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Drilling Toward Success: ON Power's Multi-Well Journey

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1 INTRODUCTION

Iceland has a long history of geothermal utilization. Natural hot springs were used for bathing, washing, and cooking from the earliest settlements, but systematic use of geothermal energy began in the early 20th century when municipalities started piping hot water into homes. This development accelerated in the mid-20th century as Reykjavík and other towns replaced oil-based heating with geothermal district heating, dramatically improving air quality and living standards. Later advances in drilling and reservoir understanding enabled high-temperature fields to be developed for electricity generation, marking a major milestone in Iceland's energy transition.

ON Power is a subsidiary of Reykjavík Energy, with roots tracing back to 1909 when the foundations of Iceland's modern energy infrastructure began to take shape. Over more than a century, Iceland has transformed from one of Europe's poorest countries, dependent on imported coal and oil, into a global leader in renewable energy. Today, Iceland is one of the few nations in the world that meets nearly all its electricity and heating needs with renewable resources. Roughly two-thirds of electricity generation comes from hydropower and one-third from geothermal power.

Formed in its current structure in 2014, ON Power is today Iceland's largest producer of geothermal energy and the second-largest electricity producer overall. With around 120 employees and operations across the country, ON Power supplies renewable electricity and hot water to about 75% of Iceland's population.

ON Power operates two geothermal power plant in the hills of Hengill central volcano, Nesjavellir and Hellisheiði (Figure 1), where both hot water and electricity are produced. Nesjavellir began operations in 1991 and provides up to 120 MW of electricity and 340 MW of thermal energy. Hellisheiði, commissioned in 2006, has since become the largest geothermal power plant in Europe and the fourth largest in the world with an installed capacity of 303 MW of electricity and 200 MW of thermal output. Together, Nesjavellir and Hellisheiði form the heart of ON Power's operations and stand as global showcases of sustainable geothermal utilization.

Geothermal drilling in Iceland is shaped by volcanic geology, high-temperature formations, and environmental sensitivity. Exploration drilling at Nesjavellir began in the mid-1960s, leading to full-scale production drilling and power development in the 1980s. At Hellisheiði, exploration started in 1985, followed by the first large-scale production wells in the early 2000s. Over the decades, Orkuveitan and ON Power have drilled 128 high-temperature wells in the Hengill area.

Hellisheiði currently operates 49 production and 18 injection wells, while Nesjavellir operates 24 production and 10 injection wells. Geothermal fluid extracted from production wells is reinjected as brine and condensate to help maintain reservoir pressure and support long-term sustainability. Hot water production capacity is 1,000 L/s at Hellisheiði and 1,550 L/s at Nesjavellir, supplying the greater Reykjavík area..

2 GEOTHERMAL POWER PRODUCTION IN HENGILL

Iceland is one of few places on Earth where a mid-oceanic ridge is exposed to the surface. The Hengill central volcano lies at a triple junction of tectonic plate boundaries, with the Hellisheiði and Nesjavellir power plants located in its southern and northern fissure swarms. Rather than drilling into deep magmatic targets, geothermal utilization at Hengill relies on repeated dike intrusions (Gunnarsson et al. 2011; Ragnarsson, 2022) that transport heat closer to the surface, maintaining the geothermal system tapped by wells 1,400–3,300 meters deep.

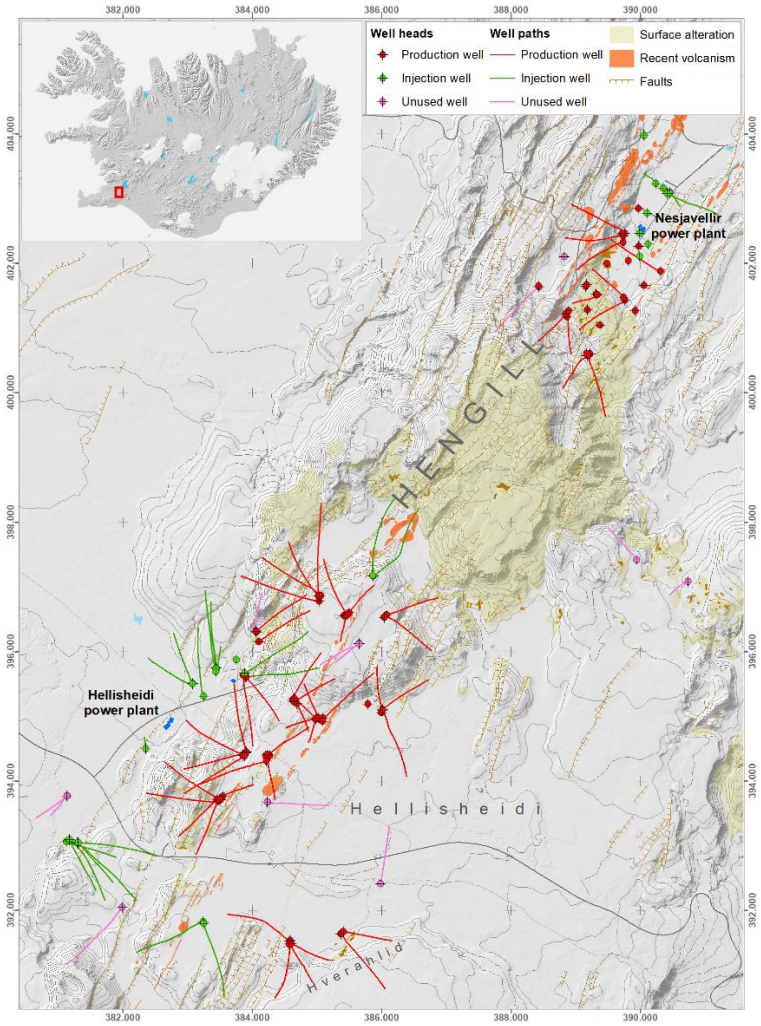


Figure 1. Location of Hellisheiði and Nesjavellir power plants. Refer to figure legend for details.

Although high-temperature geothermal systems like Hengill can be sustainable over centuries, short-term utilization typically exceeds natural recharge (Björnsson 2006; Gunnarsson 2011). Continuous production reduces reservoir pressure, lowers boiling points, and initially increases steam output before ultimately leading to cooling and declining productivity. Without intervention, falling pressure and temperature would gradually reduce well output until power generation is no longer possible, making careful resource management essential.

Several measures can counter this decline. Improving turbine and plant efficiency reduces steam demand, easing pressure on the system. Adjusting reinjection strategies can help stabilize reservoir pressure and manage cooling, though results vary by field. Reducing production to match natural inflow is technically possible but economically impractical, as geothermal provides essential baseload power for Iceland.

The primary method to sustain production is drilling make-up wells to offset declining output from aging wells. Conventional make-up wells target new areas of the geothermal reservoir, but expanding laterally requires more land for additional well pads, roads, pipelines, and infrastructure. As development progresses, suitable targets become increasingly limited, and simply spreading production across a wider area cannot indefinitely compensate for natural decline.

A longer-term option is drilling deeper into hotter zones below the current reservoir. These wells could access higher-temperature fluids with greater energy potential, but the technology remains under development. Efforts such as the planned IDDP-3 well in 2026–2027 will be important for testing advanced drilling methods, materials, and well designs capable of withstanding more extreme conditions. Success in these efforts could mark a significant step in the future sustainability of high-temperature geothermal systems.

With 423 MWe of installed capacity, ON Power is entering a new phase of development focused on drilling 16 make-up wells between 2025 and 2027, one of which has already been completed. These wells are located both within existing production areas and in new zones extending along Hengill's fissure swarms. This approach aims

to sustain current output while improving understanding of the reservoir's lateral extent and identifying new productive zones.

These efforts are necessary because production decline is an inherent part of high-temperature geothermal utilization. With typical annual decline rates of 1–10 percent (Axelsson 2013; Grant & Bixley 2011), and assuming a typical 4-percent decline, ON Power must replace around 140 MWe of lost production over the next decade simply to maintain today's output. In practical terms, this equates to drilling enough make-up wells to replace the entire Krafla power plant in about four years, Þeistareykir in six years, and Nesjavellir in eight years—underscoring the scale of continuous drilling and reinvestment required to sustain geothermal production even before accounting for growing renewable-energy demand (Figure 2).

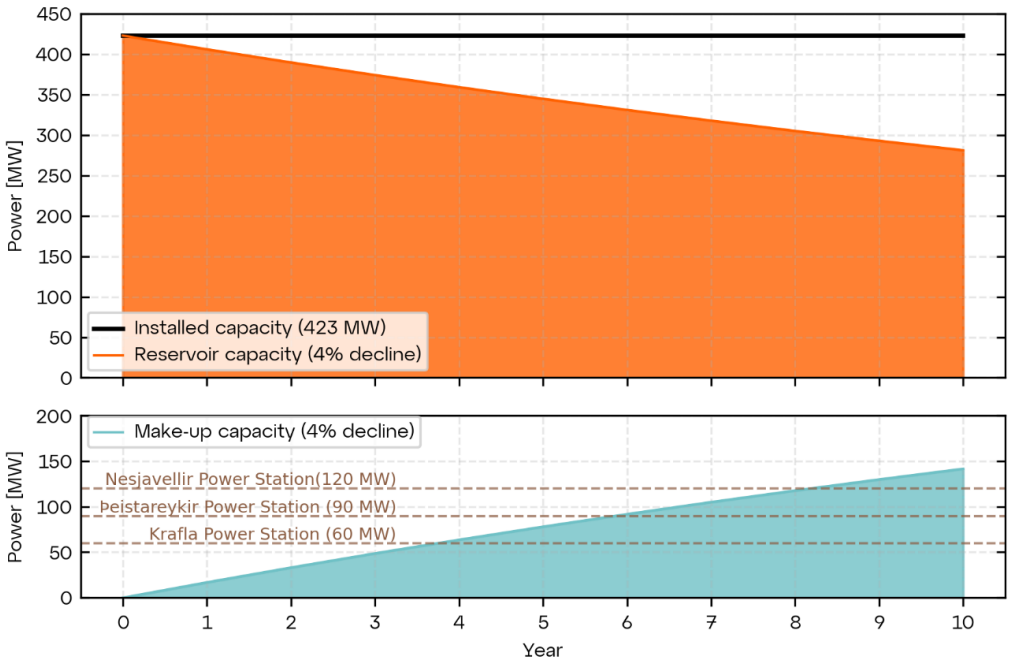


Figure 2. Impact of a theoretical 4% annual decline in reservoir capacity over 10 years without mitigation. The lower graph shows the additional capacity required to maintain 423 MW, compared to selected Icelandic geothermal plants (Nesjavellir, Þeistareykir, Krafla).

3 DRILLING PROGRAM AND CHALLENGES

In 2025, ON Power launched an initiative to drill 16 new make-up wells in the Hengill area to secure continued production capacity at Nesjavellir and Hellisheiði power plants. Drilling a single production well requires extensive preparation so each production well is managed as a separate project. These projects are then organized within a single umbrella program. The benefit of such a program is to provide an overview of time, cost, and all the preparation required for the projects. This enables prioritization, reorganization, and ensures that project objectives are achieved within the set timeframe and budget. Figure 3 shows an example of a program timeline, one in the scenario that one drill is used and another scenario where two drills are in use at the same time.

Good preparation is essential for success and must be thorough and timely, especially given the intention to drill all production wells in sequence. A comprehensive overview of human resources and collaboration is key when preparing for and executing the project. This requires significant coordination among many parties working towards the same goal. It is important to connect different roles, such as project managers, resource specialists, geologists, designers, and contractors, while also ensuring clear division of tasks, responsibilities, and prioritization within the project team.

The main challenges for the program are the timeline and permits. The timeline depends on many variables such as delivery of materials, production forecast for the geothermal reservoirs, permitting requirements and weather conditions, which are hard to predict. The biggest bottleneck for the program is permitting. Before drilling can begin, all required permits must be obtained in time so that work can commence. To determine which permits are required for each production well, the well's location must first be verified, and the applicable permits

identified. If a production well is located in a new area where drilling has not previously occurred and the necessary permits are not in place, work must be done to amend the municipal and local plans and possibly submit a new environmental assessment to the municipality and relevant institutions. This is a time-consuming process and can take anywhere from 1.5 to 2.5 years, assuming there are no municipal elections that could disrupt the process if a new council has a different vision than its predecessors.

For all production wells, it is necessary to apply for a construction permit for access roads and well pad construction, as well as an operating permit that authorizes the contractor to begin drilling in the area. Applying for such permits can take 2–6 months. Delays in permitting can affect the entire program timeline, so it is important to start preparing permit applications as early as possible to avoid delays that could lead to setbacks across projects, as every project in the program is interdependent in terms of drilling timelines. Therefore, it is essential to be proactive and apply for all necessary permits as soon as possible, as the timeline can change very quickly.

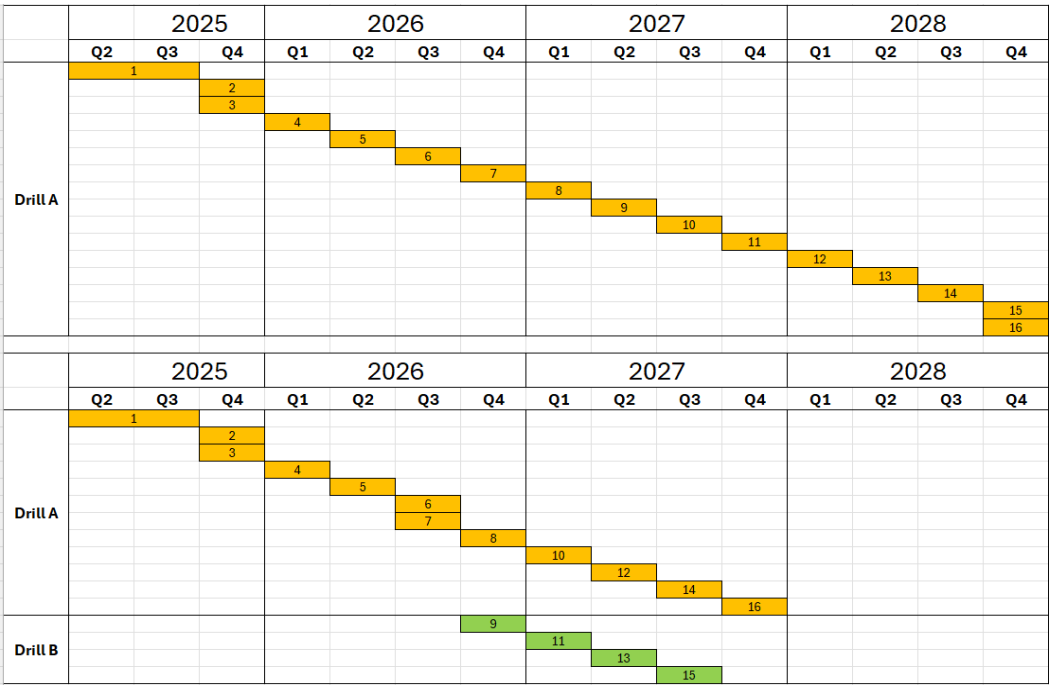


Figure 3. An example of a program timeline. Upper panel shows drilling with one drill and lower panel shows when drilling commences with two drills. Yellow squares are for drill A and green for drill B. Number denotes well number.

Weather conditions in Iceland change rapidly and are difficult to manage. Cold and frost can delay the construction of access roads, well pads, and drilling activities. However, with good preparation, risks can be minimized or mitigated, delays can be prevented, and it becomes possible to respond to unexpected events. Preparation also involves having contingency plans ready so that priorities or operations can be changed if circumstances require.

By emphasizing good oversight, thorough preparation, and flexibility in execution, the likelihood of success can be maximized and risks minimized. This is a complex and demanding project where cooperation, organization, permitting, and good preparation are all crucial.

4 CHALLENGES AND LESSONS FROM FOUR DECADES OF GEOTHERMAL DRILLING IN ICELAND

The drilling philosophy is effective management, minimal bureaucracy, pragmatic and rapid decision-making (Hole, 2013). The CEO and steering committee are directly accessible, while day-to-day control rests with the project manager and company man. Standard well design includes 22-1/2" surface casing, 18-5/8" anchor casing, 13-3/8" production casing, and 9-5/8" slotted liner. Wells are directionally drilled using a mud motor and MWD (measurements while drilling), with kick-off points at 300–400 m. When circulation losses reach around 20 L/s, the MWD and mud motor are removed from the bottom-hole assembly to minimize the risk of losing tools in the event of total circulation loss. The final inclinations around 30°, reaching depths of 1800–2500 m.

Cementing operations are deliberately simple and robust. Surface, anchor and production casings are cemented using Portland cement with additives a retarder, inner string method pumped bottom-up until returns are visible at the surface. Downhole logging during drilling is kept to a minimum to reduce cost and operational complexity. Continuous drilling campaigns of 10–20 wells are planned several years ahead to maintain efficiency and contractor engagement.

Between 2017–2022, ON Power completed a 12-well campaign with an average cost of 5.2 MUSD per well and 8.5 MWe power output. The ongoing campaign (12–16 wells) is estimated at 6.1 MUSD per well, with expected lower outputs as drilling extends toward the boundaries of the geothermal resource. Operational experience has defined practical thresholds, such as maintaining drilling rates below 10 m/hr to prevent cuttings fallback during total loss zones, and using simple, effective cementing practices with Portland cement and retarders.

Operational experience has provided a series of practical lessons. Well NJ-34 in Nesjavellir was drilled under overpressured conditions and required multiple cementing jobs between 130–400 m. Lost circulation began at 1,200 m, and the well was subsequently drilled blind to 2,030 m. It is currently heating up, with final output to be determined. At Nesjavellir, well NJ-37—the first well in the field to use flexible couplings—required intervention after a water pocket was detected behind the production casing at 106 m. To relieve the pressure, four 10-mm perforations were shot in the casing. Drilling then continued to a final depth of 2,200 m, and the well is now in production, adding steam and brine to the Nesjavellir power plant.

Iceland's geothermal drilling success relies on disciplined simplicity, close collaboration between geoscientists and engineers, and fast, pragmatic decision-making. Adaptability and field-based experience have shaped a cost-effective and resilient drilling culture in the land of fire and ice.

5 CONCLUSIONS

The development of the Hengill geothermal system shows both the potential and the challenges of high-temperature geothermal utilization. Sustaining production in an active volcanic environment requires continuous reinvestment, careful resource management, and flexible drilling strategies. As ON Power begins its new multi-year drilling program, it builds on decades of experience while advancing what is technically possible in Icelandic geothermal fields.

Looking ahead, disciplined well design, improved reservoir forecasting, efficient project management, and strong collaboration between geoscientists and engineers will be vital to meeting Iceland's growing renewable-energy needs. With deeper targets emerging and a drilling culture defined by resilience and pragmatism, Hengill continues to show how Iceland leads in harnessing geothermal heat.

REFERENCES

Axelsson, G.: Sustainable management of geothermal resources. Proceedings of the European Geothermal Congress 2013, Pisa, Italy, 3–7 June (2013).

Björnsson, G., Gunnlaugsson, E., and Hjartarson, A.: Applying the Hengill Geothermal Reservoir Model in Power Plant Decision Making and Environmental Impact Studies (2006).

Grant, M. A., & Bixley, P. F.: *Geothermal reservoir engineering* (2nd ed.). Academic Press (2011).

Gunnarsson, G., Arnaldsson, A., and Oddsdóttir, A. L.: Model simulations of the Hengill area, Southwestern Iceland. *Transport in porous media*, *90*(1), 3-22 (2011).

Hole, H. M.: Geothermal drilling-keep it simple. In *Proceedings of the 35th New Zealand geothermal workshop. Rotorua, New Zealand* Vol. 1720 (2013).

Ragnarsson, S.: Repeated Dike Intrusions as Heat Sources of Volcanic Geothermal Systems (Master's thesis). Faculty of Earth Sciences, University of Iceland (2022).