

Deploying Electrolytic Hydrogen for Green Ammonia Plants

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Almost a century of electrolyzer innovation in Norway

- Nel's history begins in 1927 when Norsk Hydro, Nel's parent company, started testing its first electrolyzer
- Hydro also built the world's two largest hydrogen production plants: Rjukan (167 MW) and Glomfjord (135 MW)
- The electrodes manufactured at Herøya today are a further improvement of Hydro's technology
- The facility at Herøya was the world's first fully-automated electrolyzer facility
- At the research center in Notodden we are developing next-generation pressurized alkaline electrolyzers



1953: A 135 MW electrolyzer system in Glomfjord, Norway

Decades of experience in the US

- Nel has been present in the US for 27 years, developing PEM electrolyzers
- Proton OnSite, which was acquired by Nel in 2017, originally utilized the PEM technology to produce oxygen for submarine life support
- Now, Nel and its technology partner, General Motors, are developing the next-generation PEM technology, improving price performance and efficiency
- Nel is also planning a gigafactory in Detroit to produce next-gen alkaline and PEM electrolyzers (FID not yet taken)



Nel's PEM technology was originally utilized for space and submarine life support

A technology leader on two platforms



Alkaline



PEM

Provides flexibility and positions Nel for growth in different market segments around the world

Strong field know-how and manufacturing capacity

PEM water electrolyzers

Wallingford, USA



Systems delivered: **2,700+**
Nameplate capacity: **500 MW/year**
Experience: **≈ 25+ years**

Alkaline water electrolyzers

Notodden/Herøya, Norway

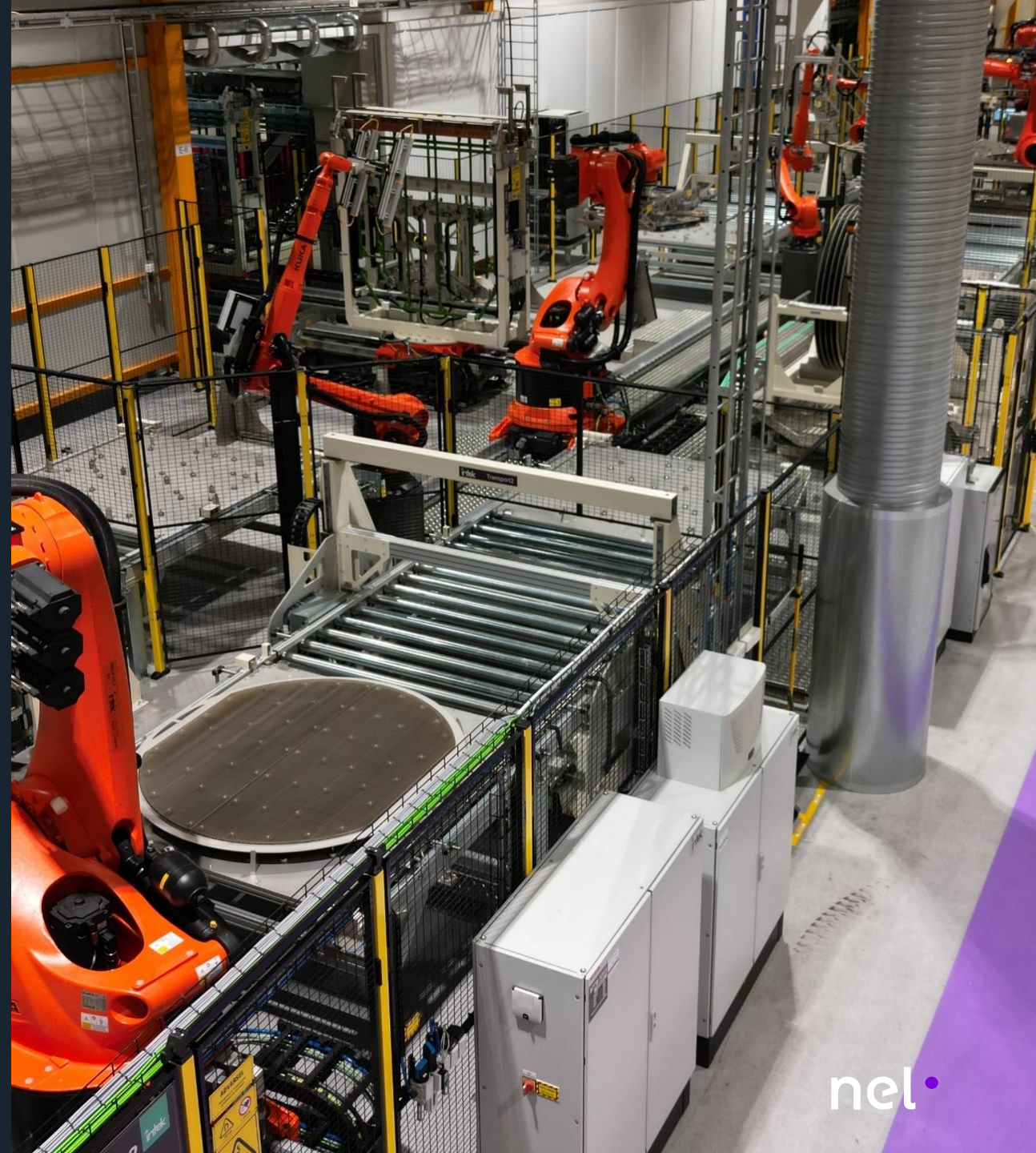


850+
1000MW/year
≈ 95+ years

→ 1GW by 2024, Expandable to 2GW/y

The world's first fully-automated electrolyzer manufacturing plant

- Construction of the second 500 MW atmospheric alkaline production line at Herøya is completed
- Nel currently has 1 GW of real, fully automated production capacity for atmospheric alkaline electrolyzers at its disposal
- Nel's automated manufacturing concept can be applied anywhere in the world and is critical to being able to scale up electrolyzer production



PEM capacity increase on schedule

- The production capacity increase to 500 MW annually for PEM electrolyzers in Wallingford (CT) is progressing according to plan
- All major production steps will be optimized and automated, some previously outsourced processes will also be insourced
- Committed investment CAPEX to completion for the expansion is ~ \$30M.



Nel plans gigafactory in Michigan

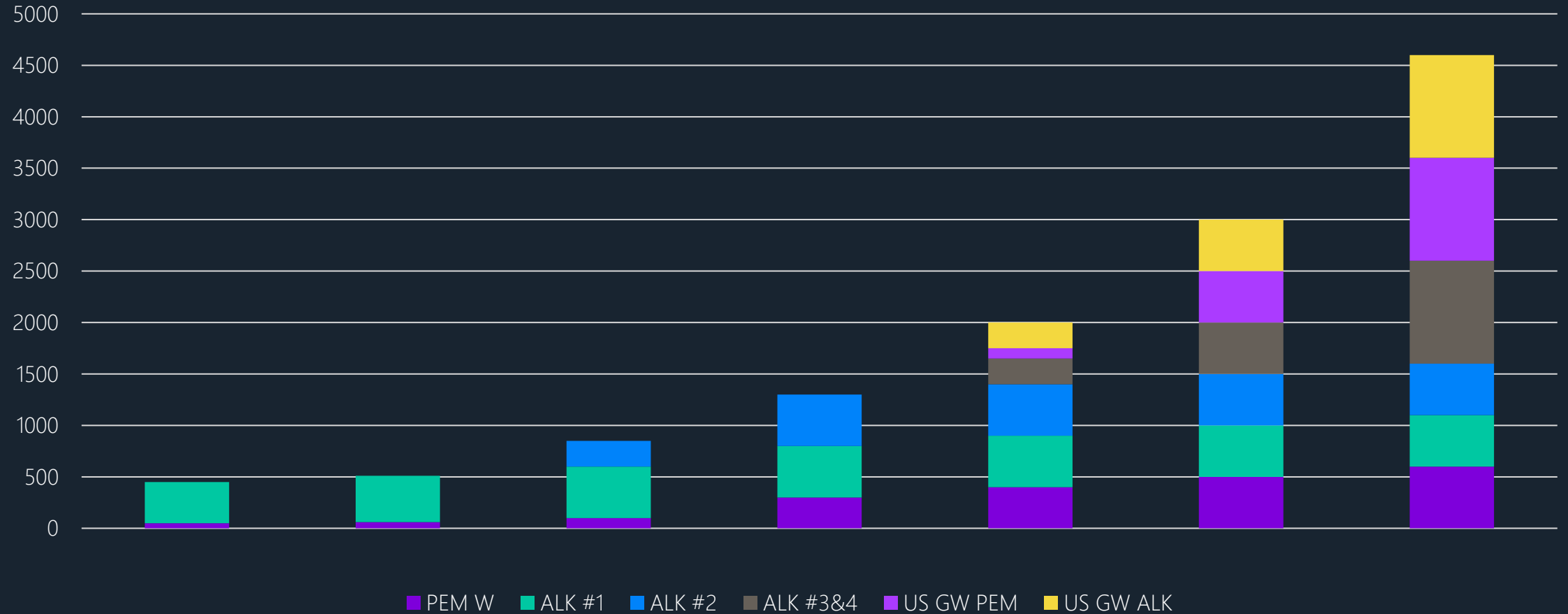
- When fully developed, the facility will employ more than 500 people and be among the largest electrolyzer manufacturing plants in the world
- The new facility will be built in steps to match supply with demand. Fully developed it will have a production capacity of up to 4GW Alkaline and PEM electrolyzers
- Michigan was elected based on an overall assessment of financial investment incentives, access to a highly skilled workforce, and cooperation with Universities and research institutions
- Short distance to Nel's collaborative partner General Motors, headquartered in Detroit, was also key to the decision of Michigan



Picture of Nel's CEO, Håkon Volldal and Governor of Michigan, Gretchen Whitmer

PEM & ALKALINE capacity plan

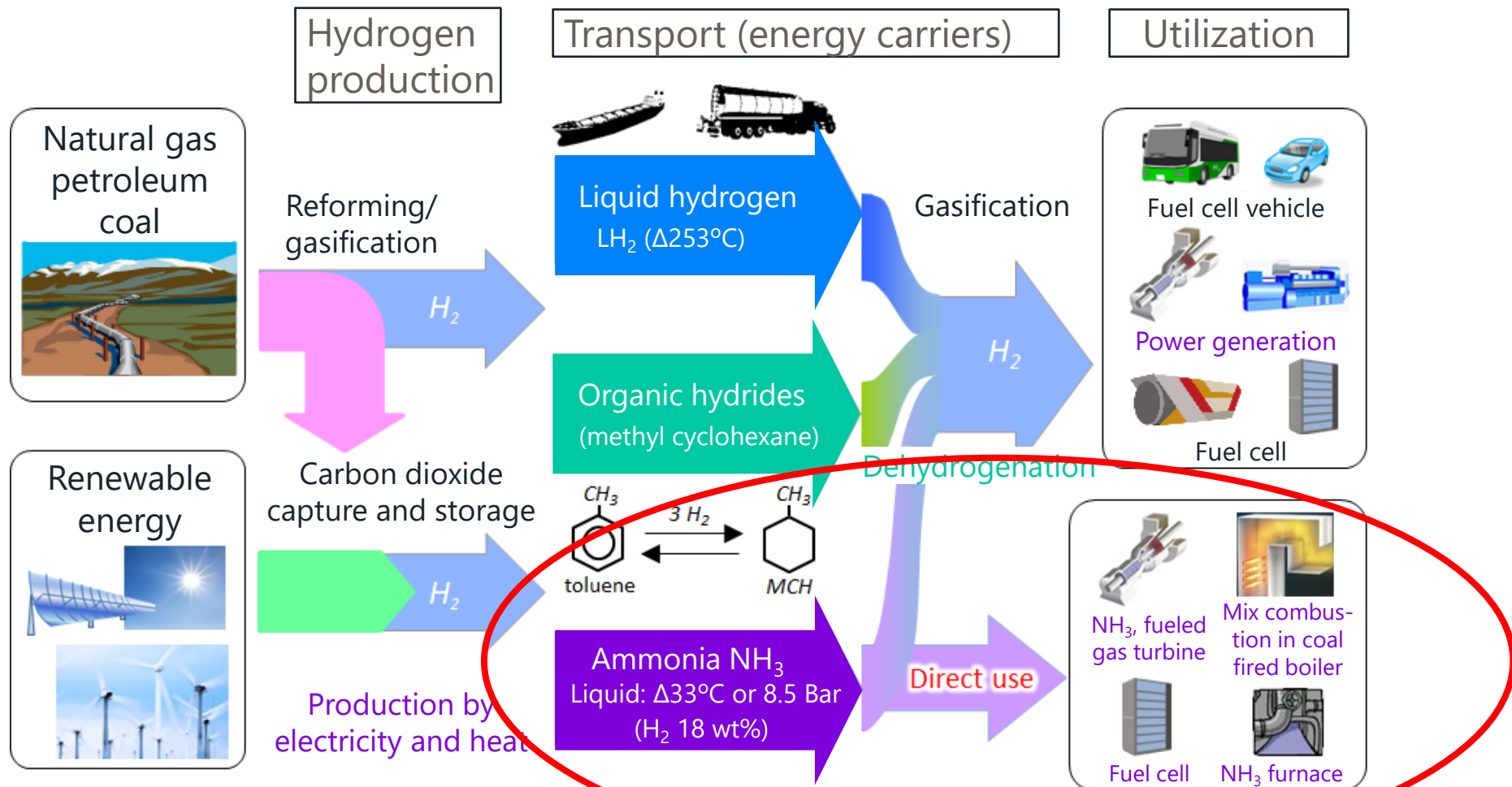
Representative capacity buildout plan/[MW]



The energy transition requires pioneering customers and partners



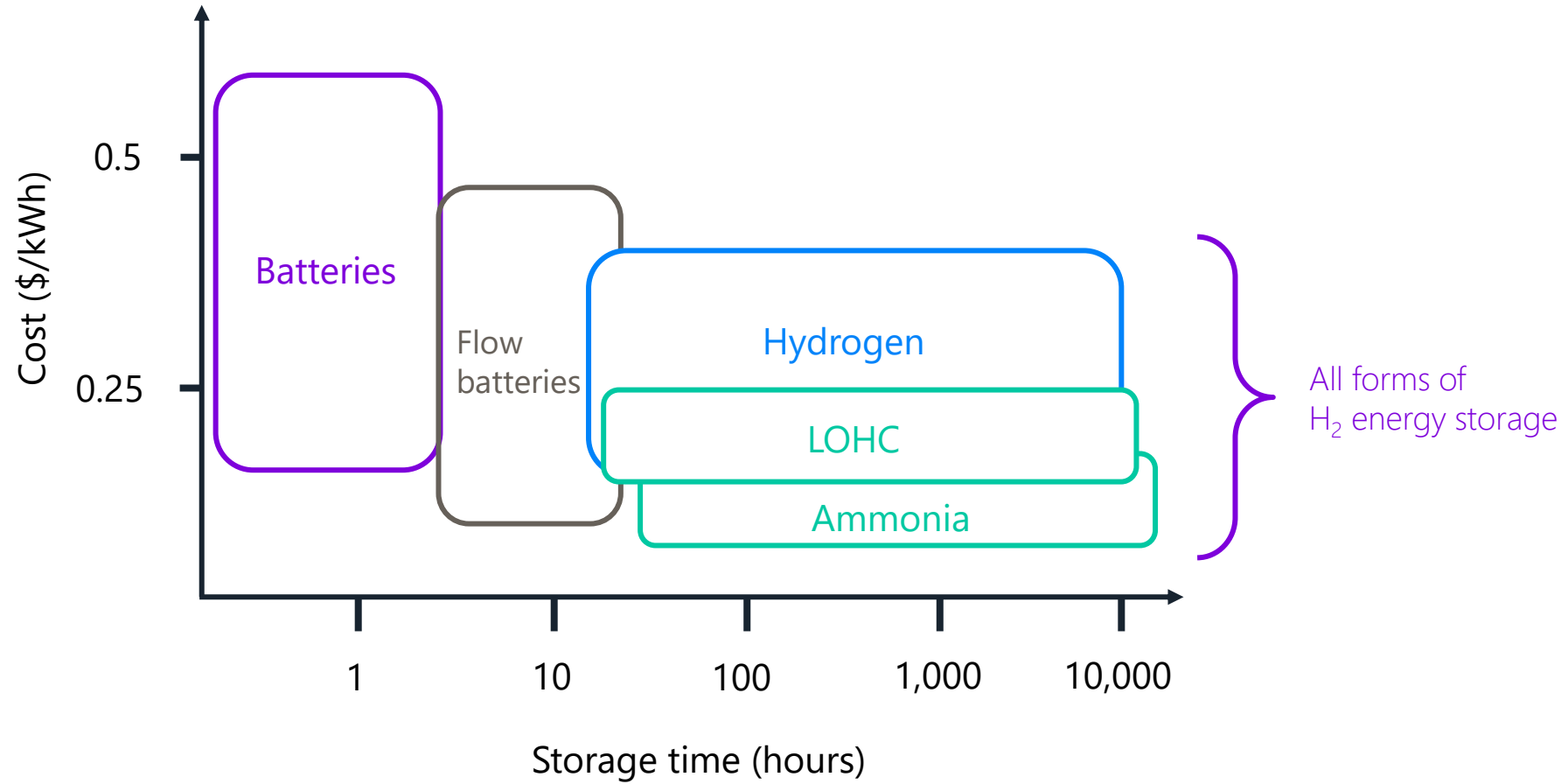
Scheme of CO₂ free hydrogen value chains



Why are we talking about ammonia?

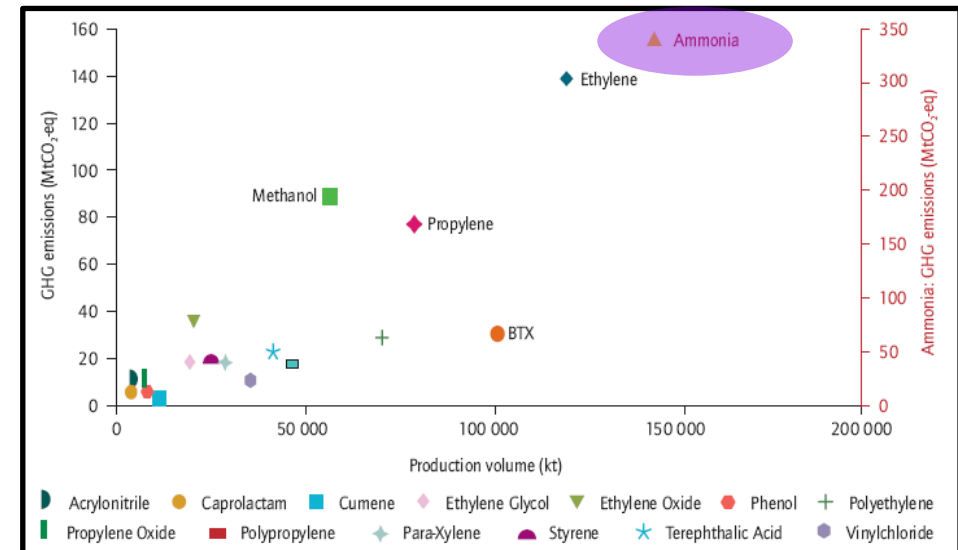
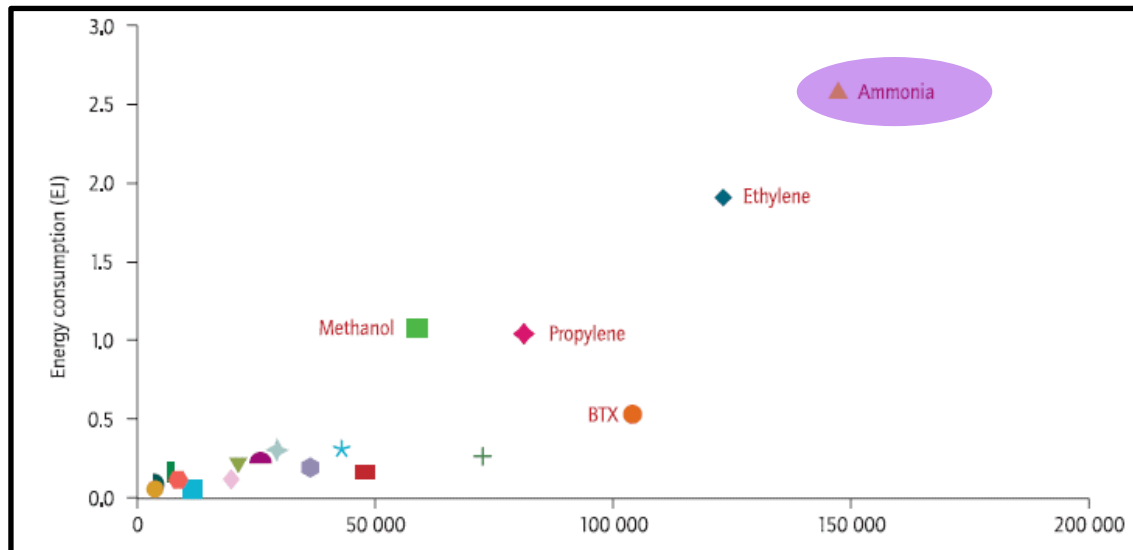
- One of the largest industrial users of hydrogen
- A high-density carrier of hydrogen
- Easily cracked to liberate hydrogen at point of use
- Massive distribution infrastructure already in place
- Enables the storage and transport of renewable energy at a transformative scale (H₂@scale)
- A promising and cost-effective vector for P2G
- Renewable hydrogen for ammonia production offers an opportunity to decarbonize both the energy and industrial sectors

Levelized cost of energy storage

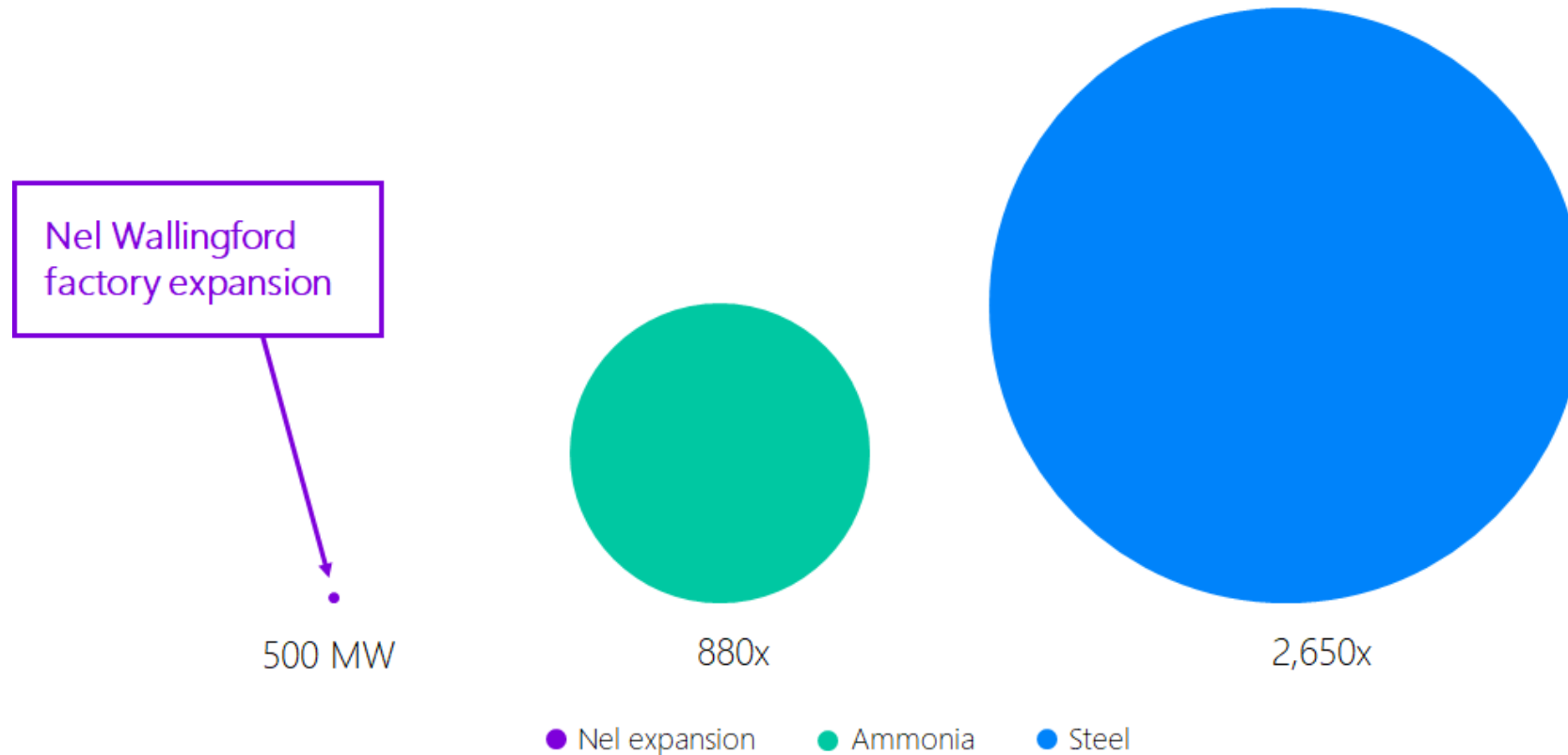


NH₃ impact: energy and GHG's

Ammonia is #1 out of 18 large volume chemicals for both energy use and GHG emissions, largely due to the H₂ reformation step from SMR



Market Outlook: A perspective on scale for just two offtaker markets



Renewable ammonia... the first to do it at scale



Rjukan, Norway 1927-1970's

- Two largest electrolyser plants worldwide
- Capacity: 30,000 Nm³/h each



Glomfjord, Norway 1953-1991

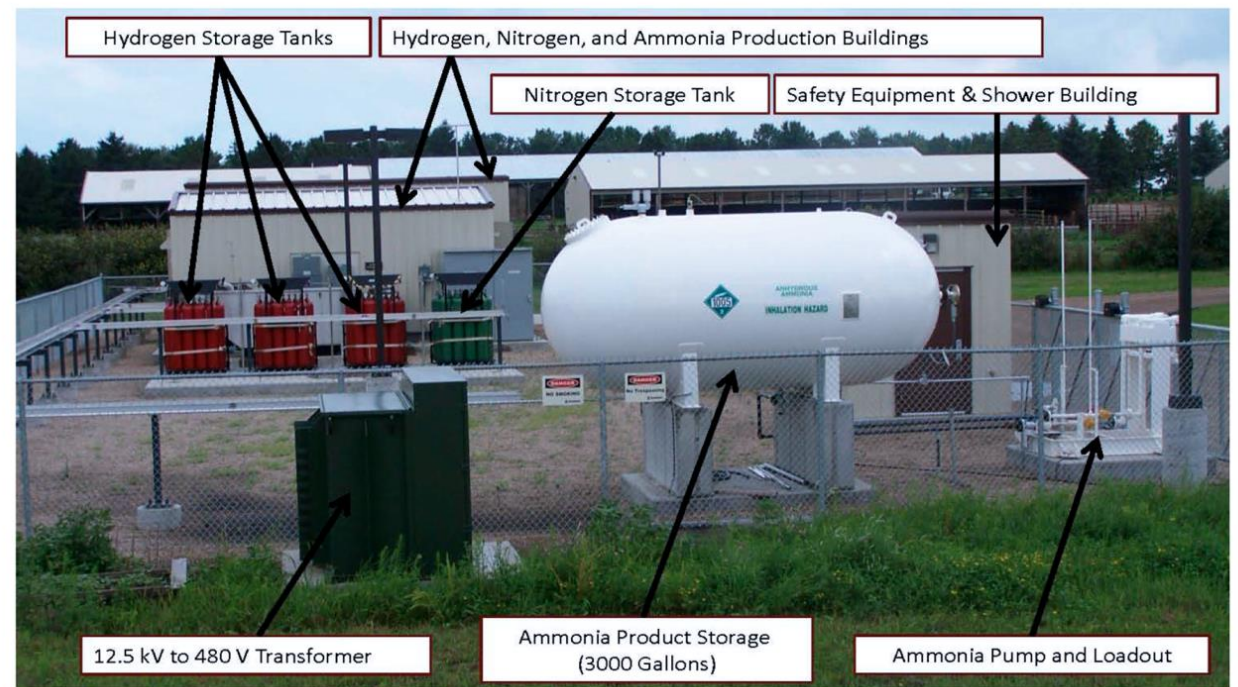
- Energy consumption: approximately 150 MW each
- Supplied by renewable hydropower

Distributed ammonia production in agricultural regions: green fertilizer where you need it, when you need it.

- Distributed ammonia plants need to be scaled to available renewable energy resources.
- Example: University of Minnesota's Zero-Emission Ammonia Pilot Plant, powered by an on-site wind turbine
 - Pilot plant increasing to 1 ton/day in 2025
 - Demonstrating capabilities of distributed ammonia plants
 - Funded by ARPA-E REFUEL program
 - Nel installing two new electrolyzers in the project for plant scale-up

Morris, MN Ammonia Pilot Plant

Scaled down conventional Haber-Bosch process, 25 ton/yr capacity

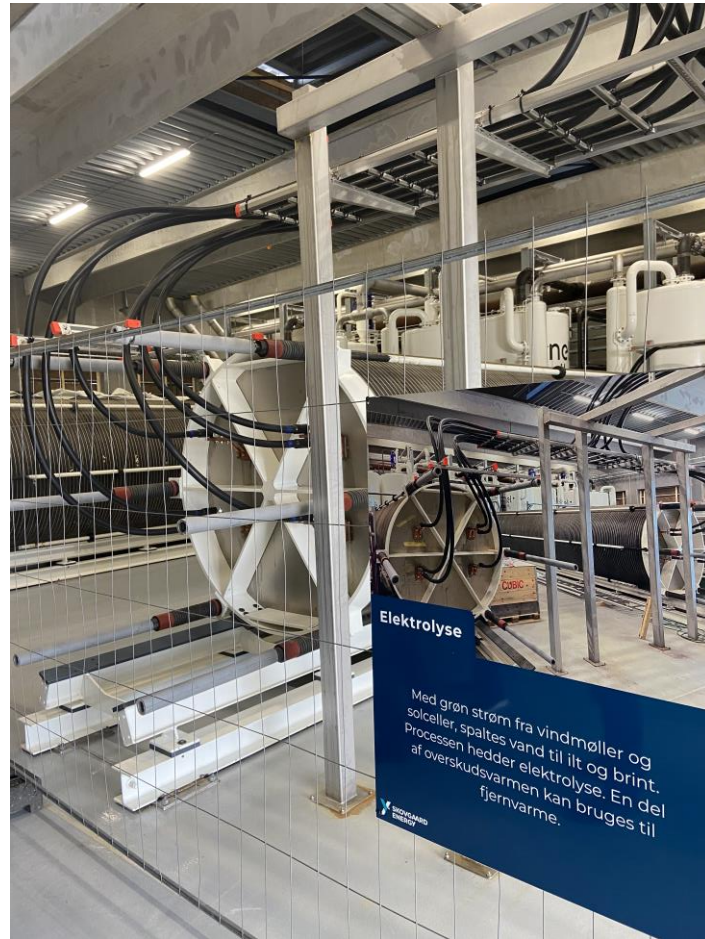


Iberdrola 20 MW PEM for green ammonia production



- Iberdrola, one of the largest electricity utilities in the world, has, together with world-leading fertilizer manufacturer Fertiberia, launched a project to establish the largest green hydrogen plant in Europe (Spain)
- Project includes 100 MW photovoltaic plant, a 20 MWh battery and a 20 MW electrolyser
- Uses hydrogen to produce green fertilizer commencing in 2021
- Key lesson learned: Benefits a modular/skid-based approach to enable factory assembly/pre-testing and limiting on-site interconnection work

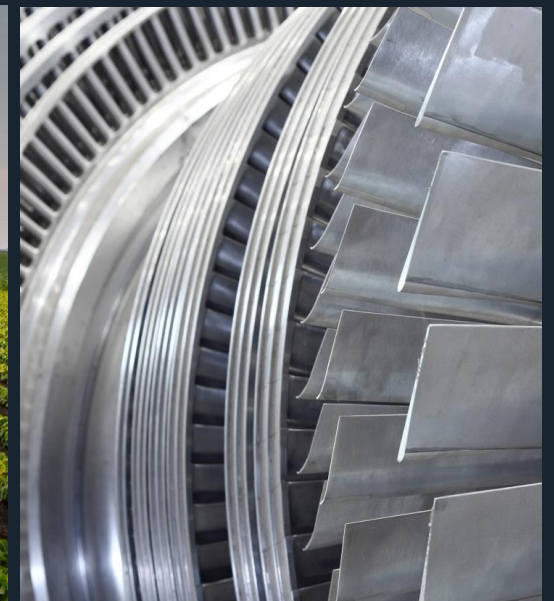
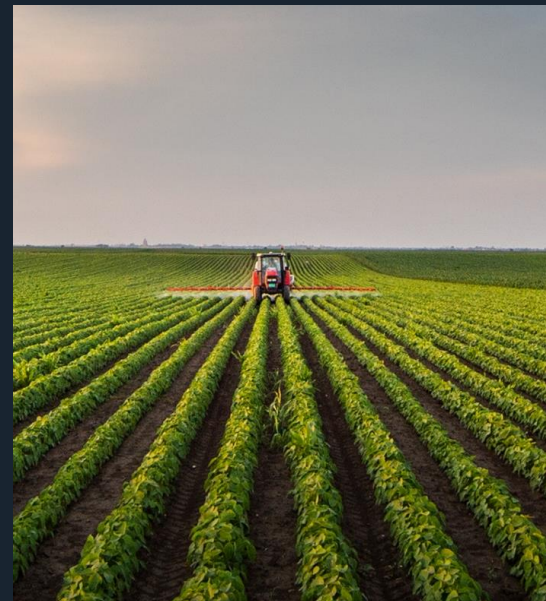
REDDAP: The world's first dynamic green ammonia plant



- The world's first dynamic Power-to-Ammonia plant, using power directly from wind turbines and solar cells to produce green ammonia according to the amount of sun and wind
- Uses four Nel A485 Alkaline Electrolyzer systems having 10MW of electrolysis capacity
- The project is a demo plant, 1/100 of standard commercial ammonia plants
- Key lessons learned: TBD

Key Challenges

- De-risking large scale projects
- Cost of renewable energy
- Lack of government mandates/incentives
- Cost of electrolyzers



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Thank you!

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