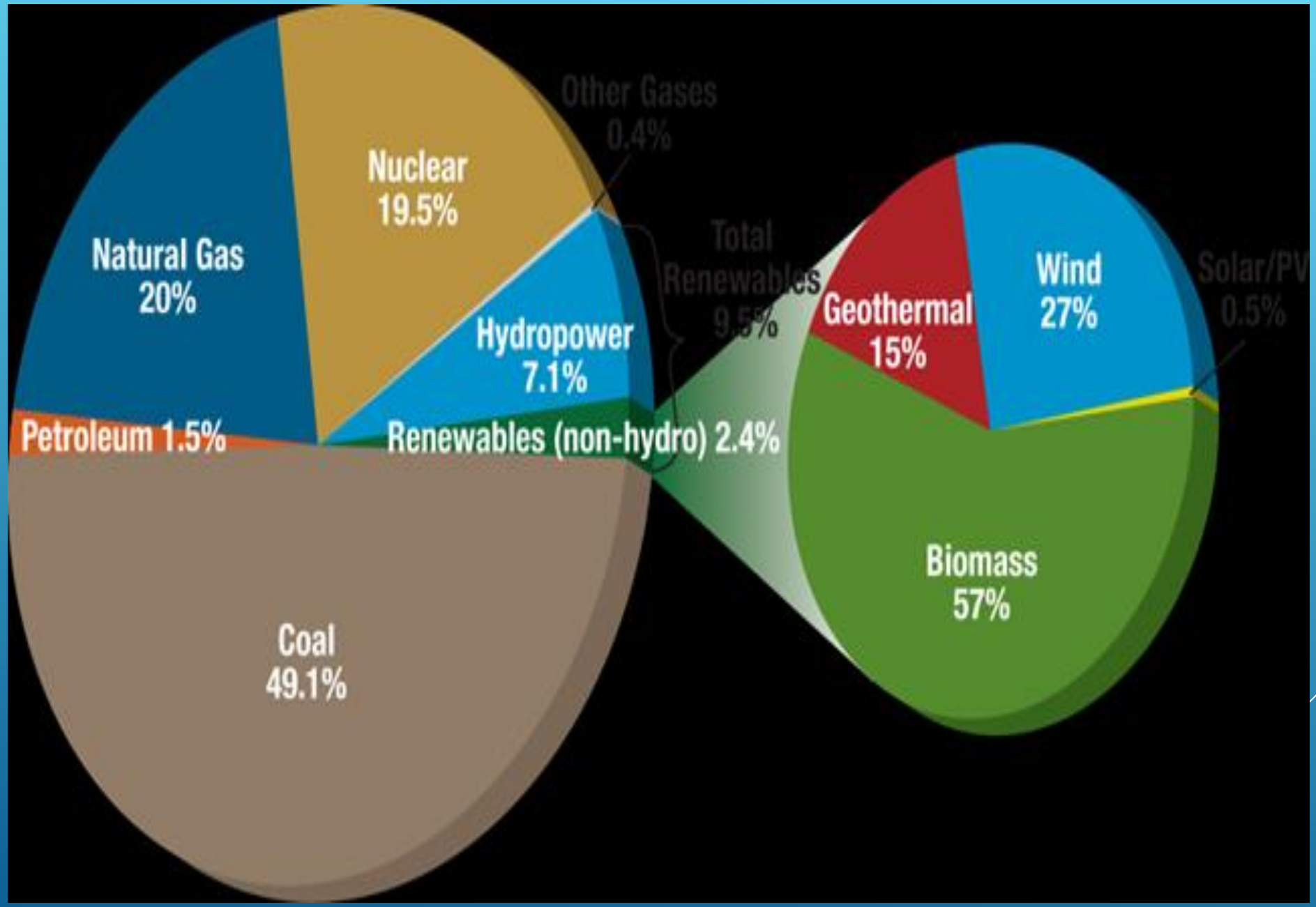
Geothermal Energy


Other Gases
0.4%
Nuclear
19.5%
Natural Gas
20%
Hydropower
7.1%
Total
Renewables
9.5%
Geothermal
15%
Wind
27%
Solar/PV
0.5%
Petroleum 1.5%
Renewables (non-hydro) 2.4%
Biomass
57%
Coal
49.1%

Geothermal Energy

- What is Geothermal Energy?
- Where can we find Geothermal Energy?
- How do we get the Geothermal Energy?
- How does Geothermal Energy work?
- Advantages and Disadvantages

INTRODUCTION

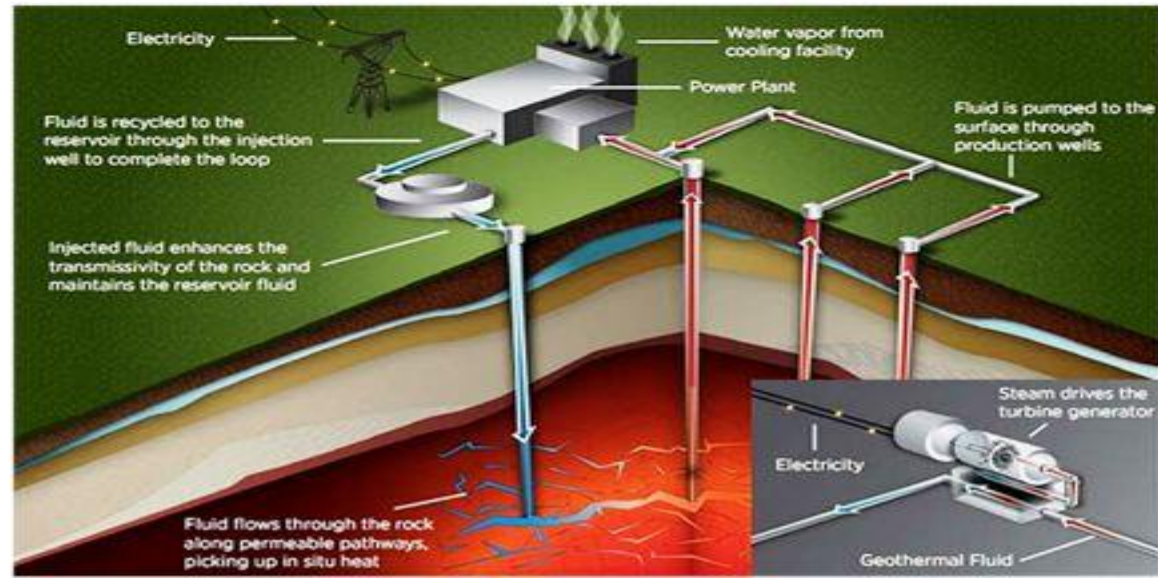
→The term Geothermal originates from two Geek words 'GEO' and 'THERM'. The Greek word ‘geo’ meant the earth whilst their word for ‘therm’ meant heat from the earth.

Geothermal energy is the energy obtained from the earth(geo) from the hot rocks present inside the earth.

It is produced due to the fission of radioactive materials in the earth’s core and some places inside the earth become very hot. These are called hot spots.

Geothermal Energy

- Geothermal energy is created by harnessing geothermal energy from the Geothermal literally means "earth heat." Geothermal energy harnesses the heat energy present underneath the Earth. Hot rocks under the ground heat water to produce steam. When holes are drilled in the region, the steam that shoots up is purified and is used to drive turbines, which power electric generators.



Geothermal Energy — A Renewable Resource

Geothermal energy is a renewable resource. This means that we will never run out of geothermal energy. Geothermal energy is renewable because the process of geothermal formation is going on right now and will continue until the earth ends. When people use geothermal water from the earth, they can return it and use it again later.

What is Geothermal energy?

It is the heat energy stored in the earth, generated by natural sources.

- From the decay of radioactive nuclei that are embedded within the Earth.
- From residual heat left over from Earths formation.
- The rest of the energy comes from meteorite impacts.

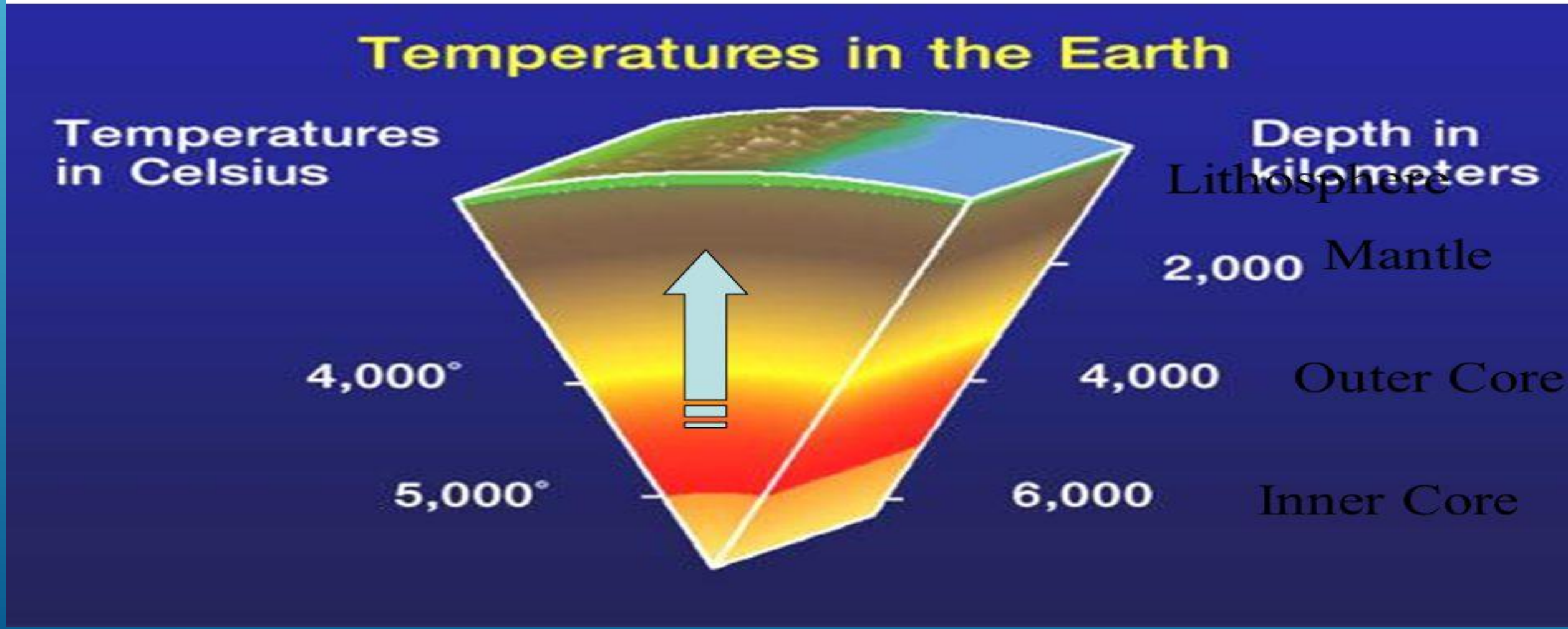
What is Geothermal Energy ?

Heat generated from the earth's core

The earth's interior

Geothermal Energy is energy stored in the form of heat beneath the surface of the solid earth. Geothermal gradient

Normally 20 to 30° C / km, 1300-1400° C at base of lithosphere, 3000-6000° C + in core



Geothermal Reservoirs

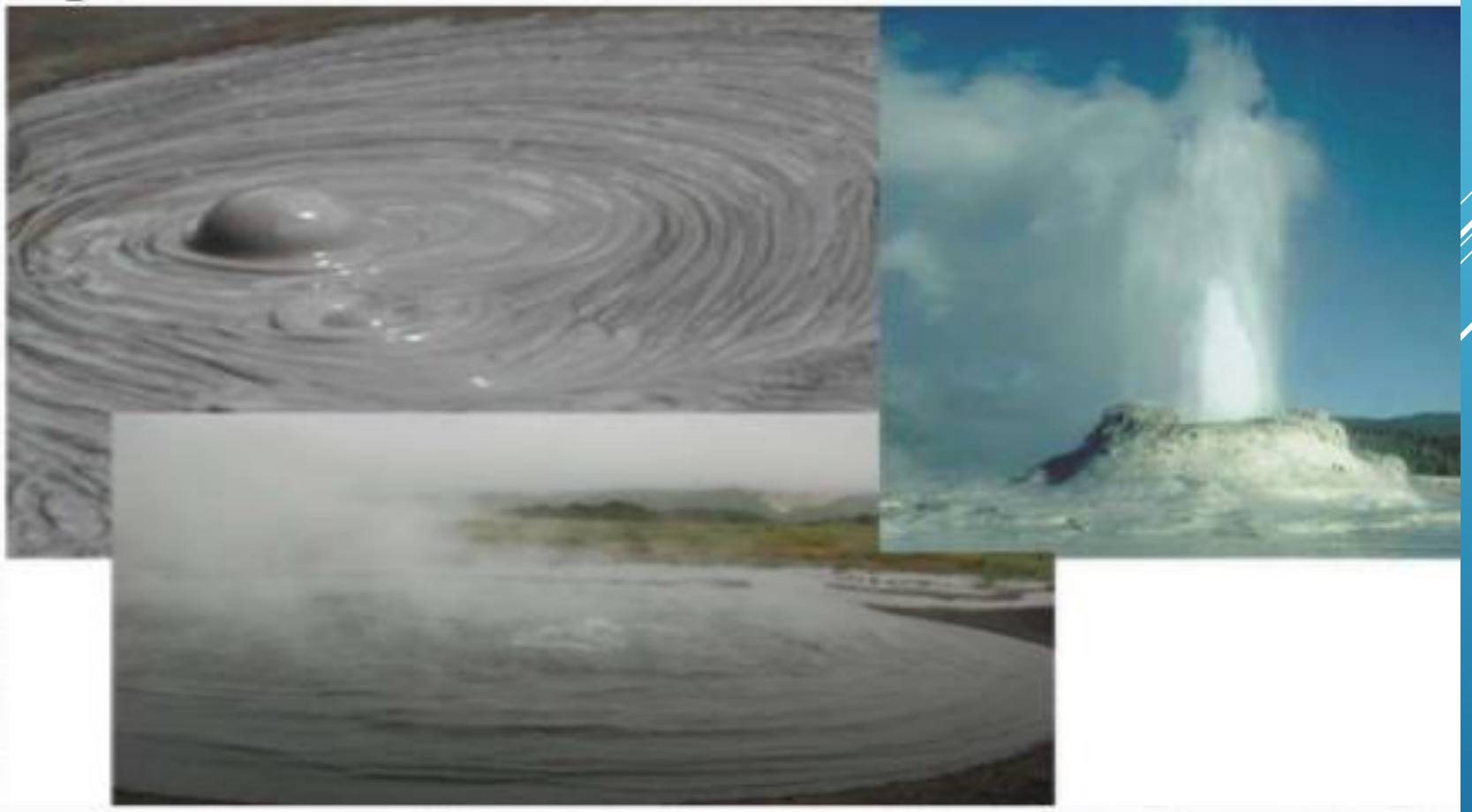
- Reservoirs can be suspected in the areas where we find :-

→Geyser

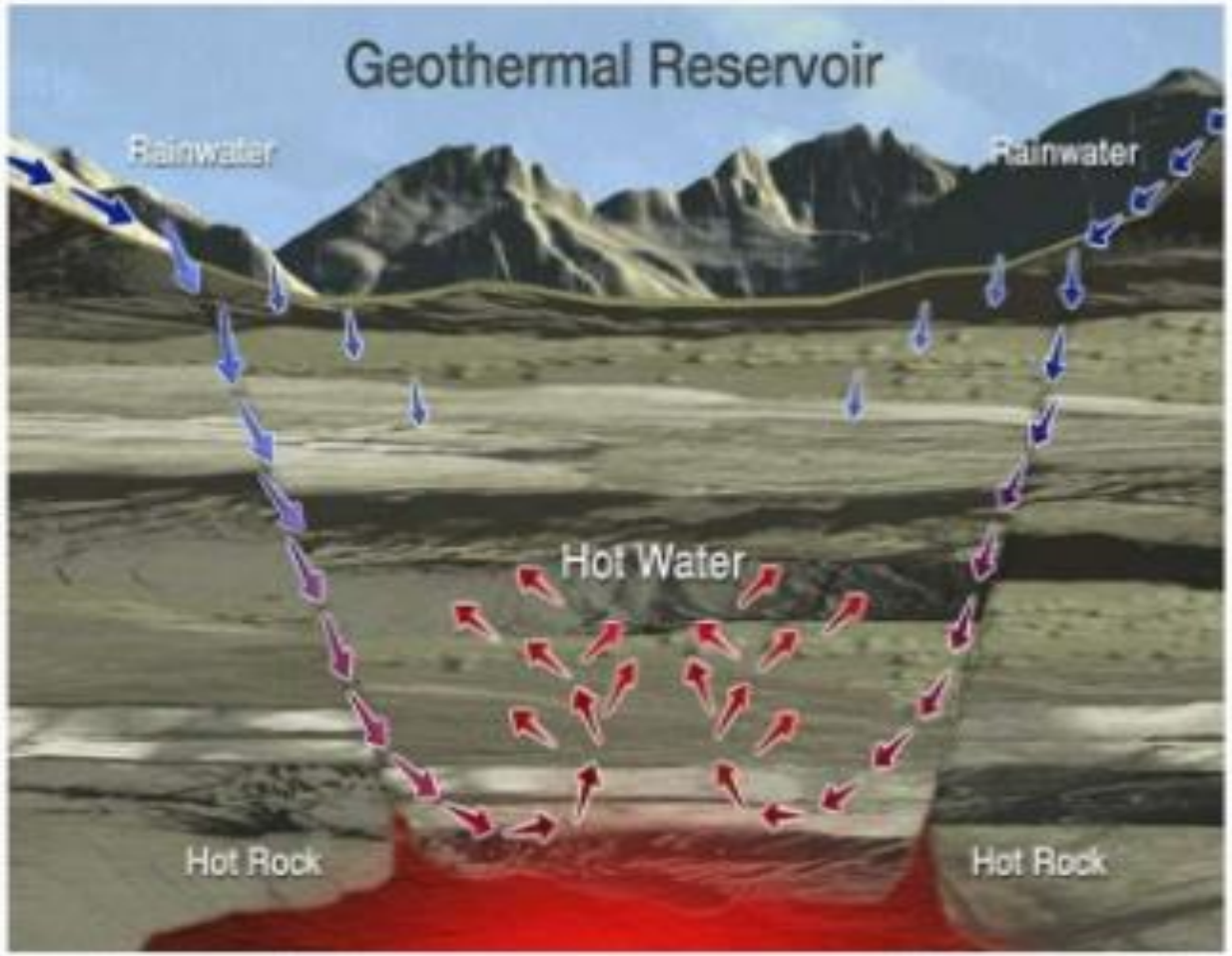
→Boiling mud pot

→Volcano

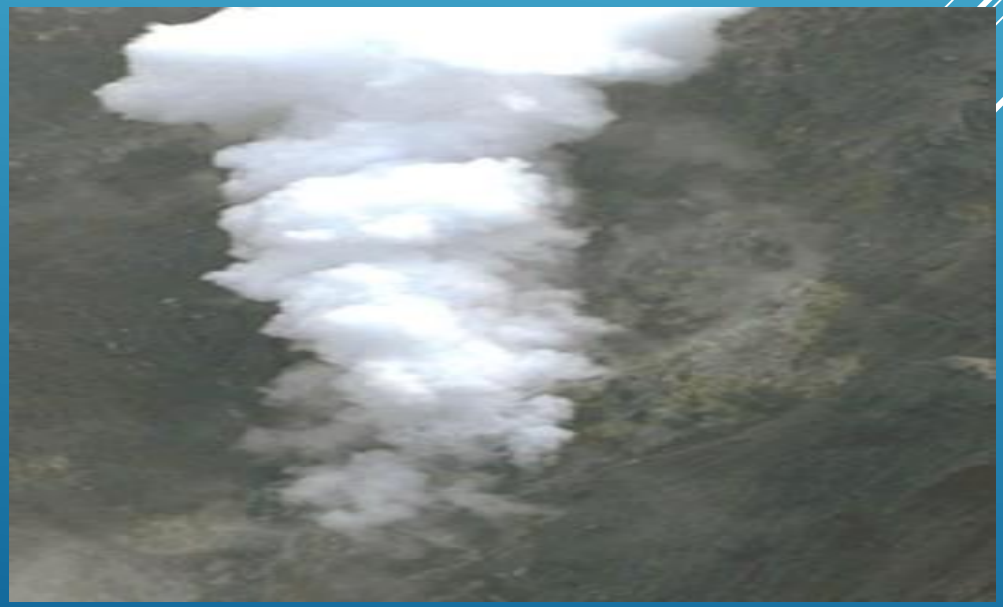
→Hot springs



Geothermal Reservoirs (cont.)



- The rising hot water & steam is trapped in permeable & porous rocks to form a geothermal reservoir.
- Reservoirs can be discovered by
  → testing the soil
  → analyzing underground temperature



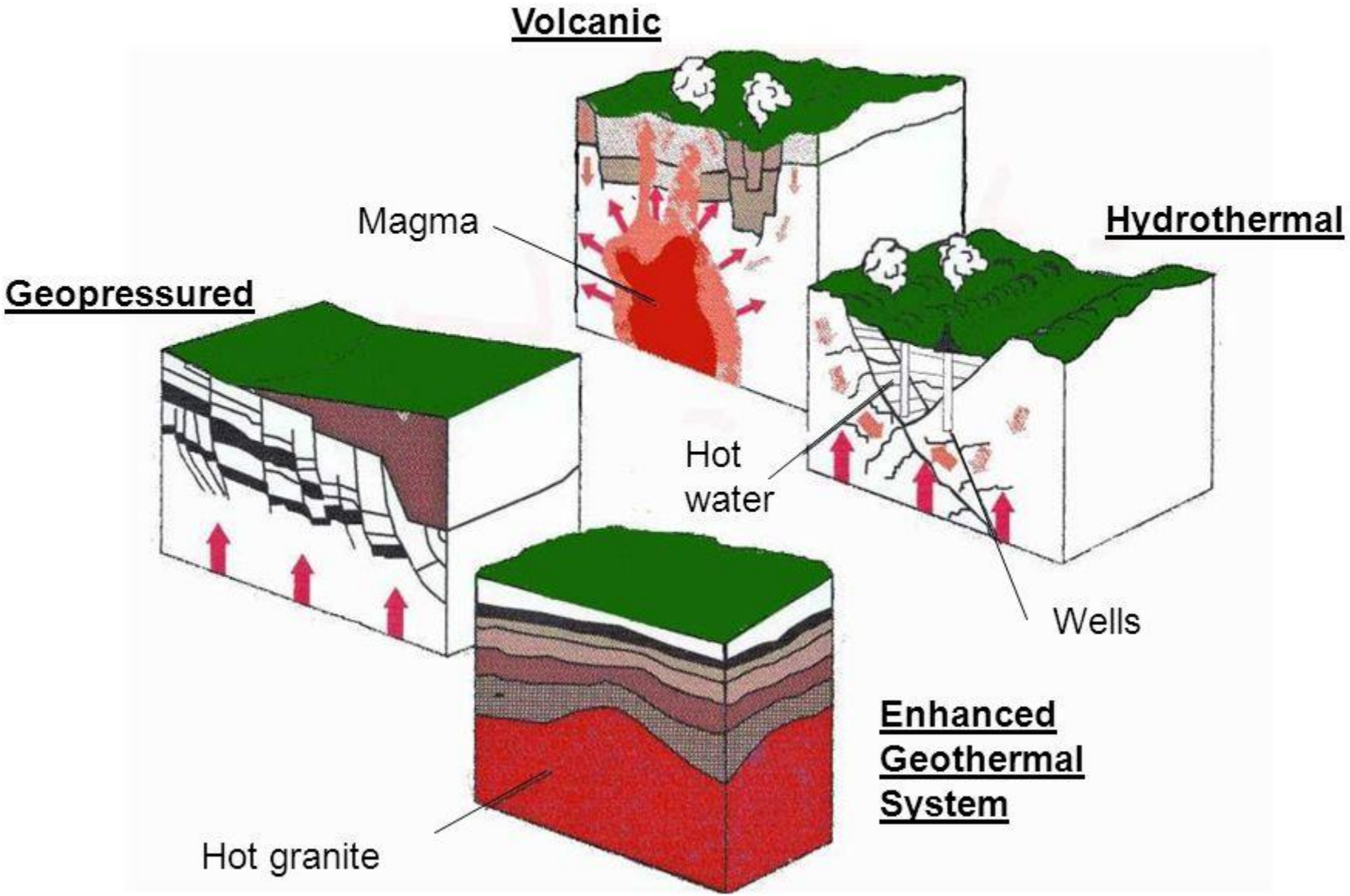
Different Geothermal Resources

Natural Steam reservoirs

Hot water Reservoirs

Geo –pressured Reservoirs

Geothermal Resources



Different Geothermal Energy Sources

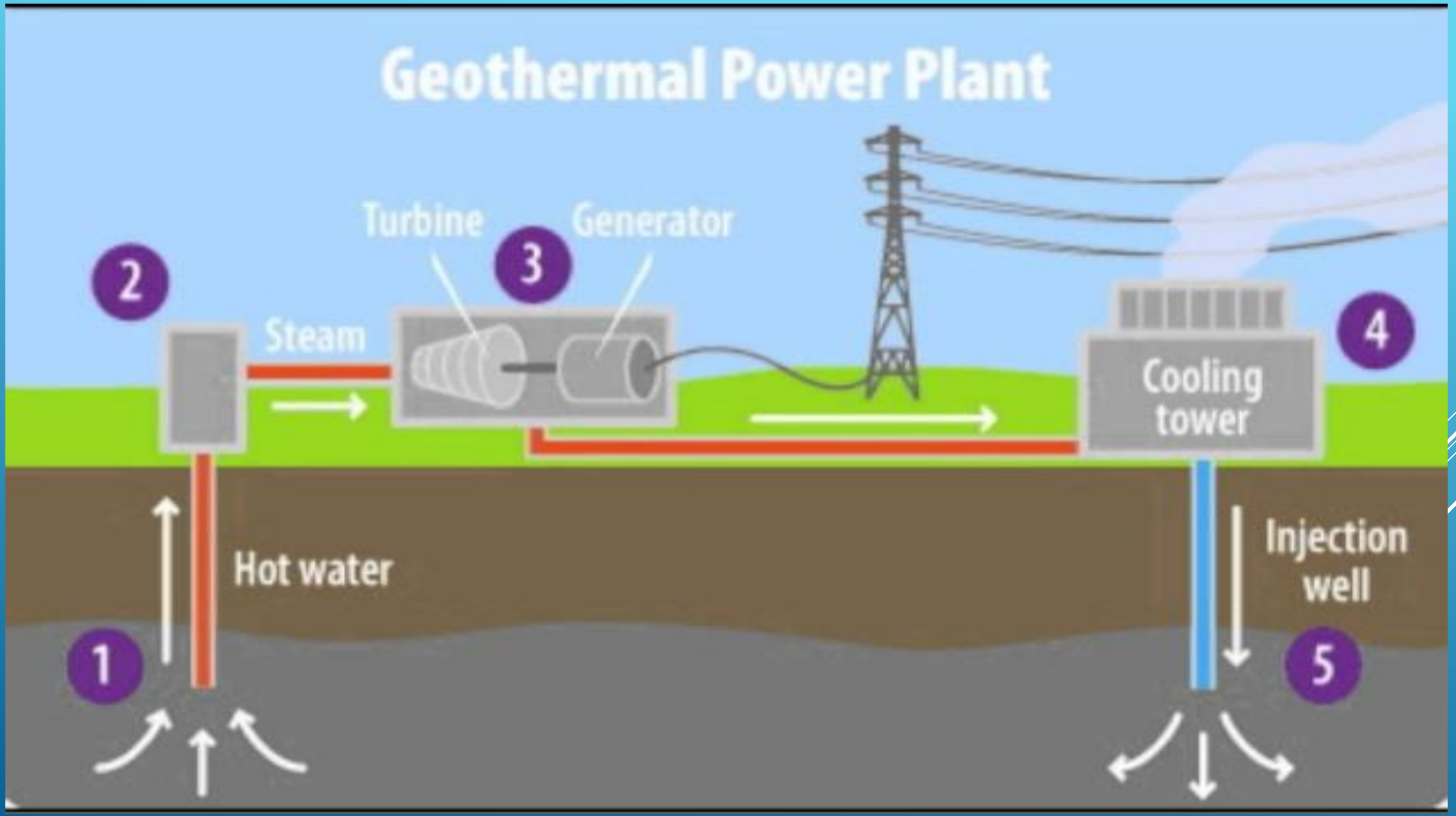
- **Hot Water Reservoirs**: As the name implies these are reservoirs of hot underground water. They are more suited for space heating than for electricity production.
- **Natural Stem Reservoirs**: In this case a hole dug into the ground can cause steam to come to the surface.
- **Geo pressured Reservoirs**: In this type of reserve, brine completely saturated with natural gas in stored under pressure from the weight of overlying rock. This type of resource can be used for both heat and for natural gas.

How does the system work

Direct Sources function by sending water down a well to be heated by the Earth's warmth.

Then a heat pump is used to take the heat from the underground water to the substance that heats the house.

Then after the water it is cooled is injected back into the Earth.

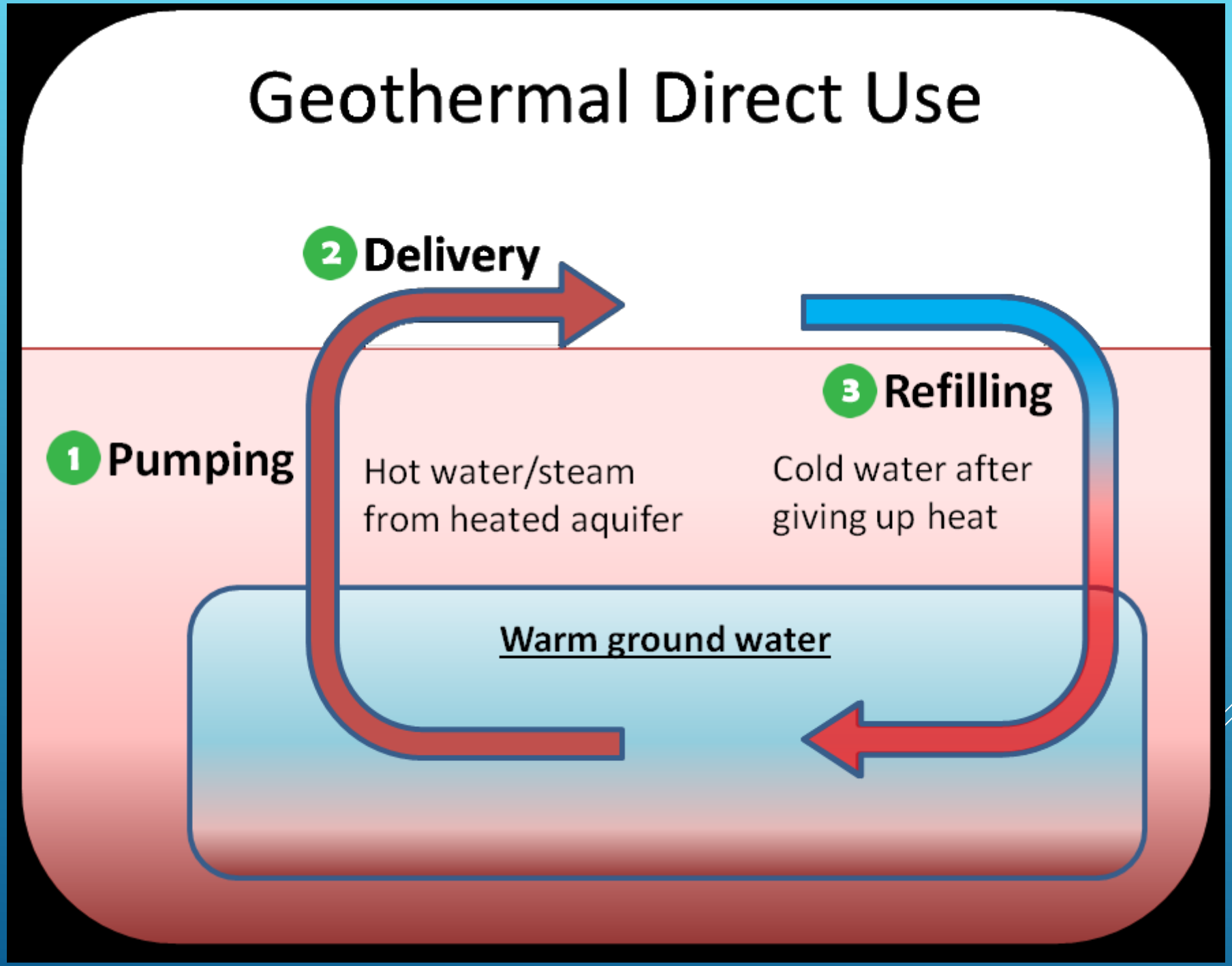

Geothermal Power Plant
Turbine
Generator
3
2
Steam
4
Cooling tower
Hot water
Injection well
1
5

Extraction & uses

- The heat energy can be brought to earth surface by following ways..
  - → directly from hot springs/ geysers
  - → geothermal heat pump

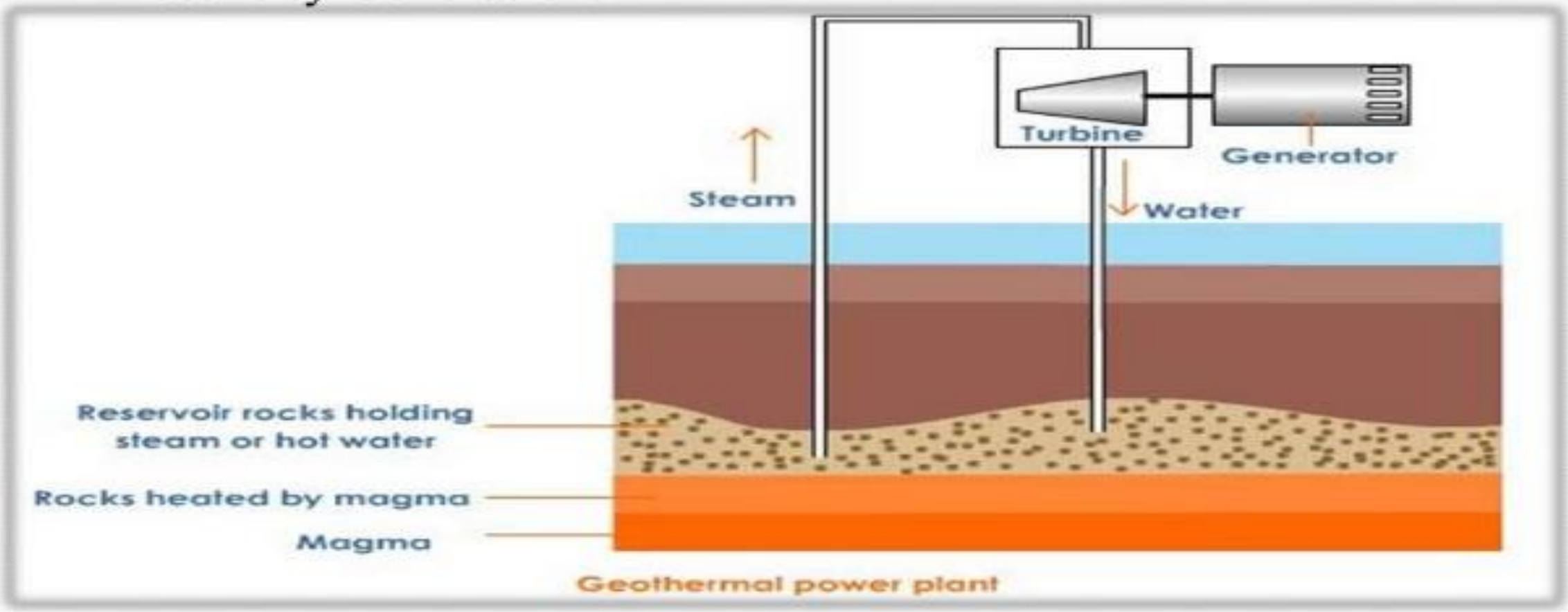
- Uses are broadly classified as:-
  - →direct use
  - →indirect use

Geothermal Direct Use



Indirect use of Geothermal Energy

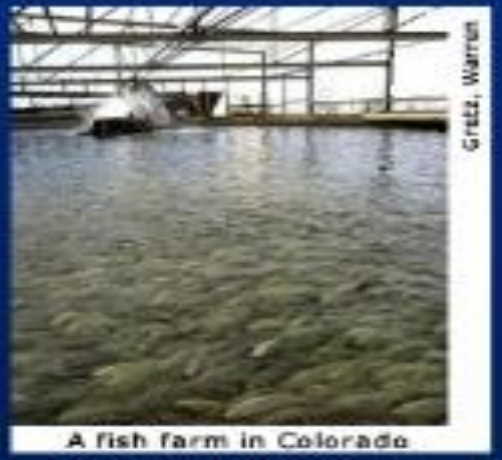
- Electricity Generation:



Direct uses of geothermal energy is appropriate for sources below 150°C

- space heating
- air conditioning
- industrial processes
- drying
- Greenhouses
- Aguaculture
- hot water
- resorts and pools
- melting snow

Crop dehydration plant in Nevada.



A fish farm in Colorado

Greenhouse in Colorado


Snow melting


Aquaculture


Winter
Summer
Space Heating/Cooling


Greenhouses

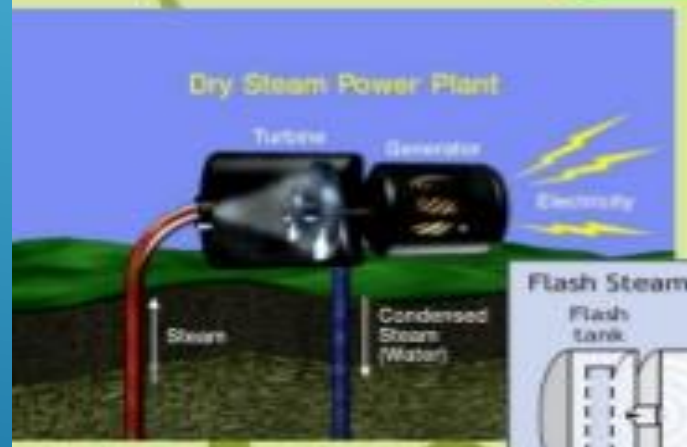
Generation of electricity

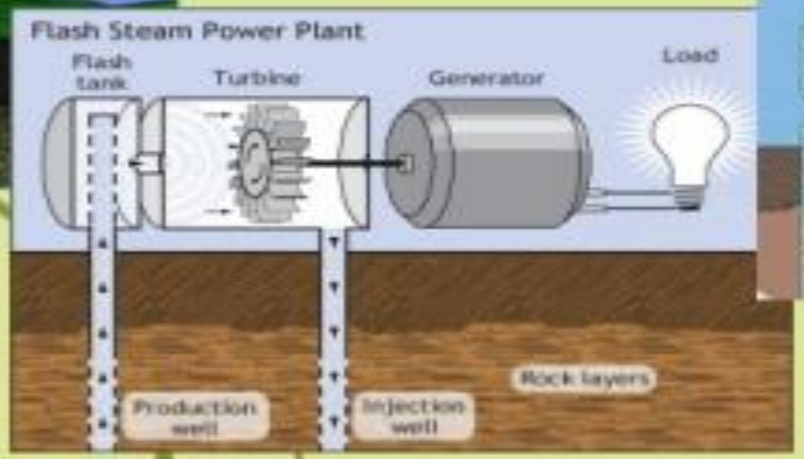
Dry Steam Plant

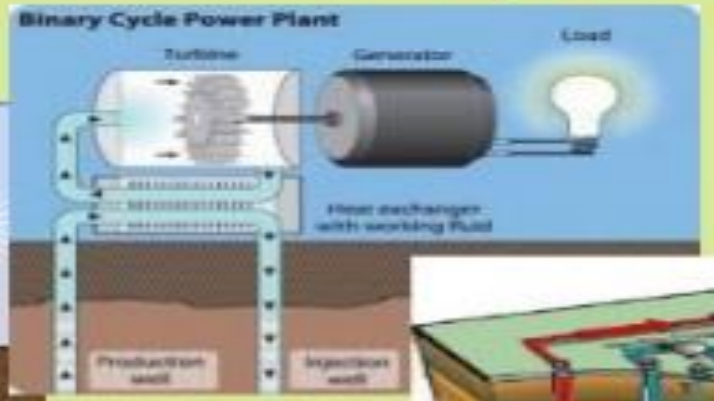
Flash Steam Plant

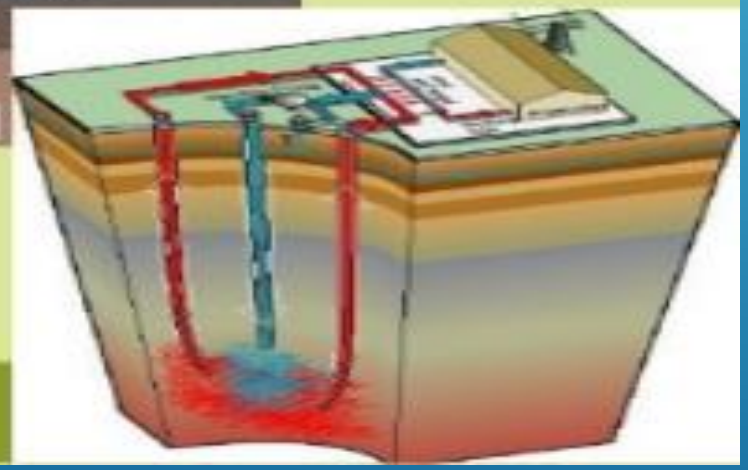
Binary Cycle Plant

Hot Dry Rock









Benefits of Geothermal Power

- Provides clean and safe energy using little land
- Is renewable and sustainable
- Generates continuous, reliable “baseload” power
- Conserves fossil fuels and contributes to diversity in energy sources
- Avoids importing and benefits local economies
- Offers modular, incremental development and village power to remote sites

Application

- Direct heating is by far more efficient than electricity generation.
- More than half is used for space heating, and another third for heated pools
- Heat may come from co-generation with a direct application and a geothermal electrical plant.
- Where natural hot springs are available, water can be directly placed into radiators.
- Where the ground is hot and dry, earth tubes can be used to collect heat.

Geothermal sources

- Five general categories of geothermal resources has been identified
- Hydrothermal convective systems
    - Vapor dominated or dry steam fields
    - Liquid-dominated system or wet steam fields
    - Hot-water fields
- Geopressure resources
- Hot dry rocks
- Magma resources
- Volcanoes

Geothermal systems

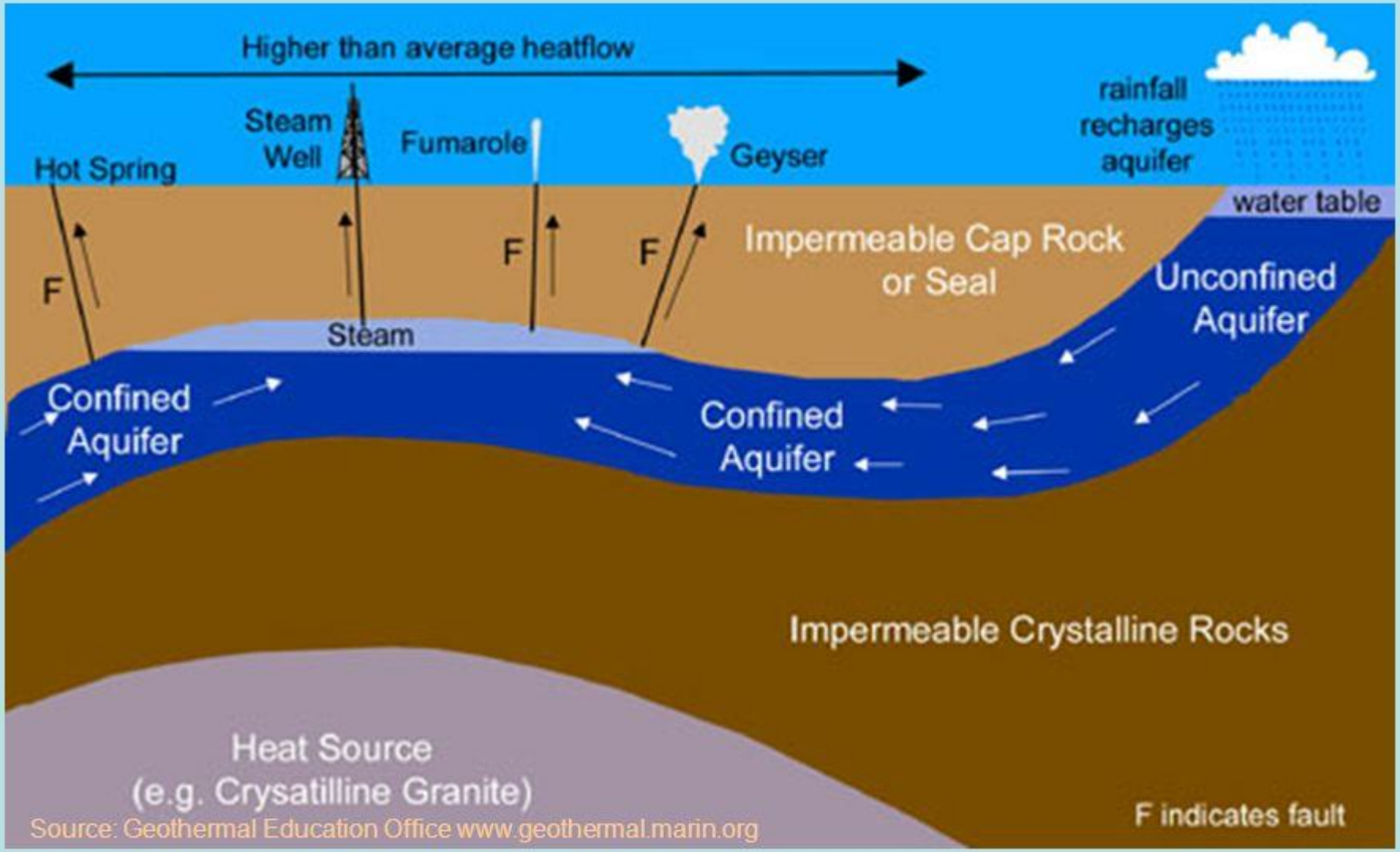
- In commercial use there are essentially five types of geothermal systems.
  - Dry steam power plants
  - Single flash power plants
  - Double flash power plants
  - Multiple flash power plants
  - Binary power plants

HYDROTHERMAL RESOURCES

- Hydrothermal resources have the common ingredients of water (hydro) and heat *(thermal)*. These geothermal reservoirs of steam or hot water occur naturally where magma comes close enough to the surface to heat ground water trapped in fractured or porous rocks, or where water circulates at great depth along faults. Hydrothermal resources are used for different energy purposes depending on their temperature and how deep they are.

Depth 100m-4500m
Temperature used for electricity
90 degree -350 degree

The Hydrothermal Resource Cycle

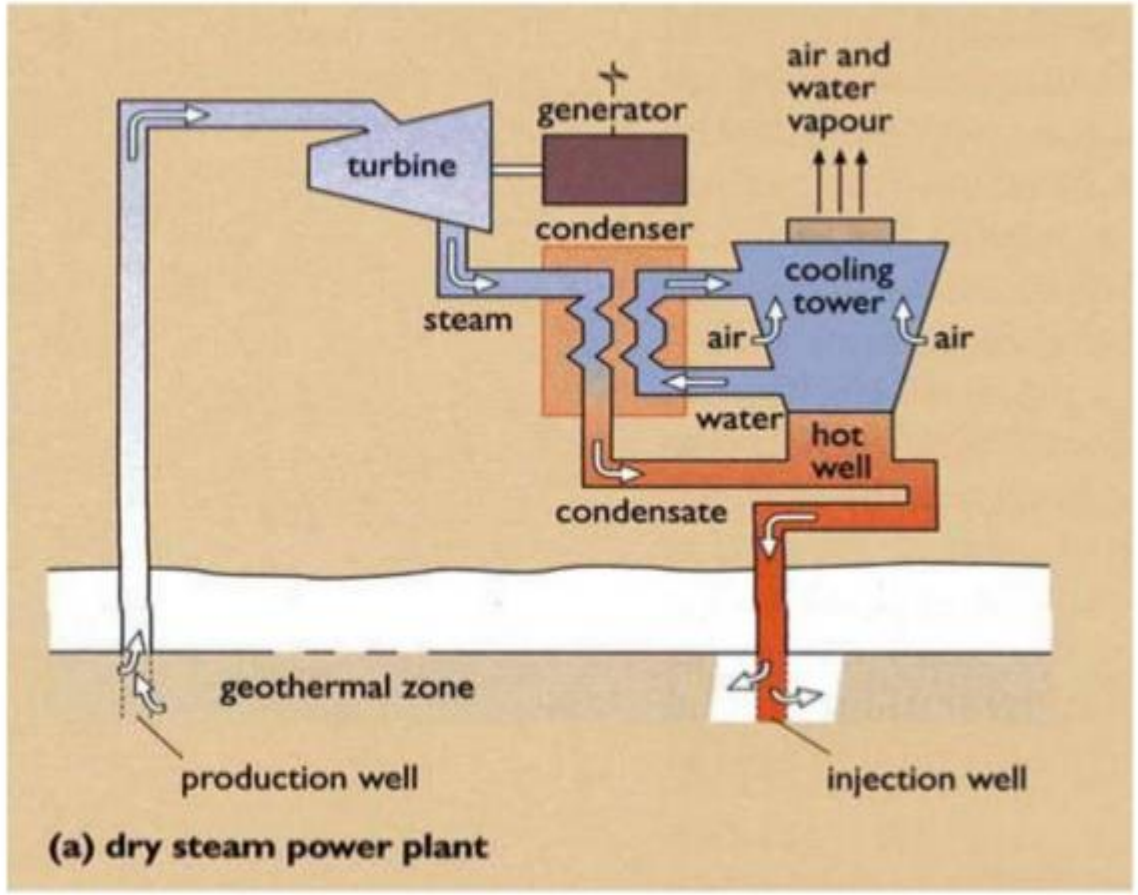


HEAT – PRESSURE - WATER

VAPOUR DOMINATED SYSTEM

- dry steam field occur when pressure is not much above the atmospheric pressure and temperature is high
- Water boils underground and generate steam at temperature of about 165 degree c and a pressure of about 7 atm
- steam is extracted from the well,cleaned in a centrifugal separator to remove solid matter and then piped directly to a turbine
- The exhaust steam of the turbine is condensed in a direct contact condenser, in which the steam is condensed by direct contact with cooling water
- the resulting warm water is circulated and cooled in a cooling tower and returned to the condenser.
- The condensation of steam continuously increases the volume of cooling water.
- the excess water is re injected at some distance deep in to the ground for disposal
- the non condensable gases are removed from the condenser by steam jet ejection

Dry steam power plants



- Dry steam power plants extract heat at 200°C and 4-8MPa
- Water is injected to the geothermal zone and the heat transported from the hot rocks by convection of water in porous medium.
- Steam drives the turbine,which coupled with the generator produces electricity.
- The steam is condensed and pumped back into the geothermal zone.

LIQUID-DOMINATED (WET STEAM) SYSTEM

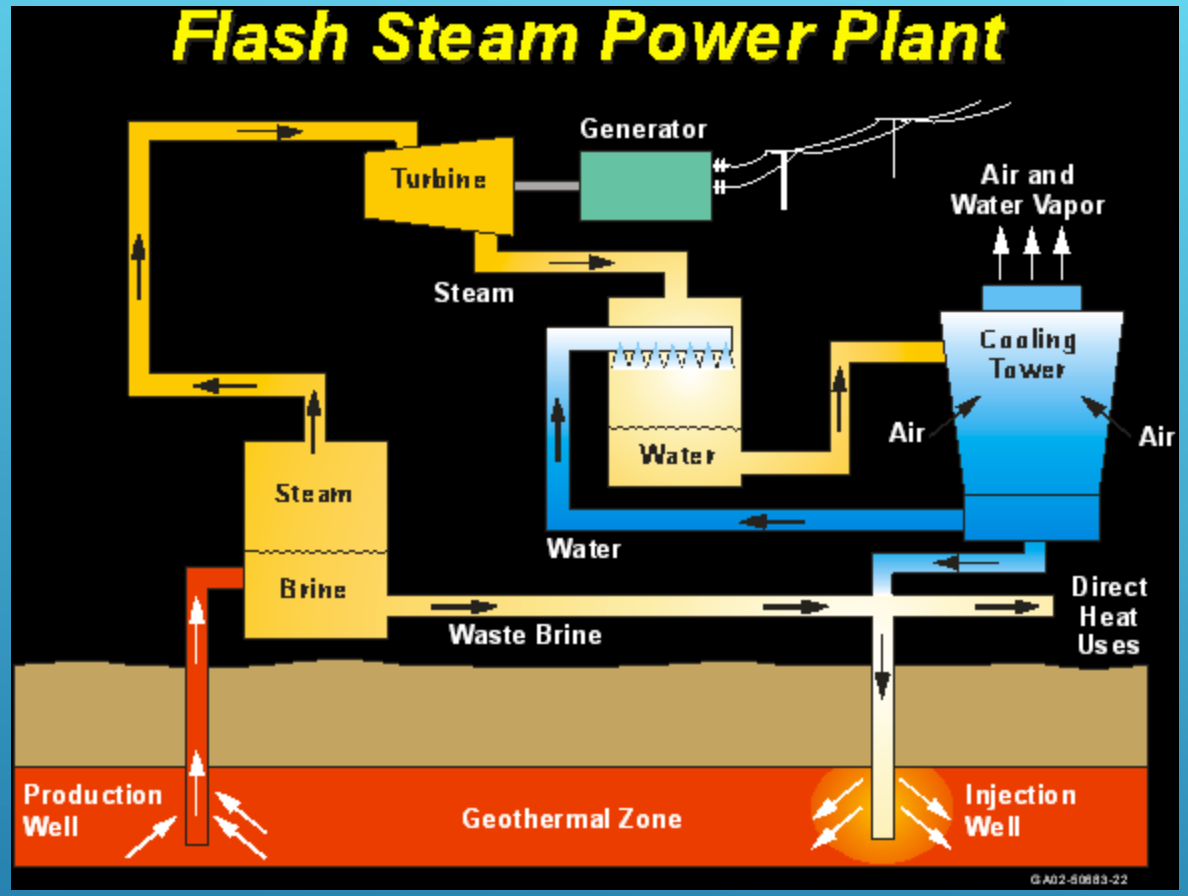
Steam plants offer the most cost-effective technology when the resource temperature is above about 175 degree C. Therefore, liquid-dominated or wet steam fields are further subdivided into

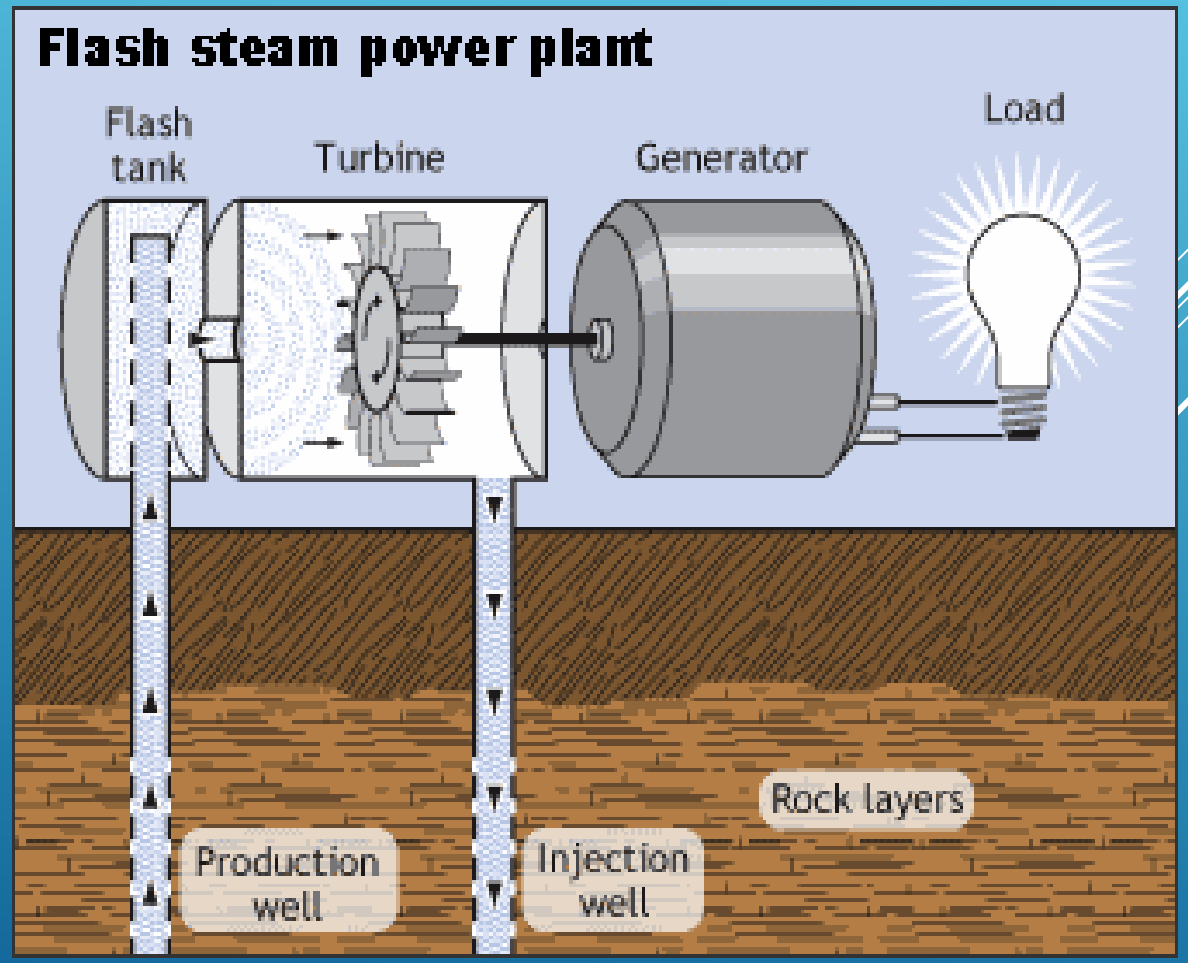
(a) high temperature ,(above 175 degree Celsius) fields, where steam plants can be used

b) Low temperature, where other technology are used

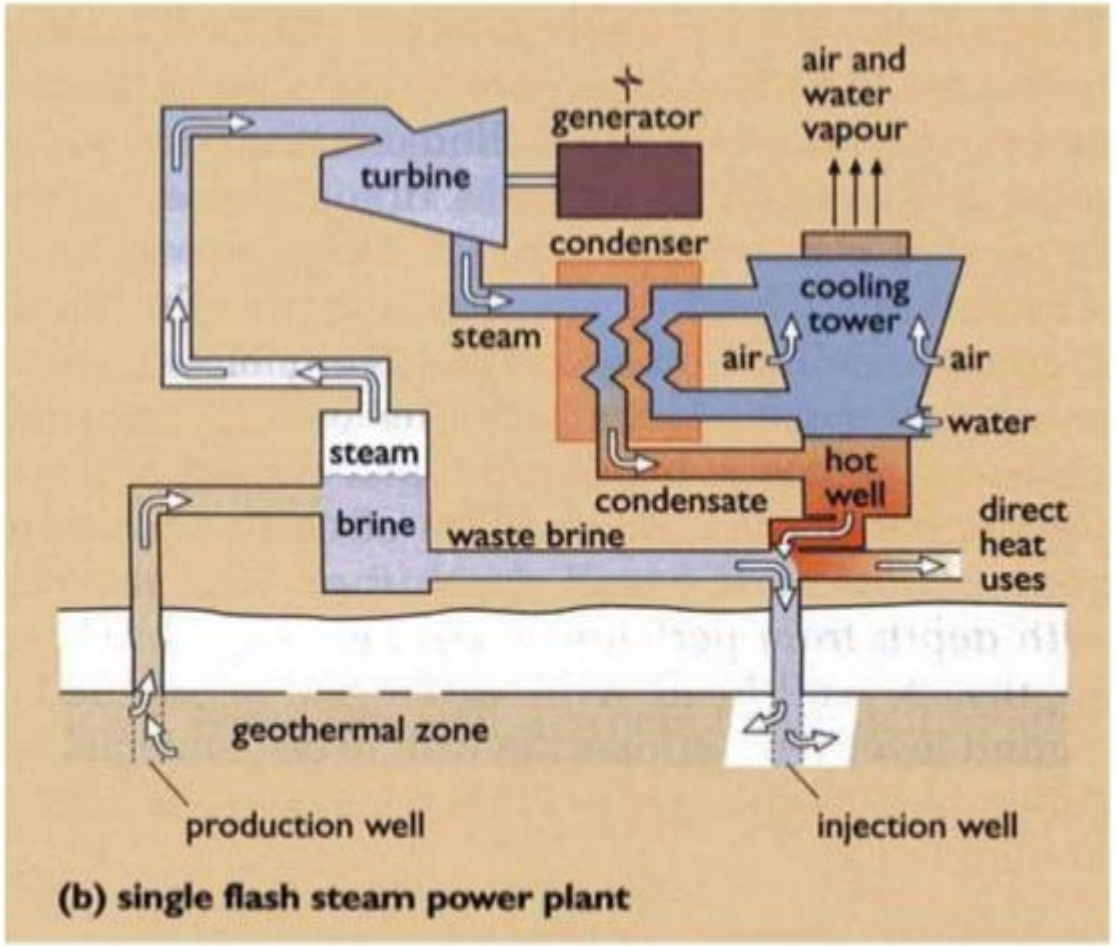
LIQUID DOMINATED HIGH TEMPERATURE SYSTEM

- In a high-temperature liquid-dominated reservoir, the water temperature is above175 degree C However it is under high pressure and remains in liquid state.
- The most developed such system is found in New Zealand, where the reservoir temperature and pressures are 230 degree c and 40 atm respectively, and depths are 600m to 1400m.
- When water is brought to the surface and pressure is reduced, rapid boiling occurs and it 'flashes' into steam and hot water‘
- The steam is separated- and used to generate electrical power in the usual manner
- The remaining highly saline hot water (known as brine) can be used for direct heat and then reinjected into the ground.
- In dual flash systems, the steam is flashed a second time from the remaining hot fluid of the first stage, separated and fed into the duel inlet turbine or into two separate turbines.
- The efficiency of such a plant is around 8%.
- The single-and dual-flashed systems are shown in Fig.
- These types of plants are being used at Salton Sea in California Dixie Valley in


Flash Steam Power Plant
Generator
Turbine
Air and
Water Vapor
Steam
Cooling
Tower
Air
Air
Water
Steam
Water
Brine
Direct
Heat
Uses
Waste Brine
Production
Well
Geothermal Zone
Injection
Well
GA02-60883-22


Flash steam power plant
Flash
tank
Turbine
Generator
Load
Rock layers
Production
well
Injection
well

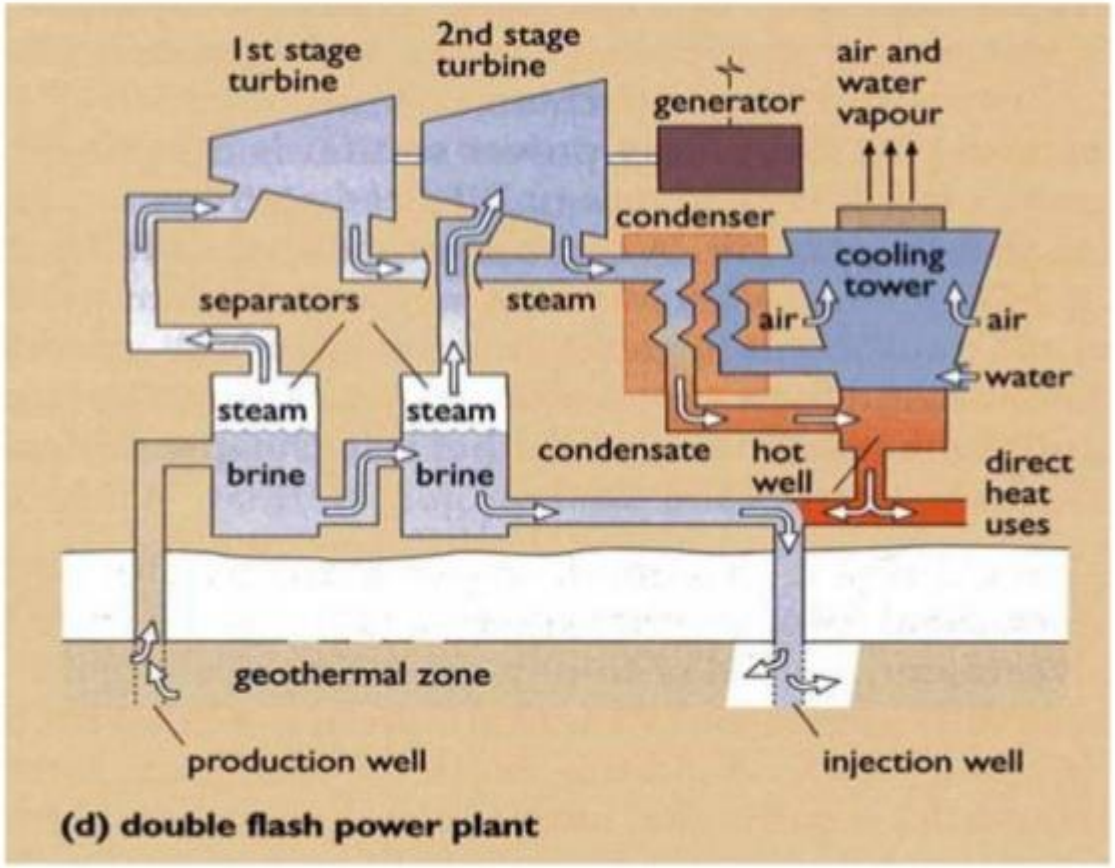
Single flash power plant



(b) single flash steam power plant

- The water in the reservoir is at 230°C and 4MPa
- The liquid originates mainly from depth of 600m to 1400m and is flashed into mixture of steam and brine at the surface.
- After passing through a cyclone separator to remove the water the steam is supplied to the turbine,which coupled with the generator to produce electricity
- The brine withdrawn from cyclone separator after flashing is injected to the well

Double flash power plant



- Double flash power plant is similar to that of single flash power plant.
- The brine from the I stage cyclone separtor is admitted to a II second stage low pressure cylone separator
- The steamfrom the II stage cyclone separtor is supplied to a low pressure turbine
- The remaining spent brine is reinjected to the ground.

LIQUID DOMINATED LOW TEMPERATURE SYSTEM

- These resources are available at moderate temperature ranges of 90 oC – 175 oC.
- This temperature is not enough for efficient flash steam production.
- A binary-fluid system is employed, where the heat of geothermal fluid is used to vaporize a volatile organic fluid, such as isobutene , under pressure in a primary heat exchanger.
- The geothermal fluid is re injected after extraction of heat. This vaporized fluid serves as a working fluid for the turbine.
- The exhaust vapor from the turbine is cooled in the regenerative heat exchanger and then condensed in a condenser.
- This condensed liquid isobutene is returned to the primary heat exchanger by way of the

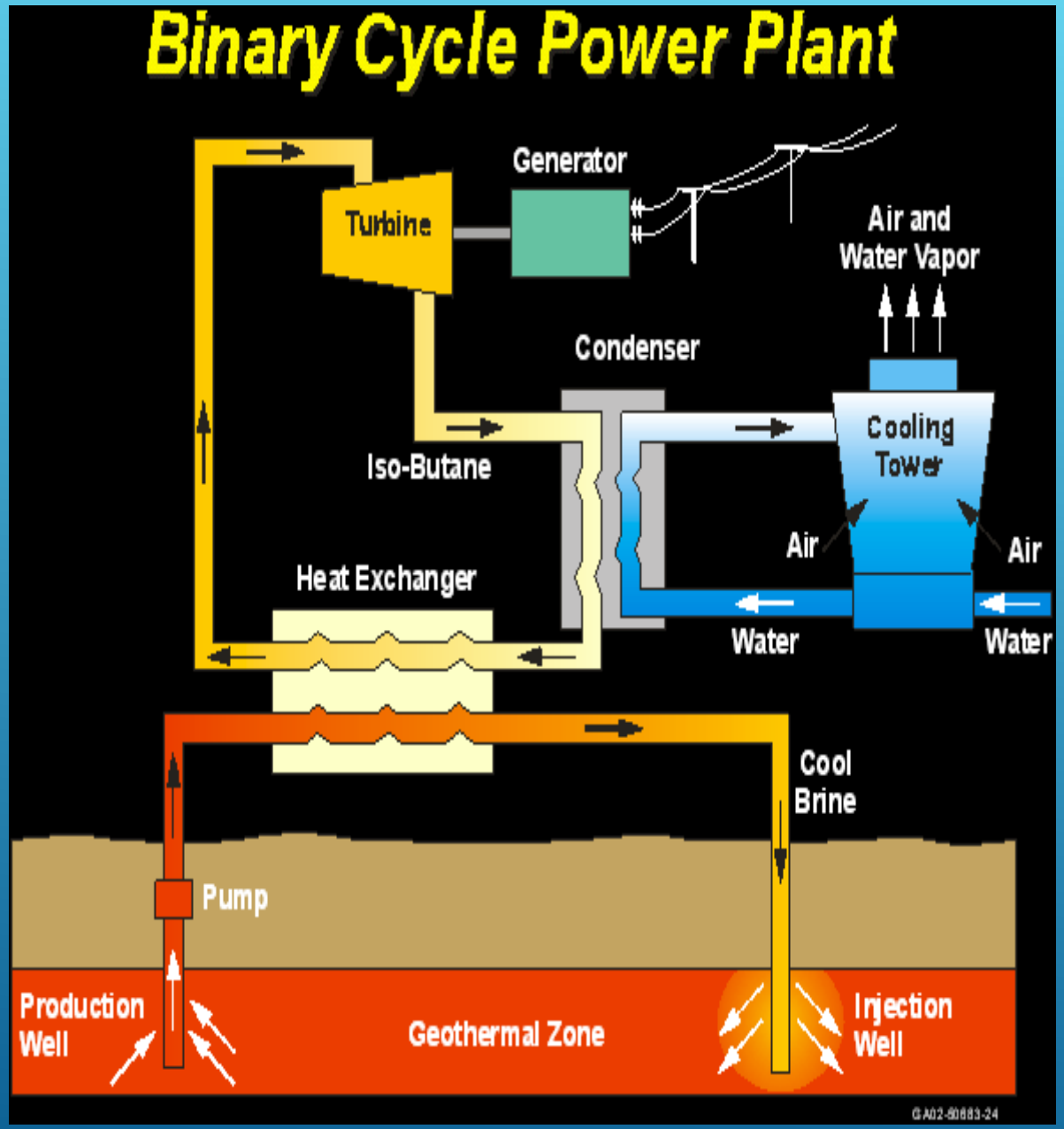
regenerative heat exchanger. This system is shown in Fig.

- These plants not produce any steam condensate and have to rely on an external source for cooling water or air-cooling.

Presently,some200MW,binarypower plant sarJin-oper-aEain world wide.

The main advantages of binary systems are

(i) they almost avoid corrosion, scaling and environmental problems as the geothermal fluid circulates through a closed-cycle and all the fluid is re injected



- In reservoirs where temperatures are typically less than 220°C (430°F). but greater than 100°C (212°F). binary cycle plants are often utilised.
- The reservoir fluid (either steam or water or both) is passed through a heat exchanger.
- It heats a secondary working fluid which has a boiling point lower than 100°C (212°F). This is typically an organic fluid such as Isopentane, which is vaporised and is used to drive the turbine.
- The fluid in a binary plant is recycled back to the heat exchanger and forms a closed loop.
- The cooled reservoir fluid is again re-injected back into the reservoir

Hot Water System

- Hydrothermal reservoirs of low to moderate temperatures (20'C-l50’C) can be used to

provide direct heat for residential and industrial uses.

- The hot water is brought to the surface where a heat-exchanger system transfers its heat to another fluid (liquid or air); although the resource can be used directly if the salt and solid content is low.
- The geothermal fluid is re injected into the ground after the extraction of heat.
- The heated fluid transports heat to the place of use.

Geopressured systems

- Occur in large, deep sedimentary basins
- Reservoirs contain moderately high temperature water(or brine) under very high pressure
- They are of special interest because substantial amounts of methane(natural gas) are dissolved in the pressurized water and are released when the pressure is reduced
- Geopressured water is tapped in much deeper underground acquifers at depths between about 2400 to 9000m

This water is thought to be at the relatively low temperature of about 160ºC and is under very high pressure of about 1050 kg/cm2 (>1000 bar)

¨ It has a relatively high salinity of 4 to 10 percent and is often referred to as brine

¨ Geopressured systems are quite large: they could be used for the generation of electric power and the recovery of natural gas if suitable technology could be developed

GEOPRESSURED RESOURCE

HOT WATER UNDER HIGH PRESSURE IS RELEASED DURING DRILLING FOR OIL AND NATURAL GAS.

3 TYPES OF ENERGY

- MECHANICAL ENERGY DUE TO HIGH PRESSURE
- THERMAL ENERGY DUE TO HIGH TEMPERATURE
- CHEMICAL ENERGY DUE TO BURNING OF DISSOLVED METHANE GAS

HOT DRY ROCKS OR PETROTHERMAL

These are very hot solid rocks occurring at moderate depths but to which water does not have access

¨ Either because of the absence of ground water or the low permeability of the rock or both

¨ Break-up impermeable rock at depth, introduce cold water, and recover the resulting hot water(or steam)for use at the surface

¨ The known temperature of HDR vary between 150 to2900C

¨ Accounts for large percent of the geothermal resouce

A way be found to render the impermeable rock into a permeable structure with a large heat-transfer surface

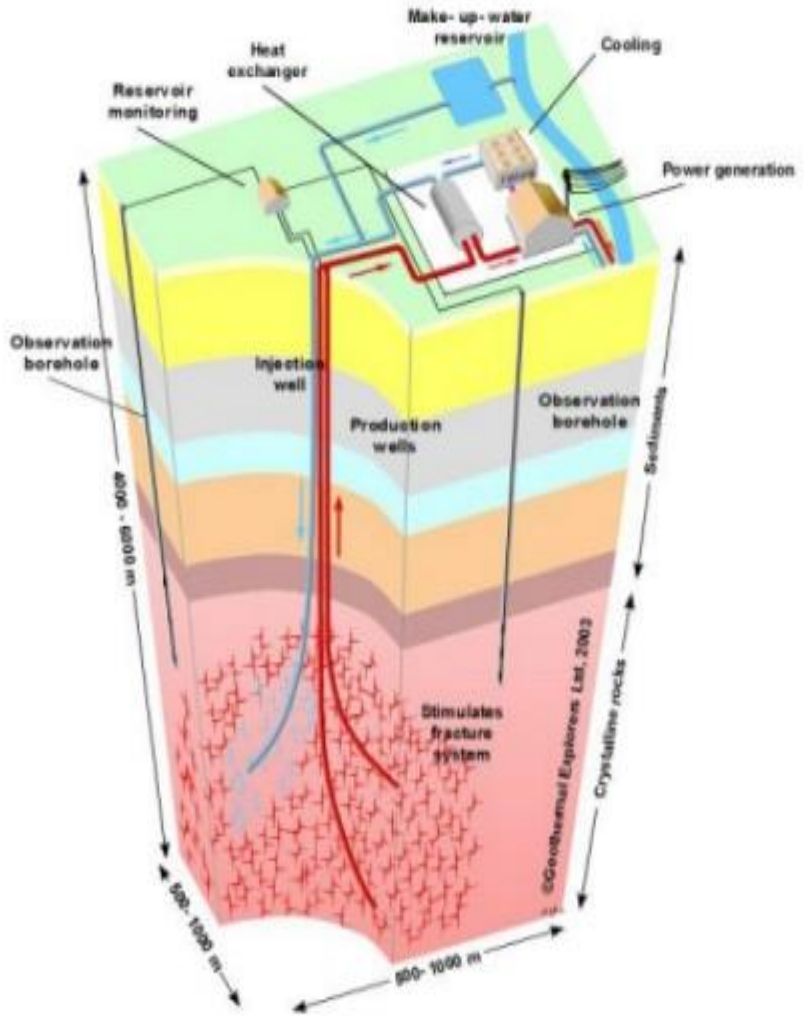
¨ A large surface is necessary-low thermal conductivity of the rock

¨ Rendering the rock permeable is to be done by fracturing it

¨ Fracturing methods involve drilling wells into the rock and then fracturing it by

¨ i) high pressure water or
¨ ii) Nuclear explosives

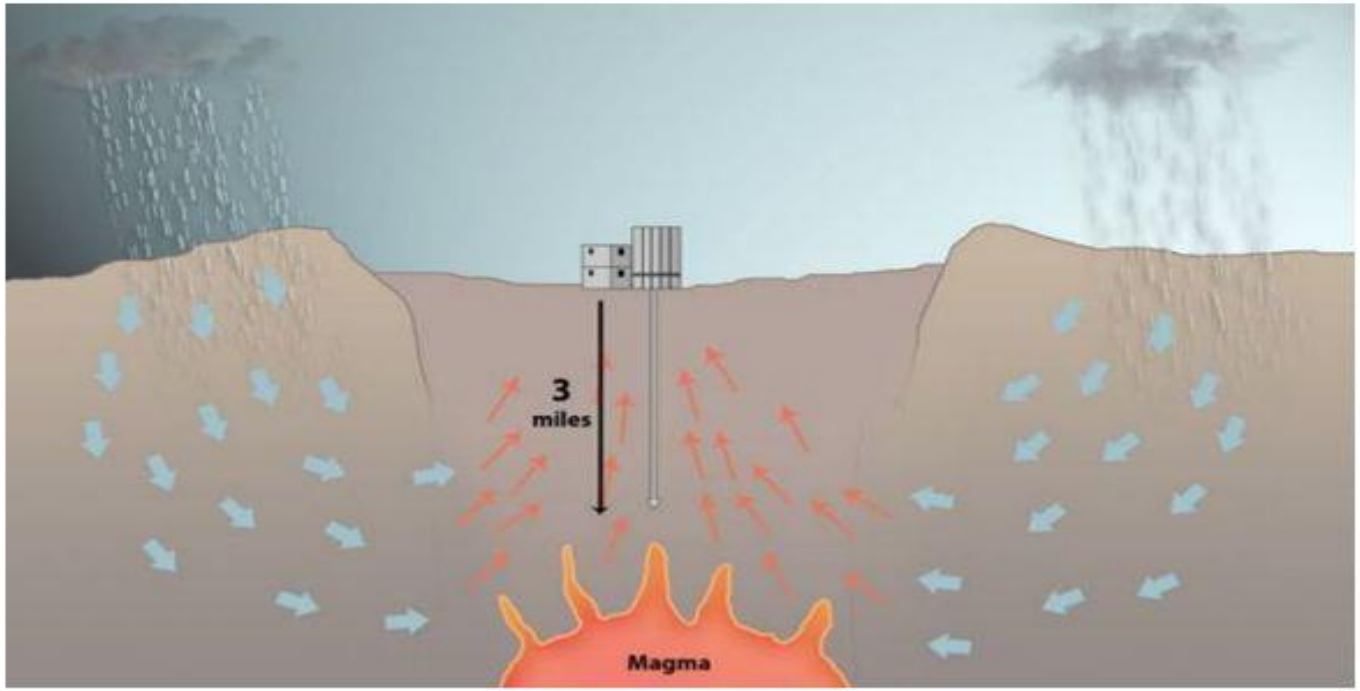
Hot Dry Rock or Enhanced geothermal systems



- Wells are drilled 3-6 km into crust
- water is pumped into hot, crystalline rock via an injection well, becomes superheated as it flows through open joints in the hot rock reservoir, and is returned through production wells.
- At the surface, the useful heat is extracted by conventional processes, and the same water is recirculated to mine more heat.

Molten Rock and Magma

- Magma may come close to the surface, if this magma heats a water source, useable geothermal energy is created.

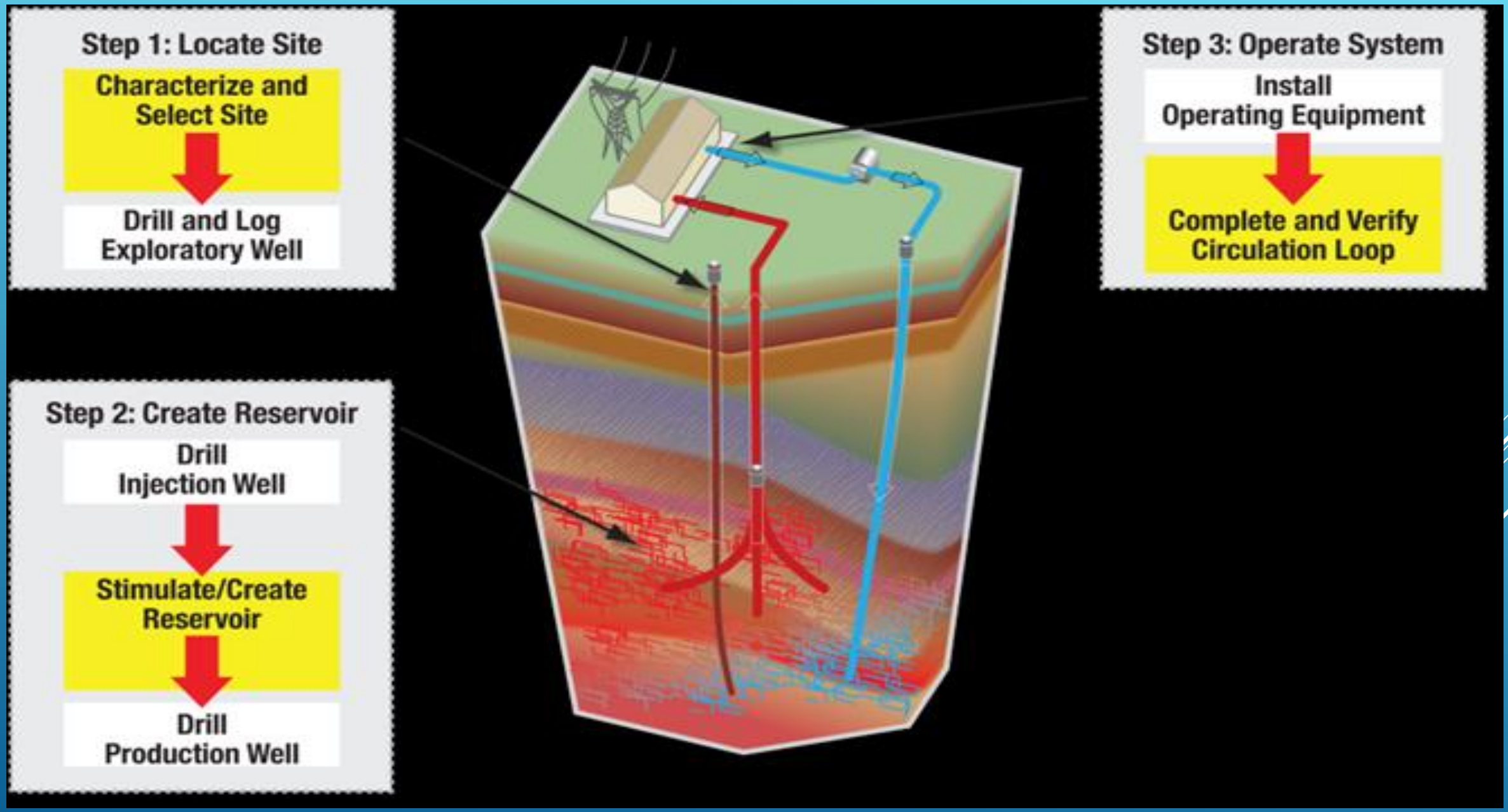


MAGMA RESOURCES

¨ Consist of partially or completely molten rock, with temperatures in excess of 6500C, which may be encountered at moderate depths, especially in recently active volcanic regions

¨ Have a large geothermal energy content but restricted to a relatively few locations

¨ The high temperatures will make extraction of the energy a difficult technological problem


Step 1: Locate Site
Characterize and Select Site
Drill and Log Exploratory Well
Step 2: Create Reservoir
Drill Injection Well
Stimulate/Create Reservoir
Drill Production Well
Step 3: Operate System
Install Operating Equipment
Complete and Verify Circulation Loop

Geothermal Energy in India

Geothermal Energy in India (cont)

- Geothermal provinces are estimated to produce 10,600 MW of power (experts are confident only to the extent of 100 MW)
- Geothermal provinces in India: the Himalayas, Sohana, West coast, Cambay, Son-Narmada-Tapi , Godavari, and Mahanadi
- Reykjavík Geothermal will assist Thermax to set up a pilot project in Puga Valley, Ladakh (Jammu & Kashmir)
- First operational commercial geothermal power plant is likely to come up in AP with a capacity of 25 MW by Geosyndicate Pvt Ltd.

PROSPECTS OF GEOTHERMAL ENERGY IN INDIA

- About 6.5% of electricity generation in the world is done by geothermal energy and India can play an important role in the coming years in this direction.

- Geological Survey of India has identified about 340 geothermal hot springs in the country. Most of them are in the low surface temperature range from 37° C-90° C which is suitable for direct heat applications.

- Grouped into seven geothermal provinces. Himalayan (Puga, Chhumathang), Sahara Valley, Cambay Basin, Son-Narmada-Tapi (SONATA) lineament belt, West Coast, Godavari basin and Mahanadi basin.

- A new location of geothermal power energy has also been found in Tattapani in Chhattisgarh. Gujarat is set to tap geothermal electricity through resources which are available in Cambay between Narmada and Tapi river.

- India's first geothermal plant to come up in Chhattisgarh. NTPC has already started exploratory and preparatory work in this area. It has also started talks with Oil and Natural Gas Corp and international organisations for drilling operation.

GEOTHERMAL FACTS

✓ *BIGGEST PRODUCERS OF GEOTHERMAL ENERGY:*
Italy , Mexico, Philippines , Japan , U.S.A. , Indonesia, New Zealand, Iceland

✓ *The United States generates 3,386 MW of geothermal electricity. The largest group of geothermal power plants located at THE GEYSERS, California.*

✓ *The Philippines, which generates 23% of its electricity from geothermal energy, is the world's second biggest producer behind the U.S.*

✓ *The first geothermal power station was built at Landrello, in Italy, and the second was at Wairekei in New Zealand.*

✓ *In Iceland*
- *86% of their space heating uses geothermal energy.*
- *16% of their electricity generation uses geothermal energy.*

Disadvantages

- Not widespread source of energy
- High installation costs
- Can run out of steam
- May release harmful gases
- Transportation
- Earthquakes

Conclusion

- Geothermal heating system can replace fossil fuel heating system in a particular area.
- Annual costs for common heating purposes can be reduced by more than 60%.
- Continued energy shortages have created added interest in geothermal energy for power generation.
- Potential exists to provide all energy requirements in the U.S
- Geothermal energy appears to be a partial solution to our energy needs.