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# The Complex History of Geothermal Utilization for the District Heating System of Hveragerði

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## ABSTRACT

The Hveragerði high-temperature geothermal field is located in SW-Iceland, close to the municipality of Hveragerði – a town with a population of about 2,500. The residents of Hveragerði have utilized the geothermal resource for house heating since the 1930's, - at first by using the direct flow from hot springs in the vicinity of the town, followed by drilling of the first wells in the area in the 1940's. Current district heating system includes a two-fold distribution system to supply 180°C steam and 100°C water from two 400 m and 700 m deep wells to industry, greenhouses and households.

Clogging of wells and precipitation within the distribution system have caused repeated operational issues, and attempts have been made to reduce these as much as possible. Measures include installation of heat exchangers and a closed-circuit district heating system for supplying hot water to households, reaming of the precipitates within the wells on regular basis and operating certain parts of the town on separate district heating systems.

Here we present the problems the district heating system of Hveragerði has been facing through its 80 years of operation and how these have been solved through repeated adjustments, redesigns and re-construction, which has resulted in the whole system being re-designed at least six times. Finally, we present the current future plans for this most complex utility found in Iceland.

## 1. HISTORY OF UTILIZATION

Hveragerði is situated in the South-West of Iceland, on the borderline between the high-temperature (>150°C) geothermal fields in volcano Hengill, and low-temperature (<150°C) geothermal fields in neighboring Ölfus (Figure 1). In various areas of the town, hot springs and pools can be found with temperatures up to 100°C. Underneath the surface are fractures containing geothermal heat, the main fracture facing North-to-South. At a depth of 125 m is a massive inflow of 180°C hot water, and another inflow of 170°C at around 250 m depth (Þórðarson, 1998).

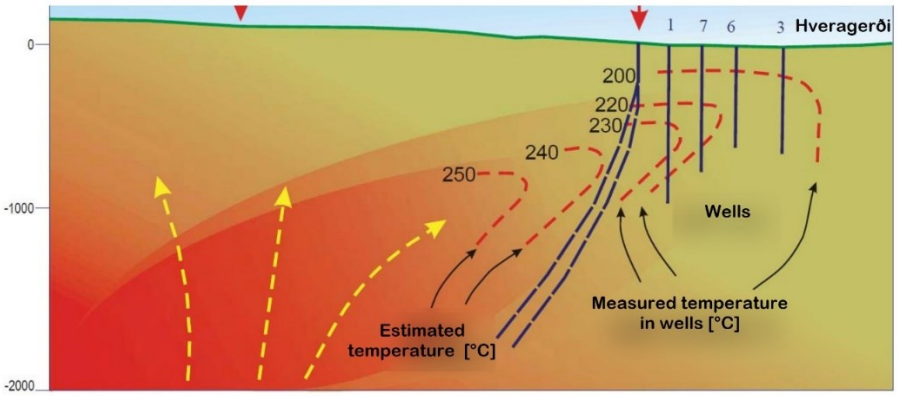


**Figure 1: An illustration of suspected geothermal heat shape, upstream of Hveragerði (Gunnlaugsson, 2018).**

A dairy-processing factory was set up in Hveragerði in 1928, and soon after habitation started to develop close to what is now the center of town (Þórðarson, 2007). Having no infrastructure to speak of, inhabitants started utilizing hot water from one of the hot springs by building timber ducts that led the water to cisterns by each house (Figure 2). In each cistern, cast-iron radiators were submerged and connected to the individual house-heating system. As the number of houses grew, more hot water was needed. In the years 1940-1945 a total of 15 shallow wells were drilled for individual usage, some of them bearing the names of individuals involved (Sæmundsson, 1970). The district heating systems were at this time almost as many as the houses, and therefore inefficient and rather expensive, considering the cost of drilling and optimal utilization of the hot water (Sæmundsson, 1970).

**Figure 2: Hveragerði geothermal park (Oren & Shimrit Nadir, 2019).**

The municipality of Hveragerði was formally founded in 1946 and from that time most of the boreholes were drilled by the municipality. Hitaveita Hveragerðis (Hveragerði District Heating Utility) was established in 1953 and the district heating in Hveragerði was monopolized. Usage of the boreholes was by artesian flow as before, but now through heat exchangers situated at the wells. Silica precipitated the wells, which in turn needed to be reamed every now and then, most often once a year (Sæmundsson, 1970). Steam from the wells, with a temperature of 180°C, was led directly through a separate supply system for heating of greenhouses that produced vegetables and flowers.

The Icelandic State had a few wells drilled in the North-Eastern part of Hveragerði and in the surrounding municipality of Ölfus, in the years 1958-1962 (Figure 3). The purpose was to feed a power-plant for electricity production, that to this date has not been erected. Some of these wells were quite powerful, and in 1972 the District Heating Utility of Hveragerði got the permission to use two of the wells. The wells supplied a mix of steam (180°C) and hot water (100°C) with artesian flow. After separating the steam from the water, the geothermal water was led through an open collection tank and from there directly through the distribution system to the users. The chemical state of the water led to hectic precipitation of pipes, mostly because of calcium. Steam was still supplied to several users, some for domestic heating, but mostly to greenhouses and for small-scale industry (Líndal, 1973).

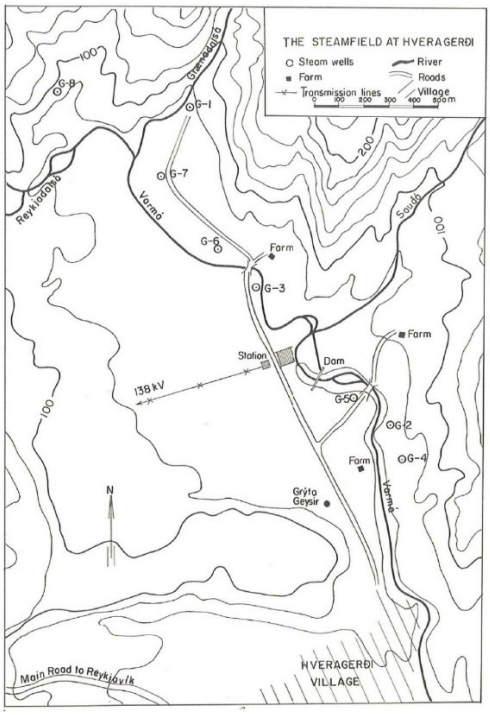


**Figure 3: Geothermal wells in Ölfusdalur (G-1 to G-8, later named HV-01 to HV-08) (Einarsson, 1961).**

In 1978, changes were made as groundwater was now heated in the collection tank and sent to the distribution system. The precipitation diminished somewhat, but still affected the distribution system, especially in small diameter pipes. Having no deaerator system also led to oxidation of the piping.

A new production well, HS-08, was drilled in a geothermal area in the center of town in 1989, and well HS-09 a few hundred meters to the north in 1999. A heat-exchanger station was erected in 1997 in the vicinity of well HS-08, heating deaerated groundwater and supplying to the domestic users via closed-circuit system, and usage of the State-owned wells was cancelled. The two aforementioned wells supply steam to the steam utility (now almost exclusively feeding greenhouses and small-scale industry) and geothermal water

to the heat exchanger station. As the wells blow geothermal steam through silencers, there have been some complaints from residents regarding the steam and noise (Figure 4).

**Figure 4: Geothermal steam from a silencer in Hveragerði (Veitur, 2018).**

As the pressure in the wells has gradually degraded through the years, the operation of the wells has gotten more and more problematic. As an experimental solution, a shaft pump was inserted into well HS-08 in 2017. As the temperature in the well is as high as 180°C, some return water from the heat-exchanger station was led back into the well, keeping the temperature at the pump around 140°C. Although the solution worked there were some issues, especially when starting up the pump and when the utility experienced electric black-out.

## 2. PRESENT SITUATION

Today there are several heating systems in operation in the municipality of Hveragerði. The main system is a closed-circuit system that transfers heat from heat exchanger station to users. The users utilize heat exchangers for domestic heating, for hot tap water and bathing, and for snow-melting systems, where applicable. The heat-exchanger station is connected to wells HS-08 and HS-09 (Figure 5), which supply artesian flow when this is written. Approximately 90% of the houses in Hveragerði are connected to this system, with relatively new piping and no major operational issues. The supply is metered in cubic meters and users charged accordingly.

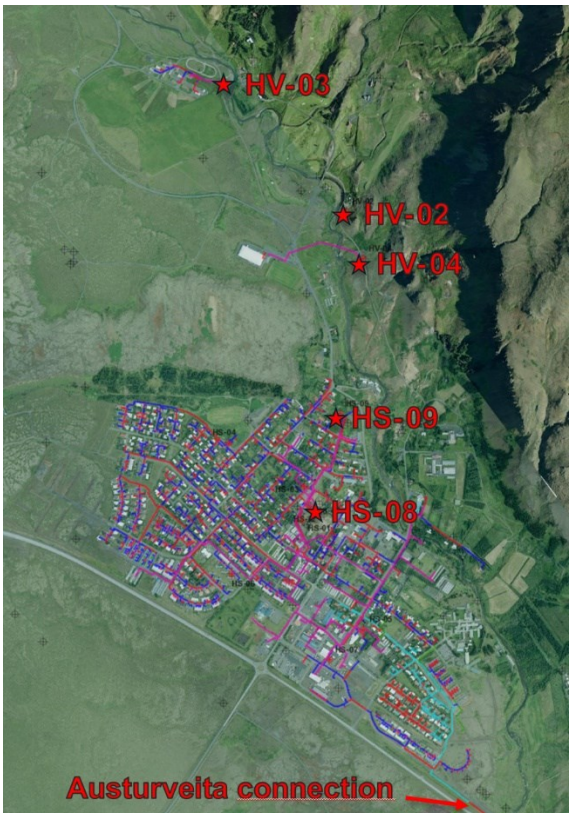


**Figure 5: Production wells in Hveragerði, Austurveita connection (light blue pipes), steam utility (velvet pipes) and closed-circuit system (red/blue lines) (Veitur, 2019).**

The second system is a direct-usage system, supplied from 3 wells in the neighboring Austurveita utility. Geothermal water is pumped up from the wells, mixed to appropriate temperature (approx. 80°C), and supplied to users. In some cases, the geothermal water is led straight through radiators for house-heating and supplies hot tap-water directly. The return water is then disposed of through the

sewage system. This system connects to around 10% of the houses in Hveragerði. In the same way as for the closed-circuit system, the supply is metered in cubic meters and users charged accordingly.

The steam utility, supplying steam of up to 180°C, is mostly used to supply steam for direct heating of greenhouses, and for industrial usages such as a microbrewery, an ice cream factory, direct heating of the local swimming pool and various other small enterprises. A few houses are connected to the steam utility for domestic heating, but work is in progress eliminating these connections and supplying said houses through the closed-circuit system. The steam utility is in a poor state, piping is aged and deteriorates rapidly, also the system is rather unstable being connected directly to the wells. Metering is non-existent and users are charged for their usage in accordance to the square meters of connected housing, which can perhaps be justified for the greenhouses but does in no way relate to the industrial usage.

In the outskirts of town to the north, there is a sports arena that is connected via a separate heat exchanger system to well HV-04. A few other users are connected via their own piping to this well and are as such not a part of Veitur's utility system. Metering is non-existent and usage is charged for in accordance to the square meters of connected housing.

Further to the north of the town, a group of horse stables are connected via a small heat exchanger station to well HV-03. This well supplies steam to the heat exchanger station, and also to a few houses across the river, being in a neighboring community and as such not a part of Veitur's utility system. Metering is non-existent and usage is charged for in accordance to the square meters of connected housing.

## 3. FUTURE DEVELOPMENTS

A study of how the future operations of the utility should be arranged, has been in progress since January 2019, and now we have a roadmap for the future (Figure 6). Submersible pumps will be inserted into wells HS-08 and HS-09. This is an experiment, as this is the first time, in our knowledge, that submersible pumps are used to pump geothermal fluid at a temperature of 180°C. It is scheduled to insert the first pump into well HS-08 in the fall of 2019, so hopefully the lecture will include a case study of the progress of that project.

Along with utilizing wells HS-08 and HS-09 with submersible pumps, well HV-02 will be reconnected, using artesian flow as an additional resource for the utility. From the wells, geothermal water and steam will be gathered to a blending station, where steam and fluid will be separated. The fluid will be led to current heat-exchanger station, that will be updated somewhat. Leaving the heat-exchanger station, the fluid will be led to two or three wells for reinjection, and possibly to some users that can make use of the brine, e.g. swimming pools. The heat-exchanger station will supply heat to a closed-circuit district heating system, supplying all normal heating of houses, hot tap water and snow melting to users, through heat-exchangers on the user side.

From the aforementioned blending station, it will be possible to supply steam to current and future users of the steam utility. This will give much better control of the steam utility, whereas users will no longer be connected directly to the wells, as is in current state.

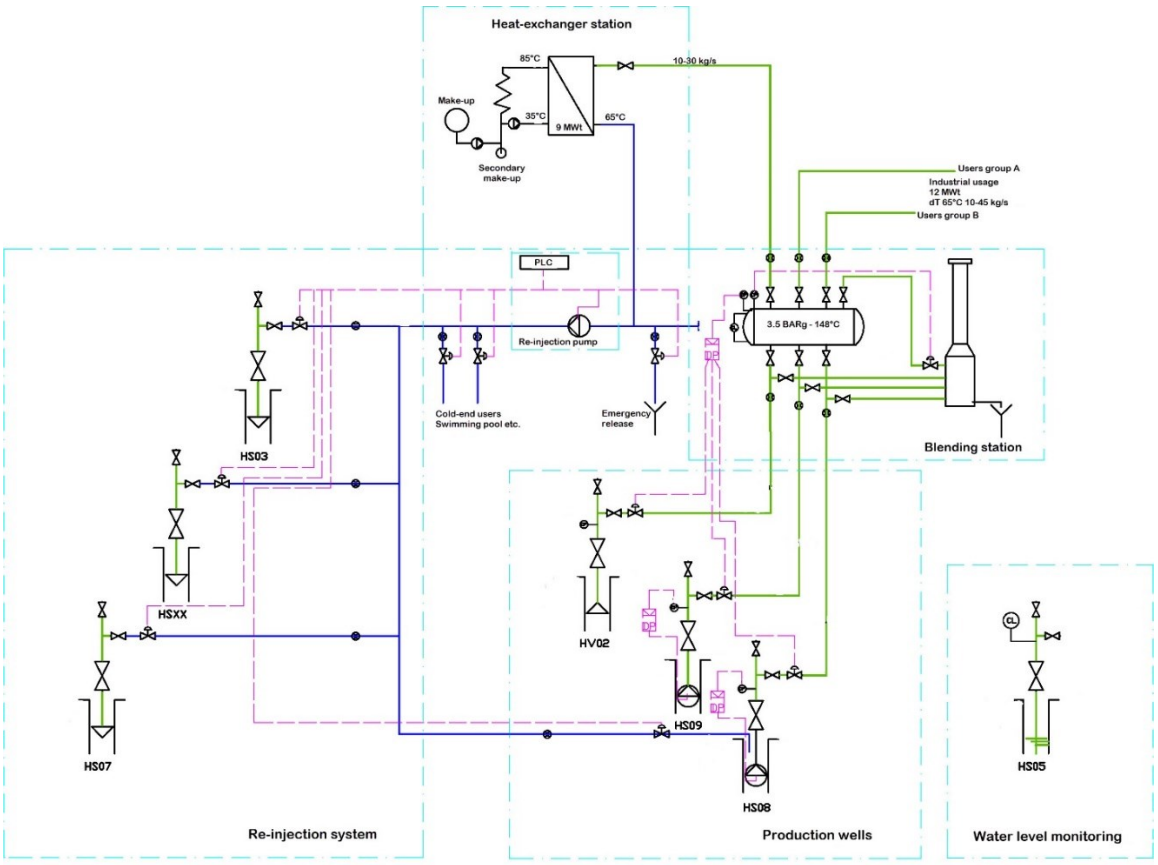


**Figure 6: Future plans for Hveragerði district heating utility (Halldórsson, 2019).**

An extension to the supply side is possible by connecting well HV-04, with artesian flow, to the supply pipe from HV-02. Experience shows that the supply of the utility has always been somewhat problematic, so having added security seems feasible.

## 4. DISCUSSION AND FINAL REMARKS

Here we have addressed the history of district heating in Hveragerði, current status of the utility and future plans for this complex system. It could seem somewhat surprising that a community with an abundance of geothermal heat could experience such difficulties. Considering the high temperature, chemical status, variable well pressure and the history of utilization, one grasps that the task of geothermal district heating for this region is a complex one.

Veitur utilities has a plan for future development of the district heating utility for Hveragerði and we are quite confident that our solution package will work. However, history tells us some bitter tales of solutions that were thought to be durable and permanent but ended up being more problematic than initially planned. Only time will tell if we will be successful in our undertakings.

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