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Study on Solar Energy Generation and its Challenges

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Abstract— This study delves into the examination of solar renewable energy as a promising source for sustainable power generation. Solar energy harnesses the abundant and clean power from the sun, offering a viable alternative to conventional fossil fuels. The study identifies key challenges specific to solar energy adoption in India, including land availability, grid integration, storage, financing, policy frameworks, skill development, and environmental impacts. By analyzing these challenges, the study aims to provide insights and recommendations for policymakers, industry stakeholders, and researchers to address these obstacles and foster the widespread adoption of solar energy. The findings emphasize the importance of innovative solutions, supportive policies, and collaborative efforts in driving the growth and utilization of solar renewable energy, ultimately contributing to a greener and more sustainable energy landscape.

Keywords— Renewable Energy, Solar Energy, Hybrid System, Solar PV Array, PV Inverter Systems

I. INTRODUCTION

Presently energy consumption is continuously increasing and it had increased the environmental pollution due to the increased usage of fossil fuels. Solar, wind, small hydro etc. are alternative sources of energy that are being used so as to mitigate environmental pollution. However, there are several drawbacks of renewable energy-based systems such as non-reliability, intermittency, power quality and security. To overcoming these problems one of the solutions is use of distributed or dispersed generation system. The advantage of distributed generation system using renewable energy sources such as solar, wind or small hydro is production of power near the load centres, thereby eliminating the losses during transmission. To increase reliability the renewable based system is connected to grid. The Kyoto agreement on global reduction of greenhouse gas emissions has prompted renewed interest in renewable energy system worldwide. Today many renewable energy technologies are well matured, reliable, and cost effective. The demand and production of renewable energy-based system are increasing and hence the cost of it is continuously decreasing.

There are two types of the renewable energy system namely, stand-alone system and grid-connected system [1]. Both systems have a number of similarities, but are dissimilar in terms of control functions. The stand-alone system is used as off-grid system with battery storage. Its control algorithm must have an ability of bidirectional operation, which is battery charging and inverting [2]. The grid-connected system, on the other hand, converts dc into ac and supplies electrical energy directly to power grid [3]-[4]. The Government of India and State Governments had taken a major initiative of the National Solar Mission for promoting ecologically sustainable growth while addressing India's energy security challenge. This initiative made a major contribution by India to the global effort to meet the challenges of climate change. As a result of the National Solar Mission and the successful completion of the first stage by end of 2019 (Installation completed in India 2022), it was expected that solar PV based power plants will become an exciting business opportunity. Power production through solar energy is possible using both solar thermal and solar photovoltaic, but worldwide electricity generation is more prominent through solar PV than through solar thermal.

The solar energy has many advantages for instance clean, unlimited energy and it has potential to provide sustainable electricity in those areas which are not served by the conventional power grid [5]. Nevertheless, a photovoltaic (PV) system is still much more costly than traditional energy sources, due to the high manufacturing costs of PV panels, but the energy that drives them, the light from the sun, is freely available almost everywhere [6]-[7]. An additional advantage of PV technology is that it has no moving parts. Therefore, the hardware is very robust. It has a long lifetime and low maintenance requirements. Finally, it offers environmentally friendly power generation. Solar energy produces dc power, and hence power electronics and control equipment are needed to convert dc power into ac [8].

A. *Types of Available Solar*

Basically, there are 3 types Of Solar Photovoltaic (PV) Systems available in the market.

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Grid-tied (On-Grid system): In this set-up, your solar PV system is integrated with the grid. 'Grid' is what they call the conventional electricity infrastructure. This is the most popular mode of going solar. Here are its features:

- This is the cheapest mode of going solar of all the three.
- You will still be dependent on the grid. On an average, up to 20% of your energy needs might still be fulfilled by the grid.
- Your dependence on the grid rules out the ambiguities and disadvantages associated with going solar on its own. You don't have to worry about whether or not your system is producing enough energy; this is very crucial as solar power is heavily contingent on weather and availability of sunlight (and thus can't be generated during the night).

Off-Grid System: This goes a step further. Not only will your Solar PV system be integrated with the grid, but will also have its own battery back-up. Batteries are meant to store excess electricity that gets generated by the Solar PV system.

- Well, batteries used in solar PV systems tend to be very expensive; hence expect to have your overall cost increase manifold.
- Your dependence on the grid will be much less when the on-grid system is backed up with the battery as well. This is because the batteries act as your primary source for power when your system isn't generating electricity, say, during nighttime. Thus, you will be more or less immune to power outages and disruptions of the grid!
- The overall efficiency of the system may suffer because of the constant charging and discharging of the batteries. Not to talk of the complexities they would add to the system's design, installation, and maintenance.
- This is an ideal choice if your grid is prone to frequent power outages and isn't a reliable energy source in the first place.

Hybrid System: If you live in a remote geographical location and hence don't have access to the conventional grid, this is your ideal choice! As the name suggests, you are completely off the hook of the grid if you opt for this.
Batteries are a must here unless your solar power is combined with other renewable energy resources like wind, generator etc.

II. SOLAR ENERGY SCENARIO IN INDIA

Renewable source of energy is the great opinion for the long-term view. Among the various renewable energy sources, India receives a very large amount of solar energy, which is about 300 clear sunny days (Pillai and Banerjee 2009) in a year. India receives approximately 5000 kWh/year and the daily average solar radiation incident over India varies from 4kwh/day to 7kWh/day. The Jawaharlal Nehru National Solar Mission (JNNSM) was launched by Prime minister of India in 2010, with a target of 20,000 MW solar power capacities by 2022. In January 2015, the Indian government expands this scheme and decided to achieve the target of 100GW and invest US$100 billion. In 2016 "Suryamitra" skill development program has also started by the government of India which is sponsored by Ministry of New & Renewable Energy and organized by National Institute of Solar Energy (NISE). The duration of this skill development program is 600 hrs. (Approximately 90 days). The aim of scheme "Suryamitra" is about to achieve the target of 175 GW which includes 100 GW from solar Energy by 2022.
These targets help not only to achieve green energy but also help to create millions of jobs in India. India also attains a target of having 70% renewable energy use by 2050. In India, the largest solar steam cooking system with capacity 15,000person/day has installed in Tirupati Tirumala Devasthanam (Southern part of India). To enhance the production of solar power in India, the government provides offers such as subsidies in a purchase of solar power-based technology and also decrease the price of equipment used in solar technology like PV cells etc.

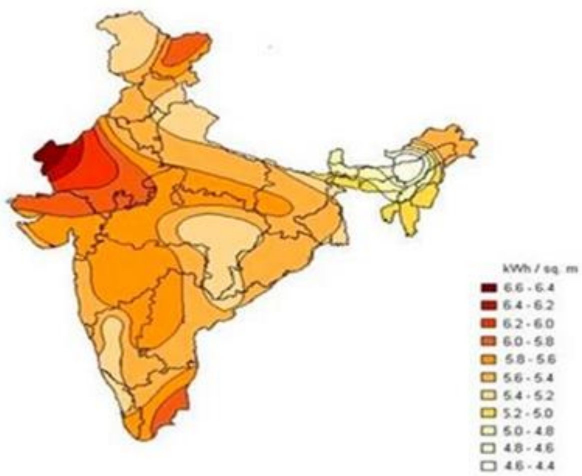

Figure 1: Irradiance distribution in India [4]

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III. Components of Solar PV Grid-Connected Inverter System

The main components of a solar PV-based grid-interactive inverter system is shown in figure 2

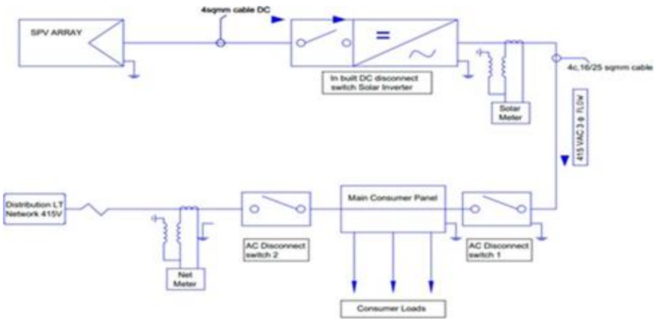

Figure 2: Components of a grid-interactive inverter system with circuit

A. *Solar PV array*

A photovoltaic (PV) array is a device by which an electrical energy is generated as a result of the photovoltaic effect. The photovoltaic effect is a phenomenon by which an electrical potential is developed between two semiconductor materials when their common junction is illuminated with radiation of photons [9]. The basic building element of a PV array is the PV cell, which is referred as a solar cell. A typical solar cell generates less than 2 W at approximately 0.5 V. Therefore, in order to obtain sufficient voltage for practical applications several cells are connected in series to form a PV panel. Commercially available PV panels may have peak output power ranging from a few watts to more than 300 W at voltages ranging from 12 V to 48 V. Grid-connected PV applications often require higher voltages and currents than the ones which is available in a PV panel. In order to obtain higher voltages and current, PV panels must be connected into arrays. When PV panels are connected in series higher voltages are obtained, while parallel connections result in higher currents. The number and configuration of the elements of a PV array vary depending on the overall system's requirements [10]-[11].

B. *Solar PV array*

PV inverter systems connected to the low voltage grid have an important role in distributed generation systems. In order to keep up with the current trends regarding the increase in PV installations, PV inverters should have the following characteristics [12]:

- Low cost
- Small weight and size, due to residential installations
- High reliability to match with that of PV panels
- High efficiency
- Be safe for human interaction

Central Inverters: Centralized inverters interface a large number of PV modules to the grid which is shown in Figure 1.4 (a). The PV modules are divided into series connections (called a string), each generating a sufficiently high voltage to avoid further amplification. These series connections were then connected in parallel, through string diodes, in order to reach high power levels. At first, line commutated thyristor based inverters were used for this purpose. These were slowly replaced by force commutated inverters using IGBT's [15]. However, there are disadvantages associated with central inverter scheme. There is a need for high-voltage DC cables between PV panels and inverter [16].

String Inverters: The present technology consists of the string inverters and the modules. The string inverter which is shown in figure 3 (b), is a reduced version of the centralized inverter shown in figure 3 (a), where a single string of PV modules is connected to the inverter. The input voltage may be high enough to avoid voltage amplification. The possibility of using lesser number of PV modules in series also exists, if a dc–dc converter or line-frequency transformer is used for voltage amplification. There are no losses associated with string diodes and separate MPPT's can be applied to each string. This increases the overall efficiency compared to the centralized inverter, and reduces the price, due to mass production [19].

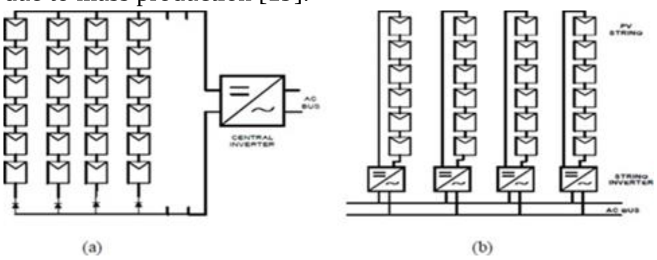

Figure 3: (a) central inverter and (b) string inverter

Module integrated inverters: A Module integrated has been shown in figure 1.4 (a). It removes the mismatch losses between PV modules since there is only one PV module, as well as supports optimal adjustment between the PV module and the inverter and, hence, the individual MPPT. It includes the possibility of an ease of enlarging the system, due to its modular structure [20]. On the other hand, the necessary high voltage-amplification may reduce the overall efficiency and increase the price per watt, because of more complex circuit topologies. On the other hand, the module integrated inverter is intended to be mass produced which leads to low manufacturing cost and low retail prices. The present solution is to use dc–ac inverters using IGBT or MOSFET [21].

Multi-string inverters: multi-string inverters have recently appeared in the PV market. They are an intermediate solution between String inverters and Module inverters. A Multi-String inverter has been shown in figure 4 (b), which has the advantages of both String and Module inverters. It consists of many DC-DC converters with individual MPPT's, which feed energy to a common DC-AC inverter. This way, no matter the nominal data, size, technology, orientation, inclination or weather conditions of the PV string, they can be connected to one common grid connected inverter [22]. The Multi String concept is a flexible solution, having a high overall efficiency of power extraction, due to the fact that each PV string is individually controlled.

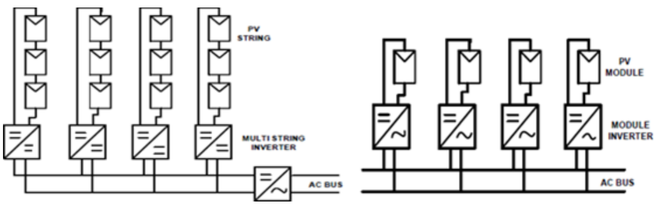

Figure 4 (a) Module integrated inverter and (b) string inverter

Multi stage inverters: Off late multi stage inverter topology has received attention for power conversion dc- to-ac). Advantages of the multi stage inverter (MSI) includes
a) The multilevel structures can ensure even voltage sharing, both statically and dynamically, among the active switches while it is difficult for a two-level inverter with a series connection of switches to do so.
b) A substantial reduction in size and volume is possible due to the elimination of the bulky coupling transformers or inductors.
c) Multi stage inverters can offer better line current waveforms with less harmonic content and thus can significantly reduce the size and weight of passive filter components.

Maximum power point tracker: Maximum power point tracking techniques are used in photovoltaic systems to maximize the PV array output power by tracking continuously the MPP which depends on panel's temperature and irradiance conditions. PV array under uniform irradiance exhibits a I- V characteristic with a unique point called the maximum power point (MPP), where the array produces maximum output power. Since the I-V characteristic of a PV array and hence its MPP changes as a consequence of the variation of the irradiance level and of the panel's temperature, it is necessary to track continuously the MPP in order to maximize the power output from a PV system, for a given set of operating conditions. MPPT is not a mechanical tracking system that physically moves the modules to make them point more directly at the sun. It is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. MPPT can be used in conjunction with a mechanical sun tracking system, but the two systems are completely different. The issue of maximum power point tracking has been addressed in different ways in the literature [23]. The conventional MPPT methods are generally categorized into the following groups:

a) Perturbation and observation (P&O) methods;
b) Incremental conductance methods;
c) Microcontroller-based methods;

Maximum power point tracking (MPPT) is the process of tracking the voltage and current from a solar module to determine when the maximum power occurs in order to extract the maximum power.

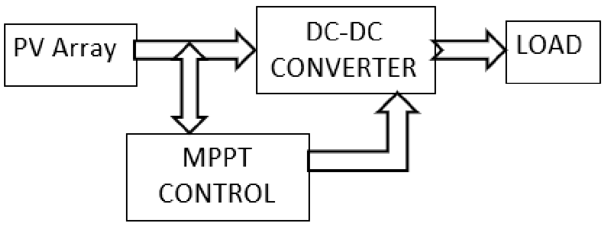

Figure 5: MPPT

IV. Conventional Methods of Monitoring of Solar Power Plant

Delta type PLC is utilized here to track the solar panels automatically. In this method this PLC monitors and tracks solar array very effectively and efficiently. It has very easy and accurate controlling structures in all-weather situations. The extract max energy generation time is evaluated using this method. With the help of magnetic reed switches and LDR Sensors which can be used for controlling of direction and speed of DC gear motors. These are interfaced with solar panels. To get high economic returns and compensating power demands within less time period these techniques are utilized [24]. PV Module, relay module, magnetic reed switches, CPU of PLC, sensors and electromechanical speed and motion control units are integral parts of this solar power tracking systems. Power supply module is also one of the essential and basic functional parts of these systems. The low density of solar energy, intermittent solar beam, proposes a method to change direction over time, the paper studies the maximum power point of photovoltaic modules based on OMRON PLC [25]. With the effective use of android OS platform, solar power plants can also be monitored. In this, renewable energy sources are controlled by low price Android platform tablets. Graphical LCD displays and modems for internet which is connected to Power Conditioning Unit (PCU). This supports high level graphical visualization and better interface for touch screen facility. Internet connectivity and Bluetooth interface these are primary requirements for this system. FPGA and DSP hardware platform are inbuilt with the UART interface is supported by Power Conditioning Unit (PCU).

The use of SCADA platform in a PV system is usually for automation and data logging purposes. Automation is very important in improving the efficiency and overall lifetime of a PV system. The current small PV systems usually use dyes and other metal alloys gather energy from the sun. The light coming from the sun is composed of diverse electromagnetic energies of different wavelengths and frequencies, which means that they also have different effects to the dye and the alloy of the PV system [9]. In general, dyes and alloys lose their capacity to gather energy as temperature increases. Ideally, the energy that comes from sunlight is all converted to electrical energy upon hitting the solar panel surface. In reality, however, a significant amount of the occurrence sunlight is converted to heat. Some of this heat is dissipated into the atmosphere – hence, producing an overall increase in local environmental temperature – while some of the heat stays in the solar panels [9]. At a certain temperature, the dye in the solar panels disintegrates and the alloys widen their band-gap, which ultimately results in the disruption of the entire energy conversion process. Depending on the dye and alloys that are used, the solar panels could acquire permanent damage due to accumulated heat [10]. Due to this problem with heat accumulation, modern-day PV systems are equipped with temperature monitoring devices [11].

V. CHALLENGES OF SOLAR RENEWABLE ENERGY SOURCE IN INDIA.

India, with its abundant solar resources, has made significant strides in promoting solar renewable energy. However, several challenges persist that hinder the widespread adoption and efficient utilization of solar energy in the country. Here are some unique challenges specific to India:

A. Land Availability and Utilization

One of the primary challenges is the availability of suitable land for solar installations. India's rapidly growing population and competing land demands pose a significant obstacle. Identifying large tracts of land and acquiring them for solar projects can be a complex and time-consuming process.

B. Grid Integration and Stability

Intermittency and variability are inherent characteristics of solar energy. Integrating large-scale solar power into the existing grid infrastructure requires careful planning and coordination. Maintaining grid stability, especially during periods of high solar generation, is a significant challenge. India's grid infrastructure also needs to be upgraded to handle the increased influx of solar power.

C. Storage and Balancing

Solar energy production is time-dependent and doesn't always align with peak electricity demand. Energy storage technologies, such as batteries, are crucial for storing excess solar power and balancing supply and demand. However, the high upfront costs associated with energy storage systems present a challenge for widespread deployment, particularly in India's cost-sensitive market.

D. Financing and Investment

The initial investment required for setting up solar projects can be substantial. Despite declining costs, access to affordable financing remains a challenge. The availability of long-term loans, low-interest rates, and investor-friendly policies are crucial for attracting investment in the solar sector.

E. Policy and Regulatory Framework

While India has made significant policy advancements to promote solar energy, challenges persist at the implementation level. Delays in project approvals, complex bureaucratic processes, and inconsistencies across different states can hinder the growth of solar energy. Streamlining regulations and establishing clear guidelines can help create a conducive environment for solar development.

F. Skill Development and Training

The solar industry requires skilled professionals for the design, installation, operation, and maintenance of solar power plants. Training programs and vocational courses need to be developed to address the shortage of skilled manpower in the solar sector. Bridging the skills gap will ensure efficient and safe operation of solar installations.

G. *Environmental Impacts*

While solar energy is considered clean and sustainable, the manufacturing process of solar panels involves the use of certain materials and chemicals. Proper management and disposal of end-of-life solar panels are necessary to prevent environmental contamination. Additionally, large-scale solar projects can impact local ecosystems and biodiversity, necessitating careful site selection and environmental impact assessments.

Addressing these challenges requires a multi-faceted approach involving policy reforms, technology advancements, capacity building, and public-private collaborations. Despite the obstacles, India has demonstrated its commitment to solar energy through ambitious targets and initiatives, such as the Jawaharlal Nehru National Solar Mission, which aims to achieve 100 GW of solar capacity by 2022. Continued efforts and innovation will be crucial in overcoming these challenges and establishing solar energy as a dominant renewable source in India.

VI. CONCLUSION

The study of solar renewable energy sources reveals both immense potential and unique challenges. Solar energy offers a clean, abundant, and sustainable alternative to conventional fossil fuels, making it a vital component in the transition to a low-carbon future. However, obstacles such as land availability, grid integration, storage, financing, policy frameworks, skill development, and environmental impacts must be addressed to unlock the full benefits of solar energy. By proactively tackling these challenges through innovative solutions, supportive policies, and collaborative efforts, we can pave the way for a brighter and more sustainable energy future powered by the sun.

VII. REFERENCES

[1] Aditya Kumar et al., Design and Analysis of Solar PV Rooftop in Motihari 2021 J. Phys.: Conf. Ser. 1817 012019

[2] R. Ahsha, R. Al-Abri, H. Al-Zakwan, N. Ambu-saidi, E. Hossain, "Design and Economic Analysis f a Solar Photovoltaic System for a Campus Sports Complex" International Journal Of Renewable Energy Research, Vol.10, No.1, March, 2020

[3] Akeyo, Oluwaseun M.; Rallabandi, Vandana; Jewell, Nicholas; and Ionel, Dan M., "The Design and Analysis of Large Solar PV Farm Configurations with DC Connected Battery Systems" (2020). Power and Energy Institute of Kentucky Faculty Publications. 6.https://uknowledge.uky.edu/peik_facpub/6

[4] Adithya Ballaji, Ananda M H, K Narayan Swamy, Venkatesh Murthy B S, "Design, Analysis and Economic Investigation of Standalone Roof Top Solar PV System for Rural India", International Journal of Applied Engineering Research, Volume 13, Number 19 (2018) pp. 14461-14468

[5] Dr. S. Prakash, Dr. R. Dhanasekaran, S. Suman Priya, "Design, Analysis And Real Time Implementation Of Solar Tree In Biher", Journal of Xi'an University of Architecture & Technology, Volume XII, Issue III, 2020. pg 1741-1745

[6] Lin Prasetyani, Mada Jimmy Fonda Arifianto, Djoko Subagio, William Sarfat, Aprilyanto, "Experimental Analysis Design of Solar Panel Energy Monitoring Prototype", Proc. of 2020 7th IEEE, Int. Conf. on Information Tech., Computer, and Electrical Engineering (ICITACEE), May 15,2021

[7] Mr. Jogendra Kumar, Ashish Sethiya, Dr. Shailendra Sharma, 2014, Designing & Cost Analysis of Solar Photovoltaic Power Plant in a Commercial Building, International Journal Of Engineering Research & Technology (IJERT) Volume 03, Issue 12 (December 2014),

[8] Ahmed, M.M.; Qays, M.O.; Abu-Siada, A.; Muyeen, S. M.; Hossain, M.L. Cost-Effective Design of IoT-Based Smart Household Distribution System. Designs 2021, 5, 55. https://doi.org/10.3390/designs5030055

[9] Qifeng Gu, Qiang Qu, Towards an Internet of Energy for smart and distributed generation: applications, strategies, and challenges, Journal of Computational Design and Engineering, Volume 9, Issue 5, October 2022, Pages 1789–1816, https://doi.org/10.1093/jcde/qwac087

[10] Kavaliauskas, Ž.; Šajev, I.; Blažiunas, G.; Gecevicius, G.; Capas, V.; Adomaitis, D. Electronic System for the Remote Monitoring of Solar ower Plant Parameters and Environmental Conditions. Electronics 2022, 11, 1431. https://doi.org/10.3390/electronics11091431.

[11] Moreno-Garcia, Isabel M. et al. "Real-Time Monitoring System for a Utility-Scale Photovoltaic power Plant." Ed. Albert M. K. Cheng. Sensors (Basel, Switzerland) vol. 16, no.6, pp.1-25, 2016.

[12] Sandelic, Monika, Ariya Sangwongwanich, and Frede Blaabjerg. 2019. "Reliability Evaluation of PV Systems with Integrated Battery Energy Storage Systems: DC-Coupled and AC-Coupled Configurations" Electronics 8, no. 9: 1059. https://doi.org/10.3390/electronics8091059

[13] Clifford Choe Wei Chang et al 2022. Embedded Control and Remote Monitoring for Photovoltaic Solar Energy Harvesting Systems: A Review. J. Phys.: Conf. Ser. 2319 01200

[14] Barron-Gafford, Greg A., et al. "The Photovoltaic Heat Island Effect: Larger solar power plants increase local temperatures." Scientific reports 6 (2016): 35070

[15] Effect of Temperature PV Education 2017 http://www.pveducation.org/pvcdrom/effect-of-temperature. Accessed 3 Sept 2017

[16] Inductive Automation. "Ignition: The New SCADA." Ignition SCADA Software. 2017 https://inductiveautomation.com/scada-software/

[17] Gonzalez-Redondo, Miguel J., et al. "Influence of data-related factors on the use of IEC 61850 for power utility automation", Electric Power Systems Research 133 (2016): 269-280.

[18] Amy J.C. Trappey, Paul P.J. Chen, Charles V. Trappey, and Lin Ma, "A Machine Learning Approach for Solar Power Technology Review and Patent Evolution Analysis", MDPI 2019.

[19] Alessandro Betti, Maria Luisa Lo Trovato, Fabio Salvatore Leonardi, "Predictive Maintenance in Photovoltaic Plants with A Big Data Approach", Jan 2019. DOI: 10.4229/EUPVSEC20172017-6DP.2.4

[20] Tingting Pei and Xiaohong Hao, "A Fault Detection Method for Photovoltaic Systems Based on Voltage and Current Observation and Evaluation, energies", MDPI 2019.

[21] Ajay Singh, M. P. S Chawla, "Zigbee and RF Module based Solar Panel Monitoring System", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278- 3075, Volume-7 Issue-12, September 2018

[22] L. Chhaya, P. Sharma, G. Bhagwatikar and A. Kumar, "Design and Implementation of Remote Wireless Monitoring and Control of Smart Power System using Personal Area Network", Indian Journal of Science and Technology, Vol 9(43), November 2016.

[23] Manh Duong Phung, Michel De La Villefromoy, and Quang Ha, "Management of Solar Energy in Microgrids Using IoT-Based Dependable Control", IEEE 20th International Conference on Electrical Machines and Systems (ICEMS), August 2017 DOI: 10.1109/ICEMS.2017.8056441.

[24] Constandinos X. Mavromoustakis, Jordi Mongay Batalla, George Mastorakis, Evangelos Markakis, and Evangelos Pallis, "Socially Oriented Edge Computing for Energy Awareness in IoT Architectures", IEEE Communications Magazine, July 2018.

[25] Kyriakos Georgiou, Samuel Xavier-de-Souza, and Kerstin Eder, "The IoT energy challenge: A software perspective", IEEE Embedded Systems Letters 2017.

[26] Davide Calì,Ekkart Kindler, Razgar Ebrahimy, Peder Bacher, Kevin Hu, Michelle Lind strup, Magnus Bachalarz, Henrik Madsen, "climify.org: an online solution for easy control and monitoring of the indoor environment", E3S,Web of Conferences https://doi.org/10.1051/e3sconf/2019111050 9) 2019.