The Icelandic Geothermal Cluster

Mapping and Mobilization

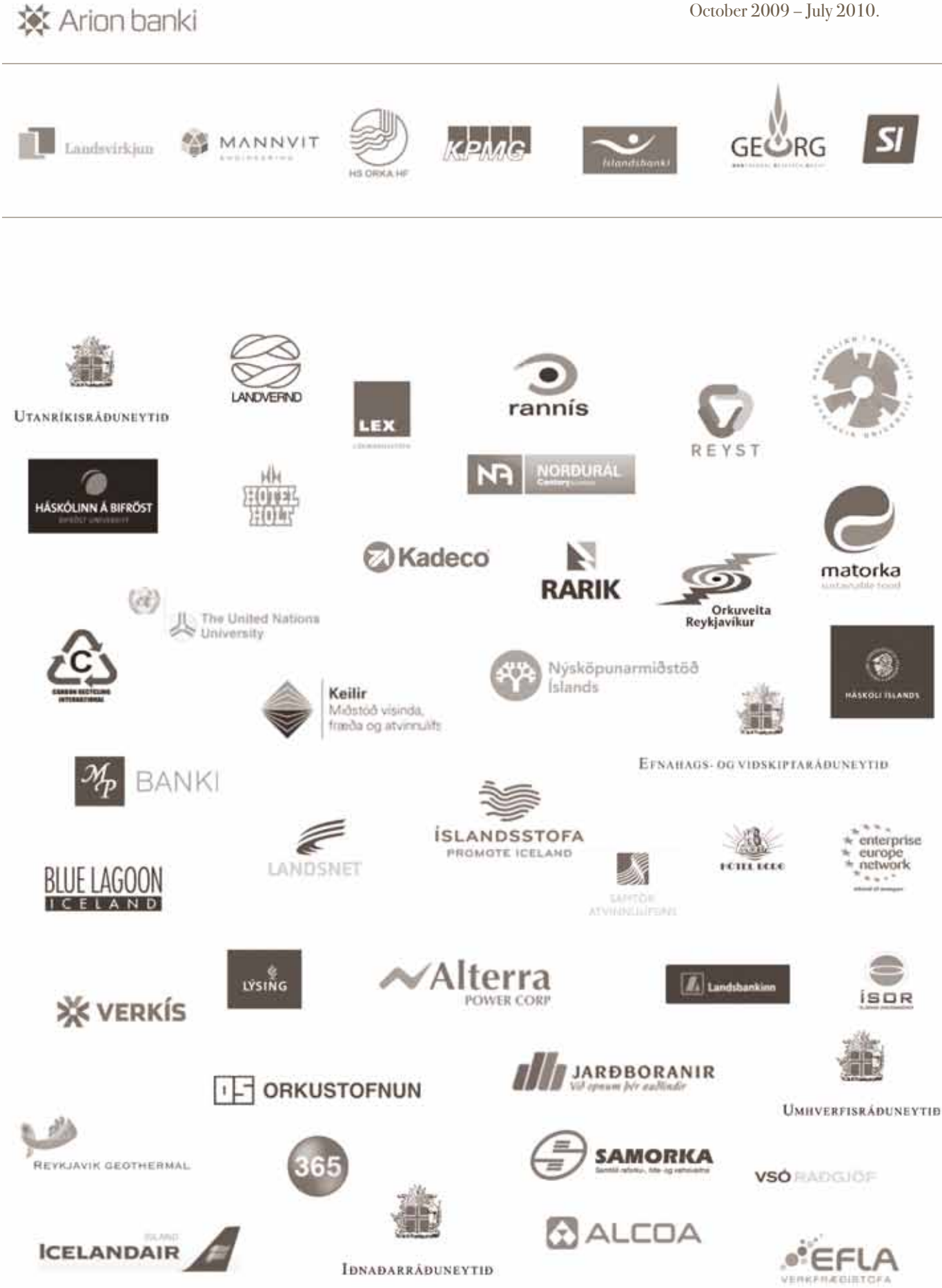
Foreword by Prof. Michael E. Porter and Dr. Christian Ketels

June 2011

Arion banki

GEKON

Participants in the development of formal cooperation within the Icelandic geothermal cluster from October 2009 – July 2010.



“Coming together is a beginning,
staying together is progress,
working together is success.”

Henry Ford (1863-1947)

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The Icelandic Geothermal Cluster; Mapping and Mobilization

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First edition, June 2011
Reykjavik, Iceland

Photographer: Thorsten Henn
Layout: Bjarni Helgason, Arion banki hf.
Print: Prentsmiðjan Oddi ehf.

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Foreword

Prof. Michael E. Porter and
Dr. Christian Ketels

Two and a half years ago the Icelandic banking system collapsed, dragging the country's economy from the heights of overheating to the lows of a deep recession. The economy has in the meantime stabilized at a lower level, and the government has gotten its budget balance so much under control that it is expected to return to the global financial markets later this year.

But stabilization is necessary and not sufficient. Iceland needs to lay the foundations for a new, more sustainable economic growth path. In February 2009, we published an article in the Icelandic press that set out an action agenda for the country. One of its key elements was cluster mobilization as a critical step to build on Iceland's unique assets and capabilities. We stressed that Iceland had to move beyond a backward looking debate about who was to blame for the crisis to a forward-looking collaboration to improve competitiveness. Clusters are a powerful vehicle to mobilize the private sector and guide the policy choices of government.

The Icelandic geothermal cluster program puts this vision into practice. It builds on Iceland's unique assets and capabilities in geothermal energy with a clear focus on creating greater value for the Icelandic economy, rather than simply selling power. The geothermal program is grounded in the realization that progress towards this goal will only materialize through collaboration.

The first phase of the geothermal cluster program, what the authors of this report call the profile phase, ended in November last year. We were proud to be involved in this research, and are encouraged by the activities that it triggered. Geothermal energy provides many interesting opportunities over the next several decades, and Iceland is well placed to capture a significant share. Success is by no means certain or automatic, but will depend on a clear plan for action.

Over the last few months, the geothermal cluster has entered a new phase of mobilizing for action. Leaders from the clusters, especially from the companies that develop and market geothermal energy and the technology needed to generate it, have met regularly to create a platform for collaboration. This process has resulted in the launch of Iceland Geothermal as a platform for joint action of the cluster. This report presents a broad action agenda for this new institution.

Today marks the beginning of a new phase in the development of the Icelandic geothermal energy cluster. Much work lies ahead, but future opportunities are encouraging for the cluster and ultimately Iceland's overall economy if it can pursue the agenda now set out. We wish Iceland Geothermal success on this path.

Prof. Michael E. Porter,
Bishop William Lawrence University Professor, Harvard Business School

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

Acknowledgements

This report deals with the development of cooperation within the Icelandic geothermal cluster. The idea for the project came from Dr. Michael Porter, professor at Harvard Business School, after his visit to Iceland in June 2009.

Subsequently Hákon Gunnarsson, CEO and founder of the consulting company Gekon, approached Dr. Porter for his participation in the mapping of the Icelandic geothermal cluster. In October of that year, Professor Porter and his principle associate from the Institute for strategy and competitiveness at Harvard Business School, Dr. Christian Ketels, agreed to participate.

Gekon wishes to express heartfelt gratitude to Dr. Michael Porter and Dr. Christian Ketels for their valuable contribution to the project and good cooperation. If something has been misrepresented it is wholly the authors' responsibility.

The President of Iceland, Ólafur Ragnar Grímsson, has supported the project since its inception and was patron of the conference Iceland Geothermal 2010 held on 1 November 2010. For this, we kindly thank him.

Gekon also wants to thank Emiliano Duch, the founder and president of Competitiveness, for sharing his great knowledge and experience with such an inspiration.

Moreover, the invaluable assistance and work of Rósbjörg Jónsdóttir, our colleague at Gekon, has been crucial. Many others have made vital contributions. These include Elvar Knútur Valsson, Einar Pálmi Árnason, and Þorsteinn J. Vilhjálmsson, all of whom have proved to be extremely valuable supporters.

Arion banki, KPMG, HS Orka, Landsvirkjun, Mannvit, Íslandsbanki, Federation of Icelandic Industries and GEORG also receive special thanks for a good support, enthusiasm and work on the progress of the project.

All other participants and benefactors of the project on the development of cooperation within the Icelandic geothermal cluster deserve a strong gratitude. Without their courage and faith in the Icelandic geothermal cluster, little success would have been achieved.

The actual test and the benefit, however, lies in the cluster cooperation itself and it will be interesting to observe its further progress.

We look forward to continued cooperation with the Icelandic geothermal cluster and wish it all the best in the future.

Reykjavík, 14 June 2011
Hákon Gunnarsson, Gekon
Þóra Margrét Þorgeirsdóttir, Gekon

Abstract

The term cluster is defined as a geographically group of companies and associated institutions in a particular field, linked by commonalities and complementarities. In a cluster there is a system of interconnected firms and institution whose value as a whole is greater than the sum of its part.[1] The cluster policy has been part of the structure of the Icelandic economy for two decades. So far, such work has mainly been formed by local conditions and initiated by the government.

In 2010, Dr. Michael Porter and Dr. Christian Ketels performed an analysis of the Icelandic geothermal cluster in cooperation with Gekon, an Icelandic consulting firm. Nearly 60 different stakeholders within the cluster were involved in the project. According to the results Iceland is naturally uniquely situated in terms of access to a quality resource. The high percentage of geothermal energy as proportion of Iceland's total primary energy consumption is unique in the world. Most of the development of geothermal utilization in Iceland has occurred for the last one hundred years or so, especially in the latter half of the 20th century. Iceland is a strong player in the global geothermal market, enjoying the benefits of a powerful geothermal cluster. The cluster's strength consists of a developed system for using geothermal energy in multiple ways, experienced specialists, and a strong international reputation and network. The cluster's weaknesses include poor access to capital, a lack of critical mass of companies, a complex domestic market environment, and fragmented educational activities.

The Icelandic geothermal cluster is a resource cluster and the geothermal resource is such that it cannot be exported directly. The main growth opportunities for the cluster involve attracting energy-intensive activities to the country (both for direct and indirect use), the laying of a marine cable to Europe and the export of Icelandic geothermal expertise. Stakeholders in the Icelandic geothermal cluster must develop a strategy and an action plan if they at all have the capacity and will to take advantage of unique opportunities in the global geothermal energy sector.

Following the analysis, work was started on creating a platform for collaboration within the Icelandic geothermal cluster. The work was led by a steering committee of leading experts within the cluster. An emphasis was placed on a value-adding cooperation on the terms of the industry. At the same time it is important that the government lend the cluster good support by engaging in a dialogue and providing it with a good regulatory transparency and efficiency.

After a workshop of cluster members in May 2011, the steering committee identified ten projects that could form a basis for a formal cooperation within the cluster for its further development and growth. The aim of the cooperation is increasing the competitiveness of the cluster and its vision, Added value in geothermal. The projects will be carried out systematically during the period July 2011 to December 2012 where cluster management techniques will be applied. At the end of 2012, the success of the projects will be evaluated and a decision will be taken on further development of the cooperation.

1. Porter, 2008.

The members of the cluster wish to tread cautiously in relation to the structure and scope of the platform. The time was deemed not ripe to bring the defined project into GEORG – a research driven entity focusing on geothermal. It was considered more opportune to ensure the implementation of the projects in industry-driven cluster cooperation, called Iceland Geothermal for differentiation.

Thus, the situation is such that one Icelandic geothermal cluster exists in Iceland. Within it, there are two approaches to cluster cooperation each to be managed by its own cluster manager: on the one hand, research-driven cluster cooperation (GEORG) and, on the other hand, industry-driven cluster cooperation (Iceland Geothermal). An emphasis is placed on good collaboration and communication between them, even anticipating the possibility that GEORG and Iceland Geothermal will later merge.

The basis for defining a strategy for the Icelandic geothermal cluster was considered not to be strong enough; further information and data need to be acquired. It is proposed that the time until December 2012 will be used to look more closely into these issues.
If the geothermal cluster and cooperation within it are properly tended to, it can be a model for other clusters in Iceland.

1

Introduction

In October 2009, Dr. Michael Porter and Dr. Christian Ketels officially accepted to participate in the project of mapping the Icelandic geothermal cluster. Subsequently, Gekon began planning the implementation and financing of the project and acquiring data for the analysis. Over the next 12 months, Gekon spoke with individuals from over 60 different organizations, all of whom had to do with geothermal in some way. At the meetings, Gekon announced the cluster ideology and the project of mapping the Icelandic geothermal cluster and requested the participation of concerned parties.

The participants totalled 58. Their involvement in the project consisted of contributions in the form of capital, goods and services as well as disclosure to the project. Only four members refused to participate when approached.

Of the 58 participants, there were 43 companies operating in a competitive environment, 11 governmental agencies and four single workers. Contributions from organizations within the cluster constituted 82% of the total cost of the project. Gekon put up 10%; the rest came from governmental agencies.

On 1 November 2010, a conference of up to 900 participants was held in Reykjavík, Iceland Geothermal 2010, where Dr. Porter and Dr. Ketels presented the results of the cluster mapping. The analysis was based on data and interviews with members of the cluster, acquired from May to October 2010.

In fact, the conference ended the first phase of the development of the cooperation of the Icelandic geothermal cluster, i.e. the profile phase. The main sponsor of this phase was Arion banki; its contribution was crucial, without it the project barely would have become a reality. Also the professional work of KPMG and the financial contribution of HS Orka weighed heavily; these companies were the key sponsors.

After Iceland Geothermal 2010, phase two began; the creation of platform for collaboration within the geothermal cluster. The CEOs of Landsvirkjun (the National Power Company) and Mannvit (Iceland´s largest engineering company), Hörður Arnarson and Eyjólfur Árni Rafnsson, stepped forward and ensured that the project will progress further. It was heavily emphasised that the development will be on the terms of the industry. On 16 March 2011 a meeting of the 35 largest stakeholders of the geothermal cluster was called. The meeting agreed to appoint the following persons in a special steering committee that will guide further work on the shaping of the cooperation: Albert Albertsson (HS Orka), Árni Magnússon (Íslandsbanki), Davíð Lúðvíksson (Federation of Icelandic Industries), Edda Lilja Sveinsdóttir (GEORG), Eyjólfur Árni Rafnsson (Mannvit), Hörður Arnarson (Landsvirkjun) and Stefán Pétursson (Arion banki). During the period 16 March to the end of June 2011, the group met seven times. Gekon worked further on the project between the steering committee's meetings.

On 4 May 2011, an open workshop was held, titled Added value in geothermal. Attendance was very good. Among other things, the ideas of individuals within the geothermal cluster about the prospects, the obstacles and the cluster's cooperation projects were collected.

The steering committee processed the data that emerged in the workshop with the help of Gekon and worked out proposals on the establishment and the tasks of a formal forum within the Icelandic geothermal cluster. These ideas assume a continued emphasis on

that the cluster cooperation will be on the terms of the industry. That the government will, however, lend an important support e.g. by engaging in a dialogue with the cluster, listening to its messages, creating a better work environment for it and representing it abroad.

If all goes as expected, at the time of this writing, a formal platform for cluster cooperation will be established 28 June 2011 on the basis of the steering committee's recommendations. On this occasion, this report will be published. As of that date, the third and most important phase will begin; the implementation. Then, work will begin on the defined projects of the cluster cooperation, continuing until December 2012. At the end of 2012, the members of the cluster will assess further development of the collaboration.

Figure 1: Three phases in developing a formal cooperation within the cluster

Figure 1 shows a summary of the three phases in the progress of cooperation within the Icelandic geothermal cluster.

The purpose of this report is, i.a. to provide a summary of the cluster mapping and the platform creation in the first two phases. It is hoped that it will be useful for the actual implementation.

The main content of the report is divided into four parts.

- At the beginning, the cluster theory and the practice of cluster cooperation in Iceland in recent years will be discussed.
- The second chapter describes the profiling results in phase one. These were partially presented by Dr. Michael Porter and Dr. Christian Ketels in the conference on 1 November 2010.
- The third chapter summarizes the creation of the platform for collaboration in phase two, i.a. by a discussion of the geothermal cluster's workshop on 4 May 2011.
- At the end of this report, ideas on the next steps in the implementation of formal cooperation within the Icelandic geothermal cluster will be addressed.

As basis to the work there is a multitude of data, articles and interviews with different stakeholders collected from October 2009 to May 2011. However, it should be noted that a major limitation to the analysis and cooperation shaping work was the difficult access to information, including statistics relating specifically to value creation of geothermal energy and geothermal energy-related activities of businesses. At this time, there were considered to be not sufficiently strong conditions to make an informed decision on the strategy and special position of the Icelandic geothermal cluster.

Written sources are referred to where appropriate, but for confidentiality verbal sources are not referred to, except as the exception and with the permission of the person in question.

It should be noted that opinions and conclusions are those of the authors of this report and are their responsibility.

2

Clusters and Cluster Management

Before looking into the Icelandic geothermal cluster, it is worthwhile to discuss cluster ideology a little and how it has been conducted in Iceland.

2.1 The cluster theory

It is not news that companies benefit from being in geographical proximity to each other. Alfred Marshall noted in his magnum opus The Principles of Economics from 1890 that companies benefit greatly from being in proximity to suppliers, labour and related activities, both with regard to specificity and economies of scale.[2]

By the mid-20th century the focus changed with the neoclassical economics and the location was considered less important in mainstream economics literature.[3] Then technology innovations, production methods, improved communication and economies of scale were the key issues.[4]

There are, however, indications that the reality is different and, more recently, many authors have regarded geographical location as a key in the structure of economies. These include the Italian Giacomo Beccatini who investigated industrial districts in Italy after 1970.[5] He leaned towards Marshall's theories, yet there were differences of emphasis. Key to his investigation was the industrial environment itself, not the companies. The inspection of relations networks, social interaction and its connection to the production chain of the companies led to further research on the effects of industrial districts on the economic well-being of certain regions.[6]

In 1990, Dr. Michael Porter put forward the theory of The National Diamond in his book The Competitive Advantage of Nations. The diamond reflects the interaction of four main factors affecting the competitiveness of nations and regions. It demonstrates the importance of geographical proximity of different stakeholders in a particular field.[7]

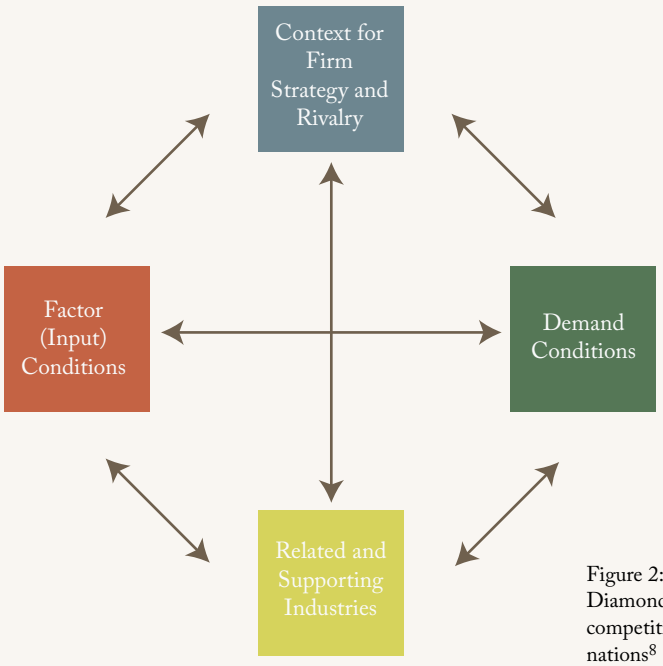

Figure 2: Porter's Diamond: The competitiveness of nations[8]

2. Marshall, 1997.
3. Porter, 2008.
4. Cairncross, 2001.
5. Beccatini, 1989.
6. Rocha, 2004.
7. Porter, 1990.
8. Porter, 2008.

The four main factors are:

Factor conditions: Infrastructure development and access to resources in a broad sense are among items that reflect the circumstances and conditions for production in each region. They dictate how well prepared the region in question is to compete in the market in the relevant field.

Demand conditions: It is important to look to the activity of the market and note the local demand. Increased demand and increased requirements by customers, especially in the local market, are crucial for advancement and stronger links with the global market.

Related and supporting industries: The third part of the diamond is the supporting industries that connect with and support the industry in question. Competitive suppliers in the local market provide the industry with an advantage in various ways, for example, with strong relationships with manufacturers and faster delivery.

Context for firm strategy and rivalry: Here are the factors that reflect how competitive the market of the relevant industry is. The better the organization by which the companies operate and the greater the competition, the greater is the incentive to innovate and minimize costs, in addition to opening up new avenues for business success.[9]

It was in this book that Dr. Porter introduced the term cluster. Clusters are in fact a manifestation of the interplay of forces that occur between the above four factors of the diamond.[10]

Clusters can be defined as a geographic aggregation of interconnected companies and institutions in a particular field, linked by commonalities and complementarities.[11]

Cluster cooperation thus consists of bringing together the various actors within the relevant cluster, such as government, public agencies, production companies, suppliers, service providers, distributors, researchers, educational institutions, financial institutions, associations and others who support the clusters by their participation. Between the members of a cluster there then occurs a certain cooperation that results in higher learning within the cluster in addition to the merger of understanding, skills, insights and techniques in different areas. At the same time, it is important that within the cluster there is active competition present, which is the driving force and prerequisite that individuals constantly seek to do better and increase productivity, and thereby enhance the competition advantage. This shows that when a cluster is formed and developed, a certain whole is created which is much stronger than each individual entity.[12]

Also, it is important to note that clusters are not created. They evolve and are gradually realized based on the conditions that can be identified from the diamond. Governments are particularly poorly suited to design and create clusters. Governments can, however, with the right approach, help the cluster to prosper and there are countless examples of that.[13]

9. Porter, 2008.
10. Porter, 2008.
11. Porter, 2008.
12. Porter, 2008.
13. Porter, 2008.

Clusters can be of various shapes and sizes. Their strengths and weaknesses can be detected from the aforementioned diamond. Clusters are demarcated geographically, but the basis of this demarcation differs greatly. Figure 3 shows examples of countries and regions that have been successful regarding cluster ideology.

Figure 3: Examples of different geographical levels of clusters[14]

In the more than two decades that have elapsed since the theory of clusters first emerged, it can be said that three periods have characterized developments in the implementation of cluster studies. The ideology attracted much attention initially and pioneers made various attempts at cluster analyses and cooperation within clusters. During the period of 1995-2005, experience started to develop in the factors that affect cluster cooperation. In recent years, the cluster ideology has grown from strength to strength and has become an accepted method in both east and west as part of economic development and employment.

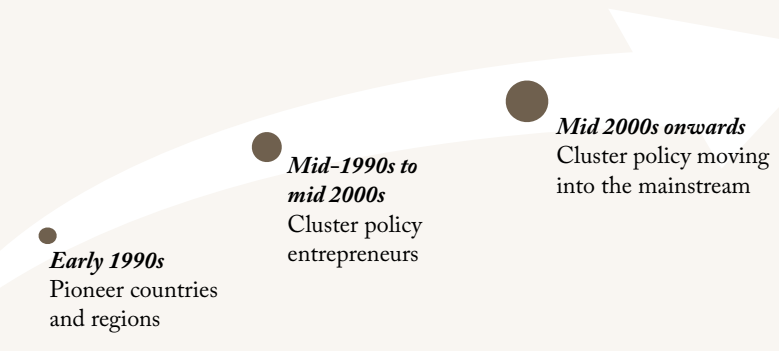

Figure 4: The changing face of cluster policy[15]

It is not easy to measure the performance of the operations of a cluster unequivocally. Yet evidence from regions where this method of developing the economy has been applied systematically point to a greater growth and prosperity. In this regard cluster developments in Catalonia in Spain and Upper Austria[16] in Austria may be mentioned. In these areas, economic growth measures above the national average.

Cooperation of clusters can be either organic or planned. There are many indications that formal cluster cooperation with a clear policy will lead to its faster development, in which case cluster management is an important factor. In a large study conducted among 143 cluster managers in Europe in 2010[17] a large impact of the services that the cluster manager provides to the cluster was observed. The results show that the services of the cluster management have a positive effect on the business development of small and medium-sized enterprises within the cluster, cf. figure 5.[18]

14. Gunnarsson & Karlsson, 2009.
15. Ketels, 2010a.
16. In the original language "Oberösterreich".
17. Among participants were Gekon and GEORG on behalf of the Icelandic geothermal cluster.
18. Maier zu Köcker, 2011.

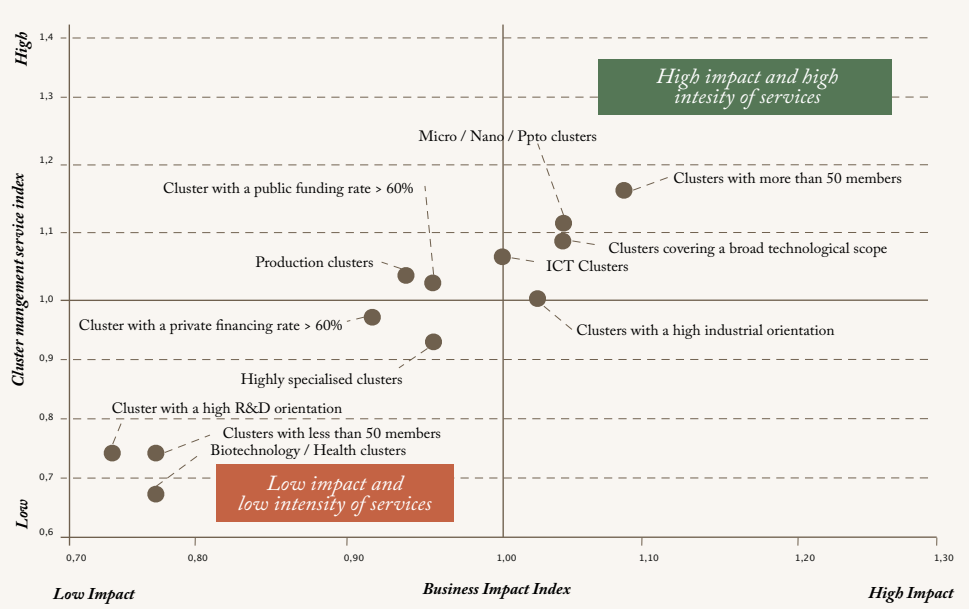

Figure 5: Impact of business oriented services provided by cluster management on business development of SME[19]

2.2 Clusters in Iceland

Clusters and cooperation on economic development have been a rich part of the policy of the Icelandic government in recent years in the field of innovation and regional development. On behalf of the government, the Ministry of Industry has worked on the development of different cluster cooperation. Basic to this work have been so-called growth contracts in eight areas where clusters of various shapes and sizes have sprouted up. An emphasis has been placed on cluster development in rural areas and outside of the capital. The aim is to strengthen the competitiveness of the countryside, focusing on innovation and collaboration among research institutions, universities, municipalities and government.

In addition to the clusters that are based on regional considerations there are also nationwide clusters. An example is GEORG, which is a research cluster cooperation in the field of geothermal energy. The same can be said about a cluster in the field of artificial intelligence. Cooperation between both clusters wins financial support from the government.

Most cluster cooperation that can be found in Iceland have emerged by government initiative. The Federation of Icelandic Industries have, however, launched networking foras in the fields of fisheries, health technologies, gaming industry and clean-tech to name few.

Furthermore, the study by Dr. Porter and Dr. Ketels of the competitiveness of Iceland in 2006 showed that in Iceland, there were two clusters that could be considered established; on the one hand, a cluster around fishing products and on the other hand, a cluster around energy-intensive metal production.[20]

It is difficult to speculate on the number of clusters and cluster collaborations in Iceland. According to the Ministry of Industry, it is however clear that the majority of them are in tourism, fisheries, food and biotechnology. Most of the clusters are emerging and cannot be seen as particularly established. Overall, their management must be considered rather informal.

The cluster term has been used in a broad sense in Iceland. The cluster and network policies are developing into a more sustainable triple-helix initiatives where national priorities and regional strongholds are in the forefront of innovation policy emphasis.

19. Maier zu Köcker, 2011.
20. Porter, 2006.

3

The Icelandic Geothermal Cluster – Mapping and profiling

The international geothermal market provides interesting market opportunities, with significant growth rates in coming years.[21] It is clear that the Icelandic geothermal cluster possesses considerable experience and expertise, and is highly respected internationally.

The economic collapse and a certain opposition to any further investment in geothermal projects in Iceland, however, have created an uncertainty about further development of Iceland's geothermal energy knowledge. An ever-increasing competition from abroad has also emerged. In recent years, there has been an increased emphasis on the development of geothermal clusters in the U.S., Germany and elsewhere. The growth of the geothermal energy market could thus entail the emergence of new and stronger competitors in the market.

Members of the Icelandic geothermal cluster therefore must develop a strategy and an action plan if they at all have the capacity and will to take advantage of their leading position and seize international opportunities within the global geothermal energy sector. One of the basic elements of such work is the performance of a specific profiling, which is in fact the first phase in the formal development of cooperation within the Icelandic geothermal cluster. In this chapter, this phase will be discussed in more detail.

The discussion is based on the cluster mapping of Dr. Porter and Dr. Ketels which was presented at the conference Iceland Geothermal 2010 on 1 November 2010. The mapping work was based on official data, information from companies and deep interviews with 33 cluster members. Gekon performed the data gathering for the most part. It took place from May to October 2010. In all, 58 different entities within the cluster participated in the project. Their involvement consisted of contributions in the form of funding, goods and services as well as disclosures.

Firstly, the mapping of the Icelandic geothermal cluster will be discussed. Then, its main strengths and weaknesses will be assessed based on Dr. Porter's diamond theory. Then the cluster's key growth opportunities will be recounted and finally the main results of the profile phase will be summarized.

3.1 Cluster mapping

3.1.1 Geothermal energy in Iceland

The source of geothermal heat in Iceland is precipitation that comes into contact with hot bedrock at a depth. There are at least 20 high-temperature geothermal areas in Iceland. They are situated in the active volcanic eruption and divergence belt, where magma can be found at a depth of only a few kilometres. The temperature of the liquid in high-temperature areas reaches up to 200°C in the upper 1000 meters of the crust.[22] The low-temperature areas in Iceland are believed to be about 250. In them, the crust is older and has cooled while at the same time it has drifted away from the eruption belts. The temperature of the liquid is in the range 50-150°C in the upper 1000 meters of the crust. Figure 6 shows the locations of high-temperature and low-temperature areas in Iceland.

21. See e.g. Friðleifsson, Bertani, Huenges, Lund, Ragnarsson & Rybach, 2008. According to the forecasts, this growth in geothermal will not be as great as in other renewable energy sources such as wind and solar, cf. Renewable Energy Policy Network for the 21st Century, 2010.
22. The National Energy Authority, 2010a.

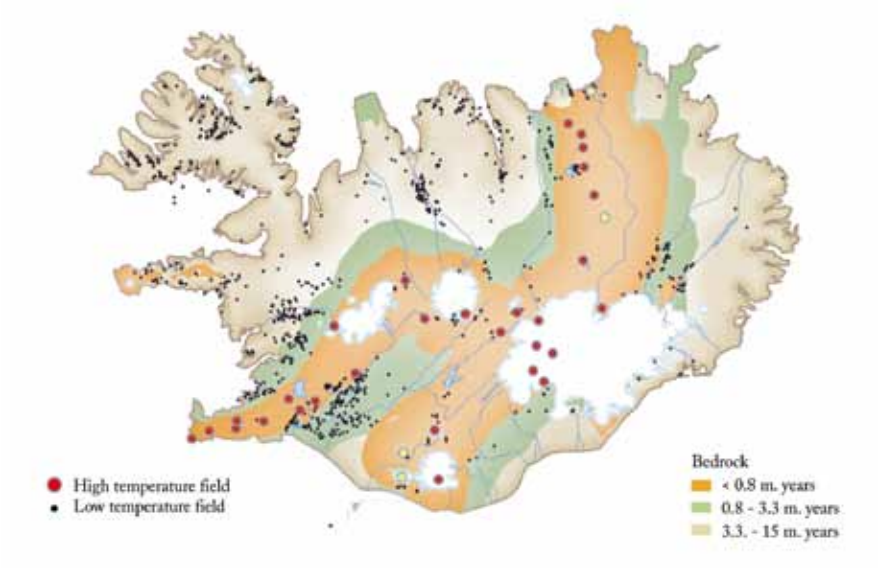

Figure 6: Geothermal fields in Iceland[23]

Under the current Act on the survey and utilization of ground resources, No. 57/1998, property rights to ground resources come with land property. However on public land, ground resources are owned by the Icelandic state. Sources of The National Energy Authority (NEA) indicate that by far the largest proportion of geothermal energy can be found in areas that are publicly owned. The state, municipalities and publicly owned companies are prohibited by law to sell its geothermal rights. However, they are authorized under the above Act to lease the utilization rights to the geothermal for up to 65 years[24]. Research and utilization is subject to licensing according to the before mentioned Act and the Electricity Act, No. 65/2003.

In the course of the recent decades, the share of geothermal energy in primary energy consumption in Iceland has grown substantially at the expense of oil. The development of primary energy consumption in Iceland in the years 1940-2008 is shown in figure 7. The high percentage of geothermal energy as proportion of total primary energy consumption is unique in the world.

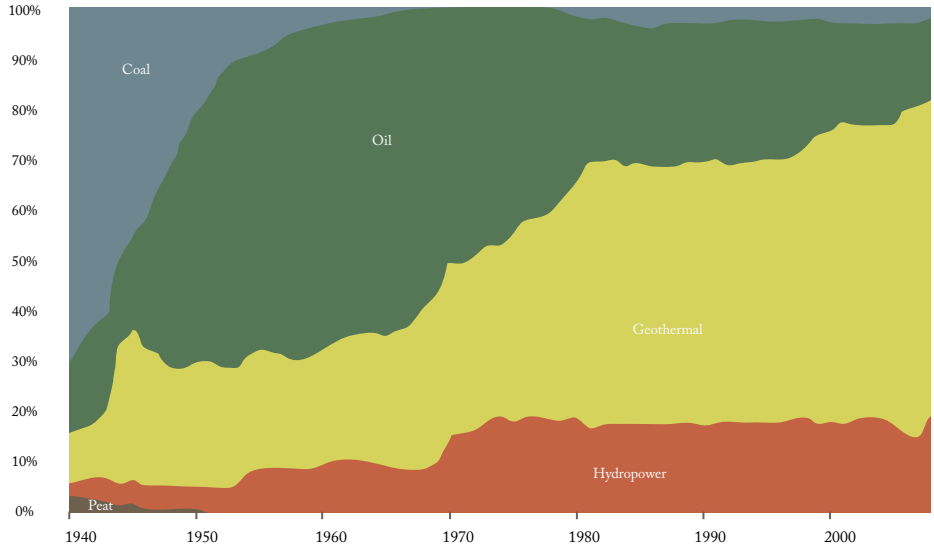

Figure 7: Net primary energy use in Iceland 1940-2008 (TJ)[25]

23. The National Energy Authority. Published with permission from The National Energy Authority.
24. The Prime Minister's Committee on the arrangement for the lease of water and geothermal rights owned by the state reported its findings in April 2010, proposing i.a. that the lease period be in the range of 40-50 years.
25. The National Energy Authority. Published with permission from The National Energy Authority.

The quality of the geothermal heat in Iceland is considered to be high, which is believed to be revealed in i.a. a greater average output of boreholes[26] and less emissions of carbon dioxide of geothermal power plants in an international comparison, according to information from NEA.

Figure 8 shows the energy flow of geothermal heat in Iceland in 2008, during which the primary energy consumption of geothermal heat totalled 144.2 PJ. The total production in low-temperature areas was 29.2 PJ. Primary energy production in high-temperature areas amounted to 121.7 PJ of which 121.1 PJ went to geothermal power plants. Of this, 14.5 PJ was converted to electricity, 11.9 PJ was used for heating and 6.6 PJ was pumped back into the geothermal systems. Untapped heat and losses totalled 105.0 PJ[27] but it should be noted that, based on the principles of thermodynamics, only a part of this energy can be utilized for generating electricity.

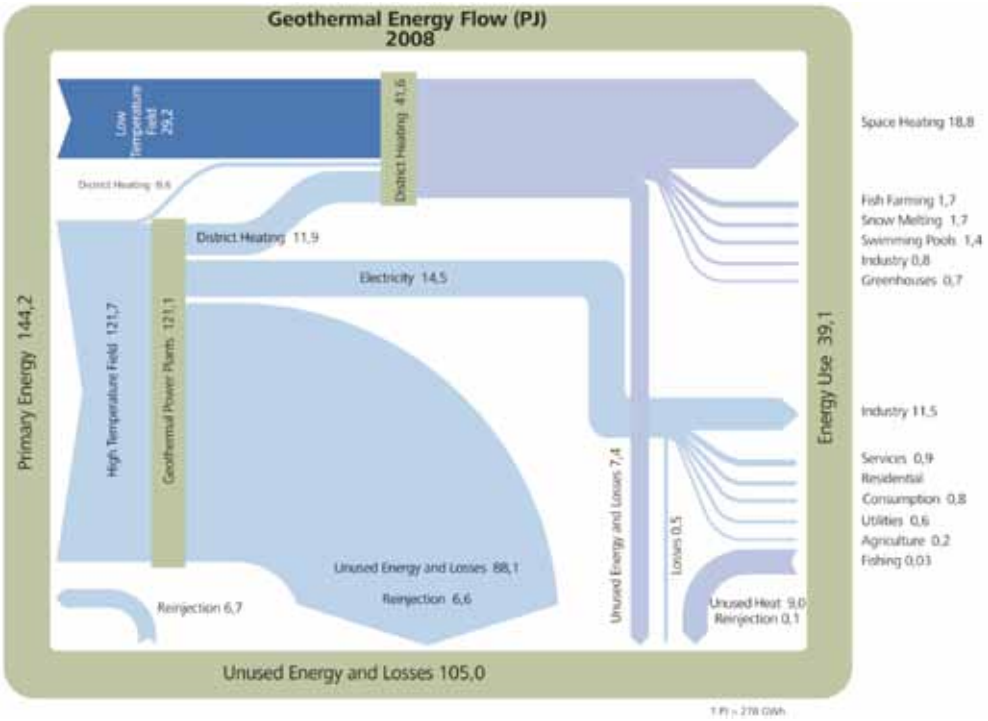

Figure 8: Geothermal energy flow (PJ) 2008[28]

In 2009, geothermal power amounted to 575 MWe and hydropower to 1883 MWe. Further details and a comparison of capacity and production of the Icelandic electricity power plants can be seen in tables 1, 2 and 3.

26. Haraldsson & Ketilsson, 2010a.
27. Haraldsson & Ketilsson, 2010b.
28. The National Energy Authority. Published with permission from The National Energy Authority.

	2009		2008	
	MWe	*%*	*MWe*	*%*
Hydropower	1883	73.0	1879	73.0
Geothermal	575	22.3	575	22.3
Fuel	121	4.7	120	4.7
Total	**2579**	**100.0**	**2574**	**100.0**

Table 1: Installed capacity in Icelandic power plants 2008 and 2009[29]

	2009		2008	
	GWst	*%*	*GWst*	*%*
Hydropower	12279	72.9	12427	75.5
Geothermal	4553	27.0	4038	24.5
Fuel	3	0.0	3	0.0
Total	**16835**	**100.0**	**16468**	**100.0**

Table 2: Electricity production in Iceland 2008 and 2009[30]

Powerplant	Installed capacity (MWe)
Húsavík	2
Bjarnarflag	3.2
Krafla	60
Svartsengi	76.4
Reykjanes	100
Nesjavellir	120
Hellisheiði	213

Table 3: Installed capacity of each geothermal power plant in Iceland[31]

In 2009, a special group of experts from NEA and ÍSOR performed an evaluation of the capacity of high-temperature areas. According to the group's report, the potential electric power of high-temperature areas for 50 years is estimated as 4300 MWe (equivalent to 35000 GWh). It is noted that the evaluation does not take the conservational value of individual areas into account. It is also noted that the evaluation of capacity may change significantly with increasing technological progress and new information. Individual sites are variably well known.[32]

On the website of the Master program for the protection and utilization of natural areas in Iceland, the following assessment of the electricity generation capacity of hydropower and geothermal heat in Iceland is presented, cf. figure 4. The assessment is rough and subject to a considerable uncertainty. Certain degradations with regard to efficiency and environmental considerations are taken into account.[33]

29. The National Energy Authority, 2010b.
30. The National Energy Authority, 2010b.
31. Haraldsson & Ketilsson, 2010b.
32. Ketilsson, Björnsson, Halldórsdóttir & Axelsson, 2009.
33. Rammaáætlun um vernd og nýtingu náttúrusvæða með áherslu á vatnsafl og jarðvarma, n.d.

	GWst
Hydropower	30-35000
Geothermal	25-30000
Alls	**55-65000**

Table 4: Evaluation of the electricity generation capacity of Icelandic energy sources per year[34]

According to the abovementioned evaluation of the Master program and information on electricity generation in 2009, 15-18% of the potential electricity generation capacity of geothermal heat has already been harnessed.

It is believed that in the next 15 years, it will be possible to double the current level of electricity generation in Iceland. An increase of about 10000-12000 GWh of geothermal and 4000-5000 GWh in hydropower are considered likely.[35]

Those plans indicate that there will be a strong need for geothermal knowledge in Iceland in the coming years; in addition, special opportunities will arise to enhance the development and uniqueness of Icelandic geothermal energy utilization.

3.1.2 Historical development of the geothermal cluster

Geothermal heat has benefited the people of Iceland for washing and bathing since the country's settlement. However, by far the largest step forward in the utilization of geothermal heat in Iceland occurred not until the last century, especially in its latter half.

Geothermal heat was first utilized in Icelandic greenhouses at the beginning of the 20th century. At the same time, people started to use hot groundwater for heating houses and for swimming pools. The oil crisis in the seventies accelerated further development of geothermal utilization for heating in the country. At that time, the Icelandic government put a big emphasis on reducing oil imports and pushing further geothermal research and the development of geothermal heating utilities. Today, almost half of geothermal energy consumption in Iceland involves heating, which benefits 89% of the population.[36]

Snow melting has enjoyed popularity from the late 20th century. Now, snow melting systems are assumed in front of most new buildings erected in areas enjoying a geothermal heating utility.[37]

Geothermal heat was first utilized for large-scale industrial use in Iceland at the end of the 1960's when the use of steam in the processing of diatomite was started. The direct use of geothermal energy in industry has, however, largely been to dry algae, fish, cement, timber etc.[38] The production of skin care products at the Blue Lagoon, the methanol production of Carbon Recycling International and salt production should also be noted.

Geothermal energy has also been used in some types of fish farming, which enjoyed a certain growth period after 1985. After stagnation in the 1990's, interest in the industry increased again in the beginning of this century. The total aquaculture production in 2007 and 2008 was about 5000 tons.[39] It seems likely that fish farming will strengthen further i.a. with the emergence of the company Íslensk matorka on the market.

34. Rammaáætlun um vernd og nýtingu náttúrusvæða með áherslu á vatnsafl og jarðvarma, n.d.
35. Arnarson, 2011.
36. The National Energy Authority, 2010a.
37. Ragnarsson, 2006.
38. Haraldsson & Ketilsson, 2010b.
39. Haraldsson & Ketilsson, 2010b.

The first geothermal power plant in Iceland was built in 1969 in Bjarnarflag in the region of Lake Mývatn. Today, there are seven geothermal power plants in the country with a total power of 575 MWe as previously stated. In 2009, 39% of the use of geothermal heat was for electricity generation.

In figures 9 and 10 time axes recount, very sketchily, the history of geothermal energy in Iceland in the past 80 years. The period 1930-1995 can be mainly described as a time of building-up of the geothermal energy in Iceland, with the first utilities, the first power plants, the establishment of energy companies, etc.

However, the years from 1995 to the present have been characterized more by a development of the commercial environment of geothermal energy utilization. This may be seen by e.g. numbers of mergers and privatization of organizations during this period of time. Also by the changes that have taken place in the legal environment of the energy market in recent years. The most extensive changes took place on the one hand in 2003 when the foundation for the commercialization of the production and sale of electricity was laid by separating the competitive and monopoly elements. However, in 2008, when the predecessor of HS Orka had been partially privatized, opportunities opened up for private parties in the EEA to acquire shares in a company that produces and sells electricity competitively.

The development of the last one hundred years or so has led to the formation of the Icelandic geothermal cluster with all the multiple uses, knowledge and experience that are found within it today.

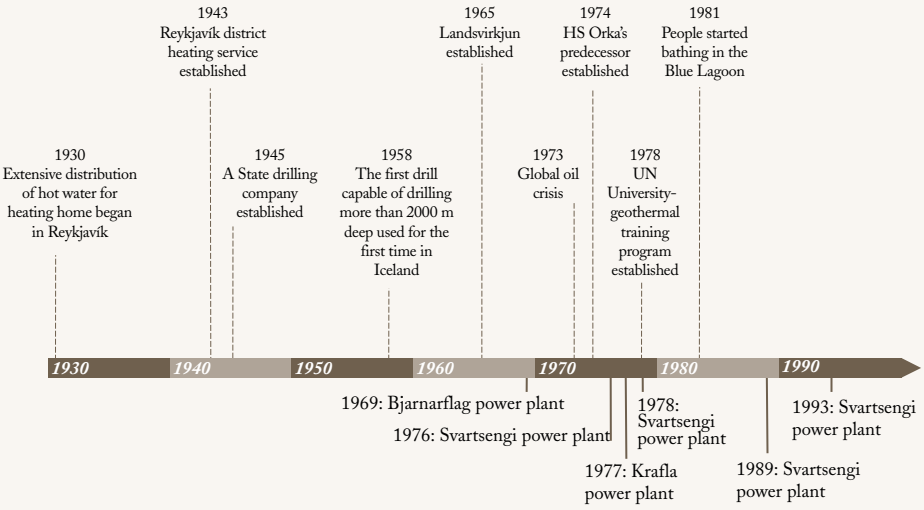

Figure 9: The development of the Icelandic geothermal cluster 1930-1995[40]

40. Authors' analysis, based on Ketels, 2010b.

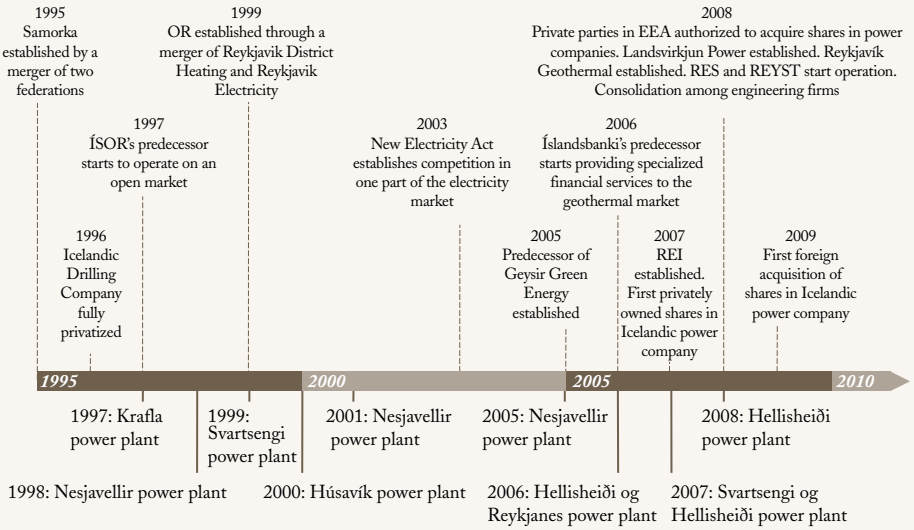

Figure 10: The development of the Icelandic geothermal cluster 1995-2010[41]

3.1.3 The cluster map

But how extensive is the Icelandic geothermal cluster? The profile work in phase one included a review of the activities and scope of the major companies and institutions within the geothermal cluster. This analysis was i.a. mapped and presented in figure 11, which now will be discussed further.

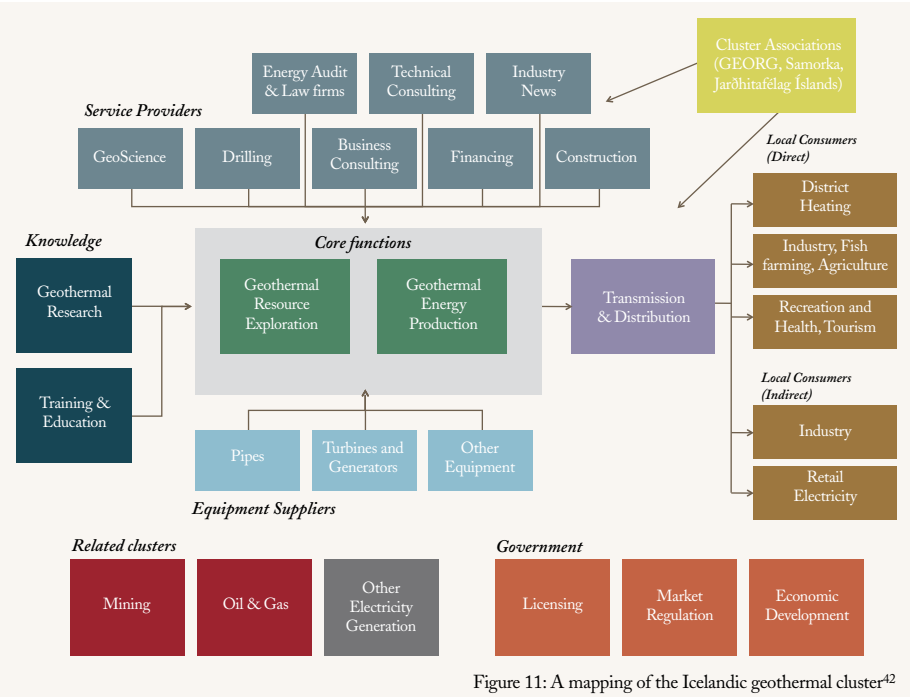

Figure 11: A mapping of the Icelandic geothermal cluster[42]

41. Authors' analysis, based on Ketels, 2010b.
42. Porter, 2010.

3.1.3.1 Core functions

On the one hand, according to the figure, the core operations of the geothermal cluster consist of geothermal exploration and surveying and on the other hand electricity generation. Here, the energy companies play the biggest role; especially Orkuveita Reykjavíkur, HS Orka and Landsvirkjun. Within them, a need is generated for research, consulting, hardware etc. - which other members of the cluster need to provide solutions for. Consequently, the active participation of the energy companies within the cluster cooperation is essential.

The ownership of the electricity companies is largely public, except HS Orka. The state marked the beginning of the privatization of the company in 2007 by selling its 15.2% stake in HS Orka's predecessor (Hitaveita Suðurnesja) in a public tender process; other shares were owned by municipalities. Between 2009 and 2010 Magma Energy Sweden A.B., a Swedish subsidiary of the Canadian company Magma Energy Corporation (currently Alterra Power), bought almost all the shares in HS Orka. At the end of May 2011 an agreement was announced that 11 Icelandic pension funds would buy 25% of the shares in HS Orka from Alterra Power, which makes Alterra Power owner of 73.526% in HS Orka. The rest is owned by municipalities in the Reykjanes region.

The ownership of the power companies is, however, not essential to the development of the geothermal cluster; the important thing is that they are operated as businesses in a competitive market.[43]

3.1.3.2 Service providers

A number of parties provides the core operations of the geothermal cluster with various consultancy services, for example in relation to geosciences, drilling, well design, choice of materials, engineering and technical consulting, audits, legal services, etc. The analysis work revealed that the service aspect of the geothermal cluster is very strong with regard to the experience and availability of different services. This aspect has strengthened in recent years, for example through mergers of smaller engineering companies into the larger companies Mannvit, Verkís and Efla. Also the policy, introduced by Íslandsbanki around 2006, to specialize in financial services for the geothermal market, was a very important step for the cluster. The same applies to the decision of Arion banki to focus its attention more to the energy market, i.a. to follow up the increased foreign interest in energy affairs. It should be borne in mind that much experience and knowledge was created by the activities of companies such as Enex, Geysir Green Energy and Reykjavik Energy Invest at the time, even though the collapse treated them harshly. Examples of other signs of the strengthening of services in recent years include the establishment of Reykjavik Geothermal and the launch of the homepage www.thinkgeoenergy.com where geothermal news from all over the world is published. Furthermore, the international auditing firm KPMG has located part of their geothermal expert team in Iceland.

However, there is a real risk that the expertise that has been built up until now will erode due to the stagnation and uncertainty that has surrounded new geothermal projects in Iceland ever since the 2008 economic collapse. Thus, for example, the most powerful ground drilling company in Iceland, Jarðboranir, had built up a collection of new high-tech drills since the turn of the century. Due to limited jobs in Iceland since the autumn of 2008, the company has had to export some of its drills to overseas projects i.a. to New Zealand.

43. Porter, 2010.

In interviews taken in conjunction with the profile work, a clearly expressed view of the interlocutors was that Icelanders lack more expertise in business development of geothermal projects in a competitive market, since most of the energy sector has been in public ownership from the beginning to the present day. Also, it was pointed out that knowledge of marketing and sales within the cluster needs improvement. In addition, companies should be less shy in recruiting experts such as anthropologists and ethnologists for foreign projects to better learn the customs and traditions of the countries in which geothermal projects take place.

3.1.3.3 Knowledge

The strength of the Icelandic geothermal cluster involves i.a. how it has used research methods and applied them to achieve success. In Iceland, ÍSOR and its predecessor have handled most research projects relating to geothermal energy, mainly for the power companies but also for NEA. ÍSOR and NEA have built up solid databases where the results of numerous studies and appraisals are available. Studies have also been conducted at universities and to some extent by energy companies. Furthermore, the engineering firm Mannvit recently commenced activities in the field of research. Most of the studies conducted outside of universities are managed and implemented for a practical purpose. It has been pointed out that basic research needs to be strengthened, especially within the universities. Also, studies have been called for that specifically aims at reducing risks and lowering the cost of geothermal energy projects.

In this context the report of Icelandic Centre for Research (RANNIS) from the year 2010 is noteworthy, on Iceland's performance concerning peer-reviewed publications and their impact. It shows that geosciences are one of the strongest academic fields in Iceland and that this has been the case for a long time; 13% of the country's publications were in this field during the period 2004 to 2008.[44]

The major parties who have provided funding for energy research in recent years are The National Energy Fund, GEORG, the Environmental and Energy Research Fund of Orkuveita Reykjavíkur and the Energy Research Fund of Landsvirkjun. Total funding of these entities amounted to ca. ISK 350 million in 2009 and about ISK 180 million in 2010. Orkuveita Reykjavíkur has stated that there will be no new allocations from the company's Environmental and Energy Research Fund in 2011.[45]

It is also worth mentioning that in the years 2001-2006 the energy and utility companies spent a total of ISK 15 billion on research and design, plus 500 million in grants for research and scientific work done by others.[46] Over the same period, the contribution of The National Energy Fund totalled 384 million, according to information from the fund.

Note that the above involves capital devoted to various forms of energy projects; comparable information on grants for geothermal projects specifically was not available from all parties.

44. Icelandic Centre for Research (RANNIS), 2010.
45. Authors' analysis.
46. Samorka, 2007.

What education is concerned, there is a significant supply of vocational and university study programs in Iceland that benefit the field of geothermal and other green energy. These mainly include the University of Iceland, The University of Reykjavik, Keilir, Reykjavik Energy Graduate School of Sustainable Systems (REYST), the Geothermal Training Programme of the United Nations University (UNU-GTP), the Technical College Reykjavík and the Technical College of Hafnarfjörður. The future structure of education in the energy sector has been undergoing certain fermentation and changes can be expected in the near future.

Information on the number of students registered in university studies mainly related to geothermal utilization provides evidence that students are actually relatively few considering the number of educational institutions. Members of the cluster have pointed out that the dispersion of university study programs that exist here lead to more costly studies, a less efficient use of the time of the experts who also teach, a limited access to specialists, dispersed forces, etc. It seems clear that the activities of institutions in these matters need to be better co-ordinated and that an emphasis needs to be placed on increasing the number of domestic and foreign students of the relevant subjects. Increasing the number of domestic students is no less important, given that a great need for recruitment in the industry is foreseen in the near future. In this context, it has been discussed that generally, the interest of students in primary and high schools for science needs to be increased and their eyes opened to the possibilities that can be found in e.g. trades, geoscience studies, technology studies, and civil engineering studies.

By integrating the supply of education, certain opportunities open up to make Iceland a leading nation in education in earth sciences and/or other subjects related to geothermal energy or energy in general. Experienced professionals are available and the access to energy resources and power plants is very good. It would be ideal to involve the energy companies and others more in teaching and training the operation and maintenance of power plants. The market appears to exist and Iceland has a good head start with regards to its image in the field of geothermal energy. A survey done by Íslandsbanki in 2010 among geothermal experts worldwide revealed that approximately 55% of the respondents believe that Iceland is a leader in education in the field of geothermal energy. [47]

Much can be achieved by strengthening education in the field of geothermal energy. It contributes e.g. to recruitment in the industry, plus the fact that foreign students who come here to study will henceforth look to Iceland and Icelandic parties to gain more knowledge, goods or services in the field of geothermal energy. This can be seen from the valuable relations that have developed with the foreign students who have pursued studies at the UNU-GTP during the last three decades.

3.1.3.4 Equipment suppliers

Production in Iceland of machinery and equipment associated with the utilization of geothermal energy is limited and one of the weaknesses of the Icelandic geothermal cluster. So far, foreign turbine manufacturers have used the Icelandic geothermal industry as a development platform for their devices, without the Icelandic energy companies having been able to gain special value from this work.

47. Íslandsbanki, Geothermal Energy Team, 2010.

Examples of equipment that has been designed and/or produced here include the manufacture of pipes by Set, the design of transportable electrical power generating units by Kaldara and the production of software for the operation, maintenance and security of geothermal power plants by a variety of entities.

Pioneers have complained about a difficult operating environment for innovation and the dominance of major companies in the market. At the same time it is worth mentioning that the energy companies have stated that they need and want to encourage innovation and technology development in the sector. In the view of some, Icelandic pioneers could have been more creative and more proactive in development projects.

It is entirely possible to strengthen the domain of machinery and equipment manufacture within the cluster and bring its expertise into the form of a product that can be sold in a scalable manner; if people have at all the interest and will to do so. Such a development e.g. took place in the fishing industry from the 1980's and onward. One can build on the knowledge that has been created with the development and operation of geothermal plants here in Iceland and with the cooperation of Icelanders with the producers in the development of hardware for them. Strong and good relations with the main manufacturers of turbines and generators in the world have been formed and could be exploited. Moreover there are strong machine shops that exist here such as Héðinn, Vélsmiðja Hjalta Einarssonar and Stálsmiðjan. At the same time, it is important to improve the work environment of entrepreneurs and strengthen ties with them.

In this context it is interesting to mention that the most direct use of geothermal energy in the world today lies in heat pumps, cf. figure 12.

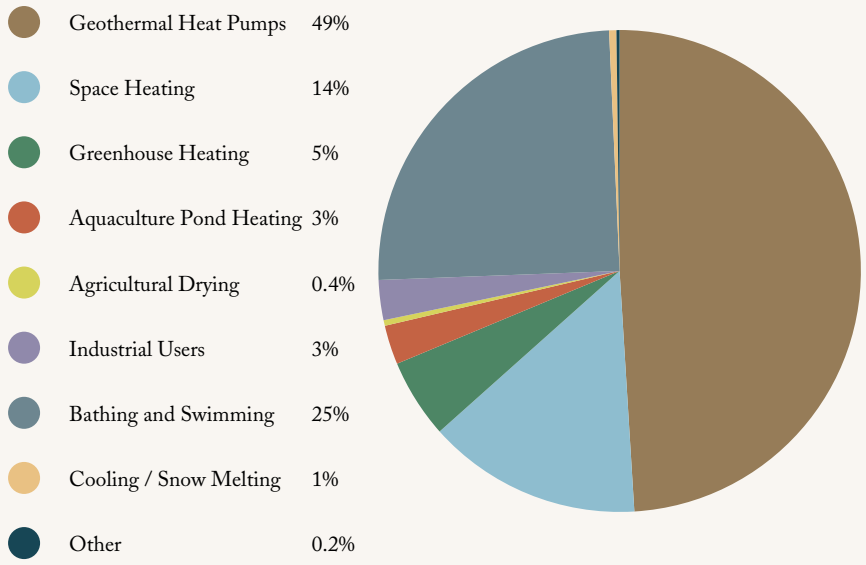

Figure 12: Direct use of geothermal energy in the world in 2010 (total 438.071 TJ)[48]

48. Lund, Freeston & Boyd, 2010.

In recent years the largest increase in the direct use of geothermal energy has been in heat pumps and growth is expected to continue, cf. figure 13.[49]

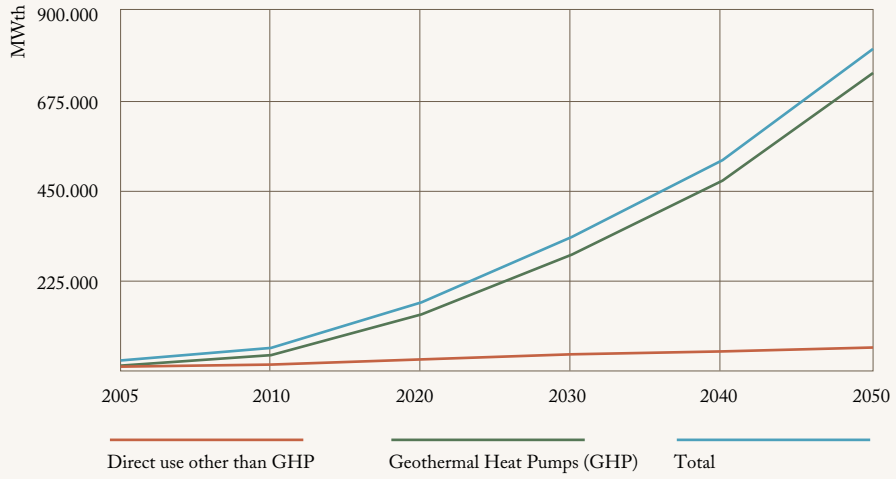

Figure 13: Likely case scenario for worldwide growth in direct use and GHP installed capacity[50]

Icelandic participation in the development and manufacture of heat pumps, however, has been minimal. It has, though, been gaining momentum in recent years with entrepreneurial activities such as Varmavélar and the partnership project Landsvarmi which the Innovation Center Iceland launched recently.

3.1.3.5 Direct and indirect local consumers

In 1973, the Icelandic chemical engineer Baldur Líndal presented a diagram showing the multiple potential uses of geothermal at different temperatures. This presentation is shown in figure 14. It has become well known in the international geothermal community, and is called The Lindal Diagram.

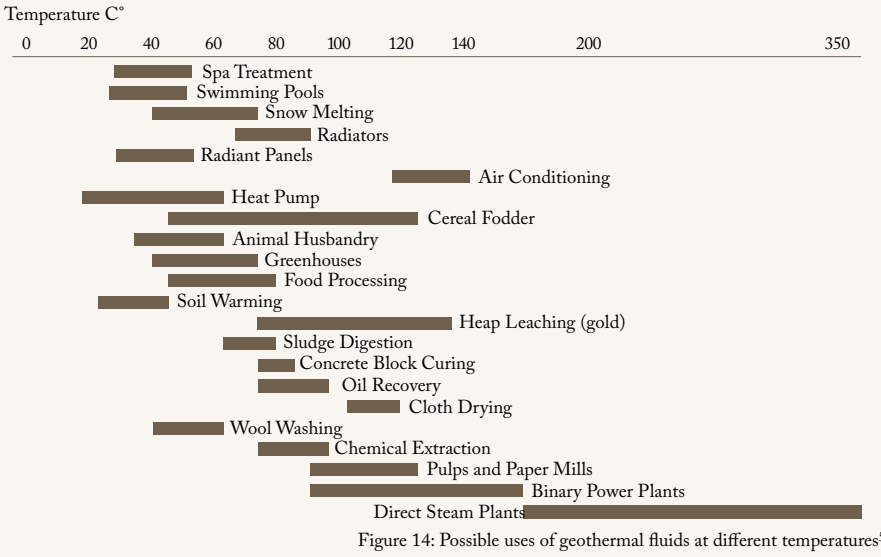

Figure 14: Possible uses of geothermal fluids at different temperatures[51]

49. Friðleifsson, Bertani, Huenges, Lund, Ragnarsson & Rybach, 2008.
50. Friðleifsson, Bertani, Huenges, Lund, Ragnarsson & Rybach, 2008.
51. KPMG Advisory, 2010.

Figure 14 makes it clear that with cascading and combined uses of geothermal heat it is possible to enhance the feasibility of geothermal projects. The resource temperature may however limit the possible uses.

One of the main strengths of the Icelandic geothermal cluster is how diversely the geothermal heat is utilized. Figure 15 shows an overview of the use of geothermal energy in Iceland in 2009.

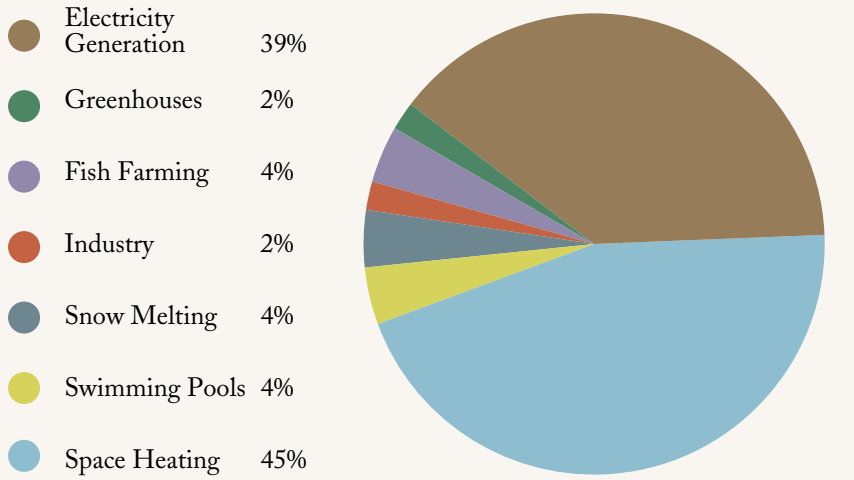

Figure 15: The use of geothermal energy 2009 (total 41.7 PJ)[52]

Compared with other countries that use geothermal energy, Iceland is among the leading countries in the utilization of geothermal energy for heating and aquaculture. Also, Iceland is one of the few countries in the world to exploit geothermal energy for drying, in industries and for snow melting.[53]

Geothermal heat is also used to produce electricity for both households and industry, including the production of aluminum. Of the 35 countries utilizing geothermal energy for electricity generation, Iceland ranked 7th with the largest installed capacity of geothermal power plants in 2010, cf. table 5. More detailed information about the use of geothermal electricity in the world can be found in the report World Geothermal Market and Outlook which KPMG Advisory in Reykjavik prepared in autumn 2010.[54]

Country	Installed Capacity 2005 (MWe)	Installed Capacity 2010 (MWe)	Installed Capacity 2005 (MWe) (forecast)
USA	2564	3093	5400
Philippines	1930	1904	2500
Indonesia	797	1197	3500
Mexico	958	958	1140
Italy	791	843	920
New Zealand	435	628	1240
Iceland	202	575	800
Japan	536	536	536

Table 5: Installed capacity in different countries 2005 and 2010, and forecast for 2015[55]

52. The National Energy Authority, 2010b.
53. Lund, Freeston & Boyd, 2010.
54. The report was prepared by the experts of KPMG in autumn 2010 in conjunction with the analysis of Dr. Michael Porter and Dr. Christian Ketels of the Icelandic geothermal cluster. It can be obtained by contacting the offices of KPMG in Reykjavik.
55. Bertani, 2010.

In 2009, the proportion of the aluminum industry was 74% of all electricity usage in the country.[56] There is a certain willingness to diversify the energy purchase group, i.a. in order to distribute the market and counterparty risk of the energy companies.

Promote Iceland and KADECO, a company leading the development and transformation of the former military area at Keflavik airport for civilian use, are among parties who have done research on the potential uses for green energy for other types of energy-intensive industries than those present. Thus, the development of resource parks and green industry parks that could offer comprehensive solutions for interested foreign investors is being looked to.

In Iceland, geothermal energy has also been utilized much in connection with greenhouse production and health-related services; out of the country's 169 swimming pools, 138 utilize hot ground water.[57] In this context, the Blue Lagoon spa, The Mývatn Nature Baths and Laugarvatn Fontana in addition to heated beaches like Nauthólsvík in Reykjavík should also be noted. There are also a number of popular tourist attractions related to geothermal energy, as is true of particular wonders of nature of high-temperature areas, hot springs and warm natural pools, not to mention special receptions in power plants.

One of the main weaknesses of the multiple-use in Iceland is however the small market for low-temperature geothermal heat.

There is a detailed account of the development of geothermal energy use in Iceland during the years 1990-2009 in the NEA report on the use of geothermal energy for power generation and direct use until the year 2009. It also contains an appraisal of the status of geothermal energy use in 2008, showing the distribution of users across the country.[58] Information about value creation of the diverse use of geothermal energy is lacking. It is though one of the fundamentals for defining the cluster's strategy and positioning.

The strong demand that exists here for the direct and indirect utilization of geothermal energy is extremely important for the cluster and its evolution. Demand in the domestic market teaches the cluster how to utilize the resource and helps it to create and define the expertise and strengths that are here present. In addition, the demand is a good indication of where the cluster can position itself and gain an even greater competitive advantage compared to other countries.

The diverse usage means more potential to exploit geothermal energy and hence make it a better saleable product in competition with other renewable energy sources. The expertise of the cluster gives it the opportunity to help other countries to exploit its geothermal energy better and in more diverse ways. Certain opportunities may be present in the developing countries that possess geothermal resources; the said countries may not have sufficiently developed infrastructure and electricity utilities but find it easier to exploit geothermal energy for greenhouses and other industries.

56. The National Energy Authority, 2010b.
57. The National Energy Authority, n.d.
58. See Haraldsson & Ketilsson, 2010b.

3.1.3.6 Associations within the cluster

Good cooperation has been customary in the Icelandic geothermal sector for years. Individuals within the cluster know each other well and feel comfortable working with each other on various projects. At least three formal cooperation arenas in the fields of energy and/or geothermal heat have been established. This involves firstly Samorka, an organization of energy companies and utilities, with related companies and organizations as associate members. Secondly GEORG, who is the cluster's co-operation platform for research of geothermal energy, as stated before. Thirdly, the Geothermal Association of Iceland, a grassroots association of professionals and enthusiasts about geothermal energy in Iceland.

There is also reason to mention the Federation of Icelandic Industries, that have traditionally worked actively on building up and shaping the strategy of the industries related to the geothermal energy cluster.

The cooperation that already exists is given good ratings by the cluster members. However, there has been a certain lack of formal platforms for cluster collaboration and coordination of geothermal development and innovation.

3.1.3.7 Related clusters

One of the weaknesses of the Icelandic geothermal cluster lies in how few clusters related to it exist here. A large part of the knowledge utilized in geothermal energy production is based on technical knowledge from the oil, gas and mining industries. Thus, many oil companies have started to establish themselves in the geothermal sector recently. Oil and gas processing and mining, however, have been minimal in Iceland. Transfers from Icelandic clusters to the Icelandic geothermal cluster have therefore been limited to the experience, knowledge and construction work around hydropower plants and even the cluster around energy-intensive metal production. In light of this, it would be interesting for the Icelandic geothermal cluster to connect better with nearby oil clusters, such as the Norwegian one.

3.1.3.8 Government

The role of the government in the activities of the geothermal cluster is important. It creates a certain working environment for the cluster by formulating policies on energy, environment and employment.

To date, no official energy policy has been in effect in Iceland. Among other things, this has meant that government actions relating to energy have not been sufficiently predictable. Also, the government has still not answered how maximum returns of the owners of the resource and the profitability of investment in energy production can be combined, while at the same time creating stability so that a long-term investment is an attractive option at all.

However, recent semesters have seen the preparation of a national energy policy through the work of various government working groups and committees. For example, the Minister of Industry appointed a special steering committee in August 2009 on the formulation of a comprehensive energy policy. The vision of the energy policy is as follows: "That the energy affairs of Iceland will be managed in a sustainable manner for the benefit of the community and the public."[59] The aim is that the group will complete its work in autumn 2011.

Moreover, Icelandic Master Plan for Hydro and Geothermal Energy Resources has been in development since 1999. It is estimated that based on the work, a strategy for the utilization rate and the priority order of new project alternatives will be set for the purpose of promoting a sustainable use of the resources. It is expected that a parliamentary resolution will be submitted in connection with the results of the Master Plan in autumn 2011.

Besides the general governmental policy in various fields, the legal and regulatory environment for licensing, environmental assessments and zoning affairs has a large impact on the operations of the cluster stakeholders. In this context, the energy companies and other parties have complained of complicated and time-consuming processes of assessments and license applications related to the exploration and exploitation of geothermal energy. Plus, government agencies do not respect the deadlines set for the handling of the affairs in question. This is one reason why time frames of geothermal projects are unpredictable.

The government can provide essential support to the cluster with a clear strategy, a good business environment, gathering of information, by representing Icelandic geothermal expertise abroad, etc. Among the key players in this context are the President of Iceland, the Parliament, the Ministry of Industry, the Ministry of Foreign Affairs, the Ministry for the Environment, the Ministry of Economic Affairs, the National Energy Authority, the Environment Agency of Iceland, the National Planning Agency, Promote Iceland, the Innovation Center Iceland, municipalities and others

It is important to create a good dialogue platform between cluster members and the government, where different parties have the opportunity to exchange ideas and opinions, to the benefit of the cluster and the whole of society.

3.2 Strengths and weaknesses

The strengths and weaknesses of the Icelandic geothermal cluster were identified from the aforementioned diamond theory of Dr. Michael Porter. As mentioned above, the diamond contains four main elements which all affect each other, i.e.: 1) Factor (Input) Conditions, 2) Demand Conditions, 3) Related and Supporting industries, and 4) Context for Firm Strategy and Rivalry.[60] The analysis of the geothermal cluster is presented in figure 16. Strengths are denoted by (+), weaknesses by (-) and mixed factors are denoted by (~).

59. Stýrihópur um mótun heildstæðrar orkustefnu, 2011.
60. Porter, 1990.

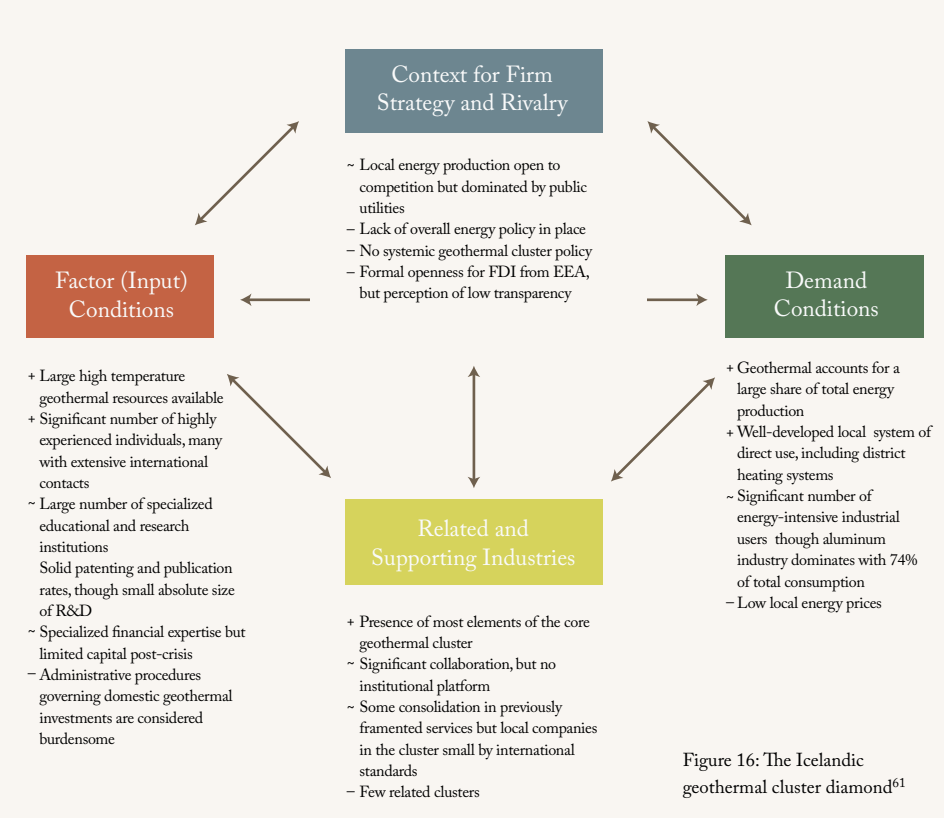

Figure 16: The Icelandic geothermal cluster diamond[61]

In the whole, the position of the Icelandic geothermal cluster today can be described as follows.

Iceland is a significant player in the global geothermal market, where a solid geothermal cluster is present and the highest share of geothermal in overall energy use.

The strengths of the cluster involve the following factors:

- Companies and staff are highly experienced. It is important to launch new projects to continue to develop more knowledge and keep workers in the industry and/or the country.
- Well developed systems for the multiple use of geothermal energy are available.
- The reputation of Icelandic geothermal knowledge is strong and the cluster's international network is dynamic.

The weaknesses of the cluster involve the following factors:

- Companies within the cluster lack critical mass and access to capital. Poor access to capital provides an opportunity to think up new ways of financing.
- The domestic market environment is complex. The regulatory framework for the issuance of licenses, environmental assessments and zoning affairs relating to geothermal projects needs to be simplified. Official energy, environmental and employment policies are lacking.
- Educational institutions are too small and lack specific integration and efficiency, despite collaborative projects.
- There is a lack of a formal cooperation platform within the cluster, despite good relations and communications between parties within it.

61. Porter, 2010.

- The nature and quality of the geothermal resource in Iceland is different from most other countries. A high quantity of a quality resource does not strongly call for a better utilization of the geothermal energy. This demand rather comes from the public for a better conduct towards the nature.
- There is a lack of related clusters in Iceland, for example in mining and oil processing.

3.3 Market opportunities

The Icelandic geothermal cluster is a resource cluster and the geothermal resource is such that it cannot be exported directly, as is true of e.g. oil. The major growth opportunities of the Icelandic geothermal cluster are therefore of three kinds, namely:

- Attracting energy-intensive activities to the country.
- Direct export of energy through a cable.
- Export of geothermal knowledge and services.

3.3.1 Attracting energy-intensive activities

Ever since the 1960's the development of energy-dependent activities in Iceland has grown steadily. In 2009, the aluminum industry and ferrosilicon industry had a total of 79% of all electricity consumption in Iceland.[62]

So far electricity in Iceland is a so-called stranded power; it can only be used in Iceland. This fact, among others, has entailed that the Icelandic electricity market for heavy industry has been a buyers' market and energy prices have been relatively low.

It has been reported that in the next 15 years, it will be possible to double the current electricity generation in Iceland so as to reach up to 34000 GWh. Challenges in this respect include, among others, finding those energy buyers who create the greatest value increase for Iceland as a whole and selling the energy at prices beneficial to both the energy manufacturer and purchaser.

Concerning the first challenge, it is very important that each option is evaluated in terms of value-adding factors for each kWh sold, i.e. the number of jobs that are created, the value of the jobs, export revenues etc. One would also have to consider what opportunities exist to exploit the relevant production as input for other parties in this country, whether the option in question fits into the cluster structure that exists, how it rhymes with Iceland's image, etc. In this whole context, one also needs to note the increasing emphasis on conservation and demands for limitations of the environmental impact of heavy industries. A similar approach applies equally to activities involving the direct use of geothermal energy.

It is clear that the government must issue clear policies on energy and foreign direct investment, stating what kinds of energy-intensive activities Iceland desires, concerning environmental impact, value creation and the country's image. Following this, the relevant parties could be effectively attracted i.a. with a more efficient and transparent regulatory framework for foreign investment and an attractive work environment. Thus, Icelanders should make every effort to become a dream partner, if an energy buyer meets the requirements set out by the policy.

62. The National Energy Authority, 2010b.

However, it has been suggested that hitherto, the interaction of the government, municipalities, energy companies and landowners has been inefficient and their priorities different. The non-compatible policies of these parties result in i.a. that it proves complicated for a business in energy-intensive activities to buy energy and locate itself where it desires.

3.3.2 Direct export of energy

The idea to export electricity via a submarine cable has been presented regularly in the past 30 years. Such a cable would be about three times longer than the one which is the longest in the world today.

It is expected that energy prices in Europe will rise in coming years, partly because of pollution taxes. As Iceland is an island, the hydropower plants need to have a certain security level to allow for low water years. The idea of the submarine cable partly involves selling to Europe the energy that the power plants already have the capacity to produce in excess of that currently sold. It is being explored how the idea can be worked out in more detail from technical, commercial and legal considerations.

Exports of electricity would open up new prospects for the Icelandic energy market. With them, the energy companies would, for example, not be as dependent on selling their energy to customers who are willing to commit themselves to long-term energy purchase. In addition, the cable would grant the energy companies a better negotiating position regarding energy prices to heavy industry in Iceland. Negative effects of the connection of the cable could include higher energy prices for households.

3.3.3 Exports of knowledge and services

Exports of Icelandic companies in the field of geothermal energy utilization have been mainly in the form of knowledge or services as figure 17 shows. Production and sale of equipment and machinery, however, has been unsystematic so far as has been mentioned.

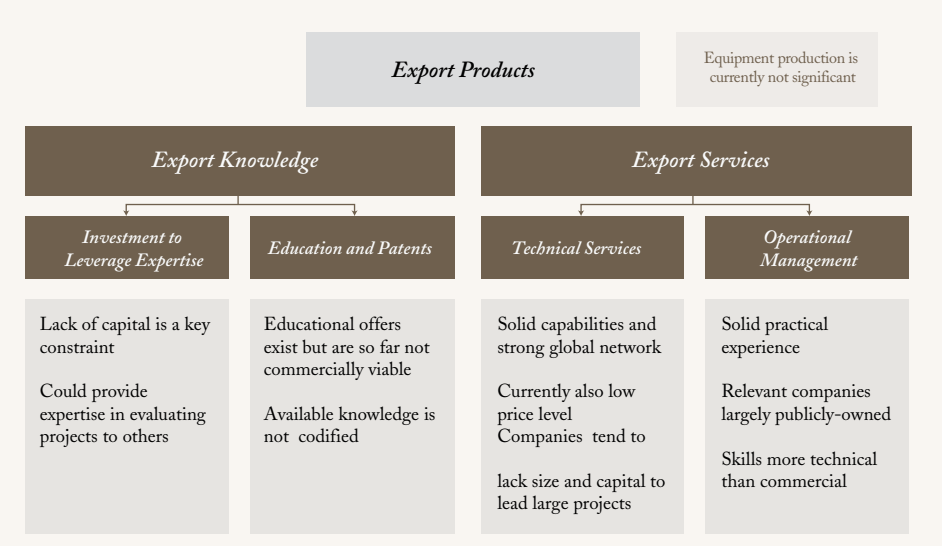

Figure 17: Opportunities for exporting knowledge and services for geothermal activities[63]

63. Porter, 2010.

Foreign markets are important for Icelandic geothermal companies, especially in times when uncertainty and stagnation prevail for geothermal projects in Iceland. Unfortunately, there is no data on the value of the export of goods and services in the field of geothermal energy; a rough survey among major exporters shows that in recent years, the share of income from overseas geothermal projects has been increasing.

In the last decades, Icelandic companies have taken part in geothermal projects around the world in various ways and their success has differed. An inspection of the said projects revealed partly the following:

- Evidence indicates that the projects of consultants such as engineers and geoscientists have been most successful. Nevertheless, the financial benefit from selling individual consultancy billable hours abroad has been questioned. In that respect, it is more important to get big contracts such as on the supervision and management of certain geothermal power projects. The weaknesses in relation to the consultancy projects are mainly thought to consist in the fact that no standards exist on Icelandic geothermal expertise and project management.
- Foreign heating projects have in general been more successful than other geothermal projects.
- Foreign projects of Icelandic companies have been more successful if parties in the relevant country have also participated in them. Thus it has proved useful to get stronger connections to the relevant country and learn its people's culture, customs, habits, etc. Likewise, it has proven fruitful for Icelandic companies to open an office in the country in question and run steady operations.
- So far Icelandic participation in international projects through ownership has not been successful. This is explained in part by the parties not having been sufficiently coordinated or critical of the projects that had been selected.
- It is easier to get a project if one can help with its funding. However, the difficulty of Icelandic parties with the financing of projects is one of the weakest aspects of the cluster. One way to address this weakness is to strengthen the cluster's cooperation with foreign investors and financial institutions in a systematic manner.

Furthermore, it is clear that the production and sales of Icelandic equipment and machinery has been limited. The possibilities that exist to reinforce the Icelandic geothermal energy cluster in this area need to be examined. If the will is there, this aspect could be strengthened through a more coordinated cooperation of energy companies, entrepreneurs, mechanics, drilling companies, foreign equipment manufacturers and others.

Finally, the export routes of Icelandic expertise in the field of geothermal energy is through education. This field can be greatly reinforced by setting and following the policy that Iceland be a leading international university nation in the fields of geosciences, geothermal and/or energy. With increased research and better integrated study programs, more foreign students could be attracted to the country and foreign currency revenues and valuable relations for the future could be created.

3.4 Profile summary

- Geothermal energy is a renewable energy source, exotic, requires technical knowledge and can be utilized through a variety of means. Certain opportunities lie in the field of geothermal energy that Iceland cannot afford to ignore.
- Opportunities within geothermal energy in Iceland do not only involve its utilization for electricity production. They consist of multiple uses and sales of goods, services and knowledge related to geothermal energy utilization in a broad sense. In this con text one may mention various forms of consultancy, research work, education for for eign students, the production of machinery and equipment, greenhouses and aqua culture products, to name a few.
- Despite good cooperation between cluster members, the geothermal sector in Iceland is not sufficiently organized and it lacks a strategy to follow the opportunities up as well as is possible, e.g. by an organized cluster cooperation.
- Formal cooperation in the geothermal cluster offers i.a. opportunities for the development of technical and value-adding expertise associated with the systematic utilization of geothermal energy.

- Icelanders enjoy the great privilege to have access to a quality geothermal resource in large quantities. As a result, the motivation for utilizing the resource better, with greater care and according to a thought-out policy has been limited.
- The demand side of the geothermal market in Iceland is strong and highly significant. It makes it possible to better understand the needs and learn how to utilize the resource better. It even gives hints on the potential of Icelandic companies on international markets.
- Iceland has strong relations and a good reputation in the international geothermal field. It is necessary to examine carefully how greater value can be created from it.
- One of the prerequisites for the possibility of taking advantage of growth opportunities within the Icelandic geothermal field is a focus on recruitment within the sector.
- Data collection on the cluster needs to be improved; there is a need for basic information about the number of staff within the cluster, salaries, revenues from foreign projects, the value creation of multiple uses, and more concerning the scope, activities and value creation within the geothermal cluster.
- Another weakness that must be addressed is the small domestic market for low-temperature geothermal heat
- The work environment of the Icelandic geothermal cluster needs to be improved i.a. by a public energy policy so that parties can know the landscape of energy affairs in Iceland in the near future.
- When viewing the potential uses of the resource, it is important to examine whether the relevant alternative maximizes value for the country as a whole. The Icelanders need to manage its geothermal resource better.
- The main objective of the public energy companies must be to increase the companies' value, not to work according to narrow short-term political interests; this confuses the prioritization of investments and the companies' operations.

- Above, there was a discussion of the purchase of the Canadian company Alterra Power (formerly Magma Energy) of part of the Icelandic energy company HS Orka through a Swedish subsidiary and the placement of part of the geothermal expert team of KPMG in Iceland. Also, one may not forget to mention The Canadian Geothermal Energy Association (CanGEA), which recently opened an office here. The interest of foreign parties to place activities in Iceland related to geothermal, is a certain development that should be regarded positively. The policy should mean that everyone who knows anything about geothermal energy wants to be located in Iceland. This entails i.a. an increased expansion of the Icelandic geothermal cluster, stronger relations with the foreign geothermal market and opportunities for Icelandic parties to obtain projects abroad with the respective parties. Also, the in creased demand of the parties who come here for the services of Icelandic companies. One of the cluster's service companies has talked about its experience that a foreign party who came to this country made higher and different demands for service and quality, beyond what was previously known. This led to both increased knowledge and development within the service company in question.
- It is also necessary for the cluster to find out more about what is happening in other geothermal clusters abroad, such as in Nevada, New Zealand and Germany. It would also be interesting to link to clusters that are in related industries, such as oil clusters in Norway and Houston.
- It is possible to address the weak aspects of the Icelandic geothermal cluster concerning funding and equipment manufacturing, by relating better and more systematically to foreign investors and financial institutions on the one hand and equipment and machinery manufacturers on the other hand.

- The geothermal energy cluster could be the cluster that has the greatest impact on the country's image and it is ideal for sending out messages about what Iceland represents.
- If the geothermal cluster is properly nurtured, it can be a certain model for other clusters in Iceland.
- The Icelandic geothermal cluster could be a catalyst for certain changes in the general business environment in Iceland and have an impact on further development regarding e.g. direct foreign investments, innovation, and so on.
- The geothermal cluster can be a part of Icelandic society that everyone can be proud of.
- This is an opportunity that the Icelanders have to exploit - or, as Dr. Michael Porter put it in Iceland Geothermal 2010 in this regard: „If we don't, then shame on us!".

4

The Icelandic Geothermal Cluster – Platform Creation

When the profile phase in the development of cooperation in the Icelandic geothermal cluster ended on 1 November 2010, a new phase began; shaping a platform for cooperation. A steering committee[64] of leading individuals within the cluster, appointed in March 2011, was responsible for managing the work.

In this chapter, the phase of the platform creation will be discussed in more detail. Yet it is worthwhile to first have a coarse look at cooperation within the cluster to date.

4.1 Cooperation so far

Members of the Icelandic geothermal cluster have from the beginning worked a lot together, both formally and informally. The cooperation appears to have worked well so far, and it has been argued that this has ensured the rapid development that has occurred in the utilization of geothermal energy in Iceland. However, it has been pointed out that cooperation between parties in research and development needs to be strengthened considerably, mainly with regard to a better and a more diverse utilization of geothermal resources.

Examples of cooperative projects between companies in this country include:

- Energy companies help if equipment breaks down, technical problems come up, parts are missing, etc. Moreover, people share their knowledge and experience if major problems have been solved.
- The energy companies have had to work together to provide sufficient energy to large users, cf. the fact that HS Orka and Orkuveita Reykjavíkur will sell power to Norðurál for the proposed aluminium smelter in Helguvík.
- All design and construction of the power plants of the energy companies have been largely in the hands of the same Icelandic service providers. Thus, knowledge that has been developed due to work in one power production area has been transferred and brought large benefits for design and construction in another power production area.
- ÍSOR has done a fair amount of geoscience work for all the energy companies and this work has been useful to all parties in one way or another.
- The energy companies and other parties have worked together on the unique Iceland Deep Drilling Project - IDDP from year 2000.
- Previously GEORG, Samorka and the Geothermal Association of Iceland have been discussed.

Icelandic companies have also worked together in foreign markets. For example the marketing bureau of ÍSOR and Verkís in Chile may be mentioned; GeoThermHydro. Also, Icelandic companies have involved their compatriots in projects they have acquired, in line with the needs, circumstances and interests of each project. Examples of this include the construction of a power plant in El Salvador; Enex involved the engineering firms Mannvit and Verkís in the project.

64. See further information in the introduction to the report.

One must also note the company Virkir Engineering Group (later called Virkir Orkint and still later Enex). This cooperation was started in 1969 by engineering and geothermal energy companies as a forum for the export of knowledge of Icelandic experts in the use of geothermal energy and electricity. NEA joined the group later and other parties in the sector such as the energy companies. In this forum, certain cooperation was shaped, both between public and private entities, about the advancement into foreign markets.

The result, however, was not satisfactory, although many good things resulted from the cooperation. Eventually, in 2008, the company was owned by Geysir Green Energy. The results from the research in the profile phase indicate following factors as explanations of why the cooperation did not work as expected:

- There were many heads but no one took responsibility.
- There was a lack of focus; people were going to swallow the whole world. Limited resources were spread too widely.
- Following-up of the policy that had been set was lacking.
- The marketing campaign lacked stability. Foreign projects were an emergency exit for the companies when projects in Iceland decreased. The Icelandic economy is very volatile and when major projects emerged here, staff was called home.
- Knowledge and experience in sales and marketing was lacking.
- Foreign affiliates were unfortunately chosen.
- Many parties participated in the venture. There was a strong demand that everyone would receive a small portion of each project, which incurred that not always did the best party carry out each task.
- The parties involved did not toe the line and differed on the expansion rate of the venture. Some wanted to move quickly while others did not like to take too much risk.
- Some members of the cooperation found that their projects and names were being used to acquire specific projects. Later, when work on the projects started, the companies in question were not allowed to participate.
- The operations of the venture in fact became independent and the participating parties were not engaged to perform the projects that arrived.

When talking about a formal cooperation in the Icelandic geothermal cluster, the Virkir/Virkir Orkint/Enex joint venture is often referred to and advised that it was not successful. In this context it should be noted that cooperation in the geothermal cluster is not about cluster members mutually contemplating or embarking on specific geothermal projects overseas as was the case with the operations of Enex and its predecessors.

It should also be borne in mind that the cluster benefits in high measure from the experience and knowledge generated by the activities of Virkir/Virkir Orkint/Enex. Important lessons can be drawn from the joint venture; it is also an important factor in the development of the Icelandic geothermal cluster.

4.2 Cluster platform

4.2.1 Workshop 4 May 2011

On 4 May 2011, approximately six months after the conference Iceland Geothermal 2010, there was a workshop that lasted a whole day entitled Added value in geothermal. The workshop was open to all, and attendance was considered very good. At the peak, the number of participants was nearly 110.

During the workshop, eight members from the entire value chain of the geothermal cluster held presentations on the needs and challenges of Iceland's geothermal energy from their own perspectives and experience. Following this, organized discussion took place at round tables collecting ideas of individuals within the cluster of prospects, obstacles and cooperation projects of the Icelandic geothermal cluster.

The purpose of the workshop was as follows:

- Review the message of the conference of 1 November 2010.
- Promote better the cluster ideology and the possibilities of cluster cooperation.
- Encourage cluster members to cooperate.
- Provide cluster members with opportunities to get their views across and take part in the shaping of the cluster cooperation within geothermal energy.
- Collect material for the steering committee regarding the vision and the cooperation projects of the Icelandic geothermal cluster.
- Bring cluster members together to mutually develop solutions and projects.

In this context, it may be noted that according to a survey conducted among the participants after the workshop, almost 85% of respondents considered the workshop's goals to have been achieved well or very well. It may also be mentioned that the same survey revealed that about 77% of respondents were positive or very positive about the establishment of a formal cooperation of the geothermal cluster. Only 1.9% of respondents were negative or very negative towards it.

4.2.2 Projects defined

Among the questions the steering committee brought up in its meetings was: "Are Icelandic companies actually good in utilizing geothermal heat? If yes, in what aspects?“. It turned out that it was not possible to provide tenable answers that could be substantiated i.a. by dollars and dimes. Thus prerequisites for definition of strategy were considered to be too weak. That there was a need for more detailed information and data, including in relation to the value creation of Icelandic geothermal expertise, like the results of the profile phase had indicated.

Therefore, it was deemed sufficient to create a platform of collaboration be defining specific projects of the cluster that should be performed within a certain timeframe, bearing in mind that the cooperation would grow and evolve. It was agreed to that the time would be used to gather additional data and information so that the cluster strategy could be better shaped.

In view of this, the projects that were raised during the workshop grouped into six categories according to their nature and content. The classification system was based on the most common cooperation interfaces, according to a study conducted in 2003 on more than 250 cluster initiatives around the world.[65] The categories are:

1. Innovation and technology.
2. Education and training.
3. Commercial cooperation.
4. Policy action.
5. Research and networking.
6. Cluster expansion.

Most of the projects fell under the first category, i.e. innovation and technology. After classification, the projects were grouped based on their main themes within the categories. From this group, eight project titles were selected and two new added, i.a. with respect to the analysis in phase one.

In the opinion of the steering committee and Gekon, the project titles share the ability to contribute to an increased value creation within the cluster and address both its strengths and weaknesses. The ten projects are shown in figure 18.The steering committee suggests that they will be used as basis of a formal cooperation platform within the geothermal cluster, for further development.

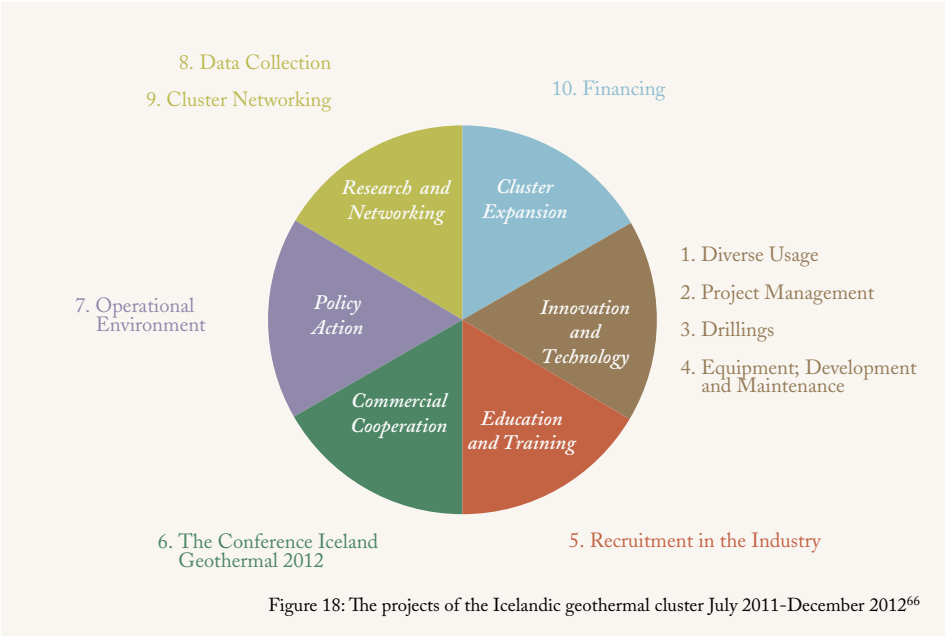

Figure 18: The projects of the Icelandic geothermal cluster July 2011-December 2012[66]

Further elaborations of the ten projects are shown in table 6. The material there presented mostly stems from the workshop. It is proposed to form a professional group around each project which develops and conducts the project further with an assistance of a cluster manager, cf. the discussion of the implementation in the next chapter. Number of suggestions for solutions to the projects are available for further processing.

65. Sölvell, Lindqvist & Ketels, 2003.
66. Based on Sölvell, Lindqvist & Ketels, 2003.

Projects	Needs that the project meets	Objectives and Benefits of the project
1. Diverse Usage	The main criticism of geothermal energy production is that the utilization of the geothermal heat is poor. Diverse usage is one of the strengths of the Icelandic geothermal cluster. By focusing on multiple uses, its strengths are thus enhanced. The revenue flows of geothermal energy production need to be increased so that not only electricity producers pay for the primary energy acquisition. Aggressive exploitation of geothermal heat must be avoided and its sustainable use aimed at. The market for low-temperature geothermal must be increased.	**Objectives:** Examine the benefits of improving the efficiency by 10% over the next ten years. Examine if/how new buyers in the field of multiple use can improve the industry's earnings and then by how much. Examine possibilities of new products, such as aquaculture, tomatoes, cosmetics, spas, etc. Optimal utilization of energy flows from the aspects of profitability, environmental impact and energy efficiency. Connect different stakeholders to collaborate in developing new solutions. **Benefits:** Increased efficiency. Enhance sustainability by better utilizing the surplus heat from geothermal power plants. Increased value creation. Increased consensus on geothermal energy utilization. Geothermal utilization is a more marketable alternative in competition with other (green) energy sources.
2. Project Management	Project management of geothermal energy could be better developed, and sometimes does not meet the requirements of the international community. Need for more disciplined practices. "Just-do-it" is an important force, but it can cause undisciplined methods. Need for a framework to manage projects so that they will be on schedule more often. Disciplined work practices are crucial when obtaining foreign capital and projects. Profitable management tools for geothermal energy clusters in the global arena need to be designed. The main obstacles are inexperience and processes that need to be adapted to geothermal projects.	**Objectives:** Examine how schedules in geothermal projects are kept in general in Iceland. Examine if planning can be improved financially by e.g. 50% over the next ten years. Observe if it is necessary and efficient to develop: - Standards. - Education/courses/training for project managers of geothermal projects. - Certification for project managers. - Else. Observe how the before mentioned could be channelled. **Benefits:** A more marketable product. Greater professionalism. Better reputation.
3. Drillings	Simplification, cost reduction, more productive holes. Recycling and cleanups of older holes. Drilling technology is expensive; there is a need for a cheaper technology that could be used for long boreholes from few drilling sites. Disruption to the surface needs to be minimized and the structures that need to be on the surface need to be blend into their surroundings.	**Objectives:** Examine how much the cost can be lowered if one manages to simplify/make holes more productive/recycle/clean holes. Examine how the average cost of drilling a hole can be lowered e.g. by 5% in ten years. Examine how the environmental impact can be minimized. Examine how the efficiency of boreholes can be increased. Examine ideas for ways/solutions for further development of drillings. Connect different stakeholders to collaborate in developing new solutions. **Benefits:** New solutions in drilling. Lower cost and environmental impact minimized. Increased consensus on geothermal energy utilization.

4. Equipment; Development and Maintenance	Limited production of Icelandic equipment for geothermal energy utilization is one of the weaknesses of the geothermal cluster. To date, the Icelandic energy companies have been involved in the development and testing of equipment from foreign manufacturers without being able to create additional value from this work. Maintenance in the operations of power plants is costly. Energy companies are always looking for solutions to streamline operations.	Objectives: Make a cost-benefit analysis of establishing a maintenance company for geothermal power plants, for example, modelled on Icelandair Technical Services (ITS). Examine the feasibility of establishing IGMS - Iceland Geothermal Maintenance Services. Examine ideas for ways/solutions for the further development of geothermal utilization equipment for better efficiency and for reducing the environmental impact. Increase collaboration with foreign equipment manufacturers. Improve connections between entrepreneurs and larger parties. Improve the conditions of entrepreneurs. Seek more ideas from entrepreneurs. **Benefits:** Development of new solutions for the machinery. New exports. Increased value creation. Streamlining in the operations.
5. Recruitment in the Industry	Foreseeable lack of people in the various fields of geothermal energy utilization. The number of staff in the field of geothermal energy utilization needs to be increased, people's access to the industry needs to be improved and current professionals need to be given the opportunity to expand their horizons. The interest of students in primary and high schools for science and technology education needs to be increased. Young people need to be informed about the opportunities inherent in the geothermal sector. The current supply of education needs to be coordinated and promoted.	**Objectives:** Examine and map education related to energy already in place. Look into ideas on the development of education related to energy. Examine the possibilities for co-ordinating the education already in place. Find ways to promote the knowledge of general workers with basic and continuing education. Explore ideas on increased connections of industry to primary and high schools. Work systematically on increasing the number of technicians (skilled trades) and academics (technology, engineering and earth sciences) within the cluster. Examine ways of increasing the number of foreign students, e.g. by 1% per year for ten years. **Benefits:** Coordinated and better supply of education. Recruitment in the industry. More supply of employees. Better use of teachers / professionals from the industry who instead will be more accessible in their usual jobs. Better opportunities for basic and continuing education.
6. The Conference Iceland Geothermal 2012	Geothermal energy utilization needs to be marketed. Icelandic geothermal expertise needs to be marketed. Geothermal needs to be made a more attractive market so that good people will be attracted; direct students into the field.	**Objectives:** The Icelandic geothermal cluster will be hosting an international geothermal conference in Harpa, November 2012; Iceland Geothermal 2012. The Conference Iceland Geothermal will be held biannually and sets for itself the goal of becoming one of the leading conferences in the field of geothermal energy e.g. in Europe. **Benefits:** Strengthen the image of Icelandic expertise in the field of geothermal energy globally. Promote the image of Icelandic companies in the field of geothermal energy globally. Enhance value creation, knowledge development and networking of participants in this field. Bring new approaches and solutions across - both domestic and foreign. Create a platform for new business opportunities and/or improve existing ones. Promote multiple uses of geothermal energy. Promote job creation in the community, both within the cluster and in other industries. Reinforce Iceland's unique image as a destination. Increase the number of tourists to the country Advance increased foreign currency revenues.

7. Operational Environment	There is a need for a public policy related to geothermal energy utilization as well as environmental and employment policies. There is a need for a comprehensive environmental policy for all the aspects of geothermal energy utilization; from the pre- and exploration stages up to production and operation. A significant added value lies in a business run under such a policy. The legal environment of assessment, the issuance of licenses and planning in the preparation and development of geothermal power plants/projects is a very complex and time-consuming process that must be gone through repeatedly. It can be costly and delay the development and research which need to be completed as early as possible in the process. The dialogue between government and geothermal corporations needs to improve. There is a need for a harmony and unity around geothermal energy utilization.	**Objectives:** Examine the waiting period for licenses. Examine why there is a waiting period and the benefits of shortening the waiting period of power plant licenses by e.g. three months on average. Examine ways to shorten the waiting periods, e.g. the legislative changes. Define all aspects of environmental affairs concerning geothermal energy utilization. The environmental impact considered at every stage of the utilization process, not only at the end. Create a coherent vision for multiple use of geothermal energy in a sustainable manner. Energy policy. Environmental policy. Master plan for Hydro and Geothermal Energy Resources. Examine legislation and public policy towards foreign investment in Iceland and innovative solutions in financing projects (in cooperation with project 10). **Benefits:** The cluster cooperation forms a platform for objective and informed dialogue between the government and various stakeholders. The cluster cooperation forms a bridge between an industry and the government. Increased dialogue. Increased harmony. Enhance transparency and efficiency.
8. Data Collection	There is a need for basic information about the extent and value creation of the Icelandic geothermal cluster.	**Objective:** Gathering and processing of basic information and data about the geothermal cluster. The gathering performed regularly, for example, on an annual basis. **Benefits:** Experience has shown that good information about clusters lead to a more successful work. Such information may e.g. show whether there is a lack of staff with certain qualifications, what is the value creation within the cluster etc. A more robust data gathering i.a. makes it possible to evaluate the actual benefits and value creation of the geothermal cluster as a whole; which is fundamental for defining the cluster strategy.
9. Cluster Networking	Many people argue that communications between cluster parties are fine and that their cooperation is already good. Others point out that the cooperation is only good in certain areas, so for example, there is a lack of coordination of development and innovation in Iceland in geothermal energy utilization. Also, "smaller" parties complain of lack of communication and interest from the "larger" stakeholders within the cluster. Also that their access to larger projects is limited. One of the most important roles of cluster managers in general consists in strong and good relations with the cluster members.	**Objectives:** A communication plan of the cluster manager with the cluster members. Open a webpage showcasing the cluster cooperation. Forum for different parties to work on ideas. Increased connections and networking. Increase flow of information between cluster members. Relations to other geothermal clusters and related clusters abroad. **Benefits:** A certain transparency among cluster members. Increased communication and networking between cluster members i.a. in order to work together on value-adding projects. Better access of "smaller" parties to "larger" parties. Opportunity to compare and learn from other geothermal clusters and related clusters abroad.

10. Financing	Financing of geothermal projects in Iceland and abroad is difficult. "We are sufficiently few in this country that all the banks need to get involved with these issues." In this context, it may be noted that one of the strengths of the geothermal cluster project to date involves the participation of the four largest banks: Arion banki, Íslandsbanki, Landsbanki and MP banki. The Icelandic financial market has been detached from the outside world. Pension funds are subject to limits to foreign investment in addition to currency restrictions. General foreign investment of any magnitude should be promoted. Lack of combined investment power on the one hand and expertise in the energy sector on the other hand.	**Objectives:** Examine ideas for new ways/solutions for financing geothermal projects. Examine "Public/Private" - financing of geothermal projects. Examine possibilities for increased cooperation with foreign investors/investment funds/financial institutions. Increase partnership between investment power and expertise in the energy sector (research, engineering firms, etc.). Examine how cost of capital in the geothermal sector can be lowered e.g. by 1%/2.5%/5%. **Benefits:** Channels for joint financing. Channels for mutual lending from several banks. Channels for the involvement of foreign investors.

Table 6: Ten projects of the Icelandic geothermal cluster July 2011–December 2012

When the projects are analyzed in terms of the mapping of the cluster from the profile phase, it turns out that they touch on all the major surfaces of the geothermal cluster, as shown in figure 19.

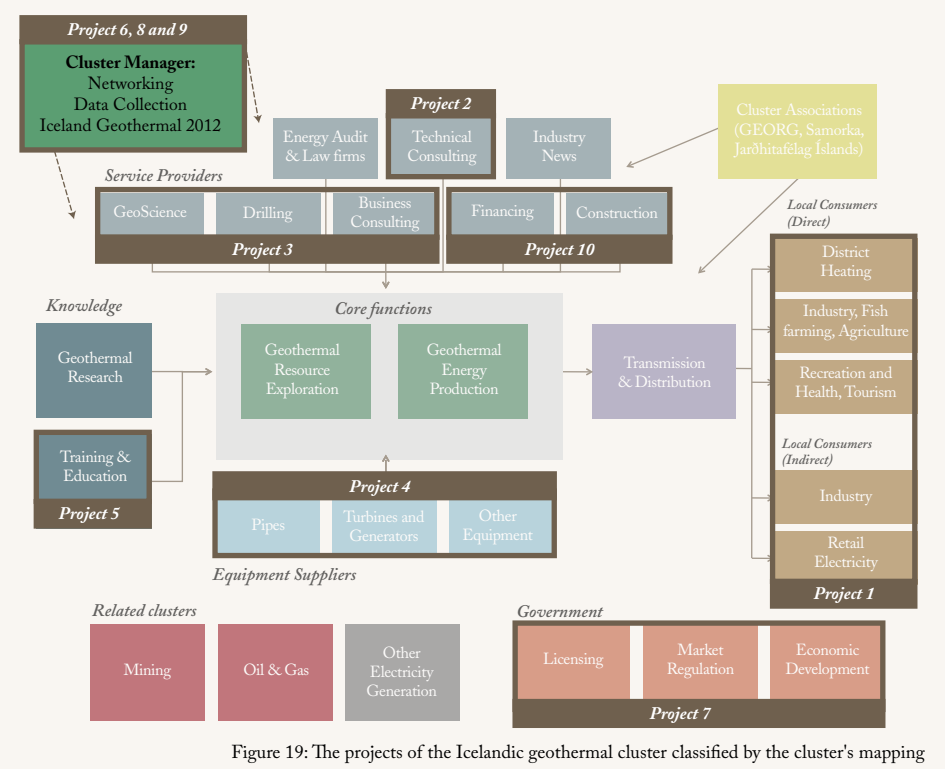

Figure 19: The projects of the Icelandic geothermal cluster classified by the cluster's mapping

As figure 19 indicates, none of the projects address geothermal research directly, since it is assumed that GEORG provides that platform concerning cluster cooperation. Some of the projects, however, touch on research in an indirect manner, hence it is important that they be defined and refined in consultation with GEORG.

Also, it can be seen that none of the projects addresses environmental impact directly. The reason is that environmental issues are not isolated: "They are ubiquitous in all areas of geothermal energy", as Ari Trausti Guðmundsson put it so well in the workshop on 4 May 2011.

An improved conduct towards the resource can improve the utilization of geothermal energy. The environmental impact is thus one of the driving forces for better utilization and innovation in geothermal energy. This is reflected clearly in the material collected in the workshop. For example, environmental impact is addressed specifically in the goals of projects 1, 3, 4 and 7. It is therefore important that environmental aspects touch the projects that have been identified here, where possible. In light of this, the participation of conservational organizations like Landvernd will strengthen the cluster cooperation.

4.2.3 The aim of the cooperation

The ten projects identified above are those projects that the cluster members have agreed need to be contemplated independent of the cluster policy. The question about the strategy of the Icelandic geothermal cluster is, however, still unanswered as noted above.

The projects define a specific cooperation policy and cooperation forum of the parties within the cluster. All in all, it can be said that their vision is Added value in geothermal.

The purpose of embarking on the said projects is, firstly, creating the cluster's cooperation platform for further development and growth. Secondly, the project work involves a certain search for key skills and added value within the cluster, on the terms of the companies.

The ten projects by no means define the ultimate challenges of the cluster cooperation in futurity. They are conceived as first steps towards a robust cluster cooperation operating by a clear strategy and objectives.

It would be preferable that the cluster be fortunate enough to seize the opportunity that arises with the processing of the ten projects, to gather the necessary data, analyze the competitive advantage and the value chain of the geothermal cluster and position it in an international context.

In this context, it must be considered whether the Icelandic geothermal cluster at all is in any way unique compared with other geothermal clusters. If so, its unique strengths can be defined in an international context. Subsequently, further cooperation projects will be agreed on and prioritized to further strengthen the defined unique position of the cluster. At the same time, the elements of minor importance in this context need to be outlined and less emphasis placed on them.

With the progress of the geothermal cluster project to date a large quantity of data and ideas has accumulated that can be used in further work. There is, however, still a lack of certain information, such as statistics related to the utilization of geothermal energy in Iceland and even comparisons from other geothermal clusters, so that thought-out policy decisions can be made.

Until the policy of the Icelandic geothermal cluster will be shaped, the objectives of the cooperation of the Icelandic geothermal cluster can be defined based on increased competitiveness - based on increased innovation - which in turn depends on the interplay between competition and cooperation within the cluster, cf. the figure 20. This is in line with beforementioned vision.

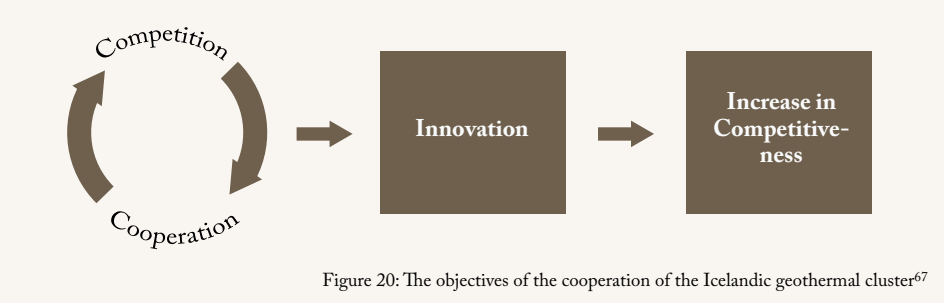

Figure 20: The objectives of the cooperation of the Icelandic geothermal cluster[67]

It is proposed that the following factors will be used as reference in the processing of the ten projects:

- Improve the competitiveness of the geothermal cluster and, consequently, Iceland.
- Promote innovation in geothermal energy.
- Increase the value of products and services in geothermal energy.
- Strengthen the existing businesses in geothermal energy.
- Promote entrepreneurialism in geothermal energy.
- Attract domestic and foreign investment in geothermal energy.
- Promote exports in geothermal energy.

It has been reported that the geothermal resources of Iceland are of high quality and that there is a large quantity left to exploit. Furthermore, an excellent cooperation between cluster members to date has been described. Members of the geothermal energy cluster therefore could get away with continuing to do things as they do them now and undoubtedly achieve good results without a formal cooperation. It is therefore natural that parties ask themselves what is the driving force for a formal cooperation of the Icelandic geothermal cluster. Among the answers may be noted:

- There is a need for a consensus on the use of geothermal energy in Iceland. The geothermal cluster could play a key role in this respect by creating a forum where there is an increased emphasis on environmental issues, multiple use, value creation and better relations with the government.
- New geothermal projects are on the drawing board. They involve the opportunity to make things better than hitherto, make the position of the cluster members even more unique and increase their value creation.
- Through the project on the development of the cooperation of the Icelandic geothermal cluster since October 2009, a certain awakening and motivation has emerged for cluster cooperation within the geothermal - which is not a given.
- Within the cluster there are leading individuals who are willing to work on the cluster's success and increased value creation.
- The Icelandic geothermal cluster could be a model for the evolution and structure of other clusters in Iceland.

67. Based on Pamminger, 2010.

- Examples from other countries show that strong formal cluster cooperation can significantly enhance the development of the relevant cluster.
- Last but not least, the primary objective of the cluster cooperation is to deliver economic benefits to the cluster members.

In this context, it is equally important to highlight what a formal cooperation in the Icelandic geothermal cluster should not be about:

- The cooperation should not overshadow the activities of individual cluster members.
- The forum does not involve that the cluster members contemplate or mutually embark on particular geothermal projects overseas.
- The cooperation should not be about grants, although they could be one part of the work as a certain kind of carrot for cooperation.
- The cooperation should not be about on lobbying, but rather be a platform for dialogue and joint action of different stakeholders.
- The cooperation should not be some kind of monolith. Rather it should be simple in operation and easy to shut down if the cluster members do not consider its continued operation beneficial.

The interest of the cluster members to work together in an orderly manner on the basis of the projects defined above has been established. At the same time, people wish to tread gently regarding the structure and scope of the collaboration platform.

The time was deemed not ripe to bring the defined projects into the geothermal research-driven cluster cooperation of GEORG. It was considered more auspicious to ensure the implementation of the ten projects in a so-called industry-driven cluster cooperation of geothermal energy, hereafter called Iceland Geothermal for differentiation.

Thus, the situation is such that one Icelandic geothermal cluster exists in Iceland. Within it, there are two approaches to cluster cooperation that will be managed by each its own cluster manager: on the one hand, research-driven cluster cooperation (GEORG) and, on the other hand, industry-driven cluster cooperation (Iceland Geothermal).

It is of paramount importance that a good cooperation and communication prevails between GEORG and Iceland Geothermal; both parties share a strong desire for this to happen.

The interaction of this cooperation can be described by the diagram in figure 21. It reflects the essence of the cluster ideology, i.e., how to create a value from research and knowledge to improve the prosperity and welfare of the geothermal cluster and society as a whole.

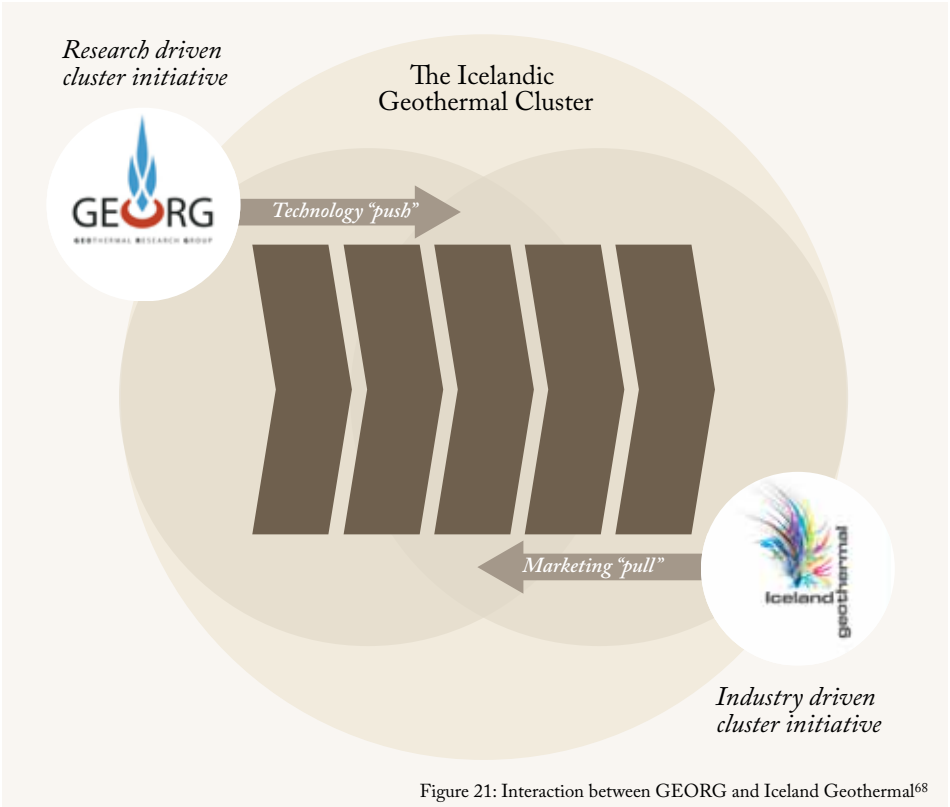

Figure 21: Interaction between GEORG and Iceland Geothermal[68]

Based on the foregoing, the cooperation policy as described in the previous chapter and consultation with the steering committee that has lead the development of the cluster cooperation since 16 March 2011, it is proposed that the implementation of the formal cooperation of Iceland Geothermal will be organized as follows.

68. Hákon Gunnarsson and Hjalti Páll Ingólfsson; based on the Danish Agency for Science, Technology and Innovation, n.d.

- The cluster cooperation is based on the ten cooperation projects that have been defined, namely;
  1. Divers usage
  2. Project management
  3. Drillings
  4. Equipment; development and maintenance
  5. Recruitment in the industry
  6. The conference Iceland Geothermal 2012
  7. Operational environment
  8. Data collection
  9. Cluster networking
  10. Financing

- The projects will be worked on temporarily, from July 2011 to December 2012.

- In December 2012 the success of the projects will be reviewed and determined if the formal cooperation of Iceland Geothermal should continue and in what form. During the 18-month probationary period cooperation with GEORG will be systematically worked on, so that the relations between industry and research within the Icelandic geo thermal cluster will be strengthened, even anticipating the possibility that GEORG and Iceland Geothermal will later merge. At the same time improved information collection will be worked on to provide the prerequisites and basis for thought-out decisions on the strategy and uniqueness of the Icelandic geothermal cluster.

- The work on the ten projects happens in the manner that the steering committee nominates 5-7 individuals from the geothermal cluster to form professional groups around each project, as appropriate.

- It is important that a good cooperation is established around each project and that appropriate partners are recruited to the table. The cluster manager ensures that experts be called in to work with the groups as needed. The work of individuals within professional groups is not remunerated separately but it is assumed that employers support the cooperation by covering the salaries of the staff involved in the work of professional groups.

- Each professional group will have finished developing their projects further by September 2011, in consultation with the steering committee and in accordance with what is considered reasonable given the time and circumstances. In this context one also needs to consider the projects that GEORG is involved in and explore how the work that takes place there can be integrated. Similarly, the goals that are to be achieved by December 2012 will be further defined. Good material is present from the profile phase and the workshop of the geothermal cluster from 4 May 2011.

- Gekon will serve as the cluster manager of the Iceland Geothermal cooperation. The role of the cluster manager includes having an overview of the projects in addition to guiding, supporting and arranging the work of the professional groups to his best abilities. The cluster manager ensures that the implementation of the projects happens

according to plan. Overlap of some projects is clear, but the cluster manager is responsible for integrating and coordinating the work of the groups as appropriate. The cluster manager informs the steering committee of developments as they unfold.

- The projects will be financed through monthly subscriptions from the cluster members under a service agreement with Gekon. In May 2012 a meeting will be held with cluster members to discuss the progress and status of individual projects. If their progression is considered unacceptable, the cluster members will be given the opportunity to withdraw from the cooperation.

- It is assumed that the cluster cooperation of Iceland Geothermal happens on the terms of the industry. Among its main workhorses are the energy companies, since they are part of the cluster's core operations. Also, it is crucial that decisive individuals within the cluster will pull the work forward.

- Last but not least, it is vital that the government does not stand on the sideline, but engages in dialogue with the cluster, listens to its needs and priorities, provides it with a better work environment and so on.

If the result is as intended, the company-driven cluster cooperation of the geothermal cluster is taking its first steps towards formal collaboration platform. It should be noted that research suggests that it takes formal cluster cooperation four years to reach maturity.[69] In time, as experience of the cooperation will develop and more detailed data on the cluster will emerge, there is hope that it will be possible to define the strategy and uniqueness of the Icelandic geothermal cluster, for its and society's continued growth and value creation.

69. Lämmer-Gamp, Hantsch & Nerger, 2011.

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Figures

Tables