RV College of Engineering®

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GeoThermal Energy

UNIT 4

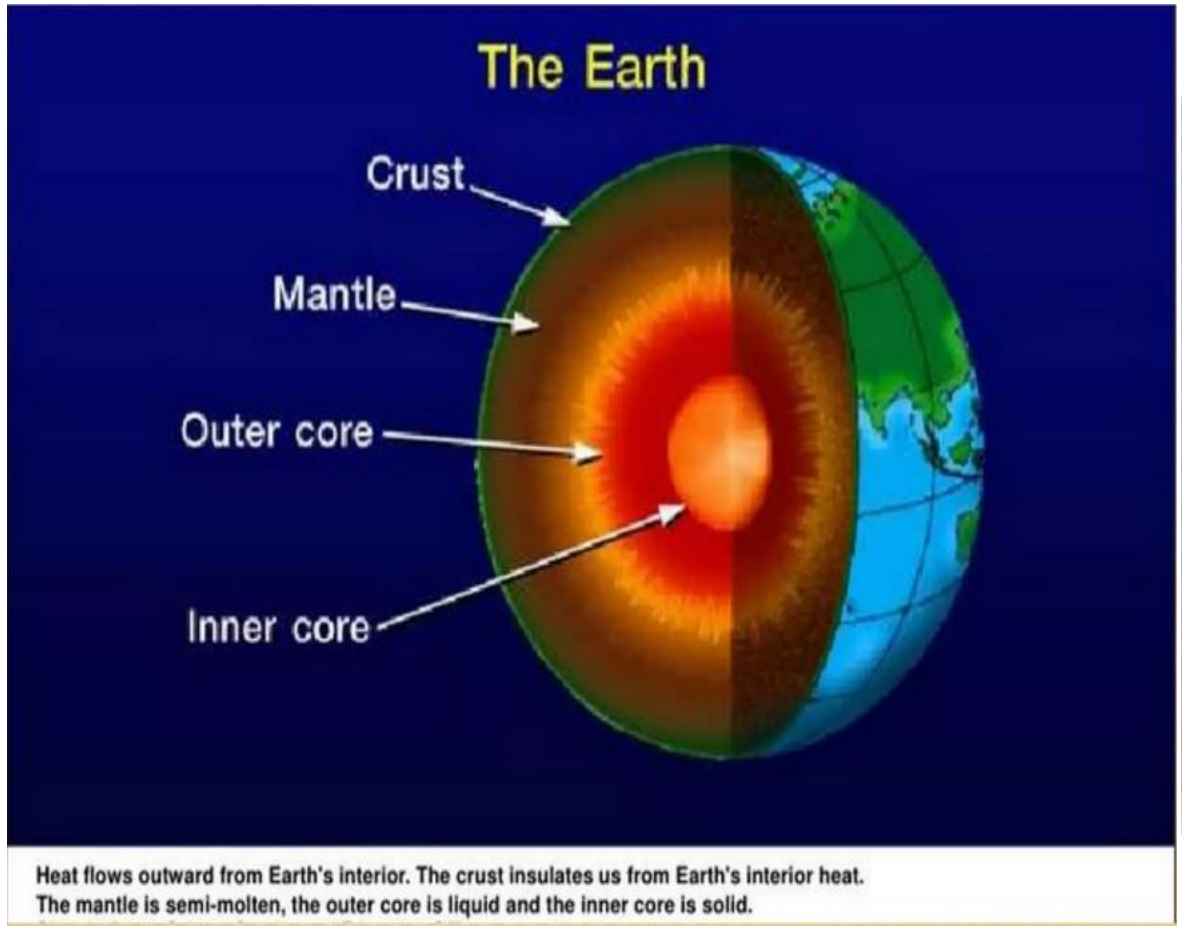
Introduction

- Our earth was a burning planet billions of years ago, Still earth core temperature is above 5000 C.
- Geo means earth and Thermal means heat , Geothermal means earth's heat
- Geothermal energy is the energy contained as heat in the earth's interior.
- Geothermal energy is energy extracted from the heat stored in the earth.
- Geothermal energy is derived from within the earth's tectonic activity that occurred since the planet was created. It also comes from solar thermal absorbed by the earth's surface.

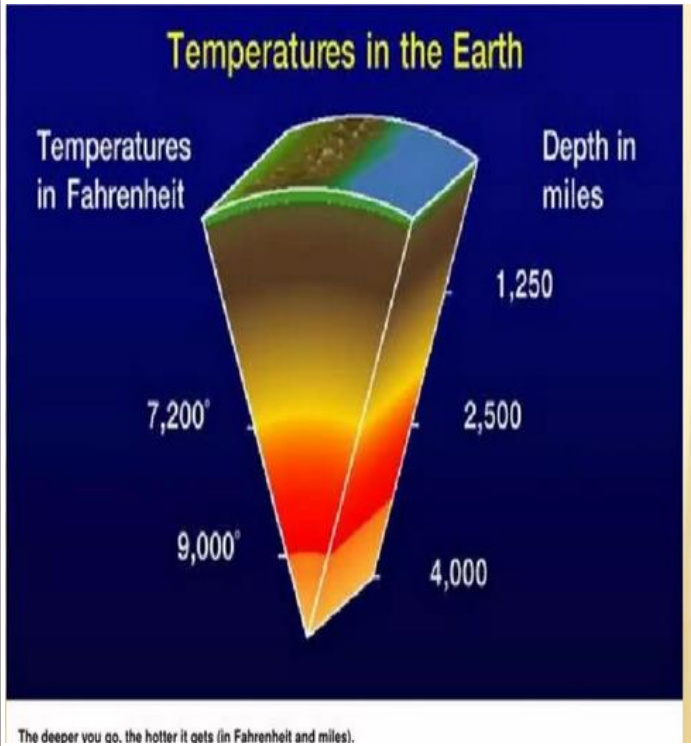
Earth's radius is approximately 6370 km and it can be divided into three zones

- Crust (7 km under ocean, 20-65 km under the continent)
- Mantle (2900 km , lies under the crust)
- Core (center, 4000°C and 3.6 million bars)

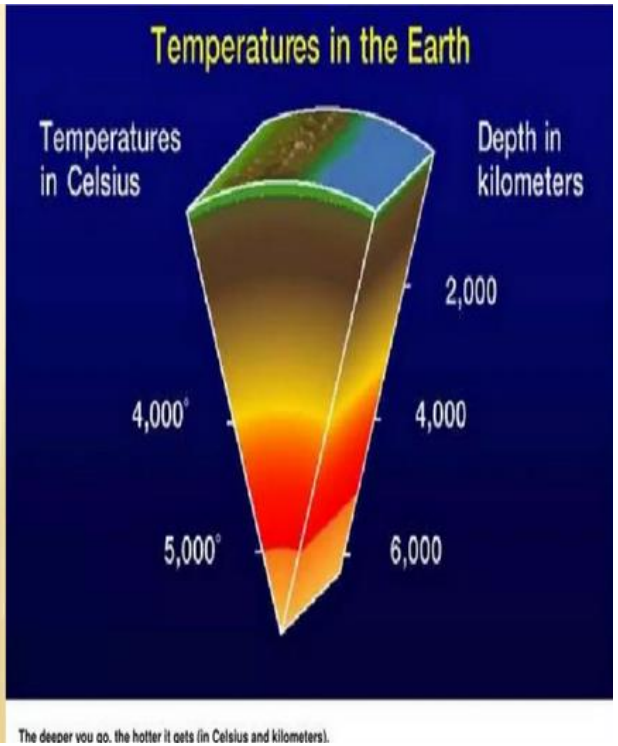
Introduction



Heat flows outward from Earth's interior. The crust insulates us from Earth's interior heat.
The mantle is semi-molten, the outer core is liquid and the inner core is solid.



The deeper you go, the hotter it gets (in Fahrenheit and miles).



The deeper you go, the hotter it gets (in Celsius and kilometers).

Introduction – Where does it come from?

- Initially, the energy transformed starts from way down the Earth's core – 4,000 miles down. At the core, temperatures may reach over 9,000 degrees Fahrenheit.
- Heat conducts from the core to surrounding rock. Extremely high temperature and pressure cause some rock to melt, which is commonly known as **magma**.
- Magma come upward since it is lighter than the solid rock. This magma then heats rock and water in the crust, sometimes up to 700 degrees Fahrenheit. This magma near the Earth's surface is what is used and transformed in power-plants.

Geothermal energy is produced through reservoirs, power plants and systems.

- Geothermal reservoirs are generally classified as being either **low temperature** (<150°C) or **high temperature** (>150°C).
- Generally speaking, the high temperature reservoirs are the ones suitable for, and sought out for, commercial production of electricity. Geothermal reservoirs are found in "geothermal systems," which are regionally localized geologic settings where the earth's naturally occurring heat flow is near enough to the earth's surface to bring steam or hot water, to the surface.

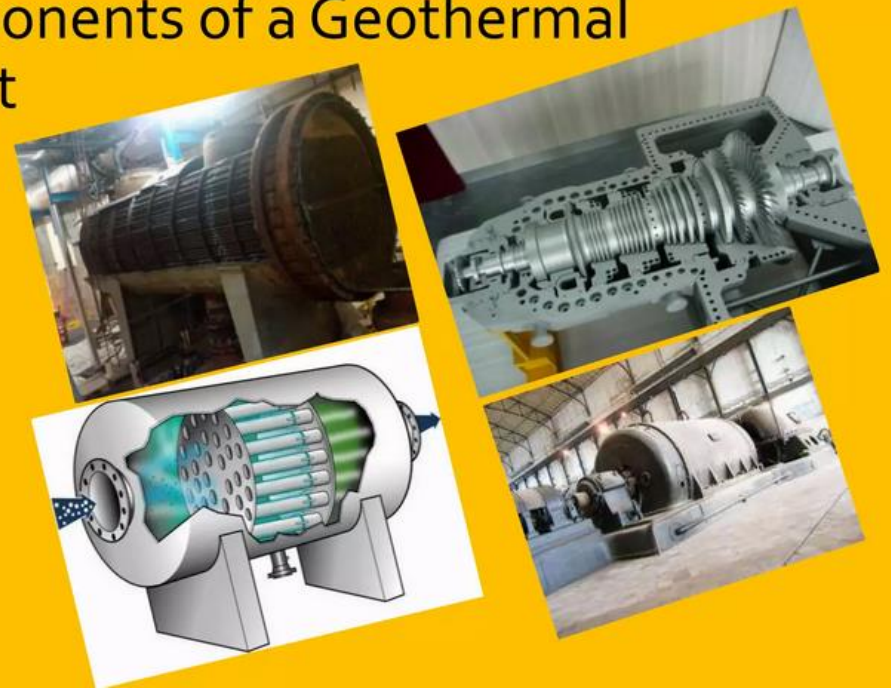
Historical Background

- Conventional geothermal plants capture hot water from geysers or steam from vents to spin turbines.
- Prince Piero Ginori Conti tested the first geothermal power generator. It successfully lit four light bulbs. Later, in 1911, the world's first commercial geothermal power station was built there.

First Geothermal Power Plant, 1904, Larderello, Italy

Main Components of a Geothermal Power Plant

- Production Well
- Separator
- Heat Exchanger
- Steam Turbine
- Condenser
- Generator
- Injection Well



Introduction

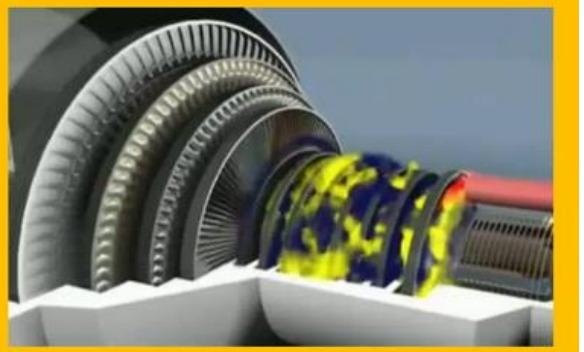
Production Well

- Source of steam
- Depth 3 km to 10 km
- Similar to production well of an oil rig
- Wells may be located as far as 10 km to 14 km from power plant
- Steam can be moist or dry, Moist steam passes through separator
- Water or brine is reinjected through injection well

Separator

- Steam contains non condensable gases including Hydrogen sulphide
- Separator are used for the purpose to remove these gases
- 2 phase and 3 phase separators are used according to requirement
- Separators are vertically horizontally designed

Steam Turbine

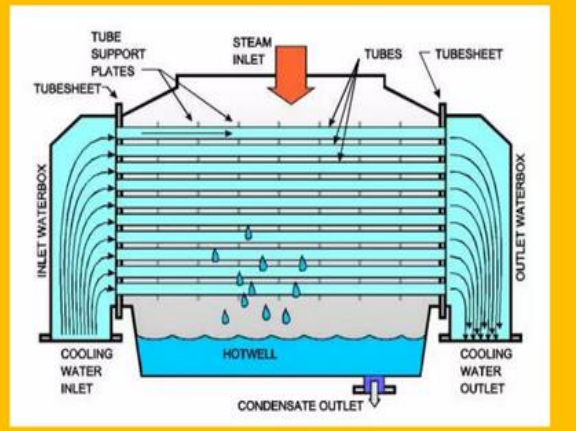


- Specially designed steam turbine are used for geothermal power plants
- Steam can be corrosive due to many non condensable gases e.g. Hydrogen sulphide
- To protect rotor blades and nozzles from corrosion special coatings and materials are used
- The generation and transmission side of geothermal power plants is similar to conventional power plants

Introduction

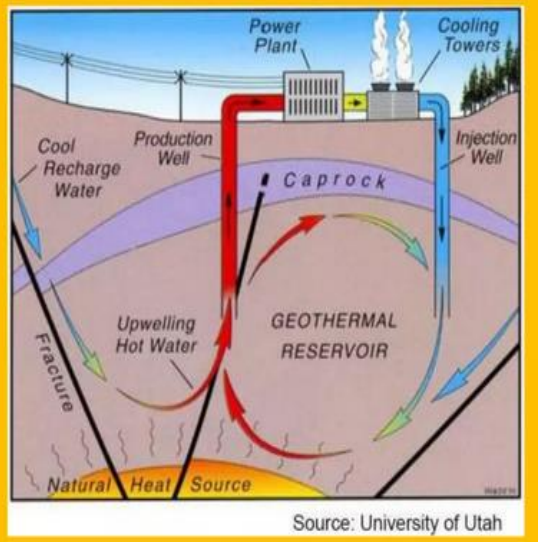
Condenser

- Steam condensed at a vacuum at the turbine exit
- Most plants use direct contact condensers that uses water itself as the cooling media.



Injection Well

- The excess condensate and the brine from the separator returns back to the underground thermal reservoir,
- Reinjection wells are located in appropriate places
- Some reservoirs can give outputs for years with out reinjection

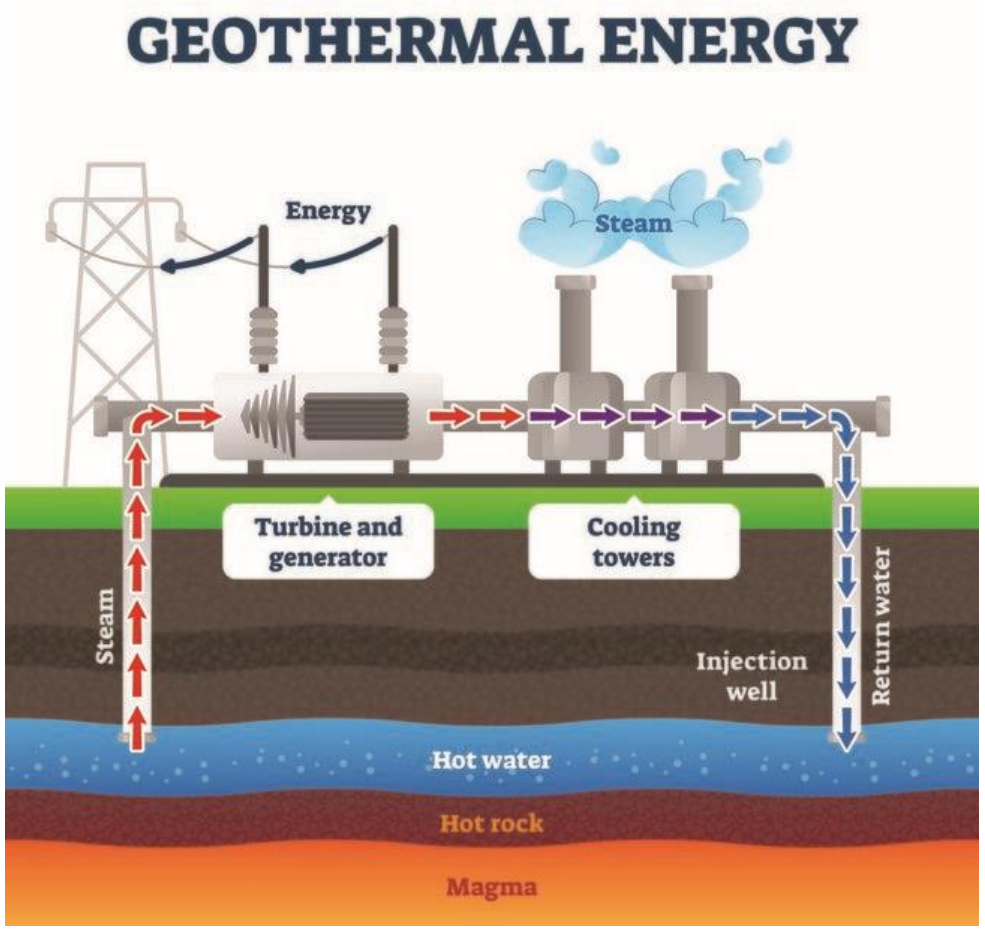


Source: University of Utah

How it works?

- Large holes have to be dug into the earth until a geothermal hotspot is found.
- Pipes are inserted inside these holes through which water is sent and steam output is obtained.
- The production involves two process
  1) Converting Geothermal energy into Mechanical energy
  2) Converting Mechanical Energy into Electrical Energy
- The success of the energy production depends on the temperature of the plant which depends on the temperature of the rocks in earth.
- The water is sent through the injection well and reaches the rocks and then hot water comes from the production well.

- Due to the high pressure when it reaches the topmost of the earth surface it is converted into steam.
- The separator is the place where steam that comes from the earth is made clean by removing the brine and dirt so that they do not damage the turbine blades.
- The high pressure and low pressure steam runs the turbine.
- The generator is coupled with turbine to produce electricity.
- The condenser is a phase changer where the steam output of the turbine is given to the condenser and gets converted to hot water.
- This hot water is then sent to the cooling tower where it loses it heat and then sent to the geothermal reservoir for further production of steam.



Types of Geothermal Power Plants

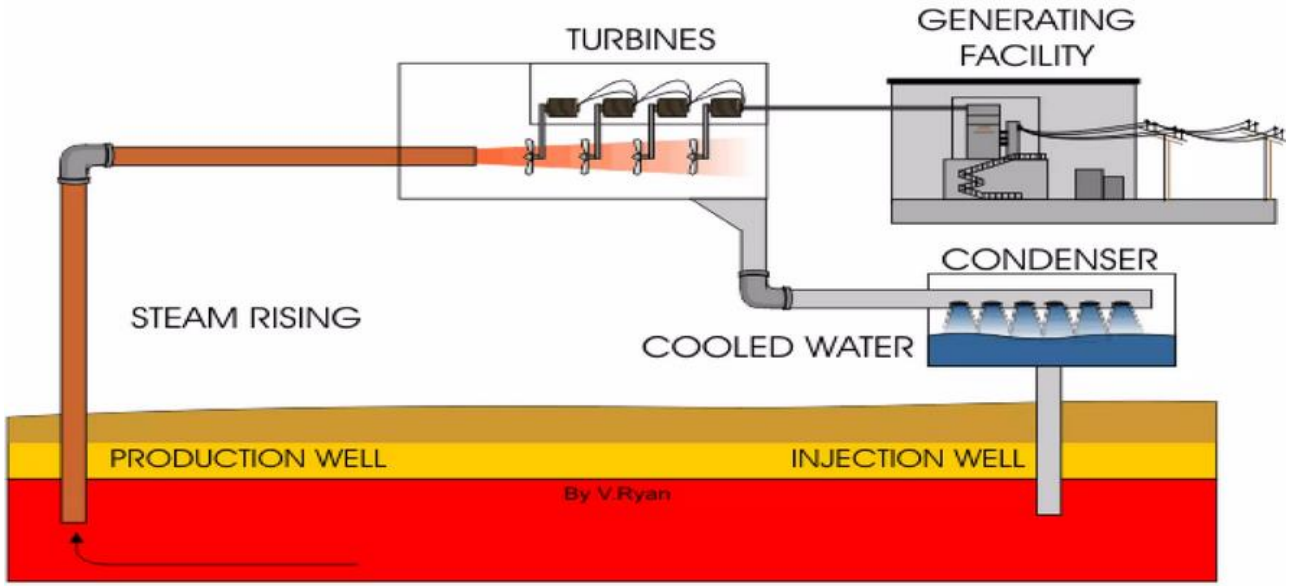
There are three different types of Geothermal power plants system designs :

- **Dry Steam Power Plants**
- **Flash / Steam Plants**
- **Binary cycle power plant**

Dry Steam Power Plant

A power plant where steam is released from the pressure of a deep reservoir, through a rock catcher, and then past the power generator turbines.

- "Dry" steam extracted from natural reservoir
  - *180-225 ºC (356-437 ºF)*
  - *4-8 MPa (580-1160 psi)*
- Steam is used to drive a turbo-generator
- Steam is condensed and pumped back into the ground
- Can achieve 1 kWh per 6.5 kg of steam
  - *A 55 MW plant requires 100 kg/s of steam*

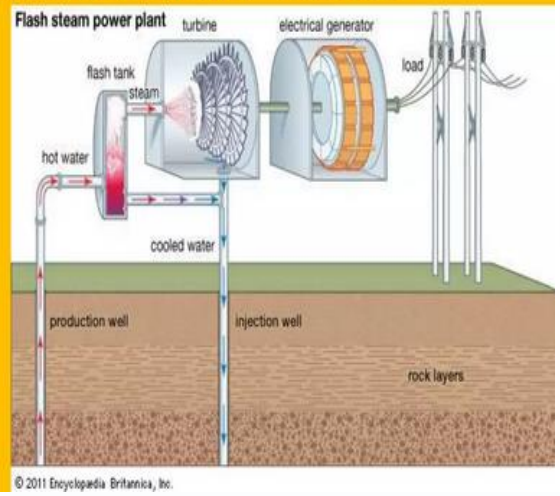


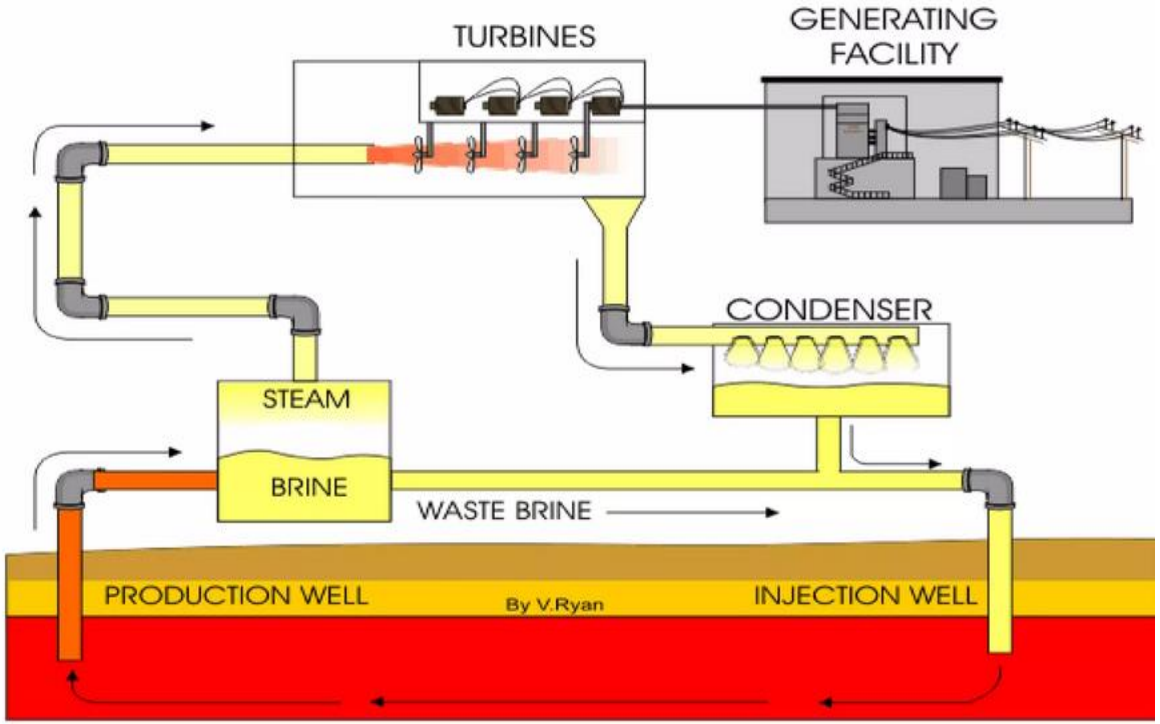
Flash or Steam plants

- A power plant where water is pumped under great pressure to the surface. When it surfaces, the pressure is reduced and as a result some of the water changes to steam. This creates a blast of steam. The water is then returned to the earth to be heated up by geothermal rocks again.

Flash or Steam plants

- Steam with water extracted from ground
- Pressure of mixture drops at surface and more water "flashes" to steam
- Steam separated from water
- Steam drives a turbine
- Turbine drives an electric generator
- Generate between 5 and 100 MW
- Use 6 to 9 tones of steam per hour



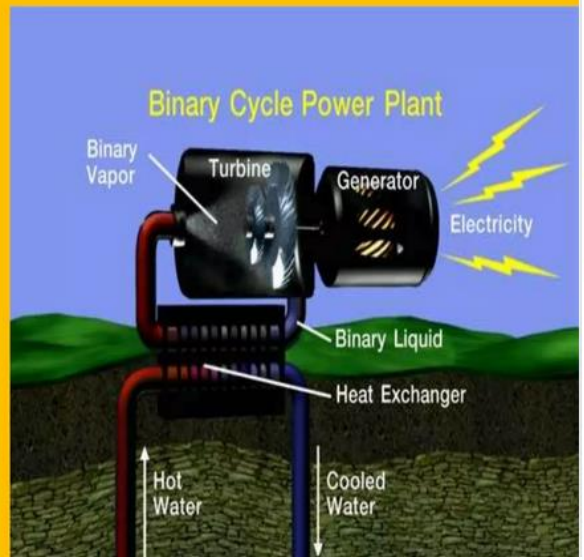


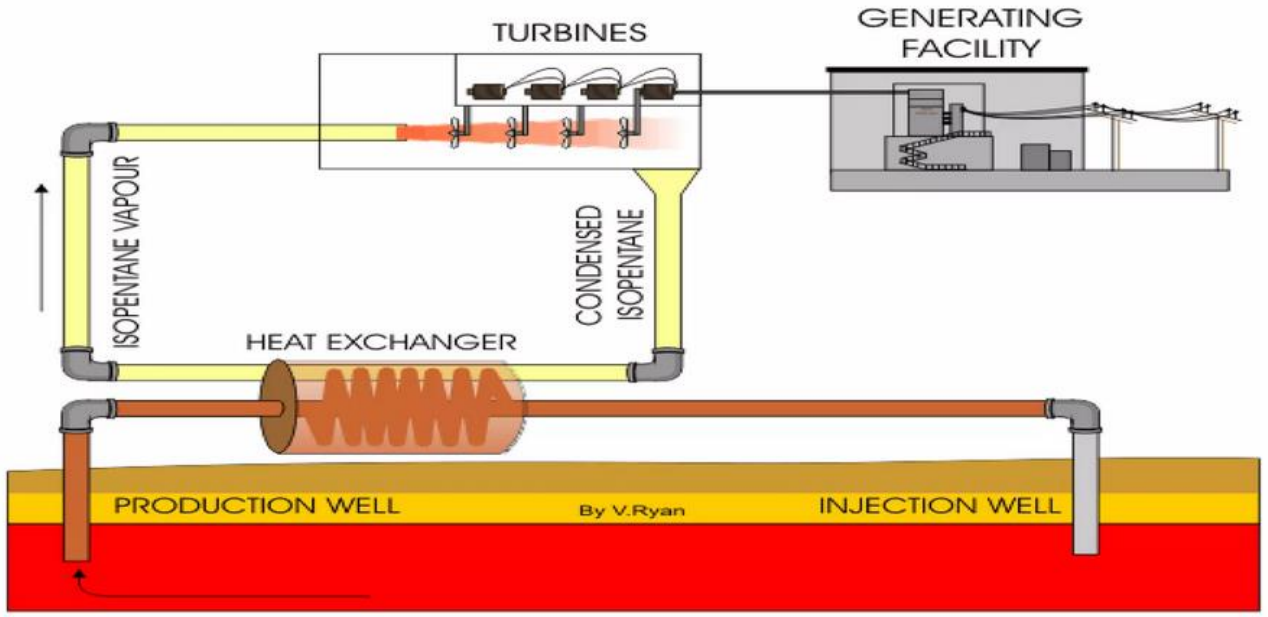
Binary Cycle Power Plant

- A power plant where warm geothermal water is pumped to the surface and passed through a heat exchanger that contains a special fluid that boils the water. The heat from the water makes this secondary fluid flash into vapor. The newly created vapor spins the turbines, while the cooled steam is injected back into the earth.

Binary Cycle Power Plant

- Low temps – 100° and 150°C
- Use heat to vaporize organic liquid
  - *E.g., iso-butane, iso-pentane*
- Use vapor to drive turbine
  - *Causes vapor to condense*
  - *Recycle continuously*
- Typically 7 to 12 % efficient
- 0.1 – 40 MW units common





Introduction

Binary Cycle-

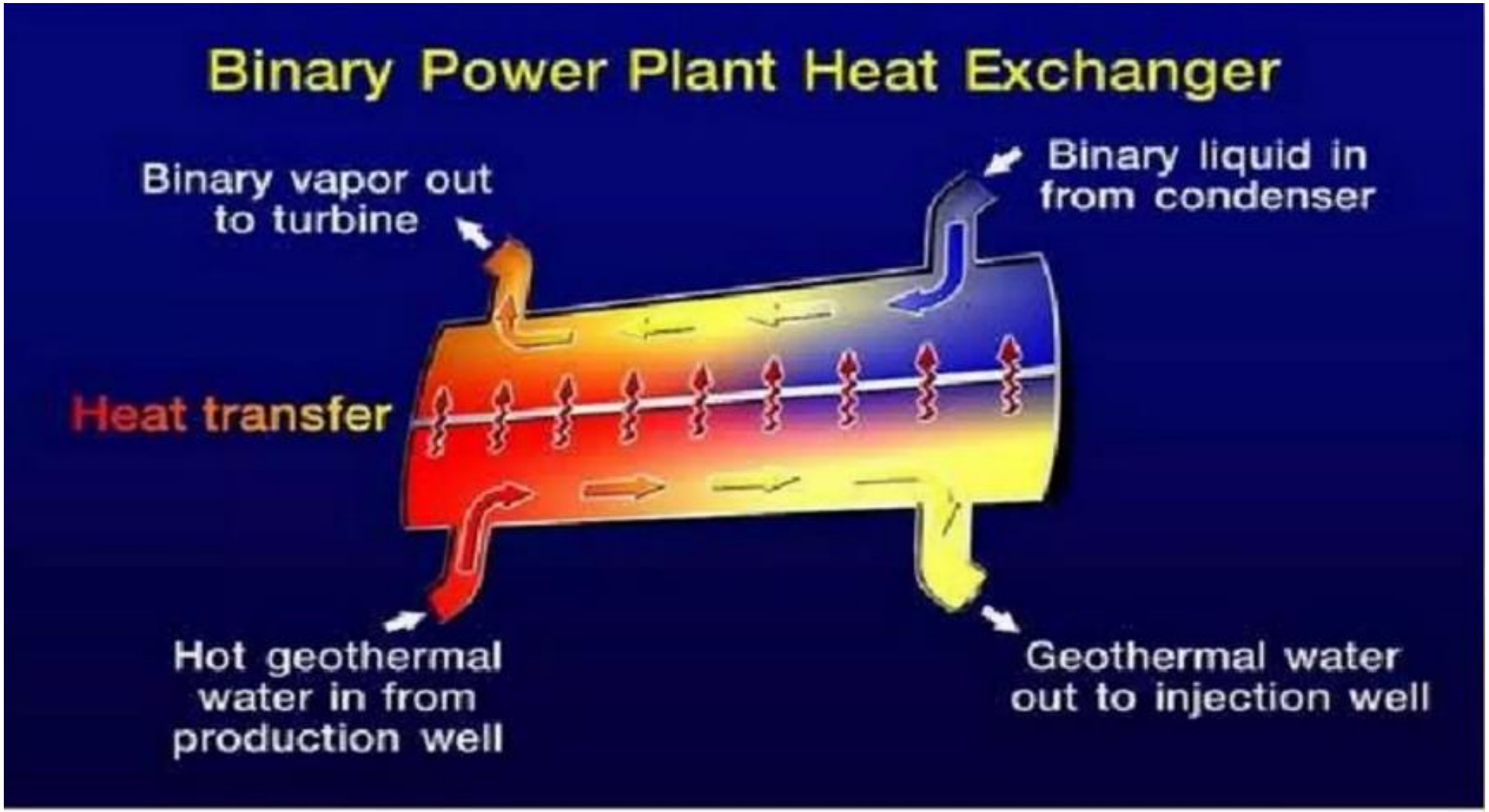
Known as binary geothermal plants, the facilities that make **this possible reduce geothermal energy's already low emission rate to zero.**

The geothermal water (called "geothermal fluid" in the accompanying image) heats another liquid, such as **isobutene** or other organic fluids such as **pentafluoropropane,** which boils at a lower temperature than water.

The two liquids are kept completely separate through the use of a heat exchanger, which transfers the heat energy from the geothermal water to the working fluid. The secondary fluid expands into gaseous vapour.

The force of the expanding vapour, like steam, turns the turbines that power the generators. All of the produced geothermal water is injected back into the reservoir.

Introduction



In the heat exchanger, heat is transferred from the geothermal water to a second liquid. The geothermal water is never exposed to the air and is injected back into the periphery of the reservoir.

Advantages

- Geothermal energy **does not produce any pollution, and does not contribute to the greenhouse effect.**
- The power stations do not take up much room, so there **is not much impact on the environment.**
- Geothermal energy generally involves **low running costs** since it saves 80% costs over fossil fuels and no fuel is used to generate the power.
- **Dependence on fossil fuels decreases** with the increase in the use of geothermal energy. With the sky-rocketing prices of oil, many countries are pushing companies to adopt these clean sources of energy.
- Since ancient times, people having been using this source of energy for taking bath, heating homes, preparing food and today this **is also used for direct heating of homes and offices.**
- Geothermal energy on the other hand has **created many jobs for the local people.**

Disadvantages

- The big problem is that there **are not many places where you can build a geothermal power station**. You need hot rocks of a suitable type, at a depth where we can drill down to them. The type of rock above is also important, it must be of a type that we can easily drill through.
- Sometimes a geothermal site may "**run out of steam**", perhaps for decades.
- **Hazardous gases and minerals may come up from underground**, and can be difficult to safely dispose of.
- To get geothermal energy, requires installation of power plants, to get steam from deep within the earth and this require **huge one time investment and require to hire a certified installer and skilled staff** needs to be recruited and relocated to plant location. Moreover, electricity towers, stations need to set up to move the power from geothermal plant to consumer.

TRIVIA:

- 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.

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.

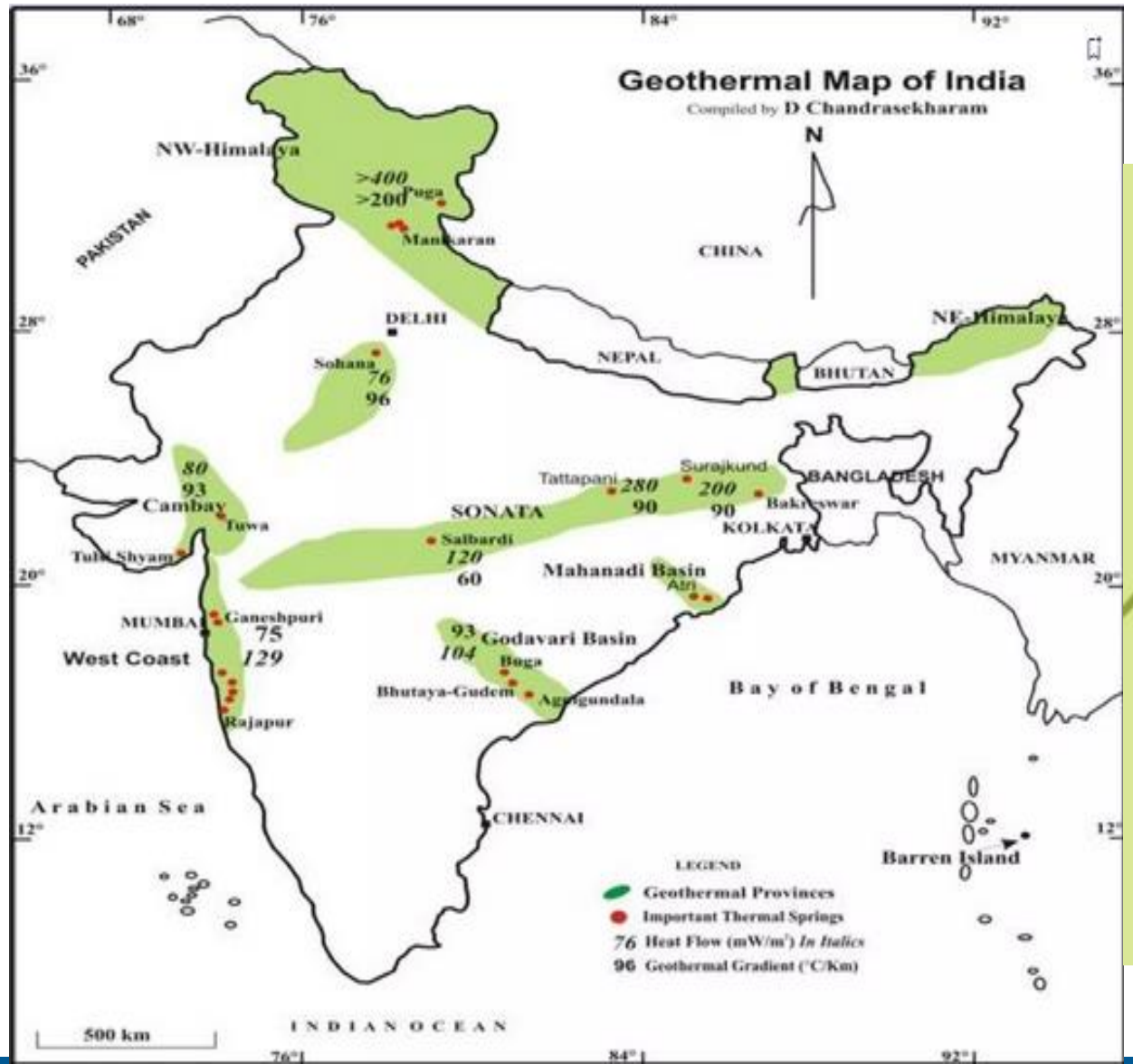
- Geological Survey of India has identified about 340 geothermal hot springs in the country. Most of them are in the low surface temperature range from 37° C-90° C which is suitable for direct heat applications.

- 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.

Prospects of Geothermal Energy in India



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.*

Conclusion

Summary

- Further development of Deep Geothermal Energy should be highly considered because of its
  - *Potential to allow new access to large resources*
  - *Environmentally friendly traits*
  - *Competitive costs in the long run*
  - *Ability to use existing technologies to begin extraction soon*