Amalgamation of Smart Grid with Renewable Energy Sources

Thalanki Venkata Sai Kalyani*, Kambhampati Venkata Govardhan Rao**‡, B. Srikanth Goud***, Gadi Sanjeev****

*Department of Electrical and Electronics Engineering, St. Martin's Engineering College, Kompally, Secunderabad, Telangana, India, 500100

**Department of Electrical and Electronics Engineering, St. Martin's Engineering College, Kompally, Secunderabad, Telanagana, India, 500100

***Department of Electrical and Electronics Engineering, Anurag University, Ghatkesar, Telangana, India, 500 088.

****Department of Electronics and Communication Engineering, St. Martin's Engineering College, Kompally, Secunderabad, Telangana, India, 500100

(kalyanieee@smec.ac.in, govardhaneee@smec.ac.in, bsgoud07@gmail.com, gsanjeevece@smec.ac.in)

‡Thalanki Venkata Sai Kalyani; Kambhampati Venkata Govardhan Rao,

Department of Electrical and Electronics Engineering, St. Martin's Engineering College, Kompally, Secunderabad, Telanagana, India, 500100

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Abstract- It is impossible to make efficient use of decentralised energy sources without first putting in place the technology that make smart grids possible. The smart grid is the future transformation of production methods and strategies as well as the interaction of all of the components of the electricity system. It is also referred to as the smart grid. The whole globe is presently grappling with the ever-increasing price of petroleum products, coal, and other commodities. At the same time, the cost of renewable energy power systems has been decreasing, which creates potential for renewable energy systems to handle the problem of electricity production. All of this is vital to keep in mind in view of the fact that the subject of climate change is becoming a more significant one of concern. As a result of this reality, the whole globe is today contending with the ever-increasing price of various commodities, including petroleum products, coal, and others. Having stated that, in order to carry out this activity, it is necessary to find a solution to the challenge of building an energy management system that is effective. The concept of a smart grid plays a significant role in this context and possesses the potential to be successfully applied in power distribution networks. In this paper, the study that was conducted on the topic of combining smart grid systems with renewable energy sources is discussed. We will begin by discussing the part that distributed generation and alternative forms of energy will play in the smart grid system as we move into the introduction. In addition to this, discussions and research are currently being conducted about both the concept of smart grid renewable energy systems and their various uses, as well as the PV smart grid system.

Keywords: Smart grid, Renewable energy resources, PV, distributed generation (DG).

1. Introduction

Over the past few years, the utilisation of environmentally friendly energy sources has been steadily increasing in smart grid systems [1]. The pursuit of new energy sources that are cleaner, more environmentally friendly, and more reliable has a significant impact on the transmission and usage of power in the here and now [2]. In the past, vast amounts of electricity were generated, and then that electricity was transported through transmission lines to large load centres. Since the beginning of time, the flow of electricity has always gone from the businesses to the customers of those businesses. In the not too distant future, renewable sources of energy won't be able to supply enough power to run the entire grid by itself [3]. Therefore, they have to be wired into the primary power grid in order to function as emergency power sources. As a result, the primary power producing units will experience decreased overall activity. It is also possible to utilise them to power load units that have been entirely severed from the main grid. Wind-powered machines, microgenerators, fuel cell-based systems, and photovoltaic (PV) systems are examples of distributed power generation (DG) systems that can be added to existing main power lines. End users of a DG system do not have to function solely as passive customers; rather, they are also capable of functioning as active providers to the grid. Distributed generation, also known as DG, is an alternative that is not only gaining in popularity but also has the potential to play a major part in satisfying the ever-increasing need for electricity[4]. This is accomplished through the utilisation of a variety of energy sources, including solar, wind, fuel cells, and so on. It is essential to incorporate renewable energy sources into the power system in order to lessen the impact that conventional power plants have on the surrounding environment [5]. The smart grid is an important component of this. The primary objective of a smart grid is to foster an environment in which utilities and customers are able to communicate with one another, as well as to increase the level of participation of customers in decision-making processes and the overall operation of the grid. Users of smart grids have the ability to influence utility companies by installing distributed generation sources at the point of use, such as photovoltaic modules or energy storage devices, and sending pricing messages[2]. In addition, corporations can assist the grid become more dependable by implementing demand response programmes, installing distributed generation or energy storage at substations, and integrating control automation into the system [3].

2. Interest of Renewable Energy Towards Smart Grids

Due to the current energy crisis, there is a lot of interest in future power generation using renewable energy potential.
The current power grids produce electricity using fossil fuels, which were the main energy sources in recent years.
The percentage of the global primary energy demand from 2000 to 2022 is shown in Table I:

Table.1: Primary Energy Demand % from 2002 to 2022

Energy Source / year	**2000 (%)**	**2010 (%)**	**2020 (%)**	**2022 (%)**
Coal	**24**	**23**	**22**	**21**
Oil	**37**	**36**	**35**	**35**
Gas	**20**	**21**	**22**	**24**
Nuclear	**7**	**6**	**5**	**4**
Hydro	**2**	**2**	**2**	**2**
Biomass and Waste	**12**	**11**	**10**	**9.5**
Others renewable	**0.53**	**0.83**	**1.12**	**1.55**

According to Table I, compared to alternative renewable energy sources that are less frequently thought of for power generation, fossil fuels account for the majority of the world's primary energy consumption between 2000 and 2022. As a result, CO2 emissions rise and have a negative impact on the environment.
Many nations experience this issue and view renewable energy technology as an effective means of generating power in the future without emitting greenhouse emissions.
The incorporation of renewable energy sources into the smart grid is another major area of research. They outline the advantages and disadvantages of using renewable energy sources when they are incorporated into an intelligent grid system.

3. General Features of Smart Grid

The term "smart grid" refers to multiple things and can be broken down into the following categories:

- Interactive with users and markets
- Adaptable and expandable under different circumstances
- Optimised to make the greatest use of available resources and equipment.
- Proactive rather than reactive to prevent emergencies.
- Plug-and-play capabilities for network equipment
- Grids that can fix themselves and have advanced automation
- Combined and integrated tracking, control, and safety,
- Maintenance, EMS, DMS, AMI, etc.
- Plug-and-play capabilities for network equipment • and ICT solutions
- Safe and dependable
- Economically advantageous
- Offers real-time data and monitoring

In a traditional power grid, power generation is centralised, and there is only one way of power flow and little market integration at the distribution level. Intelligent power networks use both centralised and decentralised power generation. Renewable energy sources are usually used for decentralised power production [6]. They add resources that are both active and spread out, like production, loads, and storage, to energy markets and power networks. Electric cars are an example of an active resource[7]. A smart grid is an electrical network that connects electricity producers and consumers in a way that is safe, reliable, efficient, and good for the economy and the environment. Most of the time, one of these two main goals for better electric power exchanges for both end-use customers and utilities is what gets smart grid technology started[8].

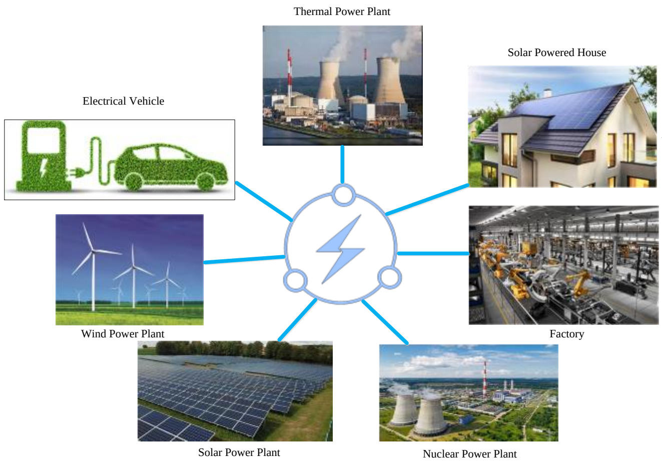

Fig 1: Smart grid features

Since the number of installations of non-conventional energy sources is growing quickly, there needs to be a coordinated effort from the planning stage all the way down to the electrical equipment that is used to make, distribute, store, and use electricity [9].

Table I shows the changes between Smart Grid and the old way of getting electricity.

Comparison	**Conventional Grid**	**Proposed smart grid**
Information flow	Single direction flow	Bidirectional flow
Electricity generation	Critical with central generation	Simple with Distributed generation
Overall efficiency	Weak	Elevated
Environmental pollution	Great	Small
Sensors	Less	More
Monitoring ability	Usually, blind	Self-monitoring
Grid topology	Radial	network

4. The Place of Non-traditional Sources of Power and Decentralised Generators in the Smart Grid

Most places in the world don't need to make big changes to how they make power in order to figure out how the climate is changing and to make sure they have enough energy. Because of this, green energy sources and distributed generation (DG) are getting more support, and their share of the total amount of energy being made is quickly going up. The main problem that peoples who work on and build smart grid systems face is that there is more green energy coming into a system that isn't very flexible[10]. The main reason for the development of the distributed system was the addition of DG to the electricity distribution system. However, DG is not very responsive to market signals and does not help run the system for two reasons [11]. First of all, distributed production usually comes from sources of clean energy. Because of this, it is usually set up by priority under feed-in rates and does not have to be based on market prices. Second, most of the time, the generators used in delivery networks are too small and don't have any new technology[12]. Also, one problem that has come up is the chance that the growing number of renewable sources could cause the distribution networks to get too crowded [13].

To figure out how climate change will affect energy security and make the world a better place for energy, it is not necessary to make big changes to the way power is made in most of the world. As a direct result of this change, green energy sources and distributed generation (DG) are getting more support [14], and their share of the total amount of power produced is growing quickly. The main problem that people who work with and make smart grid systems have to deal with is how to fit more and more green energy sources into a system that isn't very flexible. But DG doesn't pay much attention to signs from the market and doesn't help run the system for two reasons [15]. Distributed generation was the main reason why the distributed system was made, because it was put into the electricity distribution system. This was the main reason why the distributed system was made[16]. First of all, most spread generation comes from renewable or alternative energy sources. Because of this, it is often sorted by priority within the limits of feed-in tariffs, and it does not have to be set by market prices[17]. Second, the generators that are usually used in delivery networks are often too small and don't have any of the latest technology. Also, one of the problems that have come up is the possibility that the growing number of renewable sources could cause the delivery networks to get too busy [18]. One of the worries that have come up because of recent events is this.

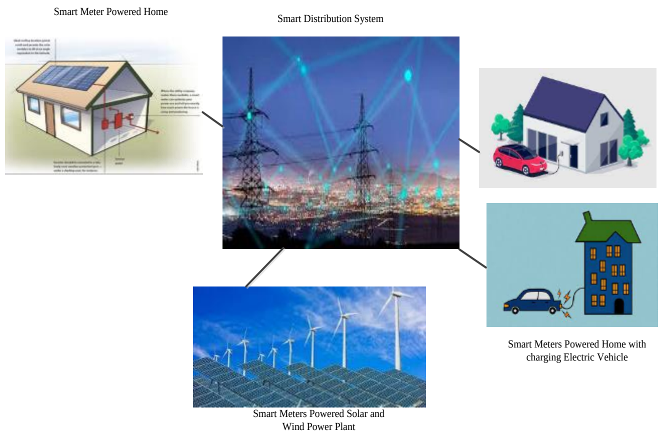

Figure 2: Renewable sources in smart grid

5. PV Smart Grid System

Solar photovoltaics (PV) are a radically new approach to the generation of energy, which stands in stark contrast to traditional methods[19]. Therefore, photovoltaics need a power electronics interface in order to convert the power production from its native format into a version that is compatible with the grid. [20] One of the forms of renewable energy that can be scaled up with the greatest ease is photovoltaic energy. It is possible to produce it in quantities ranging from a few kilowatts (KW) at the residential scale to several megawatts (MW) at the utility scale. KW is for kilowatt, while MW stands for megawatt[21]. PV smart grid systems seem to be growing better and more helpful when the price of oil goes up, the demand for energy goes up, and the cost of PV systems goes down a little bit each year [22]. This is because the price of oil is increasing, the demand for energy is increasing, and the cost of PV systems is decreasing. When exposed to light, arrays of solar cells [23], which are the most important part of photovoltaic energy devices, turn light into electricity[24]. The amount and length of time that light shines on the photovoltaic (PV) cells is the most important factor in how much power the system makes. Solar power gives us a way to get clean, renewable energy that doesn't use up natural resources, is good for the earth, and is site-specific.[25] PV is a clean, quiet, and emission-free way to change energy into something else. It does this without using any active moving parts. Since this is powered by electricity alone, it can last for more than 20 years [26]. A lot of work needs to be done to improve the efficiency of the solar cell, which is the most important part of a photovoltaic (PV) system.

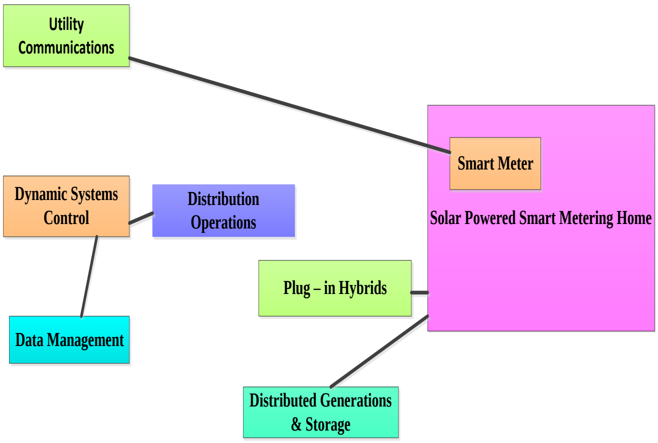

Figure 3: Photovoltaic cell network in building

- Because of this, most of the attention is being directed towards the fields of nanotechnology, electro physics, and material science. Some of the currently available PVs, along with their respective efficiencies, are
- Solar cells that are crystalline or multi-crystalline and have an efficiency of at least 11 percent.
- Amorphous thin-film silicon with an efficiency of less than ten percent.
- Thin-film copper indium Di selenide, which has an efficiency of approximately 12%.
- Thin-film cadmium telluride, which has an efficiency of approximately 9%.

There is very little maintenance required for PV modules, and they can easily be expanded to satisfy the ever-increasing demand for electricity. Because of its modular design, photovoltaic systems can be customised to meet the needs of individual users. The primary drawbacks of photovoltaic energy are its high upfront cost and the requirement that the application or load be matched with the appropriate amount of light output. However, developments in technology that lower the cost of photovoltaics (PV) and enhance their efficiency, among other things, could alter the scenario.

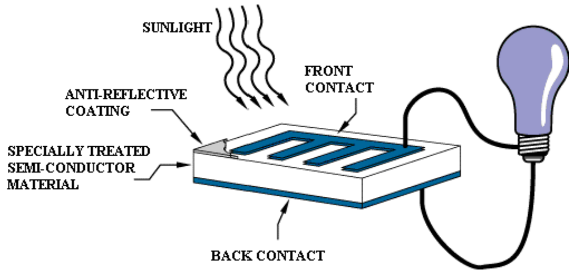

Figure 4: PV Cell

6. Conclusion

This paper is a full study and analysis of the most important technologies of the smart grid. There has been a lot of talk about how important distributed power generation, energy conversion devices that use renewable energy, and renewable energy sources all are. Based on the progress being made in the fields of green energy and distributed power generation, it seems likely that the smart grid will play an important, if difficult, role in the future of power generation and distribution. A photovoltaic (PV) system is an innovative way to make power, especially since it is an energy source that is good for the environment. Still, a lot of problems need to be fixed or dealt with before a goal can be reached. Most of these problems have to do with the design and size of the system, finding the best and most efficient way to cover the technical and financial parts of putting PV into a smart grid to deliver electricity, and making sure that the price of electricity stays the same. We might be able to improve the smart grid's efficiency in the not-too-distant future by adding more nanotechnology-based solutions and uses to the devices and parts.

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