

A photograph of a vast green field with a single, large, leafy tree in the center. The sky is bright blue with scattered white clouds. The text is overlaid on the bottom half of the image.

Agent-based modelling of the scale-up of hydrogen production and eletrolyzers manufacturing

Bernhard Jesse, Gert Jan Kramer, Vinzenz Koning



Big plans for hydrogen





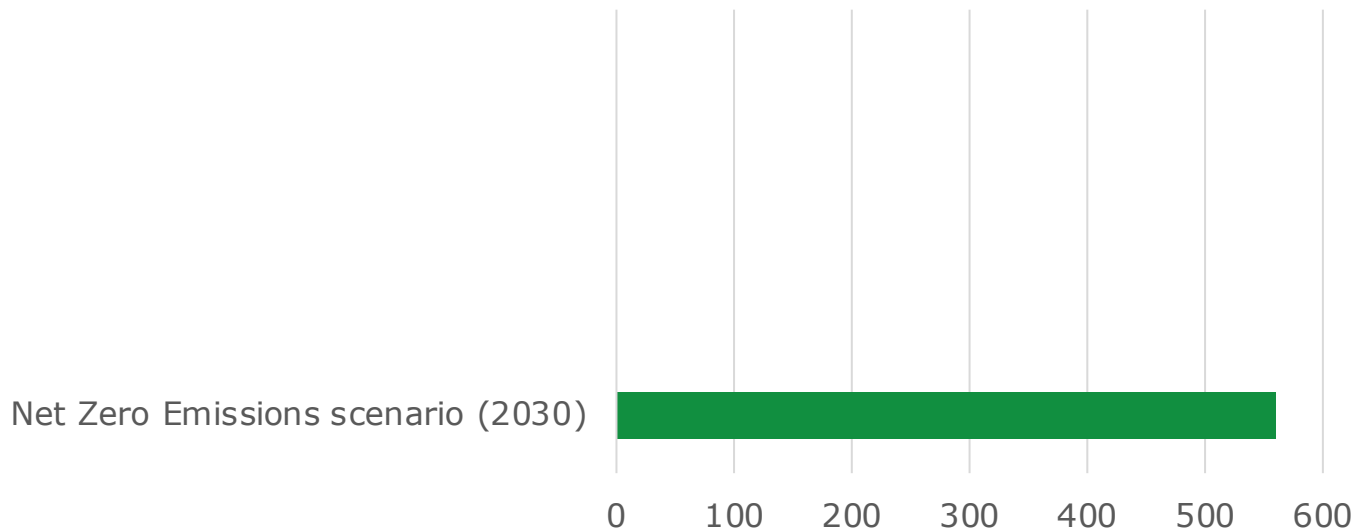
Big plans for hydrogen





Ambitions

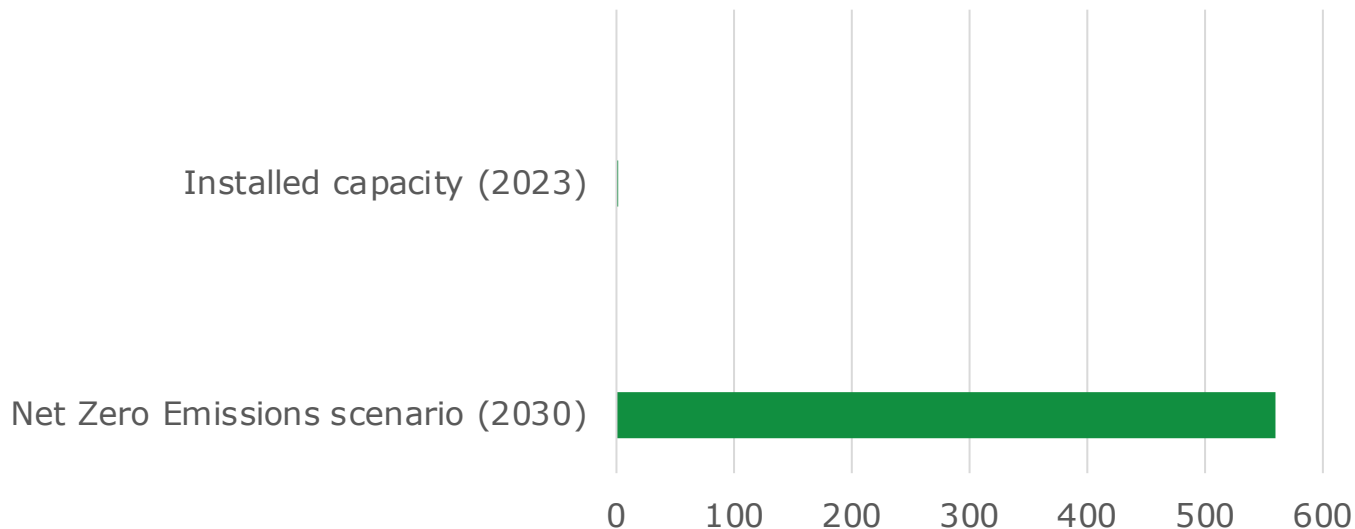
Global Electrolyser Capacity (GW)





Ambitions vs reality

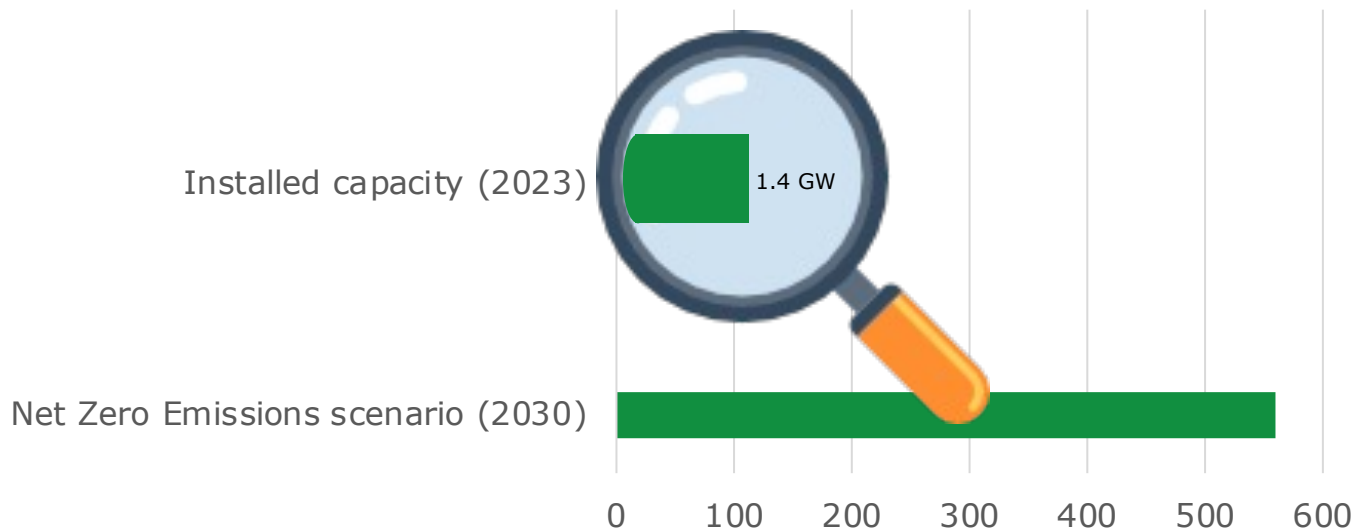
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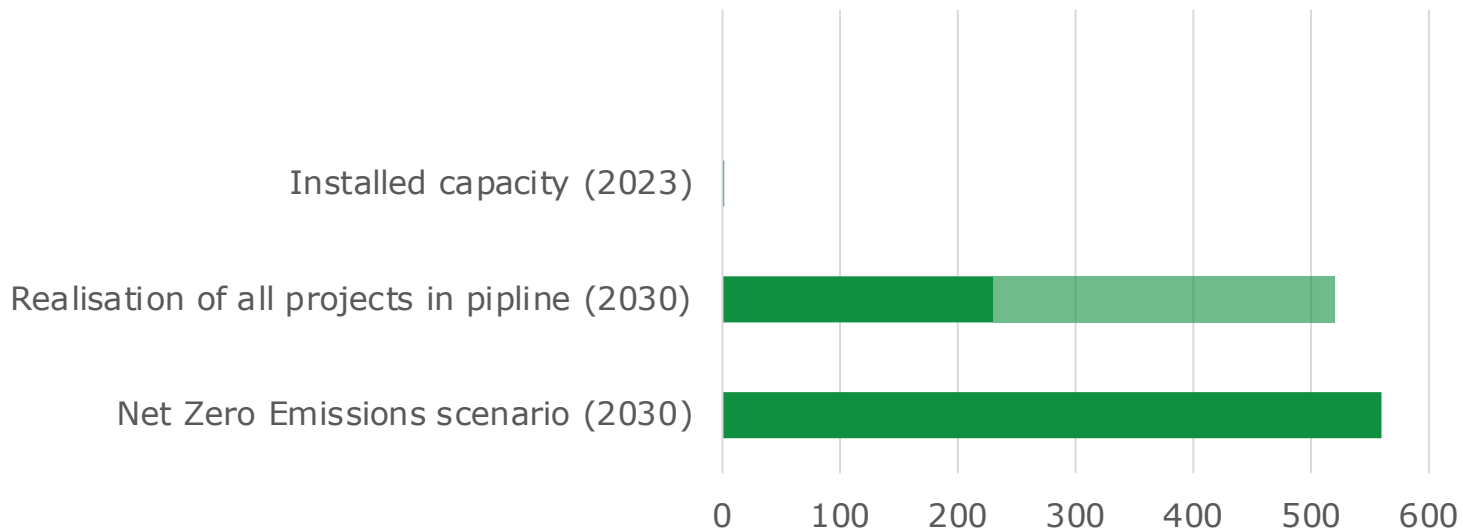
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Ambitions vs reality

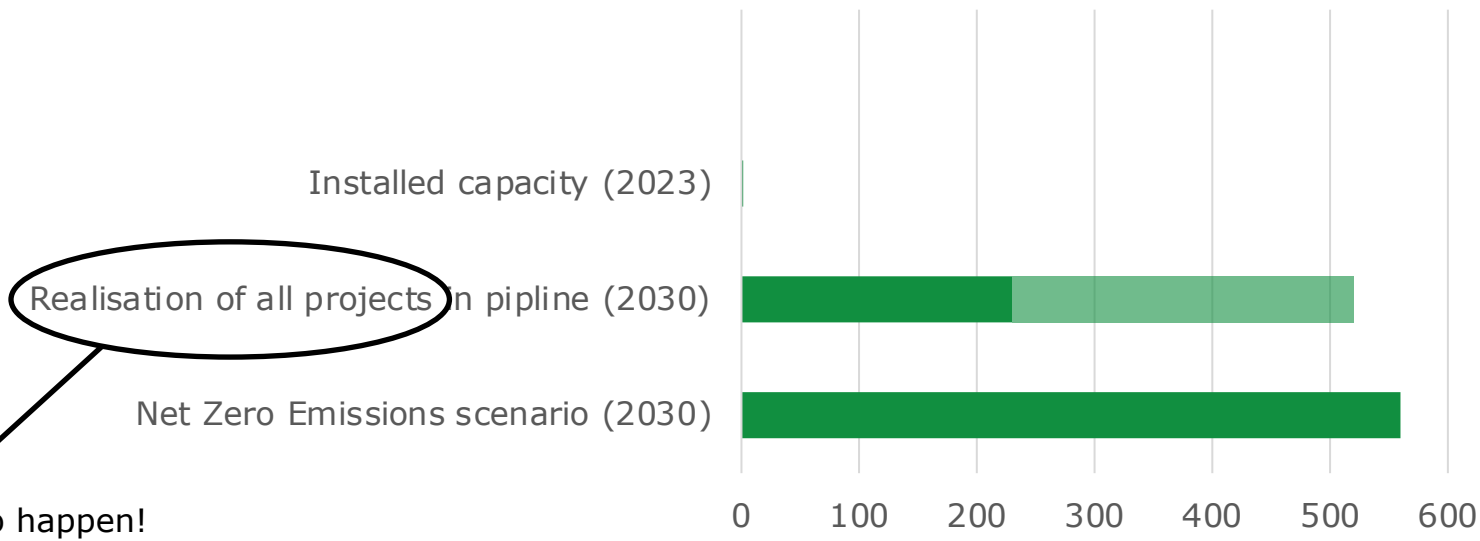
Global Electrolyser Capacity (GW)





Ambitions vs reality

Global Electrolyser Capacity (GW)





Electrolyser manufacturers are operation at a loss

KEY FIGURES CONTINUING OPERATION

PERFORMANCE MEASURES	2024	2023	2022
Revenue	1 390	1 350	708
EBITDA	-173	-272	-428
Operating loss	-389	-444	-552
Pre-tax income (loss)	-264	-574	-464
Net income (loss)	-258	-566	-456
Net cash flow from operating activities	-83	-464	NA
Cash balance end of period	1 876	3 363	3 139





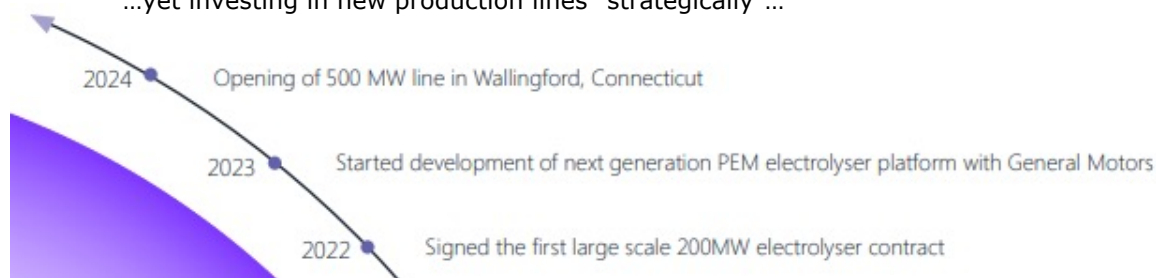
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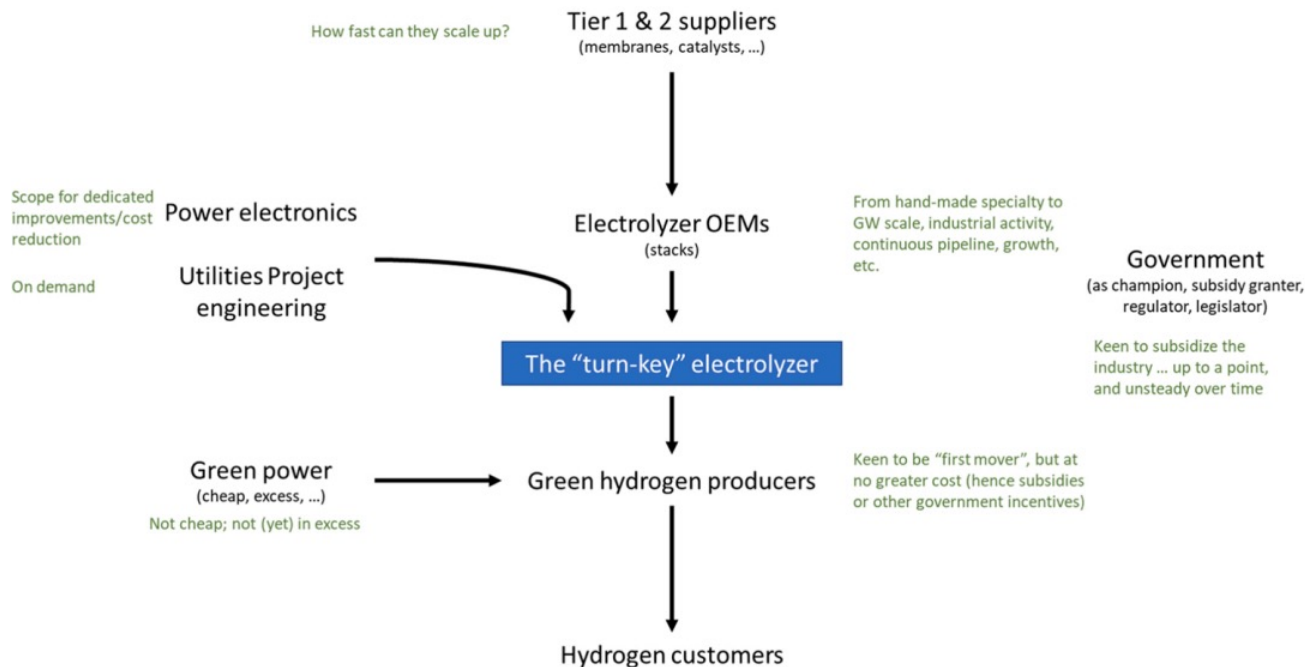


...yet investing in new production lines “strategically”...



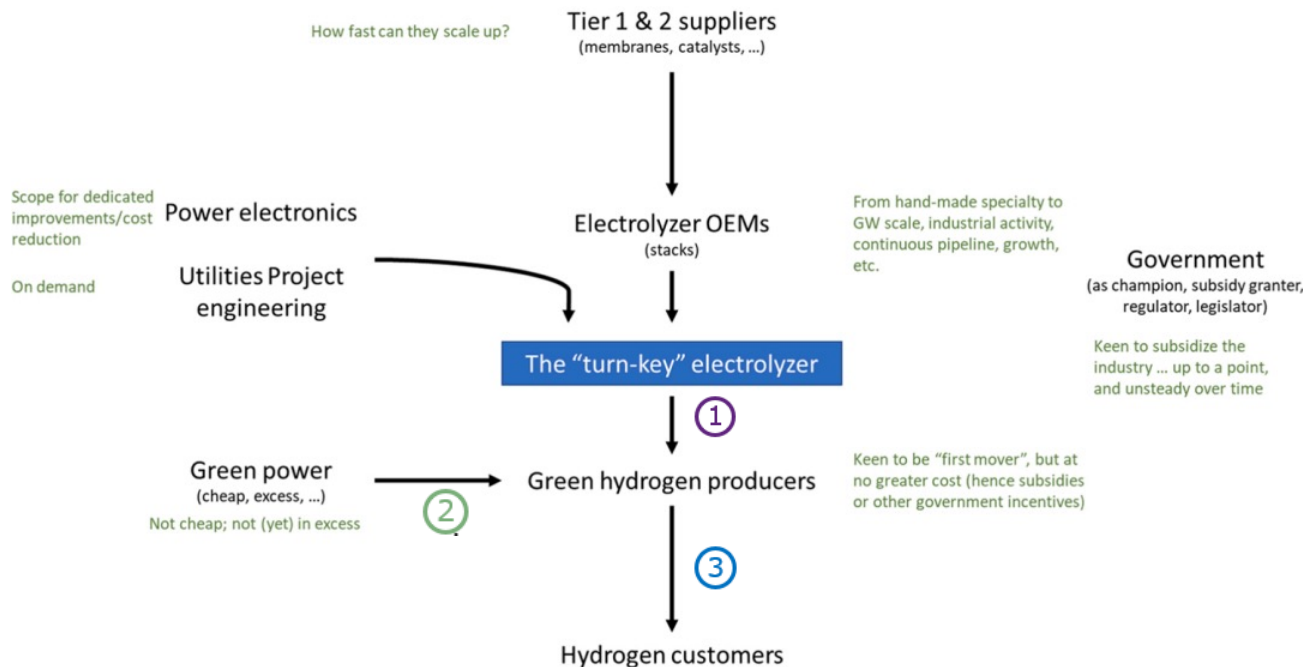


Investability in H2 & electrolysis?





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How will players invest in sync?

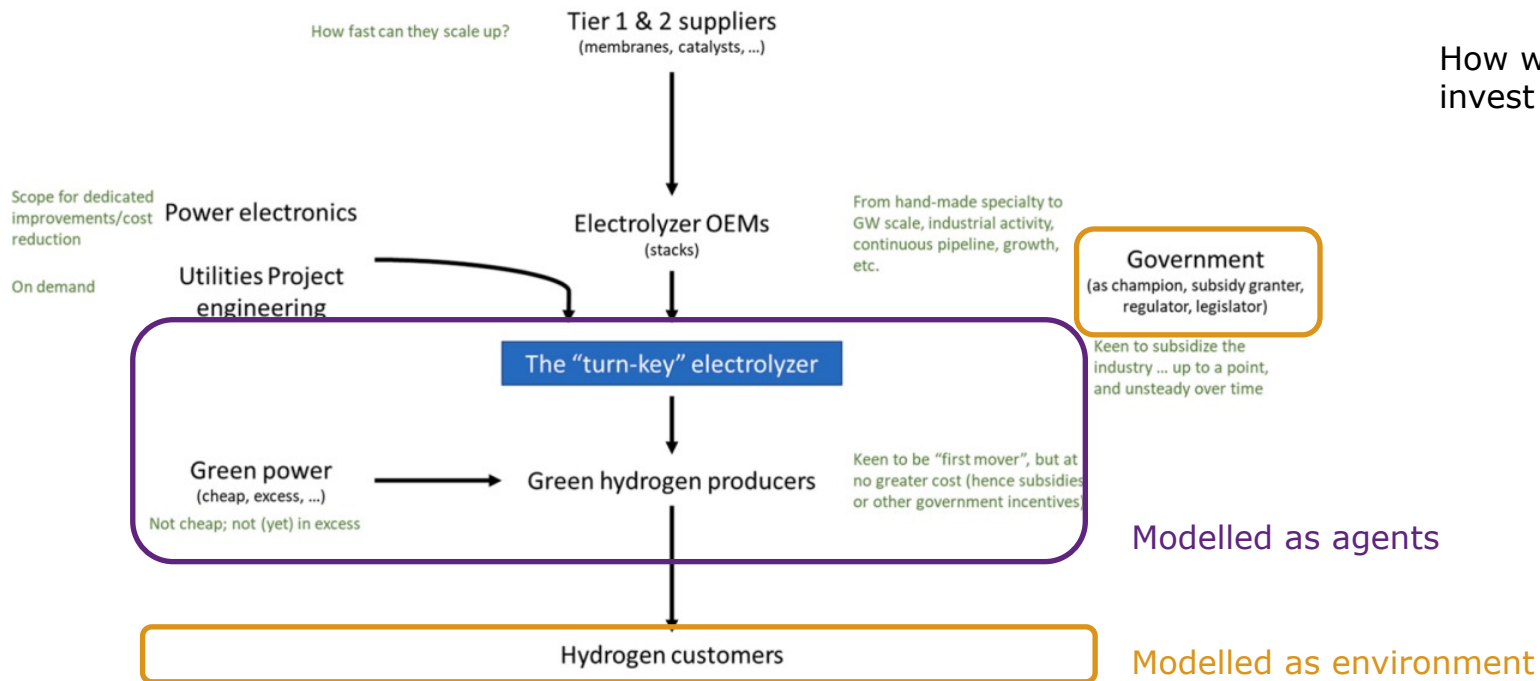
Interview results
Challenges are:

- ① High electrolyser cost ~2000-6000 €/kW
- ② Lack of abundant, cheap renewable power
- ③ Low WTP for green hydrogen



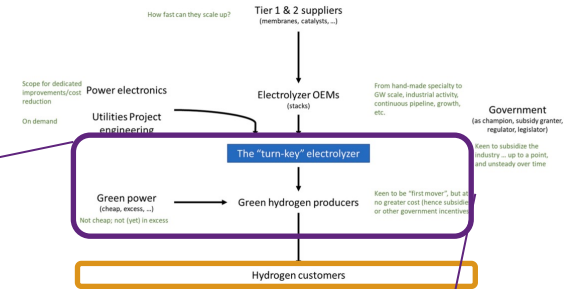
Investability in H2 & electrolysis?

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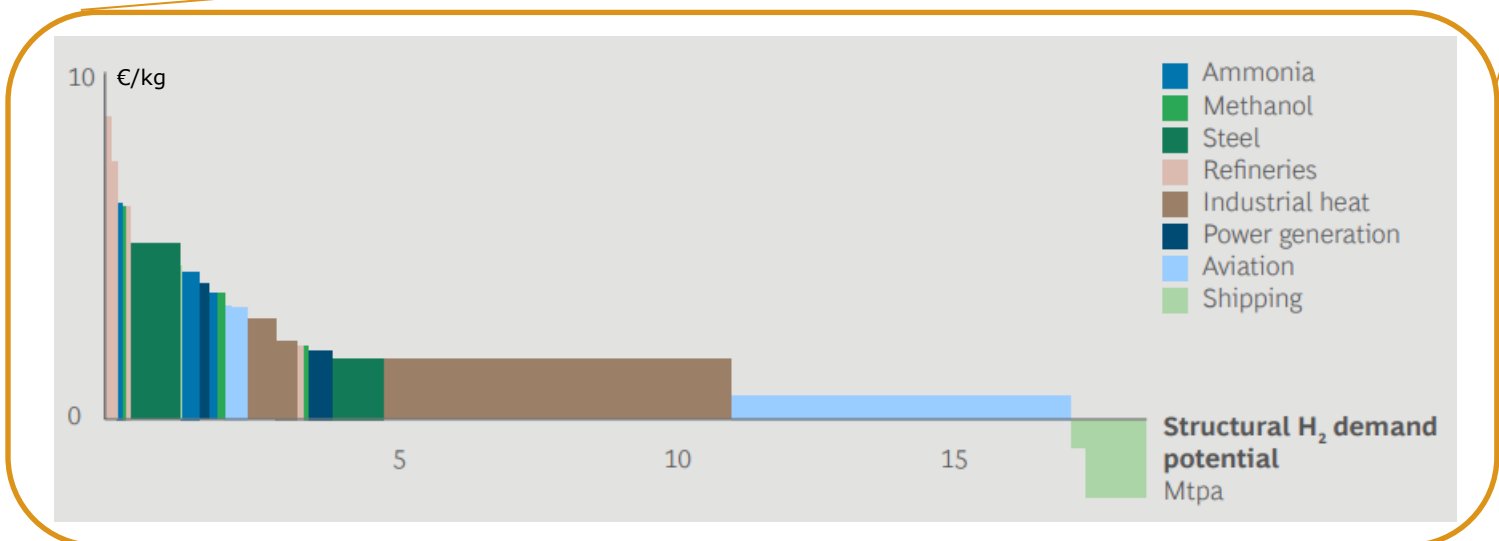
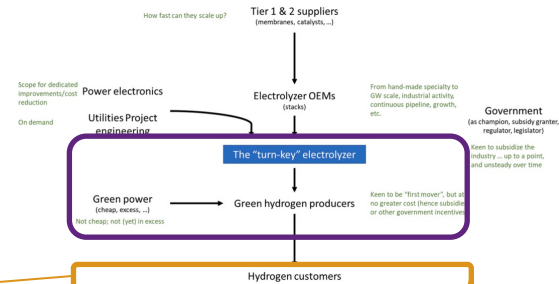
Model assumptions



1. **Short-sightedness.** Future electricity, fuel and technology prices are not known to agents.
2. **Heterogeneity** Investment decisions based on heterogeneous expectations about the future.
3. **Adaptation.** Past performance of investors affects their investment capacities and colours their outlooks.
4. **Strategic behaviour.** Electrolyser manufacturers and hydrogen producers can take "strategic" decisions in the early phase of scale-up, up to ~2030 policy target
5. **Technological learning.** Electrolysers will come down in cost with cumulative production
6. **Interactions.** Via trading of electricity, hydrogen, electrolysers. Trading of electrolysers based on bargaining power of hydrogen producers and electrolyser manufacturers.



Optimistic WTP for H2

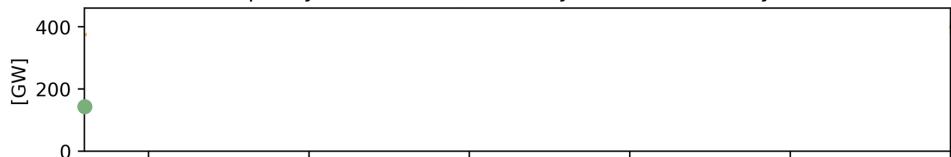




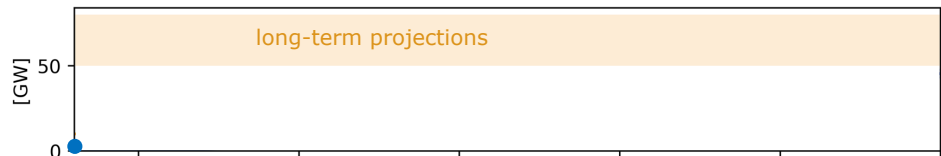
Optimistic WTP for H2

Installed capacity Renewables, Electrolyzers and Electrolyzer Factories

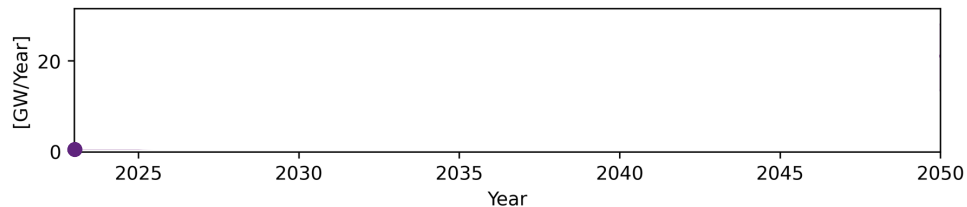
Renewables capacity



Hydrogen production capacity

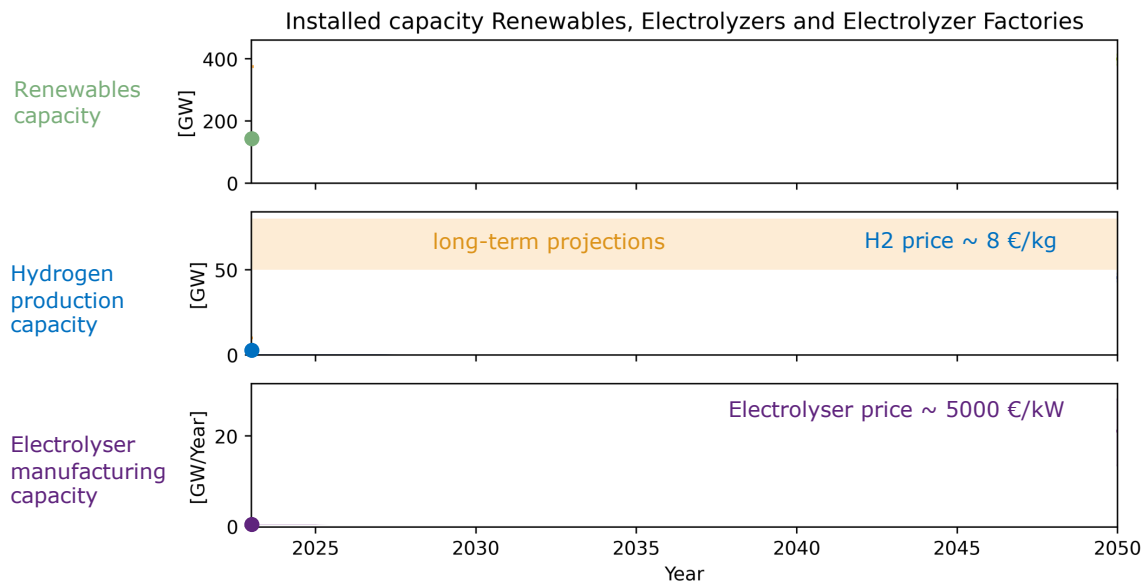


Electrolyser manufacturing capacity

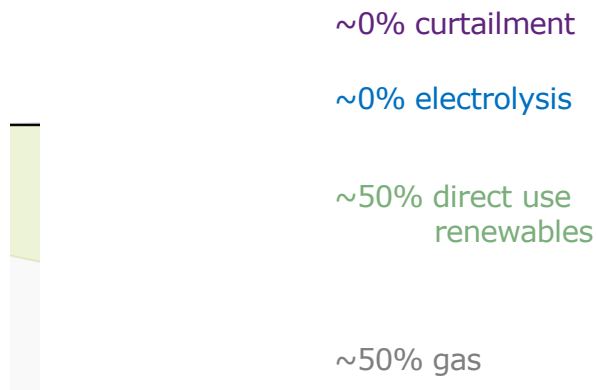




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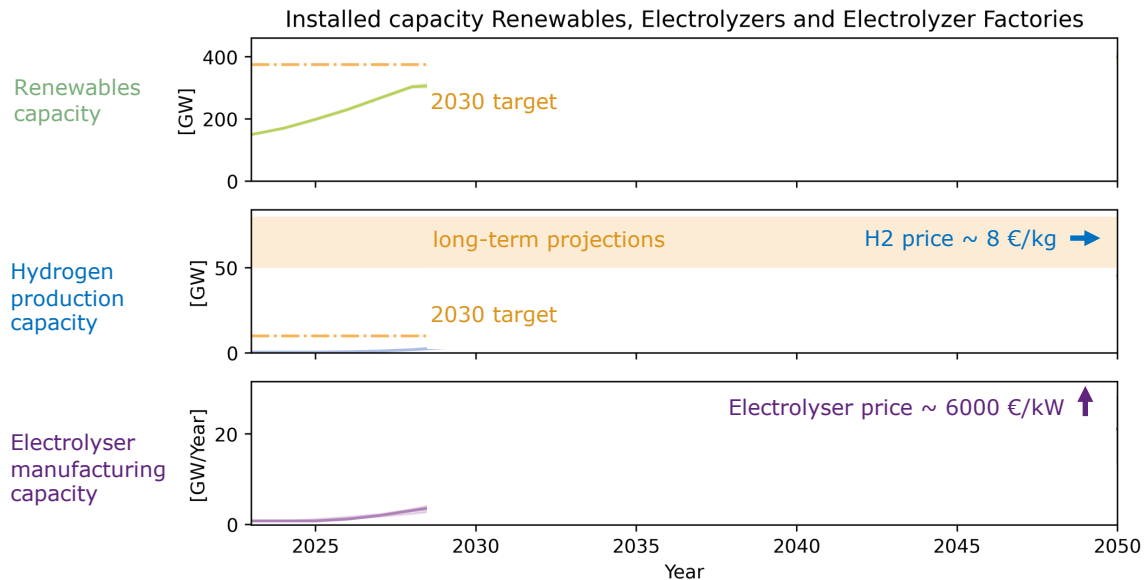


Electricity mix

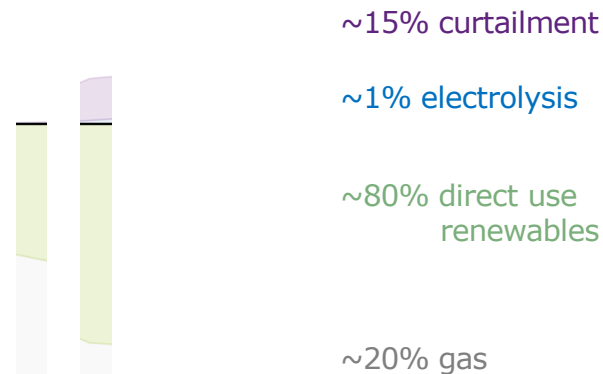




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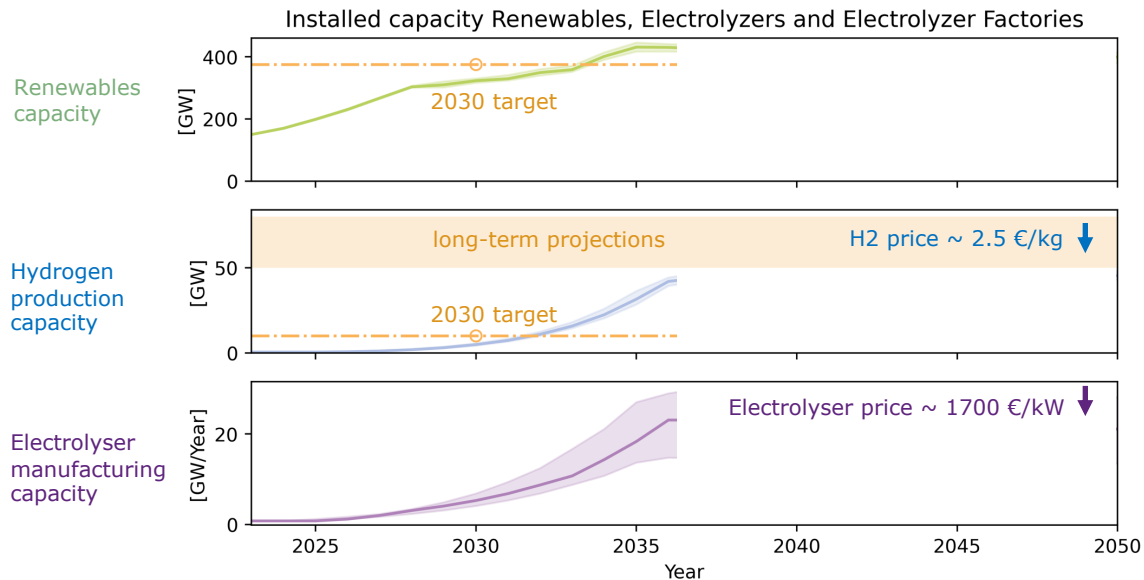


Electricity mix

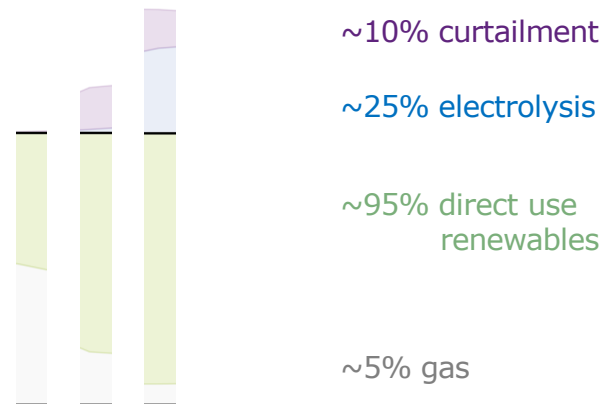




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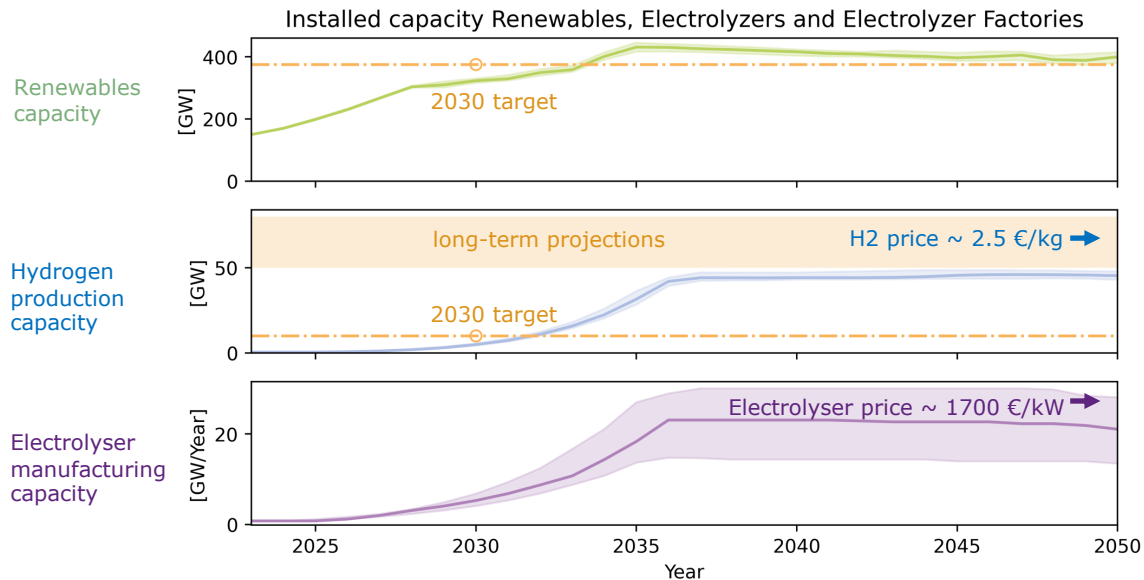


Electricity mix

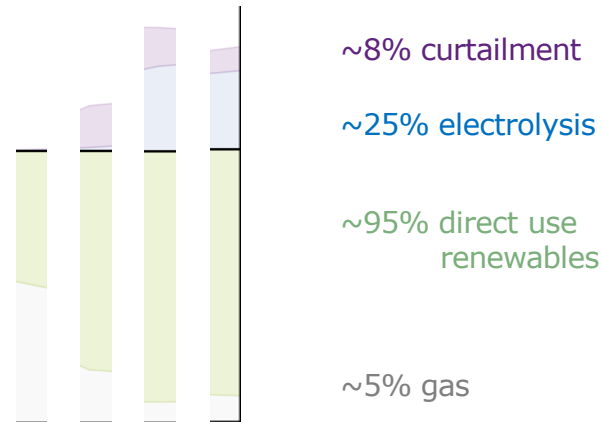




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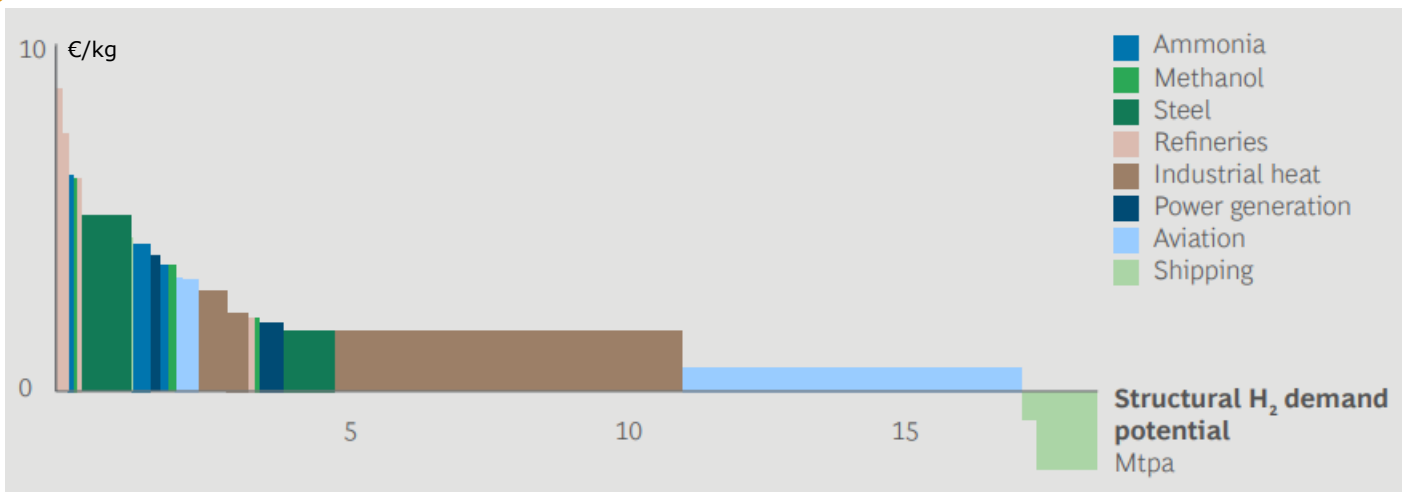
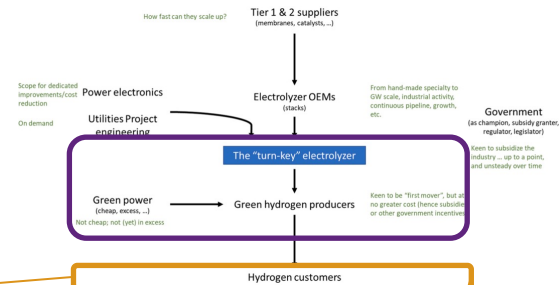


Electricity mix



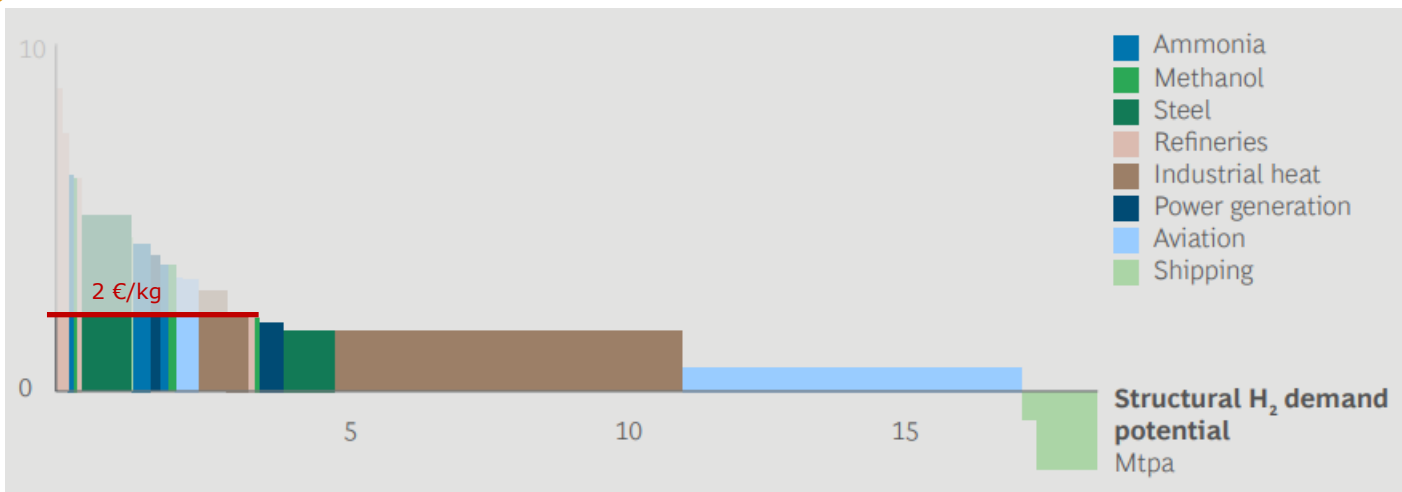
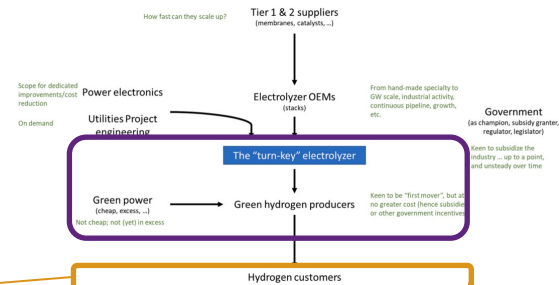


Optimistic WTP for H2



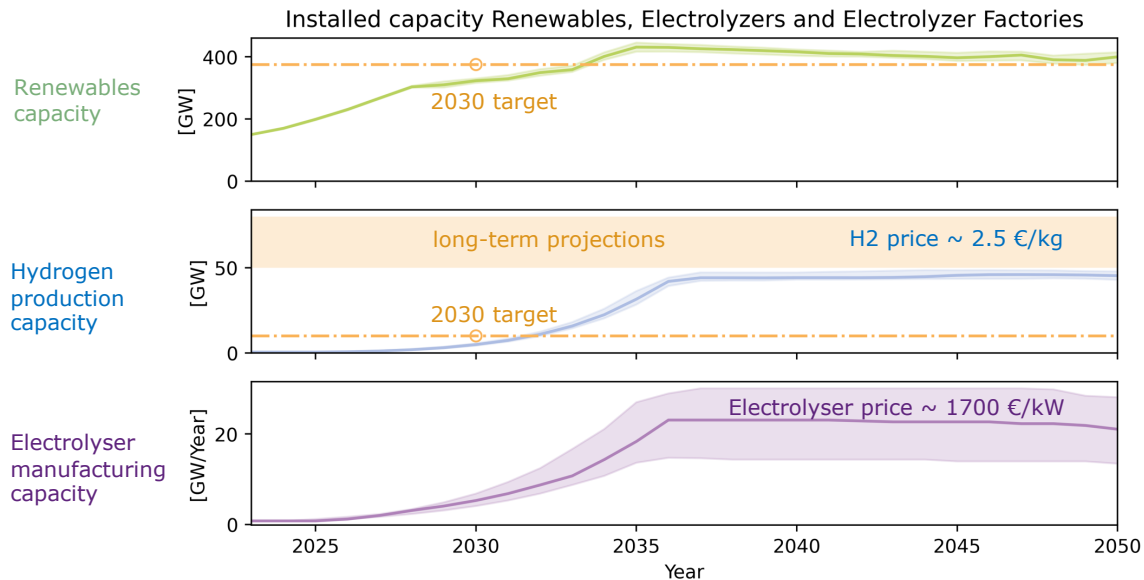


Pessimistic WTP for H2

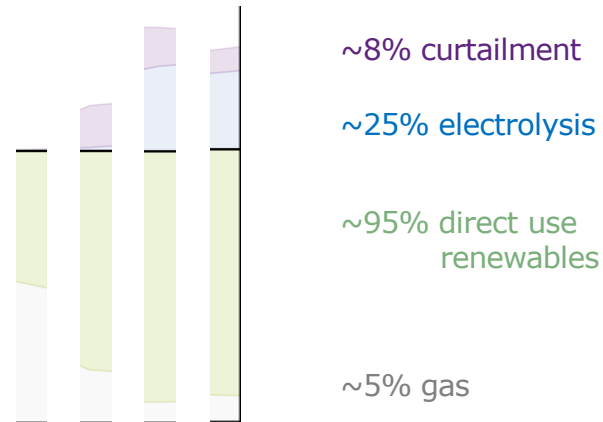




Optimistic WTP for H2

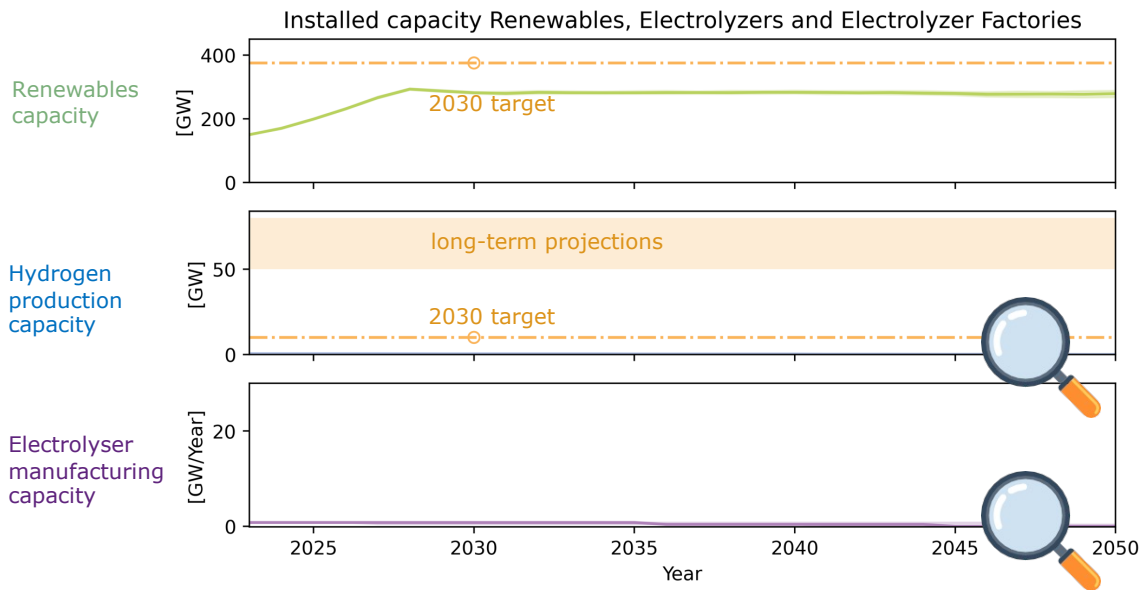


Electricity mix

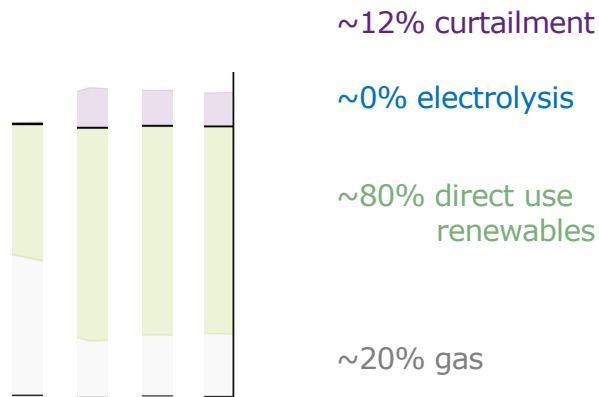




Pessimistic WTP for H2



Electricity mix





Conclusions

- Green hydrogen production and electrolyser manufacturing is not profitable today
- Current electrolyser cost are high at $\sim 2000-6000$ €/kW
- First 80% of renewables is to be decarbonized, before onset of scale-up of green hydrogen production and electrolysers manufacturing
- Scale-up relies on a questionable and uncertain willingness-to-pay for green hydrogen from industry (e.g. refineries)
- Future studies will investigate which policy mechanisms are effective and which players in the value chain should be targeted



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