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SUSTAINABLE DEVELOPMENT AND SOLAR ENERGY TECHNOLOGIES

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ABSTRACT

In addition to being a fantastic source of energy and environmentally friendly technology, solar energy is one of the most significant renewable and green energy sources. It makes a major contribution to the realisation of sustainable development's energy solutions. Consequently, the massive amount of energy that can be gathered daily makes solar energy a very attractive resource for creating power. Applications for concentrated solar power and solar photovoltaics are continually being developed in order to meet our energy needs. Thus, in the same context, a high installed capacity of solar energy applications across the globe supports the energy sector and satisfies the need for employment in order to achieve sufficient development.

Keywords – green energy sources, solar energy, terrific source energy, ecologically friendly technologies.

INTRODUCTION

This research looks at the uses of solar energy, how important it is for sustainable development, and how many jobs may be created by renewable energy sources in general. This means that it provides viewpoints and analysis on solar energy sustainability, including both environmental and economic development. Furthermore, it has demonstrated how solar energy applications meet energy needs, create jobs, and enhance environmental protection in order to promote sustainable development. Finally, considering solar energy technology from the standpoint of the energy industry offers a glimpse of future advancements in this subject. Over the past two decades, sustainable development has gained global attention in several domains of life and work. Examining the connection between energy and sustainable development is crucial in this regard. Traditional energy sources include wood, coal, oil, and water. Geothermal, wind, and solar energy are examples of renewable energy sources. Nuclear energy is used globally other from these. Environmental contamination results from the usage of nuclear energy and burnable energy sources including coal, wood, and oil. Ecophysics only accepts energy sources that cause the least amount of environmental contamination. The sun is the cleanest energy source since it emits free radiation that is essentially available to everyone on Earth. In response to UN recommendations, the Climate Change Conference (COP26) was convened in Glasgow, UK, in 2020. They reached a consensus through the delegates of the 197 countries, pledging to reduce their dependency on coal and other fossil fuels. Another statement made during the meeting was about "the various opportunities for governments to prioritise health and equity in the international climate movement and sustainable development agenda". "Energy systems that protect and improve climate and health" need to be developed, according to one of the testimony. The Paris Climate Accords, a worldwide climate change accord encompassing finance, adaptation, and mitigation, were reached in 2015. 196 national delegations decided to lower their greenhouse gas emissions as a result. The Paris Agreement is required to provide a more secure and safe environment for present and future generations. The primary objectives of the Paris Agreement have been to ensure that everyone has the right to live in a clean, healthy environment free from the negative consequences of climate change and to protect people from an environment that is growing more unpredictable and dangerous. Over the past few decades, there has been an increase in demand for cleaner energy options. Based on that, officials across the globe have created long-term plans that utilise renewable energy sources. Thus, by substituting alternative energy technologies for conventional energy sources, these initiatives reduce dependency on such sources. Consequently, there is a shift occurring in the global community towards the use of sustainable energy sources and a reduction in dependence on traditional fossil

fuels. The UN created the Sustainable Development Goals (SDGs) in 2015, and they are now considered international law. The SDGs ask for a global effort to end poverty, safeguard the environment, and guarantee that humanity lives in prosperity and peace by 2030. Therefore, advancements in sustainable economic, social, and environmental models need to be balanced. To control the emissions of gases and other pollutants that harm the environment, many national and international regulations have been implemented. However, the negative effects of increased atmospheric carbon have been worse during the last ten years. The extraction and use of fossil fuels releases methane (CH4), carbon dioxide (CO2), and carbon monoxide (CO), which are the main contributors to environmental emissions on our planet.

INSTALLED CAPACITY AND APPLICATION OF SOLAR ENERGY WORLDWIDE

(i) **Installed capacity of solar energy-** Solar-powered mirrors were first utilised in the seventh century, marking the beginning of solar energy history. Scientists discovered the photovoltaic (PV) effect in 1893, and decades later they improved this technique to generate energy. Based on this, after many years of research and development by scientists worldwide, solar energy technology has been split into two primary categories: solar thermal and solar PV. PV systems convert solar radiation into electrical power using solar panels. These PV systems have quickly become the most cost-effective option for new electricity generation in many parts of the world due to their widespread use. For example, between 2010 and 2018, the cost of generating power from solar PV plants decreased by 77%. However, between 2005 and 2018, the installed capacity of solar PV expanded 100 times. Solar photovoltaics (PV) has thus become a crucial component of the low-carbon sustainable energy system in order to provide access to affordable and dependable electricity and to help achieve the 2030 SDG targets and the Paris Climate Agreement. The installed capacity of solar energy has grown quickly worldwide to meet the demand for electricity. On the other hand, between 2010 and 2020, the installed capacity of PV technology went from 40 334 MW to 709 674 MW, while the installed capacity of concentrated solar power (CSP) applications increased from 1266 MW in 2010 to 6479 MW after a decade.

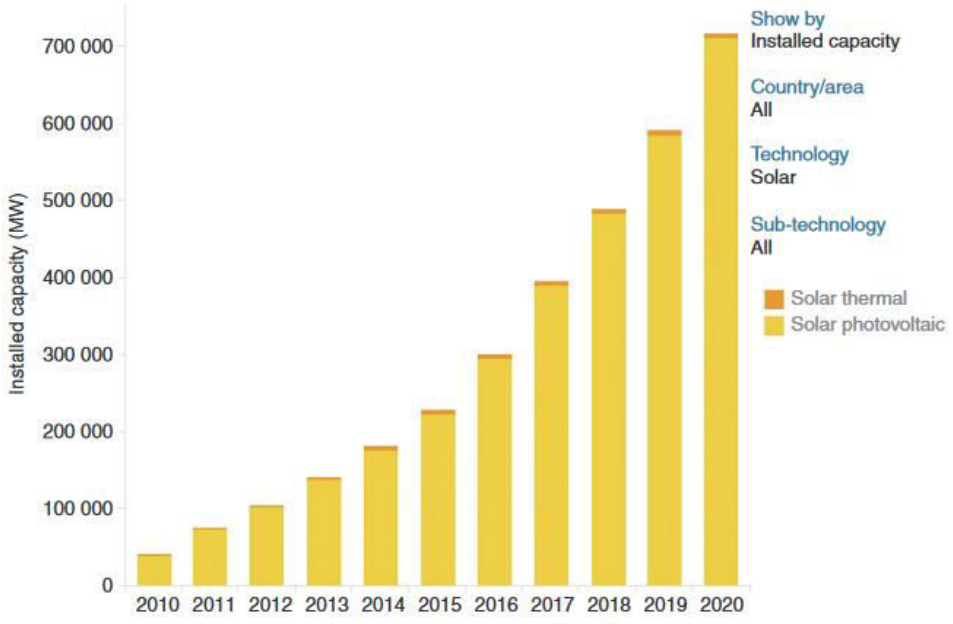

Figure 1- Installation capacity of solar energy worldwide

(ii) **Application of solar energy-** The type of energy that can be obtained directly from the Sun is called solar energy. Since solar energy can be utilised to provide power, heat, and desalinate water, among other things, its applications have grown around the world. A taxonomy of solar energy applications is as follows: PVs (i) and CSP (ii). Fig. 1 depicts the taxonomy of solar energy usage. PV solar cell devices are composed of common

semiconductor materials and are capable of directly converting solar light into electrical current. Electronic equipment known as photovoltaic (PV) devices, or solar cells, use sunlight to create energy. PVs are yet another cutting-edge renewable energy technology that is growing rapidly. Therefore, it is anticipated that make a substantial contribution to the global power generation mix in the future.

ENERGY CONSUMPTION IN THE WORLD

The industrial revolution at the end of the 19th and the beginning of the 20th centuries was based on massive energy usage. The establishment of new production facilities and energy consumption were used to gauge each country's economic development. The amount of energy used in modern life has increased dramatically. With the rise of 11.3% from 1990 to 1998, the total primary energy consumption of the globe (coal, oil, gas, etc.) was 8, 477 Mten (million tonnes of equivalent oil). higher energy use per person. In the United States, primary energy consumption increased by 12.9% and coal consumption by 8% between 1990 and 1998. The amount of coal consumed in European nations has significantly declined. The issue of environmental quality is becoming more pressing as industry grows and energy use rises. The world is dealing with the issue of environmental contamination, which affects the ozone layer and upper atmosphere. Many environmental protection associations came to an agreement at the Kyoto climate change summit in 1997 to reduce greenhouse gas emissions by 5% between 2008 and 2012 compared to 1990 levels of emissions. The NATO members were also assigned personal responsibilities: Reductions of 8% were promised by the EU, 7% by the USA, 6% by Canada, and so on. The global temperature is predicted to rise by 1-3,5 °C and the sea level by 0-0,95 m by the end of this century, respectively, and these changes may have a negative effect on the environment based on a report from the World Meteorological Organisation (WMO) and environmental programmes initiated by the European Union.

SOLAR ENERGY

The Sun is one of 400 billion stars in the Milky Way Galaxy. Astronomers classify it as a "yellow" dwarf. The sun contains more than 99 percent of all the stuff in the solar system.

The surface of the Sun is 5,500 degrees Celsius. The Sun's core has a temperature of 15•10 6 K and a pressure of 10 7 Pa. The fusion of hydrogen into helium is the main thermonuclear reaction occurring in the sun's nucleus. Later, this energy is converted into electromagnetic waves and sent from the Sun's nucleus to its surface and out into space. Only a half-billionth of the Sun's energy reaches Earth. There are two ways that solar radiation comes to Earth. The weather and the angle at which the sun's rays strike Earth greatly influence the intensity of the incoming energy. In a clear sky, 10% of the total energy travels as diffuse radiation to Earth. Sun energy is clean, boundless, and transformable into many forms of energy, such as thermal, chemical, electrical, and mechanical.

(i) **Passive Intake-** The cornerstone of contemporary solar design is a direct (passive), indirect (active), or combination (passive and active) sun irradiation intake. Passive solar radiation intake is used on the designated object to absorb solar radiation and transform it into various forms of energy without the need for any extra equipment. To use solar energy effectively, the object needs to be correctly oriented towards the sun. The position of the windows, the glass veranda, the Trombe wall, etc., the object's thermo-isolation, the colour of the walls and furnishings, shadow, thermal shutters, heat storage on the floor, and more are additional factors to take into account.

(ii) **Active Intake-** Active solar radiation intake is carried out by devices for thermal, photovoltaic, and hybrid sun irradiation conversion. Heliostats, vacuum collectors, concentrators, sun ovens, and flat collectors (water and air) are some of the equipment used for heat conversion. Solar radiation can be converted photovoltaically using solar cells made of silicium and other minerals, either poly- or mono-crystal. Solar cells provide direct current and voltage.

(iii) **Hybrid Conversion of the Sun Irradiation-** Hybrid solar radiation conversion is the process of concurrently converting solar radiation into thermal and electrical energy. For the hybrid conversion of solar radiation, hybrid collectors—which differ from thermal collectors in the absorber construction—are employed. A metal stem, water flow tubes, and solar cells—either amorphous or monocrystalline silicon—

that are physically fastened to the metal stem make up a hybrid collector absorber. Hybrid collectors are used in sanitary water heating systems, electric energy production systems, hotels, schools, flat buildings, and tourist attractions. The hot water is sent to the solar boiler via circulation pumps or thermostats. A battery charging regulator that is put into the battery or a DC/AC inverter that supplies electricity directly are the two ways that electricity is supplied.

THE ROLE OF SOLAR ENERGY IN SUSTAINABLE DEVELOPMENT

The growth of the energy sector in terms of energy production, distribution, and utilisation that are founded on sustainability principles is known as sustainable energy development. The environment will be greatly impacted by energy systems in both industrialised and developing nations. As a result, the world's sustainable energy system needs to minimise emissions and maximise efficiency. The economic viewpoint serves as the foundation for the sustainable development scenario. It also looks at the actions that will be necessary to reach targets for clean air, energy access, and shared long-term climate benefits. The IEA's sustainable recovery plan, which intends to advance economies and jobs by creating a cleaner and more dependable energy infrastructure, serves as the foundation for the short-term details. Furthermore, smart grid technology, energy security, energy pricing, and the use of renewable energy applications are all components of sustainable development. A strong energy policy is also essential. By varying demand across time, demand-side response can assist in meeting the flexibility requirements of electrical systems. As a result, system stability is maintained, the integration of renewable technologies to help facilitate peak demand is decreased, and overall costs and CO2 emissions are decreased. Currently, demand-side response is mostly targeted at large commercial and industrial electricity consumers in North America and Europe. A top-notch infrastructure must adhere to international standards. Encouraging competition, fostering innovation, and establishing legislative convergence will enable players to engage in the global photovoltaic industry. A greater number of nations could gain from taking a more active role in creating international solar PV standards. Leading nations in the production and installation of solar photovoltaic systems have embraced international PV standards and made significant contributions to the advancement of renewable energy. Expanded implementation and adherence to international solar PV standards may be facilitated by more support and capacity-building aimed at improving quality infrastructure in developing nations. Support can therefore ensure that legislative frameworks and requirements are consistent and provide further momentum for the sale of safe and high-quality solar PV products. Constantly promoting solar photovoltaics and other renewable technologies through commerce will fortify the country's infrastructure. For example, healthcare facilities might simply use off-grid solar energy options, such mini-grids and stand-alone systems, to power vaccination coolers and portable testing locations while also enhancing their level of service.

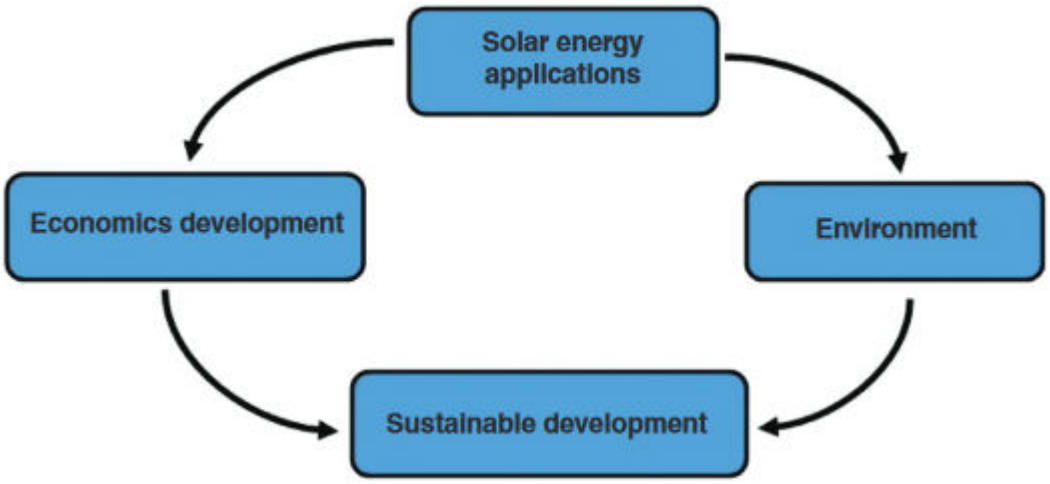

Figure 2- Framework for solar energy applications in energy sustainability

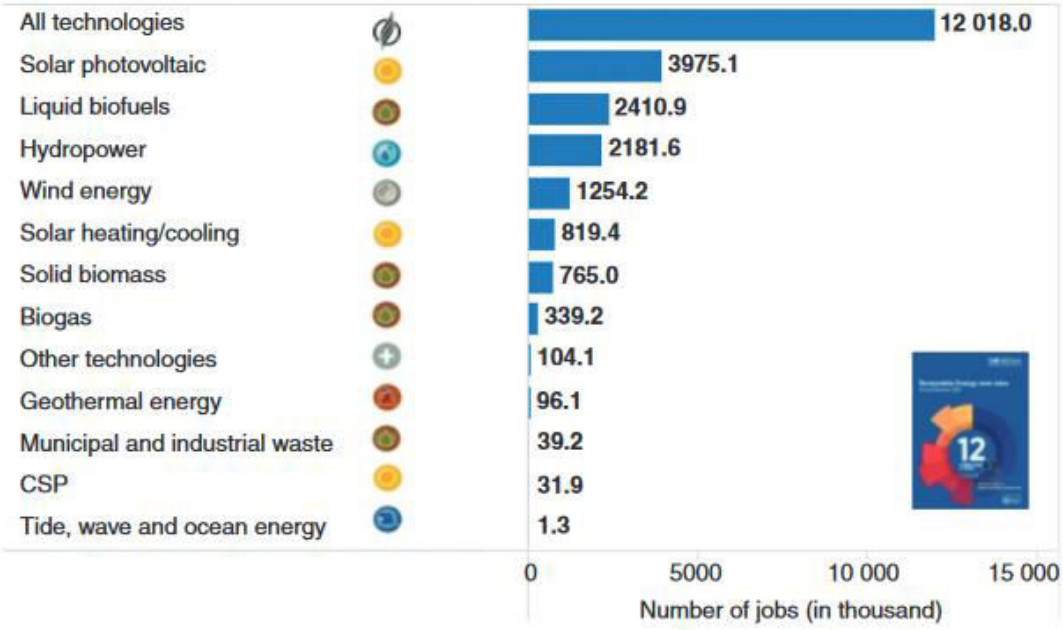

Figure 3- World renewable-energy employment

Table 1- List of the top 10 countries that created jobs in solar PV applications

Continent	Country	Prevalent jobs (millions of jobs)
Asia	China	2.240
Asia	Japan	0.250
North America	United States	0.240
Asia	India	0.205
Asia	Bangladesh	0.145
Asia	Viet Nam	0.055
Asia	Malaysia	0.050
South America	Brazil	0.040
Europe	Germany	0.030
Asia	Philippines	0.020

Trade-led solar PV adoption could contribute to the recovery of the economy from the COVID-19 pandemic in addition to assisting with the immediate medical emergency. This is because employment in the renewable energy sector, which are expected to number in the over 40 million range by 2050, will be created. One method to accomplish that is through the deployment of solar energy in the framework for energy sustainability development. We can progress towards energy sustainability thanks to the abundance of solar energy resources available for PV and CSP energy applications. Plans for sustainable solar energy are shown in Fig. 2. Such applications' environmental considerations, such as a component of the working environment, environmental conditions, etc., have been evaluated. It is energy-efficient, environmentally benign, and clean.

CONCLUSION

This paper highlights the significance of generating sustainable energy. Apart from offering noteworthy benefits to society, the environment, and the economy, solar energy could contribute to the stabilisation of energy prices. This is exemplified by the way solar energy meets energy demands, creates jobs, and protects the environment to support sustainable development. Consequently, it is essential to investigate a critical component of long-term sustainability. It is expected and important to find innovative ways to deploy clean energy technologies given the status of fossil fuel supplies, which are thought to be dwindling energy sources. In spite of this, development of solar energy, and specifically CSP technology, has not yet reached maturity. Furthermore, there is a huge global need for PV technology applications as PV systems continue to progress. new work needs to be done in order to generate energy in a sustainable manner and to take into account new clean energy resources. Moreover, a comprehensive strategy to experimentation and validation is required in the development of cleaner energy sources to decarbonise our planet.The aforementioned indicates that there is a global focus on sustainable development and the use of clean energy sources. Agenda 21, which was unveiled during the 1992 UN summit on environment and development in Rio de Janeiro, The cleanest energy source is the Sun, which has enabled and supported life on Earth for five billion years. Plants use photosynthetic reactions to use sun energy for growth and development. Passive and active photo-conversion devices can also be used to convert solar radiation into heat energy. The basis for creating products that employ passive photo-conversion technology is solar architecture. Concentrators, vacuum collectors, flat collectors, and other parts of active photo-thermal conversion systems are divided into different categories. Solar radiation is converted into electrical energy using solar cells. Solar light is concurrently converted into thermal and electrical energy using hybrid collectors.

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