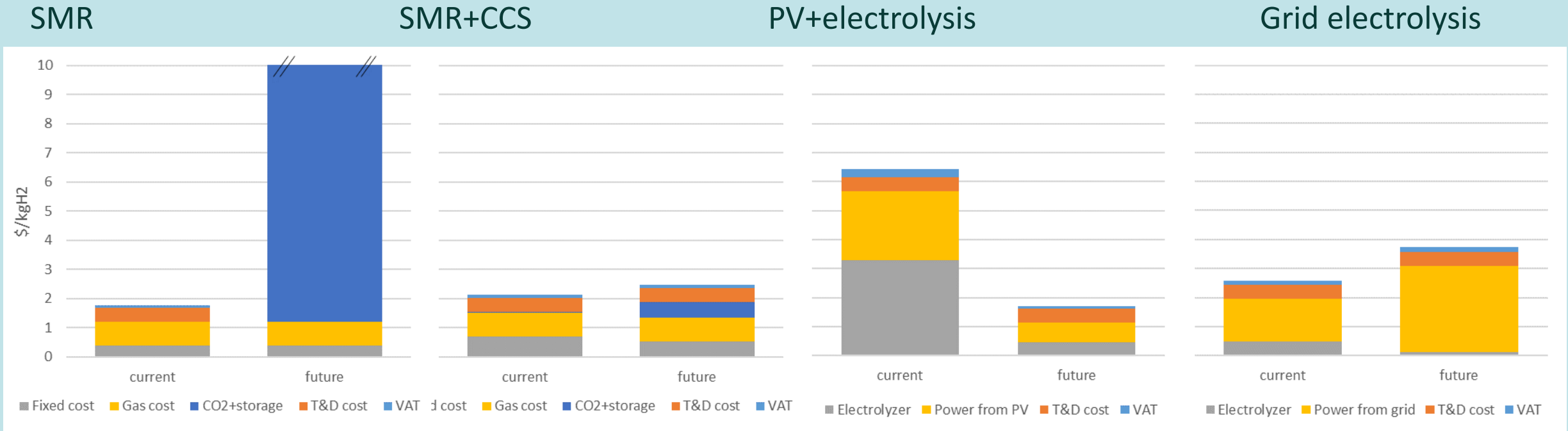
Emissions



Plan

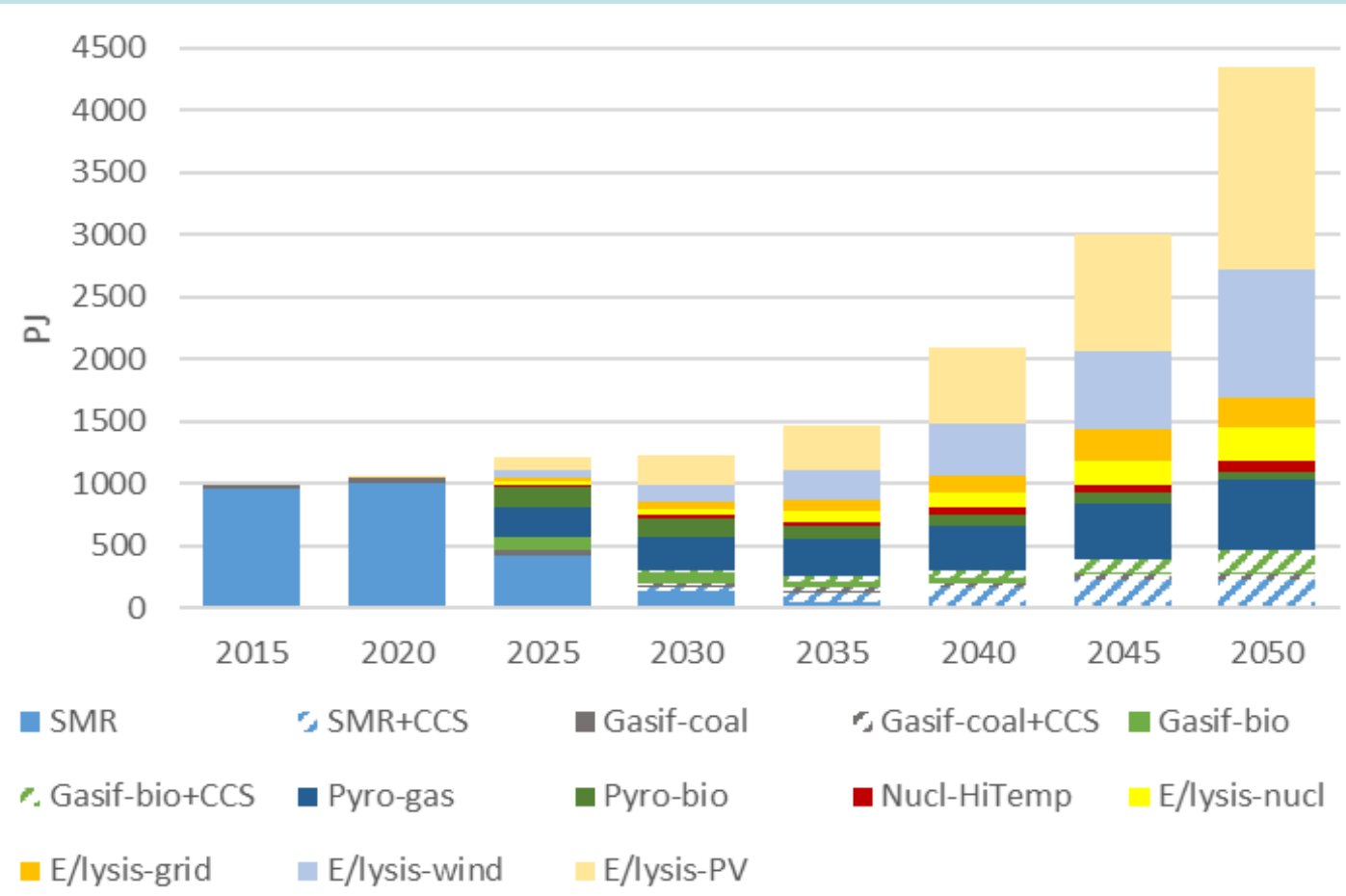
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Hydrogen: production costs

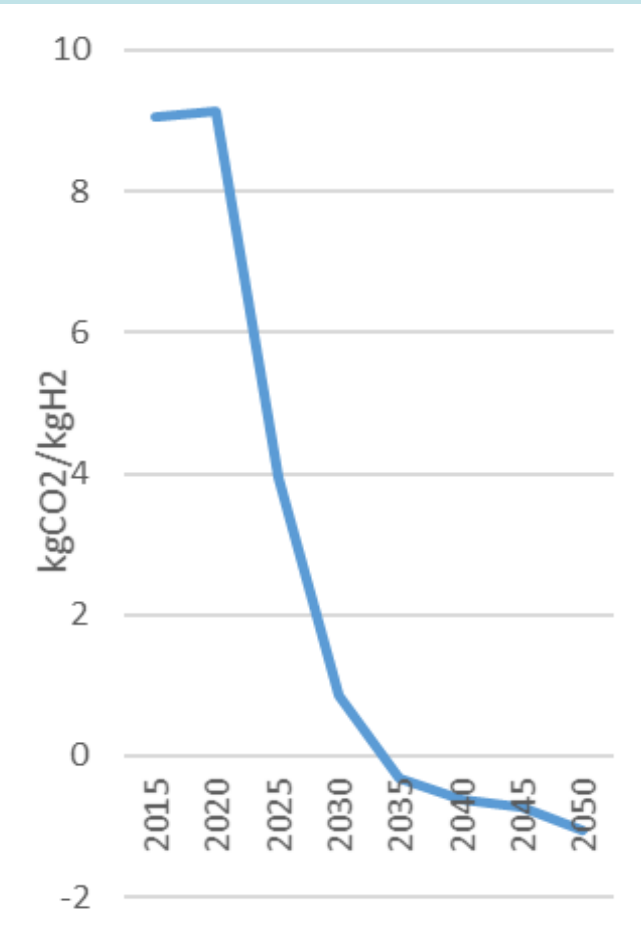


Projections: EU hydrogen production and emissions

H2 production mix



H2 carbon content



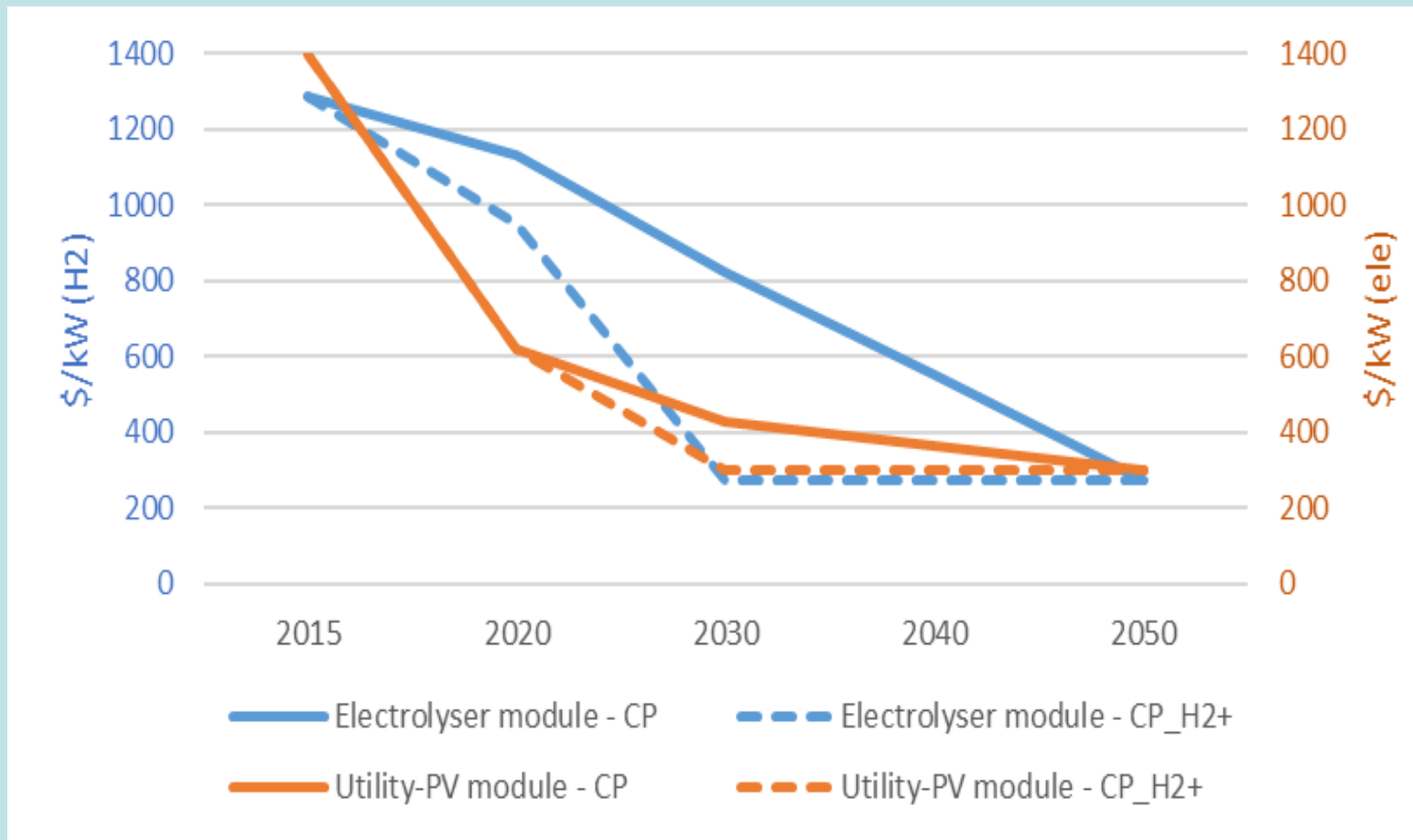
CP scenario

Plan

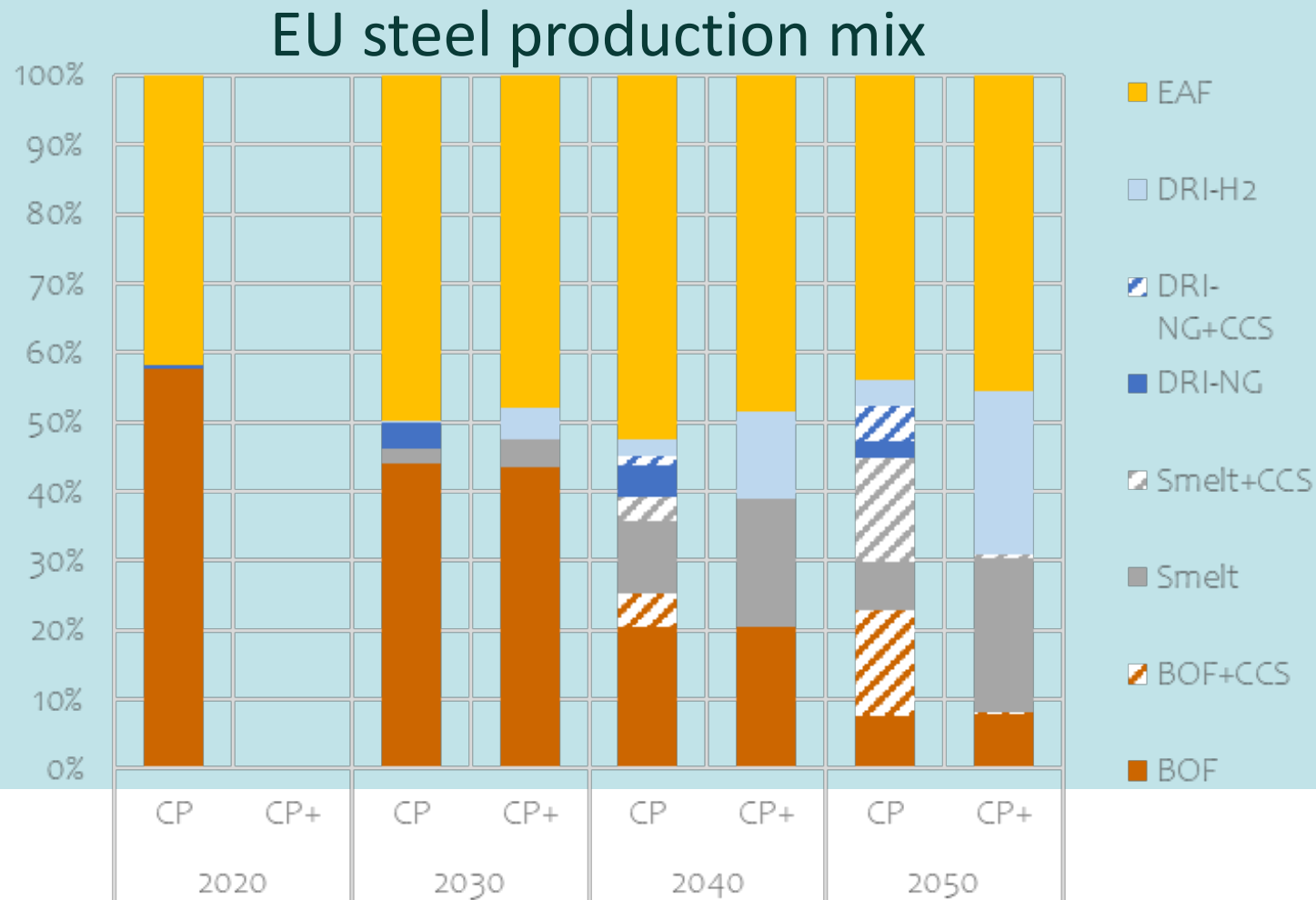
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Variant configuration to encourage hydrogen adoption in steelmaking

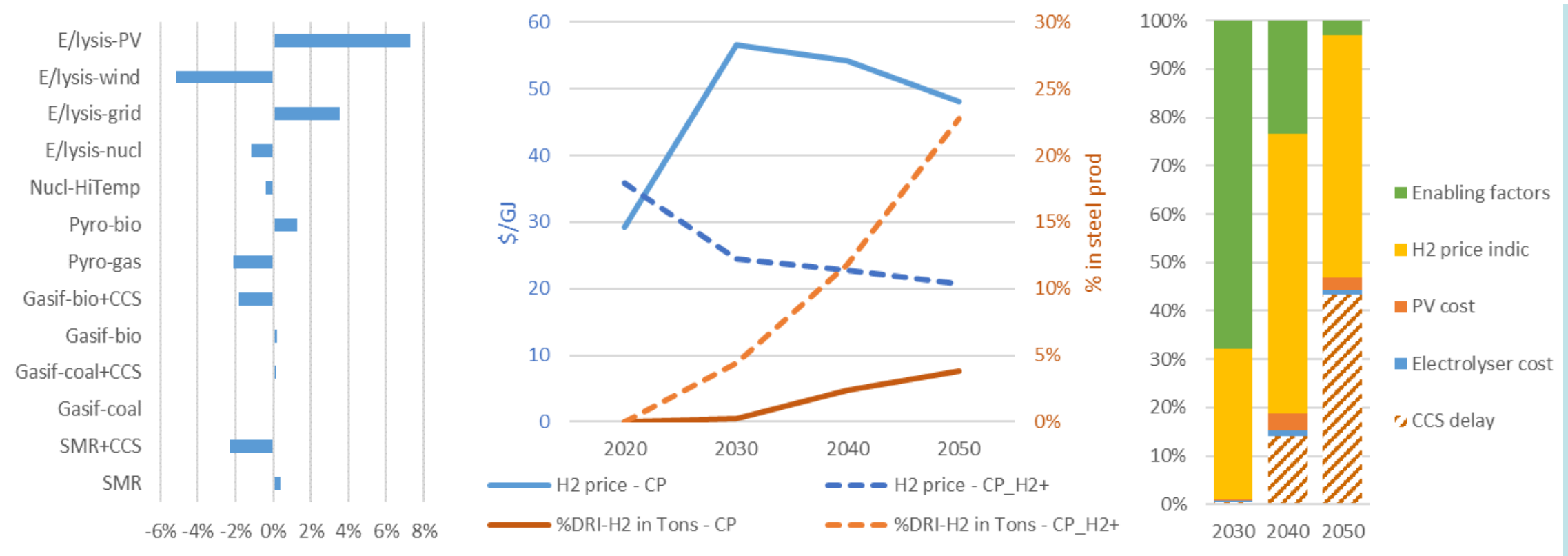
1. *Hydrogen production technology costs:* electrolyser, PV modules
2. *Competitors:* delay for CCS
3. *H2 price:* steel producers choose green & turquoise H2 only
4. *Enabling factors in the investment environment:* no risk premium for new solutions



Variant configuration to encourage hydrogen adoption in steelmaking



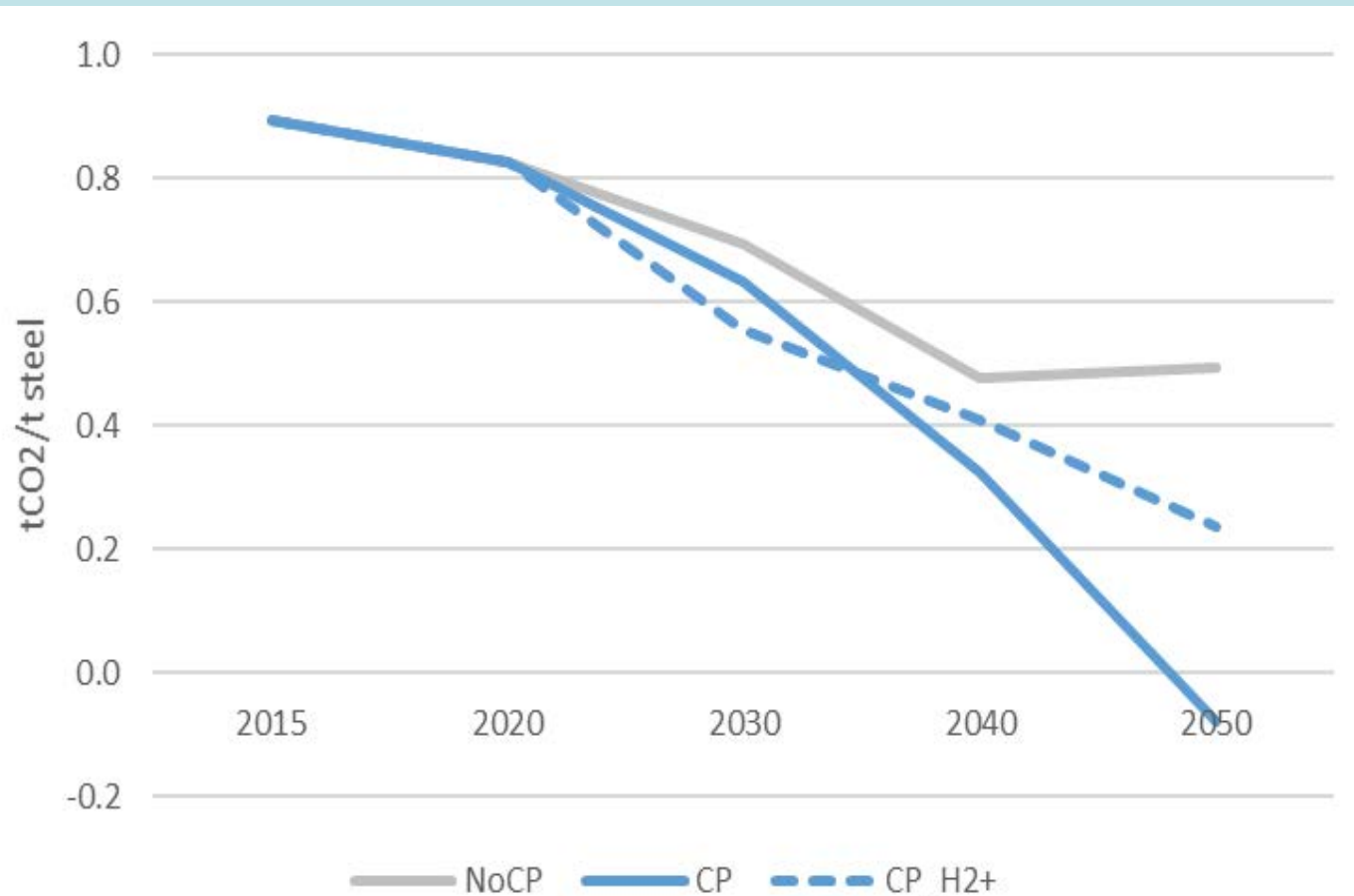
Variant configuration to encourage hydrogen adoption in steelmaking



→ Importance of decreasing risk perception for new processes

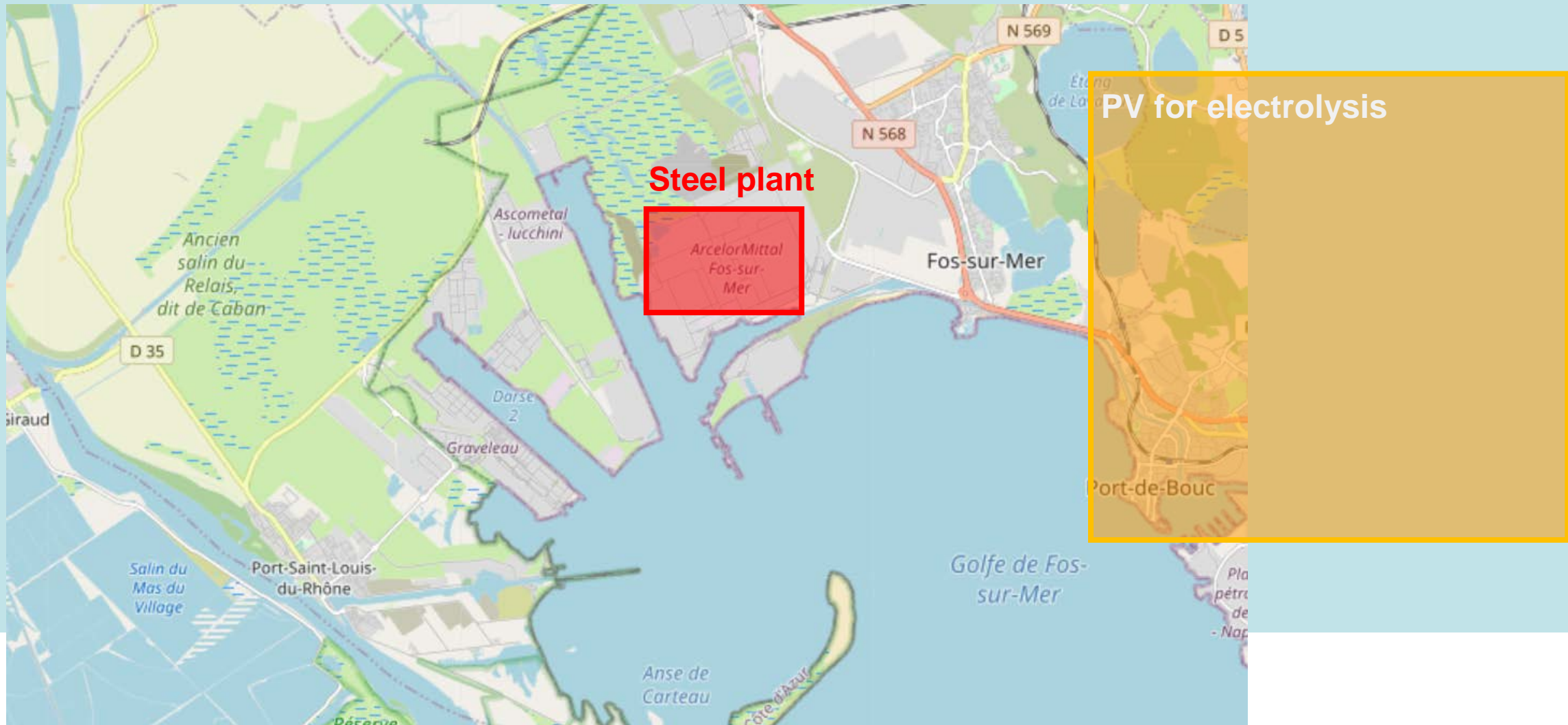
→ H2 market driven by grey/blue H2 production cost

Wider trade-offs



- Delayed CCS: higher H2 but more emissions
- Consequences on land use of hydrogen electrolysis: 1.8 GW of PV per Mt steel, 14x land area of steel plant
- Opportunity to import low-CO2 steel?

Land requirements: Fos-sur-Mer, south France



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Prioritising actions over the next 3 decades

Ranking of steel reduction options:

1. **Material efficiency:** revise construction codes in buildings, partial substitution by timber, recycling rate
2. **Electrify** as much as possible – mature technology
3. **CCS:** untested at large scale – retrofit on existing plants, start building associated transport storage infrastructure
4. **Hydrogen:** still costlier – invest in R&D of green hydrogen production, use of non-green hydrogen as transitory phase
5. **Biomass:** consider trade-offs with other sustainability indicators, use when necessary
6. **Reindustrialisation vs delocalisation:** consider wider social implications, consider carbon content of imported products

