The Role of Green H_2 and PtX Value Chains in economic diversification & decarbonisation of SA ports

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International Cooperation, PtX Value Chains & Economic Diversification

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Introduction: an idea…

SA renewables potential and constraint

Available land + excellent solar resource + good wind resource = large renewable electricity potential at world competitive costs.

But

1) RE potential far exceeds local electricity demand

2) Electricity export potential is limited:
   a) Neighbouring economies << SA
   b) No HV DC line to Europe

What if we can sell RE as molecules instead of electrons?

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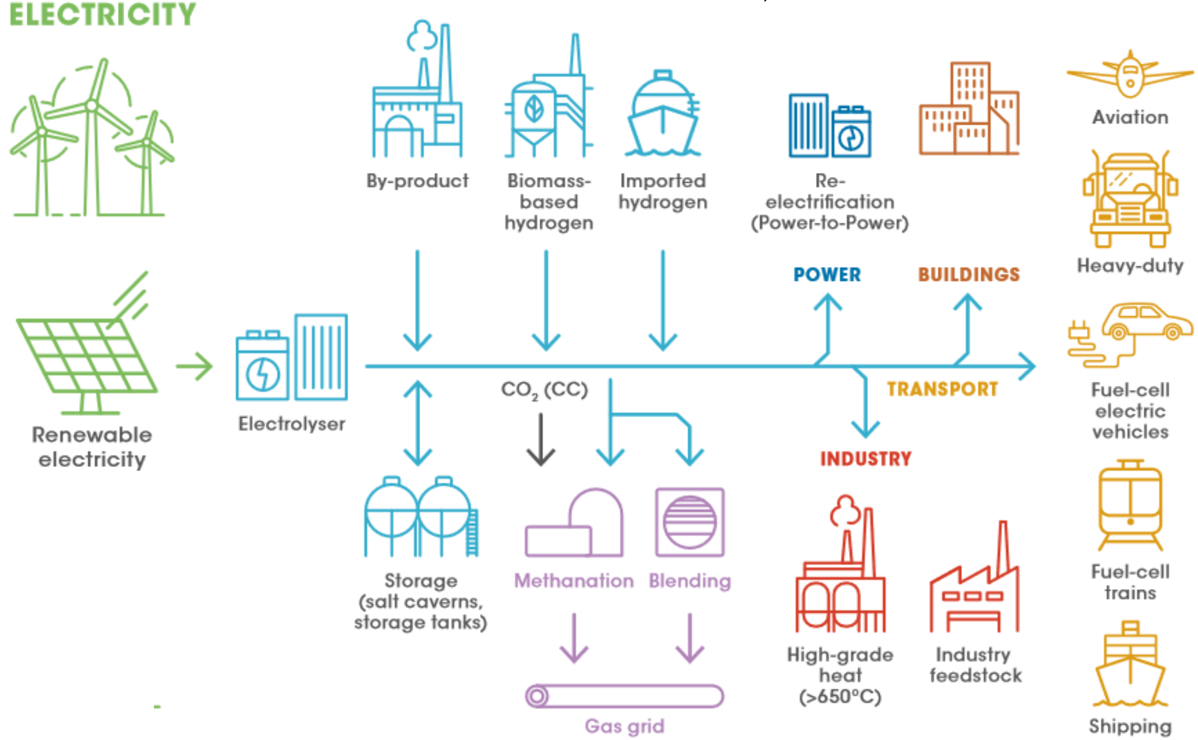
PtX: Fuel & products from RE-based H_2

Necessary to meet climate goals in "hard-to-abate" sectors

Decarbonisation choices:

- **1st & best choice: Always cheapest & most efficient to electrify all possible sectors with RE**
  - E.g.: BEV for private commuter transport, heat pumps for heating
- **2nd best choice: H_2 & PtX more expensive & less efficient, only option for "hard-to-abate" sectors**
  - Heavy-duty, long-distance transport: trucks & buses, aviation, shipping, rail*
  - Industry: Iron & steel, cement, ammonia, plastics.

Source: IRENA, 2018a



* Special case: technically possible, expensive to retrofit

What is driving the market?

Convergence of several trends

1) **Climate regulatory and financing pressure**

- Paris Agreement (1.5 ˚C), European Green Deal (2050), Finance activism (exit fossils, especially coal)

2) **Economics: Declining costs of RE in good areas - competitive since ~2014**

3) **Public policy support for imports of PtX**

- Japan (2014): 300 kt/y @ $3/kg from 2030 → 5-10 Mt/y by 2050 @ $2/kg
- EU (2019): RED II 14%, EGD (steel, transport), Hydrogen Strategy (40 GW inside, 40 GW outside)
- Germany: NHS needs ~3 Mt/y by 2030, only 420 kt/y in-country, rest from EU, RE-rich partner countries
- Netherlands: Port of Rotterdam aggregator for NW Europe

Finally

- Invasion of Ukraine: REPowerEU to reduce Russian gas, increase GH_2 imports by 10 Mt/y

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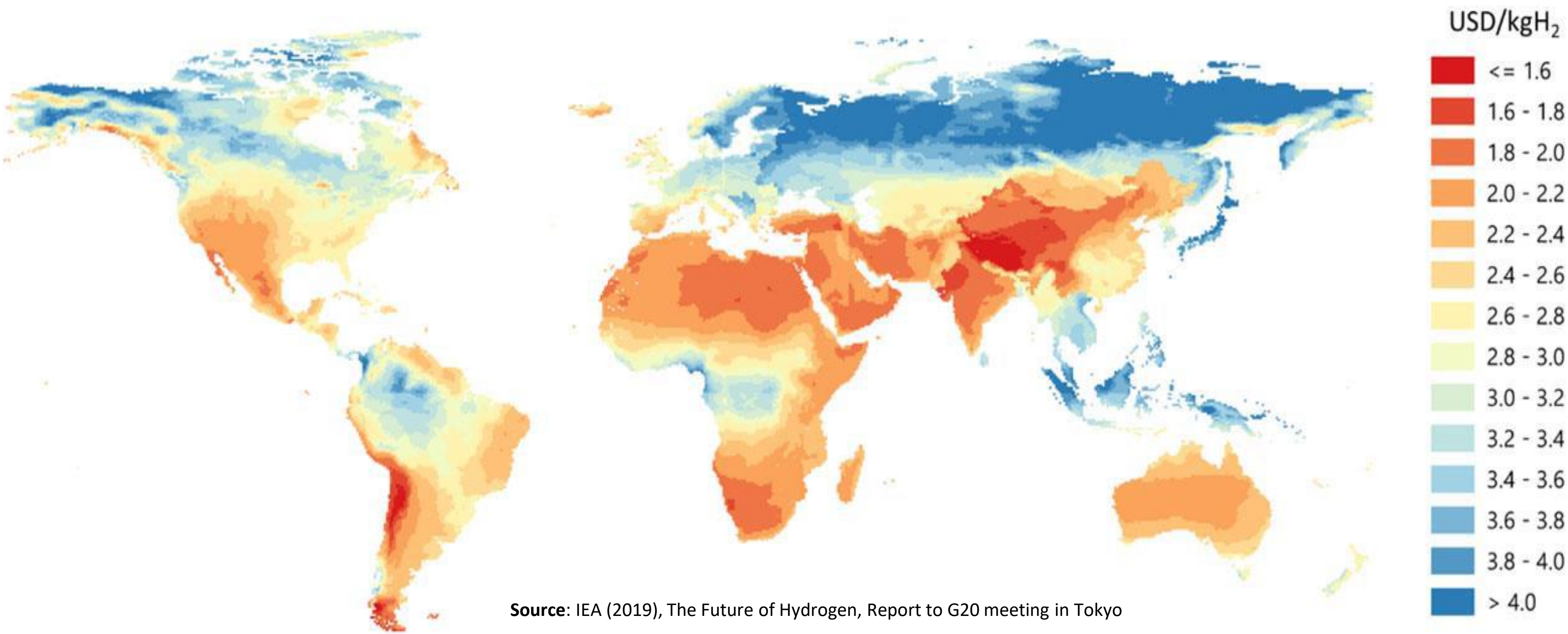
Export market opportunity

Excellent SA solar & wind resources → bulk GH_2 costs competitive to other coastal countries

For islanded RE power: H_2 generated in SA at lower cost using the following options:

- Scale: large-scale (≥ 20 MW) electrolysis rather than smaller scale (~ 1 MW)
- RE power: hybrid RE (roughly equal wind & SAT PV capacities), rather than PV or wind alone
- Electrolyser technology: Alkaline rather than PEM or SOEC.

Better economics for grid-connected systems: RE can be oversized, better electrolyser utilization rates, excess electricity can be sold



Source: IEA (2019), The Future of Hydrogen, Report to G20 meeting in Tokyo

What about conversion & shipping costs?

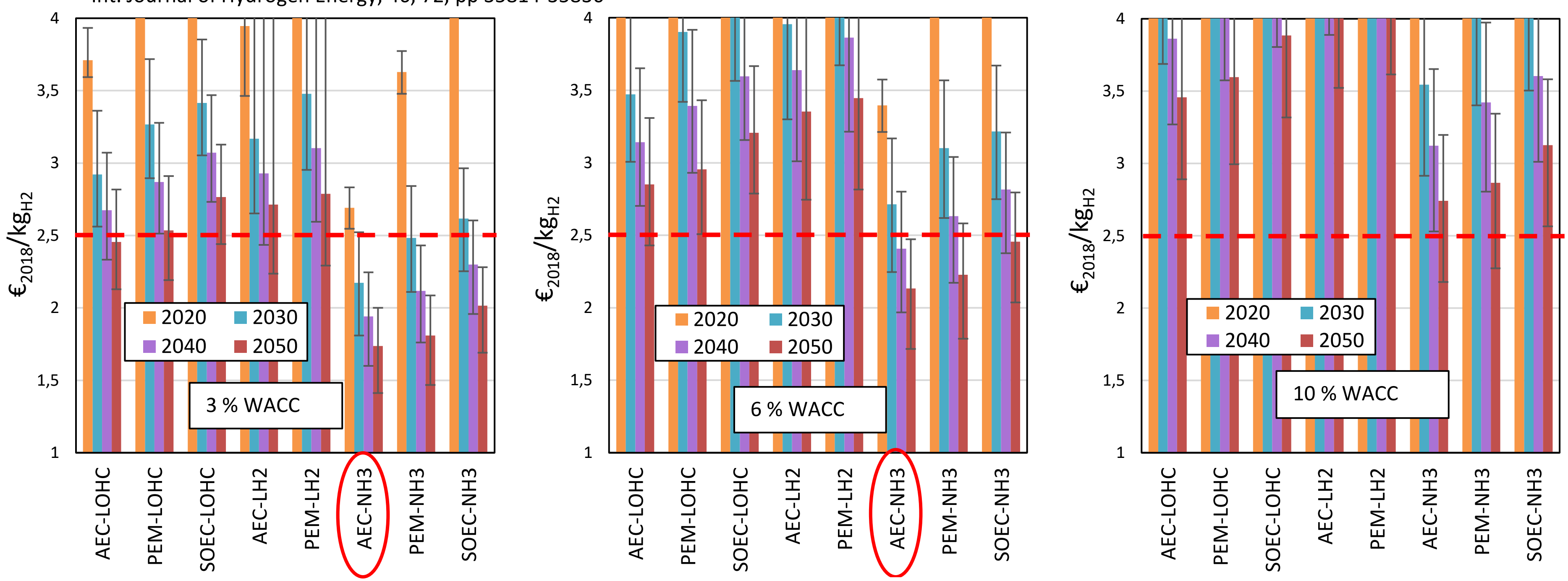
Ammonia looks most attractive

Carrier: H_2 may be shipped to Japan/EU & reconverted to H_2 gas at lower cost as NH_3 than LH_2 or LOHC.

Cost: meets Japan's target of $3/kg (€2.5/kg):

- if reconverted to gas, by 2030 at 3% WACC, by 2040 at 6% WACC.
- If left as NH_3, the cost target may be met 10 years earlier: by 2030 at 6% WACC.

Roos, T H (2021): The cost of production and storage of renewable hydrogen in South Africa and transport to Japan and EU up to 2050 under different scenarios, Int. Journal of Hydrogen Energy, 46, 72, pp 35814-35830



There are 3 classes of H_2 market for SA…
Each with different characteristics

1) Export: generated at or near ports

- SA can capture maybe 7-12% of international GH_2 market, mostly as ammonia
- Green Iron: Saldanha Steel san supply 1 Mt/y DRI to EU (1.5 Mt/y capacity), will need 104 kt/y GH_2.
- Long-term offtake agreements → cheap financing possible → can build at scale, lower 1st costs → some GH_2 available for local consumption

2) Local consumption: inland

- More difficult to get scale and lower costs
- 1st movers likely industries with pressure from global carbon reporting (such as mines)

3) Intermediate (at borders): Refuelling aviation and shipping calling at SA

- Aviation: can only really use kerosene, and existing SA Fischer Tropsch infrastructure is available
  - 160 000 bbl/d FT facility at Secunda (Sasol) – Sasol (with partners) planning SAF
  - 45 000 bbl/d FT facility at Mossel Bay (PetroSA) – Declining NG feedstock, no sustainable movement yet
- Shipping: If large vessels already calling at SA ports decarbonise, they will need:
  - Preferred sustainable bunker fuels:
    - CMB prefers ammonia (setting up refuelling station Walfis Bay, Namibia)
    - Maersk prefers methanol, Cargill not yet committed
  - GH_2 Volumes (vessels already calling at SA ports, not including bypass traffic rounding the Cape)
    - Saldanha Bay and Cape Town: 504 kt/y GH_2
    - Port Elizabeth and Coega: 247 kt/y GH_2
    - Compare with Japan (300 kt/y from 2030) and Germany (~3 Mt/y by 2030)!
  - Decarbonised port equipment: reach stackers, yard tractors, forklifts, APU's

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Issues with sustainable maritime bunker fuel adoption

Mechanism for compliance in international waters

Limited compliance framework

- IMO is slower than other jurisdictions: 50% carbon reduction by 2050

3 available mechanisms for sustainable maritime bunker fuel adoption

1) Voluntary decarbonization by shipping lines (like CMB, Maersk, Cargill)
2) Clydebank Declaration (at COP26): setting up of green corridors
   - Comprises a defined cargo and two ports – must be carried using sustainable bunker fuel
   - 1st green corridor: iron ore between an Australian and a Japanese port
   - SA is not a signatory, needs to be rectified!
3) Shipping of PtX to EU will (eventually) require sustainable bunker fuel for those vessels

World Bank is funding feasibility studies for sustainable bunker fuel at 4 SA ports

- Boegoebaai, Saldanha Bay, Coega and Richards Bay

Getting to Zero / P4G / Global Maritime Forum studies

- South Africa: fueling the future of shipping - SA's role in the transformation of global shipping through green hydrogen-derived fuels
- Shipping's Energy Transition: Strategic Opportunities in South Africa

So, what else has been happening?

Several things are in motion in/by SA:

- H_2 Society Roadmap approved by Cabinet, launched February by DSI
- Green H_2 Panel set up by DTIC, developing Green H_2 Commercialisation Strategy
- 1st H_2 Valley being set up connecting Durban & Gauteng via N3, Mogalakwena via N1
- Presidency, NC Government and Sasol exploring Boegoebaai for export
- NC and WC setting up collaboration framework: “Western corridor”

EU Delegation in SA support:

- 2 H_2 studies by CSIR, each presented in public webinar
- EU H_2 tour in March: DMRE, DTIC, DoT, DSI, Presidency, Transnet, IDC, EIB, CSIR

German support:

- KfW Development bank: ~200 million euro in concessionary financing for GH H_2
- KfW Development bank: Supporting Transnet develop a hydrogen strategy
- GIZ:
  - H2SA (with Presidency):
    - Policy, regulatory and strategy alignment
    - Lighthouse projects
  - PtX Pathways (with DTIC):
    - Will compare 7 ports and 3 inland sites regarding H_2/PtX production costs
    - Will explore local GH_2 demand
    - Will assist PetroSA and Sasol

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Water security
Sustainability and desalination water costs

Sustainability

- Water for electrolysis can't be diverted from communities, agriculture or the environment.
- Seawater desalination is more sustainable

Cost implications

- Desalination component <0.02 $/kg of H_2, less than 1% of H_2 target price (CSIR calculations)
- For export, produce PtX H_2 at/near the port of shipment, using desalinated seawater.

Recommendation for bulk PtX H_2 production

- For "social licence to operate", oversize desalination plants for electrolysers plants by 300%
- Build the extra CAPEX costs into the PtX H_2 price (which will not be greatly affected):
  - The capital repayment costs are paid for by the H_2 business
  - During drought: Operate desalination plants at full capacity. The local water utility buys the excess water, paying only for the electricity component.
  - During good rains and full dams: Operate the desalination plants at 30% capacity, supplying only the electrolyser plant.

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