ENERGY, ENVIRONMENT AND SOCIETY

Chapter - 11

Geothermal Energy and Introduction of Biomass

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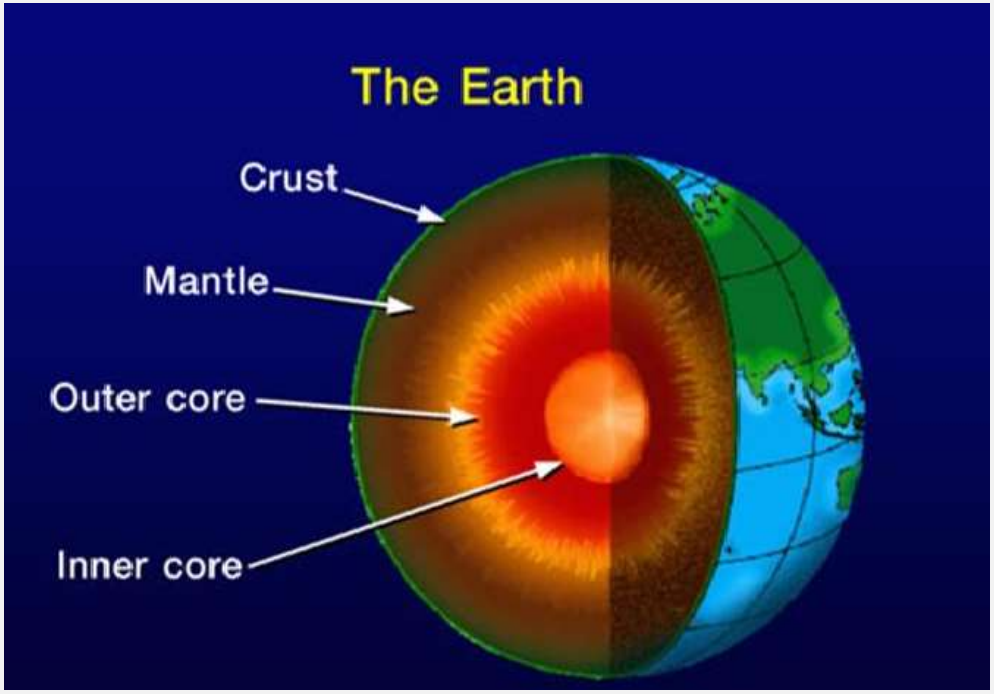
LEARNING OBJECTIVES OF THE LECTURE

- Basics of Geothermal Energy
- Types of geothermal energy sources
- Utilization of Geothermal Energy Sources
- Introduction of Biomass

INTRODUCTION

- Earth is composed of inner core, outer core, lower mantle, upper mantle and crust.

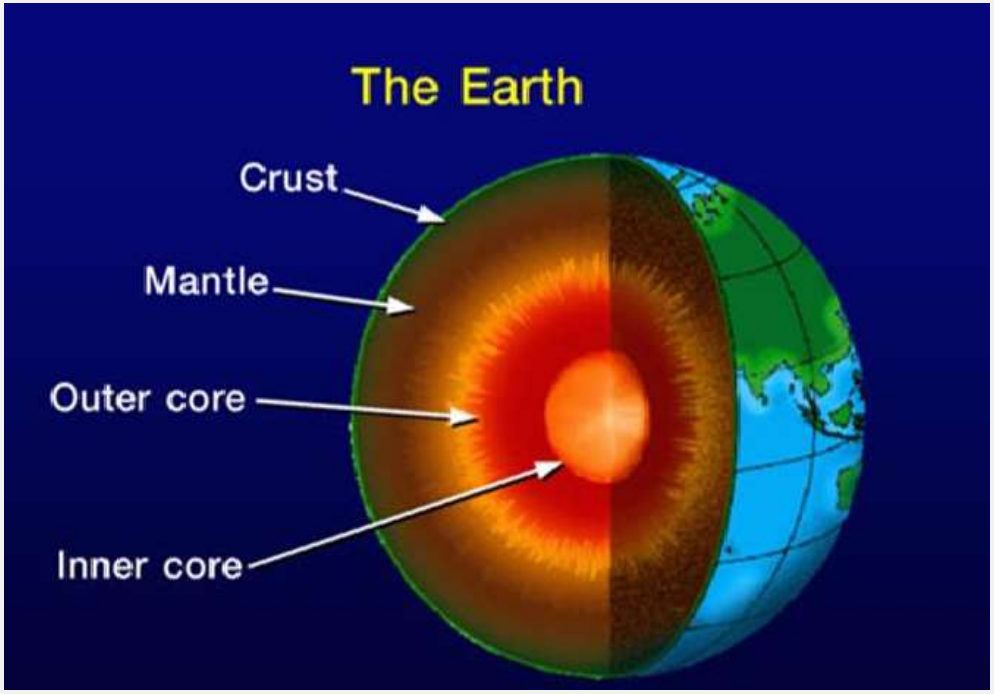


Source: (Engineering Corner., 2022)

INTRODUCTION

The Crust

- It is uppermost layer of the surface of earth that extends to variable depths below mountains, continents and oceans (S. Hasan & Sharma, 2009).
- The thickness of crust varies according to various regions in the earth. In the mountainous region, the thickness is 70-75 km, in continental areas the thickness is 30-40 km and in the oceanic water, it varies from 19 km to 5 km in deep oceans.

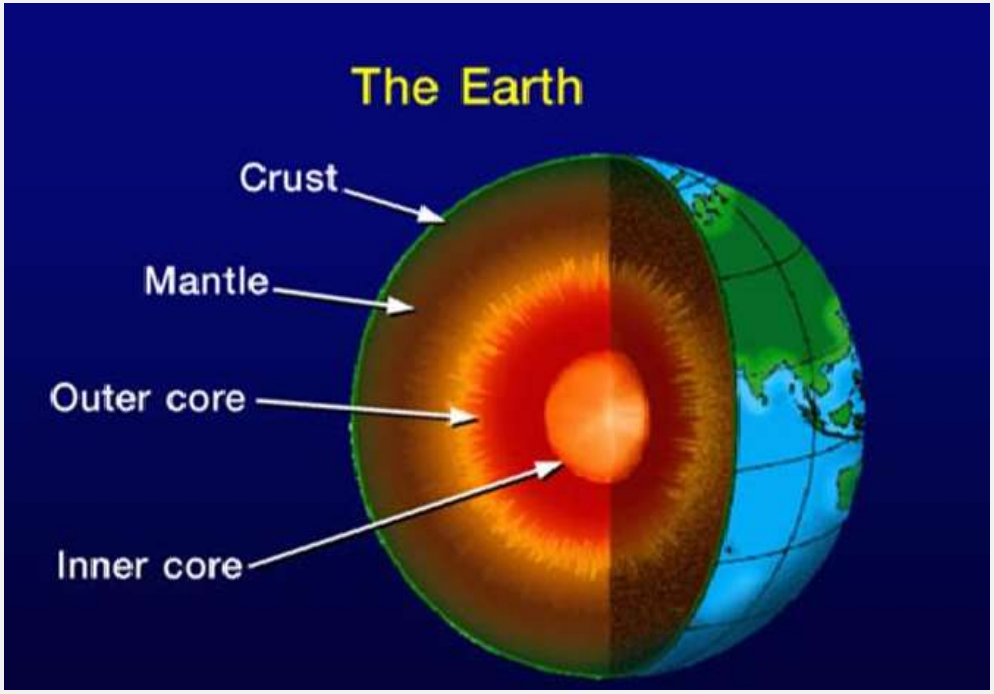


Source: (Engineering Corner., 2022)

INTRODUCTION

The Mantle

- Mantle is the second layer of earth which lies below the crust. The depth of mantle ranges from bottom of the crust to depth of around 2900 km.
- The thickness of mantle is divided into upper and lower mantle. The boundary between the two mantles lies at 900-1000 km below the earth.

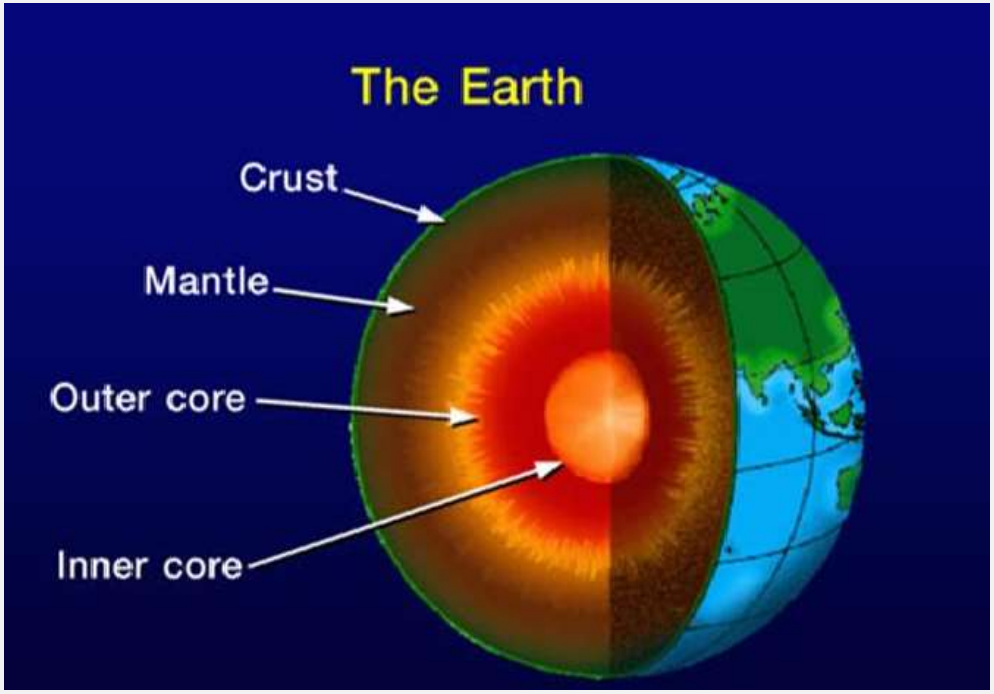


Source: (Engineering Corner., 2022)

INTRODUCTION

The core

- Core is the innermost layer of the earth. The core extends from bottom of mantle that is 2900 km below the earth's surface, to the center of the earth at 6371 km.
- The outer core behaves like liquid and the inner core is believed to be metallic body (S. Hasan & Sharma, 2009).The temperature at the center of the earth is around 7000 ºC.



Source: (Engineering Corner., 2022)

INTRODUCTION

- Geothermal energy means basically the thermal energy trapped beneath the earth's surface. The energy exists in the form of either hot water or steam, and/or hot or molten rock.
- Due to various faults and fractures in earth's surface (due to earthquakes or surface movement), rain water can seep down such faults for miles.
- After being heated, it can return to the surface as steam or hot water. The sources of geothermal energy are basically the thermal energy present in the core of the earth during its formation as well as the decay of heavy radioisotopes present within the earth.

TYPES OF GEOTHERMAL RESOURCES

- There are three main kinds of geothermal resources:

- Hydrothermal
- Geopressured
- Hot Dry Rock and

TYPES OF GEOTHERMAL RESOURCES

Hydrothermal

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.

The hydrothermal geothermal energy sources can be either liquid based or steam based that is Hydrothermal resources are used for different energy purposes depending on their temperature and how deep they are.

USES OF HYDROTHERMAL

- **Low Temperature “Direct Use”**
- **High Temperature Uses “Producing Electricity”**

USES OF HYDROTHERMAL

Low Temperature: "Direct Use" or Heating

- When the temperature of hydrothermal resource is around 50 F and up, it can be used directly in spas or to heat buildings, grow crops, warm fish ponds or for other uses. Heat from geothermal resources is also used to dry ceramics, lumber, vegetables and other products. Other uses can be

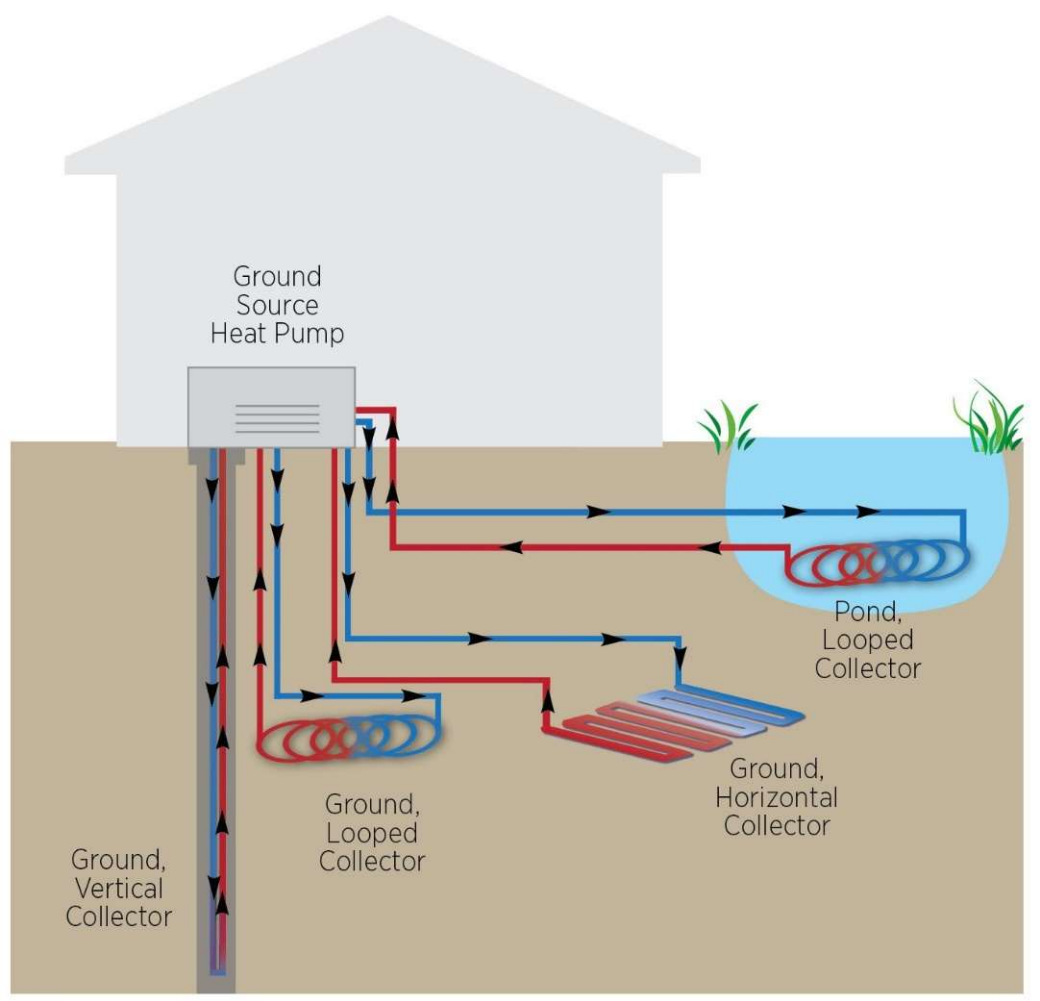
- Building air conditioning
- Greenhouse heating
- Drying food items
- Fish farming
- Hot water swimming pools
- Bio-digester heating
- Snow melting
- Soil warming
- Animal husbandry

USES OF HYDROTHERMAL

Ground Source Heat Pump

Heat pump is the similar device to refrigerator which used electrical energy to operate a compressor which then powers a cycle to producing heating or cooling effect.

Heat pump is basically used for space heating and/ or cooling. The main component of the heat pump is electrically driven compressor.



Source: (Colorado Country, 2022)

USES OF HYDROTHERMAL

Ground Source Heat Pump

A geothermal heat pump is the device similar to the conventional heat pump except for it utilizes the geothermal energy.

It differs from the other conventional geothermal energy utilization by the fact that heat is extracted from the wall of the bore from conduction rather than by using liquid as in cases of most of the geothermal energy utilization.

USES OF HYDROTHERMAL

Ground Source Heat Pump

The heat available from a well 100-150 m deep is only few kilowatts capacity and are sufficient for domestic installation.

For the depth, the cost of geothermal heat pump is competitive with conventional heat pump.

A pipe in a loop is installed where the heating or cooling agent circulates through the loop to the space required to be heated/cooled.

USES OF HYDROTHERMAL

High Temperature: Producing Electricity

When the temperature of a hydrothermal resource is around 220 F and up, it can be used to generate electricity.

Most electricity-producing geothermal resources have temperatures from 300 to 700 F. the high temperature based hydrothermal energy sources can be either vapor dominated or steam dominated system.

Vapor dominated systems have very small or no quantity of water present where as the liquid dominated system has mixture of steam and water.

USES OF HYDROTHERMAL

Following main types of hydrothermal resources are used to generate electricity:

- Dry steam reservoirs
- Hot water (flash steam power plant) reservoirs
- Binary cycle power plant
- Combined cycle power plant

USES OF HYDROTHERMAL

Dry steam reservoirs

These are rare but highly efficient at producing electricity.

Dry steam power plant is used for vapor dominated resources.

These kind of reservoirs have temperature typically around 180-225º C and pressure of 4-8 MPa, so that the steam from the reservoir reach the surface at very high velocity.

USES OF HYDROTHERMAL

Dry steam reservoirs

In a dry steam reservoir, the natural steam is piped directly from a geothermal well to power a turbine generator.

The steam is expanded in a steam turbine causing the blade to rotate which is utilized to generate power (Boyle, 2013).

The spent steam (condensed water) can be used in the plant's cooling system and injected back in to the reservoir to maintain water and pressure levels.

USES OF HYDROTHERMAL

Flash steam power plant:

Flash steam hot water geothermal reservoirs are the most common type. In a liquid dominated reservoir, the hot water has not vaporized into steam.

So to convert the water in to steam, it is piped from geothermal wells to one or more separators where the pressure is lowered and the water flashes (is converted) into steam.

USES OF HYDROTHERMAL

Flash steam power plant:

The steam then propels a turbine generator and produces electricity. The steam is cooled and condensed and either used in the plant's cooling system or injected back into the geothermal reservoir.

The flash steam power plant can be single flash steam power plant or double flash steam power plants depending on whether single separator or two separators are used to convert water into steam.

The main purpose of double flash steam power plant is to produce more steam

USES OF HYDROTHERMAL

Binary cycle power plant

This type of power plant is used when the water in a hot water reservoir is not hot enough to flash into steam.

Instead, the lower temperature hot water is used to heat a fluid that expands when warmed. The turbine is powered from the expanded, pressurized fluid.

Afterwards, the fluid is cooled and recycled to be heated over and over again. It can be used for reservoir with temperature less than 220-degree Celsius.

USES OF HYDROTHERMAL

Combined Cycle power plants

It is the combination of dry steam technology and binary cycle technology. Its overall efficiency is high. It can be used for reservoir with high as well as low temperatures

TYPES OF GEOTHERMAL RESOURCES

Geopressured

Geopressured resources are found when there is an impermeable later of sedimentary cap rock that traps a geothermal reservoir.

In these instances, the weight of the sediment layer and the lack of permeability increases the pressure inside the reservoir.

Geopressure resources typically range from 90 ºC to 200 ºC and the increase in pressure reduces the energy required to pump the resource making geopressured resources desirable

TYPES OF GEOTHERMAL RESOURCES

Hot Dry Rock

It is also known as Petro-Geothermal energy resources.

Hot dry rock is the high temperature rock available deep inside earth's surface with no water contact.

To utilize the energy of hot dry rock, water is pumped into hot crystalline rock via an injection well, which becomes superheated as it flows through open joints in the hot rock reservoir, and is returned through production wells.

TYPES OF GEOTHERMAL RESOURCES

Hot Dry Rock

At the surface, the useful heat is extracted by conventional processes, and the same water is recirculated to mine more heat.

Overall size of the reservoir is a direct function of the total amount of water pumped into the rock.

TYPES OF GEOTHERMAL RESOURCES

Hot Dry Rock

At the surface, the useful heat is extracted by conventional processes, and the same water is recirculated to mine more heat.

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ADVANTAGES/ DISADVANTAGES

Advantages

- Environment friendly
- Sustainable energy source
- Resistance to climatic variation
- Low operating cost
- Independent of future fuel cost
- Multiple direct use application
- High plant life

ADVANTAGES/ DISADVANTAGES

Disadvantages

- Environmental issues
- Tectonic movements
- Low efficiency
- Geographical difficulties
- Surface instability
- Heat and gas leakage
- Undesirable transfer of warm/cold water
- High initial investment
- High capital cost in comparison to other energy sources

BIOMASS INTRODUCTION

- With the growing world population, the emerging global shortage of fossil fuels and the rising concern about the shortage of conventional fuels, a new interest in wider and more effective use of the biomass has appeared.

- The word “biomass” is a very comprehensive term comprising of all forms of matter derived from biological activities and are present either on the surface of the soil or at different depths of vast body of water, lakes, streams, river, seas, ocean etc.

BIOMASS INTRODUCTION

- It is organic carbon based material that reacts with oxygen in combustion and natural metabolic processes to release heat.
- The initial material may be transformed by chemical and biological processes to produce intermediate biofuels, such as methane gas, ethanol liquid or charcoal solid.
- The initial energy of biomass-oxygen system is captured from solar radiation in photosynthesis process

BIOMASS INTRODUCTION

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Almost 43% of the energy used by the third world country is derived from biomass. Over 2 million people are totally reliant on biomass fuels for their energy needs.

About 90% of the total energy consumed in Nepal at present is supplied by biomass.

In a plant body during the process of photosynthesis, the sun's energy converts water and carbon dioxide into organic matter. About 3 $x10^{21}$ J of energy is stored in 2 x 10^{11} tonnes of organic matter produced annually by photosynthesis.

Yet only 14% of the world's energy comes from biomass.

BIOMASS INTRODUCTION

. **Biomass Sources**

The main sources of biomass are

Forests

Woods, twigs, branches, saw dust etc.

Agricultural residues

Rice husk, bagasse, straws, coconut shells, coffee husks, cotton stalks, jute stalks etc.

Aquatic and marine biomass

Algae, hyacinth, aquatic weeds.

BIOMASS INTRODUCTION

The energy value of biomass is best utilized by its conversion into more efficient biofuels.

Biofuels are the fuels derived from biomass conversion from materials such as wood, crops and waste materials. Biofuel can be solid, gaseous or liquid.

A distinction is made between primary and secondary biofuels.

In the case of primary biofuels, such as fuelwood, wood chips and pellets, organic materials are used in an unprocessed form, primarily for heating, cooking or electricity production.

Secondary biofuels result from processing of biomass and include liquid biofuels such as ethanol and biodiesel that can be used in vehicles and industrial processes.

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THANK YOU