ALCUE NET
Latin America, Caribbean and European Union Network on Research and Innovation

Geothermal Power in Iceland

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Geothermal Energy Workshop
Salta – December 2014

ALCUE NET

EFLA Consulting Engineers

- General engineering and consulting company
  - 240 employees
  - Additional 60 employees in international affiliated companies
  - 35-55% of activities international
- All main disciplines of engineering and related fields
- ISO 9001 QM Certification, ISO 14001 EM Certification, OHSAS 18001 in 2011
- Recipients of the Icelandic Quality Award
- Recipients of the Icelandic Environmental Award
- Among 1% of Iceland´s strongest companies (Creditinfo)

ISO 9001 FS 70294 ISO 14001 EMS 500841

OHSAS 18001 OHS 567076

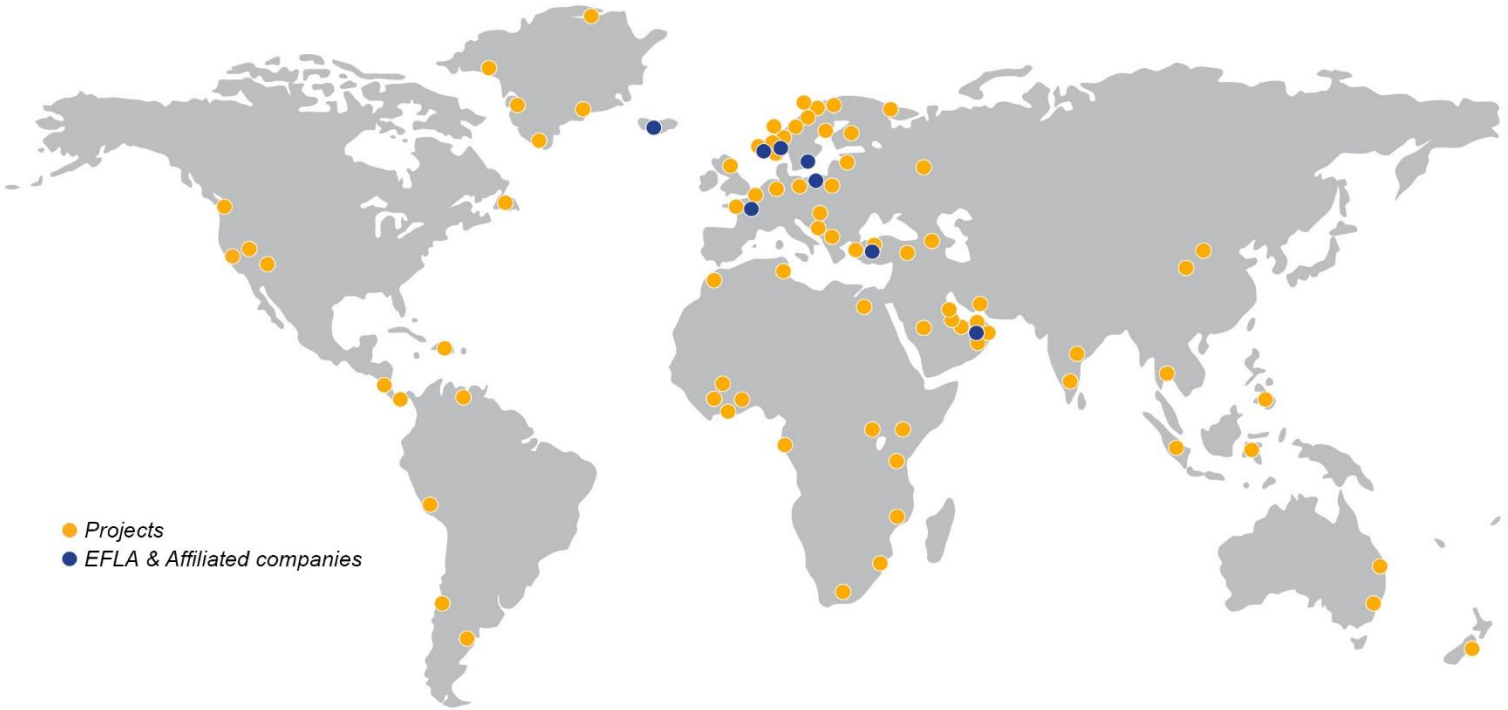
The strongest in Iceland 2010

The strongest in Iceland 2011

The strongest in Iceland 2012

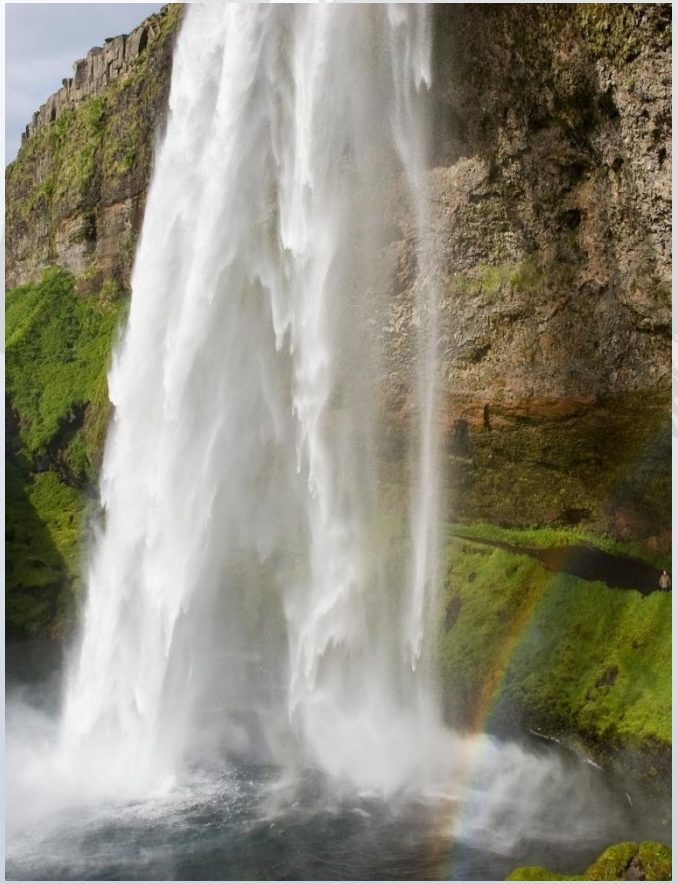
The strongest in Iceland 2013

EFLA Locations & Project clusters



Role of Orkustofnun/National Energy Authority of Iceland

- Public administration of the energy sector and specialist services to the government
- Long term planning of energy utilisation and the energy system
- Contracting and conducting research on resource utilisation
- Accumulating and maintaining databases on energy utilisation and forecasts for future trends



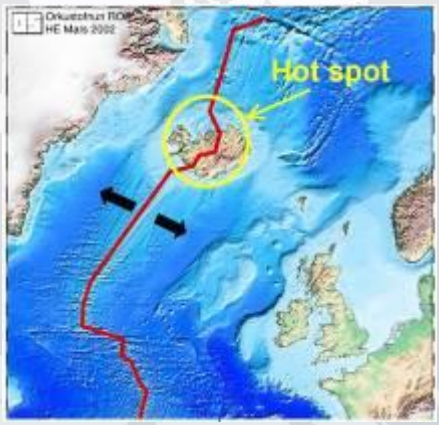
Source: Orkustofnun

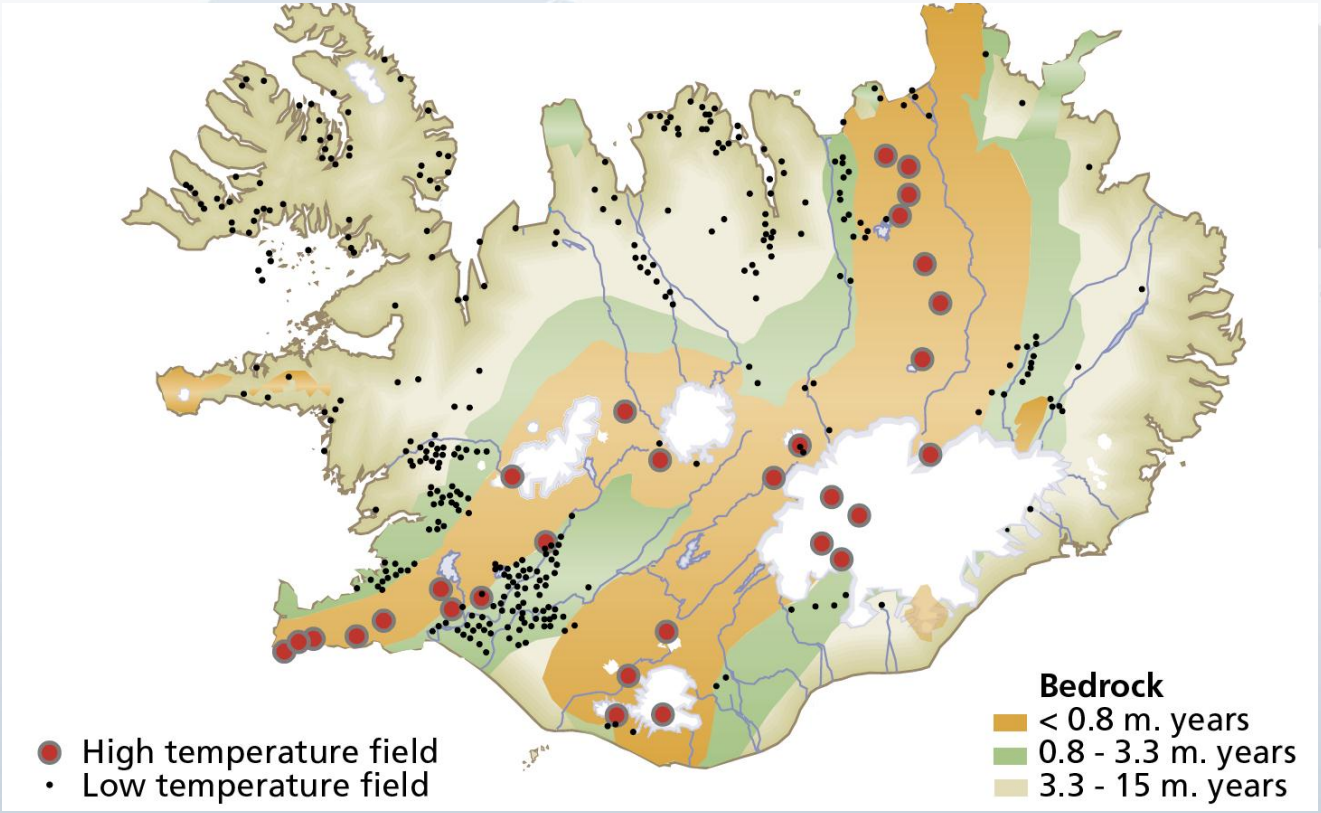
Role of Orkustofnun/National Energy Authority of Iceland

- Issues permits for exploration and utilisation of energy and earth based resources
- Issues power plant licences
- Is the regulator for the national grid
- Is the official monitoring body of issued licenses
- Administrates The Energy Agency, The Energy Fund and special initiatives for geothermal exploration
- Hosts the UN University Geothermal Training Programme

Source: Orkustofnun

Geothermal Fields in Iceland





T_{avg} = 0°C (january) to 10°C (july) in Reykjavík

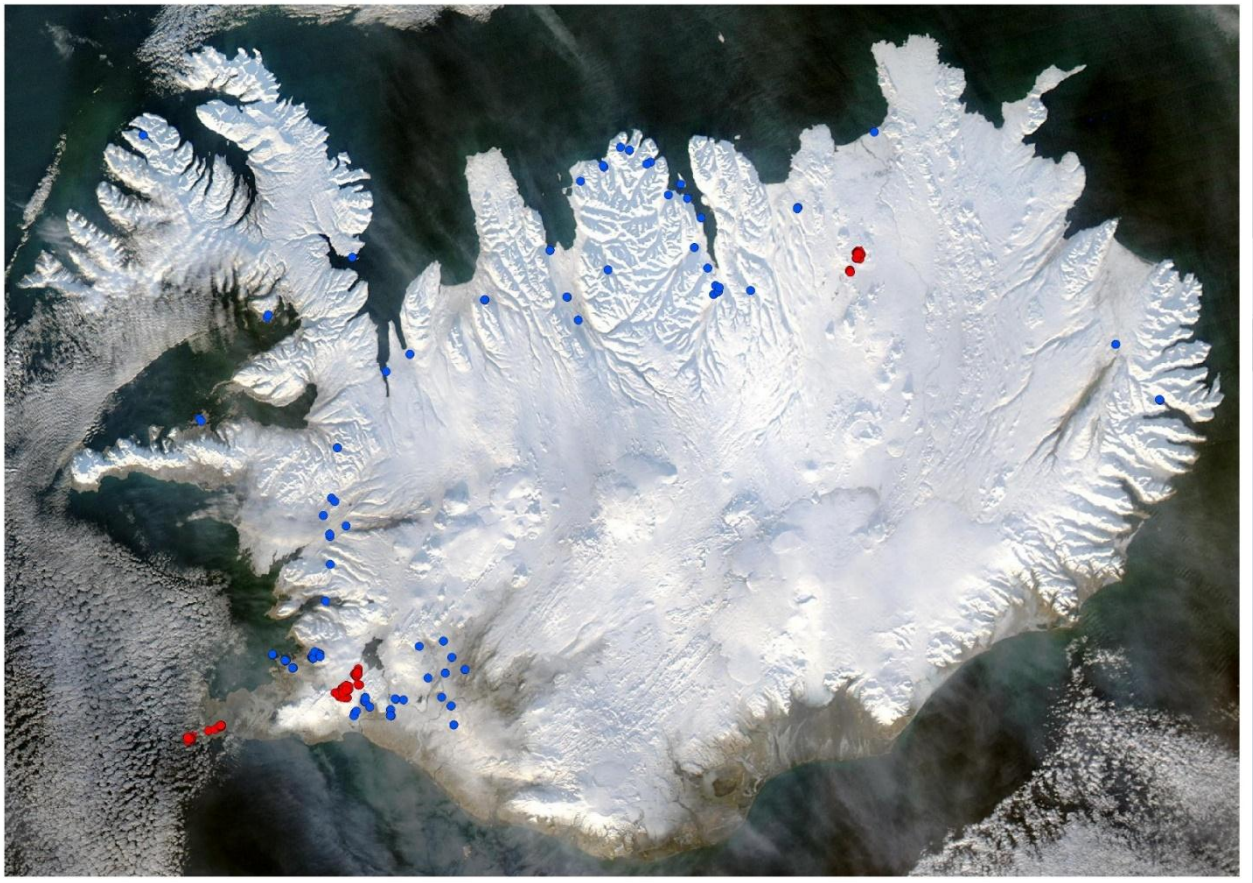
High and low temperature

In low temperature geothermal systems, temperatures in the uppermost 1,000 m may reach up to 150°C. In the high temperature fields, on the other hand, temperatures reach over 200°C at 1,000 m depth. High temperature geothermal areas are found within the active volcanic zone of Iceland.

Source: Orkustofnun

Iceland – Land of Ice and Fire

Source: Orkustofnun



Satellite image of Iceland in winter time illustrating geothermal production wells in operation in year 2014 for geothermal power plants (red) and wells operated by heat utilities with a natural monopoly for distribution of heat. Over 100 production wells operated by small auto-producers are excluded.

Energy Security – Development driven by Poverty

- Due to the First World War, 1914–1918, the market price for coal increased and coal was rationed.
- Combined with extremely cold weather conditions when temperatures measured minus 25 degrees Celsius in Reykjavik at the most on January 21,1918 possibilities of geothermal based DHS was discussed.
- The Prime Minister, Jón Þorláksson, an engineer, initiated the discussion on building a district heating system in Reykjavik in 1926. He later became the Major of Reykjavik in 1933–1935.

Source: Orkustofnun

First Geothermal based DHS in 1930

Laugarnes Production Field 3 km away

- After two years of drilling in Laugarnes 14 shallow wells where drilled. The result was 14 l/s of artesian flowing water at 87° C (deepest 246 m).
- The water was transported 3 km to two primary schools, a swimming hall, the main hospital, public buildings and 60 family homes in the capital area where connected over the next decade with good success.

The primary school Austurbæjarskóli

Source: Orkustofnun

Expansion of the DHS 1934–1955

Reykir Production Field 18 km away

- It became apparent that the Laugarnes field would only be able to supply hot water to part of Reykjavik. After negotiations drilling took place east of Reykjavik in Reykir area.
- Second World War (1939–1945) made the expansion more difficult but stressed the importance of energy security.
- Reykjavik Energy was issued a natural monopoly for District heating in year 1940.
- 72 shallow wells where drilled in Reykir area. The result was 320 l/s of 86° C of artesian flow.

Source: Orkustofnun

Political and legal milestones

- **1938** Expansion of the DHS was an influential part of the municipality elections in Reykjavik
- **1940–1945** National Research Council supported exploration drilling into high temperature systems.
- **1953** The parliament passed a law allowing the state to finance up to 80% of the total investment cost of drilling and building a DHS outside of the capital area.
- **1961** Geothermal Energy Fund and State Drilling Company established offering financing for research and drilling.
- **1961–1983** Over 350 loans issued for drilling and building DHS across the country and over 20 DHS where built.

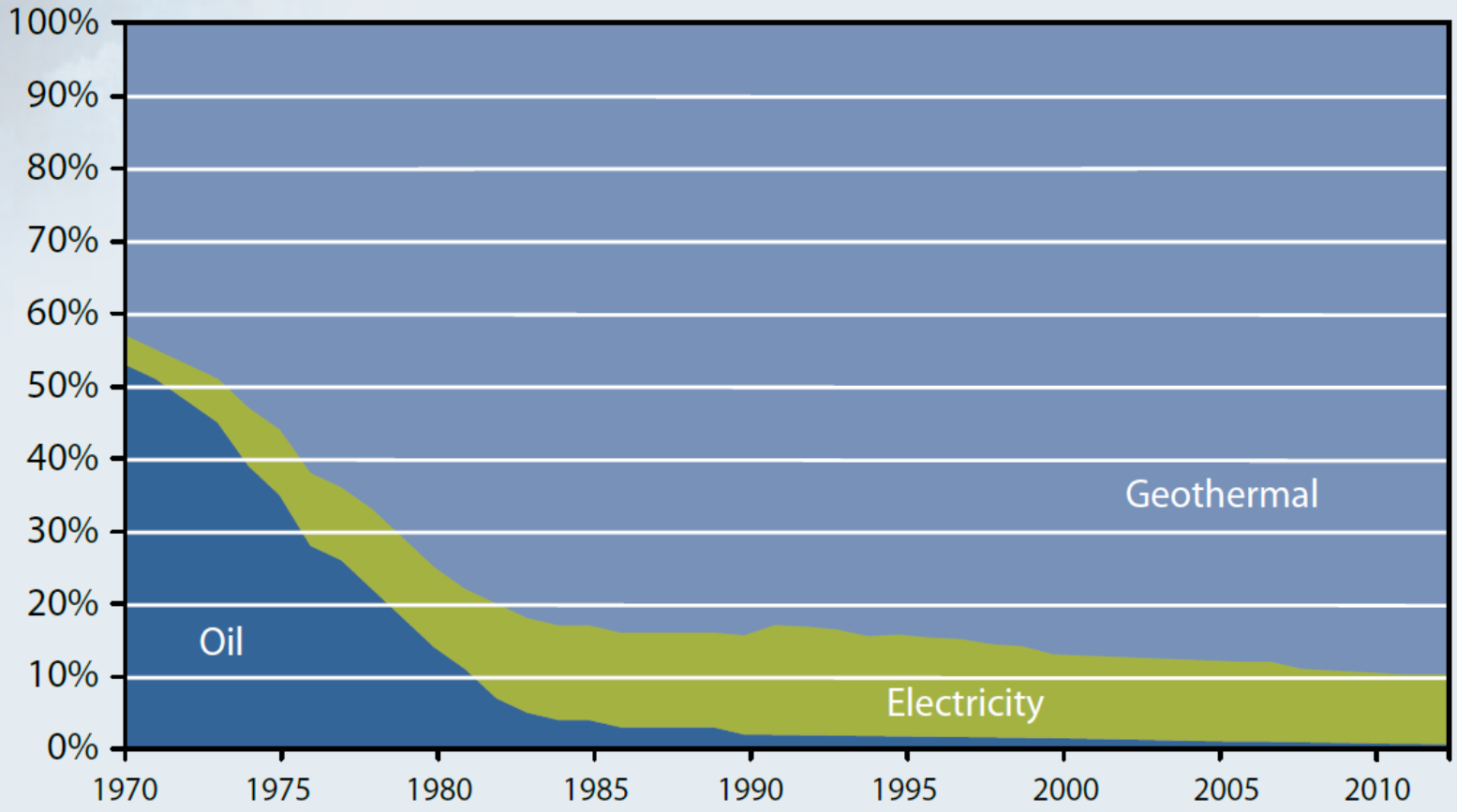

Morgunbladid

Kjósið hitaveituna í dag — C-listann

Reykvíkingar! Tryggið yður hitaveituna með því að kjósa C-listann

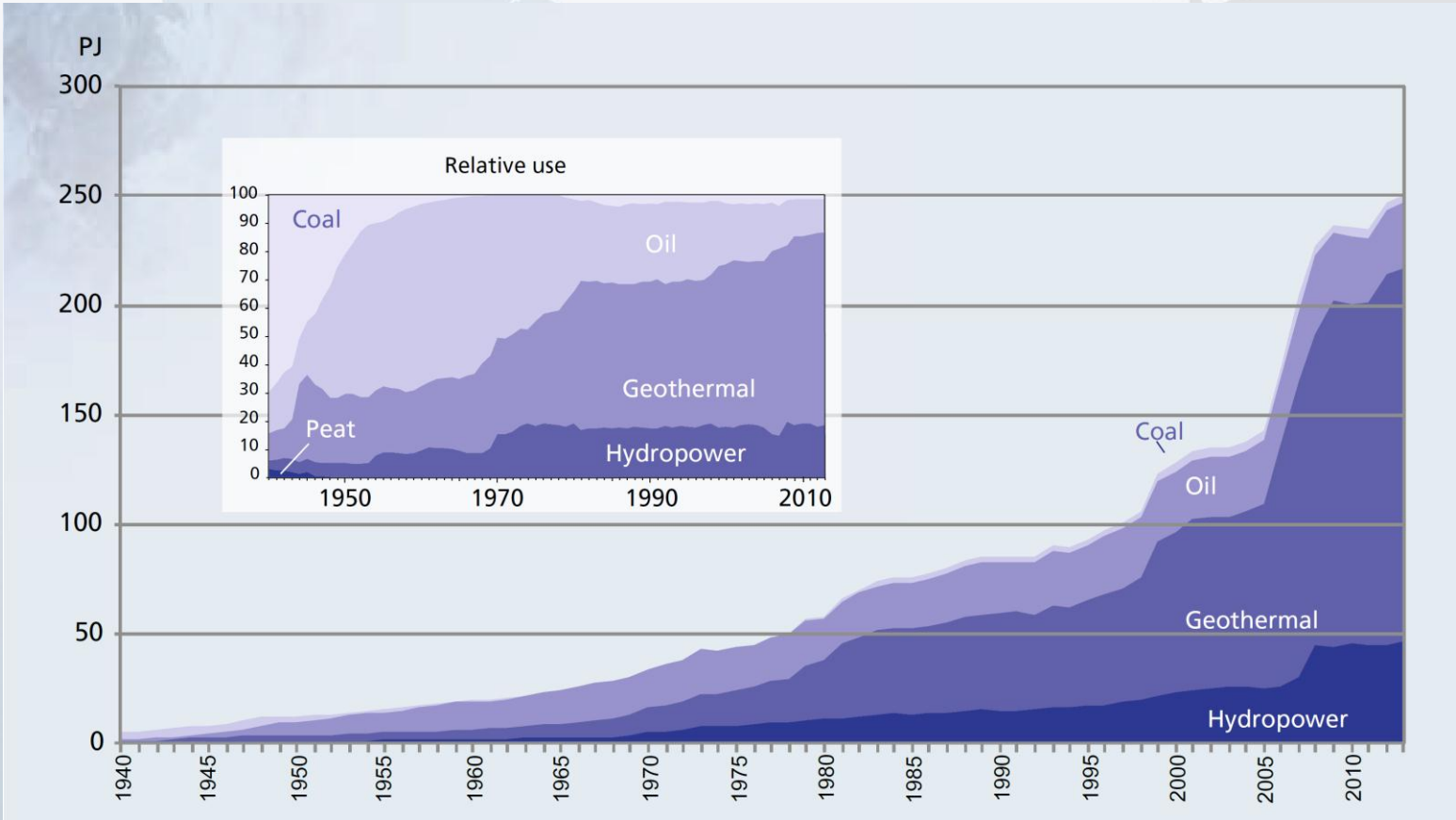
Source: Orkustofnun

Space Heating by Source 1970–2013



Source: Orkustofnun

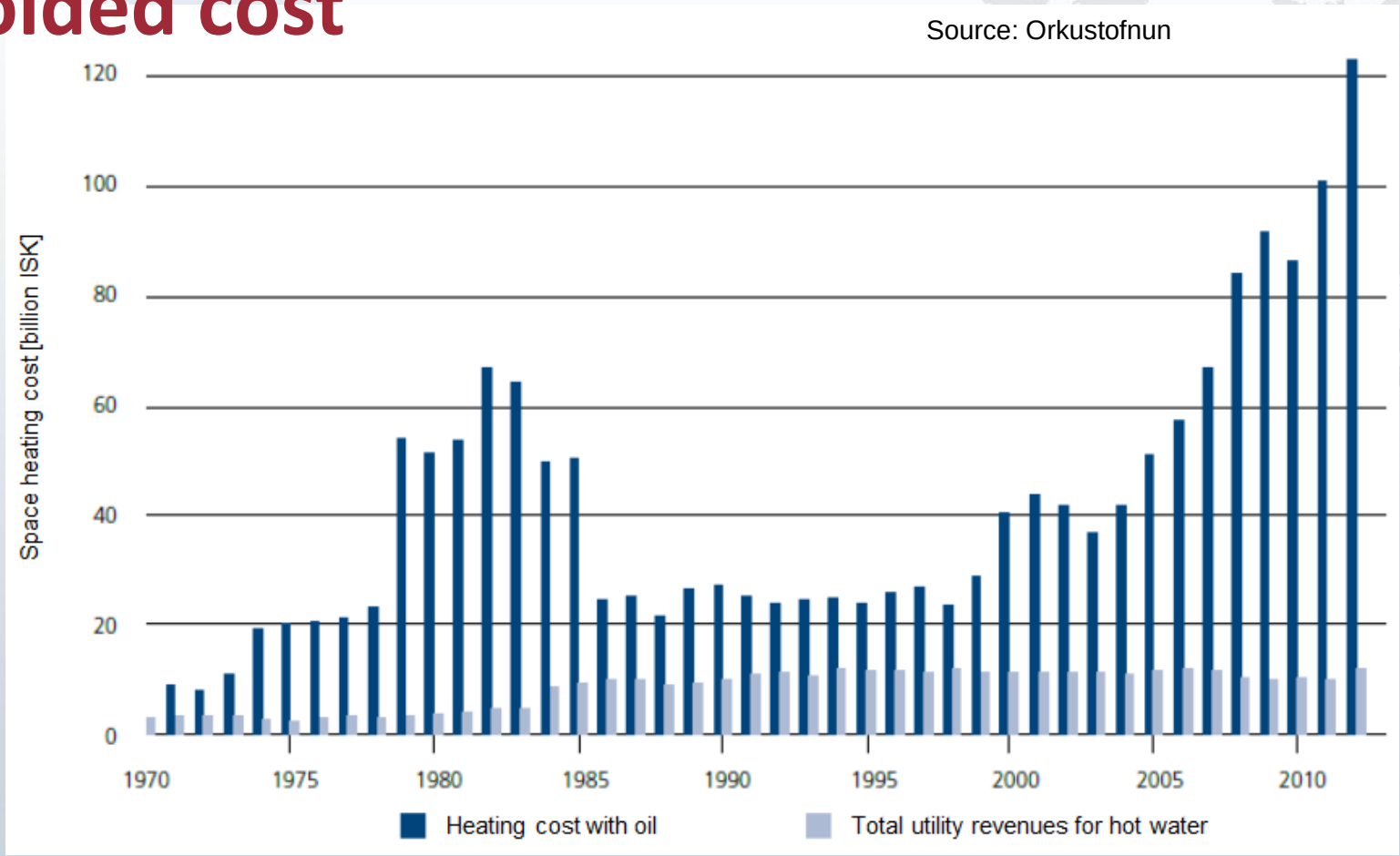
Primary Energy Use 1940–2013



Source: Orkustofnun

Avoided cost

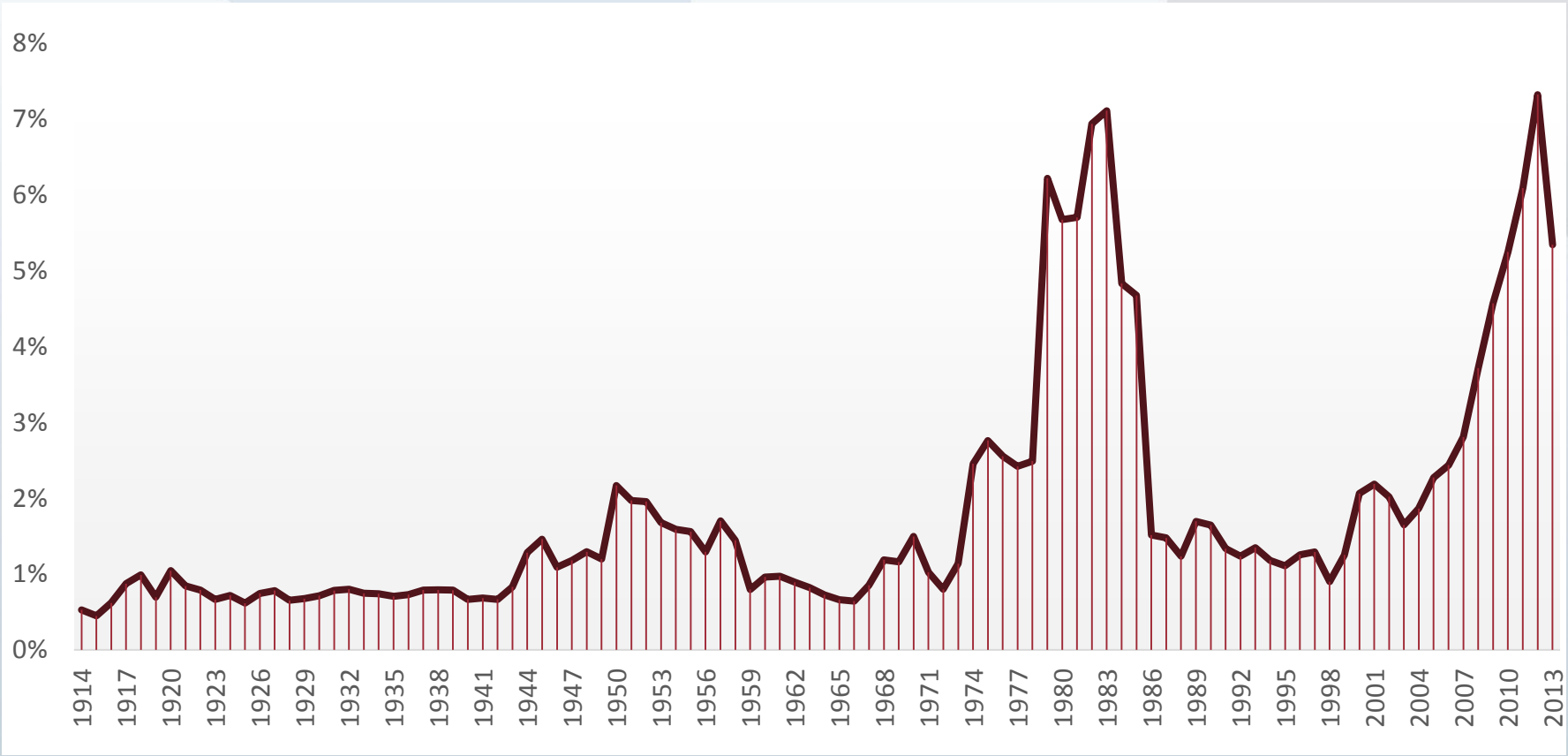
Source: Orkustofnun



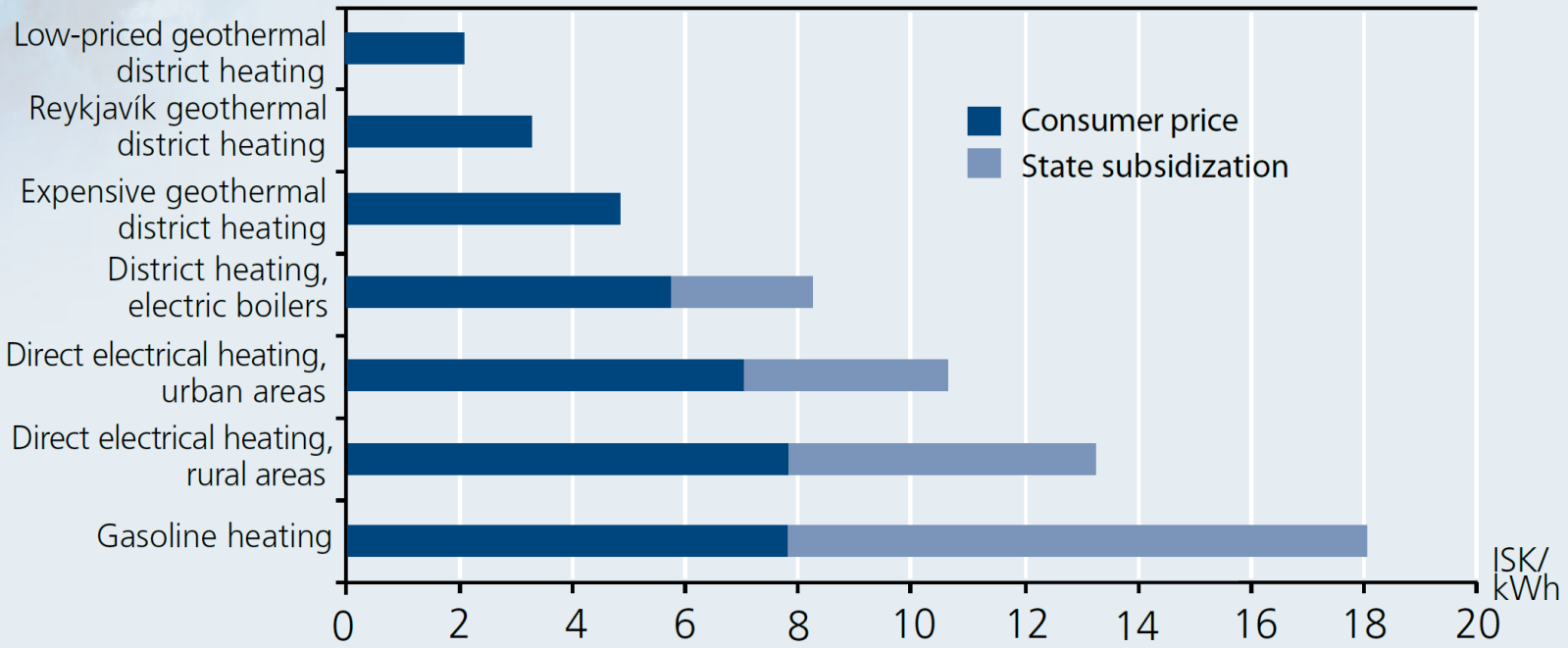
From an economic perspective, the present value of the estimated savings of space heating with geothermal instead of oil between 1914 and 2012 is estimated at 2300 billion ISK. In 2012 the estimated savings of that year amounted to about 7% of GDP or 3000 US$ per capita.

Avoided cost in ratio with GDP 1914–2013

Source: Orkustofnun

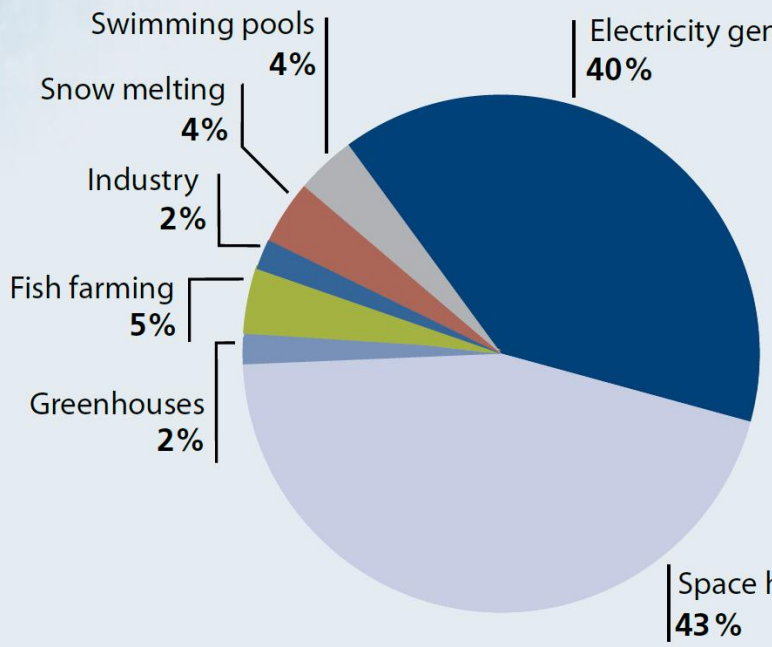


Comparison of Energy Prices for Residential Heating Mid year 2013



Source: Orkustofnun

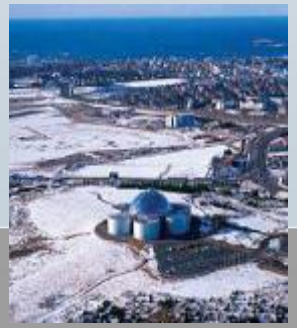
Utilization of Geothermal Energy 2013



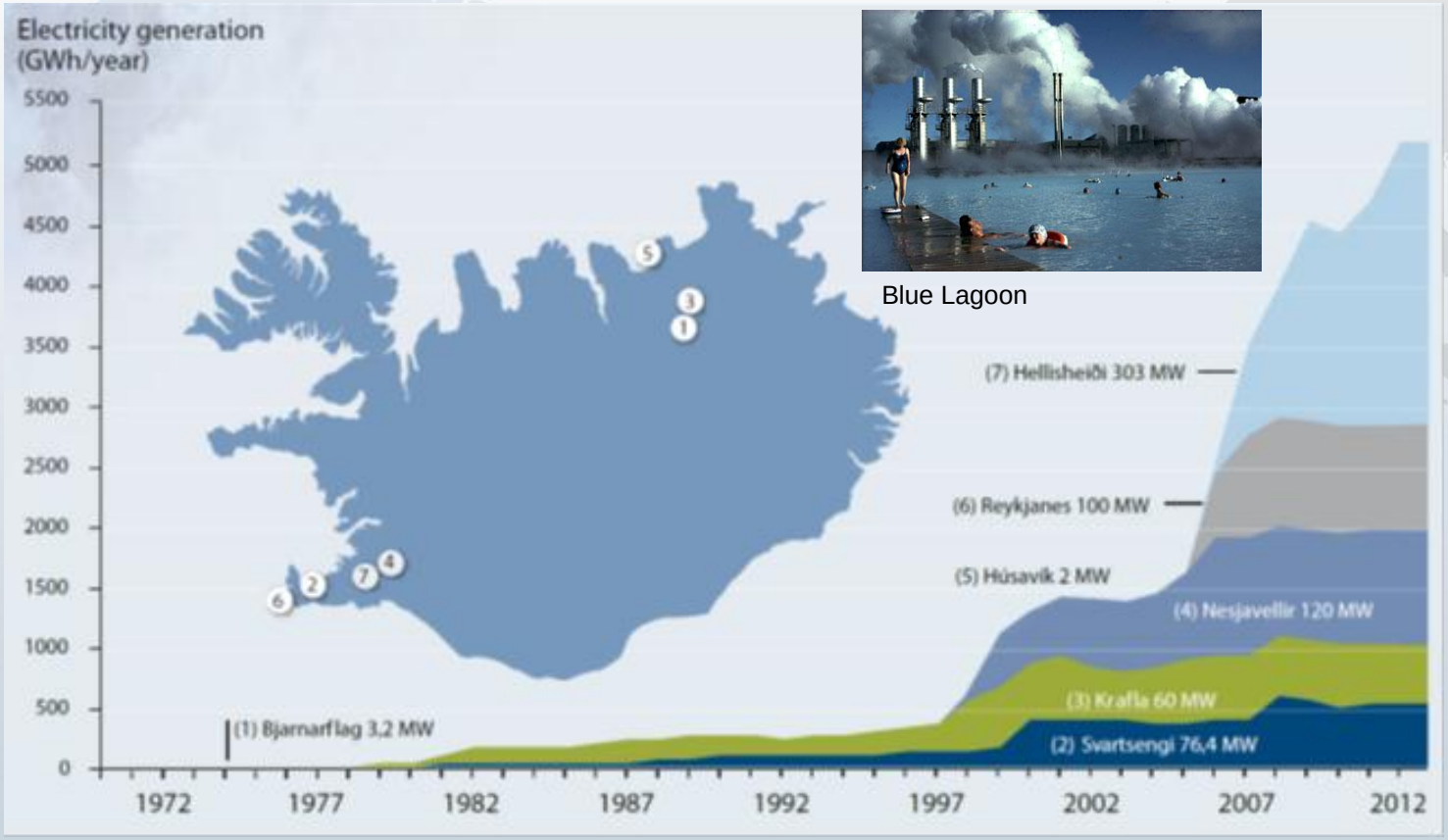
Source: Orkustofnun

Total 46,7 PJ




Electricity Generation from Geothermal



Blue Lagoon

Orkustofnun, www.os.is

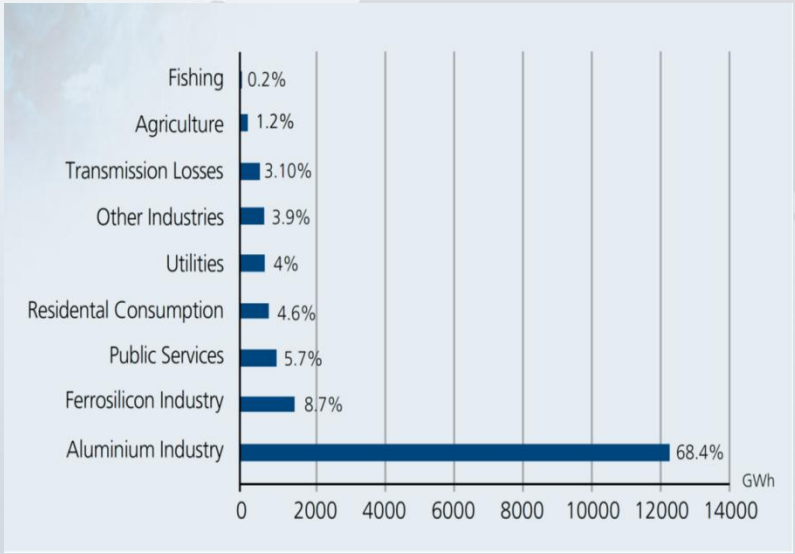
Electricity Generation and Use 2013

General use	3.153 GWh	17.4%
Large industries	13.980 GWh	77.2%
System loss and plant use	414 GWh	2.3%

Source: Orkustofnun

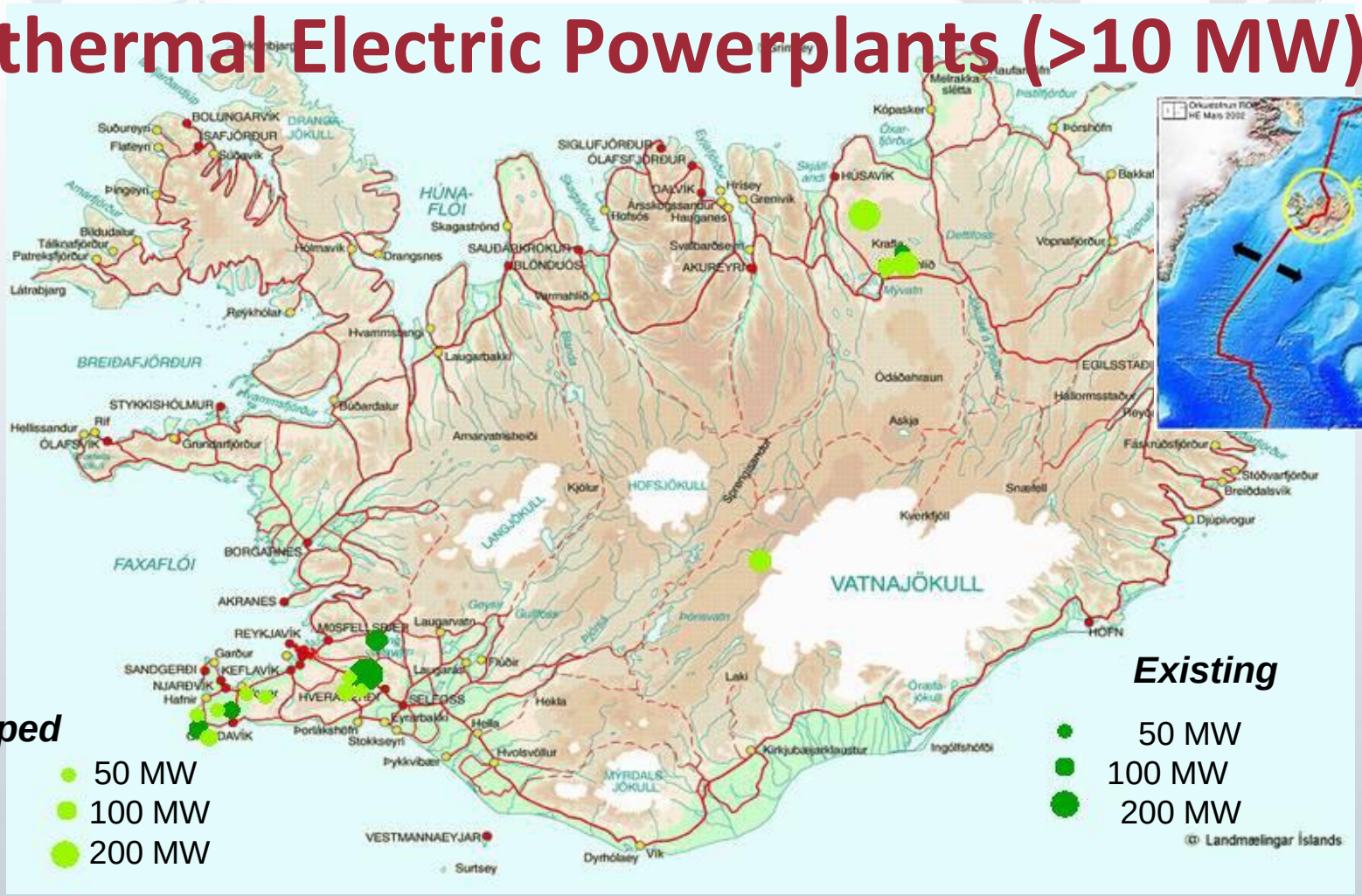
Project Outlook – Energy Consumption 2013

- Growth and new PP´s in line with new in coming industries (Silicon Industry, Aluminum smelters, Data centers, Green house projects).
- Unused potential is between 2553 and 7659 MWe.
- Due to environmental reasons it is more likely to see PP build up in 50-75 MWe phases.
- New geothermal PP´s with installed power between 200-300 MWe during next 10-20 years.
- The Iceland deep drilling project (IDDP) second well will be drilled soon.



Source: Orkustofnun

Geothermal Electric Powerplants (>10 MW)

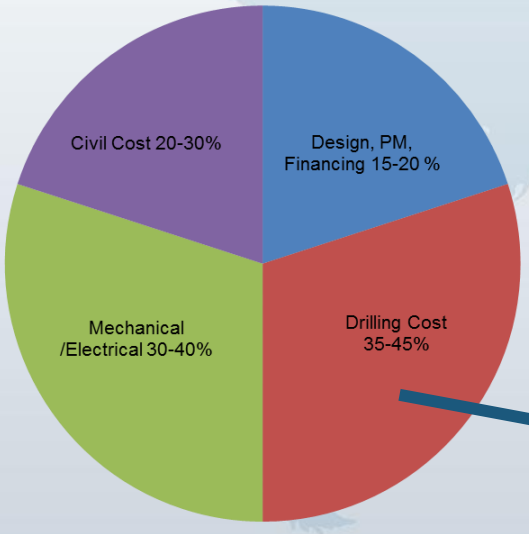


To be developed

Source: Orkustofnun

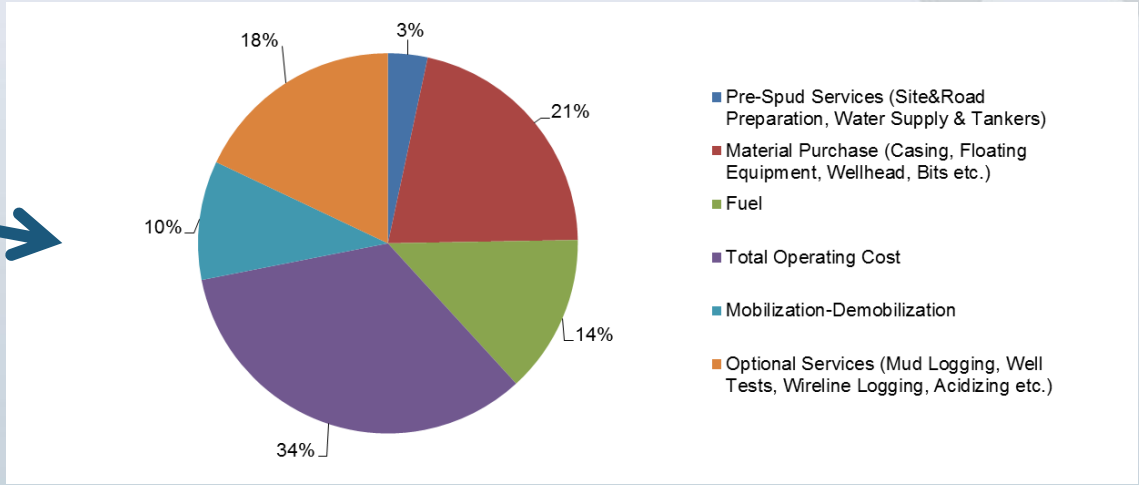
Cost of Geothermal PP Projects

Diviation of total cost for PP projects, sourse EFLA

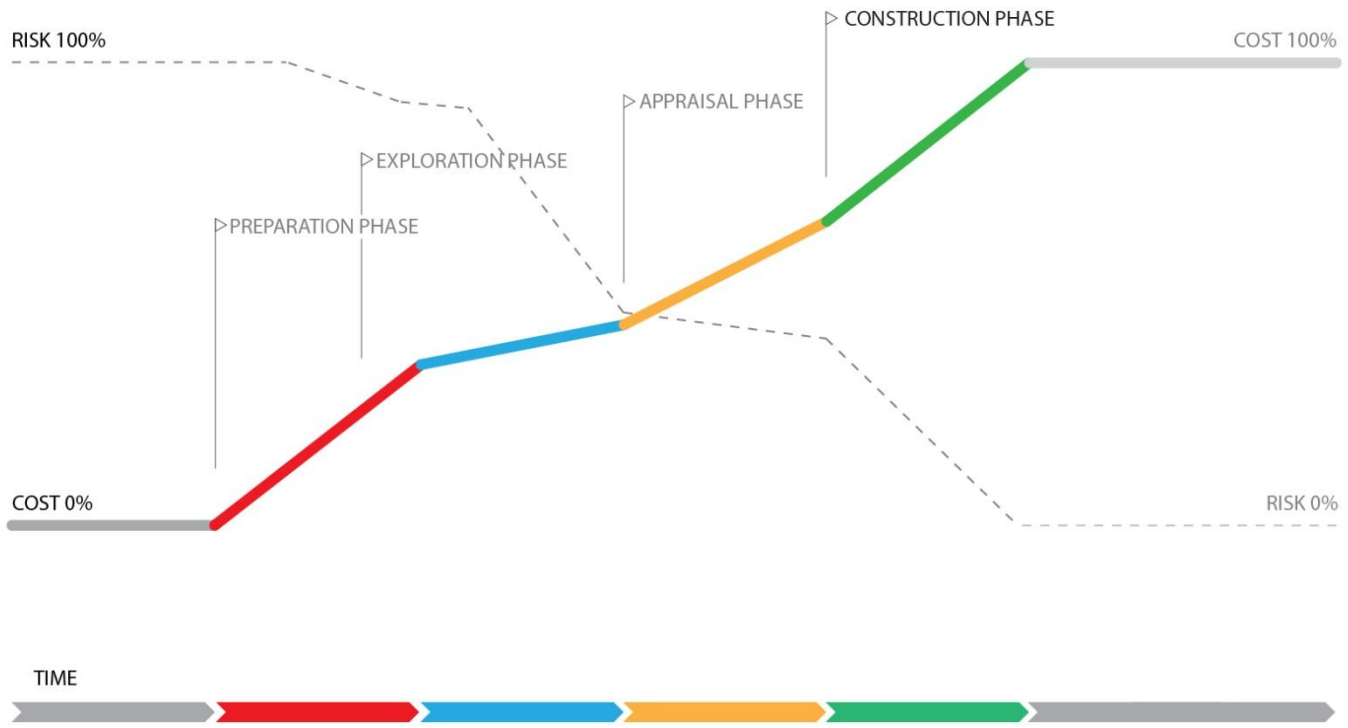


Division of drilling cost of 2600m deep well in Turkey

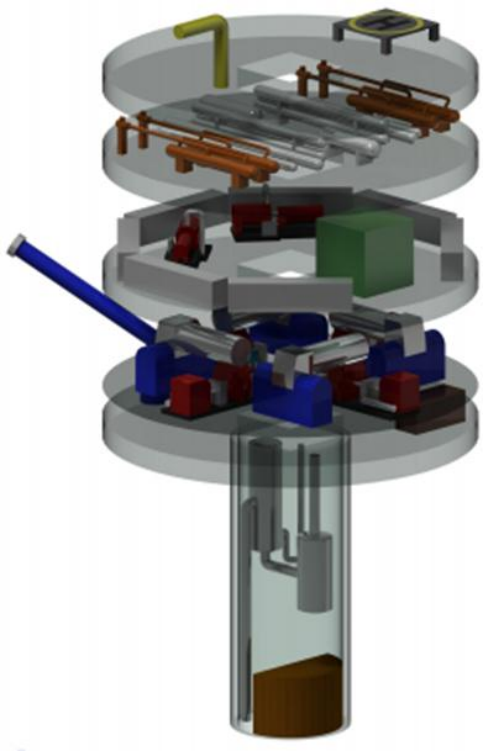
(sourse T.Kaya GRC confrence 2011)



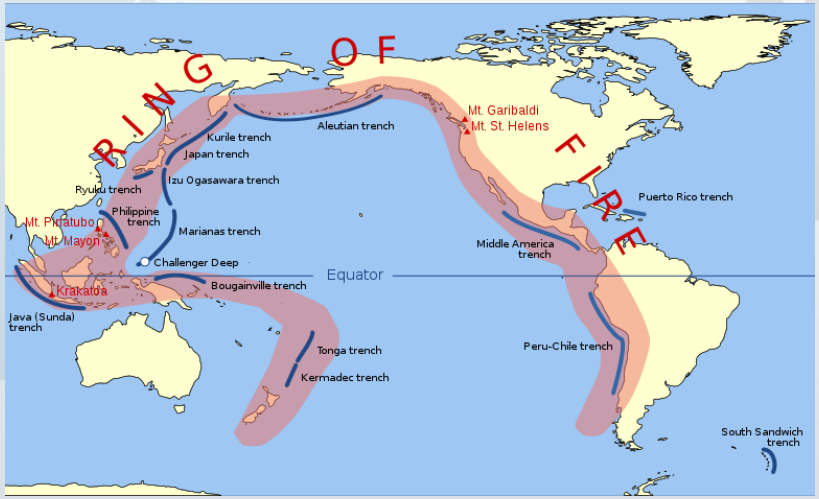
The Cost & Risk Profile

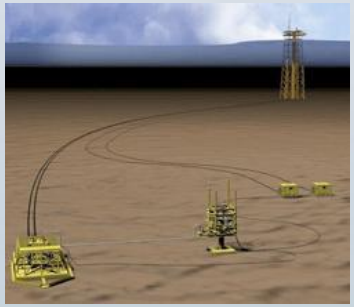


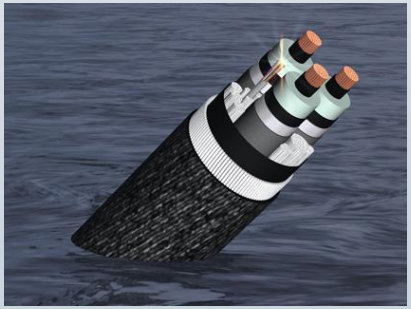
Research & Development-Offshore Geothermal PP



Combined cycle with condensing unit. Source: Efla Consulting Engineers







Siemens press picture of offshore transformer platform

Conclusion

- Utilisation of geothermal energy has expanded rapidly during the last decade.
- Iceland‘s long-term objective is to ensure long term utilisation of the resource and the legal amendments as future implementation of the Master Plan are steps in maintaining and sustaining this objective.
- The legal framework is extensive. Effective policy making and official monitoring of geothermal development for sustaining a renewable energy society in Iceland is crucial for sustaining a long-term sustainable yield of the resource.

Any Questions?