Meet Iceland

– a Pioneer in the Use of Renewable Resources

The solution to the threat of climate change is based on diverse clean, renewable and environmentally sound sources of energy.

Why is Iceland one of the world's greatest potential sources of renewable energy?

Located just south of the Arctic Circle, Iceland is located on both a hotspot and the Mid Atlantic Ridge, which runs right through it.

This combined location means that geologically the island is extremely active with an eruption every five years on average.

Despite its fiery nature, about one-tenth of Iceland's landmass is covered by glaciers, from whose icecaps flow many powerful rivers, providing the nation with a wealth of hydro-power.

The country's geographical peculiarities have endowed Iceland with an abundant supply of geothermal resources and hydropower.

Iceland has succeeded in doing what many consider impossible: transforming its energy system from fossil fuels to clean energy. The use of geothermal energy in Iceland is highly cost-effective, reliable, clean, and socially important. It has also dramatically increased the quality of life for the inhabitants.

ORKUSTOFNUN
National Energy Authority

Ministry of Industry, Energy and Tourism

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Harnessing Natural Resources

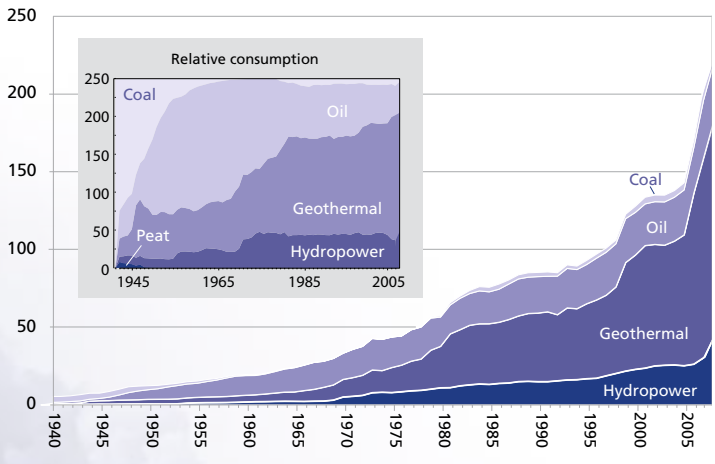
Iceland is a country of 300,000 people, located on the mid-Atlantic ridge. It is mountainous and volcanic with much precipitation. The country's geographical peculiarities have endowed Iceland with an abundant supply of geothermal resources and hydropower.

During the course of the 20th century, Iceland went from what was one of Europe's poorest countries, dependent upon peat and imported coal for its energy, to a country with a high standard of living where practically all stationary energy, and in 2008 roughly 82% of primary energy was derived from indigenous renewable sources (62% geothermal, 20% hydropower). The rest of Iceland's energy sources come from imported fossil fuel used for fishing and transportation.

Today, this makes Iceland a world leader in terms of the share of renewable resources that the country uses.

Iceland's energy use per capita is among the highest in the world, and the proportion of this provided by renewable energy sources exceeds most other countries. Nowhere else does geothermal energy play a greater role in proving a nation's energy supply. Almost three-quarters of the population live in the south-western part of the country, where geothermal resources are abundant.

Primary energy consumption in Iceland 1940–2008



Harnessing Rivers

Less than 10 years after Thomas Edison opened the world's first hydroelectric power station, a group of visionary Icelanders began exploring the possibility of harnessing some of their own country's rivers and waterfalls as an energy source to create light and heat.

In 1904, Iceland's first hydropower station brought electricity to some inhabitants of the port of Hafnarfjörður, and switches clicked on in Reykjavík in 1921. The next decades saw the electrification of rural areas, and 1946 saw the formation of Iceland State Electricity, followed in 1965 by the National Power Company (Landsvirkjun).

Demand for electricity in Iceland increased dramatically with the opening of the country's first aluminium smelter in 1969. Today 80% of the nation's electricity use, is due to power intensive industries.

At the end of the year 2008, Iceland has hydroelectric power stations with a total installed capacity of 1.880 MW.

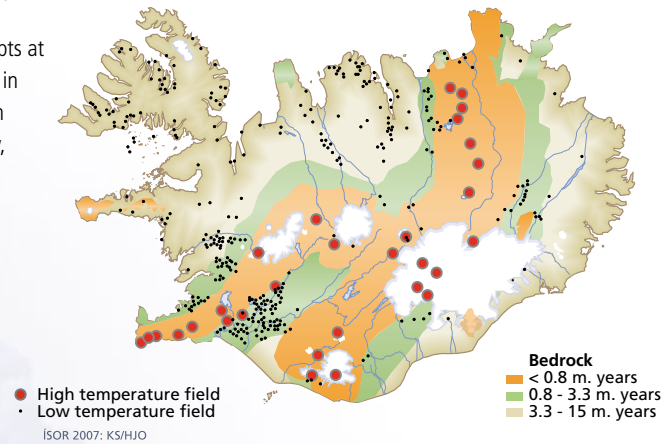
Nature's Central Heating

Geothermal energy begins life as rainwater, which gradually seeps deep into the ground where it is heated by hot rock. While some of this water returns to the surface as hot springs or geysers, most remains trapped underground, from where it is extracted using technology similar to that used to obtain oil or fresh water.

In the active volcanic zone of Iceland, 30 high temperature fields have been identified and on the flanks of the volcanic zone clusters of low temperature fields exist. In low temperature systems, temperature in the uppermost 1000 m may reach up to 150°C. The water is mostly used directly to supply hot water for district heating, greenhouses, swimming pools etc. In the high temperature fields, on the other hand, temperatures reach over 200°C at 1000 m depth. Electricity can be generated from these fields due to the high temperatures but since the water is much richer in minerals and gases, the hot water is used for heating fresh water.

While the first attempts at drilling for hot water in Iceland were made in the mid-18th century, it was not until 1930 that a Reykjavík school became the city's first building to be heated using geothermal water. As further wells followed, more buildings were connected to the system, a process greatly accelerated by the global oil crises of the early 1970s. Today, almost 90% of Iceland's houses and buildings are heated by natural hot water. Geothermal power facilities currently generate 25% of the electricity (4.038 GWh of total 16.467 GWh), and the official energy forecast projects a 50% increase in the use of geothermal energy by 2030.

Geothermal fields



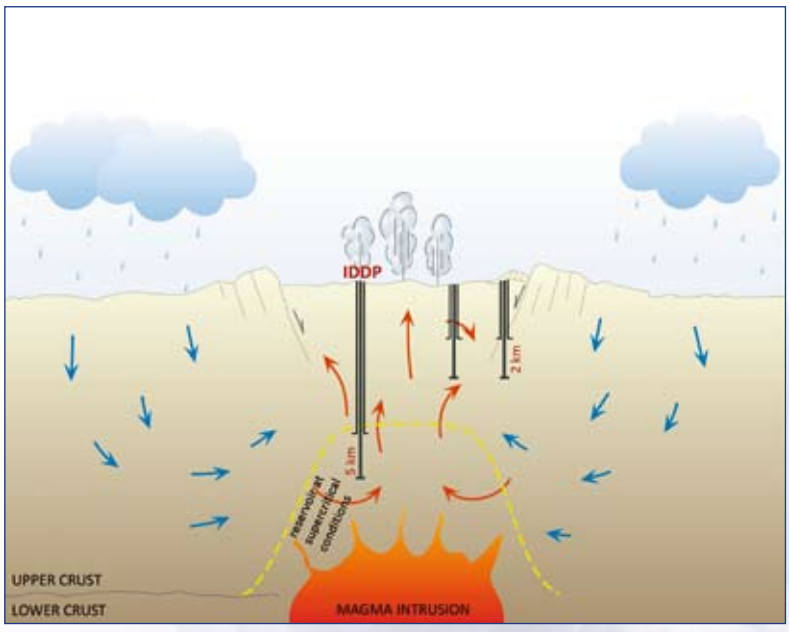
Deep resources – More Energy

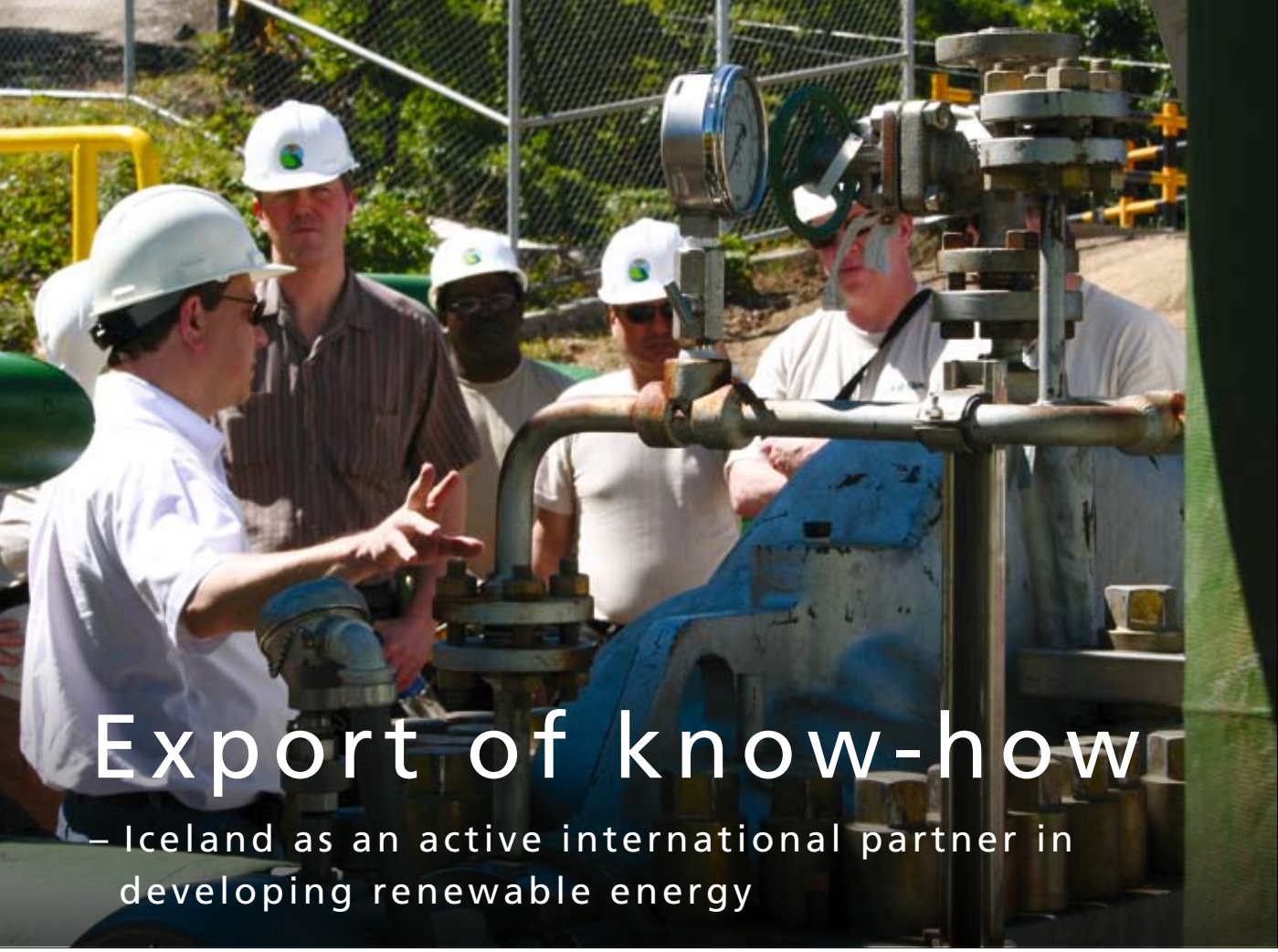
The Iceland Deep Drilling Project (IDDP) is a long-term study of high-temperature hydrothermal systems in Iceland.

The IDDP is a collaborative effort by a consortium of Icelandic and foreign power companies and the Icelandic government, formed to determine if utilizing supercritical geothermal fluids would improve the economics of power productions from geothermal fields. Over the next several years the IDDP, expects to drill and test a series of boreholes that will penetrate supercritical zones believed to be present beneath three currently exploited geothermal fields in Iceland. This will require drilling to a depth of about 5 km in order to reach hydrothermal fluids at temperatures ranging from 450°C to ~600°C.

A feasibility study completed in 2003 indicates that relative to the output from conventional geothermal wells, which are 2.5 km deep, a ten-fold increase in power output per well could result if fluid is produced from reservoirs hotter than 450°C.

A typical 2.5 km-deep geothermal well in Iceland yields power equivalent to approximately 5 MWe. Assuming a similar volumetric inflow rate of steam, an IDDP well tapping a supercritical reservoir at temperatures above 450°C and at a pressure of 23-26 MPa may be expected to yield ~50 MWe.





Export of know-how

– Iceland as an active international partner in developing renewable energy

As global warming poses a threat to the world, it is now mostly acknowledged that an increased use of renewable energy could play a key role in reducing this development.

Geothermal energy can play a significant role in the electricity production of countries and regions rich in high-temperature fields which are associated with volcanic activity. Capacity building and transfer of technology are key issues in the sustainable development of geothermal resources.

Icelandic emphasis in bi-lateral development assistance has therefore focused on geothermal energy and cooperation with countries who sit on unexploited geothermal resources. The objective being to assist them to develop their renewable energy resources.

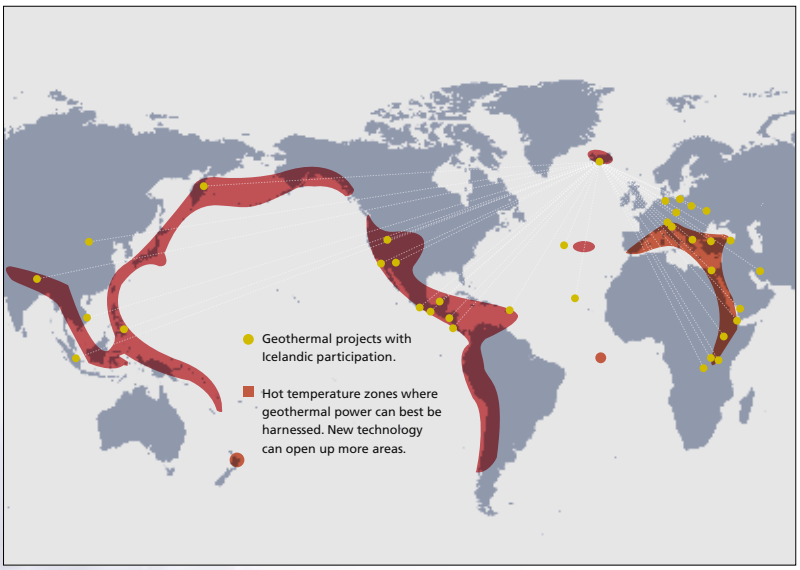
In addition, several Icelandic companies make it their business to export geothermal and hydropower know-how and experience. Icelandic experts participate in geothermal projects worldwide, and have contributed to the world's best known geothermal projects. Geothermal experts from Iceland are now at work in the United States, China, Indonesia, the Phillipines, Germany, Hungary, Djibouti, Eritrea, Nicaragua, and El Salvador to name but a few examples.

Engineering and consulting companies:

Efla – www.efla.is
Icelandic Geosurvey – www.isor.is
Mannvit – www.mannvit.is
Verkís – www.verkis.is

Energy and contracting companies:

Geysir Green Energy – www.gge.is
Iceland Drilling – www.iceland-drilling.com
Icelandic State Electricity – www.rarik.is
HS Orka – www.hsorka.is
Landsvirkjun Power – www.lvp.is
Reykjavik Energy – www.or.is



Knowledge is Power

Renewable energy has become an important field of study in Iceland. The Icelandic universities have taken the lead, founding graduate and post-graduate courses in many fields of expertise in clean energy, collaborating with some of the world's leading institutions.

UNU-GTP – The United Nations Geothermal Training Programme

www.unugtp.is

The UNU-GTP has since 1979 been assisting developing countries with significant geothermal potential to establish groups of specialists in geothermal exploration and developement by offering six month specialised training and, furthermore, the possibility of extending their studies to a MSc and PhD degree in geothermal sciences or engineering, in cooperation with the University of Iceland.

RES – The School for Renewable Energy Science

www.res.is

RES has since the year 2007 offered an intensive and unique interdisciplinary research oriented one-year graduate programme in Renewable Energy Science. The programme is offered in cooperation with University of Iceland and University of Akureyri, as well as in partnership with a number of leading technical universities around the world. In 2009 the school will offer four specialisations of study: Geothermal Energy; Fuel Cell Systems & Hydrogen; Biofuels & Bioenergy; and Energy Systems & Policies.

REYST – Reykjavik Energy Graduate School of Sustainable Systems

www.reyst.is

Since 2008 the school has offered an international graduate programme based on the three pillars of engineering, earth science and business. The programme is characterized by its focus on sustainable energy use, practical experience in the field and ready access to on-site work with experts on various subjects.

The University of Iceland

www.hi.is

The University of Iceland is an active coordinative partner in the programmes of REYST, RES and KEILIR., but also offers in-house graduate studies in the field of Renewable Energy Engineering: an interdischiplinary study on the technical and environmental aspect harnessing, distributing and consuming energy in a sustainable manner.

Reykjavik University

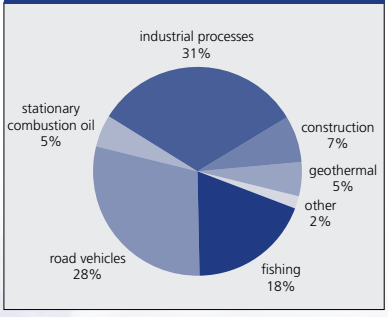
www.ru.is

Reykjavik University offers a BSc programme in Mechanical and Energy Engineering with a strong tradition of practical orientation in cooperation with the industry. The research focus is on applied research in cooperation with specialized companies and institutions in the energy field.

Alternative Fuels

In spite of the widespread use of renewables for electricity and heating, Iceland is still dependent on fossil fuels when it comes to transportation and fishing. Those two categories represent about a third of the country's CO2 emissions.

Distribution of CO_2 emissions by source in 2006



All fossil fuels are imported, and the price tag is about one tenth of the cost of Iceland's entire imports. Finding alternatives to fossil fuels should therefore be a priority, especially those alternative fuels that can be produced locally.

Electricity based alternatives, such as battery vehicles, hydrogen and designer fuels are obvious candidates for Iceland, given the country's abundant renewable energy resources. However, biofuels shouldn't be overlooked, in particular those that can be produced by utilizing waste products.

The Icelandic government supports innovative companies in clean energy, energy efficiency, and clean technology. These are a couple of expamles:

SMART H2 is one of many ongoing alternative fuel projects in Iceland, managed by **Icelandic New Energy.** It's a demonstration project testing hydrogen fuelled vehicles and vessels, including a hydrogen auxiliary power unit for a whale safari tour ship – shown on picture above.

ÍSLENSK NYORKA ehf
ICELANDIC NEW ENERGY Ltd.

CARBON RECYCLING INTERNATIONAL

Carbon Recycling International captures carbon dioxide from industrial emissions and converts carbon dioxide to ultra clean fuel. The sources of emissions can be from basic infrastructure industrial processes including geothermal power plants, aluminum smelting, ferro silicon manufacturing, cement production and coal fired power generation. Carbon Recycling International was selected at Cleantech Forum XXII in Copenhagen in April 2009 as one of the five most promising cleantech firms in the Nordic region.

MARORKA

Marorka is a leading producer of energy management systems for ocean vessels. The company's aim is to enable customers to maximize their operating results by minimizing fuel consumption and harmful emissions. Marorka won the Nature and Environment Prize awarded by the Nordic Council in 2008.

Biofuels in Iceland

Methane

Methane has been collected from a waste yard since 2000 and utilized as fuel for transport since 2003. It is estimated that the production capacity of the methane collecting yard is enough to provide about 4000 cars with fuel, but so far only a fraction of that number are using methane.

Metan Ltd.

Metan Ltd. was founded as a subsidiary of the waste disposal company Sorpa, with the purpose of producing and selling energy from waste landfills. Metan Ltd. is now a marketing and development company for alternative fuel in the form of methane. The role of the company is to market and distribute energy in the form of electricity, raw gas, landfill gas and upgraded methane as well as knowledge collection within the field of biogas and landfill gas utilization.

Ethanol

Ethanol has been imported since 2007 and sold as an E85 fuel blend. Ethanol is produced using plant waste, energy crops or industrial waste. It is possible to produce ethanol locally although the climate in Iceland is not ideal for growing energy crops. Ethanol can be blended in gasoline as an additive and as such utilizes the current infrastructure.

Biodiesel

Biodiesel has been imported since 2004 and sold as a B5 or B10 fuel blend. Biodiesel can be blended with fossil diesel oil and as such utilizes the current infrastructure. Biodiesel is produced using animal waste or energy crops. It is possible to produce biodiesel locally from waste fat from food production or energy crops.

Using current technology in biofuels, it is difficult or even impossible to substitute the entire fossil fuel use in Iceland with biofuels produced locally. However, it is quite possible to substitute some of the fossil fuel use with locally produced biofuels from waste. Such production reduces waste, CO2 emissions and lessens Iceland's dependence on imported fuels.

Electricity as a Fuel

The Icelandic President, Olafur Ragnar Grimsson, test-driving the electric vehicle Mitshubishi i-Miev. In 2008 Mitshubishi Motors Corporationh and the Icelandic Ministry of INdustry, Energy, and Tourism, signed a MoU regarding fleet testing of the zero emissions i-Miev electric car. The fleet testing will start in 2009.

- All electricity in Iceland is produced from renewable energy sources – 100%
- This means that all use of electricity in transport, in Iceland, can be fossil free from well to wheel

Fossil Free

Iceland is ideal for utilizing electricity as fuel, since all electricity is produced from renewable resources, and is therefore mostly CO2 free. Electricity can be used directly in battery vehicles, or as designer fuels, including hydrogen. Cleaner vehicle technologies help everyone breathe easier, cut down greenhouse gas emissions and reduce our dependence on imported fossil fuels. Electric drive is a compelling solution to these national concerns.

Improving Efficiency

The efficiency of electricity as a fuel is strongly dependent on the medium used. Battery vehicles have the highest efficiency, but the energy density of batteries is rather small, and it is therefore difficult to imagine battery powered ships or airplanes. Fuel cells using hydrogen are somewhat more efficient, but expensive. Designer fuels are the least efficient, but often easiest to use since they can utilize existing infrastructure.

Electric Drive in Iceland

Changing the fleet to electric drive won't happen overnight. It will require substantial investments in technology, manufacturing, modernizing infrastructure and market development. This is why we need to get on the right road, right away and why Iceland already has several experimental projects in various stages concerning the utilization of electricity as fuel. To name a few examples:

- A project concerning the conversion of a hybrid car into a plug-in hybrid.
- Fleet vehicle testing of electric vehicles with lithium batteries.
- Feasibility studies of designer fuels production and pilot plants.
- A very successful and a long running hydrogen project has seen the operation of hydrogen busses, passenger cars and even the installation of a hydrogen fuel cell as an auxilliary engine on board a whale watching ship.

Energy Meets Tourism

The Icelandic energy industry has opened up it's doors to all those interested in the development of renewable energy in Iceland, it's products, and by-products.

Power Plants

In Iceland, various high tech geothermal power plants, as well as hydropower plants, have an open door policy and offer tours around their facilities, explaning the technical aspects of how they generate power.

Power Plant Earth

Power Plant Earth is a new exhibition located in Reykjanesvirkjun, a geothermal power plant. Located in a lava field in the south west point of the Reykjanes peninsula it´s natural surroundings make it an extraordinary place to visit. The museum is only a 15 min. drive away from the Blue Lagoon.

Mývatn Nature Baths

Containing a unique blend of minerals, silicates and geothermal microorganisms, the warm, soothing waters of Mývatn Nature Baths are beneficial to skin and spirit alike, creating a sense of wellbeing which lingers on as a lasting memory of your visit to this spellbinding area at Europe´s outer limits.

Blue Lagoon

The Blue Lagoon geothermal spa offering a unique experience based on bathing in the Blue Lagoon geothermal brine, a unique ecocycle where high technology and nature work in perfect harmony in Iceland's extreme environment.

Nauthólsvík Geothermal Beach

In Iceland the sea is normally far too cold to tempt swimmers, but at Nautholsvik bay in Reykjavik, a thermal beach has been created, where natural hot water flows out into the sea, and you can frolic in the waves as if you were in the Mediterranean!

Thermal Pools

Heating of outdoor swimming pools is among the most important uses of geotherrmal energy in Iceland. There are 136 recreational swimming centers in Iceland using geothermal heat. One of the delights of a visit to Iceland is bathing in one of the many thermal pools, filled with geothermally heated water. The pools are mostly open-air, and always pleasantly warm - whatever the weather - and most have outdoor whirlpools or 'hot-pots' to bask in before or after swimming.

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