



# Status of Electricity Generation Based on Sustainable Energy Resources Worldwide

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**ABSTRACT:** *The production of the electricity by utilizing the sustainable energy resources growing rapidly across world. The existing commercial technologies of the electricity generation based on the non-renewable energy resource that produces the harmful gases and hazardous wastes that has huge adverse impact on the environment. On the other hand, renewable energy resources offer various advantages such as availability, capability, eco-friendly in nature and doesn't produce any kind of hazardous wastes. Currently, the implementation of the renewable energy resources-based power plants growing faster, developed as well as developing countries shifts from traditional electricity generation technologies to the renewable energy resource-based technologies. This review paper highlighted about the status of the electricity generation grounded on the sustainable energy resources worldwide. The utilization of the sustainable energy resources will help to conserve our ecosystem more efficiently and electricity demand by growing population can be fulfilling effectively in clean manner. Renewable energy resources will also help in economic growth.*

**KEYWORDS:** *Electricity Generation, Hydro energy, Renewable Energy, Solar power, Wind power.*

## INTRODUCTION

The population of the world increases in exponential manner due to which demand of the various basic needs such as food, shelter and electricity also increases continuously. Among all the basic needs, electricity is also important because many daily-to-daily activities depends on the electricity. Various electrical appliances such as washing machine, fans, refrigerator and television etc. runs on the electricity. Electricity now the important part of our daily life. Not only for the household purpose, is electricity also heavily consumed in the various industries such as agriculture, automobile and food industry etc. In order to fulfil the need of the electricity, the existing commercial technologies are used energy resources such as petroleum, coals as well as nuclear power [1]. Fossil fuel is the leading energy resources in the power sector for the generation of the electricity. These energy resources have great potential to generate the electricity at greater scale but there is a disadvantage of the consumption of the non-renewable energy resources is that these energy resources are not eco-friendly in nature. During the production of the electricity, there are harmful gases and hazardous as well as toxic products are generated at large scale that has huge adverse effect on the environment. It contributes in the climate change and global warming [2].

In contrast, sustainable energy resources are well known for its eco-friendly nature, availability and capability for the production of the electricity. There is various sustainable energy are existed in nature like wind power, ocean power, biofuels, earth's energy, solar power and hydropower.

Since the population of the world growing quickly that is why the production of the electricity based on the renewable energy resources plays an important role because it has capability to fulfil the demand of the electricity along with the conservation of the ecosystem [3]. Various countries such as USA, China, Germany, Spain and India etc. put heavy investment in the renewable energy sector because it will not only help in conserving our ecosystem but also helps in growing their economy. Solar energy sector is widely implemented in various countries for the production of the electricity as greater scale as compared to the other renewable energy resources. Continuous research and development will help to expand the deployment of the other renewable resources for the production of the electricity. This review article provides an overview of the status of the electrical energy production utilizing the sustainable power resources worldwide [4]. This article will cover generation, contribution of the sustainable energy resources for production of the electrical energy and also discuss about the advantages and challenges associated with the sustainable energy resources.

### SUSTAINABLE ENERGY RESOURCE

Sustainable drive resources never run out in terms of quantity, these energy resources are well known for its availability such as wind, sun and ocean energy etc. Renewable energy resources are sustainable and well suited for the production of the electricity. These energy resources have huge capability for fulfilling the demand of the electricity by growing population. The major renewable energy resources are listed in the Table 1.

**Table 1: List of the Sustainable Energy Resources for the Production of Electrical Energy**

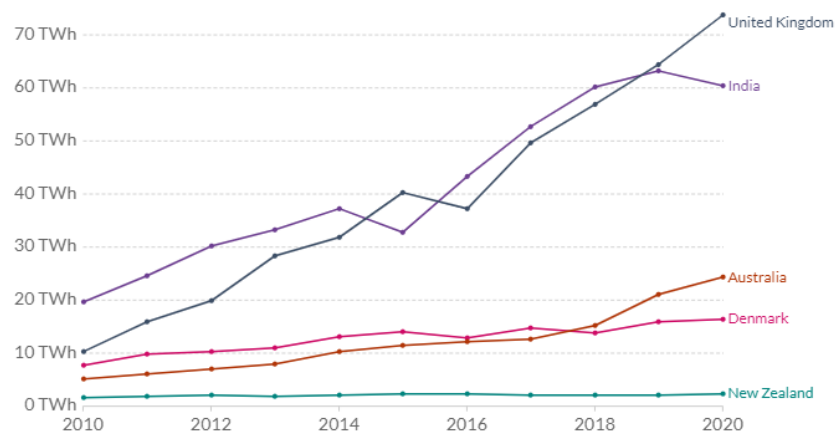
Renewable Energy Resources	Detail
Solar Energy	Solar energy-based technologies are quite mature for the production of the electricity. Photovoltaic cells are utilized for the production of the electricity based on the solar energy. It is PN junction-based semiconductor device that is developed by the p types and n-type semiconductor material. When sunlight incident of the interface of the semiconductor materials, large number co-valent bond breaks that leads to the generation of the electron-hole pair at greater scale. These charge carriers move to the opposite terminal and contribute an electric current [5]. It is heavily depending on the weather conditions and availability of the sun that is why it is very important to store the electricity produced by the solar energy so that it can be used when sun is not available.

Wind energy	<p>Wind energy is another form of the renewable energy resources that depends on the wind flow. Wind energy is well known from thousands of years. Earlier it was used for the sailing purpose. Wind flow from the higher atmospheric pressure location to the lower atmospheric pressure locations. Wind turbines are utilized for the electricity generation based on the wind energy. When Wind flow cross through the blades of the wind turbines, the blades rotate the turbines that subsequently produces electricity by the generator that is connected to the turbines. Wind turbines generally installed at the open area such as near the ocean or open land area where the wind can be easily capture by the wind turbine blades [6].</p>
Geothermal Energy	<p>Geothermal energy is the earth's core energy that is utilized for the generation of the electricity. As we go deeper inside the earth, the temperature is increasing. The temperature of the earth's core is as greater as temperature of the sun's surface. For the electricity production based on the geothermal energy is done by injecting the water to the reservoir that is near the core. Due to the high temperature of the earth's core, the water converted to the steam that has been further utilized for the electricity production by turbines and generator [7]. The geothermal energy greater depends on the geographical locations, it is not available everywhere.</p>
Hydropower	<p>Hydropower basically depends on the water sources such as lakes, rivers and artificial dams. For instance, the dams collect and store the water in large quantity, it acts as a barrier to the water flow. When the stored water flow through the pipes, due to the momentum of the water flow the turbines rotates and subsequently produces the electricity by the generator that is connected to the turbine. Not only electricity generation, also provided various services to the locals such as irrigation, tourisms and supply of the fresh and clean drinking water.</p>

Ocean energy	Ocean energy depends on the periodic wave generated on the surface of the ocean. These up and down periodic waves has been utilized for the generation of the electricity. The movement of the waves provides electricity generation system. Ocean energy also known as the wave energy. Ocean or wave energy greatly depends on weather conditions that is why the electricity generation based on the ocean energy is highly uncertain. The quantity of the electricity can't be predicted easily.
Biofuels	Organic wastes have been generated by the various sectors including agriculture, municipal and industries. The organic wastes include food waste, kitchen waste water etc. Organic wastes also refer as biomass that has been converted to the biogas by the digestion process with the help of the microorganisms [8]. During the digestion process, methane and carbon dioxide gas has been produced and these two gases separated by the separation membrane and converted to the bio methane. The digestion process has been done in the absence of the oxygen [9].

### STATUS OF RENEWABLE ENERGY RESOURCE GENERATION

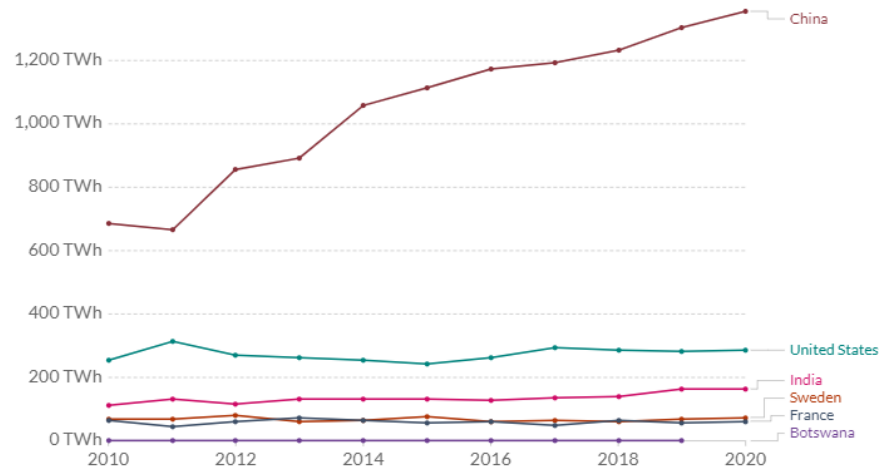
By giving an importance to the renewable energy resources in terms of the electricity generation, each nation focused on utilization of sustainable drive resources for production of the electrical energy as maximum as possible. The status of the wind and hydropower generation is shown in the figure 1 and 2 respectively.



**Figure 1: Graphical Representation of the Wind Power Generation from 2010 to 2020.**

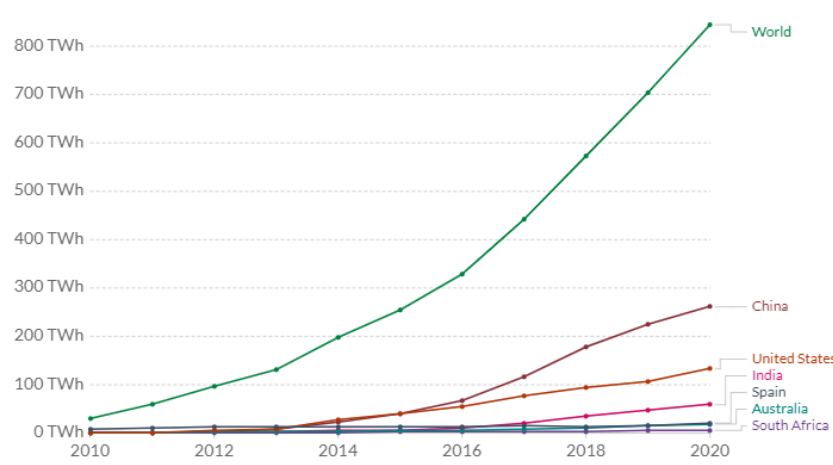
From the Figure 1 it is clear that United Kingdom is the leading country that works in the field of the wind power generation more effectively as a result it gained rank 1 in wind power generation followed by the India. More than 70 TWh wind power energy has been generated by the UK in

the year of 2020 and India generated approximately 60 TWh wind power. The growth of the wind power generation by these two countries has been grown significantly.



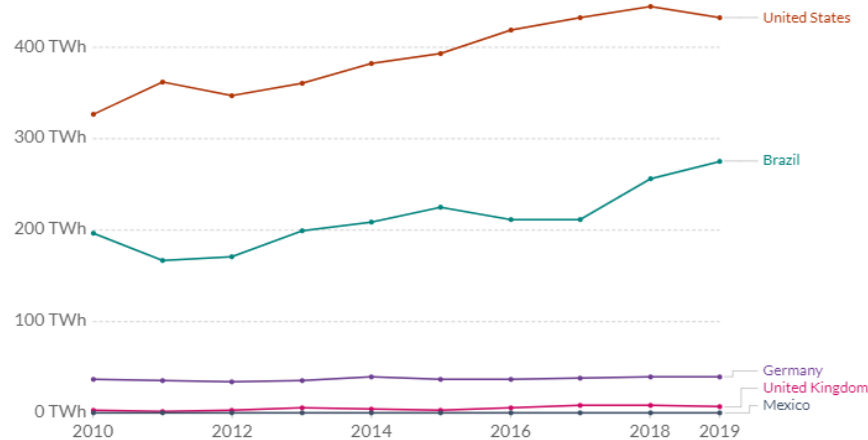
**Figure 2: Graphical Illustration of the Hydropower Generation from 2010 to 2020.**

In the field of the hydropower generation, the electricity generated greater than as compared to the wind power. China reported more than 1200 TWh hydropower generation in the 2020. UK got second position in the hydropower generation with the capacity of 200 TWh power generation. Hydropower in the other countries as compared to the China doesn't utilize full capability of the hydropower generation [10]. It is still in the developing mode. The status of the solar power generation across the world is shown in the Figure 3.



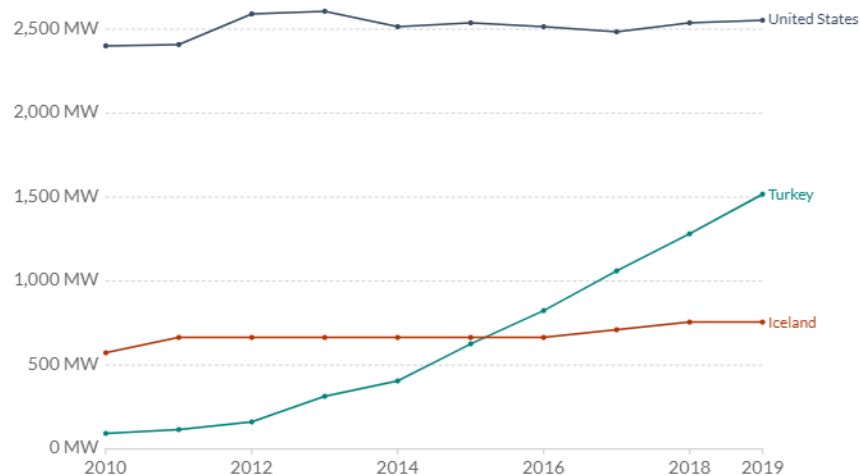
**Figure 3: Graphical Representation of the Electricity Generation based on the Solar Energy from 2010 to 2020.**

The utilization of the solar power for the electricity generation has been grown exponentially across the world. Among the all countries, China is leading again in terms of the electricity generation based on the solar energy. In 2020, China generated approximately 300 TWh solar power energy followed by the United States of 120 TWh power generation based on solar energy. India got third position in the solar power energy generation. The status of the electricity generation based on the biofuel and geothermal energy has been shown in the Figure 4 and 5 respectively.



**Figure 4: Graphical Representation of the Status of the Biofuel Energy Production from 2010 to 2019.**

In this sector, American and European countries are leading for the biofuel energy production. United State reach approximately 450 TWh biofuel energy production in the 2020 followed by the South American country Brazil with the 280 TWh biofuel energy production capacity. Asian countries are still lagging in the biofuel energy sector. There have been tremendous efforts needs to be put in order to make this technology to be more productive. The power generation capacity based on the geothermal energy is highlighted in the Figure 5.

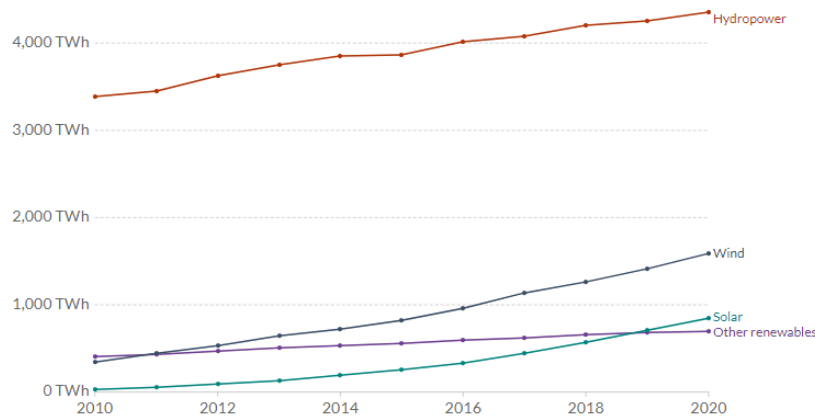


**Figure 5: Graphical Illustration of the Installed Geothermal Energy Capacity from 2010 to 2019.**

Since, geothermal energy is greatly depending on the geographical locations that is why it is not available at each location. It is location specific energy resource. As compared to the other renewable energy resources, geothermal energy contributes relatively less in the power sector for the electricity generation. United states is in the first position in the geothermal energy installation capacity from the 2010 to 2019 with the capacity of the 2500 MW capacity followed by the Turkey with 1500 MW capacity. An exponential growth has been observed in the geothermal energy capacity from 2010 to the 2019.

## SHARE OF ELECTRICAL ENERGY PRODUCTION FROM SUSTAINABLE DRIVE RESOURCES

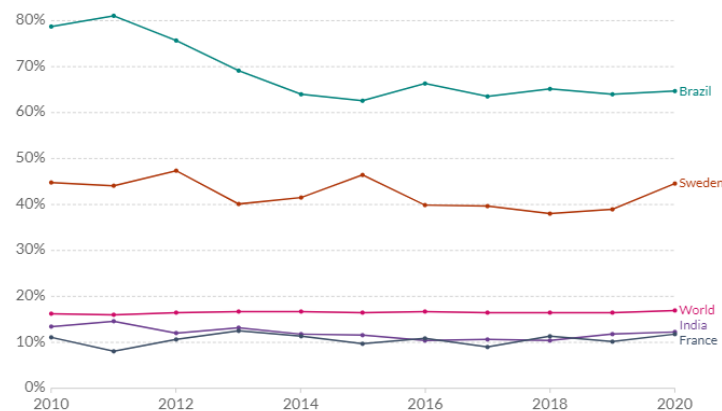
The electrical energy generation based on the renewable energy resources has been exponentially grown in the last one decade. Each country has been expanding its energy sector based on the sustainable energy resources for producing the electricity with green manner and conserve the environment. The comparative power generation capacity by the different renewable energy resources has been highlighted in the figure 6.



**Figure 6: Graphical Illustration of the Renewable Energy Generation from 2010 to 2020.**

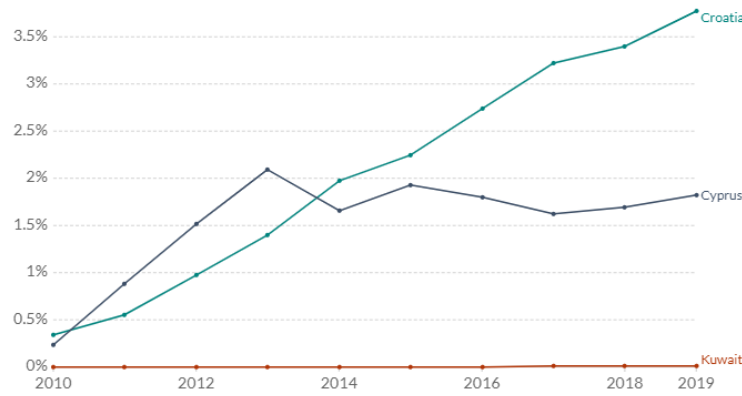
From the above figure it is clear that hydropower is the leading renewable energy resources that is utilized for the electricity generation. More than 4000 TWh electricity generation capacity has been recorded in the 2020. Wind energy is gain second position for the electricity generation worldwide with the capacity of the 1500 TWh followed by the solar energy with the capacity of 900 TWh power generation.

Each country contributes to energy generation sector according to their resources and capacity. Each country contribution helps in the fulfilling the demand of the electricity by the growing population. The share of the various countries in different renewable energy resources-based power sectors has been discussed below. The share of the hydro-energy for the production of the electrical energy is shown in Figure 7.



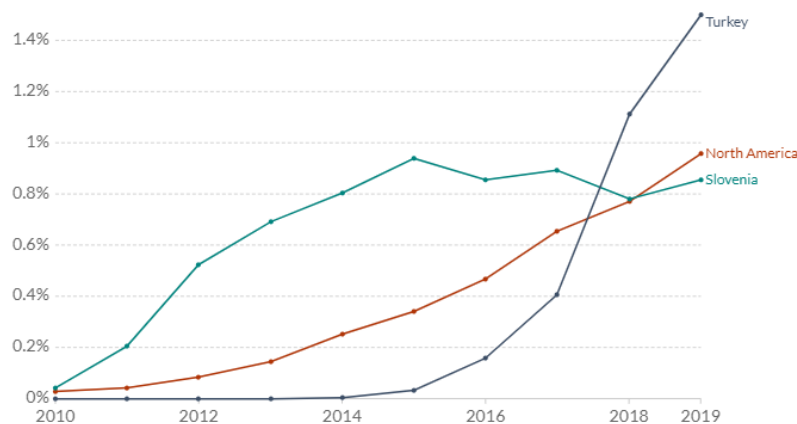
**Figure 7: Graphical Representation of the Contribution of the Hydro-energy in Production of Electrical Energy from 2010 to 2020.**

Brazil shares maximum contribution to the electricity generation based on the hydropower followed by the Sweden and India got the third position. Each country from the last one decade contributes consistent to the hydropower with constant share that means no progress has been overserved in terms of the contribution in the electricity generation based on the hydropower. The share of the wind energy in the electricity generation has been highlighted in the figure 8.



**Figure 8: Graphical Representation of the Contribution of the Wind Power for the Production of Electrical Energy from 2010 to 2019.**

Wind energy is dependency greatly works in terms of the geographical locations. The wind turbines are usually installed in open area either in the land or near the oceans. Croatia is leading in the field of production of electrical energy based on wind power. The contribution of wind energy is less that hydropower for the production of the electrical energy among the all-renewable drive resources. Cyprus is on the second position for the share of the electrical energy production grounded on the wind energy followed by the Kuwait. The share of the solar power for production of the electrical energy is shown in figure 9.



**Figure 9: Graphical Representation of Share of the Solar Power in Production of Electrical Energy from 2010 to 2019.**

Solar energy sector is quite mature field in terms of electricity generation. From the Figure 9, it has been clear that, Turkey gained significant amount of growth in contribution of power production grounded on solar power. From 2010 to 2019, Tukey makes more that 1.4% share in



the production of power grounded on solar power followed by the North America with the approximately 1% in the 2019.

### **ADVANTAGES AND CHALLENGES ASSOCIATED WITH RENEWABLE ENERGY RESOURCES**

Renewable energy resources offer various advantages over the non-conventional energy resources such as petroleum products, coal as well as nuclear power in terms of electricity production. The benefits as well as issues linked with the sustainable energy resources has been listed in the Table 2.

**Table 2: List of the Benefits as well as Issues Linked with the Sustainable Energy Resources**

<b>Benefits</b>	<b>Issues</b>
Eco-friendly in nature	Not mature enough to produce electricity at larger scale in order to fulfil demand of electricity by growing population
It is a renewable resource	The efficiency of the electricity production quite low
Reliable sources of energy	High investment required initially for the establishment
Helps in job creation	Require relatively larger area for the installing the power plant
Help in reducing the electricity bill	Not has capability at this time to compete with the existing commercial technologies
Technology development	Generates pollution in the small quantity
Helps in recycling the solid waste	Heavy R&D investment required

### **DISCUSSION**

Renewable energy resources are the best alternative of non-renewable drive resources for production of the electrical energy. Growing population demand more electricity that has to be fulfilled by the advanced power generation technologies. The existing commercial technologies generated harmful as well as toxic gases to the atmosphere during the electricity generation. It is necessary to tackle these issues otherwise the environment health will be in danger in the future. In contrast the electricity generation based on the renewable energy resources has great potential in order to fulfil the demand of the electricity by growing population. Among the all-renewable energy resources, hydropower is the leading energy resources that has been greatly utilized for the production of the electricity followed by the wind energy. But due to many challenges such as lack of proper implementation framework, financial investment and R&D, there are lots of efforts needed to make then renewable energy resources-based electricity generation technologies can compete with the existing commercial technologies.

### **CONCLUSION**

The electricity production utilizing the sustainable drive resources is an emerging technology. Each and every nation tries to implement and install the electrical energy generation plants grounded on the sustainable drive resources in order to fulfil the demand of the electricity. China

is the leading country in the production of the electricity based on the hydropower followed by the United States. Among the all-renewable energy resources, hydropower is the leading sustainable drive resource for production of the electrical energy followed by wind energy in the year of 2020. There are various advancement and efforts has been made in the renewable energy resources-based power sector but these technologies are still lagging to the existing commercial technologies. It is recommended that proper implementation framework need to prepare by the government authorities so that R&D in these fields can be promoted to the next level that will help in the advancement of the power sector based on the renewable energy resources.

## REFERENCES

- [1] P. A. Østergaard, N. Duic, Y. Noorollahi, H. Mikulcic, and S. Kalogirou, "Sustainable development using renewable energy technology." Elsevier, 2020.
- [2] S. D. Musa, T. Zhonghua, A. O. Ibrahim, and M. Habib, "China's energy status: A critical look at fossils and renewable options," *Renew. Sustain. Energy Rev.*, vol. 81, pp. 2281–2290, 2018.
- [3] M. Melikoglu, "Current status and future of ocean energy sources: A global review," *Ocean Eng.*, vol. 148, pp. 563–573, 2018.
- [4] P. Moriarty and D. Honnery, "Global renewable energy resources and use in 2050," in *Managing Global Warming*, Elsevier, 2019, pp. 221–235.
- [5] B. Bollinger and K. Gillingham, "Peer effects in the diffusion of solar photovoltaic panels," *Mark. Sci.*, 2012, doi: 10.1287/mksc.1120.0727.
- [6] "Wind energy handbook," *Choice Rev. Online*, 2011, doi: 10.5860/choice.49-2091.
- [7] J. L. Renner and M. J. Reed, "Geothermal energy," in *Energy Conversion, Second Edition*, 2017.
- [8] Y. Demirel, "Biofuels," in *Comprehensive Energy Systems*, 2018.
- [9] S. K. S. Prasad, K. R. Sheetal, V. Venkatramanan, S. Kumar, "Sustainable Energy: Challenges and Perspectives," *Sustain. Green Technol. Environ. Manag.*, 2019.
- [10] T. Weir, "Renewable energy in the Pacific Islands: Its role and status," *Renew. Sustain. Energy Rev.*, vol. 94, pp. 762–771, 2018.