Hydrogen + Fuel Cells
International Conference
Hannover April 2005

Experience with creating a Hydrogen Economy in Iceland- newest results

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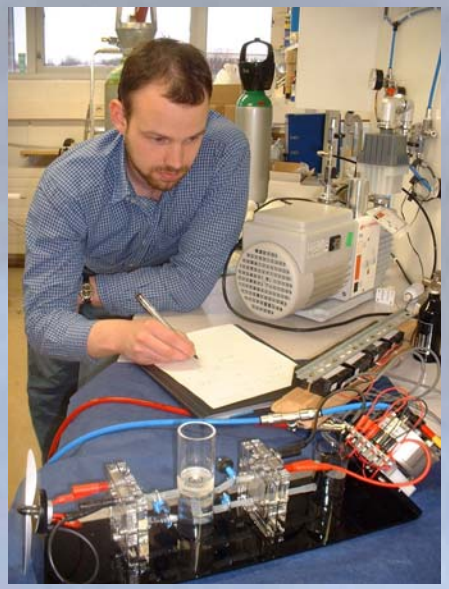
Why hydrogen in ICELAND

1. **Iceland has the unique circumstances to enable operating a "hydrogen based fuel project" in a CO_2 neutral environment**
2. **Iceland is the country in the world with the highest proportion of renewables in its energy portfolio, 71%.**
3. **Iceland has experience in converting from one energy source to another. In the past century two conversions were made to hydroelectric and geothermal energy.**

Why hydrogen in ICELAND

4. **It is very important that the project makes a big impact (real-scale project)**
5. **The new technology needs to be evaluated under severe weather conditions**
6. **The government of Iceland has announced that it is aiming to transform Iceland into a hydrogen society in the near future**

Unique INE structure / objective



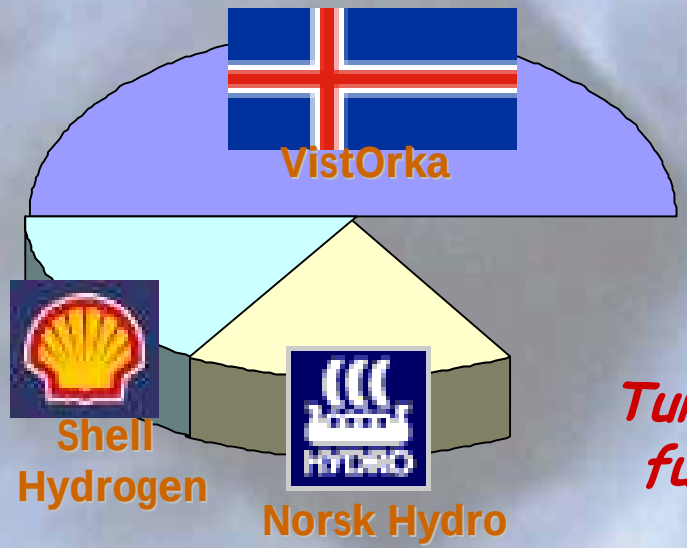
Energy, know-how and an exellent H_2 research platform

Icel. New Business Venture Fund, Reykjavik Energy, The National Power Company, Hitaveita Sudurnesja, University of Iceland, The Technological Institute of Iceland, Fertilizer Plant, Reykjavik Resources, Government of Iceland

Unique INE structure / objective

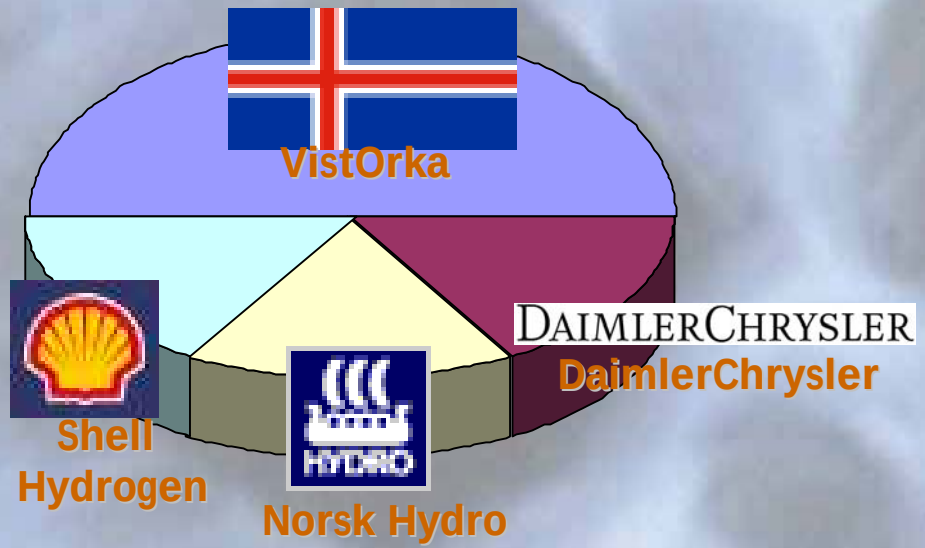
Design for the future H_2 infrastructure

Unique INE structure / objective



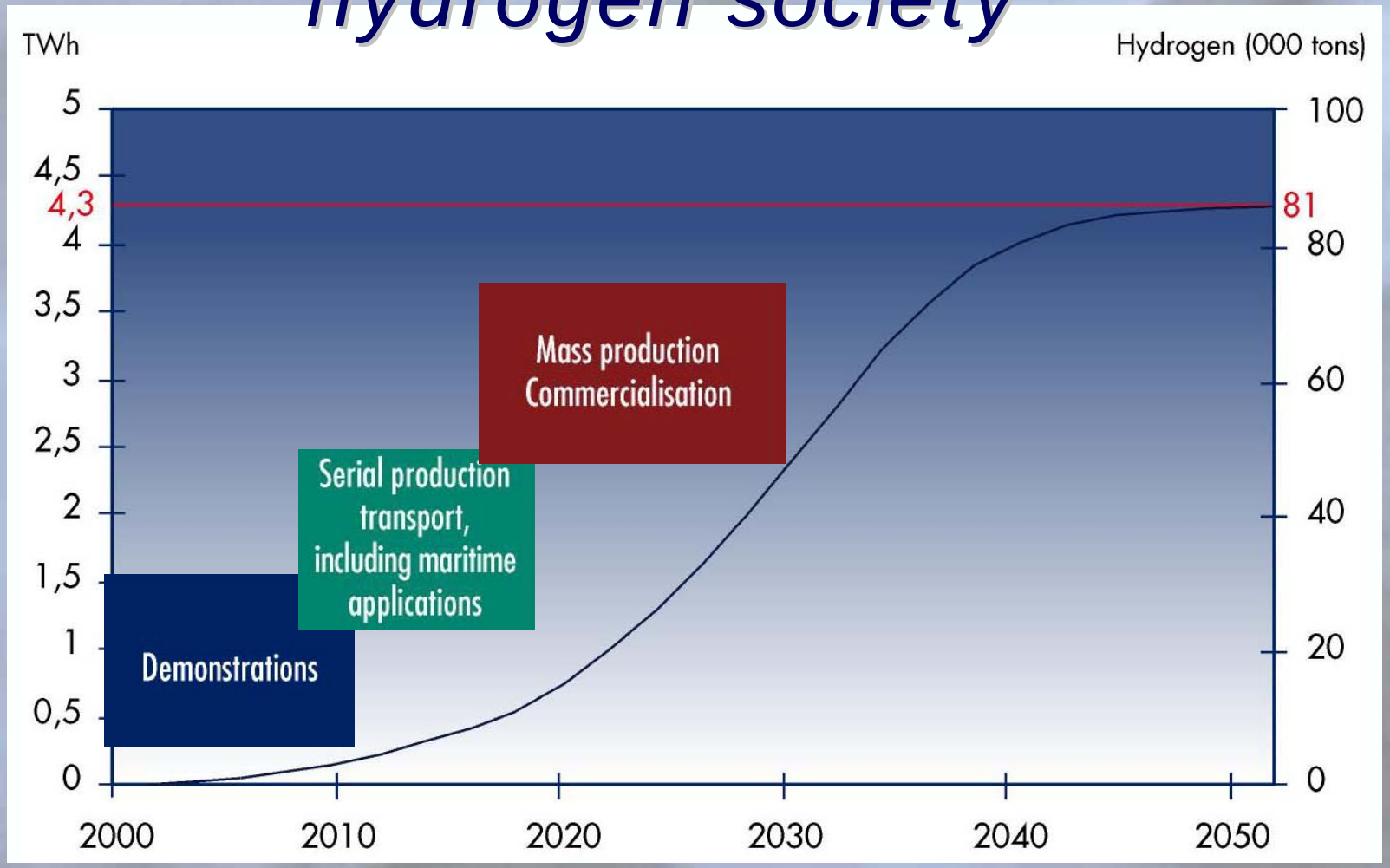
Turn key solutions for the future H2 infrastructure

Unique INE structure / objective



H_2 and fuel cell vehicle development

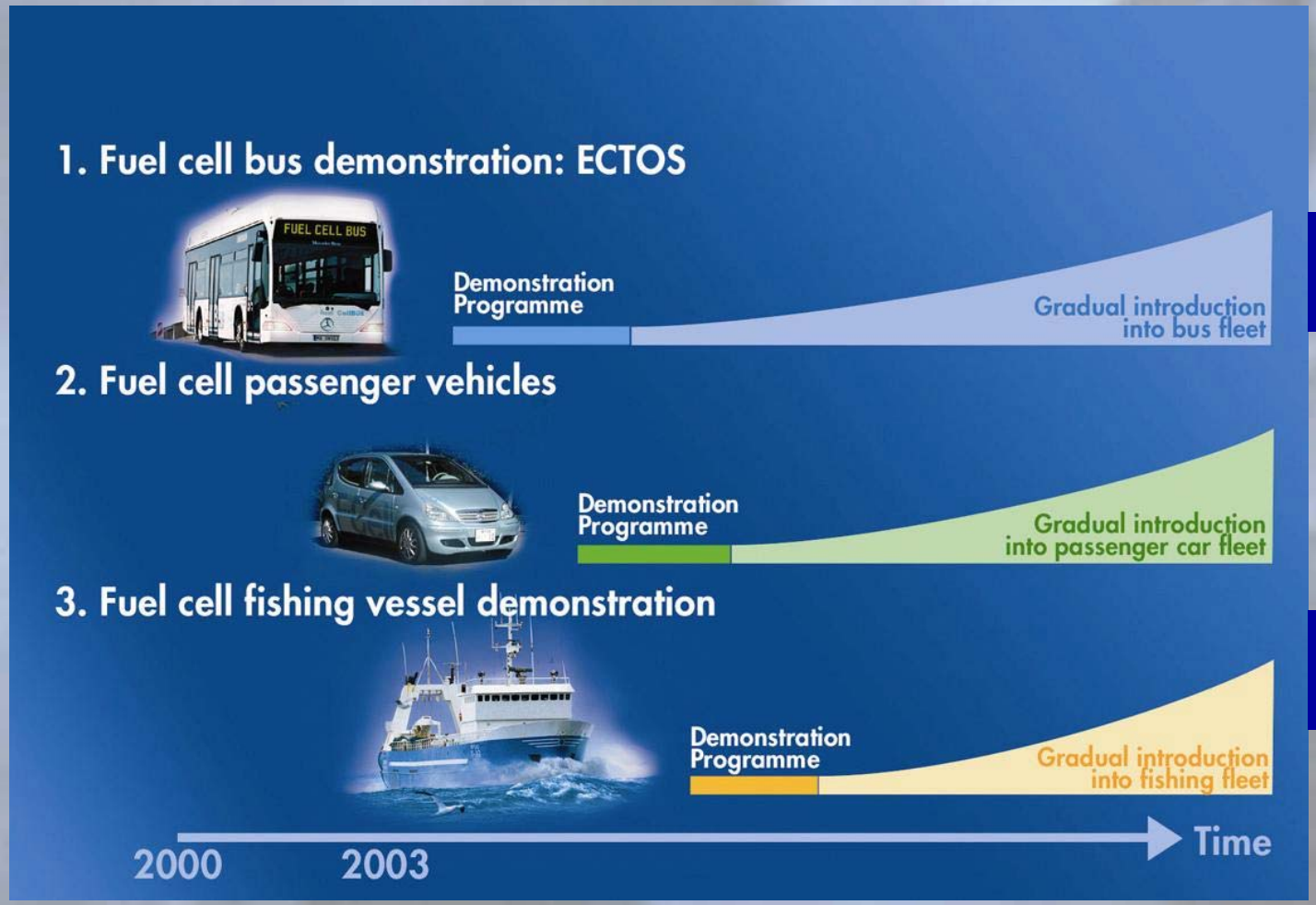
Energy use in a hydrogen society



Energy use in a hydrogen society (cont.)

- **This plan is in coherence with projected development in the field**
- **Iceland has an advantage**
  - **Abundant renewable energy source**
  - **Small society - an island society**
  - **High level of energy know-how**
  - **Political stamina**
- **Every opportunity to accelerate the pace**

Key Projects



NEW-H-SHIP

The ECTOS-project (2001-2005)

- **The ECTOS-project is a 4 year project**
- **The project can be split into two key phases:**

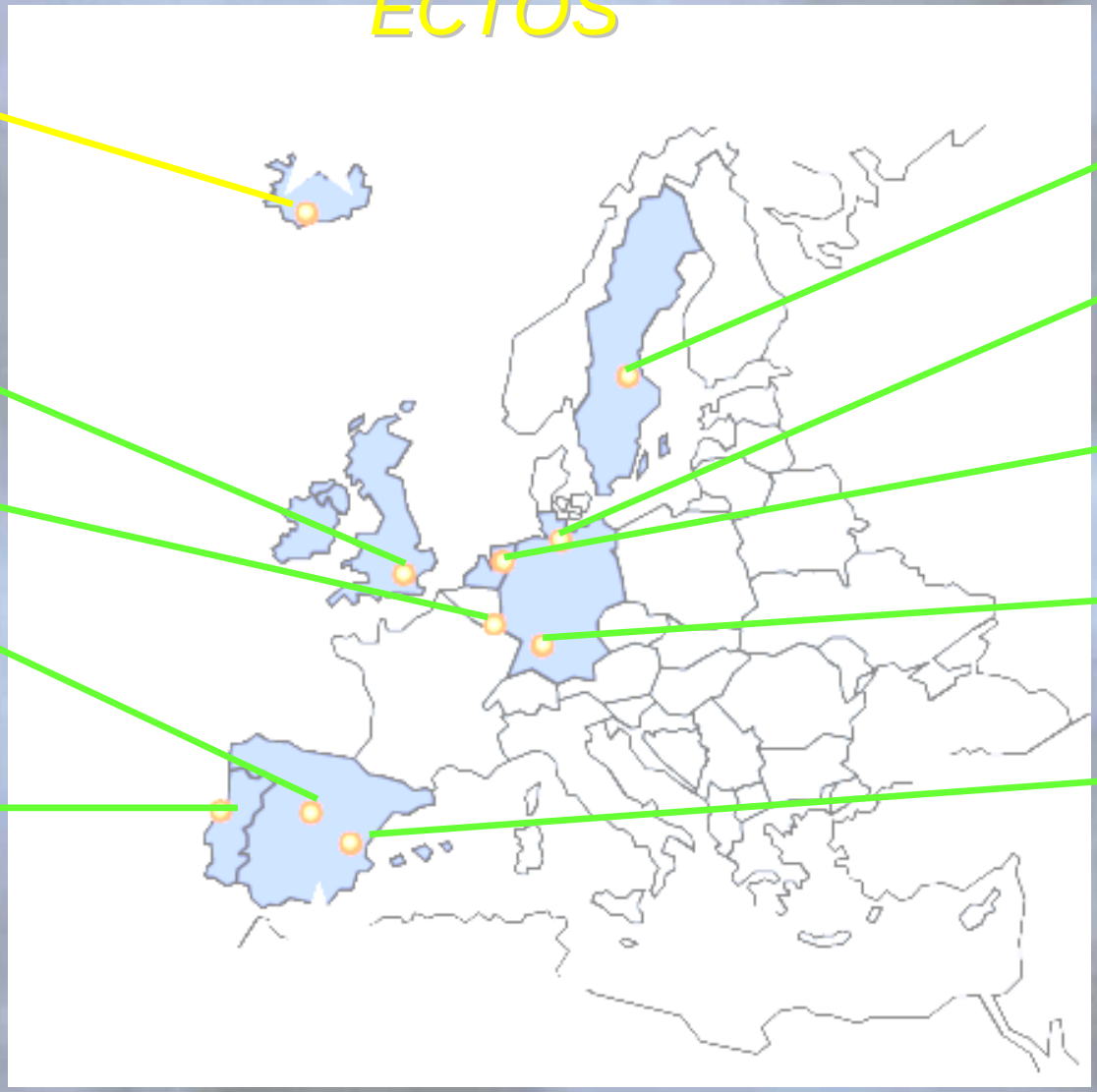
The first two years

Preparation, establishing infrastructure, maintenance facility, economic/social research, etc.

The second two years

The actual demonstration of infrastructure and 3 fuel cell buses

European Cities in CUTE and ECTOS

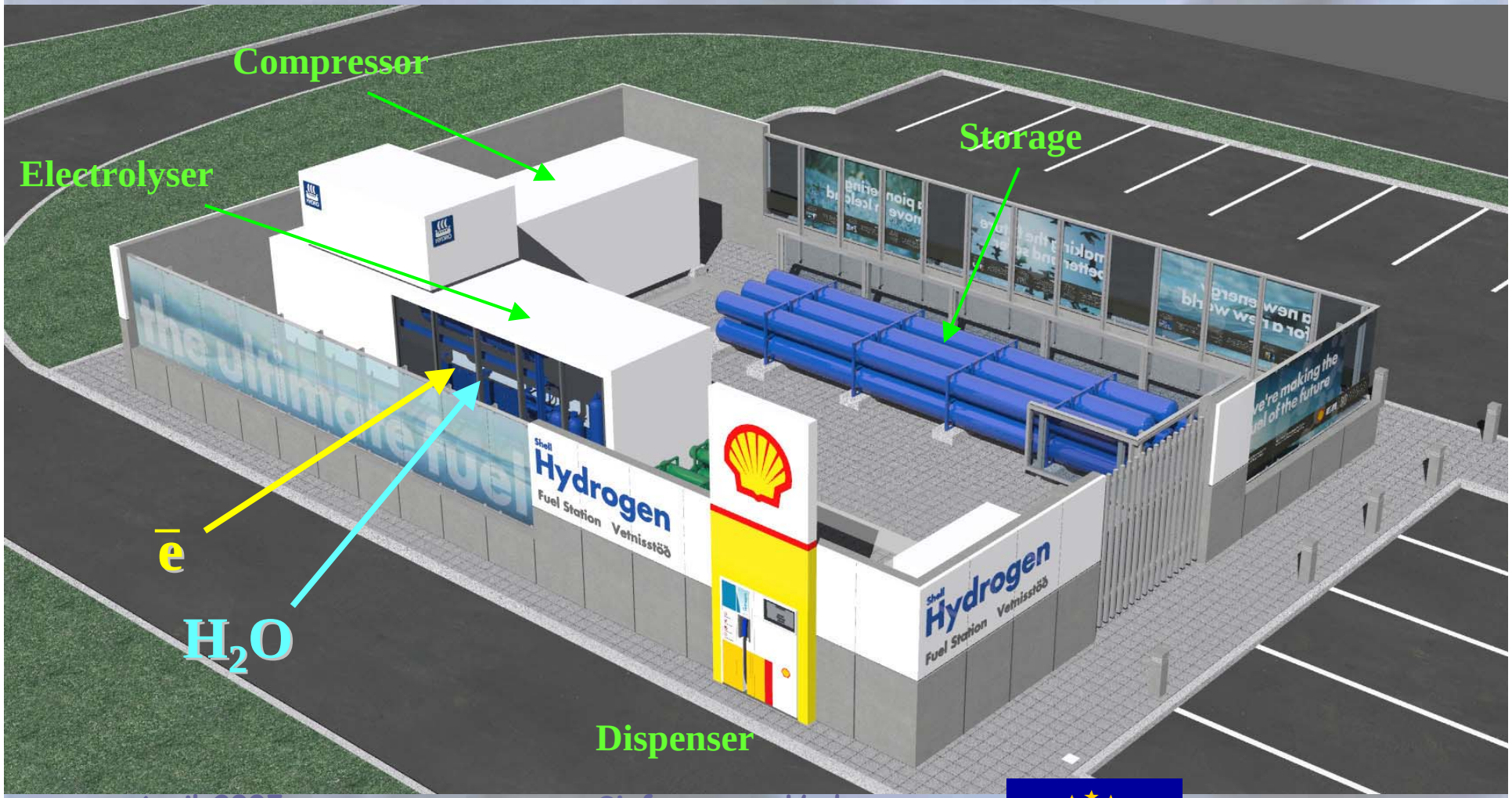


ECTOS-project, Infrastructure

- **Integrating hydrogen infrastructure into the existing urban setting in Reykjavik**
- **Production; On site electrolyser (using renewable electricity to split water into hydrogen and oxygen). Only supply: WATER and ELECTRICITY**
- **Storing; Compressor delivering hydrogen at 440 bar**
- **Distribution on site of gaseous hydrogen directly on to vehicles.**

The ECTOS-hydrogen station,

An example of pre-commercial filling station



Hydrogen Station

Opened April 24, 2003

Only station in the world operating at a conventional gasoline station (has full commercial license)

The ECTOS-project, *Fuel cell bus*

DaimlerChrysler

Citaro

Zero emission bus

- **Length: 12m**
- **Width: 2.55m**
- **Height: 3.7m**
- **Net power of the fuel cell: >250kW**
- **Passenger: 72 passengers, range 200km**

Buses arrived September 30th 2003

Infrastructure

Old

New

- The first dispenser had communication problems with the vehicles
- We had problems of getting up to 350 bars
- The Norsk Hydro team developed a new dispenser, installed in Iceland for testing
- Since then:
  - <10 minute refuelling
  - problem free operation

A demonstration project is for learning!

- Cooling loop failed
- Cooling liquid sprayed over the hot engine
- Steam, smelling of glycoles, came from the vehicle, also inside
- Police and firebrigade clueless, what to do??
- They shut down roads around
- Maintenance team arrived reconnected and drove away
- Very important learning for the authorities, regarding incident reaction

Vehicle research *(cont.)*

- **An example:**
  - **Fuel measurement, i.e. comparison between the energy consumption of a hydrogen bus vs. a diesel (not a fully compatable as the diesel bus was not a DaimlerChrysler Citaro)**
  - **All three hydrogen buses in use**
    - One was fully loaded, weight roughly 18,8 tons
    - One was only with sitting passengers
    - One was empty
    - The diesel bus was fully loaded
  - **All drove the same route in a row**

Vehicle operation research *(cont.)*

To reach a full load of the vehicle we filled the floor with concrete tiles. Then with voluntary senior citizens!

Vehicle operation research (cont.)

And finally the bus company's choir and musicians played for entertainment

The Icelandic accomplishment to date

- Most km driven in 2004 (CUTE/ECTOS)
  45.000 km to date (2003-2004)
- Highest availability in 2004 (CUTE/ECTOS)
- Pumped over 7.000 kg of hydrogen
- Saved over 20.000 l. of diesel / and more than 50 tons less greenhouse gas emissions
- Indication that there is over 90% of the public is positive toward the new fuel

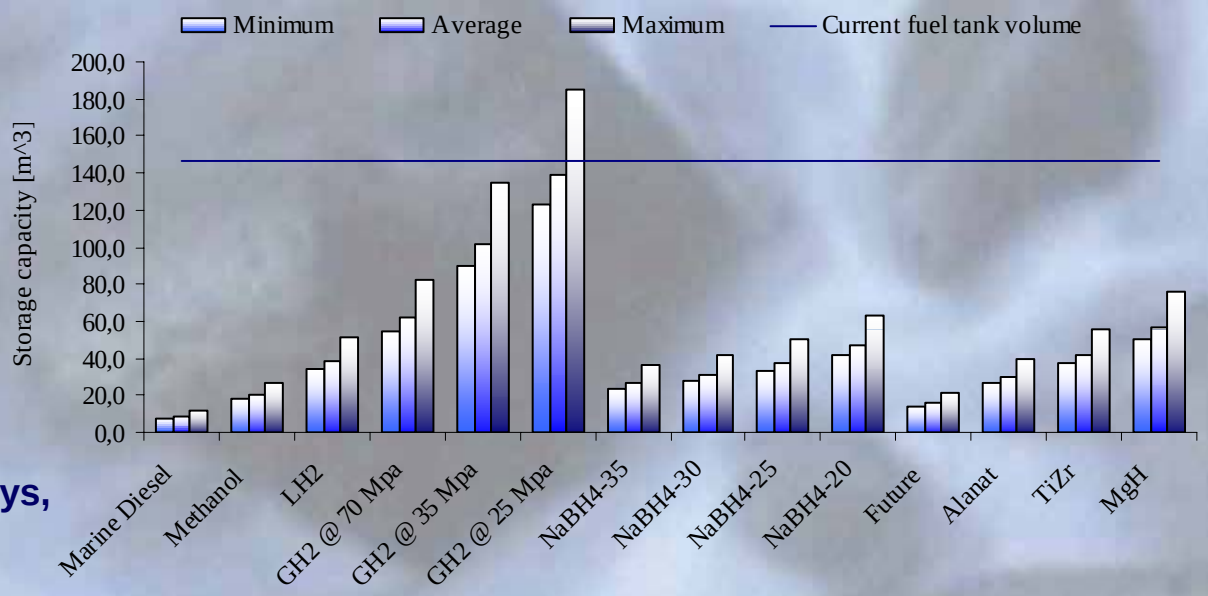
Hydrogen passenger vehicles

- **INE is seeking partners for launch of fleet application of fuel cell / hydrogen passenger vehicles**
- **A number of companies have shown interest. Negotiation phase.**

Hydrogen in a fishing vessel: M.b. Valdimar

- **Size:**
  569 GT
- **Engine**
  Main engine: 507 kW
  Aux engines: 2x110 kW
- **Average fishing trip = 5 days, maximum length = 7 days**
- **Oil consumption**
  Mean consumption: 7,5 t/trip ≡ 321 GJ/trip
  Maximum consumption: 10,0 t/trip ≡ 428 GJ/trip
  Minimum consumption. 6,7 t/trip ≡ 285 GJ/trip

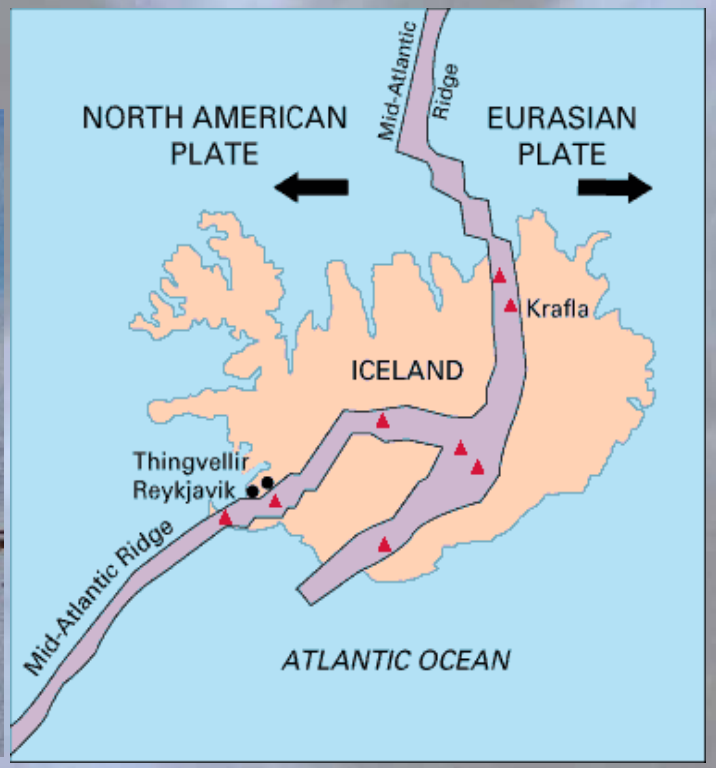
Results from the NEW H SHIP-project
Coodrinated by Icelandic New Energy



Sigfusson on Hydrogen in Hannover

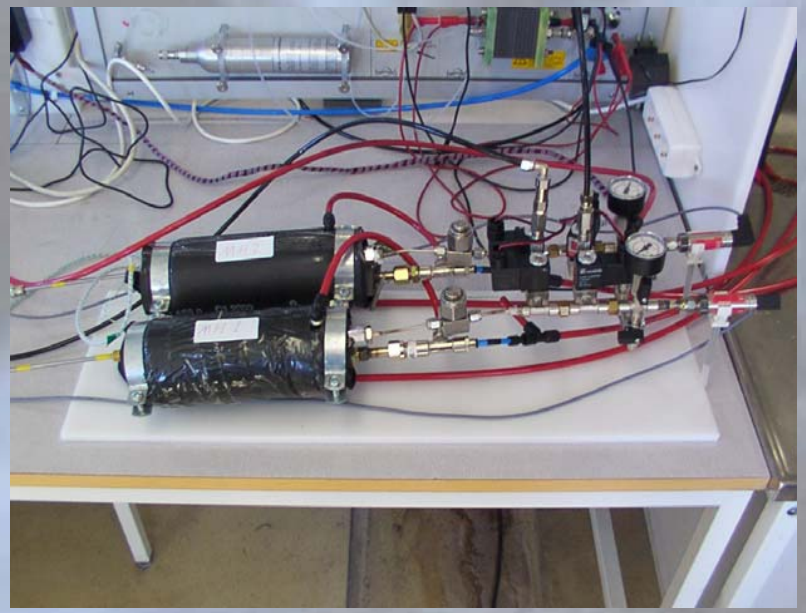
Extracting H_2 from geothermal gases

Geothermal Vents Along the Terrestrial Section of the Mid-Atlantic Ridge at the Bjarnarflag Geothermal Field, Near the Krafla Volcano, Northern Iceland…



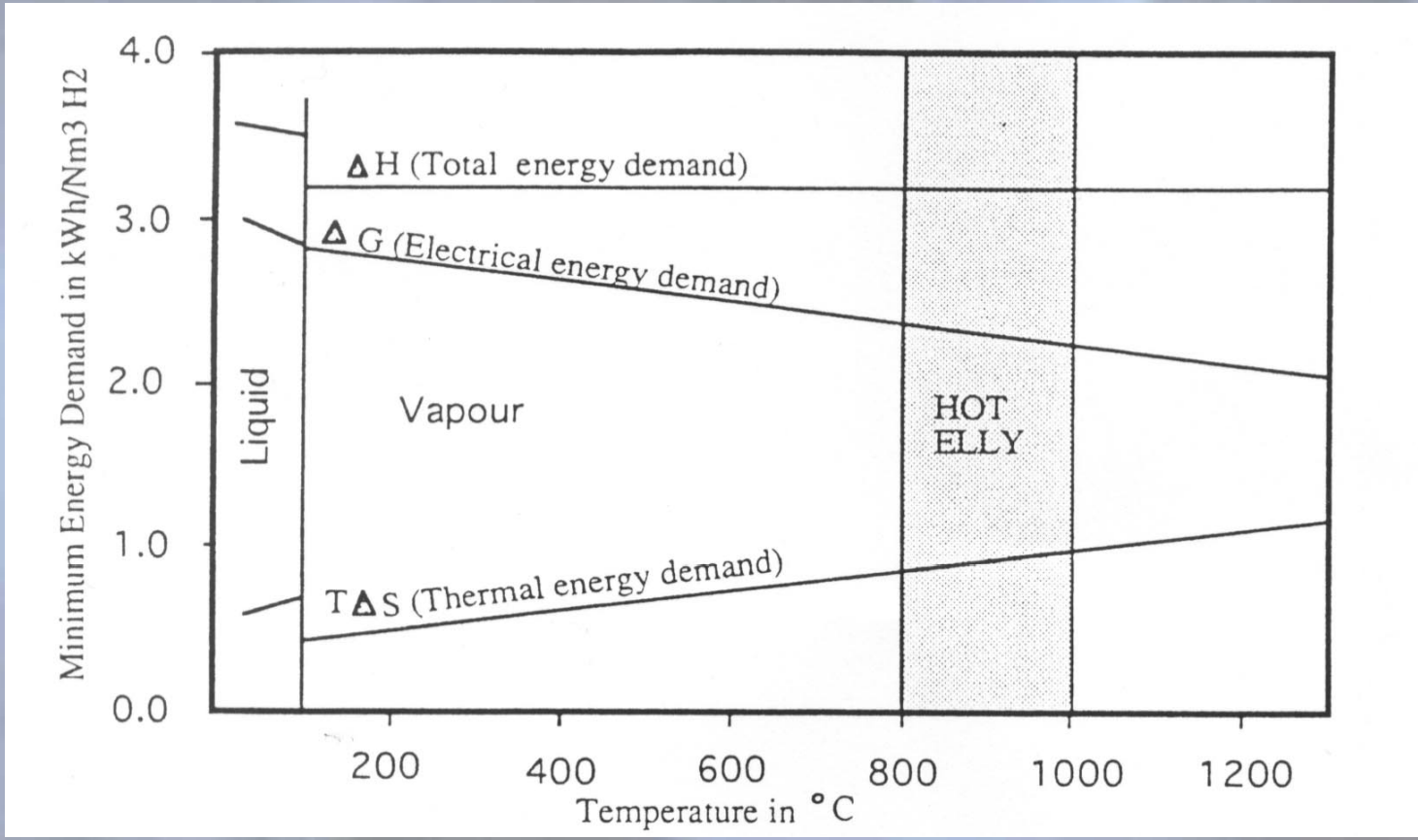
Geothermally Operated Hydrogen Compressor

- **This metal hydride-based compressor was designed and constructed as a joint effort between the University of Iceland and Varmaraf ehf. This device is capable of pressurizing hydrogen gas up to 10-20 bars in each stage and is intended to represent a component of a proposed hydrogen fueling station. Hallmar Halldorsson and Thorsteinn I Sigfusson**



Hot Elly + Geothermal Heat

Geothermal heat could provide energy for high temperature electrolysis of water



International recognition

- **International recognition of the Iceland Programme**
  - Supports new projects
  - Attracts participation
  - Creates local good-will

April 2005

The Energy Policy of the Government

"To promote utilisation of Iceland´s clean and renewable geothermal and hydropower energy resources in harmony with the environment"

- for sustainable development
- to diversify industrial activity and economy
- to further improve standard of living
- to expand exports and stimulate foreign investment, based on renewable energy resources

Towards a H_2 Economy
Policy of the Government

The Government's Policy has 5 aspects:

- Favorable framework for business and research
- International co-operation
- Hydrogen research
- Education and training
- Ongoing policy formulation

Iceland

As an International Platform for Hydrogen Research

IPHE – Ministeral Meeting

Washington November 2003

The International Partnership for the Hydrogen Economy (IPHE) Ministerial meeting brought together energy ministers from 15 countries and European Commission to discuss common areas of interest in, and obstacles to, the hydrogen economy in the fields of research, development and demonstration projects, hydrogen policy and regulation, and the commercialization of hydrogen based energy technologies.

April 2005

Sigfusson on Hydro – in Hannover

Towards a Hydrogen Economy
International Platform for Hydrogen Research in Iceland

Global Co-operation

- ✓ **Iceland a founding member of the IPHE Nov. 2003 Washington US**
  - the International Partnership for the Hydrogen Economy
- ✓ **Memorandum of Understanding between Manitoba and Iceland,**
  - R&D, Education, training, etc.
- ✓ **Statement of Common Understanding for the Global Icelandic Hydrogen Partnership - GETF, USA and Iceland**
- ✓ **The ECTOS Project, Euro-Hyport, HySociety,**
- ✓ **NORDIC ENERGY RESEARCH**
- ✓ **Nordic Summer School on Infrastructure**
- ✓ **Co-operations with CEA France, Japan, United States.**
- ✓ **EU/EEA projects, IEA, etc.....**

Conclusion

- Being independent of fossil fuel imports is an enthusiastic vision, which could be realised in Iceland during the next decades
- Projects like ECTOS and others that INE is working on with international partners can and will provide valuable information for next steps as we are "learning by doing".
- Together it is possible to create a:

"HYDROGEN SOCIETY"

Conference
Key results – next steps

Hy-Pro-Files

First Lessons & New Challenges

April 27-28th 2005
Reykjavík, Iceland

Follow up of the 2003 ECTOS conference:

Making Hydrogen Available to the Public

For more information:

www.newenergy.is/hy-pro-files

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