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### RESEARCH ARTICLE

#### SOLAR ENERGY AND SUSTAINABLE DEVELOPMENT

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#### Abstract

The sun is the main source of energy on Earth. Other energy sources include coal, geothermal energy, wind energy, biomass, petrol, nuclear energy, and many more. Energy is classified into various types based on sustainability as renewable sources of energy and non-renewable sources of energy.

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#### Introduction:-

Energy is one of the important sources for the economic development of the country. Increasing energy demand needs huge investment to meet them.

The classical description of energy is the ability of a system to perform work, but as energy exists in so many forms, it is hard to find one comprehensive definition. It is the property of an object that can be transferred from one object to another or converted to different forms but cannot be created or destroyed. There are numerous sources of energy.

During the Stone Age, it was wood. During the Iron Age, we had coal. In the modern age, we have fossil fuels like petroleum and natural gas.

Energy is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical, or other forms. Energy is the ability to do work.

#### Following are the examples of sources of energy:

1. Biofuel energy
2. Hydropower
3. Geothermal energy
4. Solar energy
5. Nuclear energy
6. Tidal energy
7. Wind energy

Energy sources can be classified into several types based on various criteria. We can classify the energy source into the following three main types:

- (i) Primary and Secondary energy sources
- (ii) Commercial and Non-commercial energy sources &

(iii) Non-renewable and Renewable energy sources.

**(i) Primary and Secondary energy sources:**

These energy sources are stored and found in nature. For example: coal, crude oil, natural gas, biomass such as wood, agricultural waste etc. These primary energy sources are mostly converted into industrial utilities into secondary energy sources. Coal, Oil or gas is converted into steam or electricity for many applications.

**(ii) Commercial and Non-commercial energy sources:**

The energy sources that are available in the market for a definite price are known as commercial energy for example electricity, petrol diesel, oil, natural gas etc. The energy sources that are not available in the commercial market are known as non-commercial energy. For example Wood for fire, agricultural waste in rural areas, solar and wind energy, tidal energy etc.

**(iii) Non-renewable and Renewable energy sources:**

For the commercial and practical purpose energy sources can be divided into Non-renewable and Renewable energy sources.

Non-renewable energy sources such as coal, oil, natural gas etc. which will be exhausted with time.

Renewable energy is the energy obtained from sources that are essentially inexhaustible. For example, solar energy, wind energy, tidal energy, geo-thermal energy, gravitational energy, hydraulic power etc.

Electrical energy is the convenient form of energy & occupies the top position in the energy hierarchy. AC power can be generated centrally in bulk and transmitted economically over long distances & almost pollution free at the consumer level. DC power can be generated from solar PV panels & can be stored in batteries. Using solar inverters it can be converted into AC form or can be utilised in DC form using DC loads. Electrical energy can be generated using various energy sources available in nature.

These sources are: Sun, wind, water, fuels, coal, nuclear energy etc.



The conventional method of electrical energy generation with prime mover includes hydro power, thermal power & nuclear power generation.

The non-conventional methods of electrical energy generation without prime mover include magneto -hydro dynamic power generation, solar power generation, fuel cells power generation, thermoelectric power generation, wind power generation, geo-thermal energy generation, tidal power generation, bio-gas, using gravitational force etc. Among these various methods and techniques of non-conventional electricity generation solar power generation is the most convenient and popular method.

**What is renewable energy?**

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us.

### Solar Energy

The Sun is the primary source of energy. Sunlight is a clean, renewable source of energy. It is a sustainable resource, meaning it doesn't run out, but can be maintained because the sun shines almost every day. Coal or gas is not sustainable or renewable: once they are gone, there is none left. More and more people want to use clean, renewable energy such as solar, wind, geothermal steam and others. It is called 'Green Power'. It lights our houses by day, dries our clothes and agricultural produce, and keeps us warm and lots more. Its potential is however much larger

Solar energy can be converted into other forms of energy such as heat, electricity, & chemicals. Following three different ways are found to convert solar energy.

1. Solar thermal Systems
2. Solar Photovoltaic Systems &
3. Photosynthesis
4. Solar thermal Systems: Solar energy can be converted into thermal or heat energy using heat transfer fluids or solar reflectors.  
Examples are: solar water heaters, solar cookers etc.
5. Solar Photovoltaic Systems: In solar photovoltaic conversion photovoltaic (PV) devices or solar cells directly convert sunlight into electricity. Solar cells are PN junction semiconductor devices made up of Silicon, Germanium or Gallium Arsenide (GaAs) with proper impurities. These cells produce electricity in sunlight. Through the phenomenon of photovoltaic effect the DC (direct current) electricity is generated. So arrays of solar cells are called as solar panel. This DC power can be directly used for DC loads using MPPT or for the AC loads solar inverters can be used. PV systems are free from noise & produce clean energy. PV systems are cost effective for the long run even though the initial cost is high.
6. Photosynthesis: In photosynthesis, energy from sunlight is converted into chemical energy that can be used to fuel the organism's activities. Carbohydrates are synthesized from carbon dioxide and water. Less than 0.03 percent of solar energy is used for photosynthesis.

#### Advantages of solar energy:

- \*Solar energy is free, clean, & abundant in nature.
- \* It is pollution free.
- \* It can be used in remote areas where it is too expensive to extend the electricity power grid.
- \*Solar energy is infinite & will be forever

#### Disadvantages of solar energy:

- \*Solar energy is available in day time & sunny days.
- \*Initial cost of solar panels & solar thermal collectors & systems are high. But prices are following rapidly.
- \* In India and Asian countries solar power is available abundant but in European countries like UK the unreliable climate lead to unpredictable solar energy generation
- \* Large areas of land are required to capture the sunlight.

#### Is Solar Energy Sustainable?

As people and governments worldwide search for sustainable power solutions, solar has emerged as a frontrunner — especially for consumers.

Solar energy is clean, renewable, and more sustainable than fossil fuels at every stage of the energy production process. Electricity from fossil fuels requires finite and limited resources, like oil or coal.

Additionally, burning fossil fuels is responsible for producing up to 70% of greenhouse gas emissions — the primary driver of human-induced climate change.

In contrast, solar energy is abundant and infinite because it comes from sunlight. Photovoltaic panels convert sunlight into electricity for an unlimited supply of clean energy.

Solar energy is the most abundant of all energy resources and can even be harnessed in cloudy weather. The rate at which solar energy is intercepted by the Earth is about 10,000 times greater than the rate at which humankind consumes energy.

Solar technologies can deliver heat, cooling, natural lighting, electricity, and fuels for a host of applications. Solar technologies convert sunlight into electrical energy either through photovoltaic panels or through mirrors that concentrate solar radiation.

Although not all countries are equally endowed with solar energy, a significant contribution to the energy mix from direct solar energy is possible for every country.

The cost of manufacturing solar panels has plummeted dramatically in the last decade, making them not only affordable but often the cheapest form of electricity. Solar panels have a lifespan of roughly 30 years, and come in variety of shades depending on the type of material used in manufacturing.



### Technologies for productive use of solar energy

Solar energy can be used to generate electricity. Through Solar Photovoltaic (SPV) cells, solar radiation gets converted into DC electricity directly. The generated electricity can either be used as it is or can be stored in the battery. The stored electrical energy can be used when solar energy is not available. SPV is nowadays successfully used for home and street lighting and water pumping in villages. In hilly areas, solar water heating is also being used.

### Types of PV Solar Panels:

Solar panels can be mainly categorised into three types: (i) Semiconductor based solar PV panels (ii) Thin film or Perovskites type solar panels. & (iii) Hydrogen solar panels

(i) Semiconductor based solar PV panels:

These can be further categorised as (a) Polycrystalline solar panels (b) Monocrystalline solar panels (c) Bifacial solar panels.

Thin-film solar panels are typically not used for residential or domestic installations due to their lower life. They are normally used more commonly in larger utility-scale power plants. There are also adhesive thin-film panels, which can be used on windows and other vertical surfaces. These are also popular for RV solar energy systems. However, thin-film panels are generally less efficient than the other two types, which mean you need to cover a larger area to produce as much solar power as mono and poly panels.

While many aspects of electricity generation from solar power are 100% sustainable, there are currently no renewable or non-renewable energy sources with zero environmental impact.

It also minimizes carbon pollution impacts and emissions of greenhouse gases. Solar energy are a clean and environmentally friendly source of energy that produces no greenhouse gas emissions. This makes it an ideal energy source for India, as it can help reduce the country's carbon footprint and mitigate the impacts of climate change.

### Conclusion:-

By relying on clean, renewable sources of energy, such as solar and wind power, we can reduce our dependence on fossil fuels and decrease the amount of harmful pollutants like carbon dioxide that are emitted into the atmosphere. Solar energy is clean, renewable, and more sustainable than fossil fuels at every stage of the energy production process.

Crystalline silicon has been the workhorse of the PV cells for the past two decades and in fact, over 95% of the solar cells produced worldwide are composed of crystalline silicon. However, recent developments in solar cell technologies have produced thin-film and other types of photovoltaic cells with greater conversion efficiencies.

There are many benefits to investing in solar power for your home.

One benefit is sustainability, but it certainly doesn't stop there.

Switching to solar can save you a significant amount of money over the long term. It reduces (or eliminates) your reliance on ageing infrastructure and the unpredictable costs of fossil fuels.

Solar power is a reliable and eco-friendly form of energy that produces no harmful emissions, emissions when operating — making it better for your family and the planet.

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