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HYDROGEN DIPLOMACY

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Hydrogen Production Potential in Nigeria

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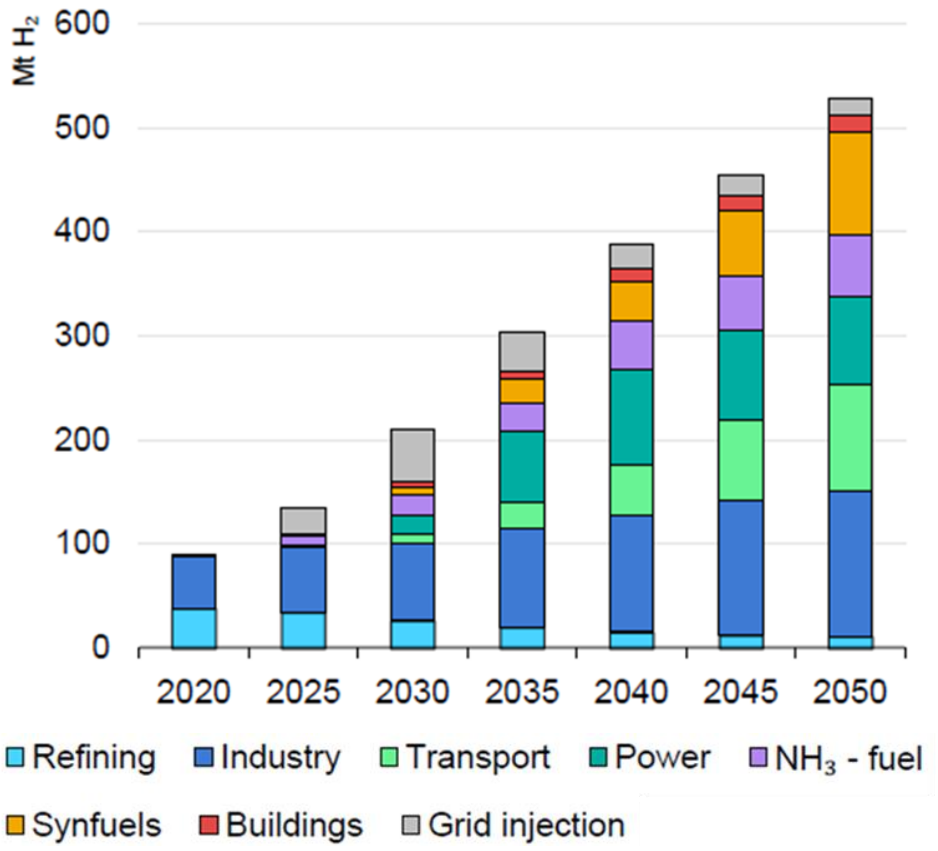
Background
Role of hydrogen in future energy systems

Projected global hydrogen / PtX demand



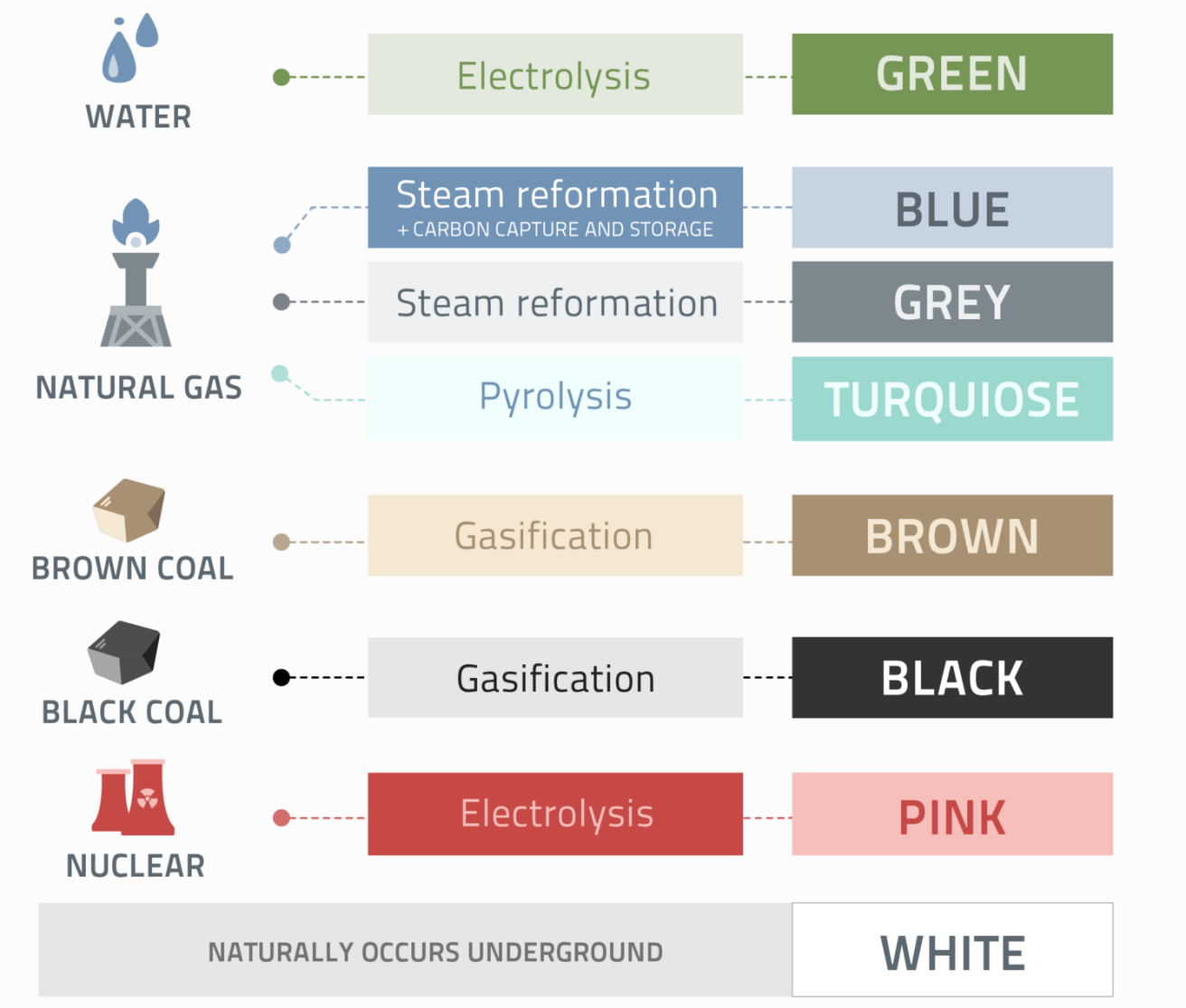
- Hydrogen might become the key “green” secondary energy carrier in the years to come, as…
  - … storage of large quantities is relatively easy.
  - … it can be transported to enable a flexible international trade with “green” energy.
  - … it can be used in many ways to defossilze sectors that cannot be directly electrified.
- An international market for hydrogen is likely to emerge. E.g. EU plans to import half of its demand (10 Mt/a by 2030).

Outline

- Comparison of “green” and “blue” hydrogen
- Producing Hydrogen in Nigeria
- Export of Nigeria's Hydrogen and PtX Products
- Conclusion

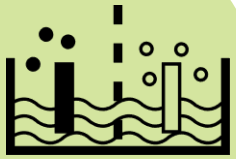
“Green” and “blue” hydrogen

Definitions



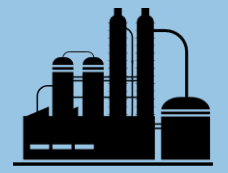
Comparison of “green” and “blue” hydrogen

Green Hydrogen



- Production highly scalable, both in terms of costs and quantities
- High space requirement for wind and solar power plants
- Carbon-neutral production based on renewable electricity possible
- Technology maturity for large scale implementation fully given
- Strong demand on international markets expected (e.g. in Europe)

Blue Hydrogen



- Production limited by natural gas reserves and exploitable CO_2 deposits
- Low space requirement
- GHG emissions barely avoidable (upstream emissions, incomplete capture, questionable long term storage)
- Technology maturity for large scale implementation with high carbon capture rates (>90%) not fully given
- Demand on international markets uncertain, especially in Europe

Outline

Comparison of “green” and “blue” hydrogen

Producing Hydrogen in Nigeria

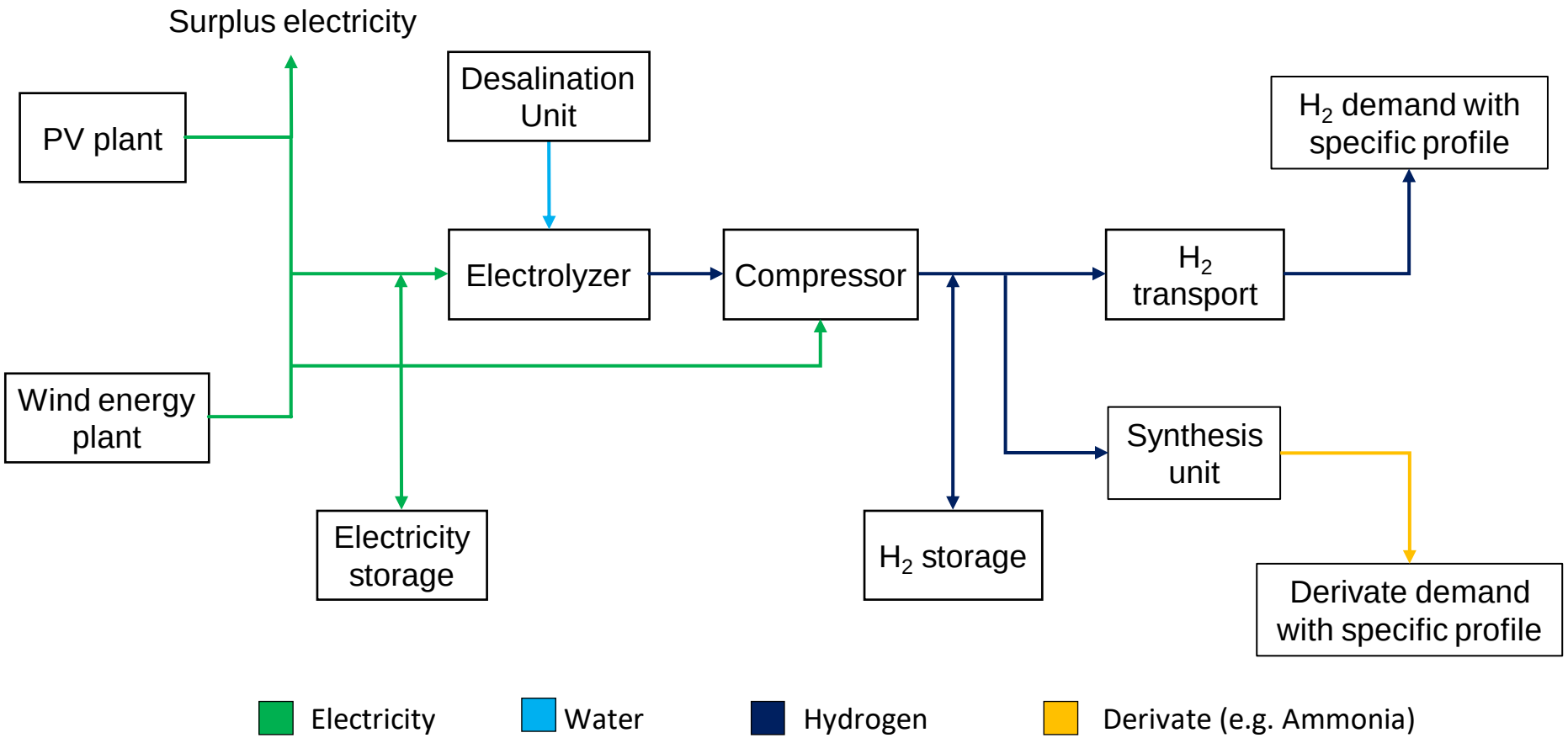
- Modelling cost-optimized “green” hydrogen production
- Breakdown of production cost for “green” and “blue” hydrogen

Export of Nigeria's Hydrogen and PtX Products

Conclusion

Modelling cost-optimized "green" H_2 production

System components



Modelling cost-optimized "green" H_2 production

System boundaries

Minimizing total system costs

$$min\left(\sum_{n=1}^{N}\left(\left(CAPEX_n\, A_{f,n} + OPEX_n\right) W_n\right) / m_{H2,produced}\right)$$

Site specific

Solar radiation

Weather data with hourly resolution (ERA5, 2012)

Wind velocity

System boundaries of the optimization

Surplus electricity

PV plant

Desalination Unit

Electrolyzer

Compressor

H_2 transport

H_2 demand with specific profile

Wind energy plant

Electricity storage

H_2 storage

Synthesis unit

Derivate demand with specific profile

Primary energy

Electricity

Water

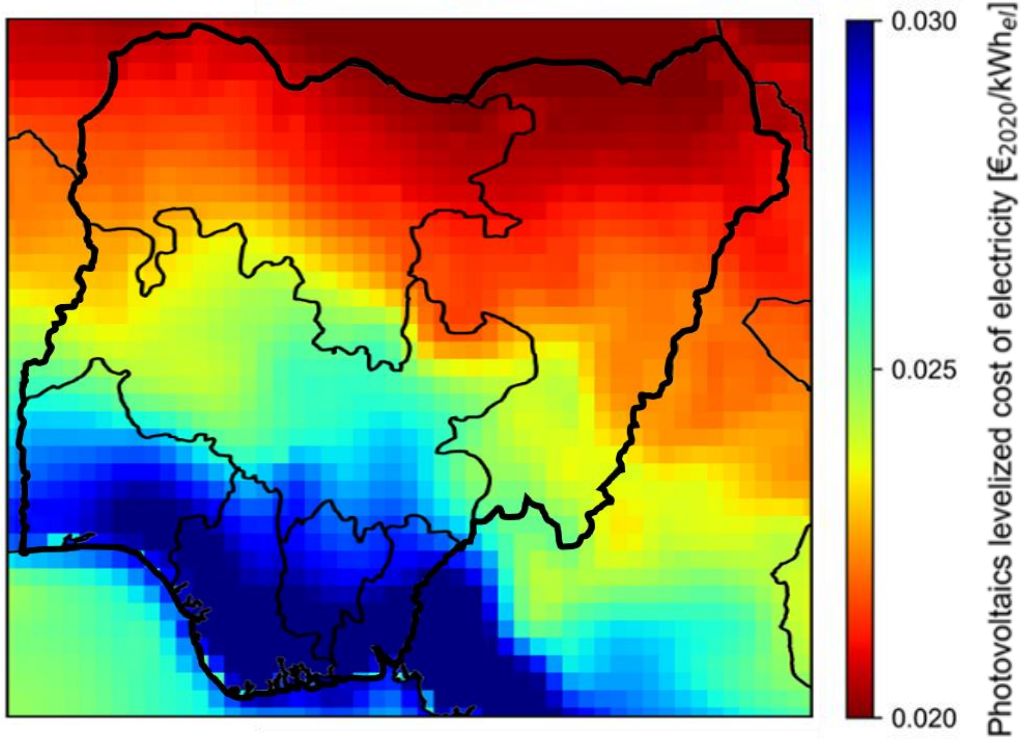
Hydrogen

Derivate (e.g. Ammonia)

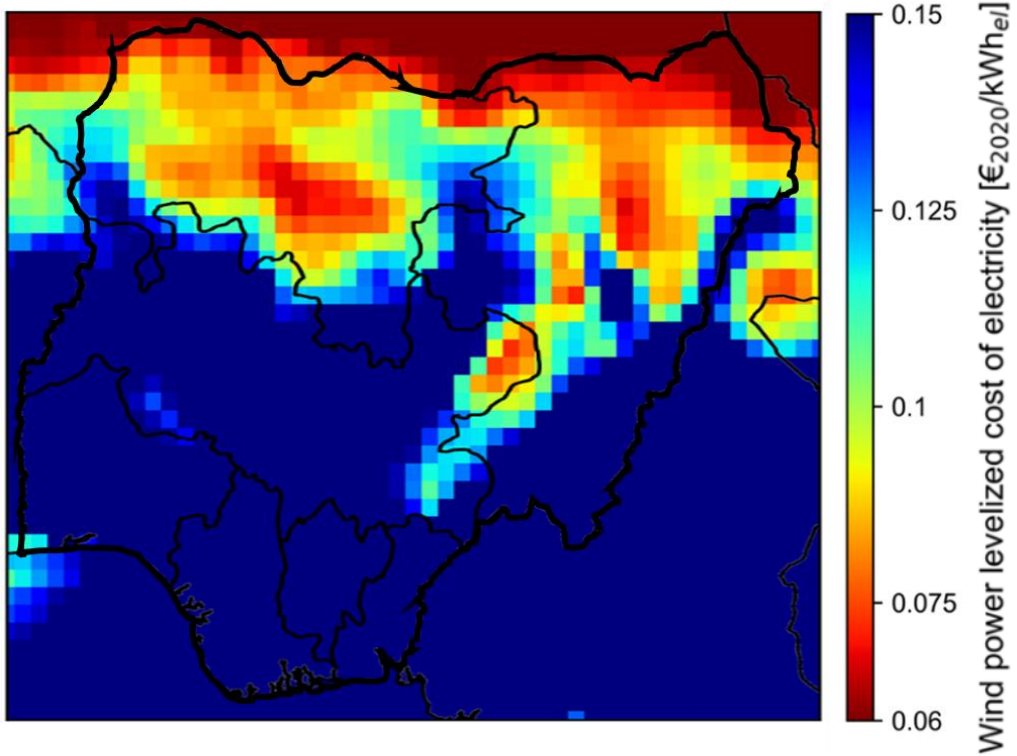
Modelling cost-optimized "green" H_2 production

LCOE for PV and wind energy – Reference year: 2030

PV



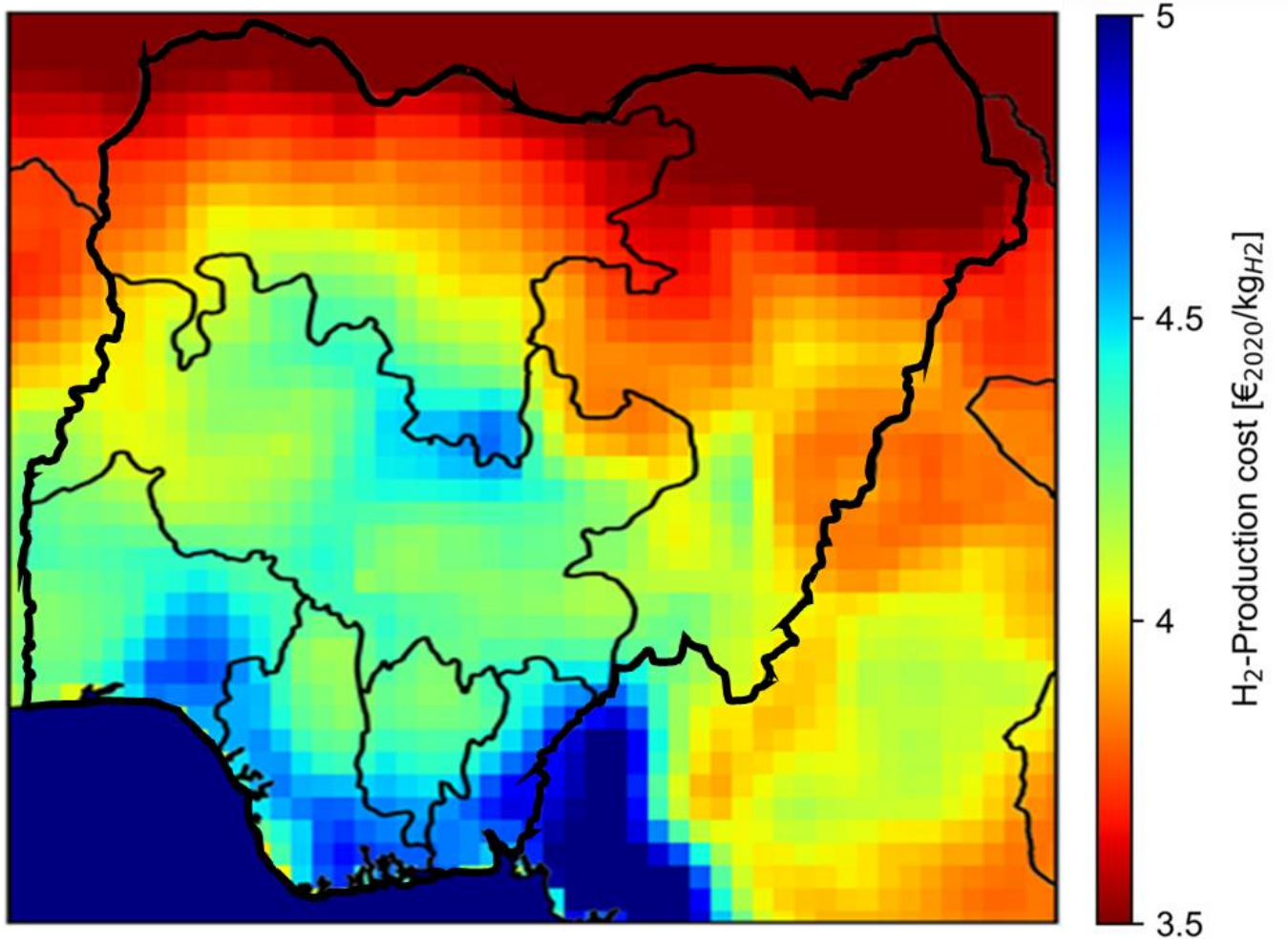
Wind energy



The potential for electricity from PV is high (<2.5 $€_{cent}$/kWh), while wind energy potential is rather low (>6 $€_{cent}$/kWh). Renewable energy potential increases from South to North.

Modelling cost-optimized “green” H_2 production

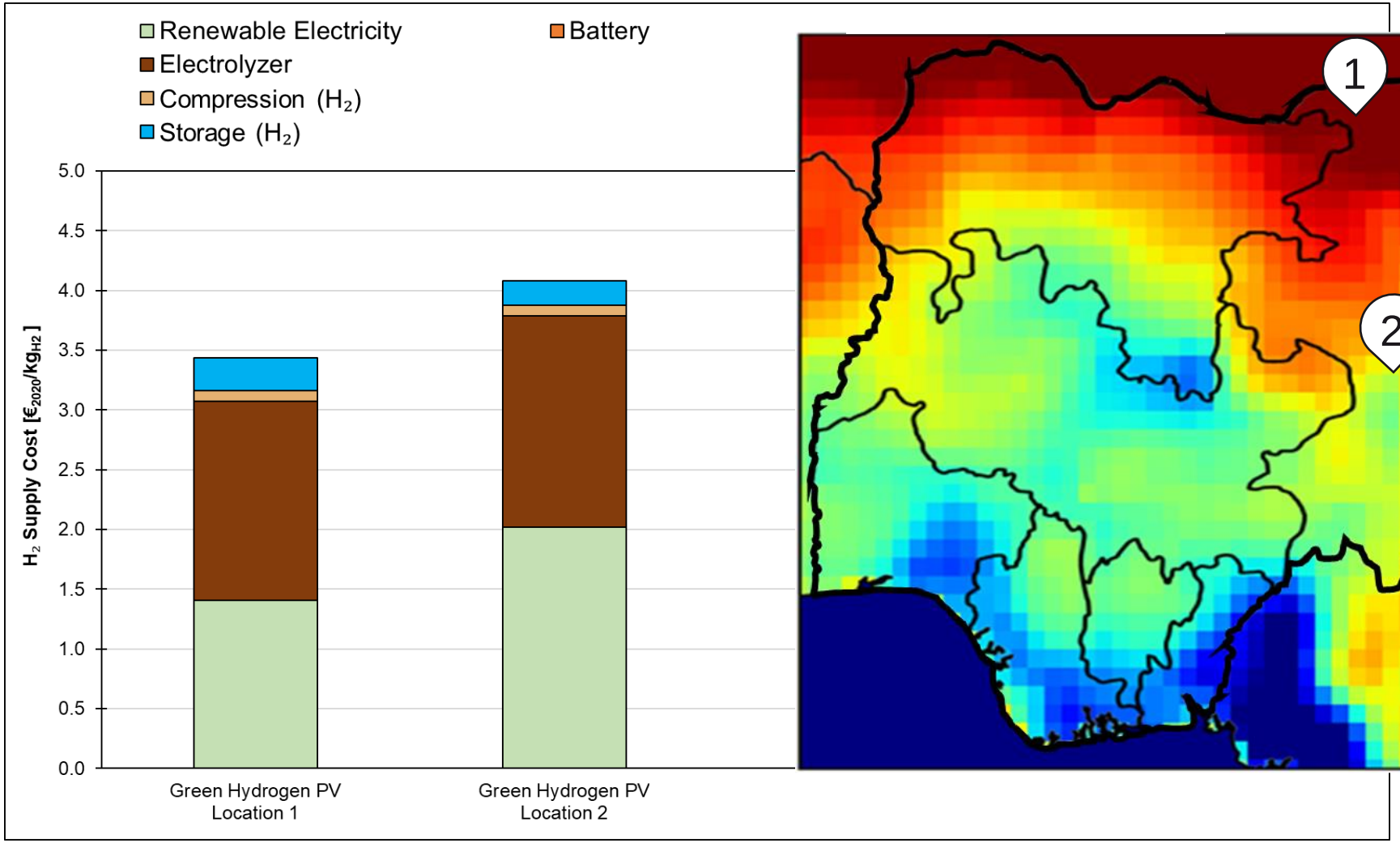
Hydrogen production cost – Reference year: 2030



In 2030, production costs for green hydrogen in the range of 3.5 €/kg are feasible in Nigeria. Attractive production sites are located mainly in the North and enter of the country. Only PV is used to supply electricity to the electrolyzer.

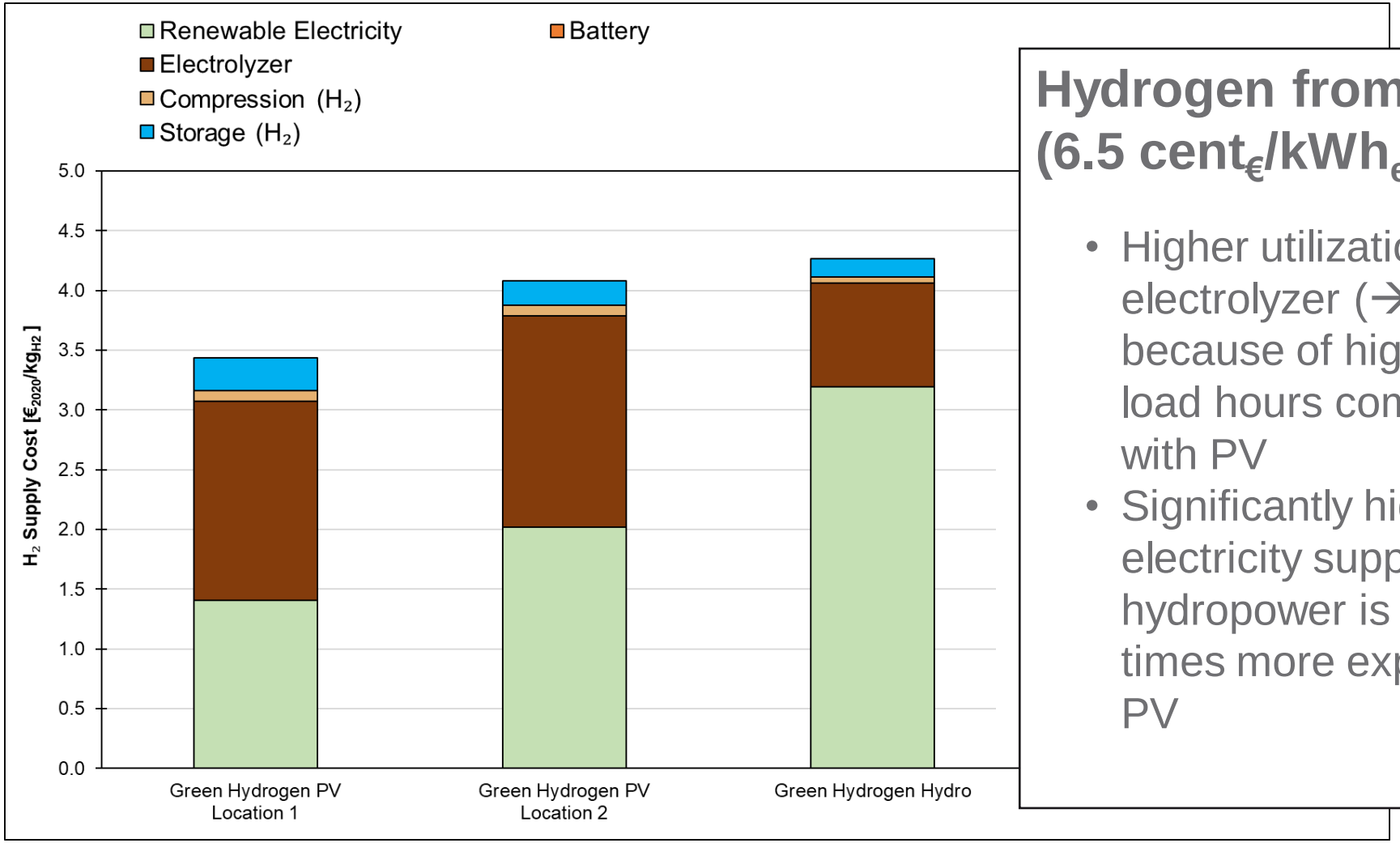
Breakdown of production cost

“Blue” vs. “green” hydrogen – Reference year: 2030



Breakdown of production cost

“Blue” vs. “green” hydrogen – Reference year: 2030

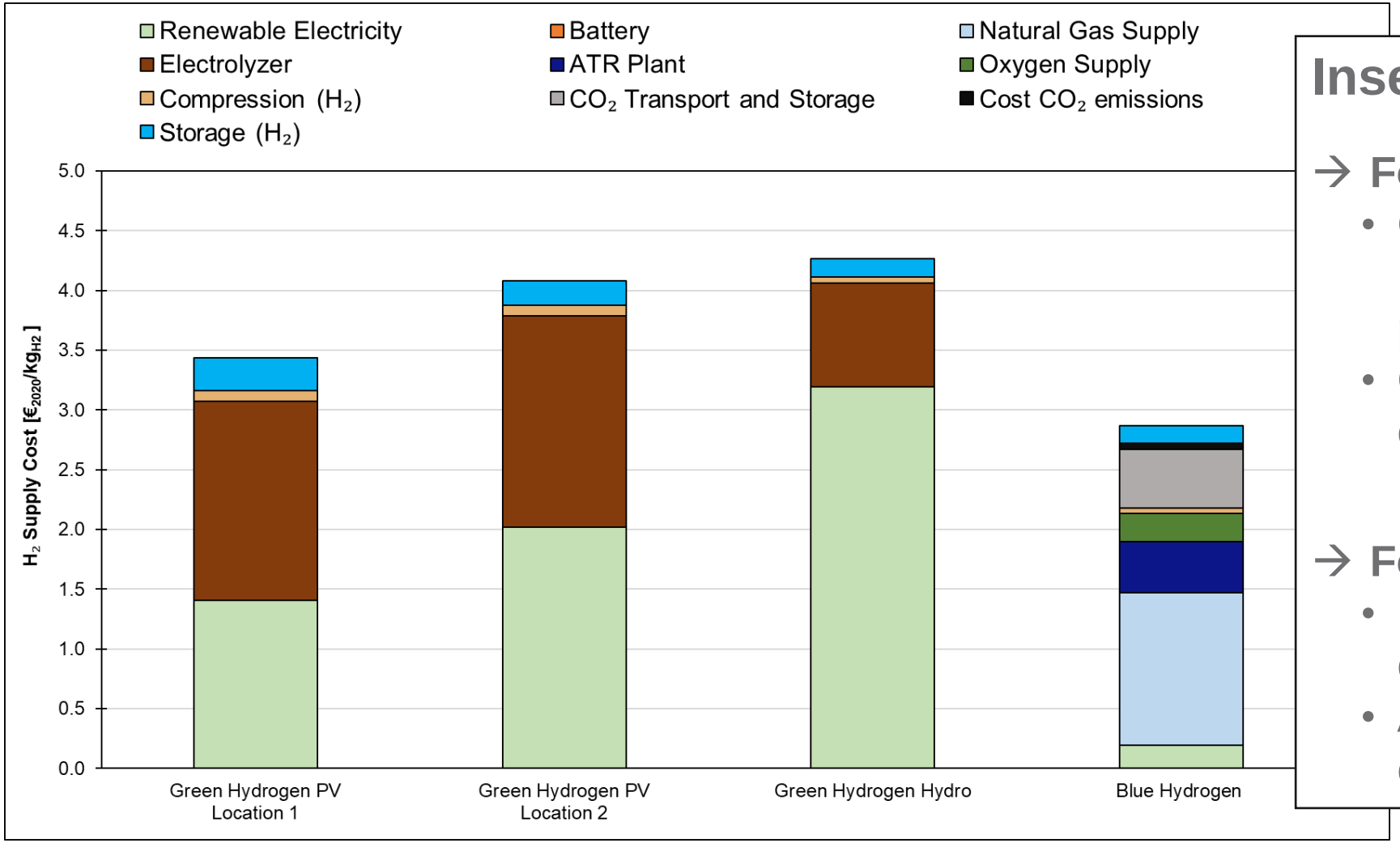


Hydrogen from hydropower (6.5 cent$_{€}$/kWh$_{el}$)

- Higher utilization of electrolyzer (→ lower cost) because of higher annual full load hours compared to system with PV
- Significantly higher costs for electricity supply, as hydropower is two to three times more expensive than PV

Breakdown of production cost

“Blue” vs. “green” hydrogen – Reference year: 2030



Insecurities

→ **For green hydrogen:**

- Cost development of PV could be more progressive
- Cost development of electrolyzer could be more progressive

→ **For blue hydrogen:**

- Market development of natural gas price
- Availability and cost of CO_2 deposit

Outline

Comparison of “green” and “blue” hydrogen

Producing hydrogen in Nigeria

Export of Nigeria's hydrogen and PtX products

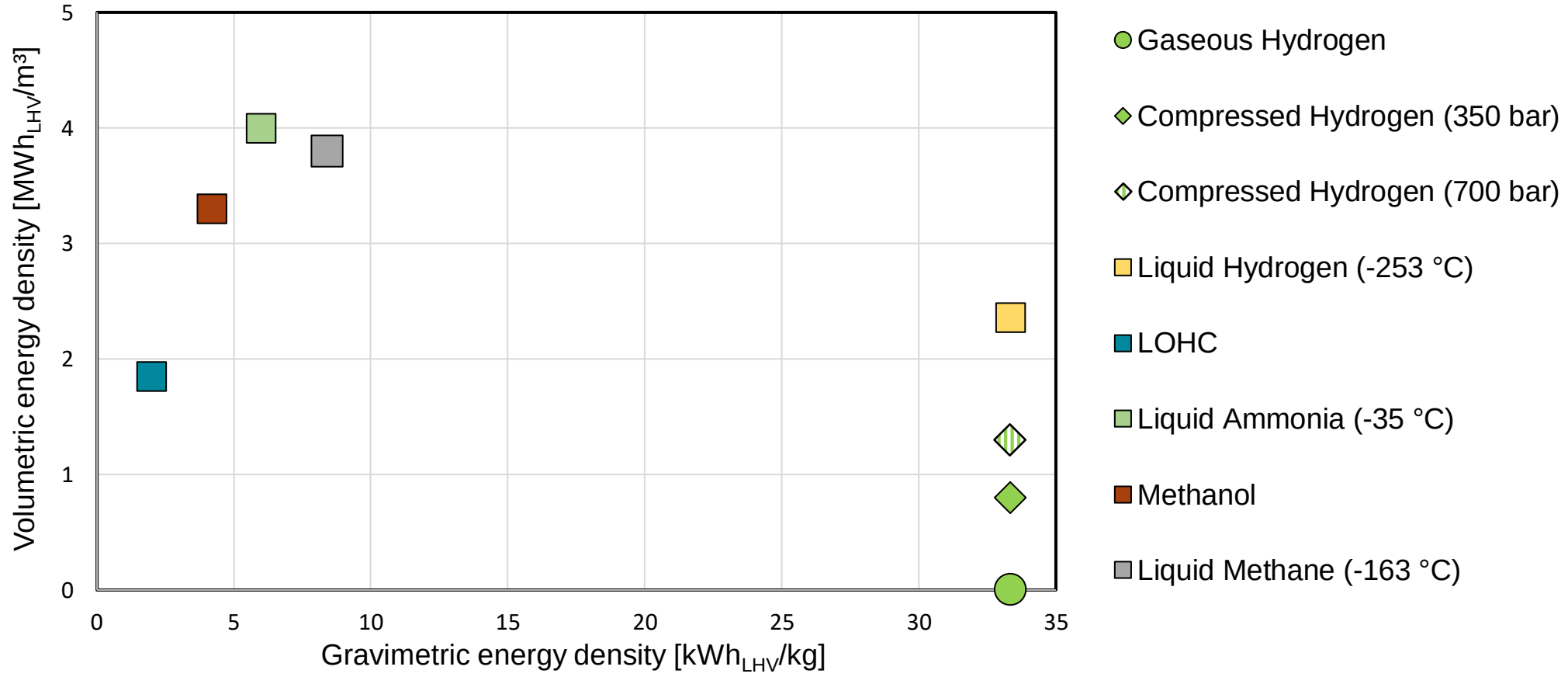
- Supply chains for exporting hydrogen and PtX products
- Hydrogen supply cost for Nigerian exports
- International competitiveness of Nigerian exports

Conclusion

Technical basics of supply chains for export

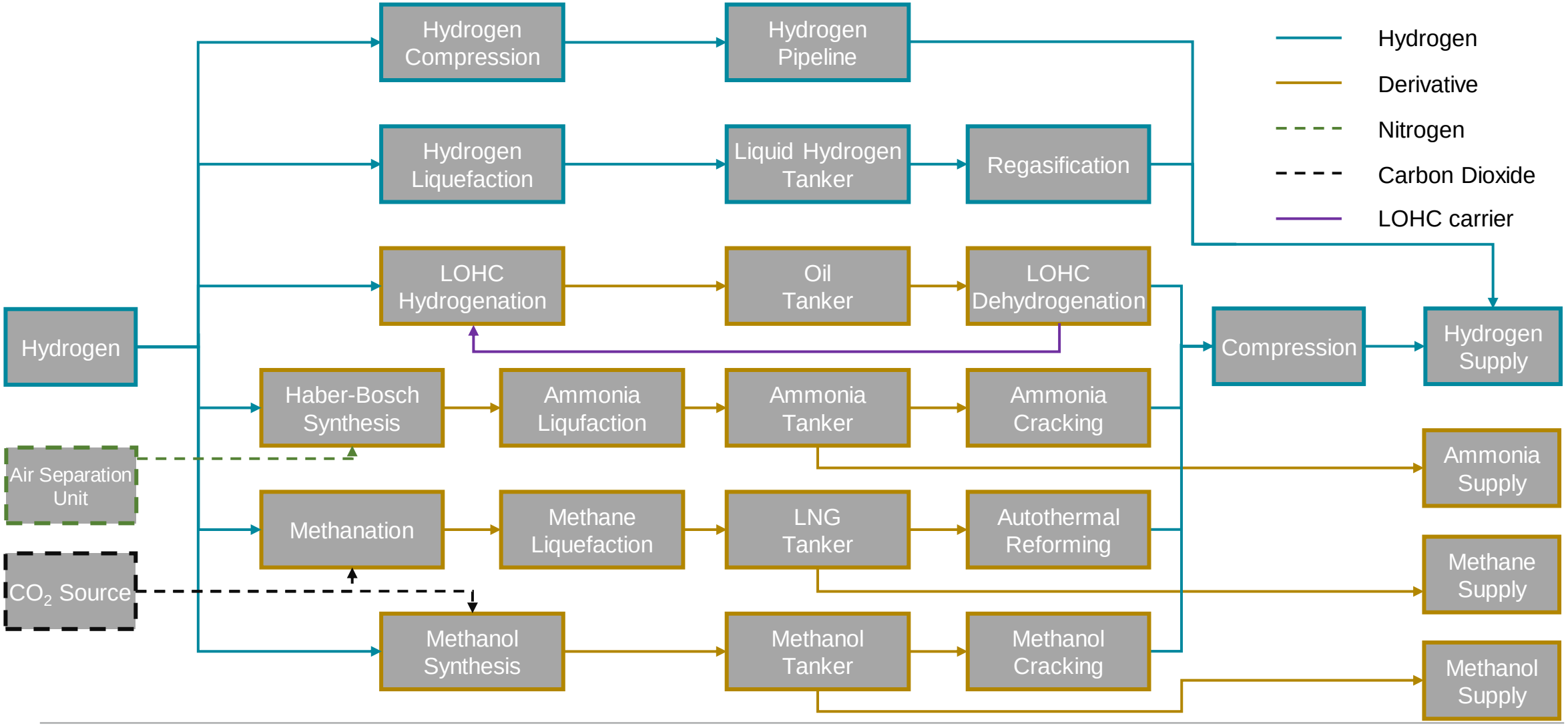
Hydrogen conditioning options

Due to its very low volumetric energy density, hydrogen conditioning is necessary for transport.

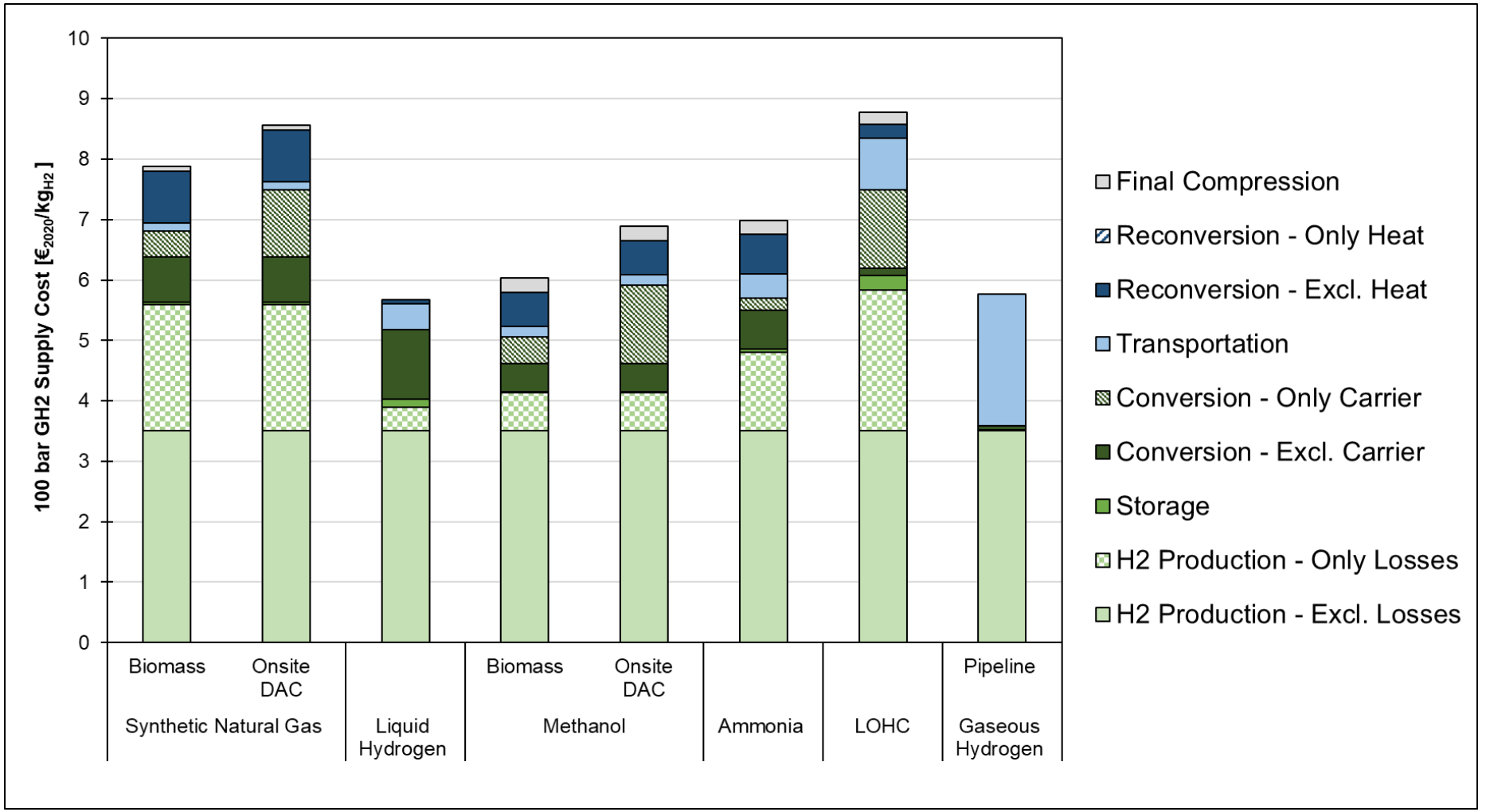


Technical basics of supply chains for export

Possible supply chains



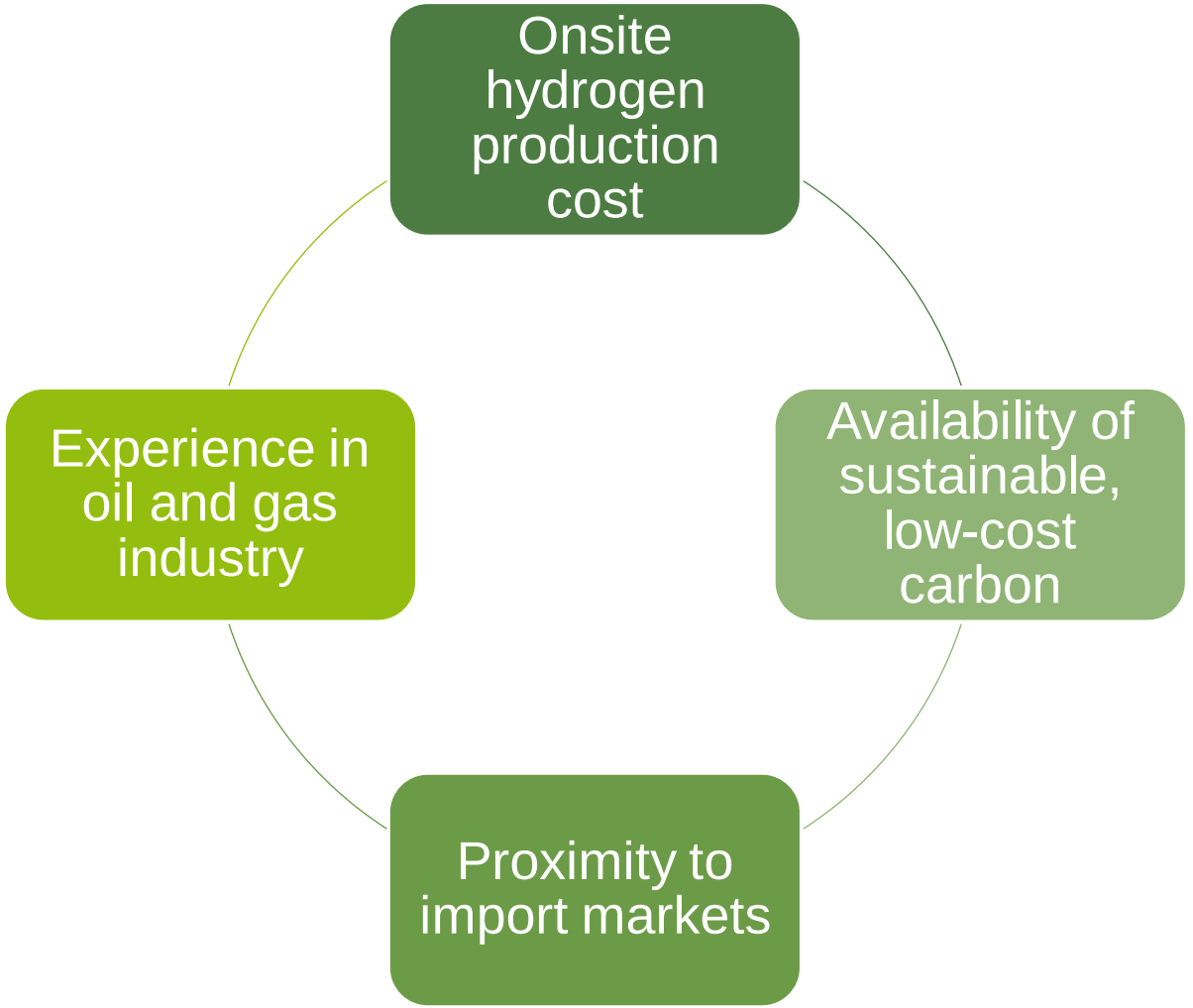
Hydrogen supply cost for Nigerian exports
Reference year: 2030



International competitiveness of Nigerian exports

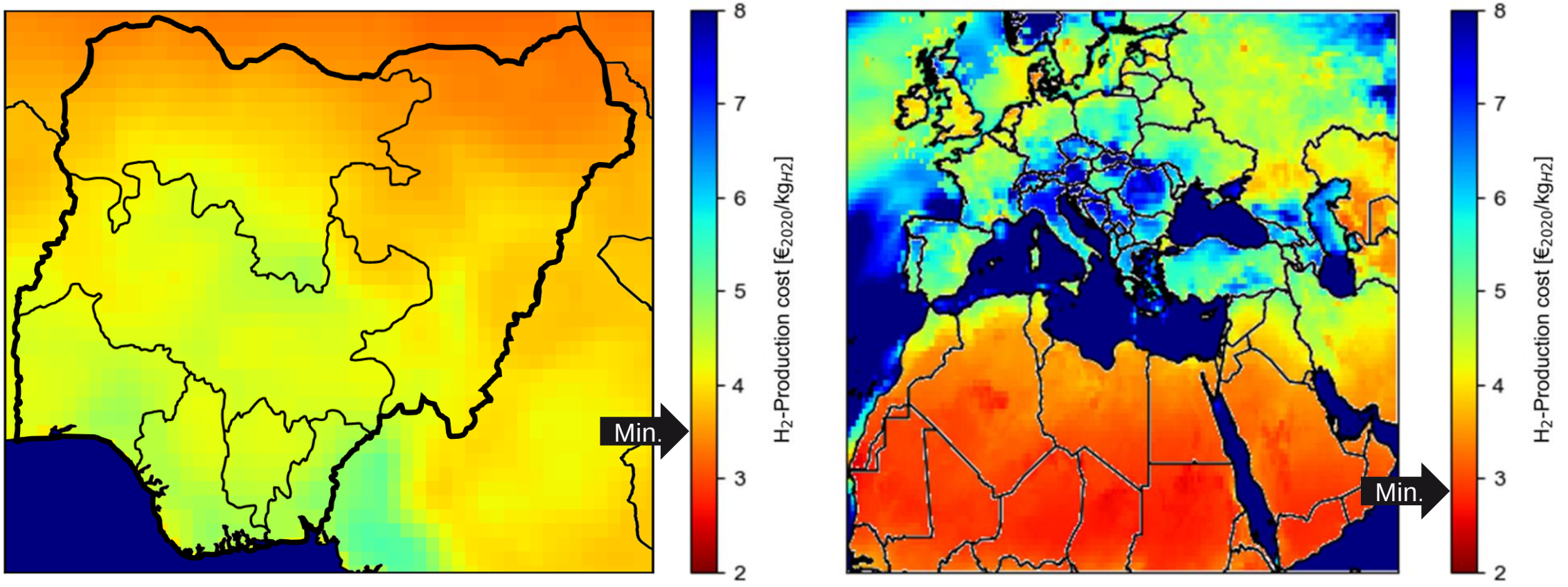
Techno-economic indicators of international competitiveness

Parameters determining the price at which countries can offer their PtX products on the international market:



International competitiveness of Nigerian exports

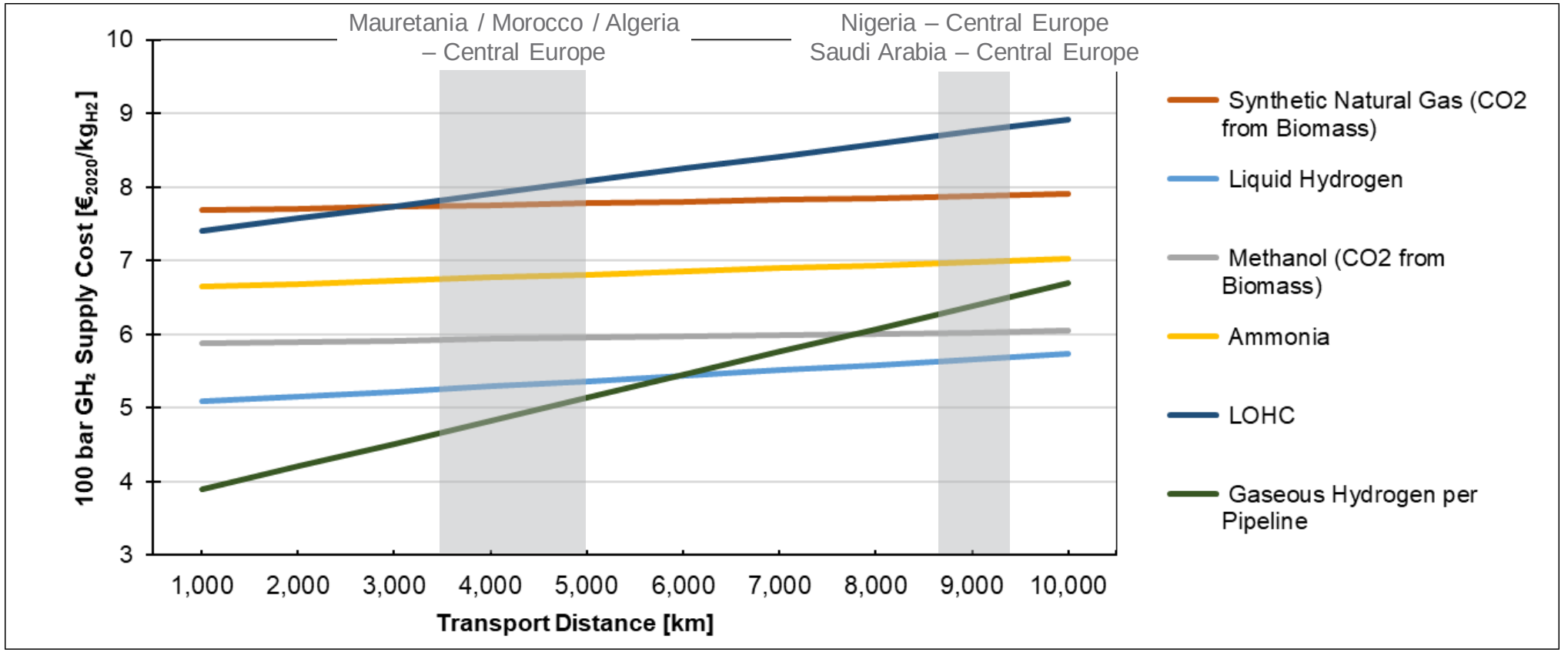
Onsite hydrogen production cost – Reference year: 2030



Green hydrogen production in Nigeria is expected to be 10-20% more expensive than in the top competing countries (e.g. Arabian Peninsula, Mauretania).

International competitiveness of Nigerian exports

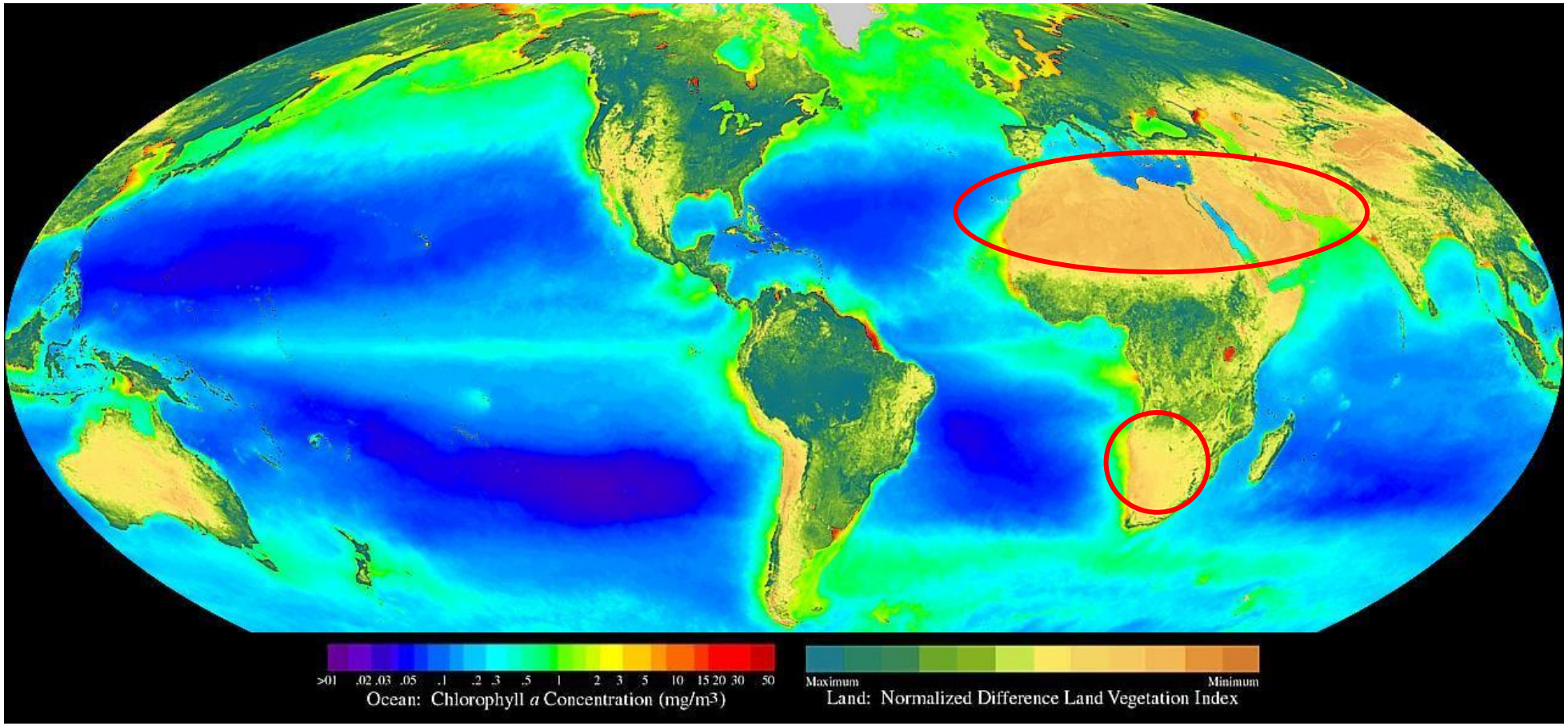
Proximity to import markets – Reference year: 2030



The transport distance has a major impact on the cost if hydrogen is supplied via pipelines, liquid hydrogen and LOHCs. In this respect, Nigeria's location tends not to be favorable.

International competitiveness of Nigerian exports

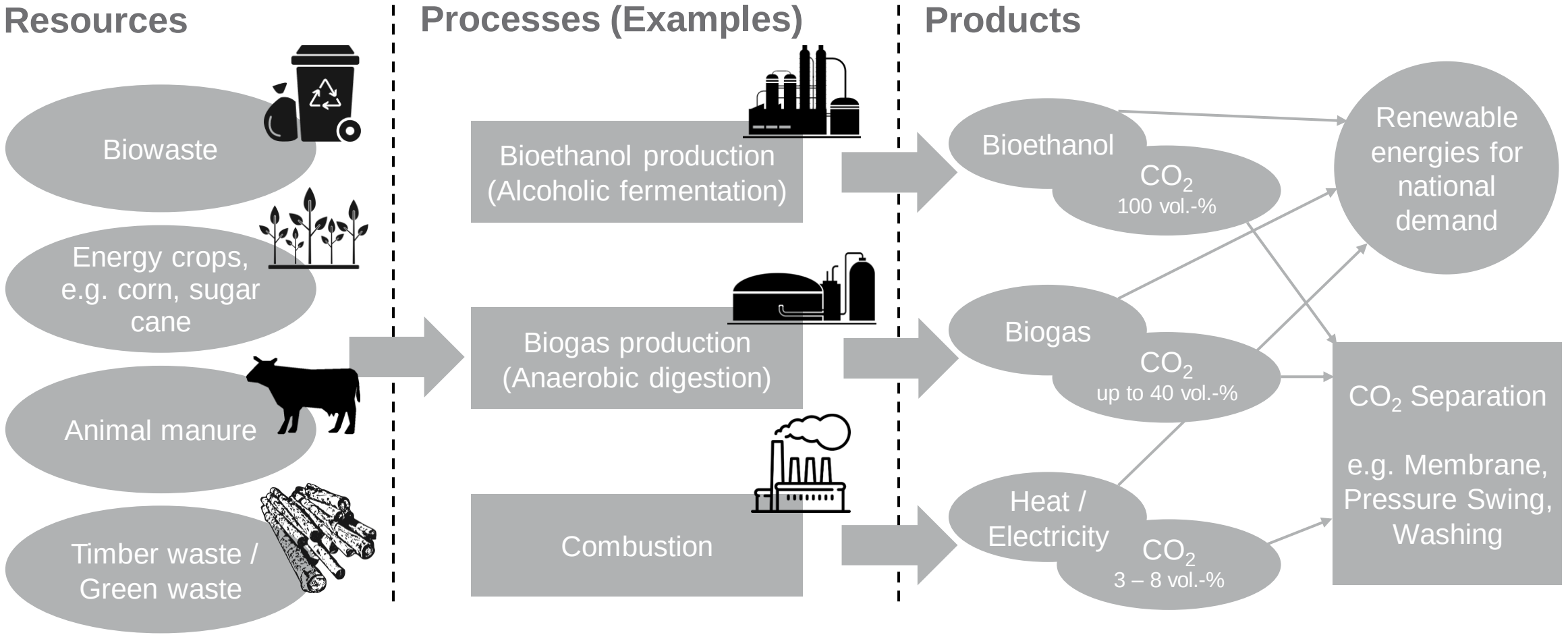
Availability of a sustainable, low-cost carbon source



The (potentially) good availability of sustainable biomass as a source of green carbon could be a key advantage of Nigeria for the supply of green hydrocarbons (e.g. methanol).

International competitiveness of Nigerian exports

Possibilities to utilize green carbon



International competitiveness of Nigerian exports

Experience in oil and gas industry

[1]

[2]

[3]

Existing infrastructure of the oil and gas industry as well as experience in realizing large-scale energy projects can help Nigeria to produce and export green PtX products.

Outline

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Conclusion

- Against the backdrop of progressing climate change and international climate protection targets, an accelerating shift towards renewable energy sources can be observed.
- Low-carbon hydrogen will in all likelihood play an important role in the future energy system.
- In principle, Nigeria has good prerequisites for the production of "green" hydrogen. In the North of the country, production costs in the range of €3.5/kg in 2030 are realistic. This is expected to be 10 to 20 % higher than in the top international competitors.
- The production of “blue” hydrogen faces unsolved technical challenges in the short term (especially high capture rates and exploitation of suitable deposits). In the long term, scalability is likely to be lower than for green hydrogen, both in terms of quantities and costs.
- The production of "green" hydrocarbons such as methanol and PtL fuels from hydrogen and renewable (biogenic) carbon could be a niche where Nigeria can exploit its advantages. Here, the long transport distance to potential sales markets plays a subordinate role.

Contacts

Global Hydrogen Diplomacy (H2-Diplo)

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