CHAPTER 11

Renewable Energy Sources and Energy Storage

Muhammet Raşit SANCAR[1]

INTRODUCTION

The energy sector in the world is undergoing great changes and energy transformation is the key point of the technical, economic and political agenda of all countries of the world. One of the first talks globally to overcome the problems at this key point started with the acceptance of the Paris climate agreement in 2015. 195 countries around the world have made a commitment to prevent the increase in global average temperature levels. In accordance with this treaty, all countries have turned to new energy sources to reduce CO2 emissions. The reason for this is the rapid increase in the world's energy demand and this demand is primarily provided by fossil energy sources. Due to the limited availability of fossil fuels and their negative effects on the environment, a significant change in energy systems and new approaches are needed to meet the increasing global energy demand without harming the environment, society, economy and the welfare of the future population. In order to reduce and eliminate these negative effects, the use of renewable energy sources should be increased and the available energy should be used efficiently.

1 Isparta University of Applied Sciences, Institute of Postgraduate Education, Energy Systems Engineering, Isparta, Turkiye, ORCID Code: (0000-0002-4488-8393), d1840640001@isparta.edu.tr

RENEWABLE ENERGY SOURCES

Hydroelectic Energy

Hydroelectric energy is among the most widely used renewable energy sources. In hydroelectric power plants, electricity is produced by utilizing the power of flowing water. Hydroelectric energy is divided into two as dam and river. Water is accumulated in the dams and then the kinetic energy of the water is utilized as a result of transferring the water from the high position to the low position. On the other hand, the kinetic energy of the water is used directly in the stream type ones. The capacity of this energy changes according to climatic conditions.

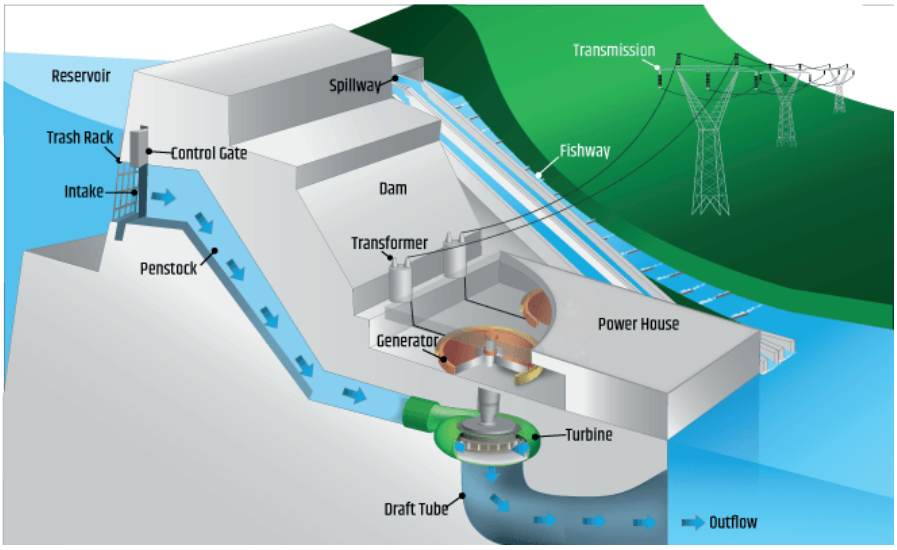

Figure 1. Hydroelectric Power Plant

Wind Energy

Wind is the movement of air caused by temperature and pressure differences in the air. Wind energy is the energy of the air flow. Mechanical systems are needed to use wind energy in electrical power generation. These systems are called wind turbines. These systems first convert wind energy into mechanical energy and then into electrical energy. A wind turbine has more than 1000 components (Olabi, 2021). These components are examined under five main headings. These are the blades, the foundation, the engine compartment, the tower and the generator (Wind Turbine, 2022). The kinetic energy of the wind is converted into mechanical energy in the rotor.

The rotational movement of the rotor shaft is accelerated and transferred to the generator in the body. The electrical energy obtained from the generator is stored by batteries or delivered directly to the buyers (Elibüyük, 2014). Wind turbines are classified in 3 main groups as horizontal axis, vertical axis and inclined axis. Horizontal axis wind turbine is most commonly used.

Figure 2. Horizontal axis and vertical axis wind turbines (Wind Power, 2022)

Solar energy

Solar energy is the source of life, unlimited and one of the best energy solutions that does not cause environmental pollution. Solar energy usage technology is increasing, progressing and becoming economical day by day. Solar energy comes to the world in the form of electromagnetic waves consisting of photons. The amount of solar radiation coming to the earth's surface depends on the region where it comes from, temporal and meteorological, etc. It reaches different amounts depending on many factors (Redweik, 2013).

An accurate estimation of the hourly, daily, weekly, monthly or annual amount of global solar radiation reaching the Earth's surface is of great importance while developing solar energy sources and technology and determining the appropriate locations where this technology will be used. It is predicted that determining suitable places for solar panel placement will provide benefits not only environmentally, but also economically by analyzing the energy production potential, existing transmission system and solar energy market, considering environmentally sensitive areas and land accessibility (Gastli, 2010).

One of the most important usage areas of solar energy is to generate electrical energy from this energy. Solar cells are used to convert this energy into electrical energy. Solar cells work on the principle of photovoltaic operation. This principle is based on semiconductor technology. These cells enable the direct conversion of solar energy into electricity using crystalline silicon or semiconductors made of different materials. Solar panels are formed by connecting solar cells in parallel and in series. Solar panels are mono and poly crystalline silicon, CdTe, bifacial, halfcut etc. It is produced and used according to its material, structure and technology. Concentrated Solar Energy (CSP) Technology is based on concentrating solar radiation into a small area using lenses and mirrors. Solar energy can also be used as a heat source in a conventional power plant (Muneer, 2011). In this field, 4 common technologies are used as parabolic chute, bowl mixers, concentrated linear Fresnel reflector and solar tower. This classification is based on different techniques used to track and focus solar radiation; however, they are close to each other in basic principle (Muneer, 2011).

Figure 3. Solar panels (Solar Energy, 2022).

Biomass Energy

Biomass refers to the mass of living organisms, including animals, microorganisms and plants, or, in biochemical terms, protein, cellulose, sugar and fats. It also includes above-ground and underground parts of plants such as branches, trunks and tree roots. Many plants such as sugarcane, corn, flaxseed, soybean can be grown to obtain biomass. Biomass is a comprehensive term for all substances of biological origin.

All natural substances of vegetable or animal origin, the main components of which are carbohydrates, are biomass energy sources, and the energy obtained from these sources is called biomass energy. Biomass energy has been used by human beings for many years. It continues to be used on a small scale as a fuel in stoves and stoves, primarily used for domestic purposes, in developing countries. In modern countries with advanced technology, it is known that in larger scale cogeneration systems, electricity generation and the waste heat generated are used for heating purposes. In transportation, biofuels are used as an alternative to fossil fuels such as gasoline, diesel and LPG. The share of biomass energy in renewable energy sources continues to increase day by day. It is foreseen that the development and regular management of biomass use and conversion technology will provide many advantages. Some of these are given below.

Potential to replace fossil fuels

To be able to meet the deficit in energy supply to a large extent,

Causes a significant reduction in greenhouse gas emissions

Being easily accessible as a local resource and reducing energy security problems during importation like fossil fuels

It has many advantages such as contributing to the economy of the rural area and social effects.

Figure 4. Biomass power plant (Energy Power Plant, 2022).

Geothermal energy

Geothermal energy is called steam or hot water energy, which is formed by the effect of heat in the core of the earth at certain depths of the earth's crust. This type of energy will not lose its feature of being a renewable energy source and its sustainability as long as the geological conditions are not deteriorated due to the fact that the sources that provide the formation of geothermal energy are the fluids on the earth and they constantly feed the underground reservoirs. This thermal energy is stored in rocks and fluids at the center of the earth. Due to the high temperature difference between the earth's core and the earth's crust, there is a continuous flow of thermal energy from the core to the earth. Geothermal energy is classified in three ways as low (20-70 °C), medium (70-150 °C) and high temperature (>150 °C). It is used in different areas according to temperature values. While it is generally used in areas such as heating, cooling and industrial sectors in areas where low and medium temperature geothermal energy is present, it is used in electricity power generation plants in high temperature energy regions. It has many advantages because it is a renewable, sustainable, clean, cheap and natural resource.

Figure 5. Geothermal power plant (Renewable Energy, 2022).

Wave energy

Wave energy is actually an intense form of solar energy produced by the action of the wind blowing on the ocean surface. When the sun's rays

warm the earth's atmosphere, a temperature difference occurs between the air masses and the air moves from the warmer regions to the colder regions, causing the formation of winds. Waves occur as a result of the wind transferring some of its energy to the water as it blows from the surface of the ocean or sea. In fact, it can also be seen as a large energy storage collector transferred to the oceans by the sun, along with the waves carrying the kinetic energy transferred across the surface of the oceans." Wave energy is one of the other types of renewable energy that can be used for electricity generation. Wave energy is captured by equipment placed on the surface of the oceans and this mechanical energy is converted into electrical energy. Thus, waves appear to be a form of energy, not a body of water moving across the ocean surface. One of the most important features of this type of energy is that they can travel long distances in open oceans with very little energy loss. As they approach the coastal area, their speed may slow down depending on the depth of the water, but their size increases. Therefore, waves hitting the shoreline release a very high amount of kinetic energy. Wave energy varies depending on geographical location, season, wind strength and duration.

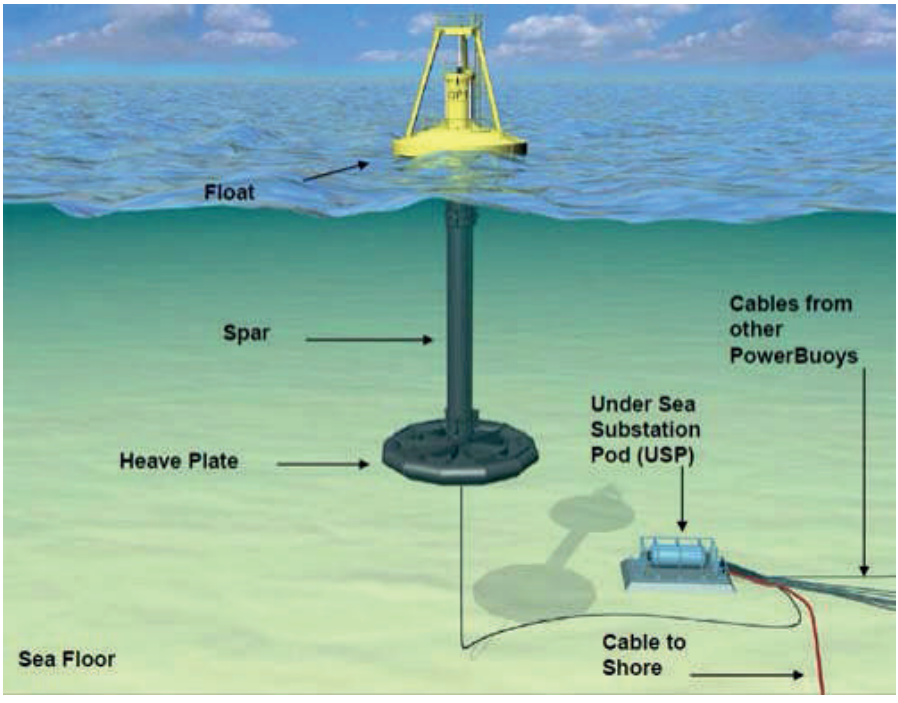

Figure 6. Wave energy converter (OPT, 2022).

Energy storage

Due to the intermittent nature of Renewable Energy systems, studies are carried out on different methods to ensure sustainability. One of the most important of these studies is the storage of energy. In order to increase the life and efficiency of power systems, there is a need for energy storage in a primary or secondary form to transfer excess demand energy to more suitable future times.

Energy storage systems can be examined under three general headings: electromagnetic, mechanical and electrochemical storage. Mechanical energy storage technologies include compressed air energy storage, Flywheels and hydro pump energy storage. Electrochemical energy storage technologies include battery and hydrogen-based energy storage systems. Electromagnetic energy storage technologies consist of super capacitors and superconducting magnetic energy storage systems. Energy storage systems can meet energy needs in a wide range of time, ranging from a few seconds to a few days. A schematic representation of energy storage systems is given in Figure 7.

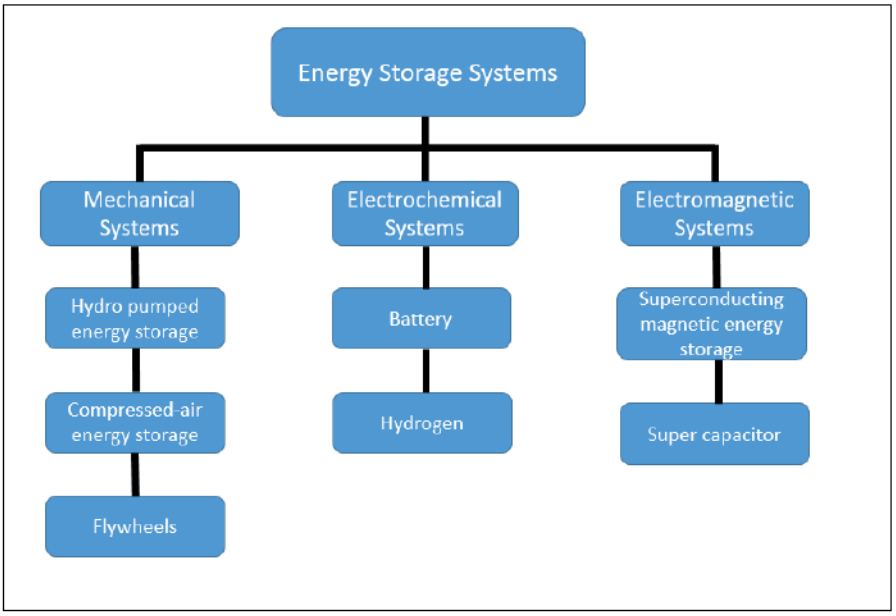

Figure 7. Schematic representation of energy storage systems

There have been many different energy storage systems on the market for many years, and technological improvement studies continue. There are many reasons why energy storage technologies are unique and used in smart

renewable energy systems. The prominence of this technology is its synergy with new processes in energy planning, its use for specific purposes and its combinations with energy resources.

Despite the positive effects of the integration of storage systems into renewable energy systems, its problems reduce its economic viability in current market conditions due to its high cost and increasing the cost of switching to renewable energy sources.

CONCLUSION

The interest in renewable energy has increased in recent years due to the fact that the reserves of fossil fuels are about to run out and the damage it causes to the environment. Studies on energy production technology from renewable sources continue. In this study, the definitions of renewable energy and storage systems are made and their technologies are mentioned. It is aimed to be a short and concise source of information for those who want to study and research in this field.

REFERENCES

Elibüyük U., Üçgül, İ., 2014. Rüzgar Türbinleri, Çeşitleri Ve Rüzgar Enerjisi Depolama Yöntemleri, SDÜ Yekarum e-Dergi, 2, 3, 1–14.

Energy Power Plant, Available at: https://www.tpc.com.tr/otomasyon/ [05.12.2022].

Gastli, A., Charabi, Y., 2010. Solar electricity prospects in Oman using GIS-based solar radiation maps, Renewable Sustainable Energy Review, 14, 2, 790–797.

Hydropower Plants, Available at: https://www.energy.gov/eere/water/types-hydropower-plants [01.12.2022]

Muneer, W., 2011. Large-Scale Solar PV Investment Planning Studies, Energy, no. January 2011.

Olabi A. G. et al., 2021. A review on failure modes of wind turbine components, Energies, 14, 17.

OPT WEC, Available at: http://nenmore.blogspot.ca/2010/04/doe-grant-for-wave-energy-project.html [01.12.2022]

Redweik, P., Catita, C., Brito, M., 2013. Solar energy potential on roofs and facades in an urban landscape, Solar Energy, 97, 332–341.

Renewable Energy, Available at: https://www.risingenerji.com.tr/projeler [12.12.2022].

Solar Energy, Available at: https://list.solar/news/hungary-opens/ [10.12.2022].

Wind Power, Available at: https://ca.audubon.org/conservation/wind-power [08.07.2022].

Wind Turbine, Available at: https://www.airpes.com/wind-turbine-parts [12.12.2022].