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CODAHEA – Hydrogen Talk
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Cost Optimized Hydrogen Production by Wind Power & Photovoltaics

– Cost & Potential in the European Catchment Area –

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[1] [2] [3] [4] [5] [6]

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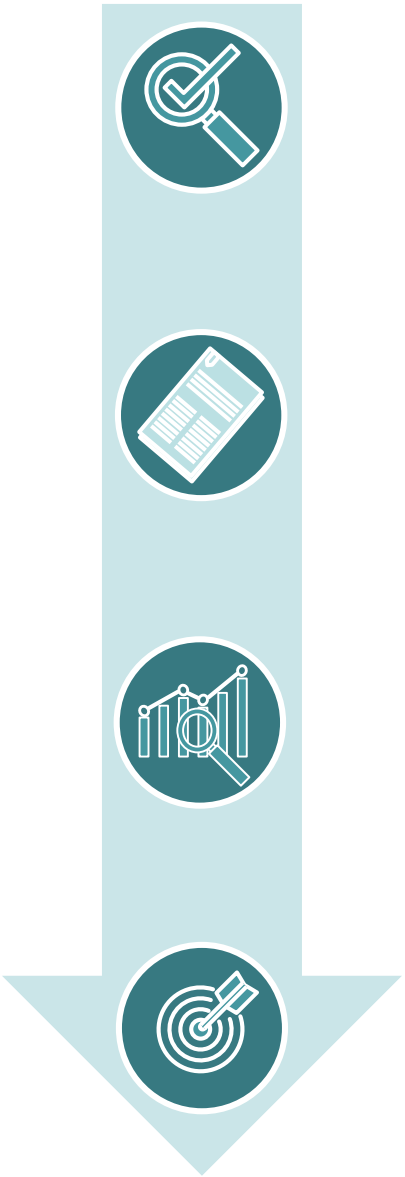
Outline

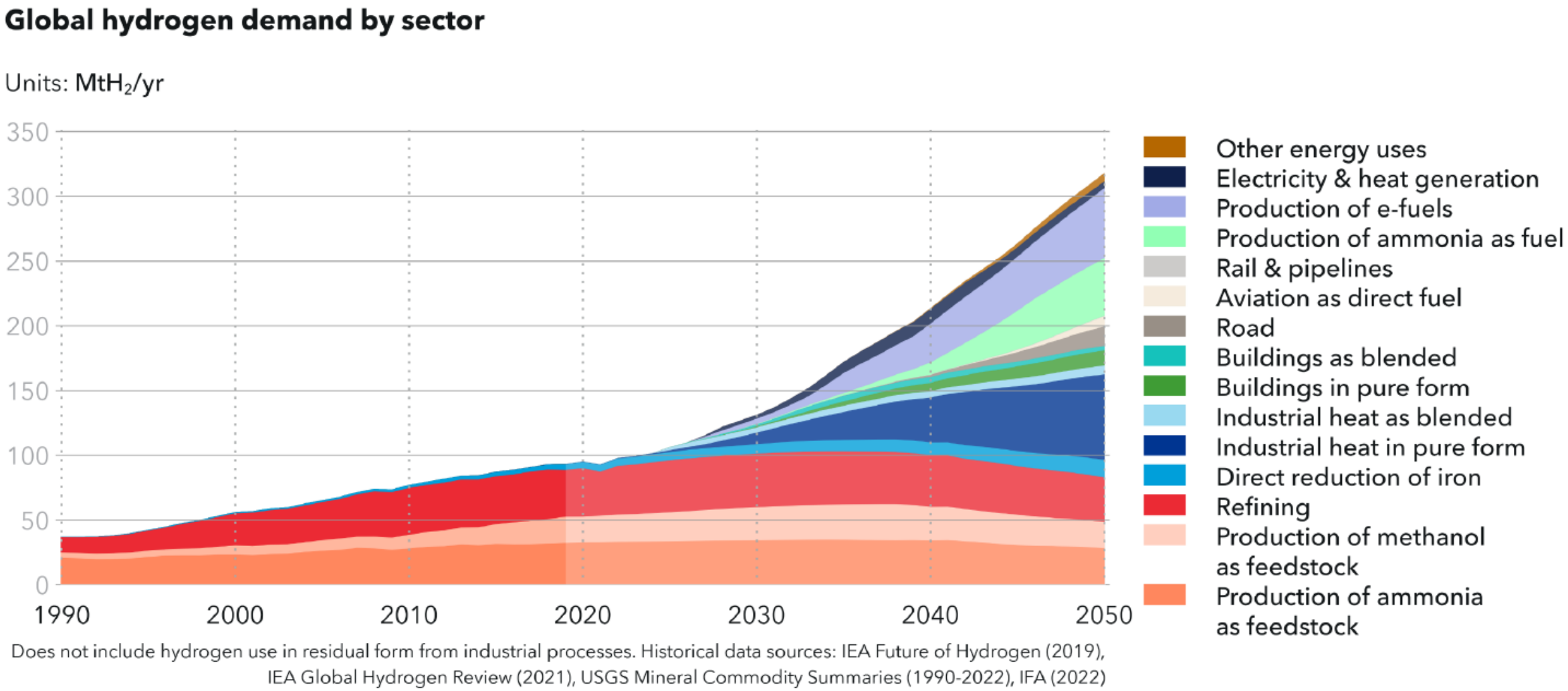


1. Background
2. System Definition
3. Results
4. Key Conclusions

Green hydrogen in a future energy system

1. Background

Hydrogen Demand Projections



Source: DNV 2022

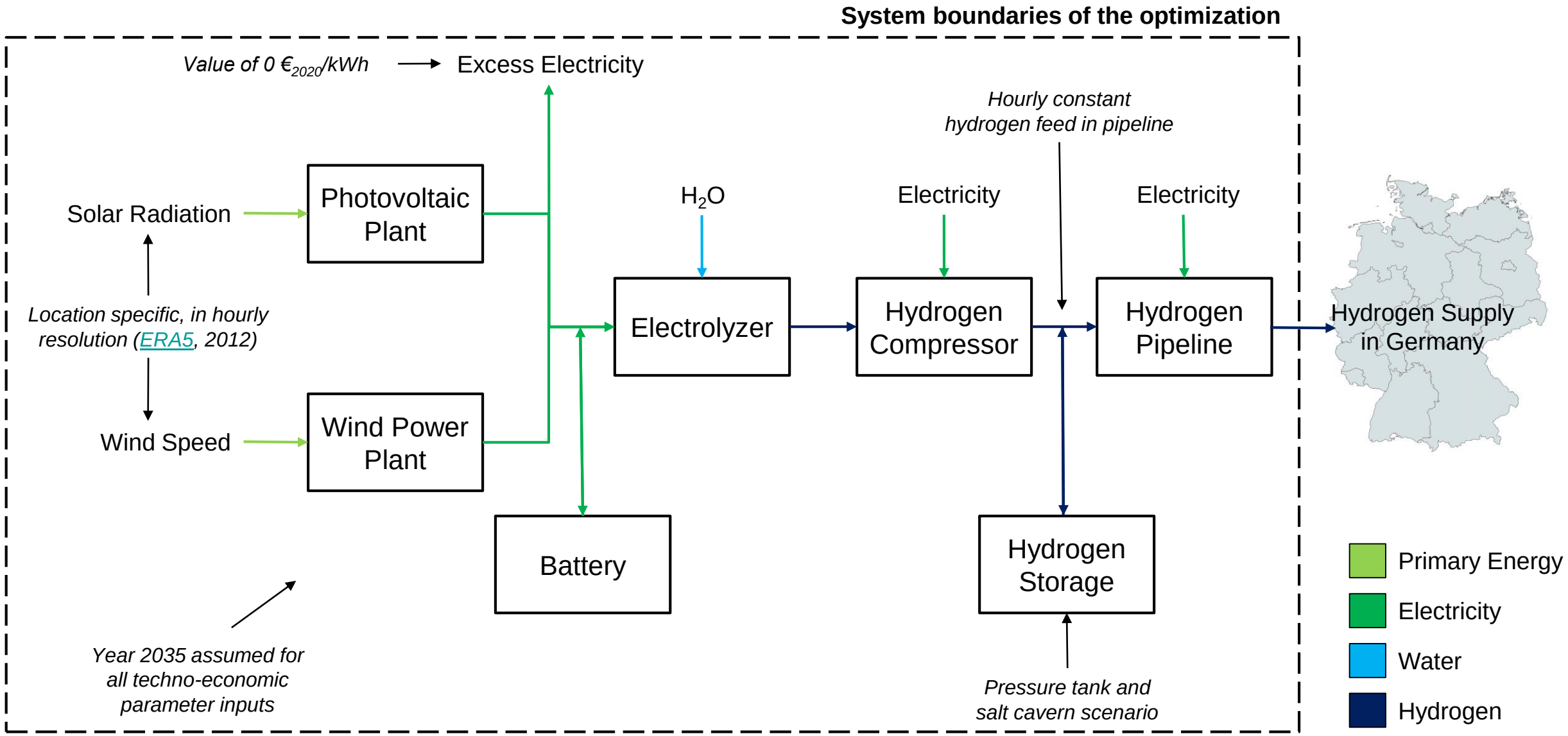
Research Questions

1. Are hydrogen costs below 2 €$_{2020}$/kg$_{H2}$ realistic in the future?
2. Which regions are most favorable for a hydrogen supply to Germany?
3. What is the influence of the implementation of salt caverns as a hydrogen storage?
4. Is the domestic production potential enough for a self-sufficient hydrogen supply in Germany?

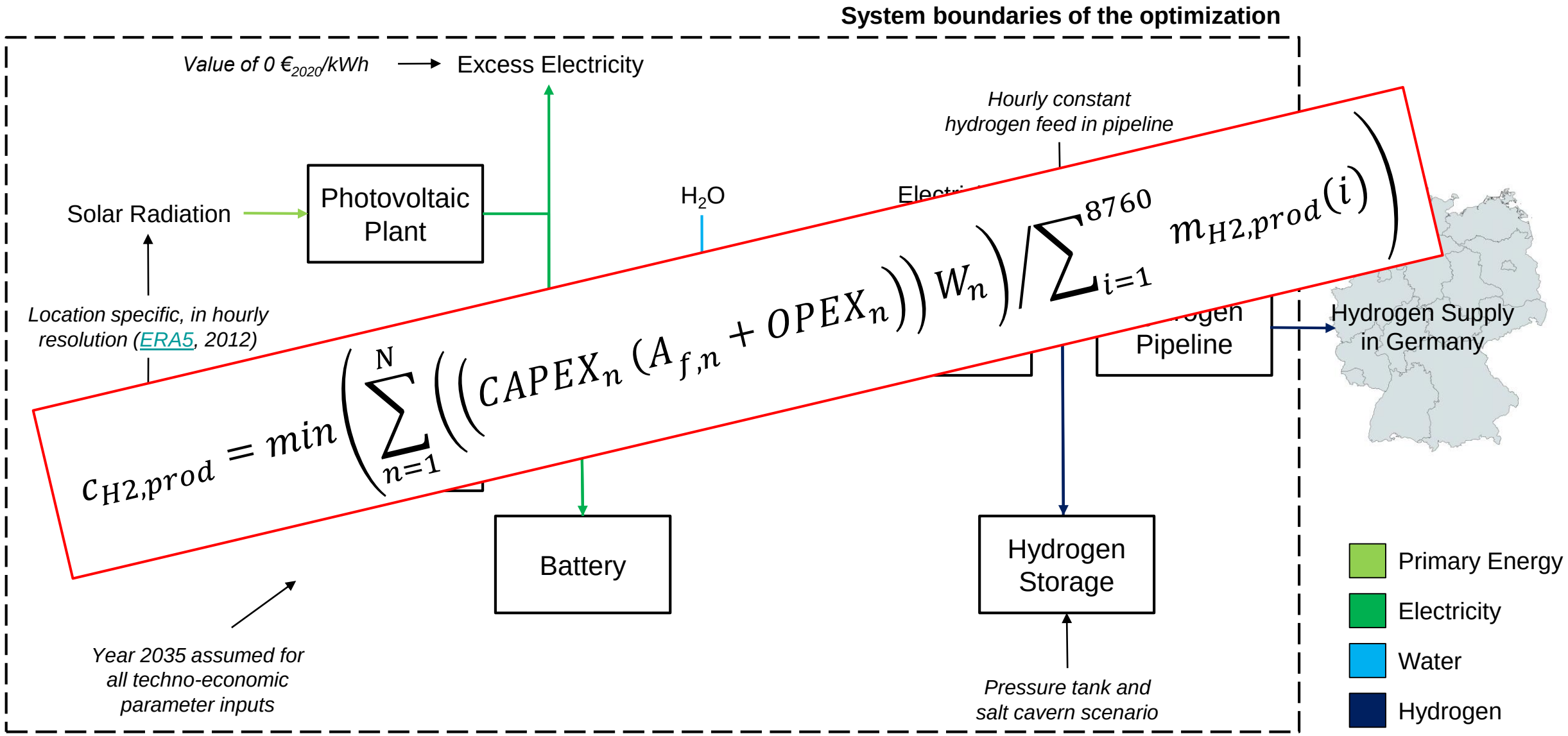
Modelling & Assumptions

2. System Definition

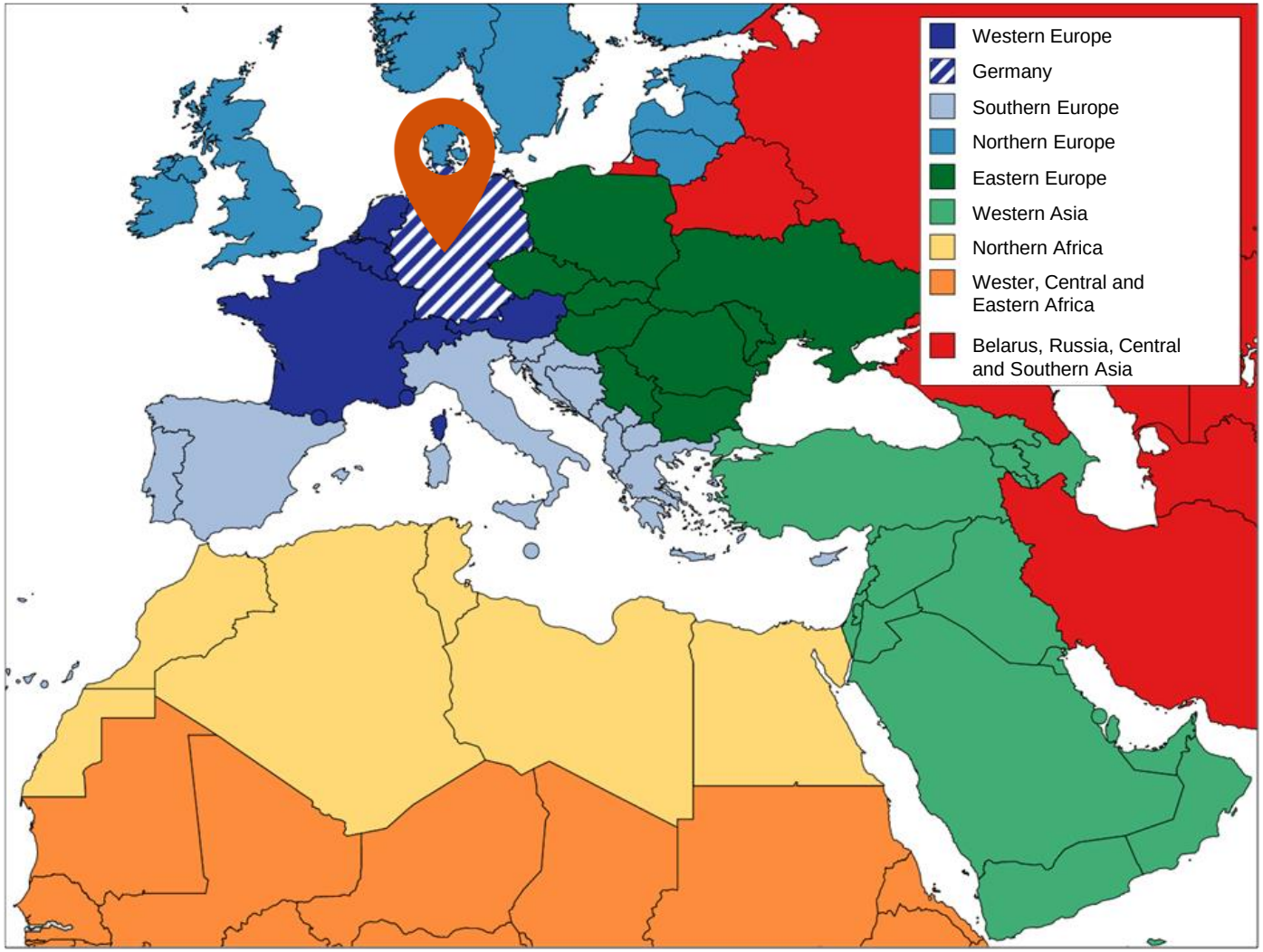
Hydrogen Production System



Hydrogen Production System



Catchment Area

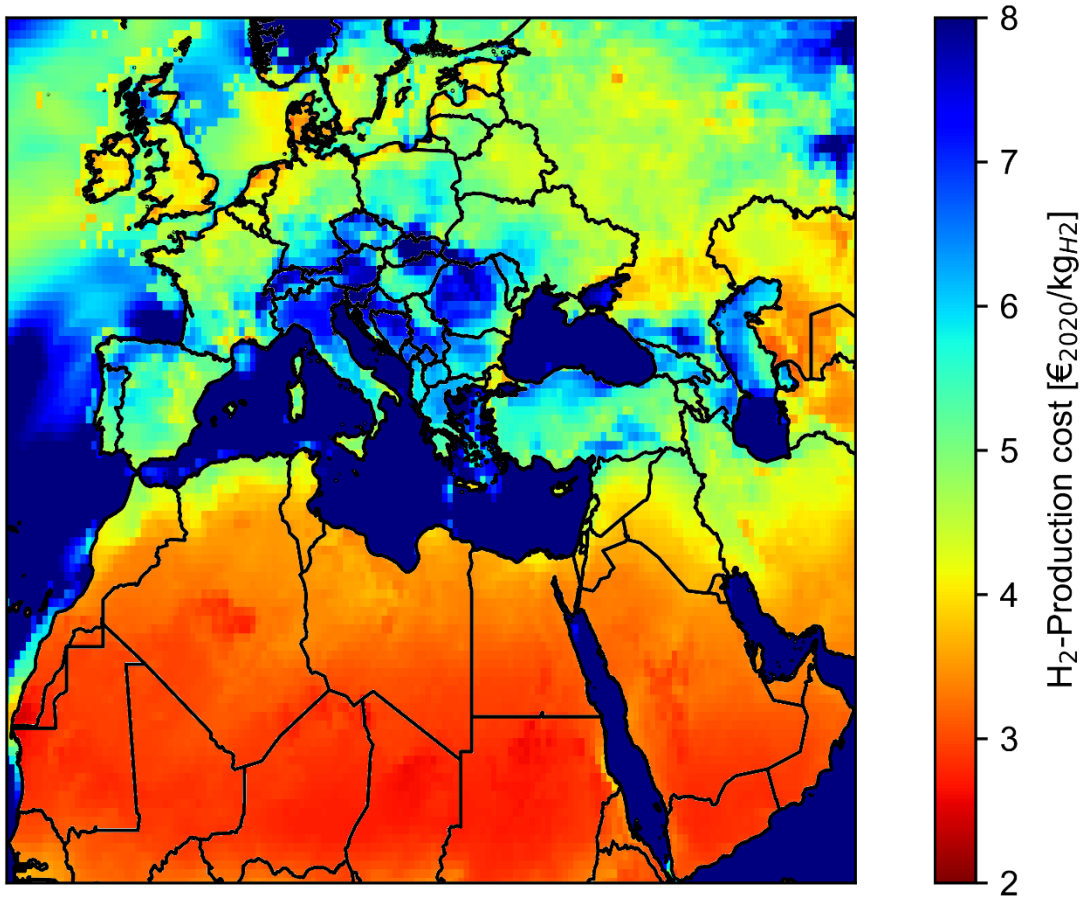


Costs and Potentials

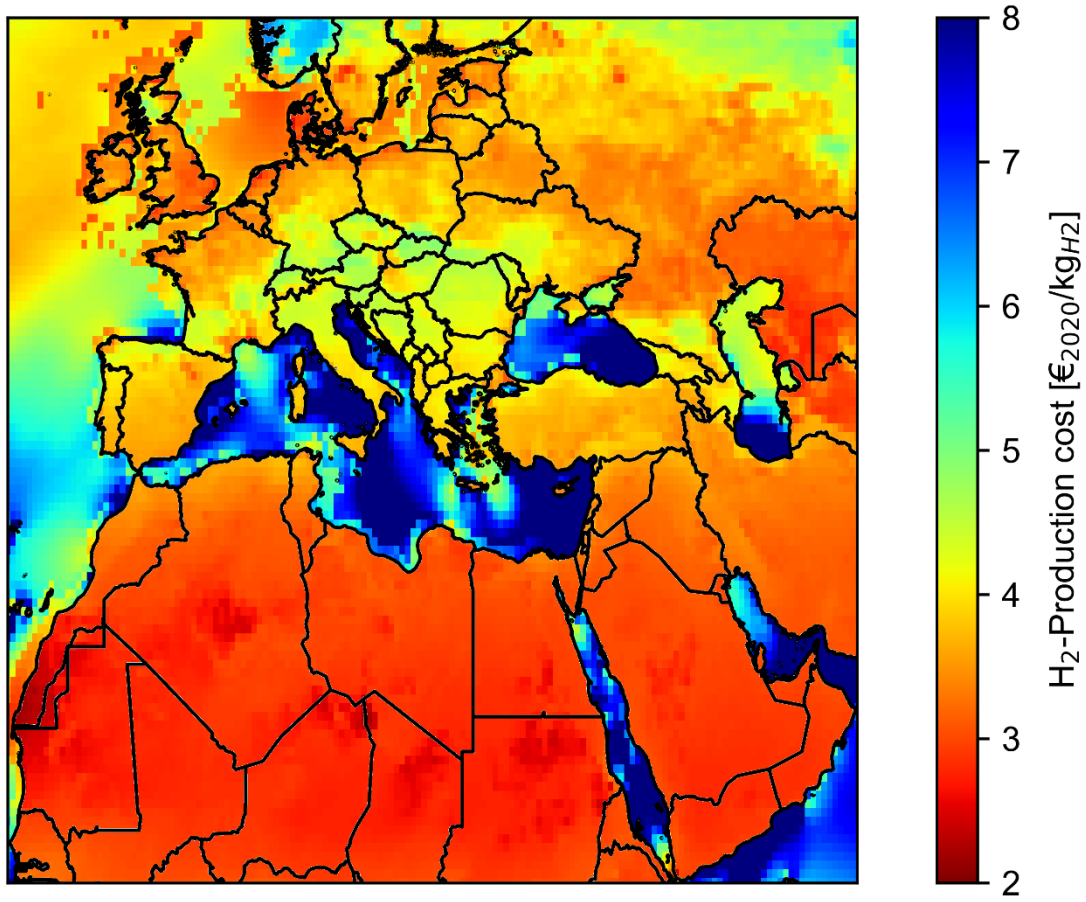
3. Results

Hydrogen Production Cost*

Pressure Tank Scenario



Salt Cavern Scenario

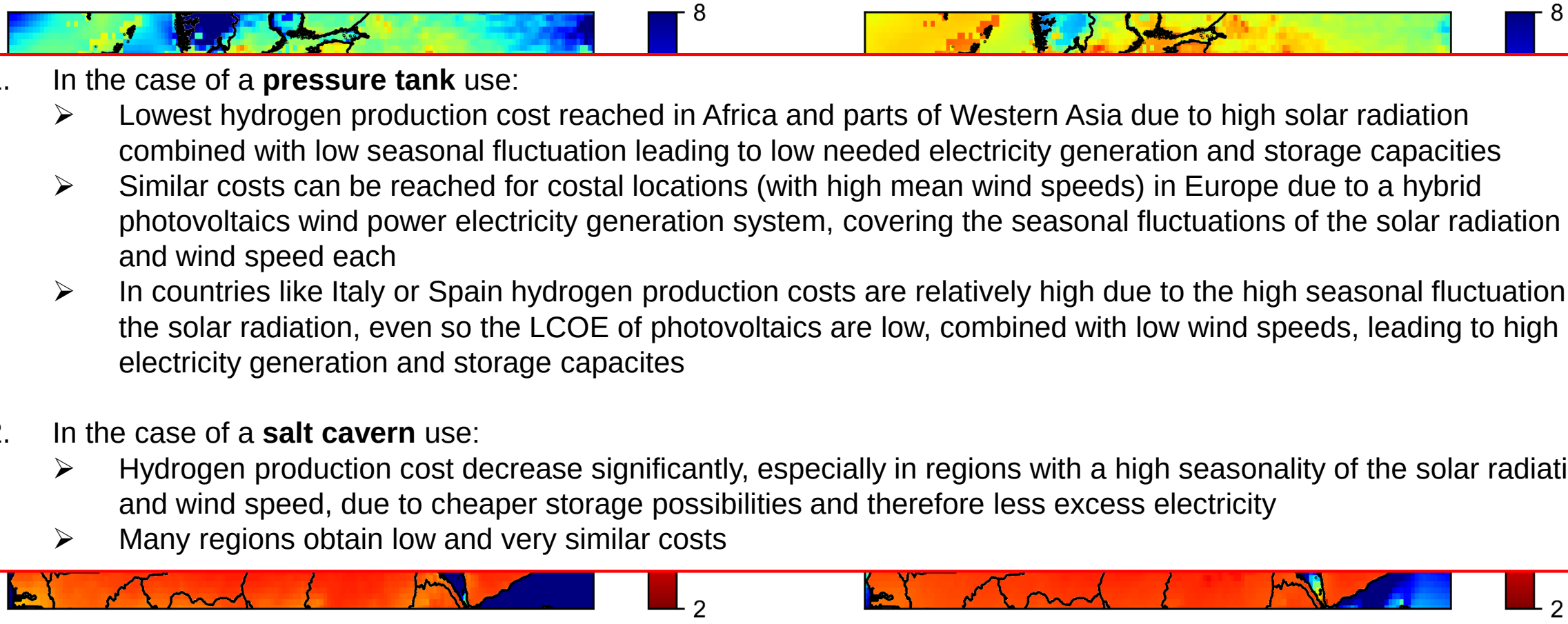


Based on: Sens et al. 2022; *includes the costs for the electricity generation, electrolyzer, compressor and storage systems for a hourly constant onsite hydrogen supply

Hydrogen Production Cost*

Pressure Tank Scenario

Salt Cavern Scenario



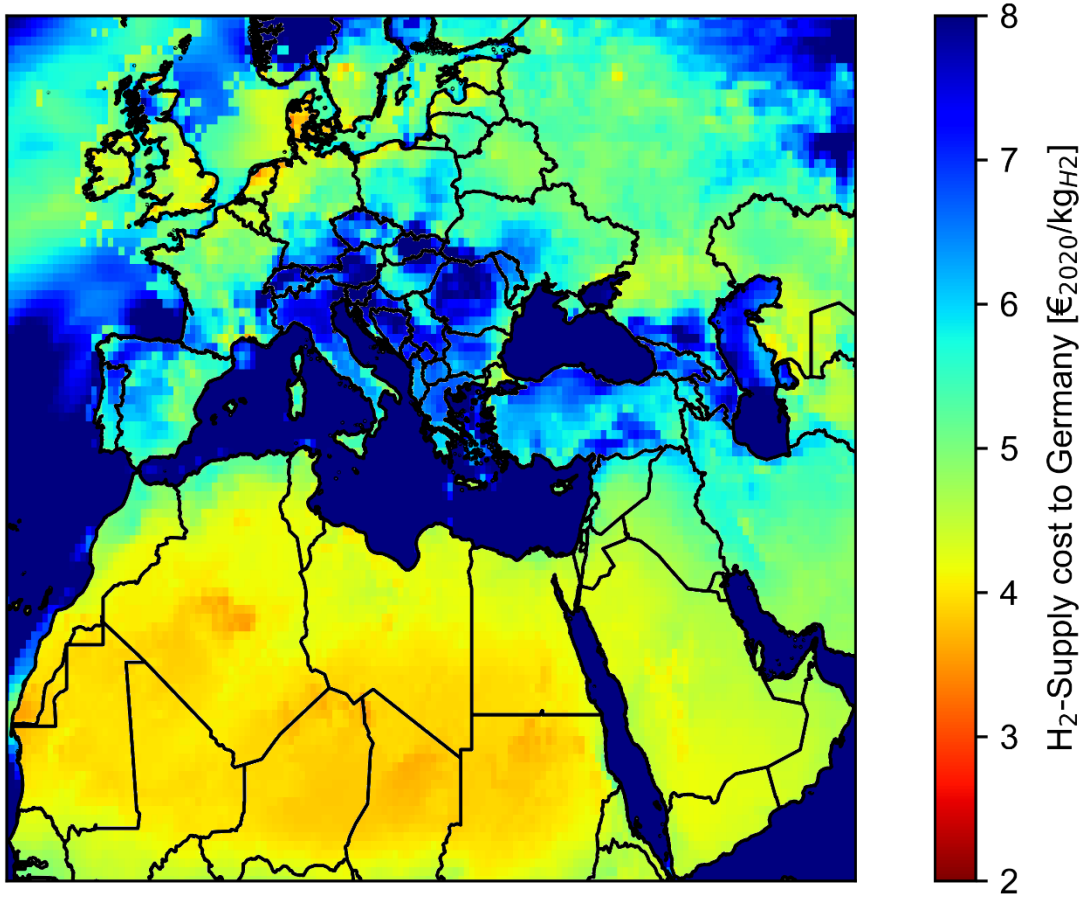
1. In the case of a **pressure tank** use:
   - Lowest hydrogen production cost reached in Africa and parts of Western Asia due to high solar radiation combined with low seasonal fluctuation leading to low needed electricity generation and storage capacities
   - Similar costs can be reached for costal locations (with high mean wind speeds) in Europe due to a hybrid photovoltaics wind power electricity generation system, covering the seasonal fluctuations of the solar radiation and wind speed each
   - In countries like Italy or Spain hydrogen production costs are relatively high due to the high seasonal fluctuation of the solar radiation, even so the LCOE of photovoltaics are low, combined with low wind speeds, leading to high electricity generation and storage capacites

2. In the case of a **salt cavern** use:
   - Hydrogen production cost decrease significantly, especially in regions with a high seasonality of the solar radiation and wind speed, due to cheaper storage possibilities and therefore less excess electricity
   - Many regions obtain low and very similar costs

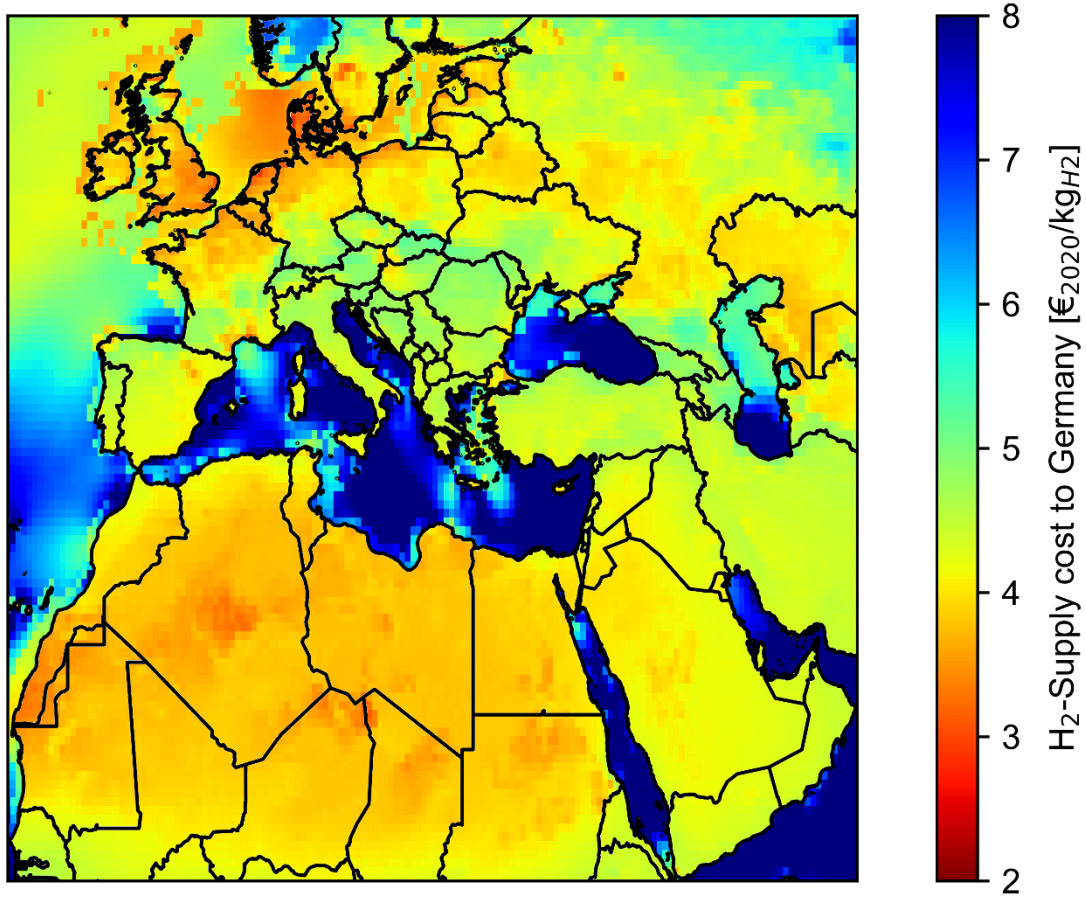
Based on: Sens et al. 2022; *includes the costs for the electricity generation, electrolyzer, compressor and storage systems for a hourly constant onsite hydrogen supply

Hydrogen Supply Cost to Germany*

Pressure Tank Scenario



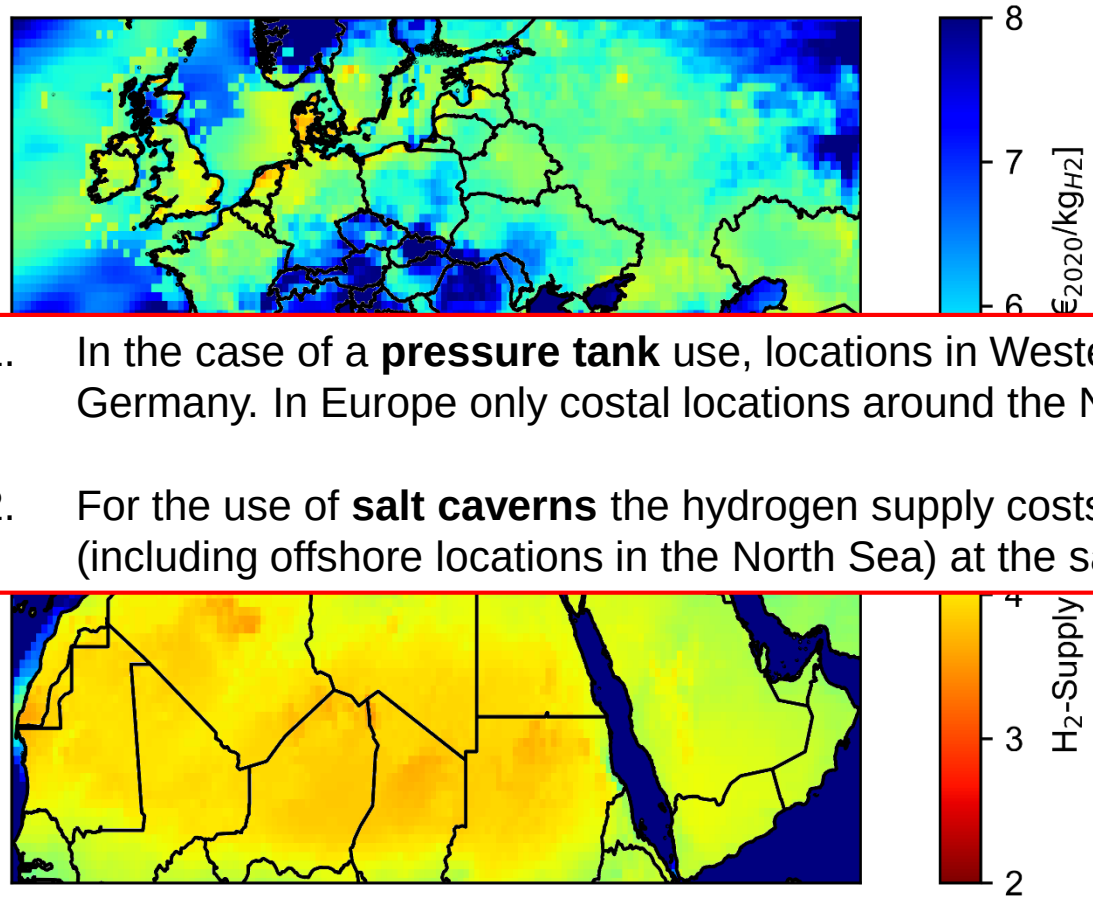
Salt Cavern Scenario



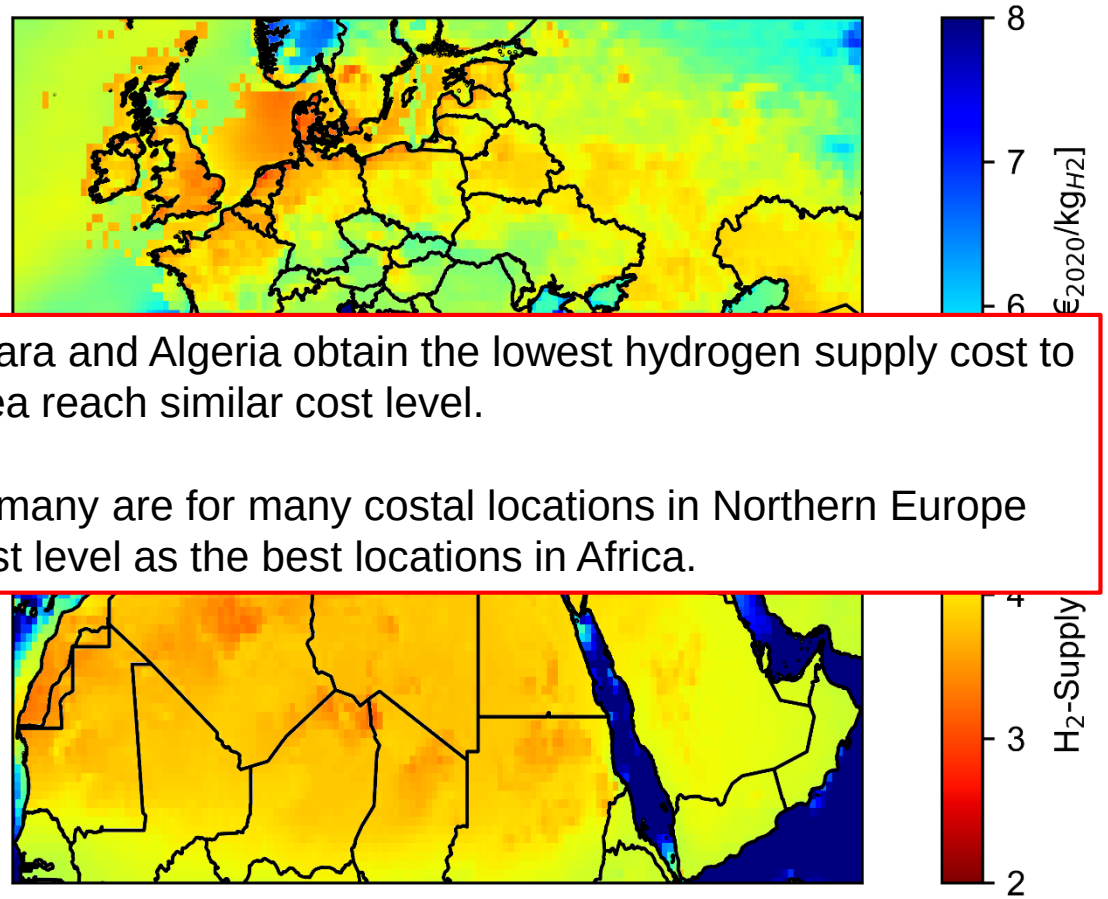
Based on: Sens et al. 2022; *includes the hydrogen production and transportation costs per pipeline

Hydrogen Supply Cost to Germany*

Pressure Tank Scenario



Salt Cavern Scenario



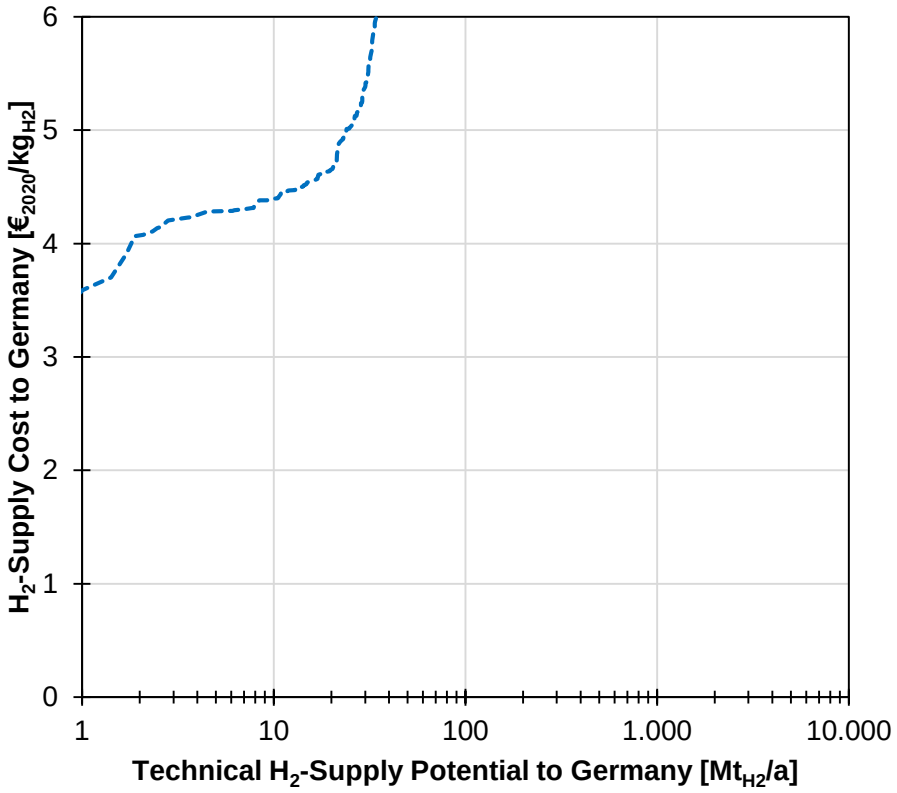
1. In the case of a **pressure tank** use, locations in Western Sahara and Algeria obtain the lowest hydrogen supply cost to Germany. In Europe only costal locations around the North Sea reach similar cost level.

2. For the use of **salt caverns** the hydrogen supply costs to Germany are for many costal locations in Northern Europe (including offshore locations in the North Sea) at the same cost level as the best locations in Africa.

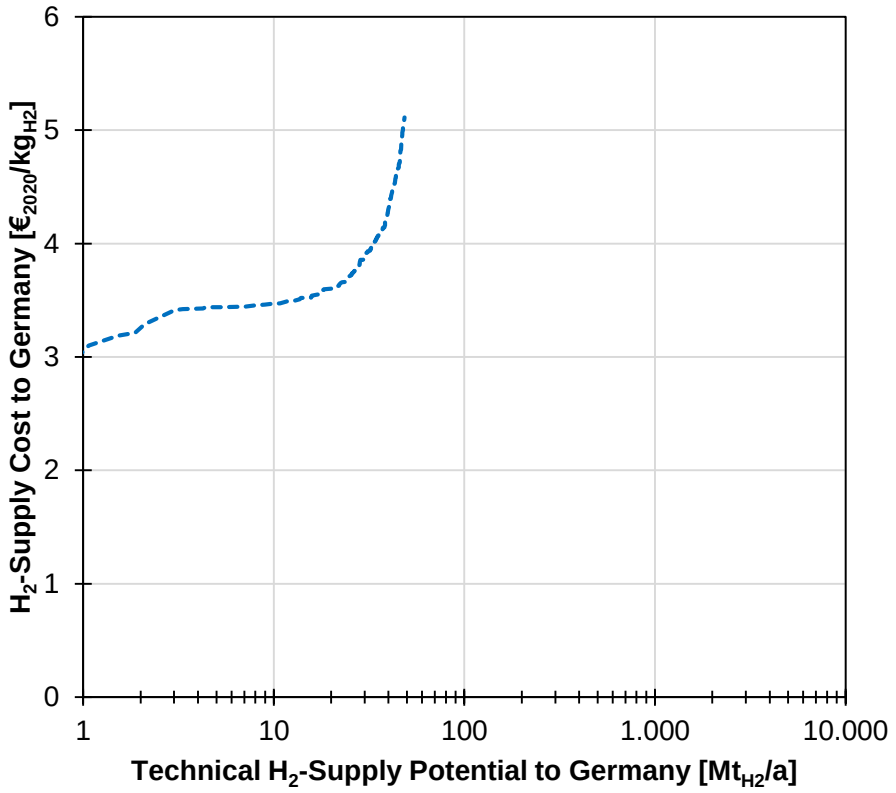
Based on: Sens et al. 2022; *includes the hydrogen production and transportation costs per pipeline

Hydrogen Supply Potential

Pressure Tank Scenario



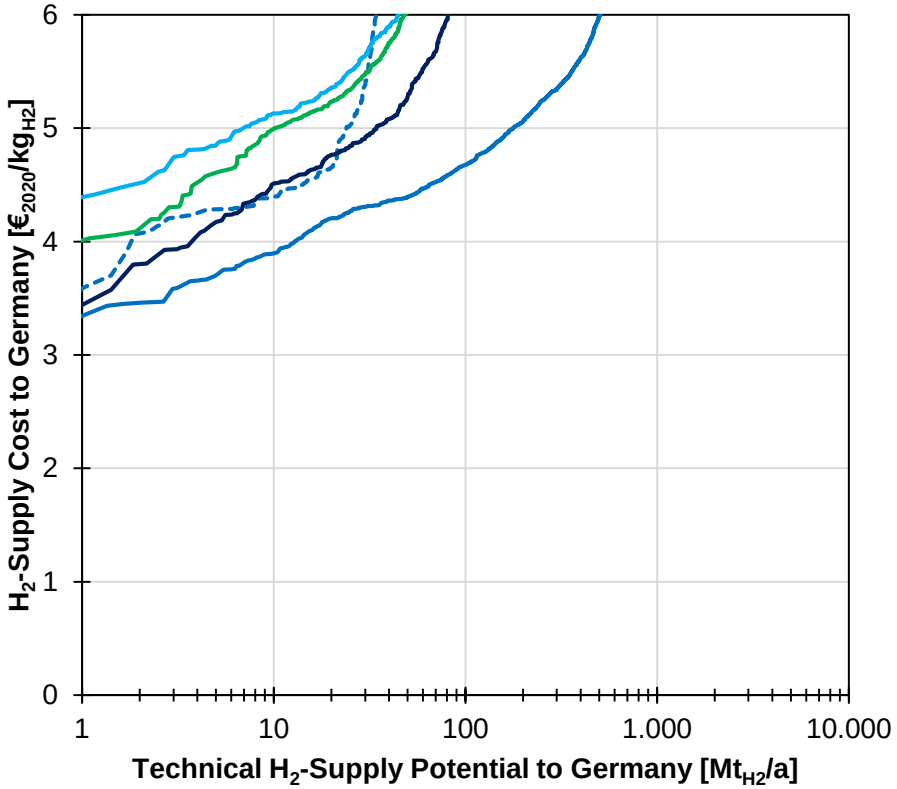
Salt Cavern Scenario



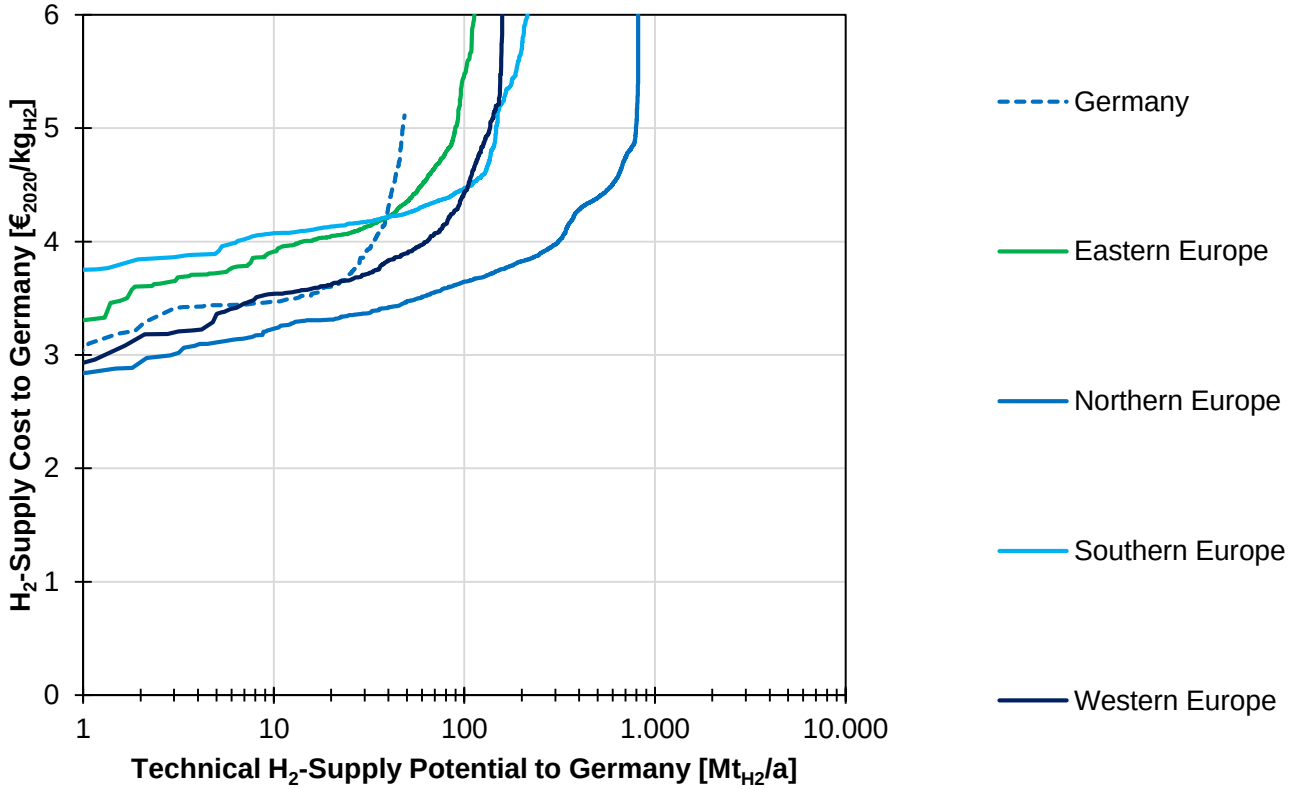
Based on: Sens et al. 2022

Hydrogen Supply Potential

Pressure Tank Scenario



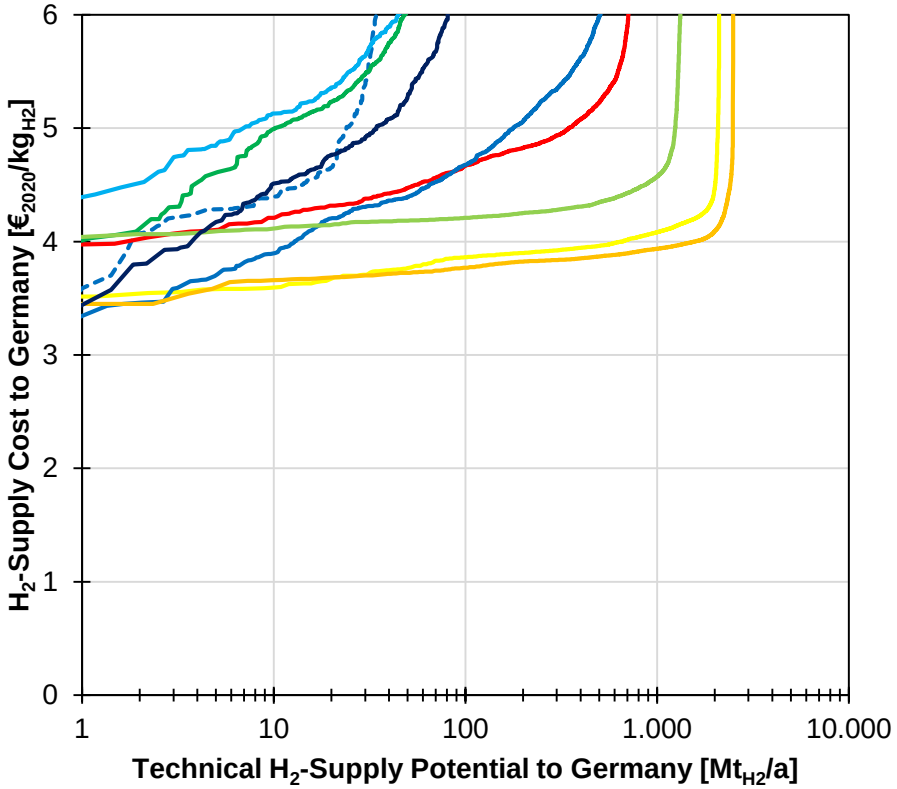
Salt Cavern Scenario



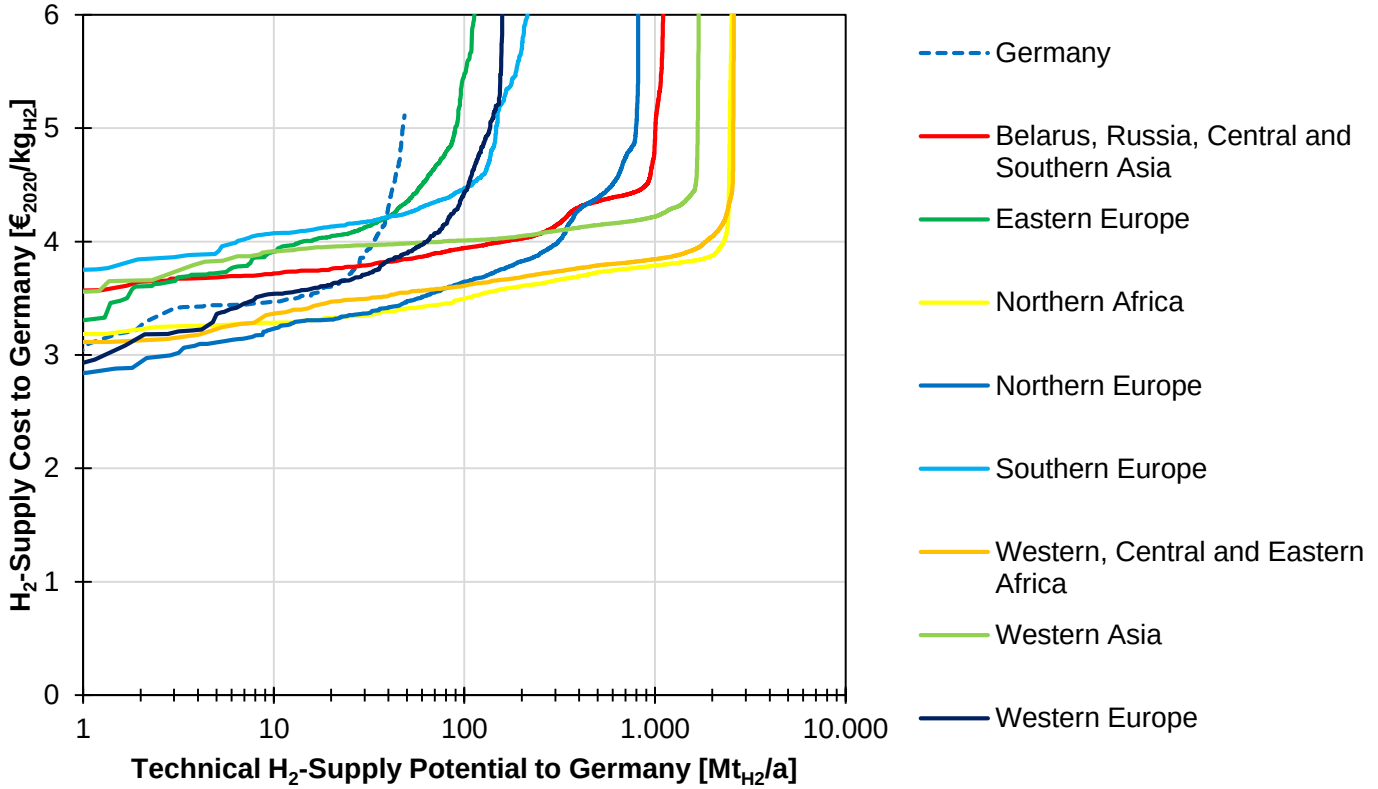
Based on: Sens et al. 2022

Hydrogen Supply Potential

Pressure Tank Scenario

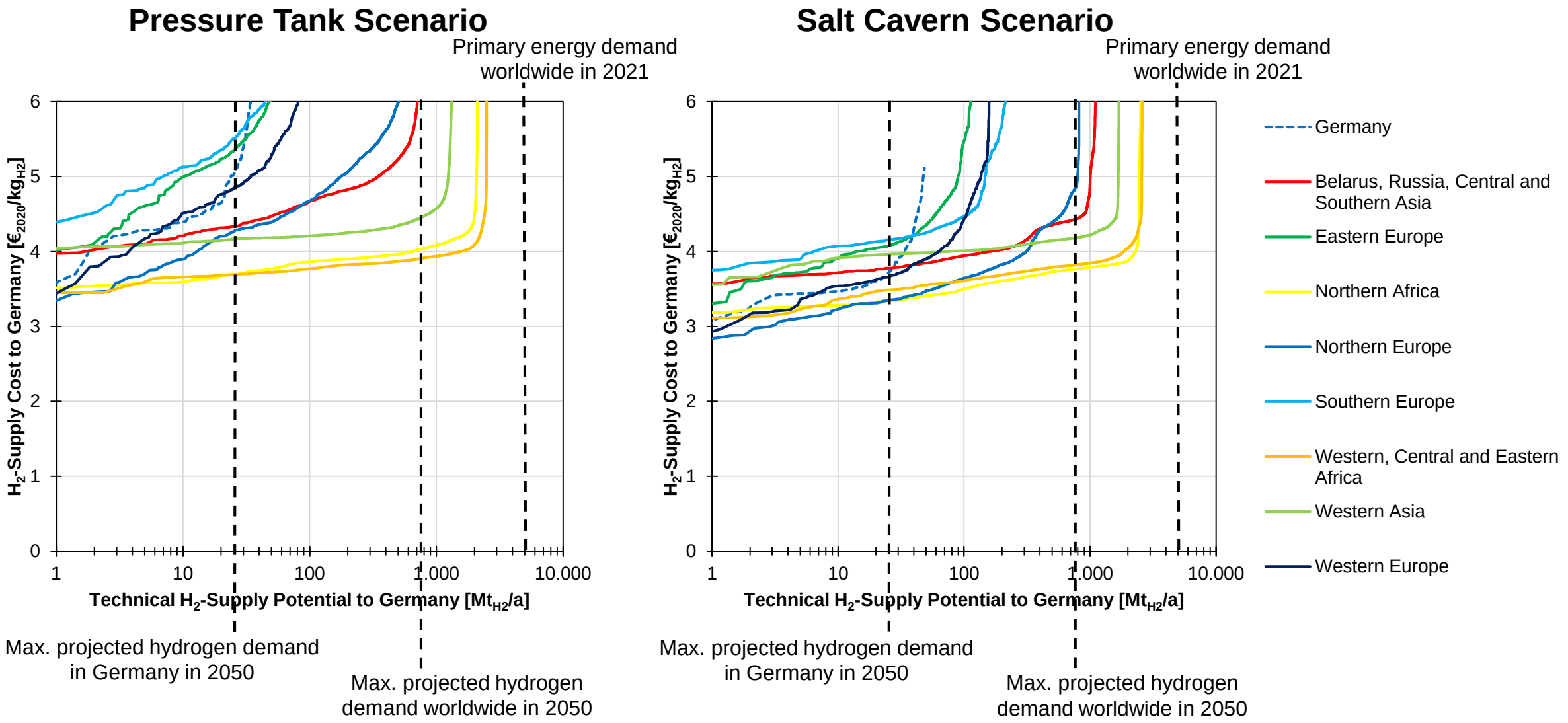


Salt Cavern Scenario



Based on: Sens et al. 2022

Hydrogen Supply Potential



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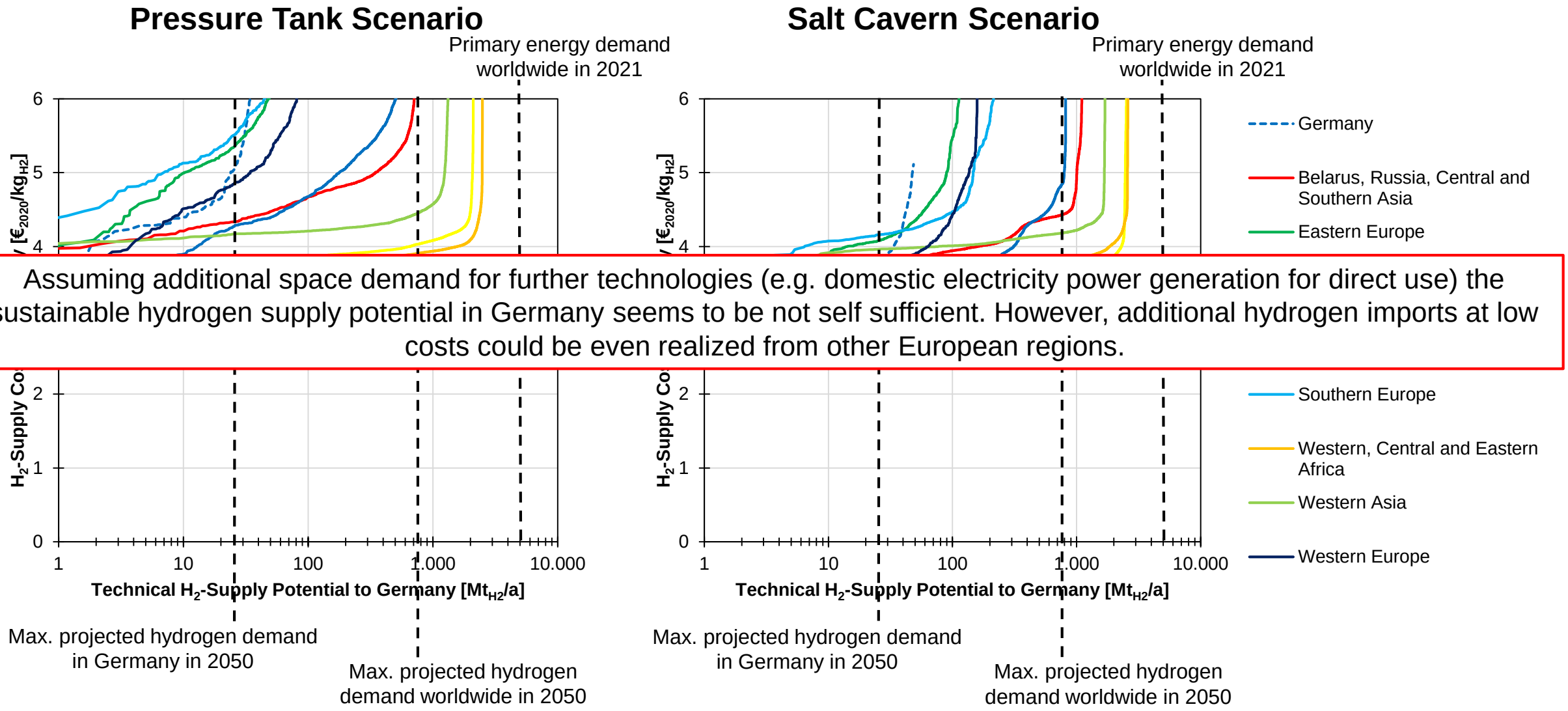
Hydrogen Supply Potential



Assuming additional space demand for further technologies (e.g. domestic electricity power generation for direct use) the sustainable hydrogen supply potential in Germany seems to be not self sufficient. However, additional hydrogen imports at low costs could be even realized from other European regions.

Based on: Sens et al. 2022

4. Key Conclusions

Conclusion

1. Are hydrogen costs below 2 €$_{2020}$/kg$_{H2}$ realistic in the future?
   - Hydrogen production cost of 2 €$_{2020}$/kg$_{H2}$ can be reached in the best locations (e.g. Western Sahara) in 2035. However, taking a subsequent transport to Germany into account costs are at likely to be around **3 €$_{2020}$/kg$_{H2}$**

2. Which regions are most favorable for a hydrogen supply to Germany?
   - Locations in **Western Sahara**, **Central Algeria** and at the **North Sea** (Onshore and Offshore) show the lowest hydrogen supply costs to Germany

3. What is the influence of the implementation of salt caverns as a hydrogen storage?
   - The use of salt caverns leads especially in regions with a high seasonality of the solar radiation and low wind speeds (e.g. Italy) to a significant **reduction** of the hydrogen production costs up to **50%**

4. Is the domestic production potential enough for a self-sufficient hydrogen supply in Germany?
   - Considering the demand for the “additional” direct electricity use a self-sufficient hydrogen supply in Germany seems **questionable** and **imports are likely**

Thank you for your Attention!

Questions and Discussion

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