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Operational Disruption Risks of the Reykjavík Area District Heating System with respect to Renewed Volcanic Activity on the Reykjanes Peninsula, SW Iceland

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ABSTRACT

Volcanic activity on the Reykjanes Peninsula is characterized by alternating periods of activity (~400 years) and quiescence (~800 years). Recent activity on the Reykjanes Peninsula demonstrates that a period of volcanic activity has started. The main operational disruption risks for the Reykjavík Area District Heating System are related to activity in Hengill. Half of the heat production capacity of the system is in the Nesjavellir and Hellisheidi Power Plants, located in Hengill, and half is in four low-temperature fields within the capital area. The Nesjavellir Power Plant is more vulnerable to disruption by volcanic activity as it is located within a rift valley, surrounded by recent craters. The Hellisheidi Plant is located west of the axis of recent volcanic activity. The pessimistic scenario assumes that lava flows from Hengill destroy the Nesjavellir Plant and take out half of the production field at Hellisheidi. This would result in a loss of 40% of the production capacity. During peak use supply to non-priority customers would be terminated and supply to households and businesses would be reduced by 25 and 50% respectively, resulting in conditions reminiscent of the pandemic when work-from-home was the norm. It is envisioned that within one year of the disruption temporary boilers to heat available return water would be installed and this would increase the capacity to about 75% of the maximum demand. We conclude that volcanic activity can potentially have a dramatic, but not catastrophic, effect on the operation of the Reykjavík District Heating.

1 INTRODUCTION

The Reykjavík Area District Heating System (RADHS) is a key infrastructure in Iceland, providing heat to about 65% of the population of the country. The RADHS runs entirely on geothermal energy, with no backup potential, neither electric nor fossil-fuel based. RADHS uses two incompatible fluid types, geothermal fluid from four low-temperature geothermal fields in and around the city and heated ground water from two geothermal CHP plants located in the Hengill Central Volcano, about 20 km to the east of the city. The production potential of low-temperature geothermal fluid and hot water from power plants is roughly equal but in recent years about 60% of the hot water has come from GPPs and the remaining 40% from low temperature geothermal production fields located within and around the city. The system is operated by Reykjavík Energy and its two subsidiaries, Veitur (e. Utilities) and ON Power (collectively referred to as Reykjavík Energy). Veitur operates the low temperature production fields and the distribution system and ON Power operates the GPPs.

The thermal power capacity of the system is currently around 1150 MW_{th}. When this capacity is compared to the maximum electricity consumption in the Reykjavík Area of about 250 MW_e it is obvious that meeting the heating needs of the Reykjavík Area with electricity is not an option, at least not in the short term. This means that the RADHS is highly vulnerable to major disruptions in the supply of hot water to the system.

The risk inherent in operating GPPs in the proximity of active volcanos was manifested when volcanic activity commenced at the Sundhnúkagígar craters, near Svartsengi GPP and the town of Grindavík, SW Iceland in December 2023. At the time of writing (October 2025) there have been nine eruptions in this system. To date it has been possible to prevent lava reaching the Svartsengi GPP by installing protective barriers but in February 2024 a lava flow destroyed the hot water pipeline to Reykjanesbær, leaving the town of 20,000 people without heating for about 4 days. This caused a major disruption for the Reykjanesbær community and massive property damage was only narrowly avoided. These events raised questions about the vulnerability of the RADHS with respect to volcanic eruptions.

This paper summarizes the findings of our analysis of the threat that volcanic activity poses for the RADHS. We evaluate possible scenarios whereby volcanic activity would disrupt the operation and how much production

capacity could potentially be lost if the most pessimistic scenarios are realized. We evaluate how the use of heat could be curtailed in an emergency and draw up a likely scenario for the response to a massive loss of production potential in the short and medium term.

2 VOLCANIC ACTIVITY IN THE REYKJANES PENINSULA

Volcanic activity in the Reykjanes Peninsula is confined to 5 to 6 distinct volcanic systems. The systems consist of eruptive fissures that can be a few km to more than 10 km long and even longer fault zones that can extend a few tens of km from the volcanically active belt. At the westernmost volcanic system, Reykjanes, the volcanic activity is mainly focused near the south shore of the Peninsula and moving eastwards the volcanic activity moves further inland. The focus of volcanic activity of the easternmost volcanic system, Hengill, is some 20 km from the shore.

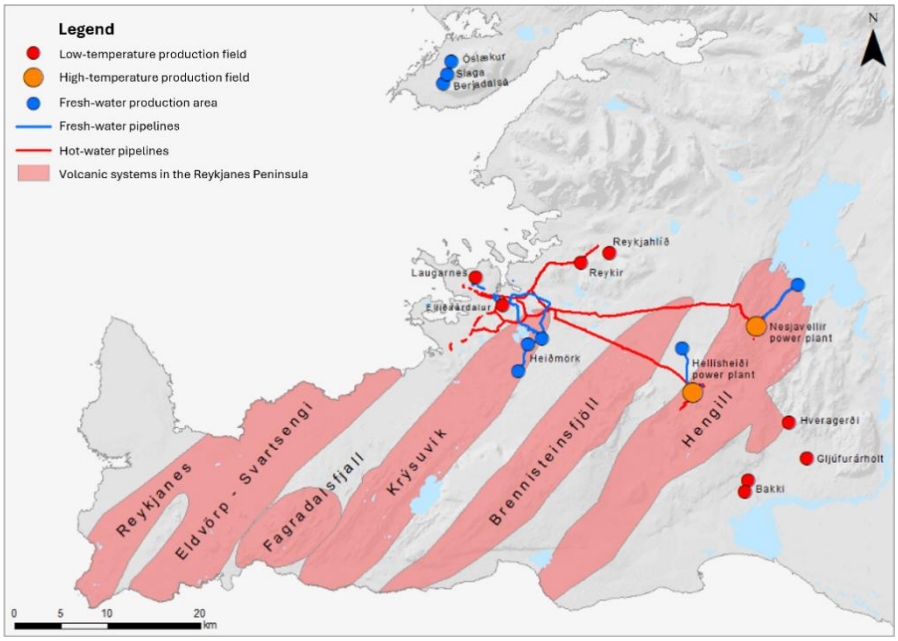


Figure 1. Volcanic systems in the Reykjanes Peninsula and Reykjavík Energy's key infrastructure for both hot and cold-water supply in the immediate vicinity (based in part on data from ÍSOR)

Figure 1 shows the location of resource areas for hot and cold-water supply that are operated by Reykjavík Energy's subsidiaries. The figure shows that the high temperature production fields in the Hengill area, Nesjavellir and Hellisheidi are located inside the Hengill volcanic system and the hot water pipeline from these fields goes across the northern tip of the Brennisteinsfjöll volcanic system and near the tip of the Krýsuvík system. The low temperature resources in and around Reykjavík are all located outside volcanic systems.

Recent geological history of the Reykjanes Peninsula shows a pattern of alternating periods of activity and quiescence. Figure 2 shows that at least during the last 4000 years, periods of activity have lasted about 400 years, interspersed by 7-800 years periods without volcanic activity. Geological mapping has shown clear evidence for three cycles of activity and quiescence, and it is generally agreed that the eruptions in Fagradalsfjall (from 2021) and at Sundhnúkagígar (from 2023) marks the beginning of a new period of volcanic activity in the peninsula.

Figure 2 shows how the four westernmost volcanic systems on the Reykjanes Peninsula have been active during the three previous volcanic periods, whereas the Hengill volcanic system appears to have a less predictable behavior. The eruptive pattern of Hengill seems to have a different rhythm than the volcanic system to the west. During the last eruptive period in the Reykjanes peninsula there were no eruptions in Hengill. The most recent eruptive period in Hengill was around 1,900 BP and three earlier periods are known, at 5,500 BP, 8,000 BP and 10,000 BP. This suggests that in the next 400 years the Reykjanes, Krýsuvík and Brennisteinsfjöll volcanic systems will very likely become active as we have already seen in the Svartsengi system. As for Hengill, whether we can expect volcanic activity there in the next 400 years remains an open question. Based on the geological history during the Holocene it seems fair to conclude that there is a 50/50 chance of volcanic activity in Hengill in the next 400 years.

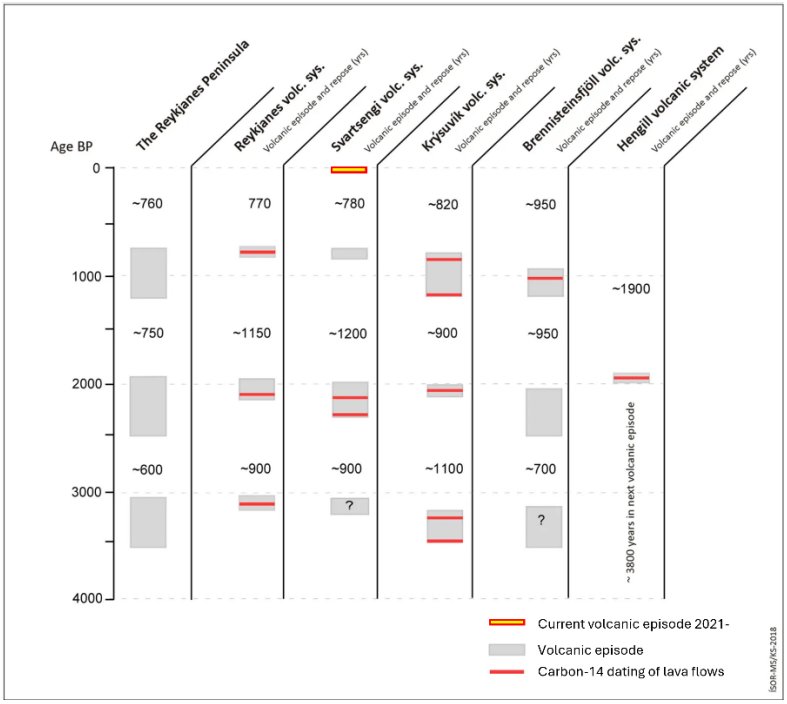


Figure 2. Volcanic history of the Reykjanes Peninsula. Modified from M. Sigurgeirsson, ÍSOR.

Figure 3 shows a closeup of the center of the Hengill volcanic system, highlighting the Nesjavellir and Hellisheidi production fields and Holocene lavas. The figure shows that during the most recent volcanic period in Hengill (at 1,900 - 2,400 BP) eruptions occurred on both sides of the mountain and that the production fields for the Hengill GPPs are largely located on Holocene lavas. During the two previous periods of volcanic activity in Hengill, i.e. at 5,500 BP and 8,000 BP, volcanic eruptions also occurred on both sides of the mountain. This implies that if the Hengill volcanic system becomes active during the current period of activity it is likely that volcanic eruptions will occur in the production fields of the two Hengill GPPs. However, the resolution in the geological record does not reveal whether these eruptions were occurring contemporaneously or if years or decades passed between eruptions on the north and south sides of the mountain. For this study it is assumed that eruptions will take place at Hellisheidi and Nesjavellir at the same time if the Hengill system becomes active in the near future.

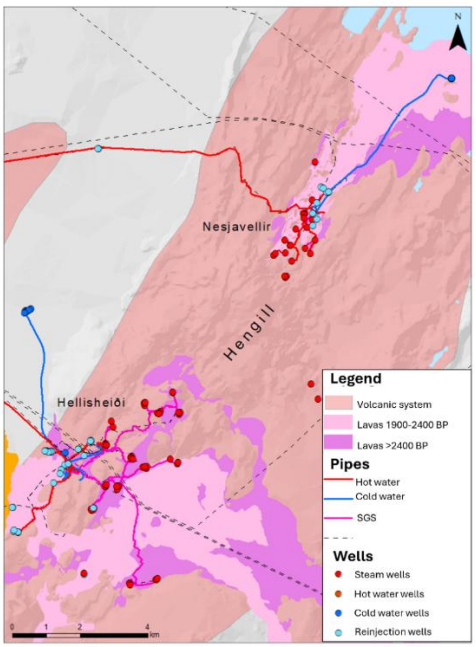


Figure 3. Production fields for the Hellisheiði and Nesjavellir GPPs and the distribution of Holocene lavas (modified from ÍSOR).

3 POTENTIAL IMPACTS OF VOLCANIC ACTIVITY IN THE REYKJANES PENINSULA ON THE RADHS

The potential impact of volcanic activity on the Reykjanes Peninsula on the RADHS depends strongly on the location of the activity, i.e. which of the five volcanic systems is active. Table 1 briefly summarizes what operational challenges for the RADHS are posed by the different volcanic systems. The table shows that the only volcanic system that poses a major threat of long-term disruption to the RADHS is Hengill. Activity in the other systems on the peninsula is not likely to result in significant, long term, disruptions in the operation of the system. As a result, the discussion in this paper will focus on potential impacts of volcanic activity in the Hengill volcanic system on the RADHS.

Table 1. Potential impacts of volcanic activity on different volcanic systems on the operation of the RADHS

Volcanic system	What could affect RADHS	Potential impact on RADHS	Probability	Severity
Reykjanes	Ash fall	Filters needed for AC equipment	Low	Negligible
Svartsengi	SO_2 gas emissions	Poor air quality complicates daily life	Low	Negligible
Krýsuvík	Deformation	Rupture of transport pipes and water storage tanks	Low	Minor
Brennisteinsfjöll	Deformation, lava flow	Rupture of transport pipes from GPPs due to deformation or lava flow. Repair could take days to weeks. Lava flows could reach the Ellidaárdalur low temperature production field.	Moderate	Significant
Hengill	Lava flow, opening of eruptive fissures, deformation	Destruction of GPP(s) could curtail full production for months to years. Rupture of steam gathering pipes could curtail production at GPP(s) for days to months. Rupture of transport pipes could limit supply from GPP(s) to Reykjavík for days to weeks	High (if Hengill becomes active)	High

3.1 The worst-case (yet plausible) scenario

Volcanic activity in the Hengill area, including eruptions, lava flows and surface deformation, could disrupt the activity of the power plants in several ways. For this paper we only focus on the most significant impacts in terms of the lost volume of production capacity and time span of the disruption. The most dramatic and long-lasting impact would be if a power plant was destroyed, either by lava flow or the opening of an eruptive fissure at the site. Other potential scenarios include lava flow across the production field resulting in the loss of some or all the production wells or damage of the SGS (steam gathering system) due to lava flow or deformation. Finally, lava flow or deformation could damage the hot water pipe to the Reykjavík Area.

Although it is impossible to assess with any certainty how future volcanic activity in the area will play out in detail there is, nevertheless, a reason to assume that Nesjavellir is more exposed to potential damage than Hellisheidi (see Figure 3). The power plant and most of the production field in Nesjavellir are nestled within the volcanic rift valley. The two most recent Holocene eruptions have occurred on either side of this valley, the eruption at 1,900 BP was on crater rows along the western slopes of the valley and at 5,500 BP the eruptive craters were on the eastern slopes. The valley floor is covered by lavas from the most recent volcanic episodes and a volcanic fissure opened in the slope immediately above the Nesjavellir Plant the last time the Hengill system was active. If an eruption occurs at the same location during the lifetime of the Nesjavellir Power Plant, it is hard to see how the plant and the production field could be protected from flowing lava. The hot water pipe from Nesjavellir also crosses crater rows from the most recent volcanic activity in Hengill, leaving it very exposed to future volcanic

activity. And finally, the fresh water supply for the Nesjavellir Plant is also within the rift valley, leaving it susceptible to damage by flowing lava and opening of eruptive fissures.

At Hellisheidi the picture is not as bleak as in Nesjavellir. First off, the power plant is located slightly to the west of the area that has been active during the Holocene (Figure 3). Even though the power plant was constructed on Holocene lavas they flowed to the area from a considerable distance and based on the experience from Svartsengi it seems possible to protect the Hellisheidi Plant from lava flow using protective barriers to divert flowing lava. Secondly, the production field at Hellisheidi is large and there are several wells that are located west of the Holocene eruptive fissures. This means that during an eruption in the area, the Hellisheidi Plant could remain connected to some of its production wells. And finally, both the fresh water supply for the Hellisheidi Plant and the hot water pipe to Reykjavík are located on Quaternary rocks, west of Holocene volcanics. Based on this we conclude that it is reasonable to assume that the Hellisheidi Plant would survive a volcanic eruption in the Hengill area. Similarly, it does not seem overly optimistic to assume that that some production wells will remain operational and connected to the power plant, despite volcanic activity in the area. In addition to currently connected production wells there are wells in the vicinity of the Hellisheidi plant that could be connected in an emergency, either by dropping the SGS pressure or by installing submersible pumps.

Following the above discussion, we assume that the most negative, yet plausible, scenario involves contemporaneous eruptions at Nesjavellir and Hellisheidi at the same time, resulting in total loss pf production capacity at Nesjavellir and that the production capacity of Hellisheidi would be reduced to about 50% of the current capacity. Figure 4 shows the implications of this scenario. It is assumed that at least for the next couple of decades the proportion between production capacities from low-temperature fields and GPPs will remain roughly the same (50/50). The total loss of production and Nesjavellir and loss of half of the production capacity at Hellisheidi would translate into a loss of about 40% of the total production capacity under current conditions. Figure 5 illustrates that a loss of about 40% of the production capacity means that the RADHS can meet full demand for approximately half of the year.

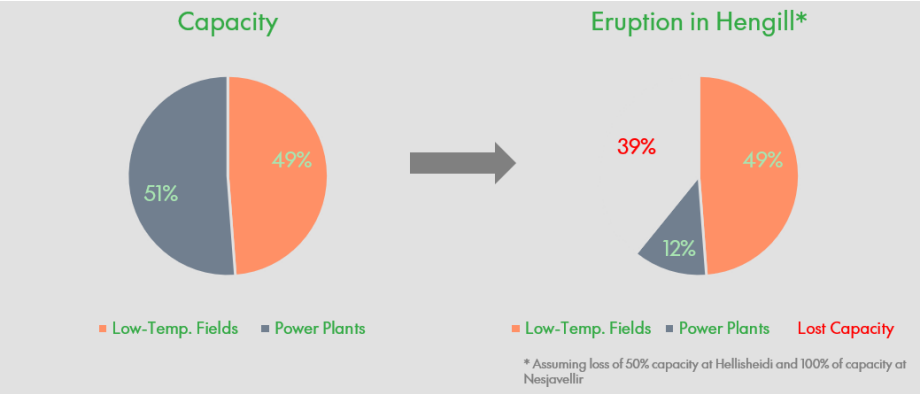


Figure 4. Relative proportions of low-temperature geothermal resources and hot water from power plants of the total capacity of the RADHS and the potential loss of capacity resulting from eruptions in the Hengill area.

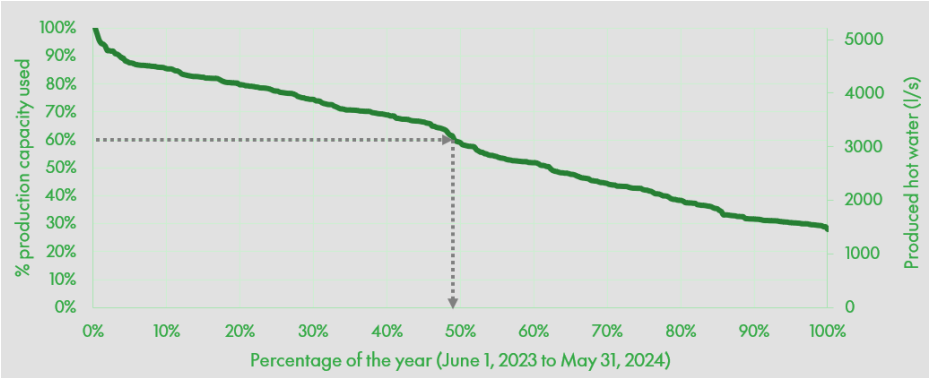


Figure 5. Duration curve for RADHS illustrating average daily production of the RADHS ordered from the highest to the lowest production. The gray arrows show that during the year in question, 60% of the production capacity would have met demand 50% of the days.

The geological record does not provide much guidance on the expected duration of volcanic activity in the Hengill system. However, it can be assumed that if power plants, production wells or SGS's are damaged by lava flows, the expected duration of the resulting disruption will be of the order of 1 to 10 years. Below we explore how Reykjavík Energy could deal with loss of 40% of its production capacity for up to a decade and what measures can and should be taken now, before any warning signs of imminent volcanic activity have been detected.

3.2 Potential responses to the worst-case scenario

3.2.1 Curtailment

It is not known what geologic or geophysical signals will indicate that the Hengill volcanic system is waking up from its dormant state, nor how long in advance such signals will be received. There are measures that can be taken to prepare the RADHS for this eventuality and they will be discussed below. However, for the sake of this discussion it is assumed that in the worst-case scenario, Reykjavík Energy is taken by surprise and must deal with the loss of 40% of its production capacity during winter, when demand is peaking.

Figure 6 shows the current proportional uses by sectors. The figure shows that about 90% of the peak demand is used for space heating of residential and commercial buildings (including all non-residential buildings, both public and private sectors). The remaining 11% are used by larger customers that have interruptible service contracts. The column on the right shows how we anticipate the proportional uses might look if 40% of the capacity of the RADHS was lost without any emergency backup solutions in place.

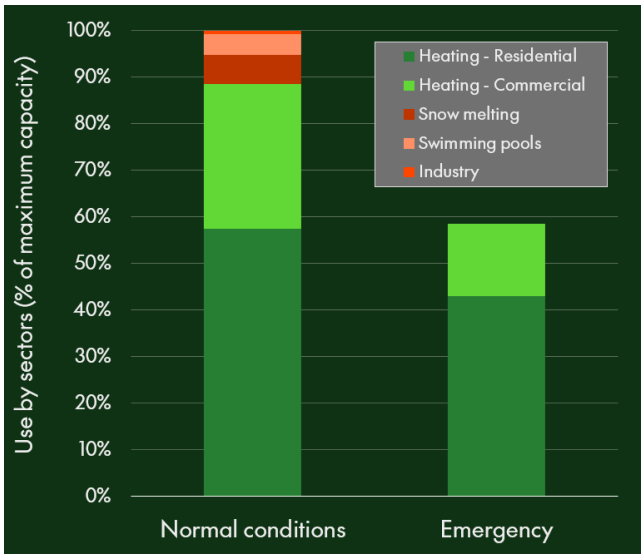


Figure 6. The column on the left shows the proportional use by sectors under normal winter conditions, and the column on the right shows how the situation could look in an emergency situation if 40% of the production capacity is lost.

Although service interruptions are rarely used and only to a limited degree, it is clear that in a disaster scenario heating of, first, residential and, second, commercial buildings will be prioritized over snow melting, swimming pools and industrial uses. Thus, we assume that all use under interruptible service contracts will be terminated under such conditions and this will cover about a quarter of lost capacity. The remaining capacity loss will have to be met by curtailing use for space heating. We think that it is realistic to aim at 50% curtailment for commercial spaces and 75% curtailment for residential heating. Under this scenario we are assuming that all but the most essential commercial/public building will be heated only to keep them frost free and that the public will respond well to advice on how to minimize hot water use at home. This will result in a major disruption of daily life and effectively cast society into COVID-19 mode at least during the first winter. Below we discuss measures that could be taken to mitigate the situation should the worst-case scenario materialize. These measures are discussed in order of increasing response time.

3.2.2 Electric heating

As discussed above, the electrical transport and distribution system in Reykjavík is far from being capable of meeting the heating needs of the city. However, when heating was lost in Reykjanesbær in February 2024, the local utility, HS Veitur, issued guidelines to the public "allowing" 3 kW of electric heating per household. Reykjavík Energy is currently analyzing how this matches with the system in the capital area. Electric heating is

expected to be deployed relatively quickly and that it might help mitigate a difficult situation even though its magnitude is expected to be modest.

3.2.3 Oil heating of return water

About 30% of return water in the Reykjavík Area is collected by the utility and piped back to central pumping stations. This water is chemically compatible with the supply water and is at 30°C when collected. Heating this water and adding it to supply water would be an obvious option if 40% of the total capacity was lost. We assume that in such a situation about 800 l/s of return water would be available for heating. This amounts to about 15% of the current maximum capacity but this may change as the system grows in the next decades. Preliminary assessment of the supply chain indicates that the necessary infrastructure could be installed within a year from the onset of the emergency, but more detailed design work and further mapping of the supply chain are needed.

This option has two major drawbacks: GHG emissions and cost. A preliminary assessment indicates that about 12 million liters of diesel would be needed to heat 800 l/s of return water to >80°C. This would result in emissions of about 30 tons of CO_2 for each month of operation. The CAPEX for boilers and associated heat exchangers is estimated at about 4 million USD, but the monthly OPEX is estimated to be about 17 million USD.

3.2.4 Increased production capacity from low temperature fields

From 1930 to 1990 the RADHS ran exclusively on low temperature geothermal water. In the 1980's, before the Nesjavellir Power Plant was commissioned, the annual production of the low temperature fields was about 30 to 40% more than it is today and the production had most likely exceeded sustainable, long-term levels. However, this experience has shown that these systems can produce more than they currently do. It is thus likely that increasing the production from these fields, temporarily, in response to a major disruption in hot water production would be a tempting option.

Reykjavík Energy is already planning drilling operation in the currently used production fields and exploration drilling in new low-temperature fields around the Reykjavík Area. There are various reasons to do this including a recent understanding of the benefit of maintaining the ratio between the production capacity from low-temperature resources and the Hengill plants at 50/50. In an emergency it is likely that a massive drilling effort would take place in the low-temperature fields. A short-term over-exploitation to bridge a gap until a more long-term solution is in place will likely seem a very feasible option. It is difficult to assess how quickly this would bring hot water to the pipes in substantial quantities but in the currently operating geothermal fields, new wells would be added to the system as soon as they have been completed. Production from new fields would take a little more time to come online as more extensive pipelines need to be laid to connect them to the system.

3.2.5 Emergency thermal plant

In the discussion above we stated that we expect the Hellisheidi power plant to retain some 50% of its current hot water production capacity in case of an eruption in Hengill. This assumes that electricity production will resume. It is, however, possible to produce more hot water at the expense of electricity. This would require an intervention from the government whereby it would use its emergency powers to decree that hot water production should be prioritized over electricity. This would involve significant changes to the current power plant. Furthermore, drilling of new wells and expansion of the transport pipeline might also be needed. The initial estimate is that this would take at least 2 to 4 years.

3.3 How could the worst-case scenario play out?

Despite the plethora of uncertainties and unknowns related to how volcanic activity in Hengill might materialize it is nevertheless valuable for Reykjavík Energy, the civil authorities and the public to have a potential timeline showing the potential responses to catastrophic loss of production potential due to volcanic activity. In Figure 7 we attempt to present such a timeline representing a likely response to the worst-case scenario. The figure shows how 40% of the production capacity is lost in the first year. In the following year we assume that diesel boilers have been installed to meet about a third of the shortfall. We assume that increased potential from low temperature fields would gradually reduce the need for diesel boilers and about 4 years after the eruption starts, we assume that an emergency thermal plant would have been installed and use of the diesel boilers can be discontinued.

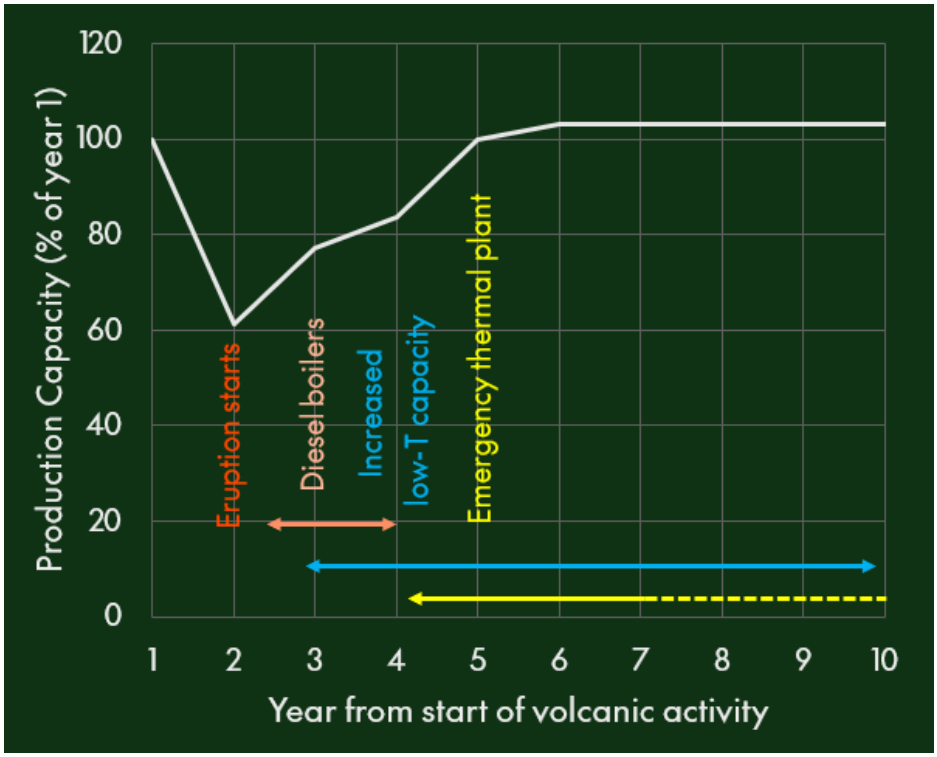


Figure 7. Potential evolution of production capacity following a loss of 40% capacity due to volcanic activity in Hengill. It is envisaged that diesel boilers would be most rapidly deployed, followed by increased capacity in low temperature resources and then an emergency thermal plant, possibly at Hellisheidi.

4 PREPAREDNESS

As stated earlier it is clear that a period of volcanic activity has started in the Reykjanes Peninsula and it is estimated to last for the next 400 years or so. Based on the current knowledge of the geologic history of the area we estimate that there is a 50/50 chance of volcanic eruptions in the Hengill area in the next four centuries. At present there are no signs of imminent threat to the Hengill power plants. Even though it can be argued that the probability of volcanic activity in the area in the lifetime of the current generation is small, it would be irresponsible of Reykjavík Energy to ignore this issue entirely. The study presented in this paper represents the first step taken by the company to prepare for this possibility. Among the outputs of the study is a list of recommendations vis-à-vis actions and activities that Reykjavík Energy should implement in the short-term to be better prepared for an uncertain future. The most important of these points are discussed below.

4.1 Volcanic monitoring

Further improved capacity for volcanic monitoring is an obvious first step for Icelandic society in general as well as for Reykjavík Energy and other stakeholders that have critical infrastructure located in the Reykjanes Peninsula Volcanic Zone. The Icelandic Meteorological Office is responsible for volcanic monitoring and relies on collaboration with local universities. These institutions have risen to the task since the beginning of the volcanic activity on the Reykjanes Peninsula in 2021. Understandably the main focus has been, and still is, on the volcanic unrest in the Svartsengi System, near the town of Grindavík and the Svartsengi GPP. It is, however, critical to closely monitor any signs of incipient activity in other volcanic systems on the peninsula. Reykjavík Energy and other similar stakeholders should push for this and provide financial support.

4.2 System Strengthening

This work has highlighted knowledge gaps and weaknesses in our system that should be addressed irrespective of potential volcanic activity in Hengill. This includes a lack of a clear understanding of the capacity of the electrical distribution system to handle increased load resulting from electrical heating. An obvious spin-off study from the current study is to complete the assessment of how much heating load per household is acceptable in different parts of the Reykjavík Area and a mapping of what needs to be done to strengthen the system. Another knowledge gap that has been identified in this work and partially addressed has to do with the capacity of the RADHS system to distribute hot water to the furthest reaches of the system in case of a massive loss of production capacity. Currently, it would be a challenge to pump low-temperature geothermal water to the southernmost extremities in the system, but this can be mitigated by the Utility during routine maintenance.

4.3 Pre-design and supply chain mapping

At this stage it does not seem appropriate to start major investments to prepare for volcanic activity in Hengill that may or may not happen in the next 400 years. There are, however, several plans that can be prepared to save time when volcanic activity resumes. Two notable examples are protective barriers and diesel boilers.

4.3.1 Protective Barriers

Protective barriers have successfully diverted lava flow from critical infrastructure in Svartsengi and Grindavík. At this stage it would be appropriate to initiate pre-design of barriers based on the behavior of previous volcanic episodes in the area, i.e. evaluate what would have been effective locations for barriers during the last eruptive episode in the area. Based on pre-design it would be possible to assess the need for material to be used for the barriers and identify potential mines where this material could be sourced. Similarly, preliminary estimates of the equipment needed for the barrier construction would also derive from the pre-design. These steps are relatively low-cost but could save critical time if the Hengill system becomes active.

4.3.2 Diesel Boilers

Although highly undesirable, diesel boilers to heat return water could be the quickest relief option in case of a large-scale loss of hot water production capacity. At this stage it would be appropriate to design equipment that can be installed on specific nodes in the system. Subsequently, to scan the market for appropriate equipment and assess which components can be bought off the shelf and which will need to be tailor made for this purpose. Assessing delivery lead time for specific components could be very useful if signs of potential activity in Hengill start to appear. If there are specific components with long lead time delays can be minimized by ordering such components in a timely manner.

4.4 Resource Diversification

An obvious approach to minimizing risk related to volcanic activity and other natural and anthropogenic hazards is to diversify the resource portfolio, i.e. having the eggs in many baskets. The RADHS already enjoys the benefit of diverse resources with half of the hot water coming from four low-temperature fields and the other half from two GPPs utilizing high-temperature resources. In chapter 3.2.1, above, we describe what can be expected for Reykjavík in case of worst-case scenario involving a volcanic eruption in Hengill. The situation described there is not nearly as bleak as the situation facing the residents in Reykjanesbær in February 2024 when the hot water pipe from Svartsengi was disconnected by a lava flow. During the next four days after this the local utility and the Department for Civil Protection were in a race against time to restore the connection or face massive property damage otherwise. This is not likely to happen in Reykjavík even though daily life could be very seriously disrupted if the worst-case scenario will materialize. To maintain this diversity of the resource portfolio it is important for Reykjavík Energy to have the eye on this ball when making strategic decisions about resource additions in the future

4.4.1 Low-temperature resources

It was mentioned in chapter 3.2.4 that Reykjavík Energy is planning to drill additional production wells in the current low-temperature production fields around the city. The decision to go ahead with this, the first drilling in production wells in Reykjavík since the 1980's, was in part informed by this study, highlighting the importance of having excess production capacity in the low temperature fields as a mitigation measure against the risk related to natural and anthropogenic hazards. Our plans involve adding a total of 8 to 12 production wells in three of the four current production fields in 2026 to 2028.

Similarly, Reykjavík Energy is exploring three low-temperature fields in and around the Reykjavík Area. If these exploration projects are successful, they will add to the production capacity of the low-temperature fields and help maintain a healthy 50/50 balance between the low-temperature and high-temperature resources for the RADHS.

4.4.2 High-temperature resources

The production capacity growth for the RADHS has been driven by successive expansions of the Hengill power plants since the 1990's; first at Nesjavellir and, later, at Hellisheidi. Currently there are plans to further increase hot water production capacity in both plants. There are many good reasons for doing this, even though these expansions do not serve to diversify the resource portfolio.

There are, however, other opportunities for Reykjavík Energy that should be pursued alongside the planned expansions at Nesjavellir and Hellisheidi that do serve to distribute the risk related to volcanic activity. One such

option is to work with HS Orka to explore the possibility of producing hot water for the RADHS in the planned Krýsuvík Power Plant. Even though Krýsuvík is within the Reykjanes Peninsula Volcanic Zone and is more likely than the Hengill Volcanic System to become active in the next 400 years it is still not considered very likely that both systems will be active at the same time and having hot water from two different volcanic systems is still advantageous from the perspective of resource diversification.

Another option along the same lines would be to actively explore the western and southern peripheries of the Hengill system for high-, medium- or low-temperature resources that could be used for the RADHS. Reykjavík Energy has recently started an exploration project in these areas with this in mind. If economically feasible resources are discovered this would be very positive for the resource diversification issue.

5 CONCLUSIONS

A new period of volcanic activity has started in the Reykjanes Peninsula, and it can be expected to last for the next 400 years or so. During this period there is about a 50/50 chance that an eruption might occur in Hengill and if that happens it is likely that the power plants at Nesjavellir and Hellisheidi might lose some or all their production capacity for up to several years. At this point, as there are no immediate signs of volcanic activity in Hengill it looks like a remote possibility that the generations currently alive will experience this.

It is, nevertheless, the responsible thing to do for Reykjavík Energy, as a provider of vital services for the society in the Reykjavík Area to assess the situation. This includes taking stock of the probability of volcanic activity disrupting their service and what would be the expected magnitude and duration of the disruptions. Our findings are that if the worst-case scenario would play out in the next decades the service of RADHS would be seriously disrupted but it is still envisaged that system will have sufficient capacity to keep all buildings in the Reykjavík Area frost free. During the first post-eruption years we anticipate that life in Reykjavík would bear resemblance to life during the COVID-19 with people working from home to the degree possible. We anticipate that within one year from the onset of volcanic activity diesel boilers to heat return water would be in place and operational. We also anticipate that drilling the available low temperature fields would take place and go well beyond the sustainable production capacity. Finally, we assume that within four years from the onset of volcanic activity an emergency thermal plant would be in place at Hellisheidi or at a similar location. We envisage that in the worst-case scenario life would still be back to near normal conditions within four years.

This work has identified several low-cost activities that Reykjavík Energy should implement in short order to prepare volcanic activity in the Hengill Area even though there are currently no indications that such activity is imminent. These include supporting increased volcanic monitoring, strengthen specific aspects of our systems that could prove essential in an emergency, preparation and pre-design work that can save time in the event of volcanic activity in Hengill and finally this work has brought increased focus on the value of resource diversification for the RADHS that is already influencing investment decisions by Reykjavík Energy.