Renewable Energy in Iceland - with focus on Geothermal District Heating

EU-Eastern Partnership STI Cooperation - Energy Research and Innovation
Minsk 12 - 13 October, 2015

Baldur Petursson
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Source: Reykjavik Energy

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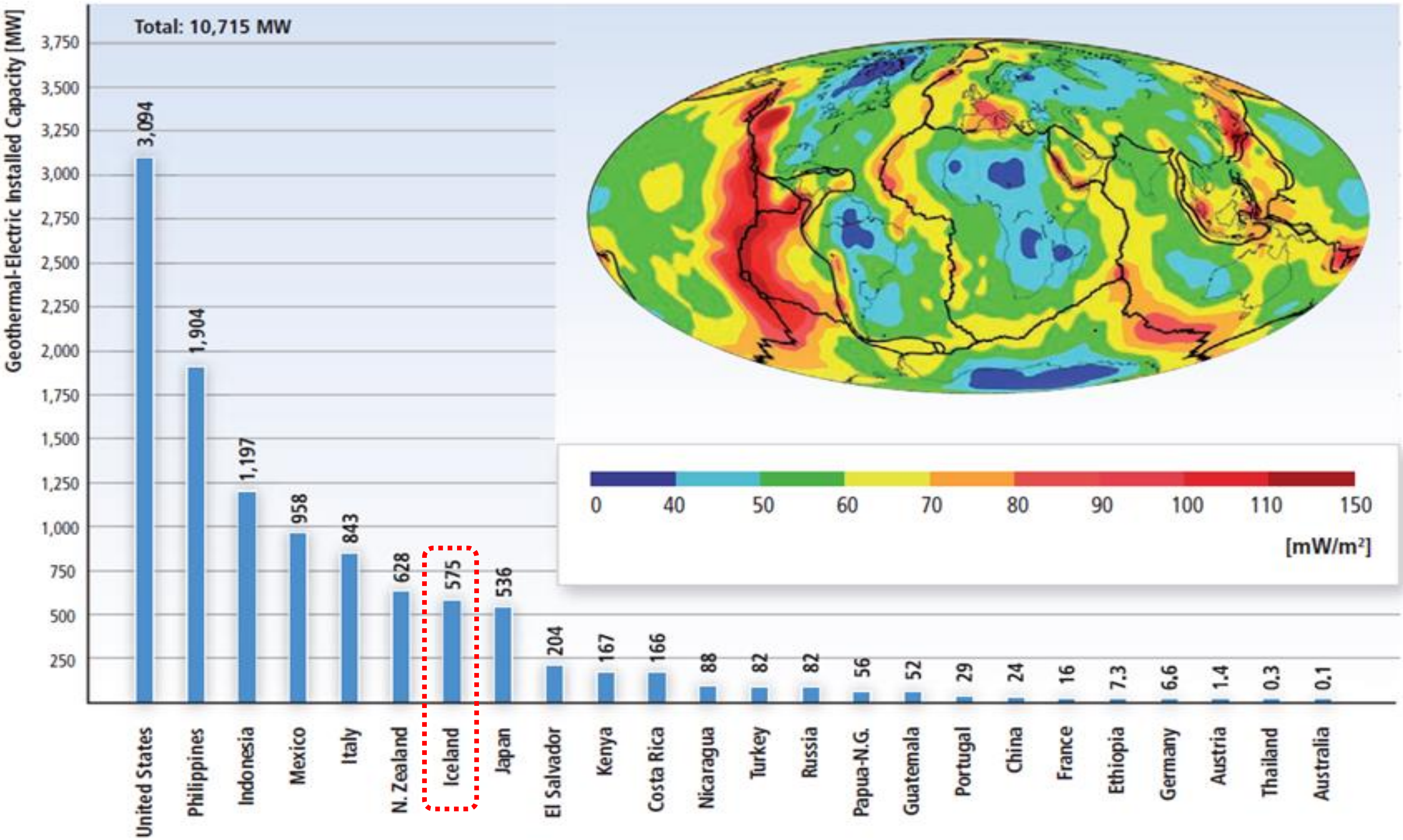
Overview of Presentation

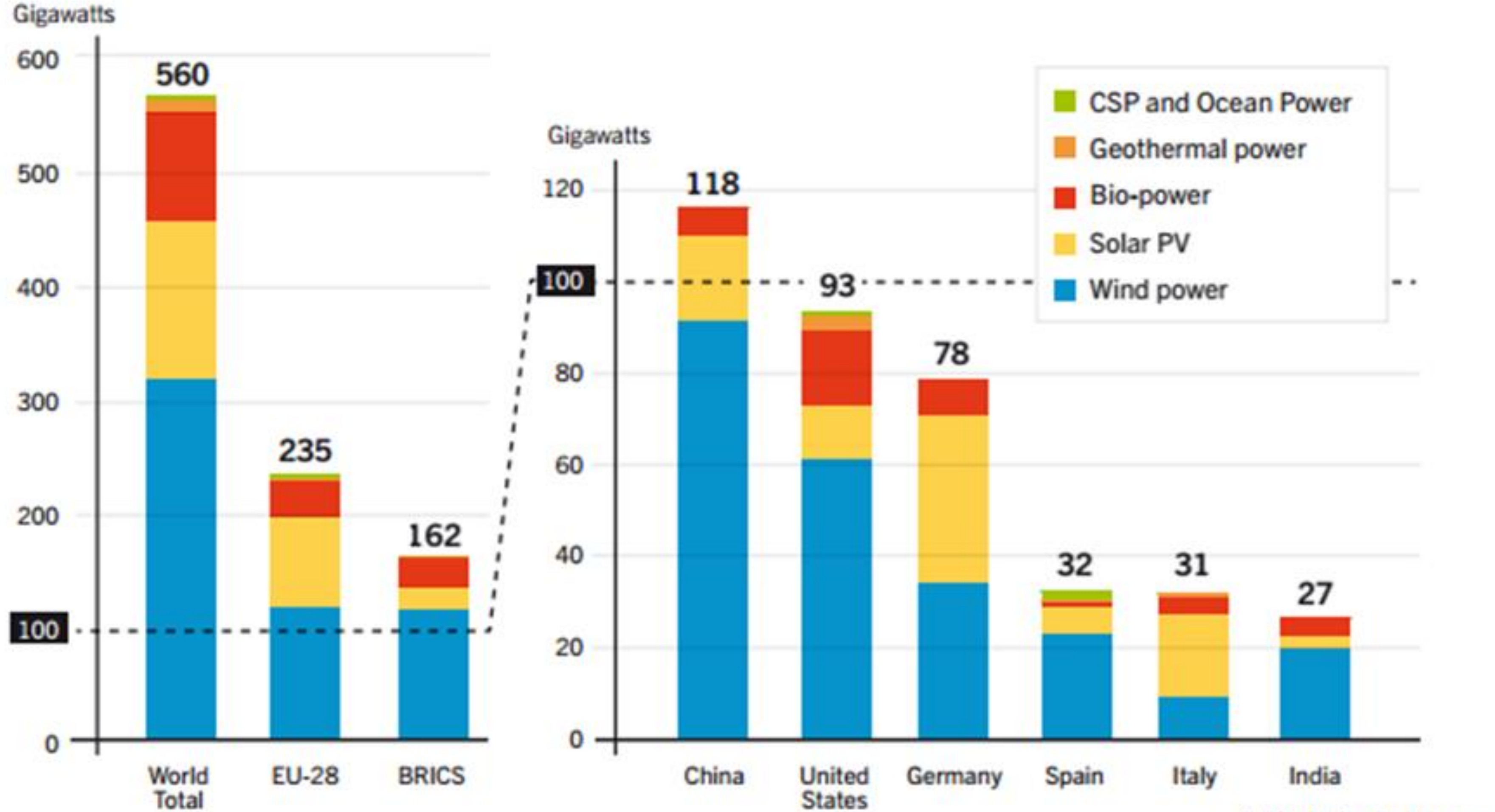
- **Geothermal - Global Overview**
- **Development of Geothermal District Heating (GeoDH) in Iceland**
- **Economic and Environmental Opportunities**
- **Geothermal Policy – Financial Support - Lessons Learned**
- **International Cooperation**
  - **UNU-GTP**
  - **World Bank Cooperation**
  - **EEA Grants**
  - **ERA NET**
  - **International Projects Cooperation**

Geothermal-Electric Installed Capacity by Country 2009 and Worldwide Average Heat Flow



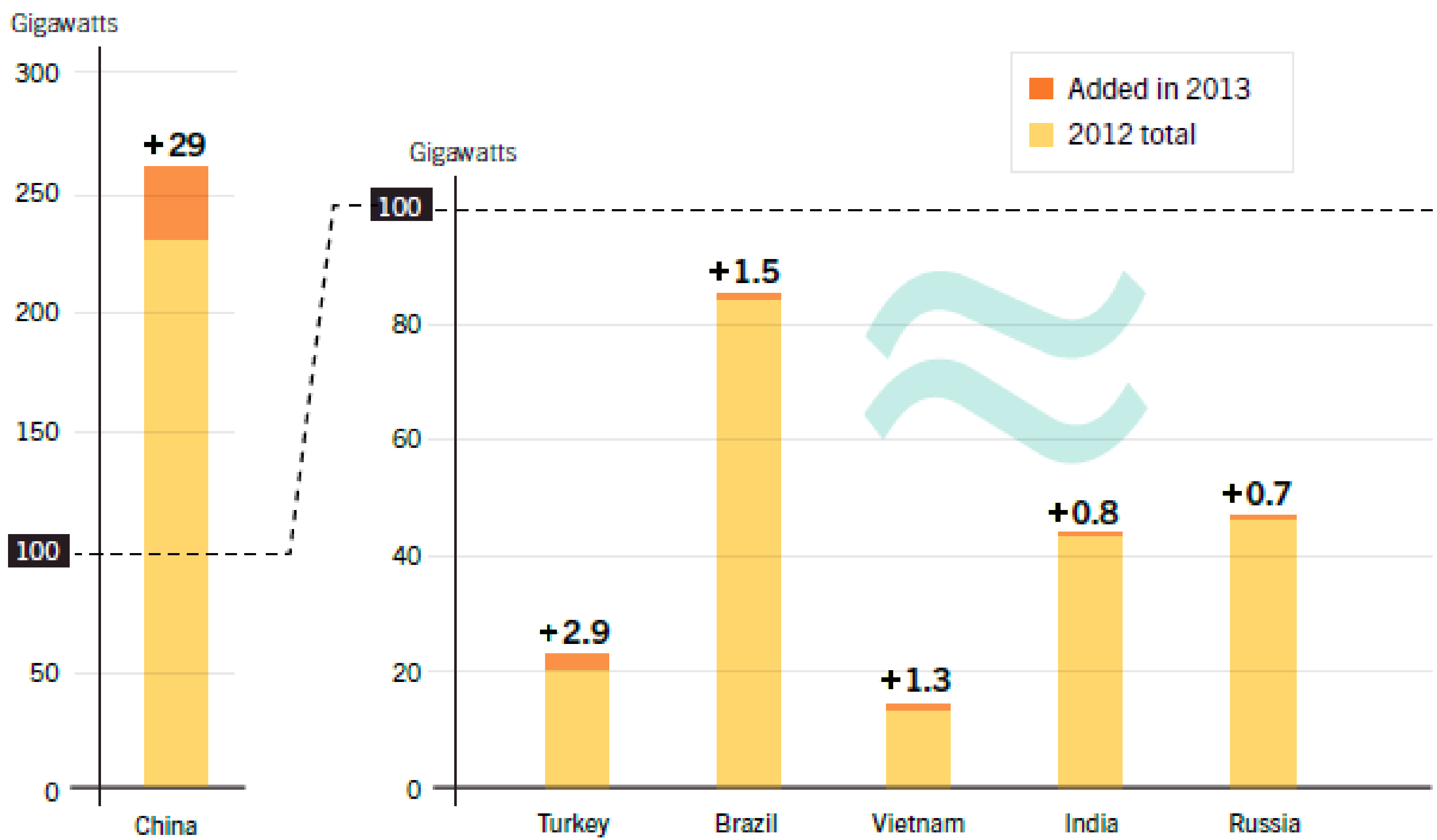
Sources: Geothermal Energy, Intergovernmental Panel on Climate Change,

Renewable Power Capacity in the World , EU-28, BRICS, and Top Six Countries, 2013



Sources: Renewables 2014, Global Status Report

Hydropower Global Capacity Additions, Share of Top Six Countries, 2013



Sources: Renewables 2014, Global Status Report

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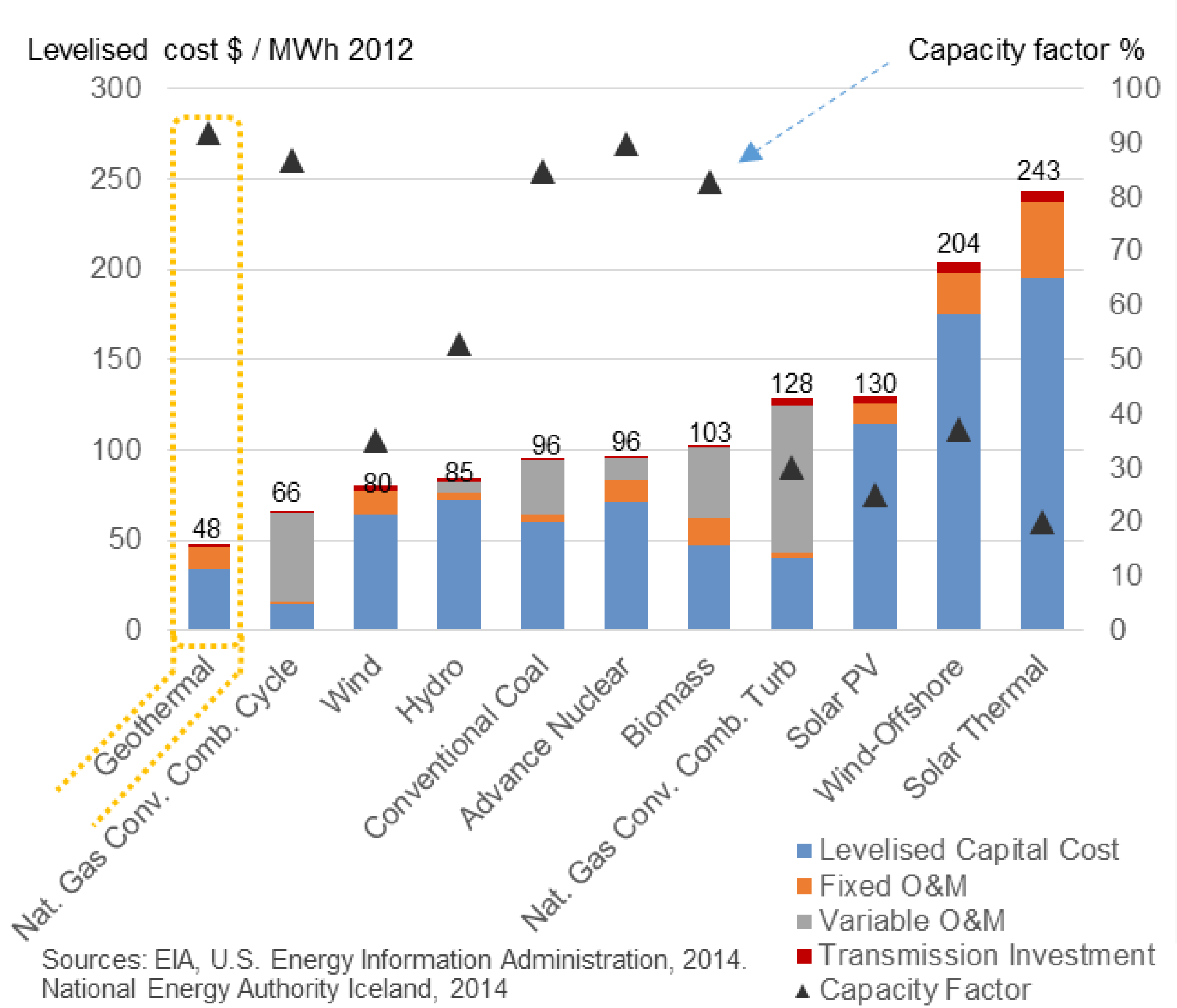
U.S. Average Levelised Cost of Electricity and Capacity Factor for Plants, entering services in 2019



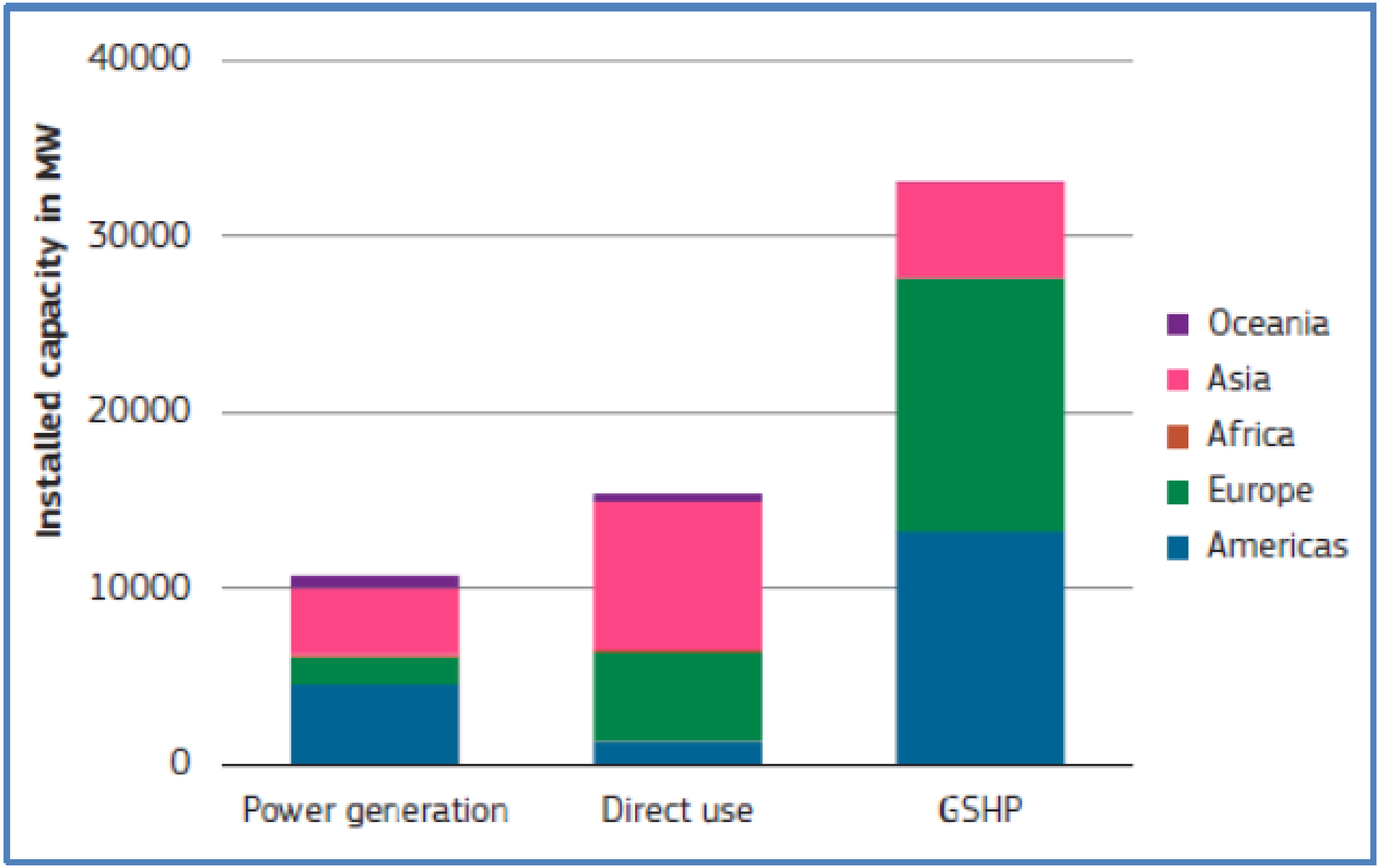
Sources: EIA, U.S. Energy Information Administration, 2014.
National Energy Authority Iceland, 2014

Geothermal Installed Capacity

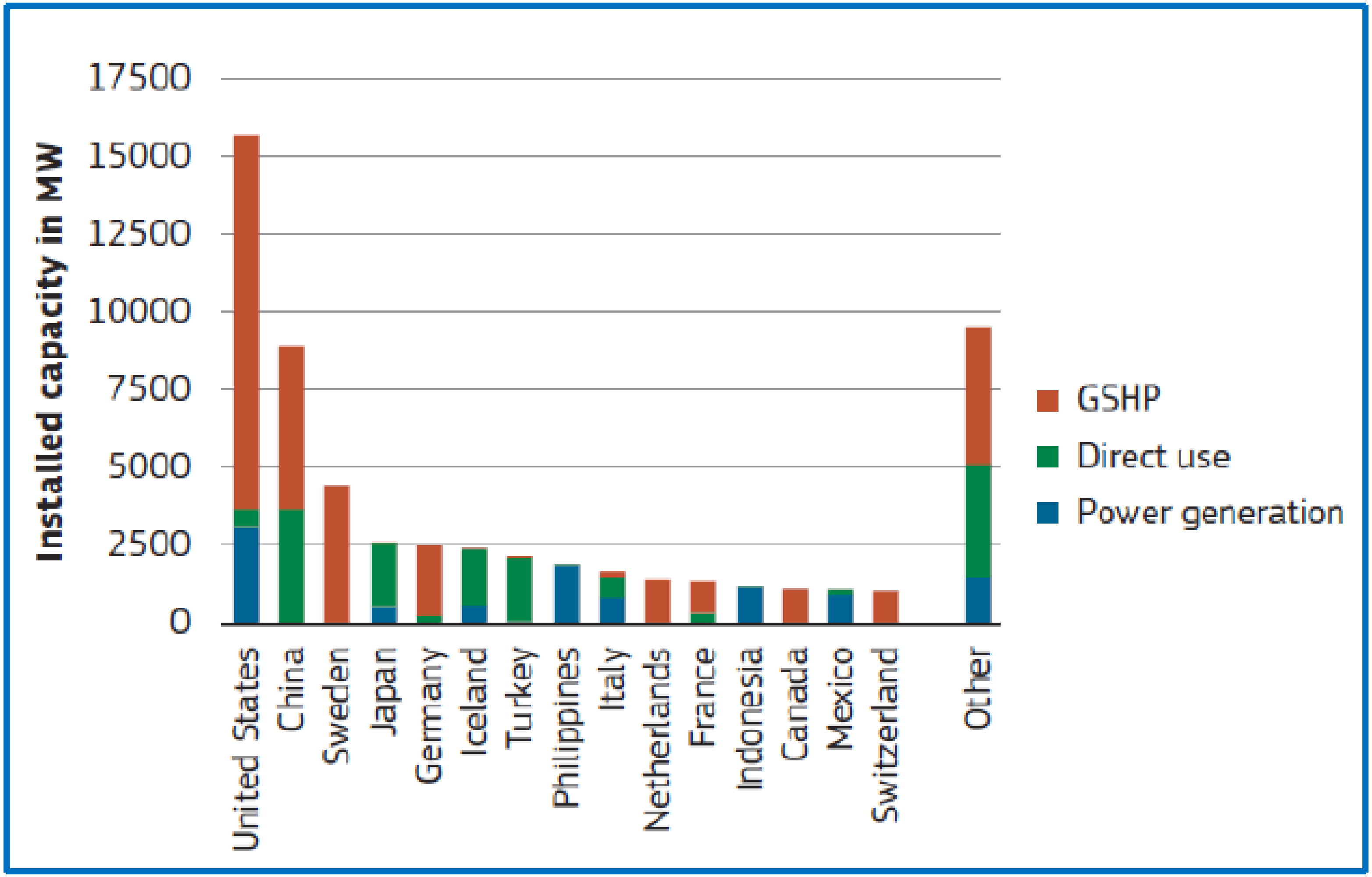
Based on a recent release (2015) of *the* ***2014 JRC Geothermal Energy Status Report*****,** from the European Commission, geothermal power and heat installations draw their energy from resources of variable depths and temperatures and no general consensus has been agreed on how to classify geothermal heat sources and production. However, when reporting on production values, the following classification according to [Antics et al. 2013] and Directive 2009/28/EC [EC 2009a] which has been adopted by Eurostat and national statistics offices, was used:

- *Power generation*
- *Direct use*
- *Ground source heat pumps (GSHP)*

Geothermal Global Installed Capacity, 2010 for Power Generation, Direct use and GSHP



Geothermal Installed Capacity by Countries, 2010 for Power Generation, Direct use and GSHP



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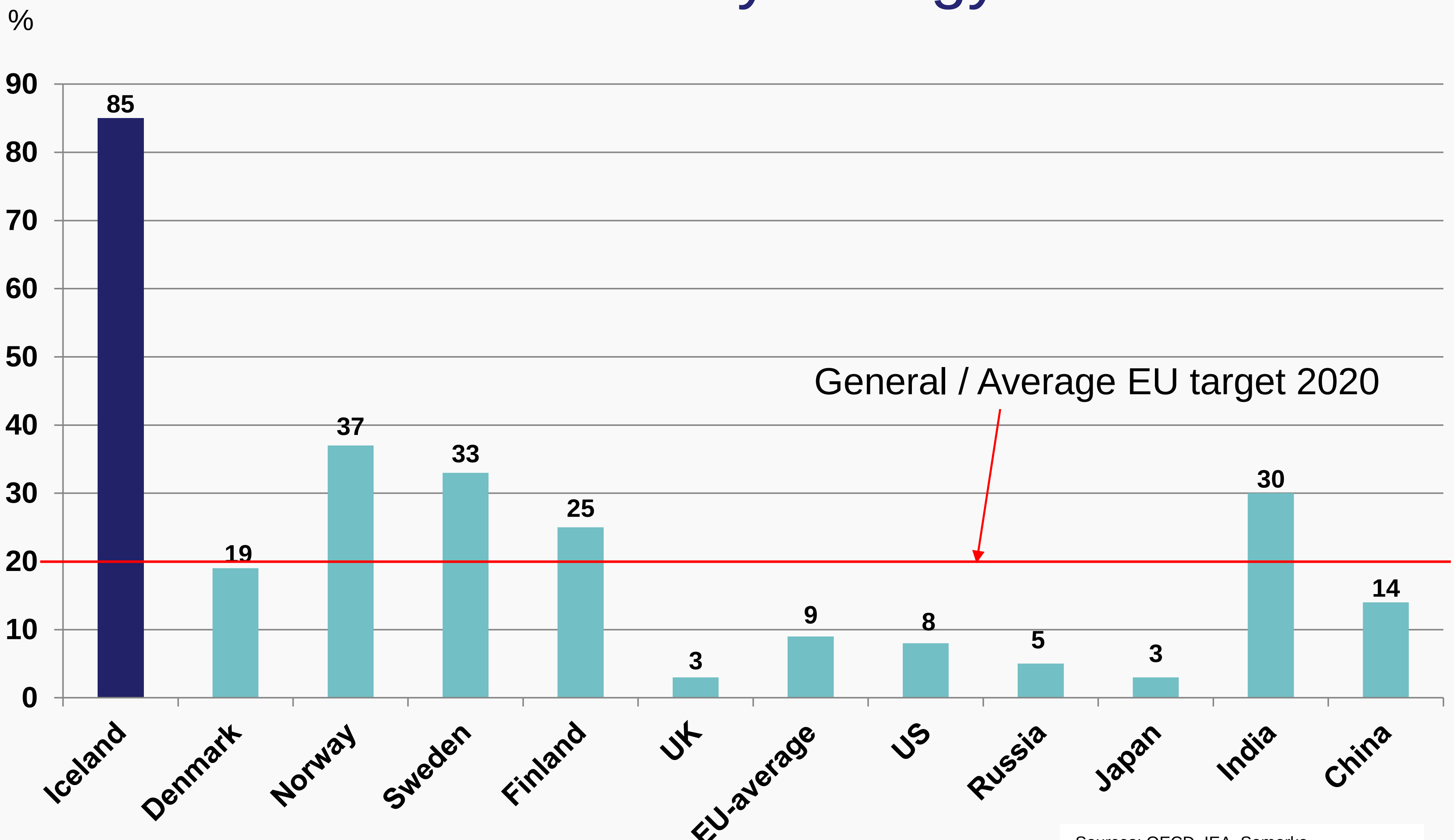
Share of Renewables in Total Primary Energy use



Sources: OECD, IEA, Samorka

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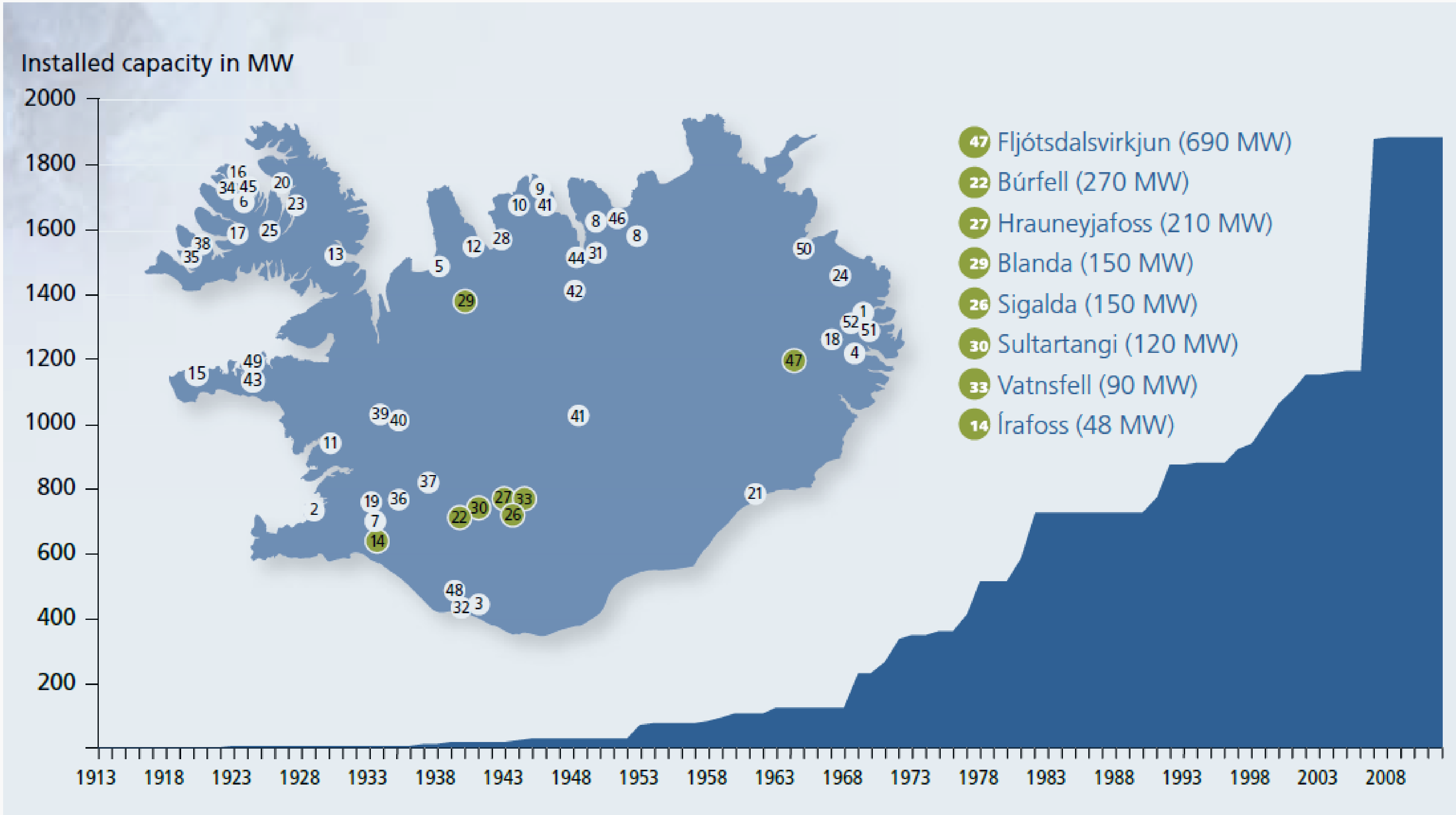
Installed Capacity of Hydropower in Iceland



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The Fljotsdaldvirkjun - Kárahnjúkar Dam, 193 m high

Ljósmynd: Sigfús Már Pétursson / Image: Sigfús Már Pétursson

Kárahnjúkar - Fljótsdals station, 690 MW_e

Ljósmynd: Emil Þór Sigurðsson / Image: Emil Þór Sigurðsson

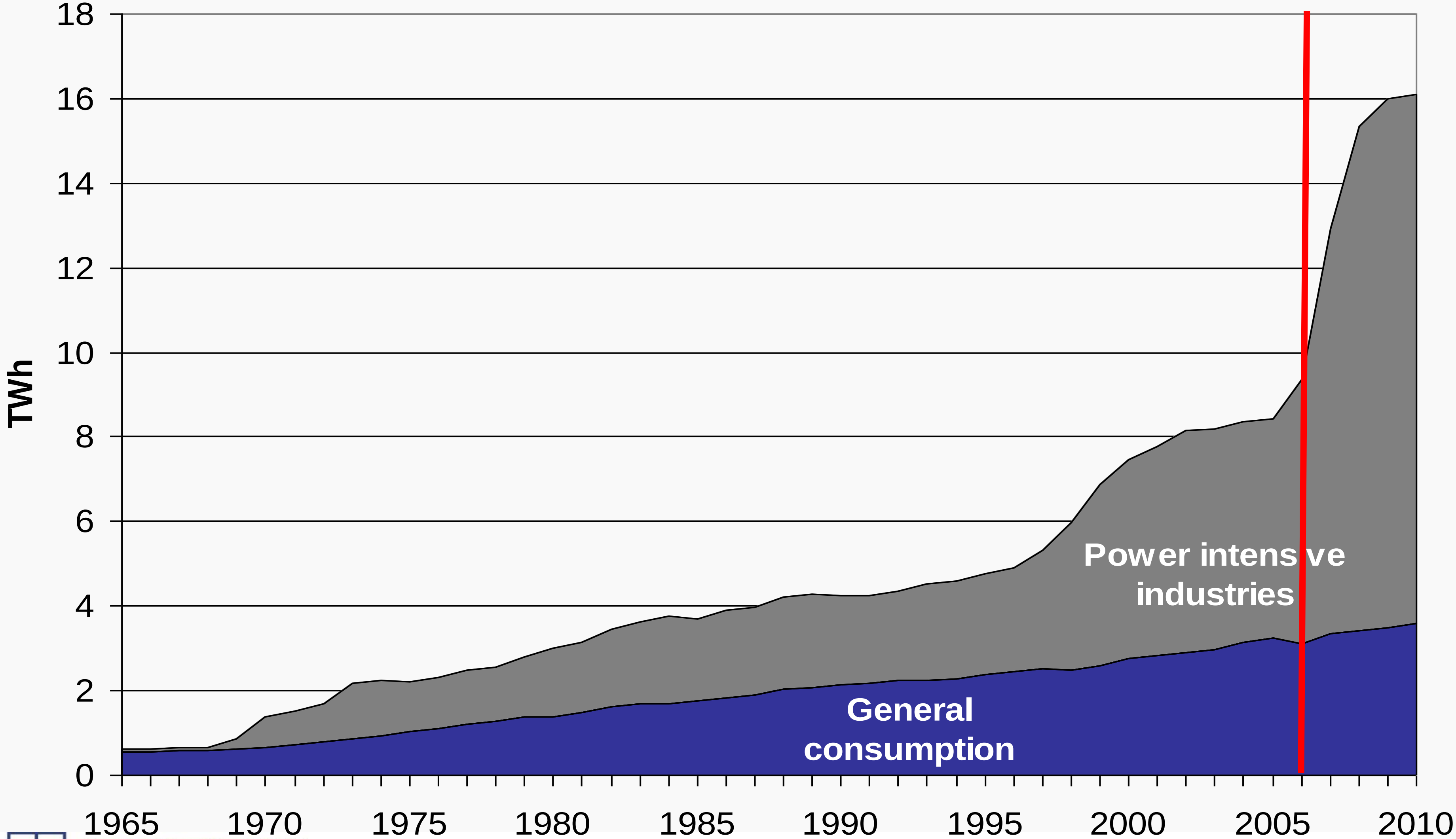
Búrfell, 270 MW_e

Ljósmynd: Ásgeir Eggertsson / Image: Asgeir Eggertsson

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%

Electricity Consumption 1965-2010



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Source: Samorka, IEA

Iceland – Land of Ice and Fire - 2014

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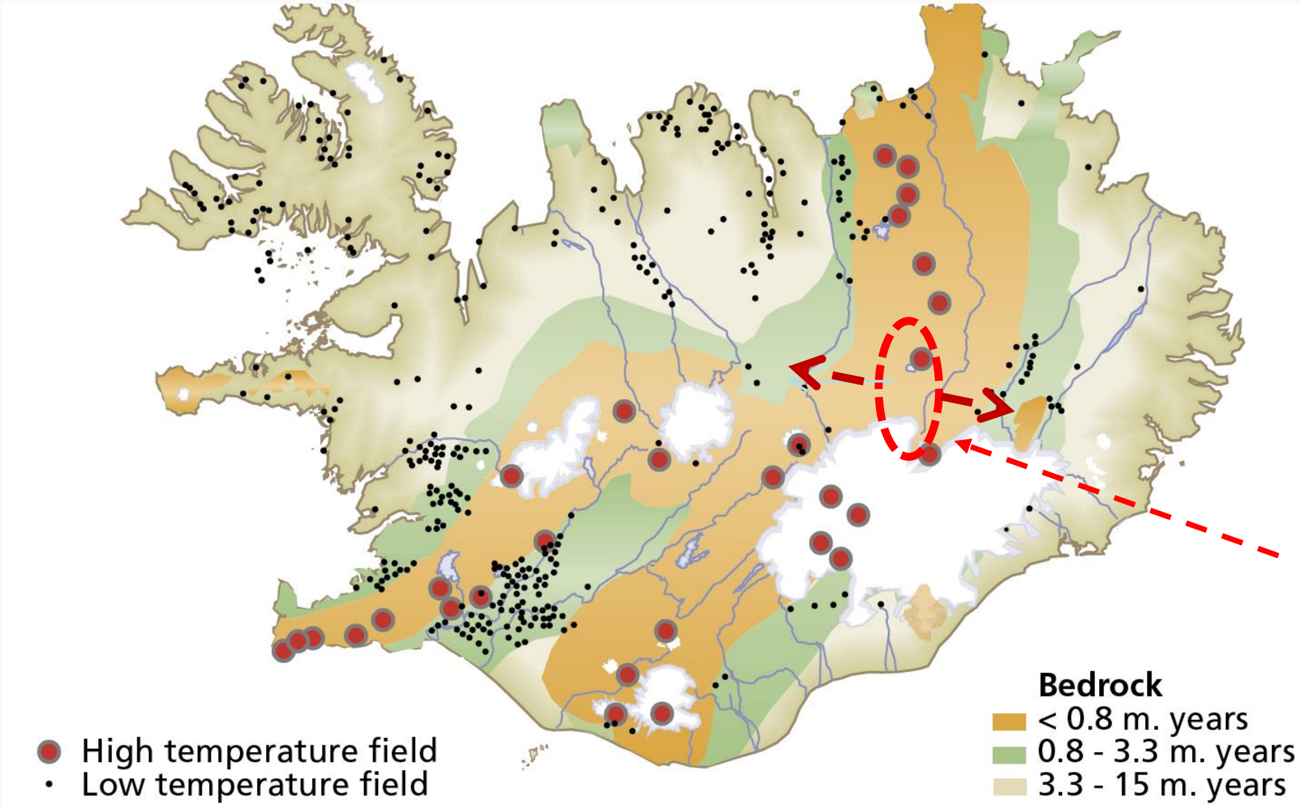
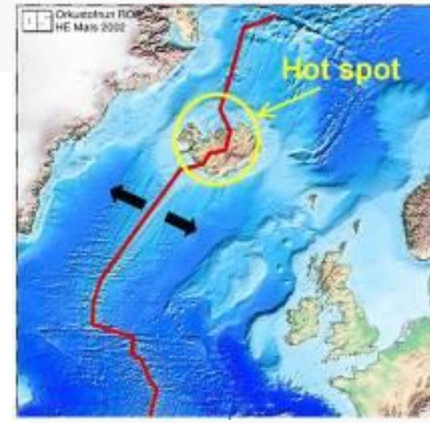
MYND: Visir Auðunn Nielsson

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.

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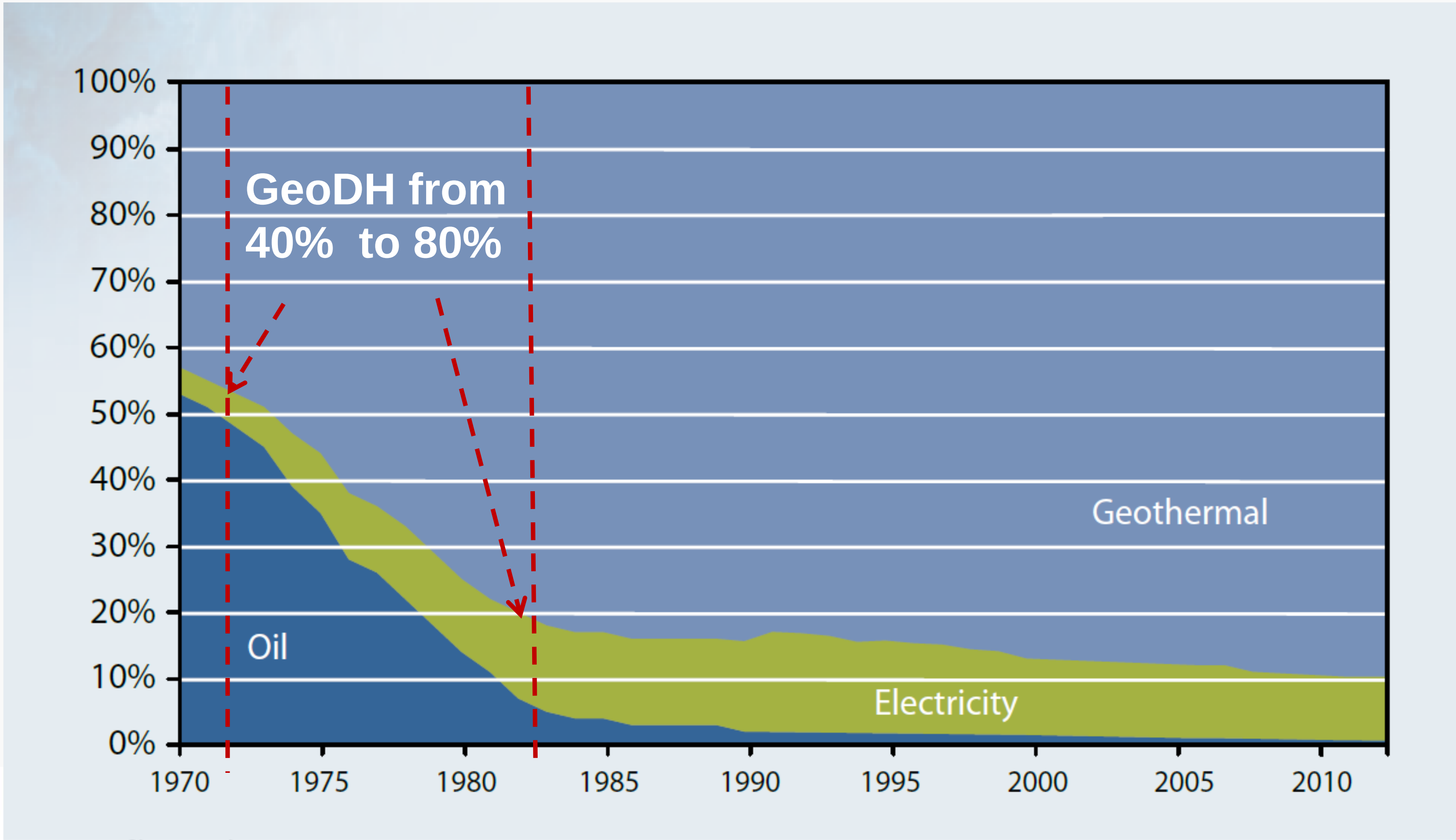
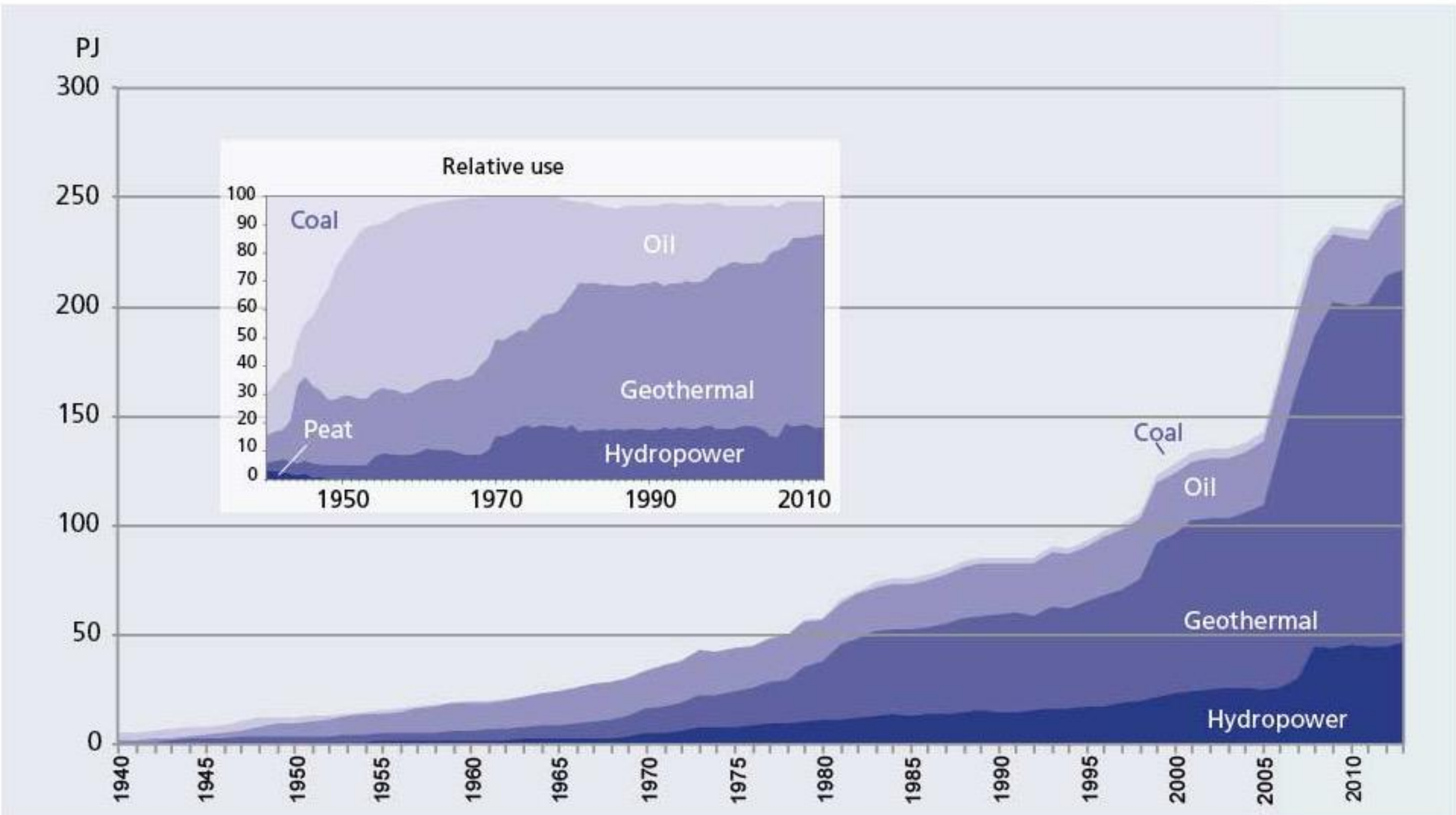
Expansion of GeoDH

Space Heating by Source 1970–2013

- Biggest steps in GeoDH were taken during the oil & war crises 1970 – 1982
- External conditions – raised the need of evaluation and GeoDH Planning
- Policy goals to increase geothermal – both national and within main cities
- It took only **12** years to increase GeoDH from **40% to 80%** of total space heating



Icelandic Primary Energy Use 1940-2013



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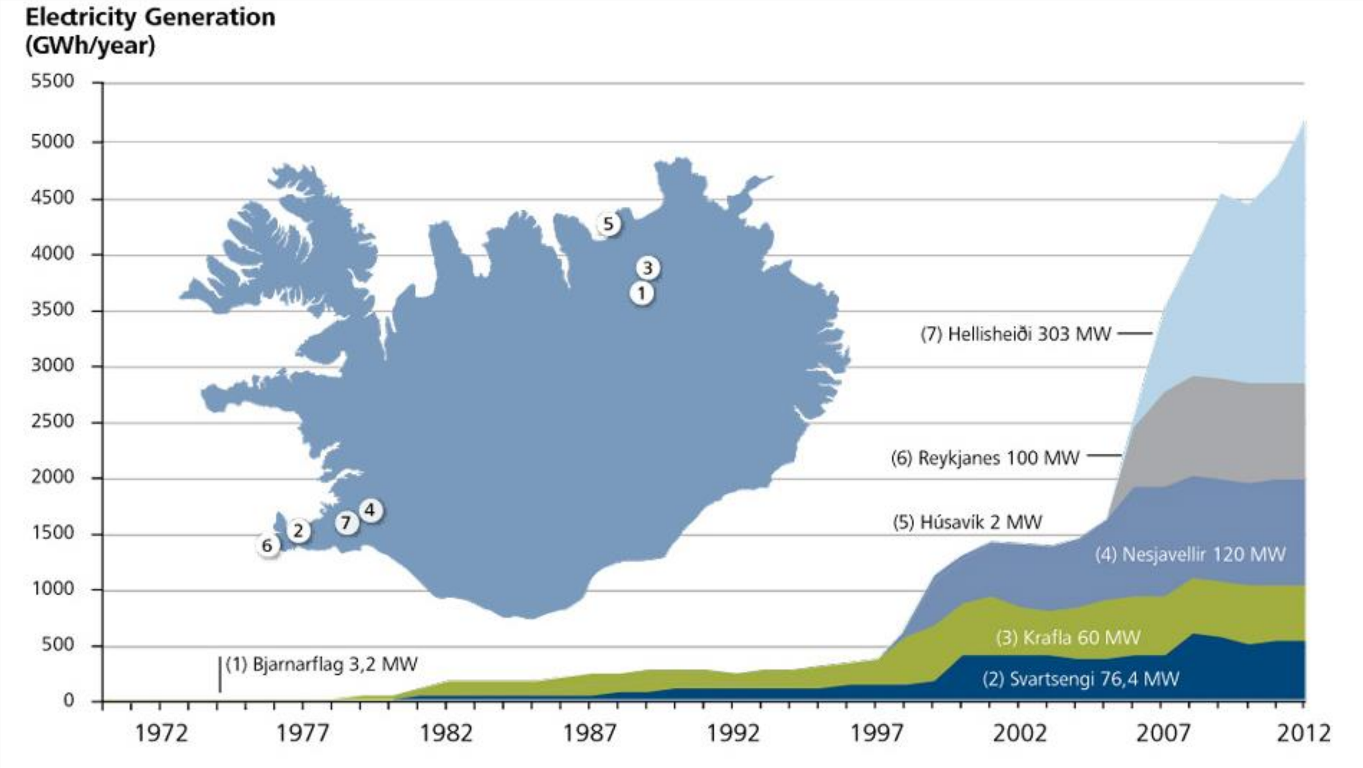
Geothermal Electricity Generation



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Environmental Benefits of Geothermal Utilisation

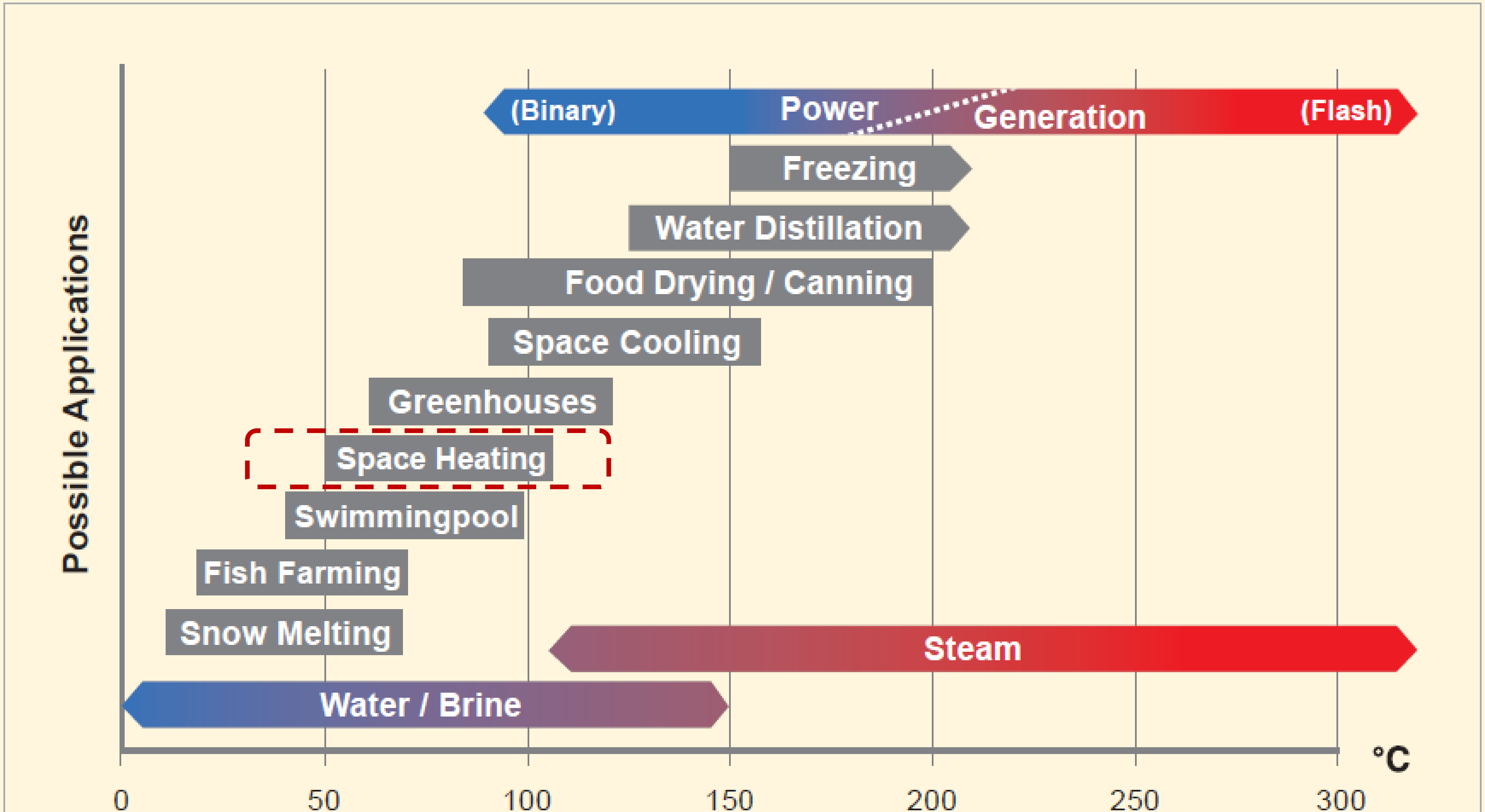
Reykjavík 1933

Source: Reykjavík Energy

Reykjavík today

Geothermal Energy - Possible Utilisation Improving Industrial Activities

Lindal Diagramc



Sources: ESMAP Report, 2012

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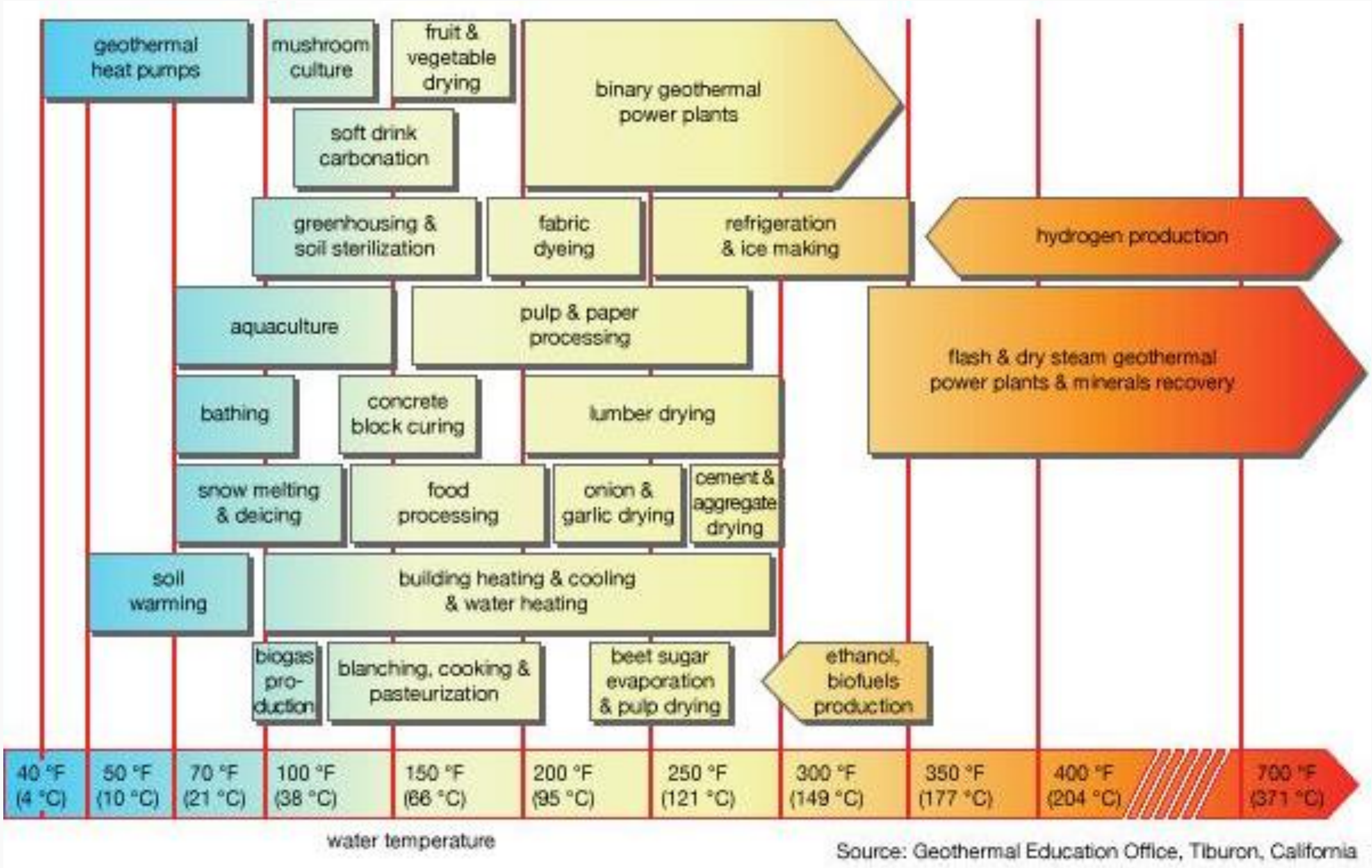
Geothermal Energy - Possible Utilisation
Improving Industrial Activities



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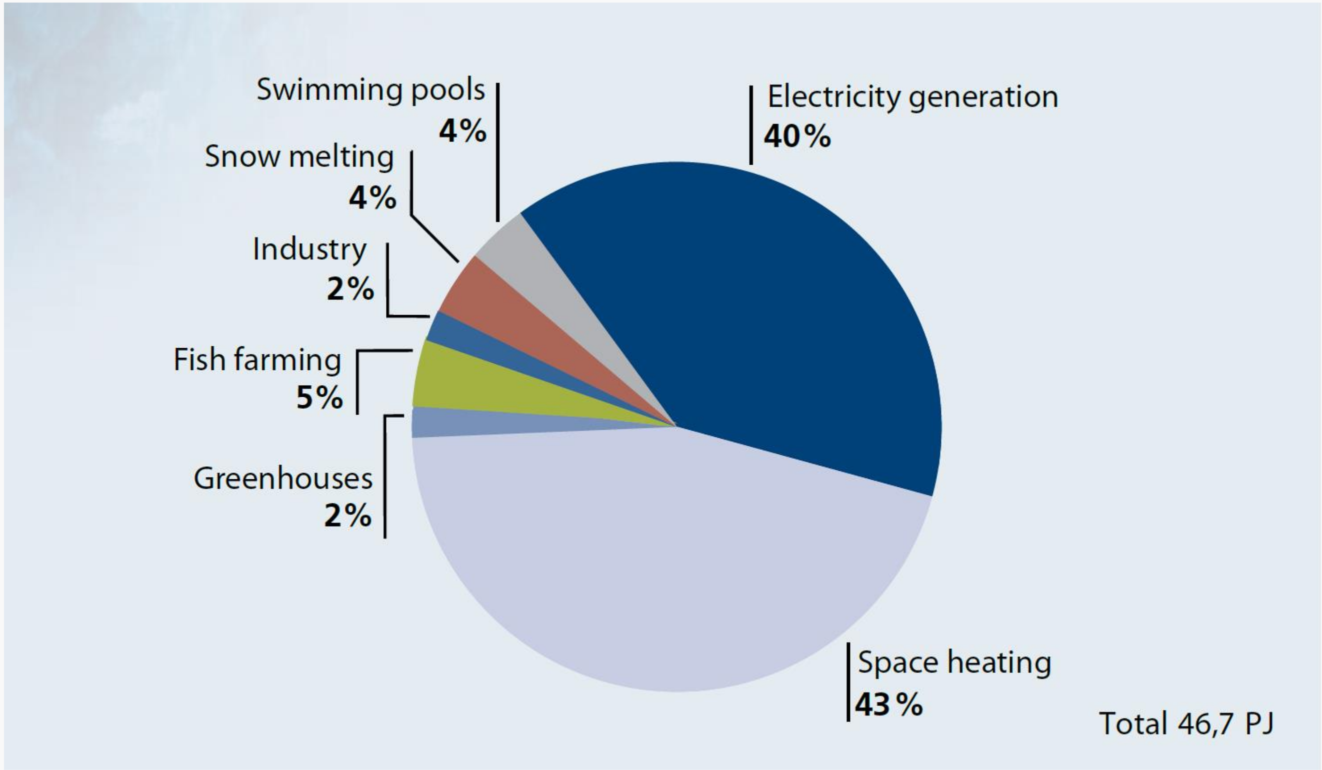
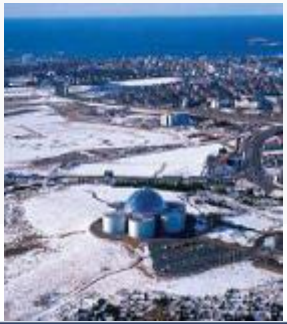
Utilisation of Geothermal Energy 2013





Utilisation of Geothermal Energy 2013

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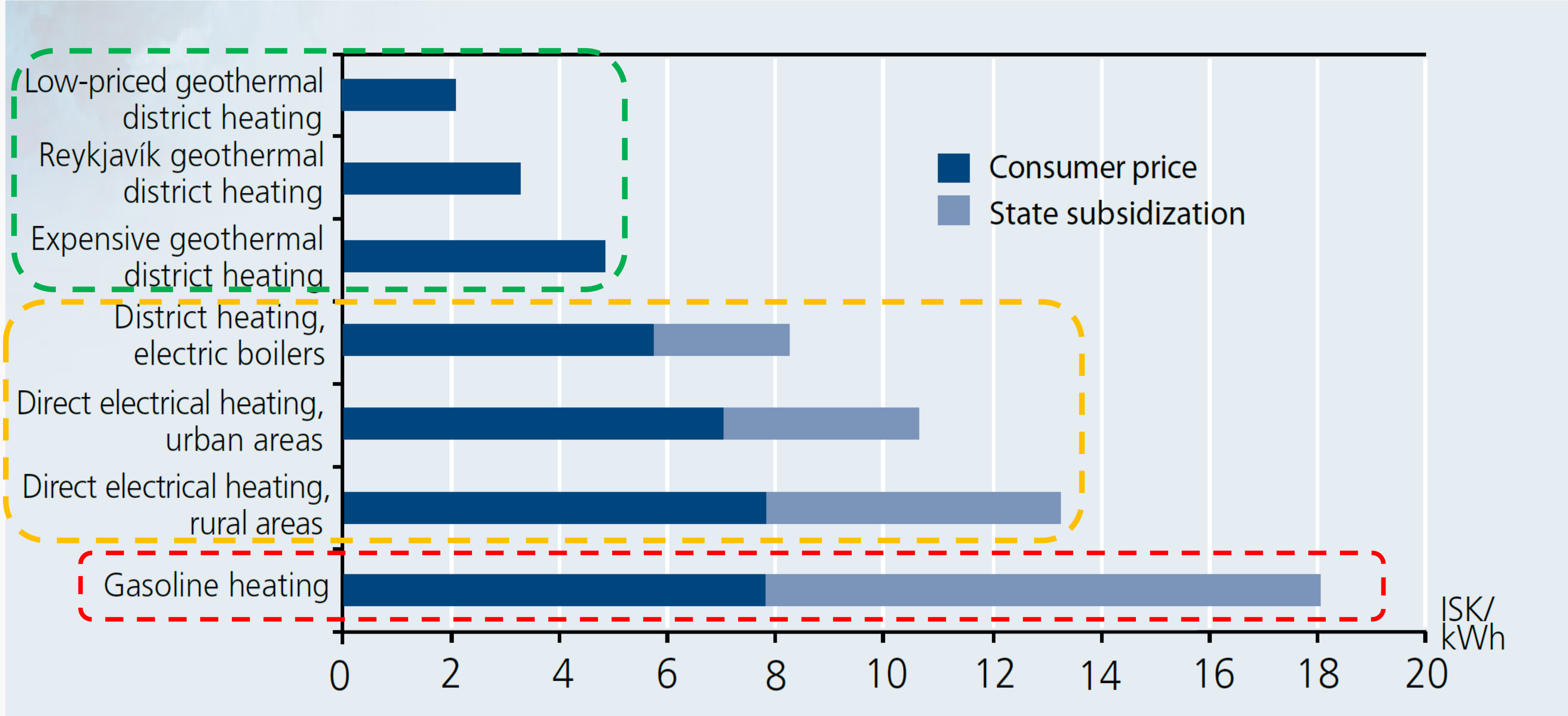
Comparison of Energy Prices for Residential Heating Mid year 2013 by Geothermal, Electricity and Gasoline



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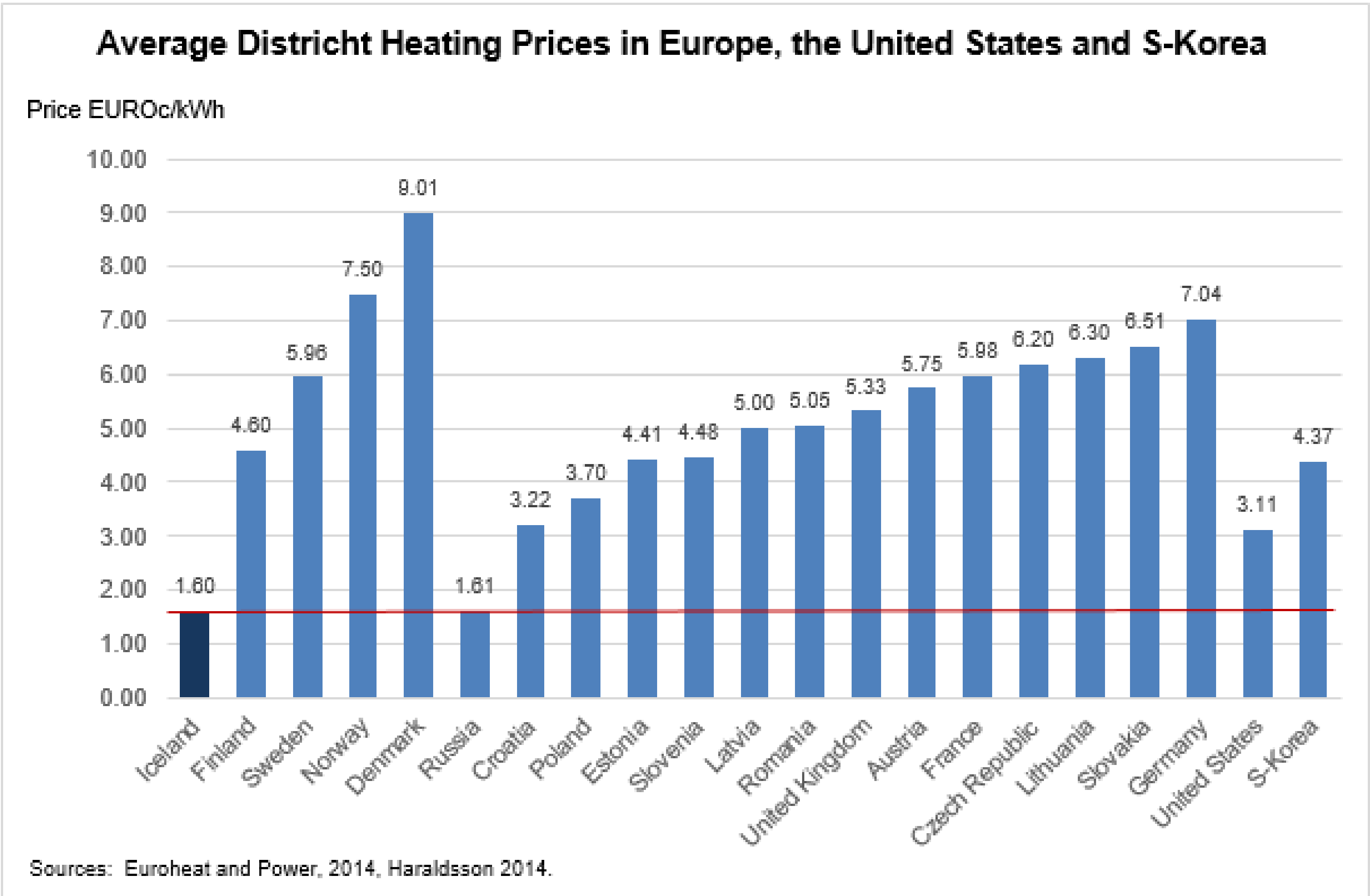
Average District Heating Prices in Europe, the United States and S-Korea



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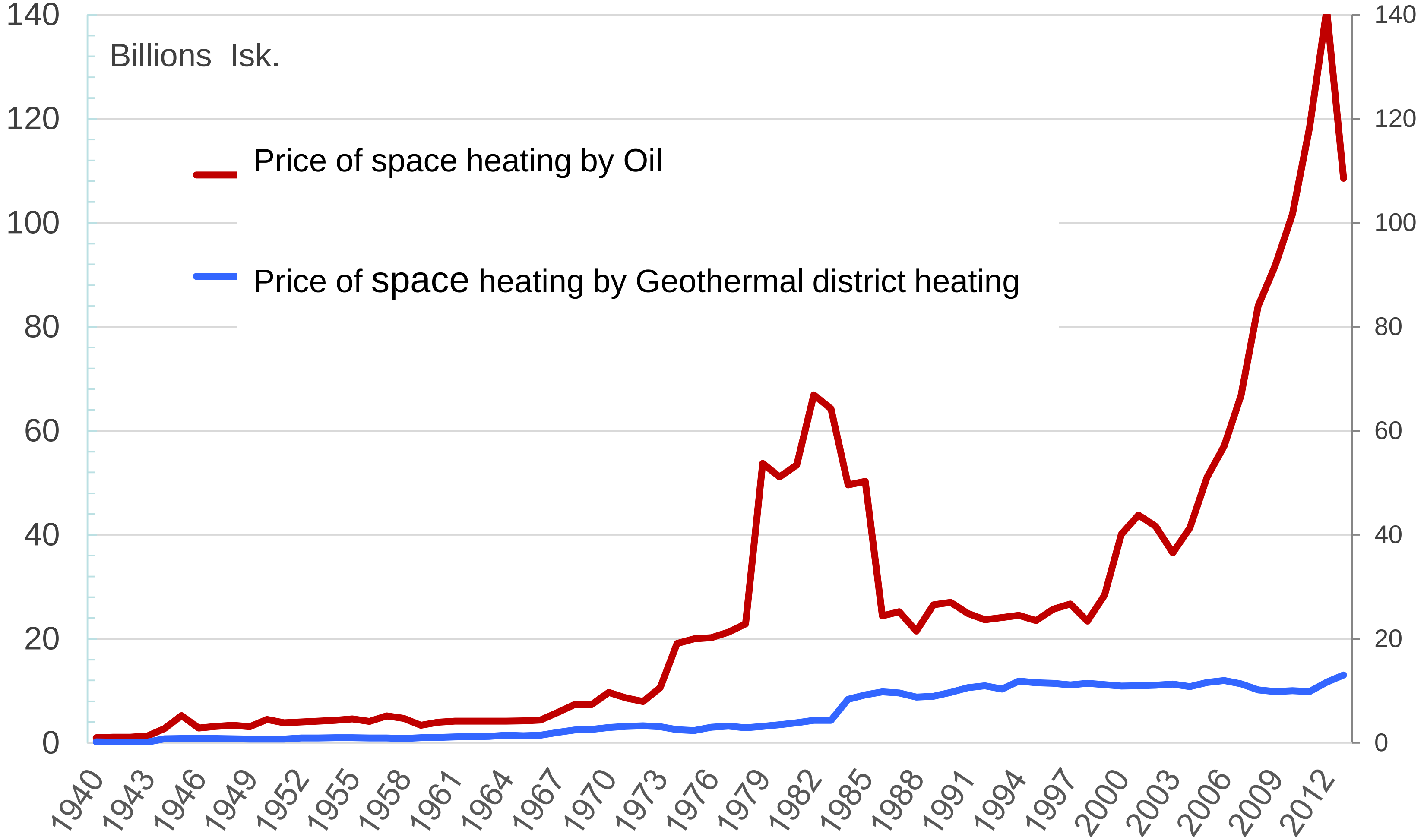
Economic Benefits of Geothermal District Heating

Price of space heating by Oil and Geothermal district heating 1940 – 2012



Source: Orkustofnun, 2014

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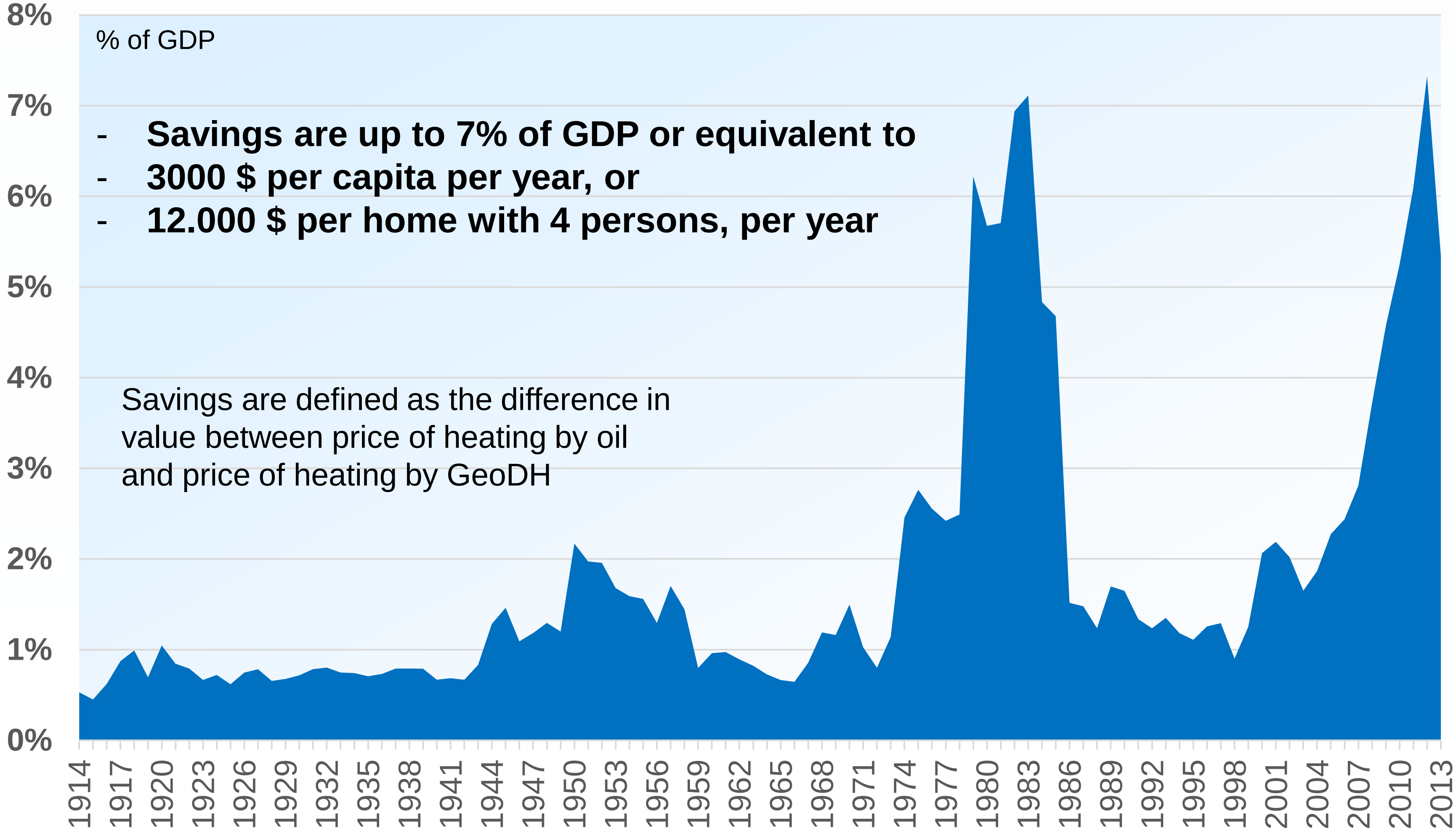
Economic Benefits of Geothermal District Heating
National Savings by Geothermal District Heating,
as a % of GDP 1914–2013



Source: Orkustofnun, 2014

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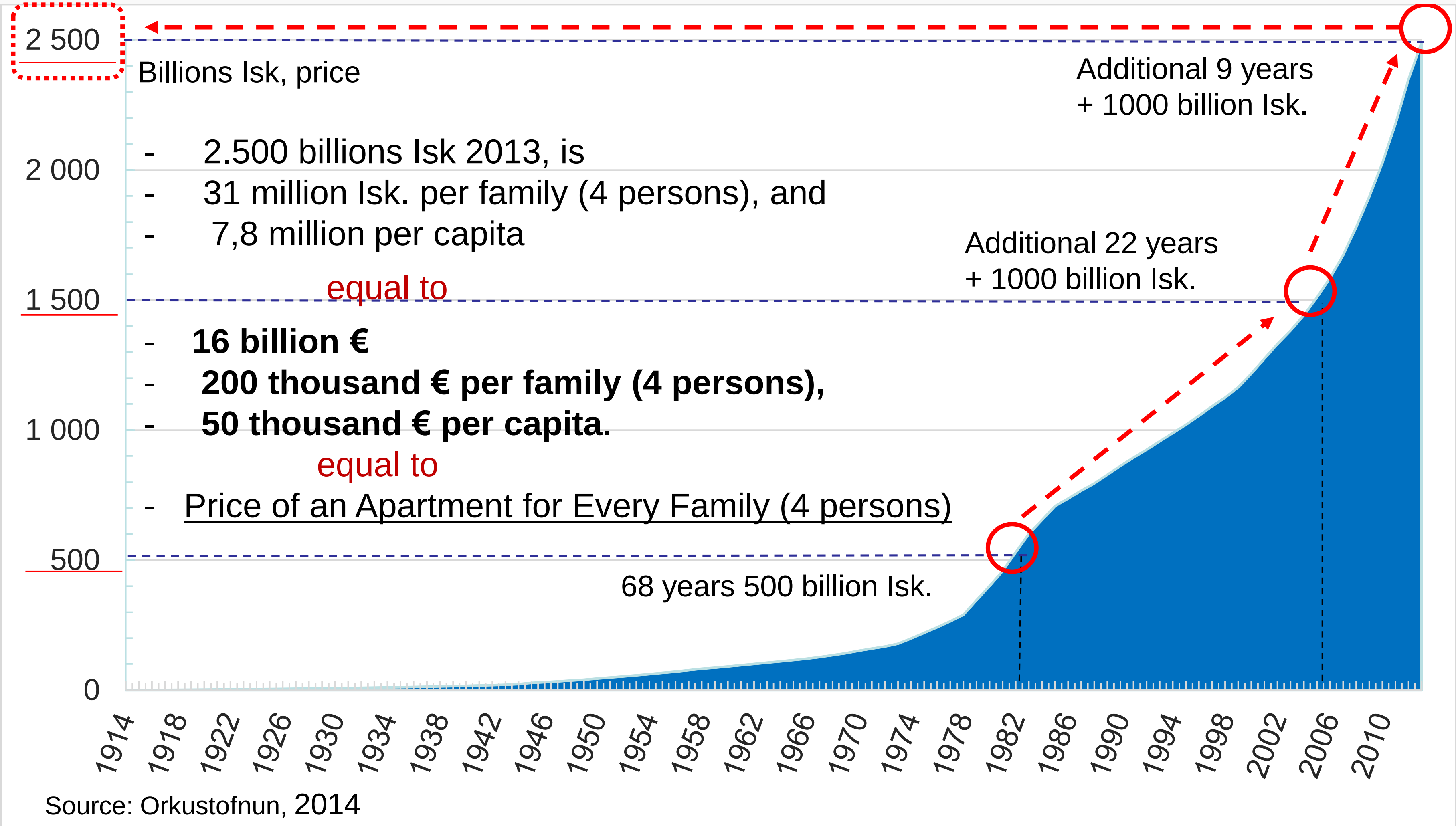
Cumulative Savings of Geothermal District Heating 1914–2013, (mostly since 1978, last 35 years)

2% interests, fixed price.



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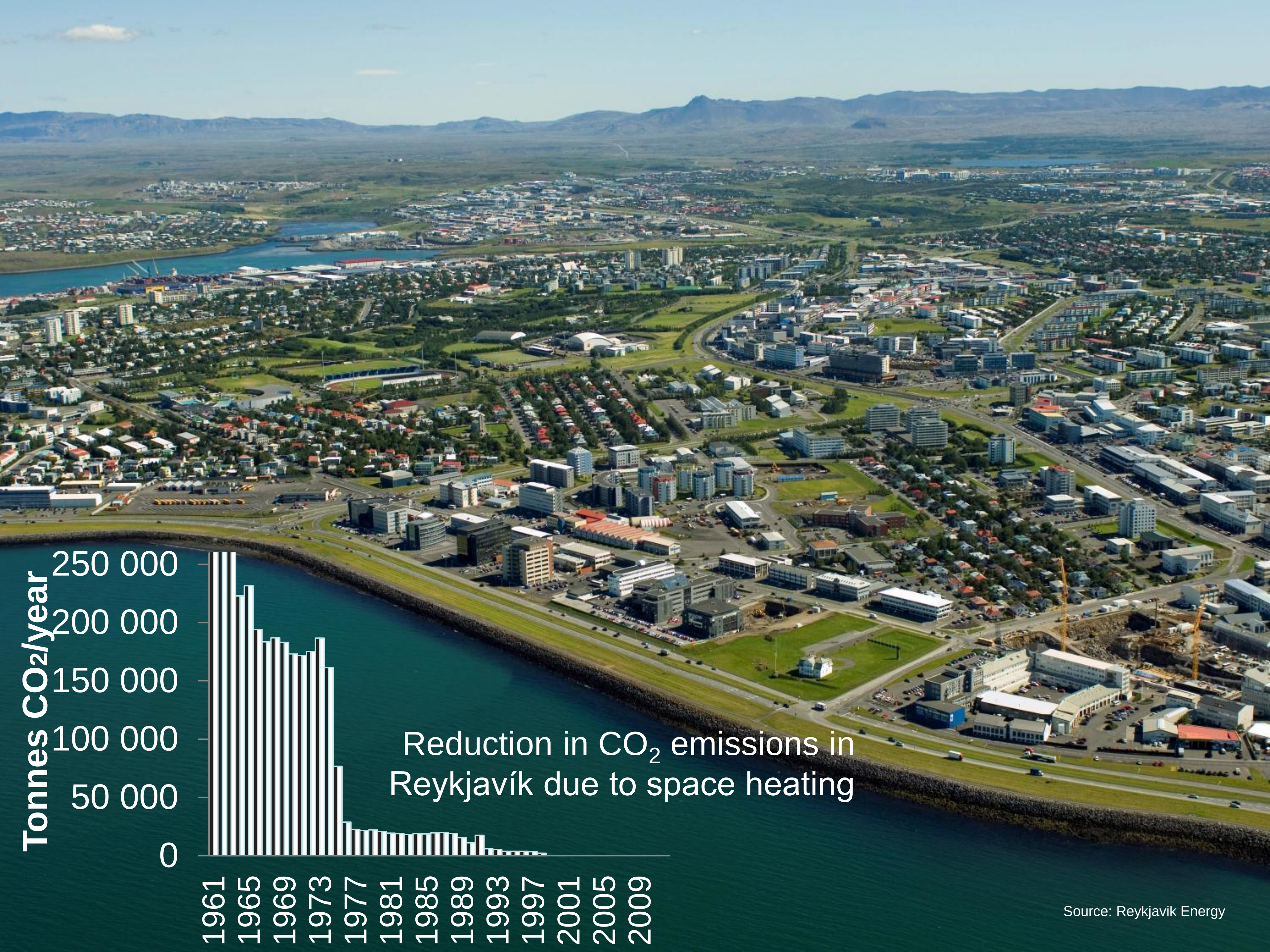
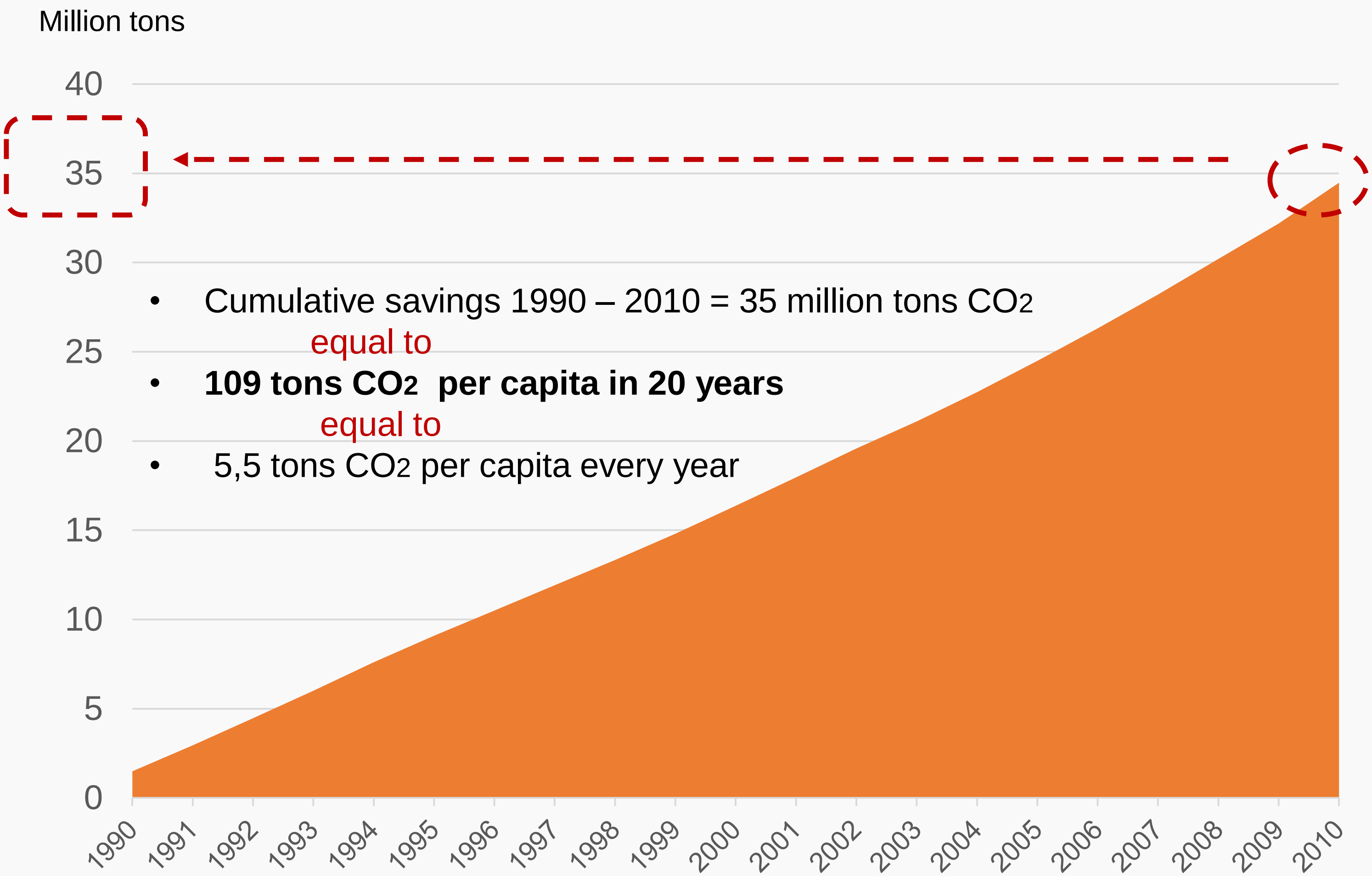

Tonnes CO2/year
250 000
200 000
150 000
100 000
50 000
0
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
Reduction in CO2 emissions in Reykjavík due to space heating
Source: Reykjavik Energy

Cumulative Reduction of CO2 in Iceland by using Geothermal District Heating instead of Oil 1990 – 2010



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Lessons learned from Icelandic GeoDH Policy

1. **World wars and oil crises (1970 – 1980) highlighted the need for GeoDH Policy**
    - These global crisis highlighted the necessity for GeoDH Policy in Iceland

2. **Political, Public, Sectoral and Financial - recognition for the GeoDH Policy**
    - For **energy security, economic and environmental** reasons (oil crises), the GeoDH policy was recognised at **national level and within main cities**
    - This political and sectoral recognition – was base for the policy and implementations

3. **Risk loans - for exploration drilling to lower the risk barriers for GeoDH operation**

4. **Financial support to homeowners for transformation to GeoDH**

5. **Finance / loans for drilling and building Geothermal District Heating (GeoDH)**

6. **Importance for Financial Institutions to recognise opportunities within GeoDH**

7. **Renewables for heating in Iceland is already saving up to 7% of GDP or equivalent 3000 US $ per capita per year**

Lessons learned from Icelandic GeoDH Policy
Benefits of Geothermal District Heationg

GEOTHERMAL ENERGY – Offers Major Opportunities

1. Harnessing Natural Resources
2. Economic opportunities and savings
3. Improve energy security
4. Reducing greenhouse gas emissions
5. Reducing dependence on fossil fuels for energy use
6. Improving industrial and economic activity
7. Growing the low-Carbon and Geothermal technology industry, and create employment opportunities
8. Improving quality of life

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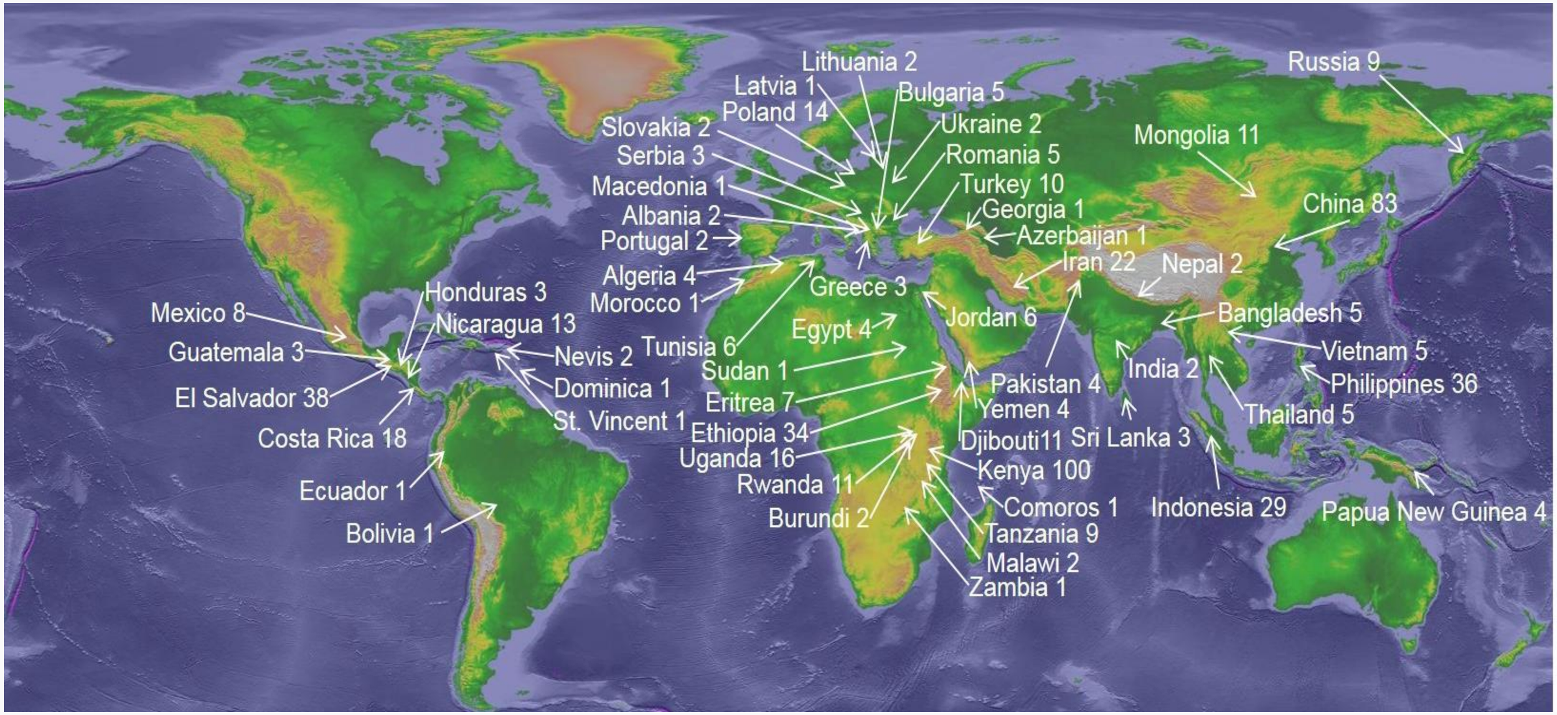
International Cooperation - Geothermal

The United Nations University Geothermal Training Programme in Iceland



UNU-GTP Fellows in Iceland 1979-2014 – 583 from 58 countries.

The Geothermal Training Programme of the United Nations University (UNU-GTP) is a postgraduate training programme, aiming at assisting developing countries in capacity building within geothermal exploration and development. The programme consists of six months annual training for practicing professionals from developing and transitional countries with significant geothermal potential. Priority is given to countries where geothermal development is under way, in order to maximize technology transfer.

International Cooperation - Geothermal
Iceland, World Bank and Nordic Developing Fund on Cooperation in Africa

November 9th. 2012, an Agreement was made between Iceland, the World Bank and Nordic Development Fund NDF. The agreement includes the development of a Global Geothermal Development Plan under the auspices of the World Bank, which could amount up to 500 million USD.
The agreement provided finance for geothermal feasibility assessments and test drilling in Africa.

Countries					Stages	1	2	3	4	5	6	7	8	9
		A	B	C	Potential	Recon.	Exploration	Exploration drilling	Pre-feasibility	Drilling	Feasibility	Design	Constr.	Operation
1	Eritrea	A			High	X	X							
2	Djibouti	A			High	X	X	X	X					
3	Ethiopia	A		N	High	X	X	X					X	X
4	Uganda	A	I	N	Med	X	X							
5	Kenya	A		N	High	X	X	X		X	X	X	X	X
6	Rwanda			N	Med/ High	X	X		X					
7	Burundi				Med	X								
8	Tanzania	A		N	Med	X	X							
9	Zambia			N	Low/ Med	X	X							
10	Malawi		I	N	Low/ Med	X								
11	Mozambique		I	N	Low	X								
12	Congo				Unknown									
13	Comoros				Low/ Med	X								

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Agents	Roles Stages	1	2	3	4	5	6	7	8	9
		Recon.	Exploration	Exploration drilling	Pre-feasibility	Drilling	Feasibility	Design	Constr.	Operations
African Union	Political Guidance	X	X	X	X	X	X	X	X	X
ARGEO	Facilitator and coordin.	X	X	X	X	X	X	X	X	X
World Bank	Funding			X	X	X	X	X	X	X
MFA Iceland	Facilitator and funding	X	X	X	X					
ICEIDA	Lead agency Exploration	X	X		X					
NDF	Funding	X	X	X	X					
UNEP	Technical Assistance					X	X	X	X	X
OFID	Funding					X	X	X	X	X
BADEA	Funding					X	X	X	X	X
KfW	Funding					X	X	X	X	X
Other funds	Funding					X	X	X	X	X
BGD	Geological research	X	X	X	X					
IEA Iceland	Framework and capacity	X	X	X	X	X	X	X	X	X
UNU-GTP	Capacity building	X	X	X	X	X	X	X	X	X

International Cooperation - Geothermal Orkustofnun (Iceland) is the lead partner for the European Geothermal ERA NET Cooperation

Geothermal ERA-NET

IS	Orkustofnun (National Energy Authority),
NL	Rijksdienst voor Ondernemend Nederland
CH	Swiss Federal Office of Energy (SFOE)
I	National Research Council of Italy (CNR)
D	Jülich (PTJ)
F	ADEME (BRGM as third party)
IS	Icelandic Centre for Research (RANNÍS)
TR	TÜBITAK (Scientific and Technological Research Council of Turkey)
SVK	Slovak Ministry of Education, Science, Research and Sport

New partners

MFIG	Hungarian Geological and Geophysical Institute
SED	Slovenian Energy Directorate
EAD	Electicidade dos Acores

Lead partner is Orkustofnun
operating the
Geothermal ERA NET
Coordination Office

Good geographical balance (North-West to South-East Europe) Partner countries chosen a.o. on basis of their 2020/2050 geothermal ambitions

Geothermal ERA NET – Objective

http://www.geothermaleranet.is/

Exchange information on the status of geothermal energy

Lay groundwork to create a **European Geothermal Information Platform**

Highlight **barriers** and **recommend practical solutions**

Recommend measures
to
Strengthen European Geothermal Development,
for
Economic Opportunities, Energy Security and Mitigate Climate Change

Geothermal ERA NET – Objective

http://www.geothermaleranet.is/

Communicate with principal **stakeholders** and enhance **public awareness** on the **added value and benefits of geothermal scientific and policy issues**

Increase **transnational collaboration** in **research training and mobility**

Prepare Policy and Implementation for a <u>Common European Geothermal Action Plan</u>

for geothermal energy technology research, development, deployment and innovation supported by member states

<u>Prepare and Implement Joint Geothermal Activities</u> (e.g. transnational funding activities)

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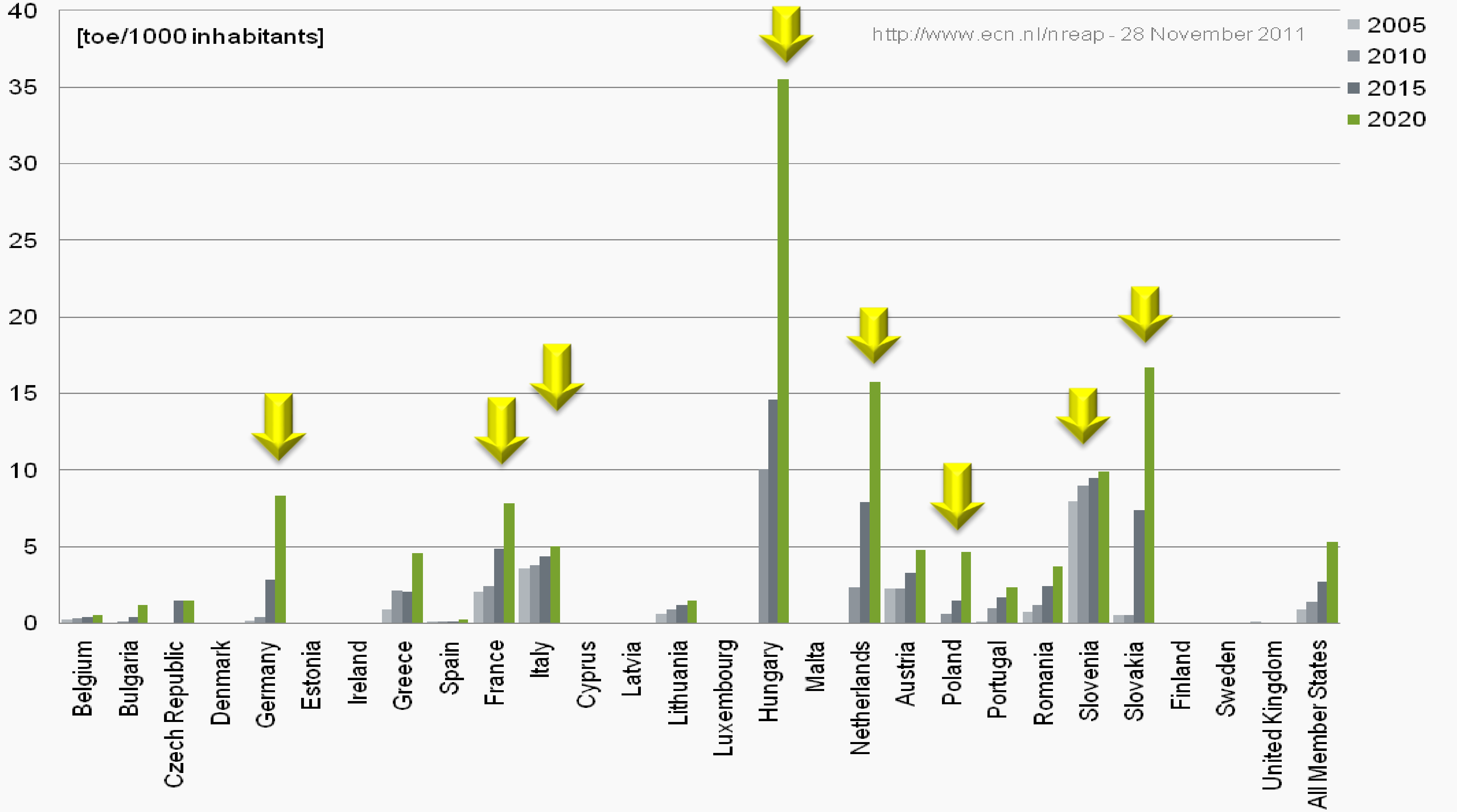
Leading European Countries?



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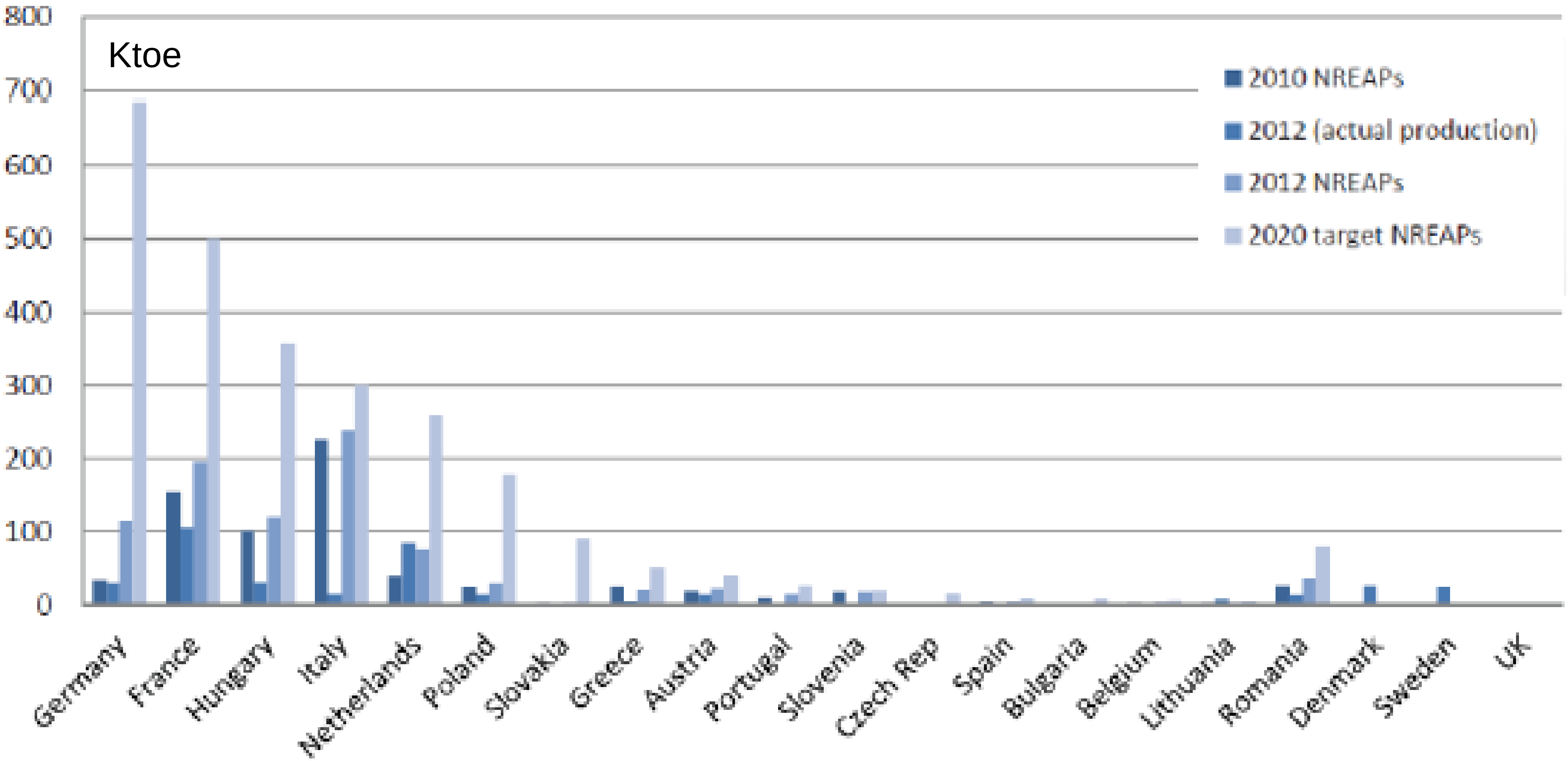
Geothermal DH Potential in Europe

Actual Geothermal DH production towards the 2020 target (ktoe)



Source: EGEC

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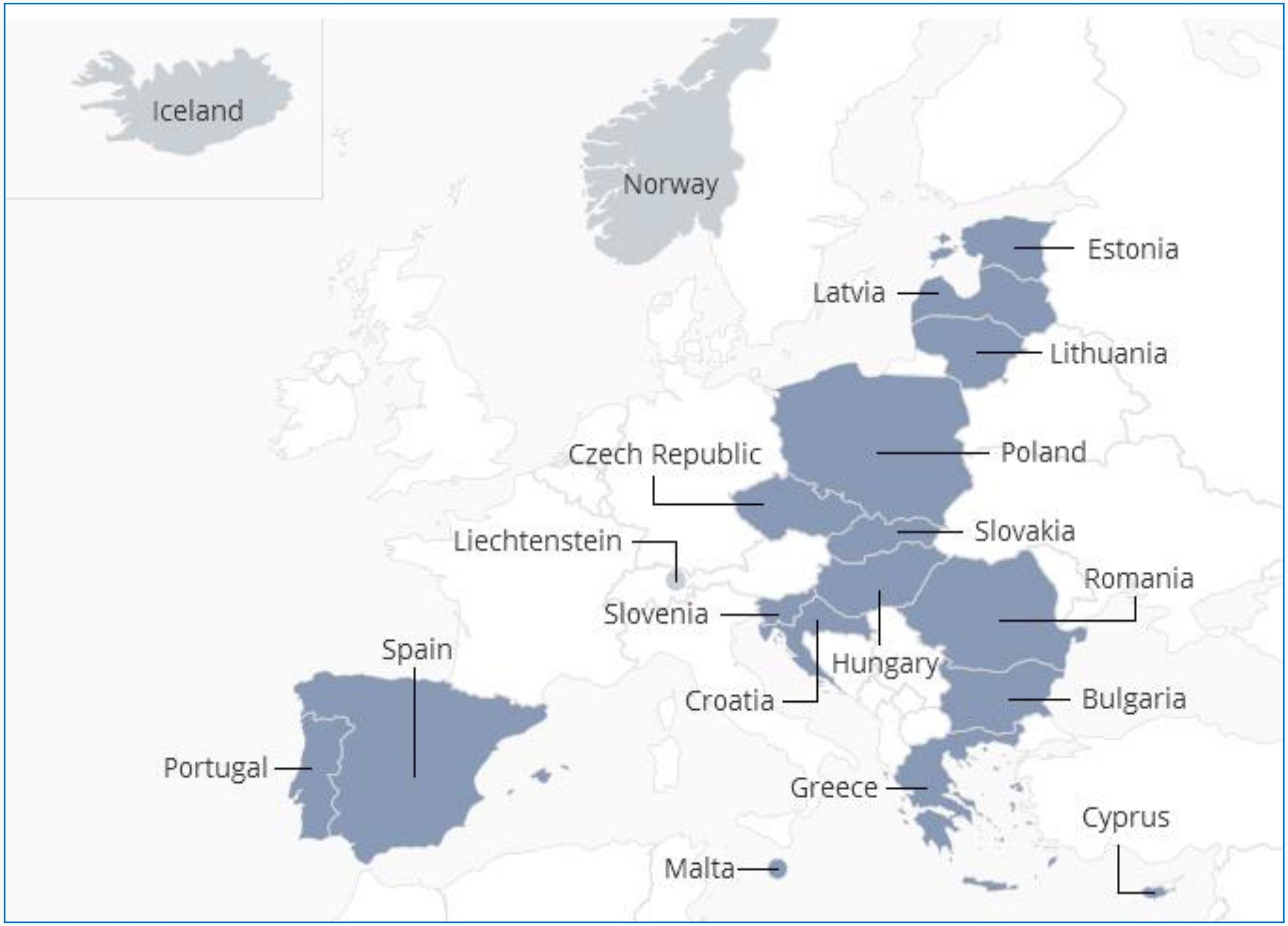
International Cooperation – EEA Grants
Orkustofnun is Donor Program Partner



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International Cooperation – EEA Grants

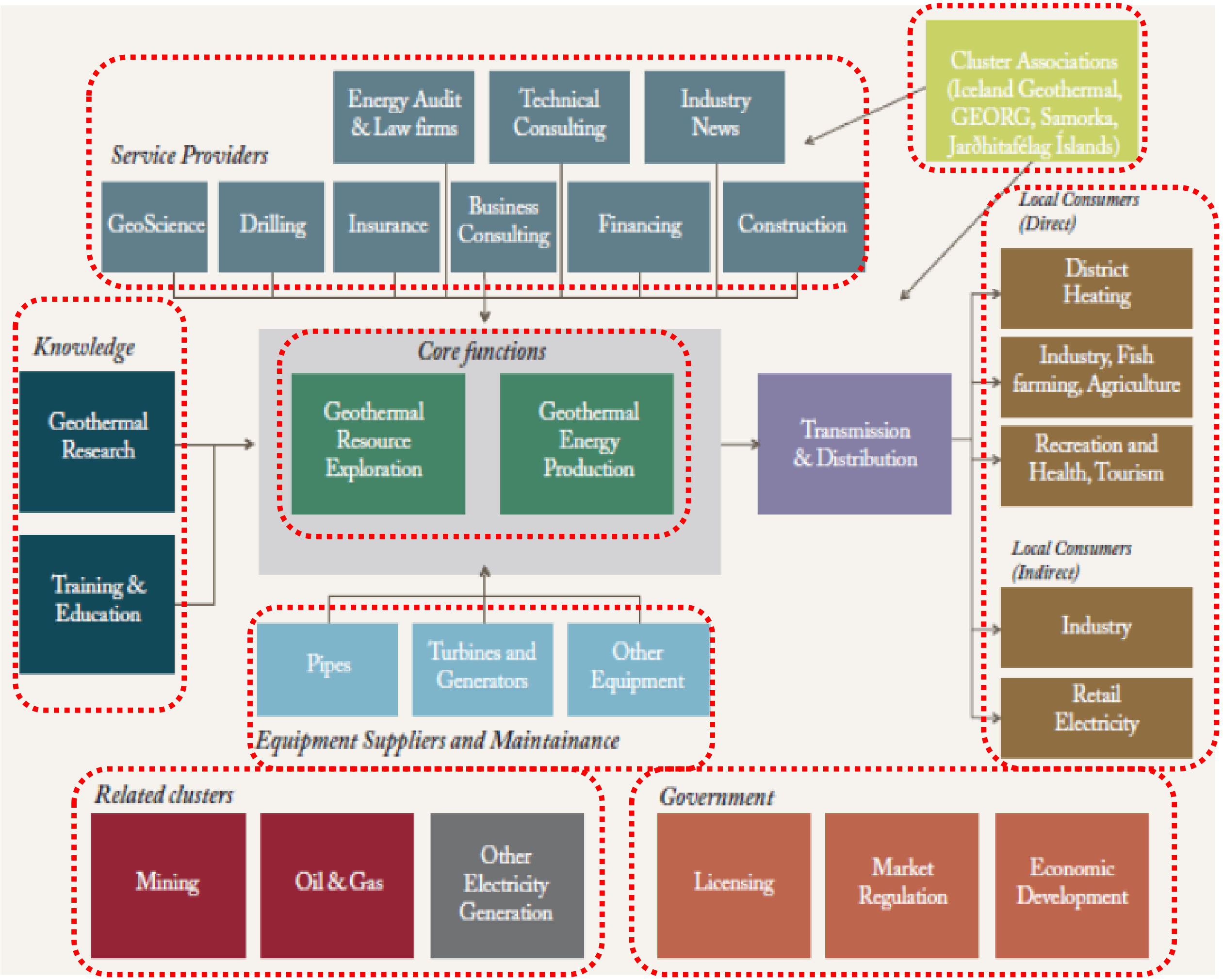
Orkustofnun is Donor Program Partner

in Eastern Europe - Romania

Summary of total numbers for all projects	
Hydropower, Installed capacity	6,44 MW_e
Geothermal, Installed capacity	9,28 MW_{th}
Production capacity	71,7 GWh
Reduction of CO_2 per year	25.430 tons
Total cost of project	6.200 m.ISK (39 m.€)
EEA Grant	2.000 m.ISK (12 m.€)

International Geothermal Projects are based on Expertise, Experience and Geothermal Cluster in Iceland

The Icelandic Geothermal Cluster



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Geothermal energy is always available in some form – with lot of opportunities and benefits

1. High enthalpy, 200-350 ^{O}C, suitable for electricity generation - usually at the border between the littoral plates (Ring of fire)

2. Medium enthalpy geothermal sources - suitable for binary plants for electricity generation

3. Low enthalpy geothermal sources , 60-100 ^{O}C, - suitable for house heating and cooling,

4. Low temperature geothermal sources 30 – 60 ^{O}C, suitable for balneal activities, horticultures, aquacultures etc.

5. Environmental annual temperature at 3+ meters below ground - suitable as source for heat pumps generating heating and cooling and even direct space cooling depending on the local climate

The more you look the more you will find

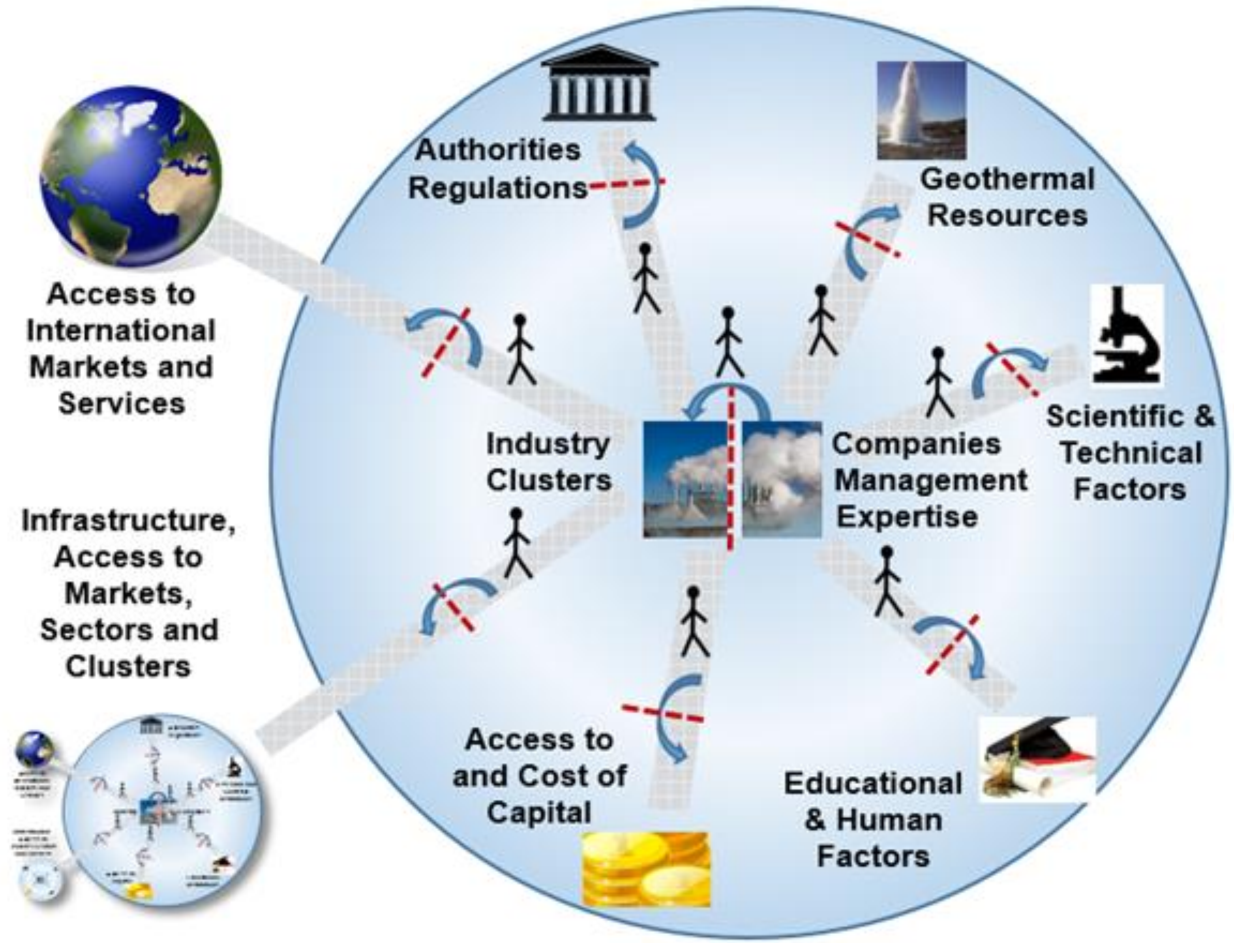
Competitiveness of the Geothermal Sector

Success of Geothermal District Heating is based on 8 Key Factors

8 Key Elements of Success in the Geothermal Sector and District Heating

1. Authorities and regulation,
2. Geothermal resources,
3. Scientific & technical factors,
4. Education & human factors,
5. Access to capital,
6. Infrastructure and access to markets, sectors and other clusters,
7. Access to international markets and services,
8. The company, management, expertise & industry, clusters assessment

In cooperation with international and domestic experts, on geothermal, finance and various expertise.



Source: Sölvell & Lindquist 2012, Amended, B. Petursson, National Energy Authority, 2014

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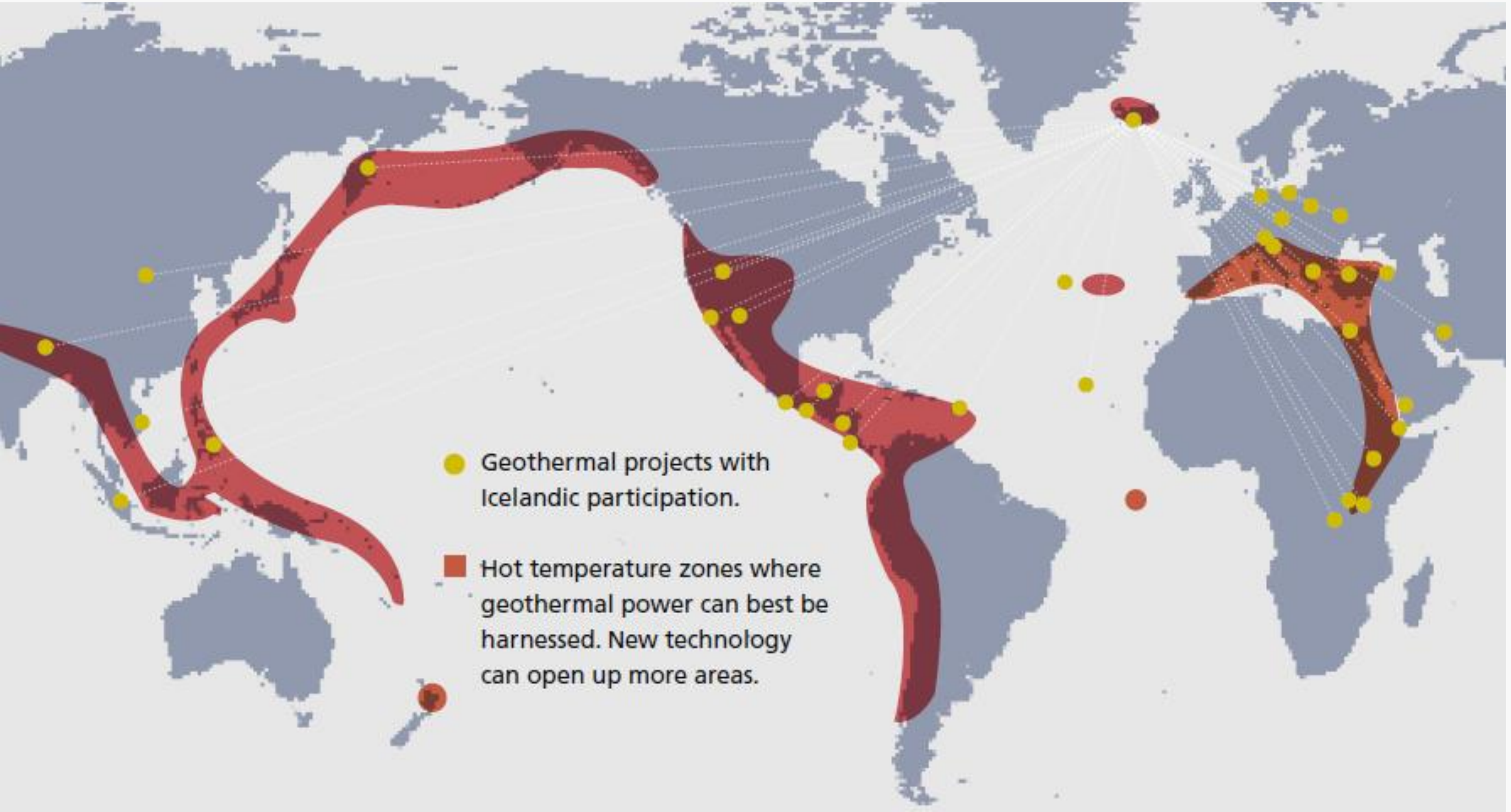
International Geothermal Projects with Icelandic Participation



Providing Solutions to the World

Renewable Energy in Iceland