The Iceland Geothermal Cluster Initiative is an industry based cooperative group focusing on the field of geothermal energy in Iceland. The role of the Iceland Geothermal Cluster Initiative is to promote Iceland’s unique geothermal energy utilization, and to label it as the land of geothermal energy and geothermal utilization.

The purpose of this organization is to stimulate competitiveness within the Icelandic Geothermal Cluster, create value, new opportunities and improve the utilization of Iceland’s geothermal energy sector. The possibility for improvement is endless. The cluster initiative focus on opportunities related to: research programs, scientific studies, exportation programs, construction, innovation, and the associated services provided during various project stages.

The Iceland Geothermal Cluster Initiative promotes the services and expertise of its member. It also organizes domestic and international events, promotes innovative programs, plans and leads field trips, hosts seminars and bringing professionals together. In turn the Cluster has created a new platform for its members to share and market their skills. The prospects for growth for the Icelandic geothermal sector have never been greater.

The Iceland Geothermal Cluster Initiative’s Board met and has agreed to emphasize three main binding topics to meet its mandate, which include: Communication, Knowledge and Innovation.

I sincerely thank the Board Members for their fruitful cooperation, which has been both professional and a great pleasure to be involved with.

Sincerely,

Albert Albertsson
Chairman of the board
The Iceland Geothermal Cluster Initiative; Origin and Development

Iceland Geothermal (IG) is a non-profit organisation that was established in February 2013. IG is an industry-driven cluster cooperation partnership which focuses on the field of geothermal energy. The Iceland Geothermal Cluster Initiative was founded by 43 diverse members, including; companies, associations and institutions.

The main role of the Iceland Geothermal Cluster Initiative is to promote Iceland “As the land of geothermal energy and geothermal utilization”. In Iceland 70% of primary energy consumption is from geothermal energy, and 100% of primary energy in the country is renewable.

The purpose of the organization is to stimulate competitiveness within the Icelandic Geothermal Cluster, add value, and improve the utilization of Iceland’s geothermal energy.

The main goals are to create new opportunities within the geothermal energy sector, facilitate cooperation with the aim of exporting services and building new partnerships, create a strong global geothermal value chain to enhance geothermal utilization worldwide. Provide benefits to the sector as well as to developing countries and protecting and valuing the environment.

The Cluster’s cooperation is based on ten defined cooperative focus areas all of which aim to strengthen the infrastructure of the Icelandic geothermal cluster, figure 1. These focus areas resulted from a special workshop that was held amongst the cluster members in May, 2011.

Who are our members?

Iceland Geothermal represents the geothermal sector in Iceland and has on average more than 50 members that together manage the geothermal resources of the country. Some of our members are active players in the development and utilization of geothermal energy outside of Iceland, as Icelandic companies are actively taking part in geothermal project all around the globe.

For more information about Iceland Geothermal Cluster, or its members please visit: www.icelandgeothermal.is
In 2013 the Board of Directors made the decision to form a strategic vision for the Iceland Geothermal Cluster Initiative.

At a general meeting in December, 2013 the Chairman presented the Board’s key strategic elements.

Mission
The mission of the Iceland Geothermal Cluster Initiative is to be a platform that provides value to both the society of Iceland and the business community, from the unique geothermal resources that the country has.

Vision
In 2019 the Iceland Geothermal Cluster Initiative will be an internationally recognised organization promoting innovation, education and business development within the geothermal energy field, as well as supporting Icelandic companies in becoming leaders in providing services to the global value chain of geothermal energy.

Objectives
The guiding objectives of the Iceland Geothermal Cluster Initiative will be to increasing innovation and development through collaboration and cooperation, by focusing on three main strategic objectives as outlined below.

INNOVATION
Increase value by supporting research, development, innovation and new ideas.
Support Cluster members trying to participate in overseas projects
To initiate the start-up of projects support and innovation.
Act as a bridge builder between researchers and the business environment to increase value creation and competitiveness within the industry

KNOWLEDGE
Increase education within the field of renewable energy at all levels of the educational system in Iceland.
Continuing to support leading edge research –and the cooperation with GEORG.
Host conferences, workshops, seminars for all levels of the geothermal value chain including Exploration, Realization and Utilisation.
Advocate on behalf of the geothermal industry on the world wide scale and continue to grow its massive international network.

COMMUNICATION
Aim to be the gateway for a “one stop shop” for both governmental and business interests from abroad.
Create a “brand” for Icelandic geothermal services and industry expertise.
Create a platform for a nationwide geothermal phenomenon.
Cooperate with geothermal clusters and initiatives in other countries.
Cooperate with related clusters in Iceland i.e. tourism, health care, maritime and others.
Development of the Icelandic Geothermal Cluster

The time axis of Figure 2 gives a rough overview of the history of geothermal energy in Iceland since 1930. The lower part of the axis shows the development of geothermal power plants. The period 1930-1995 can best be described as a time of build-up of the geothermal energy systems in Iceland, including the founding of the first utilities companies, the completion of the first power plants, the establishment of distribution systems, etc.

The years from 1995 to the present can be characterized by the development of the commercial geothermal energy utilization environment. This can be seen, for example, by mergers as well as the commercialization and privatization of various companies and institutions during this period. At the same time, there were some changes in the regulatory environment of the Icelandic energy market. These diverse usages, knowledge and experiences have culminated in the formation of the Icelandic Geothermal Cluster Initiative.

Foundations: 1930-1994


Renewable Energy in Iceland

The solution to the threat of climate change can be found by utilizing locally sourced clean, renewable and environmentally sound sources of energy.

Why is Iceland one of the world’s greatest potential sources of renewable energy? Located just south of the Arctic Circle, Iceland is located on both a hotspot and the mid Atlantic Ridge, which runs right through it. These combined geological conditions means that the island is extremely volcanically active with an eruption occurring on average every five years.

Despite its fiery nature, about one tenth of Iceland’s landmass is covered by glaciers, from whose icecaps flow many powerful rivers, providing the nation with a wealth of hydropower.
Clusters and Cluster Cooperation

A cluster can be defined as a geographically group of companies and associated institutions in a particular field, linked by commonalities and complementarities. Clusters are not created, but rather emerge from where there are already a sufficient number of firms competing among themselves and a competitive advantage can be achieved through collaboration.

In order to enhance the business environment and infrastructure of a cluster further, a cluster cooperation can be founded, which involves bringing together various actors within the relevant cluster, such as manufacturers, suppliers, service providers, distributors, researchers, educational institutions, financial institutions, associations, the government and government agencies. Cooperation between the different cluster members can result in strengthened knowledge acquisition within the cluster in addition to the pooling of understanding, skills, insights and techniques in different areas.

At the same time, the cluster needs the presence of an active competition, which is the driving force and prerequisite for to improving their workplace and increasing their productivity, thereby enhancing their competitive advantage. This shows that by the formation and development of a cluster, a certain whole is created which is much stronger than the individual entities.

Iceland Geothermal Cluster Initiative

| November 1st 2010 | Island Geothermal Conference 2010 Dr. Porter and Dr. Koteab presented the results of the cluster mapping. |
| May 4th 2011 | Geothermal cluster workshop Cooperation projects defined. |
| June 28th 2011 | Iceland Geothermal cluster initiative, a project-based cluster cooperation, established. |
| February 15th 2013 | A legal entity for the Iceland Geothermal cluster initiative established. |
| March 5-8th 2013 | Iceland Geothermal Conference 2013 An international conference on geothermal, hosted by the Iceland Geothermal initiative. |
| January 14th 2014 | Startup Energy Reykjavik launched for the first time. |
| October 3rd 2014 | Iceland Geothermal selected to host WGCC2010 |

2010 2011 2012 2013 2014

Figure 3. Development major milestones of Iceland Geothermal Cluster.

Harnessing Natural Resources

During the course of the 20th century, Iceland went from what was one of Europe’s poorest countries, dependent upon peat and imported coal for its energy use, to a country with a very high standard of living where practically all electricity and household heating is derived from renewable resources.

Geothermal energy has played an important role in the lives of Icelanders since ancient times, as is reflected in the large number of place names that are derive from it. Most prominently, this involves the capital Reykjavík (“The Bay of Smokes”), which it is said to have received its name from the steam (smoke) that Ingolfur Arnarson, the first settler in Iceland, saw rising from hot springs as he approached the shore.

For a long time after, the geothermally heated water was mainly useful for washing and bathing. However, by far the biggest progress in the utilization of geothermal heat in Iceland has only occurred in the last century. The first use of geothermal heat in Icelandic greenhouses started at the beginning of the 20th century; at about the same time people started to use geothermal heat for space heating and swimming pools. The oil crises in the 1970s accelerated the further development of geothermal utilization for space heating in the country. At that time, the Icelandic government put an emphasis on reducing oil imports and pushing further geothermal research and the development of geothermal heating utilities.

Geothermal heat is also used for the production of electricity. The first geothermal power plant was built in 1969; today there are seven plants. Their installed capacity in 2011 was 663 MWe; in that year 40% of geothermal utilization in Iceland was for electricity production. This resource has furthermore been used for snow melting on sidewalks and pathways, in aquaculture, in greenhouse cultivation, for industrial drying and manufacture of skin care products and for salt and methanol production to name a few.

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1 The National Energy Authority (2012).
Geothermal energy in Iceland

Located between the North Atlantic and Arctic oceans, Iceland was created on one of Earth’s major fault lines, the Mid-Atlantic Ridge. Iceland has a population of 320,000 people with a land area of 103,000 sq. km. Iceland is a relatively young country geologically speaking, and remains both volcanically and geologically active. Iceland has used geothermal energy since the early parts of the 20th century. The country’s geological peculiarities have endowed Iceland with an abundant supply of both geothermal resources and hydropower potential.

The Mid-Atlantic Ridge marks the boundary between the North American and Eurasian tectonic plates. The two plates are part of a divergent tectonic plate boundary and are moving apart at an average rate of about 2.5 cm per year. Iceland is located on an anomalous part of the Mid-Atlantic Ridge where deep mantle material have welled up and have created a hot spot of unusually abundant volcanic activity. This makes Iceland one of the few places on Earth where an active spreading ridge can be seen above sea level.

As a result of its location, Iceland is one of the most tectonically active places on earth, resulting in a large number of volcanoes and hot springs. Earthquakes are frequent, but rarely cause serious damage. More than 200 volcanoes are located within the active volcanic zone stretching through the country from the southwest to the northeast, and at least 30 of them have erupted since the country was settled.

The source of the usable geothermal heat comes from precipitation that has seeped into the ground and has come into contact with the hot bedrock below the Earth’s service. While some of this water returns to the surface as hot springs or geysers, most remains trapped underground, from where it is extracted using technology similar to that used to obtain oil or fresh water. Within Iceland’s volcanic zone there are at least 20 high-temperature areas containing steam fields with underground temperatures reaching 250°C within 1,000 m depth of surface. These areas are directly linked to the active volcanic systems. About 250 separate low-temperature areas, with temperatures not exceeding 150°C at a depth of 1,000 m below surface, are found mostly in the areas flanking the active volcanic zone. To date, over 600 hot springs (temperature over 20°C) have been located on the island.

Nowhere else does geothermal energy play a greater role in a Nation’s energy supply than it does in Iceland. Iceland’s energy use per capita is among the highest in the world, which is partly due to this clean, affordable and available energy resource. The proportion of total energy consumption provided by renewable energy sources in Iceland exceeds most other countries within the world.

Figure 4: Geothermal fields in Iceland (The National Energy Authority).
For centuries Icelanders have utilized geothermal heat to make the cold island a better place to live. The early settlers used the geothermal waters for bathing and washing and quite a few priests received a Saints status after blessing a hot pool that later proved to have healing powers.

With the introduction of new piping material by the early part of the 20th century, the District Heating Revolution started. Iceland is the global pioneer in using geothermal energy for space heating. Currently, over 90% of Iceland’s homes are connected to the geothermal district heating systems. According to a national survey, Iceland’s total economic benefit from geothermal power was calculated to be about $480-830 million, which equalled four to six percent of the country’s gross domestic product in 2010.

While the first attempts at drilling for hot water in Iceland were made in the mid 18th century, it was not until 1930 that a primary school in the capital of Reykjavik became the first building directly connected to the district heating system and used geothermally heated water. Expansions to the district heating system made it possible for normal households, hospitals, schools and businesses to be connected to a hot water supply from hot springs. Soon swimming pools were built around the country to improve swimming skills of fishermen. The 1973 oil crisis served as the impetus for Iceland’s full-fledged development of a geothermal energy system, including electricity generation.

Today, almost 90% of Iceland’s houses and buildings are heated by natural hot water. Geothermal power facilities currently generate 25% of the electricity (4.038 GWh of total 16.467 GWh) utilized in Iceland, and the official energy forecast projects a 50% increase in the use of geothermal energy by 2030.

Electrical power has been produced by geothermal energy in Iceland since the 1960’s. However, the Power Revolution did not really start until the mid 1990’s. This revolution was led by better estimates of the quality of geothermal resources available, as well as the efficiency and effectiveness of the geothermal drilling equipment, and the right balance of local and imported skills. As a result electricity production with geothermal energy in Iceland is as competitive as the alternative, hydropower generation. The addition of geothermal energy availability to hydropower availability has supported and allowed for the development of energy intensive industries in Iceland. For example Iceland is one of the biggest producer of smelted aluminium in Europe.

The geothermal industry in Iceland continues to develop to meet the needs and demands for the future. Although geothermal is generally considered a clean source of energy, there is still room for improvement by; reducing the volume of geothermal gasses released to the atmosphere, minimizing footprint sizes, limiting visibility impact and avoiding risks of earthquakes to mention a few. Perhaps the greatest challenge of all is to improve the energy efficiency of the utilization. Iceland is on the brink of the third revolution, the Environmental Impact Revolution.
Primary energy consumption in Iceland

The approximate installed capacity of geothermal direct heating applications in Iceland is 1,900 MWth. The breakdown of the utilization is given in the table. Space heating is by far the most important direct utilization sector in the country, composing 90% of all space heating needs within the country. The share of space heating is about 73% of the total direct energy use and 47% of the total geothermal energy utilized (including electricity generation).

Generating electricity with geothermal energy has increased significantly in recent years. Geothermal power facilities currently generate 30% of the country’s total electricity production with hydropower generating the remaining 70%. The share of geothermal energy in the nation’s primary energy supply was 66% in 2012, higher than in any other country in the world.

In recent decades, the share of primary energy consumption from geothermal energy in Iceland has grown substantially at the expense of oil with it currently supplying 69.2%. of the nation’s primary energy. The various types of energy generation in Iceland from 1940-2008 are shown in figure 5. It should be noted that the relatively high percentage of geothermal energy generation as a proportion of total energy generation is unique in the world.

The development of primary energy consumption in Iceland

![Image of energy consumption graph]

Figure 5: Net primary energy use in Iceland 1940-2010 (The National Energy Authority).

### Geothermal Energy Utilization

<table>
<thead>
<tr>
<th>Installed power [MW]</th>
<th>Energy Consumption TJ/year</th>
<th>GWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space heating</td>
<td>1500</td>
<td>18638</td>
</tr>
<tr>
<td>Snow melting</td>
<td>125</td>
<td>796</td>
</tr>
<tr>
<td>Fish farming</td>
<td>75</td>
<td>1576</td>
</tr>
<tr>
<td>Swimming pools</td>
<td>80</td>
<td>673</td>
</tr>
<tr>
<td>Industry</td>
<td>75</td>
<td>1826</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>45</td>
<td>1768</td>
</tr>
<tr>
<td><strong>Direct uses total</strong></td>
<td><strong>1900</strong></td>
<td><strong>25277</strong></td>
</tr>
<tr>
<td>Electricity generation</td>
<td>660</td>
<td>16923</td>
</tr>
<tr>
<td><strong>Geothermal utilization total</strong></td>
<td><strong>2560</strong></td>
<td><strong>42200</strong></td>
</tr>
</tbody>
</table>

Table 1: Geothermal Energy Utilization (The National Energy Authority).
The Resource Park of HS Orka at the Reykjanes Peninsula is comprised of a diverse group of high tech companies which utilize the effluent streams from the CHP (Combined Heat and Power) geothermal power plants. The Blue Lagoon was the first company in the Resource Park and is in a way the paradigm of the Park and the concept it is based upon. The Resource Park was originally structured around the Svartsengi CHP geothermal Power Plant. The first phase of the plant was inaugurated in 1976 to delivering hot potable water for district heating from the peninsula.

Today at Svartsengi the geothermal CHP power plant feeds 4 Resource Park companies: the Blue Lagoon, Hotel Northern Light Inn, Carbon Recycling International’s renewable methanol plant and ORF Genetic’s molecular farming plants. The sea water cooled 100 MWe CHP geothermal power plant at Reykjanes feeds 3 Resource Park companies: two state of the art fish drying facilities Háteigur and Haustak and Stolt Sea Farm Iceland a sophisticated fish farm breeding sole Benegalensis. The feedstock the Resource Park companies get from the CHP geothermal power plants are: steam, brine, condensate, geothermal gas, ground water, potable hot water, pure lava filtered sea water and power.

The number of employees of the Resource Park companies is somewhere between 500 and 600. Most of the sophisticated products of the companies are exported and their value count for around 2% of the national GNP.

The core of the “Resource Park” ideologies put forth by Mr. Albertsson focuses on six topics:

- Integrated usages of a variety of subjective and objective resources of different nature.
- The Resource Park is to equally accentuate ecological balance, economic prosperity and social progress, doing so it fully supports the sustainable development in society as defined by the Brundtland commission.
- Interdisciplinary cooperation of different entities.
- The Resource Park is to bridge different technical and social cultures.
- Read the Nature–holistic approach to the project – be in the nature.
- The inherent time scale of the Resource Park activities spans centuries.
The visionary behind the concept

In 1977 Mr. Albert Albertsson began working for Hitaveita Suðurnesja, predecessor of HS Orka, as the chief engineer and until end of 2014 as deputy CEO. From the beginning Mr. Albertsson was interested in the philosophy on zero waste and soon became an advocate for the vision of a comprehensive “Resource Park” Concept. With persistence and resourcefulness he has helped transform the resource park from an idea to reality.

Today Mr. Albertsson main task is development of the resource park and in 2015 he took over the newly created position of “Visionary” at HS Orka. This is a fitting title for the pathfinder and visionary of the Resource Park concept.

Icelandic Companies Involved in Geothermal Projects in Other Countries

Iceland is a leading country in the utilization and development of geothermal resources. The Icelandic holistic approach of utilization of geothermal resources is unique in the world. Geothermal energy is not only used for electricity generation, but also in various direct and indirect applications, leading to secondary businesses like household space heating, aquatic farming, methanol production and health related productions, to mention only a few. Icelandic companies and organizations work globally on a number of diverse projects within the various fields of geothermal energy utilization. Up to twenty Icelandic companies are currently working on geothermal projects within 70 different countries. The figure below shows where some Icelandic companies are working worldwide.

Figure 7. Icelandic Companies Involved in Geothermal Projects in Other Countries
The Iceland Geothermal Conference (IGC) is a result of the Iceland Geothermal Cluster Initiative, and started in October, 2009. After mapping the geothermal cluster in Iceland in collaboration with the Icelandic consultancy Gekon, Professor Michael Porter and his team at Harvard Business School recommended an optimal path to take to strengthen the infrastructure within the geothermal sector in Iceland. IGC takes place in Reykjavik, Iceland during spring time every third or second year. The first conference took place in Háskólabíó, on November 1st, 2010, when Professor Michael Porter announced his results of the mapping phase of the indicative.

Testimonials:

“It was a unique experience to meet all the right people that work for the various aspects of geothermal business and technologies. Occasional hard snow storm welcomed us, revealing the power of geothermal heating systems in Reykjavik.”

Dr. Kasumi Yasukawa, National Institute of Advanced Industrial Science and Technology, Japan.

“Iceland Geothermal Conference 2013 is the best organized conference I have attended in Iceland”

Mr. Hoskuldur Olafsson, CEO of Arion Bank, Iceland.

The second conference, IGC 2013, was held in March, 2013, were 600 participants, delegates, and exhibitors attended the conference to discuss changes and forward thinking ideas within the geothermal industry. 57 presentations were given by global figureheads within the geothermal industry. There were more than 40 nationalities that presented at the conference.

The third and upcoming IGC 2016 will take place April 26th - 29th, 2016. The overall theme of the Iceland Geothermal Conference 2013 was to share effective exploration methods, and lessons learned in order to maximize the utilization of geothermal energy development. The conference topics address the different phases of geothermal projects, i.e. exploration, feasibility of geothermal projects, operation and maintenance, and finally multiple purpose for geothermal resources.

The host location of the Iceland Geothermal Conference, with its proximity to geothermal areas, ease of access to Icelandic geothermal experts and hand selected speakers from all around the world ensured that the quality and content of this conference was first-class. Further information regarding the IGC and updated conference information can be found on its events web page at: www.geothermalconference.is
“Coming together is a beginning, staying together is progress, working together is success.”

Henry Ford (1863-1947)