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Energy crisis and renewable energy solution

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Abstract

The primary challenge of energy crises is due to triple threat of resource depletion, geopolitical volatility and the climate change. While finite fossil fuels face eventual physical scarcity, a more immediate crisis is their concentrated and often unstable supply chain, which fosters global insecurity. Concurrently, the relentless carbon emissions from these energy sources are driving catastrophic climate change, creating an environmental crisis of unprecedented scale.The solution lies not in a single technology but in a fundamental and rapid transition to a sustainable, resilient, and decentralized energy system. This paradigm shift is twofold: a radical improvement in energy efficiency across all sectors to reduce overall demand, and a wholesale decarbonization of the energy supply. The cornerstone of this transition is the massive deployment of renewable energy sources, primarily solar, wind, and geothermal, supported by enabling technologies that address their intermittency. In the present review article, I discussed the region of energy crises and their possible solution.

Keywords: Energy crisis, renewable energy, solution, climate change, energy sources

Introduction

The significant shortage in energy supply to a region or country is termed as energy crisis. The main cause of shortage in energy supply is the depletion of non-renewable energy resources and disruption in energy supply chain due to worse geo-political conditions. Sometimes short-term hike in energy demand due to bad weather conditions is also the main cause of energy crisis. The main cause of energy crisis in India is due to their large dependence on non-renewable energy resources. India fulfill their energy demand by importing fossils oil and gases from middle east countries, Russia, United states etc. Any geo-political conflict in middle east countries disrupted the power supply chain and resulted in huge oil prices which directly impacted the cost of importing oil prices. Sometimes the lack of proper energy distribution infrastructure and inefficient power transmission is also responsible for the energy crisis in India. Some of the world important energy crises are as follows:

(i) Energy crisis in 1970: This crisis was due to huge demand and peaking of major oil production by industrial nations.

(ii) Energy crisis in 2000: This crisis was due to depreciations in U S dollar value and hike in global petroleum demand and oil prices.

(iii) California electricity crisis in 2000-2001: This crisis was due to oil market manipulation by Enron.

(iv) China energy shortage in 2005 and 2008: This energy crisis in china is due to damaged power transmission network and shortage of fossils fuels.

(v) Energy crisis in central Asia 2008: This energy crisis is due to bad weather conditions such as extremely cold condition and low level of water which badly disrupt the hydroelectric power generation.

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(vi) Global energy crisis: This energy crisis was escalated after COVID pandemic-2019 due to huge global energy demand.

(vii) Russia-Ukraine war 2022: Russia's full - scale military invasion of Ukraine on 24-02-2022 escalated geo-political tension across the globe. The geo-political tension induced a long time uncertainty in oil prices and global oil supply network.

The energy crises have huge impact on social, economical, political and environmental conditions. The impact of energy crises is discussed pointwise as follows-

(i) Environmental impact: The most of the country in the world's are depend on few oil producing country to meet their energy requirement. Any energy crisis leads to the more production of oil and coals which is also known as fossils fuels. The burning of fossils fuels produces green house gases such as CO_2 and CH_4 that act like a blanket wrapped around the earth trapping the Sun's heat and rising the environmental temperature. This is called as Green-house effect. The permanent changes in the environment temperature leads to the climate change. Climate change refers to long term shifts in temperature and weather patterns. Such shifts can be natural, due to changes in sun's activity or large volcanic eruptions. But since 1800s, human made activities have been main driver of climate change. Climate scientist showed that humans are responsible for virtually all global heating over the last 200 years. The average temperature of the earth surface is now about 1.2℃ warmer than it was in the late 1800s (before industrial revolution). The earth is a system in which any changes in each environmental condition are connected to each other.Therefore permanent changes in earth temperature leads to the intense droughts, heavy rain, flooding, rising sea levels, water scarcity, severe fires, melting of polar ice storms and decline of biodiversity.

(ii) Political and social conflict: Sometimes energy crisis leads to the geopolitical conflict among the nations. Geopolitics such as political instability, war and terrorism can impact energy security by disrupting energy supplies and infrastructure. Geopolitics may also effect investment in energy production and infrastructure.

(iii) Economical problem: In emerging and developing economy, where the share of house- holds budgets spent on energy and food is already large, higher energy bills have increased extreme poverty and set back progress towards achieving universal and affordable energy access. Even in advanced economies, rising prices have impacted vulnerable households and caused significant economic, social and political strains.

2. Renewable Energy Sources: Renewable energy sources are natural resources that are available in abundance and that are constantly renewed in nature. Although they cannot be considered inexhaustible, they differ from non-renewable sources that take millions of years to decompose. The main types of renewable energy are wind, solar, hydro, geothermal, biomass, ocean energy, and hydrogen.

2.1 Solar energy: Solar energy is a clean, inexhaustible, and abundant renewable energy source, but it is not continuous. To ensure greater energy efficiency in the absence of the sun, studies are continually carried out in order to improve the storage and conversion of thermal energy. According to studies, only 0.015% of all solar radiation transmitted annually to the Earth would be able to meet global energy demand (Chen et al., 2023). It is a type of energy that has the potential to replace traditional energy sources. It has significant environmental advantages. It helps to reduce the emission of CO_2 and other gases such as SO_2, responsible for the greenhouse effect and acid rain, respectively. It uses an inexhaustible source of energy as raw material. In this way, it reduces the depletion of natural resources and dependence on non-renewable resources, such as petroleum products. It guarantees energy security, as it is a perennial energy source.

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Solar energy is generated by photovoltaic conversion and solar thermal conversion technologies. In photovoltaic systems, electrical energy is generated and stored from solar irradiation. Photovoltaic solar energy is based on the photoelectric effect, in which some materials are able to absorb luminous particles and release electrons. The capture of solar radiation takes place by photovoltaic panels that are made up of smaller structures, called photovoltaic cells. Photovoltaic cells (made of semiconductor material) absorb photons, elementary particles present in sunlight. The absorbed photons excite the electrons present in the photovoltaic cell and the movement of these electrons generates an electric current. In solar thermal conversion, solar energy is stored in the form of thermal energy. The solar thermal energy system uses solar thermal collector panels to capture the sun′s heat and transfer it to a fluid (usually water). The liquid is heated to a certain temperature. After reaching the programmed temperature, the liquid is transferred to a reservoir that keeps the fluid warm for a long time. Thermal solar energy has domestic and industrial applications. Heats water for taps, showers, swimming pools, and boilers. Rainy days can reduce heating efficiency, but there are mechanisms that aim to minimize these effects. Heating systems are usually linked to the electrical network or gas heating systems. So, you can keep the water warm on rainy days.

It has disadvantages as in any power generation system. Its main disadvantage, in addition to the high cost, is the need for a huge area for installing solar panels. However, new models have been created to remedy these problems, and solar panels can take advantage of unused areas and can be installed on the roofs of houses and industrial buildings. In addition, the intermittency of the solar energy system requires the implementation of a storage system. It entails additional cost and the systems have low storage capacity. The generation of electricity from solar energy has shown a vertiginous growth in recent decades. Fig. 1 shows the world electricity generation corresponding to solar energy in the period from 2001 to 2023.

2.2 Wind energy: Wind energy has a relatively low cost and does not emit polluting gases into the atmosphere. It does not produce waste when generating electricity and there are no costs related to obtaining raw materials. Energy production stems from an inexhaustible natural resource. Therefore, it is a type of renewable energy. One obstacle encountered in wind power generation is related to the acquisition of advanced technology equipment. Countries like Brazil and India rely exclusively on imports. These countries employ North American and European technology, making installation expensive. However, the installation and maintenance costs of a wind farm have been reduced over the years. In this way, wind energy has become more competitive in the international market and may be more economically viable than hydroelectric energy. There are moreover problems of an environmental and social nature. The installation of equipment interferes with the flight of birds, causes noise pollution, and changes the local landscape. Wind energy is influenced by the wind regime, but this can be compensated with new technologies that allow conversion and constant transmission of energy. There are two types of wind energy, and they depend on where the wind power plants are installed. Installing turbines on land (usually close to shore) is called onshore wind power. They can also be installed in regions farther from the coast, but they need a constant regime of strong winds. Preferably, they should be installed far from urban centers, such as in depopulated rural areas. This type of installation is advantageous because it has lower installation and maintenance costs. On the other hand, wind farms can be installed on the high seas and are called offshore. In these places, the winds are usually stronger and more constant, increasing energy efficiency. In addition, turbines can be larger and more powerful than onshore equipment.

Despite the obstacles, it can be used as an alternative to diversify the energy matrix, mainly replacing fossil fuels. It is a cleaner and more sustainable energy source and can complement the energy supply in countries

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with permanent or seasonal energy shortages. It also contributes to new job opportunities in regions that generally receive little investment. It is speculated that wind power will be the largest source of electricity generation by 2050, and will have the capacity to supply a third of the global electricity demand (Zhang et al., 2022). The growth in wind energy production in recent decades has been remarkable. Fig. 1 shows the world electricity generation corresponding to the wind in the period from 2001 to 2023.

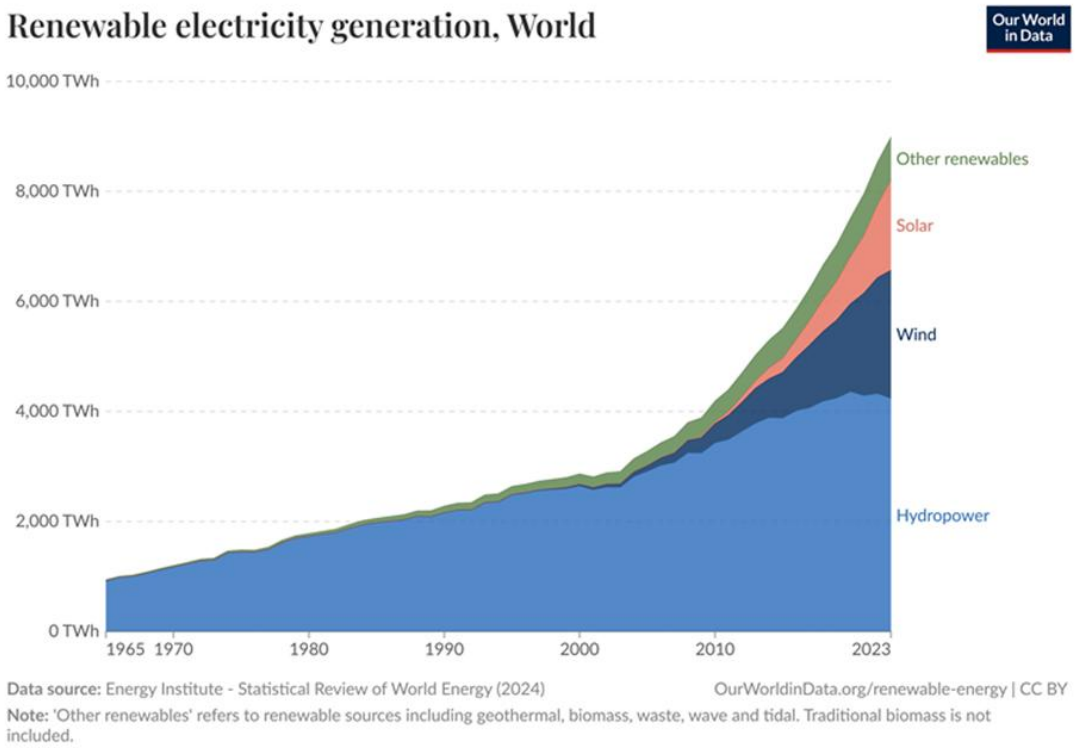

Fig.1 Depicts contribution of different components of renewable energy in the world total renewable electricity generation.

2.3 Hydroelectric power: Another type of renewable energy that is widely used is hydroelectric power. In this type of energy, electricity is generated by the force of water. The potential energy of water is transformed into kinetic energy and subsequently converted into electricity. It is a type of renewable energy that has already been consolidated, has high efficiency, and has several advantages. The water used is potable and can even be used for irrigation. Hydroelectric power plants require low investments compared to other renewable energy sources such as solar and wind. In this way, electricity can be supplied at cheaper rates, and CO_2 emissions are low in relation to fossil fuels (Chang et al., 2022). Despite the advantages, compared to solar and wind energy, it cannot be considered clean energy. Hydroelectric dams emit greenhouse gases, such as methane, from the rapid degradation of organic matter in areas that are flooded during damming. As the level of reservoirs rises, the methane concentration in the water also rises. Upon reaching the turbines, the dissolved methane is released into the atmosphere. The increase in temperature also causes the release of methane into the atmosphere. CO_2 is emitted due to the decomposition of dead trees that are above the water level of the reservoirs. The green house gases emitted annually by hydropower plants are estimated at 48 Mt of carbon in the form of CO_2, and 3 Mt in the form of CH_4 (Gemechu and Kumar, 2022). In addition, they furthermore have other disadvantages. The construction of hydroelectric plants usually requires the relocation of traditional populations and causes the loss of biodiversity, especially in the Amazon region. The filling of the reservoirs alone causes numerous impacts and makes the flooded lands unusable, as well as changing the courses of

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rivers and affecting ecosystems. In the same way as solar and wind energy, energy from hydroelectric plants depends directly on weather conditions. In periods of drought or low rainfall, the reservoirs present a reduction in the volume of water and, therefore, the hydraulic potential is also reduced and causes an increase in the price of the energy tariff for the final consumer. On the other hand, the construction of hydroelectric plants tends to benefit the local economy. The development of infrastructure makes it possible to set up companies and businesses in the region, with the creation of jobs. In addition, hydroelectric plants are transformed into tourist attractions, as in the case of the Itaipu plant, on the border of Brazil and Paraguay. Despite the counterpoints, the production of electricity from hydropower has increased in recent decades. Fig. 1 shows the world generation of electricity corresponding to hydroelectric plants in the period from 2001 to 2023.

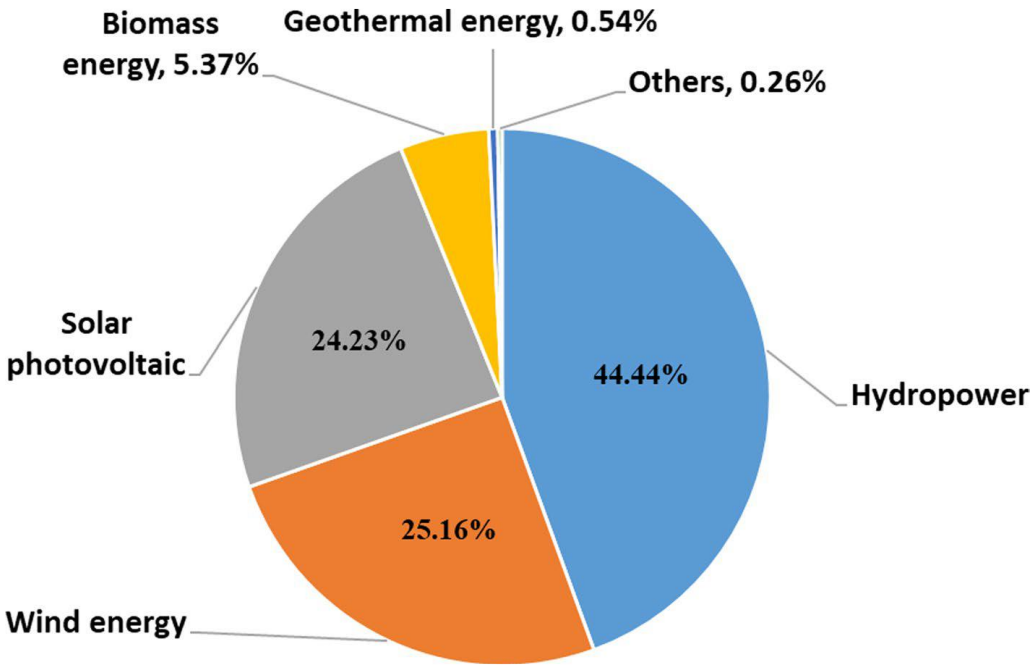

Figure. 2 After Rehman et al 2022. Share of energy renewable sources in electricity generation.

2.4 Geothermal energy: Geothermal energy, unlike those mentioned above, is not dependent on climatic conditions, is not affected by seasonality, and is a renewable and stable energy. Extracted in a viable, efficient, and sustainable way, it is an almost inexhaustible source of energy. Geothermal energy is characterized by heat from the Earth, generated in a layer of molten rock called magma, which can reach up to 6000°C. If the earth′s crust has cracks, the magma can come to the surface in the form of volcanic eruptions or heat groundwater, being expelled in the form of geysers. It is usually used in conjunction with other energy sources and can be used to supplement non-renewable energy, such as in coal-fired power plants in the heating of boilers. It moreover supports renewable energy sources, mainly solar and wind and, although it is not a fully sustainable renewable energy, it is a low-carbon alternative and has the potential to replace fossil fuels and initiate decarbonization processes in energy-transition countries (Spijkerboer et al., 2022). It is possible to transform geothermal energy into electricity from the installation of geothermal plants close to geothermal reservoirs that have a high amount of steam and hot water. The hot water or steam is collected through pipes and is directed to the plants and released under high pressure. The high flow moves turbines that mechanically drive the generator that produces electricity. But the evaluation of geothermal resources is essential, as high consumption rates can cause cooling of the original reservoirs, though exploration strategies and the use of

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certain equipment can avoid environmental impacts and even disasters (Liu et al., 2022), such as small earthquakes, caused by geothermal good drilling, which generates fractures in the ground and sometimes landslides. This ground drilling can cause the emission of toxic gases into the atmosphere and drinking water can become contaminated with hydrogen sulfide or ammonia, for example. A geothermal energy installation project is usually long and expensive. By the year 2050, geothermal energy is expected to have an annual electricity generation potential of 1,400TWh, which corresponds to approximately 3.5% of world energy production (Spijkerboer et al., 2022). However, in the year 2021, the global geothermal renewable energy capacity was only 15,960 MW, which represents only 0.50% of the global renewable energy capacity (Our World in Data, 2022b).

2.5 Biomass energy: One type of energy, unknown to some and little explored, is ocean energy. Unlike wind and solar energy, there are several types of ocean energy, namely thermal, mechanical, and gravitational energy, which can be converted into electricity via appropriate devices. These types of energy are captured in wave energy, tidal energy, energy from differences in temperature, and ocean current energy. Classified as mechanical energy, wave energy technologies convert kinetic and potential energy into electricity, tidal energy uses water level variation for power generation, and ocean current energy extracts kinetic energy from the marine current and transforms it into electricity through the rotation of turbines (Li et al., 2022). Energy from the difference in temperature, furthermore, known as ocean thermal energy, is produced by the temperature differences of ocean waters, as surface waters are warmer and deep waters are colder. Ocean energy is renewable, abundant, non-polluting, available 24 hours a day, and promising. It is feasible for countries close to seas and oceans, considering that the planet is formed by 70% of water and, of this total, 97% comes from the oceans. In 2021, it represented only 0.02% of the global renewable energy capacity (524 MW) (Our World in data, 2022b). As with any energy source, there are disadvantages; unstable power supply, dependence on weather conditions, high cost of installation and maintenance of equipment, noise that affects the marine fauna and local population, visual pollution, and interference with sea navigation are some of them.

2.6 Ocean energy: One type of energy, unknown to some and little explored, is ocean energy. Unlike wind and solar energy, there are several types of ocean energy, namely thermal, mechanical, and gravitational energy, which can be converted into electricity via appropriate devices. These types of energy are captured in wave energy, tidal energy, energy from differences in temperature, and ocean current energy. Classified as mechanical energy, wave energy technologies convert kinetic and potential energy into electricity, tidal energy uses water level variation for power generation, and ocean current energy extracts kinetic energy from the marine current and transforms it into electricity through the rotation of turbines (Li et al., 2022). Energy from the difference in temperature, furthermore, known as ocean thermal energy, is produced by the temperature differences of ocean waters, as surface waters are warmer and deep waters are colder. Ocean energy is renewable, abundant, non-polluting, available 24 hours a day, and promising. It is feasible for countries close to seas and oceans, considering that the planet is formed by 70% of water and, of this total, 97% comes from the oceans. In 2021, it represented only 0.02% of the global renewable energy capacity (524 MW) (Our World in data, 2022b). As with any energy source, there are disadvantages; unstable power supply, dependence on weather conditions, high cost of installation and maintenance of equipment, noise that affects the marine fauna and local population, visual pollution, and interference with sea navigation are some of them.

3. Summary: Energy produced from fossils fuels contributes significantly to global climate change. It accounts more than 75% of global green house gas emissions and 90% of all CO_2 emissions. To decarbonize the energy sector, an alternative energy from renewable energy sources must be utilized. However, the adverse

effects of climate change, such as increasing temperatures, extreme winds, rising sea levels, and decreased precipitation may impact renewable energy. Renewable energy sources could decarbonize 90% of the electricity energy by 2050. By establishing the zero carbon emission decarbonization concept, the future of renewable energy is promising, with the potential to replace fossil fuels derived energy and global temperature rise to 1.5°C by 2050.

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