Geothermal Energy, an option for hydrogen production?

Presentation given by

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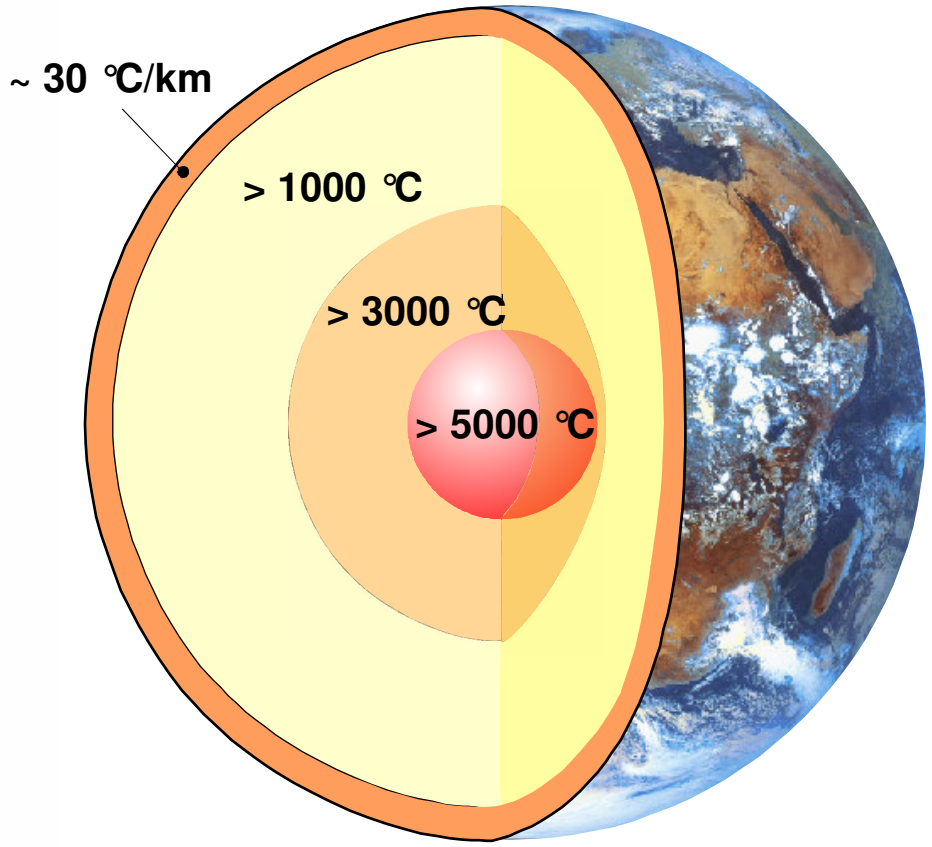
Content

- The geothermal resources in the world
- Basic geothermal concepts
- The Icelandic road to renewable energy society
- Concluding remarks

The heat of the Earth



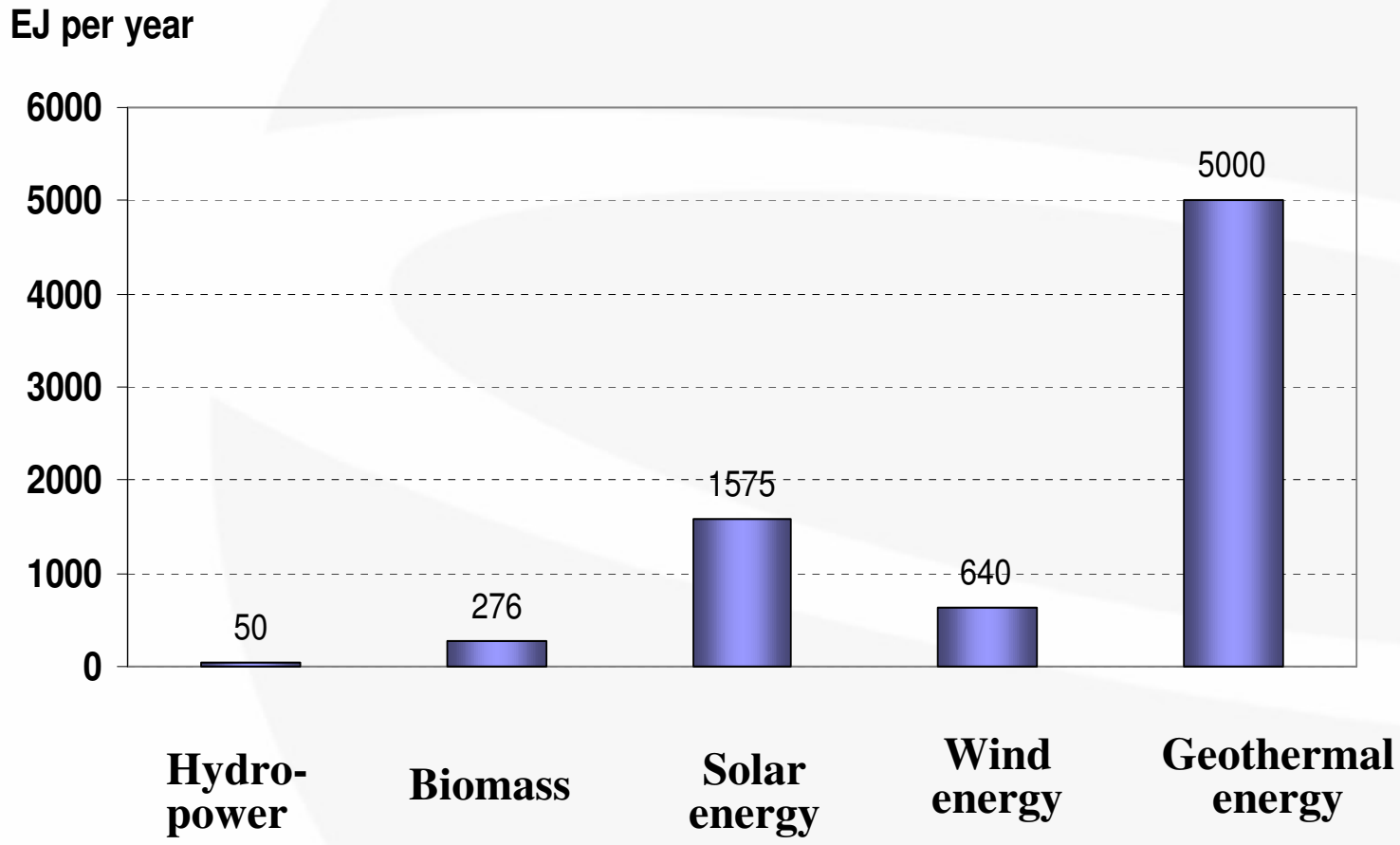
Heat is constanly produced within the Earth from decay of radioactive material.

The heat is moved to the surface by heat conduction, convection or advection.

The heat stored in the Earth´s crust

- The total amount of heat stored in the crust is of the order of 5.4 billion EJ ($5.4* 10^9$ EJ).
- If we could use 0.1% of this it would satisfy the world energy consumption for 13.500 years.
- **The geothermal energy resource is huge but we have technical problems to harness it.**

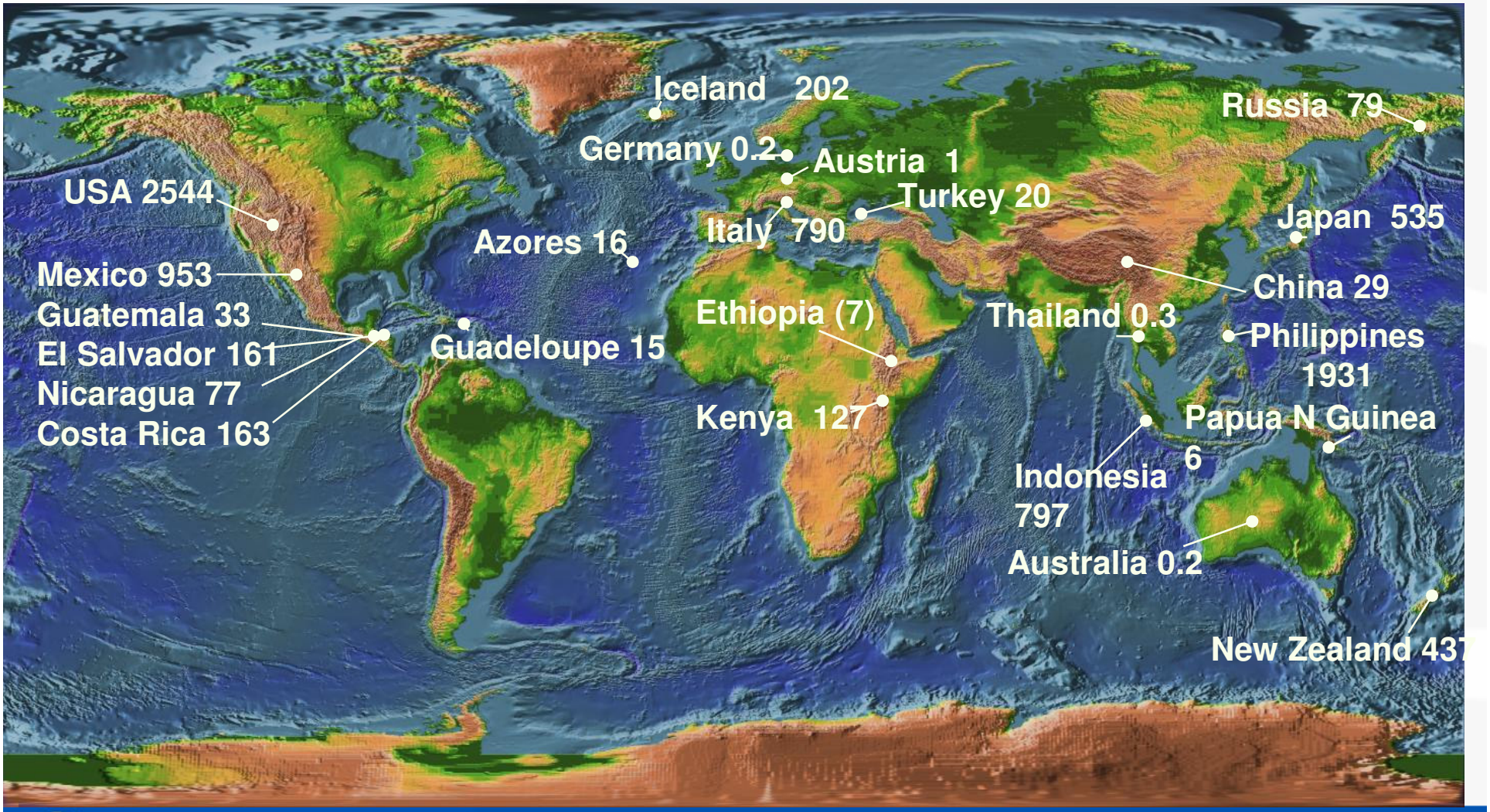
Worldwide technical potential of renewable energy sources (EJ per year)



Key question

- How can we extract and utilize the geothermal heat for sustainable energy production with low environmental impact?

Geothermal electricity
Installed capacity MWe 2004



Basic geothermal concepts

Three main types of geothermal fields for electricity production:

- High temperature fields
- Medium temperature fields
- Low temperature fields

We distinguish between:

Conventional geothermal systems

Enhanced geothermal systems

High temperature fields

- 200 – 350℃
- Depth: 1 – 3 km
- Related to volcanism and plate boundaries
- **Suitible for electricity production with conventional turbines**
- **Small content of hydrogen and hydrogen sulfide in the emission**

Nesjavellir, Iceland. 300°C fluid used to produce electricity

Medium temperature fields

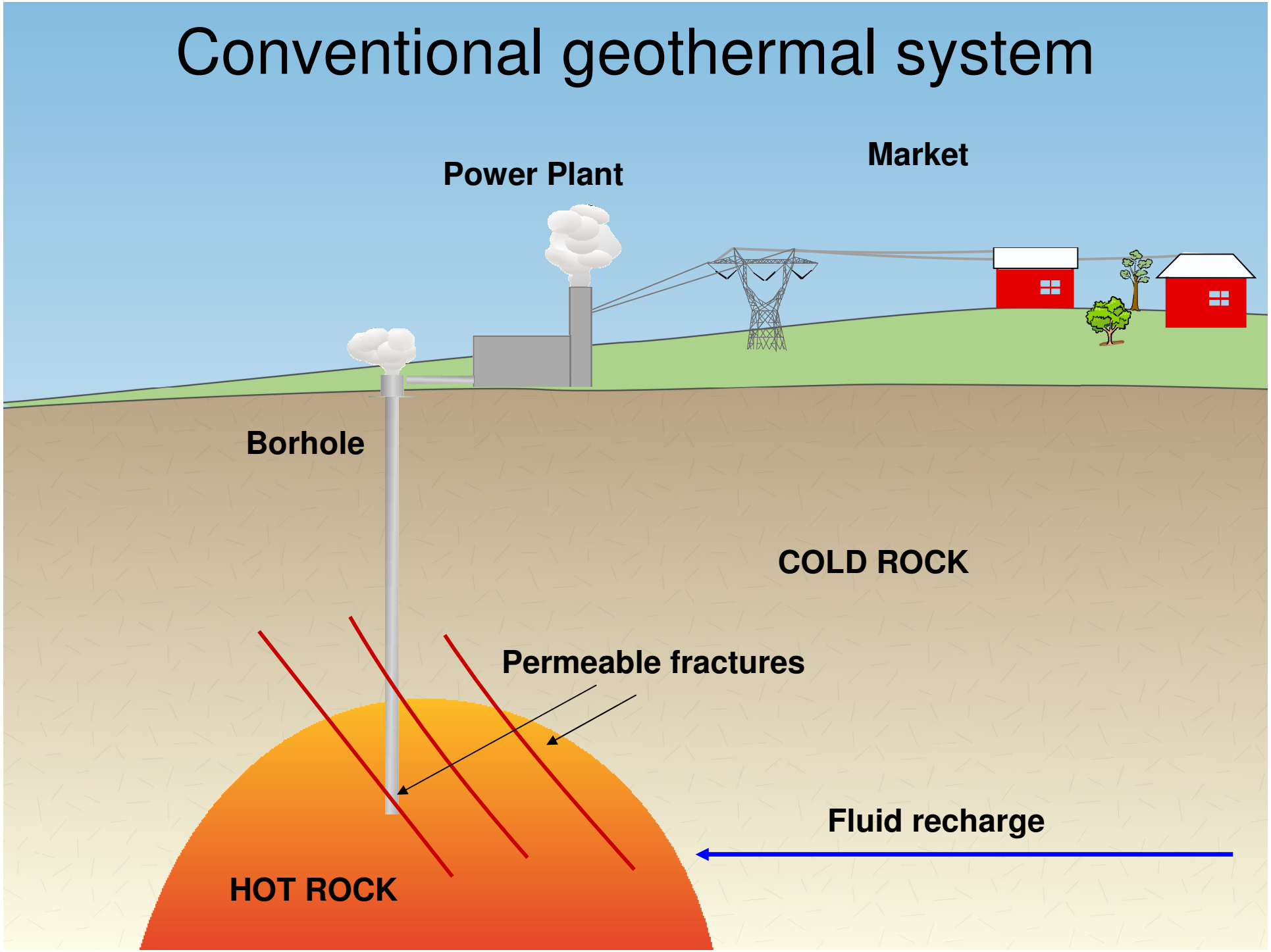
- 120-200°C
- 1 – 5 km
- Mostly found in deep sedimentary basins around the world as well as in volcanic areas
- High flowrates necessary for electricity
- Binary systems needed for electricity production

Húsavík, Iceland. 124°C water used to produce electricity

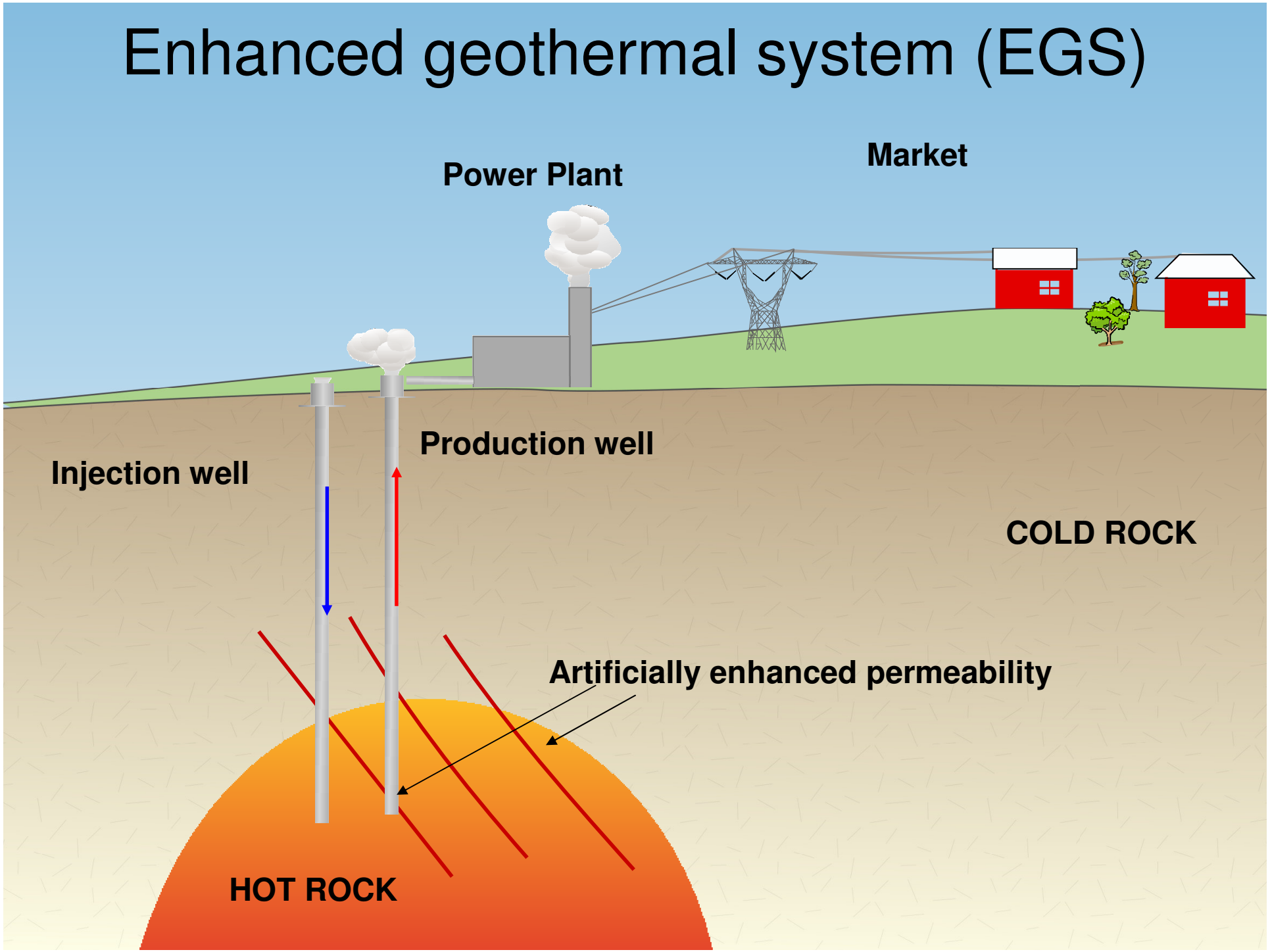
Low temperature fields

- Below 100 ℃
- At 1 – 3 km depth
- Mostly found in sedimentary basins and fracture zones around the world
- Suitible for space heating, balneology, fish farming etc.
- Not for suitible for electricity nor hydrogen production

Conventional geothermal system



Enhanced geothermal system (EGS)



Developing techniques for EGS

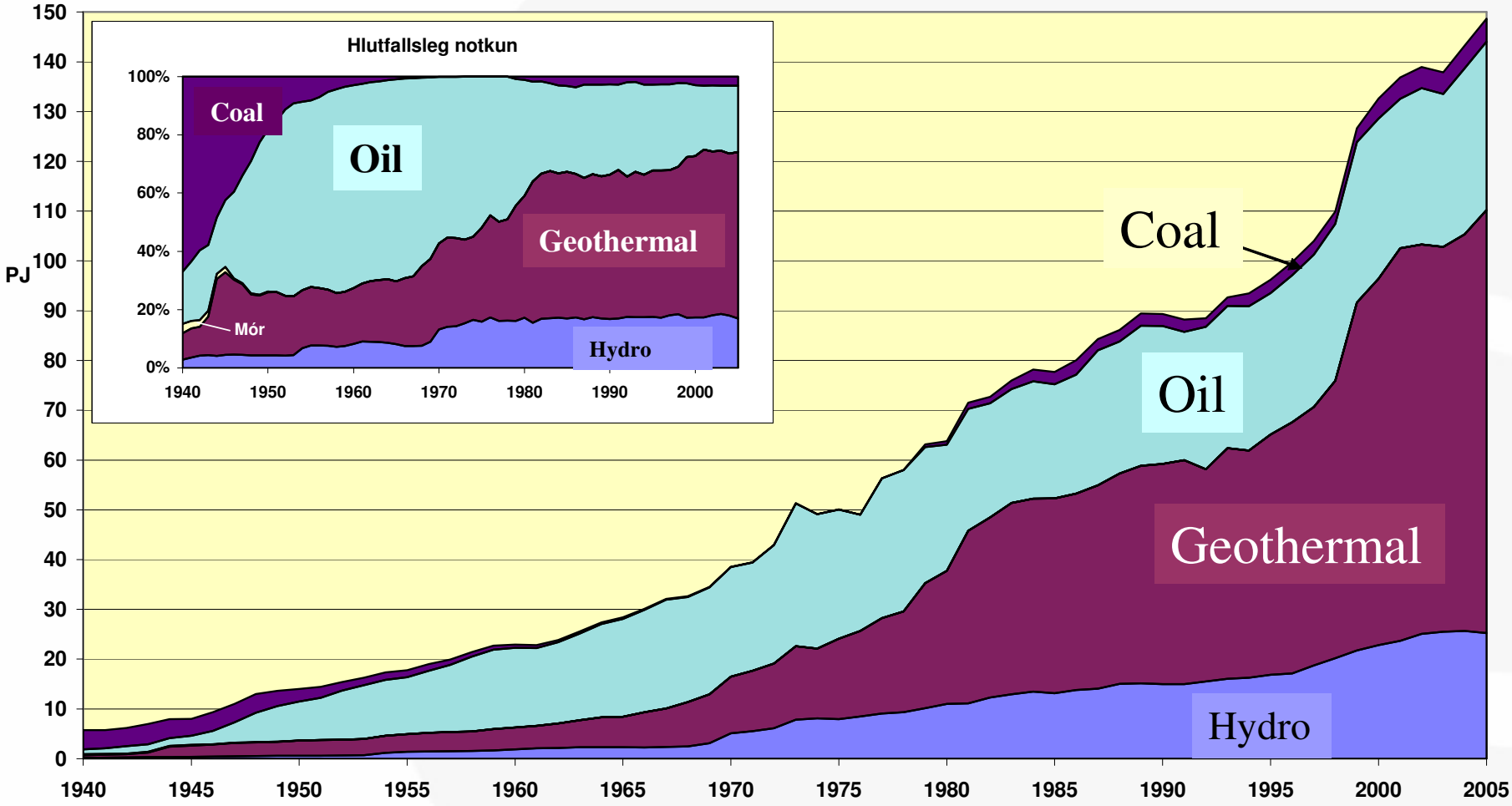
- Experiments ongoing at several places, mainly in central Europe and Australia
- If the outcome will be positive there is huge potential for **distributed small scale electricity production from medium temperature fields** in many countries that could be used for hydrogen production

Near Berlin in Germany

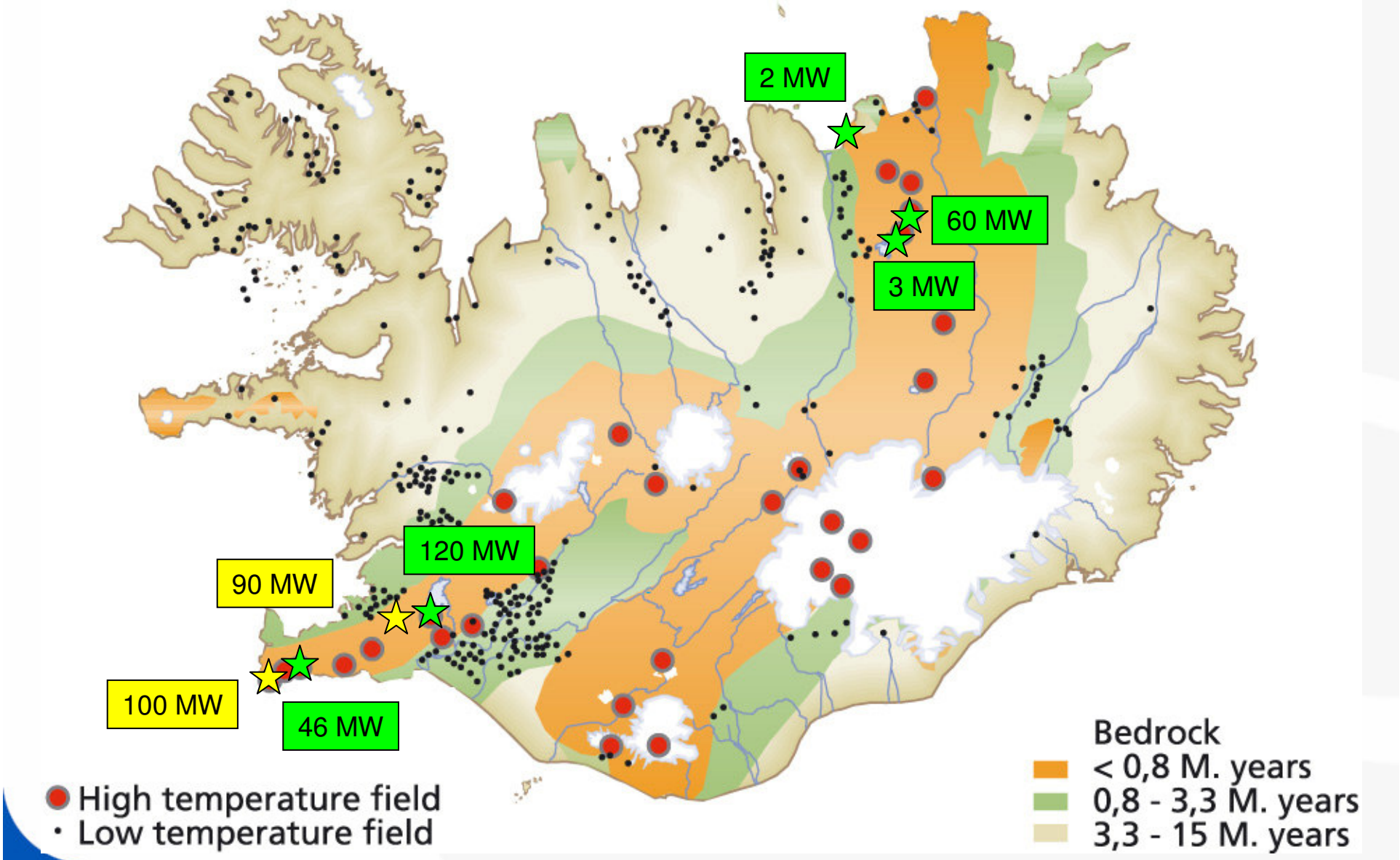
The geothermal progress in Iceland:

The Icelandic road to the renewable energy society

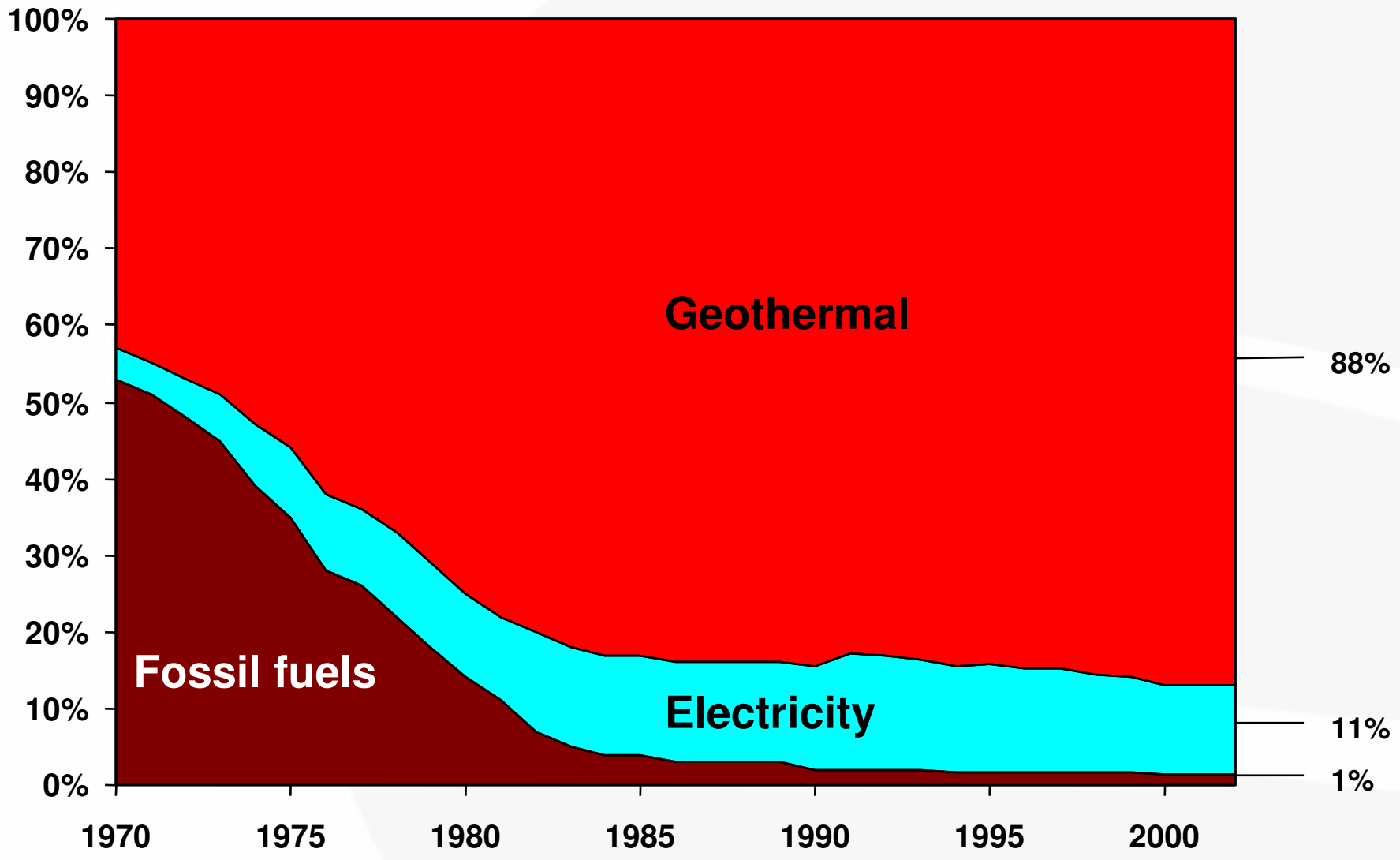
Primary energy consumption in Iceland 1940-2005



Geothermal fields



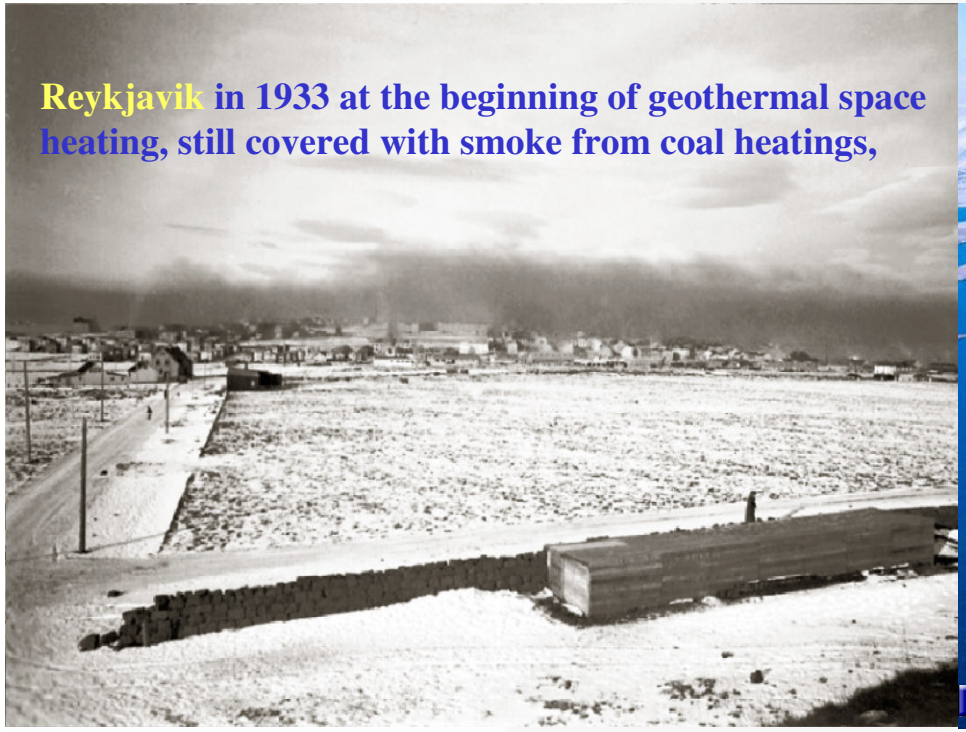
Space heating in Iceland by sources 1970-2002



Source Árni Ragnarsson, Orkustofnun

ÍSOR ICELAND GEOSURVEY

Air pollution from space heating disappeared in Reykjavik



The reason for the good result in Iceland

Governmental support actions:

- **Intensive support to geothermal research**
- **Risk loans**
- **Favourable legal and regulatory environment**

How can we use geothermal energy in Iceland for hydrogen production?

- Produce electricity from geothermal and then hydrogen by electrolysis.
- Extract hydrogen directly from geothermal gas or through chemical processes.

Hydrogen by electrolysis in Iceland

- Electricity from geothermal energy is now produced in Iceland at competititve prices
- The geothermal resources of Iceland are large enough to provide enough electricity to produce hydrogen for the local transport sector
- The cost of large scale hydrogen production from electrolysis could be similar to the price of petrol today.

Hydrogen from geothermal gas

- Geothermal gas emission from power plants contain pure hydrogen and hydrogen sulfide.
- Different concentration from site to site
- Not a major soure for hydrogen in Iceland but might contribute to hydrogen driven transport fleet.
- Technically possible – question of cost
- Desirable to remove H_2S from the emission

Concluding remarks I

- The Icelandic experience shows that geothermal energy can contribute considerably to renewable energy production world-wide.
- There are large conventional geothermal resources available worldwide.

Power plant in Turkey

Concluding remarks II

- New technologies based on the concepts of Enhanced Geothermal Systems could multiply the possibilities of geothermal energy production.
- **The possibility of worldwide small scale production of electricity from geothermal systems might in the furture be an option for distributed hydrogen production in many countries.**
- **The relative cost of hydrogen production is a key issue for the future development.**

Concluding remarks III

- Th energy that can be produced from geothermal in Iceland at competitive prices is much more than would be needed to produce hydrogen for the transport sector in the country.
- Iceland could in near future become a totally renewable energy society based on geothemal, hydropower and hydrogen, if hydrogen can be produced at competitive prices.

Thank you for your attention