# Heat Budget of the Earth

The concept of heat budget refers to the balance of heat energy received by the Earth from the sun and how it is distributed and utilized within the Earth's atmosphere and surface. The heat budget of the atmosphere is the amount of heat that is required to raise the temperature of the water lakes to a maximum level in the summers. The heat budget of the atmosphere is a combination of the following:

- 34% of radiations from the outgoing long-wave terrestrial,
- 48% of the solar radiation, and
- 14% of the radiation emerges from the shortwaves that enter the solar radiations.

## Components of Heat Budget of Earth

According to the wavelength of the radiation, we can categorize them into two parts i.e., Insolation and terrestrial radiation. Shortwave radiation, such as insolation, primarily consists of shorter wavelengths, including ultraviolet (UV) and visible light. On the other hand, terrestrial radiation, also known as longwave radiation, primarily consists of longer wavelengths, particularly in the infrared (IR) range.
Understanding the components of the heat budget of Earth is essential for comprehending phenomena such as temperature variations, heat transfer mechanisms, and the impact of human activities on the Earth's climate.

### Insolation

The solar radiation received by the Earth's surface in the form of shortwave rays. The mechanisms associated with insolation in maintaining the equilibrium of heat are:

| Component | Description |
|---|---|
| Reflection | The phenomenon where solar waves rebound off surfaces in the atmosphere, land, or water without being converted into heat. |
| Absorption | The process of converting electromagnetic radiation into thermal energy. |
| Scattering | The dispersal of solar waves in various directions when they encounter small objects in the Earth's atmosphere, such as air molecules, water droplets, or aerosols. |

### Terrestrial Radiation

The emission of longwave radiation from the Earth's surface or the atmosphere. The mechanisms associated with terrestrial radiation in maintaining the equilibrium of heat are:

| Component | Description |
|---|---|

| | |
|---|---|
| Latent Heat Transfer | The transfer of heat that occurs during a change in the phase of a substance, such as the transition from solid to liquid or from liquid to gas. |
| Sensible Heat Transfer | The transfer of heat to an object without causing a change in its physical state. |
| Emission by Vapour | The release of substantial amounts of terrestrial radiation due to the presence of water vapor. |
| Emission by Clouds | The release of significant quantities of terrestrial radiation by clouds. |

## Significance of Earth's Heat Budget

The heat budget holds immense significance as it maintains the Earth's temperature at levels suitable for supporting life and plays a critical role in various processes such as solar energy generation, temperature fluctuations, and facilitating the growth of plants through photosynthesis.
Variations in the net heat budget occur across different latitudes. In the tropical zone, there is an excess of insolation relative to terrestrial radiation, resulting in an abundance of heat. Conversely, the polar zone encounters a heat deficit, where heat loss surpasses heat gain, leading to a heat imbalance among latitudes. To counterbalance this inequity, winds and ocean currents play a pivotal role in redistributing heat from regions with a surplus to those with a deficit, thereby establishing a more uniform distribution of heat.

## Heat Budget of Earth Diagram

The heat budget of the Earth represents the balance achieved between the incoming solar radiation (insolation) and the outgoing terrestrial radiation, ensuring an equilibrium between heat acquisition and loss on a global scale. A heat budget diagram shown below illustrates the flow of energy in the Earth's system. It includes incoming solar radiation (insolation), reflected radiation along with other aspects highlighting the balance of energy within the Earth's heat budget.

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## Working of Heat Budget of Earth

Here, we have explained how the heat budget of Earth works:

- About 30% of all solar energy that reaches Earth is reflected back into space by Earth's atmosphere, clouds, and surface. The other 23% of energy is absorbed by water vapour, clouds, and dust in the atmosphere, which is converted into heat.
- Solar radiation is assimilated by ocean and land, and the Earth's surface gets heated with this energy. The atmosphere receives energy absorbed by the Earth through three processes: radiation, conduction, and latent heat.
- To understand how the heat budget of Earth works, consider that we receive hundred per cent of isolation at the topmost layer of the atmosphere. Some energy is reflected, some absorbed, and some scattered. Only a part of this energy reaches the Earth.
- Roughly the amount of energy reflected back to space is 35 units; 27 units of energy are reflected from the clouds, and areas that are covered with ice of the Earth reflect two units. This amount of reflected radiation is defined as the Albedo of the Earth.
- 48 units are being absorbed by the atmosphere, and a part of it is also radiated back to space. Hence, the total amount of radiation that returns from the Earth is around 65 units. The perfect balance of both incoming and outgoing heat forms the stable Heat Budget of Earth.

## Heat Budget of Earth and its Connection to Earth's Energy

To understand the heat budget, it is important to know the basics of the earth's energy flow. Despite the enormous transfer of energy in and out of the Earth, the Earth maintains its constant temperature because, as a whole, there is no net gain or loss. This is because the Earth emits the same amount of energy as it receives. This crucial mechanism forms the foundation of the Heat Budget of Earth.

### Heat Budget of Earth - Incoming Solar Energy

- The total amount of energy received on Earth per second at the top of the Earth's atmosphere is called Incoming solar energy.
- This is added to the total value of the heat budget. It is also called short-wave radiation. It is measured in watts.
- The Earth's sphere shape receives the approximate amount of 340 watts per square meter. Also, the amount of energy absorbed varies with location.
- Out of this 340 watts per meter square, 77 watts per metre square is reflected back to space by clouds and the surface of the Earth, and the rest 240-metre square is added to Earth's solar energy budget. This amount is called absorbed solar radiation.

### Outgoing Solar Energy and its Impact on the Heat Budget of Earth

- The total amount of energy leaving the Earth is called outgoing solar energy. It is also called longwave radiation.
- Energy absorbed is converted into different forms of heat energy, and some of it is emitted out of space in the form of OLR (outgoing longwave radiation). This energy is subtracted from the total energy value in the heat budget of the earth.
- We can say that Earth receives a certain amount of insolation in the form of short waves and gives back heat in the form of longwave radiations, and through this, the Earth can maintain its temperature and, consequently, a constant Heat Budget of Earth.
- Earth's energy is governed by the first law of Thermodynamics, which states that energy cannot be created nor destroyed.