

Reasons for the aim to hydrogenize Iceland with H₂ from renewables



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Structure of talk

- Energy sources of Iceland
- Dependence upon imports
- Threats to security and the need for domestic source
- Enhancement of present resources

- Projects aiming at domestic energy production
- The hydrogen economy



- Gaia, the goddess of Earth, has a very special place in Iceland. The island forms a spot on an ocean ridge just surfacing and where a geological hot-spot is situated.

- The island is expanding as the plate dynamics of the Eurasian and North American plates float apart by as much as an inch every year.

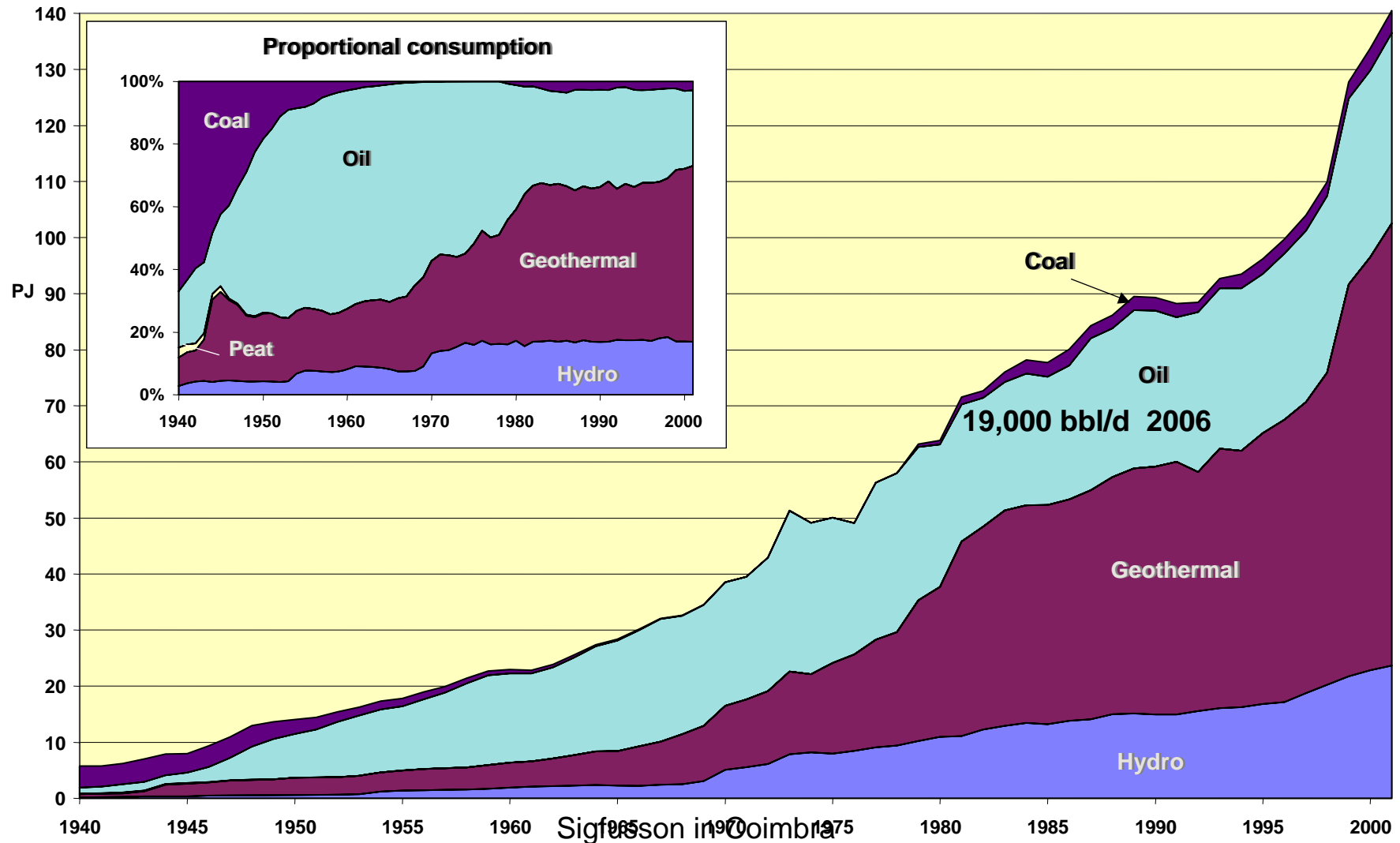
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Active volcanism creates eruptions at least once every decade



Grimsvötn – Vatnajökull icecap 2004

Primary Energy Consumption in Iceland 1940-2001



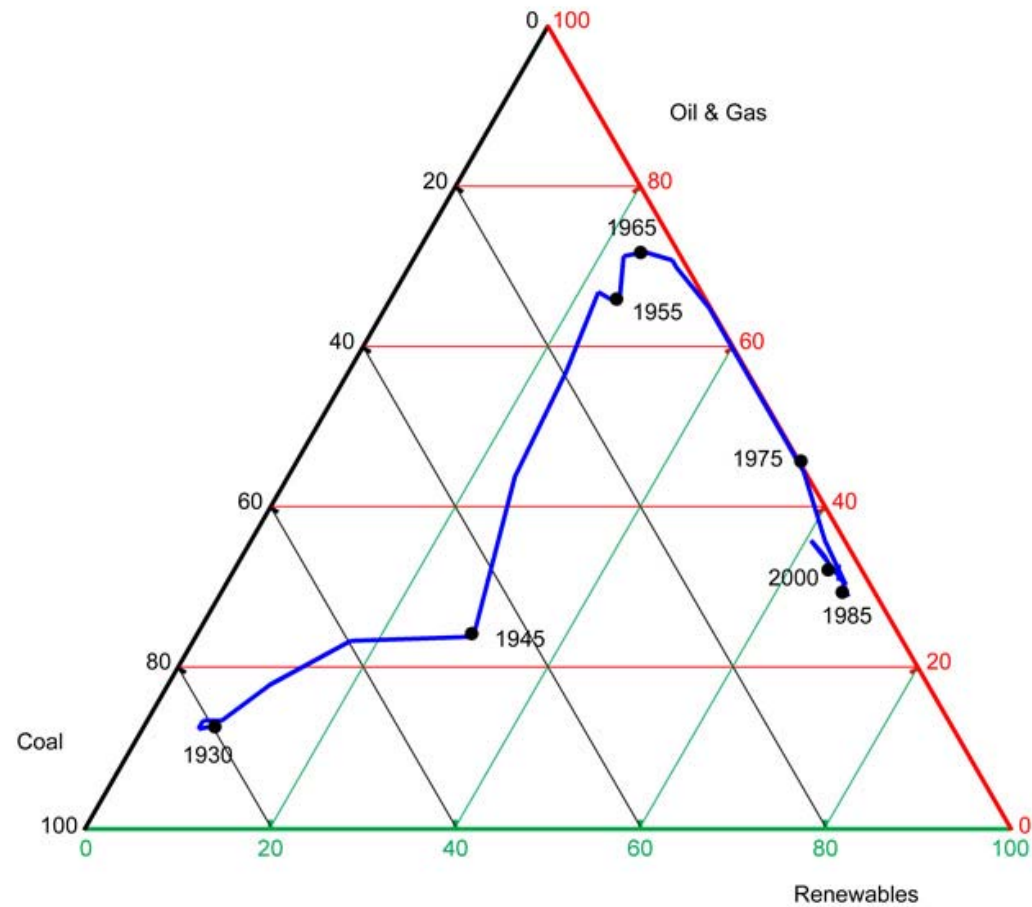
Coal smog in Reykjavik 1930

Reykjavik Energy Geothermal space heating
now displaces some $\frac{3}{4}$ million tonnes of coal annually



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The primary energy sources in Iceland from 1930- seen as a three component diagram: Coal, oil/gas, renewables



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Mechanical power in 2000AD

Guzzling with hydrocarbons!

Family car
~150 kW



Modern trawler
5,000 kW



Boeing 747
45,000 kW



At settlement in 874 AD:



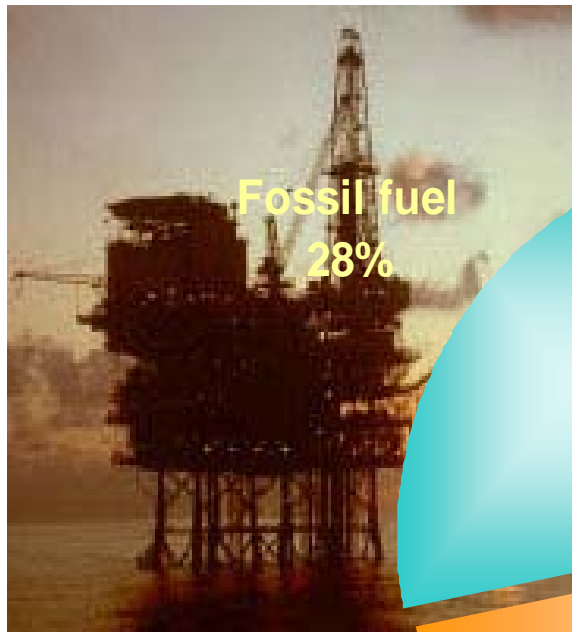
horse and plough <1kW/



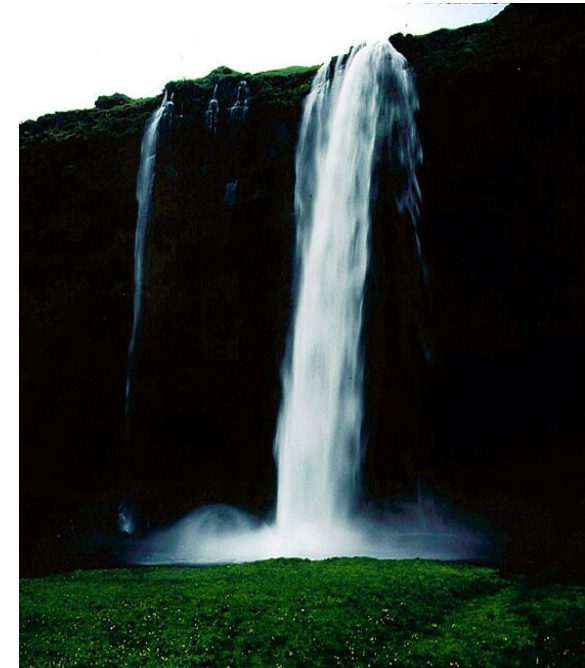
Viking ship 150 kW !

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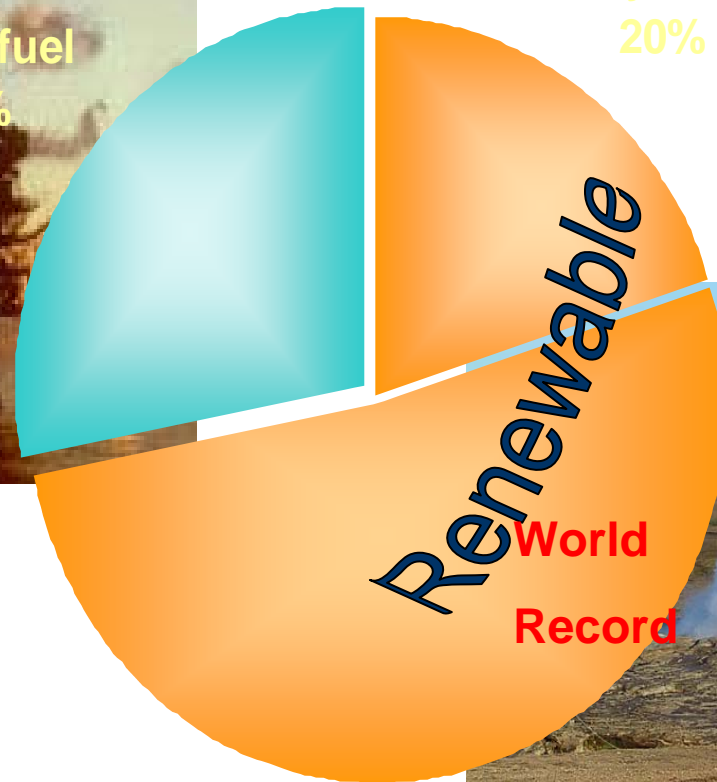
Type of energy used in Iceland



Fossil fuel
28%



Hydro
20%



World
Record

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Geothermal
52%



Fossil fuel use at the turn of the century

Fishing vessels
41%



Transport
44%

Other
15%

CO₂ emissions 3.1 million tons
11 tons per capita per year

Renewable energy Resources in Iceland

- Iceland possesses no fossil fuel
 - except some peat reservoirs
- However compared to population, Iceland possesses abundant energy resources:
 - The economically harnessable hydro energy is
 - ~ 30 TWh/yr of which only 15% has been harnessed
 - The harnessable geothermal energy is
 - ~ 200 TWh/yr of which only 1% has been harnessed

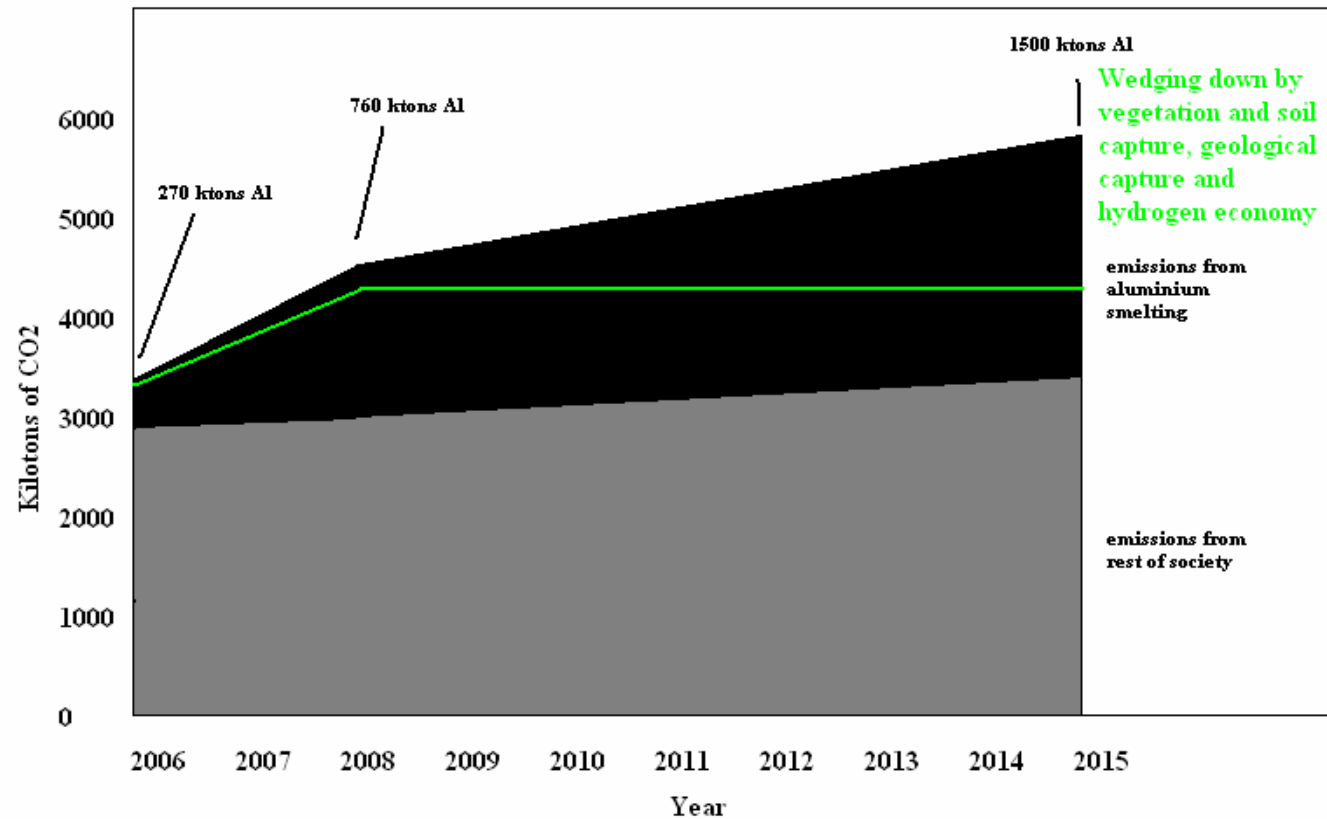
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At the turn of the millenium there were two unresolved energy security/greenhouse gas threats in Iceland

- Imports of fossil fuels for the transport sector and the fishing fleet
- Leading to Kyoto related problems and greenhouse gas emissions amounting to half a ton of CO₂ per caught ton of fish! and about 11 tons of CO₂ per capita average emissions annually.

Challenges to wedge down emissions by various means



DECARBONIZATION

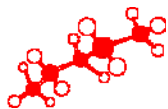
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Possible decarbonization actions

- Hydrogen from renewable energy replacing imported fossil fuels: pure hydrogen and/or Artificial Liquid fuels made from hydrogen and



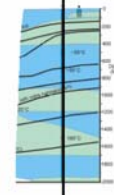
CO₂



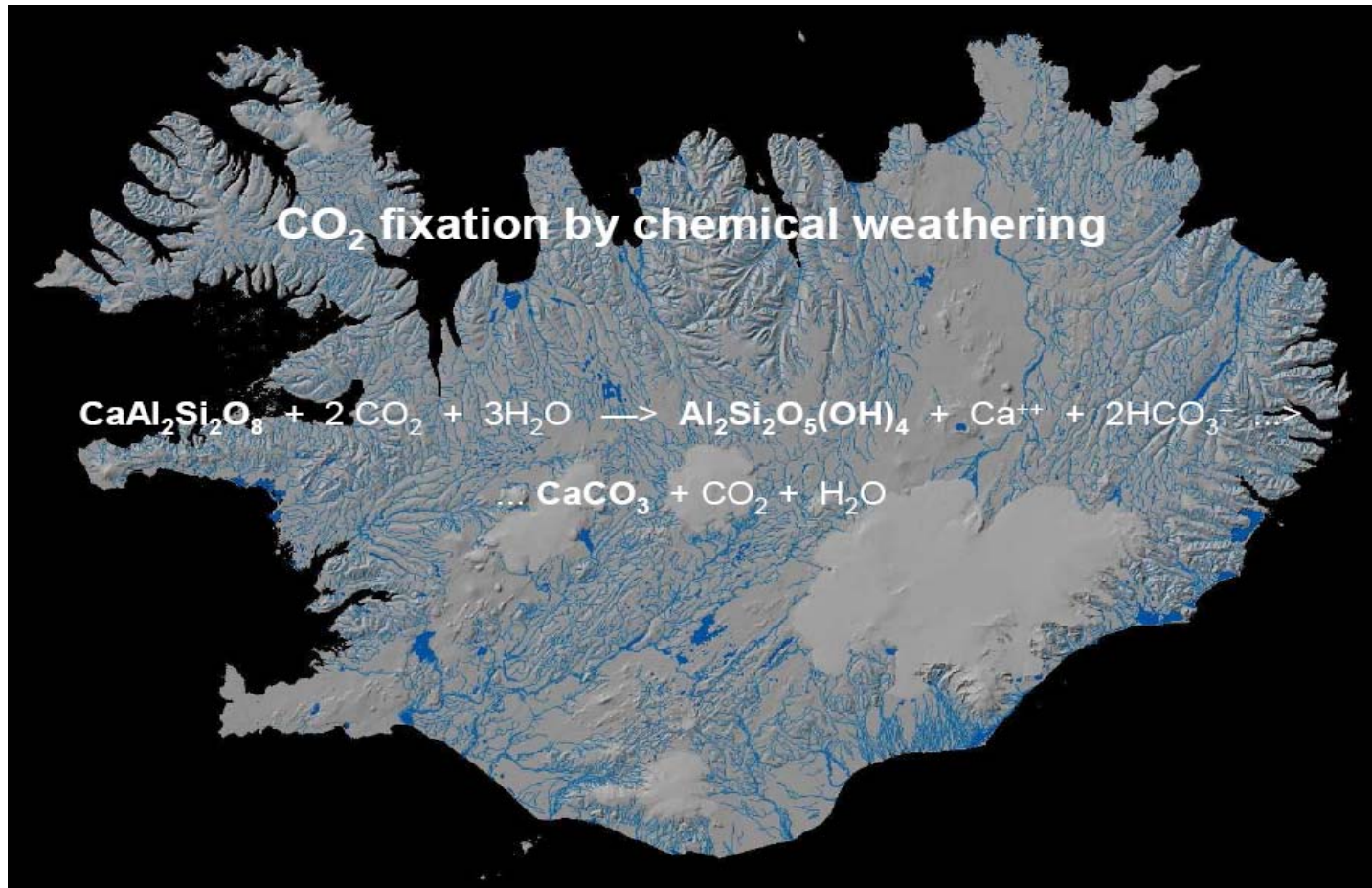
- Capture of CO₂ through vegetation and soil



- Capture and storage of CO₂ by geological methods



Carbondioxide can be fixed in basalt and we are experimenting with sequestering in rock



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GEOHERMAL ENHANCEMENT

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Can Iceland increase the geothermal energy utilization?

- Yes, for example by drilling deeper into the crust



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An example of a place to drill deeper: Krafla central volcano



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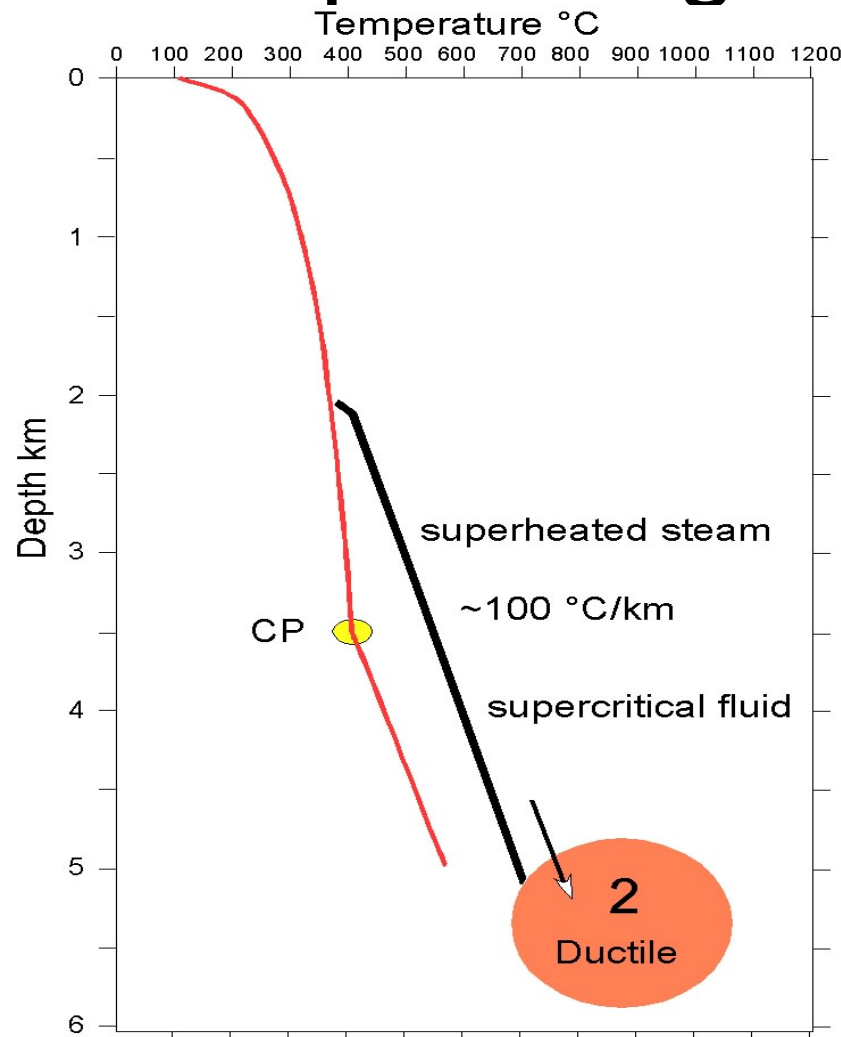


I DDP ?

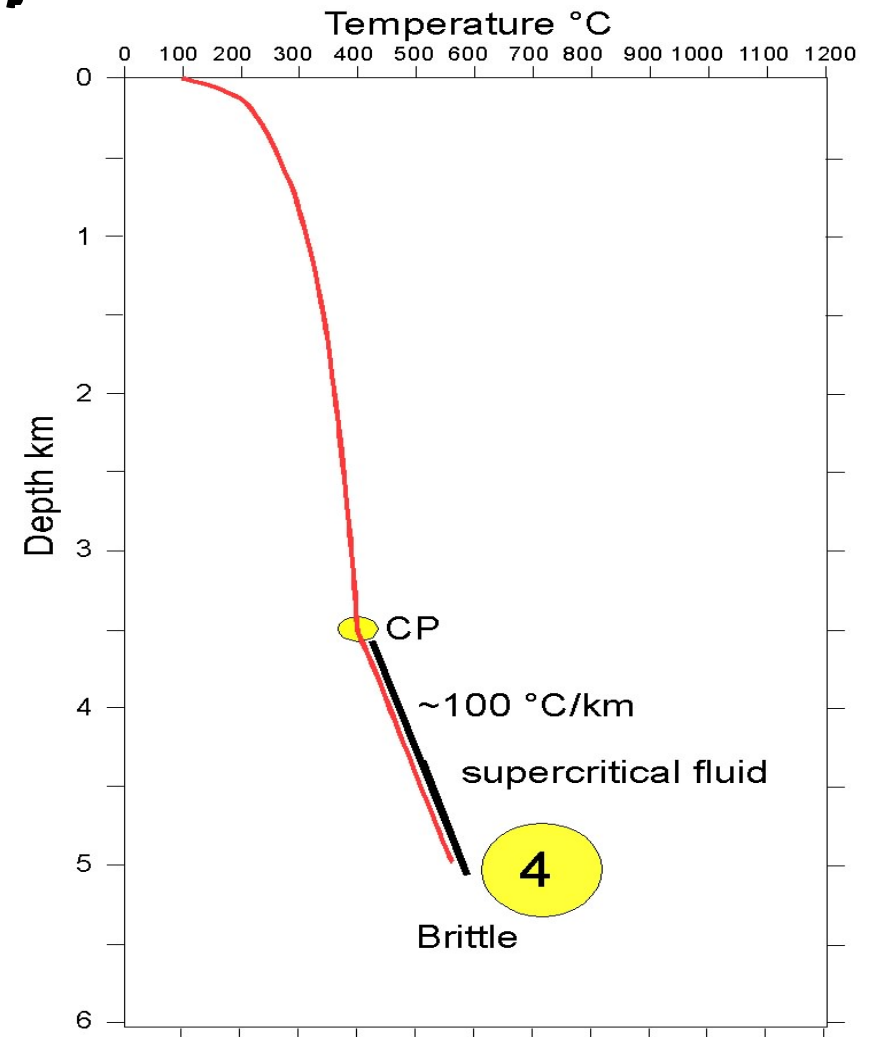
Krafla

I DDP ?

Deep Drilling Project in Iceland



Senario 2 :Contact aureole to subvertical gabbro

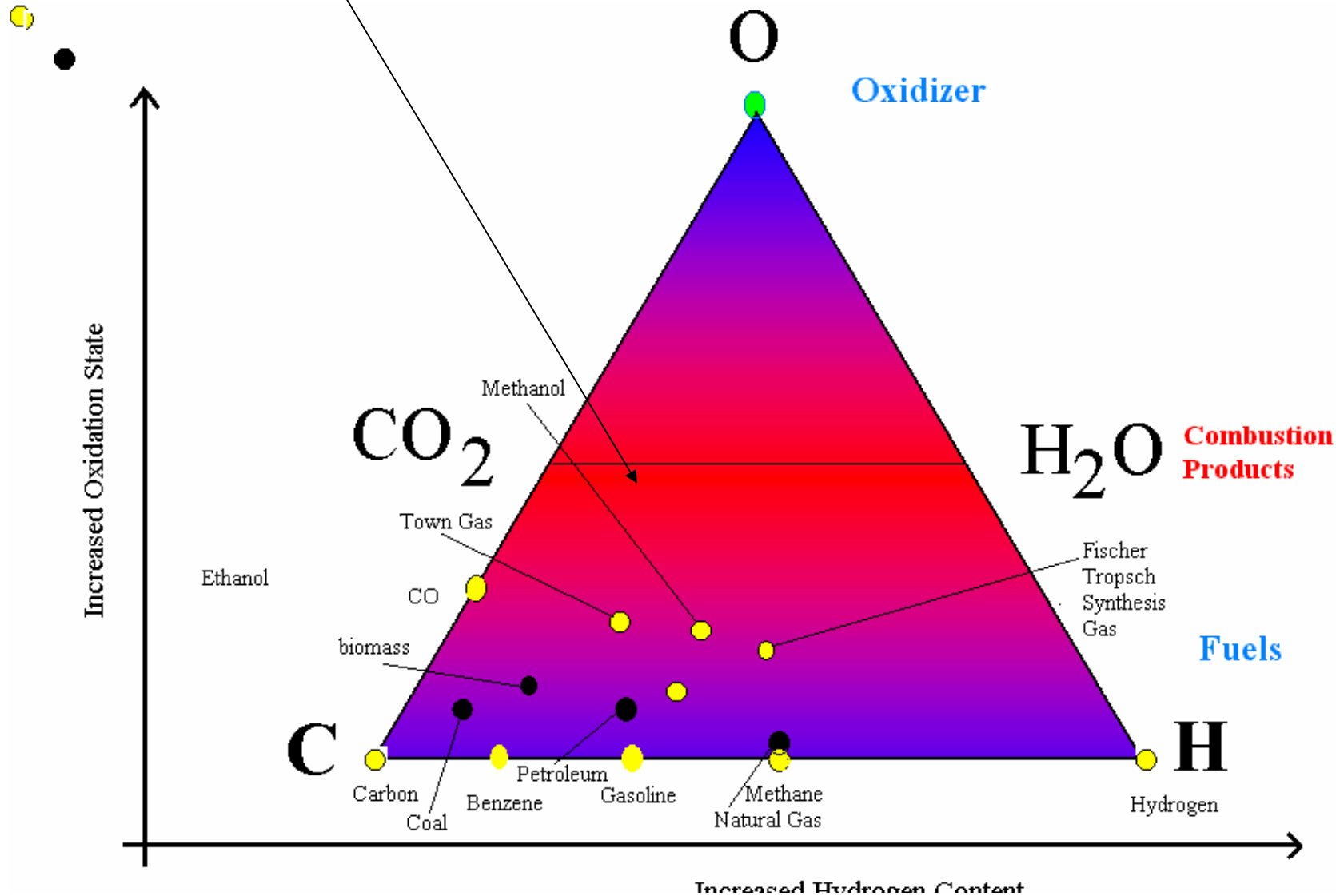


Senario 4 : Heat source deeper still

DESIGNER FUELS FROM HYDROGEN AND CARBON

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Designer fuels from hydrogen with different amounts of carbon



A HYDROGEN ECONOMY: The complete solution to the problem

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The Energy History of Iceland 874-2007

AD 2000

Advent of a hydroelectric
hydrogen economy



HYDROGEN
Paradigm
shift ?

AD1940



Geothermal space heating

Infrastructure
change II

AD1900

Hydroelectric energy

Imported liquid fossil fuel

Infrastructure
change I

AD1800

Imported coal and coke

AD1700



Settlement of Iceland



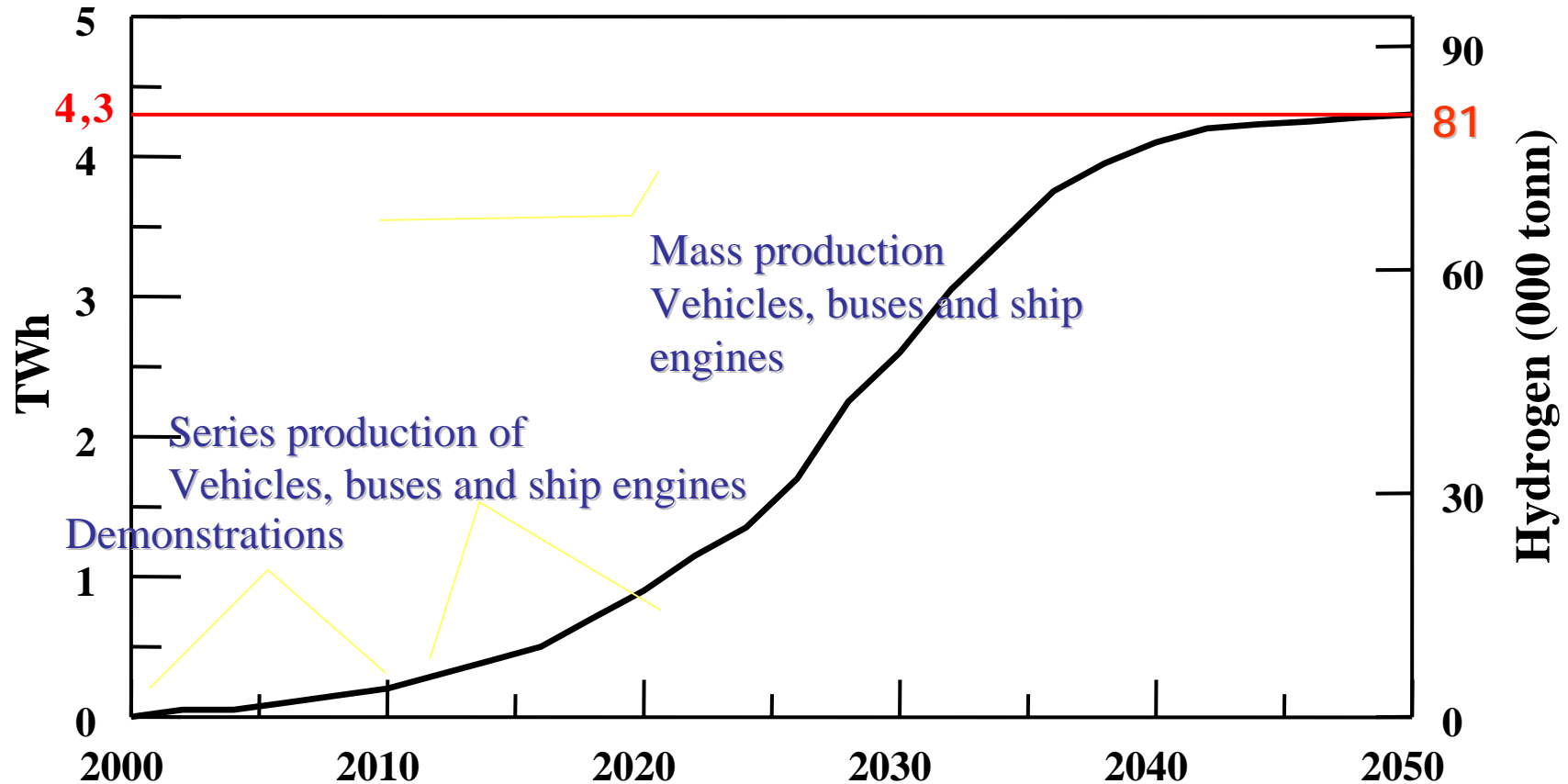
Wood and peat

AD 874

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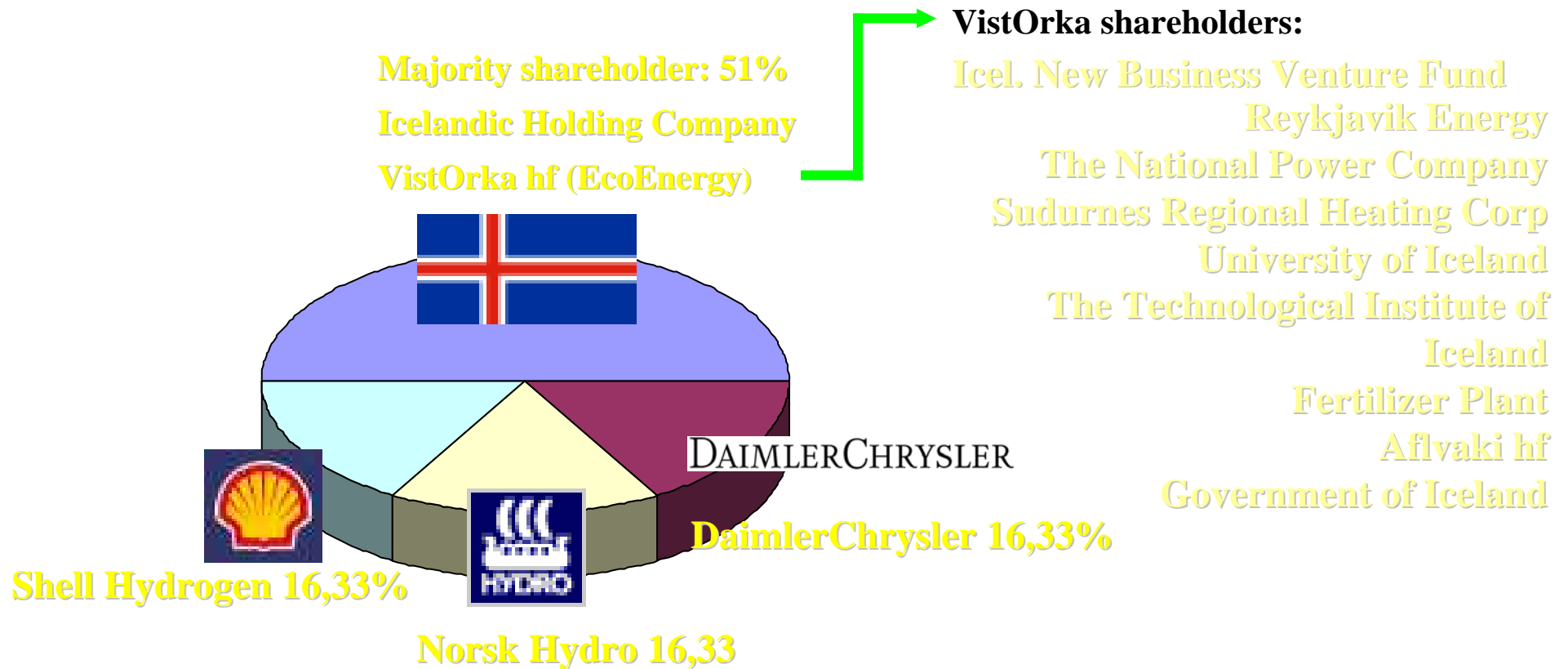
Iceland: Historical Milestones in Energy Economy

Hydrogen produced by electrolysis from renewables could create a new energy economy in Iceland



Forecast for the development of the usage of hydrogen as a fuel in cars and ships. Technical developments during the next few years could considerably influence the graph.

Icelandic New Energy Ltd (INE) the public-private hydrogen company



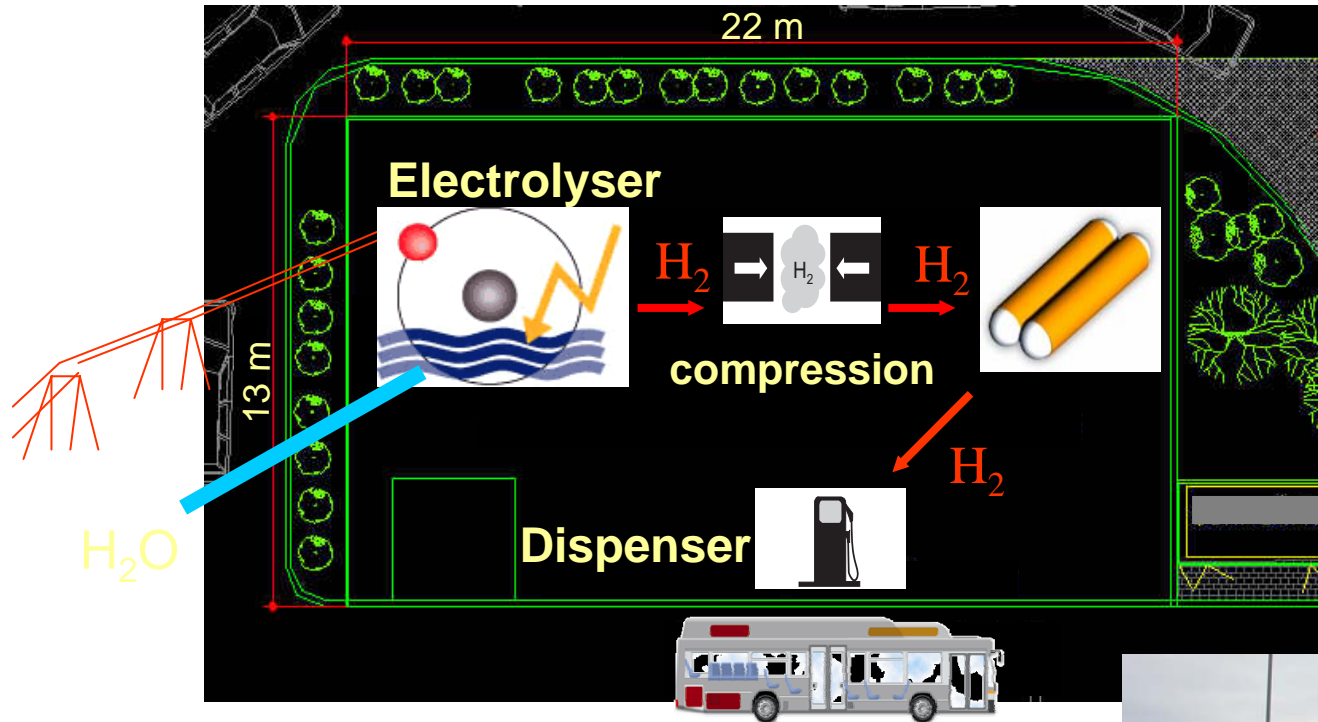
A joint venture company to investigate the potential for eventually replacing the use of fossil fuels in Iceland with “hydrogen based fuels” and create the world’s first hydrogen economy”

A fuel cell bus tanking up at the hydrogen station in Reykjavik, the first commercial H-fueling station in the world.



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Fueling infrastructure



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International Partnership for the Hydrogen Economy established in Washington 2003



Russian Federation



USA



Canada



Iceland



IPHE Partners' Economy:

- Over \$35 Trillion in GDP, 85% of world GDP
- Nearly 3.5 billion people
- Over 75% of electricity used worldwide;
- > 2/3 of CO₂ emissions and energy consumption



Japan



Republic of Korea



China



India

United Kingdom



France



Germany



Italy



Australia



Brazil



Norway



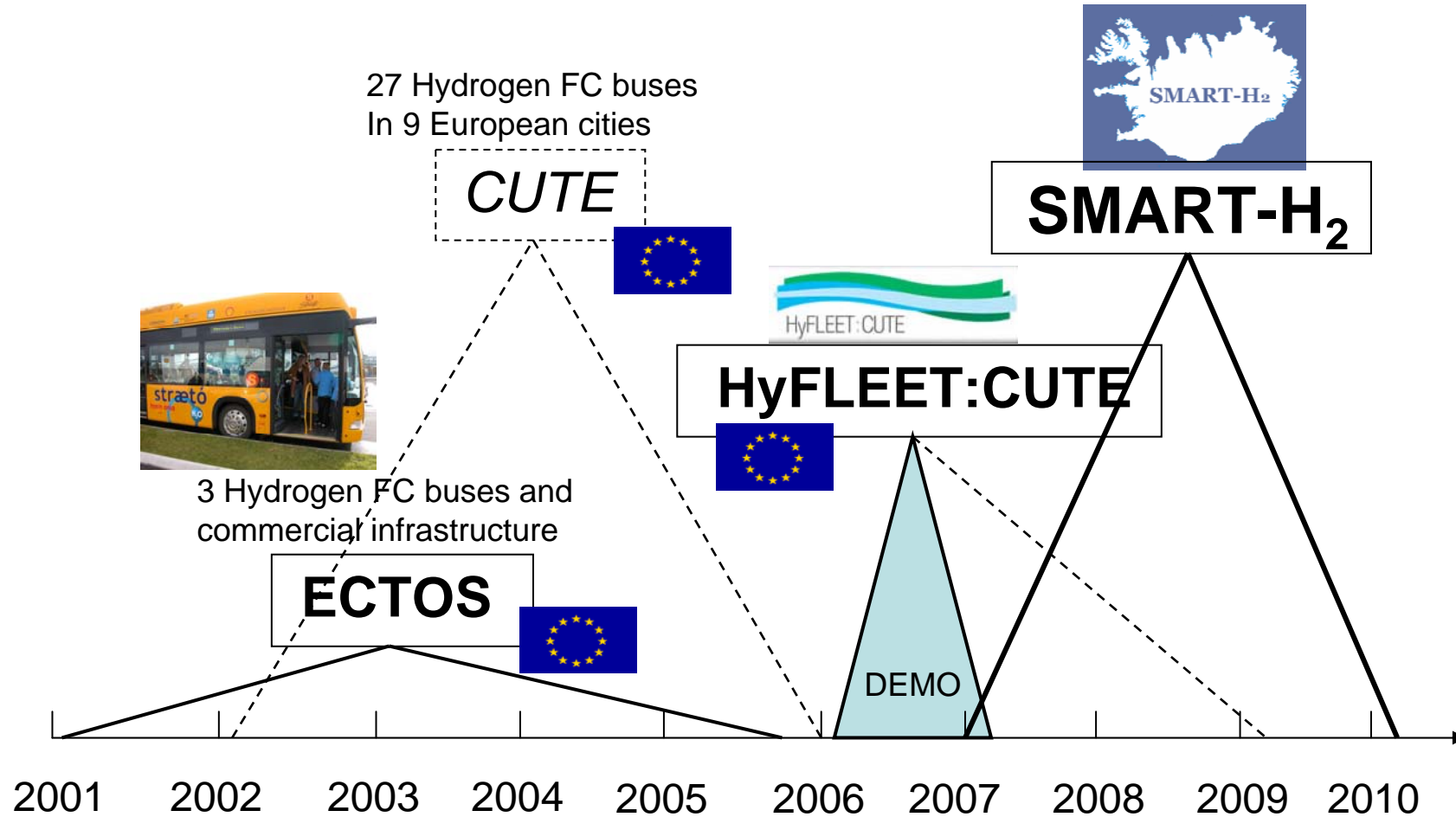
European Commission



New Zealand



Iceland – H₂ continuity



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European cooperation has been a must for this work.... Thank you!

Iceland - the first hydrogen society!



Owners:

VistOrka

DaimlerChrysler AG

Norsk Hydro ASA

Shell Hydrogen



Replacing fossil fuels with hydrogen

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Iceland is surrounded by energy!
It could become self-sufficient with all
its energy needs within a few decades

Thank you!

THE FULL STORY WILL BE APPEARING
IN A BOOK TO BE PUBLISHED IN
OXFORD NAMED:

PLANET HYDROGEN

**THE TAMING OF THE
PROTON**

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