Aloha Iceland Geothermal

By

S. Amelia Kajiyama

Hawaii picked the wrong geothermal, but we can fix it!

Me and my husband, Pomaika'iokalani (Pomai)

My name is S. Amelia Kajiyama. I'll take you along my journey of learning and discovery of how I learned that Hawaii picked the wrong geothermal technology.

I grew up in Kehena Beach in Lower Puna near Kalapana on Hawaii Island and proud Pahoa High School alumni.

I experienced numerous Puna Geothermal Venture noxious gas releases and loud noises for decades while visiting friends in Leilani, our family farm in Kapoho area, and at our home in Kehena Beach.

In 1991, I experienced the Puna Geothermal Venture's well blowout. I remember hearing the loud roaring noise, smelling the strong hydrogen sulfide (H_2S) gas, watching our yard grass and plants die, and listened to many other family and friends' stories about how their health was negatively affected by the well blowout.

Being curious, I wondered if there was better geothermal.

I came across a National Geographic article about Iceland's Blue Lagoon.

Blue Lagoon Resort and Spa is right next to Svartsengi Geothermal Power Plant. The lagoon is composed of the Svartsengi's geothermal outflow water. Tourists booked months to years in advance to swim in the water for its health benefits. They also make spa products using its water too.

Later, while in college first at UH Hilo and then at University of Arizona at Tucson, AZ while earning my BS Geoscience emphasis in Structural Geology and BS Geological Engineering emphasis in Geotechnical Civil Engineering.

I learned about Iceland's Geology and Geothermal Technology.

Iceland is one of the few places that is **most geologically similar to Hawaii**.

Iceland is a geological hot spot and has shield volcanoes **just like Hawaii**.

Iceland has a'a and pahoehoe lava flows **just like Hawaii**.

Iceland has the world's best geothermal technology. Iceland exports their technology around the world.

They have developed geothermal wells and plants to withstand high temperatures and volcanic gases.

They are also known for being respectful to people's safety and cultural concerns.

New Zealand adopted Iceland's geothermal technology in the 1970's. **Maori tribal councils' approval is required to develop a geothermal plant**.

New Zealand has had **no documented geothermal plant accidents**.

Hawaii picked the wrong geothermal, but we can fix it!

- In 2016, I got a chance to travel to Iceland for a month. I toured the world's largest geothermal plant 303 MW Hellisheidi Geothermal Plant and 100 MW Reykjanes Geothermal Plant, which are open to the public year-round and are cooperatively owned by Icelanders. 1MW can power ~ 1000 to 650 homes. When I visited these plants, I experienced very little smell and very little noise. They were cited near dormant and/or extinct volcanoes. Therefore, Icelandic geothermal technology could work for Kauai, Oahu, Maui, and Hawaii.
- I went to a geothermal spring and/or geothermal heated public pool everyday. I swam in the waters of the Blue Lagoon. It was amazing. I talked to people from all around the world enjoying swimming in the Blue Lagoon. Many people I talked to didn't notice Svartsengi geothermal plant nearby or realize that they were swimming in its outflow water, which all started back in 1974 when an outflow pipe leaked. Best Industrial accident I ever experienced!
- In 2025, with my husband's encouragement, I started my non-profit Aloha Iceland Geothermal to educated and advocate the usage of Icelandic Geothermal in Hawaii.
- I highly recommend a Hawaii Delegation go to Iceland and see themselves how Iceland geothermal can work for Hawaii.
- I would be more than happy to share what I have learned about Iceland and Iceland geothermal. I will also be happy to assist in planning for any tours to Iceland's Geothermal Plants and meeting Iceland's Geothermal Industry Leaders.
- Iceland Environmental and Energy Agency Project Manager- International Projects Baldur Petursson, MSA can assist in providing a tour to a Hawaii Delegation. Baldur Petursson's email is baldur.petursson@os.is and work phone # 354-569-6000.


Reykjanes Geothermal Power Plant

Hawaii picked the wrong geothermal, but we can fix it!


Hellisheidi Geothermal Power Plant


Selfloss Geothermal Heated Public Pool

Iceland Geothermal versus Puna Geothermal Venture Overview

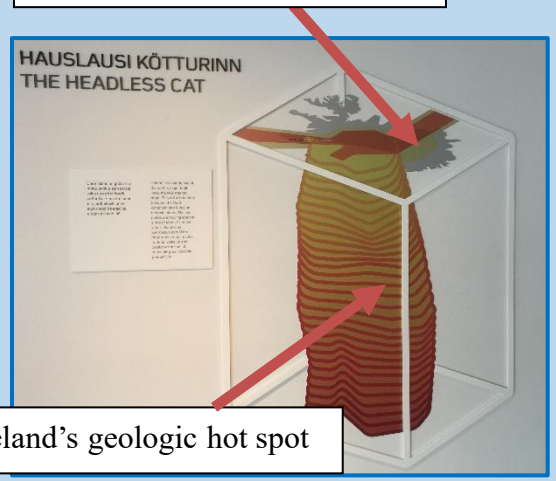
Iceland

- **World leader** in deep high temperature geothermal & low temperature geothermal. Iceland exports their technology around the world. They are also known for being respectful to people's safety and cultural concerns.
    - New Zealand adopted Iceland's geothermal technology in the 1970's. **Maori tribal councils' approval is required to develop a geothermal plant**. New Zealand has had no documented geothermal plant accidents.
- All Iceland Geothermal plants are cooperatively owned by the people of Iceland.
- Iceland Geothermal plants provide 80% of electricity and 100% of municipal hot water and thermal energy/heating for multiple uses.
- **Iceland** is one of the few places that is most geologically similar to **Hawaii**. Iceland is a geological hot spot just like Hawaii. They have shield volcanoes just like Hawaii. Iceland has a'a and pahoehoe lava flows just like Hawaii. Iceland has 30 active volcanoes.
- All Iceland Geothermal plants are cited on dormant or extinct volcanoes

Puna Geothermal Venture (PGV)

- PGV in Pohoiki was started in 1982 by State of Hawaii, Halliburton & Ormat. It is now operated by Ormat and Halliburton assists in well drilling and maintenance. Halliburton is mainly an oil and gas company. Ormat is an Israeli based geothermal company.
- Ormat is not leader in the geothermal industry. They have a reputation of damaging geothermal fields, poor plant maintenance, and poor treatment of employees. Halliburton has had multiple infamous well drilling failures and oil spills, such as 2010 Deepwater Horizon Oil Spill in Gulf of Mexico.

Mid-Atlantic Spreading Ridge



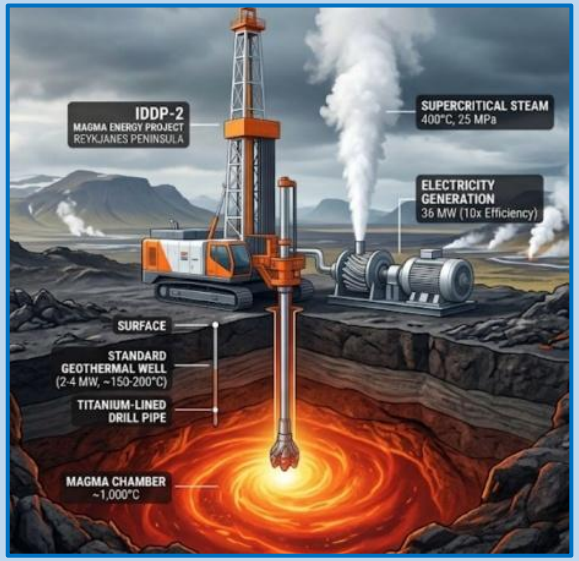
Iceland's geologic hot spot

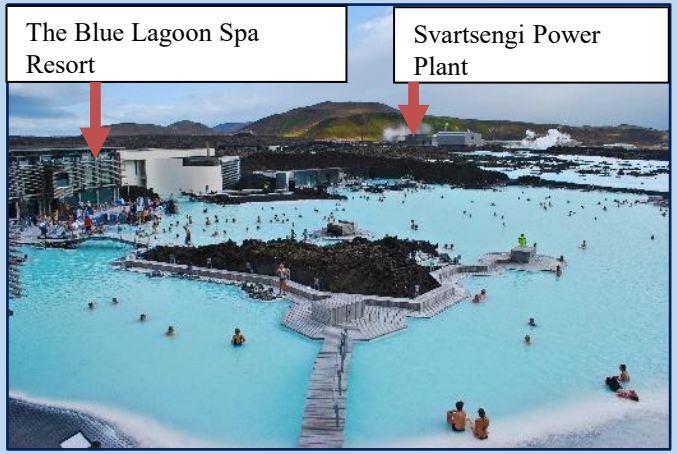
2025 Iceland's Sundhnuksgigar Volcano Eruption

Iceland Geothermal versus Puna Geothermal Venture Overview

Iceland

- **Iceland has an impeccable Safety record – only two recorded incidents**
  - In 1974, Svartsengi geothermal plant had **a pipe leak** that development into the **world-famous Blue Lagoon Resort & Spa.**
  - In **2009, Iceland Deep Drilling Research Project (IDDP) accidently drilled into a magma chamber at ~6890 ft . They successfully harness power directly from the magma chamber. The first time this has been accomplished in the world**.





- Iceland uses direct dry steam system in high temperature fields which uses steam directly from well to generate electricity and hot seawater brine to heat municipal hot water.
- Iceland uses binary cycle system in low temperature fields. Binary system uses low to moderate heated geothermal heated fluids to heat a fluid that reaches a boiling point lower than water to drive a turbine to make electricity.

Puna Geothermal Venture (PGV)

- PGV has poor safety record.
  - Puna Geothermal Venture has had 38 documented leaks and counting.
  - Puna Geothermal Venture had a borehole well blowout accident in March 1991. It lasted for a week and forced many residents to leave their homes and many suffered from excessive hydrogen sulfide (H_2S) exposure health related issues.
  - Puna Geothermal Venture accidently drilled into magma in 2009 and closed the well.
  - Hawaii County Civil Defense issued an evacuate alert on August 20, 2014 during Hurricane Iselle due to the uncontrolled release of H_2S at the Puna Geothermal Venture.
- PGV Uses pentane binary cycle system which is suited for low temperature field. Pentane Binary system uses low to moderate heated geothermal heated fluids to heat a fossil fuel pentane which reaches a boiling point lower than water to drive a turbine to make electricity.
- PGV is located on Kilauea Volcano southeast rift zone, which is a high temperature field. Kilauea is the most active volcano in the world.

Iceland Geothermal versus Puna Geothermal Venture Overview

- Icelandic geothermal wells have ceramic fibers in the concrete well casing to prevent well corrosion and use chemicals to remove volcanic gases such as hydrogen sulfide (H_2S) and hydrogen chloride (HCl) to prevent corrosion and to prevent such noxious gases from being emitted into the atmosphere
- Iceland's average cost to design/build a geothermal plant is approximately $1 million/MW to $1.5 million/MW, operation cost $1.9 million/1 MW/ year. 1MW can power ~ 1000 to 650 homes.
- Iceland's reported direct dry steam system electrical conversion efficiency is 10% to 20% and thermal energy conversion efficiency is 50% to 60%
- Iceland's reported binary cycle system electrical conversion efficiency is 8% to 12%
- Iceland reports electricity a transmission loss of 3%
- Iceland electricity cost for residential is $0.15 per kWh (~$30 to $125/month) and commercial is $0.10 per kWh
- Iceland's energy use per capita is among the highest in the world and has one of the lowest electrical costs per capita.
- Iceland uses 100% renewable energy resources for power (80% geothermal / 20% hydropower) only using fossil fuels for vehicles and fishing fleet and intend to switch all vehicles and their fishing fleet in the country to a renewable fuel source in the future.
- Iceland use geothermal to grow 60% of their vegetables and fruit in greenhouses and raise 100% of their diary, eggs, and meat and use geothermal heat their livestock barns. Iceland currently imports approximately 40% of their food supply.

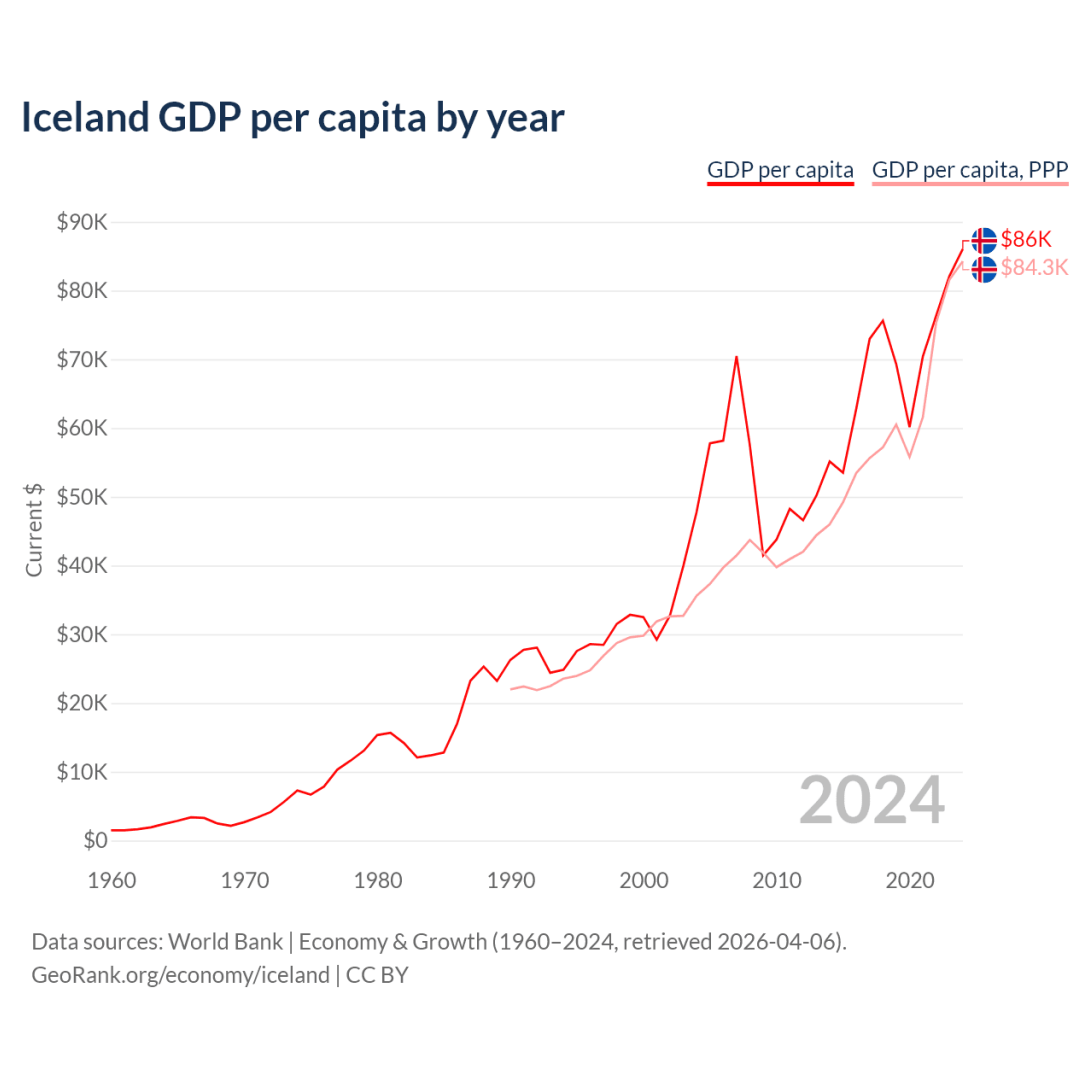
- No reported methods used to prevent noxious gases being emitted into atmosphere or prevent well corrosion. PGV has had numerous issues with severe well corrosion and numerous excessive noxious gas emissions.
- PGV provides 30% of electricity to Hawaii Island
- PGV's binary cycle system electrical conversion efficiency is not reported.
- Hawaiian Electric reports a transmission loss of 10%
- Hawaii electricity cost for residential is $0.46 per kWh (~$200 to $450/month) and commercial is $0.50 per kWh
- Hawaii has the highest electricity cost in the U.S.
- PGV has provided geothermal power to Hawaii since 1982. State of Hawaii has a goal of switching to 100% renewable energy by 2045. So, far the State of Hawaii gets 22% from renewable energy.
- Hawaii currently imports approximately **85% to 90%** of its food supply

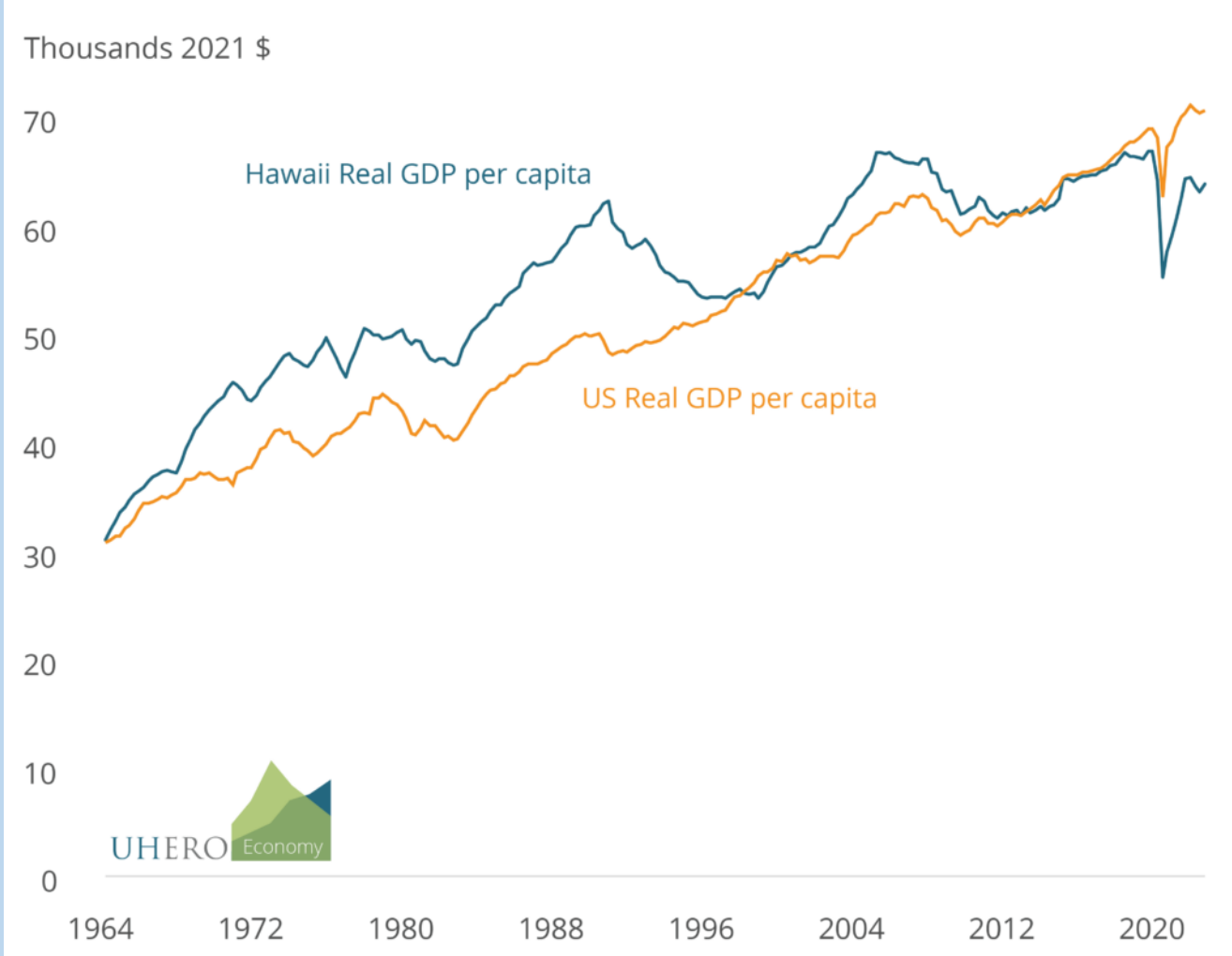
An Icelandic Greenhouse


Inside the Icelandic Greenhouse

Iceland Geothermal versus Puna Geothermal Venture Overview

- Icelandic power plants started using geothermal resources at a large scale in the 1970's. When Iceland switched from fossil fuels to renewable geothermal and hydropower they went from being the poorest country in Europe to now having one of the highest standards of living in the world.
- The Graphs below illustrate Iceland's GPD growth vs Hawaii and U.S. Please note-GPD is a region and/or country's economic output divided by its total population.





Iceland Geothermal versus Puna Geothermal Venture Overview

Iceland

•Iceland Environmental and Energy Agency has Borehole Directory for all 13,500 borehole wells drilled in Iceland since 1904 that is available on their website.

•Iceland universities in conjunction with Icelandic geothermal power companies and the United Nations have college and post-graduate programs for students and leaders in power utility industry to learn how to develop geothermal power throughout the world.

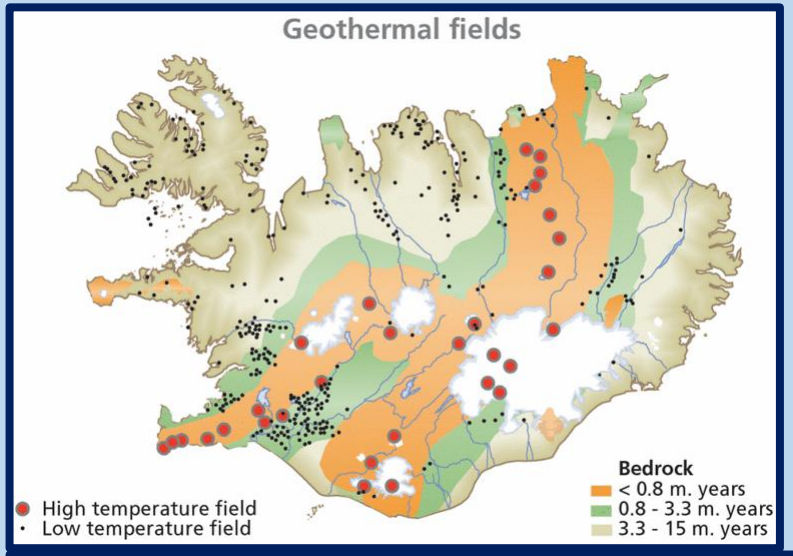
•Many Icelandic consulting firms (such as Iceland GeoSurvey, Manvit Engineering, Iceland Drilling) and Icelandic geothermal power companies, such as Reykjavik Energy, make it their business to export geothermal know-how and experience worldwide. There are now projects in Nevada, Nicaragua, New Zealand, China, Indonesia, Philippines, Germany, Hungary, Kenya, Azores to name a few.

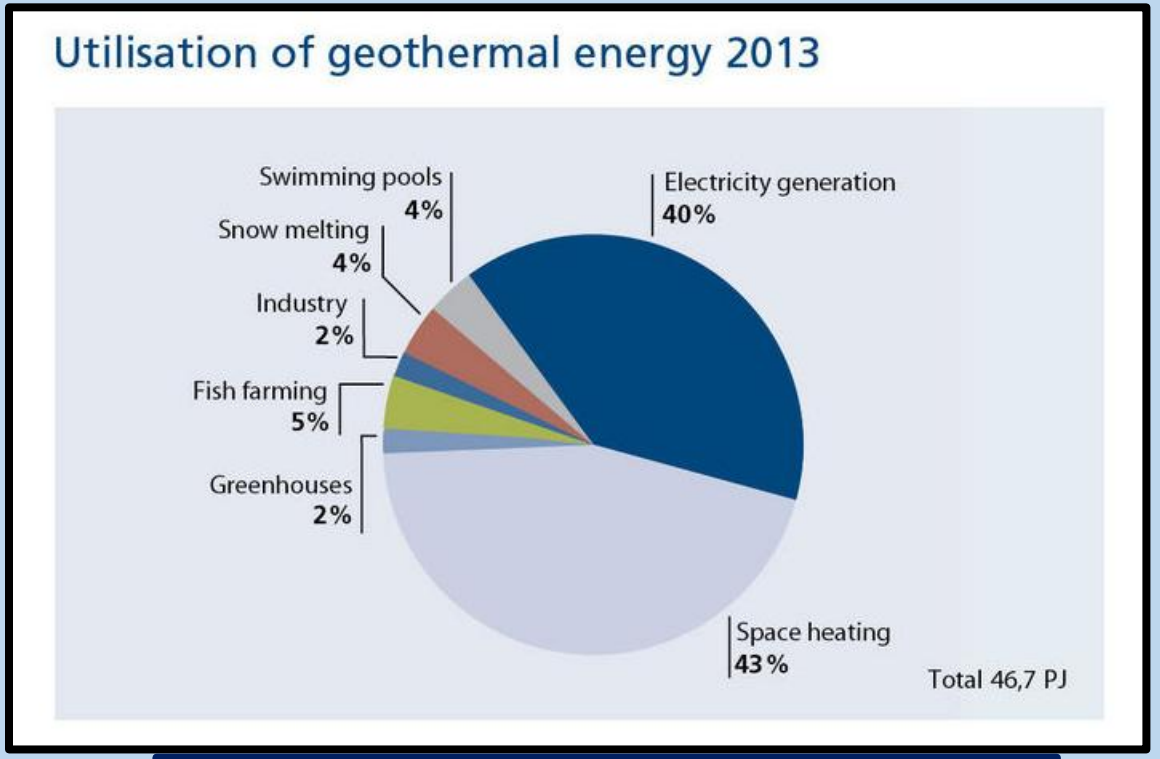
•Iceland Environmental and Energy Agency Project Manager-International Projects Baldur Petursson, MSA can assist in providing a tour to a Hawaii Delegation. Baldur Petursson's email is baldur.petursson@os.is and work phone # 354-569-6000.

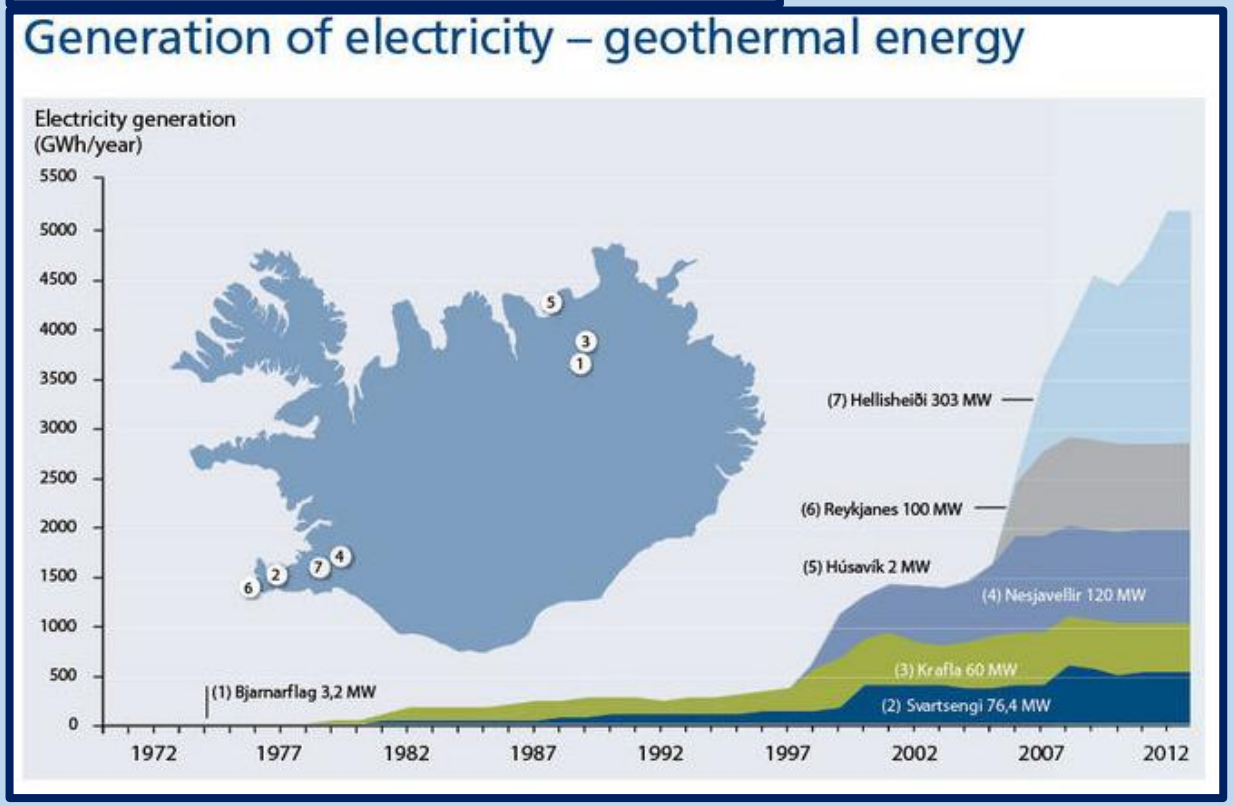
Puna Geothermal Venture (PGV)

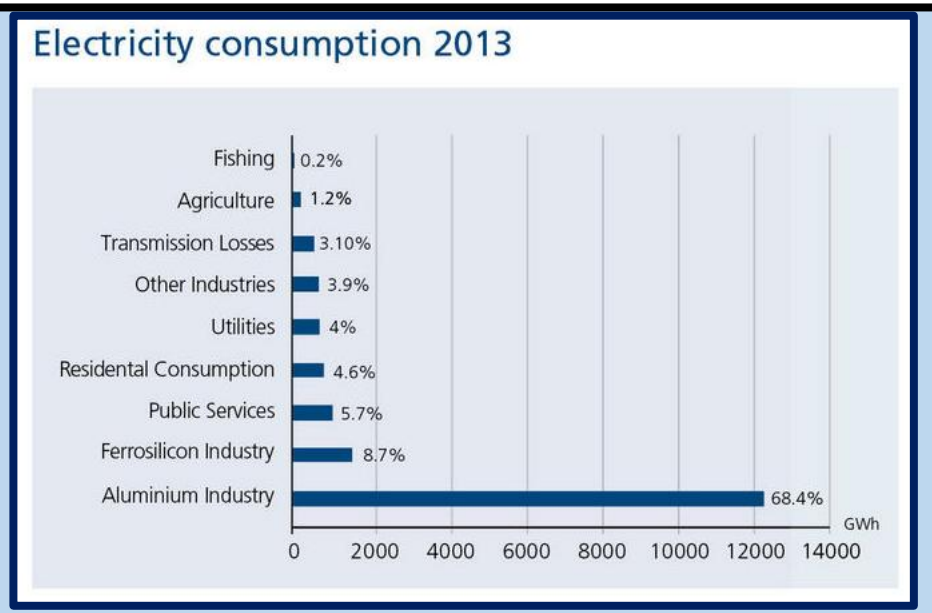
- UH Manoa Hawai'i Groundwater & Geothermal Resources Center has geothermal and water well database
- No known U.S. universities work with United Nations to conduct research and/or training of students to learn about geothermal power
- Ormat is not know for being leader in the geothermal industry. Many places where Ormat operate plants there have been numerous concerns and complaints about environmental degradation including the local aquafer damage, and poor workplace conditions.

Overview of Iceland Geothermal Uses



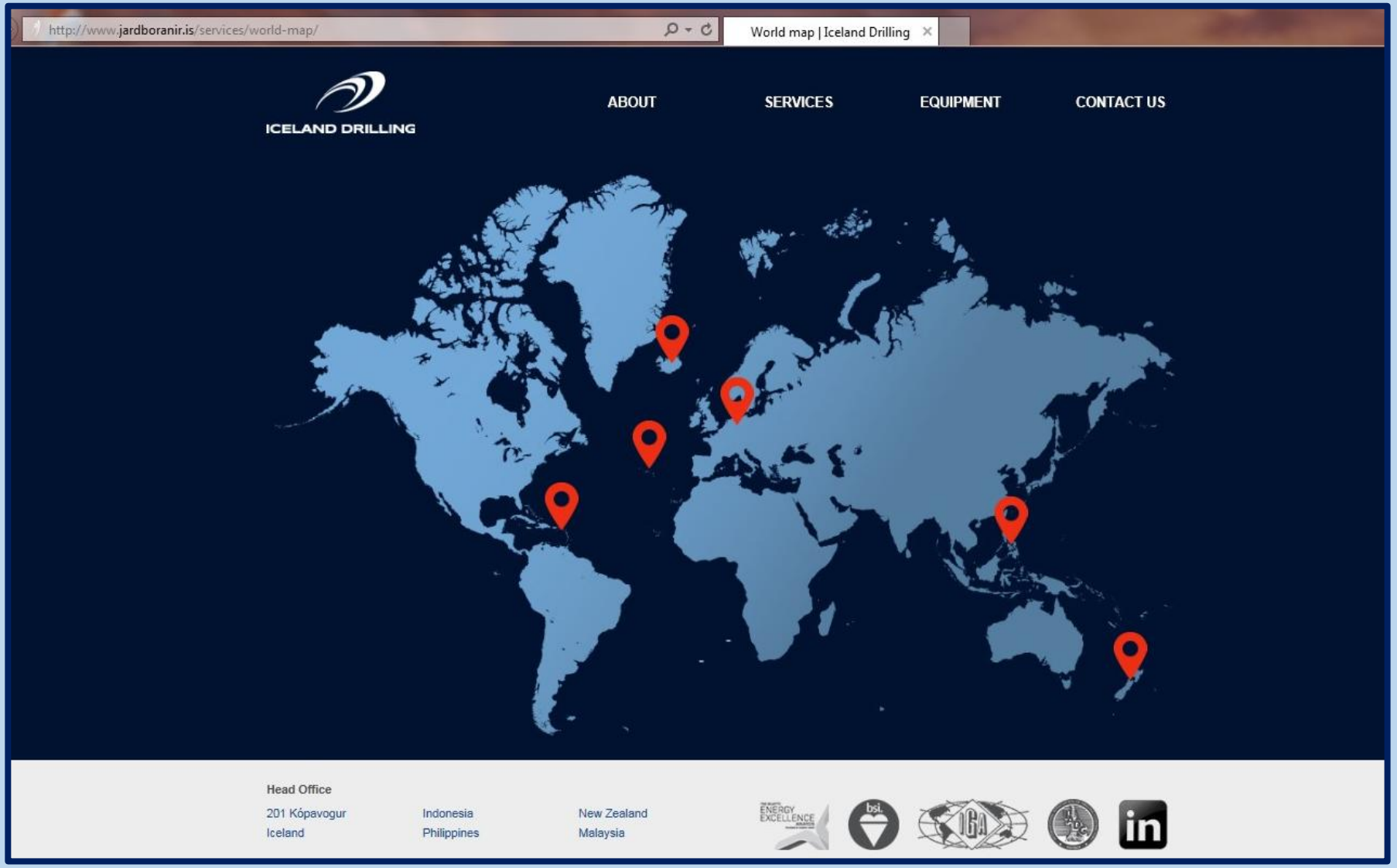




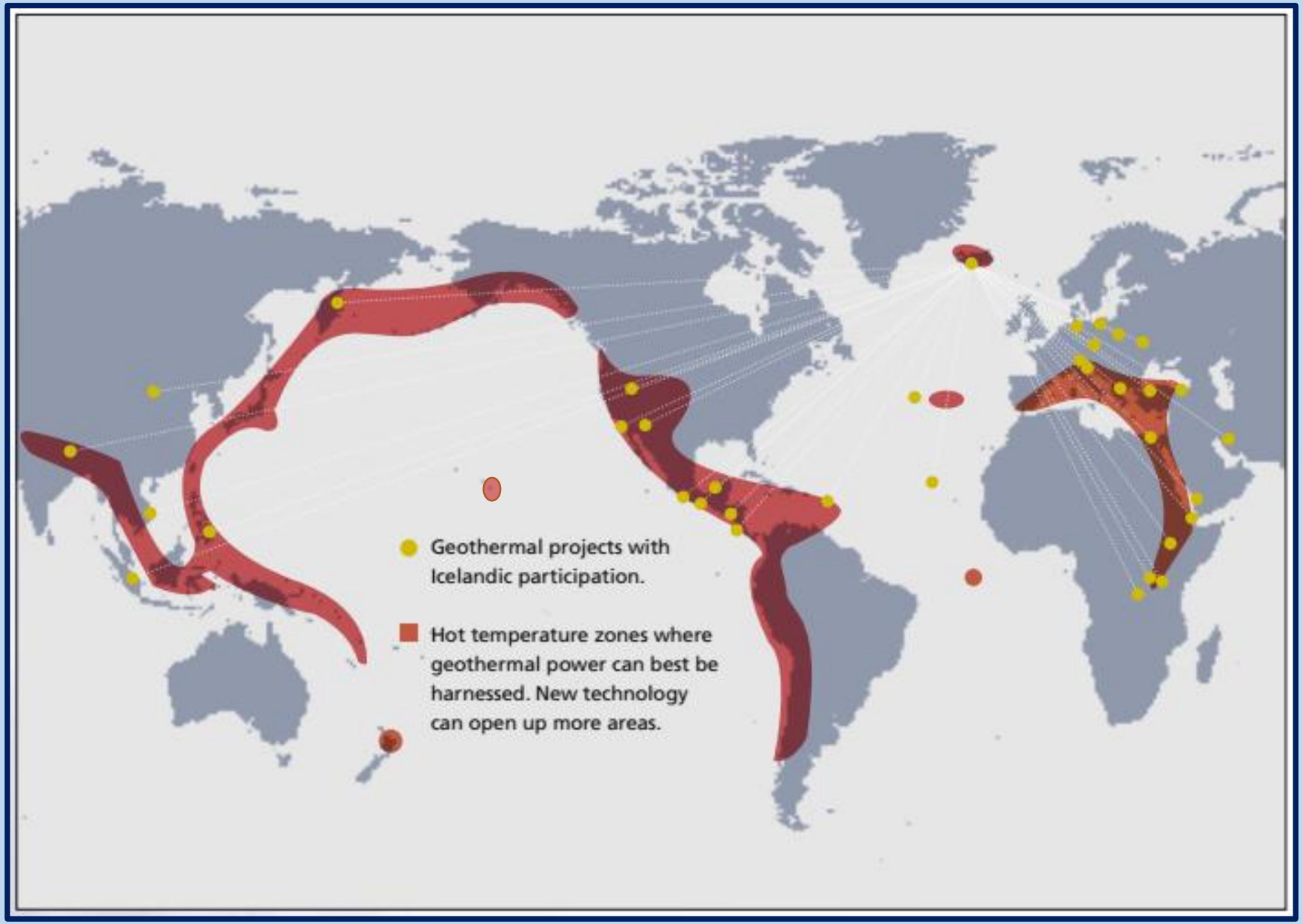


Iceland Geothermal Safety Record

Iceland Drilling, the main private geothermal drilling company in Iceland is the world leader in deep high temperature geothermal & low temperature geothermal with over 1000 successfully developed wells worldwide. They have offices in New Zealand, Indonesia, Philippines, Azores, Dominica, and Malaysia and have multiple projects worldwide.



Summary of Current Geothermal Projects with Iceland Drilling Participation

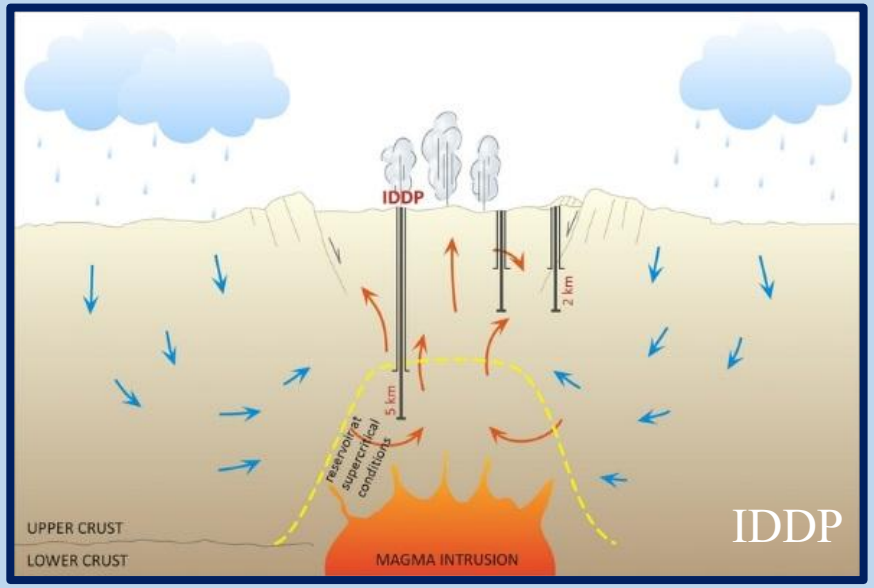


Iceland Geothermal Research

- Iceland Deep Drilling Project (IDDP)-reached magma at ~6890 ft and successfully harness its power in 2009, the first time this has been accomplished in the world.

- CarbFix, Hellisheidi Power Plant with University of Iceland & Columbia University research project, successfully injected CO_2 with water into basalt lava formation and found that 95% of the CO_2 injected mineralized into Calcite ($CaCO_3$) in the basalt lava rock in less than 2yrs.

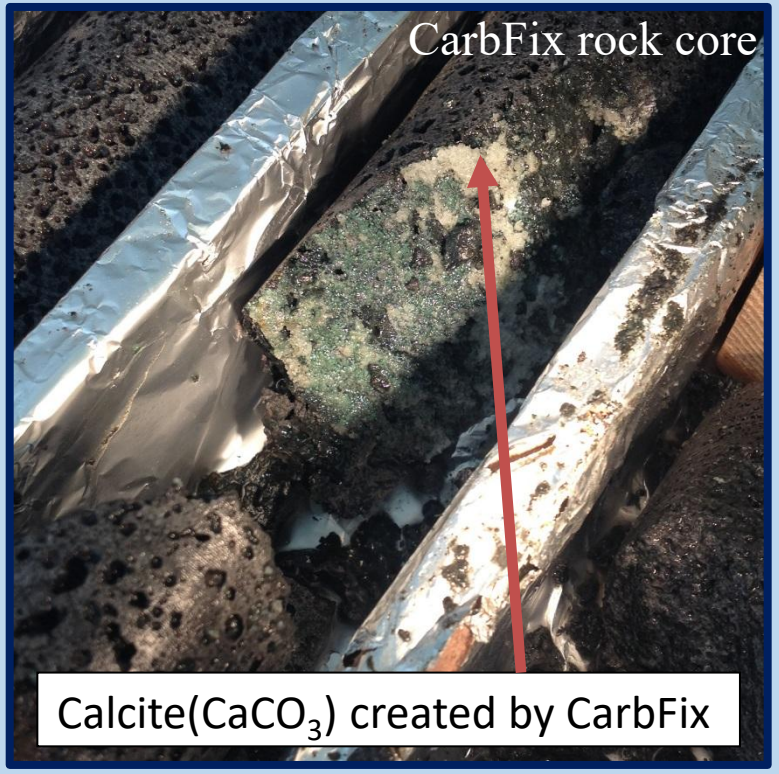
- Carbon Recycling International Inc. uses CO_2 produced from Svartsengi Power Plant, (which amounts to 8% of what oil plant produces) and converts it into methanol and uses power generated from geothermal and/or hydropower power plants in the area to make the fuel that can be used for cars.

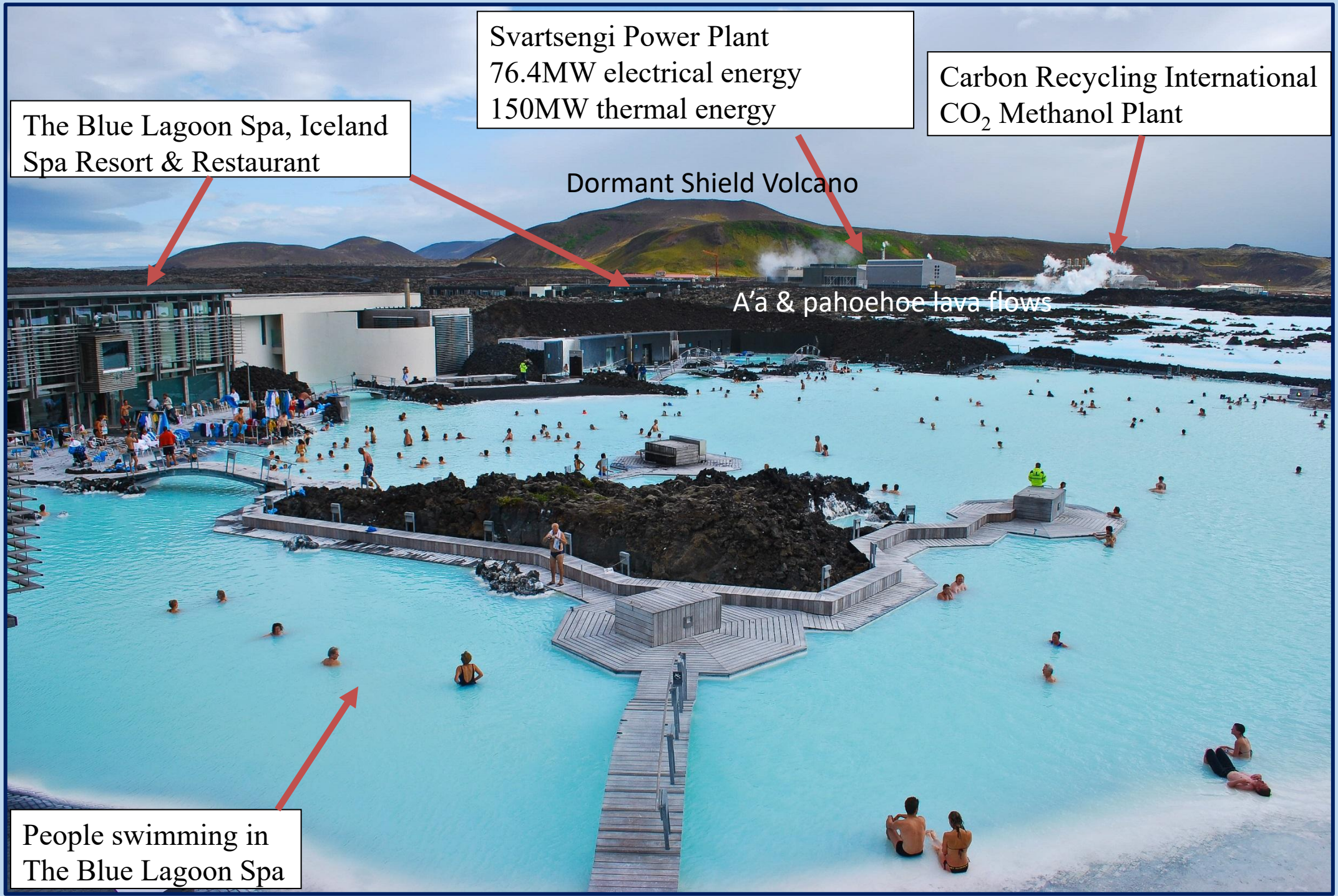


IDDP


Hellisheidi Geothermal Power Plant


CO_2 Methanol Plant




Svartsengi Power Plant
76.4MW electrical energy
150MW thermal energy
Carbon Recycling International
CO_2 Methanol Plant
The Blue Lagoon Spa, Iceland
Spa Resort & Restaurant
Dormant Shield Volcano
A'a & pahoehoe lava flows
People swimming in
The Blue Lagoon Spa

Iceland's Geothermal Springs & Geothermal Heated Public Pools Bathing Culture

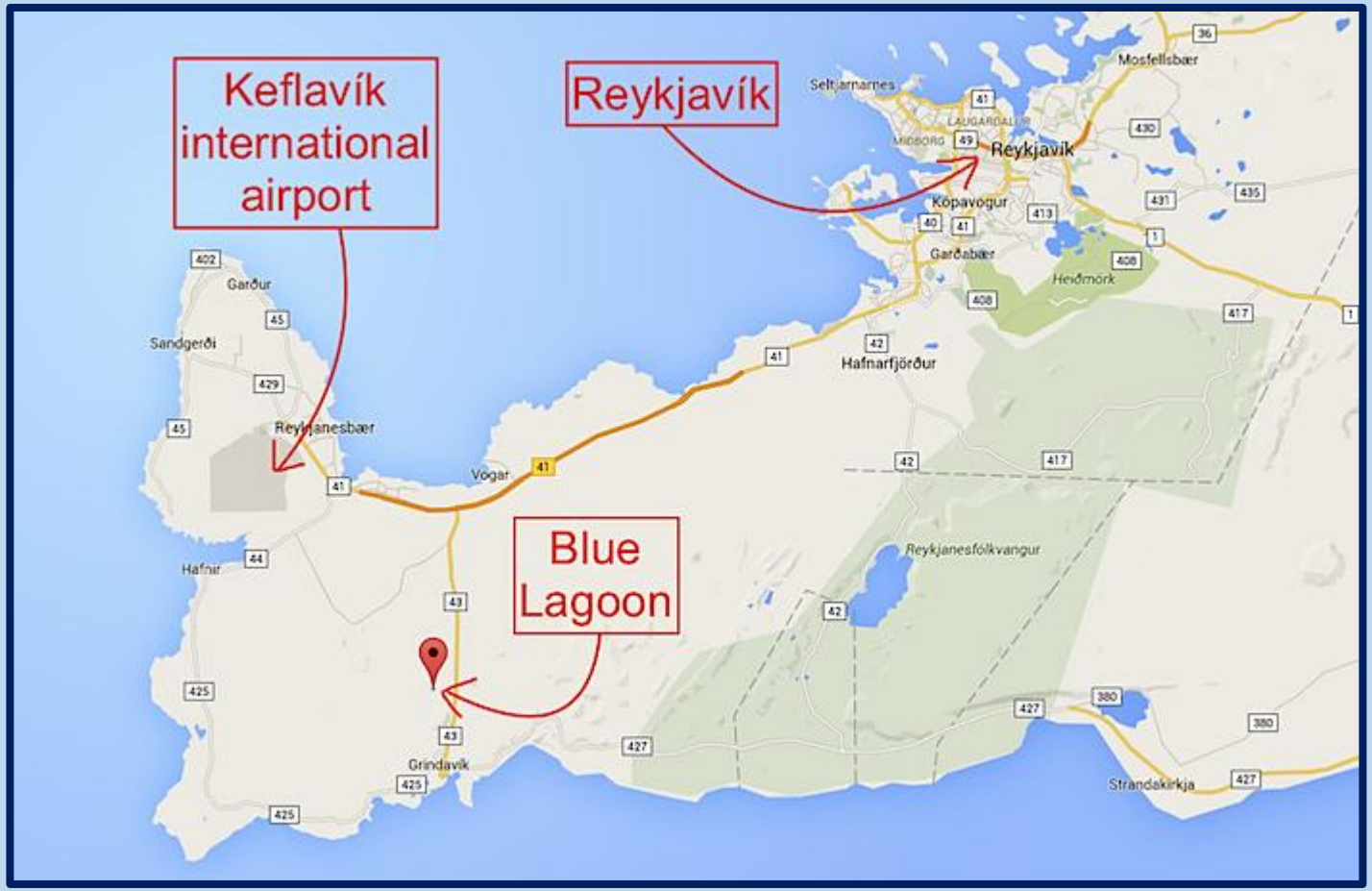
- Iceland has numerous natural public and private geothermal springs and geothermal heated public pools

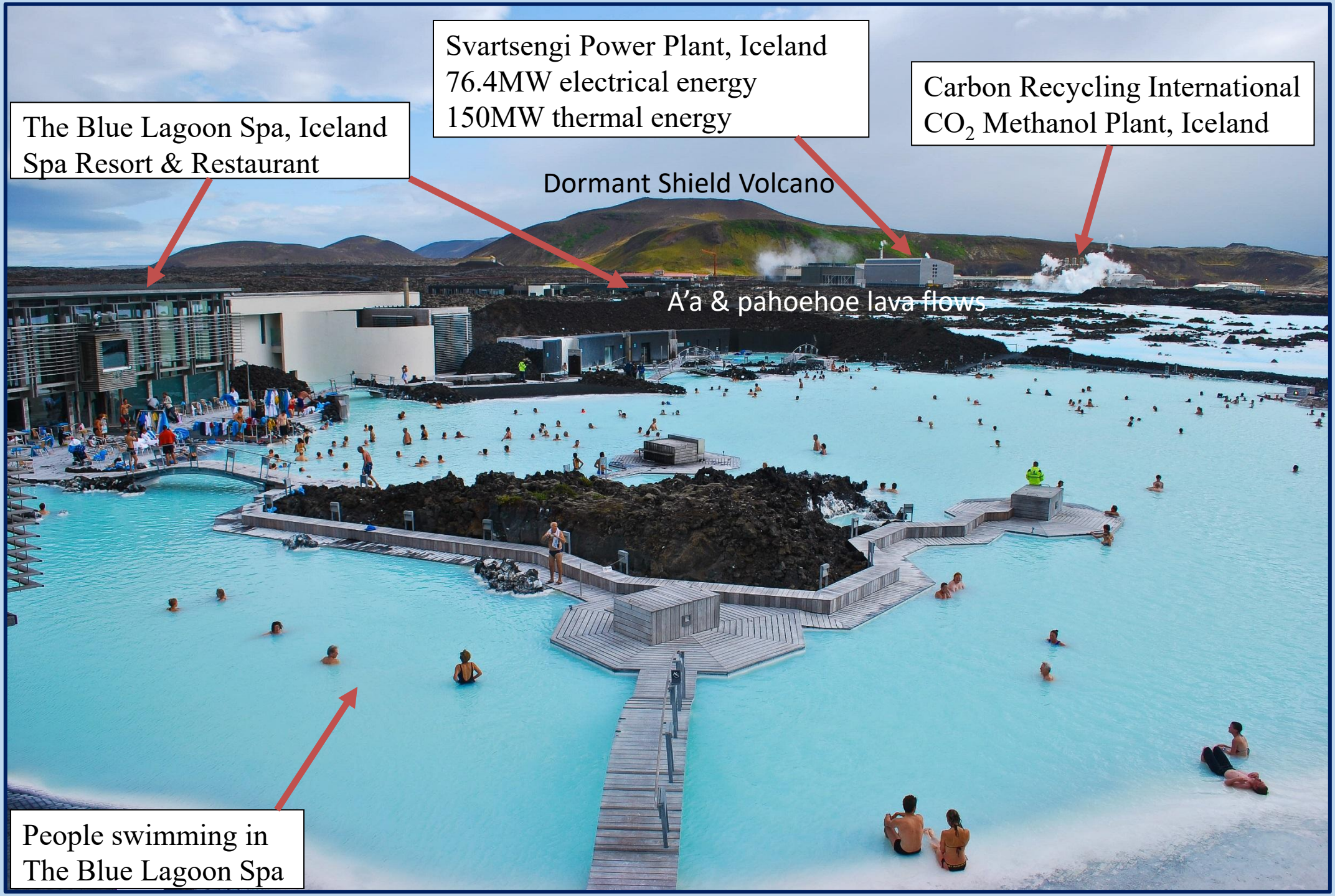
- Iceland geothermal bathing tradition dates to mid 800's

- Iceland's heated public pools dates to when Iceland switched from fossil fuels to renewable geothermal energy in the 1970's. Almost every town in Iceland has geothermal heated public pools. They receive their geothermal heated hot water from nearby geothermal plant. The public pools are often set at different temperatures to get a full "spa" like experience.

- During my month-long visit around Iceland, I went to a geothermal spring and/or geothermal heated public pool everyday. The next slides are some of the places I went to and photos I took while at these places.

Blue Lagoon Iceland




Svartsengi Power Plant, Iceland
76.4MW electrical energy
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The Blue Lagoon Spa, Iceland
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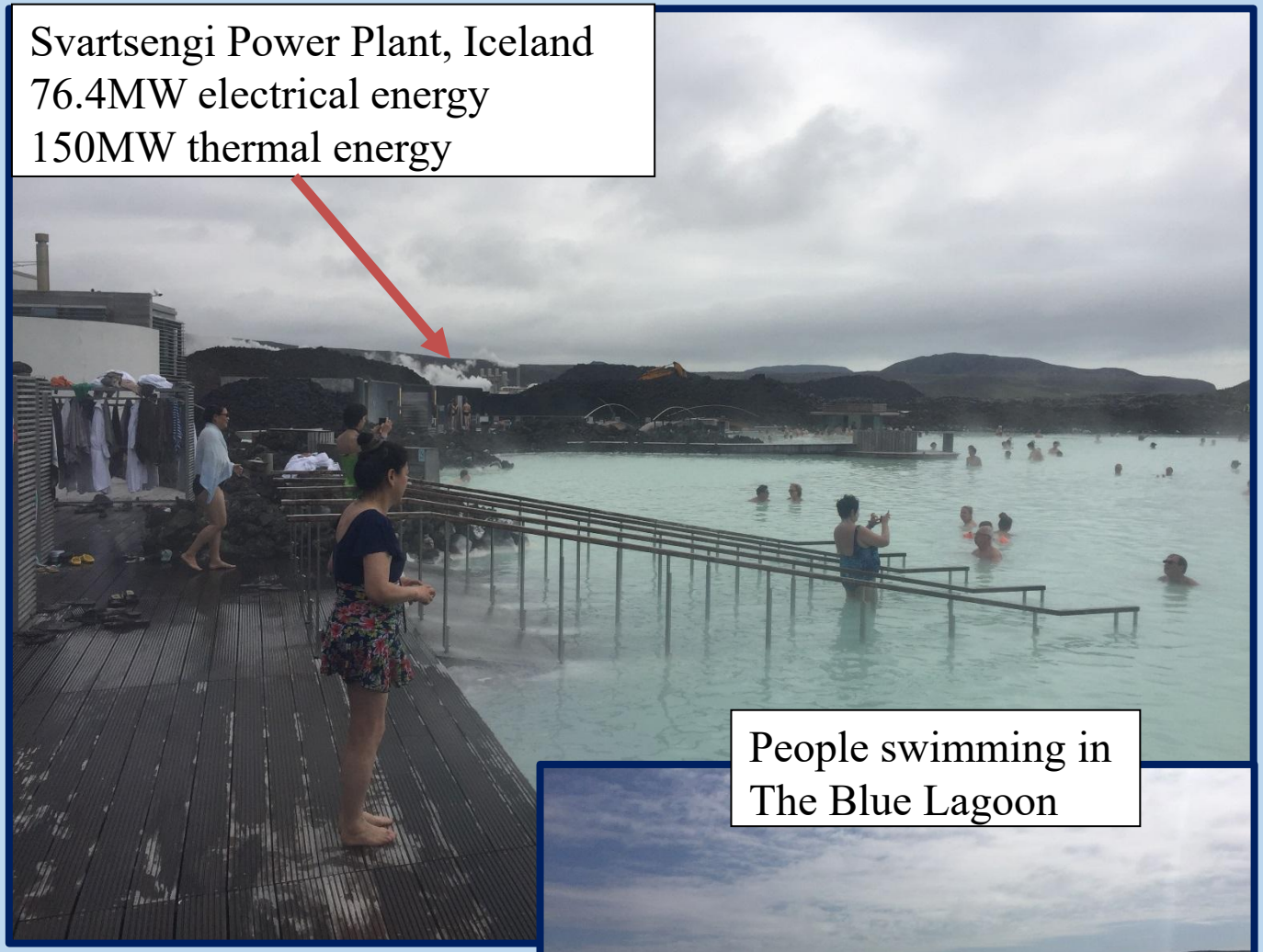
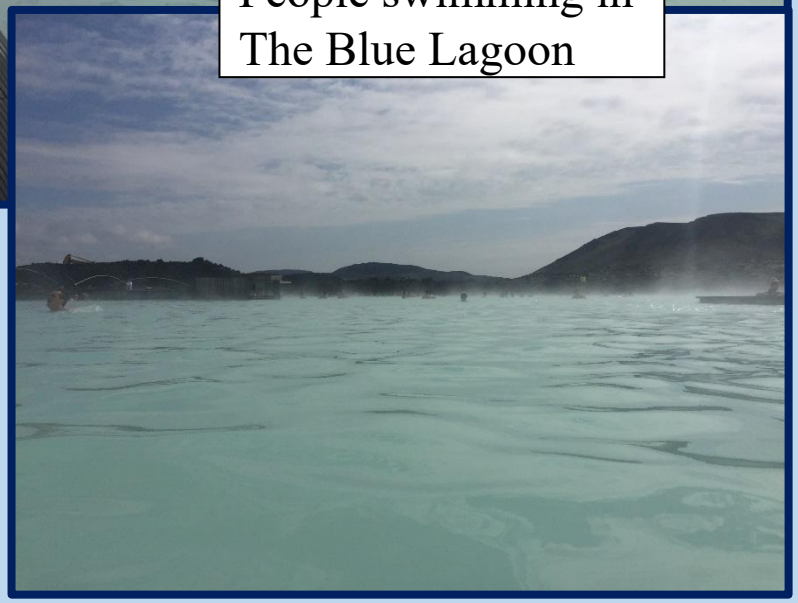
Dormant Shield Volcano
A'a & pahoehoe lava flows
People swimming in
The Blue Lagoon Spa

Me swimming in
The Blue Lagoon

People swimming in
The Blue Lagoon

Svartsengi Power Plant, Iceland
76.4MW electrical energy
150MW thermal energy





People swimming in
The Blue Lagoon

Have ~ 1/2 million visitor per year; therefore, pre-booking is required

BLUE LAGOON OVERVIEW

BLUE LAGOON FACTS

9 MILLION LITERS
The amount of geothermal seawater in the Blue Lagoon

40 HOURS
The time it takes for all the Blue Lagoon's water to naturally renew itself

6,500 FEET / 1,981 METERS
The distance below the surface to the origin of the geothermal seawater

800 YEARS
The age of the lava field surrounding the Blue Lagoon

100°F / 38°C
The average temperature of the Blue Lagoon

BLUE LAGOON ACTIVE INGREDIENTS:

ALGAE

Research shows that Blue Lagoon coccoid algae reduces UV-induced degradation of collagen in the skin, and Blue Lagoon filamentus algae stimulates the skin's natural collagen production.

SILICA

Research shows that Blue Lagoon silica strengthens the skin's barrier function which is one of the key elements in maintaining healthy and radiant skin.

MINERALS

Blue Lagoon geothermal seawater contains a unique combination of pure minerals which are an important part of Blue Lagoon skin care formulas for their revitalizing effects.

Iceland straddles the Mid-Atlantic Ridge, where the North American and Eurasian tectonic plates are pulling apart. Upwelling magma built the island and heats its vast reservoirs of water, creating a geothermal paradise. First among the country's many simmering geothermal pools is the Blue Lagoon, a turqoise vision in a black basaltic moonscape. The geothermal spa is fed by seawater 6,500 feet (1,981 m) beneath the surface, where it reaches a searing 464°F (240°C). Capturing silica and other minerals on its way to the surface, it emerges from the ground at a balmy 100°F (38°C), just right for pampering visitors.

(2011) Blue Lagoon. National Geographic, Wonders of the world, p.125.

BLUE LAGOON IS ONE OF THE 25 WONDERS OF THE WORLD

- National Geographic -

Myvtan Natural Baths

Myvtan Natural Baths

The water supplies for the lagoon run straight from the National Power Company´s bore hole in Bjarnarflag. The water has a temperature of about 266°F when it arrives to the huge basin beside the lagoon itself forming an impressive, man-made hot spring. Altogether, the lagoon and the basin contain around 1 million gallons of water with a temperature of 97 – 104°F.

Selfoss Geothermal Heated Public Pools

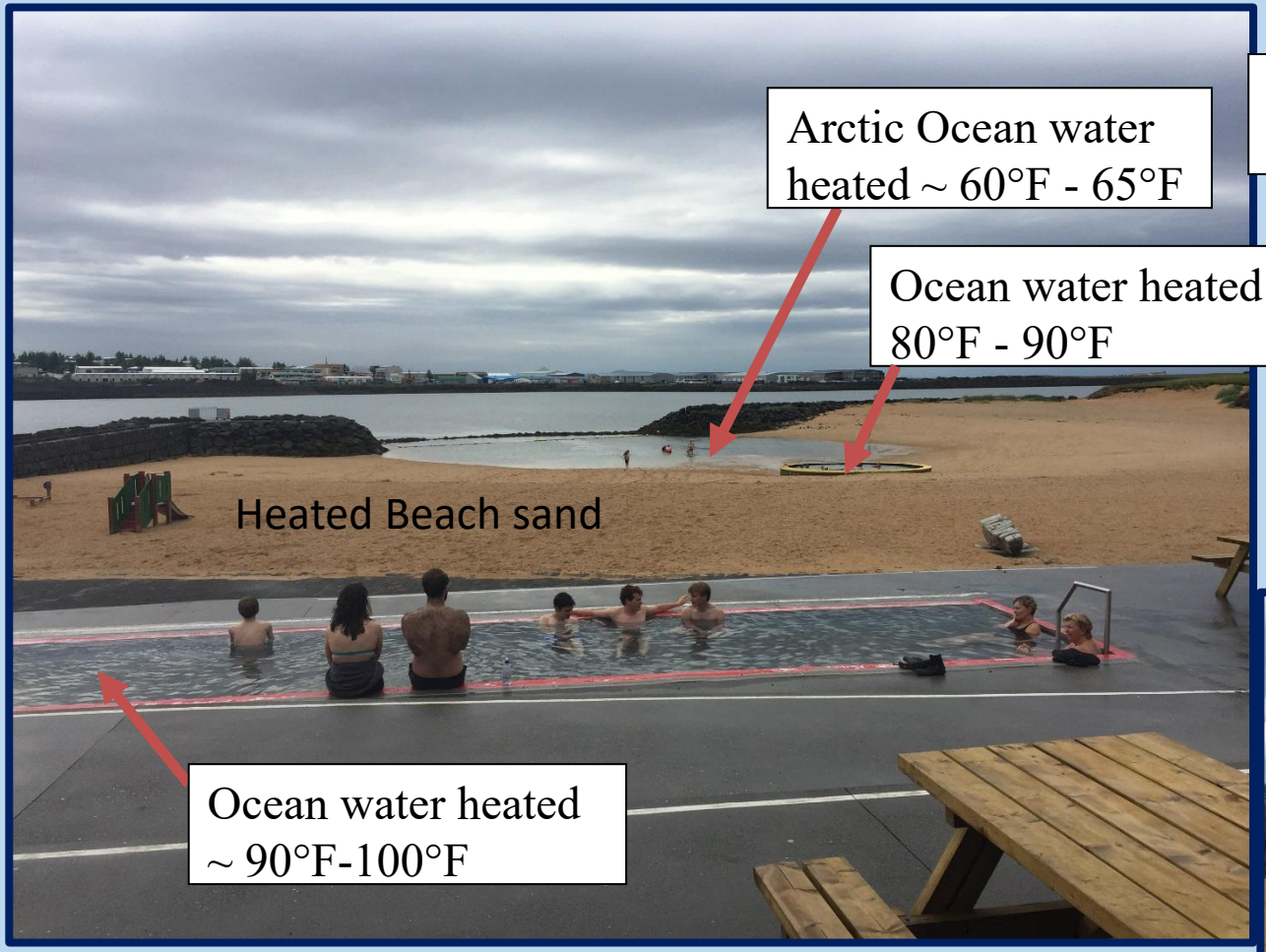
The multiple public pools are set at different temperatures, which provided a full “spa” like experience.

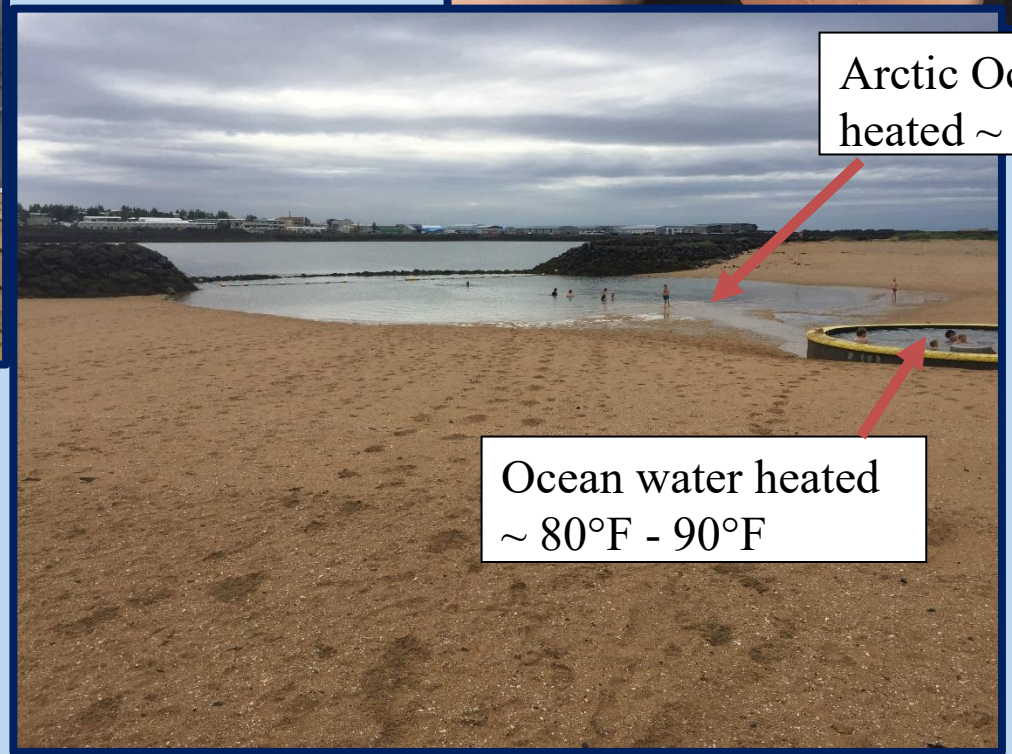
Reykjavik's Nautholsvik Geothermal Heated Beach

Nautholsvik Geothermal Heated Beach

Hellisheidi Geothermal Power Plant produces so much thermal heat that Reykjavik decided that wanted a beach!
This free public beach is heated so can swim in the hot tubs and the ocean cove year-round.

Reykjavik's Nautholsvik Geothermal Heated Beach





Hellisheidi Geothermal Power Plant produces so much thermal heat that Reykjavik decided that wanted a beach!
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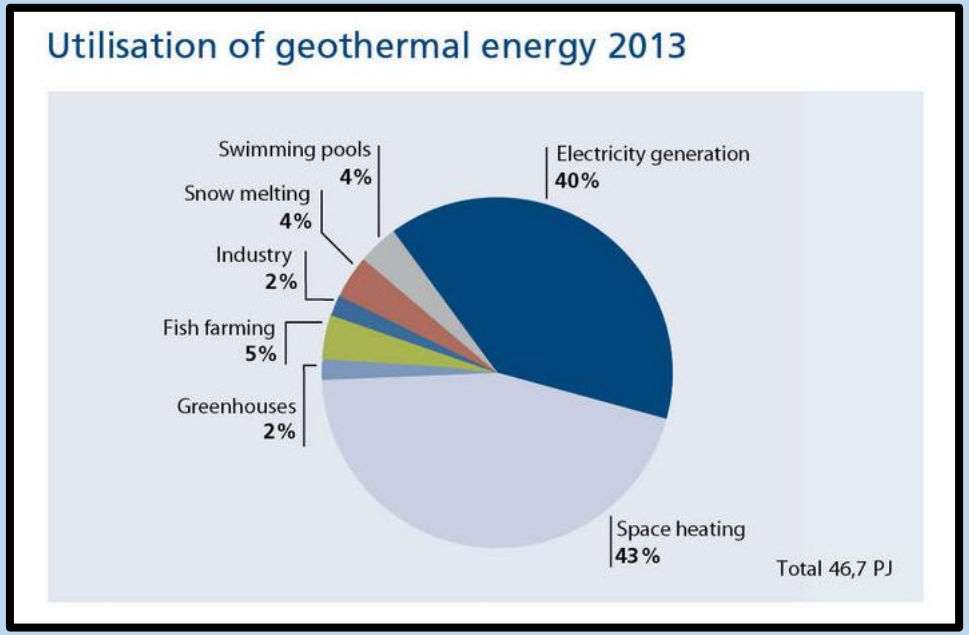
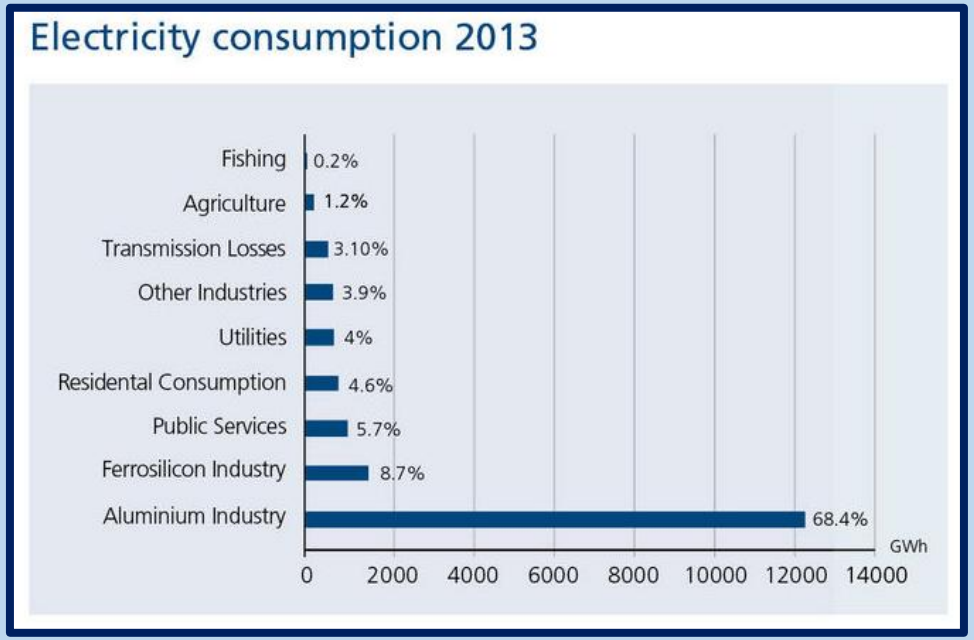
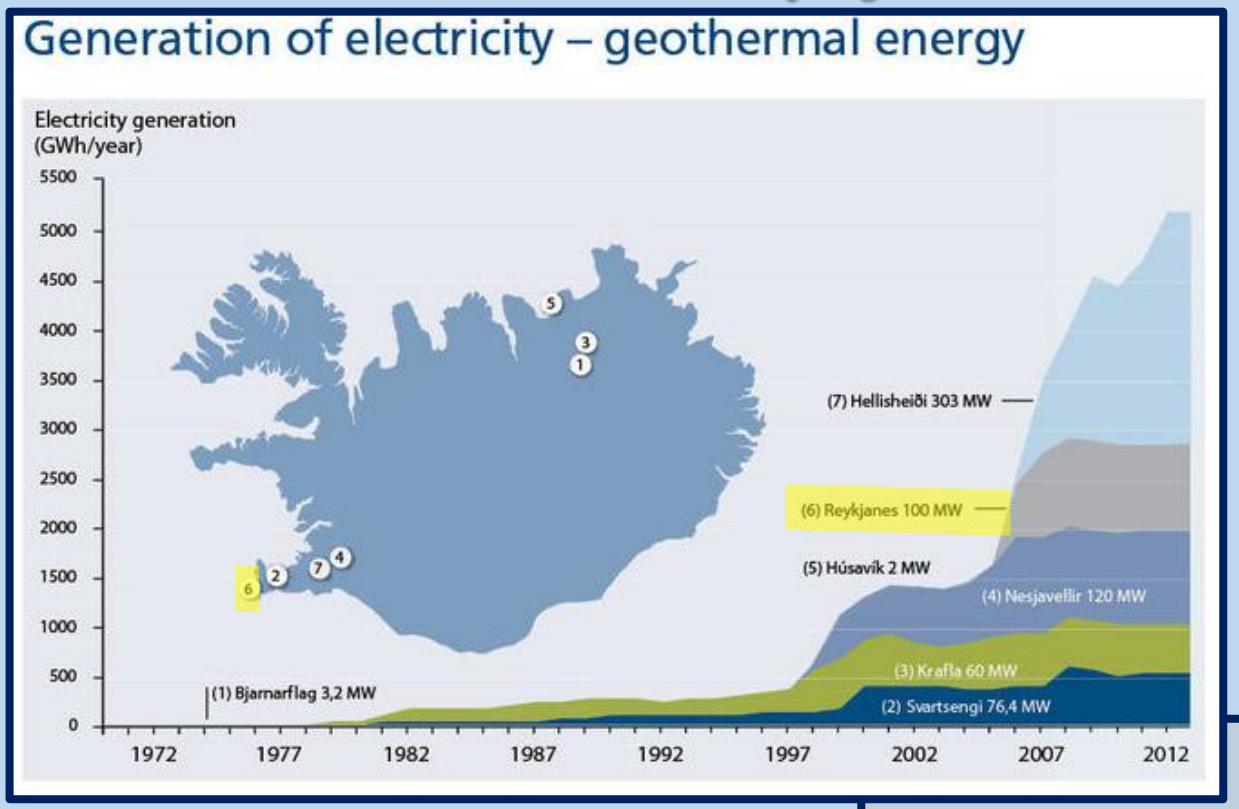
Iceland Geothermal Plants

- All Iceland Geothermal plants are cooperatively owned by the people of Iceland.
- Iceland Geothermal plants provide 80% of electricity and 100% of municipal hot water and thermal/energy heating for multiple uses.
- I visited the following Iceland Geothermal Plants:
  - Reykjanes Geothermal Power Plant & Museum
  - Hellisheidi Geothermal Power Plant & Visitor Center. Hellisheidi is the world's largest geothermal power plant.
  - Reykjanes and Hellisheidi are both direct dry steam system plants
  - Many of the photos in the next slides are photos I took while touring the plants
- All Iceland's Geothermal Plants are open year-round to the public. They are popular tourist attractions. They also work with many Icelandic and international companies and universities in business and research ventures.
- They have guides and specialists' staff at their plants that are more than happy to explain and show how their plants operate.

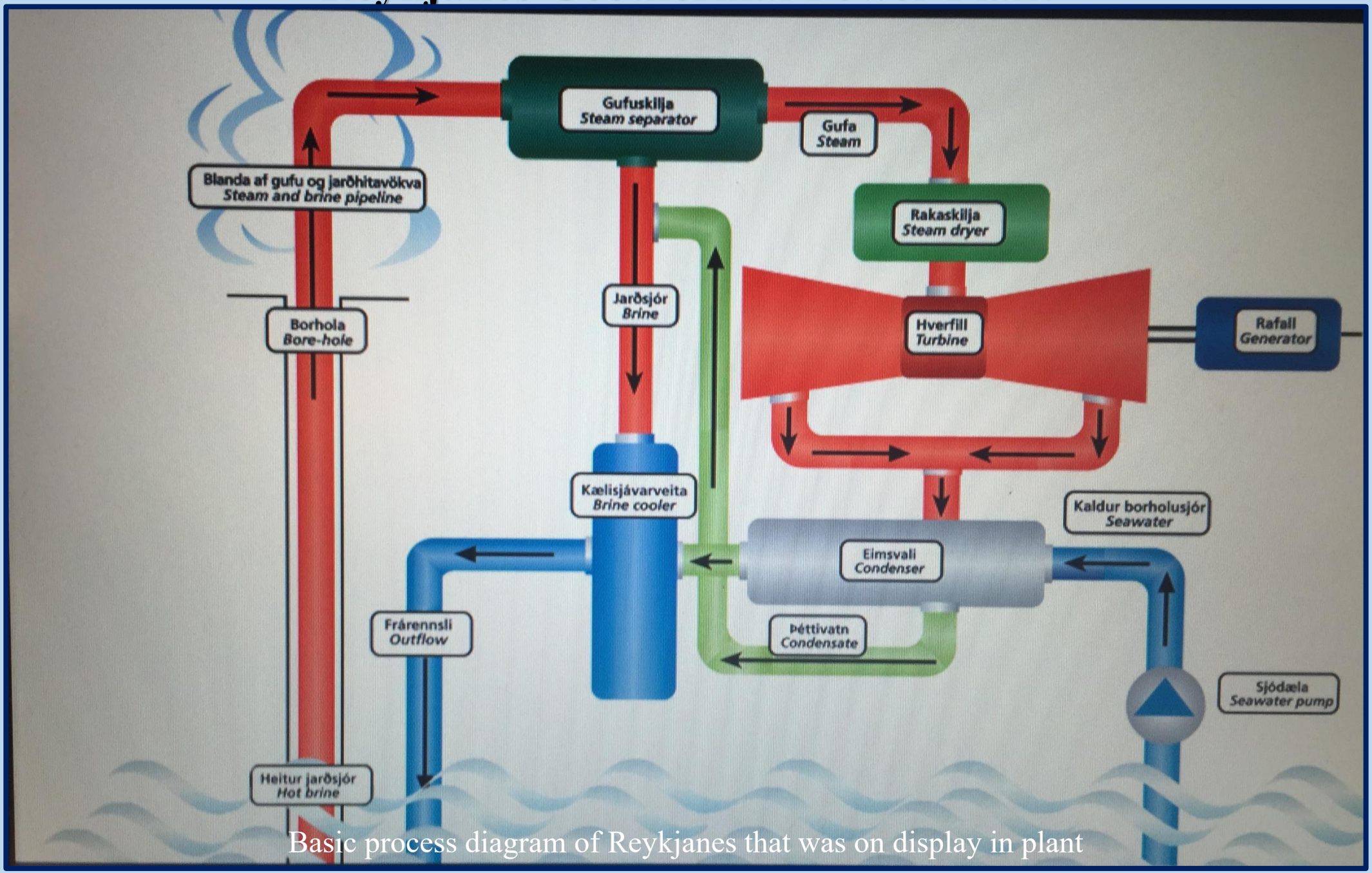




Reykjanes Geothermal Power Plant



Reykjanes Geothermal Power Plant



Basic process diagram of Reykjanes that was on display in plant

Reykjanes Geothermal Power Plant

Operating Hole

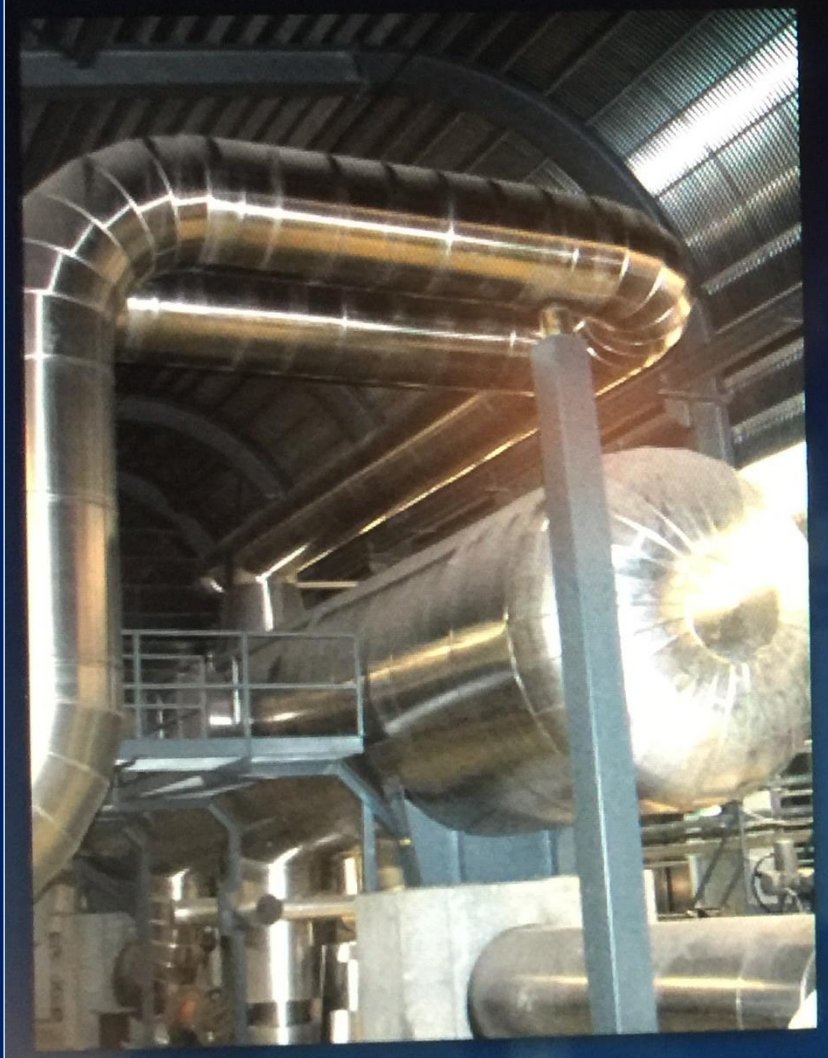
Hot brine (300°C) and steam come from an operating hole about 2700m deep.

300°C ~ 572°F 2700m ~ 8860ft

Phase 1 - Basic process of each phase that was on display in the plant

Reykjanes Geothermal Power Plant

Steam Separator



The hot brine and steam mixture is piped into a steam separator which separates the steam from the liquid.

Phase 2 - Basic process of each phase that was on display in the plant

Reykjanes Geothermal Power Plant

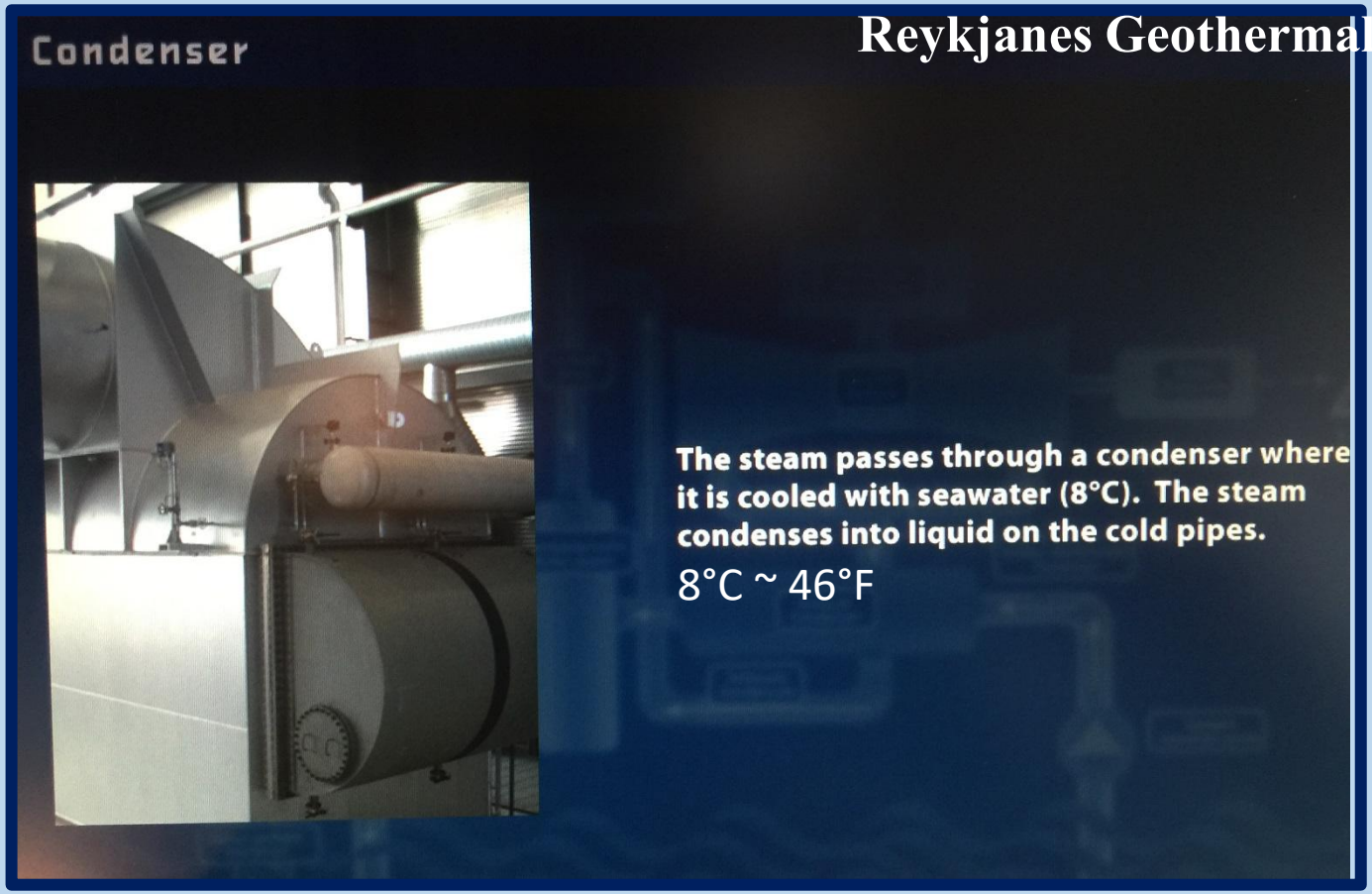
Turbine

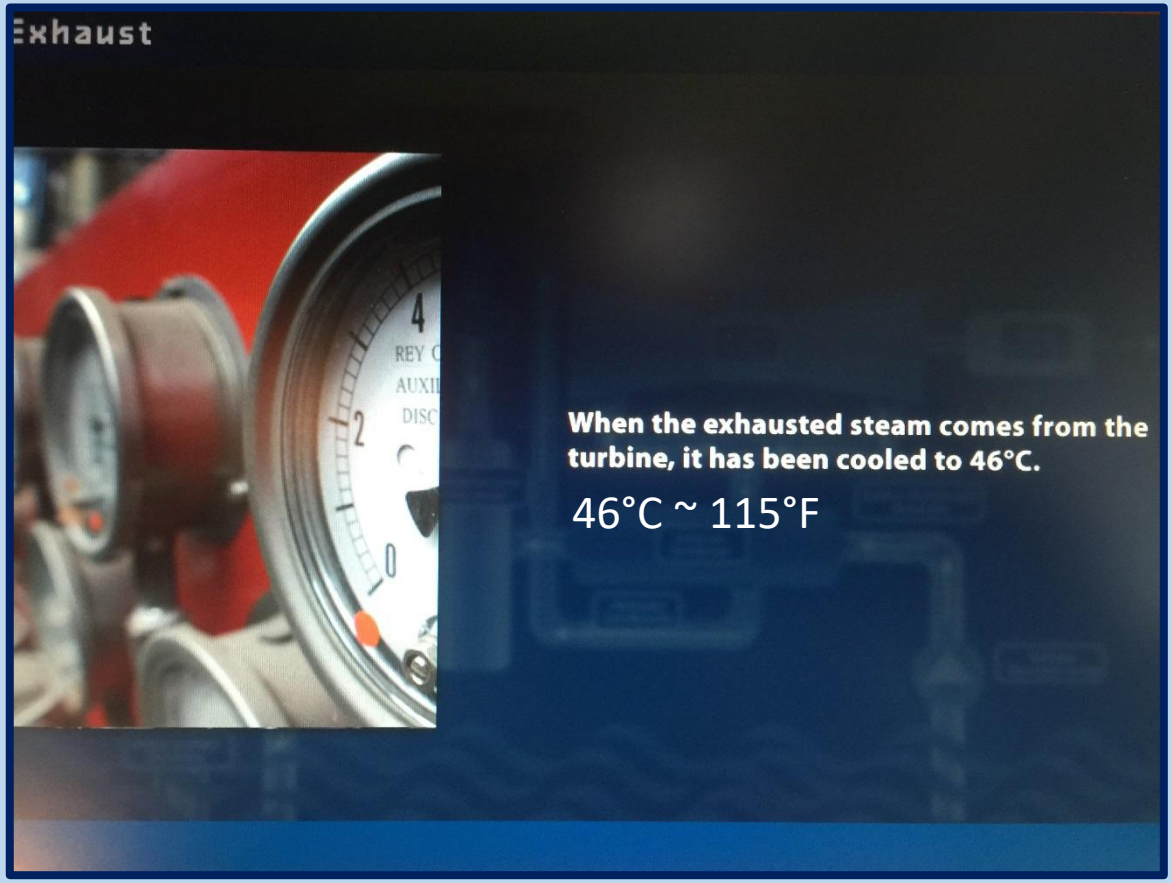
From the separator, the pressurized steam passes through the steam dryer to the turbine units, each producing 50MW of electricity.

1MW can power ~ 1000 to 650 homes

Phase 3 - Basic process of each phase that was on display in the plant

Reykjanes Geothermal Power Plant

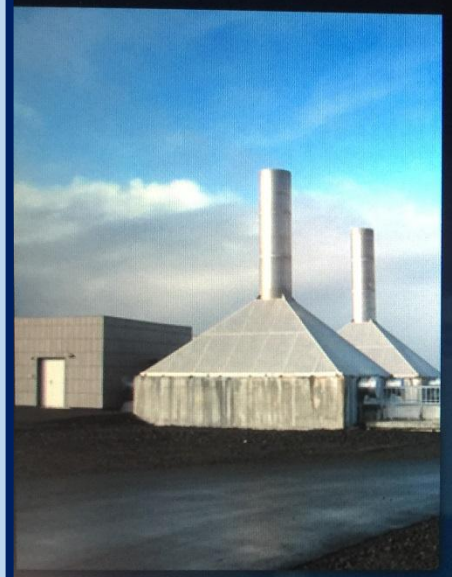




Phase 4 - Basic process of each phase that was on display in the plant

Reykjanes Geothermal Power Plant

Brine Cooler



The brine is cooled, thinned with condensate and at a temperature of 190°C is piped to the brine cooler.

190°C ~ 374°F

Outflow

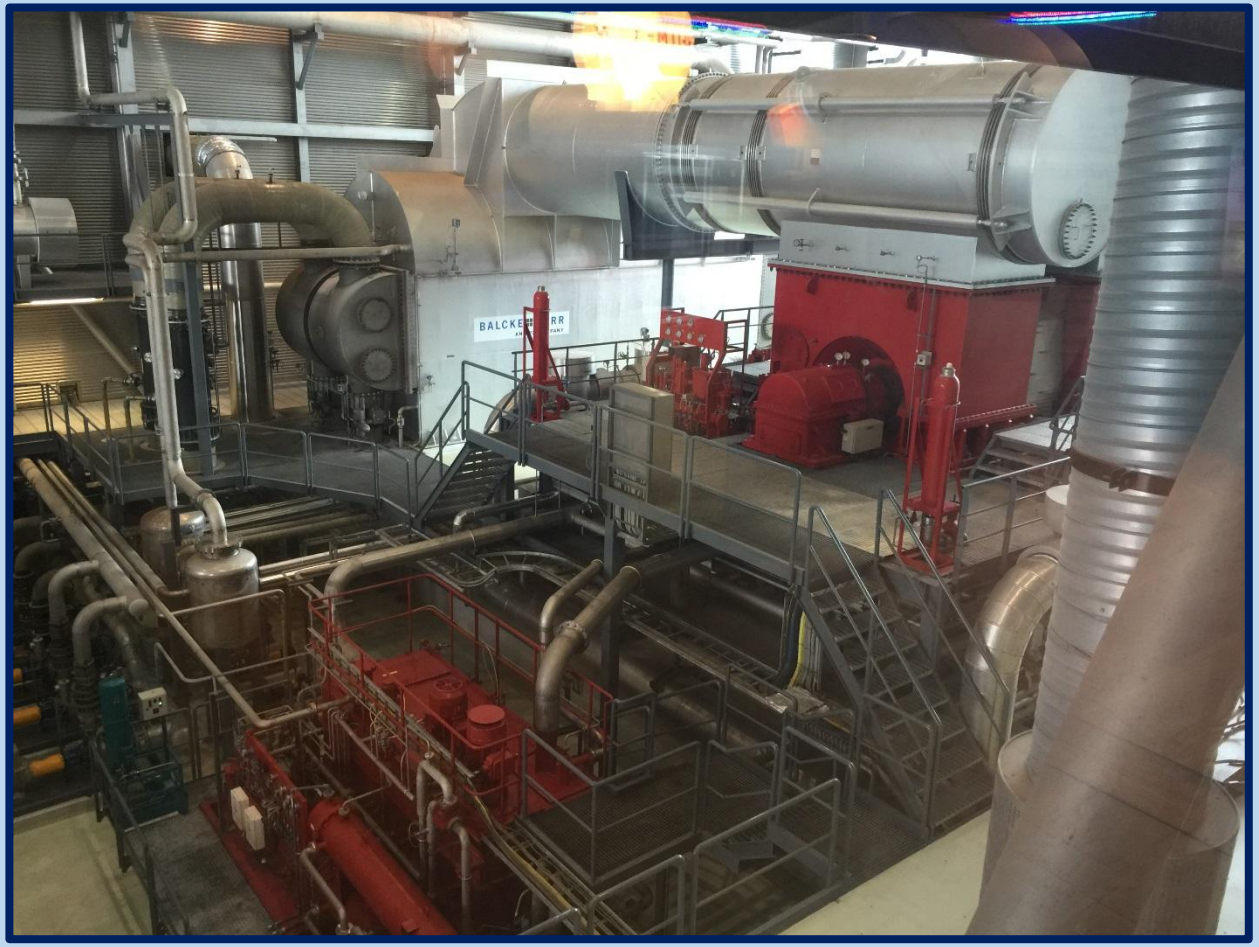
Note: Not all Icelandic Geothermal power plants disposed outflow water into ocean, others (like Hellisheidi) inject outflow water back into the ground to allow magma heated rock to reheat outflow water so it can be reused. Blue Lagoon and Myvtan Natural Baths water is outflow water from nearby geothermal power plants.

Condensate, seawater and waste brine are mixed together and channeled back into the sea at a temperature of 57°C.

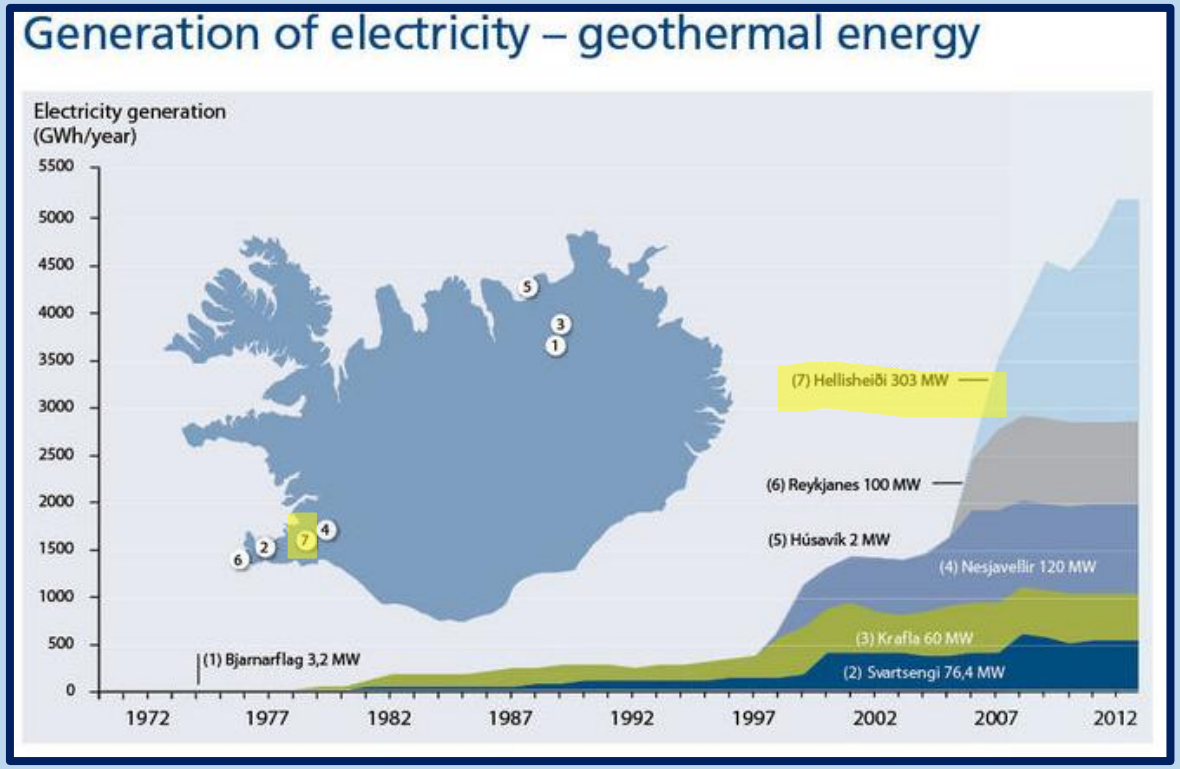
57°C ~ 135°F

Phase 5 - Basic process of each phase that was on display in the plant

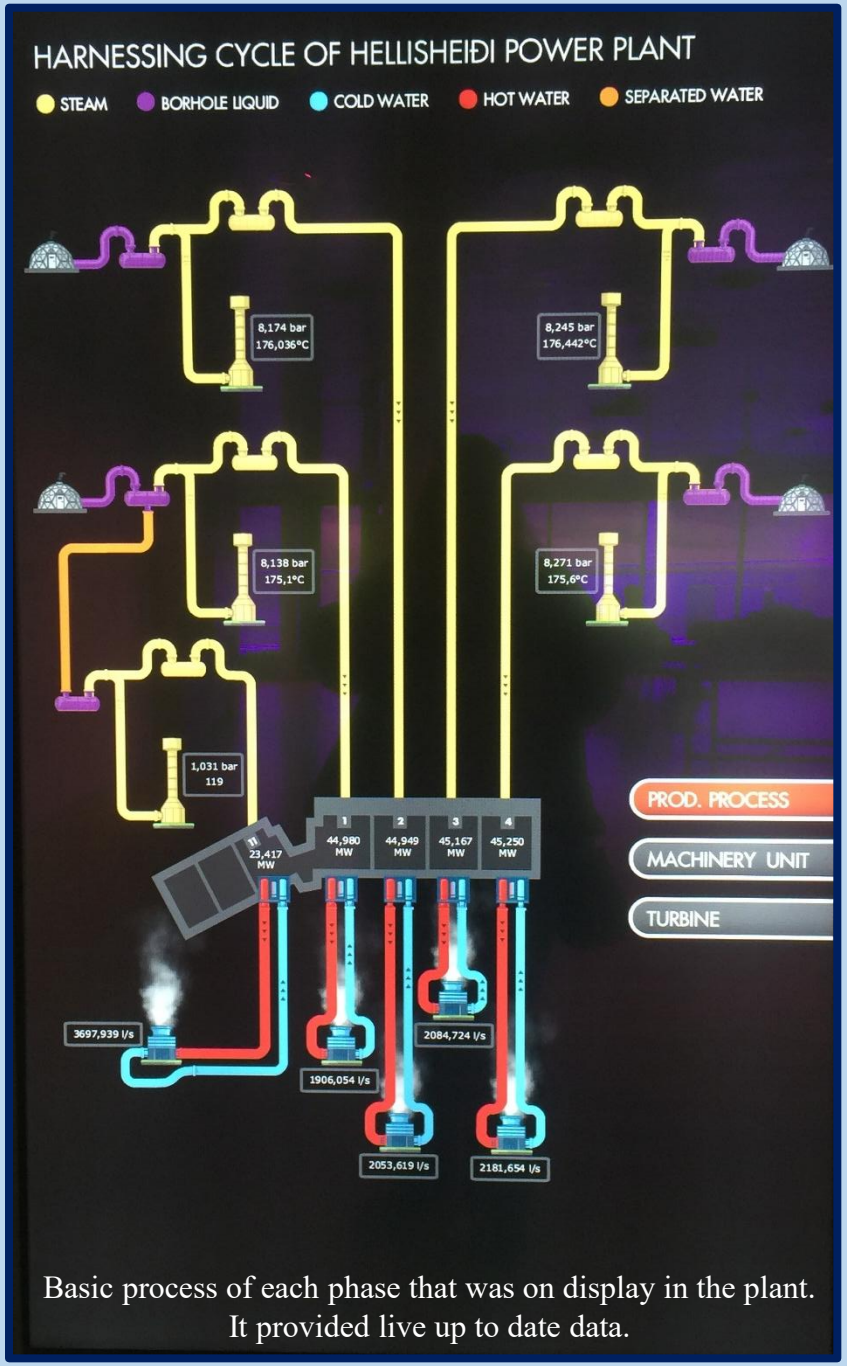
Inside the Reykjanes Geothermal Power Plant



Hellisheidi Geothermal Power Plant

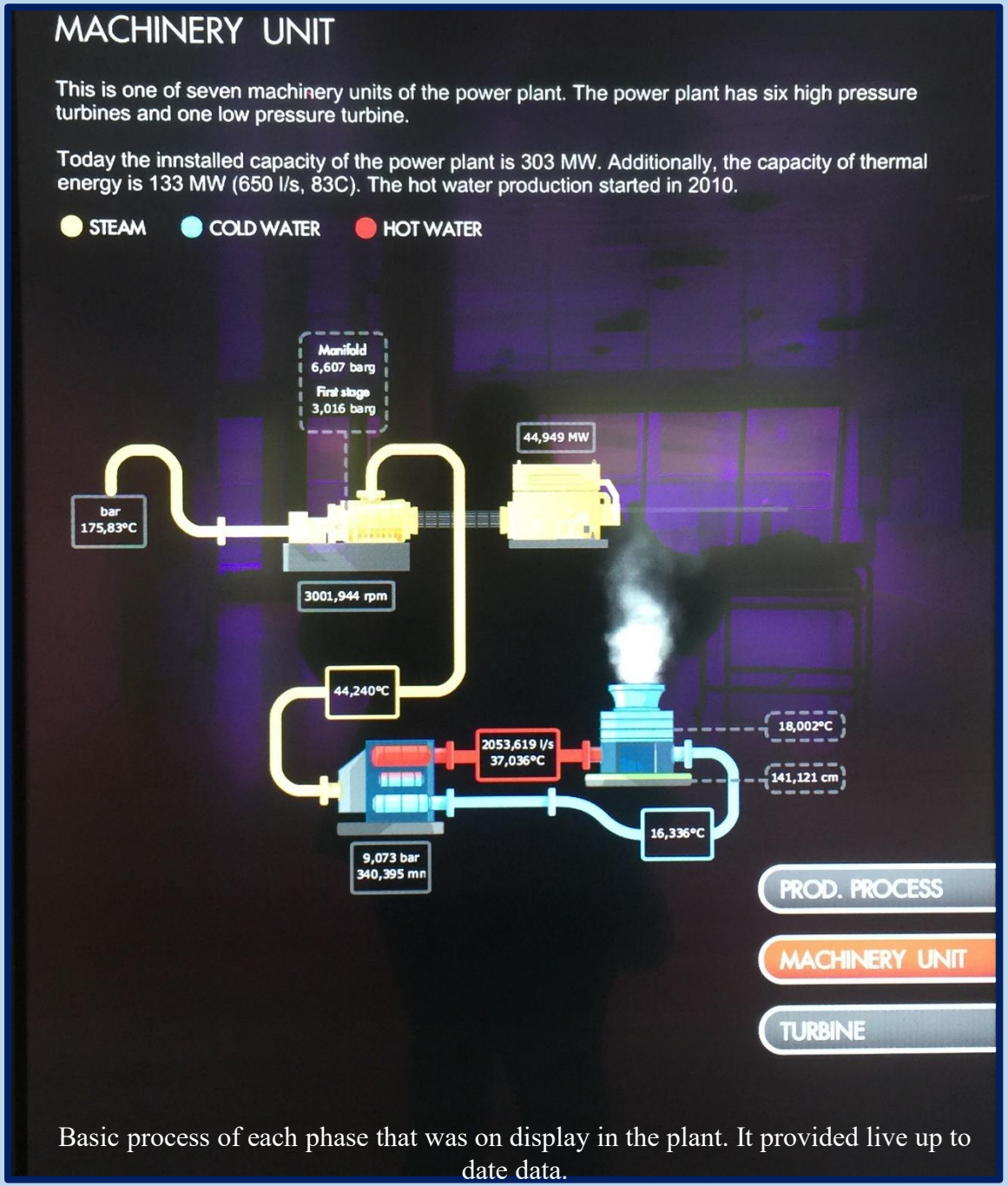


Hellisheidi Power Plant & Visitor Center



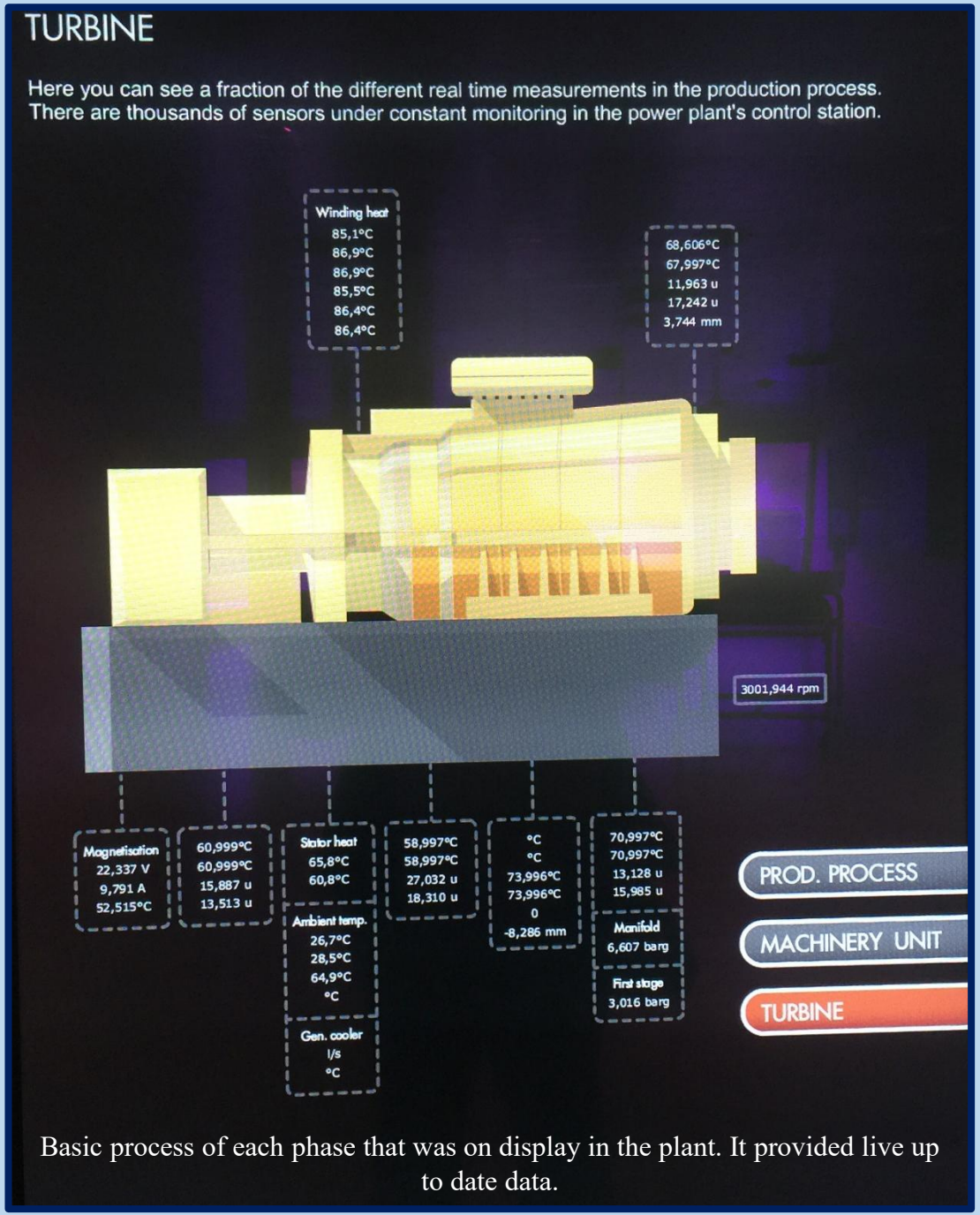
Basic process of each phase that was on display in the plant.
It provided live up to date data.

Hellisheidi Power Plant & Visitor Center



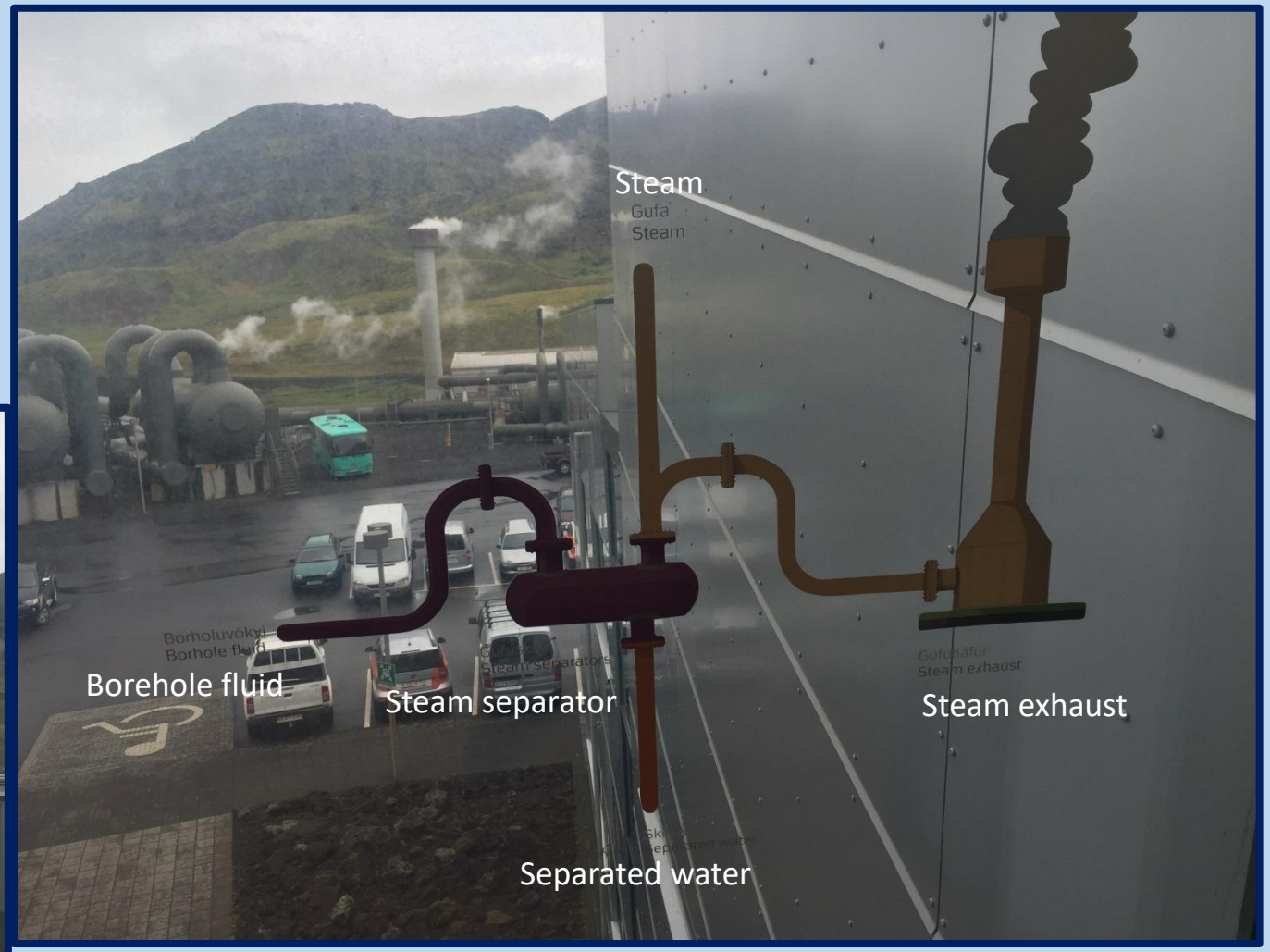
Basic process of each phase that was on display in the plant. It provided live up to date data.

Hellisheidi Power Plant & Visitor Center

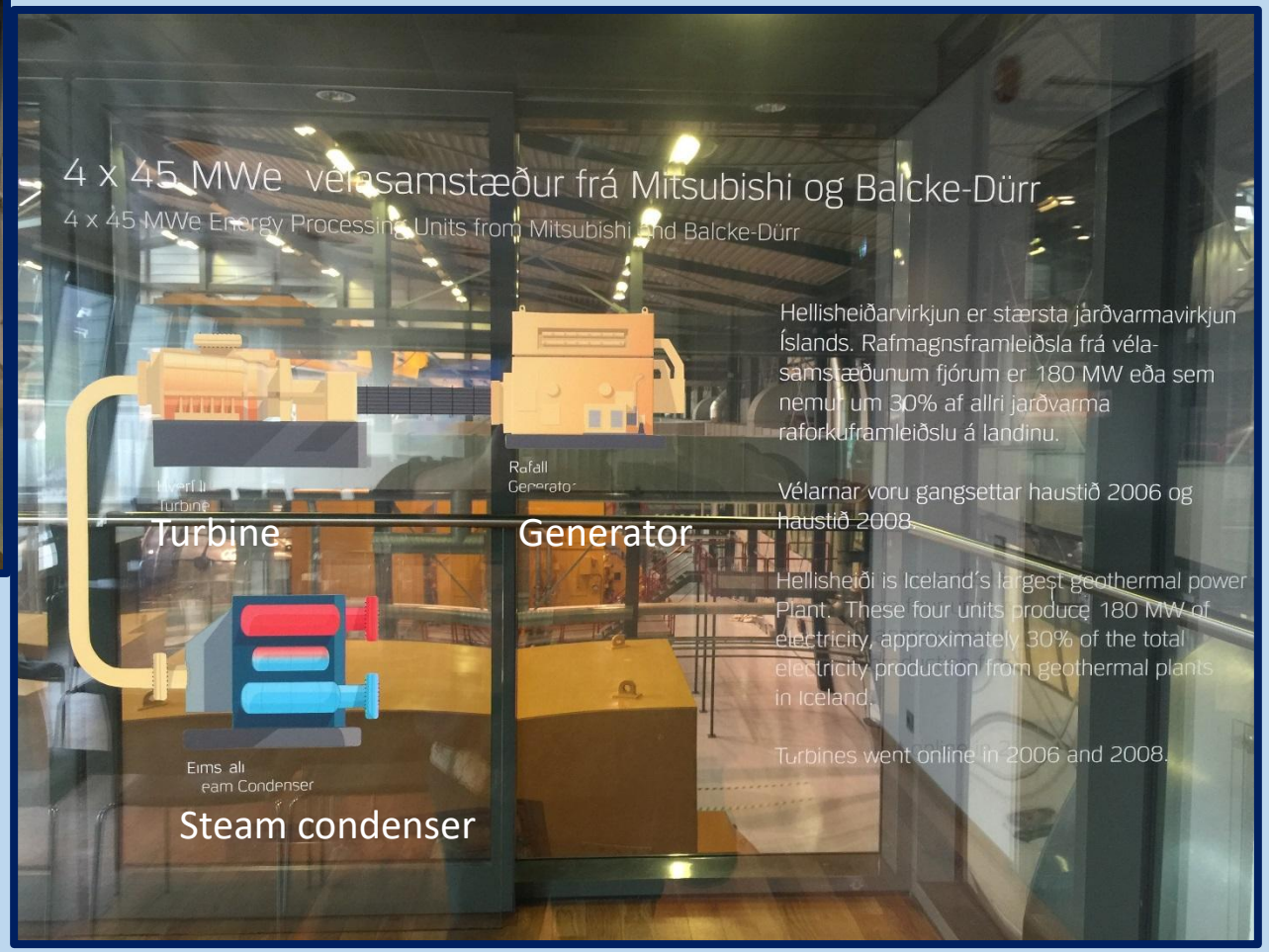


Basic process of each phase that was on display in the plant. It provided live up to date data.

Pictures inside the Hellisheidi Power Plant



Pictures inside the Hellisheidi Power Plant



Let’s fix pick Icelandic Geothermal for Hawaii

- Iceland’s average cost to design/build a geothermal plant is approximately $1 million/MW to $1.5 million/MW, operation cost $1.9 million/MW/year. 1MW can power ~ 1000 to 650 homes

- Iceland electricity cost for residential is $0.15 per kWh (~$30 to $125/month) and commercial is $0.10 per kWh
- In 2024, HS Orka’s total revenues were ISK 14.6 billion ~ 117 million USD. HR Orka operates Svartsengi and Reykjanes Geothermal Plants

  Hawaii electricity cost for residential is $0.46 per kWh (~$200 to $450/month) and commercial is $0.50 per kWh

- Economic opportunities:
  - Cheap, abundant electricity and thermal energy
  - Thermal heating of municipal hot water
  - Aquaculture
  - Food & Beverage Processing
  - Greenhouses
  - Other Industries that need a lot of energy: producing hydrogen fuel cells, aluminum smelting, recycling, manufacturing
- I would be more than happy to share what I have learned about Iceland and Iceland geothermal. I will also be happy to assist in planning for any tours to Iceland’s Geothermal Plants and meet Iceland Geothermal Industry Leaders.
- Icelandic Environmental and Energy Agency Project Manager- International Projects Baldur Petursson, MSA can assist in providing a tour to a Hawaii Delegation. Baldur Petursson’s email is baldur.petursson@os.is and work phone # 354-569-6000.

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