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SOLAR CELLS: A SOURCE OF RENEWABLE ENERGY

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ABSTRACT

Solar photovoltaic (PV) cells offer a historical perspective on the evolution of solar energy-harnessing technologies. The paper underscores the critical role of efficient nanoscale materials as core absorber layers in solar energy conversion. The review outlines the progress in renewable energy harvesting techniques, focusing on environmentally friendly chemical methods and various vacuum and non-vacuum-based approaches. Solar cells are categorized into three generations, reflecting the evolution of solar energy technologies over time.

KEYWORD

Renewable energy, solar cells, pollution, PV.

INTRODUCTION

The growing environmental challenges including the local air pollution emissions, ecological degradation, and depletion of the fossil fuel reserve, as well as the demand for energy sources, all promote research into renewable energy sources such as biofuels, wind power, solar power, tidal power, and hydropower (Berrueta & Ursúa, 2019; Kulkarni et al., 2017; Trigg, 2014; Verma et al., 2021). Researchers are interested in increasing and maintaining the share of renewable energy sources in global energy production by storing energy generated by renewable energy sources and making it available for use whenever it is needed (Aneke & Wang, 2016; Demirbaş, 2006; Libich et al., 2018). It results in greater adoption of renewable energy and the benefits of renewable energy systems such as environmental benefits and cost savings (Owusu & Asumadu-Sarkodie, 2016).

Air pollution is the primary reason that many countries are increasing their research into alternative energy sources such as renewable energy sources, particularly because around two-thirds of global greenhouse gas (GHG) emissions are attributable to the supply and use of fossil fuel energy. Annual energy-related CO_2 emissions must be reduced by 85% between 2015 and 2050, and carbon dioxide (CO_2) emissions must be reduced by more than 70%, as seen in Figure 1. This is consistent with the Paris Agreement's aim of reducing CO_2 emissions by 2050 to keep global warming well below 2°C. To accomplish this, renewable energy and electrification of heat and transportation are estimated to account for 75% of the CO_2 emissions reduction target("Global Energy Transformation: A Roadmap to 2050 (2019 Edition)," n.d.). According to the US Energy Information Administration's (EIA) annual energy forecast for 2021, the share of renewable energy in the US power generation mix will increase from 21% in 2020 to 42% in 2050, as illustrated in Figure 2. The majority of this growth is due to solar and wind energy generation. Renewable energy's percentage of total power is expected to increase while nuclear and coal-fired output decline and natural gas-fired generation remain almost steady (Demand for U.S. Natural Gas Exports to Surge Through 2021, EIA Says - Natural Gas Intelligence, n.d.).

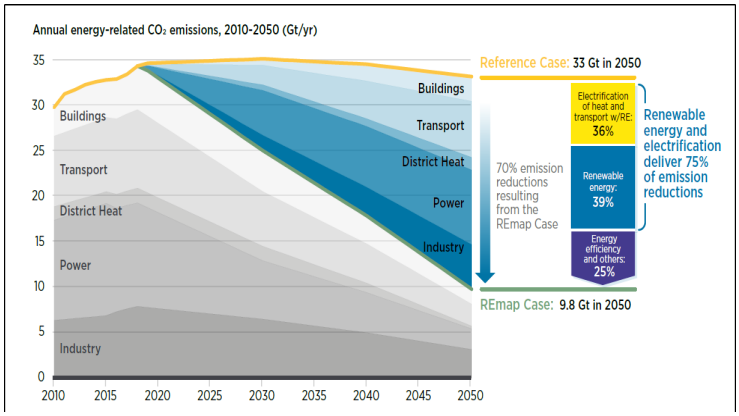

Figure 1: CO_2 emission reduction potential by technology in the Reference Case and REmap, 2010–2050 ("Global Energy Transformation: A Roadmap to 2050 (2019 Edition)," n.d.).

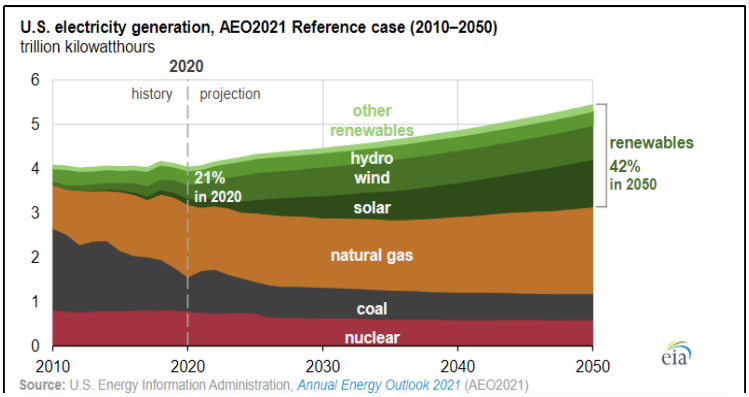

Figure 2: U.S. Energy Information Administration (E.I.A.) forecasts slower growth in natural gas-fired generation while renewable energy rises source: U.S. Energy Information Administration. Short-term Energy Outlook, February 2021(Demand for U.S. Natural Gas Exports to Surge Through 2021, EIA Says - Natural Gas Intelligence, n.d.).

RENEWABLE ENERGY

The most common renewable energy sources include solar, hydrogen, bio, tidal, geothermal, and wind (Ellabban et al., 2014; Hussein, 2015). Increasing energy consumption and emissions necessitate a move to renewable energy sources. These sustainable energy sources can replace fossil fuels as a key energy source. Renewable energy sources are appealing but must be improved to compete with fossil fuels. As demonstrated in Figure 2, renewable energy already meets a large share of demand in many nations and areas. Local, national, and regional policies have propelled the rapid and significant growth of renewable energy in recent years.

Solar power is a renewable energy source, which is the conversion of energy from sunlight into electricity using a photovoltaic (PV) system concentrated solar power, or a combination. Concentrated solar power systems are a system that generates heat by concentrating a large area of sunlight into a small beam. While PV system consists of sophisticated yet efficient cells that can convert light into an electric current using the photovoltaic effect. PV system has huge potential in combatting the depletion of fossil fuel, but up until now, it remains small to medium-sized due to the low power conversion efficacy of solar cells. Solar cells have three generations of cells (Rhodes, 2010). Figure 3 shows two sources of solar energy: photovoltaic (15%) and thermal (7%) respectively.

Fuel cells are another renewable energy device that converts renewable energy into electricity utilizing nanostructured catalyst materials. It is a technology that uses an electrochemical reaction

to generate energy and heat. It occurs between oxygen and hydrogen to form water. Fuel cell technology may replace fossil fuels in rural locations where the public grid connection is difficult or expensive (Mekhilef et al., 2012). Many studies have shown that fuel cell systems are simple to build, reliable, quiet, efficient, and have a low environmental impact. Solar energy paired with a fuel cell can produce hydrogen.

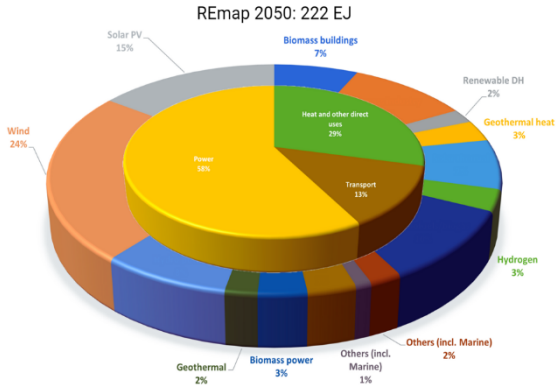

Figure 3: Breakdown of renewables use in total final energy consumption terms, REmap 2050.

SOLAR ENERGY (PV)

Ever since the Becquerel discovered the first photovoltaic effect in 1839, utilising solar energy as alternative renewable energy has been a major goal in the scientific world. The abundance of solar irradiation that can be absorbed by Earth's atmosphere from the sun is more than enough to satisfy global energy needs for an entire year (Ranabhat et al., 2016). Solar cells need to absorb a range of energy corresponding to the solar spectrum to be efficient. The solar spectrum has a range of 100 nm to 1mm, but most of the irradiance occurs between 250nm-2500 nm as shown in Figure 4. The maximum in the visible region of light (400-700nm) for air mass (AM) is 0, which means that the solar cells should strive to absorb as much in the visible region of the solar spectrum as possible (Kruse et al., 2005). Figure 4 shows the solar spectral irradiance curve covers a broad range of wavelengths and forms the distribution of extraterrestrial radiation.

Their main purpose is to develop the most effective materials that have unique properties at the nanometres scale as the core absorber layer for solar energy harnessing. Continuous efforts have been dedicated to the development of renewable harvesting technologies, particularly by an environmentally friendly chemical method and several vacuum and nonvacuum-based techniques. Solar cells are generally classified into three generations depending on time which depends on the basic material used and the level of commercial maturity that is used for their fabrication as shown in Figure 5 (Moaz Baig, 2021).

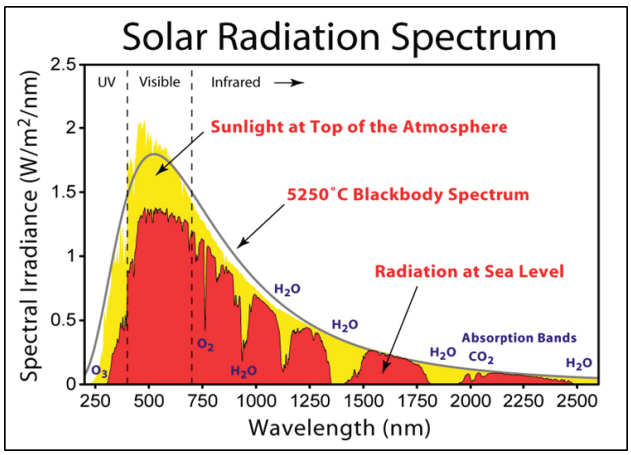

Figure 4: Solar irradiance spectrum above the atmosphere and at the surface.

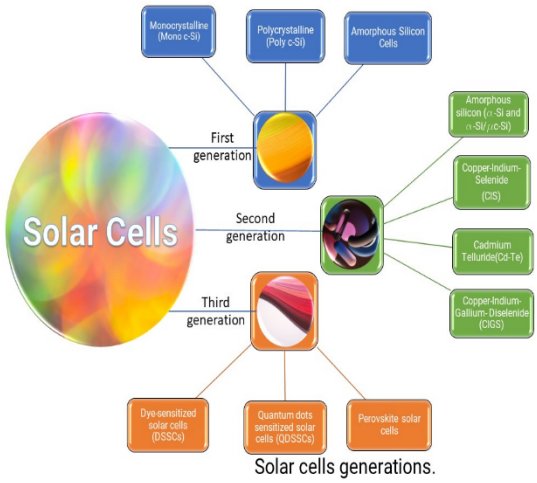

Figure 5: Solar cell generations.

CONCLUSION

In conclusion, solar power, in particular, emerges as a prominent renewable energy source. Its conversion into electricity through photovoltaic (PV) systems and concentrated solar power systems has gained significant traction. The paper underscores the challenges and potential of solar power, emphasizing the imperative of efficient solar cells to effectively compete with fossil fuels. It also explores fuel cells as another renewable energy technology, highlighting their potential in areas with limited grid access.

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