

# ENERGY IN ICELAND

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Geographic location and features  
History background  
Population (distribution, major cities)  
Economy  
Energy consumption and production  
Energy policies  
Geothermal energy  
Hydro energy  
Environmental impact  
Innovative technology

# Geography

- Island is the second largest island in Europe
- 40,000 square miles (size of Kentucky and Portugal)
- Located near Arctic Circle
- It's the youngest landmass on the planet
- Sits on the Mid-Atlantic Ridge (*Thingvellir*)
- Growing about 5 cm per year



Thingvellir 2007

# Geography

- Contains the biggest glacier in Europe
- 62.7% is tundra
- 14.3% is lakes and glaciers
- 22% is vegetated
- Climate is relatively mild (North Atlantic Current)



# Demography

- Population as of July 2014- 317,351 people
  - 40.7% from ages of 25-54(working class aged)
  - Median age 36.4 years old
- 93.7% of the country is urbanized (2011)
- 3.2 people per square kilometer April 2015
  - Versus 33 people per square kilometer in U.S.A.



**Population Density (inh/sqkm)**

0,00 - 3,00

3,01 - 5,00

5,01 - 10,00

10,01 -

# Major Cities

- Reykjavík and the Capital area
  - Nation's capital, holds 60% of population
- Akureyri
  - Largest town outside of Reykjavik, center for trade, service, and communication in northern Iceland
- Ísafjörður
  - On the West Fjords, center for trade in west Iceland, town surrounded by mountains
- Egilsstaðir
  - Newer city, founded in 1944, provides services in east Iceland, known for being country's execution place, on the banks of Lake Lagarfjot
- Höfn
  - Popular tourist destination because it is close to two national parks: Vatnajökull and Jökulsárlón



Greenland Sea



# Economy

- capitalist structure and free-market principles
- extensive welfare system
- seventieth most productive country in the world per capita US\$ 47,461 in 2013 (it was the seventh in 2007 before the financial crisis of 2008) (Source: World Bank)
- GDP 5,330 Million US\$ (2013) (Source: World Bank)
- About 85 percent energy supply in Iceland from domestically renewable sources
- the 2014 Global Green Economy Index ranked Iceland among the top 10 greenest economies in the world

PERFORMANCE RANK	COUNTRY	SCORE
01	Sweden	68.1
02	Norway	65.9
03	Costa Rica	64.2
04	Germany	63.6
05	Denmark	63.2
06	Switzerland	63.1
07	Austria	63.0
08	Finland	62.9
09	Iceland	62.6
10	Spain	59.2



# Economy

- 2008 economic crisis
- 3 largest banks taken into government administration
- Collapse of banking sector
- Depreciation of Icelandic krona
- But due to:
  1. Clean energy
  2. Marine resources
  3. Strong infrastructure
  4. Well-educated workforce
- Sign of recovery in the last 5 years
- Unemployment rate has declined consistently since the crisis
- From 8.1% (2010) to 4.8% (2012)



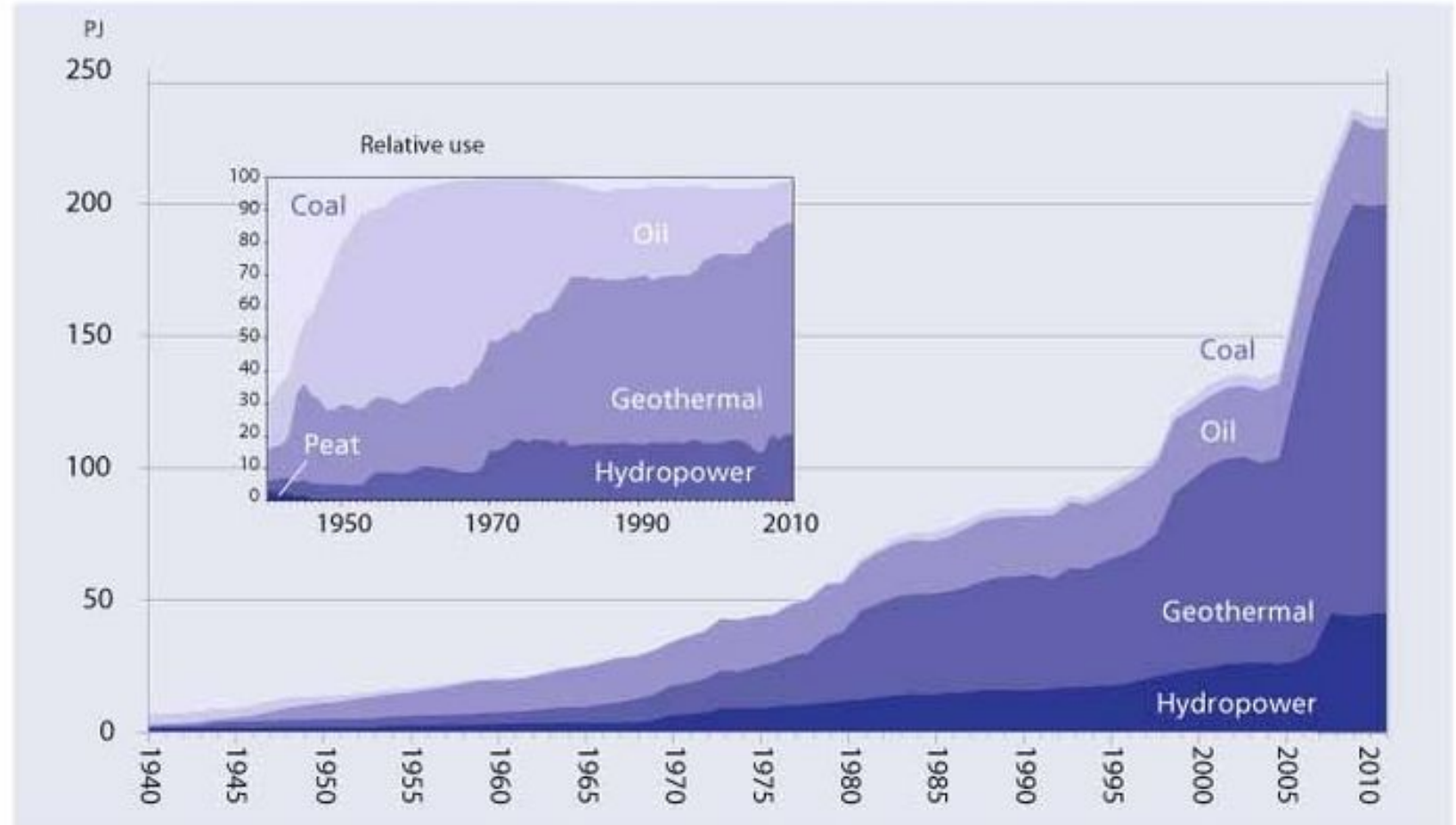
# Economy

- Basic sectors of Icelandic economy:
  1. Services (accounting for 71.2% of GDP 2013)
  2. manufacturing industries, construction and utilities (22.9%)
  3. fisheries (5.9%)
- Export base is relatively narrow and depends on natural resources:
  1. fishing (40% of export earnings and employs 4,8% of the work force)
  2. Metals from Energy intensive industries
  3. Tourism
- Industrial investments in Iceland has grown considerably since 1995
- Geothermal and Hydropower sources attract foreign investments
- Investments are likely to increase in the future



# ENERGY - Primary Energy

- 236,000 TJ in 2011
- 750 GJ per capita (2010)
- Primary Energy:
  - 15% imported
  - 85% domestic renewable
- Domestic renewable:
  - 22% Hydropower
  - 78% Geothermal
- Energy imported:
  - 90% petroleum products

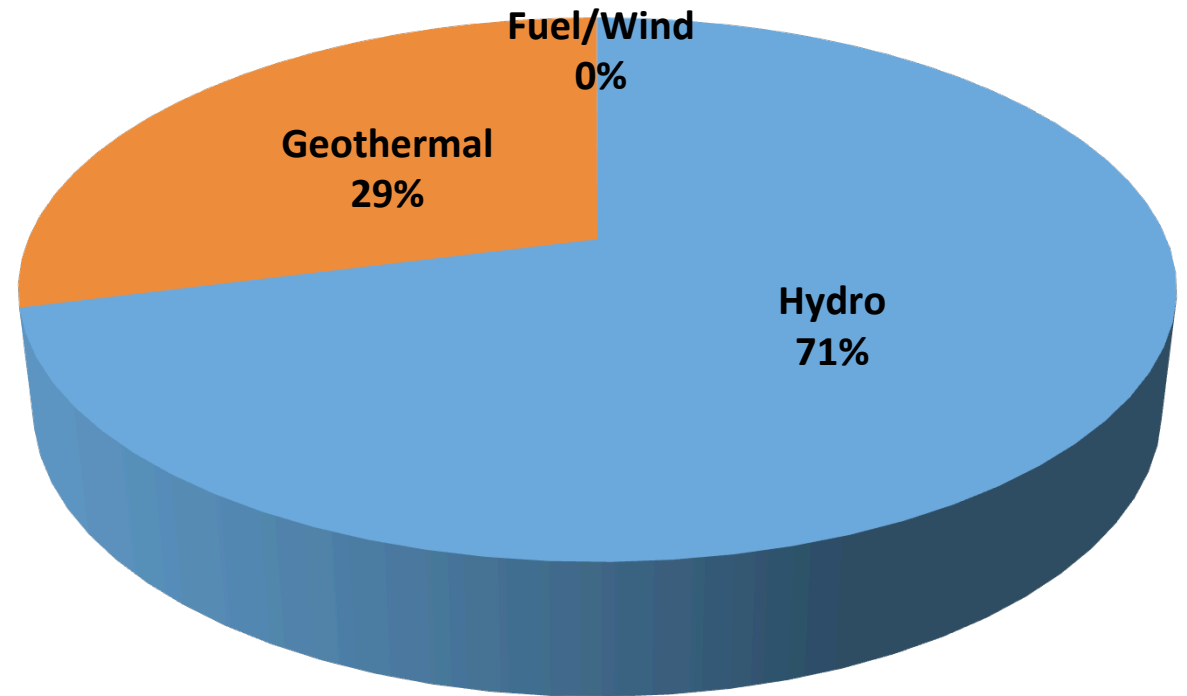


# ENERGY – Electrical Energy Generation

Electricity generation in Iceland in 2013: (GWh)

- Hydro: 12,863
- Geothermal: 5,245
- Wind: 5
- Fuel: 3
- TOTAL 18,116

(TOT per capita 57,100 kWh)

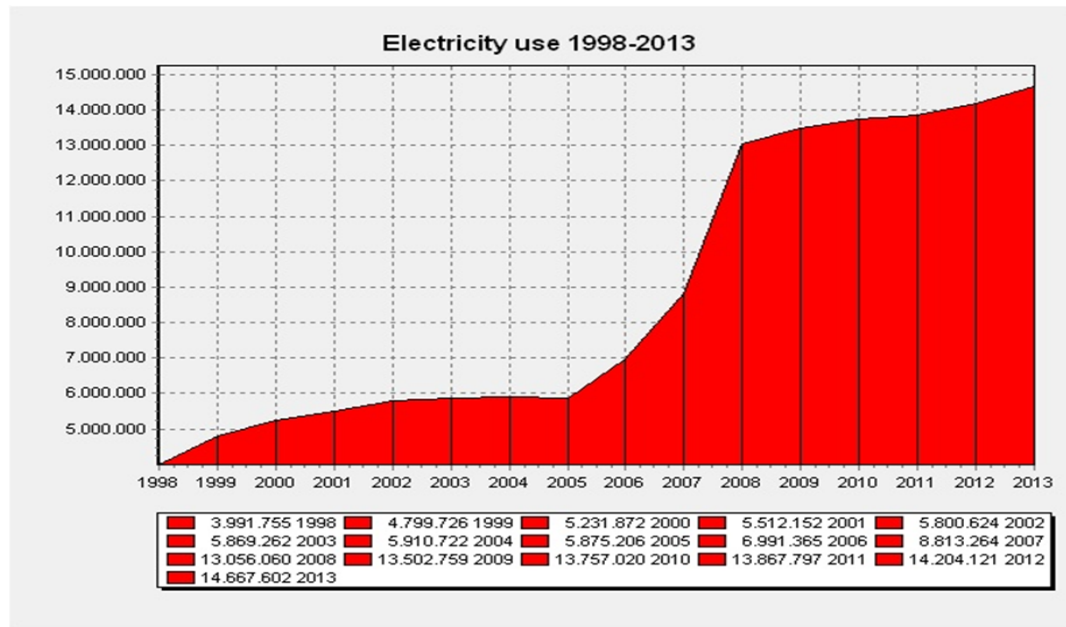


# ENERGY — Electrical Energy Use

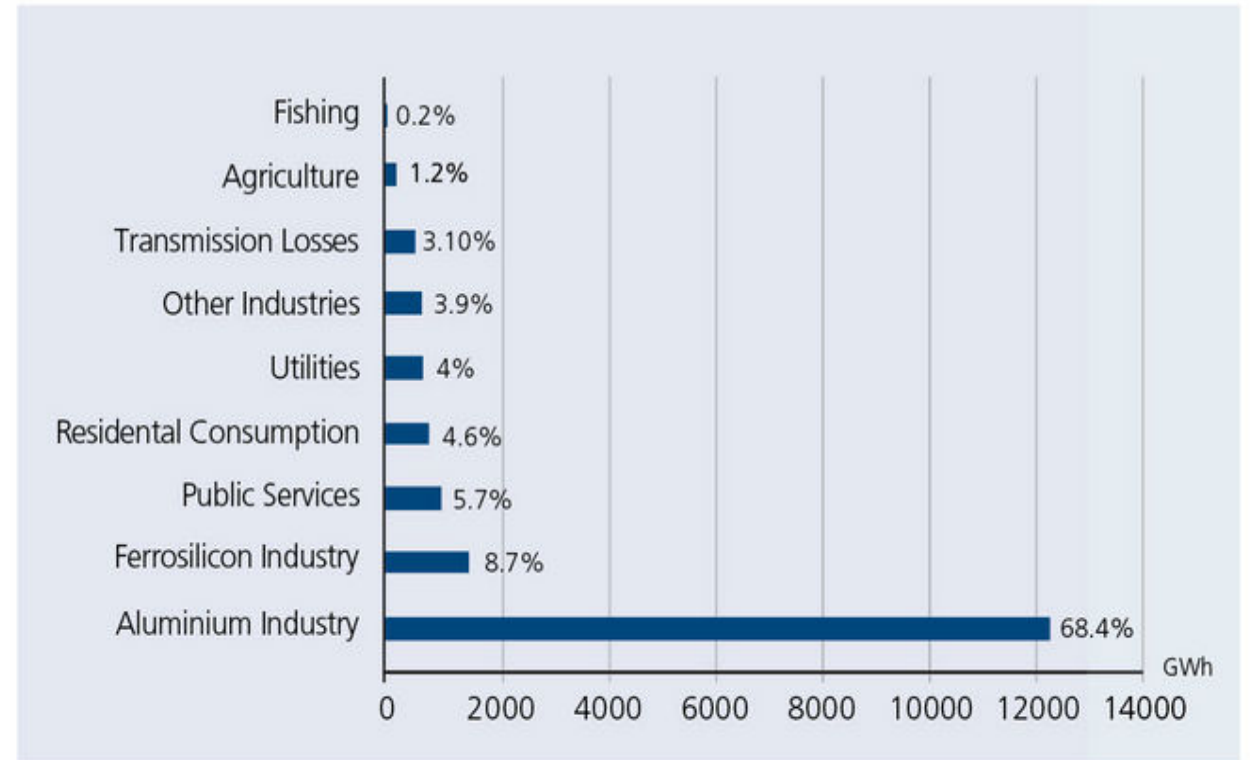
The use of Electricity in  
2013 by Industries

was the 81%:

- Energy intensive: 77.1%
- Other: 3.9%



## Electricity consumption 2013

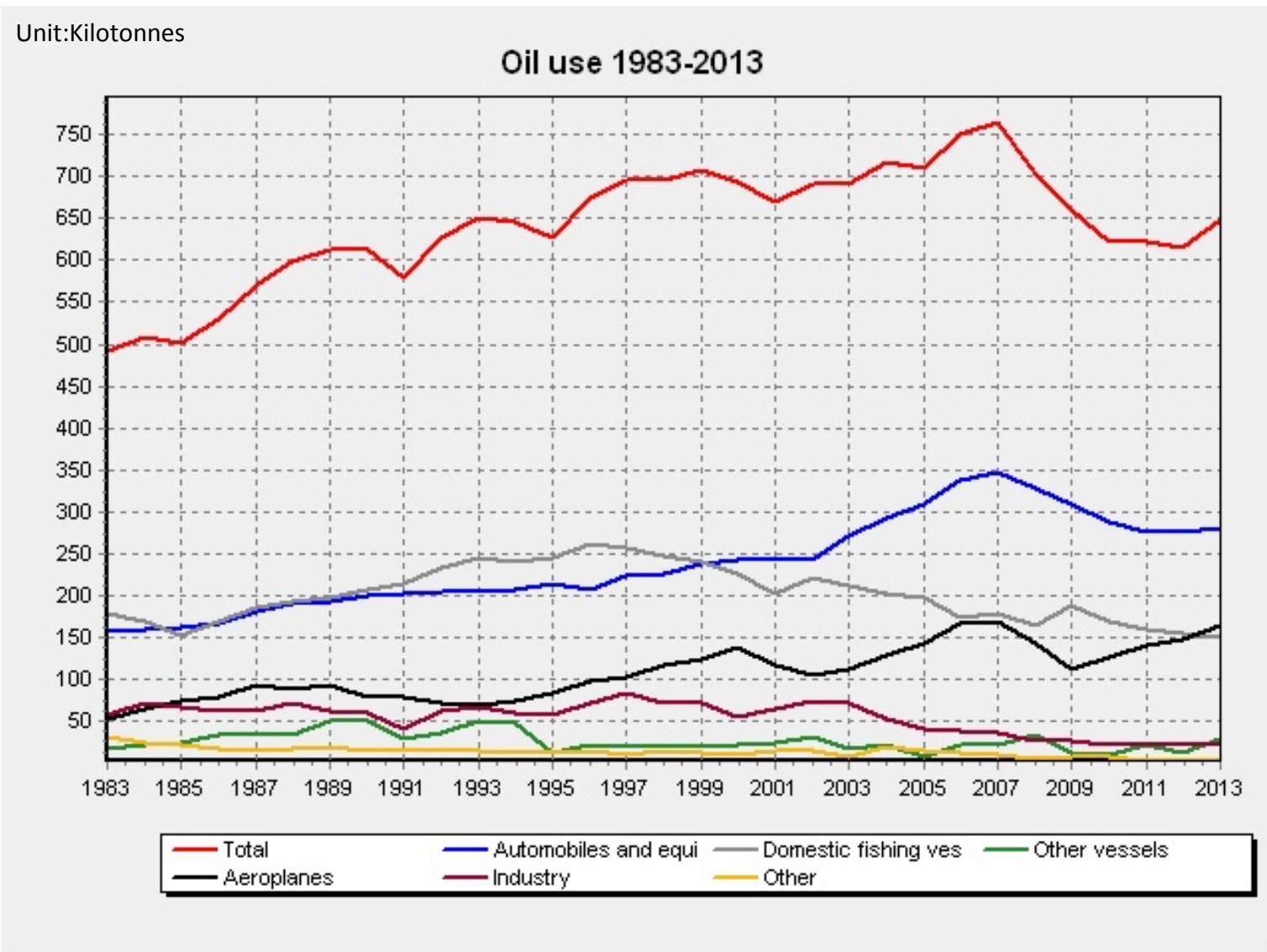


# ENERGY – Oil use

- Evolution of Iceland oil use

- 2013:

- Automobiles 43%
- Fishing vessel 23%
- Airplanes 25%
- Other vessels 4,5%
- Industry 3%
- Other 0,5%



# Energy Policy Summary

- Main goal of all policy is to achieve carbon neutrality
- Eliminate use of fossil fuel in all ways possible
- Maximize use of Renewable Energy

# Energy Policies

- To make full use of the abundant renewable resources on the island in a sustainable manner
- All electricity and space heating comes from renewable sources
  - 87% of space heating comes from geothermal power
- By offering country as a site for power intensive industries helps increase sustainable energy use

\*believe this information is from 1999



# Energy Policy

- To boost research, development and production of domestic, environmentally friendly fuel and increase the number of alternative energy outlets. The aim is to enable Iceland to lead the way in coming years in experiments and production of environmentally friendly energy sources, in part by supporting research and development and building up infrastructure.
- To encourage better energy utilization, for instance, by developing industrial parks and factories, horticulture stations, recycling and other activities utilizing the steam energy of sustainable geothermal plants.

To formulate a comprehensive energy strategy, aimed at having renewable energy sources replace imported energy. A precautionary and protective approach will be followed in hydroelectric and geothermal energy production. The energy strategy will support diversified industry, emphasizing the development of ecologically beneficial high-tech industry. The energy strategy will aim at sustainable utilization, avoiding for instance aggressive utilization of geothermal areas.

# Energy Policy

- Preparation of an energy efficiency plan for both commercial enterprises and households. Finalization of the Master Plan for Utilization of Renewable Energy Resources as soon as possible and presenting it to the Althingi this coming winter so that it will acquire a legal status. No further decisions will be taken concerning power development on the lower reaches of the River Þjórsá until the Master Plan is available.
- Promotion of transparency in agreements for energy sale and ways sought to remove secrecy surrounding energy prices to power intensive industries. The aim will be equitable pricing of electricity for different industrial sectors.

# Energy Goals

- Having renewable energy sources replace imported energy.
- Iceland's energy harnessing shall be sustainable for the good of society and the public.
- A precautionary and protective approach will be followed in hydroelectric and geothermal energy production.
- The energy strategy will support diversified industry, emphasizing the development of ecologically beneficial high-tech industry.
- The energy strategy will aim at sustainable utilization, avoiding for instance aggressive utilization of geothermal areas.
- To encourage better energy utilization, for instance, by developing industrial parks and factories, horticulture stations, recycling and other activities utilizing the steam energy of sustainable geothermal plants.
- Connection of the Icelandic electricity system to Europe, through an interconnector, shall be examined further.

# ENERGY – Geothermal

Geologically young Country

Mid Atlantic Ridge

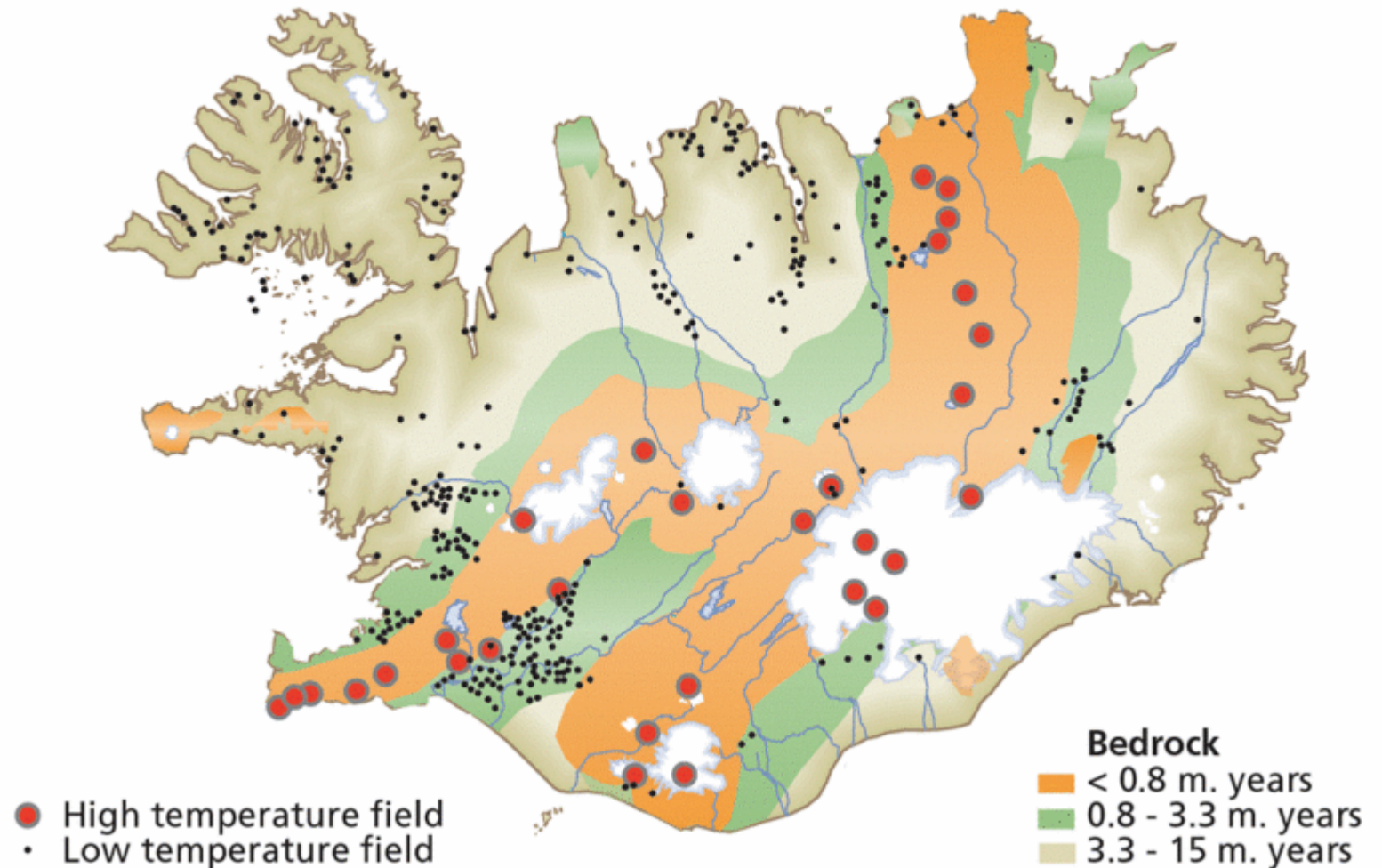
Great volcanic productivity:

- 200 volcanoes
- 20 high-temperature areas (250°C within 1000 m depth)
- 250 low-temperature areas (150°C in the upper most 1000 m)
- 600 hot springs (over 20°C)

Italy and Iceland the only high temperature geothermal sources in Europe

Iceland: a pioneer for space heating

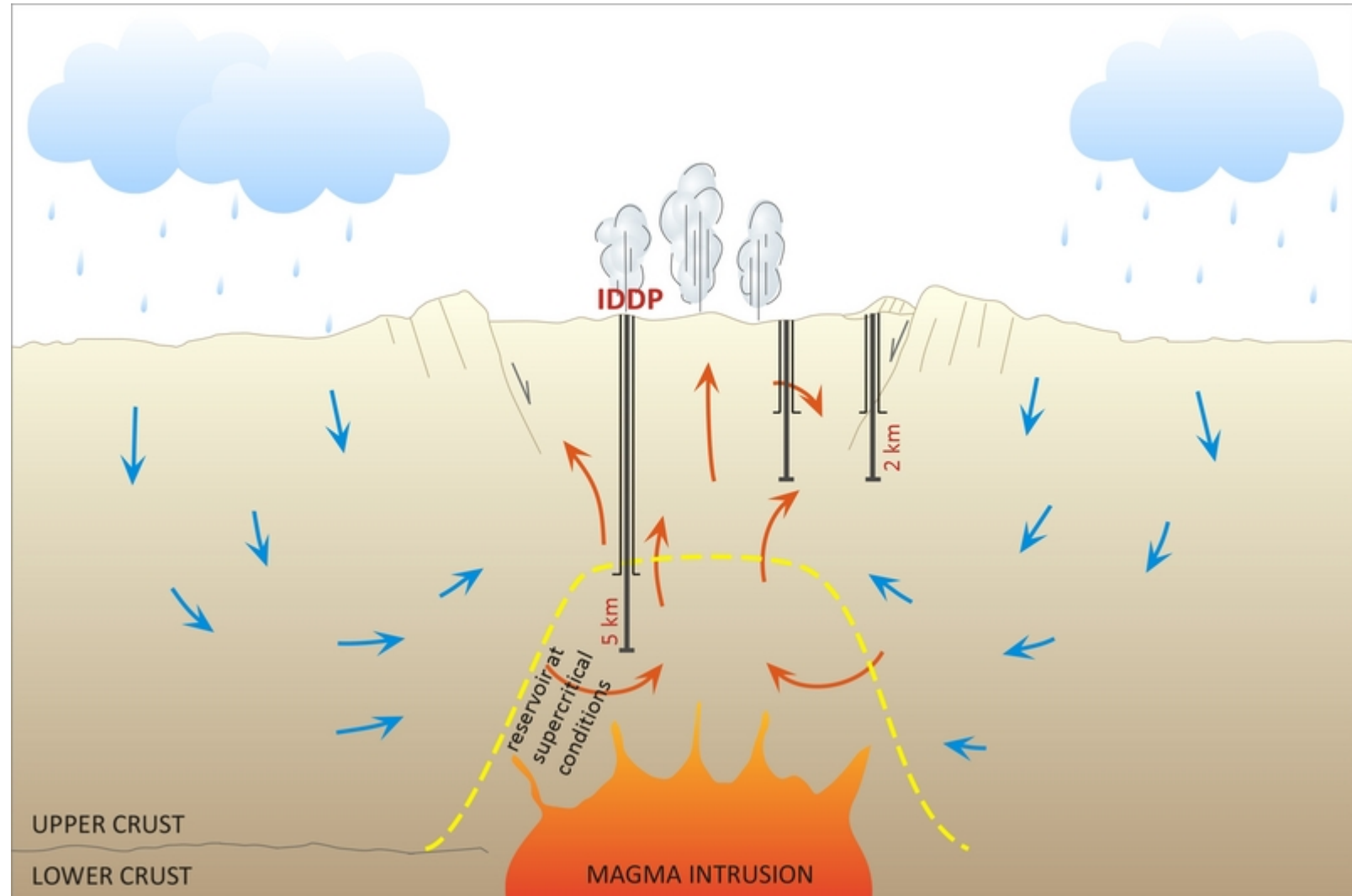
## Geothermal fields



# ENERGY – Geothermal

## The Iceland Deep Drilling Project (IDDP)

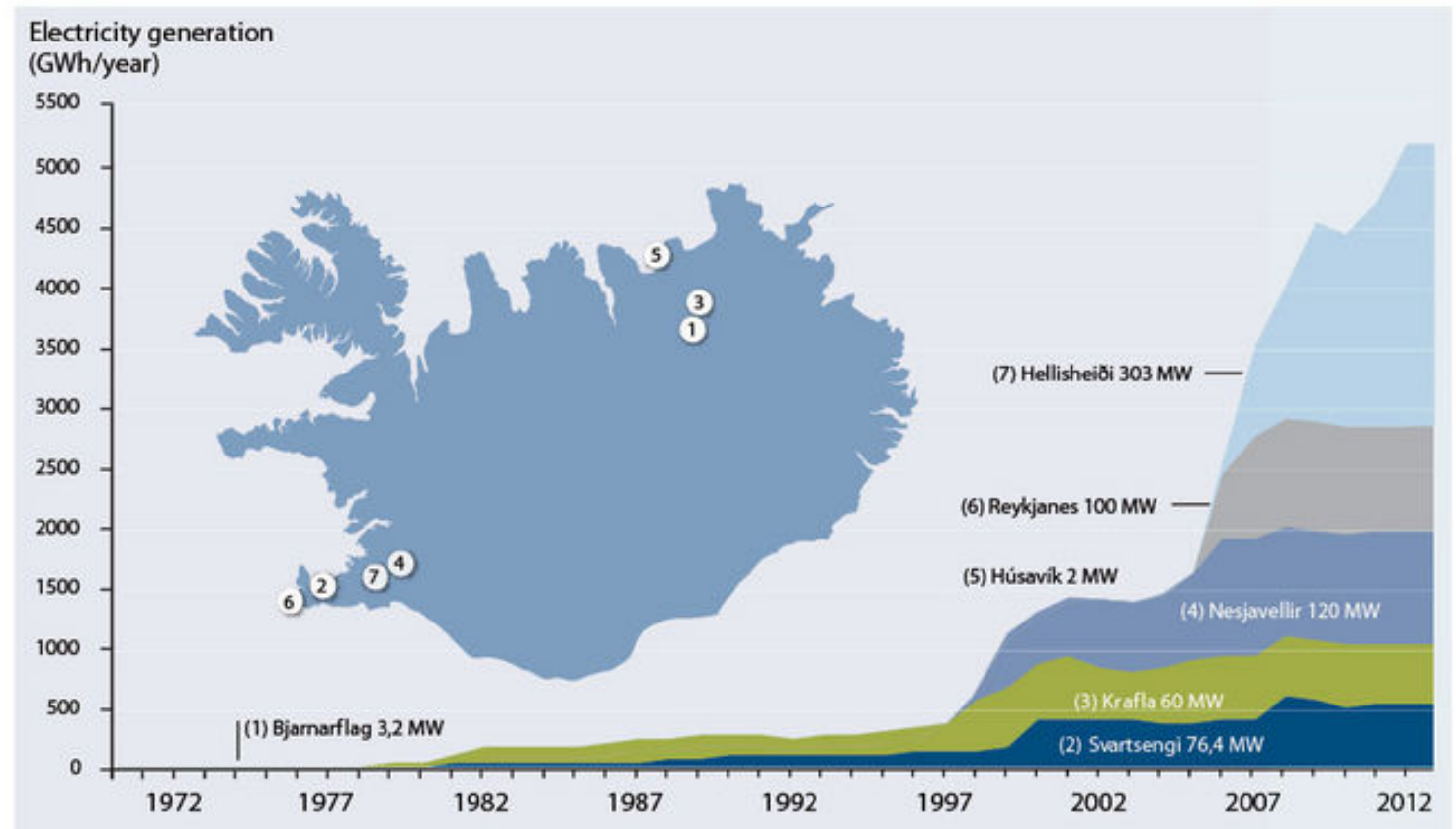
- Study in Krafla area
- penetrate supercritical zones
- reach hydrothermal fluids at temperatures ranging from 450°C to ~600°C
- drilling to a depth of about 5 km instead of 2.5 km
- yields of approximately 50 MWe power equivalent instead of 5 MWe (10-fold increase)



# ENERGY – Geothermal generation

- Production: 5,200 GWh (29% of the country's total electricity production)
- Total installed generation capacity of geothermal power plants: 665 MWe in 2013 (24.5%)
- Main plants:
  - Hellisheiði (303 MW)
  - Nesjavellir (120 MW)
  - Reykjanes (100 MW)
  - Svartsengi (76.4 MW)
  - Krafla (60MW)

## Generation of electricity – geothermal energy

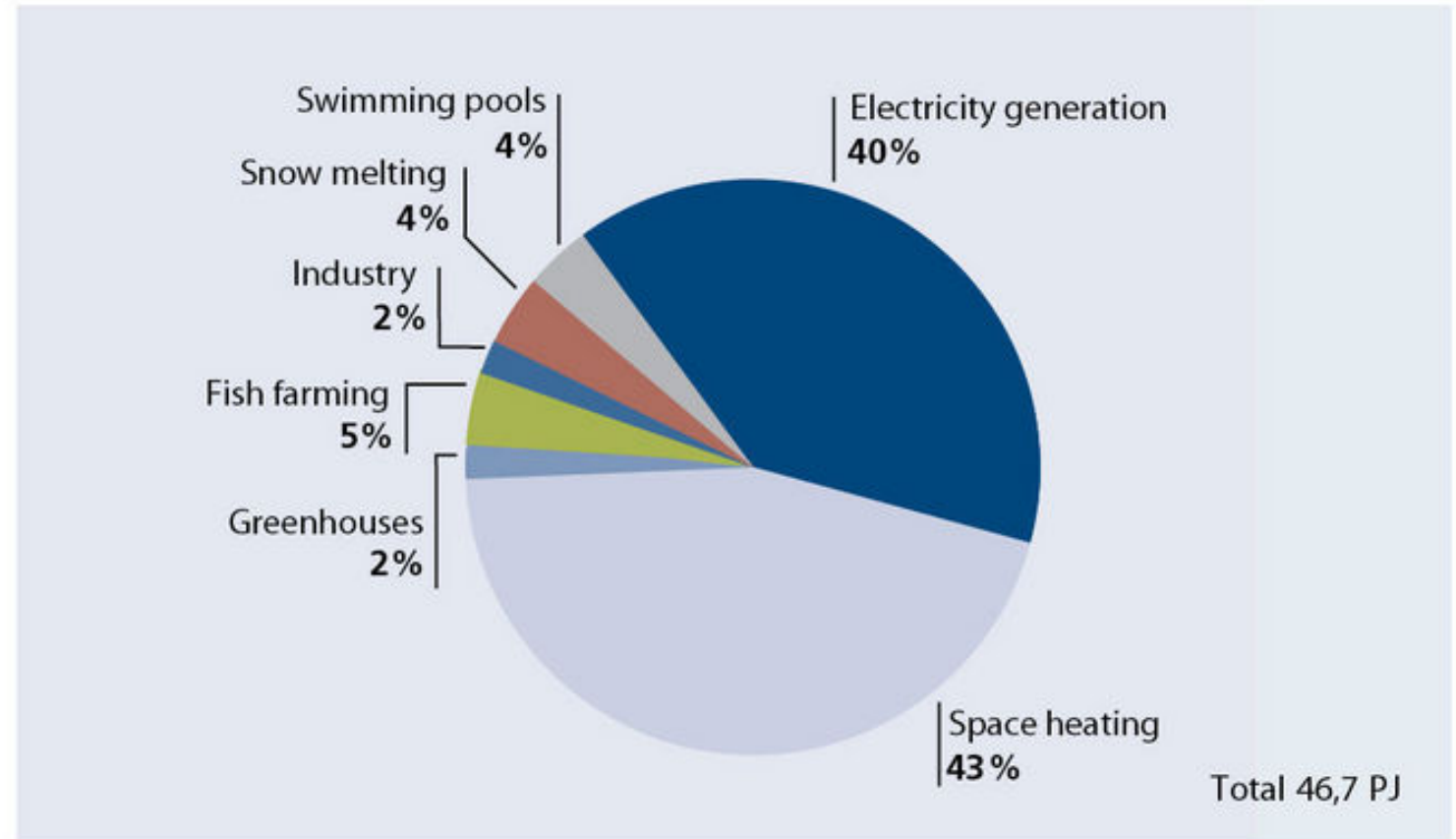


Source: OS ORKUSTOFNUN (Iceland National Energy Authority)

# ENERGY – Direct use of Geothermal energy

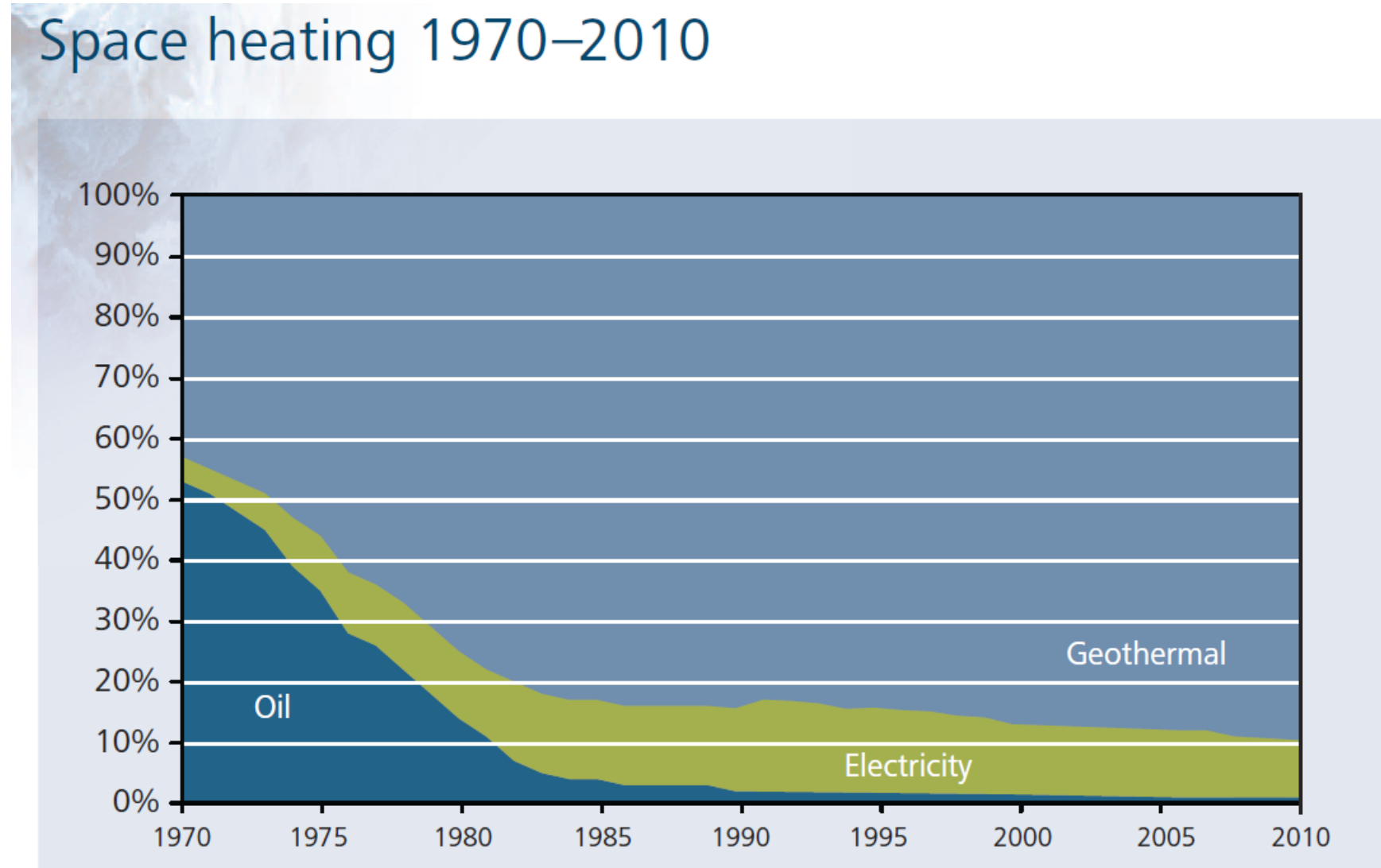
- Iceland world leader in the use of geothermal district heating
- 9/10 households are heated with geothermal energy
- Space heating is the largest direct use of geothermal energy
- 2013: space heating 43% of the total use of geothermal energy (46,700 TJ/13,000 GWh)

## Utilisation of geothermal energy 2013



# ENERGY – Space heating use of Geothermal energy

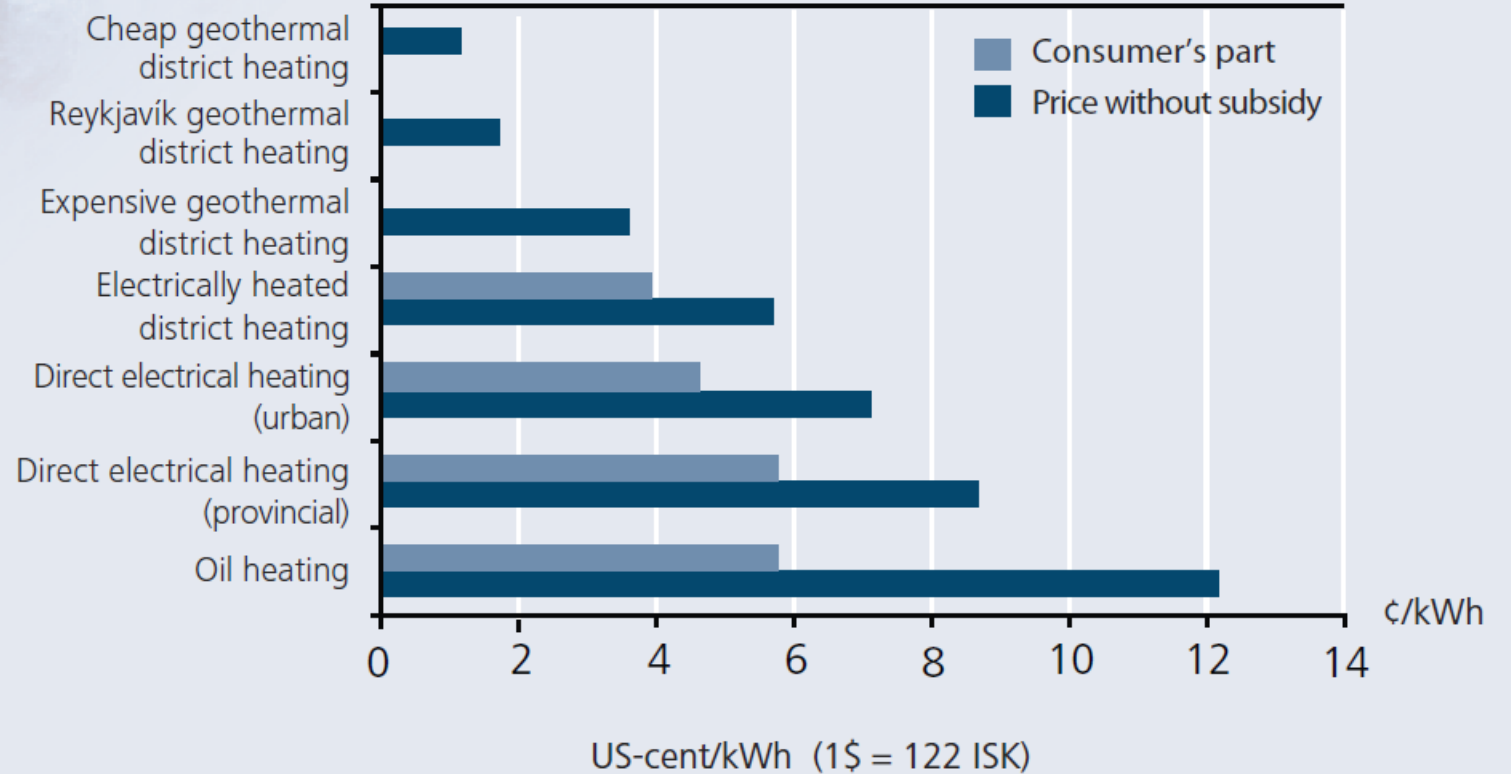
- Great development of geothermal space heating till 1985
- 89% of population
- 10% electricity (district heating)
- 1% oil (more than 50% in 1970)
- Proportion using geothermal is still increasing





# Production

## Comparison of energy prices for residential heating mid year 2010



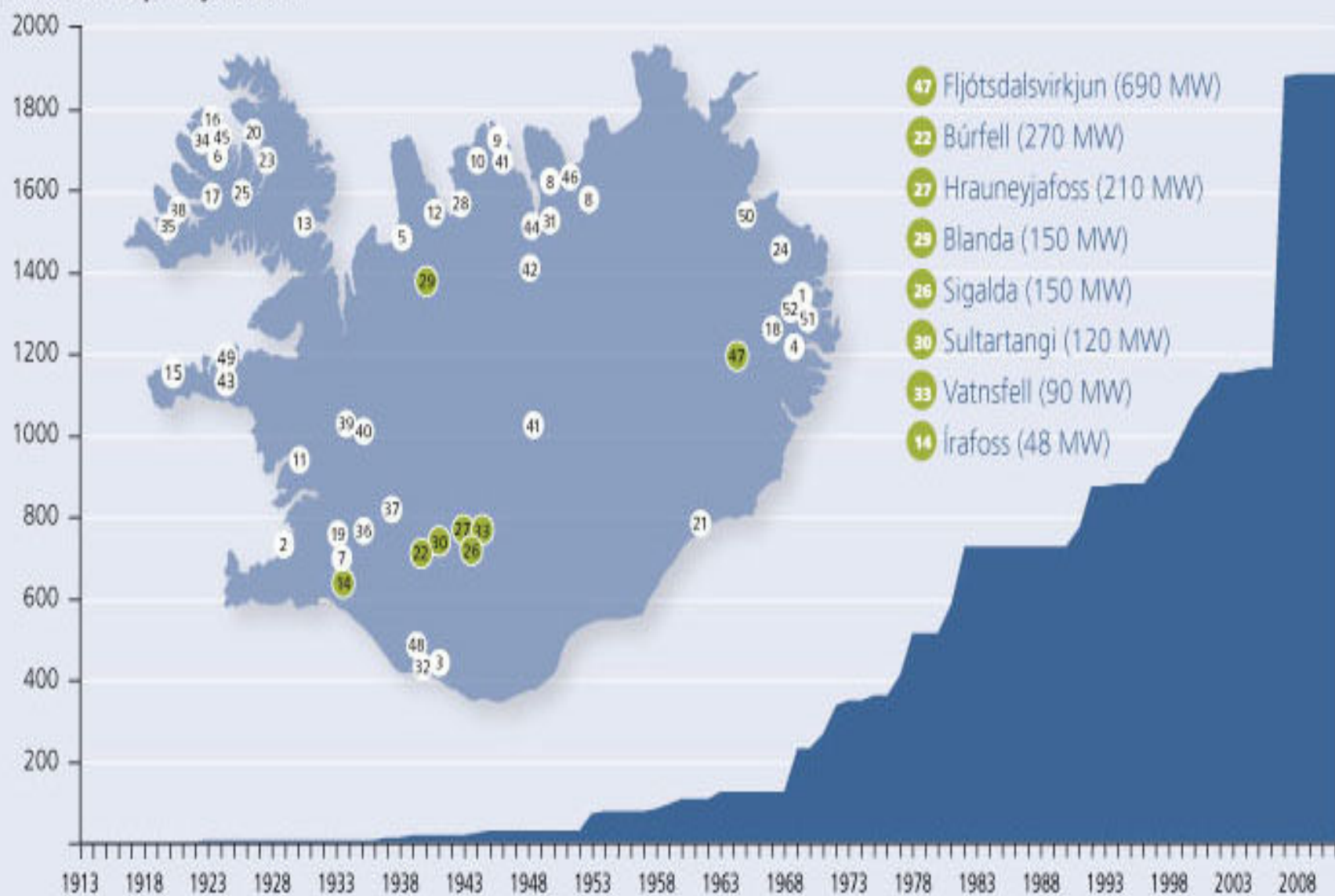
# Hydroelectric Power

- 71.8% of total electric network (2013)
  - 12,863.0 GWh Installed capacity and generation in public power plants
  - Iceland's precipitation combined with extensive highlands, has an enormous energy potential or up to 220 TWh/yr
- According to Electricity Act, landsnet, a private enterprise, was established to provide the electrical transmission and system operations services, Landsvirkjun is the biggest shareholder at 65%
- Only two islands are not connected to nation's electrical grid; Grimsey and Flatey
  - These islands use diesel generators for electricity
- All hydro-plants larger than 1 MW must be connected to the national grid
  - All smaller plants can sell their production to the grid

# Hydroelectric Power

- Landsvirkjun is largest company to produce energy at 12,469 GWh
  - Attributes to 75% of the grid
- There is Environment assessment impact act that has a final say on if a project for a new plant will continue
  - If it is deemed there is too large of an impact the plant will be shut down
  - All Icelanders are entitled to submit comments to the environmental impact assessment of every project. This supports democratic decision making and an open public debate.

## Installed capacity in MW

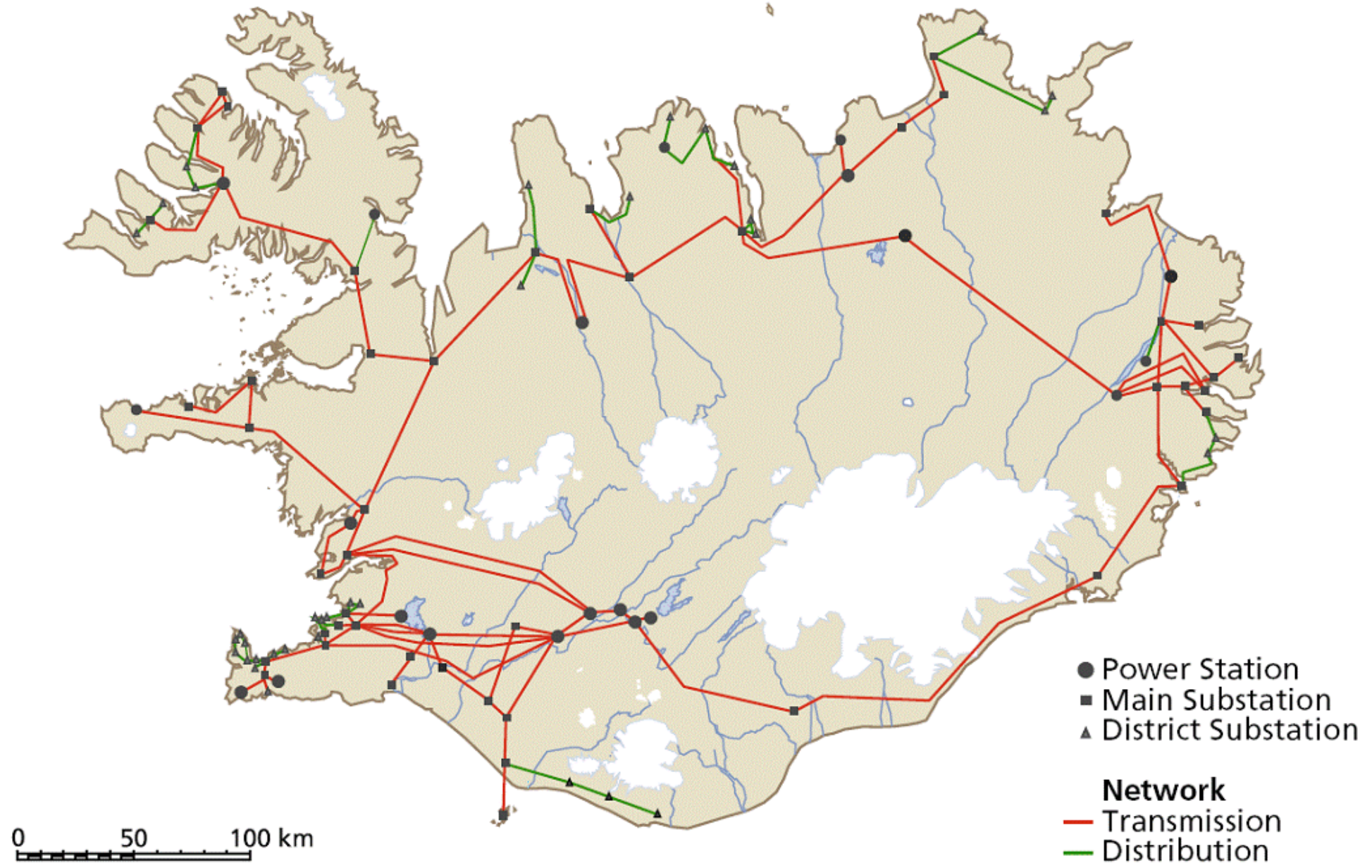


# Landsvirkjun Hydro-Plants

- Blanda- 150 MW
- Búðarháls – 95 MW
- Búrfell- 270 MW
- Fljótsdalur- 690 MW
- Hrauneyjafoss- 210 MW
- Irafoss- 48 MW
- Laxa I/II/III- 5/9/13.5 MW
- Vatnsfell – 90 MW
- Ljosafoss- 16 MW
- Sigalda – 150 MW
- Steingrimsstöð- 27MW
- Sultartangi- 120 MW

Capacity of all plants

# Electricity network



# Environmental Impact

- Air quality in Iceland is generally good, but particulate matter (PM) pollution from road traffic, with sporadic additions from volcanic ash
  - sometimes exceeds EU limit values
  - In Reykjavik region hydrogen sulfide is problematic from geothermal plants
- Iceland's greenhouse gas footprint (in tonnes of carbon per capita per year) is relatively high compared to other (The Organisation for Economic Co-operation and Development )OECD countries.
  - Impact is high due to dependence on fossil fuel for transportation and fishing and metal smelting industry

# Environmental Impact

- Tourism is another issue causing growing environmental concern.
  - The number of tourists visiting Iceland per year will soon amount to three times the country's population.
  - All tourist tend to visit the same sights
- Increasing debate and controversy over both hydro-electric projects and geothermal developments have bolstered the scope for alternative energy solutions such as wind power and tidal energy.



# CO<sub>2</sub> Emissions

Emission of carbon dioxide (CO<sub>2</sub>) by source 2005–2012

Tonnes

**Man-made emissions (without carbon sequestration), grand total** 3,324

**Fuel combustion, total**

1,491

**Industry and construction**

172

**Road transport**

782

**Other transport**

35

**Fishing vessels**

\*6.2 metric tons per capita in 2010

485

**Other combustion**

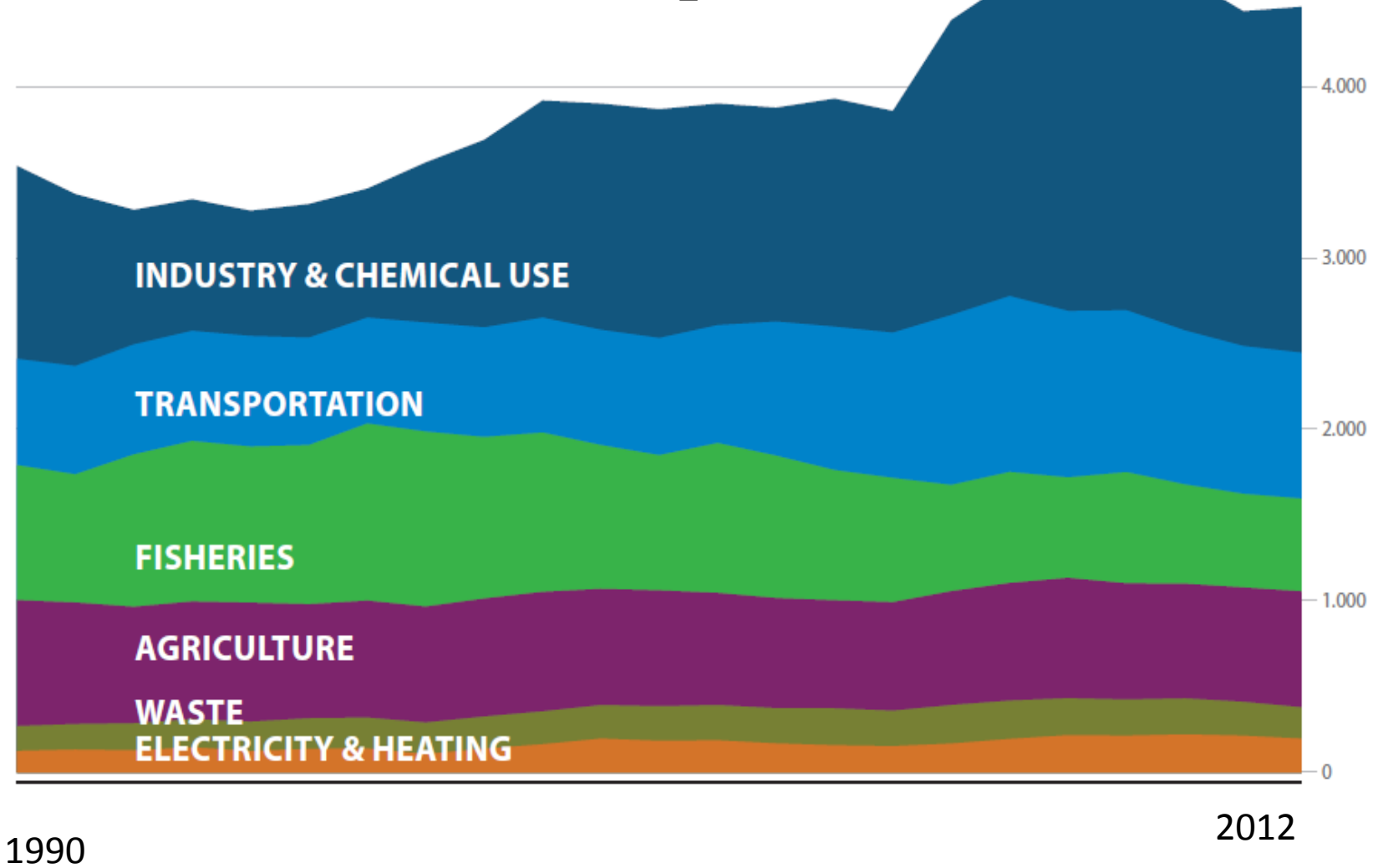
# Greenhouse Gas

## Greenhouse gas emissions 1990-2012

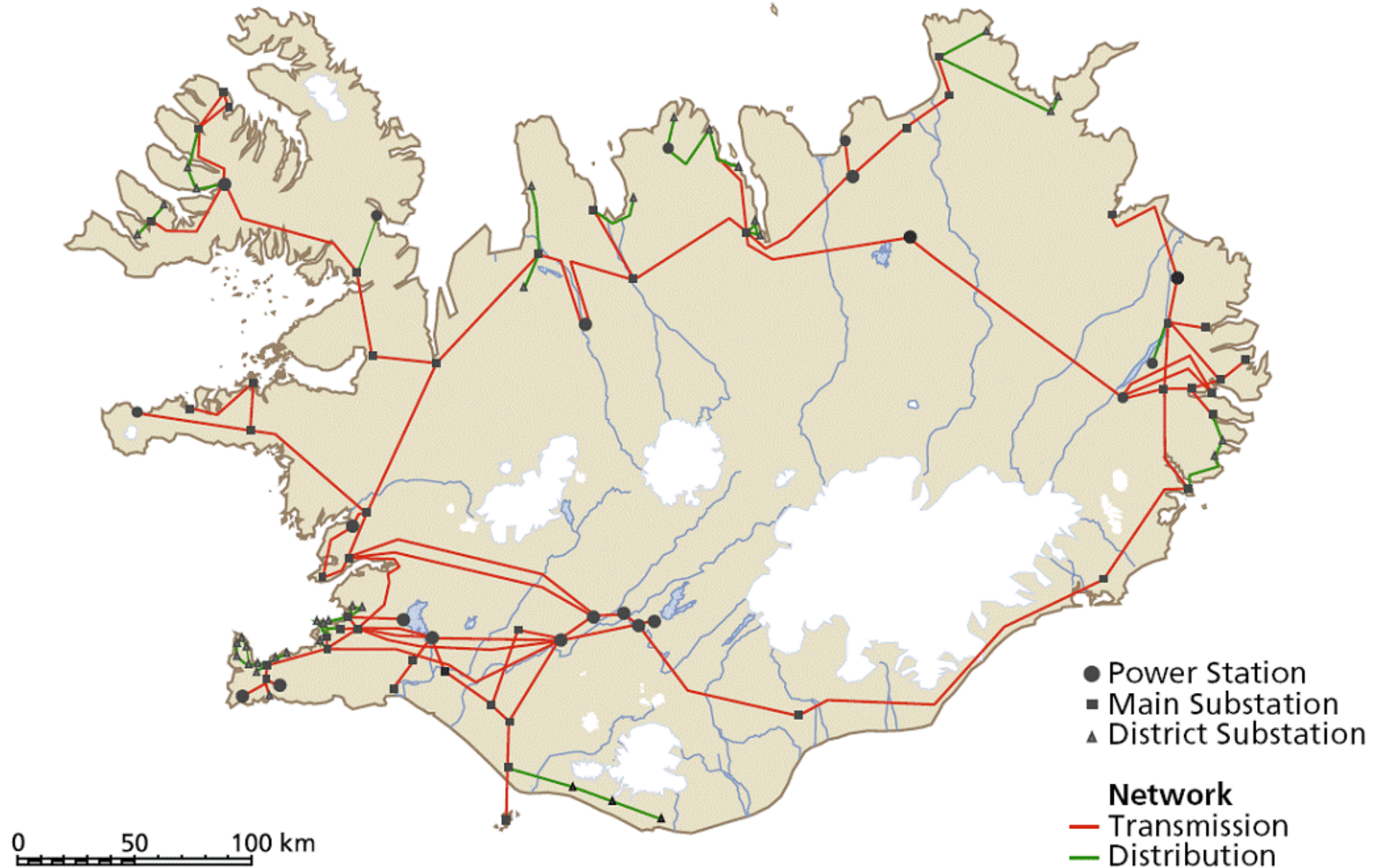
1000 Tonnes in CO<sub>2</sub> equivalents

<b>Man-made emissions, total</b>	<b>4,469</b>
<b>CO2</b>	
3,324	
<b>CH4</b>	<b>457</b>
<b>N2O</b>	<b>458</b>
<b>HFC</b>	<b>144</b>

# Greenhouse Gas emissions by Category thousands of tons of CO<sub>2</sub> equivalent



# Electricity network



# ENERGY – Hydrogen as an alternative fuel

- Use of fossil fuel for private transportation and fishing:
  - 1/3 of Country CO<sub>2</sub> emissions
  - 9/10 of all imports
- Alternatives:
  - Biofuels
  - Battery vehicles
  - Hydrogen vehicles
- Surplus of energy used to produce Hydrogen (gas)
- Wind to produce Hydrogen

## Smart H2 project:

the project aim is to test various types of Hydrogen-fuelled company cars and other equipment running on Hydrogen (Hertz car rentals and turist boats)

## Ectos Project:

Reykjavík has a pilot project of a bus fleet hydrogen fuelled: 3 buses and 1 fuel station (Shell)



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