



Norwegian Efforts in Hydrogen

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Norwegian spending on H2&FC in 2008

Area of research	US\$: (millions)	Norwegian Kroner (millions)
Production of hydrogen	4,5 M\$	25,8 MNOK
Hydrogen storage	4 M\$	22,5 MNOK
Hydrogen transportation	2,8 M\$	32,3 MNOK
Other infrastructure and systems R&D	0,08 M\$	0,420 MNOK
Stationary fuel cells	2 M\$	11,5 MNOK
Transport fuel cells	2,2 M\$	12,4 MNOK
Total	18,82 M\$	105 MNOK

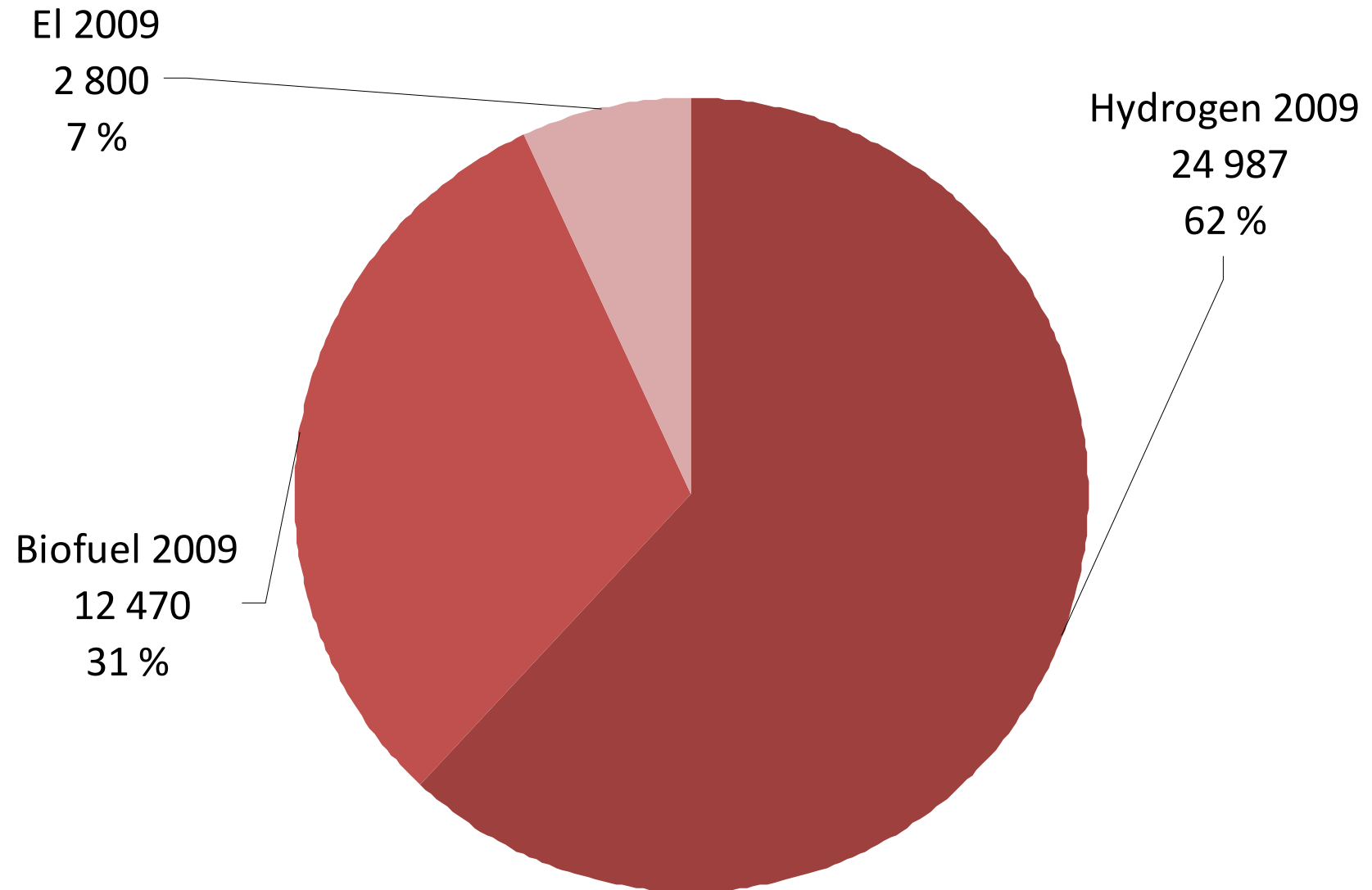
RCN Large Scale Program

RENERGI - Clean energy for the future

- Priority research areas

- Renewable energy
- **Natural gas and hydrogen**
- Energy efficiency
- Energy markets and Energy policy
- **Environmental friendly transportation**
- Energy systems

Transportation portfolio RENERGI 2009



Hydrogen in RENERGI

Total project portfolio of 32 projects in 2009

Area of research	No of projects:	Funding by RCN in 2009
Production of hydrogen	15 projects	31 MNOK
Hydrogen storage	5 projects	5,6 MNOK
Demonstration in transportation	12 projects	29 MNOK
Total	32 projects	61,6 MNOK (11M\$)

Production of hydrogen

- 15 projects
- Total funding from Research Council in 2009: 31 MNOK (5,6M\$)
- Important aspects in the Norwegian effort:
 - Large resources of natural gas
 - Well developed industry in both steam reforming and electrolysis

Project example:

Developing next generation low cost and durable pem water electrolysers

Sintef



Hydrogen storage

- 5 projects
- Funding from Research Council in 2009: 5,6 MNOK (1M\$)
- Important aspects in the Norwegian effort:
 - High competence in research institutes, especially in solid materials
 - Also high competence in related technologies as CNG, LNG
 - Several hydrogen tank producers (Raufoss, Umoe, Hystorsys)

Hybrid Hydrogen Storage

Hydrogen storage in vehicles by using hybrid storage units - pressurised metalhydrides in composite tanks

IFE, Hystorsys

Hydrogen demonstration

- 8 projects
- Total funding from Research Council in 2009: 29 MNOK (5M\$)
- Important aspects in the Norwegian effort:
 - Hy-nor project
 - Develop filling stations with H₂ from a variety of sources

Think Hydrogen

- **Objectives:** develop, demonstrate and produce a HFC-battery plug-in hybrid vehicle
- Think city battery electric vehicle developed in Norway. Integrated into a hybrid system with a 10 kW Ballard fuel cell by H2-Logic in Denmark
- Long range due to a hybrid solution of a battery and a fuel cell system (120 + 120 km)
- Status: 5 cars delivered to Danish customers, 5 more cars to be delivered to Hynor in 2010.
- RENERGI supports two projects: development of the vehicle + customers purchase and use of the vehicle

Title: Think Hydrogen and use of Think hydrogen in the Hynor project

Support from RENERGI: 9,1 + 2,1 mill. NOK (1,63M\$ + 0,38M\$)

Duration: 2007 - 2010



HyNor – short history

- Initiative started in 2003
- Objective: broad market demonstration of hydrogen for transportation in Norway
- Vision:

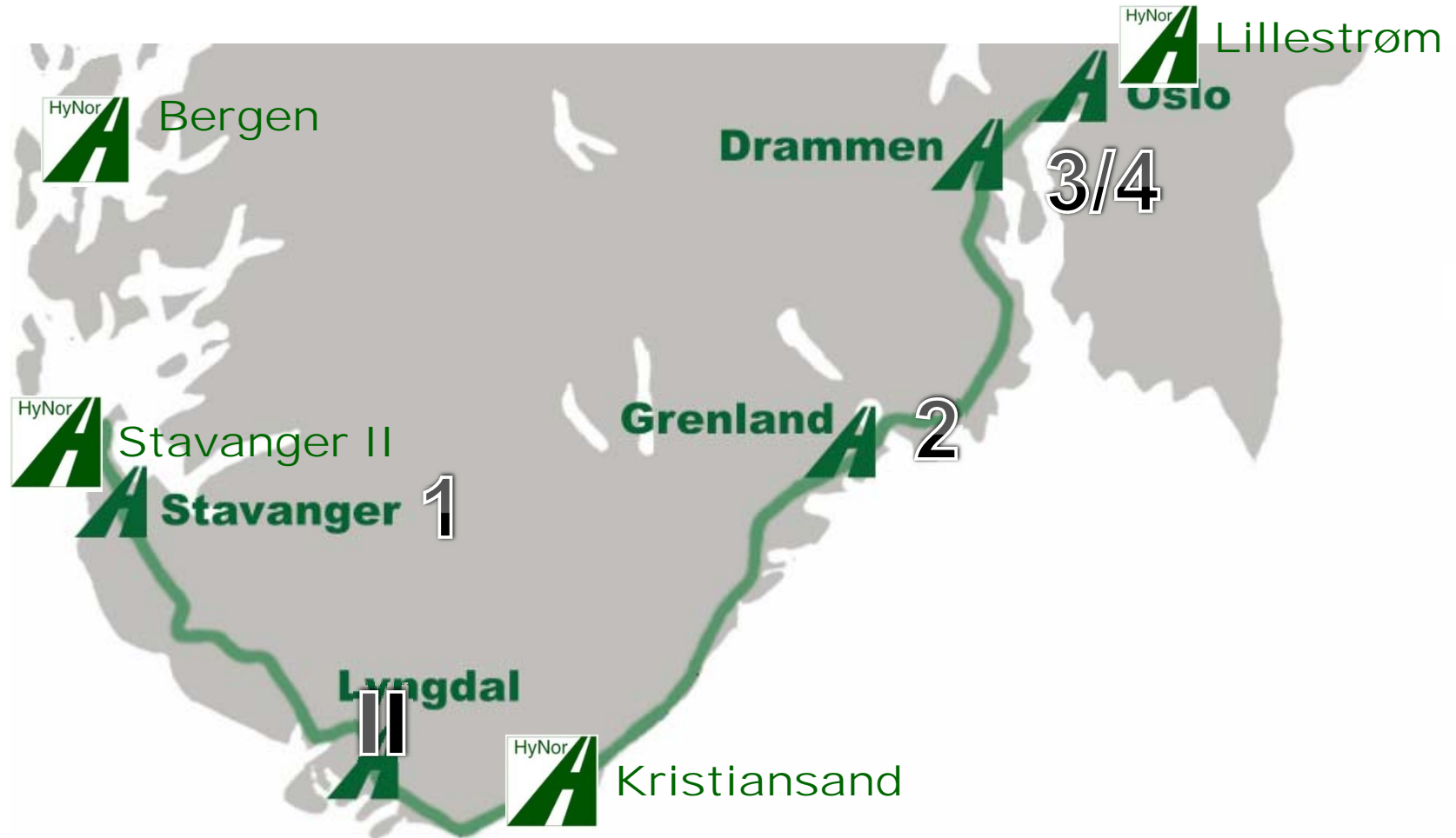
“In 2009 it shall be possible to drive hydrogen fuelled vehicles between Stavanger and Oslo ”

- Public-private partnerships



The Hydrogen Road of Norway

The HyNor nodes



Approach – integration into retail

- All hydrogen stations are open to the public and/or integrated into a public filling station
- High visibility – people get used to having it around
- High focus on safety
 - At and around dispenser
 - While filling
 - Emergency response plans
- Payment – based on card payment at dispenser
- Learning, training and systematic HSE and quality work needed
 - Operators of station
 - Local fire and police department



HyNor Stavanger – Norway's 1st hydrogen station



- Opened August 2006 as an integrated part of a petrol station
- Hydrogen, Hythane (8% H₂ in Natural Gas) and Natural Gas
- Start-up with trucked in hydrogen
- Upgraded to 700 bar technology in 2009

HyNor Grenland



- Opened in 2007
- Next to Statoil research centre at Herøya, Grenland
- Directly linked to large scale hydrogen production, scalable solution
- Possibility for supply and back-up for other HyNor stations
- Underground storage, 150kg @ 400 bar, high pressure tanks submerged in liquid
- Hydrogen delivered at 350 and 700 bar

Opening of HyNor Oslo + Drammen, May 11th 2009



HyNor Oslo and HyNor Drammen concept



- Filling station concept developed by Statoil – working on commercialization
- Moveable solution
- 350 and 700 bar fillings, 2-nozzle dispenser
- Storage: 46 kg @ 900 bar, 34 kg @ 200 bar
- Room for electrolyser at station

Vehicle fleet in the HyNor project



15 Toyota Prius
Converted to ICE Hydrogen
by Quantum (US)
Range: 170 km



5 Think Hydrogen
10kW FC (range extender)
Total range: 250 km



10 Mazda RX-8
Delivery in 2009/2010
Flexifuel wankel engine
Range: 100 km H₂,
50 km gasoline



More cars + buses
Other car manufacturers
have expressed interest in
testing their H₂-cars in HyNor

Ongoing work with acquiring a
number of buses to 2011

HyNor phase II, 2010 - 2015

- Focus on market, diversity and adapting infrastructure
- Strengthen cooperation with neighbour countries and other projects
- Making the hydrogen road longer, but also “thicker”
 - 4 new filling stations
 - 30 additional vehicles
 - 5 hydrogen buses
 - Hydrogen utility vehicles
- Maintaining HyNor’s attractiveness for large scale testing of hydrogen vehicles
 - Clusters of stations
- Repeating this year’s success of the Viking Rally



HyNor phase II – new stations

- **HyNor Lillestrøm (2010)**
 - Located 20km north of Oslo, close to IFE
 - Grid-connected PV & PEM-electrolyzer
 - Bio-hydrogen via Sorption Enhanced Steam Methane –Reforming (SE-SMR)
 - Thermal Sorption Metal Hydride Compression
- **HyNor Bergen (2011)**
 - ZEGPower concept
 - Solid oxide fuel cell coupled with SE-SMR
- **HyNor Stavanger II (2011)**
 - New filling station at Risavika pier, Norway's biggest harbour
 - On-site natural gas reforming
 - Hydrogen utility vehicles
- **Lyngdal and Kristiansand (hopefully 2011)**
 - Need of a hydrogen station to cover HyNor road stretch between Grenland and Stavanger





Some challenges

- Industry- science mismatch: few active firms
- Lack of SME industry base
- Strong R&D in research inst. but few start-ups
- Large firms - less attention to hydrogen



Thank you!

Incentives supporting Hydrogen in Norway

- Hydrogen vehicles exempt from purchase tax (2006)
- Admission to public lanes
- Free public parking for fuel cell vehicles (2008)

