

Kraftprodusentenes betydning for utvikling av hydrogenøkonomien

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DIREKTØR FORRETNINGSUTVIKLING OG SAMFUNNSKONTAKT



**Råstoffene til fremtidens drivstoff:
elektrisitet og vann**

..for snart 150 år siden

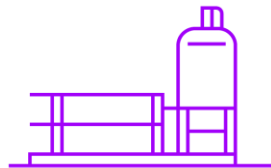
‘Ja, mine venner, jeg tror at vann en dag vil bli benyttet som drivstoff, at hydrogen og oksygen som vann består av, brukt for seg eller sammen, vil bli en uuttømmelig kilde til varme og lys, av en intensitet som kull ikke er i stand til. (...) Vann vil bli fremtidens kull.’

Jules Verne

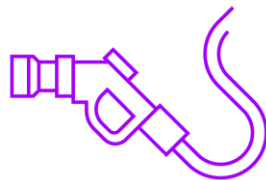
DEN MYSTISKE ØYA, 1874

Nel ASA

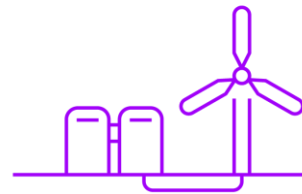
- Pure-play hydrogen company listed on the Oslo Stock Exchange – facilities in Norway and Denmark
- Three divisions offering hydrogen technology and solutions for industrial and energy applications
- More than 850 hydrogen solutions delivered in 60 countries world wide since 1927
- World #1 on hydrogen electrolyzers and hydrogen fueling – unrivalled performance and track-record
- Financially strong company with a world-class experienced management team in place



Hydrogen Electrolyzers



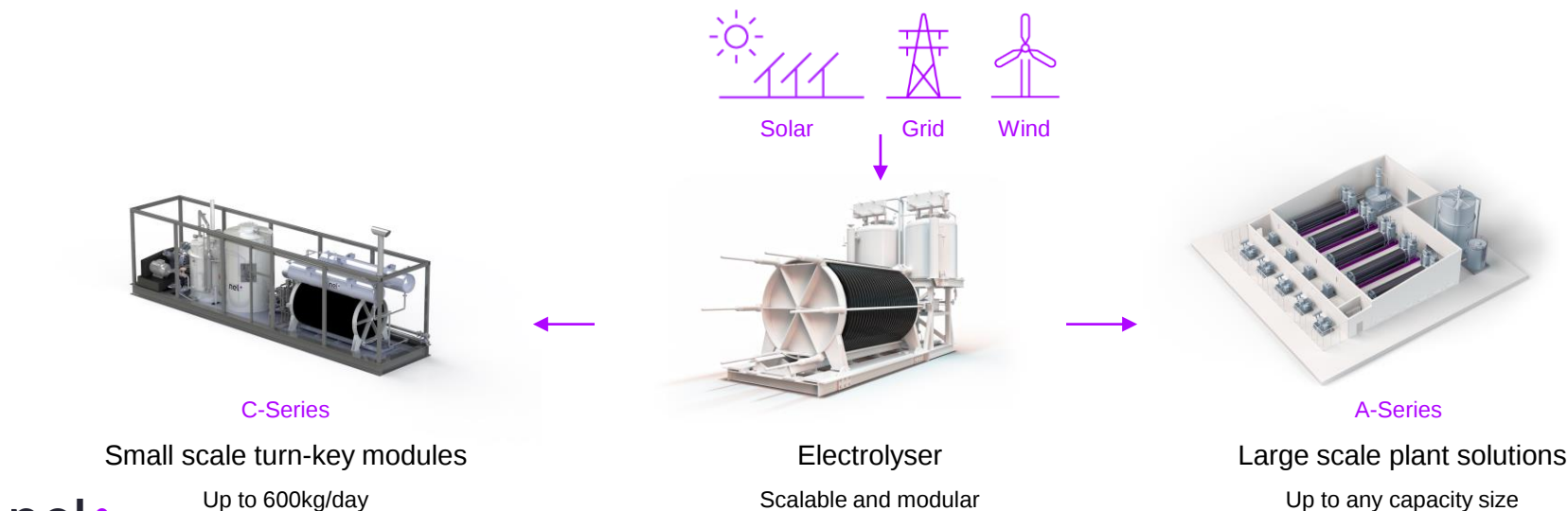
Hydrogen Fueling



Hydrogen Solutions

Nel Hydrogen Electrolyser

- Global leader in hydrogen prod. plants - highest uptime, lowest conversion cost, robust and reliable
- More than 850 hydrogen solutions delivered in 60 countries world wide since 1927
- Highly scalable production capacity for industrial, energy and transport applications



Nel Hydrogen Fueling

- Global leader within hydrogen fueling solutions, first to adapt the newest fueling standards
- Delivered more than 30 stations in 8 countries across Europe since 2003
- Highest reported availability and innovative, in-house developed technologies



High capacity, smallest footprint

200 kg/day, 10m²



Flexible installation, smallest footprint

50 m from station, 1/3 size of normal dispenser



Largest manufacturing facility

300 station per year capacity

Nel Hydrogen Solutions

- Unified delivery of complex renewable hydrogen solutions, efficient system integration, project development and sales across segments
- Only provider of integrated solutions along the entire value chain:
 1. Fueling Networks
 2. Renewable Hydrogen & Storage Solutions

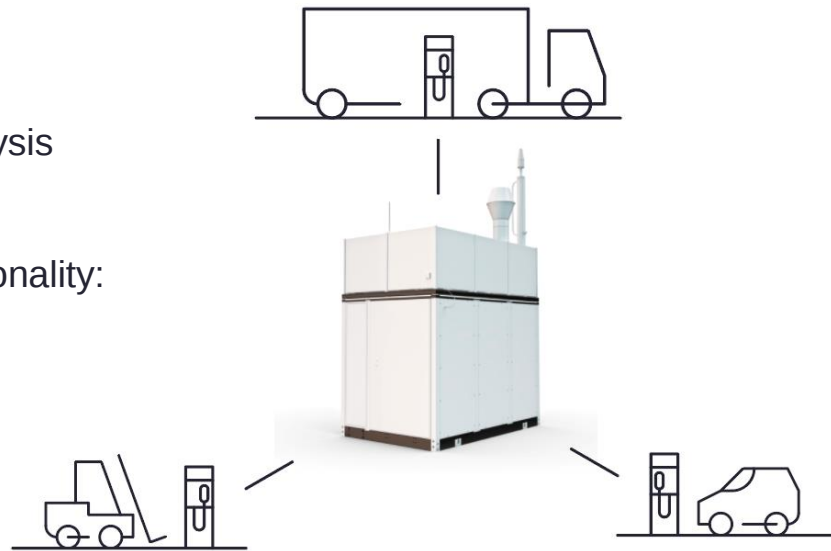


Nel integrated capabilities example: Multi Purpose Station for ASKO

Nel Hydrogen Solutions

Nel awarded contract with ASKO, Norway's largest grocery wholesaler with 600 trucks on Norwegian roads

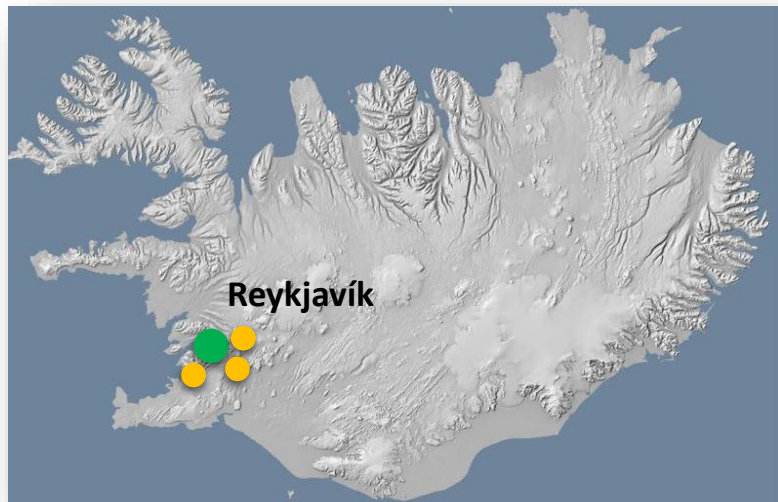
- Will be installed in Trondheim during 2017
- Locally produced renewable hydrogen from electrolysis
 - Will be tied to solar power from warehouse roof
- H2Station® will be installed with triple-fueling functionality:
 - Trucks
 - Forklifts
 - Cars



Infrastructure examples globally: Iceland & California

Nel Hydrogen Solutions

Will build hydrogen network in Iceland



- Central hydrogen production
- Hydrogen station

Will build hydrogen network in California

Awarded framework contract with Royal Dutch Shell Plc (Shell) to deliver several HRS in California

- Shell will build 7 hydrogen fueling stations through a partnership with Toyota Motor Corp.
- Nel will deliver H2Station® and associated operation & maintenance services



The hydrogen opportunity

Why now?

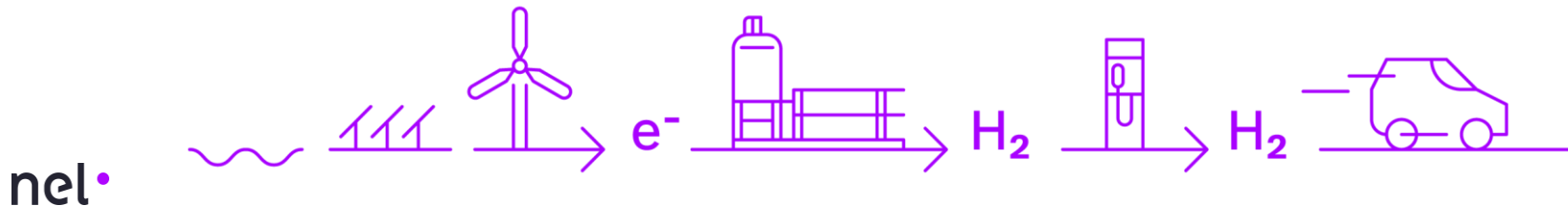
The hydrogen opportunity

Renewable electricity is becoming competitive & also creates new challenges

- Cheap renewable = cheap hydrogen, creating “fossil parity”
- Timing of supply/demand does not always match - hydrogen “bridges the gap”
 - Hydrogen solutions needed to realize full potential of renewable energy

Hydrogen cars are available and affordable

- High global focus on zero-emission transportation
 - Climate, environment, local energy security & health
- Big advances in cost/quality within hydrogen technology for automotive purposes
 - Majority of car manufacturers see hydrogen as the main breakthrough for electric/zero emission mobility



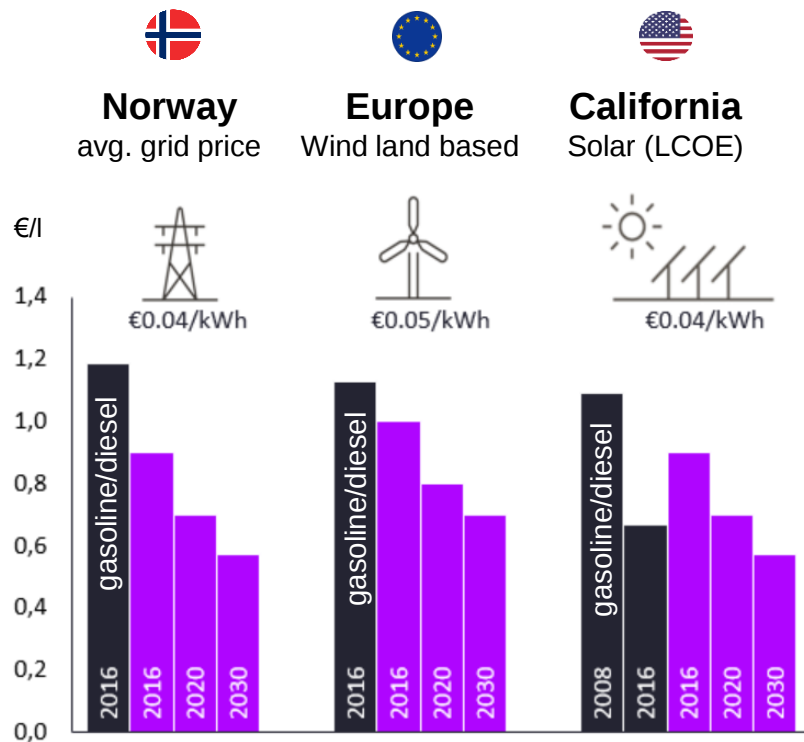
Renewable hydrogen has reached “fossil parity” in multiple markets

The hydrogen opportunity

Renewable hydrogen is set to out-perform gasoline on a cost basis, due to substantial cost reductions for renewables & hydrogen technologies

Assumptions:

- Pump price for hydrogen is converted to a €/litre equivalent
- Incl. both CapEx and OpEx without subsidies
- Electricity and gasoline prices incl. applicable energy taxes, excl. VAT
- **Capacity utilization makes the difference, assumes utilization of 70% on installed equipment**



Available and affordable

The hydrogen opportunity

- All major car manufacturers are deploying Fuel Cell Electric Vehicles (FCEVs)
- Major cost reductions enable commercial introduction
- Additional car manufacturers are expected to launch FCEVs models in the coming years

\$499/month lease
(incl. hydrogen)



\$349/month lease
(incl. hydrogen)



TOYOTA

\$369/month lease
(incl. hydrogen)



HONDA

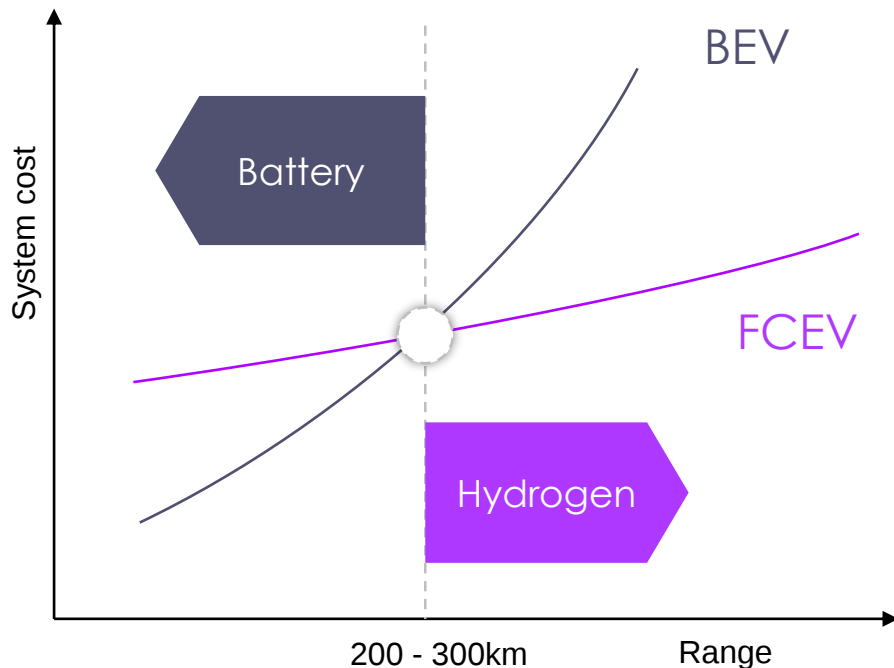
2018



Mercedes-Benz

Is the solution batteries or hydrogen? ..or both?

The hydrogen opportunity



- For small vehicles with short – medium range, BEV is the lowest cost solution
- However, increasing BEV-range comes at a higher system cost than increasing FCEV-range
- Cost-curves between technologies intersect around 200 – 300 km for passenger vehicles
- For heavy duty vehicles, cost-curves intersect at a lower range

Batteries and hydrogen – best of both worlds

The hydrogen opportunity

BEV-only range:

170km (24 kWh)

BEV + FC range:

500km (24 kWh + 3,8 kg H₂)



Nissan E NV200

The automotive industry sees hydrogen as the most important fuel of the future

The hydrogen opportunity

78%

of executives absolutely or partly agree that FCEVs will be the real breakthrough for electric mobility

62%

of executives absolutely or partly agree that BEVs will fail due to infrastructure challenges



KPMG: Global Automotive Executive Survey 2017

..and are putting money behind their words: pledge USD 10.7 billion investment

The hydrogen opportunity

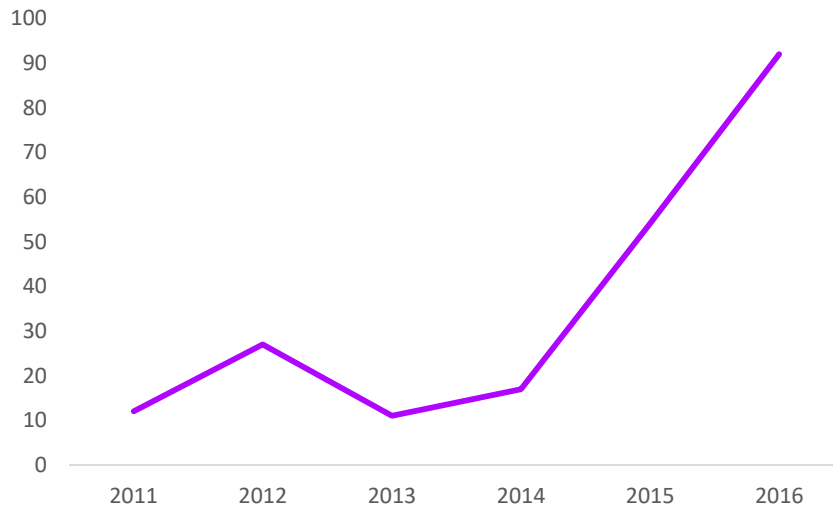


When will it “take off”? Are we at the inflection point?

The hydrogen opportunity



Number of new hydrogen refueling stations opened globally



Local is good – short distance to market is key

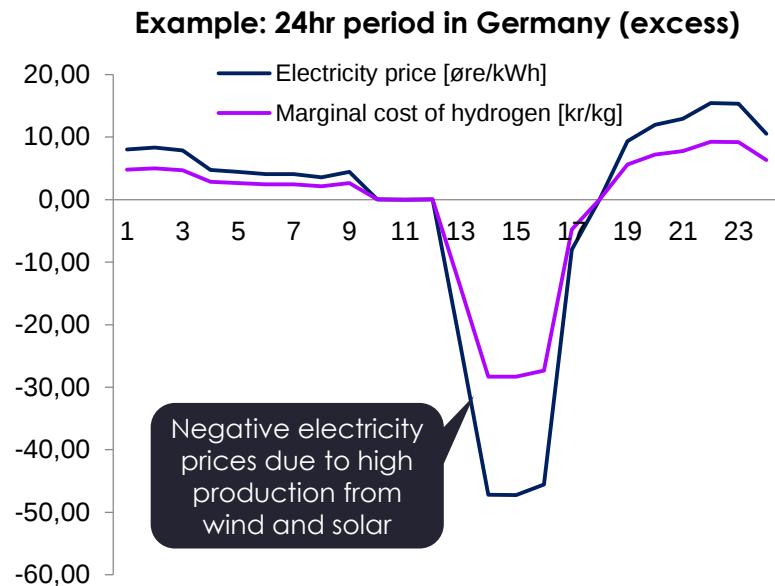
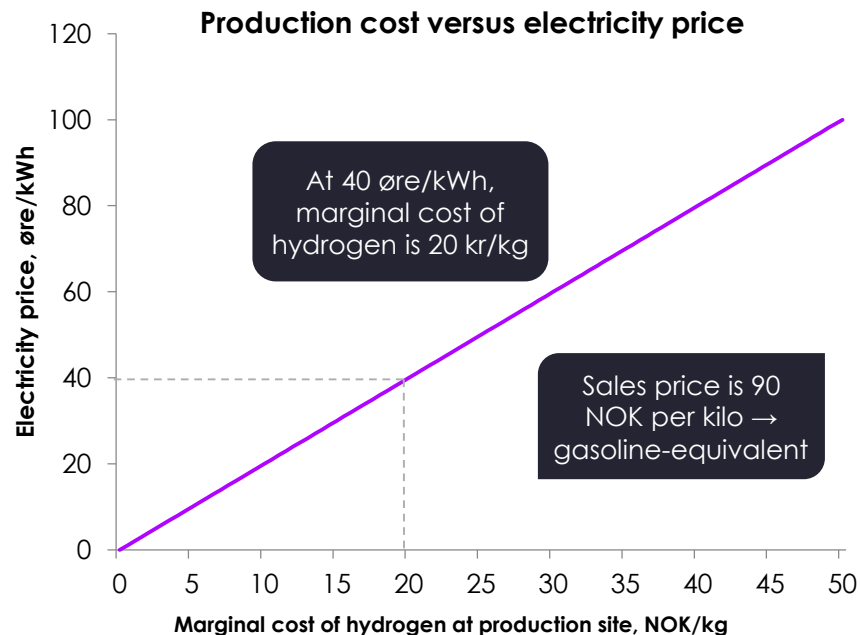
The hydrogen opportunity

- Several opportunities for electricity production have prohibitively high grid-connection costs
 - Option to establish dedicated hydrogen production
- Hydrogen production from electrolysis is exempt from electricity tax (elavgift)
- Transport of hydrogen costs 30 NOK/km for one load
 - If distance is 100 km and payload is 300 kg, cost will be 10 NOK/kg.
- **NEED LOCAL CONSUMPTION**
 - Cars, buses, trucks, ferries



Cheap electricity = cheap hydrogen

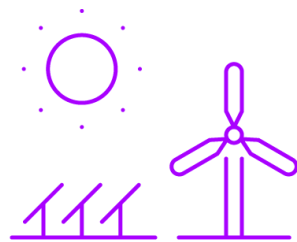
The hydrogen opportunity



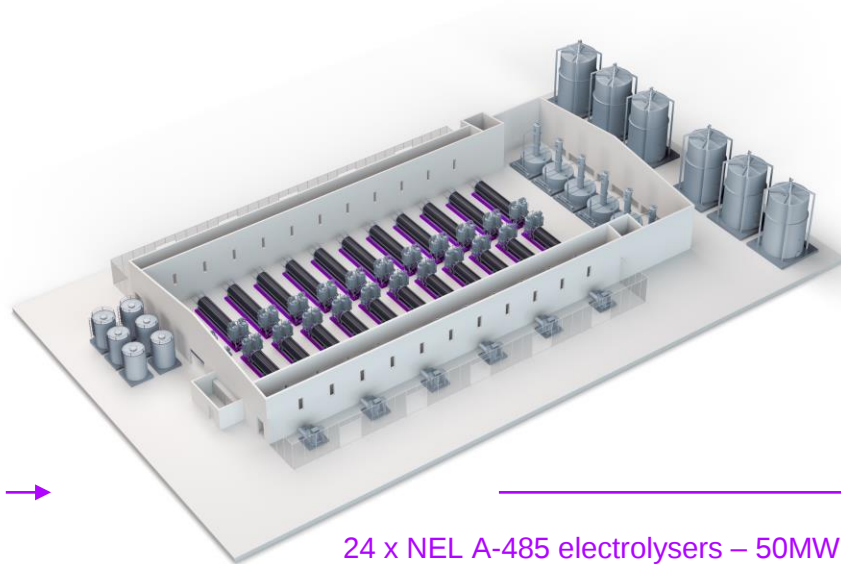
Hydrogen can be produced at a very competitive price from renewables

The hydrogen opportunity

Renewable power at 40 øre/kWh enables production of hydrogen at plant < 30 NOK/kg, including capital investments



40 øre/kWh



24 x NEL A-485 electrolyzers – 50MW

< 30 NOK/kg



55.000 cars/year



1.000 buses/year



500 trucks/year

The new “milk van”

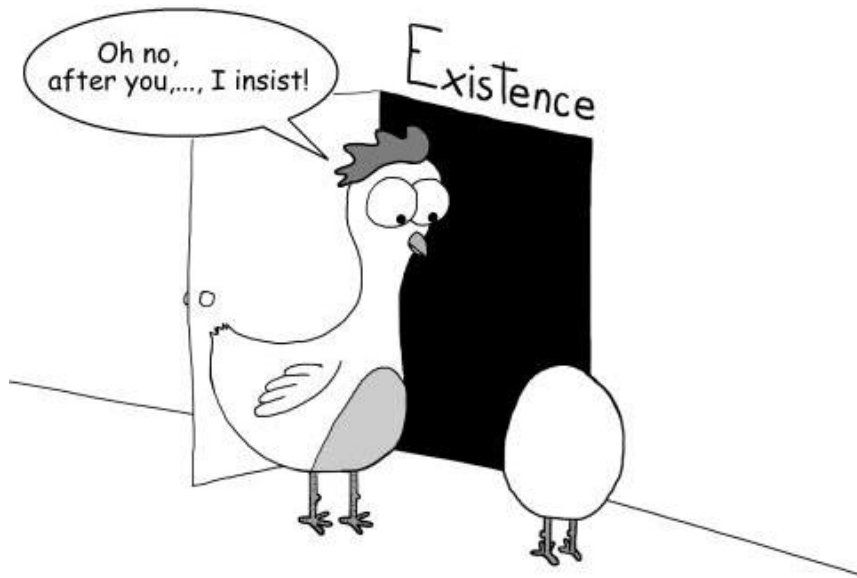
The hydrogen opportunity

- Hydrogen can be produced at power plants, and stored as compressed gas on-site. Two main transport options:
 - Cartridge-type storage containers for direct transport & installation/swap at user
 - Transport trailer filled at site & unloaded into fixed storage at user
- Storage and transport as liquid hydrogen also an option, but due to significant capital investments and energy demand, only suitable for large plants (minimum 5 ton per day), in excess of 20 MW continuous power. Also demands special storage tanks at user.
 - Maritime sector evaluates liquid hydrogen as attractive option for large vessels



What are the obstacles to implementation of hydrogen in Norway?

The hydrogen opportunity



Need for incentives to support both infrastructure and users

Near- and long term market opportunities



New support program for zero-emission vehicle (ZEV) procurement

- Support program from Enova for ZEV procurement for professional/non-private users
- Supports added costs of purchasing ZEVs:
 - Small companies: 50%
 - Large companies: 40%
- Taxis, trucks & fork lifts included
- Program for establishment of hydrogen infrastructure will follow during spring 2017

- Det er starten på slutten for fossil kjøring

Energiministeren og Enova innfører støtte til utslippsfrie varebiler og lastebiler for bedriftene. Miljøstiftelsen Zero sier dette er begynnelsen på slutten for fossil kjøring.



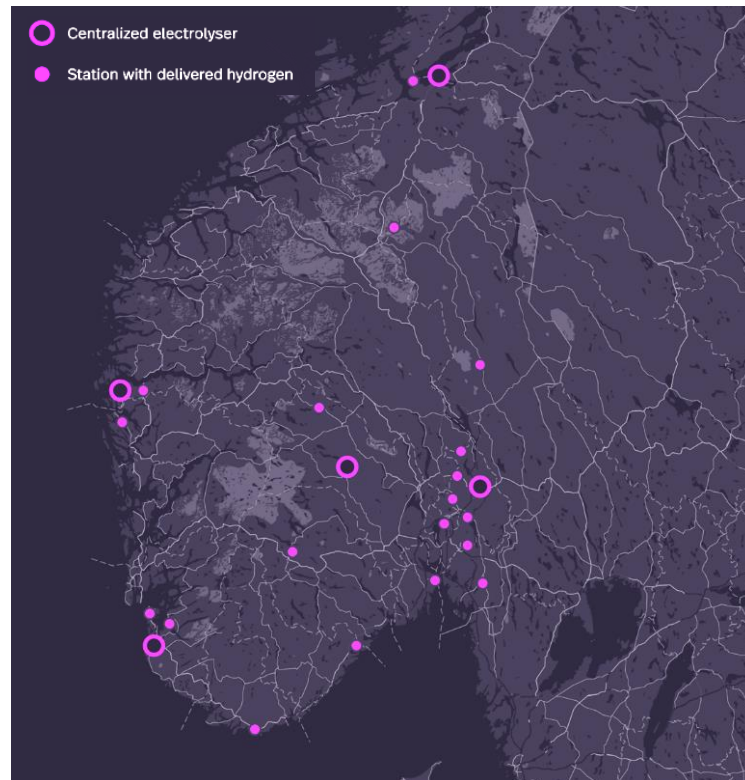
Hedvig Bjørgum
@nrkhedvig
Journalist

- MER OM KLIMA OG MILJØ
- MER OM BIL OG MILJØ
- MER OM KLIMATOPPMØTET I PARIS

Oppdatert 31.01.2017, kl. 15:52

Uno-X Hydrogen – JV to build Norwegian HRS infrastructure

- JV between Uno-X (41%), NEL (39%) and Praxair (20%)
- Target to build nationwide hydrogen fueling station network in Norway by 2020 (minimum 20 HRS)
 - 1st station opened Nov. 2016, target of 4 new during 2017
 - Strong partners with complementing knowledge and experience, Nel to provide hydrogen technology and competence
- Norway is attractive for FCEV-users:
 - World-class FCEV incentives, with no vehicle or value-added tax, free access to public transport lanes, free public parking, and free passage on toll roads
 - Hydrogen in Norway is 100% renewable



Svalbard as a «hydrogen society»

Svalbard currently generates all its electricity production from coal power

- Resulting CO₂-footprint per citizen is 40 tons per year, 4x mainland emissions, included petroleum activities
- Alternatives for electrification have been evaluated by SINTEF
 - Compared to cable to mainland Norway, a hydrogen pathway will save Svalbard NOK 100 million annually

	CO ₂ -utslipp (tonn/år)	Strømpris (kr/kWh)	Investeringskostnad (i millioner kr)	Årlig kostnad (i millioner kr)
 Diesellaggregat	60 000	1,80	30	200
 Sjøkabel	0	3,60	5 000	400
 Vind + H ₂	0	4,80	5 500	530
 H ₂ -import	0	2,60	1 000	290
 Sol + H ₂ -import	0	2,40	1 500	270

<http://gemini.no/2016/10/svalbard-kan-bli-hydrogensamfunn/>



Chimney from the coal power plant
in Svalbard
Photo: Roy Mangersnes / Samfoto

Mega-scale hydrogen production and export to international markets

BIG opportunities for exporting renewable energy to the global markets via hydrogen

- Kawasaki Heavy Industries is developing a liquid hydrogen carrier in collaboration with Shell
- Several Japanese delegations have visited Norway to explore potential further, looking both at pathways from natural gas and renewable electricity
- Best wind resources in north of Norway, but weakest grid – also short route to Asian markets
- Nel part of feasibility study with strong partners¹ with with to study large scale hydrogen export from Norway



January 26, 2016 2:22 am JST

Japanese energy industry

Hydrogen import hub seen to further diversify fuel supply

OSAKA -- Two companies will partner with the city of Kobe to establish a hydrogen import terminal to debut in fiscal 2020, with the project aimed at expanding the use of the environmentally friendly fuel in Japan.

Energy supplier [Iwatani](#) and [Kawasaki Heavy Industries](#), an industrial machinery maker, will build the roughly one-hectare hub on city-owned land inside the island housing Kobe Airport, with total costs estimated to exceed 10 billion yen (\$83.5 million).

Illustration/Source: Kawasaki Heavy Industries|Nikkei Asian Review

Summary

1. Renewable electricity is becoming competitive & also creates new challenges

- Cheap renewable = cheap hydrogen, creating “fossil parity”
- Timing of supply/demand does not always match – hydrogen “bridges the gap”

2. Hydrogen cars are available and affordable

- High global focus on zero-emission transportation
- Big advances in cost/quality within hydrogen technology for automotive purposes

3. Incentive schemes to stimulate market are being established in Norway

- Support for users of hydrogen vehicles
- Support for hydrogen infrastructure

Electricity being the *raw material* for the future fuels, this represents large opportunities for the power sector in Norway, both near- and long term

Number one by nature