

Unlocking the Potential of Geothermal Energy: Strategic Implications for Iceland, Other Nations and the International Community

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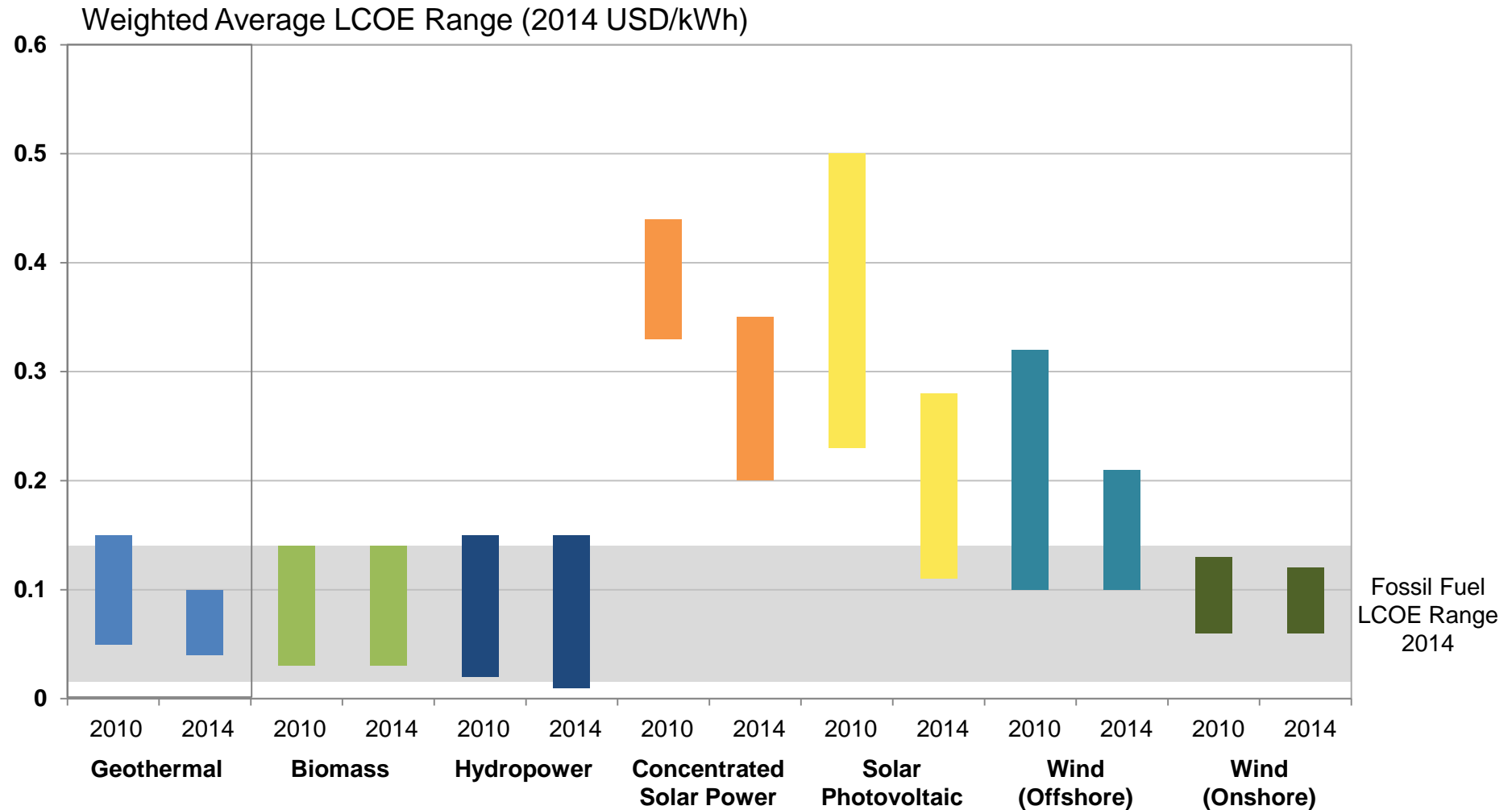
This presentation draws on ideas from Professor Porter's articles and books, in particular, The Competitive Advantage of Nations (The Free Press, 1990), "Building the Microeconomic Foundations of Competitiveness," in The Global Competitiveness Report (World Economic Forum), "Clusters and the New Competitive Agenda for Companies and Governments" in On Competition (Harvard Business School Press, 2008), "Clusters and the Great Recession" (Delgado-Porter-Stern, Working Paper 2014), "Defining Clusters of Related Industries" (Delgado-Porter-Stern, NBER 2014), "Clusters, Convergence, and Economic Performance" (Delgado-Porter-Stern, NBER 2012), "Cluster and Entrepreneurship" (Delgado-Porter-Stern, CES 2010), "The Economic Performance of Regions" (Regional Studies 2003), and ongoing related research. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means - electronic, mechanical, photocopying, recording, or otherwise - without the permission of Michael E. Porter. For further materials, see the website of the Institute for Strategy and Competitiveness (www.isc.hbs.edu).

The Potential of Geothermal

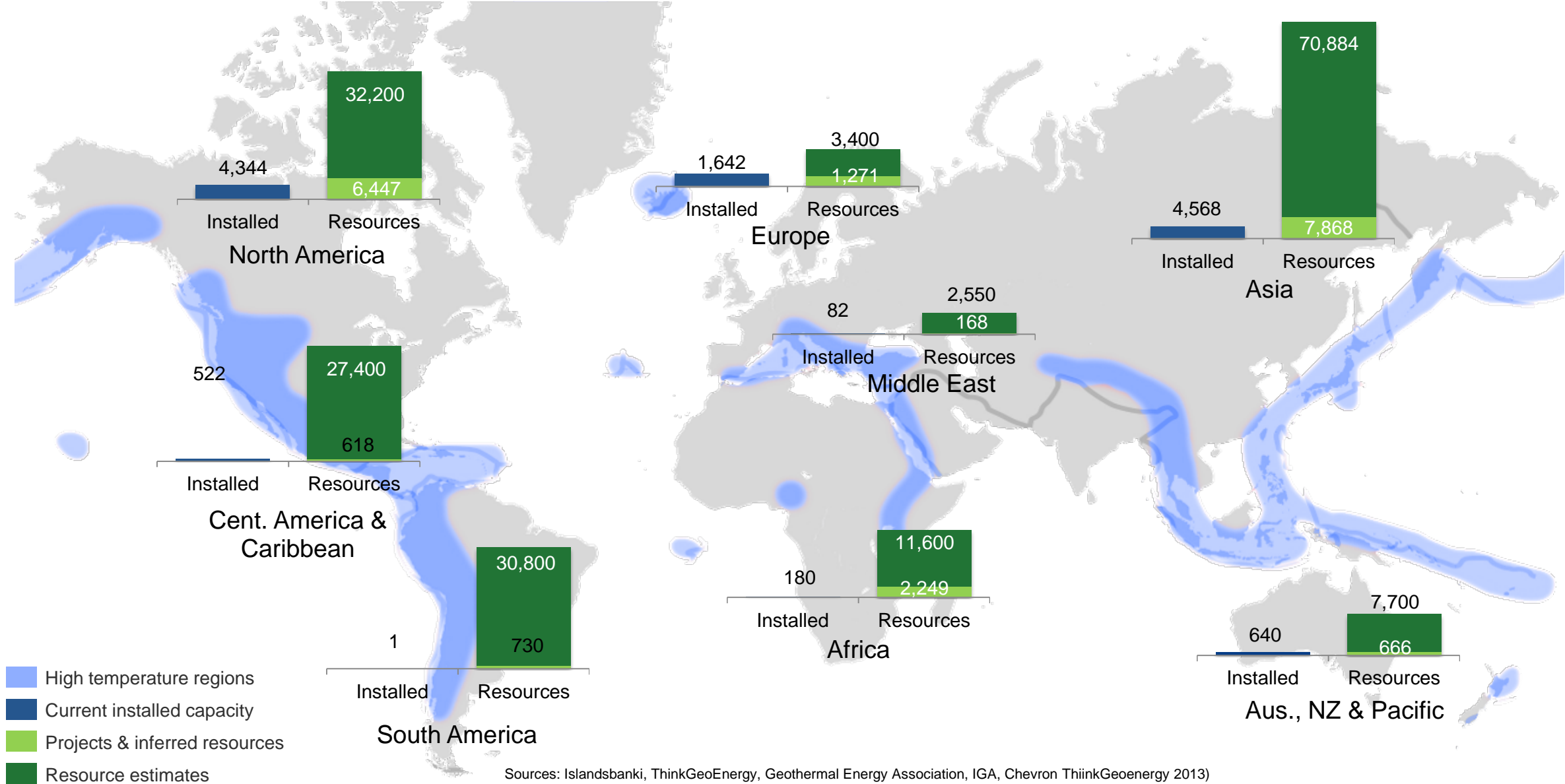
- Provides **clean, sustainable** energy
- Geothermal energy operates **24 x 7**
- Geothermal energy has unique advantages in **heating**
- Geothermal energy can be **exported** via energy intensive products
- Expands energy **self-reliance**
- Geothermal resources are available in **many locations** with significant unmet energy needs
- The potential for combining power generation and direct use together creates major **economic and societal benefits** for local communities and industries (e.g. food production, heating, other energy intensive activities)

Relative Cost Position of Clean Energy Sources

Levelized Cost of Electricity (LCOE), 2010 and 2014

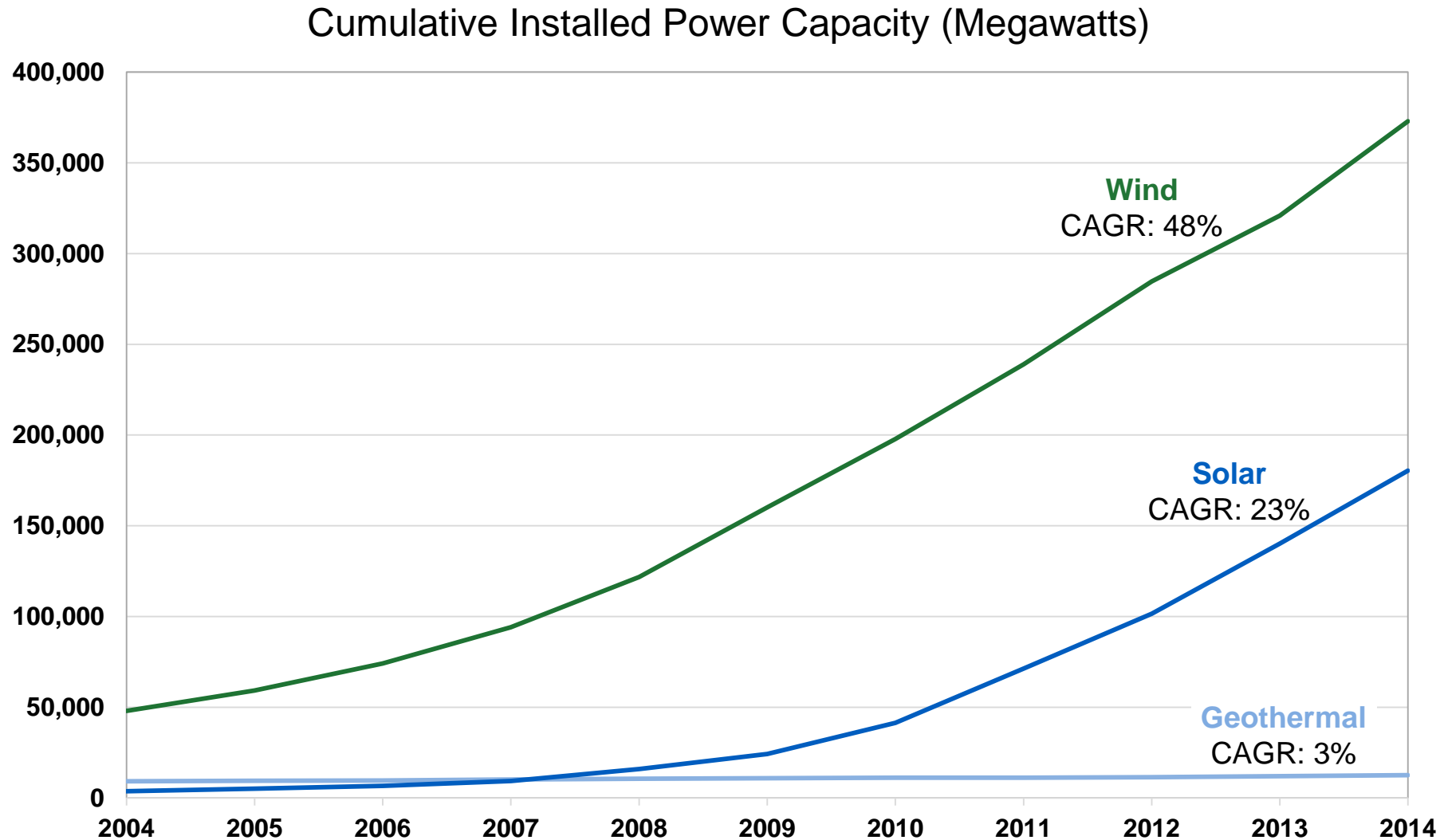


Geothermal Potential Globally



Sources: Islandsbanki, ThinkGeoEnergy, Geothermal Energy Association, IGA, Chevron ThinkGeoenergy 2013)
Note: Installed Capacity of 2010 (2012), resource estimates combined (1999-2012) – IGA estimates a conservative total potential of 70,000 MW and with technology improvements (extended use of low heat and EGS resources) at around 140,000 MW in power generation capacity.

Growth of Renewable Energy Sources



The Future of Geothermal

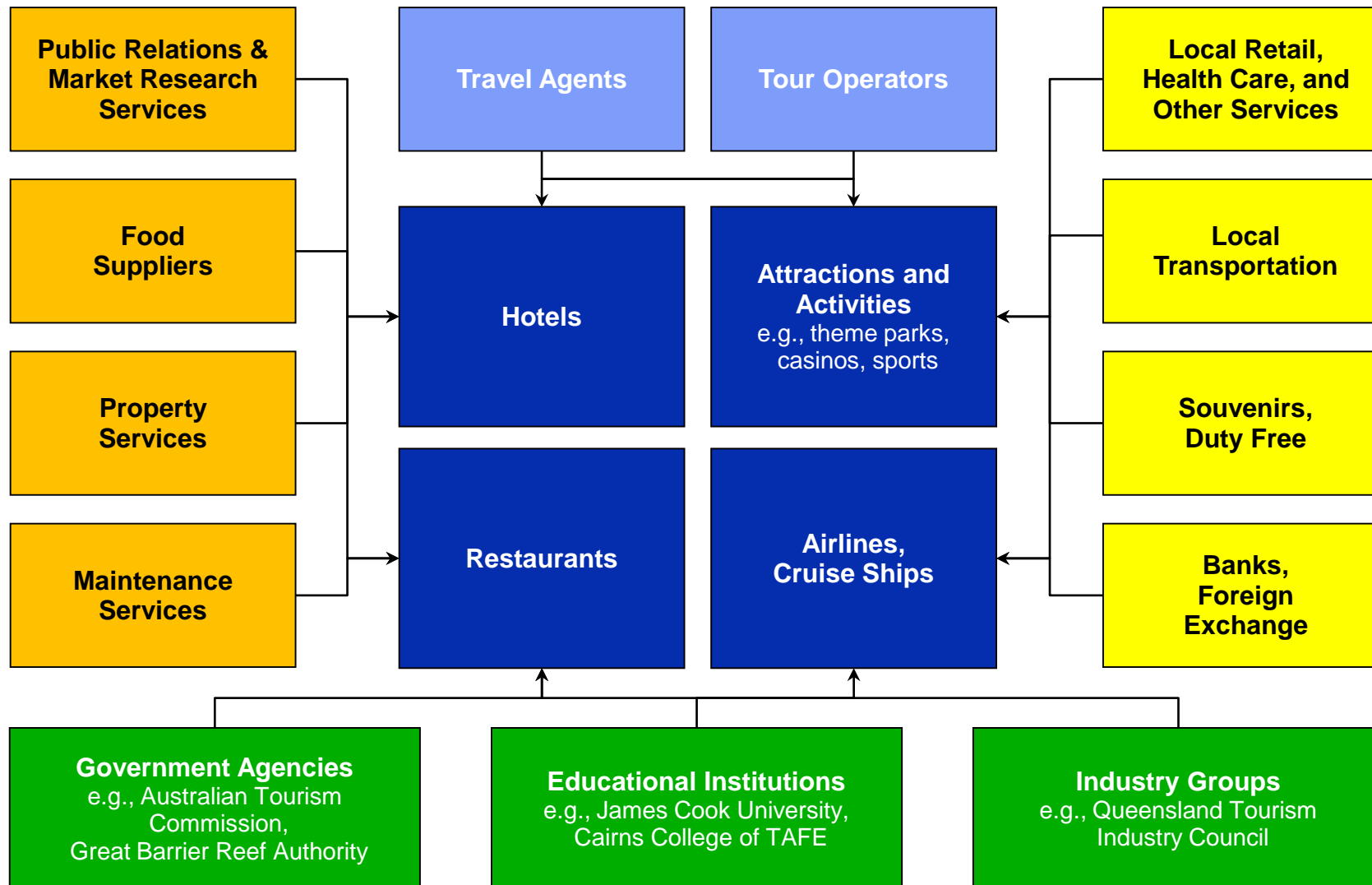
- Geothermal has significant **technical and economic advantages** relative to other renewable and even traditional sources of energy
- There is **up-front risk** in exploration and verification of the quality of the available resource
- **Public policy support** for renewable energy sources has been much stronger in wind and solar, despite their inferior economics



- How do the industry and governments around the world move ahead to capture the **economic and social benefits** of the resource?

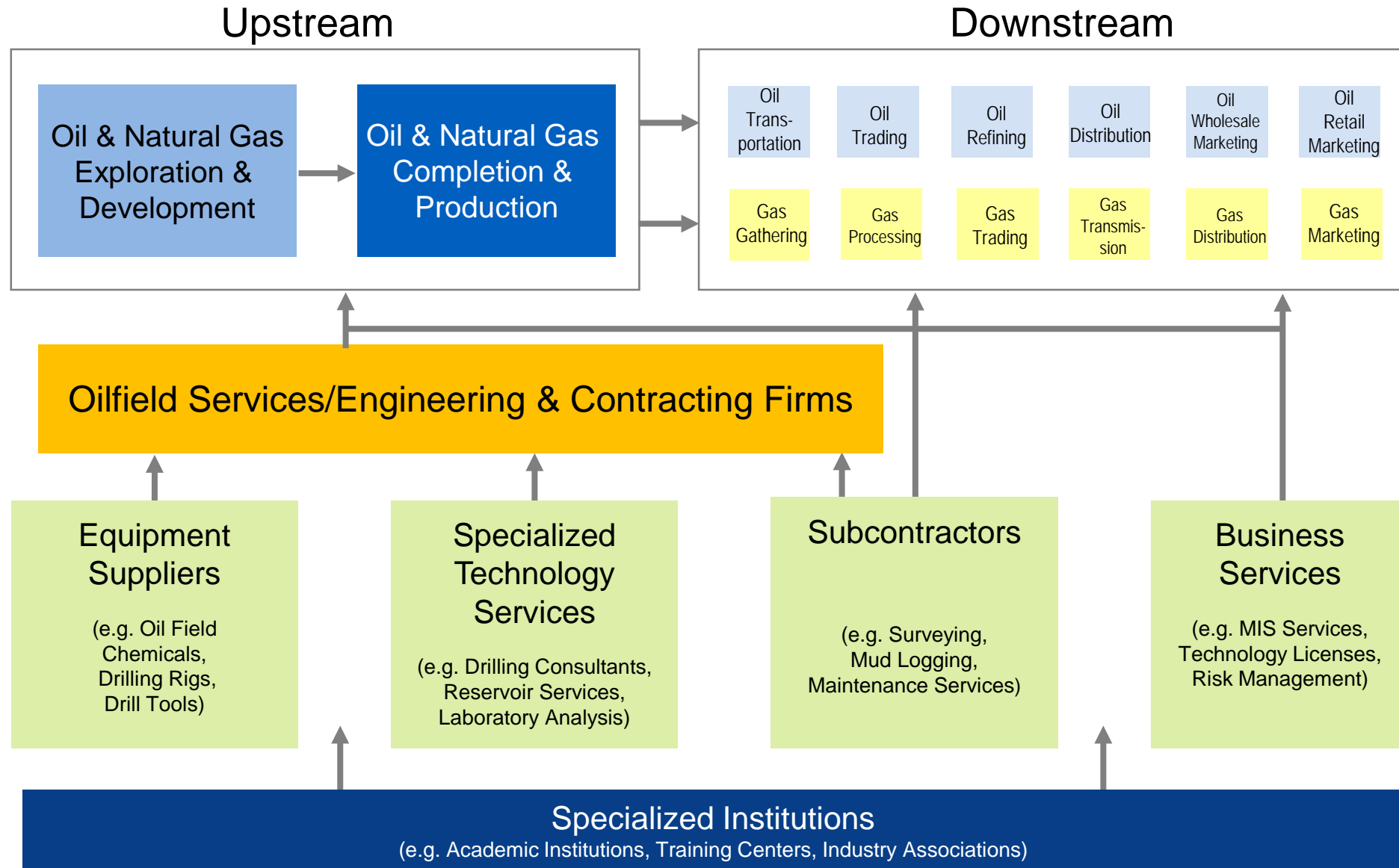
What is a Cluster?

The Cairns (Australia) Tourism Cluster



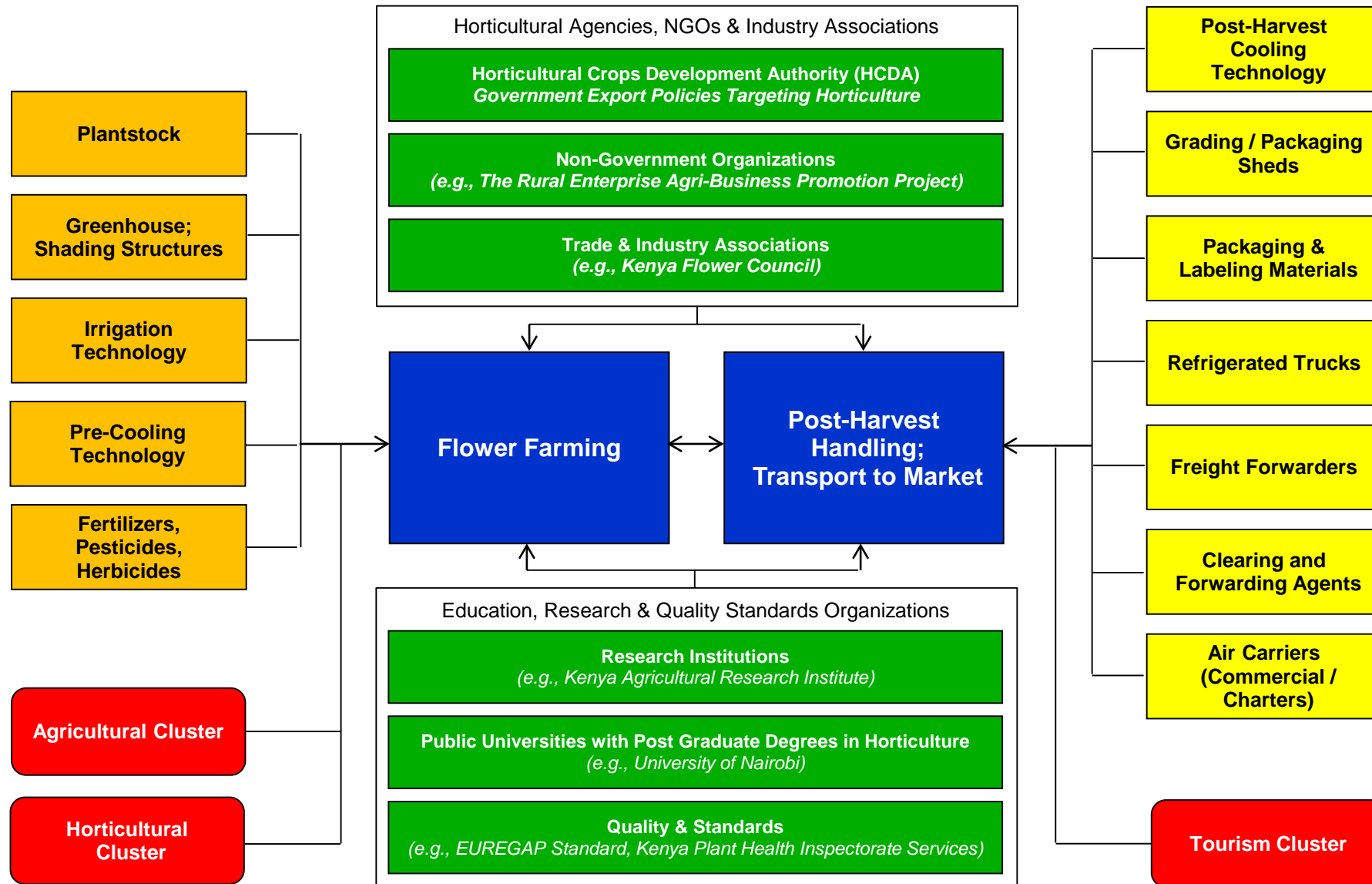
Mapping a Cluster

The Houston Oil and Gas Cluster



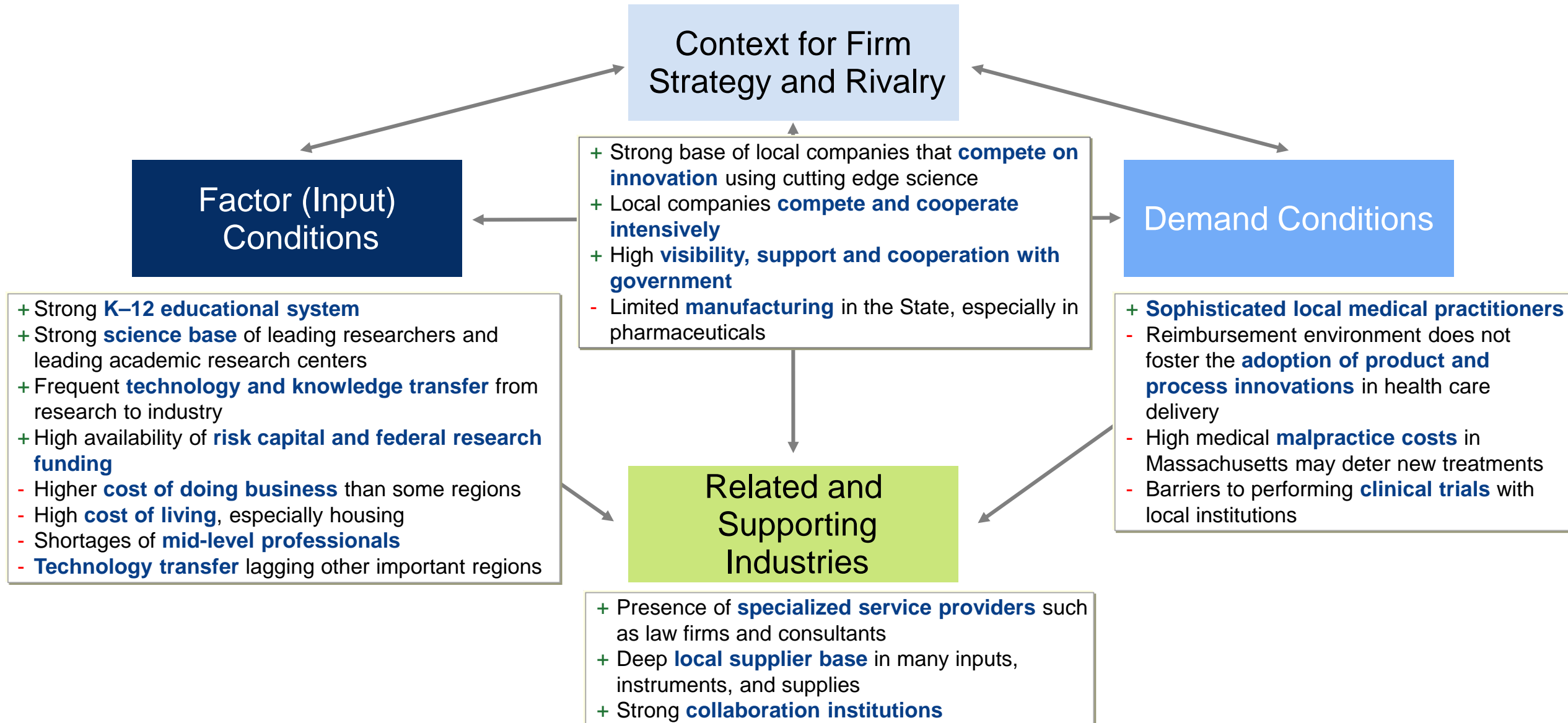
Clusters in Developing Countries

Cut Flower Cluster in Kenya



Assessing the Cluster Business Environment

Massachusetts Life Science



Why Clusters Matter?

- Clusters **increase productivity** and **operational efficiency**
- Clusters stimulate and enable **innovations**
- Clusters facilitate **commercialization** and **new business formation**



- **Growth** and **exporting** across border is accelerated by cluster development

Empirical Evidence on Clusters

- Presence of **strong clusters**
- **Breadth** of industries within a cluster
- Strength in **related clusters**
- Presence of a region's clusters in **neighboring regions**



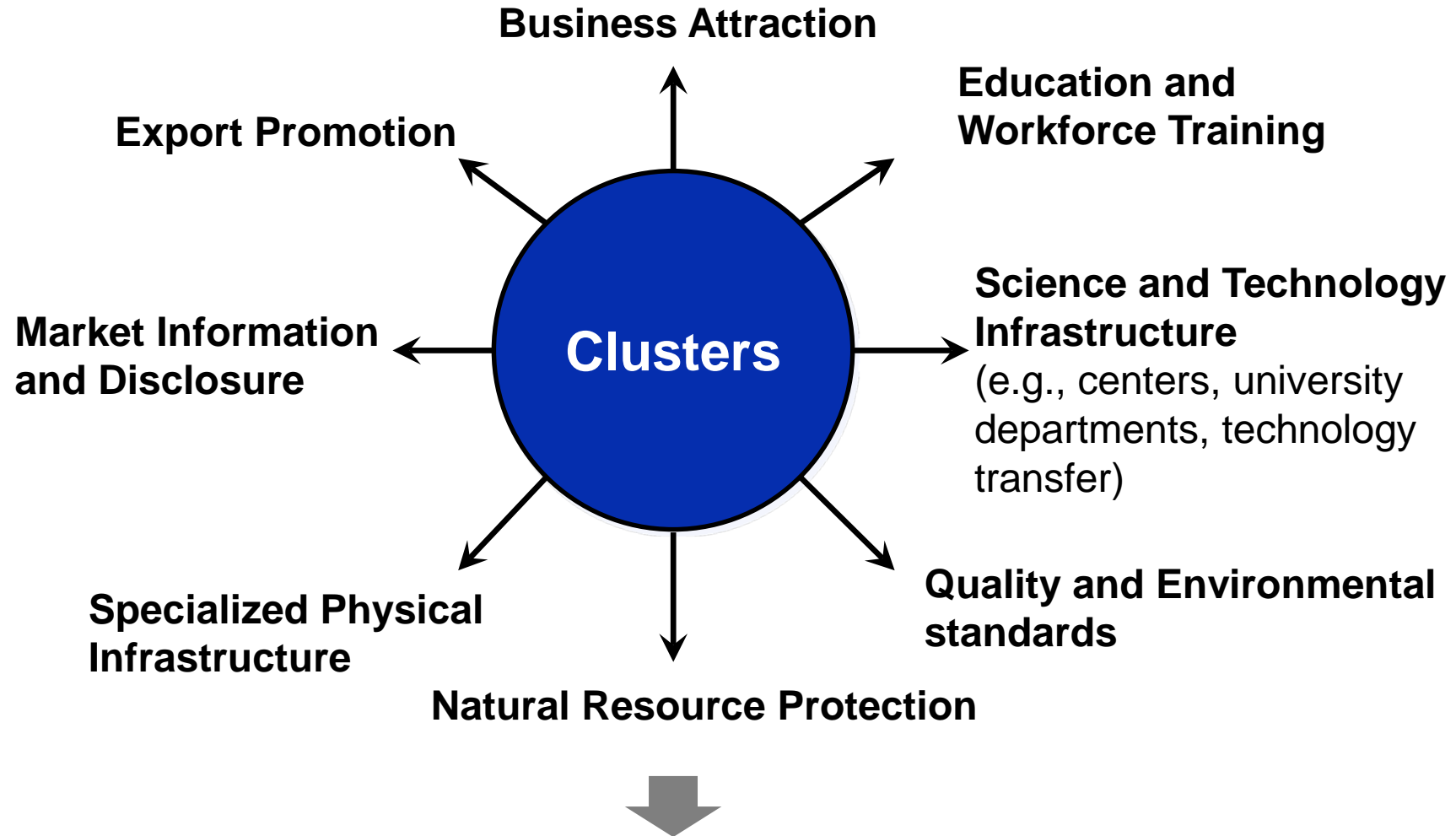
- **Job** growth
- Higher **wages**
- Higher **patenting** rates
- Greater **new business** formation, growth and survival
- **Resilience** in downturns

- Build on the region's **existing** and **emerging** clusters rather than chase hot fields
- Economic diversification occurs **within clusters** and **across related clusters**

Clusters as a Tool for Economic Policy

- Cluster upgrading fosters **greater** and **more sophisticated** competition rather than distorting the market
- **Leverages** the power of linkages across companies to drive rapid economic development
- Policies and investments strengthen **multiple related firms/institutions** simultaneously
- A forum for **collaboration** between the private sector, trade associations, government, educational, and research institutions
- Enhances the effectiveness of **traditional economic policy** areas, such as training, R&D, export promotion, FDI attraction, etc.

Organize Public Policy Around Clusters



- Clusters provide a framework for **organizing the implementation** of many public policies and public investments directed at economic development

Iceland's Role in Geothermal Energy

Top 10 Geothermal Energy Countries

Global Geothermal Electric Capacity (GW_e)

Country	2010	2014	% of total Electric Cap	Increase (%)
1 Iceland	0.6	0.7	25.0%	17%
2 Kenya	0.2	0.5	17.0%	150%
3 Philippines	2	1.9	10.6%	-5%
4 New Zealand	0.7	1	9.8%	43%
5 Indonesia	1.2	1.4	2.7%	17%
6 Mexico	1	0.8	1.3%	-20%
7 Turkey	0.1	0.5	0.9%	400%
8 Italy	0.7	0.8	0.7%	14%
9 USA	2.4	2.6	0.2%	8%
10 Japan	0.5	0.5	0.2%	0%
World Total	10	11.5	0.2%	15%

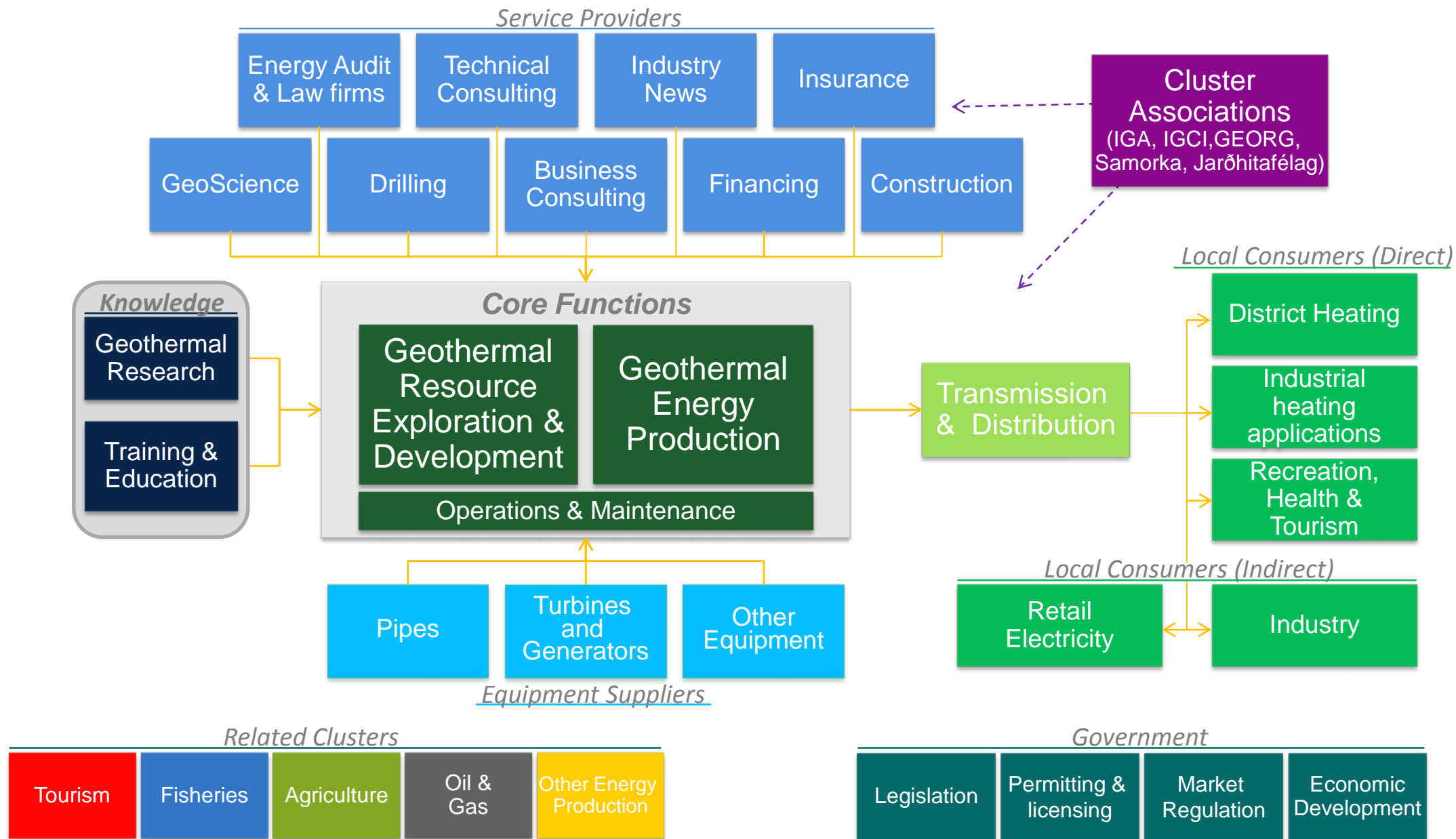
Global Geothermal Direct Use Capacity (GW_t)

Country	2010	2015	W _t Per Capita	Increase (%)
1 Iceland	1.8	2	6667	42%
2 Sweden	4.5	5.6	566	96%
3 Finland	1	1.6	291	26%
4 Switzerland	1.1	1.7	207	38%
5 United States	8.9	17.4	54	15%
6 Turkey	2.1	2.9	38	74%
7 France	1.3	2.3	36	4%
8 Germany	2.5	2.8	34	12%
9 Japan	2.1	2.2	17	63%
10 China	12.6	17.9	13	57%
Total	37.9	56.5	7923	49%

ICELANDIC PARTICIPATION IN GEOTHERMAL PROJECTS:



The Icelandic Geothermal Cluster



Strong Factor Conditions

Geothermal Skill and Research Base in Iceland

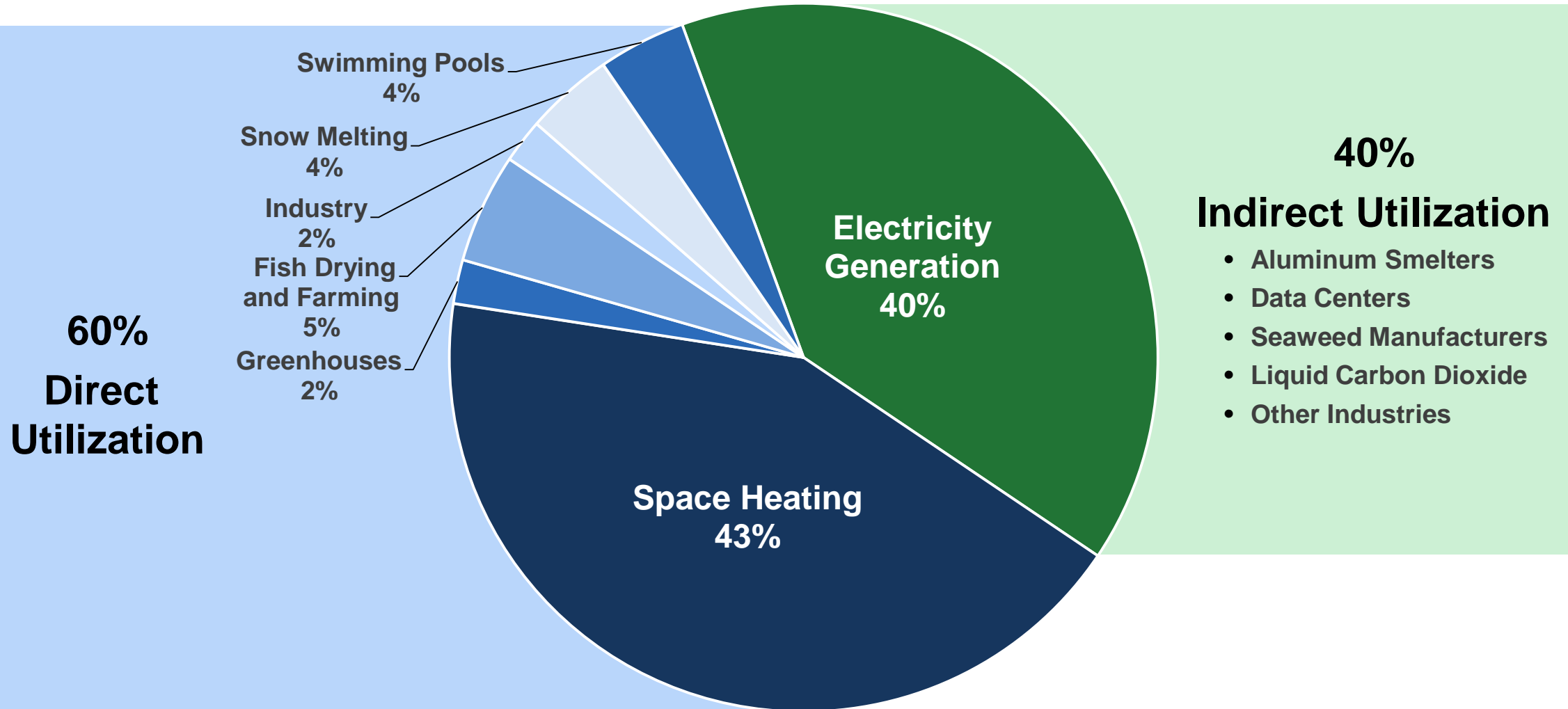


- International leader in geothermal energy **research**
- Six month postgraduate training program aimed to improve the **capacity building** of developing countries in geothermal exploration and development
- Offers graduate and professional development **courses** in geothermal studies



Sophisticated Local Demand

Icelandic Geothermal Energy Use by Application, 2013



Leading Geothermal Companies in Iceland

Major International Players Operating in Iceland



Leading Technical Consultants

SKM	Australia
Borealis Geopower	Canada
Technip	France
Geox Geothermische Energie	Germany
EFLA	Iceland
Mannvit	Iceland
Reykjavik Geothermal	Iceland
Verlos	Iceland
JFE Engineering Corporation	Japan
Global Synergy Link	Kenya

Leading Drilling Companies

Perforadoras Santa Barbara	El Salvador
H. Anger's Sohne	Germany
Iceland Drilling	Iceland
Constructora y Perforadora Latina	Mexico
Industrial Perforadora de Campeche	Mexico
MB Century	Oman
Filtech Energy Drilling Corp.	Philippines
Podzemburgaz	Russia
Geothermal Anywhere	Slovakia
DHS Drilling	United States

Members of the Iceland Geothermal Cluster Initiative

Service Providers



Knowledge



Core Operation



Distribution



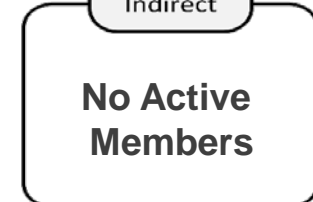
Direct



Equipment Suppliers and Maintenance



Indirect



Association



Support



Government



Development of Iceland Geothermal Cluster



Recent Activities of the Cluster Initiative

Policy Influence

- Worked with the Icelandic government and DG Energy (EU) on energy efficiency and renewable energy topics
- Represented Iceland at COP21 talks on district heating
- Initiative to increase geothermal technology patenting in Iceland starting in 2016

Export Promotion

- Signed an agreement with GEODEEP in France to create a framework of standardized model licenses for exploring and developing geothermal energy resources

Skills & Company Development

- Executive seminars for foreign business executives
- Start-up Energy business accelerator

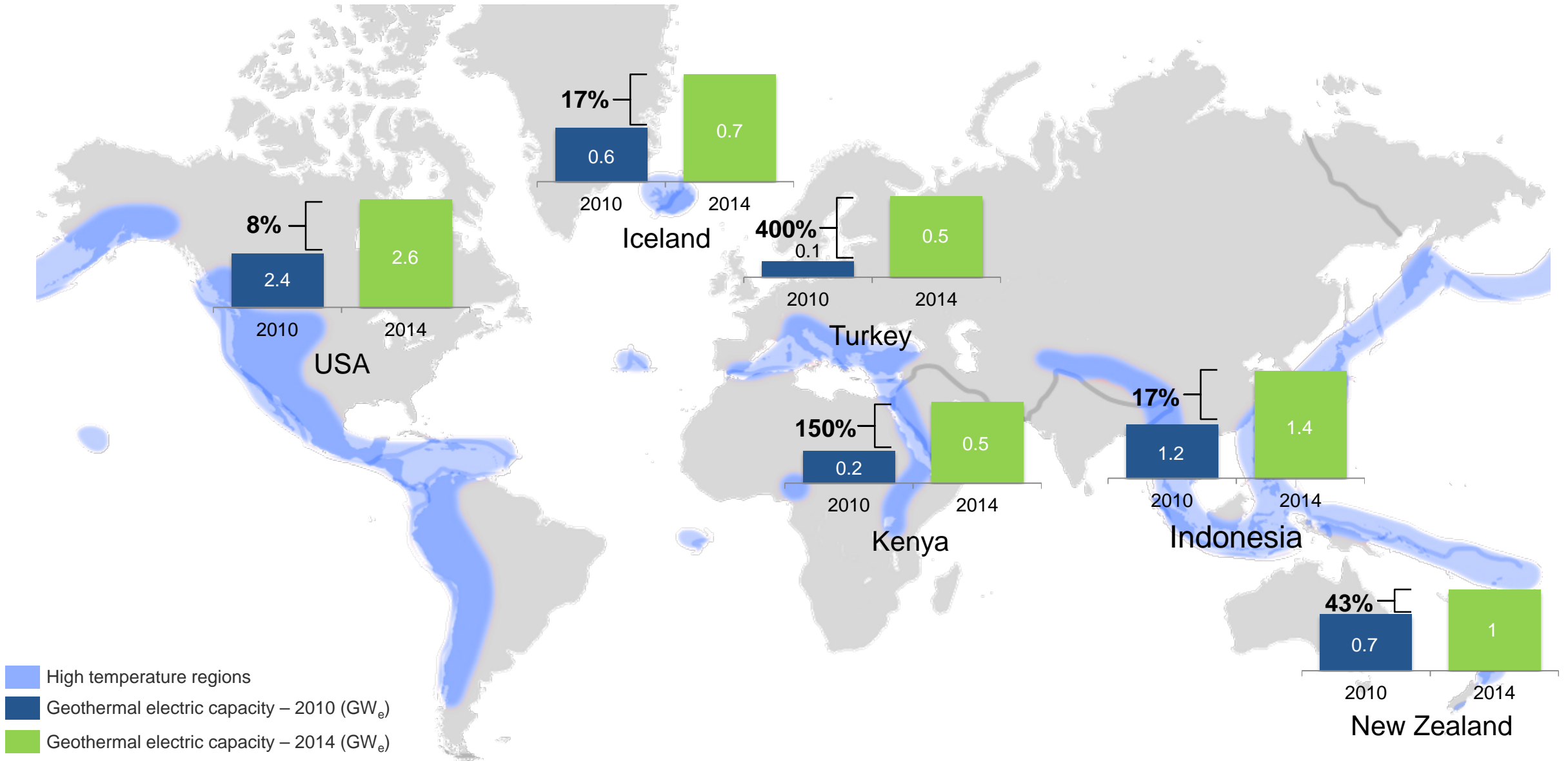
Network and Partnerships

- Promoting the concept of resource parks domestically (Northeast of Iceland) and abroad (Nicaragua)
- Cooperating with the tourism cluster initiative

Action Agenda for the Iceland Geothermal Cluster

- Fully engage **government** and **research institutions** in the cluster effort
- Connect **research priorities** in academic institutions with the needs of companies in the cluster
- Put stronger focus on **patents** as way to capture economic value of research findings
- Encourage direct **collaboration between companies and research institutions**
- Step up direct **collaboration between companies**
- Move beyond exporting discrete services to **full solutions**
- Enhance **collaboration between companies** in approaching foreign markets
- Package Iceland projects for **replication internationally**
- Develop **financing mechanisms** for geothermal projects abroad, including strong relationships with international development institution
- Create an overall strategy for **marketing the geothermal opportunity globally**

Global Emerging Geothermal Clusters



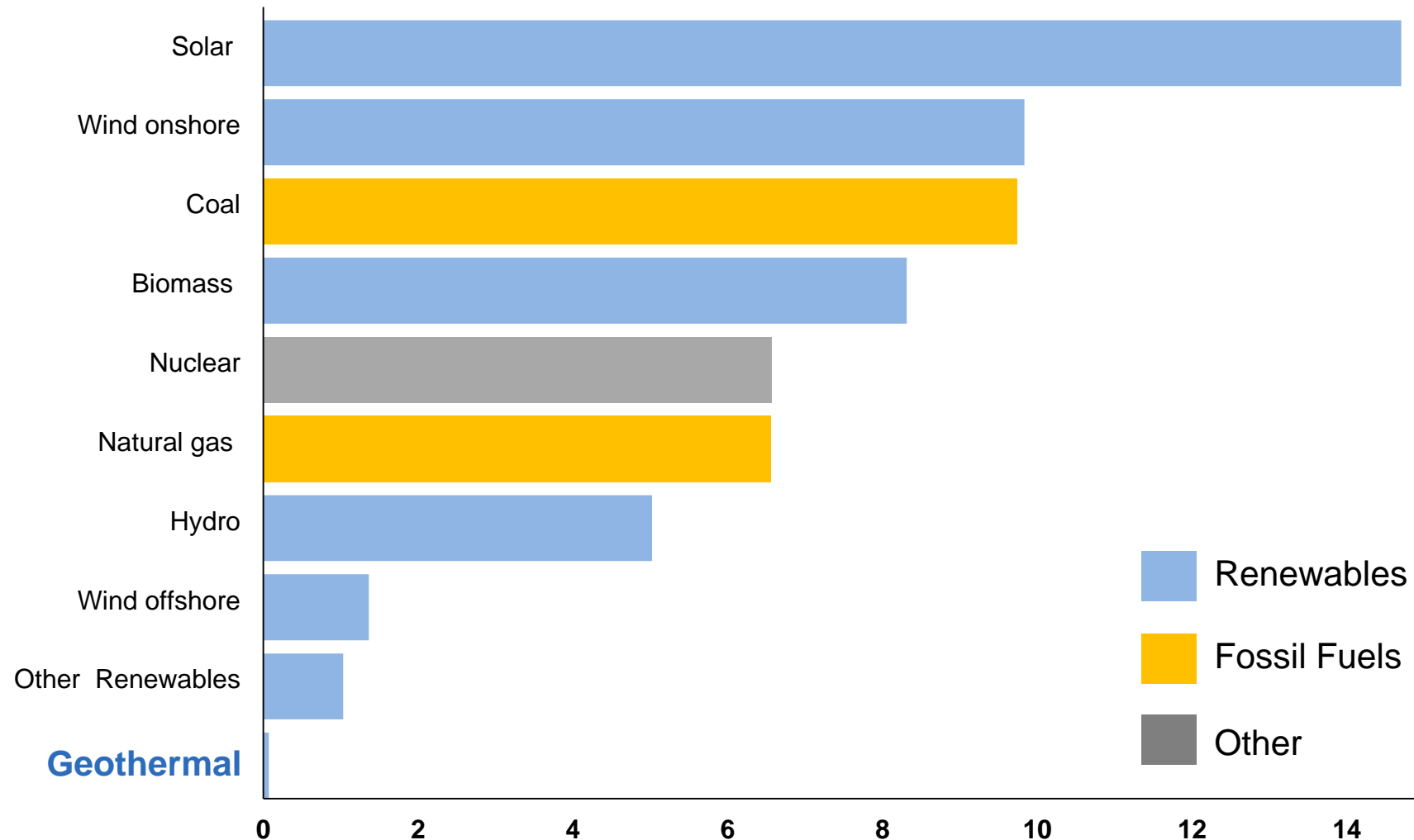
The Global Agenda

- Visibility

Policy Support by Energy Source

European Union, 2012

Total support provided in the 28 Member States (in billion €2012), including EU level support



The Global Agenda

- Visibility
- Financing
 - Financing structures must be better developed, reducing reliance on limited public sector funding sources

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- Direct utilization
 - Systematic integration of direct use to enhance project economics
 - New kinds of government and private sector participants

Benefits of Direct Utilization

- Cascading use of geothermal energy, combining power generation with direct utilization, provides **increased efficiency** and **improved economics**
 - Only 10% net efficiency is achieved when generating electricity alone
 - Waste heat from the electricity generation process can be **recovered for direct use**
- Adding a secondary use, such as a greenhouse to a small (\$1m/year) geothermal plant can **decrease payback period from 6 years to 2 years**
- However, cascading use **requires significant coordination** among actors



Direct Utilization in Indonesia



- In West Java, Indonesia, the local government has **passed legislation** mandating the **simultaneous development** of direct use, along with electricity generation and defined a direct-use **development roadmap**
- One project adapted a geothermal electricity generation plant to **support mushroom cultivation**, enabling growth of the local agriculture
- The program **expanded the mushroom growing capacity** to 25,000 bag-logs per month

The Global Agenda

- Visibility
- Financing
 - Financing structures must be better developed, reducing reliance on limited public sector funding sources
- Direct utilization
 - Systematic integration of direct use to enhance project economics
 - New kinds of government private sector participants
- Industry standards
- Cluster development
 - Fragmented groups of small companies must organize in cluster efforts to be able to offer integrated solutions and effectively engage government

Cluster Collaboration Across Countries

