INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue I January 2025

Parameters of Consideration on Smart Grid Integration of Renewables: A Review

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DOI: https://doi.org/10.51244/IJRSI.2025.12010068

Received: 08 January 2025; Accepted: 13 January 2025; Published: 18 February 2025

ABSTRACT

To reach the sustainable pressing power demand, the adoption of diverse variable renewables has become a subject of interest. These renewables have their short comings due to their unpredictable form and limited inertia input. The thresholds of frequency, current, power factor, temperature, inertia and voltage are what generally the parameters that brings forth the operational complexity from the power generation up to the consumer. Furthermore the green energy which is now accommodated to the grid infrastructure has different properties which needs constant monitoring to meet the required standard. However the introduction of smart grids proved to be of significance use in the tracking, trouble shooting, analysis, communication and strengthening the reliability of the power industry. And also optimisation of renewables into smart grids seems to be a game changer to address the energy needs and to reduce the energy load demand. Not only the special type of communication which makes it easier to track if any faults, it has also the component of smart bidirectional metering in it.

Keywords: smart grids, integration of renewables, smart metering, grid reliability

INTRODUCTION

In recent years it has become evident that the quantity of renewables were enormously increasing in their value and usage. This has been amplified by the need to desist from the sources of energy that are not environmentally and climate friendly and that do not increase the effects of the climatic changes. And as it stands the trend is moving towards the green energy and it is no surprise that in the near future the transmission grid will be filled with more renewables than the normal supply from the traditional generation such as thermal power plants. As for the moment in most cases the grid is the reference and statistics shows that the grid can take up to around 20 percent of its own value that can be injected in to the grid [3]. In this context, that is where it becomes more interesting and if the supply for example surpass the grid carriage the result is a new development that's why the concept of a virtual synchronous machines, smart grid etc comes to the picture. But the renewables are a unique type of energy in the sense of their different unpredictable nature because of different sources and methods of generation. However the challenge is always to synchronise these sources of energy with different properties together into the transmission grid.[1] Countless efforts and researches have been done to try to solve these challenges. The power electronics and the principles of communication are playing a pivotal blow in the managing of the energy conversions of the variable DC-DC, DC-AC into the acceptable forms of energy that can be acquired by the grid. Even though it has to be noted that one of the key challenges in the context of the variable renewables is the energy storage part. Which in some cases needs batteries or fuel cells in conjunction with the power electronics interface (convertors, invertors, rectifiers etc). From all these issues associated with renewable energy integration, reliability and stability, it is justice to mention the smart grids, in the sense that smart grids are for the assurance of energy to the consumer and provides a platform for tracking down all the path starting from the production, transmission up-to the consumers.

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The concept of smart grids

Smart grid is the more advanced interconnected network with a handshake type of communication which is in the electrical power movement starting from the diverse sources of generation up to the user in real time. In reality, it is the act of engaging more sensors and soft-wares to enhance the utility and the user information and data sharing.[12] Meaning, if there's any external shock or physical fault in between the generation up to the end user can be detected, unlike to wait for the physical inspection by the utility. It can be detected fast and more accurately by the smart grid. In addition, the fluctuating electricity billing i.e. from pick hour to the normal times, cannot be monitored by the traditional meters. Moreover the smart grids can pick all this up, actually smart grids can inform the end user with the necessary billing and trends to do informed decisions. A good example is that, the end user noticing that the prices if they are more expensive during pick hour.[13] The end user can decide to do operations that need more energy not in the pick hour knowing that the prices will be lower.

Table1

Bi-directional Smart Meters
Information and Communication Set-up
Different types of Energy Generation and Storage
Automation, Instrumentation and Sensory Network
Phasor Measurement Set-up

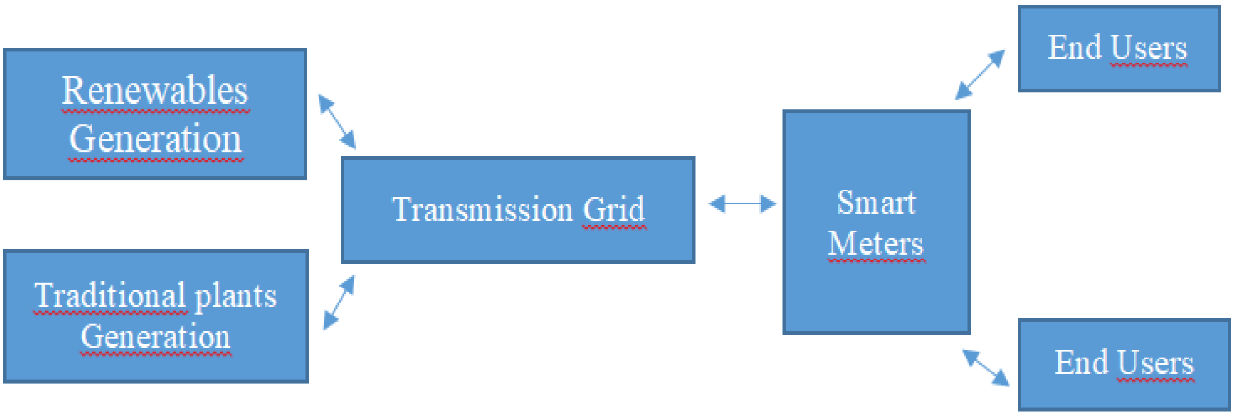

Fig 1 The figure above shows the pictorial view from the utility to the end user, and it tries to potray the two way communication which is in smart grids.

Programmable Logic Controllers. Such as siemens automation tools e.g step7
Wireless Sensory Network and Communication such as Wi-Fi, Li-Fi, WAN, LAN, NAN.
Satellite Communication System. Such as radio frequency communication, Internet of Things, Cloud Computing,
Power Line Communication. Such as AMI, Home area network, and Automatic Meter Reading.
Advanced Smart Meters, this is at the centre of the heart of the smart grids. They work on an advanced two way communication which makes it special for the net metering of energy and with this ability makes it best for the power quality management.

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Types of smart grid protection and control mechanisms

Faults protection

The fundamental principle of the protection system in the smart grids is not solely for the intention of intercepting the outages but to ensure the overall smooth flow of energy between the utility and the end user, better stability, efficient and sustainable quality of power delivery. With the current nature of renewables which are currently progressive in grid penetration, with also the emergency of artificial intelligence [3]. The emerging faults also require smarter and better ways to lessen them hence maintaining the grid reliability and reduced losses.

Cyber security related protection

The smart grid integration with renewables has a special component of data and information in nature. That makes a special relevant target by the threat actors. On the way when information and private data is shared between the utility and the end user.

Data protection between utility and end user

When it comes to the data and information sharing security is the primary concern. The utility and the end user have to successfully implement an active security security assurance tools and techniques. They have to initiate a structured authentication, filtering processes, the control panel which controls the flow of the detailed information and communication mode. There's also need for securing the platform which the information is being transmitted a good example is the networking and routing protocols [11].

Bi-Directional smart meter protection mechanism

In the context to smart grids, it is comfortable to also note that energy is not only one direction as compared to the tradition transmission grid. In addition to the above, it also means that the protection has to be bi-directional too [7]. So the necessary sufficient breakers have to be installed on the right place according to the grid codes and the necessary regional standard regulations.

Protection of the Generation side

The protection of the generation of power is one of the fundamentals of the sustainability of the grid. Their primary design role is to protect the equipment, faults intercept and guaranties the robust stable power generation in all angles. One of the core parameters to be protected is against overcurrent which is done by fuses and breakers. Another one is the overvoltage and under voltage which is protected on the substations on the bus bars[5]. The earth faults are dealt with by immersion of one of the specified conductors according to the each nation's rule to the ground. The anti-islanding is done on the bus bars where the need to isolate the production plant because of diverse reasons. Moreover, for the generation sources which generate DC supply there's also the necessity to have the necessary DC disconnecting switch in accordance to the IEEE or each nation's regulations. There are cases where the differential protection is essential. These are found in the generation side which uses the generator. And the actual faults are witnessed on the generator windings of the stator [6]. The pressure within the turbines protections and water-level protection mechanisms are evident in the generation which is of the hydro in nature. Furthermore the generation which happens as a result of turbines movement, the vibrations are to be monitored and protected so as to have a smooth flow in harnessing energy in the tolerated thresholds. In agreement with the stated above protection mechanisms, the wind generation which is a renewable energy in nature has a unique area where it needs constant monitoring and protection mechanism. This is the pitch or angle of the blade. This is because the turbines in working mode, smoothly adjusts their respective pitch to perpetuate the operation speeds within the acceptable working limits [7]. In addition to the above, the relay protection are also one of the sure pillars in power generation. They protect the over-currents and another type, protects the generation side so as to put out the generator when its frequency is attaining the unstable ranges out of the Nadir frequency [8]. The flame and temperature protection are usually witnessed in the thermal power plants because of its combustive nature in its principle of working.

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The supervisory control and data acquisition acts also as a protective measure in the context where it has to deliver real time data, controlling and bringing out zones of faults.

On the control mechanism

The major control mechanism is the supervisory control and data acquisition which is an automation software based mechanism which monitors and control basic industrial processes such as faults and equipment failures. Another method is the wide are monitoring and controlling method, this basically studies and monitors the behavioural pattern of the smart grids over a large space [10]. It applies the advanced information and data acquisition methods to process and analyse the data. However automation and power electronics plays a major role in the grid integration.

On the storage side

The renewables due to their nature, they have limited inertia contribution which is otherwise compared to the energy which is generated by the traditional synchronous machines. And to cater for inertia, they use battery storage to address this limitation. However since the flow is both ways, even so the protection has to be both ways.

Challenges of smart grids

Vicious cyber threats.

Lack of supportive policy and investment backing.

Expensive capital investment of the infrastructural setup.

Lack of adequate telecommunication and Internet of Things infrastructure.

Benefits of smart grids

Fast and efficient response to unpredictable surges in external disasters and faults.

Transparency, since the utility and the end user share meaningful data in real-time.

It enhances energy management and informed decision making.

It lessen the unnecessary power losses between the utility and the end user.

Efficiency optimisation and computational analysis.

Active support of the grid interaction and independent grid contributors.

In case of excess energy from the electric vehicles, this type of grid is accommodative.

They are eco-friendly in the sense that they accommodate more green renewables which a great input considering the global efforts to lessen the sources of energy that causes climate change.

CONCLUSION

The adoption of smart grids and the integration of them with the green renewables is at its pick at the moment. Even though there is a potential grid instability if the generation of green renewables surpass the grid power capacity and their limited inertia. Its high time researcher to put maximum efforts in this smart grids and to integrate more renewable energy into the grid and we have to embrace it by support and putting to place the necessary policies in support of it.

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