# ADVANTAGES OF LIVING IN A VOLCANIC AREA: ICELAND

by Lindsay Frost

PHYSICAL PROCESSES (eg volcanoes) do not become hazardous until they affect people through death and/or destruction. Iceland lies on a constructive plate boundary between North America and Europe (Figure 1), which is moving apart at 2 cm per year, and therefore has volcanic activity and earthquakes. It also has an unusual hazard called a *jökulhlaup*. This occurs when there is a volcanic eruption under an ice cap; the heat melts the ice, water builds up and eventually bursts out causing floods.

Despite natural hazards people still live in risky areas. For example, 300,000 people live and work in Iceland, so there must be some benefits. The GDP per capita of Iceland was similar to that of the UK in 2004, and it has a young population (22.3% under 15). There are small benefits from being in a volcanic area – for example, after the eruption of Eldfell on Heimaey in 1973 a lava flow improved the harbour. There are larger benefits as well.

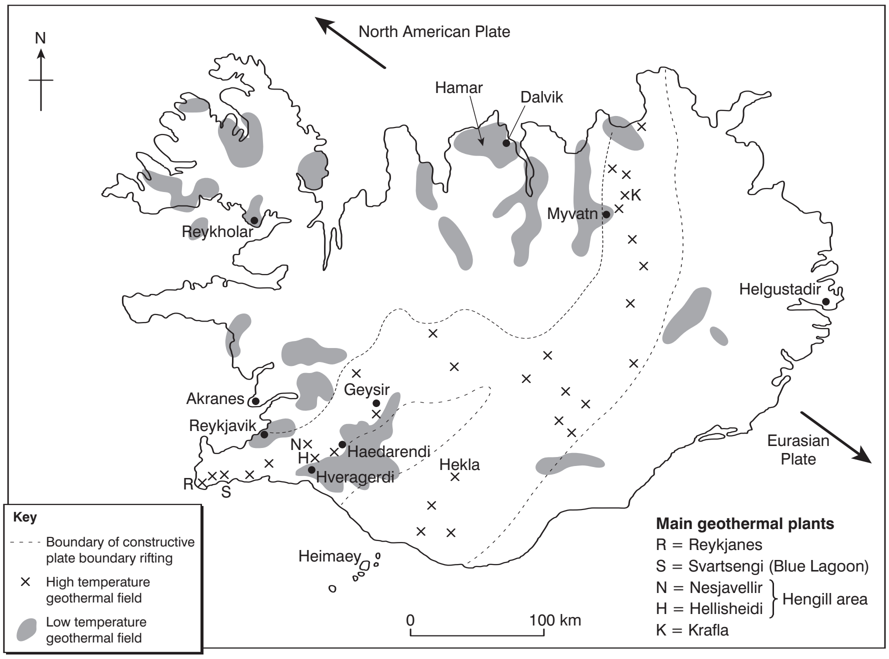


Figure 1: **Geothermal features and resource locations**

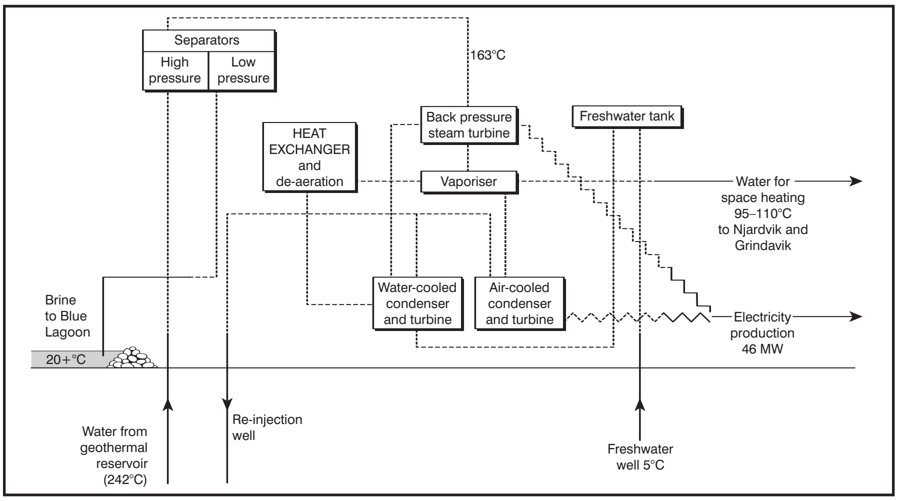


Figure 2: **Simplified flow diagram of Svartsengi geothermal power plant**

## Geothermal energy

The biggest benefit is geothermal energy. It can be used to generate electricity for Icelandic homes and industries, eg manufacturing aluminium, paper, refrigeration, and drying and curing cement blocks.

Where magma is close to the surface, groundwater turns to steam. This can be used to drive a turbine which generates electricity very cheaply (Figure 2). Geothermal energy is renewable, environmentally friendly, and sustainable (with careful management of groundwater levels). There are two types of area (Figure 1):

- Low temperature (below 150°C): these are non-active volcanic zones (eg Hamar), but the groundwater is still 65°C due to hot crustal rocks and open fissures. Hamar's small geothermal system has heated homes in Dalvik since 1969, but careful management is needed as cold water is cooling the ground and decreasing efficiency.
- High temperature (above 150°C): active zones, such as the fissure swarms of the Reykjanes peninsula (eg Hengill is the second largest geothermal area in Iceland: 100 km$^2$) where shallow

 

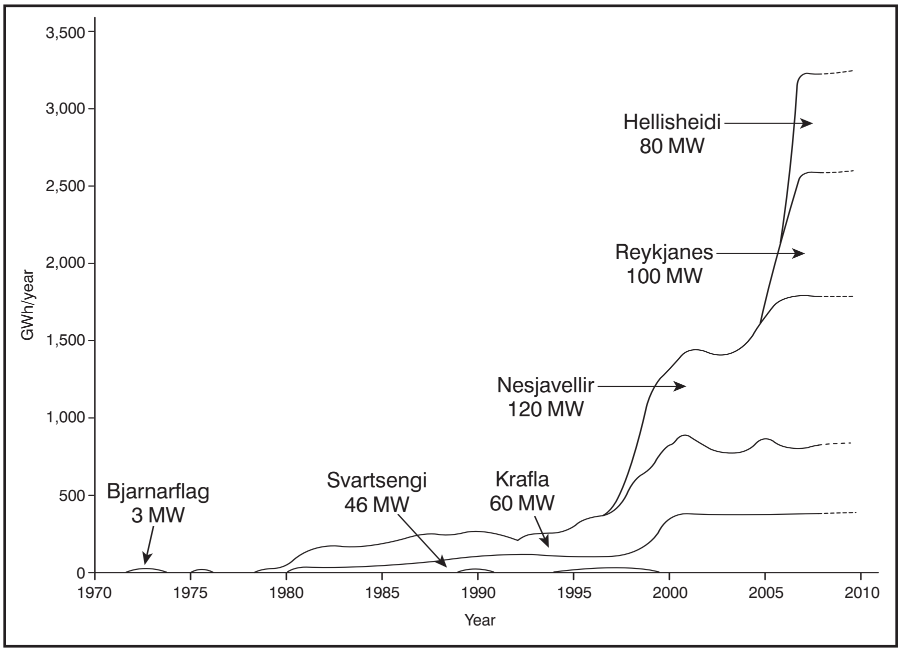


Figure 3: **Generation of electricity from geothermal energy, 1970–2008**
*Source: Geothermal Development and Research in Iceland*, April 2006. National Energy Authority and Ministries of Industry and Commerce

magma intrusions heat percolated precipitation, and in some places marine water as well. Exploration started 40 years ago and there are now nine geothermal centres with combined heat and electric plants. Reykjavik is the only capital in the world that has a heating system based on natural hot water. In 2006 the Sudurnes Regional Heating Company opened a 100 MW (Reykjanes) and an 80 MW power plant (Hellisheidi to serve Reykjavik).

Figure 3 shows that there has been a dramatic increase in geothermal energy production since 1997 with the building of the Nesjavellir (90 MW) power plant to serve Reykjavik, taking the total production to over 1,500 GWh/year in 2005 and reaching 3,200 GWh/year by 2009. But geothermal energy only supplies 20% of Iceland's electricity; the majority comes from hydro-electric power. So Iceland does not rely on expensive imported fossil fuels such as oil, and spare energy could be exported to Scotland via a submarine cable, so earning Iceland revenue. These are great benefits in a polluted and energy hungry world.

## Geothermal heating

In 1970 only 43% of homes were heated by geothermal energy. By 2005 this reached 89% and is likely to rise to 92% in the future. Water from hot springs has been piped to homes in Reykjavik since 1930, and in 1943 the Reykjavik District Heating Service began operating. There are now over 2,200 km of pipe around the capital. After leaving the power station the water cools and can be safely piped to settlements to be used as space heating in buildings, eg in Reykjavik and Dalvik. This is very useful in the Icelandic winters and half the cost of conventional energy sources! There are 740,000 $m^2$ of snow melting systems in Iceland, 75% being in Reykjavik. Pavements and car parks have underground heating systems which use water returned after heating buildings.

Hveragerdi is the only town in Europe with an active high-temperature geothermal area in its centre. Since 1929 the town has used geothermal energy, and individual homes still tap directly into hot water springs for heating and hot tubs. In the Hveragerdi area geothermal energy heats 50,000 $m^2$ of greenhouses (Figure 4), 650 houses and 3 swimming pools, and helps in the washing of wool, baking bread, and health spas. The town uses 90 GWh per year, 72% of this in greenhouses. Tomatoes, cucumbers, peppers and even flowers are grown in greenhouses, where the soil and air are heated and lights provided by geothermal power.

Figure 4: **Greenhouses at Hveragerdi**

The government sells hot water to residents and industries and avoids importing expensive oil. Between 1970 and 2000 the government saved $8.2 billion. There is also less air pollution, with an estimated 37% saving in carbon dioxide emissions (2003). There are also social and health benefits for people because Icelanders have been encouraged to live in communities using geothermal energy; living conditions are more comfortable in winter and there are many recreational opportunities with swimming pools (130 in Iceland) and spas.

## Tourism and recreation

Iceland has spectacular scenery. There are basaltic cliffs, waterfalls, gorges, rifts and grabens, crater lakes, volcanic cones, basalt columns and lava caves. There are hot bubbling springs of water and mud, fumaroles, solfataras, blue mud pools, yellow sulphur deposits, and other mineral deposits that give areas a wealth of colour. These sights attract many people each year. A famous example is Strokkur geyser at Geysir, which regularly discharges boiling water to a height of 15 metres or more.

Figure 5: **Blue Lagoon and Svartsergi geothermal power station**

In Reykjavik 13 swimming pools use geothermal water and the nearby Blue Lagoon is supplied with 5 to 6 million tonnes of hot water from the Svartsengi geothermal plant each year (Figure 5). The water has 75% of the salinity of seawater and contains many minerals, mostly dissolved silica. As the water cools, 2,000–2,500 tonnes of silica are deposited each year, hardening gradually to form a dense layer that prevents the water from seeping into the permeable volcanic rock. The minerals and blue-green algae combine to give therapeutic properties, especially for skin ailments (eg psoriasis). The Blue Lagoon is a tourist attraction, receiving 120,000 visitors in 1995 and 354,000 in 2005. A new 5,000 $m^2$ lagoon, 800 metres west of the original, was opened in 1999. By 2007 it will be extended (50% bigger) with better facilities.

## Micro-organisms

Within hot springs there are unique micro-organisms and enzymes.

- Proteases are used in the food industry and washing detergents.
- Amylases are used in the food industry (eg brewing and baking).
- DNA polymerases are used in DNA research and medicine (to identify genetic factors related to disease, and in criminal forensics).
- Thermophylic (heat loving) micro-organisms are useful to high-tech industries.

## Primary industries

Iceland is young geologically and so there are not very many useful minerals or rocks:

- Ferrosilicon – produced from local silica combined with imported iron (in decline).
- Diatomite – produced from Lake Myvatn, a silica-based deposit found on the bottom of the lake; used in filters.
- Calcite crystals (Iceland spar) – found in a basalt cavity at Helgustadir, these were used for optical purposes, but the pure crystals have been used up.
- Pumice – production is concentrated around Hekla; it is used for light concrete and building blocks.
- Basalt and rhyolite – crushed and used for road building and construction, including cement production (eg Akranes).
- Liquid $CO_2$ – since 1986 this has been extracted from geothermal fluid at Haedarendi, used in carbonated drinks and other foods, as well as for enriching the $CO_2$ in greenhouses.

The climate and landscape make farming difficult in Iceland. However, southerly coastal plains and valleys support livestock farming (Figure 6) with grasses on fertile volcanic ash. These soils are also used in the greenhouses at Hveragerdi. Geothermal heat is used for drying: seaweed (at Reykholar), salt (at Reykjanes – now closed), pet food, and fish (eg cod heads). Fish farm water is also warmed to help raise trout.

## Conclusion

- Tourism is growing rapidly in Iceland, with 360,000 visitors in 2004 creating 6,800 jobs, 12.4% of foreign income and 5.1% of GDP.

Figure 6: **Icelandic farm on the southern coastal plain**

  Natural characteristics were the main reason for people visiting – so the active constructive plate boundary has brought economic benefits.
- Geothermal energy will develop further. The Iceland Deep Drill Project is drilling down to 5 km to find temperatures of 600°C where the power output should be ten times higher than at current boreholes. However, their 2005 drill hole suffered a cave-in.
- The Geothermal Training Programme of the United Nations University was established in Iceland (1978), educating people from all over the world. Iceland has an international reputation for expertise, helping Icelandic companies abroad, and attracting Foreign Direct Investment (FDI) in energy, and in research and development (eg from the USA and Switzerland). Iceland also helps LEDCs develop their geothermal potential.

In Iceland people have learnt to cope with the short-term natural hazards, such as *jökulhlaups*, moderate earthquakes and volcanic eruptions, and have moved on to use the long-term benefits that the natural processes provide. In this way Icelanders are living with the Earth in a sustainable way.

# Activities

1 What is a *jökulhlaup*? Why can it be classified as a hazard? Investigate the Grimsvötn volcanic eruption in 1996.

2 Where is Europe's largest ice sheet? What is it called?

3 Study Figure 7, which shows how geothermal energy is used in Iceland. Draw a pie graph to show this information.

| | |
|---|---|
| Heating buildings | 57.4 |
| Electricity generation | 15.8 |
| Fish farms | 10.4 |
| Snow melting | 5.4 |
| Industry | 4.7 |
| Swimming pools | 3.7 |
| Greenhouses | 2.6 |

Figure 7: **Percentage of geothermal use in Iceland 2005**

4 Study Figure 2.
(a) What are the inputs and outputs from the geothermal energy system?
(b) Why does the geothermal water need to be cooled?

5 Study Figure 3. Describe the increase in geothermal energy production between 1970 and the present.

6 (a) List all the uses of geothermal energy. Put these in rank order to show which you think is the most important (position 1 = most important).
(b) Briefly explain why your first choice is the most important.

| | |
|---|---|
| Scandinavia | 27.1 |
| UK | 16.9 |
| North America | 14.6 |
| Germany | 11.4 |
| France | 6.2 |
| Netherlands | 3.2 |
| Japan | 1.8 |
| Rest of Europe | 18.8 |

Figure 8: **Percentage of visitors from different countries to Iceland in 2004**

Figure 9: **Strokkur geyser**

7 What would the quality of life be like for Icelandic people without geothermal energy? (Think about home, work and recreation.)

8 There were over 360,000 foreign visitors to Iceland in 2004, mostly visiting between June and August. Half of the visitors were from managerial or professional occupations with above average incomes.
(a) Why did people visit mostly between June and August?
(b) How would Iceland benefit from the type of person visiting the country?
(c) Study Figure 8. Then on a map showing Iceland and its nearest neighbours, draw proportional arrows to show where the visitors to Iceland came from in 2004.

9 What benefits and hazards may a geothermal area like that in Figure 9 bring to Iceland?

10 (a) Why are greenhouses necessary for growing flowers and vegetables in Iceland?
(b) Explain the effects that carbon dioxide enrichment of the air in greenhouses will have on plants. (**Hint:** photosynthesis)

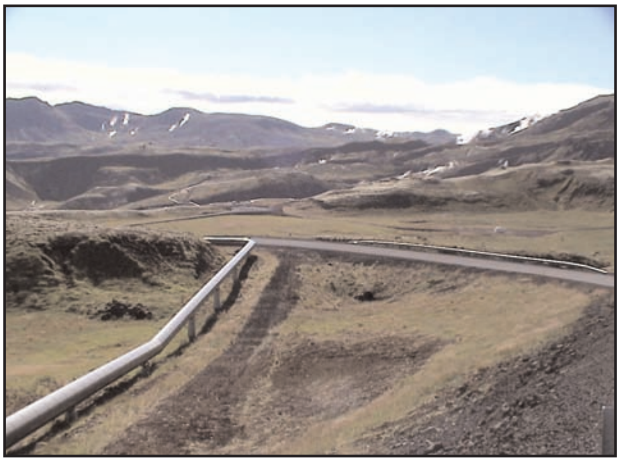

Figure 10: **Hengill geothermal area**

11 Explain in detail how the benefits of natural hazards in Iceland have helped the Icelandic economy (business, industry, and jobs in Iceland and overseas).

12 What issues may arise from human use of the natural environment shown in Figure 10?

13 'It is a moral obligation of the world's nations to reduce greenhouse gas emissions. Increased use of renewable energy could play a key role in this respect. Iceland is a world leader in terms of the share of renewable resources.'

*Source:* S. Bjornsson, *Geothermal Development and Research in Iceland*, National Energy Authority and Ministries of Industry and Commerce, April 2006

In small groups, consider each of the statements in this quotation. Do you agree with these statements or not? Give reasons for your answers, including facts if possible.