The United Nations University

GEOTHERMAL TRAINING PROGRAMME
Orkustofnun, Grensásvegur 9,
IS-108 Reykjavík, Iceland

20th Anniversary Workshop
October 1998

HITAVEITA REYKJAVÍKUR
PAST – PRESENT – FUTURE

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ABSTRACT

The district heating utility in Reykjavík is the largest municipal geothermal heating service in the world. It started on a small scale in 1930 and now it serves more than half of the nation's populations. The harnessed power of the geothermal areas is about 750 MW thermal. Annually, 60 million m^3 of hot water flow through the distribution system.

1. THE HISTORY OF DISTRICT HEATING IN REYKJAVÍK

Geothermal activity has been known in Reykjavík from the time the first settlers arrived, over 1100 years ago, naming the place after the steam they saw rise from the hot springs. During Reykjavík's first 1000 years geothermal heat was primarily used for washing, bathing and cooking. For centuries women carried their laundry to the hot springs for washing (Figure 1). In 1928 drilling for hot water started at the thermal springs in Reykjavík. Fourteen holes were drilled and the result was 14 l/s of about 87°C. In 1930 a 3 km long pipeline was built and the first house connected. This was the beginning of district heating in Reykjavík. Shortly afterwards, a hospital, another schoolhouse, an indoor swimming pool and about 70 private houses were connected to the district heating system.

Figure 1: The use of geothermal water in Reykjavík around 1900 was mainly for washing

In 1933 about 3% of Reykjavík's population were connected to the Hitaveita Reykjavíkur (Reykjavík District Heating). At that time coal were mainly used for heating and a dark cloud of smoke was commonly seen over Reykjavík (Figure 2). The good success in district heating led to further development. A large geothermal area, Reykir, is located about 17 km east of Reykjavík, and was considered to be ideal for that, as it was both relatively close to Reykjavík and capable of producing great quantities of geothermal water. After

Figure 2: In the 1940's black cloud of smoke was common to be seen over Reykjavík.

acquiring geothermal rights from landowners, drilling commenced in 1933 and in the next decade some 72 holes were drilled. Work began in 1939 on laying the pipeline to Reykjavík as well as laying distribution pipes within the city. By the end of 1943, Hitaveita Reykjavíkur could deliver 200 l/s of water at 86°C.

Test drilling and additional research also resulted in more geothermal water being found inside Reykjavík. In 1957, the state and the city together purchase a more powerful drill rig. That, including the installation of pumps in existing wells, increased the efficiency of drilling and water extraction. In spite of this only about half of the residents had access to hot geothermal water in the 1940's and 1950's.

Several holes were drilled between 1967 and 1970 in a geothermal area by the river Ellidaár and the Reykir field was re-opened by drilling deeper wells. At the end of 1972, 97% of houses in Reykjavík had geothermal water for heating. Moreover, pipelines were laid to nearby municipalities, which are now supplied with geothermal water by Hitaveita Reykjavíkur.

The use of geothermal water for space heating in stead of fossil fuels reduces air pollution. Thanks to geothermal district heating, Reykjavík is one of the cleanest capitals of the world. Today almost all houses in the area are connected to the district heating system. Hitaveita Reykjavíkur serves 56% of the population of Iceland with geothermal water and is the world's largest municipal geothermal heating service. The installed power is about 750 MWt.

The cost of heating in Reykjavík is only around 1/3 of the price of heating oil. Figure 3 shows the average price of heating in the Scandinavian countries compared to the heating cost in Reykjavík. The price of heating in Finland is more than double, and in Sweden and Denmark it is more than four times more expensive to heat the houses than in Reykjavík.

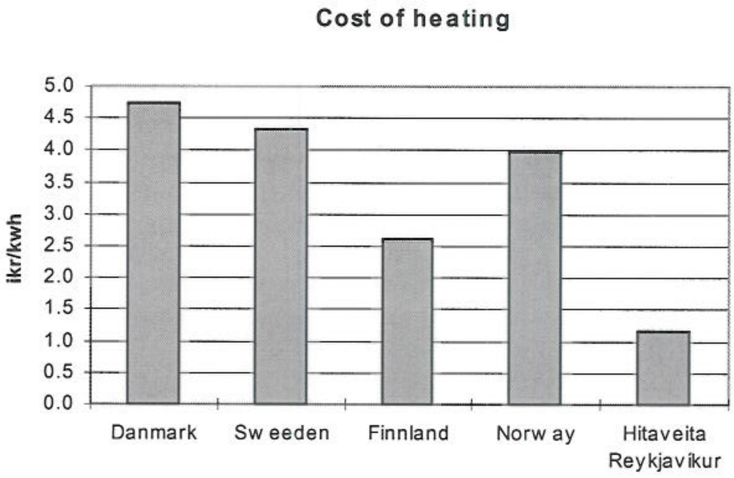

Figure 3: Price of heating in Reykjavík compared to the price of heating in the Scandinavian countries

2. THE GEOTHERMAL FIELDS

Three low-temperature geothermal areas utilized for district heating in Reykjavík and a high-temperature geothermal field at Nesjavellir (Table 1). In the low-temperature fields there are total 52 production wells with a total capacity of about 2300 l/s. At the Nesjavellir high-temperature field 200 MWt are installed, equivalent to about 1100 l/s. The temperature of this field is around 300°C. There cold water has to be heated in heat exchangers. From the beginning of October 1998, 30 MW electricity have also been generated at Nesjavellir and additional 30 MW will be on line at the end of the year 1999. At Nesjavellir 18 deep holes (1000-2200 m deep) have been drilled into the area. Ten of these are now connected to the plant.

Table 1: Summary of the geothermal fields

Field	Temp °C	Capacity l/s	No. of wells
Laugarnes	125-130	330	10
Elliðaár	85-95	220	8
Mosfellssveit	85-95	1700	34
Nesjavellir	250-300		15

2.1 Chemical composition

In general, more dissolved solids are found in geothermal hot water than in cold water, sometimes so much that it can not be considered healthy for consumption. Fortunately, the geothermal fields in Reykjavík and surroundings contain relatively low content of dissolved solids and can be used directly for heating and even cooking and drinking. The water almost fulfils the recommended values in drinking water standards. Only the sulphide concentration and the pH value are higher.

The water from the high-temperature geothermal fields can not be used directly for space heating due to the relatively high content of dissolved solids and dissolved gases. Therefore at Nesjavellir water and steam are used to heat cold groundwater in heat exchangers. After that the heated groundwater is deaerated and pumped to Reykjavík.

2.2 Production

Annual water production from 1944 is shown in Figure 4. For the first years the production was below 10 million tons per year but from about 1960 there has been an increase in production until about 1990. Since then the production has stabilized although the system has expanded and more houses are connected every year. The main reason for this is that today new houses are better insulated than old ones and water losses in the system have been reduced in the last few years due to more regular maintenance of the system. The weather is also a large factor and the last years have been relatively warm during the winter months.

The total power production in 1997 was equivalent to 323 MWt of which about 25% came from the Nesjavellir high-temperature field and 75% from the low-temperature fields. The largest low-temperature field, Reykir, accounts for more than 50% of the production both in power and volume of water.

2.3 Monitoring

Successful management of a geothermal reservoir relies on proper understanding of the geothermal system involved. The most important data on a geothermal system is gathered throughout the exploration and exploitation history through careful monitoring. The main factors are the production, the flow rate, the temperature of the flow, water level and chemistry. These values are important for all evaluation of changes in the reservoir and are important for simulations. Changes in chemistry are often seen before changes in temperature and can therefore predict further changes. The chemistry is also important for

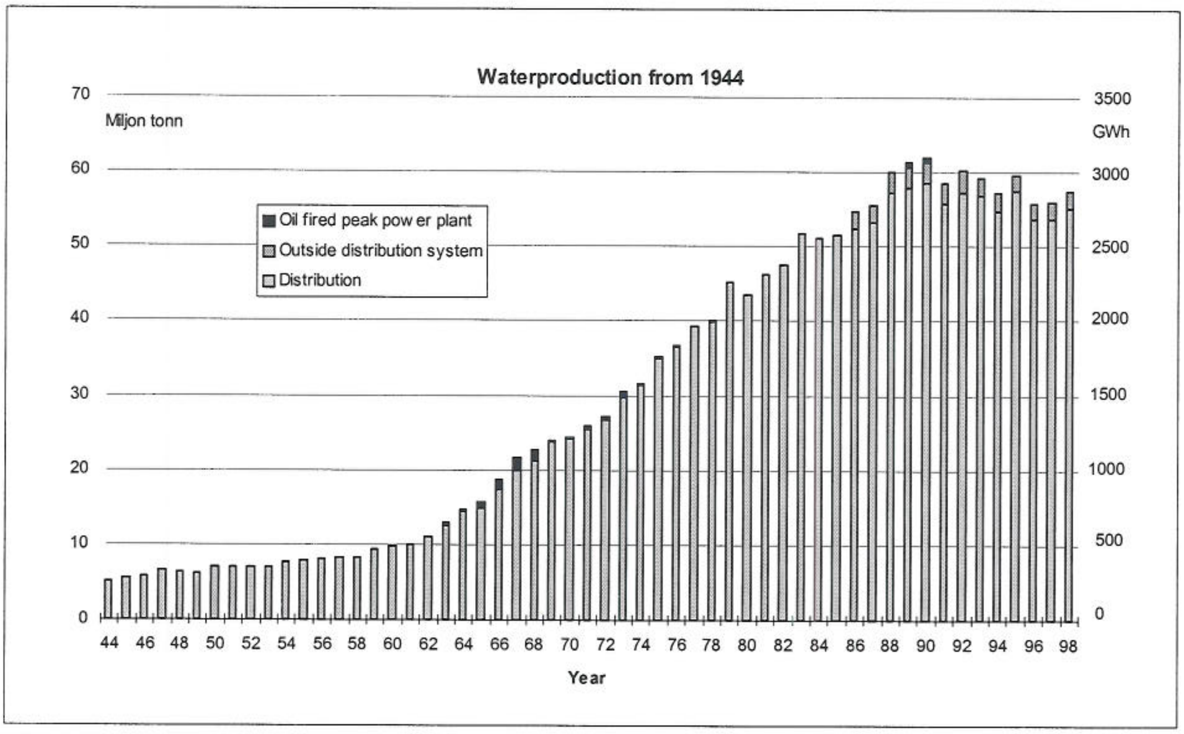

Fig. 4. Water production from 1944

Figure 4: Water production from 1944

all evaluation of corrosion and scaling.

Figure 5 shows exploitation and water level for the Reykir geothermal field over a period of 13 years. The production shows annual variation where the exploitation is high during the winter and low during the summer. The water level is shown as line for the same period, also showing annual variation. During the winter when the exploitation is highest the water level is lowest but it increases again during the summer when exploitation decreases. There is a steady drop in water level as pumping increases in the period from 1985 to 1990. In 1990 Nesjavellir were added to the system, and then pumping from the low-temperature fields could be reduced. Immediately, the water level rose. Balance between production

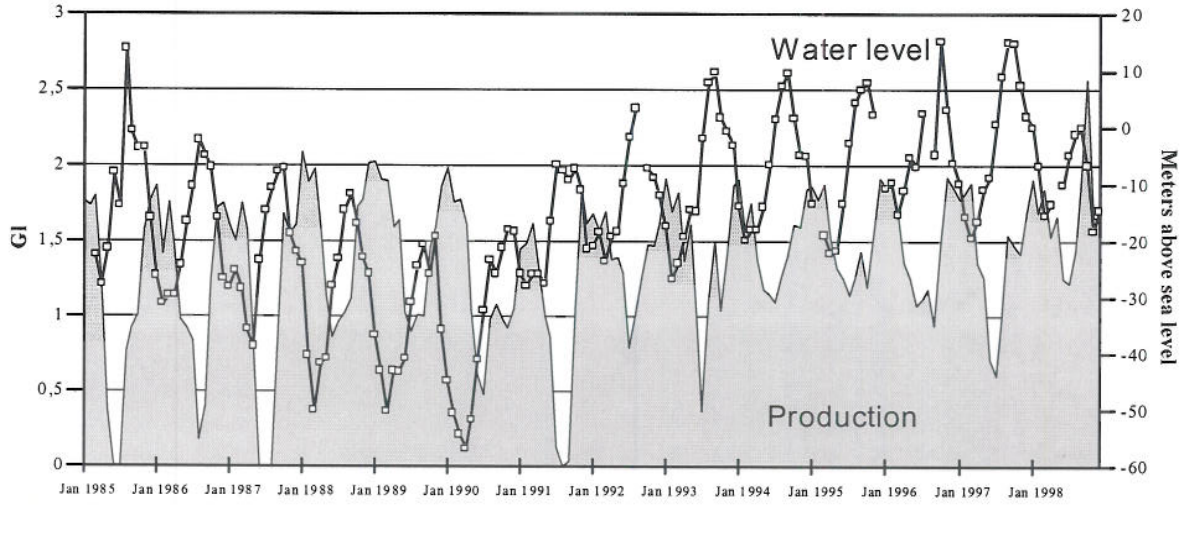

Figure 5: Production and water level for the Reykir (Reykjahlíð) field

and water level has been reached which indicates that the geothermal fields are sustainable. Similar can be seen for the other low-temperature geothermal fields where pressure decline reached maximum in 1990.

In 1985-1990 the water level was rather steady for the Ellidaár field but pressure drop caused increased flow of groundwater which led to temperature decrease and changes in the chemistry (Figure 6). Mixing with cold groundwater causes decrease of silica and fluoride concentration as well as decrease in temperature. Chemical changes can often be seen before noticeable changes in temperature are observed.

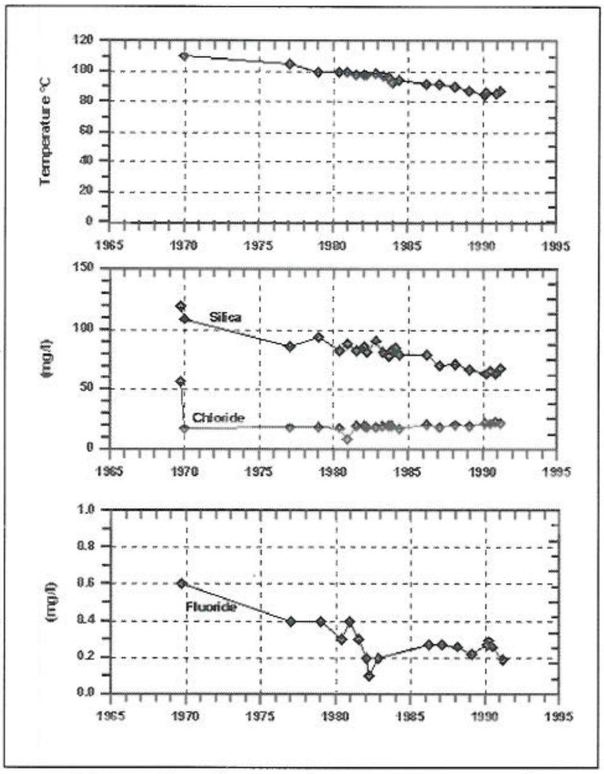

Figure 6: Changes in temperature and chemistry at the Ellidaár field

Monitoring data from the high-temperature field at Nesjavellir has made it possible to estimate total production from the field from the beginning of exploration (Figure 7). For the first years, only one well was producing but after 1983 the production increased as the number of wells increased. In 1985-1987 most of the wells were tested and in 1990 the thermal power plant went into operation. Total cumulative production is shown as a line. At the end of 1996 the total production of water and steam approached 80 million tons.

3. FUTURE OF DISTRICT HEATING IN REYKJAVÍK

More than half of the population in Iceland lives in Reykjavík and the surroundings. Hitaveita Reykjavíkur serves now about 56 % of the total population of Iceland. Besides the geothermal fields now

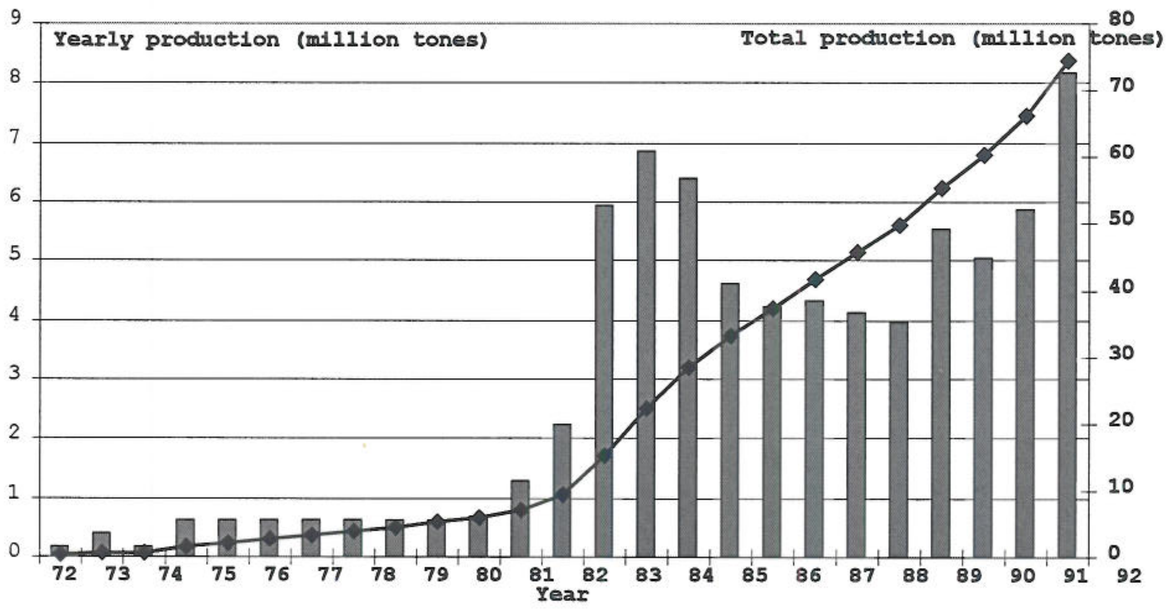

Figure 7: Production of water and steam from the Nesjavellir field

in use, there are other low-temperature fields in the vicinity of Reykjavík. Thermal water has been found on Geldinganes which might be used in that area. Three high-temperature areas are within appropriate distance from Reykjavík. These are the Krísuvík area, the Brennisteinsfjöll area and the Hengill area. The shortest distance from the Krísuvík thermal area to the distribution system is about 12 km. Since 1973, Hitaveita Reykjavíkur has had the right to use geothermal water from that area for space heating. But the main focus in next years will be in the Hengill area.

The Hengill geothermal area is one of the largest high-temperature areas in Iceland covering about 100 km^2 according to resistivity measurements and location of thermal activity. The Nesjavellir field is located on the northern part of the area and Hveragerdi near the southeast boundary. The chemistry of steam from fumaroles indicates temperature over 250°C in most of the area. The thermal activity has been divided into three main centers connected with three volcanic systems.

Nesjavellir is located in the northern part of the active Hengill volcanic system. To the east lies the Hrómundartindur volcanic system which last erupted about 10.000 years ago. The thermal activity in Ölkelduháls is connected with that volcanic system. The geothermal heat in Hveragerdi belongs to the oldest system, called the Grensdalur system. The main research focus of Hitaveita Reykjavíkur for the next years will be connected to the geothermal activity associated with the Hengill and Hrómunartindur volcanic systems. One deep exploration well has been drilled southwest of the Hengill mountain confirming temperatures of 260-270°C. Another deep exploration well has been drilled in Ölkelduháls but more drilling will take place there in coming years. The future for district heating is Reykjavík is bright as many unexploited geothermal fields are located in appropriate distance from the city.