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Who Generates Demand for Sustainable Energy Transitions? Geothermal Heating in Reykjavík[1]

Looking around Iceland's capital today, one might think that it was only a matter of time before the inhabitants of Reykjavík would tap the geothermal resources under the city. Virtually all houses are connected to the city's geothermal district heating utility, supplying abundant hot water for residential heating, swimming pools, and snow melting. But Reykjavík has not always been this way. Before the geothermal utility was constructed between 1930 and 1944, the inhabitants relied on imported coal for heating, and shifting to geothermal heating was not easy. How can this sustainable transition be explained? Starting with a brief overview of the geothermal utility's history, I argue that its breakthrough depended not only on the availability of sufficient resources and the application of suitable technologies, but also—above all—on the creation of a new societal demand.

Reykjavík's Transition

Geothermal heating started out as an experiment in the early 1930s. Several large public buildings, initially an elementary school, a hospital, and an indoor swimming pool, were supplied with hot water from local boreholes. The experiment was a success: the water sufficed both in temperature and quantity and could be pumped into existing central heating systems. Given how much it cost to heat the same spaces with coal, the city's geothermal investment seemed worthwhile and was extended to 50 or so residential houses in the vicinity between 1933 and 1938. The rest of the city's 3,000 buildings, however, remained heated with coal.[2]

Motivated by this success, the municipal government planned a citywide geothermal utility. This was a massive undertaking, with the heavy infrastructure costs exceeding

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2 Reykjavík Municipal Archives, Málasafn borgarstjóra 965, Report on the Laugar Utility, 16 July 1937.

what the city government could afford. And it meant that geothermal heating would have to replace coal as the primary form of heating. Construction began in 1939, when the city partnered with a Copenhagen contractor and secured a Danish bank loan, but was delayed by the outbreak of the Second World War. The utility was ultimately completed in 1943–1944, years later than planned and three times over budget. With all the houses connected to geothermal sources, however, coal heating had been eliminated.[3]

How did Reykjavík succeed in transitioning from coal to geothermal heating? The geographical and societal circumstances certainly helped. Reykjavík is situated atop an extinct volcano that still radiates heat into the bedrock, providing a relatively high geothermal energy potential. And, of course, Reykjavík is situated at the edge of the Arctic, which means there is a high demand for indoor heating. In addition, the construction of the utility coincided with a period of urban growth. New public buildings and (public and private) housing favored innovation in the heating sector. There was also an increase in engineering know-how, as Icelanders trained abroad, returned, and became influential public and private engineers. But those were only preconditions. The breakthrough in geothermal heating depended on overcoming three central challenges: sufficient resources had to be made available, suitable technologies had to be applied, and societal demand for the geothermal alternative had to be created.

Harnessing the Earth's Power

Reykjavík is named after the steam from the hot springs at Laugarnes, which the first settlers saw when they entered the bay in the ninth century (Reykja- = steam/smoke, -vík = bay). The hot-water springs in their natural state could be used only for laundry and swimming. Harnessing greater quantities required drilling into the earth and tapping hot water reservoirs. And because the demand for heating was highest during winter, the utility's potential supply needed to be much higher than average demand. The early geothermal experiment of the 1930s drew water from the hot springs at Laugarnes. For the citywide project, the hot water needed to be transported from the farm of Reykir, 15 kilometers outside the city, where much more geothermal energy

3 For an overview, see: Lýður Björnsson, *Saga Hitaveitu Reykjavíkur* (Reykjavík: Orkuveita Reykjavíkur, 2007); Sveinn Þórðarson, *Auður úr iðrum jarðar: saga hitaveitna og jarðhitanýtingar á Íslandi* (Reykjavík: Hið íslenska bókmenntafélag, 1998).

could be harnessed. (Even in Iceland, geothermal energy is not always found where it is needed.) As with other energy carriers, transportation from the center of production to the center of consumption made citywide geothermal heating a costly project.

The infrastructure was crucial. The geothermal utility required boreholes to tap the hot water, basins to collect it, pumps to regulate its flow, insulated pipelines for transportation, storage tanks, an insulated grid under the surface to distribute the water, house connections with regulators and measuring devices, indoor central-heating systems, and a means of discharging the water into the sewage system. To build such a system, the engineers mainly needed to adapt existing technologies. The drilling technology was essentially the same as that used to search for cold water, minerals, or oil. The transportation technology could be borrowed from district heating systems, which had already been established in cities such as Copenhagen. But the technology needed to be adapted to cope with mineral-rich, near-boiling water. This required extensive experimentation to find suitable materials for pipes, joints, and sealing rings. To limit heat loss during transportation, the 15-kilometer-long pipeline was covered with pieces of cheap, locally available turf, while the underground pipes in the city were placed in a bed of cinder (porous lava rock).[4]

The technology for geothermal indoor heating was almost completely taken from central heating. While older homes in Reykjavík still used indoor coal ovens for heating and cooking, new houses were equipped with updated technologies. From the 1920s, the city's hydroelectric plant supplied most homes with power for lighting and cooking; hydroelectric power had replaced the need for coal ovens for cooking and "town gas" for lighting. By the late 1930s, most houses were also equipped with water-based central heating systems. Instead of burning coal in the kitchen or living room, the fuel was stored down in the basement and shoveled into a burner to heat up water, which was circulated through the house's radiators. The spread of central heating systems—to almost 80 percent of the houses by 1938—facilitated the transition to geothermal heating; the existing pipes could simply be connected to the hot-water grid in the street.[5]

4 Helgi Sigurðsson, "Hitaveita Reykjavíkur," *Tímarit* VFÍ 32, no. 2 (1947): 26–39.
5 Reykjavík Municipal Archives, Málasafn borgarstjóra 965, Comment on Central Heating Systems, 16 September 1938.

The Creation of Demand

Recent studies in energy history, such as Christopher Jones's *Routes of Power*,[6] have shown that the creation of user demand is a key factor in transitions from one energy carrier to another. Actors involved in the building and operation of new energy infrastructures cannot rely on preexisting demand but have to help create new demand. This was also the case in Reykjavík. The geothermal project's success depended on prospective users for a return on investments. They needed to be willing to abandon coal and switch to geothermal heating.

Before the twentieth century, geothermal resources were little valued by Icelanders. While hot springs were used for bathing, laundry, and cooking, the springs also lowered the value of land, as they could be hazardous to people and animals and make freshwater unpotable.[7] Perceptions changed in the early twentieth century. Icelanders first considered geothermal heating a feasible alternative to solid fuels in cities upon learning about the geothermal district heating utility in Boise, Idaho, in 1910. But the initial excitement about becoming another Boise soon faded, as the construction of a new harbor, a freshwater utility, as well as a hydroelectric and manufactured "town gas" plant were prioritized.[8] Outside of Reykjavík, however, around 20 small heating systems were set up in the years that followed, mostly for houses close to hot springs. These pioneering projects, and the early 1930s experiments in Reykjavík, were an important factor in convincing people of the feasibility of geothermal heating. The first experiences in Reykjavík were not solely positive, however. Users complained about the price scheme, which required them to pay a fixed rate per month even though they used little hot water during the summer. They also objected to the fact that the centralized geothermal utility could not be controlled as coal heating could. During the coldest days of the year, the system repeatedly failed to provide enough hot water, and the radiators remained cold. With coal, on the other hand, consumers could simply burn more fuel if they wanted to increase the heat.[9]

6 Christopher Jones, *Routes of Power: Energy and Modern America* (Cambridge, MA: Harvard University Press, 2014).

7 Árni Magnússon and Páll Vídalín, *Jardabók Árna Magnússonar og Páls Vídalíns* III (Copenhagen: Hið Íslenska fræðafjelag, 1923), 318.

8 A. G. Johnson, "Er mögulegt að hita Reykjavík upp með Laugunum?" *Þjóðviljinn* 24, no. 23–24 (1910): 90–91.

9 Jón Þorkelsson, "Haglegur hitakútur," *Morgunblaðið*, 22 July 1943, 6.

When the citywide geothermal utility was being planned during the 1930s, many of the inhabitants were still not fully convinced. They had heard users' earlier complaints. By the time the project was launched in 1939, however, it had widespread support. How was this demand eventually created? Two groups were involved in this transition: builders (city government actors and engineers), who actively promoted geothermal heating, and users (the inhabitants as prospective consumers of hot water), who embraced the builders' promotions and ultimately constructed the demand. Through a broad newspaper campaign for geothermal heating during the late 1930s, the builders managed to communicate the feasibility and the advantages of geothermal heating. Yet it was not enough just to praise the geothermal option. Coal was more than a prehistory to geothermal heating; when imported coal became readily available in the early 1900s, it was considered a godsend. For centuries, Icelanders had struggled to heat their homes with peat, animal dung, or whatever bushes could be gathered on this largely deforested island. Coal was valued for the reliable indoor heating it provided, which created a culture of temperate comfort (for those who could afford it). By targeting the disadvantages of coal and systematically reinforcing negative views of the fuel, builders were able to brand geothermal heating as the better alternative. This can clearly be seen in an advertisement from 1938 (Figure 1).

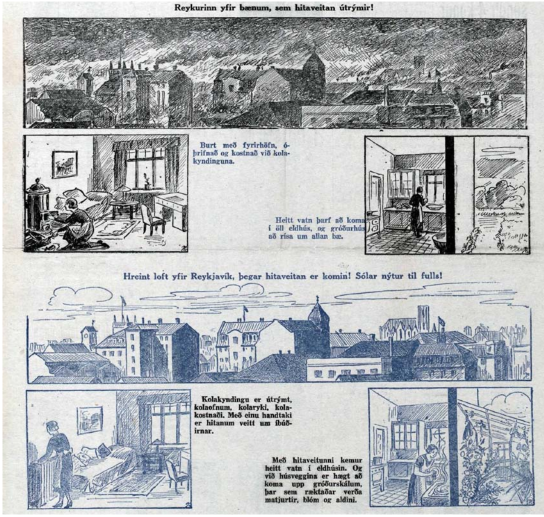

Figure 1: Newspaper advertisement for the planned geothermal heating utility. Source: Icelandic National Library. *Morgunblaðið*, 30 January 1938, 1. Available at: https://bit.ly/2XkuDSV.

In essence, four issues were raised to discredit coal.[10] First, coal was branded as dark and dirty, while geothermal heating was praised as bright and clean. Reykjavík was not plagued by coal smoke as badly as other industrial cities, since there were no heavy industries and there was usually plenty of wind to circulate the air. Yet there were also exceptionally cold and still winter days, when the coal smoke lay over the city like a dark

10 See also Helgi Eiríksson, "Hitaveitan," *Lífið* 4, no. 1 (1939): 458–66; Árni Óla, "Hitaveita Reykjavíkur," *Lesbók Morgunblaðsins* 23 (1936): 177–81.

cloud, dimming the day and polluting the air. Coal was condemned for the soot, dust, and dirt it spread on the streets and inside buildings. The geothermal alternative, it was promised, would clean up houses, streets, and the air.

Second, coal was branded as unhealthy both because of the poisonous smoke it created when it was burned and because it cost so much to heat up homes to what were considered "healthy" room temperatures. Geothermal heating would improve public health by eradicating the coal smoke from the urban environment and by providing more reliable, regular, and above all, affordable heating, which would reduce health risks.

Third, geothermal heating was said to bring comforts that coal simply could not offer. It would end the days of coal shoveling around the house and liberate housewives from this arduous and filthy task. Homes would be warm day and night, as people could simply turn on their radiators. It would even improve one's surroundings, as excess water could be used to heat up sunrooms, where the inhabitants could cultivate exotic flowers and vegetables. And Reykjavík would become prettier: the first chimney-free city in the world. (The chimneys became useless and did gradually disappear from the urban scene.)

Fourth, there was a promise of energy autarky in using domestic resources instead of imported fuels. This was popular following the experience of coal shortages during the First World War and the 1930s, when Icelanders realized how much they depended on fuel imports. The citywide geothermal utility was framed as a prestigious project of utmost national importance. Like hydropower, geothermal energy was portrayed as a "national" energy carrier.

Yet all this changed little if geothermal heating was not cheaper than coal. Price incentives are often considered key drivers of energy transitions. In Reykjavík, the promise of affordable heating via the geothermal grid became quite popular, as the periodically high cost of coal during the 1930s had made heating barely affordable to many. And geothermal heating promised to liberate the inhabitants from their dependency on local coal merchants. The coal merchants were despised for receiving profits from what inhabitants perceived to be unethical price agreements. But how was the price of hot water to be determined? The builders' strategy was to link the hot water price to that of coal, but keep it 10–20 percent below what it would cost to heat the same spaces with coal.[11] That way, geothermal heating could compete with coal and at the same time generate maximum revenue to ensure a return on investments. While this price difference was not as great as many users wanted, the perceived benefits of geothermal heating sufficed to outweigh discontent with prices. The key to popular acceptance of geothermal heating was the construction of user demand during the 1920s and 1930s.

Conclusion: Learning from the Past for the Future

Though it may sound futuristic to suggest that any town on Earth could be heated (or cooled) with geothermal energy, it is available all around the globe. Moreover, while intensity varies, it can be harnessed anywhere with today's technology, be it by drilling for hot water and steam in the depths of the Earth or by transferring ground heat through heat pumps. In the light of current aspirations for sustainable development, geothermal energy has much potential as a renewable, clean, and locally available resource. Like oil and natural gas in many other cities today, coal was the incumbent heating regime that needed to be replaced for geothermal heating to succeed in Reykjavík. This was achieved by making sufficient resources available, applying adequate technologies, and creating societal demand for geothermal heating by promoting it as the better and cheaper alternative.

The case of Reykjavík shows that we cannot assume that humanity will automatically strive towards a sustainable future. We have not always chosen the newest, most effective, or most sustainable energy options, and the availability of renewable resources such as geothermal energy does not predetermine local heating systems. Energy systems are always built into the natural environment, with the help of technology for a complex set of reasons. Reykjavík also shows us that consumers play a central role in energy transitions. As prospective users, the city's inhabitants were as important as the builders were. Even though the users' agency might not seem obvious, it was they who had to provide the demand to fund the geothermal alternative. We cannot assume that if technologies become more efficient and cheaper, this will eventually spur demand and lead to their use worldwide. If today's and tomorrow's engineers, researchers, and policymakers wish to transform energy systems, they will have to put the construction of demand at the core of the transition.

11 Reykjavík Municipal Archives, Málasafn borgarstjóra 965, Comment on Hot Water Prices, 8 December 1939.

Further Reading

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