Geothermal Utilization
Direct use and Power Generation

Geothermal Workshop

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Content of presentation

- Classification - Geothermal resources and utilization
- Direct heat uses
  - Space heating/cooling
  - Industrial applications
  - Agriculture
  - Aquaculture
  - Bathing and swimming
  - Snow melting
- Electricity generation
- Co-Generation

Classification

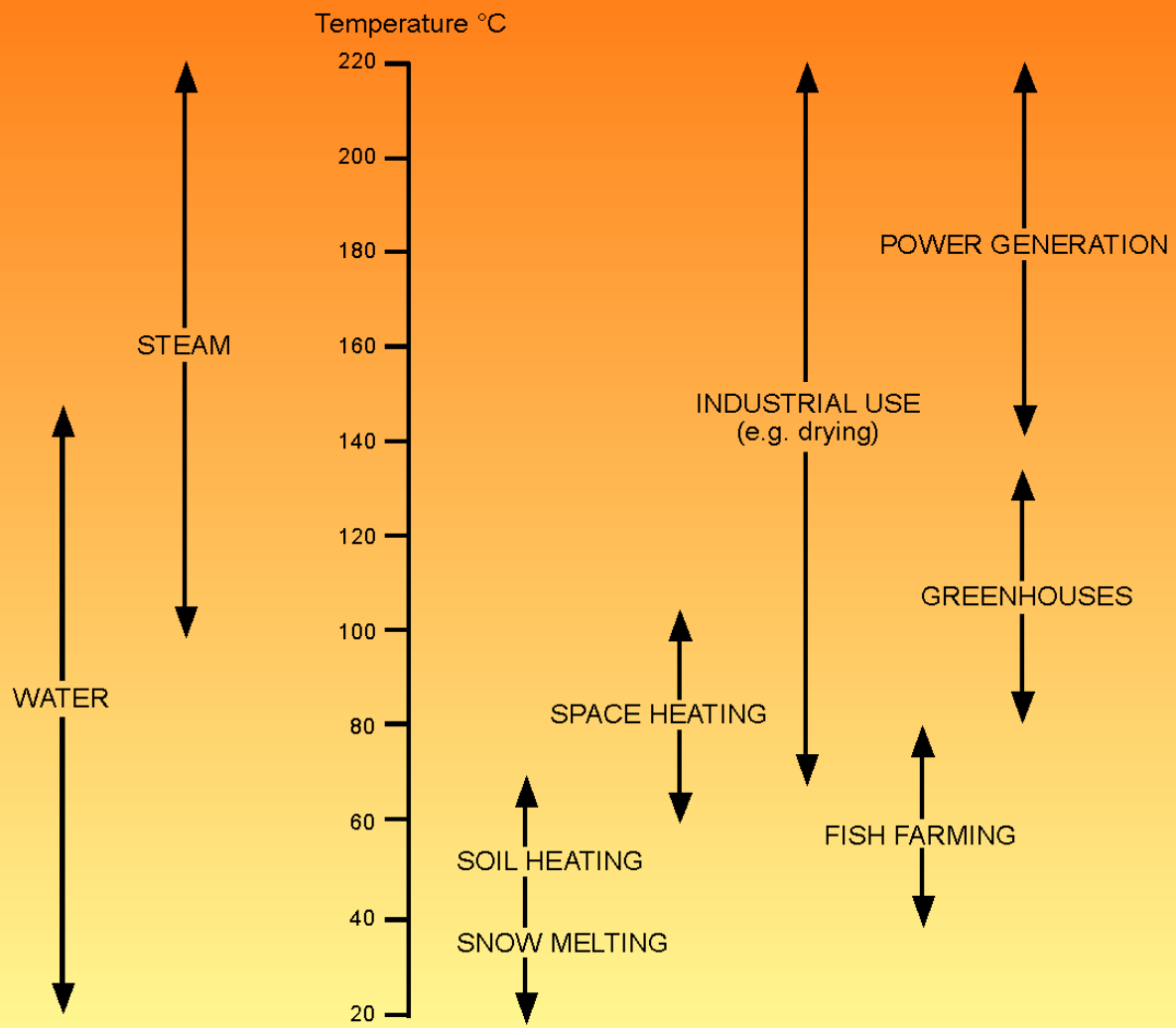
Resources – various definitions

- Low-temperature utilization if the tempereature of the source is below 150°C
- Intermediate temperature resources 150-200°C
- High-temperatute utilization if the temperature of the source is higher than 200°C

Utilization

- Electricity generation
- Direct heat uses
- Co-generation

Geothermal utilization at different temperatures
(Líndal, 1973)



The value of the geothermal resource

- The Lindal diagram empasizes two important aspects:
  - Possible to enhance the feasability of geothermal projects with cascading and combined uses.
  - The resource temperature limits the possible uses
- The value of the resource depends on:
  - Temperature
  - Available flow rate
  - Chemistry of the geothermal fluid
  - Distance from potential market

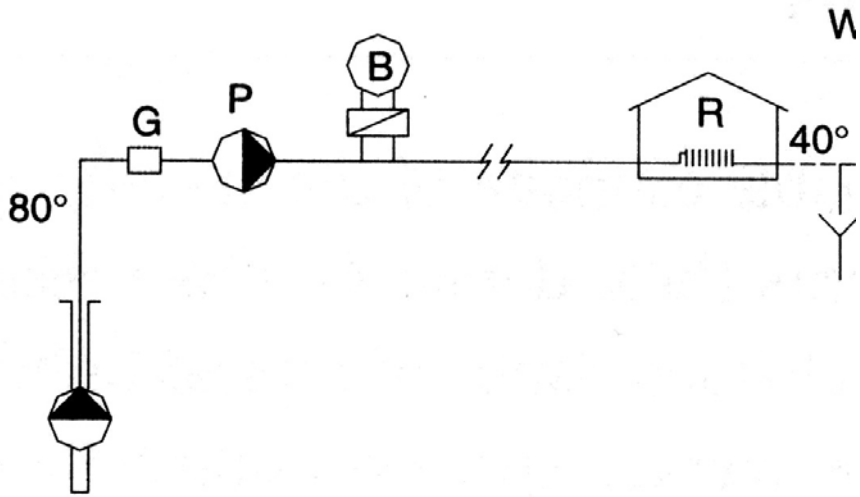
Space heating – main characteristics

- Preferred water temperature is in the range 60-90°C. Common return water temperature is 25-40°C
- Chemical composition of the water is important
- Radiators or floor heating systems are commonly used. Air heating systems are also possible.
- Geothermal heat pump can be used if the temperature of the resource is too low for direct application

Space heating

- Individual users or district heating
- Geothermal water used directly, both for hot tap water and radiators
- Spent water from radiators is discharged to waste.

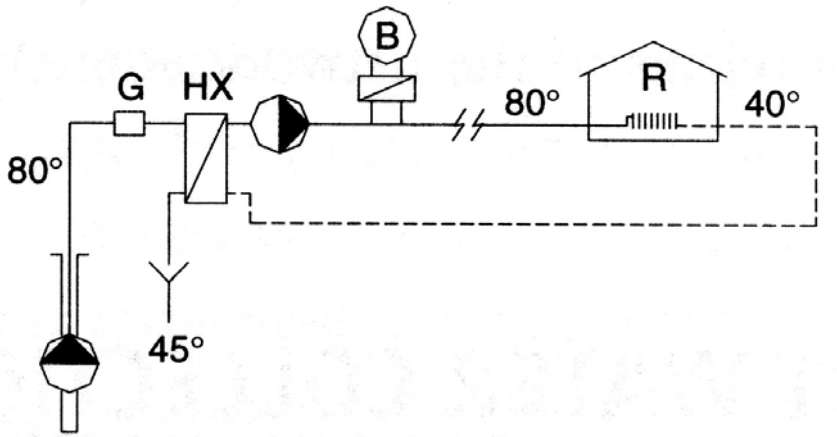
Open loop – single pipe system



Space heating

- Heat exchangers are commonly needed because of the chemical composition of the geothermal water
- More flexible than open loop systems – other energy sources possible

Closed loop – Double pipe system



Geothermal heat pump

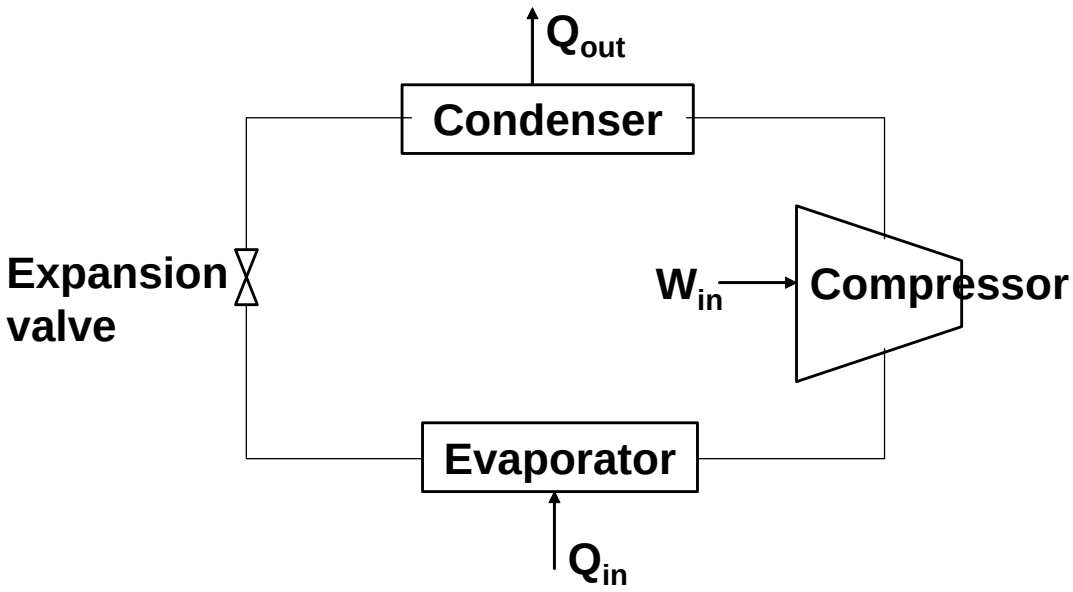
- A heat pump works in the same way as a refrigerator, but the purpose is the opposite (heating)
- Transfers heat from a heat source in the environment at a relatively low temperature (hot spring, well, air) to a place at a higher temperature (indoor air)
- COP - Coefficient og performance:

$$COP = \frac{P_t}{P_e}$$

P_t=Thermal power out

P_e=Compressor power (electricity)

Geothermal heat pump

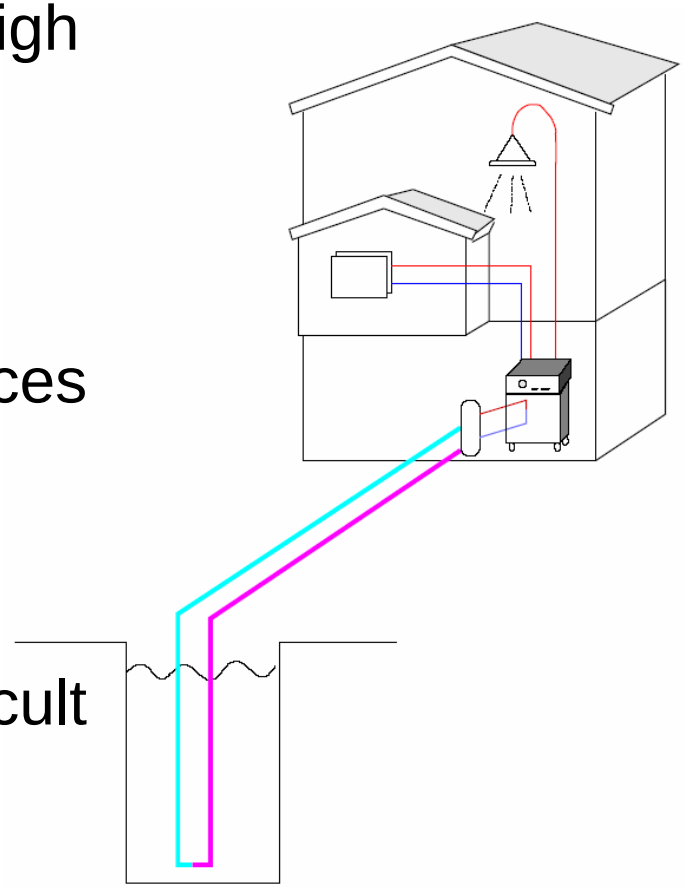


Main types

- Air/air
- Water/air
- water/water
- rock/water
- soil/water

Economy of a heat pump installation

- Installation cost of a heat pump is high
- Running cost is relatively low
- Annual operating time needs to be relatively long
- Comparison with other energy sources over a long period decides the economy of the project
- Subsidised electrical heating in Iceland makes this comparison difficult



Space cooling

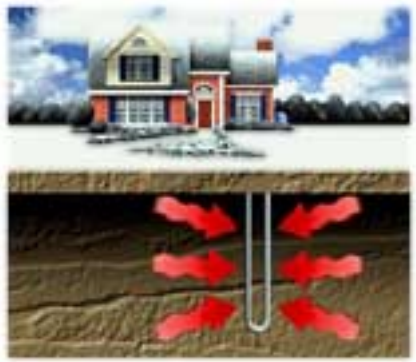
- Geothermal heat pump can be used for:

  heating during winter

  and

  cooling during summer

- Absorption machines using geothermal energy for cooling – mainly large sytems and relatvely high temperature of the geothermal fluid



Industrial applications

- Geothermal energy is attractive if:
  - The quality and price of geothemal energy is as good or better than the alternatives
  - The geothermal energy will reliably be available for the life of the plant

Industrial applications

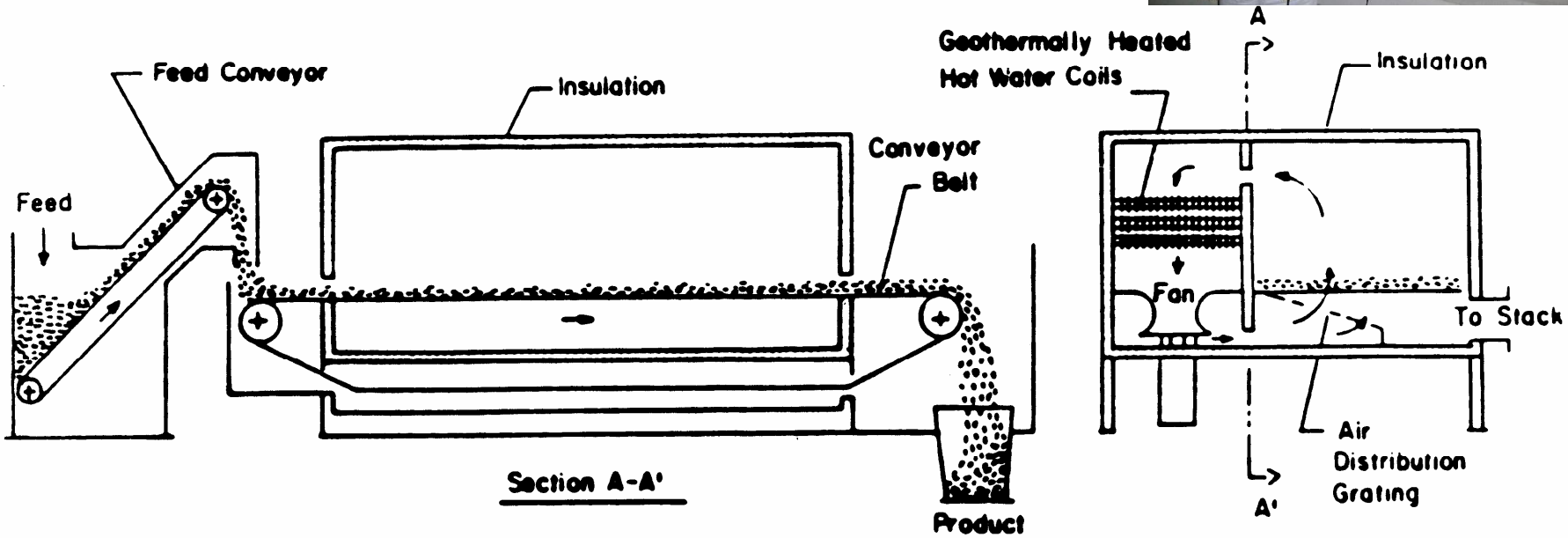
- Drying - The most common operation
- Process heating – preheating of boiler water etc.
- Evaporation – extraction of salt
- Distillation – liquor and hydrocarbon industry
- Washing – food industry
- Chemical extraction – gold separation from ores
- Pasteurization of milk
- Refrigeration – absorption freezing (lithium-bromide and ammonia)

Industrial drying and dehydration

- Agrucultural crops
  - Vegetables, fruits, grain, coffee, tea leaves, onion and garlic
- Pulp, paper and wood processing plant in New Zealand
- A diatomite plant in Iceland
- Fish products
- Drying of wood

A belt dryer

For a large scale drying of agricultural products.
Continious production.
This one is for fish drying.

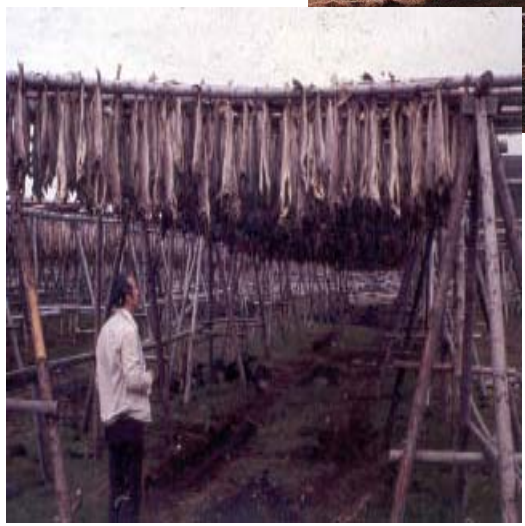


Kísiliðjan diatomite plant

- Since 1967 Kísiliðjan has produced 28,000 tonnes diatomite filter aids per year
- Annual steam consumption 230,000 tonnes at 10 bar abs
- For technical and marketing reasons the plant was closed down at the end of 2004

Other industrial applications in Iceland

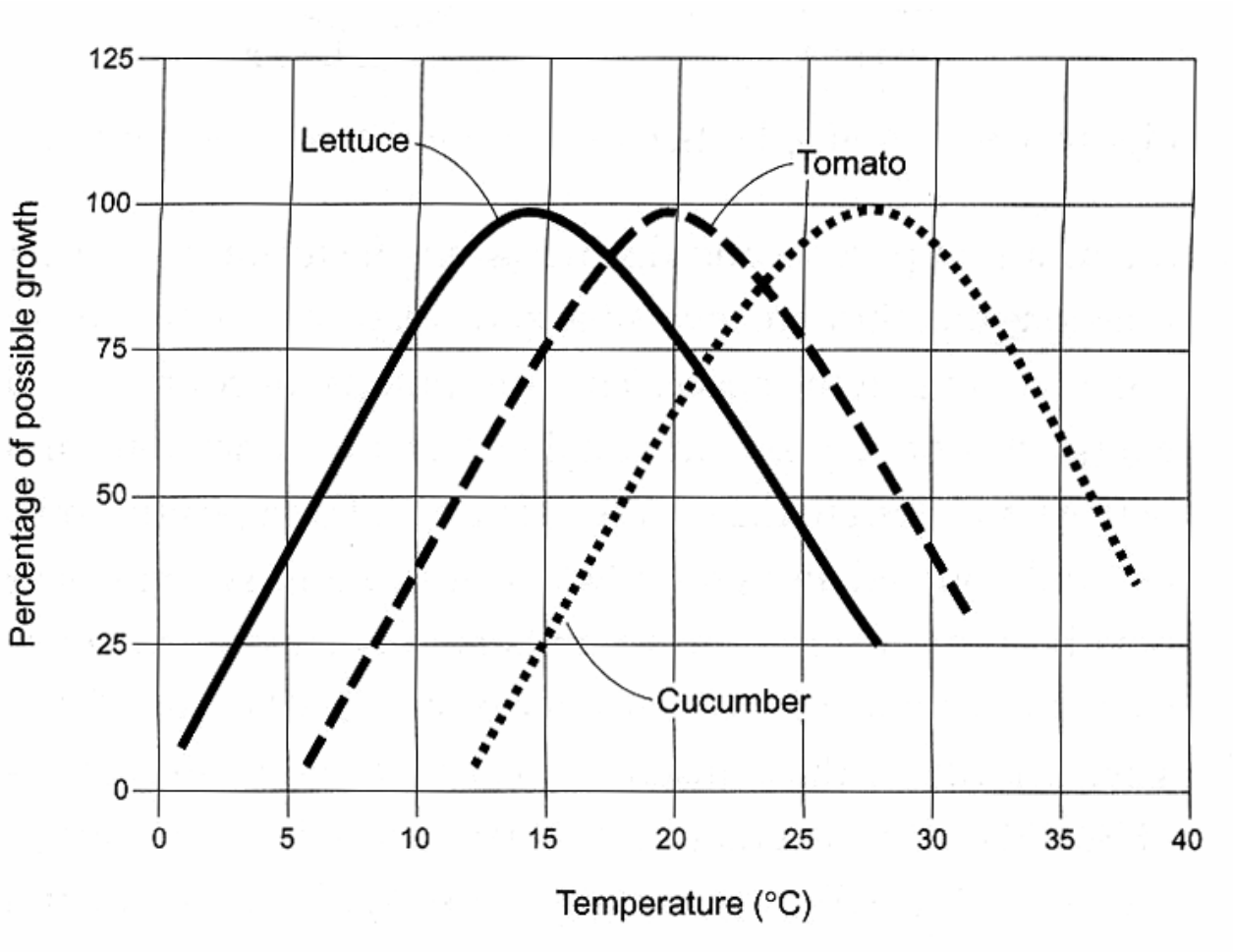
- Reykhólar seaweeed processing plant
  - Produces 2,000-4,000 tonnes of rockweed and kelp meal annually
  - Uses 34 l/s of 107°C geothermal water for drying.
- Hæðarendi – CO_2 production
  - Produces 2,000 tonnes CO_2 annually
  - Uses 6 l/s of 160°C geothermal fluid with high gas content
- Drying of fish products
  - About 20 small companies are drying codheads indoors using geothermal water



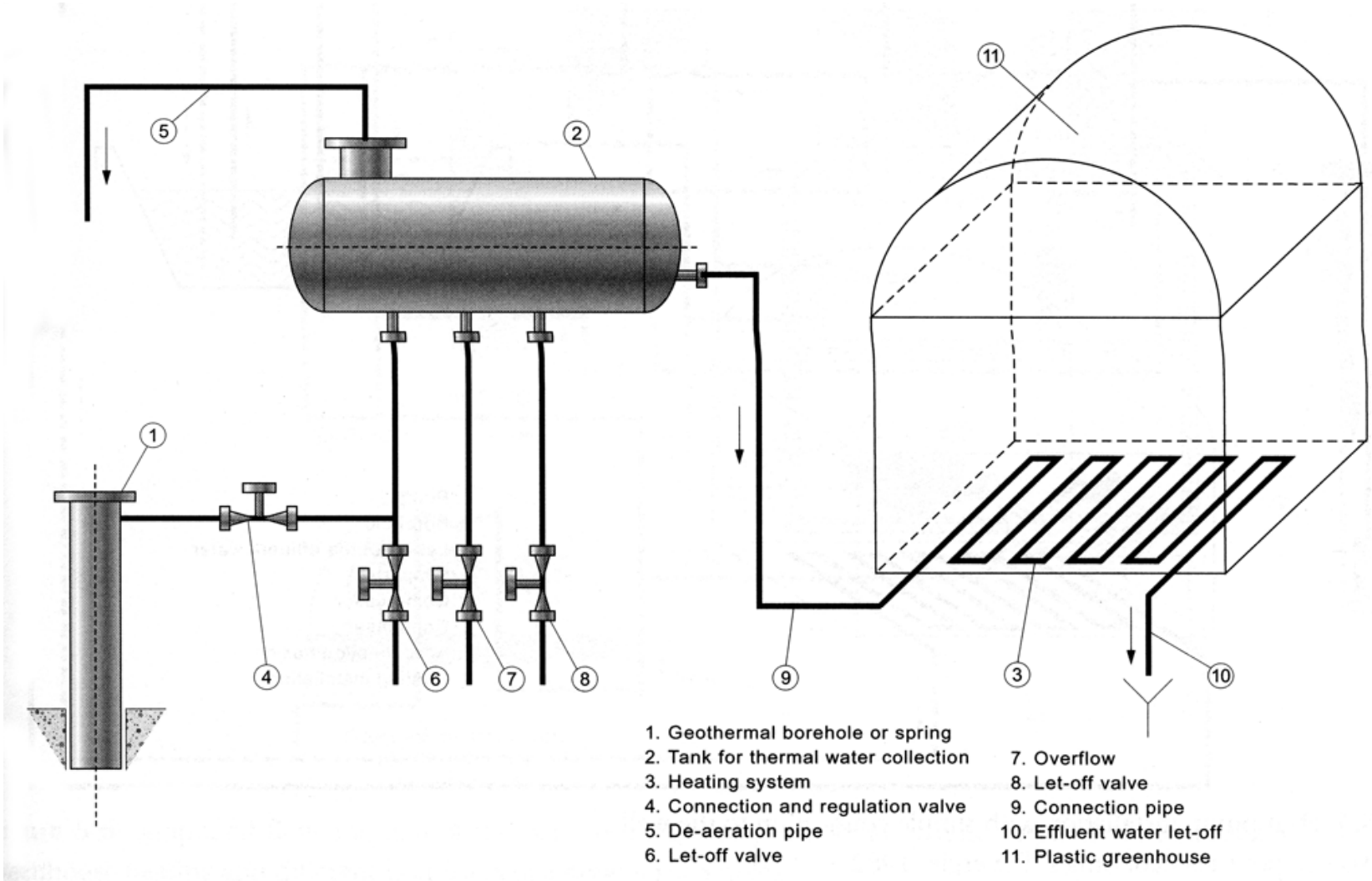
Agriculture

- Greenhoue heating
  - Heating to maintain optimum plant growth
- Animal husbandry
  - Environmentally controlled livestock raising
- Soil warming
- Mushroom raising

Greenhouse heating



Greenhouse heating



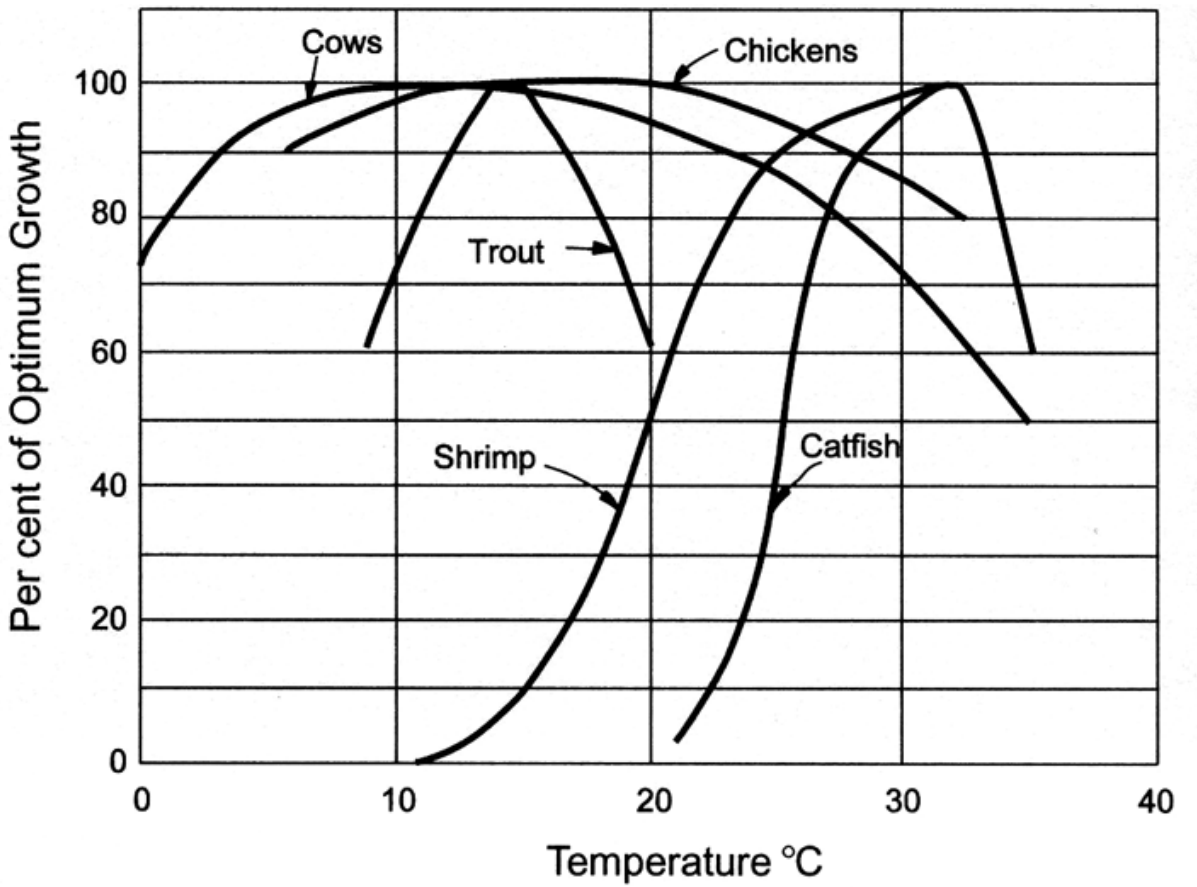
Obstacles – industry and agriculture

- Lack of availability of steam
  - Steam sources only in volcanic regions
  - Transport distances are limited
  - Temperature and pressure limitations
- Financial
  - High investment cost
  - High-temperature areas in remote regions
- Institutional
  - Lack of suppliers
  - Obtaining permits and concessions takes long time
- Environmental

  Many geothermal areas are within protected areas

Aquaculture

- Ambient temperature is more important for aquatic species than for land animals



Aquaculture

- The main species are: carp, catfish, bass, tilapia, frogs, mullet, eels, salmon, trout, sturgeon, shrimp, lobster, crayfish, crabs, oysters, clams, scallops, mussels, abalone, tropical fish, alligators and crocodiles.

Colorado Alligator Farm, Mosca, CO

Bathing and swimming - Spas

- Geothermal water has been used for bathing and health care for thousands of years
- Balneology: The practice of using natural mineral water for the treatment and cure of diseases
- In Europe and Japan, the use of medically supervised spas has long been accepted. They are used both for treatment and preventive therapy.
- Contributes to the development of sustainable tourism - Ecotourism

Steps in building up a balneology industry

- Define the geothermal resource, physically and socially
- Classification of geothermal waters
- Checking the availability of mineral water
- Checking the availability of medical services and recreation
- Make market analysis
- Define a business project based on previous steps

Different spa services

Bathing and swimming - Iceland

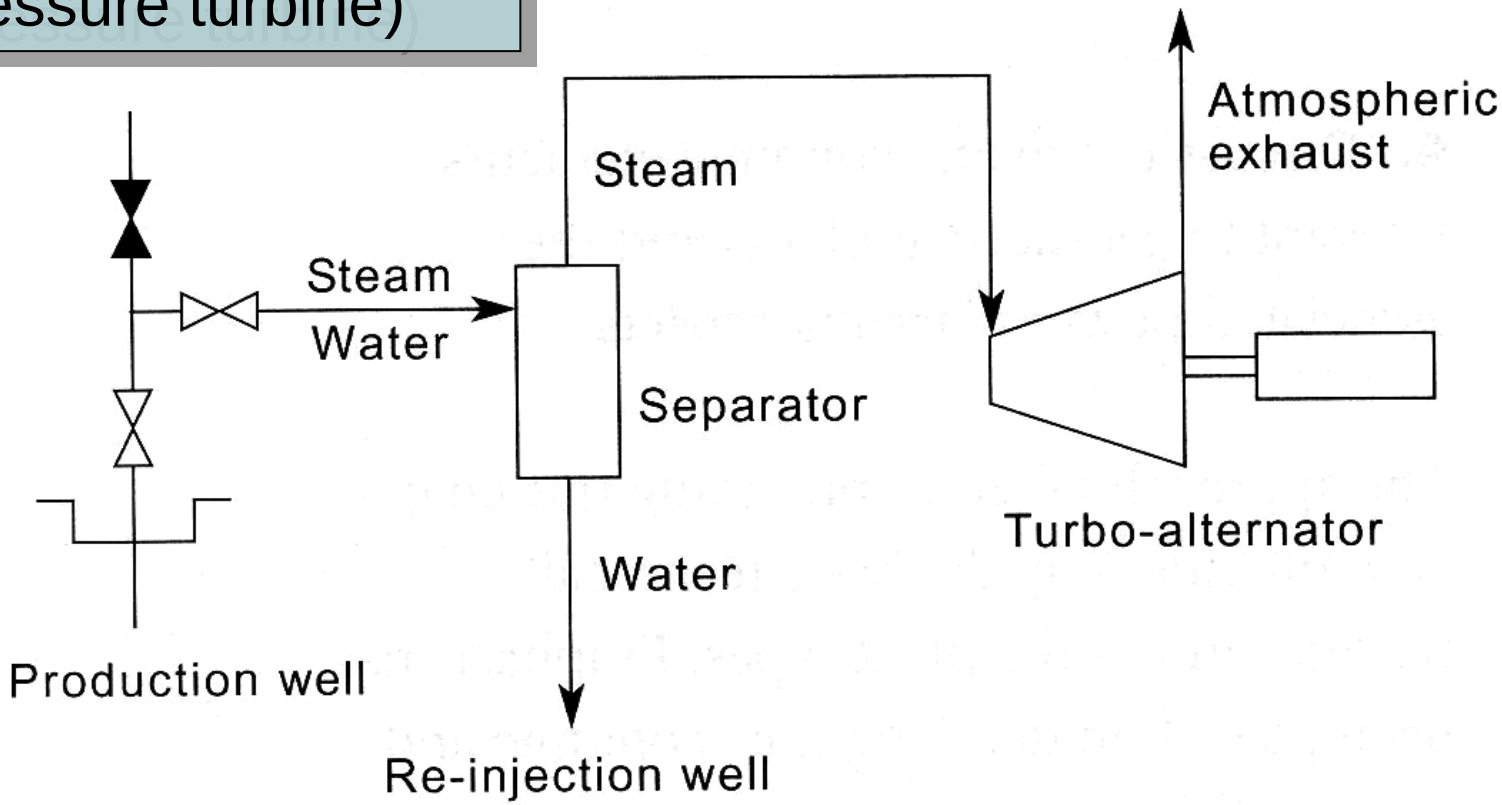
- 130 geothermally heated swimming pools
- Mostly outdoors, water temp. 27-29°C
- Total surface area 28,000 m^2
- 220 m^3 water used annually per m^2 pool area
- Total energy used 1,200 TJ/year

Snow melting

- Spent water at 35°C used. Sometimes mixed with 80°C hot water
- Total area covered 740,000 m2. Of that 550,000 m2 in Reykjavik
- Annual energy consumption 430 kWh/m2
- 55% from spent water, 45% from 80°C hot water

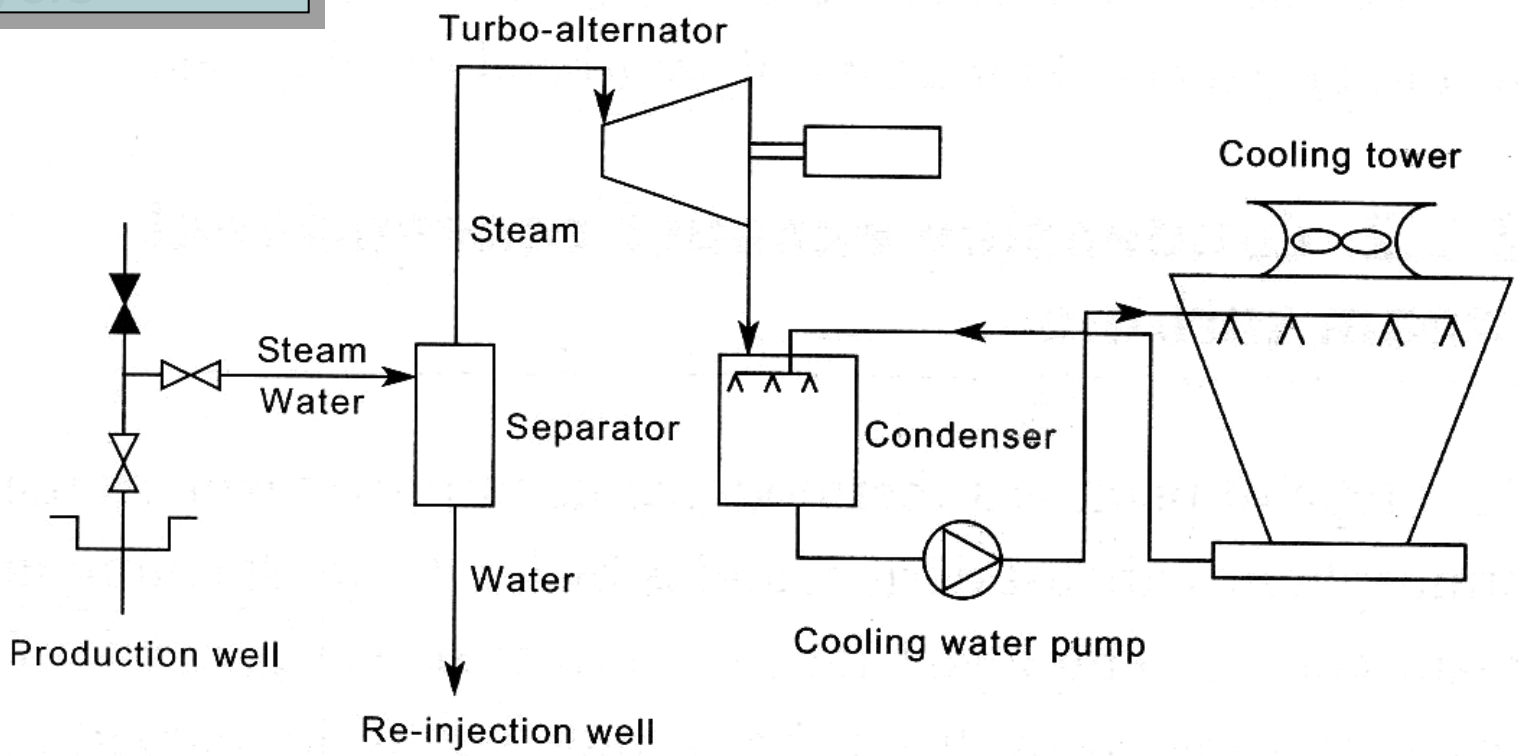
Electricity generation – back pressure

Atmospheric exhaust cycle (back pressure turbine)



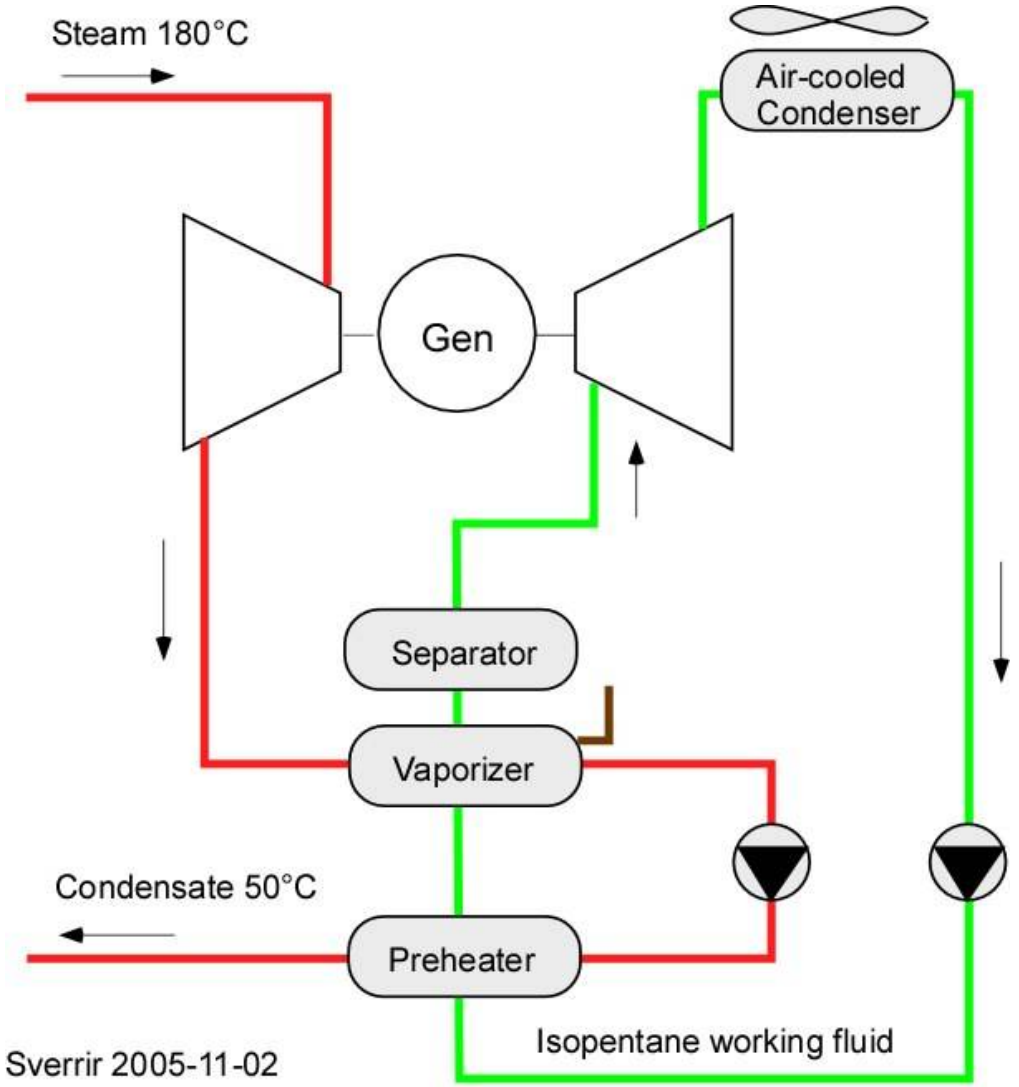
Electricity generation – condensing

Condensing cycle

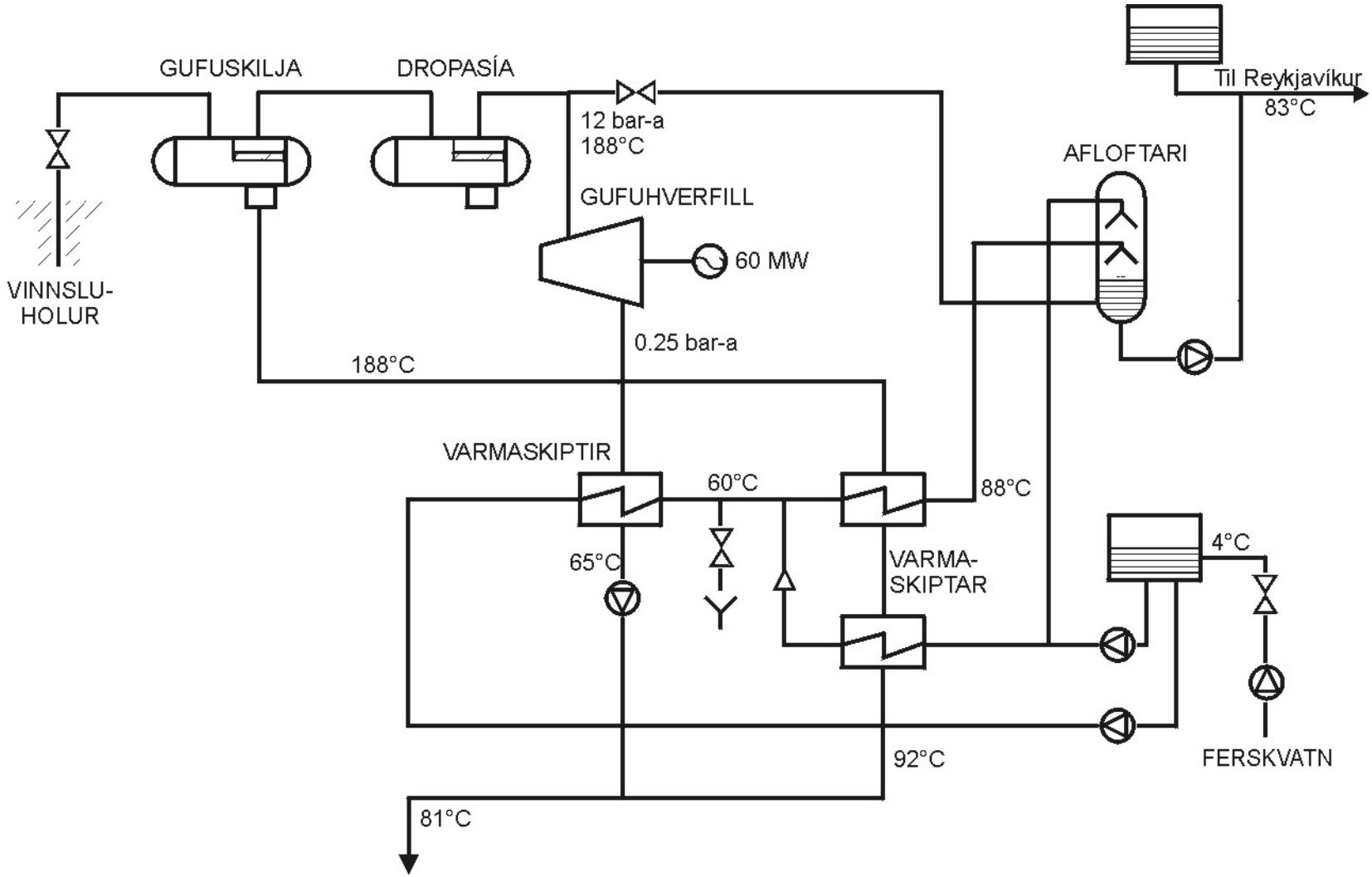


Electricity generation – binary cycle

Binary cycle



Co-generation power plant at Nesjavellir



Conclusions

- Annual use of geothermal energy worldwide is roughly equal for electricity generation and direct use.
- The generation of electricity from geothermal sources will likely continue to be the most important use.
- Direct use for space heating and cooling is likely to grow where the climate calls for it and also the use in agriculture.
- Interesting possibilities are found in spa and balneology, both for tourists and local people.
- Industrial use will continue to play a minor role for a variety of reasons. Use of steam in industry is preferable.