



# Norwegian Efforts in Hydrogen

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## Norwegian spending on H2&FC in 2008

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

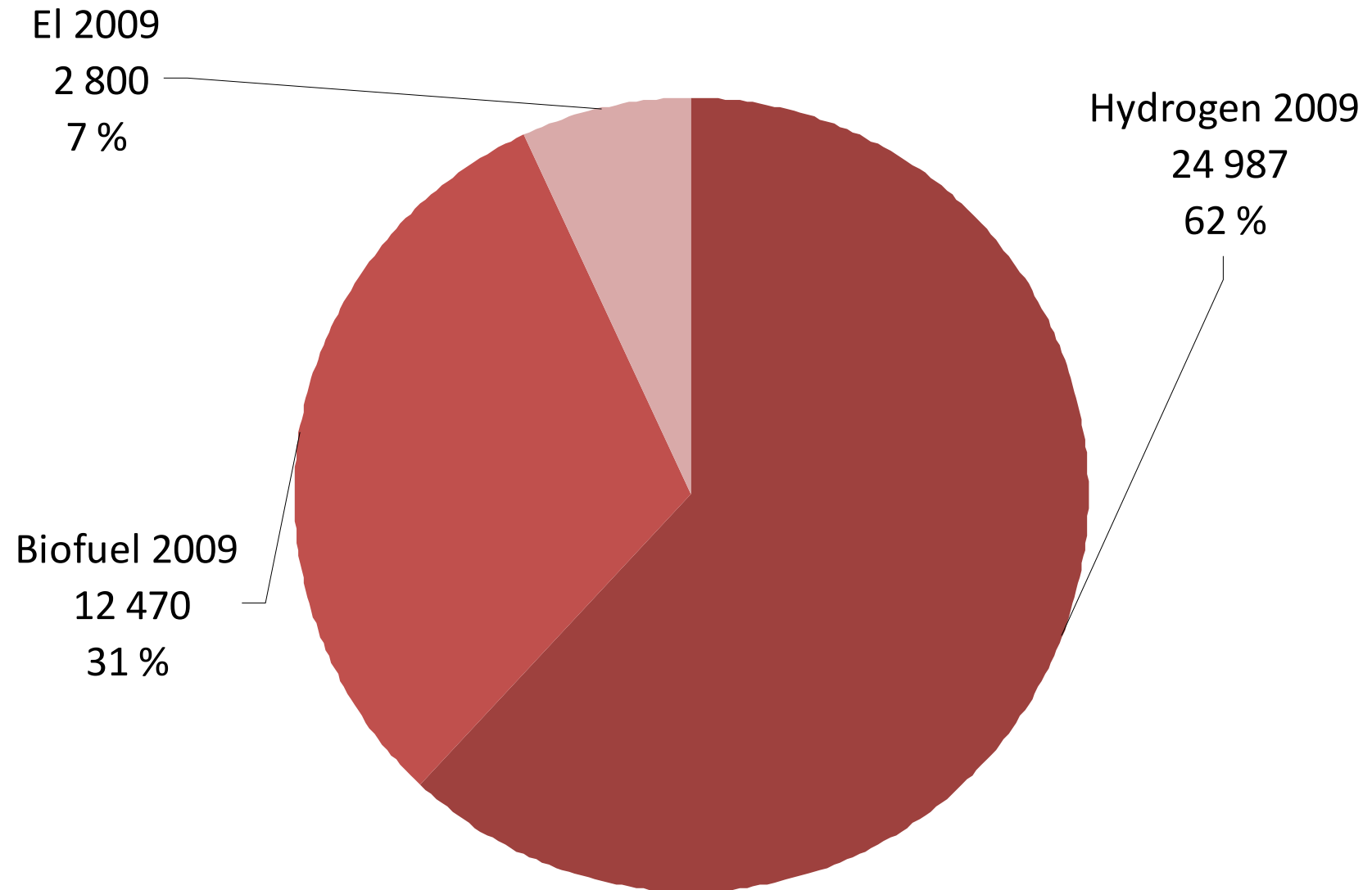
## RCN Large Scale Program

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
<b>Production of hydrogen</b>	<b>15 projects</b>	<b>31 MNOK</b>
<b>Hydrogen storage</b>	<b>5 projects</b>	<b>5,6 MNOK</b>
<b>Demonstration in transportation</b>	<b>12 projects</b>	<b>29 MNOK</b>
<b>Total</b>	<b>32 projects</b>	<b>61,6 MNOK (11M\$)</b>

## 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

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## Hydrogen demonstration

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- 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 H<sub>2</sub> 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:

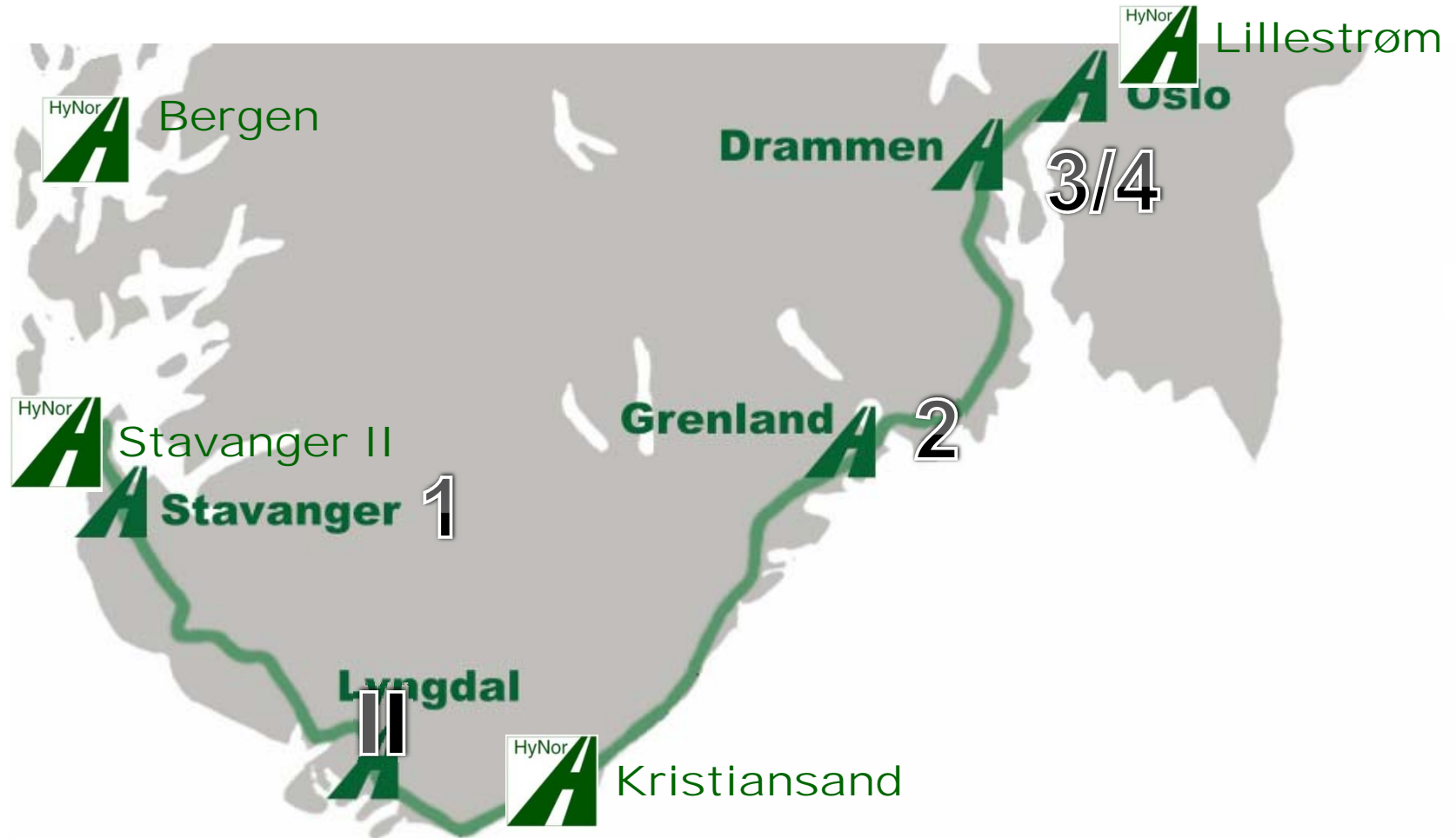
***“In 2009 it shall be possible to drive hydrogen fuelled vehicles between Stavanger and Oslo ”***

- 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 1<sup>st</sup> hydrogen station



- Opened August 2006 as an integrated part of a petrol station
- Hydrogen, Hythane (8% H<sub>2</sub> 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 11<sup>th</sup> 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 H<sub>2</sub>,  
50 km gasoline



**More cars + buses**  
Other car manufacturers  
have expressed interest in  
testing their H<sub>2</sub>-cars in HyNor  
  
Ongoing work with acquiring a  
number of buses to 2011

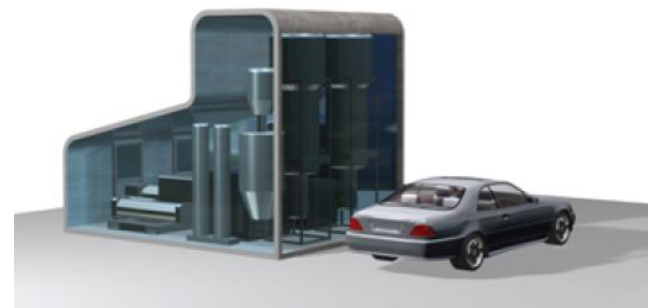
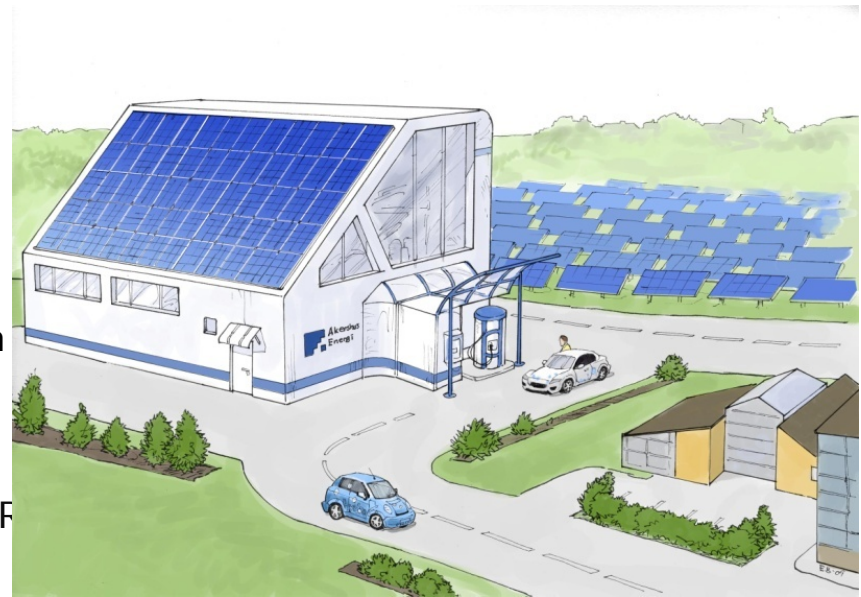
## HyNor phase II, 2010 - 2015

- 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)

