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A Review on Renewable Energy and Role of Power Electronics Converters in Different Renewable Energy Conversion Systems

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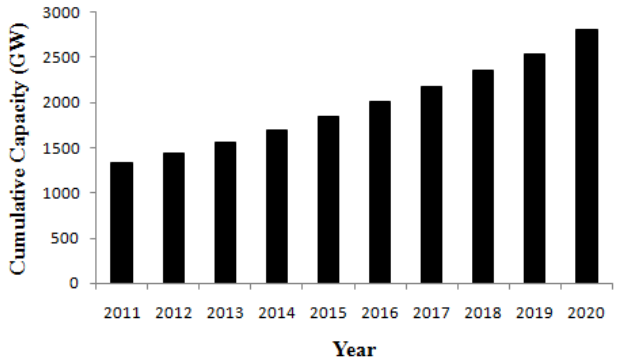
Abstract: Energy demand is increase globally and to meet this demand energy resources have to play an important role. But with the consumption of fossil fuels the greenhouse gas are realized in the environment, this effect leads energy industries to move toward an economical and green source of energy. From last few decades renewable energy resources has became a point of interest for researchers and energy industries around the globe. Renewable energy conversation systems (RECSs) is a clean energy conversion system and this the reason the understanding and knowledge of RECS is compulsory to extract the electrical energy from these energy sources. This paper presents a study on major renewable energies and power electronics converter's effects and importance of quality description in wind, solar and hydro power energy conversion system.

Keywords: Renewable Energy Conversion System (RECS), Power Electronics, Solar Energy, Wind Energy, Hydro power, Wind Energy Conversion System (WECS), Solar Energy Conversion System (SECS), Hydro Power Conversion System (HPCS).

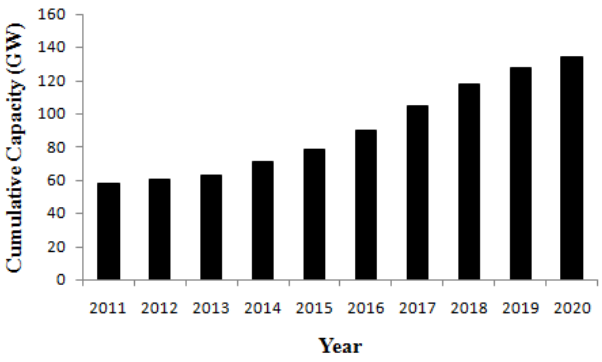
I. INTRODUCTION

Power electronics is dealing with the command and conversion of electric energy in various energy systems. In recent years, power electronics have been growing-up more and more due to more reliable, well-developed and cheaper components as compare to the conventional electronics components. Power electronics components become cheaper due to increasing of production and demand. Power electronics generate energy from continuous energy source like water, sun and wind. Since the fossil fuel is the world's primary fuels.

So the result is rapidly increasing of carbon dioxide (CO2),it can be seen that emission of CO2 related to the world's energy increased between 2012-2020 from 32.3 billion tons (bmts) to 35.6 billion tons (bmts) and still it'll increase and in 2040 it would be 43.2 billion tons (bmts) [1].



(a) Global total renewable power installed capacity 2011 to 2020.



(b) India total renewable power installed capacity 2011 to 2020.

Fig. 1. World and India renewable energy trend [5].

Power generation sources like natural gas, coal and oil consider as emissions of global greenhouse gas. The standards of living can raises through more reliable electricity and cleaner [2]. Renewable energy is describe as that's type of energy whose source are unlimited or can be constantly refill [3, 4]. It is obtained directly from natural sources such as

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rain water, wind, sun light, tides heat and also from geothermal and biomass from deep inside the earth the generated heat. It also reduced the general emission of air pollutants, like due to combustion of fossil fuel produced sulfur dioxide as the result and common emission of air pollutants like sulfur dioxide which are produced burning of fossil fuels.

In last few decades, researchers had listed various topologies and methods of power electronics converters (PECs) for interaction with grid. These PECs improves the extraction of energy and in case of hydro and wind energy systems PEC also gives an extra benefit of variable-speed operation of turbines used in WECS and HPCS. Fig. 1(a) shows the total global installed capacity from 2011 of RECS to 2020 [6] and Fig. 1(b) shows the India renewable power installed capacity 2011 to 2020 [5]. Total of approx. 2799.094 GW generation capacity of RECS was installed till 2020 worldwide, only in year 2020 the generation capacity of RECS is increased by 260.623 GW. India is the fourth place in the world having total generating capacity of 134.197 GW in the world's green energy generation [5].

This paper provides a comprehensive review on renewable energy including hydro-energy, solar energy and wind energy. And it also discusses the role of PECs in the different renewable energy conversion systems.

A. *Solar Energy*

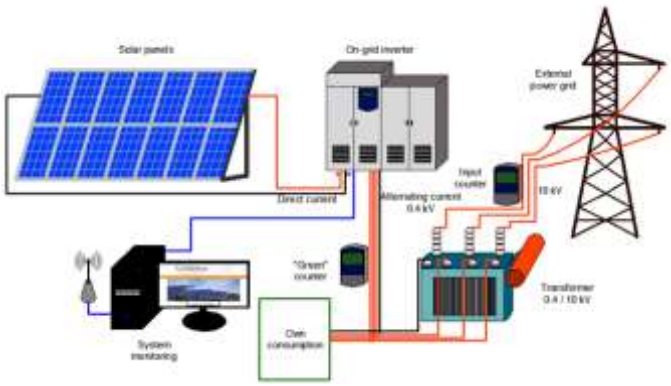
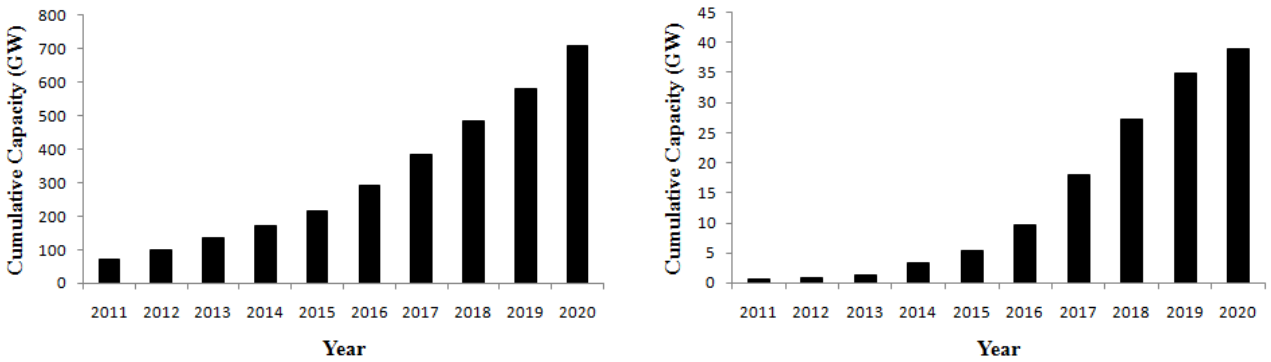


Fig. 2. Solar energy system setup.



(a) Global total solar power installed capacity 2011 to 2020.

(b) India total solar power installed capacity 2011 to 2020.

Fig. 3. World and India solar energy trend [5].

Solar energy is a real and most plentiful renewable energy resource [6]. It is pollution-free, does not generate greenhouse gases or petroleum-based energy, and does not generate waste that needs to keep in stoke like nuclear power. It's also soundless to generate and use, which reduces the required amount of noise and converts useful form from energy. As compared to the other renewable energy residential-size solar panel systems have very little environmental impacts like wind turbines and hydropower. After installation the maintenance cost of solar panels is very low with no static parts replace and to disintegrate. The photovoltaic cell provides clean energy conversion with no noise and no emissions, without the need for an active mechanical system. Fig. 2 shows a setup for solar energy extraction in form of electrical energy. Whereas, Fig. 3(a) shows the total global installed capacity from 2011 of solar energy to 2020 [6] and Fig. 3(b) shows the India solar power installed capacity 2011 to 2020 [5]. Total of approx. 707.495 GW generation capacity of SECS was installed till 2020 globally, only in year 2020 the generation capacity of SECS is increased by 125.836 GW. India is on fifth position in world and on third place in Asian countries having total

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generating capacity 39.211 GW in the world's solar power generation [5].

B. *Wind Energy*

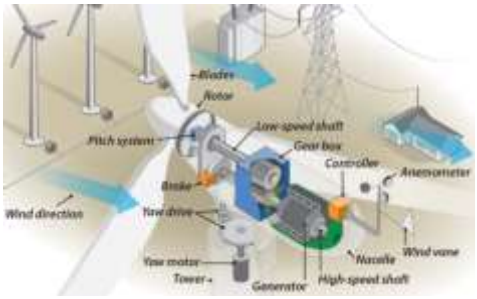


Fig. 4. Parts of wind turbine [10].

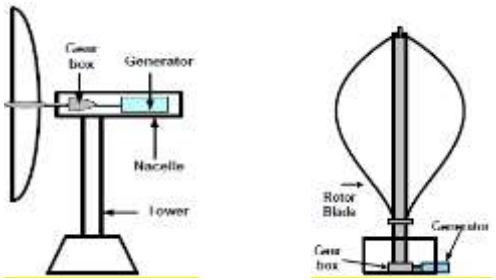
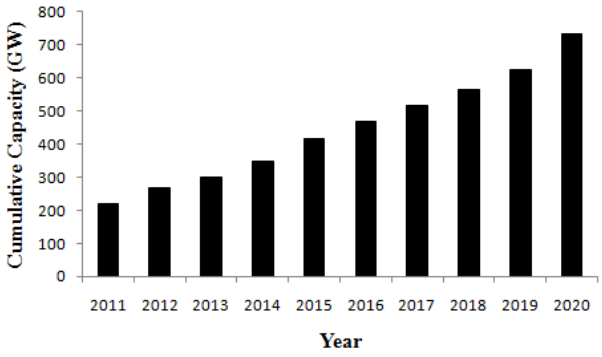
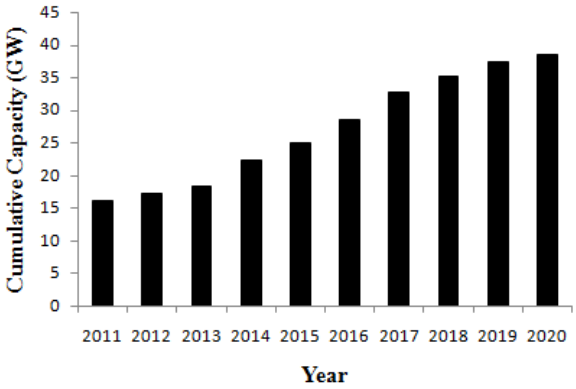


Fig. 5. Different types of wind turbine (a) HAWT, (b) VAWT [10].

Wind is a free, abundant and sustainable energy that make up the largest share of the renewable energy sector [11, 12]. The generation of electricity through wind energy is environmental friendly, pure and any air pollutants doesn't emits by wind turbine. Once the turbine is built, its maintenance cost almost zero. The kinetic energy (movement) of the wind is converted into mechanical energy by the turbine and mechanical energy is used to generate electric energy. Wind power has many benefits, such as reducing greenhouse gas emission through the use of turbines that generate electricity. Since it generated electricity through wind power hence it reduce the electric costs. Wind turbine drive by natural air and air found everywhere. Wind energy is a better option to promote harmony with nature, promotes social development saving from the dire prognosis of the world in which fuels and oil are depleted [13]. The unpredictable and regular nature of wind energy would contribution limit at any region unless intercontinental transmission or large-scale energy storage available. The location of wind turbine as simply public acceptable and also environmental restrictions like forest reservations act and protection areas further limits the wind turbine location [14]. Fig.4 shows all the different parts of wind energy conversion system and Fig. 5 shows different types of wind energy installation configuration (a) (HAWT) Horizontal axis Wind turbine system and (b) (VAWT) Vertical axis wind turbine system.



(a) Global wind power installed capacity 2011 to 2020.



(b) India wind power installed capacity 2011 to 2020.

Fig. 6. World and India wind energy trend [5].

Total global installed capacity of wind energy from 2011 to 2020 in Fig.6(a) [5] and Fig.6(b) shows the India wind power installed capacity 2011 to 2020 [5]. Total of approx 733.276 GW generation capacities of WECS was installed till 2020 across the globe, only in year 2020 the generation capacity of WECS is increased by 111.025 GW. India is now listed on fourth position in world and is on second place in Asia with a present total installed generating capacity of 38.559 GW [5].

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C. *Hydro Energy*

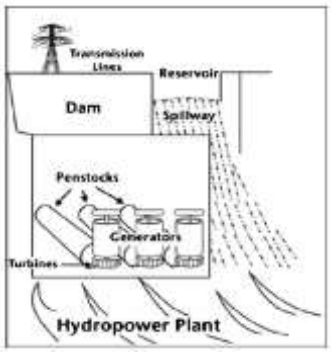
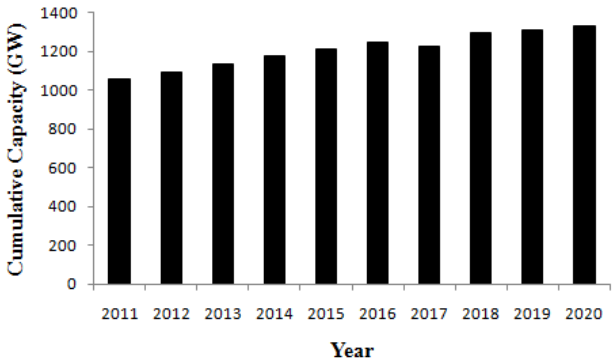
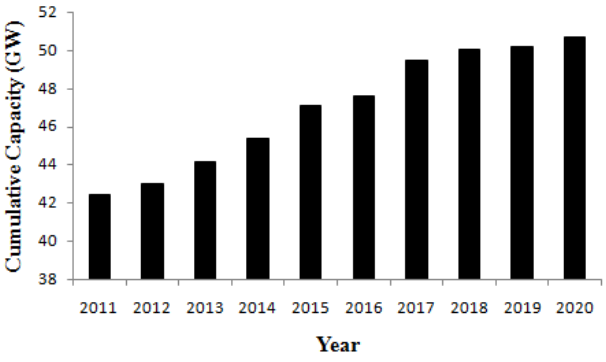


Fig. 7: Typical hydropower plant [15].

Hydro power is a renewable and clean energy source. Most countries prioritize hydropower development taking benefits into the account of economic, technical and environmental energy. The importance of hydro-power is overcome pollution and energy crisis which is the result of rapid growth of china economic and other countries in the 21st century [16]. Hydro-power is created when mechanical energy from water flows forcibly through the pipe (called gate) start turns the generator and produce electricity. The tidal and wave energy are also consist in hydraulic energy which are mentioned in early stage of the research [17]. Hydropower has great potential over other power generation sources, such as higher degree of reliabilities, operating and maintenance cost lower, efficiency high, proven technology and easy load adjustable functions. In general, most of the hydro-power plants installed where that provide flood control, water and recreational profits to the communities. Extra benefits is that any waste products doesn't created by hydropower plants that become the result of global warming and acid rain. Although there are some disadvantages including the higher installation cost for facilities; high speed dependence (not have any control on available water); changing of river regimes (temperature, due to varying of water level can affect the fish, wildlife, plants and river patterns); Flooding on wildlife habitat and also on land (creating reservoir); displacement between reservoir to people living area [18]. Total global installation capacity of hydropower from 2011 to 2020 shows in Fig 8(a) [5] and Fig 8(b) shows the India hydro-power installed capacity 2011 to 2020 [5]. Total of approx. 1331.889 GW generation capacity of HPCS was installed till 2020 across the earth, only in year 2020 the generation capacity of HPCS is increased by 20.581 GW. With the net generating capacity of 50.68 GW India is the fourth position in world and is on second place in Asia [5].



(a) Global hydro-power installed capacity 2011 to 2020.



(b) India hydro-power installed capacity 2011 to 2020.

Fig. 8. World and India Hydro-energy trend [5].

II. POWER ELECTRONIC CONVERTER'S ROLE IN DIFFERENT RECS

Due to development of semiconductor devices and microprocessor technologies the application of power electronics is increase in houses & in industries level. The some areas of silicon it steadily gives high performance rate in both cases. Its price decrease continuously due to easily presence of resources. A typical power electronics system consists of a control unit, power converter and a load/source as shown in Fig 5. The power converter is a configuration between grid

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and load/generator. Depending on applications and topologies the power may flow in both directions. There are three most important issues are concern by using such system - reliability, efficiency and cost [19].

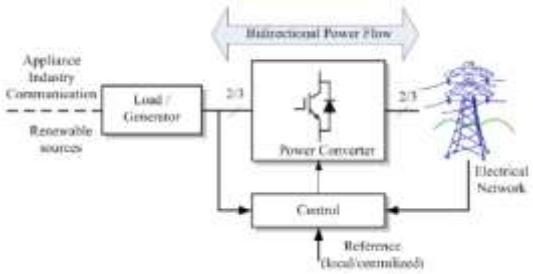

Fig 9: power electronics system with load/generator, control and power converter [19].

A. *Solar Energy Conversion System (SECS)*

Mainly solar energy system divided in two types Active and Passive which are again classified into different types [20.21]. The main perspective of power electronics will be focus on photovoltaic (PV) solar cell which is a type of Active solar energy system. The photovoltaic is all-electrical device which consist of array of solar cell. It produce electrical energy from irradiate light. PV connected with suitable load and when exposed to sunlight then it produced electrical power [19]. The yield of PV system primarily depends on the intensity and durations of illumination [9]. The PV cells are used in designed SES as maximum power point tracking (MPPT), stored electrical energy (battery), protection circuitries. The algorithm of MPPT based on the measuring PV power-voltage curve presented on slope of graph, which may be implemented by using analog circuit [22]. In case of without moving any part of PV cell module PV cell has very long time durability (>2 years). For increasing the efficiency of solar cell the lot of work being done, the works are basically focused on materials domain and electro-physics.

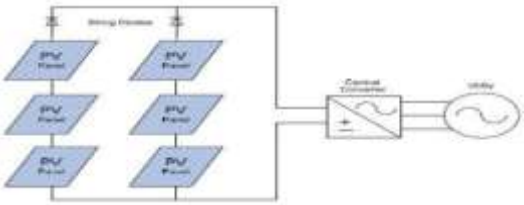

Fig 10: PV configuration with a centralized power electronic coupling.

PV panel formed when certain numbers of solar cell are connected in series. Due to the series connection of solar cell build up a terminal voltage and weaker solar cell decide the current flow through which panel [9, 23]. The low current issues can be solved by parallel connection of solar cell but it produced very low voltage (< 5.0V). The power handling capacity would be further increase by series combination of all panels. For to increase the reliability and efficiency of the system, employed the power electronics conditioning interfaces with the seen entire PV system as small DC source. The power electronics roles are mainly: (I) all the solar panels are individually interconnected: it means two identical solar panel cannot be join together; therefore the required current and voltage will maintain by the help of interfacing the two DC-DC converter. For this purpose some non-isolated DC-DC converter like- cool topologies, boost, buck and Buck-Boost can be employed with suitable modifications [23]. (II) The DC output of the PV system interface to the load and the grid: The conversion of DC-AC-AC and DC-DC-AC is includes in this process. For include the usage of Z-source inverter the grid interconnected with PV based system and topologies interconnected with fuel-cell system. In Fig.10, the connection of PV system in series / in parallel then after connected with centralized AC\DC converter. The series connection of PV panels with one inverter per string and also having single string is called String-array PV system. For maximize the power production of the PV system inverter offering the possibility of MPPT and PV string have a DC-DC converter plus [22]. In PV system the discussion of DC-DC and DC-AC is more significant, because energies are converted into AC by generator in wind and hydroelectric power converter. But in SES, photovoltaic panel convert the solar energy into DC. Below the various types of useful inverter are described [24]: (a) String inverter: Here, each set of PV module is series connection to a string inverter. Further connection of string in parallel configuration and resultant output gets in AC form. (b) Module inverter: Here, each inverter is connected to the PV

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separately and then inverters are paralleled which gives resultant output in AC form. (C) Multiple-String Inverter: The modified form of string inverter in which all string inverters are replaced by DC-DC converter. An inverter connected before the resultant output, after connecting these in parallel.

B. *Hydro Power Conversion System (HPCS)*

Hydro-power also known as water power, in which falling or fast running water in form of velocity and position produced hydraulic energy. In hydro-power system turbine has rotator motion cause by water pressure on turbine blade surfaces and angular changing of angular moment of falling-water. Hydropower system not consumes any type of working fluid and it can be use as electrical generator or power machine at one time. The mechanical application of hydropower plant is used in small-size hydro-power plant where small equipments like- grinding, milling, pressing and also small size mechanical tool powered by power generator. In some cases, for to provide the mechanical-power and electrical power hydro-power extends its shaft in both direction [29].

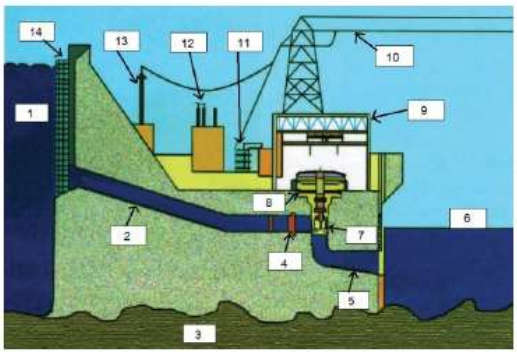

Fig 11: A schematic view of a hydropower station along its basic parts, source: International Energy Agency (1) Reservoir, (2) Penstock, (3) Bed rock, (4) Valve, (5) Draft tube, (6) Tailrace water, (7) Turbine, (8) Generator, (9) Power house, (10) Transmission lines, (11) Transformer, (12) Insulators, (13) Transmission tower, (14) Trash rack [30].

For to generation electricity the large scale Hydro-power plants are used. Fig. 11 shows the systematic diagram of hydro-electric power generation system. For to produce electricity the generator couple with output turbine shaft. The rotor is made up of electromagnets and containing the binding of electric wire that is located inside the stator. On operation time, the rotor part start rotation and produced electricity and stator kept in rest. The transmission system consists of parts like- transformer, transmission lines and control yards. In case of electricity generation cost the hydro-power plant is once cheapest technology for well-operated and well planned project [31] because fuels available in water form which not need to purchase and saves direct cost of fuel purchase [32]. Since the electricity generation cost is very low, recommended to maximum heavy power utility company used hydro-electric energy as a source or load. In terms of power conversion technology the hydropower plant is more flexible. In the comparison of other electric generation plant the hydro-power plant has more capacity to full fill the fluctuation of power generation [33-34]. Further, hydroelectric power technology convert huge amount of mechanical energy into high forms of electrical energy this process is known as conversion of efficient energy. Hydro-power plant has 85% efficiency of energy conversion system while thermal power plant system has only less than 50% [35].

C. *Wind Energy Conversion System (WECS)*

The basics principle of wind energy system is used to generate electricity through the wind [1]. The mechanical power the wind turbine blades convert the wind energy into electrical energy and this electrical energy used for different purpose. A multi-pole generator can be used gear used according to need. A power converter can be place between the generator and the grid. One end of power converter used to interface to the grid. The output of system is either in DC or AC current. Wind energy system has propose to coupling Matrix converter at high frequency and the grid proposed to coupling AC-AC converter of the wind energy converter. Additionally, also wind turbine gives ability of higher potential control in the presence of power converter. The modern wind farms and wind turbine are full-fill their technical requirements by grid which imposed such as- quick response under dynamic power and transient system situation; power quality improve and on network stability influences [22]. The Aerodynamically designed wind-turbine blades power take from wind and convert into mechanical-power. The three blades are used in wind turbine. The

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rotational speed of blade is inversely proportional to the radius of blades. The standard fixed generator and gear box is used to electric power from low speed and high-torque power because blade tip-speed must be lower than half of sound [19]. As illustrated in Fig 12.

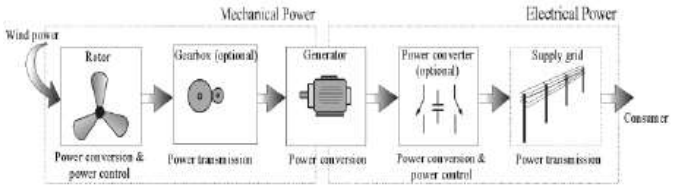

Fig 12: Converting wind power to electrical power in a wind turbine [26].

The wind energy system associate with following necessary features: First, available wind energy. Second, Employed type of power electronic circuitry and electric generator for interface with the grid and third is, employed type of wind turbine. The wind-energy system includes highly inter-linked parameters such as- surface temperature of earth, atmospheric temperature, wind speed, etc. Due to inherent complexity the prediction of wind intensity on physical basis is very difficult. However, the distribution based model have been employed and proposed for to predict the intensity of wind energy conversion system [26]. On the basis of aerodynamic principle, wind-turbine classified as: Drag based and lift-based turbine. Also they are classified on the basis of mechanical structure: Horizontal axis and Vertical axis wind turbine. Wind turbine divided two types on the basis of rotation of rotor: Variable speed and fixed speed wind-turbine [9], [12].

The power electronic circuit in variable based wind energy conversion system play important role on other hand wind turbine are easy to robust, operate and reliable, the grid frequency fixed the speed of rotor. In situation of varying wind speeds they cannot find the optimal power extraction point and also cannot give the optimal aerodynamics efficiency. In variable speed wind turbines, the rotor mechanical frequency partially or completely decoupled by power electronic circuit, the electrical frequency of grid enable the operation of variable speed. The requirement of interfaces of power electronic is dictates by grid condition and the type of electrical generator. The double-feed generators used to depute the partial variable speed of wind-turbine [26]. As the power converter this method handle ~ 25%- 50% fraction out of total power in the system.

The use of rotor side AC-DC converter is makes by the power converter system, DC link capacitor and inverter DC-AC connected to the grid. The converter toward stator control or maintain constant voltage of DC link capacitor, rotor speed and torque is control by rotor side. Irrespective of rotor powers magnitude. In case of fixed speed system this method is more useful; but possible optimal solutions don't obtain by this method. For to perform winder range of optimal operation the wind turbine is completely decoupled from the grid and full a AC-AC converter system is employed. The turbine fed the variable frequency in three phase AC-DC-AC converter. The generator side AC-DC converters control the predetermined value at the end DC link capacitor. Than Six-switch of DC-AC inverter invert the DC voltage. Since the inversion is buck operation, so the AC-DC converters toward the turbine side provide sufficient level voltage. An addition, for additional boosting voltage maybe employed the DC-DC converter. This increase the capacity and overall cost. The inverter based on Z-source may be employed for to overcome this shortcoming. The advantage of Z-source over the voltage/ current source inverter is following: Buck-Boost ability, improved EMI as dead band are not needed, Inherent short circuit protection due to its configuration. Since the wind power conversion system based on Z-source is relatively new topologies hence the researcher are investigating its applicability.

III. CONCLUSION

It is necessary to protect our planet by including renewable and ecological energy sources in our daily life. A growing number of local governments are using renewable energies to reduce greenhouse gases, improve air quality and energy security, stimulate the local economy and pave the way for a sustainable energy future. Renewable energies can contribute to the local economy by creating jobs and opening up new markets, and as a hedge against fluctuations in fossil fuel prices. The power electronics now take care of the efficient conversion and control of electrical energy and the next focus.

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REFERENCES

[1]. Deepak Kumar Chy. and Md. Khaliluzzaman "The Significance of Power Electronics Components on Sustainable Energy Sources", 9th ICCCNT 2018 July, IISC, Bengaluru, India, 2018.
[2]. Chr. Von Zabeltitz, "Effective use of renewable energies for greenhouse heating", Renewable Energy, Vol. 5, Issues 1–4, 1994, pp. 479-485.
[3]. Henrik Lund, "Chapter 1 – Introduction", in Renewable Energy Systems (Second Edition), Academic Press, 2014, pp. 1-14.
[4]. U. Shahzad, "The Need for Renewable Energy Sources", International Journal of Information Technology and Electrical Engineering, 2015, Chapter 4, pp. 16-19
[5]. IRENA Report, "Renewable Capacity Statistics 2021", International Renewable Energy Agency, 2021.
[6]. Adam J. Moulé, "Power from plastic", Current Opinion in Solid State and Materials Science, Vol. 14, Issue 6, 2010, pp. 123-130
[7]. Pogson, M., Hastings, A. and Smith, P., "How does bioenergy compare with other land-based renewable energy sources globally?", GCB Bioenergy,Vol. 5, 2010, pp. 513-524
[8]. Renewable-Energy-Sources: http://www.renewable-energy-sources.com/
[9]. Frede Blaabjerg, Zhe Chen and Soren Baekhoej Kjaer, "Power Electronics as Efficient Interface in Dispersed Power Generation Systems," IEEE Trans. Power Electron., Vol. 19, no. 5, pp. 1184-1194, Sep. 2004.
[10]. Tanuj Jhankal, "A Review on Various Topologies of Generators, Power Converters and Control Schemes in Wind Energy Systems", International Journal of Trend in Scientific Research and Development (ijtsrd), Volume-5, Issue-6, October 2021, pp.886-894.
[11]. D.P.Kothari, K.C.Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", Eastern Economy Edition.
[12]. Thomas Ackermann, Lennart Söder, "Wind energy technology and current status: a review", Renewable and Sustainable Energy Reviews, Vol. 4, Issue 4, 2000, pp. 315-374
[13]. S. R. Bull, "Renewable energy today and tomorrow," in Proceedings of the IEEE, vol. 89, no. 8, pp. 1216-1226, Aug. 2001
[14]. Steve Fetter, Michael Flynn & Linda Rothstein, "Energy 2050", Bulletin of the Atomic Scientists, Vol. 56, Issue 4, 2015, pp. 28-38.
[15]. Round, George. F., "Incompressible Flow Turbo-machines", Butterworth-Heinemann, Burlington, chapter 3(turbines), ISBN 978-0-7506-7603-8.
[16]. Hailun Huang, Zheng Yan, "Present situation and future prospect of hydropower in China", Renewable and Sustainable Energy Reviews, Vol. 13, Issues 6–7, 2009, pp. 1652-1656.
[17]. US Energy Information Administration, http://www.eia.gov/
[18]. Jian Liu, Jian Zuo, Zhiyu Sun, George Zillante, Xianming Chen, "Sustainability in hydropower development—A case study", Renewable and Sustainable Energy Reviews, Volume 19, 2013, pp. 230-237
[19]. F. Iov, M. Ciobotaru, D. Sera, R. Teodorescu and F. Blaabjerg, "Power Electronics and Control of Renewable Energy Systems," 2007 7th International Conference on Power Electronics and Drive Systems, 2007, pp. 6-28.
[20]. Ahteshamul Haque, "Chapter 3 - Solar energy", in Electric Renewable Energy Systems, Academic Press, 2016, Pages 40-59.
[21]. Yinghao Chu, Peter Meisen, "Review and Comparison of Different Solar Energy Technologies", in Report of Global Energy Network Institute, 2011.
[22]. Swapnil Srivastava, "Role of power electronics in non renewable and renewable energy systems", International Journal of Technical Research and Applications, Volume 1, Issue 3, 2013, PP. 91-94
[23]. Geoferry R. Walker, Paul C. Sernia, "Cascaded DC- DC Converter Connection of Photovoltaic Modules", IEEE Trans. Power, Electron., vol. 19, pp. 1130-1139, July 2004.
[24]. Blaabjerg, K. Ma and D. Zhou, "Power electronics and reliability in renewable energy systems," 2012 IEEE International Symposium on Industrial Electronics, Hangzhou, 2012, pp. 19-30.
[25]. Marian P. Kazmierkowski, R. Krishnan, Frede Blaabjerg, "Control in Power Electronics Selected Problems", In Academic Press Series in Engineering, Academic Press, 2002,
[26]. T. Burton, D. Sharpe, N. Jenkins, E. Bossanyi, "Wind Energy Handbook". John Wiley & sons, ltd, 2001.
[27]. Munteanu, L., Bratcu, A.I., Cutululis, N. A,. and Ceanga, E., "Optimal Control of Wind Energy Systems", Springer, 2008.
[28]. D. Mahinda Vilathgamuwa, Wang Xiaoyu, Gajanayake, "Z-source Converter Based Grid - interface for Variable-speed Permanent Magnet Wind Turbine Generators," in Proc. PESC2008. Conf, 2008, pp. 4545-4550.
[29]. Chiyembekezo S. Kaunda,1 Cuthbert Z. Kimambo,2 and Torbjorn K. Nielsen1 "Hydropower in the Context of Sustainable Energy Supply:A Review of Technologies and Challenges", International Scholarly Research Network ISRN Renewable Energy, 2012.
[30]. International Energy Agency, Hydropower and the Environment, "Present Context and Guidelines for Future Action", Subtask 5 Main IEA Report, Volume 2, International Energy Agency, Amsterdam, The Netherlands, 2000.
[31]. USA Department of Energy, "Hydropower Technology Information", Basic Energy Information, 2012.
[32]. A. Brown, S. Muller, and Z. Dobrotkova, "Renewable energy markets and prospects by technology," International Energy Agency (IEA) Information Paper, International Energy Agency (IEA), Paris, France.
[33]. International Renewable Energy Agency (IRENA), "Renewable energy technologies—cost analysis series, volume 1: power sector," IRENA Working Paper, vol. 3, Issue 5, 2012.
[34]. H. Locker, "Environmental Issues and Management for Hydropower Peaking Operations", United Nations, Department of Economic and Social Affairs (UN-ESA), 2004.
[35]. E. Roth, "Why thermal power plants have relatively low efficiency," Sustainable Energy for All (SEAL) Paper, Leonardo ENERGY, February 2005 Issue, 8 pages.

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