

# **Profile of the Icelandic Geothermal Cluster**

Dr. Christian Ketels  
Institute for Strategy and Competitiveness  
Harvard Business School

*Reykjavik, Iceland  
November 1, 2010*

# Levels of Analysis

**Overall Economy**

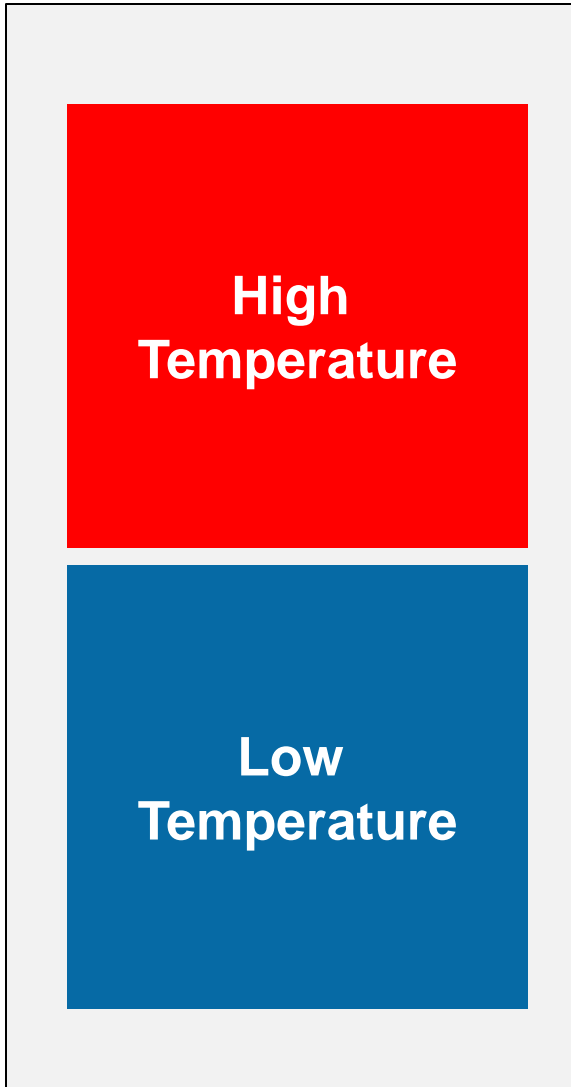
**Cluster**

**Industry**

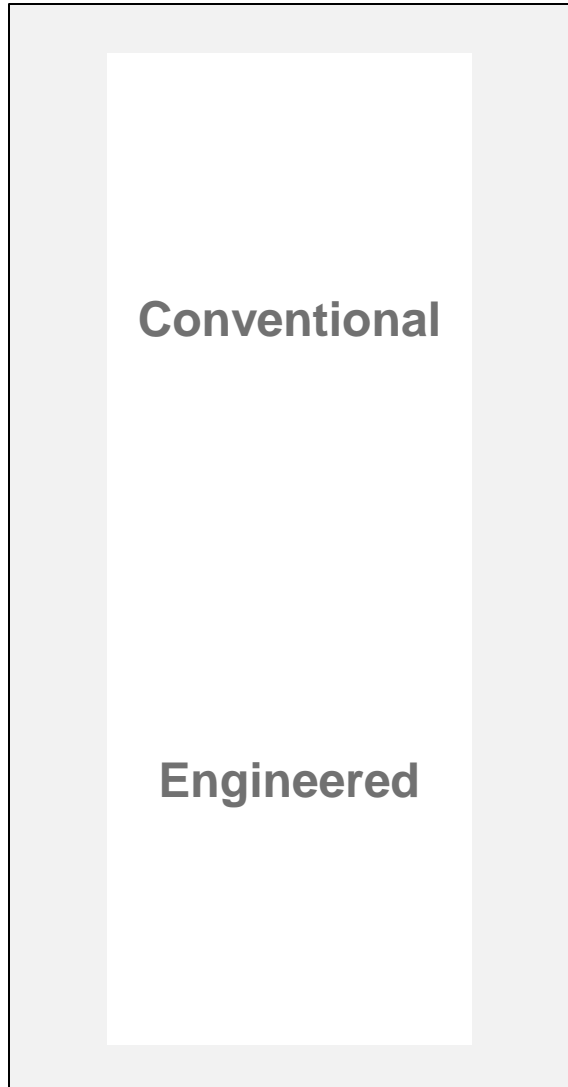
**Firm**

# Geothermal Energy: Segments

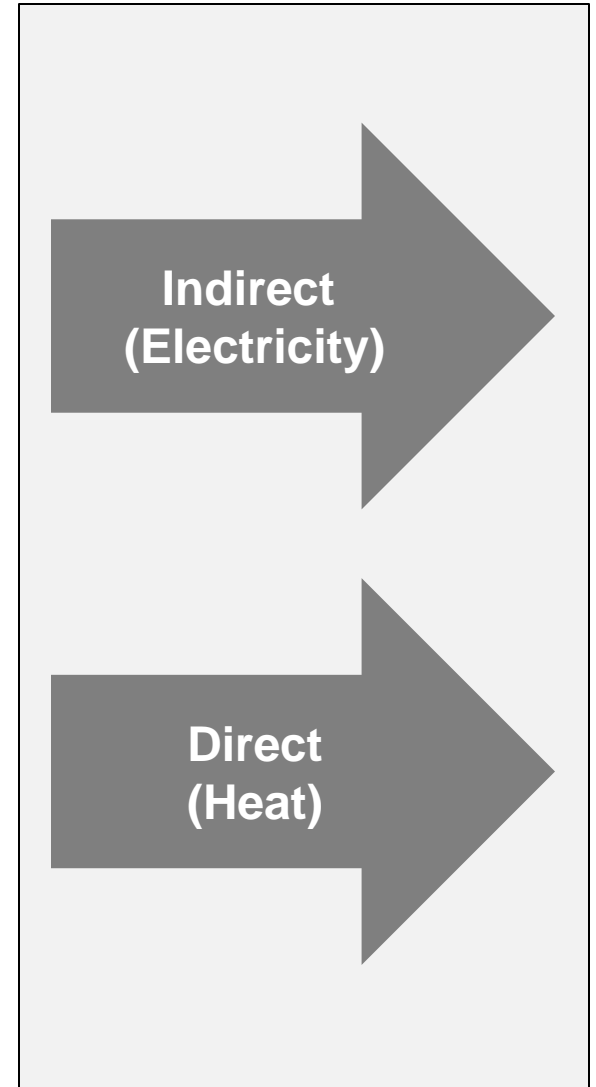
## Resource



## Extraction



## Usage

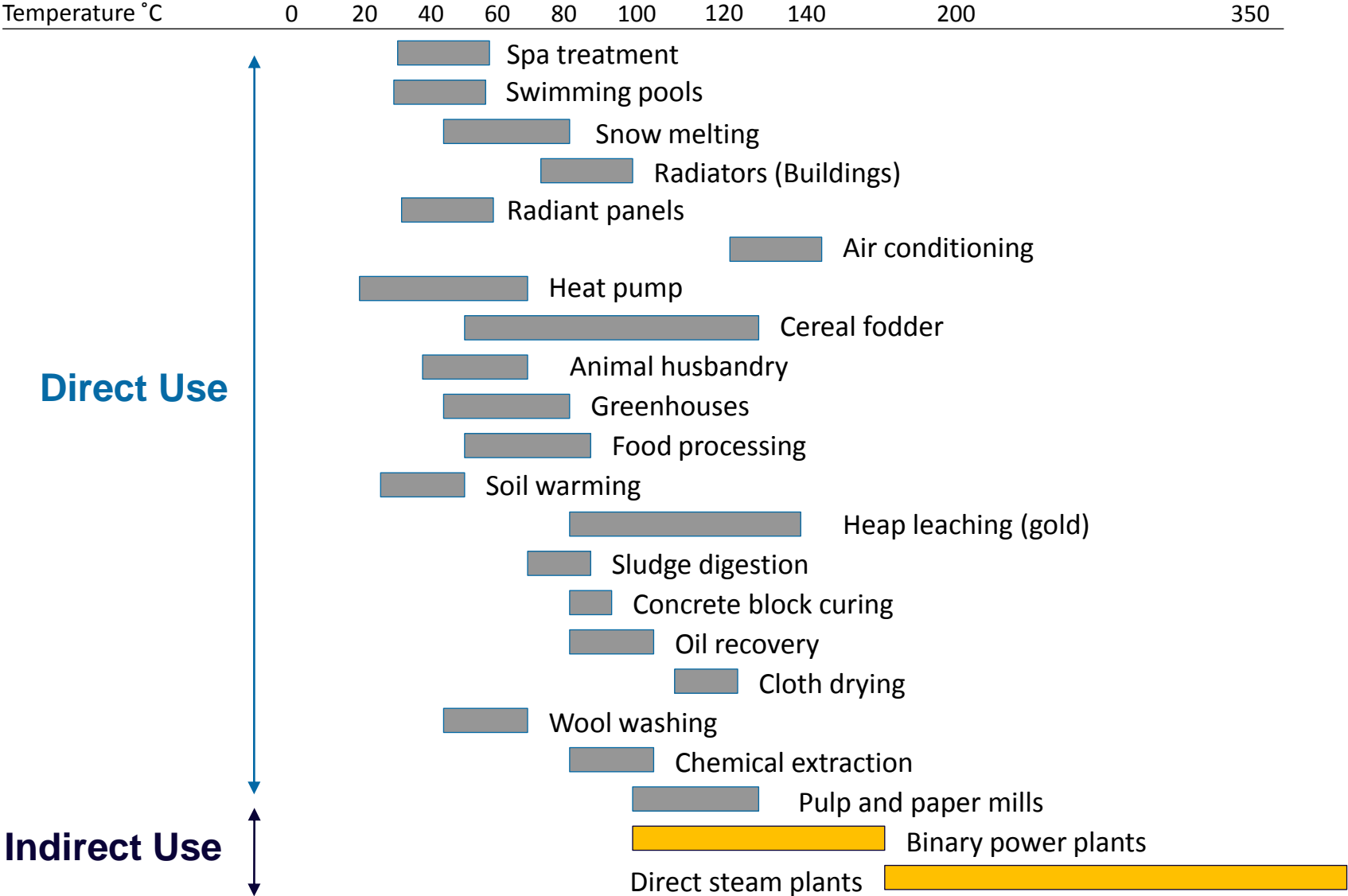


# Globally Installed Geothermal Capacity

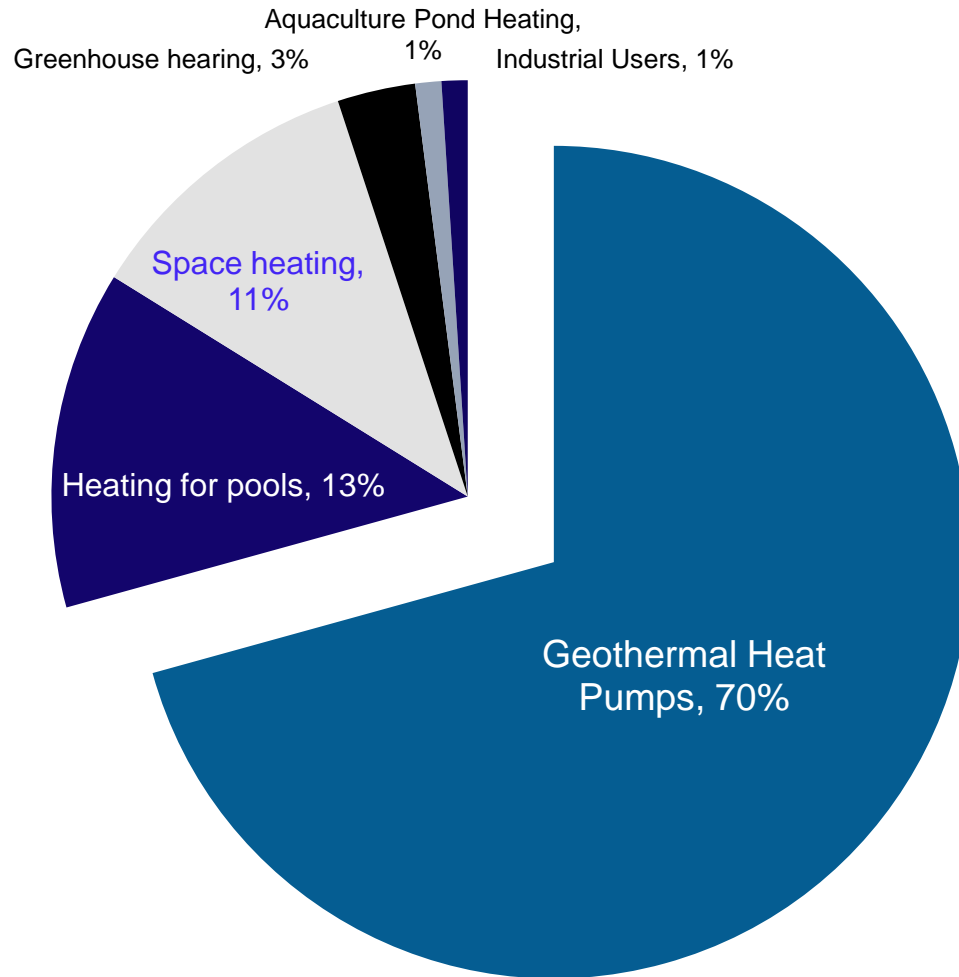
Indirect Use Capacity (GW)			Direct Use Capacity (GW)		
	<i>GLOBAL</i>	<i>10.7</i>		<i>GLOBAL</i>	<i>50.6</i>
1	United States	3.1		United States	12.6
2	Philippines	1.9		China	8.9
3	Indonesia	1.2		Sweden	4.5
4	Mexico	1.0		Norway	3.3
5	Italy	0.8		Germany	2.5
6	New Zealand	0.7		Japan	2.1
7	<b>ICELAND</b>	<b>0.6</b>		Turkey	2.1
8	Japan	0.5		<b>ICELAND</b>	<b>1.8</b>
9	El Salvador	0.2		...	
10	Kenya	0.2		...	

Source: KPMG analysis, Proceedings from World Geothermal Congress, 2010

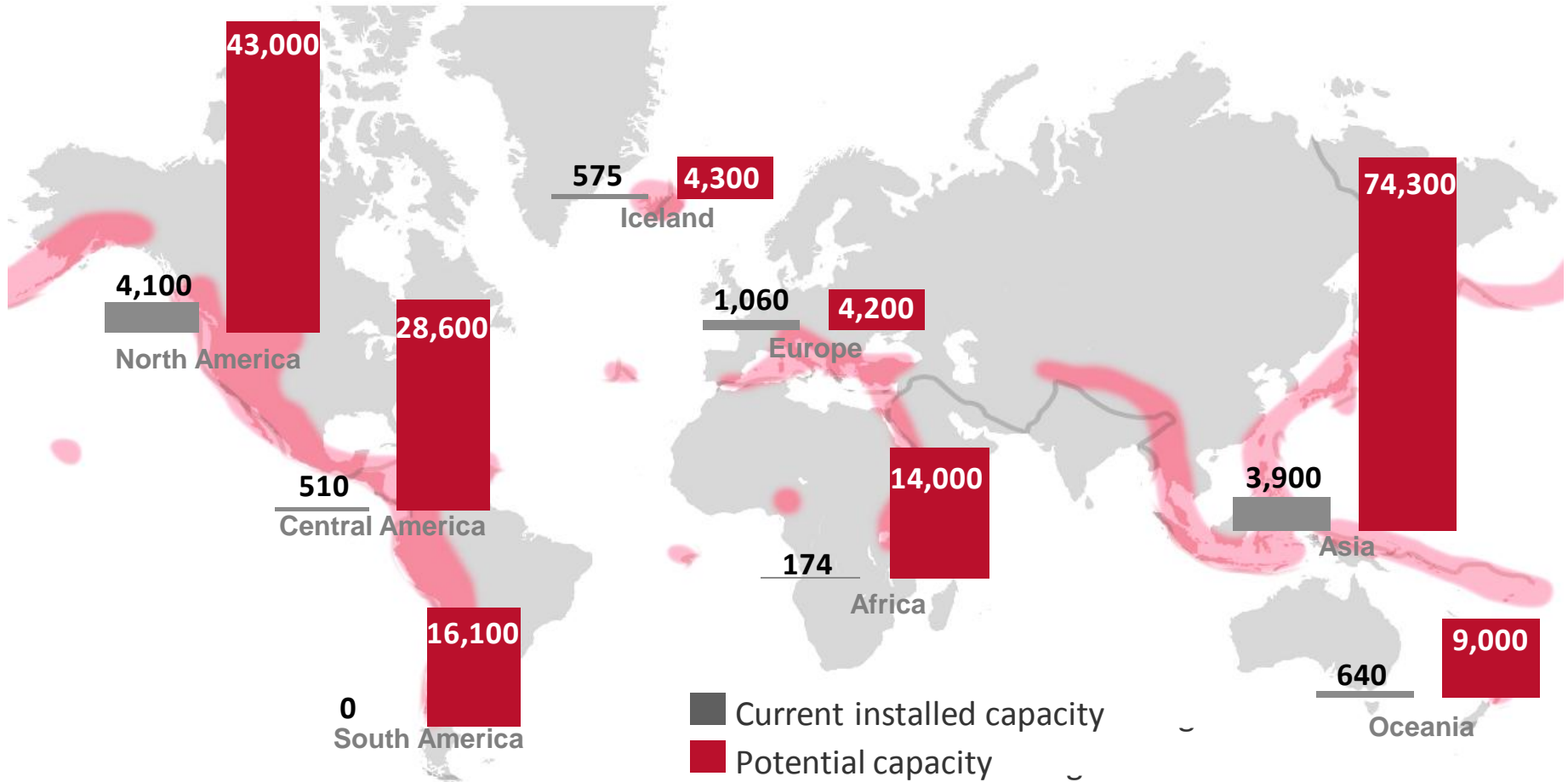
# Geothermal Applications: The Lindal Diagramm



# Direct Geothermal Use by Sector Globally



# Indirect Geothermal Use: Current and Potential Capacity



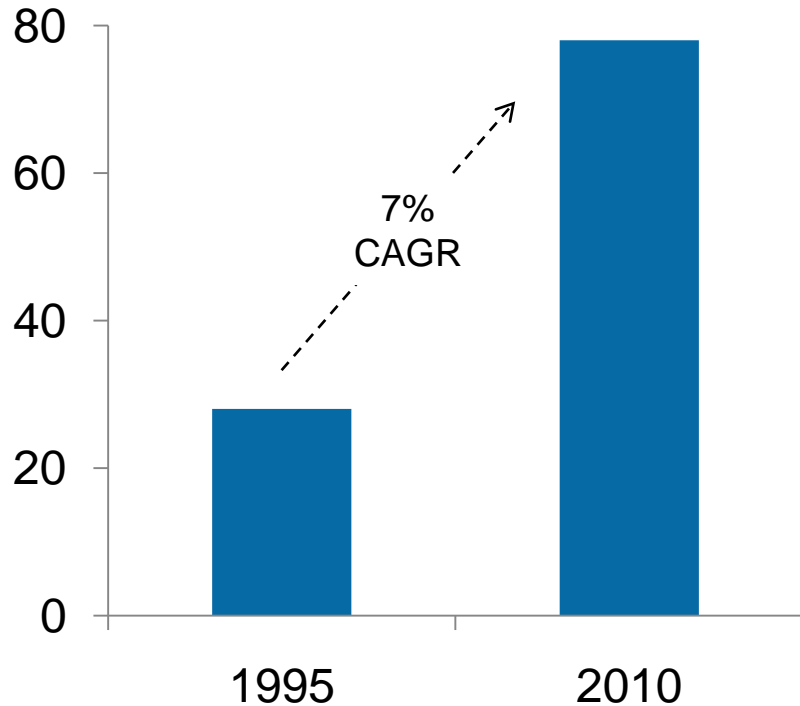
Source: Islandsbanki, 2008

- Only about **5% of potential capacity** has been exploited
- About 40% of unexploited global capacity is in **Asia**, and 20% in North America

# Growth of Geothermal Usage

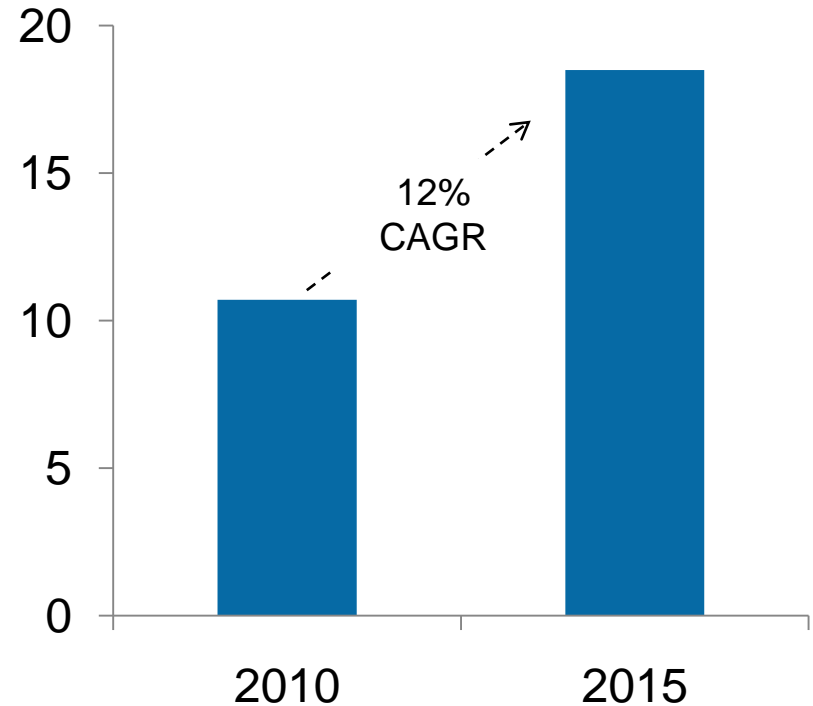
## Direct Use

### Countries with Active Projects



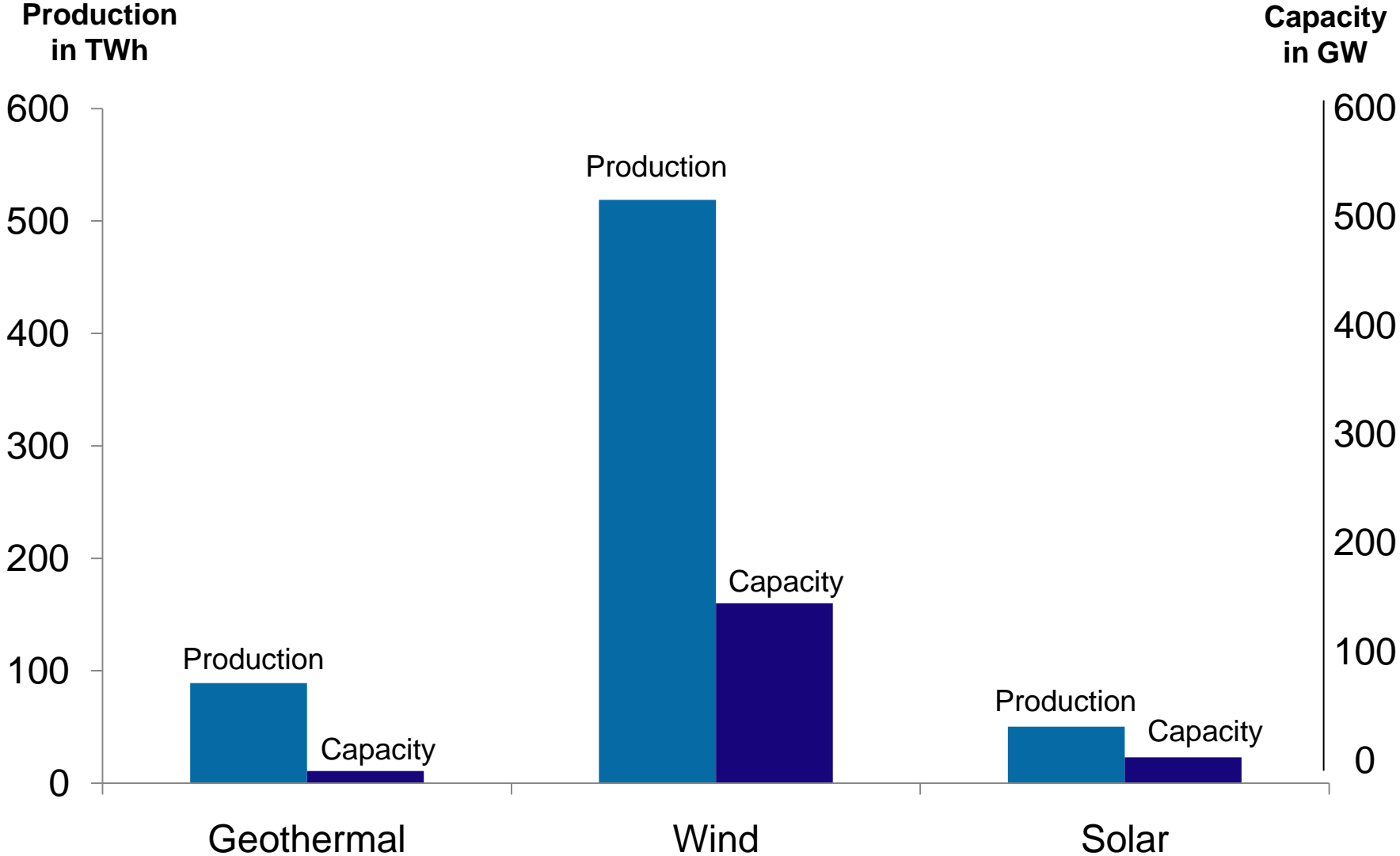
## Indirect Use

### Installed Capacity in GW





# Geothermal Energy versus other Renewables

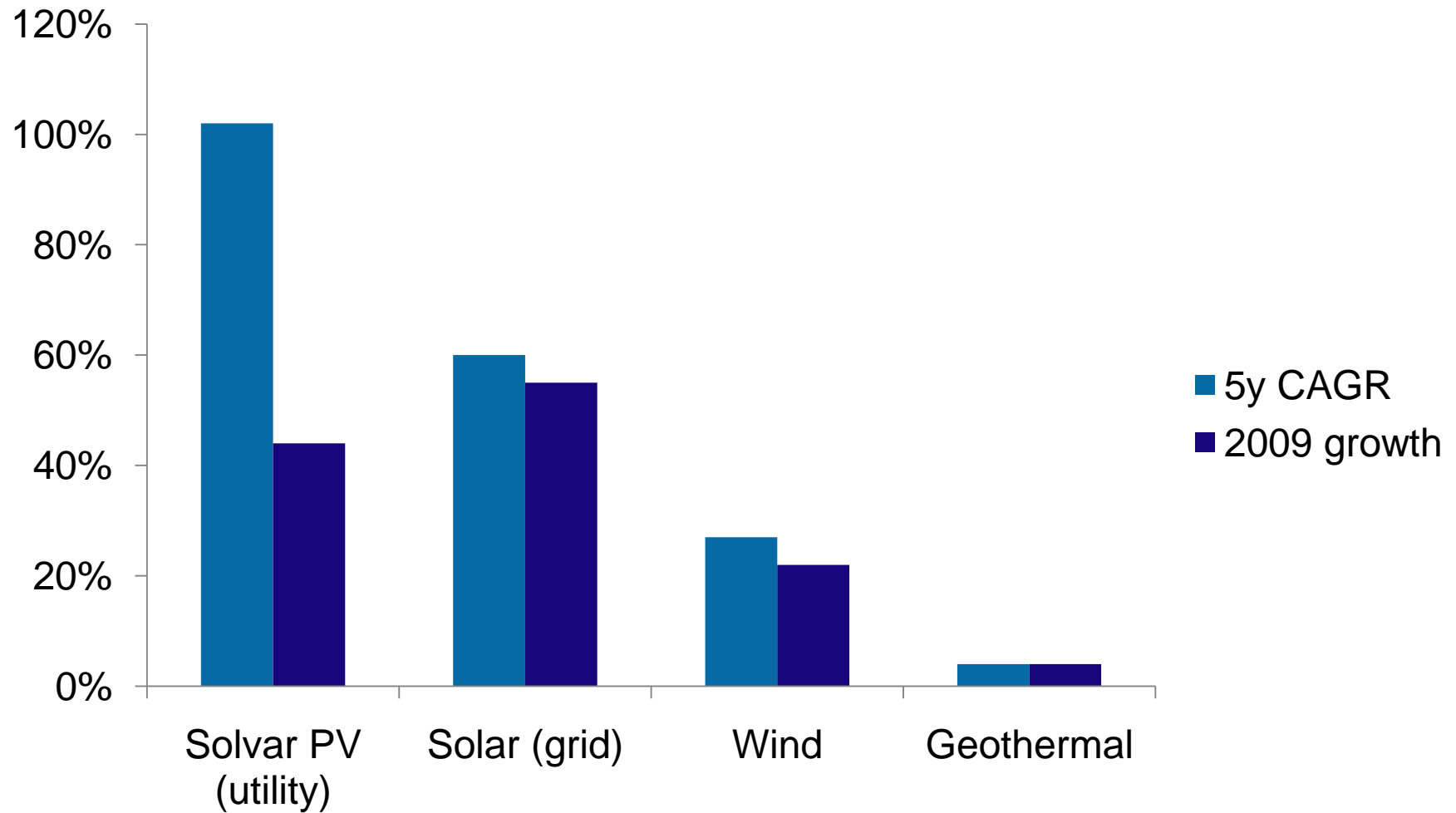


Wind, geothermal, and solar account for **1.7% of global electricity production** in 2009

Source: BP

# Global Renewable Electricity Generation Capacity

## Growth Rates



Source: Renewables 2010 Global Status Report

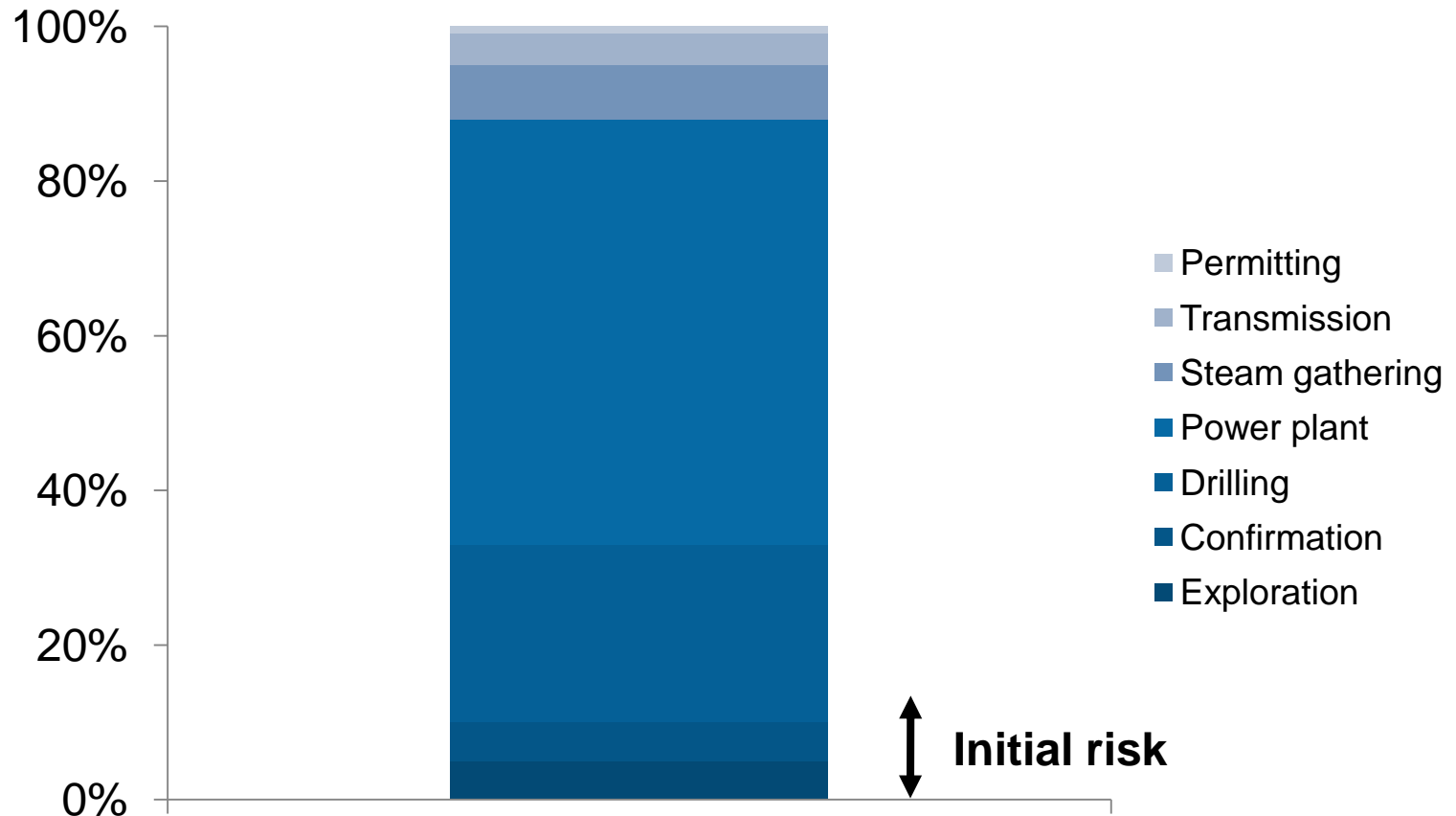
- In 2009, Geothermal accounted for **less than 2%** of global renewable energy investment and global renewable energy R&D

# Comparison of Energy Sources

	Capacity Factor	Land Use		Cost to Build	Total Operating Cost
	Ratio of actual to potential production	Sqm/Gwh		USD/KW	USD/Kwh
<b>Geothermal</b>	<b>95%</b>	<b>404</b>		<b>1750 - 5000</b>	<b>115</b>
<b>Wind</b>	37%	1335		1950 - 3900	150 - 190
<b>Solar</b>	20-30%	3237		5150 - 6200	390
<b>Coal</b>	70%	3642		1000	80 - 130
<b>Gas</b>	60%			2200	120
<b>Nuclear</b>	90%			3800	100 - 130

# Geothermal Project Cost Structure

Share of total cost



Source: KPMG analysis, Proceedings from World Geothermal Congress, 2010

About 11% of costs occur **before** the projects viability is confirmed

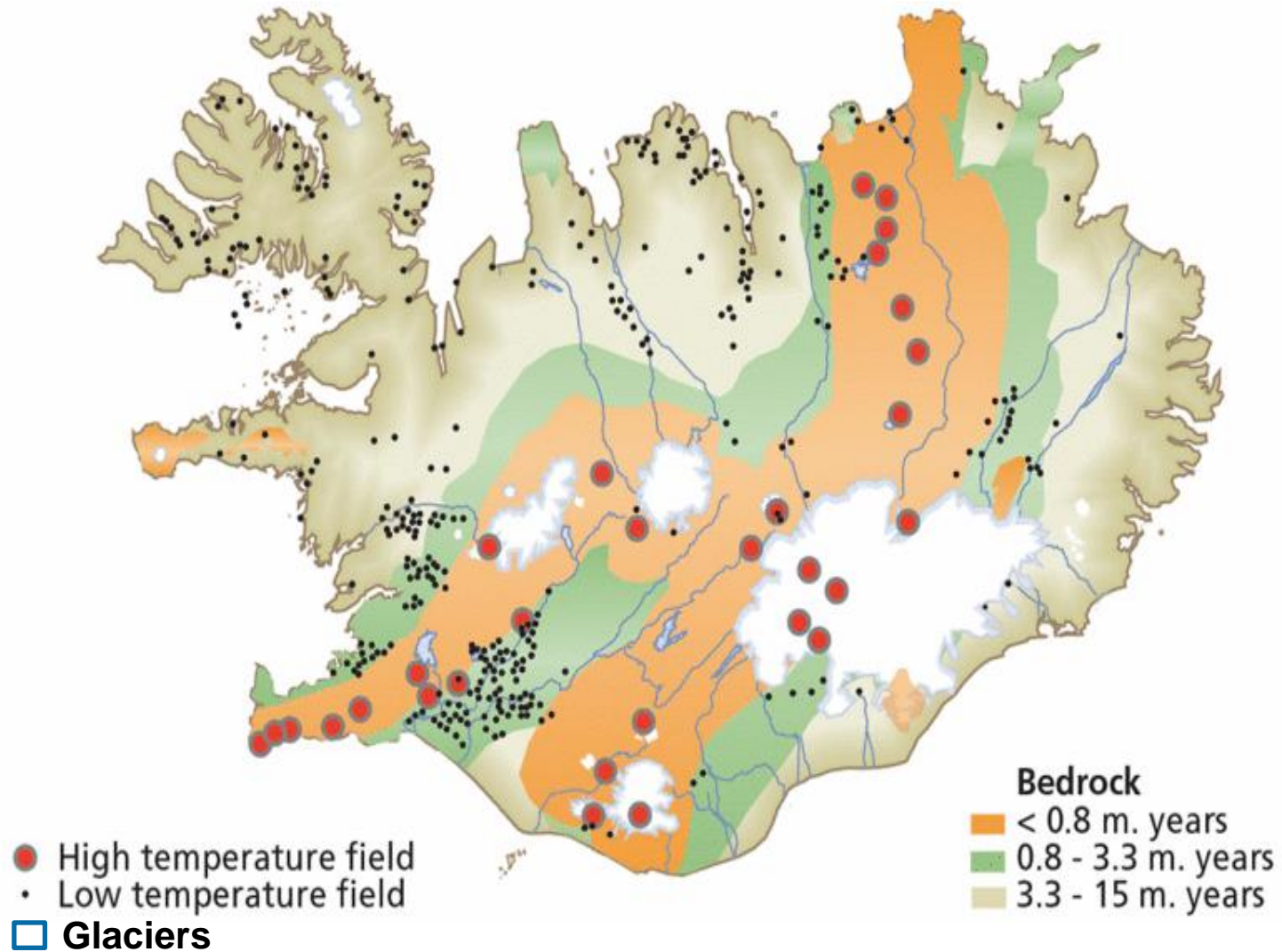
# The Future of Geothermal

- Geothermal has significant **technical and economic advantages** relative to other renewable and even traditional sources of energy
- There is significant **up-front risk** in exploration and verification of the quality of the available resource
- The **geographical availability** of geothermal resources is more limited than wind or solar
- **Public policy support** for renewable energy sources has traditionally been biased in favor of wind and solar, despite their inferior economics

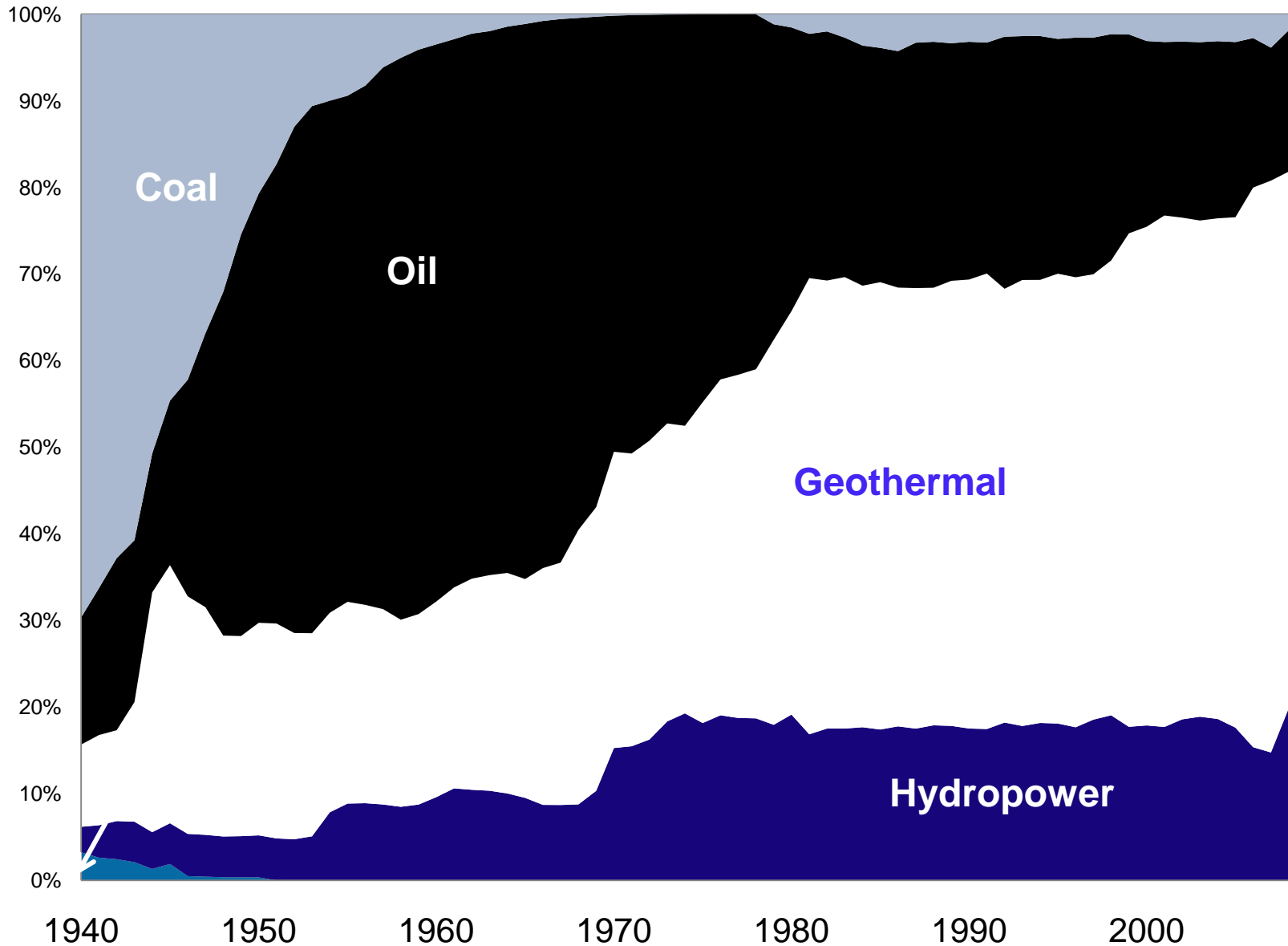


- Geothermal has **significant potential** but is currently a niche market compared to wind, solar, and traditional energy fields
  - Low temperature and high temperature geothermal are different businesses

# Natural Conditions for Geothermal in Iceland

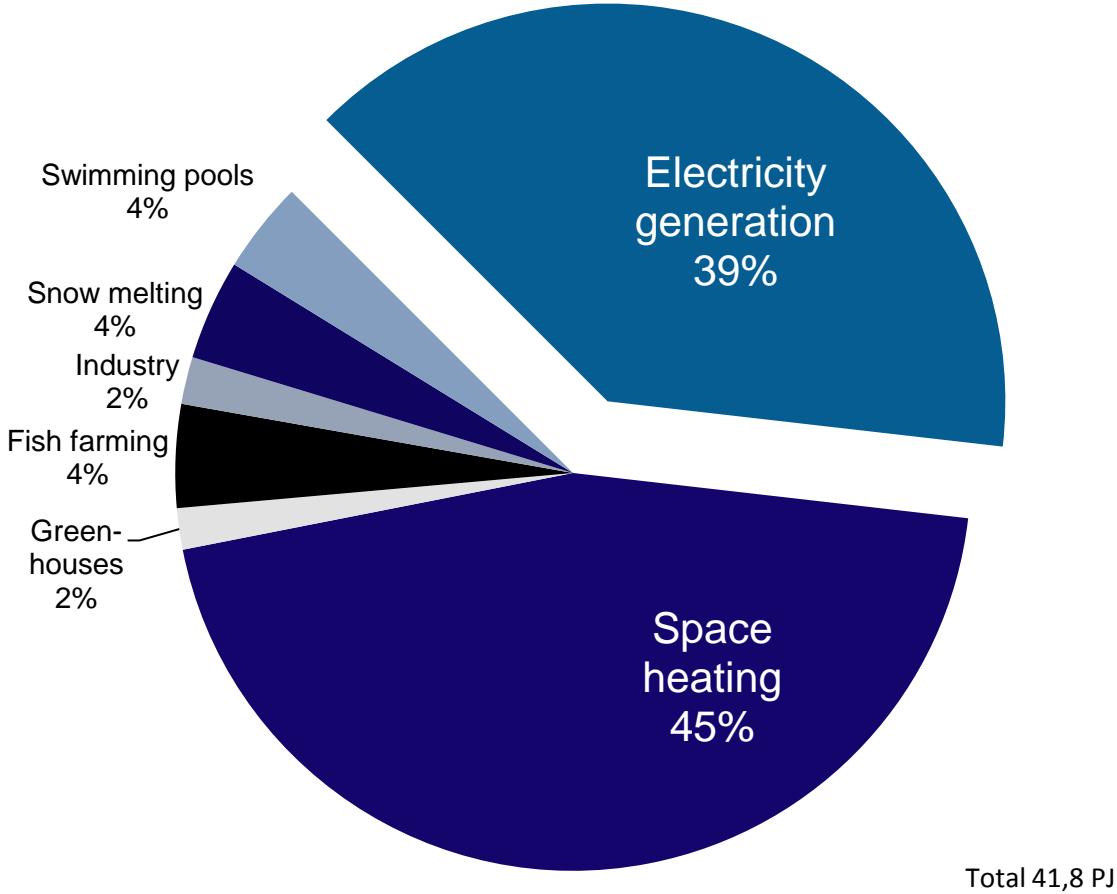


# Net Primary Energy Use in Iceland, 1940-2009



# Geothermal Energy Use by Application

## Iceland, 2009

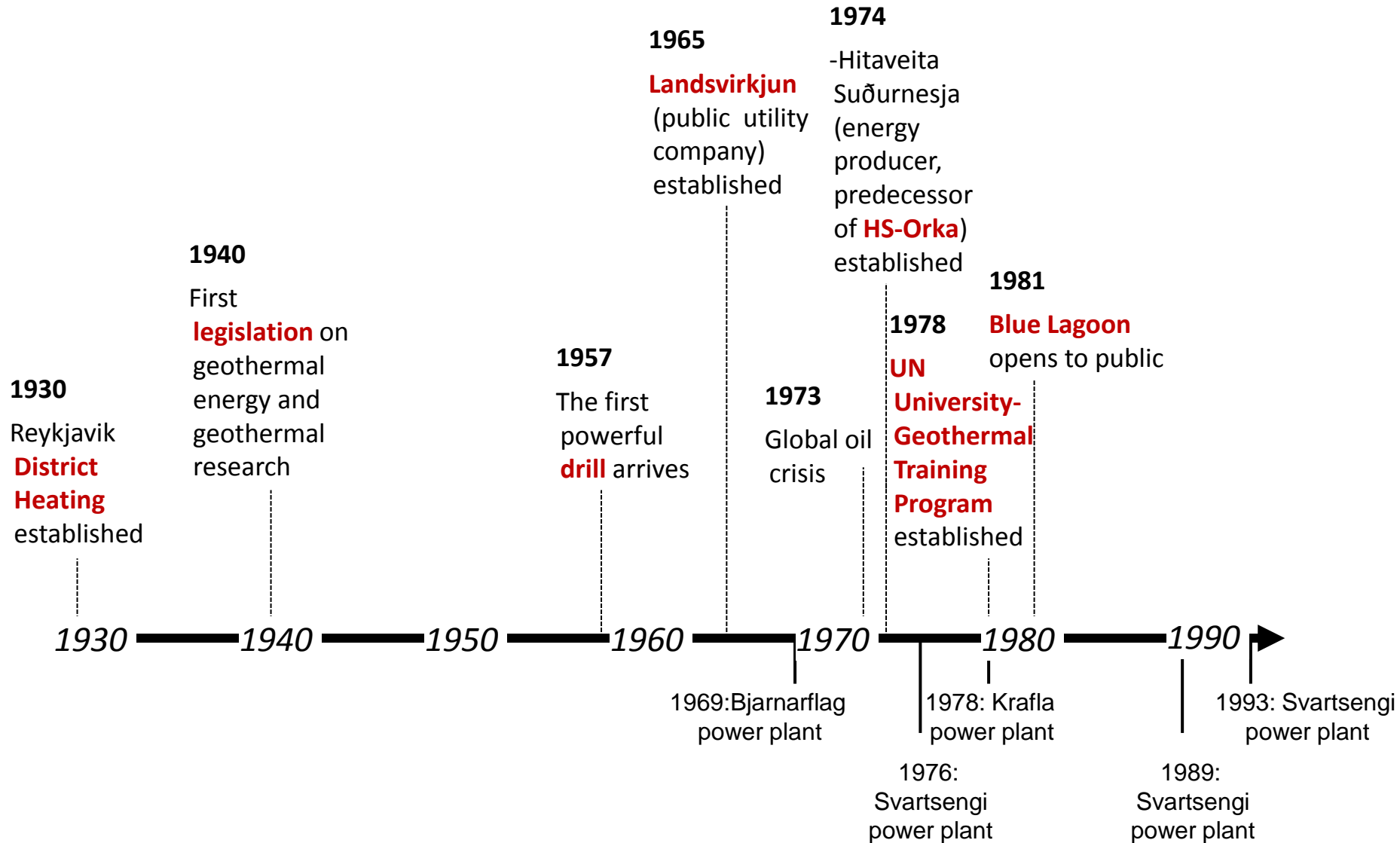


Source: Natural Energy Authority of Iceland



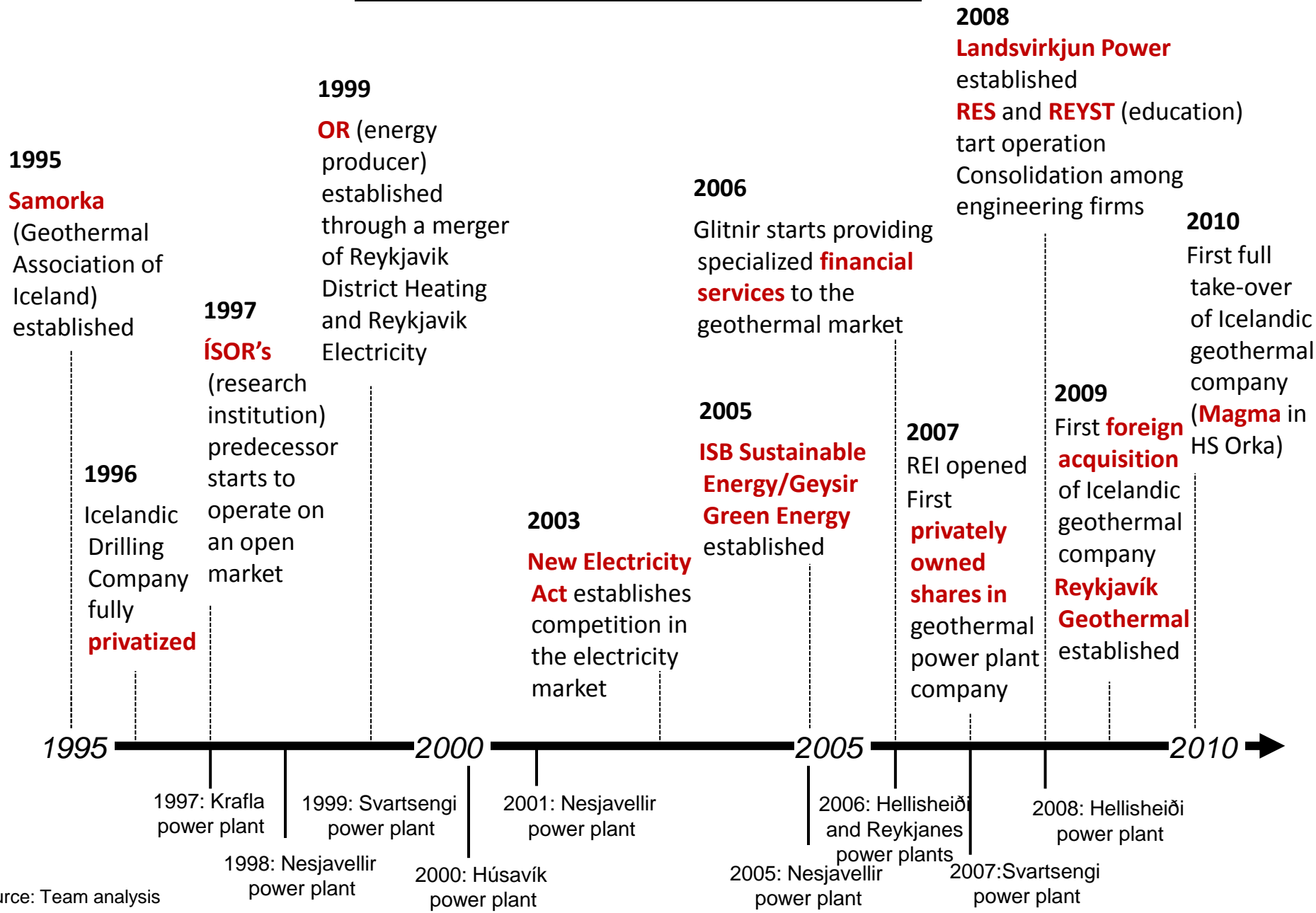
# The Development of the Icelandic Geothermal Cluster

## 1930-1995: Foundations



# The Development of the Icelandic Geothermal Cluster

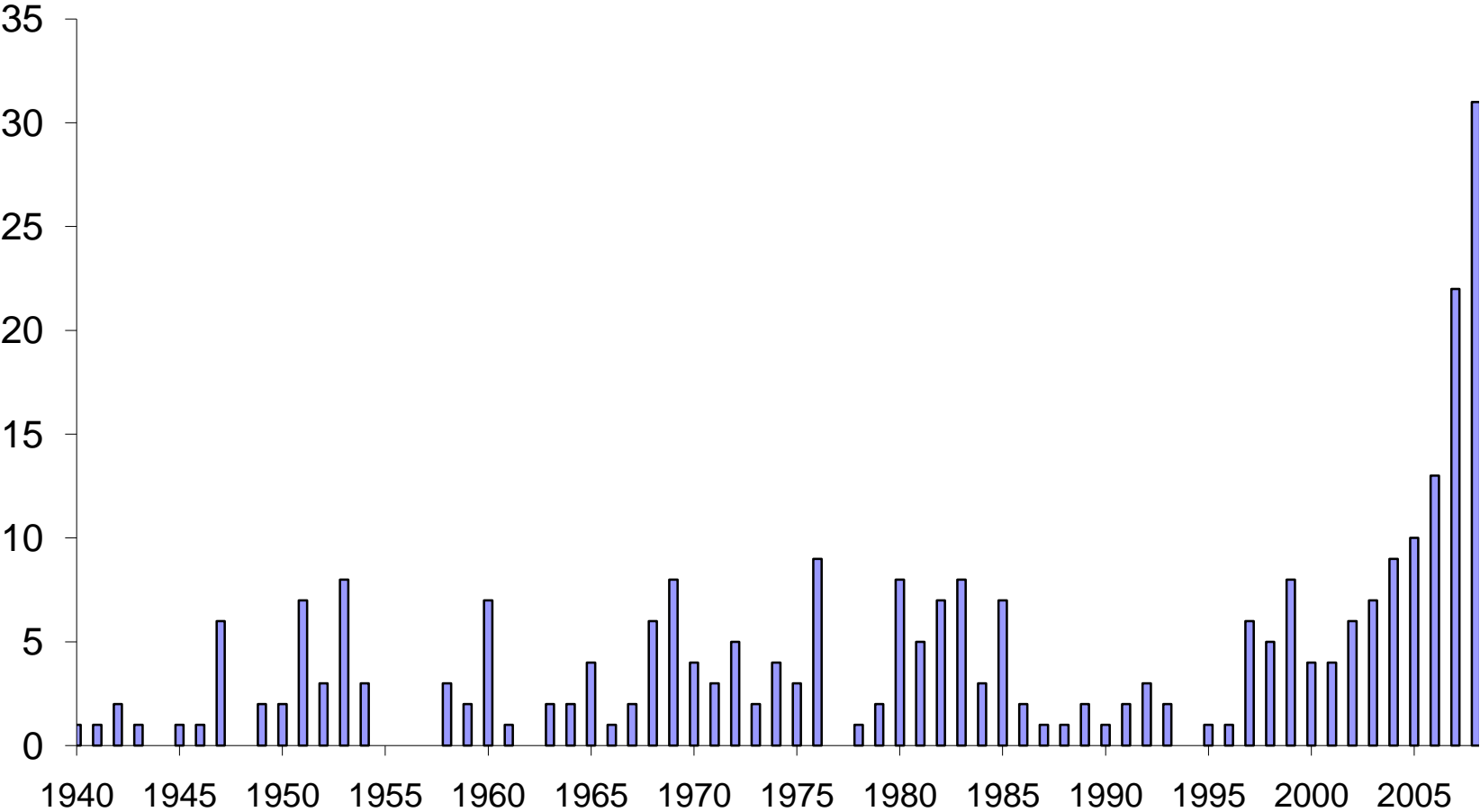
## 1995- date: Commercial Growth



# Drilling Activity in Iceland, 1940 – 2008

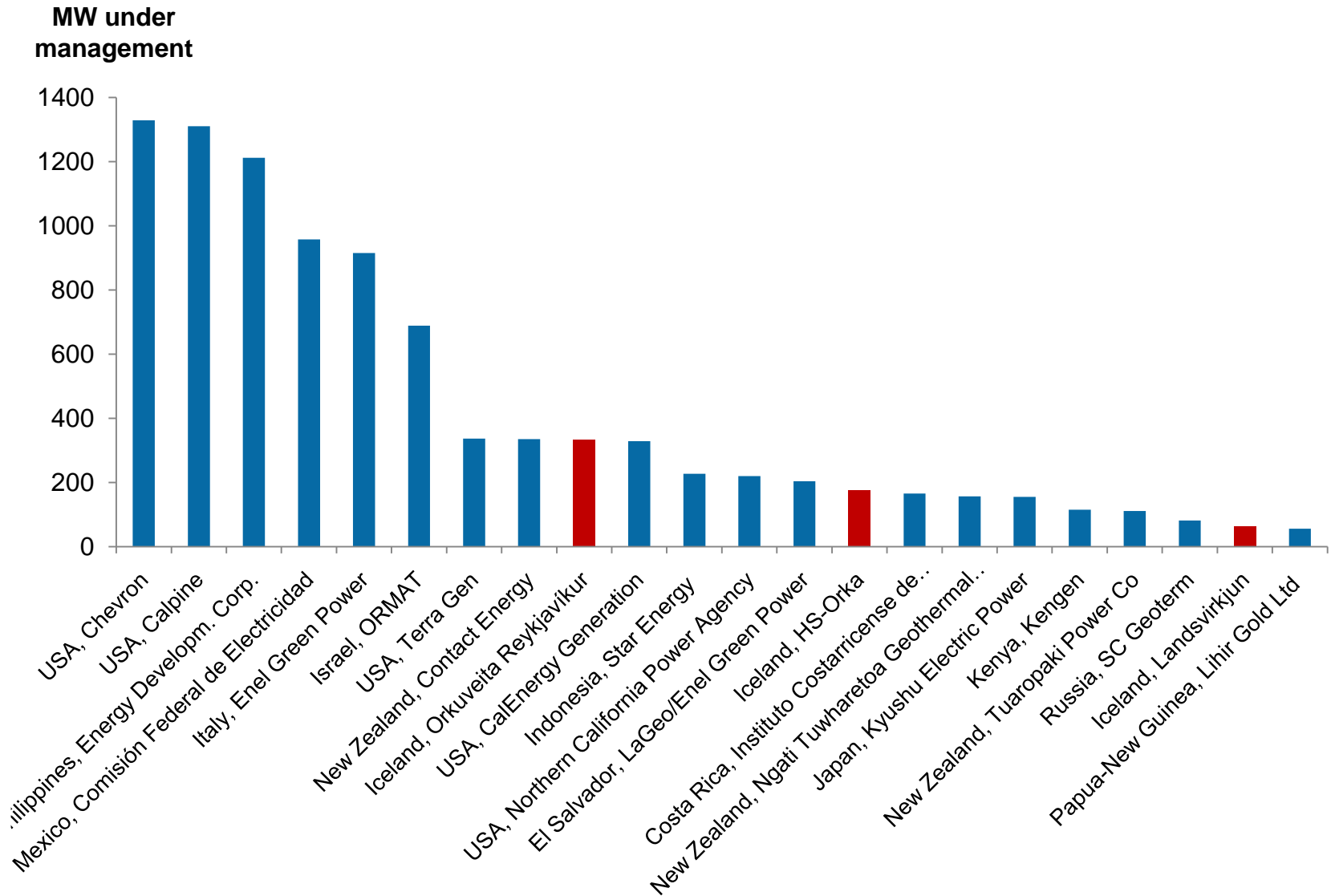
## High Temperature Fields

Number of Fields  
Drilled



Source: Natural Energy Authority of Iceland

# Leading Global Geothermal Plant Operators



# The Geothermal Market Opportunity

Rank	Country	2010 Installed Capacity (MW) <sup>1</sup>	2050 Projected Installed Capacity (MW) <sup>2</sup>	40-yr Market Opportunity (million) <sup>3</sup>	Annual Market Size (million/yr) <sup>4</sup>	Average Annual Market Size for Plant Cost Components <sup>5</sup>	
						Field Costs (million/yr)	Plant Capital Costs (million/yr)
1	United States	3,086	30,860	\$98,084	\$2,452	\$1,296	\$1,038
2	Philippines	1,904	19,040	\$60,516	\$1,513	\$800	\$641
3	Indonesia	1,197	11,970	\$38,045	\$951	\$503	\$403
4	Mexico	958	9,580	\$30,449	\$761	\$402	\$322
5	Italy	843	8,430	\$26,793	\$670	\$354	\$284
6	New Zealand	628	6,280	\$19,960	\$499	\$264	\$211
7	Iceland	575	5,750	\$18,276	\$457	\$241	\$193
8	Japan	536	5,360	\$17,036	\$426	\$225	\$180
9	El Salvador	204	2,040	\$6,484	\$162	\$86	\$69
10	Kenya	167	1,670	\$5,308	\$133	\$70	\$56
11	Costa Rica	166	1,660	\$5,276	\$132	\$70	\$56
12	Nicaragua	88	880	\$2,797	\$70	\$37	\$30
13	Russia	82	820	\$2,606	\$65	\$34	\$28
14	Turkey	82	820	\$2,606	\$65	\$34	\$28
15	Papua New Guinea	56	560	\$1,780	\$44	\$24	\$18.8
16	Guatemala	52	520	\$1,653	\$41	\$22	\$17.5
17	Portugal	29	290	\$922	\$23	\$12.2	\$9.8
18	China	24	240	\$763	\$19	\$10.1	\$8.1
19	France	16	160	\$509	\$13	\$6.7	\$5.4
20	Ethiopia	7.3	73	\$232	\$5.8	\$3.1	\$2.5
21	Germany	6.6	66	\$210	\$5.2	\$2.8	\$2.2
22	Austria	1.4	14	\$44	\$1.1	\$0.6	\$0.5
23	Australia	1.1	11	\$35	\$0.9	\$0.5	\$0.4
24	Thailand	0.3	3	\$10	\$0.2	\$0.1	\$0.1
		10,710	107,097	\$340,392	\$8,510	\$4,497	\$3,604

# Global Competition in Geothermal, 2010

## Main International Players



Human Energy



### Main technical consultants in the geothermal sector

Name	Country
SKM	Australia
Borealis Geopower	Canada
Technip	France
Geox geothermische energie	Germany
EFLA	Iceland
Mannvit	Iceland
Reykjavik Geothermal	Iceland
Verkís	Iceland
JFE Engineering Corporation	Japan
Global Synergy Link	Kenya
Allied Industrial Engineering	New Zealand
Beca	New Zealand
Mechanical Technology Limited	New Zealand
Geothermex	United States
Power Engineers	United States
ThermaSource	United States

### Main drilling companies in the geothermal sector

Name	Country
Perforadoras Santa Bárbara	El Salvador
H. Anger's Söhne Bohr- und Brunnenbaugesells	Germany
Iceland Drilling	Iceland
Constructora y Perforadora Latina (Coperlasa),	Mexico
Industrial Perforadora de Campeche (IPC)	Mexico
MB Century	Oman
Filtech Energy Drilling Corp	Philippines
Podzemburgaz	Russia
Geothermal Anywhere	Slovakia
DHS Drilling	United States
Potter Drilling	United States
ThermaSource	United States
Trinidad Drilling	United States
Schlumberger	USA, France, and Netherlands

# Findings

- Geothermal energy provides an **interesting global market opportunity**, with significant growth rates in coming years
- The Icelandic geothermal cluster has **considerable experience** and is **internationally well respected**

## HOWEVER

- In Iceland, the **economic crisis** and a **backlash** against further geothermal investments are affecting the outlook
- Abroad, emerging geothermal **cluster efforts** in the US and other countries are increasing rivalry; market growth could easily trigger **entry** from new rivals



- The stakeholders in the Icelandic geothermal cluster will need to develop a **concerted strategy and action agenda**, if it is to capitalize on its leading position and turn geothermal into a truly international opportunity