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Survey of Solar Photovoltaic Systems Under Renewable Energy For Different Applications

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Abstract: The permanent increase in the energy demand is considered as one of the most critical issue nowadays. Besides, as conventional power sources are limited and have adverse effects on the planet, has necessitated an imperative search for renewable energy which causes no pollution of the earth. Solar-powered (photovoltaic) systems are one of the viable alternatives that have attracted considerable attention in this regard. They have been deployed in many remote regions for various applications, ranging from rural electrification and community water supplies to irrigation and livestock water supplies. Although photovoltaic (PV) systems generally have a high investment cost, it has many features which make it attractive as an alternative source of power for water pumping. This paper presents a detailed intensive review of solar-powered water pumping systems as reported in the literature to serve as a quick reference to researchers and engineers who are working or interested in the subject.

Keywords: *Photovoltaic system, solar system, water pumping, simulation, modeling, grid power.*

1. Introduction

A renewable electricity generation technology harnesses a naturally existing energy flux and converts that flux into electricity. It must be located at the place where natural energy flux is available to occur. This technology is differed from the conventional fossil-fuel and nuclear electricity generation. Unlike conventional fossil-fuel and nuclear electricity generation, this technology has no fuel cost. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services. The main factors for developing renewable energies are able to lead a number of the positive results. Renewable energy sources are capable of controlling the greenhouse effect and climate change. In the area of space heating and transportation, the biogenetic fuel plays an appreciable function that verifies sustainable energy [7]. The development of renewable energy technologies is now widely recognized as a crucial component in providing an integrated solution to limit greenhouse gas emissions. It is an important opportunity to foster innovation and promote economic growth while enhancing access to secure, clean, and affordable energy . Developing countries like India, Pakistan, Sri Lanka, Bhutan, etc., are looking into inexhaustible and repeatable alternative energy sources such as solar, wind, hydro and biomass. South Asian countries' rapid population growth and economic development have increased the energy demand. Currently the South Asian countries have initiated several efforts to move to alternative types of energy, specifically renewable energy, to reduce South Asian countries' overdependence on fossil fuels and manage the growing demand for energy. There will be a large gap between the potential of fossil fuel supply and the energy demand to achieve the South Asian countries new social and economic development target for 2020 set by their central government. So renewable energy is an inevitable choice for South Asian countries to secure their electricity supply and to facilitate greenhouse gas mitigation. Many types of renewable energy resources such as wind and solar energy are constantly replenished and will never run out. Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, biomass and bio-fuels for transportation [18].

Various types of energy sources are given below:
Solar energy- Sunlight is one of our planet's most abundant and freely available energy resources. The amount of solar energy that reaches the earth's surface in one hour is more than the planet's total energy requirements for a whole year. Although it sounds like a perfect renewable energy source, the amount of solar energy we can use varies according to the time of day and the season of the year as well as geographical location. In the UK, solar energy is an increasingly popular way to supplement your energy usage [4].
Wind energy- Wind is a plentiful source of clean energy. To harness electricity from wind energy, turbines are used to drive generators which then feed electricity into the National Grid. Although domestic or off-grid generation systems are available, not every property is suitable for a domestic wind turbine.

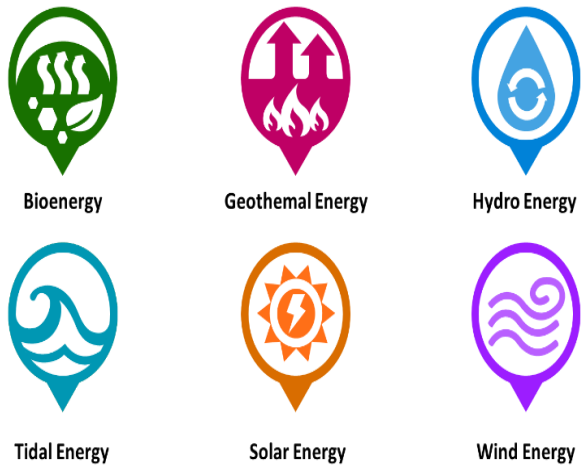

Fig. 1 Types of Renewable Energy sources.

Hydro energy- As a renewable energy resource, hydro power is one of the most commercially developed. By building a dam or barrier, a large reservoir can be used to create a controlled flow of water that will drive a turbine, generating electricity. This energy source can often be more reliable than solar or wind power (especially if it's tidal rather than river) and also allows electricity to be stored for use when demand reaches a peak. Like wind energy, in certain situations hydro can be more viable as a commercial energy source (dependant on type and compared to other sources of energy) but depending very much on the type of property, it can be used for domestic, off-grid generation.
Tidal energy- This is another form of hydro energy that uses twice-daily tidal currents to drive turbine generators. Although tidal flow unlike some other hydro energy sources isn't constant, it is highly predictable and can therefore compensate for the periods when the tide current is low. Find out more by visiting our marine energy page.
Geothermal energy- By harnessing the natural heat below the earth's surface, geothermal energy can be used to heat homes directly or to generate electricity. Although it harnesses a power directly below our feet, geothermal energy is of negligible importance in the UK compared to countries such as Iceland, where geothermal heat is much more freely available.
Biomass Energy- This is the conversion of solid fuel made from plant materials into electricity. Although fundamentally, biomass involves burning organic materials to produce electricity, this is not burning wood, and nowadays this is a much cleaner, more energy-efficient process. By converting agricultural, industrial and domestic waste into solid, liquid and gas fuel, biomass generates power at a much lower economical and environmental cost.
The rest of this paper is organized as follows in the first section we describe an introduction of different types of energy sources, and their applications. In section II we discuss their advantages and disadvantages too. In section III we discuss about solar photovoltaic system and their issues are discussed in section IV. Section V gives the architecture of microgrid and solar powered water pumping system (SPWPS) is discussed in Section VI. Finally, the conclusion is given in Section VII.

2. Related Work

Solar energy- It is used in cooking, lighting, and water heating. Its mitigation benefits are less consumption of fuel wood, kerosene and batteries, improved local air quality. Its adaptation benefits are Illumination for rural education and access to information and communication technology. Its socio-economic development benefits are Improved quality of life as well as better health and sanitation through streetlights and boiled water. Its negative impacts are:

- Requires sizeable amount of land
- Poses environmental hazards if the production process is not handled appropriately

Hydro energy- It is used in lighting, agricultural processing. Its mitigation benefits are Reduced greenhouse gases, protection of land. Its adaptation benefits are Improved social resilience. Its socio-economic development benefits are Improved agricultural yield. Its negative impacts are:

- Native population displacement
- Soil erosion

- Reduced agriculture land
- Ecosystem disturbance

Wind energy- It is used in power generation, crop processing, irrigation, and water pumping. Its mitigation benefits are decreased dependence on wood/biogas, avoidance of CO2 emissions. Its adaptation benefits are Reduced vulnerability to water scarcity, more adaptation choices through irrigated agriculture, Its socio-economic development benefits are Income generation, improved quality of life, reduced risks of vector borne diseases, improved water supply/food security, school attendance (especially for girls), reduced migration. Its negative impacts are:

- Alteration in migrating birds flight path
- Electromagnetic interference for radio signals
- Consequential noise from rotating blades
- Eyesore to the landscape

Biomass- It is used in electricity generation and heat. Its mitigation benefits are reduced use of charcoal and fuel wood, less pressure on natural resources. Its Adaptation benefits are reduces the likelihood of deforestation and desertification. Its socio-economic development benefits are creation of jobs and livelihood opportunities, reduced drudgery, reduction of incidents related to indoor air pollution and respiratory infections. Its negative impacts are:

- Fuel source uncertain and requires land for waste production
- Facility requires sizeable amount of land and water
- Affect surrounding biodiversity
- Emission of GHG such as deadly methane and CO2

Biogas- It is used in thermal energy production of sludge for fertilizer. Its mitigation benefits are reduced use of charcoal, fuel wood, and liquefied petroleum gas; reduced use of pesticides and fertilizers. Its adaptation benefits are reduces the likelihood of deforestation; adapting to soil erosion, aridity, and environmental degradation. Its socio-economic development benefits are Reduced drudgery, reduction of incidents related to IAP and respiratory infections; better prospects for agricultural productivity and income generation [18]. Its negative impacts are:

- Fuel source uncertain and requires land for waste production
- Facility requires sizeable amount of land and water
- Affect surrounding biodiversity
- Emission of GHG such as deadly methane and CO2

3. Solar Photovoltaic System

A system that generates the electrical energy by exposing to the solar radiations or by the photoelectric effect is known as photovoltaic or PV system. A PV system consists a number of solar cells which can be connected in parallel or series array pattern based on the voltage or current requirement. The connection of PV cells or solar cells can be done parallel to get the maximum output current, while the solar cells series connection is done to have maximum output voltage. Recently many countries are adopted the PV-based energy generation unit to get the long term solution for the load demands. The maintenance cost of PV cell is very less. The non-linearity in the PV system is a major issue that can affect the efficiency of power generation and also, the irradiation issues like a cloud, buildings shadows, etc [5]. Today, the world has adopted many renewable and easily available resources to generate the electric power. Among these resources, the solar rays of the sun are easily available resources by which the electric energy is generated. The solar-based energy system is commonly known as photovoltaic (PV) system. The cost of a photovoltaic cell is very high and its efficiency varies with climatic conditions like rainy, foggy, etc., and even depends on the shadows of the building, falling over the solar panel. In today's generation, the supply power needs to meet the entire load. It is being surveyed that efficiency of supply is needed to achieve the overall load.

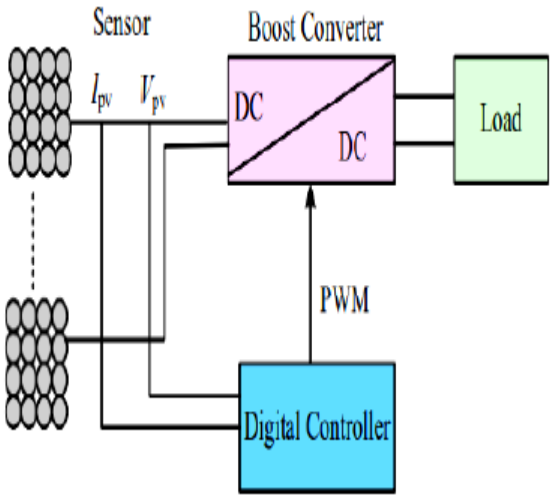

Fig. 2 Block Diagram of Photovoltaic System

The proper optimization approach will help in achieving the load needs. In that sense over the year's study has taken place to meet the load needs. The fact is that the

optimization concept of a power electronics composed of many aspects like mass, efficiency, temperature, etc. The DC-DC converter also helps to achieve the better efficiency in PV models [5].

First, the non-renewable energy resources like coal are mostly used for the generation and supply of electrical energy which demands in the world. This generation of electricity will increase carbon content in the climate, which lead to increase the pollution environment and global warming. Hence the use of renewable energy source is increased like wind energy, geothermal energy and solar energy etc. Second, the lack of electrical energy is the main problem in the development of rural India. India's grid system in considerably under development, hence the most of the areas are not connected to the grid system. The solution to this problem is to use of standalone photovoltaic system. Because many sunny days are accessible throughout India [10].

There are two types of photovoltaic system

Grid interfaced PV System- These systems are made to operate the PV system in parallel and interfaced with the grid. This system mainly composed of DC to AC conversion unit known as an inverter. This type of PV system can be operated by interfacing with grid.

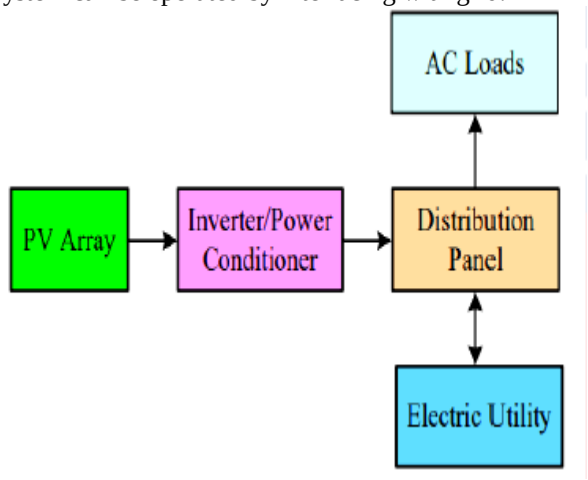

Fig. 3 Block Diagram of Grid Interfaced PV System.

Standalone PV Systems- These systems operate without any dependency over the grid and also on supply loads. This PV system is directly coupled system and works during the sun light and it will not store the generated power. These systems are used for running the fan, water pumping, etc. One of the most important applications of the standalone photovoltaic system is for the water pumping, especially in the rural areas that have a lot of amount of solar radiation and very far from the national grid. So in that areas solar photovoltaic water pumping system can be used for the supply of water. Particularly an effective solution must ensure that the PV generator run at the maximum power point (MPP) and that the pump which is driven by the single-phase induction motor run at the high efficiency and give the maximum output [10].

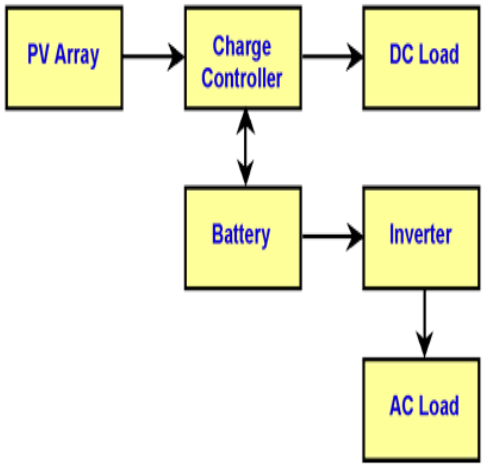

Fig. 4 Block Diagram of Standalone PV Systems.

4. Issues In Photovoltaic System

Solar energy is easily available and it is free of cost. By using the energy conservation law, it can be possible that the solar energy can be used to produce the electrical energy and such systems are considered as photovoltaic systems. The main drawback of the PV system is that the power efficiency decreases, when the climatic conditions vary and also the shadows on the PV arrays also decrease its efficiency. Some of the important issue in PV systems is given below [5]:

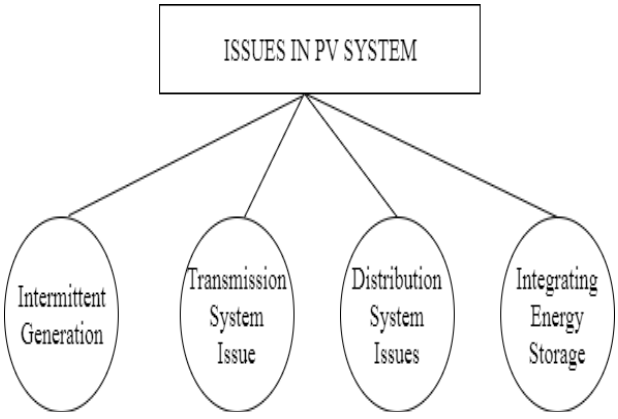

Fig. 5 Issues of Photovoltaic System Systems

Intermittent Generation- The constantly changing environment condition needs proper weather forecast to schedule the better power generation.
Transmission System Issue- The transmission of high energy over the existing transmission line is quite tough and is one of the notable points in PV system.
Distribution System Issues- The distribution of power to the different sectors is very tough in PV system.
Integrating Energy Storage- To attain the better efficiency, we can integrate grids and PV module but the storage system for this generated energy is very difficult.

5. Microgrid Architecture

A Microgrid is defined as a group of Distributed Energy Resources (DERs), including Renewable Energy Sources (RES) and Energy Storage Systems (ESS), plus loads that operate locally as a single controllable entity. Microgrids can be found in both low and medium voltage operating ranges, typically from 400 V to 69 kV. In addition, they exist in various sizes. They can be large and complex networks, up to tens of MW in size, with various generation resources and storage units serving multiple loads. On the other hand, microgrid can also be small and simple systems, in the range of hundreds of kW, supplying just a few customers [20]. MGs are strategic entities located in the LV distribution network. It is connected to the grid supply point (GSP) or the MV/LV substation at a single bus called point of common coupling (PCC) through circuit breaker or static transfer switch. It is controlled to switch between two modes of MG operation. A central controller for the whole MG is placed on LV side of GSP and it is known as microgrid central controller (MGCC) as shown in Fig. 1. It takes care of the power flow between the upstream utility network and MG, cost optimization of MG and deciding mode of operation and islanding detection. Various types of MSs and storage units are connected to LV radial feeders through PEI and MS controllers (MC). The loads are also distributed along the feeders via load controllers (LCs) for individual or aggregated loads. The MG control functional requirements for economical and reliable working can be formulated as [2]:

- Regulation of voltage and frequency (V-f) within limits.
- Efficient load sharing i.e. active and reactive power (P-Q) balance and proper communication among DERs.
- Seamless transition between two modes of operation i.e. proper synchronization and early islanding detection.
- Economic dispatch of the DERs units by optimization to reduce MG running costs.
- Power flow control between MG and PS network i.e. an energy management system (EMS).

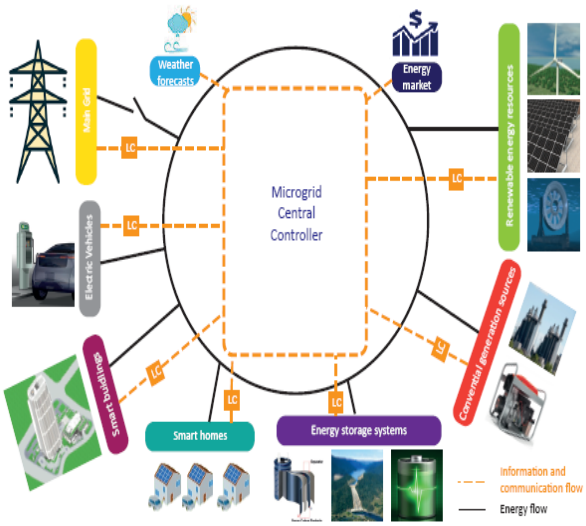

Fig. 6 Microgrid Architecture.

An MG is composed of different DERs, responsive loads, and critical loads, as shown in Figure3.2. The MG is connected to the main grid through a point of common coupling (PCC). In both grid-connected and islanded modes, each DER is connected with PEI to achieve control, metering, and protection objectives together with an ability of a plug and play feature. During grid-connected mode, an MG reaps advantages of power trading with the main grid. However, in case of disturbances or failure in main grid, MG shifts its operation to islanded mode to ensure system stability. In this mode, it provide continuous supply to critical loads by efficient integrated operation of DERs, DR, and load shedding (LS). The entire MG operation is controlled and coordinated by MG central controller (MGCC) and local controllers (LCs). The effective management and coordination of DERs in MG results into improved system performance and sustainable development. Due to the increased awareness of climate change, socioeconomic development, and the need to mitigate GHG emissions, MGs mainly consist of sustainable energy systems, as renewable energy systems and energy efficient systems that use local heat waste. Optimization of these energy systems is achieved by MG EMS that solves decision making strategies. These strategies consider increased

system energy efficiency, increased reliability, reduced energy consumption, decreased operational cost of DERs, reduced system losses, and mitigation of GHG emissions for sustainable development [8]. Microgrid can enable local electricity, energy storage, loads etc. to operate independently from the macro grid. During the interruption of the power flow of the main grid or when the main grid is unavailable, microgrid has an ability to operate locally. It must need sufficient capacity to fulfil the load requirements. Higher utilization of renewable energy sources, higher reliability, flexibility, power quality and sustainability, low capital investment, easy to operate, make it popular throughout the world [7].

6. Solar Powered Water Pumping System (SPWPS)

Water is a necessity for surviving. It is needed for drinking and domestic uses, and it is required for large-scale irrigation, construction, and power production. Water plays a significant role in the development of any country. The quality of life in any country greatly depends upon the quantity and quality of available water resources in that country. It is estimated that an average of five litres of fresh water is required per person per day for daily survival. The majority of the commercially available water pumps run on electricity or Diesel oil. Conventionally, electricity mostly generated by burning fossil fuels has been supplied from the national grids. This presented a problem for supplying water to remote areas which cannot be connected directly to a national grid station. Also, with the realization of the negative impacts of burning fossil fuels on the environment, researchers became more focused on developing standalone water pumping systems that could be powered by renewable sources of energy. Several renewable sources of energy can be used for water pumping. However, solar photovoltaic (PV) turned out to be the suitable one. While being clean and naturally available, solar energy has been proved to have a direct relationship between its availability and water demand. The solar intensity is high in many locations where the electric grid does not reach and there is a high need for water. Photovoltaic panels use solar energy to directly generate electricity which could be used to power the electricity-operated water pumps. These systems have been proven reliable even in severe weather conditions such as snowfall, and the recent search revealed that the largest PV system installed in the world is Tengger Desert Solar Park in China with 1500 MW installed capacity. Many aspects of solar-powered water pumping systems have been investigated, such as its overall efficiency, the efficiency of its individual components, its economic viability, and its size optimization. In economic terms, the problem associated with the use of fossil fuel such as availability, transportation cost, price, and effect on the environment while the reduction in PV panel prices due to advancement in the PV technology; adds on increasing the feasibility of using solar-powered water pumping systems [6].

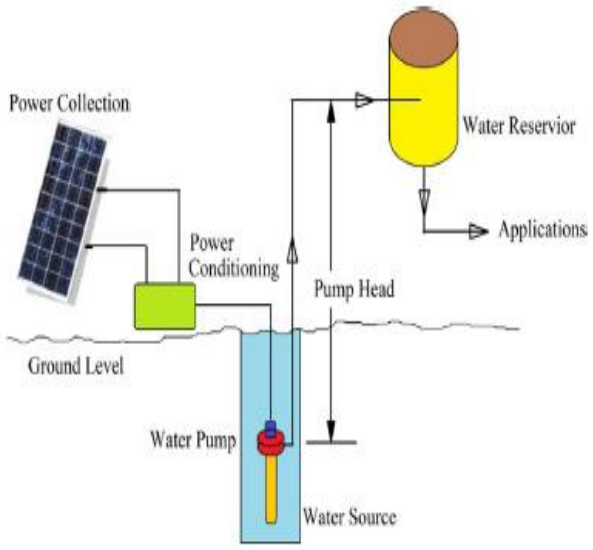

Fig. 7 Generalized solar powered water pumping system

With increasing awareness about the emerging energy crisis in the world, solar-powered water pumping systems (SPWPS) have been a real focus of interest of researchers for decades. There are various possible designs for developing SPWPS. However, the most common is the one that involves PV panels. Fig. 3.3 shows a schematic diagram of a generalized SPWPS. It is composed of a power collection system, power conditioning unit, water pump, and a water reservoir. The power collection system mostly involves the PV panels that collect solar energy and converts it to electrical energy. The generated electricity is normally DC while most of the water pumps available on the market require an AC electrical input. Therefore, there is a need to condition the generated power from the power collection system so that it can power up the water pump. A water pump is installed in the water source. It pumps the water from the source to a water reservoir located at a higher elevation from the ground level. The elevation difference from the water pump to the inlet of the water reservoir is known as the pump head. This pump head is an important parameter in designing the pumping system [6].

7. Conclusions

The permanent increase in the energy demand is considered as one of the most critical issue nowadays. Besides, as conventional power sources are limited and have adverse effects on the planet, has necessitated an imperative search for renewable energy which causes no pollution of the earth. Current research contribution and day to day experience news show used of alternative energy sources either in standalone or grid integrated form. Between these sustainable energy sources, wind and photovoltaic can be considered as the most promising technologies to produce electricity. This survey paper gives the existing mechanisms for power efficiency enhancement. The recent research work provides an idea of the research gap. Power efficiency is a key driving force due to the continual increase of energy consumption and costs. Therefore, now the development focuses on high-efficiency power supplies, which enable cost and cooling effort reduction. From the survey, research carried by various researchers, it is known that efficiency is the major concern for power generation.

References

[1] Rajan Kumar, Bhim Singh, "Grid Interfaced Solar PV Based Water Pumping Using Brushless DC Motor Drive", IEEE 2016, pp 1-6.
[2] Sachidananda Sen, Vishal Kumar, "Microgrid control: A comprehensive survey", Elsevier 2018, pp 1-34.
[3] J. Prasanth Ram, Himanshu Manghani, Dhanup S. Pillai, T. Sudhakar Babu, Masafumi Miyatake, N. Rajasekar, "Analysis on solar PV emulators: A review", Elsevier 2017, pp 149-161.
[4] Ajay Saini, Rahul Kumar, Monika Bazzad, "Survey Of Renewable Energy Sources Used In India", International Journal For Technological Research In Engineering 2020, pp 6860-6862.
[5] Priynka Verma, Chirag Gupta, "A Survey on Grid Connected Solar Photovoltaic System", International Conference on Contemporary Technological Solutions towards fulfilment of Social Needs 2018, pp 106-110.
[6] Mansur Aliyua, Ghassan Hassana, Syed A. Said, Muhammad U. Siddiqui, Ali T. Alawami,Ibrahim M. Elamin, "A review of solar-powered water pumping systems", Elsevier 2018, pp 61-76.
[7] Faisal R. Badal, Purnima Das, Subrata K. Sarker and Sajal K. Das, "A survey on control issues in renewable energy integration and microgrid", Springer 2020, pp 1-27.
[8] Muhammad Fahad Zia, Elhoussin Elbouchikhi, Mohamed Benbouzid, "Microgrids Energy Management Systems: A Critical Review On Methods, Solutions, And Prospects", Research gate 2018, pp 1-25.
[9] Samir M. Dawoud, Xiangning Lin, Merfat I. Okb, "Hybrid renewable micro grid optimization techniques: A review", Elsevier 2017, pp 2039-2052.
[10] Bhagyashri Charjan, Prof. Sachin Wadhankar, "Design of Solar Powered based Water Pumping System", IJSRSET 2018, pp 679-682.
[11] Mustapha Errouha, Aziz Derouich, Babak Nahid-Mobarakeh, Saad Motahhir,Abdelaziz El Ghzizal, "Improvement control of photovoltaic based water pumping system without energy storage", Elsevier 2019, pp 319-328.
[12] Mohammad Faisal, M A Hannam, Pin Jern Ker, Aini Hussain, M Mansur, F. Blaabjerg, "Review of energy storage system technologies in micro grid applications: Issues and challenges ", IEEE 2017, pp 1-21.
[13] Adam Hirscha, Yael Parag, Josep Guerrero, "Microgrid: A review of technologies, key drivers, and outstanding issues", Elsevier2018, pp 402-411.
[14] Amira Mohammed, Shady S. Refaat, Sertac Bayhan and Haitham Abu-Rub, "AC Microgrid Control and Management Strategies", IEEE 2019, pp 18-31.
[15] Malla.Jagan Mohana Raoa,Manoj Kumar Sahub,Pravat Kumar Subudhi, "PV Based Water Pumping System For Agricultural Sector", Elsevier2016, pp 1008-1016.
[16] Pushpendra Kumar Singh Rathore, Shyam Sunder Das, Durg Singh Chauhan, "Perspectives of solar photovoltaic water pumping for irrigation in India", Elsevier2017, pp 385-395.
[17] Gajraj Singh Rawat, Sathans, " Survey on DC Microgrid Architecture, Power Quality
Issues and Control Strategies", IEEE 2018, pp 500-505.
[18] Akash Kumar Shukla, K. Sudhakar, Prashant Baredar, "Renewable energy resources in South Asian countries: Challenges, policy and recommendations", Elsevier2017, pp 1-5.
[19] Omar Ellabban, HaithamAbu-Rub, FredeBlaabjerg, "Renewable energy resources: Current status, future prospects and their enabling technology", Elsevier 2014, pp 748-765.
[20] Mostafa Farrokhabadi, Claudio A. Canizares, "Microgrid Stability Definitions, Analysis, and Examples", IEEE TRANSACTIONS 2019, pp 1-17.