## Norway - an energy nation. in 2050 ?

Intl. Workshop RES & H<sub>2</sub> for Export

Trondheim, 24<sup>th</sup> March 2015 **Dr. Steffen Møller-Holst** Vice President Marketing, SINTEF

> Chairman Transport FCH JU – N.ERGHY

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## Outline

- Norway's position as an energy nation
- Pre-requisites for retaining this position
- Norway's potential role in an international context
- Hydrogen export as one potential pillar in the energy future

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Courtesy: RCN

#### Norway - an energy nation.....





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7<sup>th</sup> largest exporter of oil
 3<sup>rd</sup> largest exporter of natural gas
 2<sup>nd</sup> highest GDP per capita

Security of supply is not an issue
Power generation, > 98 % renewable, potential for more

- Robust distribution grid for electricity
- Norway has 50% of Europe's capacity for pumped hydro

Courtesy: RCN

## Norway's oil- and gas production

 Return on investment > 1 100 Bill € since 1970 a'collective'

NORWEY

- Constitutes 22 % share of total GDP
- Employs ~ 50 000+ people
- responsibility The CO<sub>2</sub>-emission from Norwegian oil- and gas export corresponds to that of a population of 100 - 150 million
- Long experience and high level of competence in Carbon Capture and Storage (CCS) technologies

- Energy resources available compatible <sup>w</sup>/sustainability criteria
- Technology available to exploit and export "new" energy
- Political ambitions, capability and courage
- Adequate framework conditions
- Industrial commitment

#### Energy resources available compatible "/sustainability criteria





- Energy resources available compatible "/sustainability criteria
   Natural Gas "/CO<sub>2</sub> capture & storage (CCS) in North Sea bed
- Huge potential for (new) renewable resources
  - Ocean energy (tidal, wave)
    On- & Off-shore wind-power
    Run-off rivers







- Energy resources available compatible "/sustainability criteria
- Natural Gas <sup>w</sup>/CO<sub>2</sub> capture & storage (CCS) in North Sea bed

**Courtesy: Statoil** 

- Large-scale storage of  $CO_2$  on the continental shelf represents a potential solution for Norwegian  $CO_2$  storage and large European  $CO_2$  emission point sources.
- Capacity > 30 Giga-tons of CO<sub>2</sub> in North Sea
  - 8 years of Europe's CO<sub>2</sub> emission
  - 500 years of Norway's CO<sub>2</sub> emission



"Norway – still an energy nation in 2050 ?"

#### **Huge Wind resources:**

~ 14 000 TWh

~100 x Domestic annual electricity production:

Courtesy: Statoi



Courtesy: Miljødirektoratet

*Onshore:* 

000 TWh

"Norway – still an energy nation in 2050 ?"

## Wind energy

Technically feasible deployment of on-shore wind in 2015 and 2025 (MW)



Area 1
Grid limitations
45 MW installed
Grid extension 2025?
→ "Stranded" wind

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Areas 4 & 5:
1000 MW wind planned
Cost ~ 1 300 M€
Require grid extensions ~ 500 M€

- Applications and notifications under evaluation
- Given concession/complaint filed
- Technical feasible deployment by 2015 (MW)
- Technical feasible deployment by 2025 (MW)

#### **Huge Wind resources:**



High political climate ambitions & Effective measures in transport Agreement across political parties:

- Cut GHG emissions by 30 % of by 2020 (vs 1990)
- Minimum 2/3 of the GHG reduction domestically (1/3 quota)
- Carbon neutrality within 2050 (incl. quota)
- Cut emissions for passenger cars to 85 g  $CO_2/km$  (EU target 95 g  $CO_2/km$ )
- Efficient taxation and strong incentives for zero- and low emission vehicles

#### Political ambitions, capability and courage

#### Low political understanding of the need for cross-sectorial action

- No consistency in policy making, lacking inter-ministerial alignment:
  - Industrial and energy policy measures for national value creation are weak
  - Long term effort for development of CCS technology has been put on hold
  - Recent fall in oil prices eventually leads to political concern and debate
  - Lack of understanding that Norway may play a central role internationally
  - Policy framework is fragmented between ministries (stationary vs transport)

Incentives for Wind power in Sweden>Norway February 2015: Alignment of rules for depreciations of wind-farms between Norway and Sweden (20% / year) → Increased investments in Norway (30 % better yield)

#### Green Certificate market, Sweden/Norway

Targeting + 26.4 TWh / year RES by 2020

- → Surplus of electricity in the Nordic countries
- Electricity prices are already falling
- → Need to increase electricity demand to stabilize market

#### Adequate framework conditions



Aluminium production (pilot) Investment decision February 2015 Cost 450 mill €, ~ 1/3 public support Capacity 75 000 tons/year, Q3 2017 Requires robust power supply 100MW



6000

www.thewindpower.ne



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#### **From: Focus on traditional industries**

- Raw materials export (fish, minerals, timber)
- Slow adaptation of new industry
- Automation/lean production → high efficiency
- Low emission and safe oil & gas production

#### **To: Industrial Innovation Clusters**

- Transfer knowledge from oil and gas to new sectors of industry, incl. renewable energies
- Maritime operations, shipping, competence
- Interdisciplinary sandpit, new ideas
- Recommends large pilot plants to be built



#### Industrial commitment



Energy resources available compatible <sup>w</sup>/sustainability criteria



Technology available to exploit and export "new" energy



Political ambitions, capability and courage



Adequate framework conditions



Industrial commitment





## Norway's potential role internationally

Exporter of renewable electricity based on favourable wind/hydro



- The green battery of Europe, ~ 50 % of pumped hydro capacity
  - Norway's largest dam, Blåsjø, (capacity 8 TWh)
  - Several cables to Europe in the planning
  - Fear for increasing electricity prices in Norway
     → reluctance from Norwegian stakeholders
  - Significant "stranded" renewable energy sources in remote areas  $\rightarrow$  H<sub>2</sub>?



# WHY hydrogen production

#### Case Raggovidda wind park, Berlevåg:

- Provides > 4000 full load hours
- Long distances to market  $\rightarrow$  H<sub>2</sub>?
- Pre-study has revealed potential profitable business cases for H<sub>2</sub> production & export to Japan
- Co-production from Natural Gas may cut hydrogen cost significantly



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"Stranded" Wind potential: Finnmark (on-shore): 2000 MW = 8 TWh/year Otherwise hardly exploitable! May provide  $H_2$  fuel for 1 million Passenger Vehicles !

# WHY hydrogen production in Norway?



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## WHY hydrogen production in Norway?

Liquefied gas tankers (1970→) supported by: ③ SINTEF ◎ NTNU

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 $LNG \rightarrow LH_2 (\& CO_2)$ 



H<sub>2</sub> Liquefaction Reduction in energy consumption: 50 %

3. Status of Development

### Hydrogen Potential from Overseas





#### The polar route will connect us soon



Nordic countries may provide H<sub>2</sub> to Japan

- Liquid  $H_2$  may be shipped via the polar route.

#### Japan may supply FCEVs to Nordic countries

- Low emission carriers powered by boil off hydrogen.



## WHY hydrogen as fuel in Norway?

Because Transport contributes by > 30% to domestic GHG emissions, and battery electric vehicles cannot cover the demand in all segments of transport

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## WHY hydrogen export from



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## WHY hydrogen export from Norway?

Blending in H<sub>2</sub> in existing NG pipelines: 40 TWh/year

Dedicated H<sub>2</sub> pipeline for higher volumes

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## WHY hydrogen technologies in Norway?

Because Norway has

- vast unexploited, remote renewable energy sources (wind)
- $\blacksquare$  > 90 years' experience with industrial scale H<sub>2</sub>-production
- Because H<sub>2</sub> may

dramatically cut domestic CO<sub>2</sub>-emissions (fuel for transport)
 supplement electricity as energy carrier (grid balancing & export)
 <u>be (co-)produced from natural gas with CCS</u>

Competent R&D institutions "/wide international network
 Engaged politicians& industry 

 National value creation
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