

Unit 5:- Other Alternate Sources

Geothermal Energy



Syllabus...Unit 5

- **Other Alternate Sources:** Ocean Thermal Energy Conversion, Geothermal, Tidal, Wave Energy, MHD, Fuel Cells, environmental issues of energy services.

Books ...

- Gilbert M. Masters, *Renewable and Efficient Electrical Power Systems*, Wiley - IEEE Press, August 2004.
- Godfrey Boyle, *Renewable Energy*, Third edition, Oxford University Press, 2012.
- Chetan Singh Solanki, *Solar Photovoltaics-Fundamentals, Technologies and Applications*, PHI Third Edition, 2015.

Supplementary Reading:

- D.P.Kothari, K.C.Singal, Rakesh Rajan, *Renewable Energy Sources and Emerging Technologies*, PHI Second Edition, 2011.

Lecture 2 Geothermal Energy

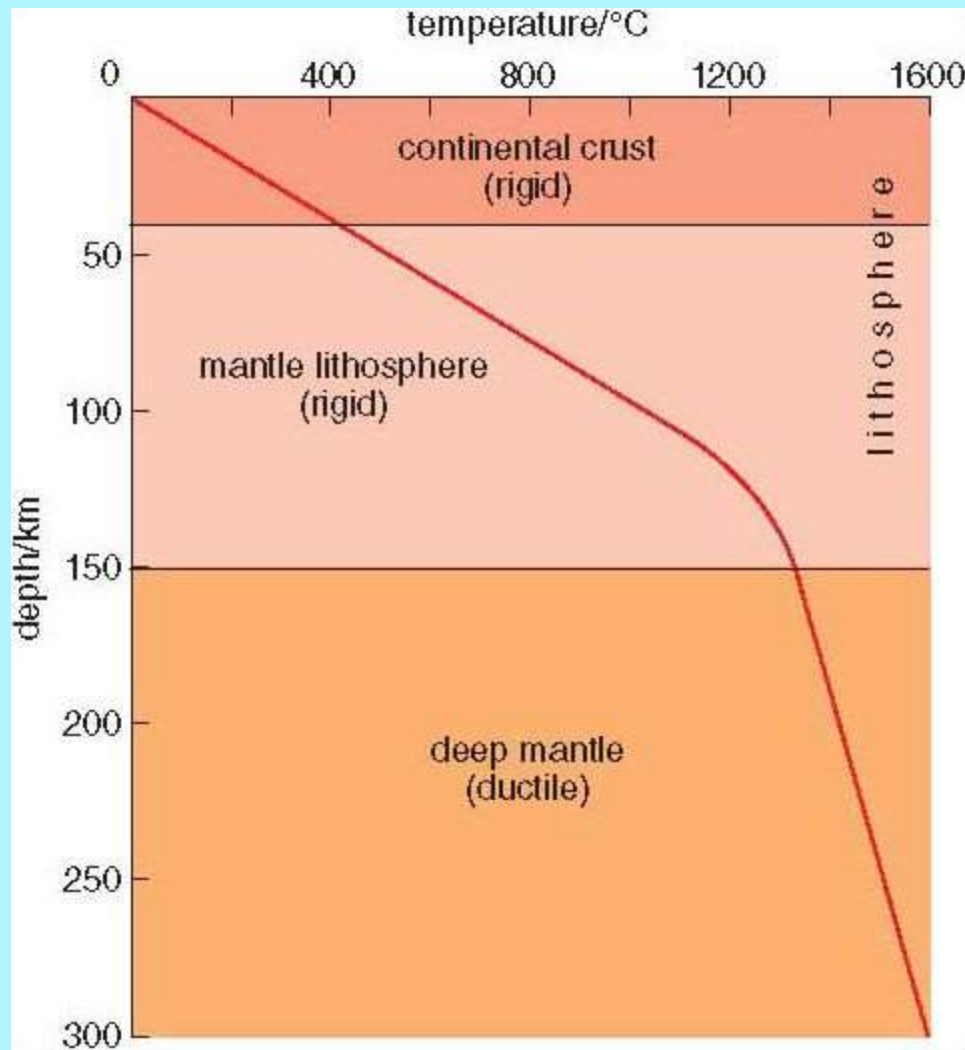
- Introduction
- Understanding Geothermal Temperature
- Geothermal Reservoirs
- Geothermal History & Installed Capacity Worldwide
- Geothermal Energy Forms: Liquid Dominated Plants
- Thermal Energy Forms
- Enhanced geothermal Energy Forms
- Generation Power Plant Types
- Dry steam power plant
- Flash steam power plant
- Binary cycle power plant
- Difference in Power Plant
- Advantages & Disadvantages
- Conclusions

Introduction



- “Geothermal” comes from the Greek words geo (earth) and thermal (heat). So, geothermal means earth’s heat
- Geothermal heat originates from earth's fiery consolidation of dust and gas over four billion years ago.
- The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials
- For every 100m down the earth temperature increases by 3°C

Understanding Geothermal Temperature



Deeper we go, the hotter it is !!!

- The heat from the earth's core continuously flows outward. It transfers (conducts) to the surrounding layer of rock, the mantle.
- When temperatures and pressures become high enough, some mantle rock melts, becoming magma
- Temperatures at the core–mantle boundary may reach over 4000 °C (7,200 °F).

Geothermal Reservoirs



←Geyser & Hot spring



←Boiling mud pot

↓ Volcano Springs



Hot springs→



Geothermal History



- The oldest known spa is a stone pool on China's Lisan mountain built in the Qin Dynasty in the 3rd century BC, at the same site where the Huaqing Chi palace was later built.



- The world's oldest geothermal district heating system, Chaudes-Aigues, in France, has been operating since the 15th century.



- The earliest industrial exploitation began in 1827 with the use of geyser steam to extract boric acid from volcanic mud in Larderello, Italy

Geothermal History



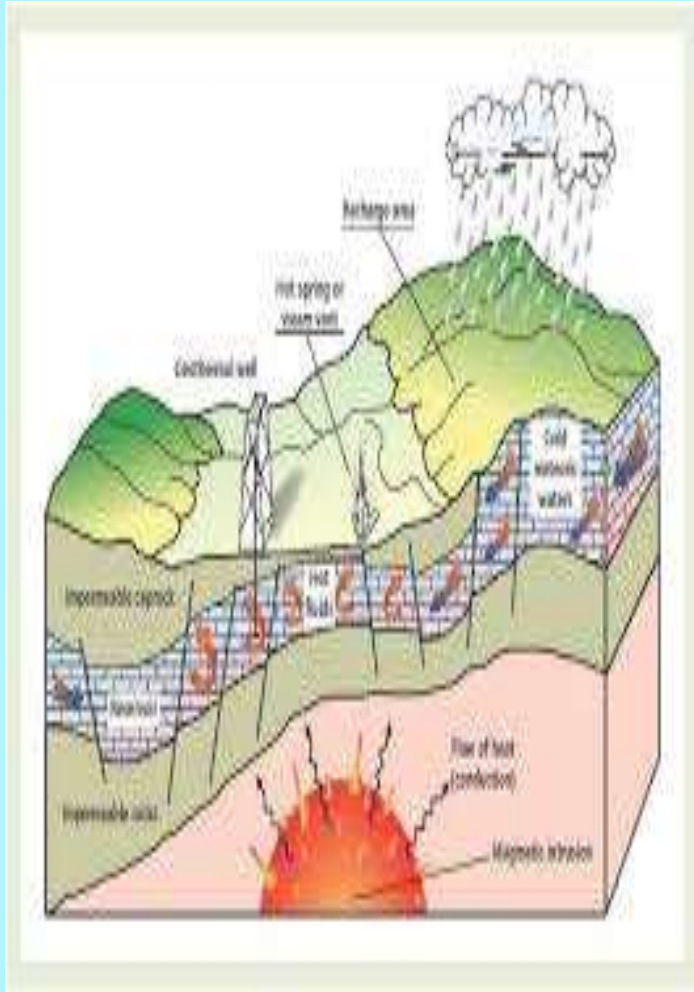
- The first known building in the world to utilize geothermal energy as its primary heat source was the Hot Lake Hotel in Union County, Oregon, whose construction was completed in 1907
- In the 20th century, demand for electricity led to the consideration of geothermal power as a generating source. Prince Piero Ginori Conti tested the first geothermal power generator on 4 July 1904, at the same Larderello dry steam field where geothermal acid extraction began. It successfully lit four light bulbs.



Geothermal Installed Capacity Worldwide

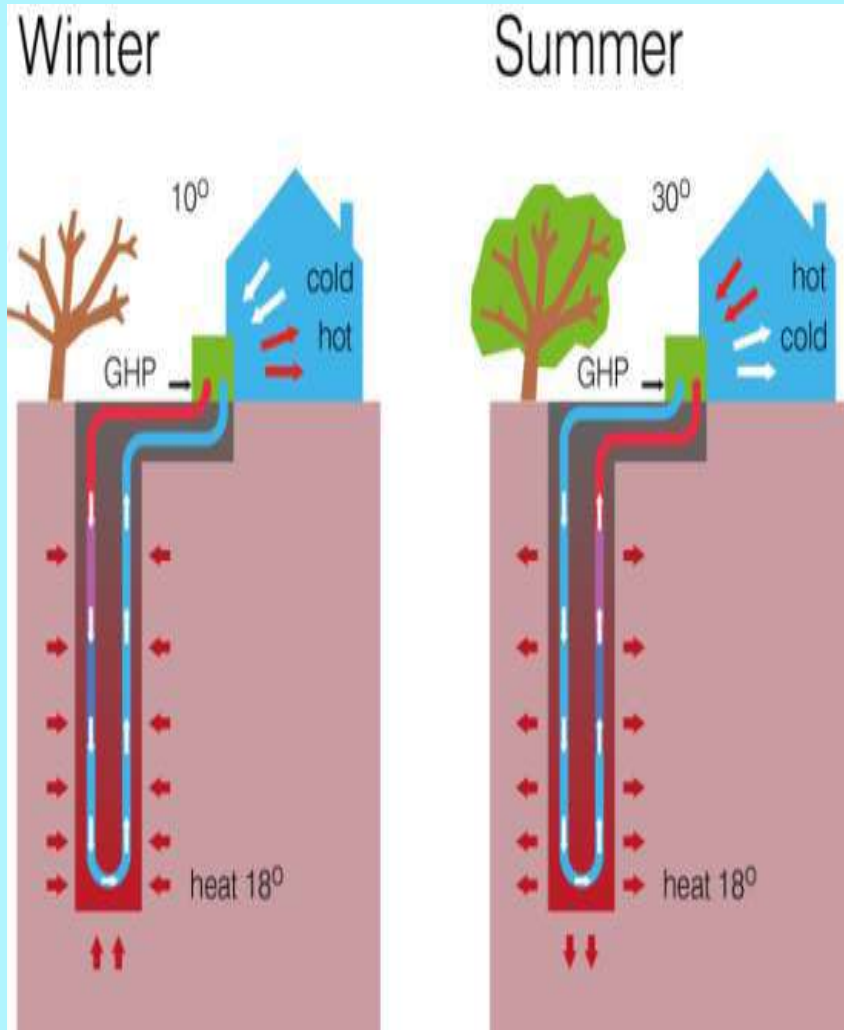
Installed geothermal electric capacity				
Country	Capacity (MW) 2007	Capacity (MW) 2010 ^[31]	Percentage of national electricity production	Percentage of global geothermal production
United States	2687	3086	0.3	29
Philippines	1969.7	1904	27	18
Indonesia	992	1197	3.7	11
Mexico	953	958	3	9
Italy	810.5	843	1.5	8
New Zealand	471.6	628	10	6
Iceland	421.2	575	30	5
Japan	535.2	536	0.1	5
Iran	250	250		

Types of Geothermal Energy Forms: Liquid Dominated Plants



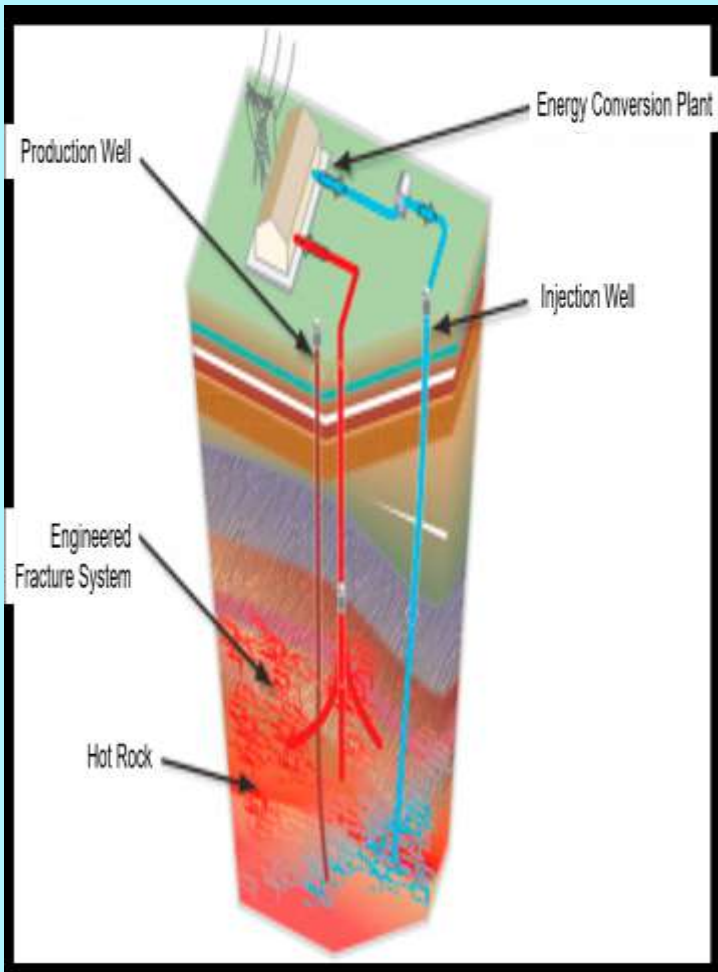
- Geothermal energy comes in either *vapor-dominated* or *liquid-dominated* forms. Vapor-dominated sites offer temperatures from 240 to 300 °C that produce superheated steam.
- **Liquid-dominated plants:** Liquid-dominated reservoirs (LDRs) are more common with temperatures greater than 200 °C (392 °F). Water passes through a heat exchanger in a Rankine cycle binary plant. The water vaporizes an organic working fluid that drives a turbine

Thermal Energy Forms



- **Thermal Energy plants:** Sources with temperatures of $30\text{--}150^{\circ}\text{C}$ are used without conversion to electricity as district heating, greenhouses, fisheries, mineral recovery, industrial process heating and bathing.
- Heat pumps extract energy from shallow sources at $10\text{--}20^{\circ}\text{C}$ used in various countries for in space heating and cooling.

Enhanced geothermal Energy Forms



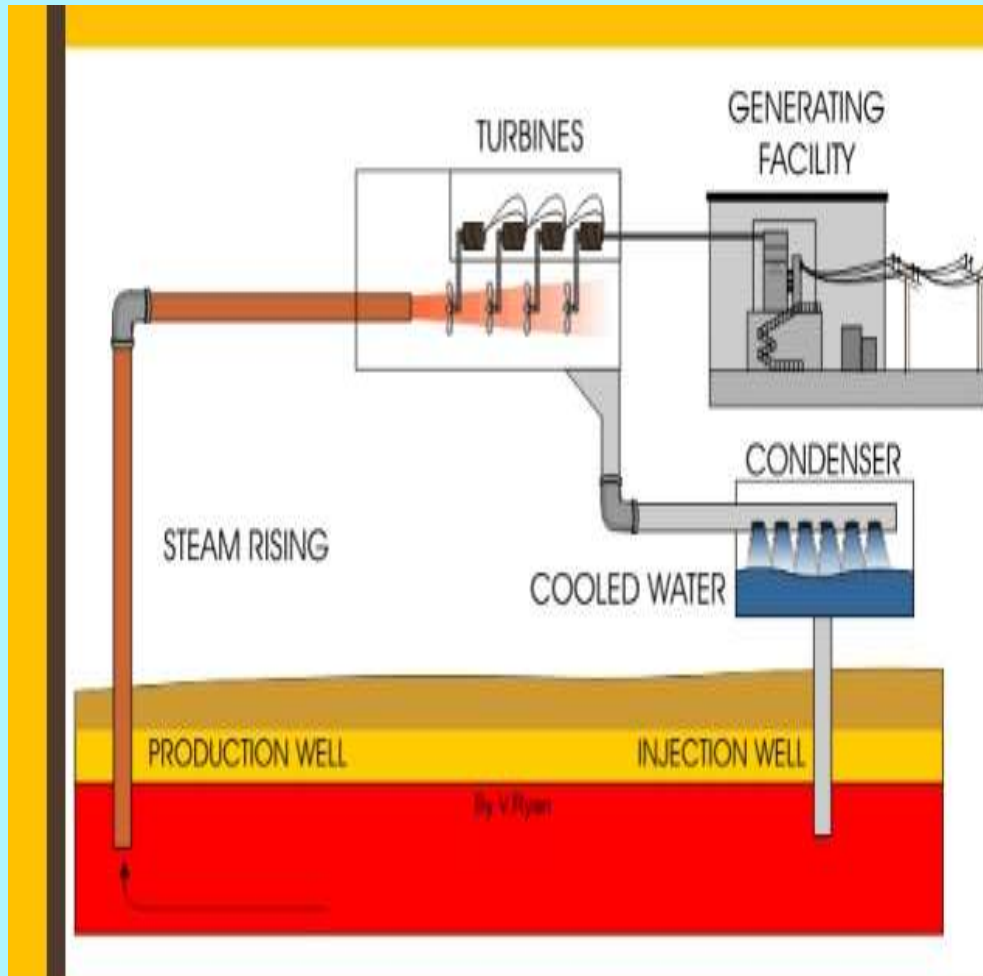
- **Enhanced geothermal:** Enhanced geothermal systems (EGS) actively inject water into wells to be heated and pumped back out. The water is injected under high pressure to expand existing rock fissures to enable the water to freely flow in and out.
- The technique was adapted from oil and gas extraction techniques.
- EGS technologies enhance and/or create geothermal resources in this hot dry rock (HDR) through 'hydraulic stimulation'.

Generation Power Plant Types



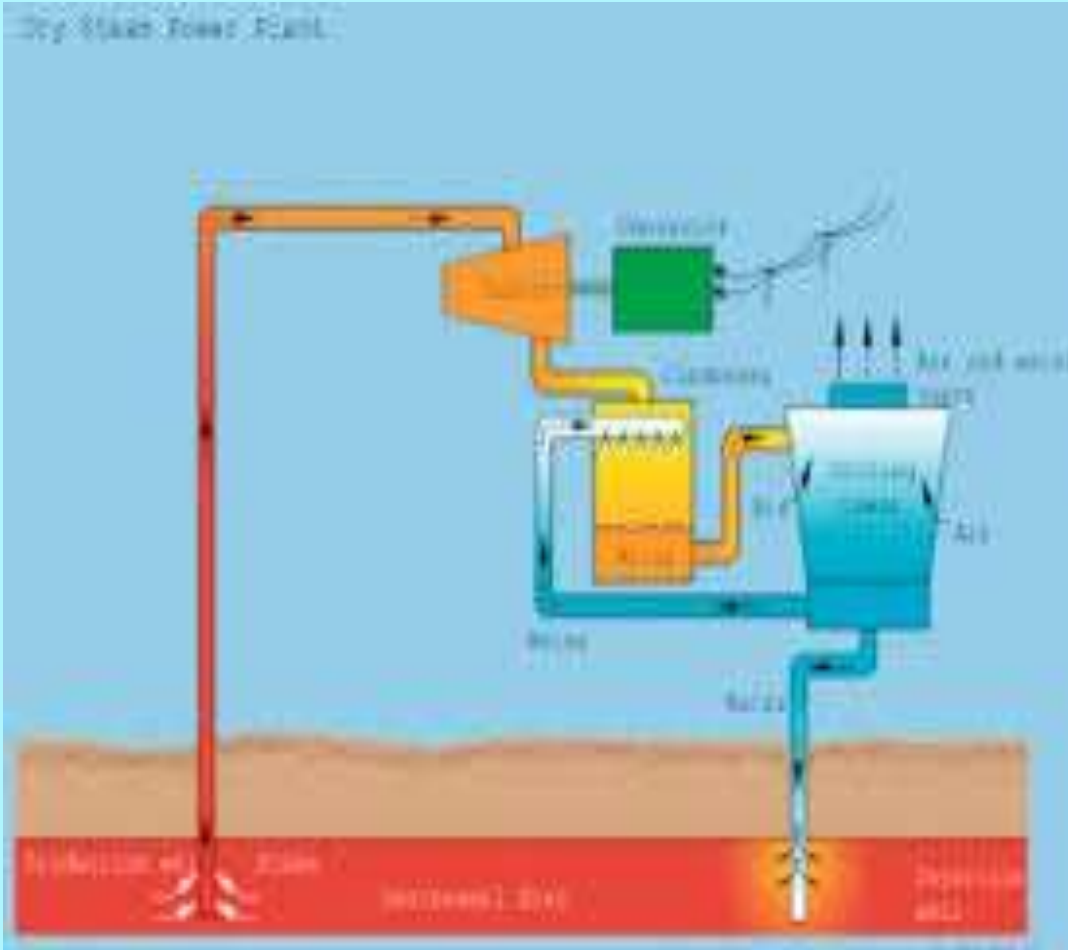
- **Dry steam power plant**
- **Flash steam power plant**
- **Binary cycle power plant**

Dry Steam Power Plant



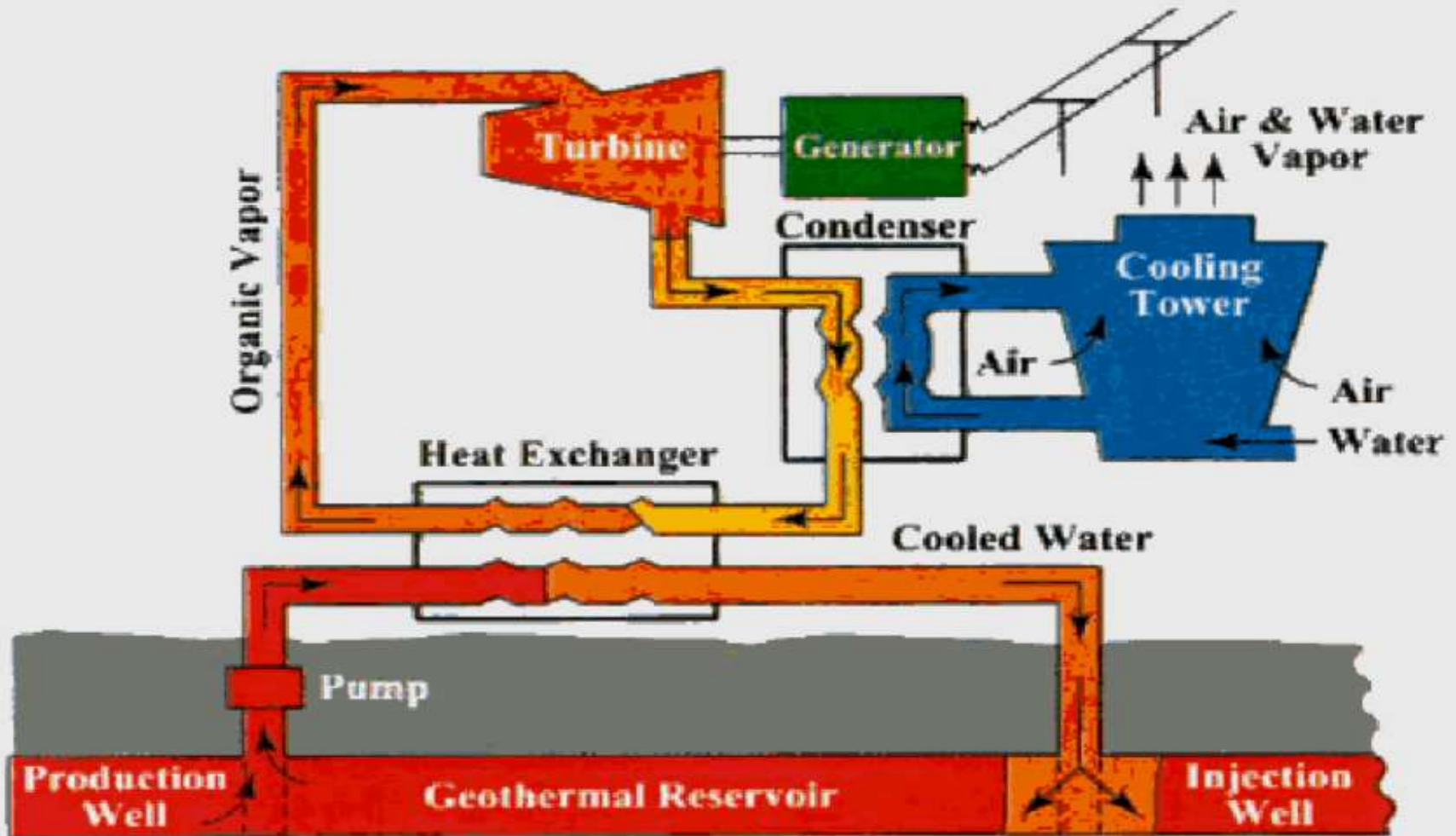
- The oldest type of Geothermal power plant used.
- Geothermal reservoir containing pure steam is required.
- Pure dry steam drives turbine.
- Very rare type of geothermal power plant.
- Operating at California, Italy, and Japan.

Flash Steam Power Plant



- Commonly used geothermal power plant.
- Geothermal reservoirs containing both hot water & steam is required. It flashes steam at 182°C
- Pressure changing system is required.
- Operating at Hawaii, Nevada, Utah & some other places

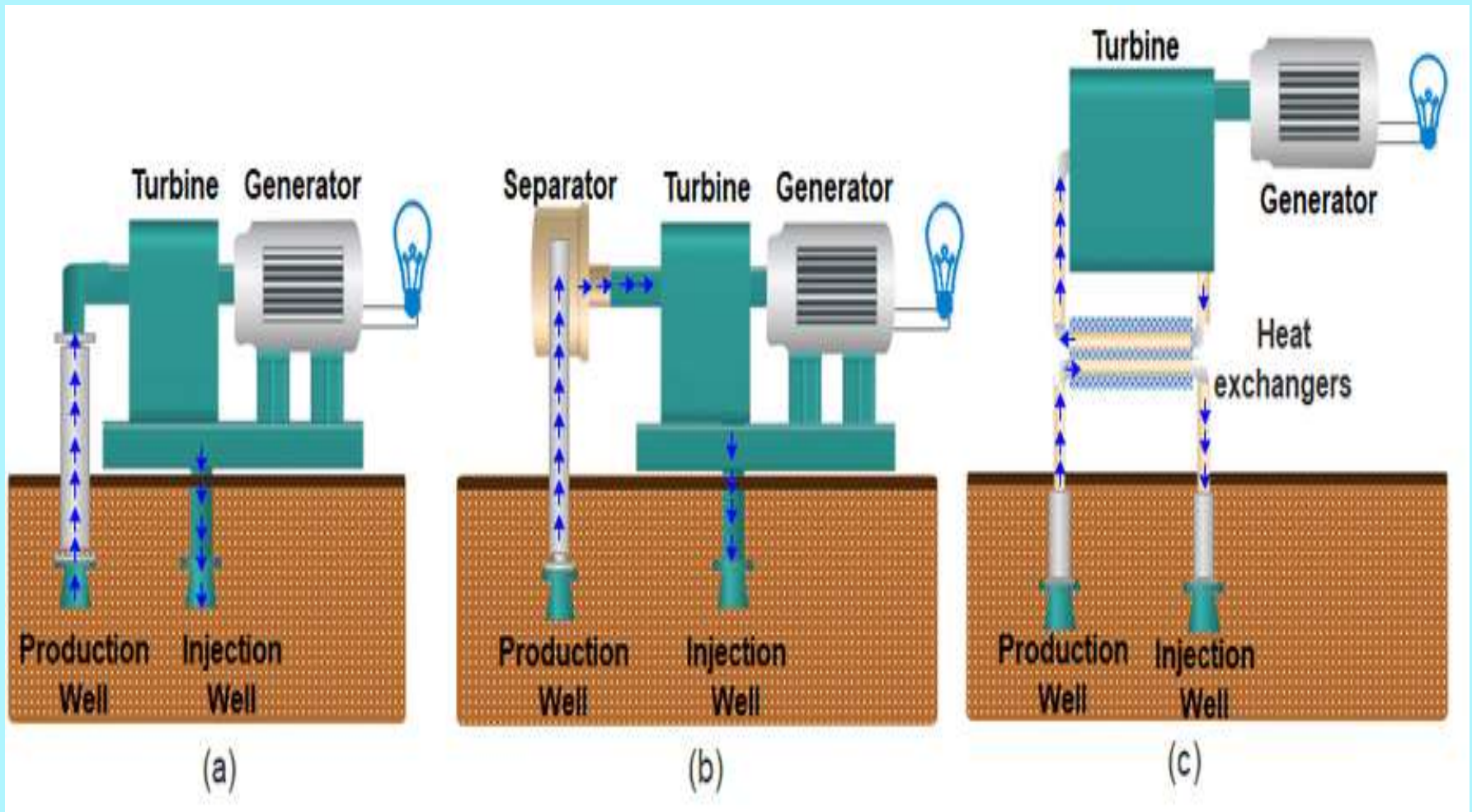
Binary Cycle Power Plant



Binary Cycle Power Plant

- Does not use steam directly to spin turbines.
- Only the heat of the underground water is used.
- Vaporized hydrocarbons are used to spin the turbine.
- Hydrocarbons having lower boiling point such as Isopentane, Isobutane and propane can be used. No harmful gas is emitted to the atmosphere because the
- underground water is never disclosed to outside.
- This's the worldwide accepted power plant.

Difference in Power Plant



(a) Dry steam plant

(b) Flash steam plant

(C) Binary cycle plant

Advantages

- Available all the year around.
- Does not involve any combustion of fuel.
- Independent of weather
- Clean Resource – Very little emissions or overall environmental impact.
- Economically Sound Alternative – The fuel is free, rate / KWh likely to be competitive
- Overall, geothermal energy is a sustainable resource.

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.

Thank You