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The Role of Smart Grid in Integrating Wind Energy in India

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Abstract — *With an ever increasing population coupled with a constant depletion of fossil fuel resources and many sites reaching their ultimate capacity, India is in dire need of a Midas touch or of an Aladdin's Lamp. A much smarter approach towards the electrical grid is needed. This smarter approach, technically referred to as the smart grid, promises affordable electrical environment which seems to be the need of the hour. India has large untapped resources of wind energy, which if utilized properly, can fulfill the energy requirements of the country to a large extent. This paper presents the journey of the Indian power sector through time, analyses various demand and supply scenarios, which are mutually exclusive, and also assesses various issues facing the Indian Power System. This paper proposes that integration of enhanced electrical capacity realized through a large-scale integration of renewable energy resources, such as wind energy, in the Indian electrical grid can lead to a smarter grid platform. This platform will ensure increased efficiency, reliability, and security, as well as reducing the environmental impact of supplying the electrical power needs of the modern society. The result is an enhanced electricity management environment and a dynamic programmable renewable source mobilization in India leading to energy independence and an electrical grid that is much more reliable, secure, efficient, and greener.*

Keywords—*Smart Grid, Traditional Grid, Renewable Energy Sources, Wind Energy, Integration*

I. INTRODUCTION

India's electric power framework, known as the grid, has served the country for a long time is finally reaching it total capacity. Grids capabilities in the present developing socio-economic scenario are not to be taken for granted. The current electric power grid was developed over 100 years ago, when the sole purpose of the power system was to transfer electricity from the generating stations to the consumer for lighting purposes. Primarily coal was used to generate power and production plants were built for local communities.With the advancement of technology and industry, the needs of the people grew, requiring the generation plants to grow to expand and supply the increasing demand for electricity. But, with the increasing reach of the electrical grid, optimization and control could not be satisfied by merely increasing the number of generating sites.

1.1 Comparision Between Traditional Grid and Smart Grid

A smart grid makes the transformation from a traditional one way (generation to consumer) grid to a highly connected and 2 way grid possible by applying the technologies and various associated operating principles to the grid. More importantly, it enables the industry's best ideas for grid modernization to achieve their full potential.The smart grid provides two way flow by which electricity and information can be exchanged between a utility and its customers. It is new network for communications, its control, computers, automation and introduction of new technologies and tools to work harmoniously, thus making the grid more efficient, more reliable, more secure and greener. The smart grid enables newer generation technologies to be integrated, such as wind energy production. It will soon upgrade and replace the aging electrical infrastructure and ensure optimized and green electricity production. India's power system needs are not necessarily the same as those in the advanced and industrialized countries. The same also goes for the most important power system constraints. Generally, not all smart grid technologies are equally relevant worldwide. In India, the most useful technologies would be those that help constrain peak demand and peak load growth at reasonable cost while cutting losses. As yet ,there is not any internationally unified definition of a smart grid.

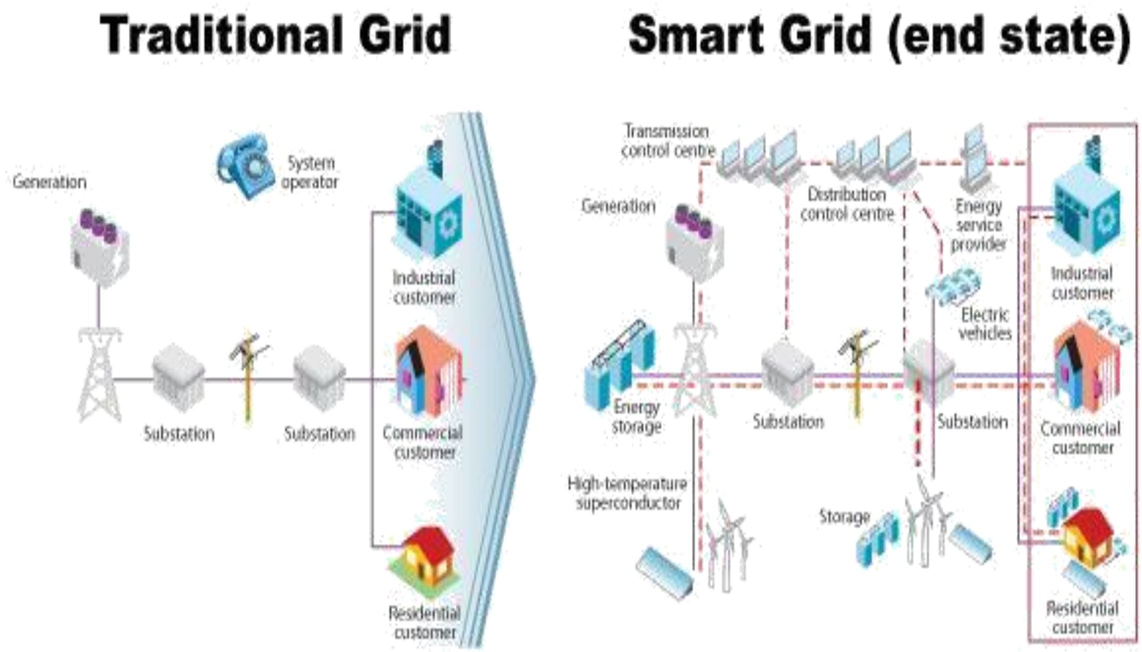

Figure:1 Evolution of Traditional Grid to Smart Grid

Today, the electrical power system delivers energy to agriculture, industry, commercial and residential consumers, utilities struggle to keep up with the ever increasing demand for electricity. Systematically, the hazards associated with relying on an overburdened grid grow in size, scope and complexity with every passing day. The limited one-way interaction makes it difficult for the grid to respond to the changing and increasing energy demands of the 21st century. To its credit, the Ministry of Power's Vision 2027 program focuses on transforming and upgrading the Indian power infrastructure into a secure, adaptive, sustainable and digitally enabled ecosystem that will provide reliable energy with the active participation of all stakeholders. The graphic illustrates the difference between traditional power grid and a smart grid. With the restructuring and broadening of power sector infrastructure; introduction of new regulations; open sourcing; and increasing the share of renewable energy in energy transactions, it is very important to design and operate the Indian grid as a centralized national smart grid. The combined total capacity of the centralized grid is estimated to be in the range of 300 GW, consisting of about 40 –50 GW of renewable energy in the next few years. Integrating renewable energy, with wind as the main energy source would lead to an increase in the complexity of monitoring and control of such a large grid, because wind is intermittent rather than constant. Application of advanced synchrophasor measurement technology, rather than the traditional electric meter, may to some extent provide the needed interface for the wide area monitoring of such a widespread grid.

The information and communication technology in the Smart Grids enables it to make envisioned benefits a reality. These technologies encompass a wide range of operations, such as detecting and identifying faults and a quick response to power outages; providing consumers with near real-time information on the amount and cost of the power they use; improving the security of the system; and linking all elements of the grid to enable better decision making on resource use. With continual up-gradation and modifications these technologies will produce more and better quality data that will give the utilities more flexibility and new opportunities to improve their analysis in areas, such as customer load patterns and tariffs, and thus offer better services to their customers.

Several of the initiatives that have already been introduced into the system include Supervisory Control and Data Acquisition (SCADA), Distribution Management System (DMS), Distribution Automation System (DA), Energy management System (EMS), Automated Meter Reading (AMR), Outage Management System (OMS), Enterprise Resource Planning (ERP) and Geographical Information System (GIS). Installing the latest technology and systems in the power system promises a decrease in loss levels and a subsequent increase in the reliability of the network. Successful implementation of the smart grid would also require introduction of a Wide Area Measurement System

(WAMS) based technology for achieving grid performance. Installation of Phasor Measurement Units (PMU's) at the utilities is a prerequisite for WAMS. The existing interface involving SCADA/EMS based grid operation has the potential to provide the

steady state view of the power grid. Dynamic real time measurements and visualization of the power infrastructure, which are useful for an optimal working of the grid as well as introducing corrective measure, can be realized only with the introduction of PMU based technology.

Smart grid deployment is a journey rather than a onetime event. Taking a cue from this universally accepted paradigm, India has to observe grass roots revolutionary changes in its power infrastructure relating to this requirement. What a smart grid can deliver is marginally driven by specific need. The western countries care more about labour costs, renewable and electric vehicles (EV). In India, however, load management, especially peak load, is a major and primary driver. Therefore, more investments are being made related to superior load management.

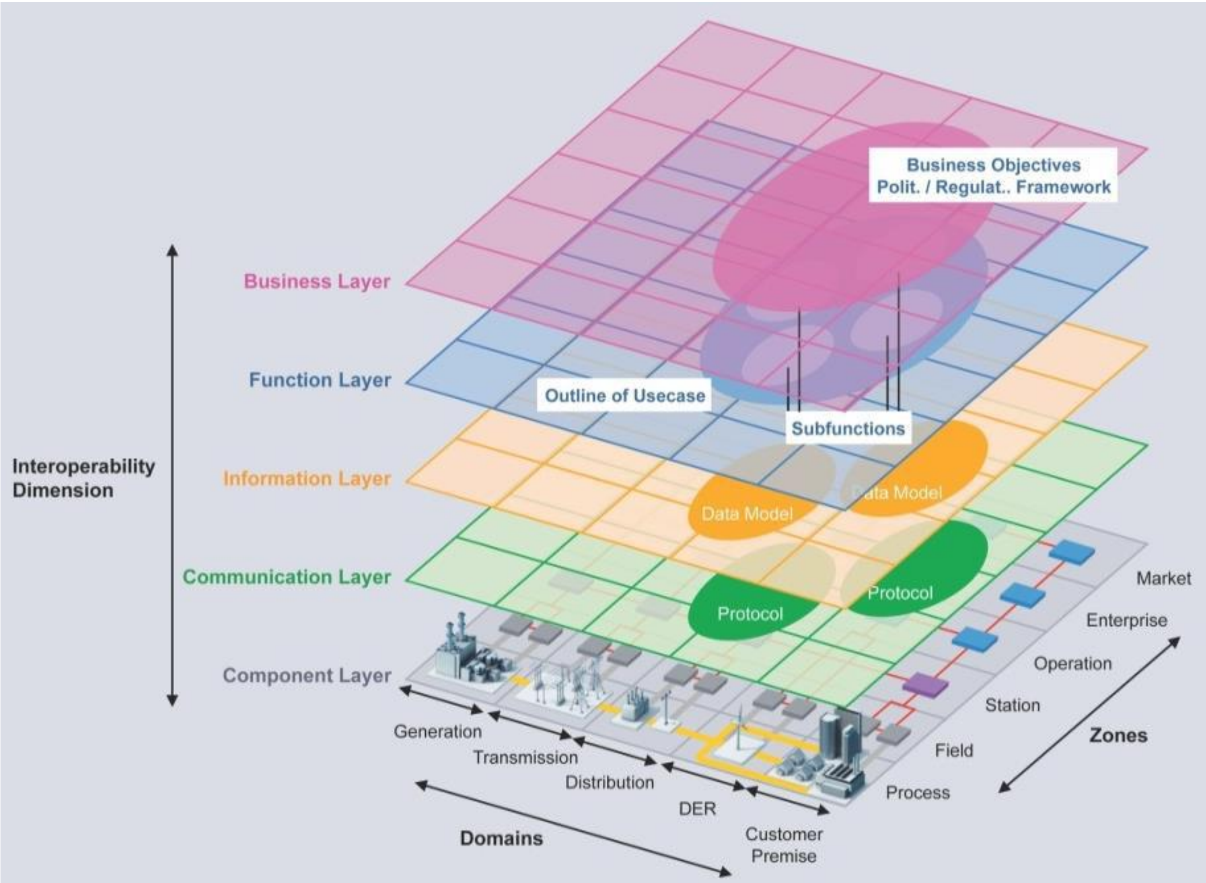

Figure 2. Various Layers of Smart Grid Infra-Structure

Integrating wind energy into the grid will allow the grid to be far more reliable, independent, and efficient and self-remedial in case of power system breakdowns and blackouts; allowing clusters of local communities to receive power from the local renewable generation and lead to a grid transition from a non-self-healing infrastructure to a detection and control infrastructure. To a large extent, this integration is directed towards managing peak loads; offering new services to meet user needs at an individual level; and improving asset use. It involves a systems approach to develop and demonstrate the technical, regulatory, economic and other barriers in the use of renewable energy and distributed generation.

2.1 Issues In Integrating Wind Energy

The major focus for the integration of renewable energy is on wind in India and while some development is already underway, wind energy both suffer from a technical issue of intermittency; a variability that cannot be controlled;

unpredictability to some extent; and location dependency. Grid operators and generation owners face three distinct issues in integrating wind energy into the grid.

2.1.1 Non Controllable Variabiliy

In the context of renewable energy resources, variability refers to a non-steady output. It is different from unpredictability, in the sense that even if operators are able to predict wind and solar output perfectly, the output will still tend to be variable and pose challenges to the operator. Grid operators need to deal with fluctuations in voltage and frequency on a second to minute scale that, if left unchecked, can do significant damage to the system, including the equipment attached with it. A possible method of doing that may be to inject power (active or reactive) into the grid having a technical characteristic of balancing the actual to the forecasted power generation which is pivotal to maintaining a steady voltage as well as frequency on the grid. There may be a number of names and descriptions of such ancillary services. An overview of the various services observed consists of:

1)Frequency regulation: Mainly done by automatic generation control (AGC) signals to renewable generation and occurs on a seconds-to-minutes basis.
□□ □**Spinning reserves**: When a generator goes down or deactivates abruptly in the system, the spinning reserves come into action providing power within 10 minutes.
3)Non-spinning reserves: Even though observing the same function as the spinning reserves, the non-spinning reserves have a much slower response time.
□ □**Voltage support**: These generators are used for reactive voltage in order to increase the voltage whenever needed.

5)Black-start capacity: In case of a cascading black-out, these generators are available to re-start the power system.

In addition, grid operators also need to track the load deviations over the course of the day and ensure that supply always matches the demand. The load following function becomes more important at peak load times of the day when electricity demand increases significantly. On the flip-side, grid operators have always maintained the voltage and the frequency, following load shifts and maintaining reserves since the installation of the electrical grid.This is attributed to the varying nature of loads. Moreover, conventional generation also faces problems time and again and the scheduled performance is not obtained. Consume demands, while predictable, have some degree of variability.
Wind and solar generation does not introduce problems that generation operators have never faced. While as at low penetrations, integrating the renewable energy introduces local grid specific and primarily device problems, such as harmonics and sub synchronous resonance; but, at relatively high penetrations, wind and solar generation adds more non-uniformity to the energy system that grid operators may not have faced before, thus introducing the need of ancillary services and energy balance over-all.

2.1.2 Extensive Unpredectibility

Unpredictability or uncertainty differs from variability in that variability of solar and wind generation is present always, as a result of reliance on the ever changing sunlight or wind speed affecting the system on a moment to moment time scale. Unpredictability on the other hand, relates to our innate inability to predict whether the wind and sun will be available for energy generation an hour or a day later. Unit commitment is used by the grid operators to manage majority of energy on the grid and hence the hour to day uncertainty is not as significant. Unit commitment refers to the process of scheduling generation beforehand, generally around a day ahead, with the purpose of meeting the expected load. Consequently when production does not meet the demand, the grid operator employs ancillary services to meet the difference.
Renewable energy generation leads to an increase in the spread between supplied and predicted energy and hence leads to an increased cost, borne ultimately by the consumers. At present, unit commitment is largely deterministic implying that once a generator is run-scheduled, it is expected to run at full capacity. This practice shows in the relative

predictability and controllability of traditional generation. Availability of resources is ensured by the operators, generators that hold the supply of energy in order to be ready to balance the supply and demand and hence protect against possible generator and transmission line outages.

A complex problem arises when the process of unit commitment and reserve calculation in order to ensure reliability is calculated based on hypothetical or random data and hence carries uncertainty. Weather predictions by forecasting technologies predicts the wind and solar resources at various time frames more accurately and consequently communicates

the predictions to grid operators allowing the operators to schedule and dispatch resources more effectively. Anticipating solar and wind output levels properly allow the operators to modify the generator schedules more dynamically and result in optimal use of all the assets by the grid operator. Advanced unit commitment methods assist the operator in the processes

that prepare the system for potentially uncertain outcomes not predicted by forecasting technologies.

2.1.3 Dependency On Locations

Long term planning, such as the utilization of new transmission lines, is not addressed to in the day-to-day management of the grid. Even though renewable energy generation plays a very important role in this scenario, it introduces new challenges. Wind energy resources are often present in remote areas far from the areas of actual usage. Being far from load centers, development of sufficient transmission infrastructure is crucial for the integration of renewable energy into the grid.

Transmission planning policies are highly varied and tend to be affected by regional politics. Capacity for energy production may be found in one state, pass through another and finally be utilized in another state. Such disparities in generation capacity, location of transmission capacity and variations in load size between various locations makes the development of renewable energy transmission complex, and more so with respect to cost allocation.

Since new transmission infrastructure that will be established will primarily carry renewable energy generation, variable electricity, certain technical needs come up regarding the technology used for transmission. Distributed energy resources provide for an alternative flexible version of the future grid where energy generation and use is local on a micro-grid thus preventing the transmission losses and capital costs of transmission lines. The electric grid can be conceptualized as a collection of cluster grids spread all over the country and working together in order to significantly reduce drastically the energy transmission needs.

III. SMART GRID IN INTEGRATING WIND ENERGY

As the level of renewable energy penetration increases, characteristic of grid will be dominated by inverters than traditional generators and the network and the impedance of the grid seen by a particular inverter would be more effective by neighbouring invertors than by the actual grid. Integration of renewable energy into power grid introduces new power quality problems- intermittency of renewable production leads to more frequent voltage fluctuation, power electronic interfaces injects high frequency harmonics into the system which may lead to harmonic resonance. Reactive power compensation alone would not be sufficient in mitigating such voltage fluctuation even with fast control because the problem is caused by active power variation. To avoid this, electronic devices are required to comply with certain electro-magnetic interferences limits (EMIs). Grid connected invertors for renewable energy application have to comply with harmonics and other power quality limits but so far no EMI limits have been set for such invertors.

3.1 Role Of Smart Grid For Efficient Integration

Power grids are facing a major transformation, driven by the need to integrate renewable energy, improve energy efficiency and allow consumers more control over their energy consumption. The integration of large quantities of renewable energy sources such as wind and solar power will require changes in how our transmission system operates. Following issues must be considered- Variability of renewable energy sources, Integration costs, Frequency response, Emissions, System balancing, Energy storage, Transmission, Solar and wind forecasting, High-penetration variable generation, Energy management systems

Developing solutions to these challenges will enable higher penetrations of renewable generation sources on the electric power system and the future growth of renewable energy. Energy management systems are used by power system operators to monitor power grid operating conditions and control grids in a reliable, secure, and economical fashion. An energy management system interfaces with the grid through a supervisory control and data acquisition (SCADA) system.The increased penetration of renewable generation on the power grid imposes great challenges to the current energy management system scheme because renewable resources largely differ from conventional generation because of their uncertainty and variability. A fully integrated and intelligent distributed energy management system is the key to meeting these challenges.

Implementation of Smart Grid will make it possible to incorporate such high levels of integration in a reliable manner. Features of Smart Grid are Network Planning, Power Electronics (HVDC/FACTS), Bulk Energy Storage, Advanced Energy Management Systems, Smart automation and protection, Integrated Substation Condition Monitoring (ISCM), Communication Solutions, Distribution Management Systems, Distributed Energy Resources, Decentralized Energy Management System (DEMS) and Smart Metering Solutions. At power plants, the focus is on ensuring reliable supply using generation resources efficiently and reducing transmission losses. An advanced EMS in a smart grid is provided with an interface which allows it to function like an EMS in a conventional plant but with the inclusion of Renewable energy generation. Thus maximum power is extracted from RE sources when they are available and during periods of fluctuations the back-up gen sets will be used in the most economic way to ensure higher efficiency and economic feasibility.

To maintain reliability of the grid, smart grid can also include the facility of interfacing the information obtained from advanced weather forecast into the system operating procedures. Wind and solar resource forecasting predicts future energy output through numerical weather prediction models and statistical approaches. Resource forecasting is relatively new

compared with system load forecasting, and it is not yet as accurate. As the smart grid is deployed, options for fast automatic response to routine generation ramps cam be improved and implemented.

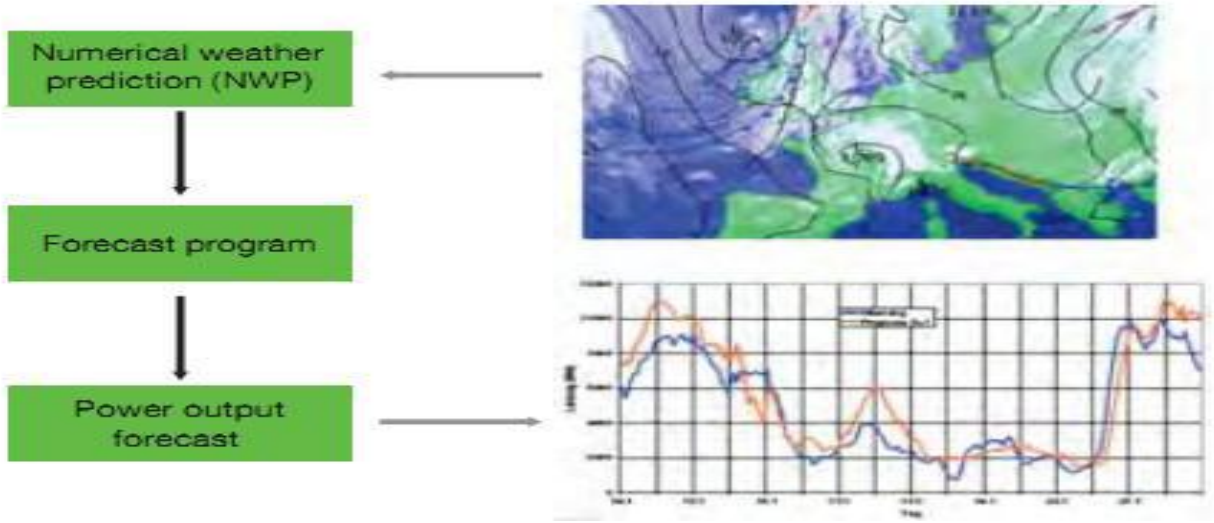

Figure 3. Principle of Short Term Wind Power Forecasting

Storage is another feature which can help smooth fluctuation in generation inherent in wind energy. Smart grid allows the deployment of efficient and reliable bulk storage devices.This storage includes a range of technologies (i.e., batteries with different fluids, flywheels, SMES devices and pumped hydro and underground compressed-air facilities) with the ability to store electricity on the grid and allow it to be dispatched as needed. Such storage can enhance the resilience of the grid through short term storage for peak-shaving and power quality uses and long-term storage for load-leveling and load-shifting applications

3.2Techno-Economical Issues In Integrating With Smart Grid

The electricity production of an individual wind turbine is highly variable. But the aggregate variability of multiple turbines at a single site is significantly less variable. The aggregation of multiple wind generation sites over a large geographic area results in even less variability. Harnessing the "law of large numbers," variability smoothing over large areas yields enhanced prediction. The variability decreases as the timescale decreases.Similarly, some aspects of solar variability are predictable (for example, sunrise and sunset), the same reduction in variability is observed for the aggregation of solar photovoltaic plants over a broad geographic area.

These facts encourage us to promote the penetration of wind energy into the grid by harnessing these resources to the fullest. But we consider the factors of not only harnessing energy from them but also making sure that the energy profile can be maintained constant by including advanced energy management systems, advanced forecasting systems, storage devices,

EMI for power-electronic equipment co-ordination, etc.The cumulative effect of considering these factors results in the concept of integration of wind energy into the smart grid highly expensive. These factors can be combated by increasing the tariffs levied on per unit of kWh energy generated but this would discourage the masses from utilizing this electricity.But the return over investment for these schemes of integration, although not immediate, will prove to be profitable in the next 20 years.

IV. CONCLUSION

Various challenges of integrating wind energy into a conventional grid have been addressed. Implementation of a smart grid can help us to improve the reliability of the Indian power grid. Renewable Energy resources are available in plenty in our country and efforts are being made to harness them to the fullest. Though the techno-economical issues for implementing these technologies act as a barrier, the positive impact that use of renewable energy resources will have on our environment will offset the economical barriers involved in the long run.

REFERENCES

1. Joshua Earnest & Wizelius, Tore – "*Wind Power Plants and Project Development"* PHI Learning Private Limited, India pp.280 – 311; 2011
2. Sushma Sekhar, Sayali Wavhal, Ashwani Budhane, Vaishanavi Ramasundaram, Anushree Ashtikar, **"I***ntegration of Solar and Wind Energy with Smart Grid- An Overview"*, IJETAE, Volume 5, Issue 2, pp.374-377, 2015
3. N.V. Vader, Manda V. Bhadang, *"System Integration : Smart grid with Renewable Energy"*, Rexjournal, Issue-1, pp1-13
4. **N.Phuangpornpitak, S. Tia, "*Opportunities and Challenges of Integrating Renewable Energy in Smart Grid System"* ,,Energy Procedia Volume 34, pp.282-292, 2013**
5. **Shushmita Banerjee, Abhishek Meshram, N. Kumar Swamy, "*Integration of Renewable Energy Sources in Smart grid"*,IJSR, Volume 4, Issue3, pp.247-250 ,2015**

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