

Engine workshop 4:

Drilling cost effectiveness and feasibility of high temperature drilling

Opening address by Ólafur G. Flóvenz, general director of ISOR

Ladies and gentlemen

I wish you welcome to this ENGINE workshop that is now held in the premises of ISOR, the Iceland GeoSurvey.

Geothermal energy is abundant in Iceland, which is indeed one of the richest countries in the world in terms of geothermal energy, thanks to the combination of its location on the Mid-Atlantic Ridge and high tectonic activity. A landward continuation of the ridge axis crosses Iceland from South-West to the North East forming a belt of volcanism and rifting that is characterized by a chain of volcanic centres with associated magma chambers, rifting processes, hot springs and steam vents.

The settlement of Iceland started in the year 874, when a Norse wiking named Ingólfur Arnarson settled down here in Reykjavik with his family. He gave the place the name Reykjavik, which translates as the „Bay of Smoke“, the smoke refers to the steam rising from the natural hot springs in the neighbourhood of Reykjavik. So geothermal was already in the name of the first permanent settlement in Iceland.

Recently archaeologist excavated ruins of a farm from this time in the centre of Reykjavik, possibly the first farmhouse of Ingólfur Arnarson. These ruins can now be seen at the settlement exhibition downtown. In addition to archaeological evidence the history of Iceland is very well documented from the early beginning both in the literature and historical documents.

Although not a major issue, evidence from the use of geothermal water can be found in the literature. It is evident that the natural hot springs were mainly used for bathing and the geothermal pools have been the arena for dramatic events. One of the most famous and dramatic love stories in the Icelandic Sagas starts when a young man and a young lady meet in a geothermal pool.

In the early 13th century the Icelandic writer Snorri Sturluson, lived in the geothermal farm Reykholt in the western Iceland. Among others, Snorri wrote the story of the Norwegian kings and one of the best existing descriptions of the ancient pre-Christian poetry and faith among the Nordic people. He made a geothermal bathing pool at his farm that still exists and there was made a geothermal conduit from a hot spring several hundred meters away. This was the first known geothermal pipeline in Iceland.

Unfortunately, Iceland lost its independence in the thirteenth century, became first part of the Norwegian kingdom and later the Danish that governed Iceland until 1918 when Iceland regained its sovereignty and became a republic in 1944. During the nearly seven centuries under foreign power, combined with relative cold climate and lack of technology Iceland was one of Europe's poorest

countries until in the 20th century. In this period there was no considerable advancement in geothermal utilisation apart from few attempts in the late 17th century, including the first geothermal drilling.

In the beginning of the 20th century technological advancement started in Iceland, mainly through the fishing sector. In the first decades of the 20th century attempts were made to heat houses in Iceland by piping hot water from natural hot springs and later shallow boreholes to the houses. The first geothermal green houses appeared at similar time. In the year 1928, the first district heating system in Iceland started, when a few kilometre long pipeline was made from hot springs in Reykjavik to a swimming hall and the nearby houses.

In the next years the progress was slow, technological problems like corrosion and scaling did cause severe problems and there was opposition to further development of geothermal for house heating. But there was also lack of technological knowledge in the country; engineers were very few and hardly any geologists.

In the late thirties two young men from Iceland went to Germany to study mechanical engineering. Both were stuck in Germany during the Second World War but came home immediately after the war and became leading persons in the post war development of geothermal energy in Iceland. This person were Gunnar Bödvarsson and Jóhannes Zoëga. Gunnar Bödvarsson was in 1945 hired as at the first director of the new geothermal division at state electricity authority that later became Orkustofnun and still later ISOR. He was a pioneer in geothermal research, in geophysical exploration, geothermal drilling and in reservoir physics. He moved to America in the sixties and where he was the rest of his life as a professor. Gunnar contributed greatly to our understanding of the geothermal systems and his work is still the basis of our geothermal knowledge. Jóhannes Zoëga became the director of Reykjavik Energy for decades. He leaded the technical development of the Reykjavik district heating system and under his leadership the technical and non-technical barriers for the geothermal development in Reykjavik was removed.

The next steps in the geothermal development were taken during and shortly after the Second World War. A 15 km long pipeline was built from a geothermal field outside Reykjavík and a considerable part of Reykjavik became geothermal heated. At the same time several towns and villages in the countryside where conditions were favourable got geothermal district heating systems. There was a slow advancement but steady in direct use of geothermal until 1970 when just over 40% of all houses were geothermal heated. But fossil fuel was cheap so the economical driving force for geothermal development was missing.

In 1973 the first world oil crisis came and the price of oil rose greatly. This made the energy bill for house heating in Iceland much higher than before, but as you might know we have to heat our houses throughout the year in our cold climate. Also at that time environmental issues became more and more important. The government of Iceland made the political decision to remove fossil fuel from the house heating sector as soon as possible. Considerable amount of official money was put into geothermal research and education and a risk mitigation fund for geothermal drilling was established. Most of ISOR's present experienced specialists started their carrier during this period.

Today almost 90% of all houses in the country are heated directly by cheap geothermal water; the consumer price is typically in the range of 1-2 eurocents per kilowatt-hour. The remaining houses

are heated by electricity that is produced from renewable energy resources, hydropower or geothermal. The space heating sector is thus saving the people lot of money in addition to the environmental benefits.

In some cases the resource is quite close to the customers but it is common that hot water is piped 5-30 km from the geothermal fields to the customers. In Reykjavik we still have the world's largest geothermal district heating system but it might soon be competed by a Chinese city. But the market for space heating in Iceland is now mature, we are still hoping to increase the ratio of geothermal heated houses and connect more villages to geothermal district heating systems. But Icelandic geothermal companies are looking for a market for their experience and knowledge abroad.

I have until now only discussed the development in direct use of geothermal in Iceland. But we do also produce electricity from geothermal. The first attempts to produce electricity from geothermal were done around 1950, half a century after the pioneering work of the Italians in this field. The first considerable geothermal power plant in Iceland, the 60 MW Krafla power plant, was built in the seventies. But during its constructions it suffered from repeated volcanic eruptions just few km away that caused lot of troubles but also technological challenges. It caused, however, that many people lost confidence in electricity production for geothermal resources. It took decades to overcome this or until very recently. Now there is ongoing a rapid development in electricity production from high enthalpy geothermal resources in Iceland. Electricity is now produced in six power plants with total of 410 MW installed. And steadily increasing technological knowledge has improved greatly the average output per geothermal well. This advancement applies to all stages of the geothermal evolution, including exploration, drilling and production.

And there are more geothermal power plants under development and it is expected that the geothermal electricity production in Iceland will double within few years and 3-4 new powerplants will be built.

But Iceland is a small country and there are big limits for how much renewable energy can be produced and consumed in the country without affecting the nature conservation areas. Therefore, for the time being there is a considerable interest among Icelandic energy companies and banks to invest in geothermal projects outside Iceland. Companies like Reykjavik Energy are already involved in development of geothermal district heating systems in China and central Europe and in development of electricity production in E-Africa. The private company Enx is developing projects in China, USA and Germany and the newly formed company Geysir Green Energy has big plans for investment in geothermal development and power plants outside Iceland.

We are often asked what is the key to the big success of geothermal in Iceland. The answer is not simple, but contains numbers of important factors. Firstly the geological conditions are favourable, but far from being unique. Secondly big governmental and political support for the development together with high public acceptance has helped a lot. Thirdly, strong scientific and technical background in domestic power companies, research institutions and engineering and construction companies has created a solid technological, theoretical and financial background, fourthly the free flow of knowledge from one partner to another and fifthly and not the least important one, strong participation in international projects, conferences and seminars.

The ENGINE initiative is a good example of the last point I mentioned. It brings together most of the geothermal players in Europe, creates a forum for exchange of information and outlines the challenges we have to deal with in the forthcoming years. It is an encouragement to all of us to disseminate our knowledge and remove barriers for development of the geothermal energy as one of the alternatives in solving the steadily increasing demand for renewable energy.

This workshop is dedicated to geothermal drilling. Technical advancements in this field combined with lower drilling cost per energy output is crucial for widespread production of geothermal energy in the future. It is my hope that this workshop contributes to this ambitious goal.

I wish you a good and fruitful workshop and hope you will have an excellent stay in Iceland.