IEA EPRI 2021: Building a Resilient Net-Zero Future

A Holistic Look at Electrification

Power System Implications of PtX

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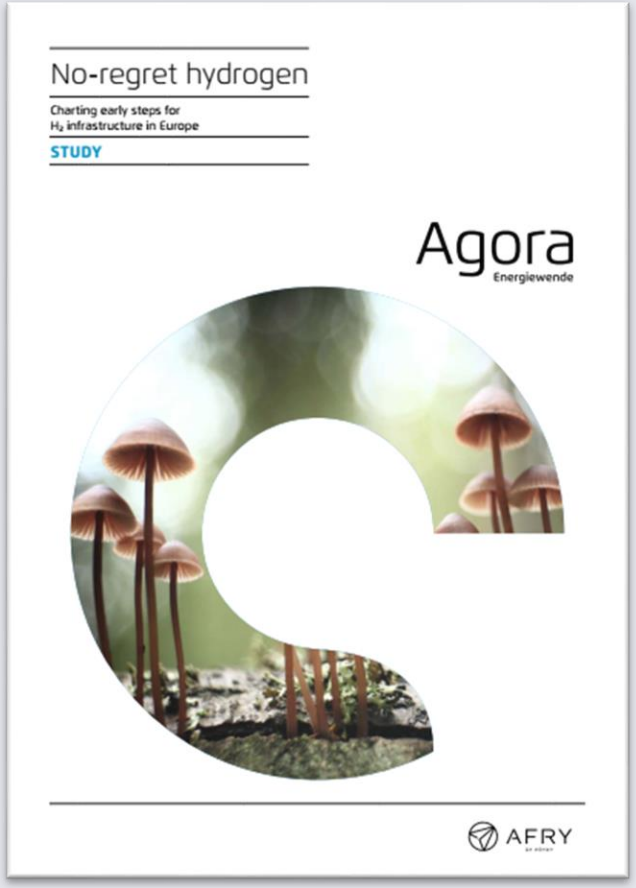
Case studies: No regrets H2 infrastructure in Europe; Green H2 cost optimization in South Africa



Power System Implications of PtX

1.	Blue H_2 versus Green H_2 is not just a question of economics: Relying on Green / PtX results in very different energy system than relying on Blue
2.	PtX is a commitment to additional renewables: The EU's 40 GW electrolyser ambition will require 80-120 GW additional solar and wind by 2030
3.	$LCOH_2$ results from location and firming via storage and / or grids: 2-4 days of storage is an acceptable firming range; using grid supply can increase the electrolyser utilization rate
4.	Optimizing electrolyser capacity utilization: Hybrid supply from solar and wind, oversizing renewable generation
5.	Trade offs: a lower headline cost for H_2 / PtX is achieved in the near-term with the implication of higher electricity system costs in the medium term

Green / PtX results in very different energy system

- Green H_2 in South Africa is currently x2-3 more expensive than Blue. An ex-post economic analysis won't add much beyond concluding that in the long run renewable PtX is cheaper. But the issue of Blue vs Green goes much beyond simple economics.
- Green H_2 needs to be coupled to renewables: therefore, solving the intermittency issue requires storage, and typically also transmission.
- Green H_2 is also an enabler of further renewable rollout by providing a price floor against cannibalisation. Blue H_2 doesn't add that benefit: a Blue world has less renewables. Also, possibly less transmission infrastructure, as production would be centralised.
- Ultimately, the Blue vs Green debate is essentially a debate about how much renewables (and how fast) we think is feasible. As such, Green H_2 is closely connected to high electrification scenarios, and a blue world to lower electrification.

➢ The Green / PtX option also has a lot of synergies and efficiencies for other outcomes.

$LCOH_2$: Location, Firming via Storage / Grids

- Capex is only one dimension of the electrolysis equipment. Efficiency and lifetime of stack are also important factors that will affect the overall $LCOH_2$.
- For Green H_2, the renewable power generation can be far from the H_2 demand: should the electrolysis plant be located near the renewables power generation and H_2 be transported? Or should electricity be transported? (The sourcing of desalinated water supply could be strategically coupled).
- Firming H_2 supply through H_2 storage: The end-user (e.g. ammonia synthesis, H_2 -DRI steel, an HDV refuelling station) would likely need firm H_2—but can require a less stringent firming than a 1-hour basis: 2-4 days of storage is an acceptable firming range and is used for the firm H_2 supply cost modelling.
- Firming H_2 supply through access to the grid: Using grid supply for electrolysis can increase the electrolyser utilization rate and reduce / eliminate the need for H_2 storage to firm otherwise intermittent H_2.
- ➢ Each MW of electrolysis matched 1:1 with MW of dedicated renewables: electrolysis only operates when the renewable generation is operating. However, there are trade-offs that can allow a lower headline cost for H_2

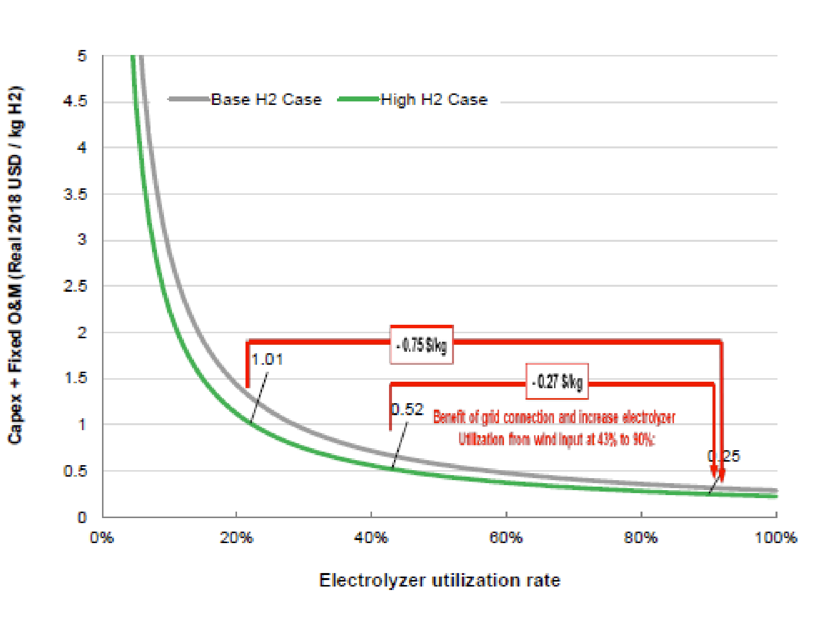
Renewable solutions: hybrid supply, oversizing

- Solar PV + onshore wind for hydrogen production in South Africa: a combined capacity factor is modelled as a weighted average and does not exceed the capacity factor of onshore wind. The net outcome for firming is highly dependant on location.
- Metrics other than capacity factor need to be considered: correlation between solar and wind—if zone X has a correlation close to -1, here the solar and wind resource tend to complement each other. The largest benefit of combining is expected for highly negatively correlated locations. Also, resource variability: intermittency is estimated as a standard deviation normalized by the average power over a year. Solar PV has a wider variation (125-135% range) than onshore wind (65%-90%).
- Small capacity electrolysis could be matched with larger capacity dedicated renewable generation. That is, renewable power generation can be over-sized compared to the electrolyser fleet to increase the PtX equipment utilization rate, provide a more stable supply of H_2 and reduce the need for H_2 storage.
- Oversizing renewables capacity by a 2-to-1 ratio reduces the storage required to provide firm H_2 : storage cost reduction from 0.6-1.0 $/kg range to 0.4-0.6 $/kg

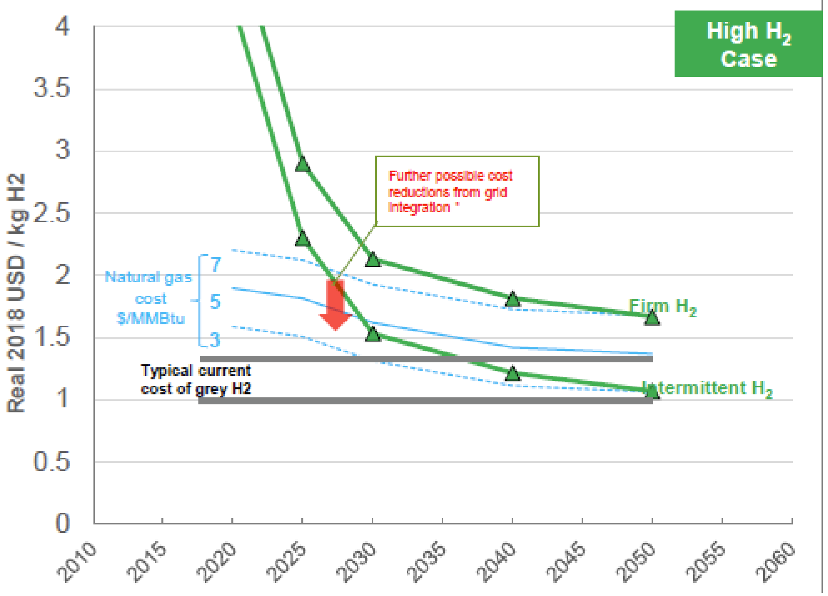
Case study: South Africa

Using grid supply for electrolysis can increase the electrolyzer utilization rate and eliminate the need for hydrogen storage to firm otherwise intermittent H_2

Effect of electrolyzer utilization rate on the unit capex and fixed O&M component of the LCOH$_2$. South Africa. 2025.



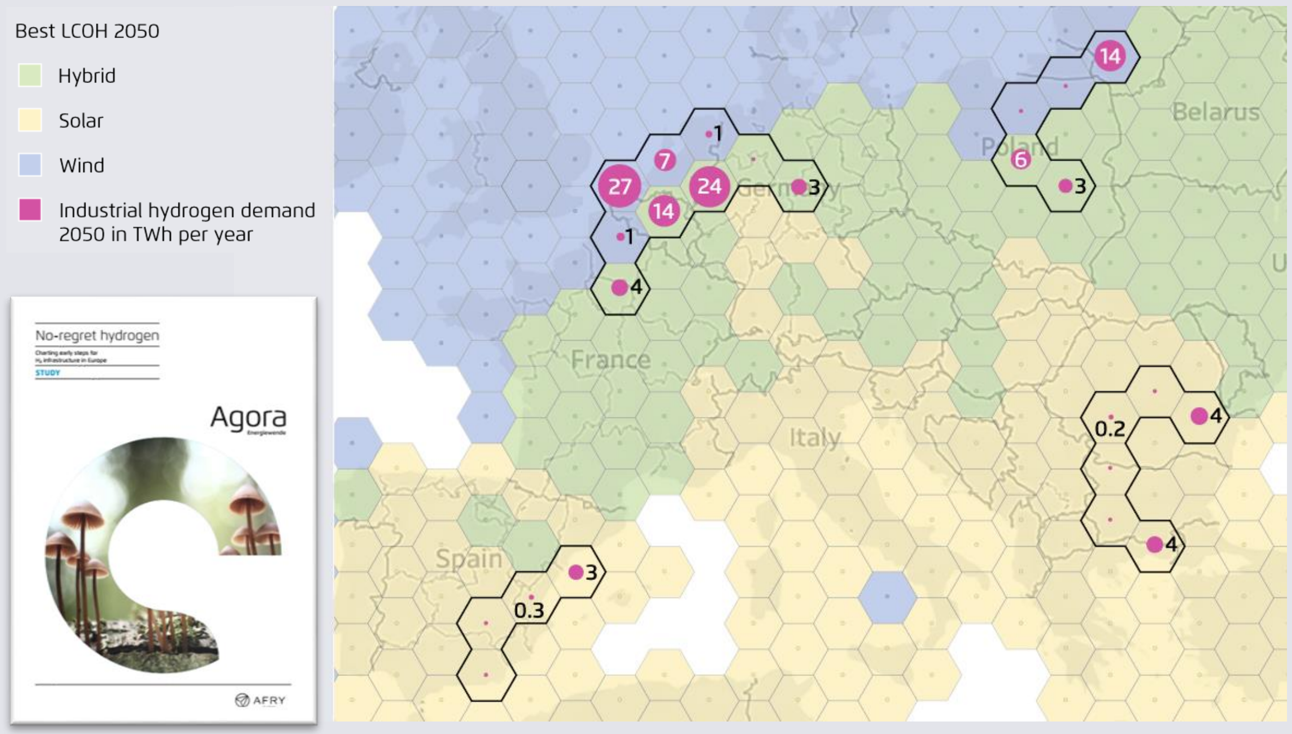
Potential impact of grid power supply on cost of green hydrogen in South Africa.



*cost reductions shown for grid integration are before any premium cost of grid power or wheeling costs for renewables across the grid

Case study: European no regrets H_2 pipeline infrastructure

No-regret corridors for 2030 based on industrial hydrogen demand in TWh/a



AFRY (2021)

Only those hydrogen pipelines that are resilient to the future levels of hydrogen demand and the technology assumptions used here have been considered to be “no-regret”.

- → Adding potential hydrogen demand from power, aviation and shipping sectors is likely to **strengthen the case** for a more expansive network of H_2 pipelines.
- → Even under the most optimistic scenarios any future **H_2 network will be smaller** than the current natural gas network.
- → A no-regret vision for H_2 infrastructure **reduces the risk of oversizing** by fo-cussing on inescapable demand, robust green hydrogen corridors and storage.
- → Ensure link between energy infra-structure **planning** and new JRC energy and industry geography labs announced in updated clean industry strategy

Trade offs

- A lower headline cost for H_2 is achieved in the near-term with the implication of higher electricity system costs in the medium term.
- Decisions around trade-offs may change with deployment—i.e. business model for early electrolysis facilities may focus on reducing the headline cost of PtX (utilization @ 5000 hours / 1500 hours)
- Can electrolysers help grid integration of variable renewables by absorbing intermittency 'noise' in the transmission grid: alleviates the traditional challenge of demand-side smarts and storage?
- Is $LCOH_2$ a useful calculation? Rather, is $VALCOEH_2$ more helpful?
- Relying on Green / PtX results in very different energy system than relying on Blue H2. Oversizing renewable generation and grids is low risk compared to oversizing H2 pipeline infrastructure.
- In Europe, even under the most optimistic scenarios any future H_2 network will be smaller than the current natural gas network. Germany's demand for H_2 and PtL amounts to 422 TWh in the "Climate-Neutral DE 2045" scenario: about 2/3rd of H_2 will need to be imported, in addition to PtL.

Thank you for your attention

For further discussions on PtX:

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