

# Review of Renewable Energy Towards Sustainability Environmental

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## ABSTRACT

The use of renewable energy resources, such as solar, wind, and biomass will not diminish their availability. Sunlight being a constant source of energy is used to meet the ever-increasing energy need. This review discusses the world's energy needs, renewable energy technologies for domestic use, and highlights public opinions on renewable energy. The literature analysis showed that despite serious efforts at all levels to reduce reliance on fossil fuels by promoting renewable energy as its alternative, fossil fuels continue to contribute 73.5% to the worldwide electricity production in 2017. Conversely, renewable sources contributed only 26.5%. Furthermore, this study highlights that the lack of public awareness is a major barrier to the acceptance of renewable energy technologies. The results of this study show that worldwide energy crises can be managed by integrating renewable energy sources in the power generation. Moreover, in order to facilitate the development of renewable energy technologies, this systematic review has highlighted the importance of public opinion and performed a real-time analysis of public tweets. This example of tweet analysis is a relatively novel initiative in a review study that will seek to direct the attention of future researchers and policymakers toward public opinion and recommend the implications to both academia and industries. The paper discusses the problems and solutions regarding the integration of nonconventional energy sources into the smart grid based on the current scenario. It outlines the systemic approach that is required to address both the technical and non-technical issues associated with the implementation.

**KEYWORDS:** *Energy policies, public opinion, renewable energy sources (RES), renewable energy technology (RET), solar energy, wind energy, Smart grid, Renewable energy sources, spinning reserve, frequency regulation.*

## Introduction

A revolutionary make over from a central, utility-controlled network to a grid that is less central and more interactive with the consumers is coming. The upgrade to a smart grid promises to widely affect the industry's entire business model that consisted of vertically integrated entities and its relationship with all stakeholders in the service chain affecting and involving utilities. Energy service provider's regulators, technology and control dealers, and users will all be impacted. Integration of Renewable Energy Sources to Smart Grids has already drawn due attention of the nation. India is at a preliminary stage of its smart grid deployments with many technologies, such as advanced metering and remote sensing of renewable generation, still at a very crucial juncture. Its deployment is being reviewed and tested at certain pilot's sites around the country. Such technologies are undergoing various trials and advanced testing before they could be deployed around the country. The subject of renewable energy (RE) concerns experts as well as the general public increasingly. Studies on renewable energy

sources (RES) has increased in the last years in absolute and relative terms [1]. RES can perform an important role by addressing the issues of fossil fuel depletion and global warming [2]. Fossil fuels, nuclear resources, and renewable resources are the three main sources of energy.

The coherence of many factors would drive India's adoption of smart grids, such as reducing all technical and commercial losses to resolve the ongoing supply/demand gap. India is upgrading its infrastructure to a more advanced electricity supply solution that has sustainable, low carbon, high growth economic development goals. Certain factors will drive the adoption of India's smart grid. All the sectors of renewable energy are being developed. However, the wind power program has been the fastest growing that contributes to about two-third of the grid connected renewable energy power installed capacity, as of now. Of course, with the potential estimated on solar power, total of off-grid and on-grid of this form of renewables would lead in the long run. Initial development of renewables concentrated following isolated systems. But with the advancement of technology with higher size and a greater number of units, particularly with wind power plants, being feasible at place grid connectivity has improved. At the same time gradual evolution of intelligent or smart grid employing extensively communication and information technology is paving the way for connection to the grid even for the remotely located plants. However, unlike developed countries, as India is still away from the use of Electric Vehicles, immediately on account of this use of battery storage is not possible. Of course, in some area's battery storage is in use (particularly with computer and communication facilities), mainly due to overall shortage in peak power and to some extent on quality of supply

## **RESEARCH METHOD**

To advance our understanding of utilizing RES effectively the present study consists of a systematic literature review (SLR) with a specific focus on RES and RET. Recently a SLR has been carried out in the combination of computer science and RE field [32], [33] and a detailed SLR was performed about public opinions [23]. A SLR is a means of identifying, evaluating and interpreting available research relevant to a particular research question or topic area [34]. The design of the SLR reported in this paper started in December 2017. After several refinements and improvements, publication search was started in March 2018. The following subsections present the research questions of the review, search strategy, searched database, search terms, inclusion/exclusion criteria and the quality criteria of the SLR.

### **A. PLANNING THE REVIEW**

The review is planned by proposing the research questions relevant to our research objective. Further, we defined the search strategy, search strings and inclusion/exclusion criteria.

#### **1) RESEARCH QUESTIONS**

The main objective of this work is to develop an understanding of the necessity for RE, RES, and RET. We have formulated the following research questions (RQs) to achieve the research objectives.

**RQ1: WHY THERE IS WORLDWIDE NEED FOR RENEWABLE ENERGY?**

The aim of this research question is to recognize the reasons for the use of RE. The results obtained will be useful to highlight the challenges with the use of energy sources other than RE and bring awareness for the use of environmentally friendly energy sources such as RES.

**RQ2: WHAT ARE THE TYPES OF RENEWABLE ENERGY SOURCES USED FOR DOMESTIC USAGES?**

The aim of this research question is to identify the various types of RES such as wind, solar and biomass, used to provide energy for domestic scale. The results will assist to develop the awareness for the use of these RES.

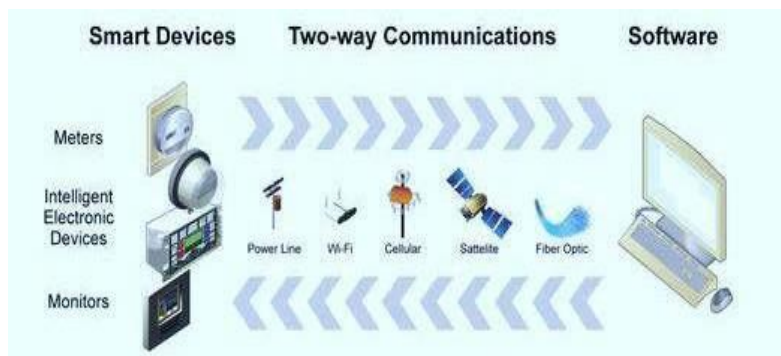
**RQ3: WHAT ARE THE PUBLIC OPINIONS ON RENEWABLE ENERGY TECHNOLOGIES?**

The aim of this research question is to identify the public opinions addressed in the literature regarding the use of RET. The results obtained will be useful to identify emerging trends and provide a possible solution to tackle the barriers for accepting RE.

### **SMART GRID TECHNOLOGY**

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. The technology makes more efficient use of the grid to identify and correct supply and demand imbalances instantaneously and detect faults in a self-healing process that improves service quality, enhances reliability, and reduces costs.



**Figure 1: Smart Grids Provide Two-way Communication**

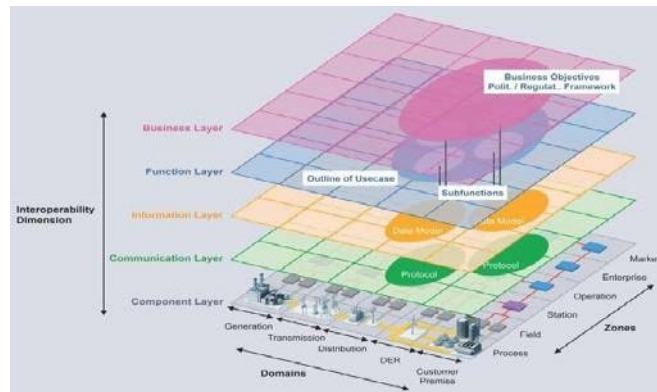


Figure 2: Various Layers of Smart Grid Infra-Structure

## Large scale wind and solar into the grid

Integrating wind and solar 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 [5].

### 1.1. Challenges

The major focus for the integration of renewable energy is on wind and solar in India and while some development is already underway, wind and solar 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 and solar energy into the grid: non controllable variability, Extensive unpredictability and Dependency on locations

#### 1.1.1 Non controllable variability

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:

- **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 few minutes.
- **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.
- **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, followed load shifts and maintained 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 do 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.

### **Extensive unpredictability**

Unpredictability or uncertainty differs from variability in which 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. 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.

### **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 and solar 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 are 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 n cluster grids spread all over the country and working together in order to significantly reduce drastically the energy transmission needs.

### **Conclusion**

With Renewables coming as big source of electric energy and due to its high potentials, particularly in the areas of wind and solar power, in the years to come it will form sizable part of generation feeding the grid. However, as it comes with unpredictable and variable contribution, while integrating smart grid utilizing advanced technologies of digital computing and communication has to operate and control the power system within the acceptable ranges of parameters. Regulatory mechanism in India, some already in vogue and others gradually coming to be in force encourages to promote distributed generation and renewables and protects the concerned green energy sources to meet the electricity demand at every instant of time along with centralized conventional thermal or nuclear generation. But at the same time stringent measures need to be complied with in operation while connected to grid, of course taking advantage of advancement in technologies as available to the smart grid

which over the years has changed from what it was in the past in terms of operation and control.

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