Hydrogen Export to Svalbard

Exploiting Stranded Wind in Finnmark

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Outline

Motivation

Opportunity: The HAEOLUS Project

Quantification

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Hydrogen Import to Svalbard

- Not considered in Multiconsult's report
- Can exploit better green H_2 sources
  - Wind in Finnmark
- H_2 can be readily imported
  - Container solutions available
  - (Initially) also non-green H_2?
- Combined heat & power (CHP) fuel cells
  - High efficiency (45 %+45 %)
  - Market ready

Flexibility & Scalability in Deployment

- Fuel cells are modular
- Can be introduced gradually
  - Start with smaller pilot
  - Extend later: future-proof
  - LNG requires MW-class investment
- Can team up with local renewables later
- Distributed generation several places
  - Same efficiency
  - E.g. replacing boilers FH1–6
  - Better reliability with multiple systems
- Can make diesel generators obsolete

Hydrogenics “closet” with 4×33 kW fuel cells systems.
Each can be replaced individually.
Already deployed in 1 MW unit i Kolon, Korea (in a 40’ container).

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The HAEOLUS Project

haeolus.eu, @HaeolusProject, @Haeolus, Haeolus

- Hydrogen production from wind power
- Similar to Utsira project, but larger: 50 kW ⇒ 2.5 MW
- Stranded wind power in Varanger
  - 320 MW concession, 95 MW built
  - Bottleneck in Varangerbotn
  - Ressurser opptil 2000 MW
- Norway's best capacity factor, 50 %
- No significant hydro power for storage
- Can import 160 MW to maintain H_2 production
- Vision: produce and export hydrogen worldwide

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HAEOLUS Facts & Plans

- Production start: summer 2019
- Location: Berlevåg harbour
- Capacity: 1 ton H_2 per day
- Total committed production: 120 tons
- Project duration: 4 years
- Own power line to Raggovidda
- Total budget about 7 M€, EU contribution 5 M€

Berlevåg and the plant site at the harbour.

HAEOLUS Consortium & Objectives

Objectives:

- Demonstration of multiple use modes
  - Also mini-grid, relevant for Svalbard
- Hydrogen valorisation
- Sale of grid services
- Remote operation
- Control algorithms development
- Minimised maintenance by prognostics
- **33** public deliverables (18 reports)

Consortium:

- SINTEF (coordinator)
- Hydrogenics
- Varanger Kraft
- Tecnalia
- UniSannio
- UBFC
- KES

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Data Sources

- Energy cost from wind in Finnmark: 215 NOK/MWh[1]
- Electrolyser: 9.3 MNOK/MW, OPEX 7 % derav[2]
- Compressors: 6 MNOK/MW_{H_2}, OPEX 4 % derav[2]
- 40’ container, 780 kg_{H_2}: 3 MNOK
- Logistics Berlevåg-Longyearbyen: 10 NOK/kg_{H_2}
- CHP fuel cells: 25 kNOK/kW, 22 years[3]

Sources:

1. Multiconsult LCOE calculation for Davvi wind power plant
2. Noack et al. (DLR, LBST, Fraunhofer, KBB)
3. FCH JU’s Multi-Annual Implementation Plan (MAWP)

Full Deployment with only Imported Hydrogen

All Items are NPV over 25 years with 4 % Discounting Rate

Energy costs (262.6 GWh/y)	882 MNOK
30 MW Electrolysers	279 MNOK
Electrolyser OPEX	304 MNOK
Compressors	158 MNOK
Compressor OPEX	70 MNOK
243 hydrogen containers	729 MNOK
Logistics over 25 years	789 MNOK
Fuel cells in Longyearbyen	212 MNOK
Total	**3423 MNOK**
Energy cost	0.91 NOK/kWh

- Not very competitive with alternatives…
- … but actually OK kWh price
- 60 MW new wind power @ Raggovidda
- Burning some H_2 for heat—wasteful
- What can improve in time?
  - Fuel cell cost
  - Electrolyser cost and OPEX
  - Cheaper H_2 storage in Longyearbyen
  - Heat savings (−40 %)
- It can land at about 2000 MNOK

Pilot Deployment in Conjunction with HAEOLUS

Adapted to a 1 t/d production in Berlevåg

Investments	
Compressor	8 MNOK
Fuel cells	16 MNOK
10 containers	30 MNOK
Total investments	54 MNOK
Yearly OPEX	
Energy	4.1 MNOK/y
Logistics	3.6 MNOK/y
Compressor OPEX	0.3 MNOK/y
Total OPEX	8 MNOK

- Budget within range of an EU demo project
  - FCH JU call coming in January…
- Proceed in steps:
  - Replace diesel gensets
  - Supplement local renewables
  - Combine with battery storage (day cycle)
  - Gradually expand capacity
- Optimise battery+hydrogen+import
- Finally, take coal plant offline

Conclusions

- Hydrogen import to Svalbard is economically viable (0.91 NOK/kWh)
- Hydrogen import is more expensive than alternatives, if stand-alone
- Storage and logistics are major expenses; unlikely to drop
- Use import as support to local wind/solar to achieve zero emission
- Gradually introduce hydrogen, complete by 2038 (coal plant decommissioning)

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Thank you for your attention!

H_2 AEOLUS

Hydrogen-**A**eolic **E**nergy with **O**ptimised e**L**ectrolysers **U**pstream of **S**ubstation

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