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BEST PRACTICES AND SUCCESS IN ICELAND ON DRILLING AND EXPLOITATION

ABSTRACT

Iceland has been at the forefront of geothermal utilization in the world and has been using geothermal energy to produce heat for the last 90 years and electricity since 1969. During this time many lessons have been learned when it comes to research and technology, but also with regards to the legal and regulatory framework as well as public acceptance. The rapid development in geothermal utilisation in Iceland is characterised by strong support from the public sector, both in the form of policy and the legal framework, but also funding for geothermal exploration, where the risk was mostly assumed by the government in the form of loans to municipalities and others that were only repaid if the exploration was successful. It is important that there is a rigorous standard in place for drilling for geothermal energy, to ensure the safety of the people and the environment. The dissemination of research and information regarding geothermal drilling and exploitation is also important, and should be publicly available much as possible.

KEYWORDS

Iceland, drilling, geothermal energy, exploitation

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1. BEST PRACTICES AND GOOD GOVERNANCE

Good governance and communication with the public are important, in addition to financial and asset viability, labour and working conditions, biodiversity and cultural heritage, to name a few factors. Aspects like geothermal resource management, and environmental and social issues often receive the most attention at the cost of other aspects. That has in some cases caused the development of geothermal resources to fail.

A sustainable approach to developing geothermal resources requires an overall strategic approach on various aspects, beside those indicators related to the resource itself or drilling. OS is in the process of developing a Geothermal Sustainability Assessment Protocol (GSAP) with the industry in Iceland, applicable to both low and high temperature resources. The protocol takes on all aspects related to sustainable development and serves as a guide for best practices. The protocol is tailored for four stages, namely early stage, preparation, implementation and operation, as illustrated in Figure 1, and addresses on a world scale what factors are important in developing geothermal resources. It uses the Hydropower Sustainability Assessment Protocol (HSAP) which is currently in use by the hydropower industry as a base for assessment and amends those topics as needed.

At the operation stage the capacity of the resource needs to be continually evaluated scientifically and technically on the basis of chemical, geological and geophysical monitoring as well as testing of wells. For the project to be within the limits of sustainable yield, the production needs to be within the limits that can sustain the long-term steady energy production from the system. Re-injection of geothermal fluid into the geothermal reservoir can support long-term utilization. Models for re-assessment of the production capacity are maintained on the basis of continuous data obtained during operation. Operation of the geothermal resource may be conditioned by regulatory requirements.

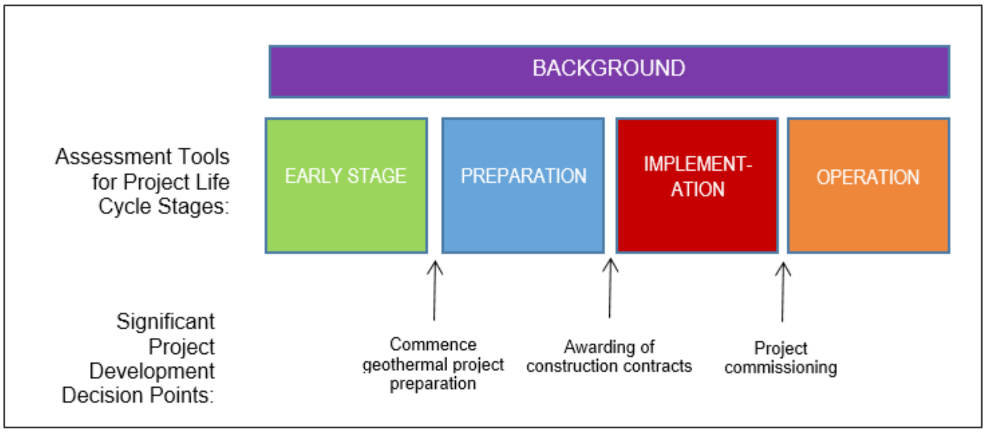

Fig. 1. Protocol Assessment Tools and Major Decision Points

Rys. 1. Protokół narzędzi oceny i główne punkty podejmowania decyzji

2. GEOTHERMAL DEVELOPMENT IN ICELAND

Geothermal resources have a minor share in the worldwide generation of electricity but they have become of major importance in many volcanic regions. Leading countries in this development have been Italy, USA, New Zealand, Mexico, the Philippines, Indonesia, Iceland and Japan. In Africa, Kenya is the leading country but no development has occurred in S-America despite its large potential.

The successful development of geothermal electricity generation in Iceland has raised interest. A country with 320 thousand inhabitants had in the year 2017 installed a capacity of 663 MW in geothermal power plants. This occurs in a country with a large potential in hydropower. Generally the risk in hydropower projects is considered less than in geothermal projects but the geothermal plants have the competitive advantage of serving a base load with full availability throughout the year. The share of hydropower is 73% and that of geothermal 27% in electricity generation.

Geothermal district heating started on a small scale in Reykjavík in 1930 and today Reykjavík Energy operates the largest municipal district heating system. The system serves about 195,000 people in the capital area with hot water. From 1998 electricity has been co-generated from geothermal steam along with hot water at Nesjavellir. However, about 70% of the energy used for district heating comes directly from low temperature geothermal fields, and about 30% from heating up cold water in CHP plants using geothermal energy as the primary energy source. Space heating is by far the most common use of geothermal heat in Iceland, or 74% of the total heat use (Figure 2).

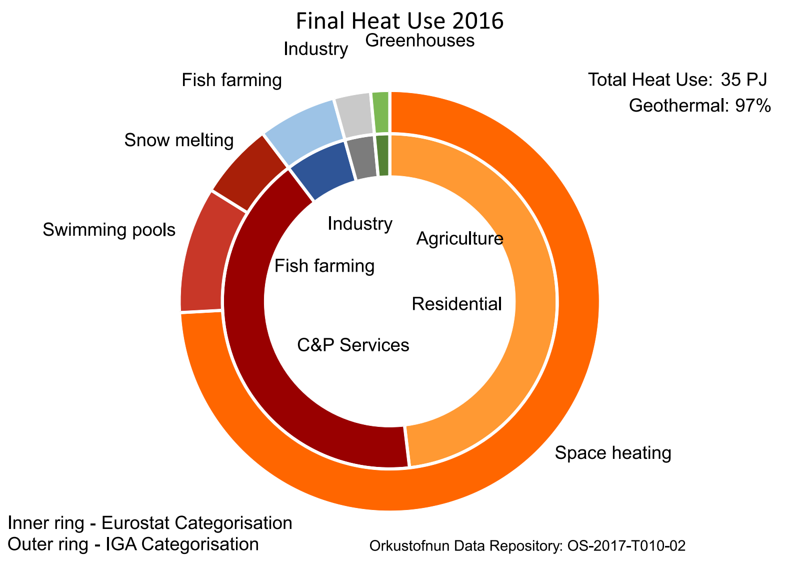

Fig. 2. Total final heat use 2016 in Iceland. Space heating is by far the most common use

Rys. 2. Użycie energii cieplnej w Islandii w 2016 r. Najpowszechniejsze jest ogrzewanie budynków

3. SUCCESS OF DRILLING FOR GEOTHERMAL ENERGY IN ICELAND

Analysis of drilling success in Iceland reveals that two of every three wells drilled are successful. Productive wells last for a long time, for example, for low enthalpy wells the average age is 35 years with some wells over 50 years of age. Therefore the cost of having one of every three drilled wells fail can be carried by the overall success rate and the long lasting yield. However, a mitigation fund is required, especially taking into account that the analysis reveals that the first well drilled has less than 50% chance of being successful in a greenfield. To mitigate this risk, Iceland introduced a financial mechanism in 1953 allowing the state to provide loans for the upfront risk but requiring those successful to pay back the loan. Overall, the same mechanism has been continued until present.

Drilling success on average in Iceland for the past 100 years is about 66%, after analysing the success of drilling 738 wells designed as production wells within 48 geothermal systems. The highest success rate is found in the high enthalpy geothermal systems where 74% of wells are successful of 213 wells drilled in 5 fields. Success is 65% in 236 wells drilled in low enthalpy systems within 6 fields near the capital and 60% of medium enthalpy systems of 289 wells drilled in 37 systems. The first wells drilled have a lower probability of success which gradually increases with increased knowledge of the geothermal system.

For low enthalpy systems there are in total 173 wells in 52 geothermal systems in use today by larger utilities with exclusive rights for distribution of heat within a given area. The average age of the wells is 35 years. They average 1055m in depth and are cased on average down to 223 meters. The average temperature is 88°C.

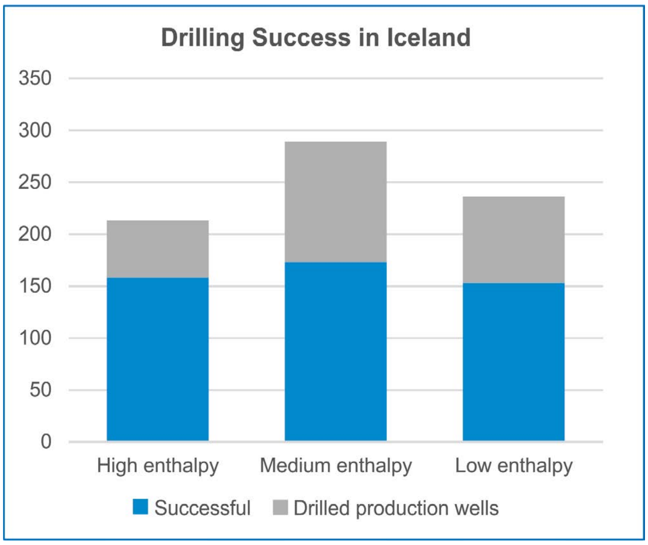

Fig. 3. Drilling success in Iceland in 48 geothermal systems after analysing 738 wells designed to be production wells

Rys. 3. Skuteczność wiercenia otworów w Islandii dla 48 zbiorników geotermalnych po analizie 738 otworów produkcyjnych

For low enthalpy systems there are in total 173 wells in 52 geothermal systems in use today by larger utilities with exclusive rights for distribution of heat within a given area. The average age of the wells is 35 years. They average 1055 m in depth and are cased on average down to 223 meters. The average temperature is 88°C. This excludes statistics from close to 200 individual producers where the data is of too low quality to be included.

4. REGULATORY FRAMEWORK AND FOR WELLS AND DISSEMINATION OF INFORMATION

Well design is important to minimize the risk of the project. OS operates a National Well Registry which is public and grants access to well logs and design. That access aids in preventing failures in the future. Using an online portal on a server, other entities can incorporate the Well Registry in their portals allowing the dissemination of information from different entities without the need to submit information between parties. Therefore it is now possible to visualize combined information on one portal, e.g. recent seismic data, wells, distribution networks for heat, water and electricity, tourist attractions, archaeological sites, planning and building drawings from various entities. Essentially this can be whatever infor-

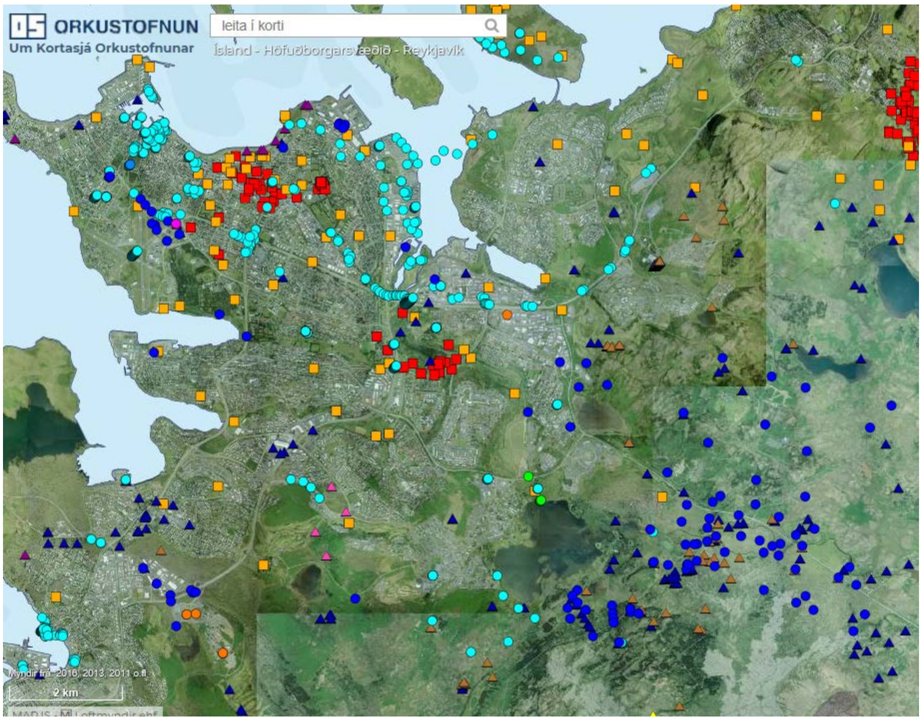

Fig. 4. A sample view from the Orkustofnun web portal, showing wells around the Reykjavík area

Rys. 4. Przykładowy widok mapy z serwera w Orkustofnun mation one can think of and is relevant to combine on a portal and a party is willing to share. Each owner is though only responsible for their dataset and updates, so the information is updated across the platform without any data submission.

OS is in the process of stipulating rules for well design, registration, drilling, completion and permanent closure. This is developed with the industry and serves as a tool to mitigate risks. In addition, resource indicators are incorporated within granted utilization licences. The two most important indicators are reduction of well production capacity (typically 3% per year on average over a period of five years) and pressure drawdown in the geothermal system. If either of those indicators surpasses levels stipulated in the license, a protocol is initiated to further understand and analyse appropriate actions to maintain a sustainable yield for generations to come.

OS in collaboration with stakeholders published rules regarding preparedness and reactions to seismic hazards due to fluid injection into the ground via wells. These rules could be reviewed in Poland as far as they are relevant. The objective of these rules is to minimize the danger of bodily harm, damage to man-made structures and inconveniences due to earthquakes related to the injection of fluids into the ground via boreholes. The rules are also intended to restrict and explain the duties, roles and involvement of licence holders, OS and other parties in each situation and promote the right focus on the preparation and execution of the injection.

The injection of geothermal fluids into the ground is an important part of the utilization of geothermal energy, on one hand to dispose of fluids, but on the other to counteract pressure decline in geothermal systems. The present guide is intended for explanation of the topics of specific paragraphs in the rules and to facilitate the preparation and execution of fluid injection

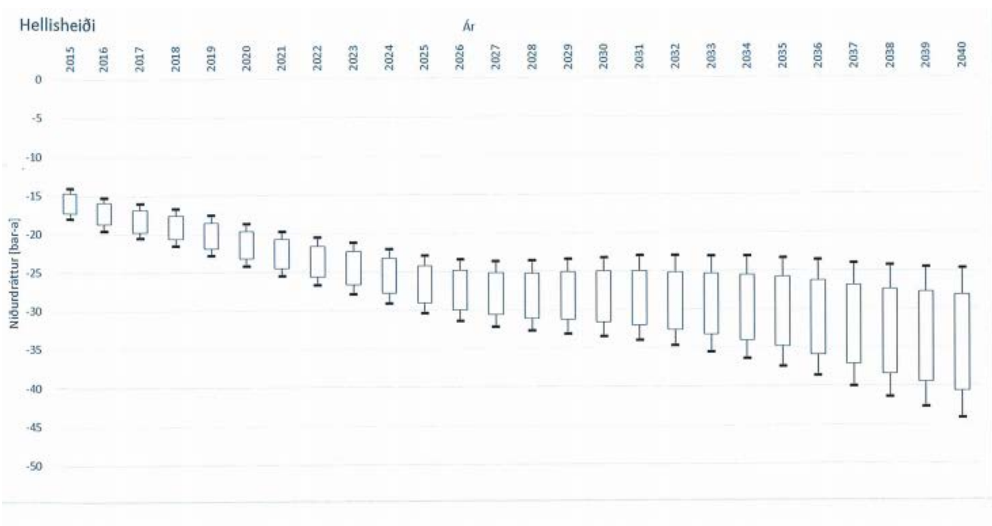

Fig. 5. An example of allowed pressure drawdown in the utilisation license issued for Hellisheiði geothermal power plant

Rys. 5. Dopuszczalne zmiany ciśnienia, zapisane w koncesji największej w Islandii Elektrowni Geotermalnej Hellisheiði into the earth for the licence holders, including the topics and execution of a preliminary assessment, a research plan, monitoring, supervision and a contingency plan. Furthermore there are examples in the guide of items that holders of geothermal utilization licences may keep in mind during preparation and execution of fluid injection into the ground via boreholes.

CONCLUSIONS AND RECOMMENDATIONS

1. Good governance and communication with the public are important to ensure the success of geothermal projects.
2. It is important that the regulatory framework supports the sustainable utilisation of geothermal resources.
3. It is important that there is an overview of the wells that have been drilled in the country, such as the National Well registry in Iceland.
4. There should be a comprehensive regulatory framework to ensure the safe drilling, operation and decommissioning of wells.
5. The key aspect of this framework would be to determine the owner of the well who is responsible for it being safe and does not harm the environment or people.
6. It is important that drilling activities are subjected to rigorous standards in order to ensure the minimum impact on the environment, that the staff is safe and that the well does not pose harm to its environment.
7. Information about wells should ideally be public, and accessible to everyone who is interested via a web tool, such as the Orkustofnun map portal. In addition, the possibility of combining information on wells, with other datasets such as infrastructure can be very informative.
8. Analysis of the success of drilled wells is a helpful tool to see how successful the drilling has been, if it has changed over time and if there are improvements to be made.
9. In Iceland it became necessary to make rules regarding the reinjection of geothermal fluids, due to induced earthquake activity. Induced earthquakes have been controversial in other countries where geothermal development has taken place and this matter should be considered carefully in order to maintain the public approval of geothermal development.

Iceland
Liechtenstein
Norway grants

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NAJLEPSZE PRAKTYKI I SUKCESY W ZAKRESIE WIERCEŃ GEOTERMALNYCH NA ISLANDII

STRESZCZENIE

Islandia znajduje się w czołówce krajów wykorzystujących energię geotermalną na świecie. Energia ta wykorzystywana jest do produkcji energii elektrycznej od 1969 roku, a do produkcji ciepła od lat 90. Szybko rozwijająca się geotermia na Islandii posiada silne wsparcie ze strony sektora publicznego (przychylna polityka oraz regulacje prawne), projekty geotermalne z racji na duże ryzyko są dofinansowane przez rząd w formie kredytów, które spłacane są tylko w przypadku gdy poszukiwania zakończą się sukcesem. Istotne jest również, by standardy geotermalnych wierceń zapewniały bezpieczeństwo dla ludzi i środowiska. Innym ważnym elementem jest rozpowszechnianie wyników badań oraz informacji dotyczących wierceń i eksploatacji geotermalnej, tak by były one w miarę możliwości dsotępne dla opini publicznej.

SŁOWA KLUCZOWE

Islandia, wiercenie, energia geotermalna, eksploatacja

Iceland
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Norway grants

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