

Federico Zenith

## Kickstarting an Arctic Hydrogen Valley

The HAEOLUS project

Next Generation Electrolysers Conference

8–9 December 2020



# Outline

Motivation

The Project

Deployment

Opportunities

# Outline

## Motivation

## The Project

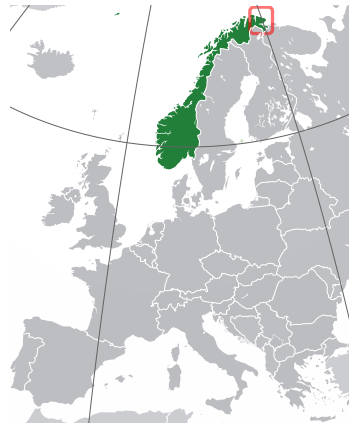
## Deployment

## Opportunities

# Raggovidda Wind Park

Berlevåg municipality, Varanger peninsula, Troms & Finnmark county

- The Raggovidda wind park:
  - 45 MW built of 200 MW concession
  - Neighbour Hamnafjell: 50 MW / 120 MW
  - Bottleneck to main grid is 95 MW
  - Total Varanger resources about 2000 MW



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  - Total Varanger resources about 2000 MW
- Capacity factor 50 %
- Local consumption max. 60 MW
- Local economy based on fishing
- Partner operator of park & grid:



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# The HAEOLUS Project

- EU project, budget 7.6 M€
- Electrolyser beside Berlevåg harbour
- Capacity: 2.5 MW or 1 t/d
- Production start expected early 2021
- New 10 km power line from Raggovidda
- Virtually “inside the fence”
- Accessibility by road or sea
- Partner electrolyser manufacturer:

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H<sub>2</sub> A  $\Xi$  L U S



View of the electrolyser  
containment building

# The Berlevåg Electrolyser

- Production pressure: 30 bar
- “Upgrades” outside project scope
- Booster to 500–900 bar?
- Liquefaction plant not realistic
  - too small scale
- Located in Berlevåg harbour
  - County road 890
  - Container ships
- Raggovidda (capacity factor 50 %):
  - today 45 MW (9 t/d)
  - concession 200 MW (40 t/d)
  - Varanger potential 2 GW (400 t/d)
- With 1 kg hydrogen a car drives 100 km
- 35,3 billion km driven in Norway (2017)
- Varanger wind can supply > 40 % of Norwegian cars



## Wider Relevance

Problems addressed by HAEOLUS:

- Remote location
- Weak grid for export
- Intermittent sources
- No available hydro for energy storage

This is a *common predicament*:

- Strong winds are bad for harbours
- No people settle, power grid is minimal
- Strong winds correlate with flat terrain
- Hydro potential correlates with mountains

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HAEOLUS' use cases:

- Re-electrification
- Island mode
- Fuel export

HAEOLUS reports (see [haeolus.eu](http://haeolus.eu)):

- Impact on energy systems/RCS
- Business case analysis
- Techno-economic analysis
- Life-cycle analysis
- Diagnostics, prognostics, control
- Demonstration protocols

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# Difference from Battery Electrification

## Wind-hydrogen vs. Wind-battery

- Conversion efficiency (battery)
- Capacity cost (hydrogen)
- Export capability (hydrogen)



Hornsdale  
Power Reserve,  
Australia  
129 MWh,  
100 MW, 56 M€

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## Application deployment

- Batteries
  - Exploit available grid
  - Expand market
  - Leverage to expand infrastructure
- Hydrogen
  - No initial infrastructure
  - Synchronise supply and demand
  - Need central planning

# How to Start a Hydrogen Valley

Hydrogen producers want:

- to sell hydrogen regularly
- to have a reliable income
- not to go broke in the “Valley of Death”

Hydrogen users want:

- to be sure hydrogen will stay available
- a reliable supply chain
- a predictable hydrogen cost
- readily available maintenance

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Regional strategy in Troms & Finnmark

- Solid, known producer (Varanger Kraft)
- Identify key first movers on demand side
- Coordinate with local authorities
- Disseminate to local businesses



Hydrogen workshop in Vadsø

# Core Distribution System

- Pressurised tanks at 350 bar
- Commercial containers
  - 20' or 40' (resp. ca. 350 and 700 kg)
  - Cost 150–300 k€ each
- Compressor in Berlevåg
  - Advantage to start from 30 bar
  - Cost about 350 k€
- Minimal distribution system
  - 1 compressor and 2 containers
  - 0.7–1 M€ in investment
  - Container leasing? Smaller compressor?





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# Liholmen Biogas Plant

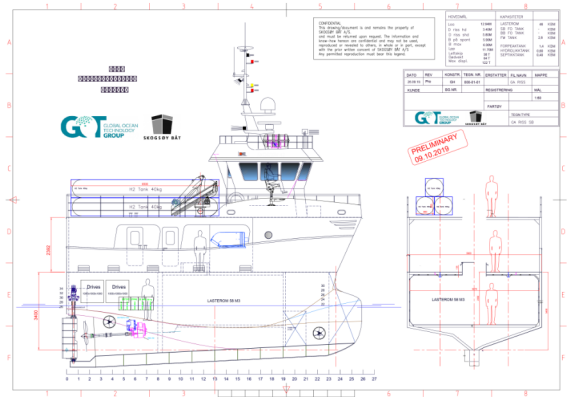
- Newly opened in “neighbouring” Båtsfjord
  - Produce biogas, burn in turbine, sell power
- Methanation of biogas ( $\text{CH}_4 + \text{CO}_2$ )
  - $\text{CO}_2 + 4 \text{H}_2 \longrightarrow \text{CH}_4 + 2 \text{H}_2\text{O}$
  - Biomethane more valuable as marine fuel
- Potential regular customer
  - Steady need for hydrogen
  - Long-term agreement possible
- Båtsfjord biogas plant
  - Right distance (90 km)
  - Right size (80 t/year)



Liholmen Biogass plant in Båtsfjord

# Fishing Boats

- Main economic activity in region is fishing
- Battery-driven boats already operate
  - *Karoline, Angelsen Senior*
  - Diesel remains for propulsion
  - Battery-only on fishing field
- Hydrogen can remove all emissions
- Several Berlevåg fishermen interested
- Feasibility study ongoing (GOT Skogsøy, Westcon, Gexcon, Hyon++)



Initial design of a hydrogen coastal fishing boat

# Fast Passenger Ferries

- Several shipyards have expressed interest
- Significant activity in other regions in Norway
- Kirkenes–Vadsø a possible case
  - Currently: 15 min plane or 2 hour drive
  - 40 km over the Varangerfjord
- Troms & Finnmark county running project
- Earliest operation in 2023



Brødrene Aa's H<sub>2</sub> Aero 42 concept

# Coastal Express

- The Coastal Express already stops in Berlevåg
  - Electrolyser is right by the dock
  - Visible application for tourists
- New competitor *Havila* seeks green profile
- 4 new ships from 2021 (all delayed. . .)
- New ships should be “fuel-cell ready”
- No fuel cells from the get-go, though



# Cars

- 1 t/d in enough for 3000 cars, not realistic but...
- Lighthouse effect (“world’s northernmost H<sub>2</sub> station”)
- Finnmark has fewest electric cars in Norway
- Users: Berlevåg municipality, Varanger Kraft, taxis
- Hyundai Nexo & new Toyota Mirai can drive & return anywhere in East Finnmark from Berlevåg
- Refuelling station in Berlevåg: Hydrogenics, Everfuel?



# Snowmobiles

- Great lighthouse potential
- Prototype developed in Austria
- Interest from Nordkapp municipality
- Zero-emission day trips for North Cape tourists
- Also relevant for Varanger Kraft to access Raggovidda



The Rotax HySnow prototype

# Hydrogen Planes

- Batteries are and will remain inadequate for commercial planes
- Airbus announced grand hydrogen strategy
- Norway has a large STOLport network in the North
- “Milk route” between Tromsø and Kirkenes
- No replacement for current Dash 8 after 2030
- Several proposals in the works



Widerøe's Dash 8's are critical to transport in Northern Norway



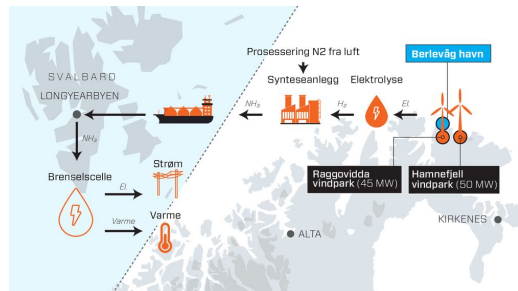
# Energy Supply to Svalbard

- 2100 inhabitants in Longyearbyen
- Old coal power plant, planned to be shut down
- LNG would be cheapest, but zero emission has support
  - Politicians, organisations and companies (Statkraft, NEL)
- Hydrogen import or  $\text{NH}_3$  as energy carrier?
- $\mu\text{CHP}$  is an off-the-shelf technology
- Gradual introduction of hydrogen into the energy system



# Ammonia Production

- “Grand plan” of Varanger Kraft
- *Green ammonia* from electrolysed hydrogen
- Extension to over 100 000 tons  $\text{NH}_3$
- Electrolyser capacity 40–50 times HAEOLUS
- Key markets:
  - Shipping industry (ZEEDS groups: Aker Solutions, Wärtsilä, Equinor, . . .)
  - Export to Svalbard and similar communities



## Conclusion

- Good areas for wind power have often weak power grid and little hydro potential
- Hydrogen deployment differs significantly from batteries
- Hydrogen infrastructure and users must be coordinated
- Several opportunities identified in Finnmark—Most promising is biogas and ammonia

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*Thank you for your attention!*



## Hydrogen-Aeolic Energy with Optimised eLectrolysers Upstream of Substation

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