Federico Zenith

Large-scale hydrogen production from wind power in Arctic conditions

The HAEOLUS project

SINTEF Mathematics & Cybernetics

Nordic Hydrogen & Fuel Cell Conference
October 9, 2018
Reykjavík, Iceland

Outline

Motivation

The Project

Future Perspective

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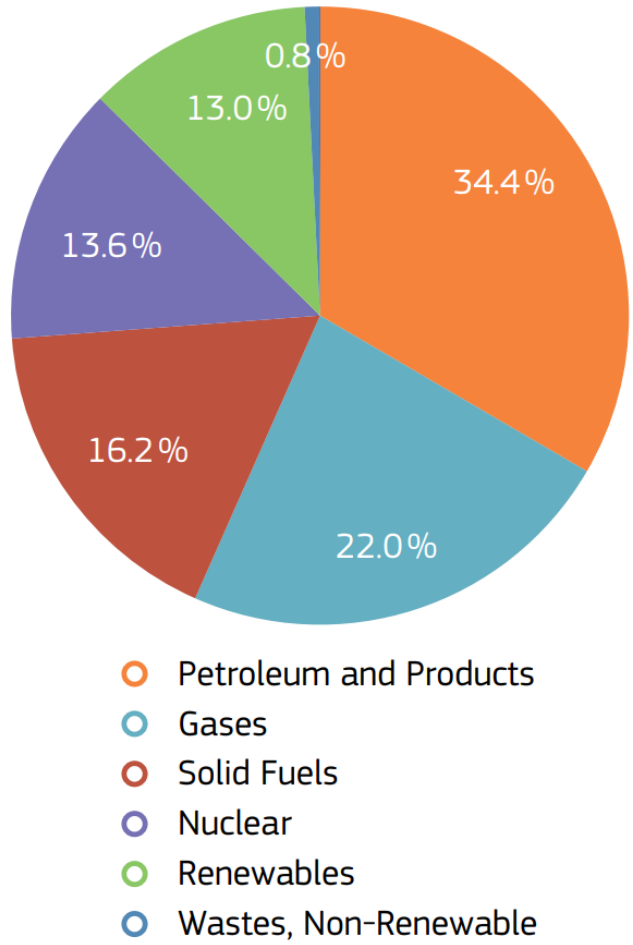
- EU 2030 target: 27 % renewable energy consumption
  - In 2015 it was 13 %
  - *Production* is already 26.2 % (2015)
  - No renewables in energy imports
- Most renewables produce electricity
- Several are not controllable
- Some are unpredictable

2015 EU consumption



Constraints of Wind Power

- Hard to predict production
- Capacity factor about 33 %
- Need reserve capacity
- Often, good wind power is found where:
  - there is little hydro potential
  - few people live
  - the grid is weak
  - accessibility is difficult
- All this even more true for offshore wind!

The Connection between Hydrogen and Wind

- Beyond 20 % wind share, value plummets
  - *Gonzalez et al., Ren. Ener., 29.4 (2003), 471–489*
- Hydro is rarely possible
- Batteries are too expensive
- Hydrogen has lower efficiency
- IEA's HIA task 24 identified 3 main cases:
  - Energy storage
  - Mini-grid (e.g. islands)
  - Fuel production
- Grid services, reserves, target matching…

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

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The Haeolus Project

http://haeolus.eu - @HaeolusProject

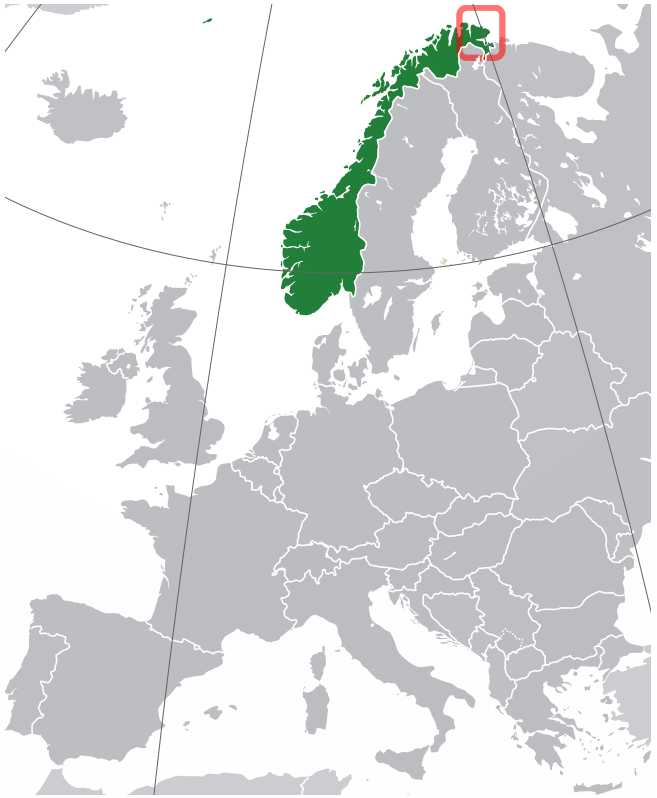
- A FCH2 JU Innovation Action
- Objectives:
  - Enable more wind power
  - Test multiple use cases
  - Demonstrate a 2.5 MW system
  - Demonstrate remote operation
  - Report & disseminate
- Key figures:
  - Budget: 6.9 M€ (5 M€ from EU)
  - Time frame 2018–2021
  - Capacity 1 t/d
  - Production start: late summer 2019

Kick-off in Oslo, January 2018

The Wind Park

Raggovidda wind park, **Berlevåg** municipality, **Varanger** peninsula, **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:

VARANGER KRAFT

The Electrolyser System's Site

Raggovidda wind park, **Berlevåg** municipality, **Varanger** peninsula, **Finnmark** county

- Located beside Berlevåg harbour
- Compact 2.5 MW PEM electrolyser
- 100 kW fuel cell for re-electrification
- New 10 km power line from Raggovidda
- Virtually "inside the fence"
- Accessibility by road or sea
- At least 120 t over 2.5 year
- Partner electrolyser manufacturer:

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

View of Berlevåg, site highlighted

H_2 ARGOLUS

Grid Services

- Wind energy production target match
  - Currently: prediction outsourced
  - 3rd party paid in % of production
  - Easily quantifiable potential
  - Adjust electrolyser to fulfil target
- Primary, secondary & tertiary reserves
  - Electrolysers are easily ramped
  - Can acquire slots in all reserves
- Project partner:

tecnalia

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.

Other Activities

- Remote operation
  - Relevant for many wind parks
  - Run demonstration from Italy
- Partner software developer:

KES
Knowledge Environment Security Srl

- System prognostics
  - Reduce on-site inspections
  - Optimise maintenance
  - Avoid unscheduled stops
- Partner university:

UBFC
UNIVERSITÉ
BOURGOGNE FRANCHE-COMTÉ

- Dynamic modelling
  - Process model & optimisation
  - Control synthesis
- Partner university:

University of Sannio

- Control implementation
- Integration with smart grids
- H_2 valorisation plan
- Coordinator:

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Expected Impact
From Short to Long Term

- Convince Varanger Kraft to expand hydrogen production
- Export model to other sites in Europe (other EU projects?)
- Allow deployment of wind power beyond 20 %
- Push hydrogen utilisation in the area
  - Mobility, industry, etc.
- Contribute to EU renewable targets & energy independence

Public Deliverables

Reports (18):

- Raggovidda energy analysis
- Dynamic model & control
- Impact on energy systems, RCS
- Valorisation plan
- Business case analysis
- Road to MAWP 2023 targets
- Techno-economic analysis
- Environmental performance
- Demonstration protocols & data

Other (15):

- Workshop at ECC2019 Naples
- Real-time demo on website
- Plant visit
- Academic seminars
- Student internship
- Presence at industrial fair

What to Do with the Hydrogen?

Valorisation Plan: Identified Opportunities

Action	Realism	Size	Gimmick
Svalbard energy supply	✓	✓	✓
Coastal ships	(✓)	✓	✓
Fishing boats	✓	✓	
Ammonia production	✓	✓	
Aquaculture	(✓)	✓	
Fast passenger boats	(✓)	✓	
Cars	✓		✓
Regional mini-buses	✓		
Waste collection trucks	✓		
Backup generators	✓		
Snowmobiles			✓
Regional planes		✓	✓
ZE steel production		✓	
Mining and ore processing		✓	

Conclusion

- Hydrogen can boost wind power
- HAEOLUS will test relevant cases for Europe and beyond
- Many possibilities for hydrogen use—the most promising still to develop, though

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Thank you for your attention!

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

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