GREEN TECHNOLOGY AND SUSTAINABLE DEVELOPMENT: ADVANCEMENT AND STRATEGIES

Abstract

Traditional energy sources are responsible forreleasing harmful pollutants and hazardous gases in the atmosphere.One of the most promising strategies to save the environment is to replace conventional energy with renewable energy sourcesthat are obtained from the sun, wind, water, tides, and geothermal. The main impediment to renewable energy systems is uninterruptible energy generation especially electrical energy. The latest trend in research is also focused on developing novel methods to generate electrical energy from renewable sources. Lot of funding from government agencies is also available to promote research in these areas to tackle energy security issues and climate change. Such innovative routes have the potential to save about 30% of energy with 80% lower prices thereby reducing global warming. This is also viable andcost-effective way to achieve long-term growth and environment sustainability.

Authors

Tank Sinderpal Kabalsingh
PG Department of Chemistry
Kanya Maha Vidyalaya,
Jalandhar, Punjab, India

Dr. Mandeep Kaur
Assistant Professor
PG Department of Zoology
Kanya Maha Vidyalaya,
Jalandhar, Punjab, India
mandeepkaur8@gmail.com

I. INTRODUCTION

The demand forenergy has witnessed a rapid increase in recent time. According to United Nations, the industrial countries have 28% world's population bututilise 77% global energy. The current population worldwide is anticipated to grow 1.26 times by 2050to 9.7 billion. The emerging countries account for nearly 90% of population growth. Although developed countries have implemented effective energy conservation policies to be achieved by 2050, yet their energy consumption hasremained constant. Researchers in underdeveloped countries, are struggling to build their own energy-generating facilities (Salvarli and Salvarli, 2020).

It is projected that fossil fuel stocks will deplete naturally.As a result, alternative viable renewable energies are need of the hour in near future. This condition will provide an impetus to creating new jobs and building future industries.Rising industry, technological advancement and human labour haveincreasingly contaminated the environment causing global climate change. Inorder to attain sustainable development, renewable energy sources should be wisely harnessed with focus on its pricing, policies, applications and technology transfer (Salvarli and Salvarli, 2020).

Green renewable energy sources (RGEs) offer chances for Sustainable Development such as energy security,social and economic development,and climate change mitigation.The popular three-pillar model, which includes economy, ecology, and society, has been used to theorize the concept of sustainability. RGEs preserve natural capital as long as resource consumption does not reduce the prospect of a sustainable future.There should be a perfect harmony between the three-pillar model andRGE technologies for evaluating renewable green energy technologies and to frame appropriate economic, social, and environmental policies. This will definitely contribute significantly to the economies of countries rich in renewable green energy sources (Androniceanu and Sabie, 2022).Governments and other authorities should also encourage generous investment in sustainable green energy production to assure a more environment friendly and sustainable future.In 2019, India ranked fourth in world for the most appealing renewable energy market. By 2030, India is aspiring to achieve world's largest renewable energy expansion target of 450 GW(Kumar and Majid, 2020).

The present chapter includes an overview of Global energy consumption, current achievements, and types of green energy.The study also summarises potential trends over the next decade.

II. GLOBAL PRIMARY ENERGY CONSUMPTION

Primary energy consumption has increased constantly in the world. Primary energy is the energy available in raw form before its actual conversion into either heat or electricity or any other type of fuels viz. fossil energy sources obtained fromcoal, oil, and gas, energy from uranium and bio-mass, energy from physical phenomenon like wind, solar radiation, and hydraulic power. The available primary energy sources have witnessed a visible transformation over last few centuries. Almost all new sources of energy have been explored to date beginning from fossil fuels to the use of nuclear and hydropower energy. The quantity produced and subsequently consumed has also increased manifold since the Industrial Revolution. Although Global energy consumption growth slowed down in 2022 (+2.1%) it is

growing at the rate of around 1% to 2% per year with a aggregate increase of around 15.10% in 10 years.

The largest energy consumers in the world are Norway, Iceland, USA, Canada, Oman, Qatar, and Saudi Arabia. India holds third positionwith 5.6% of the growth ratein the world in primary energy consumption in 2017. Statistics reveal that energy consumption growth in 2022slowed down in the two largest consuming countries China and USA. On the contrary, primary energy consumption declined in Europe due to fears of recession after Russia's invasion of Ukraine and surging energy prices.

Activities related to power generation from primary energy sectors, deforestation, transportation, and industrial and technological advancements are responsible for CO_2 emissions. Hence high energy consumption is coupled with an increase in global CO_2 emission. It is a serious agendathat needs immediate solution to meet ambitious climate mitigation goals. Hence recently, at international level rigorous changes and adjustments are happening(Nfah et al., 2007).

To popularize sustainable green energy among the masses, the prime agenda of the international global energy policies now is to focus on the transition of the fossil energy-based system to low-carbon energy-based system (Dizdaroglu, 2017). In order to achieve a breakthrough from the high-carbon energy-based system to the low-carbon one, national and international policies, market mechanisms, and legal systems should be synchronous with each other and should actively acknowledge the energy issues to establish the best consumption model and renewable energy production.

III. CURRENT ACHIEVEMENTS IN GREEN ENERGY IN INDIA

The Government of India have initiated ample national programs in different areas of the renewable energy sector to deploy and popularize renewable energy systems among the general public. Government and private institutes such astheMinistry of New and Renewable Energy, The Energy Resource Institute, Centre for Wind Energy Technology, Indian Oil Corporation Ltd., IITs, NITs, Universities are involved in Research & Development of renewable sources of energy. For smooth implementation, delivery, and outreach of renewable energy projects, the government has constituted District Advisory Committees , and developed Akshay Urja Shops, Renewable Energy Clubs, and Energy parks (Purohit and Michaelowa, 2008; Maithani, 2008;Chaturvedi and Garg, 2007).

The major achievements of India in the field of renewable energy is as follows.

1. Wind Energy Technology Centre at Chennai has created a scientific and industrial research cell for assessment of wind resources, equipment certification, and R&D.
2. Solar Energy Centre at Gurgaon, Haryana is specialized for solar energy systems development.
3. Integrated Rural Energy initiative has been administered in 860 blocks.
4. Sixteen hundred renewable energy projects has funded by Indian Renewable Energy Development Agency Limited.
5. Solar Photovoltaic products of 30 MW capacity has been exported to countries all over the world.

6. 280 Energy Parks has been established for illustration of renewable energy devices in various educational institutions
7. Heating systems powered by solar energy has been equipped in 7 lakhsm^2 collector domain.
8. Over 4200 MW grid power is successfully generated from wind, small hydro, biomass and solar energy.
9. Largest solar–steam cooking system is installed at Tirumala Devasthanam, Tirupati for fifteen thousand persons per day.
10. Biogas plants worth 3.5 million for cooking and lighting applications and wood stoves worth 35 million has been improved in rural abodes.
11. 3600 remote villages/hamlets including those in Ladakh and the North East are electrified through solar energy.

IV. TYPES OF GREEN ENERGY

Renewable Energy sources are distributed over a wide geographical area and available throughout the year. These resources do not exhaust and can be easily revivedby a natural phenomenon. It does not cause contamination of environment. The advantage of availing renewable resources is that by one-time investment one can take benefitwithout affecting the environment for many decades.

There are five main types of green energy:

- Solar energy
- Hydro energy
- Geothermal energy
- Wind energy
- Vibration energy

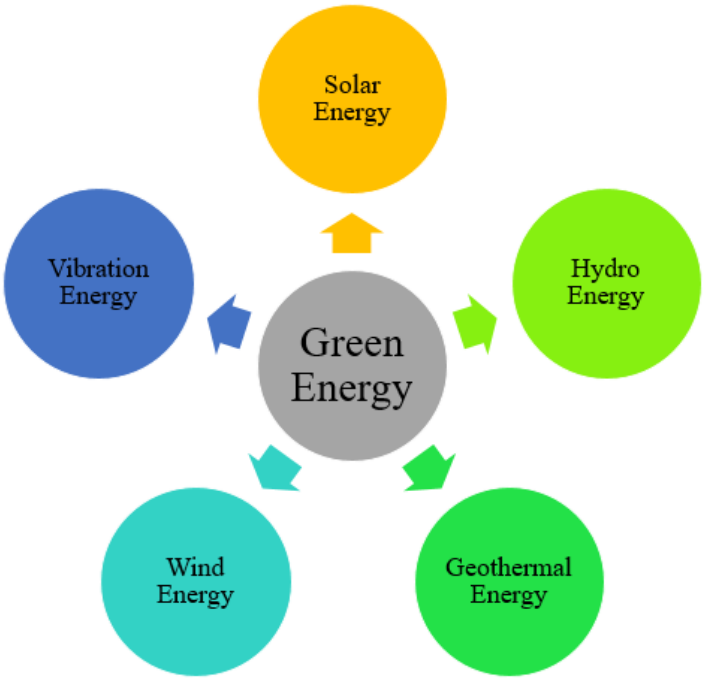

Figure 1: Types of Green Energy

1. **Solar Energy:** Sun is an abundant solar energy source providingvital energy to the living organisms, flora, and fauna on earth. It is a sustainable, clean, and direct energy withminute impact on the surrounding. It does not produce harmful gases like carbon dioxide as a co-product and therefore do not contribute to global warming. It can be successfully harnessed into useful energy using Parabolic Trough Systems and Solar Photovoltaic cells. Many everyday low-power absorbing devices like calculators can be efficiently powered by solar energy. It's also a longer lasting energy source for future generations because it lasts forever.

2. **Hydro Energy:** Hydro energy is electricity generated from the water cycle by continuous process of falling and fast-running water. Hydroelectric power is major reliable, affordable, domestic and well established renewable energy that meets approximately 19% of the world's electricity requirements (Maithani, 2008). Large-scale schemes and projects are undertaken by the government to harness hydroelectric power in the world. It is also specific clean energy sources as it does not lead to any by-products during conversion.

3. **Geothermal Energy:** Geothermal energy is produced inside the earth in the form of heat from the radioactive decay of radioactive materials like uranium. The pioneering geothermal power plant was constructed in Larderello. The US National Renewable Energy Laboratory reported that hot dry rockshave potential to supplyaround 4 million MW capacity electricity, which is higher than that used by the United States today. Due to negligible emissions, it is considered to be an exceptional alternative over traditional fossil fuel energy sources for mitigationof global warming. It is the cost-effective, reliable, affordable, renewable, and sustainable source of energy used for household purposes.

4. **Wind Energy:** The energy producedusing wind turbines by the flowing wind is called wind energy. Wind is actuallytype of solar energy.It is created by heating of the earth atmosphere by the sun and by the rotation of the earth. Wind turbines used for energy production are usually installed in huge open-land farms. Empty land around wind turbines can be effectively used for agriculture and horticulture.Wind turbines do not contribute to acid rain or greenhouse gases. It is a clean and renewable energy source and requires less cost.

5. **Vibration Energy:** This mechanical phenomenon in which the vibration occurs at equilibrium is known as vibration energy. The study on vibration energy came into focus in recent years. The vibration produced in the surrounding by a large traffic on the road or a large crowd or by vibrations of skyscrapers, vehicle systems, bridges, railways, and ocean waves can also be harnessed efficiently. These vibrational energies can be transformed into electric energy that can be stored. This energy can be used to power electronic appliances required low-power. Usually, harvesting of vibrational energy from large sources produces about 1W to 100 kW energy (Chaturvedi and Garg, 2007). Vibration energy has been successfully used to replace the batteries in medical implants as traditional batteries loaded with toxic heavy metals. Vibration energy can be used to control the noise in the environment generated by industries, air craft's etc by vibration damping and isolation.

V. STRATEGIES FOR A GREEN SUSTAINABLE ENERGY FUTURE

In 2019, India ranked fourth in the world for the most appealing renewable energy market. An progressive target of 450GW of renewable energy by 2030 has set by India.This is the world's largest renewable energy expansion plan.India has three of the top Five largest solarparks in the world. It also includes the second-largest solarpark in the world at Kurnool, Andhra Pradesh, with acapacity of 1000 MW. In Rajasthan the world's largest solarpower plant, Bhadla Solar Park exist with a capacity of2255 MW.

According to Organization for Economic Cooperation and Development (OECD) and European Union 27 (Eurostat, 2013),Denmarkis regarded as one of the most energy stable and sustainable country (Sovacool and Brown, 2007). Denmark has expeditiously reduced (from 90% to almost zero in the 1970s) its reliance on external energy sources, and has become a net exporter of fuels and power (Sovacool and Tambo, 2016). The heart of effective approach of Denmark is obligation toliability to energy efficiency,increased taxes on energy fuels, electricity, carbon dioxide, subsidies for Combined Heat and Power (CHP) and wind turbines (Sovacool, 2013). Denmark's goal is to achieve 100% renewable energy by 2050 (Sovacool, 2013; Danish Government. Energy Strategy, 2011).

Germany, one of the EU's top energy importers and will undergo bold energy revolution.Germany is most prosperous country forpromoting renewable energy. is (Proskuryakova, 2018). (Liu, 2018). Germans outperformed the rest of the EU in terms of energy security in 2014,due to lower oil and coal use and increased diversification of energy imports (Matsumoto et al., 2018). The energy transition policy (Energiewende) of German is widely regarded as the most popularsustainable national energy policy in the world (Harjanne and Korhonen, 2018). The Energiewende seeks to 80-95% reduction (relative to 1990)in greenhouse gas emissions by 2050, at least 60% increase in the sustainable energy, and 80% increase in the renewable part of power demand (Hansen et al., 2019). By 2022, Germany also wants to finish its nuclear wind-up (Energiewende, 2019). According to Hansen et al. (2019), to achieve100% renewable energy for the whole energy system of German, implementation of crucial regulations is essential policy.

China is the major energy consumer in the world (British Petroleum, 2019), and the largest emitter of greenhouse gases (Yang et al., 2050).The world's fifth largest producer of oil, seventh largest producer of natural gas, and largest producer of coal in the world (Zhang et al., 2017; Wang et al., 2018). China intends to reduce the use of coal in electricity production, but use of coal is increasing day by day as power projects are being plannedrequire the use of coal. Actually, total primary energy consumption of China andthe proportion of fossil fuelsserving as the major source is predicted to approach 90% (Matsumoto and Andriosopoulos, 2016). At the same time, China has the maximum hydropower resources in the world, with a total theoretical hydropower potential of 694 GW (Zhang et al., 2017). By the end of 2015, China's hydropower capacity has surpassed 25% of the world's nonhydro renewable capacity, accounting for 63.1 and 117.0% more than the US and Germany, respectively (Yang et al., 2016). Until the end of 2017, the total installed sustainable energy generation capacity of China's was 635 million kW, accounting for 35.7% of total installed electric power capacity (Liu, 2019).

Russia haslargest fossil fuel reserves in the world and is fourth highest (after China, the United States, and India) greenhouse gases emitter in the world. Russia is second largest producer of natural gas in the worldafterThe United States (British Petroleum, 2019) and play a significant role in primary supply of natural gas to most of European countries. Russia ispromoting the implementation of solar and wind energy for the betterment of isolated populations by providing employment, research, technology, and energy security (Gielen et al., 2019). Although Russia is a pioneer in sustainable energy technology, butmajorstrategy of country is focused on the expansion of fossil fuels and nuclear energy(Lanshina et al., 2018). The Russia introduced the Capacity-Based Renewable Energy Support Scheme (CRESS) in 2013 (Smeets, 2017). Under this scheme, each year, a maximum installed capacity of solar, wind, and small hydro projects might get financial guarantees on Russia's wholesale power market (Boute, 2012). Russia's energy security will be dependenton its natural gas supplies, and its capacity to export it to Europeas well as other countries.

Renewable energy is better adapted to distributed production than the fossil fuel paradigm, making it more secure. Renewable energy will contribute to the emergence of an era energy democracy, in which a system of decentralised prosumer systems will replace large-scale power generation.

VI. ENERGY SECURITY, SUSTAINABILITY CHALLENGE AND EXPECTATIONS

Recently, there has been a rising support for integratingsustainable energy into the energy supply as a primary measure for addressing energy security and climate change (Hache, 2018). Energy security planning is becoming increasingly focused on developing a low-carbon economy and meeting climate mitigation targets (Hamed and Bressler, 2019).

Article 2 of the Paris Agreement (United Nations, 2015)directs the different countries to implement nationwide contributions and gradually increase their goals in order to keep meanglobal temperature rise level below 2°C (Rogelj et al., 2016).Renewable energy is leading energy option as new energy must cause less pollution than the optionsit replaces. Goldthau and Sovacool (2012) discussed three major challenges of energy: energy security, energy justice and a low-carbon transition. The authors emphasised the role of energy security as a democratic issue, equity as animportant part of accessibility and global climate change as keycharacteristic of acceptability.

Similarly,Sovacool and Rafey (2011) proposed a four aspects of energy security: (1) availability, i.e., alternative fuels, preparing for disruption recovery, and reducing dependence on foreign supplies; (2) affordability, that is, providing affordable energy services and minimising price variability(3) efficiency and development, which includes increasing energy efficiency, changing consumer attitudes, and building energy infrastructure; and (4) environmental and social stewardship, which includes safeguarding the natural environment, communities, and future generations.

According to Sovacool and Brown (2009), energy securityis defined by the following criteria i.e.availability, affordability, energy and economic efficiency and environmental stewardship. Availabilityis evaluated by reliance on import of oil andnatural gas import and availability of alternative fuels. Whereas affordability ismeasured by retail of electricity, gasoline and petrol prices.Energy intensity, electricity use per capita, and average

fueleconomy of automobiles are parameters for Energy and economic efficiency measurement. Environmental stewardship is measured by sulfurdioxide (SO_2) and carbon dioxide (CO_2) emissions.

The worldwide move to sustainable energy demonstrates a more powerful global response to change in climate. Maximum European countries have validatedstrategies that will have substantial economic, social and political ramifications. This shift to environment friendly energy will change the geopolitical landscape, dynamics between producer and consumer countries (International Renewable EnergyAgency, 2009) and set up new energy norms for exporting countries (Overland, 2019).The renewable energy revolution will be one of the major characteristics and pillars of the low-carbon transition. Transitions from coal to natural gas as well as transitions from non-renewable to renewableenergy will be important step (Matsumoto and Andriosopoulos, 2016).

VII. RECENT ADVANCEMENTS IN GREEN ENERGY

Renewable energy (RE) sources include biofuels, geothermal, hydro, solar, tidal, waste, and wind. The main obstruction to RE systems is uninterruptible energy generation. As compared to other renewable energy sources, solar and wind energy are most unpredictable as well as their variability is substantial (Ghosh, 2022).For the expansion of renewables, the power electronics have been the main promotor among all the supportive technologies.The electrical converters enabled the coupling of renewable energy producers to legacy power systems, as shown schematically in Figure 1, and enhanced energy harvesting efficiency via customised controls. In addition to this, power electronics is key as well as widely used component on the consumer side of the future smart grid.Wind turbine systemshave evolved significantly over the years. In the 1980, 50kW wind turbine was large, butnow normal wind turbine is rated at 2 to 3 MW. The development for larger units was driven due to need of lower energy costs, whereas improvements in performance particularly in terms of grid connection, requireupgradation of the electric technology.

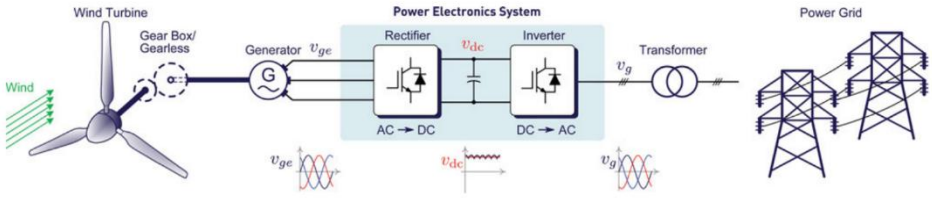

Figure 1: Power electronics enabled wind turbine energy conversion system (Source: Blaabjerg and Ionel, 2015)

Grid-connected photovoltaic (PV) systems, shown schematically in Figure2, consists of a power electronics DC/DC converter for maximum sun energy harvesting through maximum power point tracking (MPPT) regulation as well as a DC/AC converter for grid hookup.PV systems are becoming in demand not only for multi-MW utility scale power plants/farms, but also for roof top installations on commercialas well as residential buildings with ratings as low as hundreds of watts.

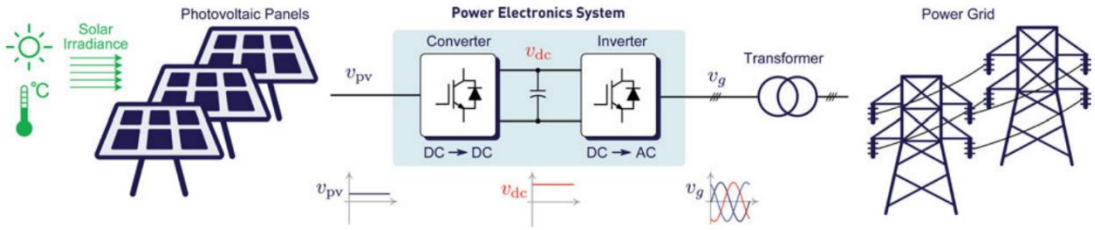

Figure 2: Power electronics enabled photovoltaic energy conversion system with DC/DC and DC/AC converter (Source: Blaabjerg and Ionel, 2015)

The SASDAC system consist of four primary components: a desiccant dehumidifier, a sensible heat exchanger, a cooling unit and a solar regeneration heat source. The essential functioning concept of the solid desiccant system is illustrated in Figure 3. The hot and humid air enters from the outside into the system, passes through the desiccant wheel and become hot and dry because the desiccant wheel absorbs moisture.Now hot and dry air from the desiccant wheel flows through the heat recovery wheel and here heat exchange occurs between the primary and return air. From heat recovery wheel air passesthrough a humidifierand it adds moisture to achieve the considerable cooling effect, suitable for the conditioned environment. After this, air returns from the room and directed through a humidifier, which adds moisture to the air to cool down. Then, the moist air passesvia a heat recovery wheel and becomes hot. At final step, the hot air flows through heating coils and desiccant material is regenerated by increasing the temperature with solar energy.

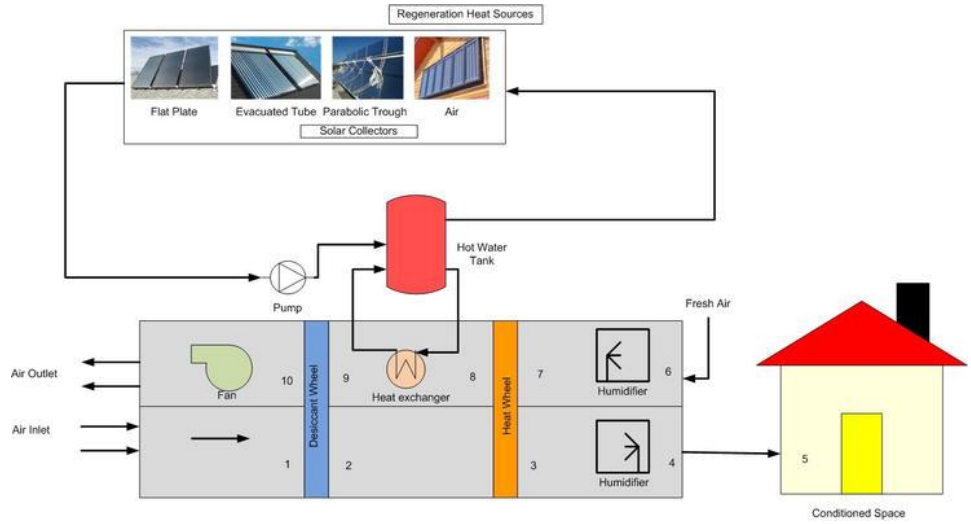

Figure 3: Working principle of solar-assisted solid desiccant cooling system [20].

Beside these technologies, methods, and devices, emphasis should be on the significant andcontinuous efforts for integrating renewables sources into the power and energy system, which make anaccurate balance between production and consumption. The major problem for science and society is control on the complete energy systemi.e. electrical power, thermal energy as well as water flow system. In this context, Smart-grid functions and facilities i.e., communications and energy storage, are considered as solution enablers in this context, but there is still a long way to go.

VIII. CONCLUSION

Fossil fuels continue to account for the majority of energy consumption and increasing around the world. In this case, environmental pollution is unavoidable and renewable energy plants haveno direct impact.For a long term plan, if investments in renewable technology continue, renewable sources have the potential to contribute considerably to fulfil energy needs.

Furthermore, many technologies including biofuels and fuel cells can contribute to the heat, transportation and energy markets.In 2023, the contribution of fossil fuels in total primary energy supply is predicted to be approximately 81%. By 2050, renewable energy will account for approximately 30% of the global energy structure.

Now a days, various energy-efficient technologies are used in power plants, industries and transportation systems to consume less and cleaner energy. These technologies have the potential to reduce costs by up to 80%, save energy by up to 30% and help to halt global warming in the future. As a result, the countries may remain economicalwhile planning long-term growth. Marketing renewable energy can also be defined as the ability to understand the requirements of consumers.

REFERENCES

[1] Agora Energiewende (2019). European Energy Transition 2030: The Big Picture. Ten Priorities for the next European Commission to Meet the EU's 2030 Targets and Accelerate Towards 2050.
[2] Agreement No.: CE 36/2000, Study on the PotentialApplications of Renewable Energy in Hong Kong, Stage 1 StudyReport, December 2002
[3] Boute A (2012). Promoting renewable energy through capacity markets: An analysis of the Russian support scheme. Energy Policy, 46:68-77.
[4] British Petroleum (2019). BP Statistical Review of World Energy. 68th ed.
[5] Chaturvedi P and Garg HP (2007). Financing renewables—emerging dimensions. IREDA NEWS; July–September 2007.
[6] Dizdaroglu D (2017). The role of indicator-based sustainability assessment in policy and the decision-making process: a review and outlook. Sustainability, 9(6): 1018.
[7] Eurostat. EU27 Energy Dependence Rate at 54% in 2011. 2013.
[8] Gielen D, Boshell F, Saygin D, Basilian MD and Wagner N (2019). The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 24:38-50.
[9] Goldthau A and Sovacool BK (2012). The uniqueness of the energy security, justice, and governance problem. Energy Policy, 21:232-240.
[10] Hache E (2018). Do renewable energies improve energy security in the long run? International Economics, 156:127-135.
[11] Hamed TA and Bressler L (2019). Energy security in Israel and Jordan: The role of renewable energy sources. Renewable Energy, 135:378-389.
[12] Hansen K, Van Mathiesen B and Skov IR (2019). Full energy system transition towards 100% renewable energy in Germany in 2050. Renewable and Sustainable Energy Reviews, 102:1-13.
[13] Harjanne A and Korhonen JM (2019). Abandoning the concept of renewable energy. Energy Policy. 127:330-340.
[14] International Energy Agency (IEA). Renewables in Russia: From Opportunity to Reality. Paris: IEA/OECD; 2003.
[15] International Renewable Energy Agency (IRENA). A New World. The Geopolitics of the Energy Transformation. Global Commission on the Geopolitics of Energy Transformation. 2019.Available from:https://geopoliticsofrenewables.org/assets/geopolitics/Reports/wpontent/uploads/2019/01/Global_commission_renewable_energy_2019.pdf
[16] Kalyani VL, Piaus A and Vyas P (2015). Harvesting Electrical Energy via Vibration. Journal of Management Engineering and Information Technology, 2(4): 2394 – 8124

[17] Lanshina TA (2018). The slow expansion of renewable energy in Russia: Competitiveness and regulation issues. Energy Policy, 120:600-609.
[18] Liu J (2019). China's renewable energy law and policy: A critical review. Renewable and Sustainable Energy Reviews, 99:212-219.
[19] Maithani PC (2008). Renewable energy policy framework of India. India: Narosa Publication Delhi,pp. 41–54.
[20] Matsumoto K and Andriosopoulos K (2016). Energy security in East Asia under climate mitigation scenarios in the 21st century. Omega, 59: 60-71.
[21] Matsumoto K, Doumpos M and Andriosopoulos K (2018). Historical energy security performance in EUcountries. Renewable and Sustainable Energy Reviews, 82:1737-1748.
[22] Nfah E, Ngundam J and Tchinda R (2007). Modelling of solar/diesel/battery hybrid power systems for far-north Cameroon. Renew Energy, 32(5): 832–844.
[23] Overland I (2019). The geopolitics of renewable energy: Debunking four emerging myths. Energy Research and Social Science, 49:36-40.
[24] Proskuryakova L (2018). Updating energy security and environmental policy: Energy security theories revisited. Journal of Environmental Management, 223:203-214.
[25] Purohit P and Michaelowa A (2008). CDM potential of SPV pumps in India. Renewable and Sustainable Energy Reviews, 12:181–199.
[26] Rogelj J, Den Elzen M, Höhne N, Fransen T, Fekete H and Winkler H (2016). Paris agreement climate proposals need a boost to keep warming well below 2°C. Nature. 534:631-639.
[27] Smeets N (2017). Similar goals, divergent motives. The enabling and constraining factors of Russia's capacity-based renewable energy support scheme. Energy Policy,101:138-149.
[28] Sovacool BK (2013). An international assessment of energy security performance. Ecological Economics, 88:148-158.
[29] Sovacool BK and Brown MA (2009). Competing Dimensions of Energy Security: An International Perspective. Working Paper #45, Working Paper Series. Atlanta, GA: Ivan Allen College, School of Public Policy, Georgia Tech.
[30] Sovacool BK and Rafey W (2011). Snakes in the grass: The energy security implications of Medupi. The Electricity Journal, 24:92-100.
[31] Sovacool BK and Tambo T (2016). Comparing consumer perceptions of energy security, policy, and low-carbon technology: Insights from Denmark. Energy Research and Social Science, 11:79-91.
[32] United Nations (UN). Paris Agreement. 2015. Available from: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[33] Wang B, Wang Q, Wei Y-M and Li Z-P (2018). Role of renewable energy in China's energy security and climate change mitigation: An index decomposition analysis. Renewable and Sustainable Energy Reviews, 90:187-194.
[34] Yang XJ, Hu H, Tan T and Li J (2016). China's renewable energy goals by 2050. Environmental Development, 20: 83-90.
[35] Zhang L, Sovacool BK, Ren J and Ely A (2017). The dragon awakens: Innovation, competition, and transition in the energy strategy of the People's Republic of China, 1949–2017. Energy Policy, 108:634-644.

