Use of geothermal energy in fisheries and aquaculture

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Presentation outline

- Geothermal energy
- Geothermal applications
- Case for The Resource Park
- Processing – Drying fish
- Aquaculture
- Seaweed
- Salt production

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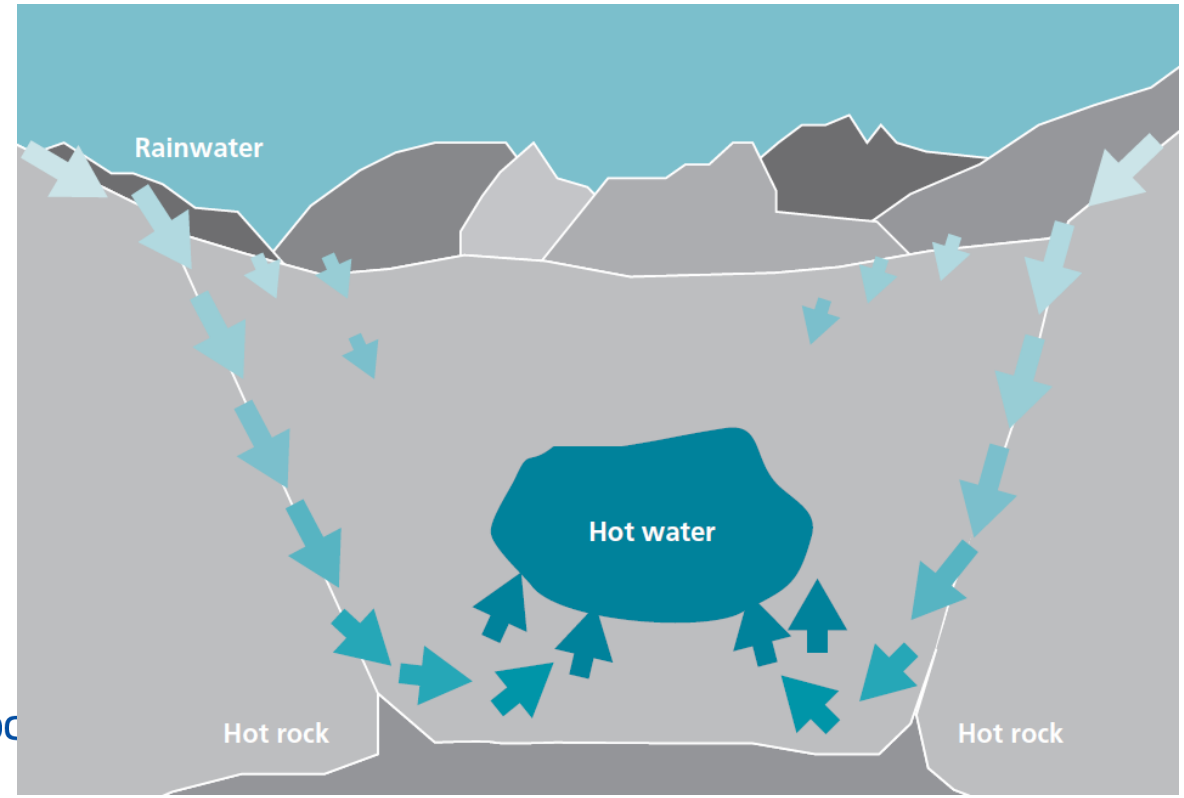
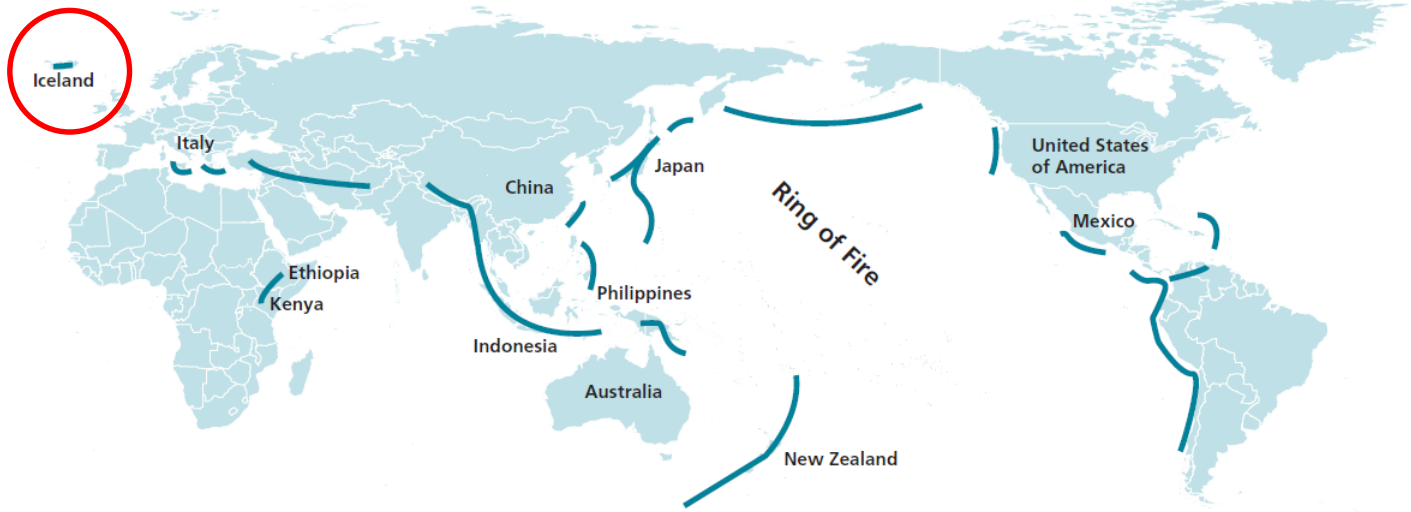
Geothermal energy

- Geothermal is energy derived from the natural heat of the earth
- Heat flow from the earth's hot interior due to plate movements
- Zones of high heat flow may be located close to the surface
- Formation of a geothermal reservoir:



Main geothermal operations around the world

- Geothermal activity locations



- Steam and hot water utilization

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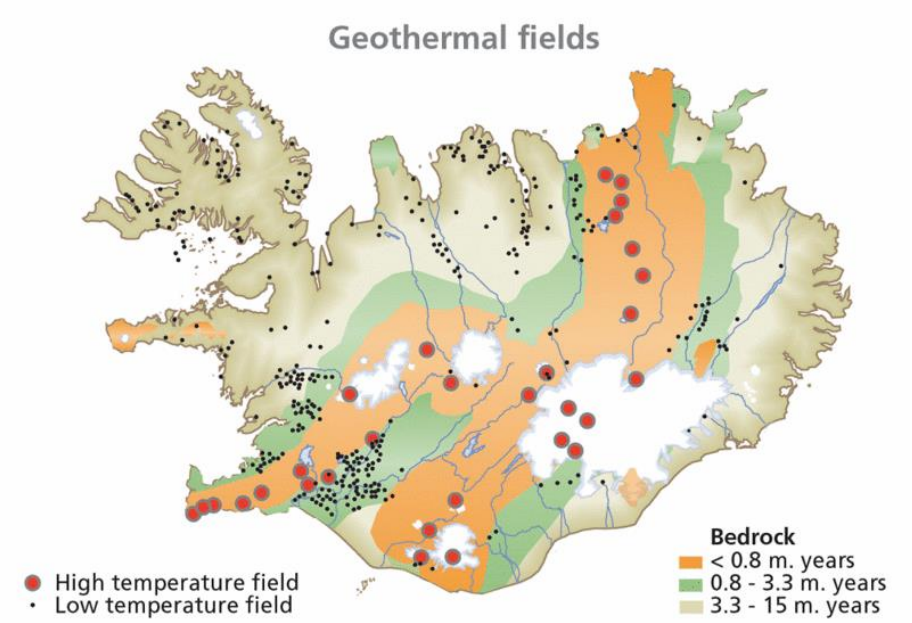
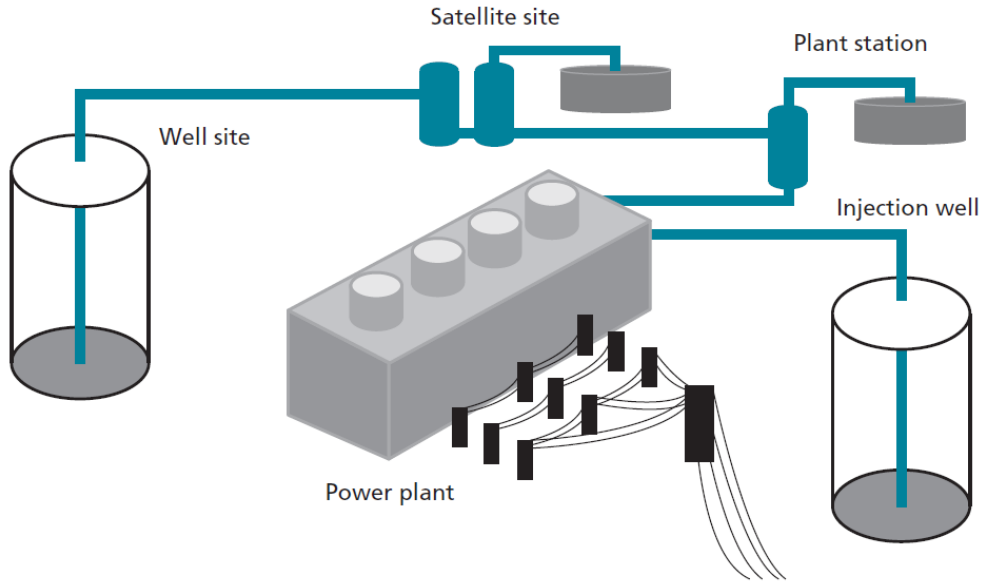
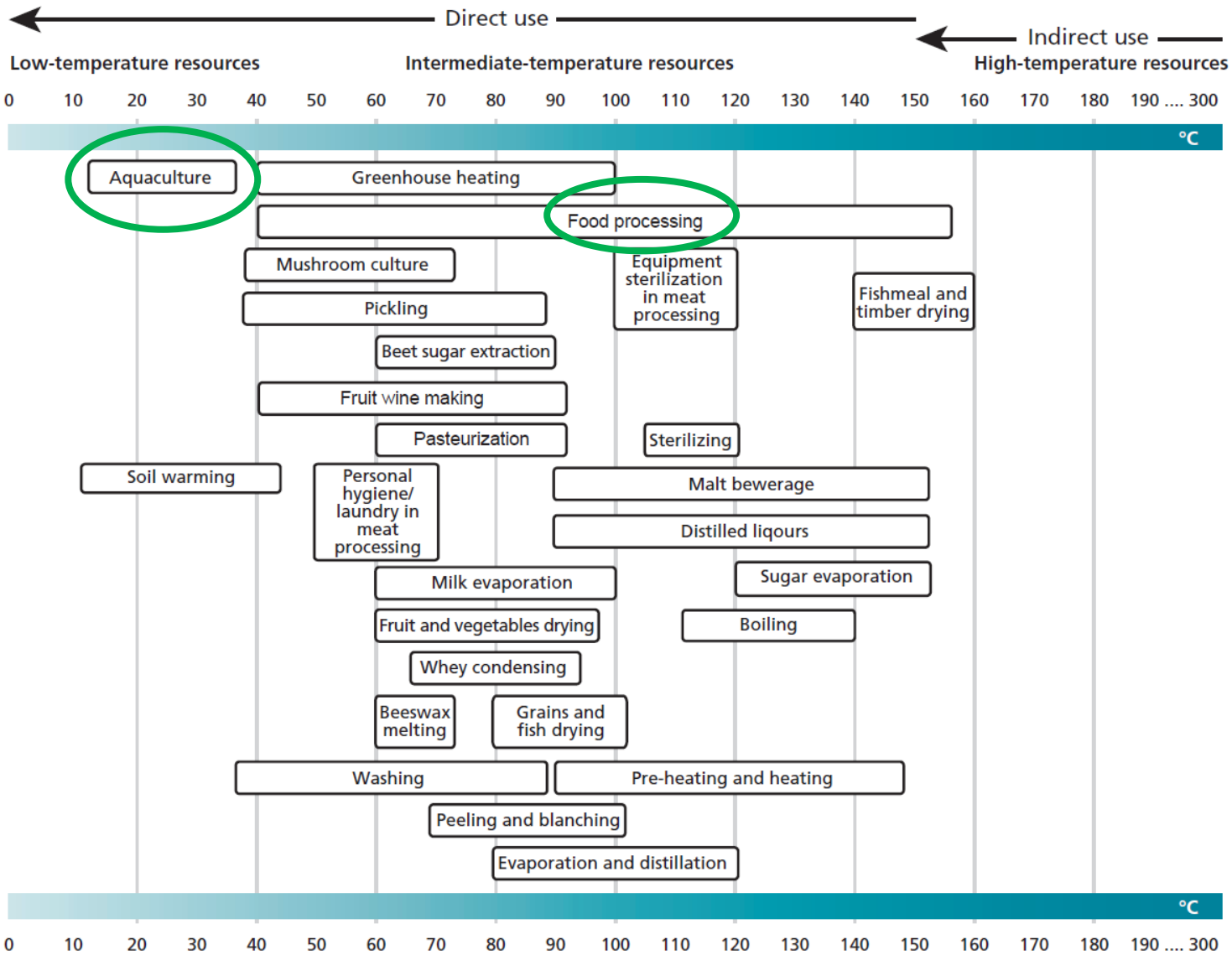
Accessing geothermal energy

- A geothermal power plant cycle
    - i. Condensing power plants (dry steam, single or double flash systems).
    - ii. Back-pressure turbines (which release into the atmosphere).
    - iii. Binary plants, using lower temperature water or separated brine.





Potential uses of geothermal energy - Lindal diagram



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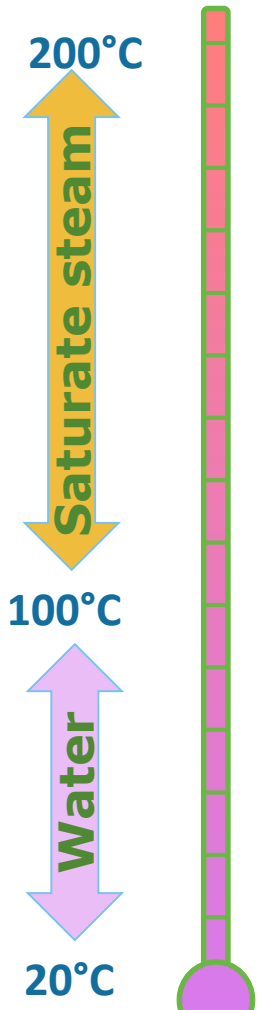
Examples of direct uses at different temperatures



Geothermal electricity

Freeze drying - Steam ejector

Evaporation, Refrigeration by ammonia absorption

Production of fishmeal

Drying farm products. Canning of food

Evaporation and crystallization – sugar, salts etc.

Fresh water by distillation, Evaporation of saline solution

Drying; seaweed, grass, vegetables, grains etc.

Drying of stock fish

Space heating - Greenhouses

Swimming pools. Fermentation

Hatching of fish. Fish farming

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Cascading from a geothermal power plant

- Utilization of low and intermediate temperature geothermal resources
- Also waste heat and cascading water from power plants

CENTRAL HEATING IN ICELAND

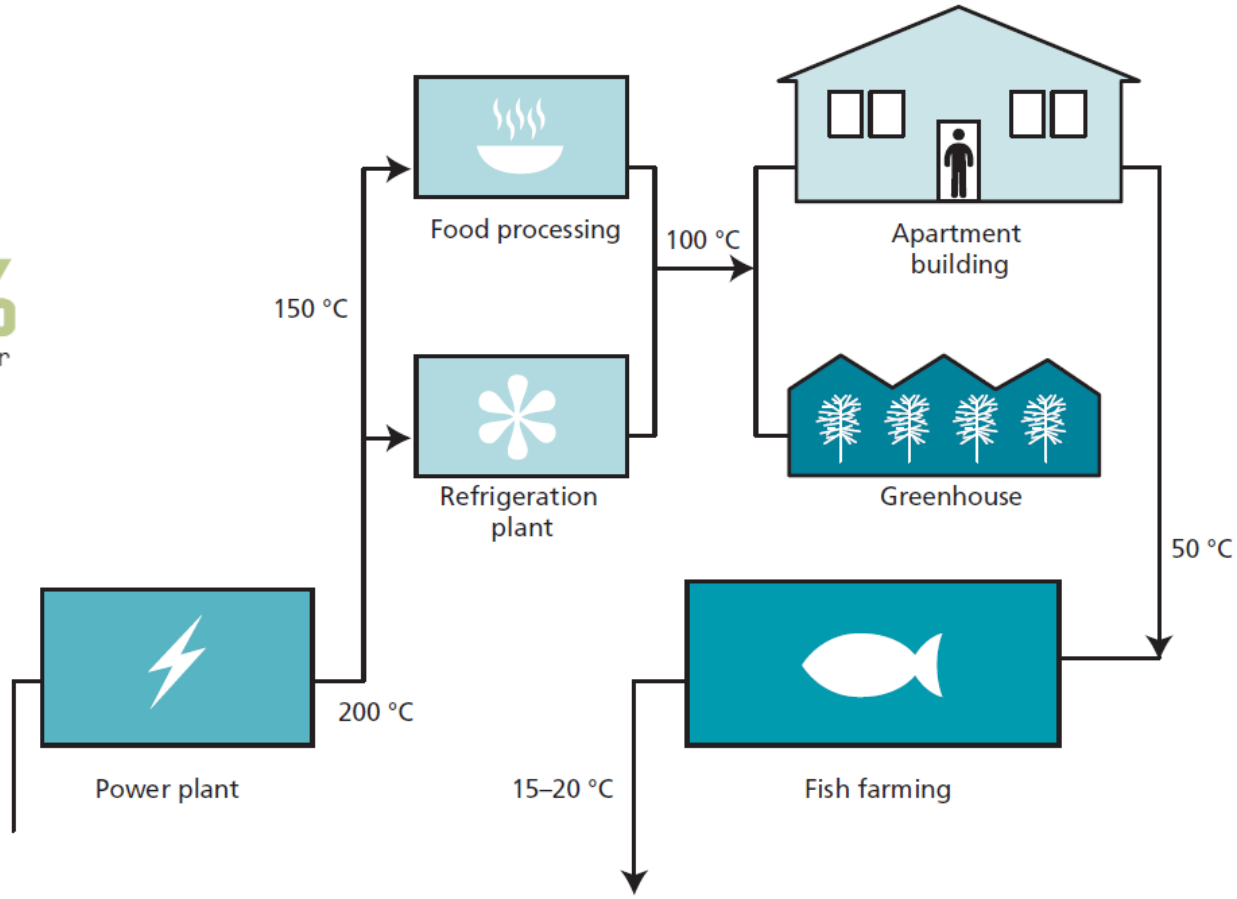
90% Geothermal

10% Electricity

ELECTRICITY IN ICELAND

30% Geothermal

70% Hydropower



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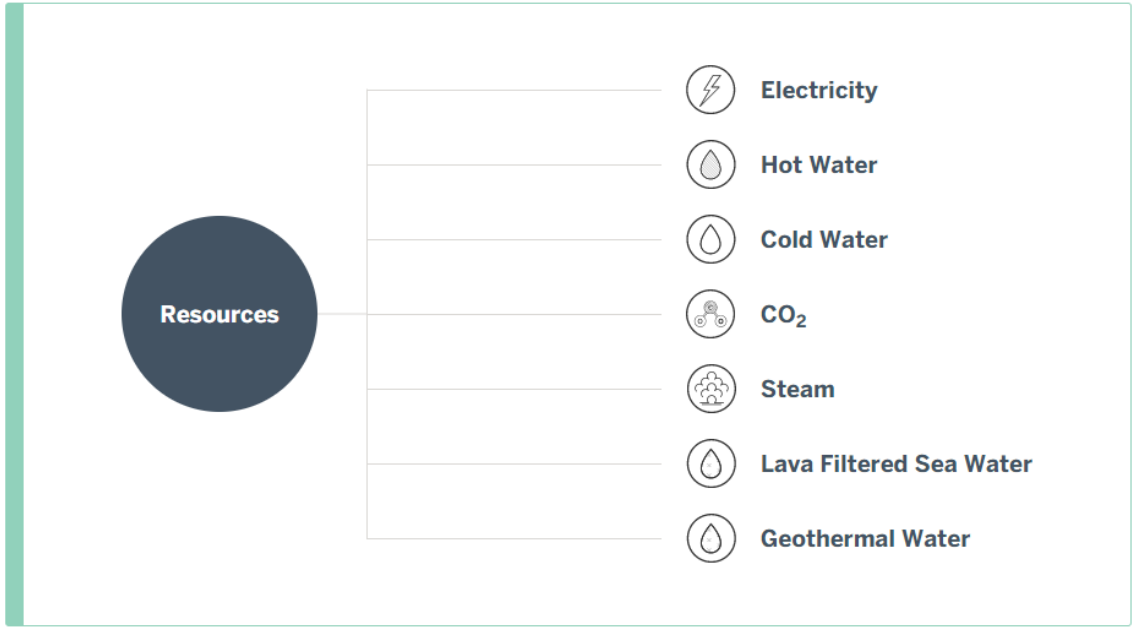
Case example

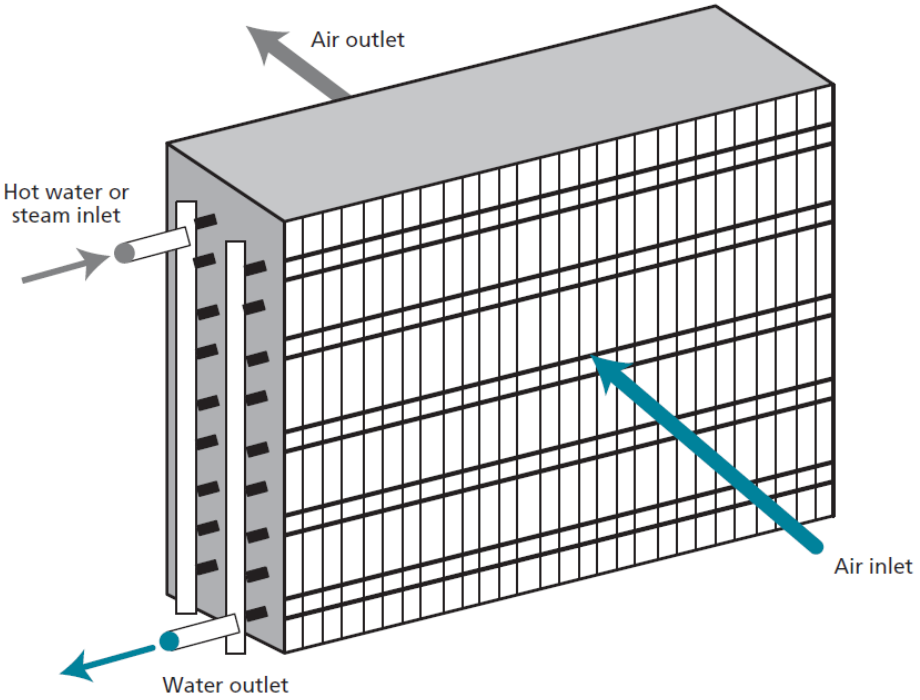
- An example of the HS Orka Resource Park concept (https://www.hsorka.is/en/the-resource-park/)

- Located in Reykjanes
- Includes the Blue Lagoon, ORF genetics, Carbon recycling, algea cultivation, electricity and hot water distribution..
- …and **aquaculture** (Matorka and Stolt Sea Farm)
- …and **fish drying** (Haustak and Laugafiskur).



Fish drying

- Indoor drying using geothermal have been operating for 40 years.
- Drying of cod heads and backbones, around 15.000-20.000 tonnes per year.
- Using a geothermal heat exchanger. This consists of steel or copper pipes equipped with copper or aluminium fins to increase the heat transfer surface. Geothermal hot water or steam is circulated inside the pipes and air is blown through the heat exchanger using a propeller fan. The air is heated by the geothermal hot water or steam and is then blown into the drying chamber for the drying process.



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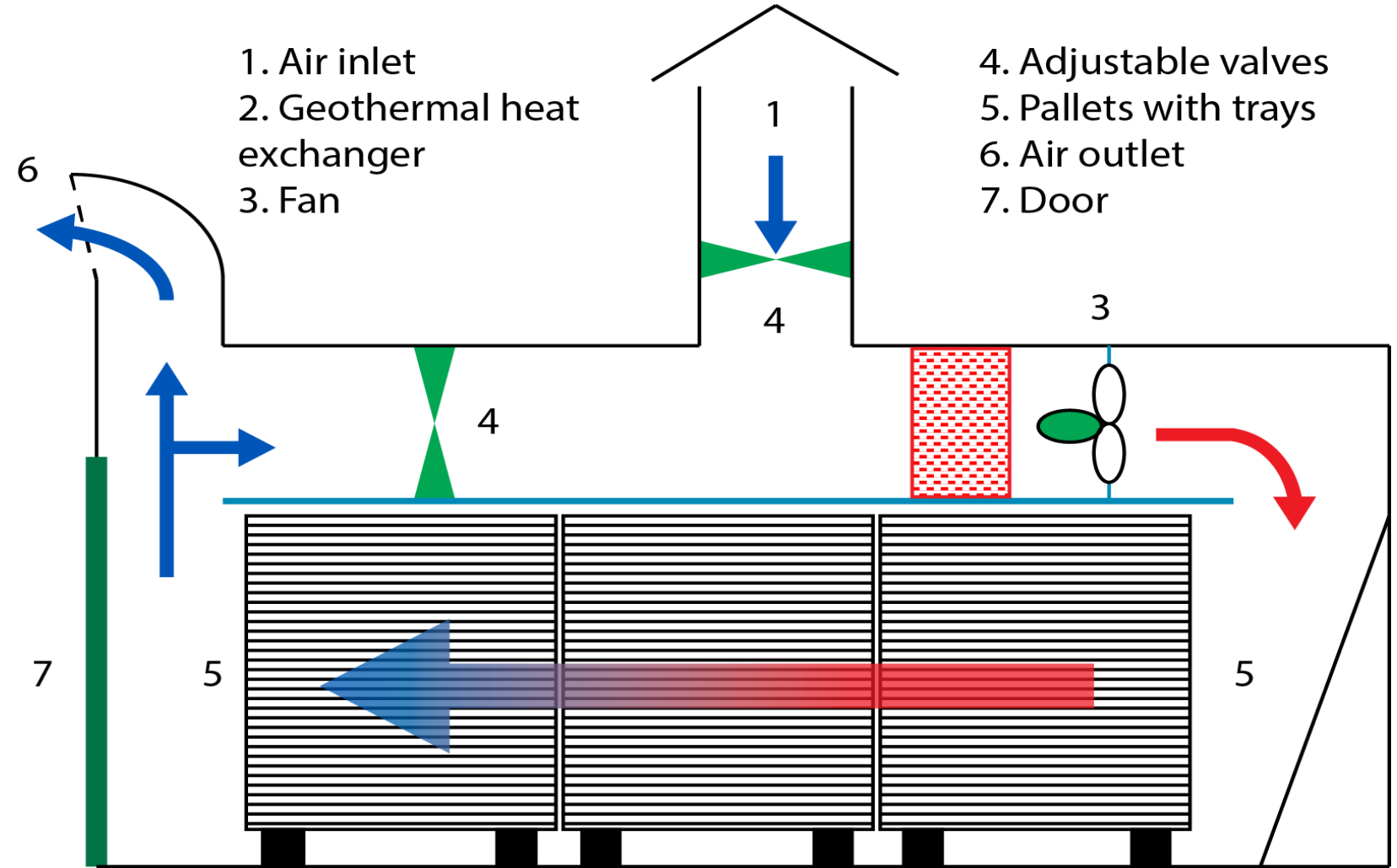
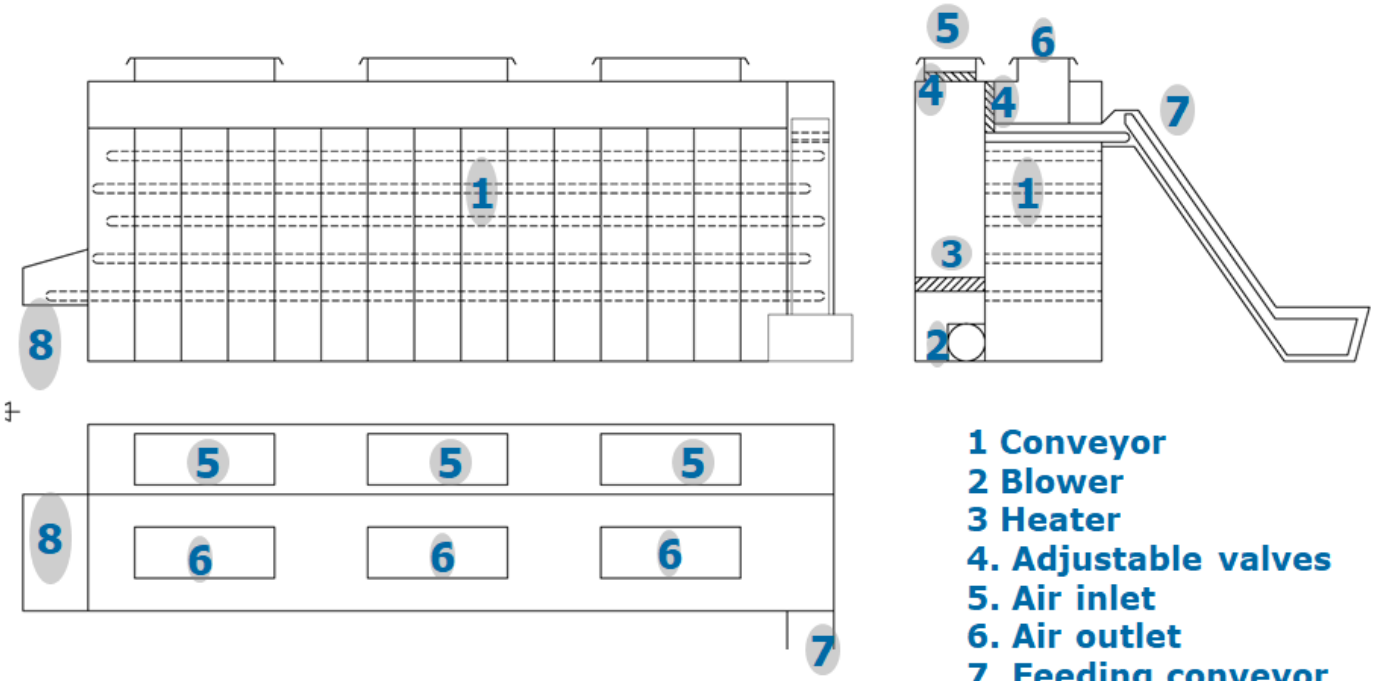
Tunnel drying using geothermal

- Operating at air temperature below 30°C



Drying cod heads – Belt dryer



1 Conveyor
2 Blower
3 Heater
4. Adjustable valves
5. Air inlet
6. Air outlet
7. Feeding conveyor
8. Product

Drying fish - Products

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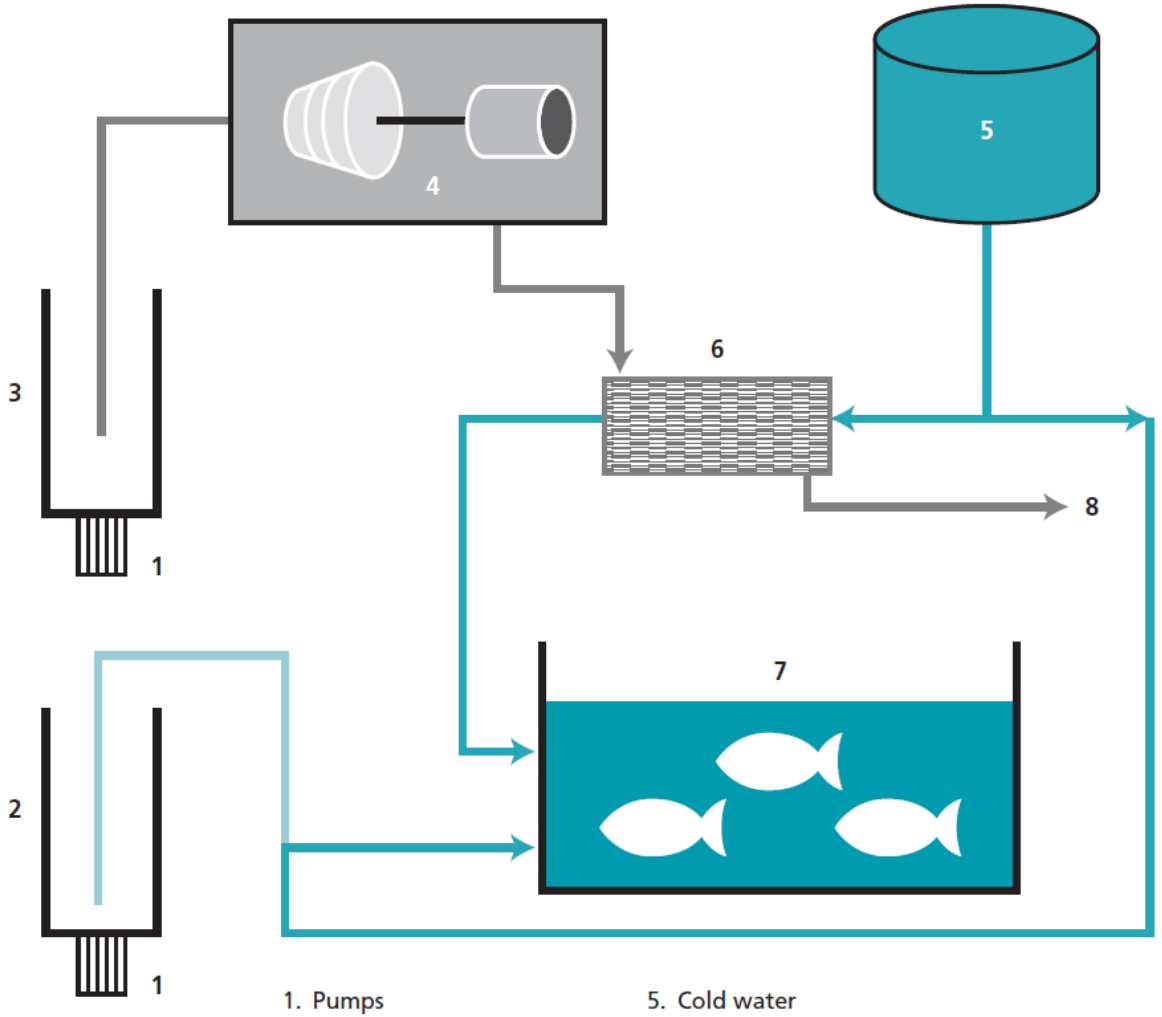
Using geothermal in aquaculture - example

- Geothermal hot water is used to heat freshwater in heat exchangers or is mixed with fresh water to obtain suitable temperatures for fish farming.
- Cold water is heated in a heat exchanger using hot wastewater from a geothermal power plant, or is mixed with water from a hot spring. Once it has reached a suitable temperature – generally about 20–30 °C – the water is pumped into the fish pond. The size of the pond depends on the temperature of the geothermal source, the temperature required for the fish species, and the heat losses incurred during operation



1. Pumps
2. Hot spring well
3. Geothermal well
4. Geothermal power plant
5. Cold water
6. Heat exchanger
7. Fish farming pond
8. Water outlet

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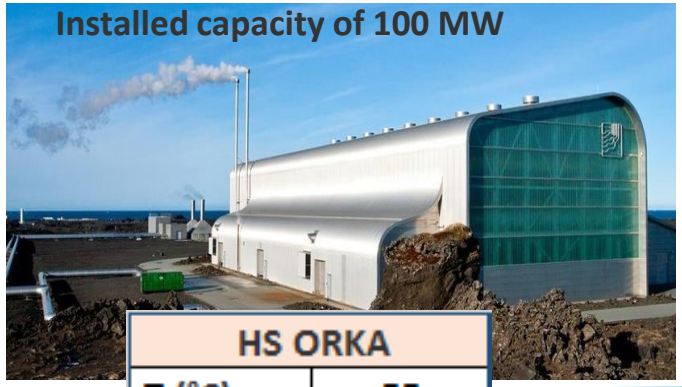
Stolt Sea Farm Aquaculture

Power Station HS ORKA

Installed capacity of 100 MW



Cooling water 35ºC

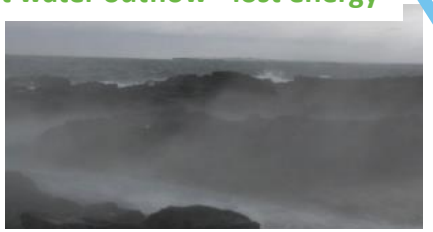
SSF WELLS	
Tª (ºC)	9
Flow (l/s)	2000

HS ORKA	
T (°C)	55
Flow (l/s)	3200

PIPE TO SSF	
T (°C)	35
Flow (l/s)	2000

SSF MIX	
T (°C)	22
Flow (l/s)	4000

Hot water outflow - lost energy



Senegalese sole

Natural distribution of Senegalese sole

OUTFLOW TO SEA	
T (°C)	37
Flow (l/s)	5200

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Aquaculture Samherji

- Land-based salmon farming in Reykjanes
- Plans for 40.000 tonnes salmon per year (the current total production in Iceland in 2021 were around 45.000 tonnes)
- Access to filtered seawater
- Electricity and hot water from geothermal plant (HS Orka)

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Drying seaweed

- Thorverk Iceland. Milled organic kelp
- Once landed, the seaweed is chopped and dried on a band dryer that uses large quantities of clean, dry air heated to 85°C by geothermal water in heat exchangers. The plant has been in operation since 1976, and produces between 2,000 and 4,000 tons of rockweed and kelp meal annually using 34 l/sec of 107°C water for drying. The product has been certified as organic. The plant's annual use of geothermal energy is about 150 TJ.

Thorverk

Key elements

- Geothermal heat
- Kelp, Rockweed
- Big rocky shores
- Clean ocean

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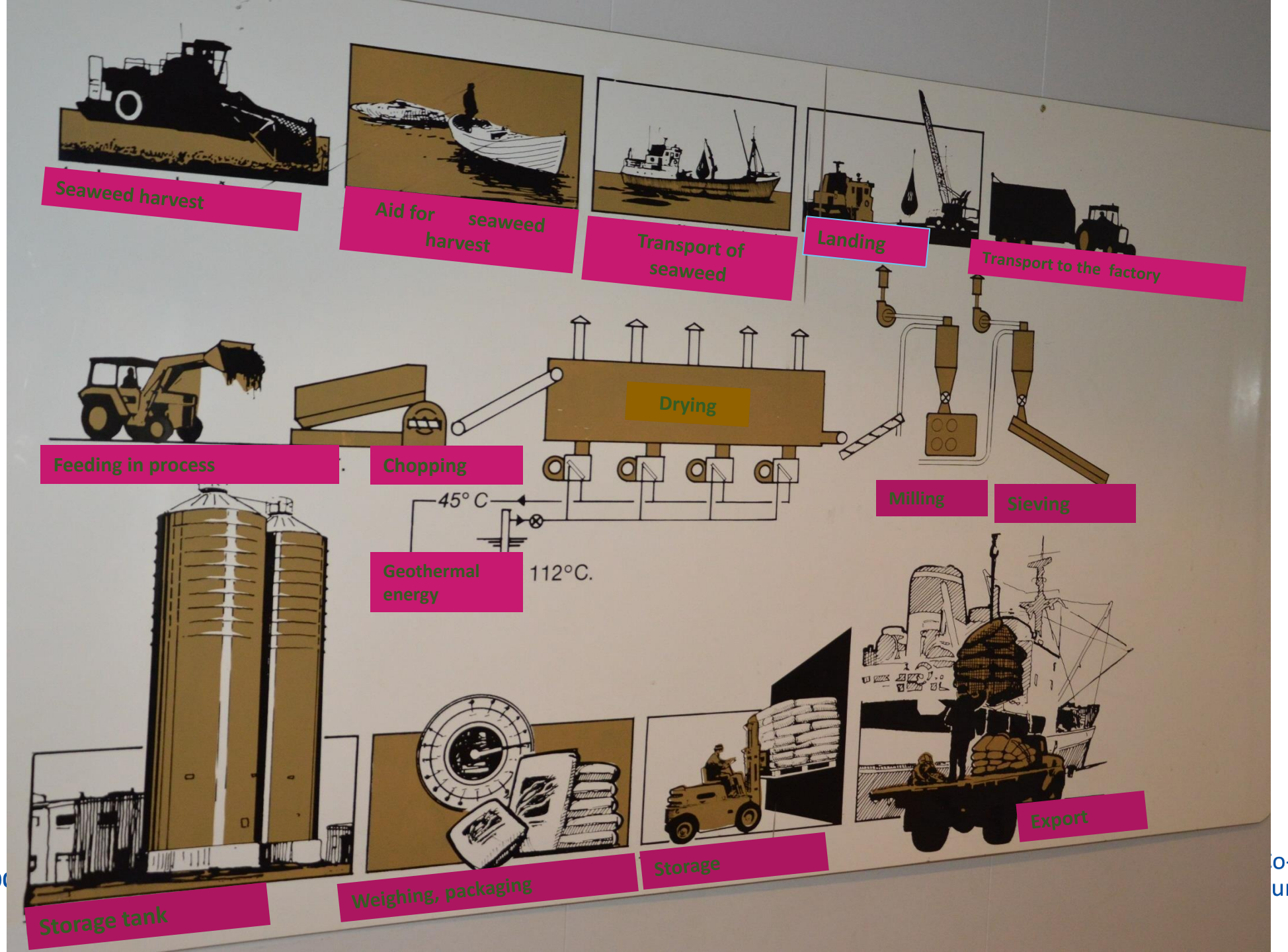

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Salt production - Norðursalt

- Evaporation from filtered seawater
- Geothermal hot water through a titanium heat exchanger

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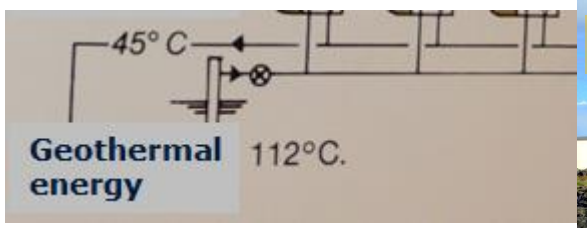

Waste energy (45-65°C)

Evaporation

Crystallization

Washing

Harvesting

Quality evaluation

Packaging

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Conclusion remarks

- Increasing interest in “green” and “renewable” energy sources
- Geothermal direct-use is in main cases replacing fossil fuels and thus reducing greenhouse gas emissions
- Geothermal can make a major contribution to the world energy needs
- Geothermal heat pumps are the fastest growing direct use of geothermal energy –available anywhere for heating and cooling
- Low temperature combined heat and power plants using the binary cycle for power and cascading for space heating is gaining popularity
- “geothermal” is not well known and the benefits generally unknown – it needs to be promoted better

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