Co-funded by the Erasmus+ Programme of the European Union

RESOR - **R**enewable **E**nergy **So**urces as a Chance for Development for the **R**ural Areas

RESOR PROJECT

Module No:
Geothermal Energy

by New Edu, n.o.

Geothermal Energy

- refers to the heat from the inside of the Earth
- can be used for:
  - directly heating or electricity generation
  - indirectly used by heat pumps
- natural temperatures of the soil or water are used in geothermal energy applications

Geothermal Energy

- Direct use for heating:
  - elevated temperature of groundwater is used
  - this technology is limited to areas that have naturally occurring hot springs or easy access to elevated temperature groundwater in the 38–120°C range
  - spas, greenhouses, or heating systems of buildings use this water
- Direct use for electricity:
  - this technology historically has used water temperatures above 150°C
  - modern technology started to make it possible to generate electricity with water temperatures lower than 150°C

Geothermal energy - Definition

- geothermal energy is not consistent with renewable energy consumption coming from a hot nuclear zone that is higher than 4 000°C
  - **However, due to inexhaustible reserves, it is classified as such**
- it reaches the surface through volcanic cracks in the rocks
- by slowly penetrating the surface, thermal fluxes are generated, which are on average 0,063 W/m^2
- near the surface of the Earth, the thermal gradient that drives the geothermal heat flux is approximately equal to 30°C/km

Geothermal energy - Definition

- the resulting power is very high, but it is spread over such a large area that its density is very low
  - it is much lower than the heat flow density coming from the sun in clear weather
- this makes the use of this energy more difficult, but in regions with unusually large geothermal springs, the geothermal gradient is greater than average
  - at such places, temperatures of up to 200°C can be found at a depth of 1 500 and 2 500 m

Geothermal Energy - Sources

- Places with high level of subsurface water, characterized are by a normal gradient:
  - hot springs, the water temperature reaches about 200°C, the impurities are K, Ca, Au
  - fumaroles are gas springs emerging hot magma degassing by radiation or surface water temperatures reaching over 1000°C
  - mud volcanoes, hot springs with high content of solid particles
  - geysers, regularly supplied with hot springs with temperatures up to 140°C

https://www.flickr.com/photos/rwhgould/5991413927

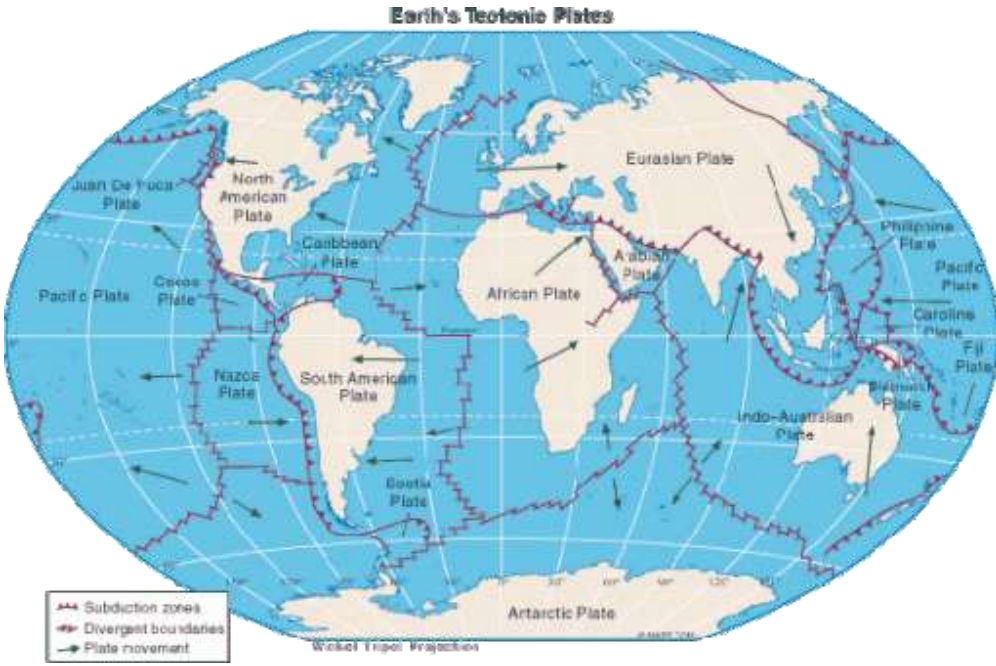
Geothermal Energy - Sources

- Hyper-thermic fields, space saturated with water or steam:
  - dry - in the form of water vapor overheating in hot rock and bringing it into a reservoir
  - wet - the water gets to the surface in liquid form and the change of pressure evaporates it to steam

https://www.science.org.au/curious/technology-future/feeling-heat-geothermal-energy

Availability of geothermal energy

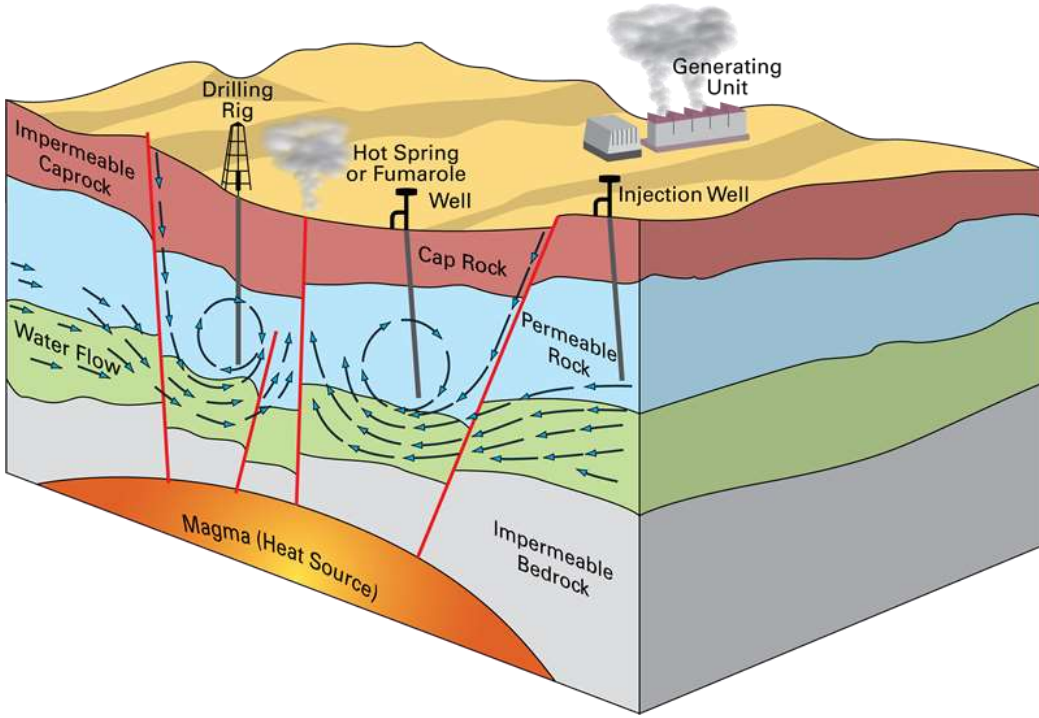
- In the Earth's lithosphere at depths of 30 to 60 km below the ocean water may be present lake, which if they meet molten casing creates bearings dry or wet steam, which comes to the surface



Earth's tectonic faults (The True Mount Sinai, 2019)

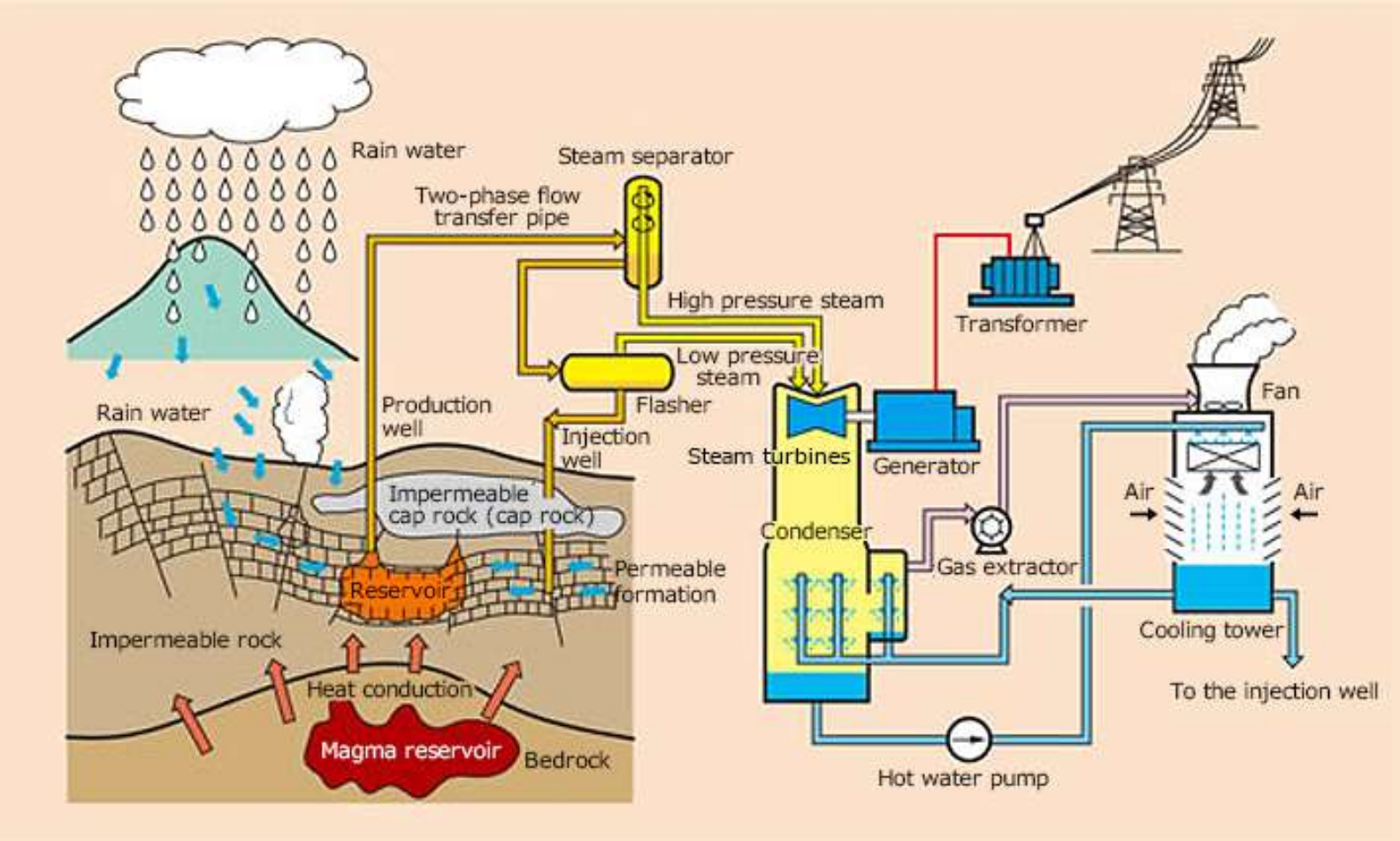
Geothermal Energy - Generation

- technologies for electricity generation from geothermal resources:
  - flash power plants,
  - dry steam plants,
  - binary plants
  - flash/binary combined plants



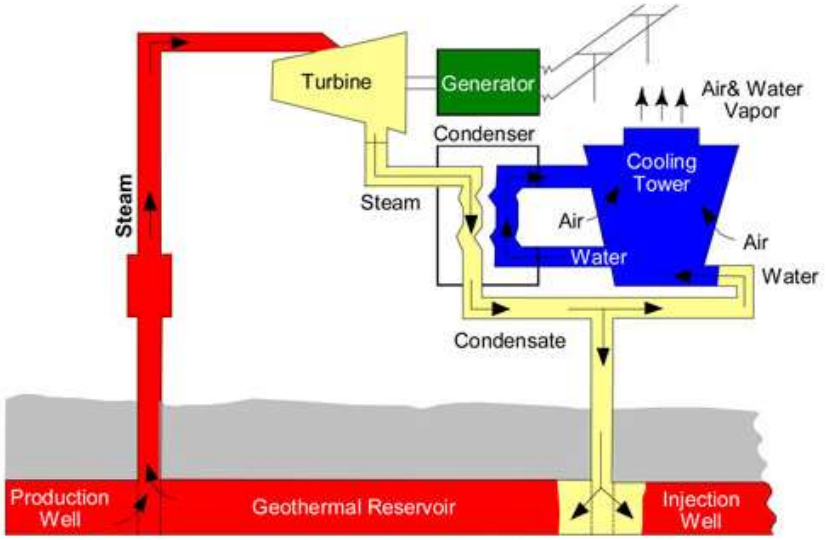
https://busy.org/@techlife/renewable-energy-how-geothermal-energy-works

Geothermal power plants



Dry steam power plants

- Used as warm steam usually over 235°C
- This steam is used for direct spin turbines and generators
- It is one of the oldest and simplest principles and is still used because it is the cheapest way of generating electricity from geothermal sources

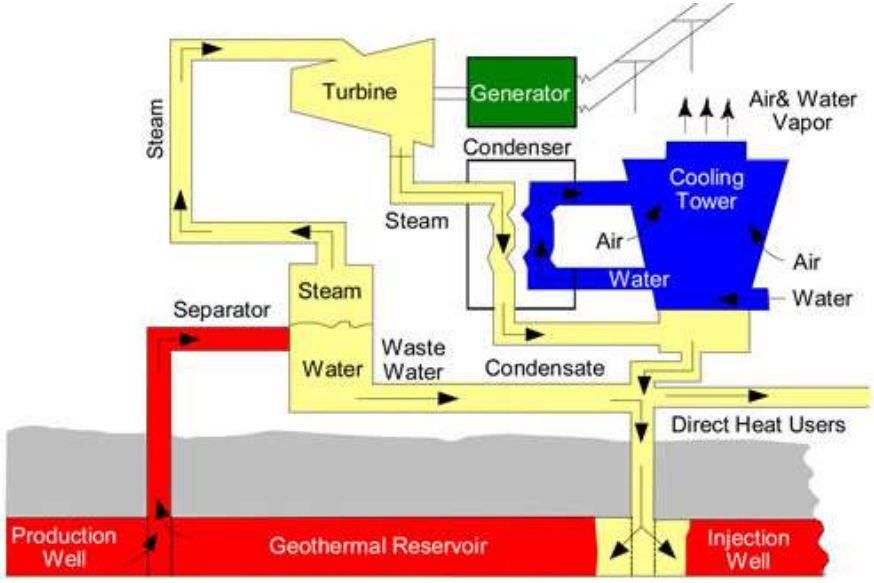


Colorado Geological Survey, 2020

First geothermal power plant in the world Landerello

Flash steam power plants

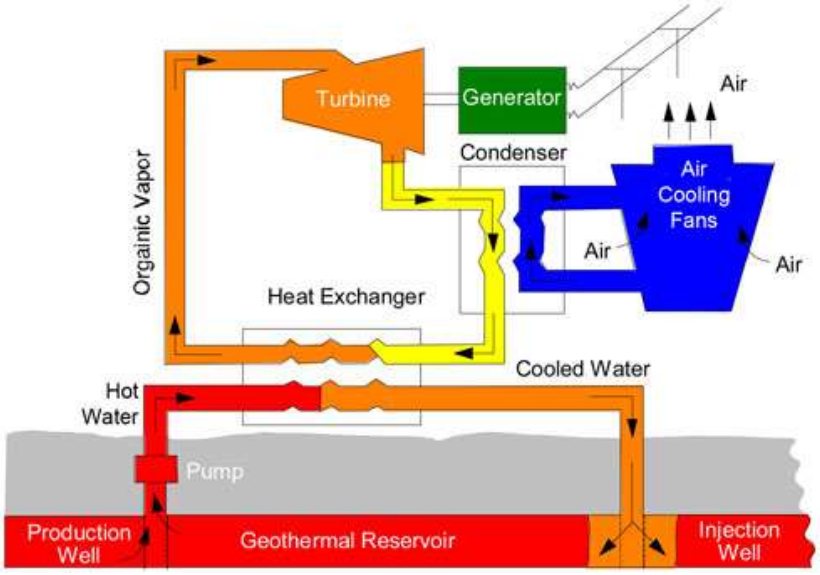
- warm water from the geothermal reservoir under great pressure and temperature higher than 182°C is used
- drawing water from the reservoir to the power plant on the surface reduces the pressure
- warm water becomes steam and overspeed a turbine
- water changed into steam is returning to the reservoir to be re-used
- most modern geothermal power plants use this principle of the work



Colorado Geological Survey, 2020

Binary cycle power plants

- water used in the binary principle is cooler than the water used in other methods of generating electricity from geothermal sources
- fluid is converted to steam at a temperature near boiling point and to spin turbine and generator
- the advantages:
  - the greater efficiency of the procedure
  - used water goes back into the reservoir and thus the loss of heat and water reduced to a minimum
- Most of the planned new geothermal power station will use this principle

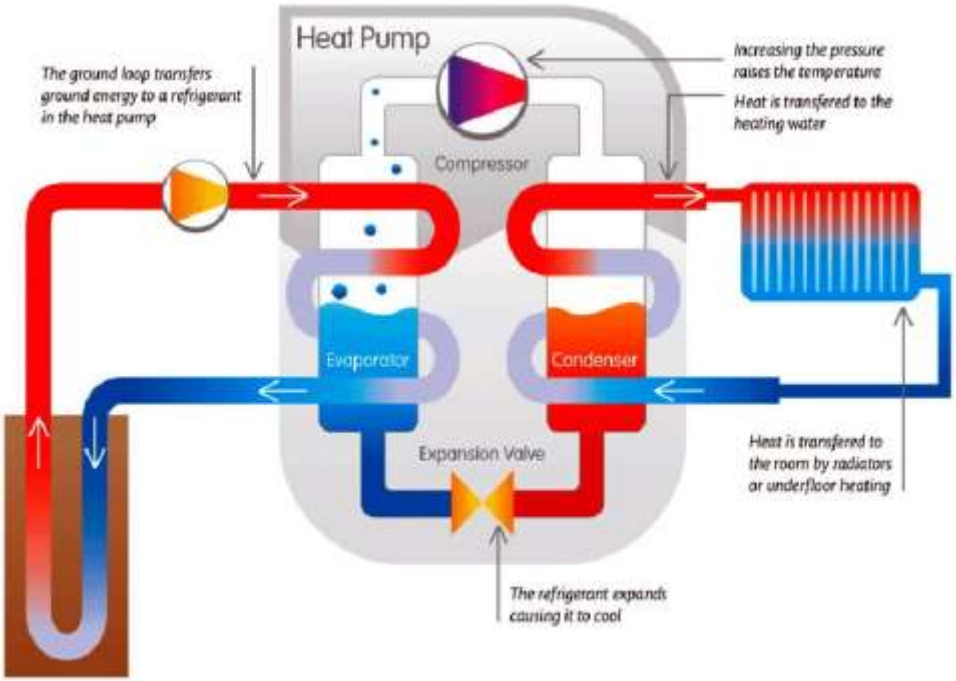


Colorado Geological Survey, 2020

Geothermal heat pumps

- another interesting way of using geothermal energy is heating
- the principle is based on the simple use of geothermal fluids that transmit water temperature in the exchanger and this is transported by pipelines to the radiators in the home or elsewhere

Heat pump

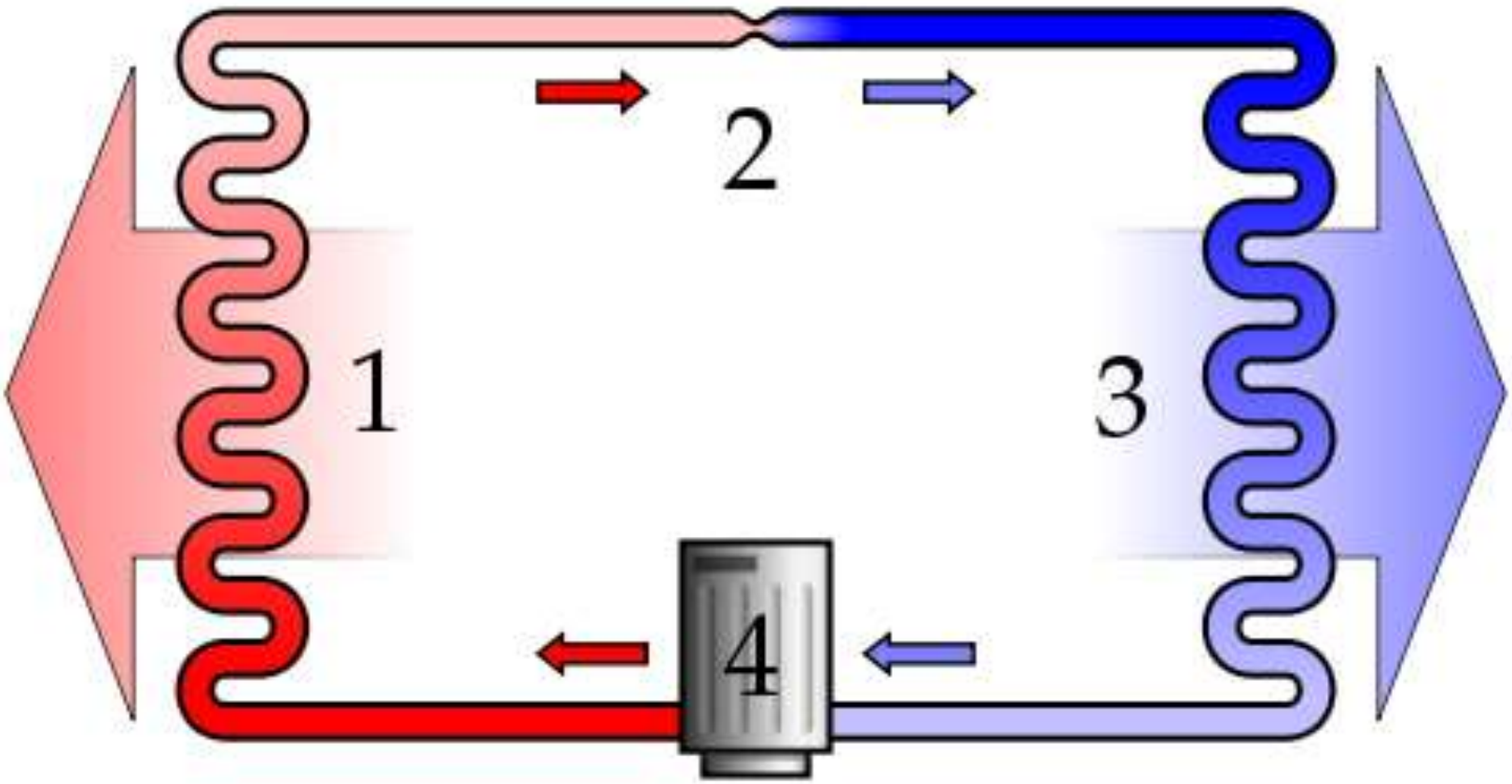


- a heat pump uses the heat energy contained in the ground, water or air
- a heat pump can thermally upgrade water, which has a temperature a few degrees above zero and so can in no way be used directly for heating the house, to a suitably higher temperature

4 phases of a heat pump

1. **Evaporation**: Refrigerant circulating in the heat pump extracts heat from air, water or earth, which changes state from liquid to gas and then evaporates.
2. **Compression**: The heat pump compressor compresses the gaseous refrigerant so that is rapidly heated by several degrees, through physical principle of compression (for higher pressure increases the temperature) to lift the small temperature increase heat to higher temperature levels, which hover around 80 ° C.
3. **Condensation**: Heated refrigerant is transmitted by a second heat exchanger in the water radiators, then cooled and condenses releasing heat to the water. Radiators deliver heat radiated into the room and the cooled water in the heating circuit goes back to the secondary exchanger for re-warming.
4. **Expansion**: The refrigerant travels through the expansion valve passage back to the first exchanger, where it is heated again.

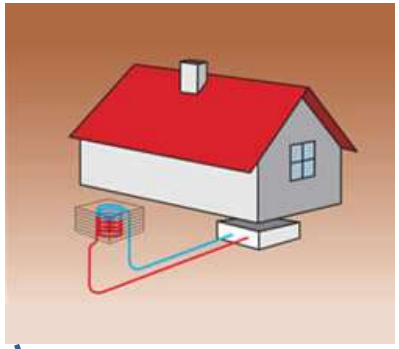
4 phases of a heat pump



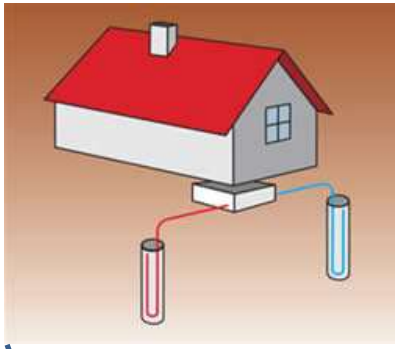
Types of heat pump

- According to the type of cooled and heated media there are classified these types of heat pumps:
  - air/water - universal type, central heating
  - air/air - additional source of heat, hot air heating, air conditioning
  - water/water - use of waste heat, geothermal, central heating
  - antifreeze/water - universal type of central heating, heat is often borehole or soil collector
  - water/air - hot air heating systems

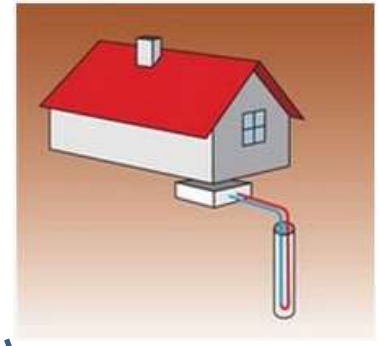
Types of heat pump



A heat pump air/water principle (Ekowatt, 2008)



A heat pump water/water principle (Ekowatt, 2008)



Land surface using for heat pumps (Ekowatt, 2008)

Deep earth using for heat pumps (Ekowatt, 2008)

Natural resources for heat pump

Natural source of heat	Temperature range [°C]
Outdoor air	-10 to -15
Waste air	15 to 25
Groundwater	4 to 10
Surface water (lake, river ...)	0 to 10
Geothermal water	15 to 90
Rocks	0 to 5
Earth, soil	0 to 10
Wastewater	more than 10

Purpose of using heat pump

- **Heating:**
  - heat pump is generally suitable for energy-saving heating systems (e.g. floor/wall heating)
  - recent developments offer heat pumps with higher performance, which are suitable for all types of family houses (not only low energy) and for all types of heating systems
  - efficiency and cost savings derived from the heat pump are larger as much as greater amount of energy we need to deliver to our house

Purpose of using heat pump

- **Water Heating:**
  - lot of heat pumps have built-in container of hot water
  - hot water heating is usually preferred before heating, i.e. firstly heat pump heats hot water and then release the heat to the heating system

Purpose of using heat pump

- **Cooling:**
  - very often is a cooling function integrated into the heat pump
  - in this case the heat pump can work "inside out" - extracts heat from the room and it cools through the working substance to transmit heat back into the wild

Before starting a head pump project…

…several important factors must be considered:

- **Intended use:**
  - a power heat pump type, function, need auxiliary heat source, and so on
- **Heating system:**
  - for heat pumps are the best low-temperature heating systems - e.g. underfloor heating
  - the output is a reduced need for useable heat energy from a heat pump, thus the system is working efficiently

Before starting a head pump project…

…several important factors must be considered:

- **Low potential heat source:**
  - except for yield, purity and temperature of the source is necessary to consider also its distance from the point of need
  - linked to this is the initial investment required - tubing, the quantity of trumpets, the depth of borehole, the cost of filter, water purification and so forth
- **Operating mode:**
  - **t**here are costs to operate the compressor and pump (usually electricity), identification performance factor
  - the smaller the difference between the refrigerant condensing temperature and evaporation, thereby increasing the efficiency of heat pump
  - guiding the winter months when the ambient temperature is the lowest and highest need for heat

Risks associated with the use of geothermal energy

- **ecological aspects:**
  - during the exploitation of geothermal energy, emissions with chemical odorous are released, especially ammonia and sulphur
  - during this transformation, big part of energy is lost
  - this is apparent from the principle of production

Pros & Cons

- a renewable energy source
- known and well-developed technology
- the price is comparable with electricity produced from another energy sources

Pros & Cons

- limited potential
- depends on the geology
- low energy efficiency, depends on the achievable temperature of the working substance
- high initial investment,
- high water consumption