Federico Zenith

Non-Technical Obstacles for Power-to-H_2

Hydrogen from Wind Power in Arctic Conditions

SINTEF Mathematics & Cybernetics

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Outline

Project and Context

Open Problems

Open Challenges

Conclusions

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The Haeolus Project

- EU innovation action, budget 6.9 M€
- 2.5 MW electrolyser in wind park
  - 1 t/d of hydrogen
- Multiple use cases, remote operation
- Objective: enable more wind power

H2 HAEOLUS

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- 2.5 MW electrolyser in wind park
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- Objective: enable more wind power
- “Stranded wind”
  - Concession: 320 MW
  - Resources: 2000 MW
  - Export capacity: 95 MW
- Site at Berlevåg harbour

Previous Projects

- The Utsira demo project
- Multiple FCH JU projects:
  - Don Quichote (2011, H_2+renewables)
  - MegaStack (2013, MW-scale stacks)
  - HyBalance (2014, power-to-gas)
  - QualyGridS (2016, grid services)
  - Refhyne (2017, industrial scale)
  - Remote (2017, mini-grid)
- IEA-HIA Task 24: *Wind Energy & Hydrogen Integration*
- Key learnings:
  - Re-electrification is economically difficult
  - Make hydrogen to sell hydrogen!

The Utsira, Norway,
50 kW / 215 kg_{H_2} system
(2004)

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Supply Chain

- Many system components are *not* off-the-shelf
- Risk of extensive downtime
- Example of Gaustad refuelling station:
  - Failure in early July
  - Delays due to holiday seasons
  - 2 months delay before repairs
- Wind power often in remote areas
- Reduce risk by:
  - Off-the-shelf components if possible
  - Redundant units
  - Backup units
  - Supply-chain risk assessment

The H_2 station in Gaustad, Oslo, facing SINTEF HQ (now decommissioned)

Market Generation

- Available applications do not consume enough
  - Too few cars, buses, etc.
- Hydrogen export to Svalbard
- Maritime applications are promising
  - Fast passenger ships
  - Coastal express (Havila)
  - Aquaculture (fish farms)
- Industry
  - Ammonia production
  - Steel production (Hybrit, H2Future)
  - Mining, ore processing

Outline

Interaction with the Grid

- Electrolysers can service all reserves
  - Nearly immediate ramping
  - Potentially attractive side-income
- Saturation already by few electrolysers?
  - Energy generation context
- Access to interruptible power tariffs
  - Produce H_2 without wind if scheduled
  - Power tariff in Norway: 36 €/kW/y
  - Interruptible tariff: 1.8 €/kW/y
  - Regional operators have their own

Hour	Price NOK/MW	Volume MW
1	180	33
2	139	34
3	139	34
4	139	34
⋮	⋮	⋮
18	18	34
19	18	25
20	17	48
⋮	⋮	⋮

Price for primary reserves on October 3, northern Norway.

Green Certification

- Norwegian-Swedish scheme for new renewable capacity
  - Energy in *new* plants (like Raggovidda) is awarded a certificate
  - Certificates are traded in their own market
  - Power companies must buy a certain quota of certificates
- In practice: boost to kWh price, about 66 %
- Note: HAEOLUS is *inside the fence*
  - Certificates are lost, energy for hydrogen more expensive
  - Green *hydrogen* certificates to compensate? CertifHy?
- Green energy certificates will be repealed
  - Plants built after 2021 are not eligible
  - Currently eligible plants will remain for 15 years

Logistics Cost

- CH_2 containers are expensive
  - Can cost as much as energy
  - Need multiple ones in movement
    - » 1 at producer
    - » 1 at consumer
    - » 2 en route to each
- Deploy cheaper hydrogen spheres
- Bulk transport options: gas, liquid
- Chemicals (CH_3OH, NH_3, LOHC…)
- Inject in natural gas grid

Political-Level Involvement

- H_2 from wind requires large consumers
- Politicians can be decisive in investments
- Easier to work in small constituencies
  - Mayor of Berlevåg present at HAEOLUS meetings
  - Good contact with Finnmark county government
- Shorter decision chains
  - Decision on project participation in Finnmark: less than 23h
  - Same in Trøndelag: days/weeks

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  - Find large-scale consumers
- Focus: maritime applications and Svalbard supply
- Further demo projects:
  - Coastal express
  - Fast passenger ferry Kirkenes-Vadsø
  - Svalbard CHP with hydrogen import

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Thank you for your attention!

H2AEOLUS

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

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