An Analysis of Opportunities and Barriers of Integrating Renewable Energy with Smart Grid Technologies in India

Dr. I.ARUL
Department of Electrical Engineering
TamilNadu Generation and Distribution Corporation Limited (TANGEDCO)
Tenkasi- India
arul1511966@yahoo.com

***Abstract*—** Smart city may be defined as a developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas economy, mobility, environment, living and government services etc. Power supply, power production and power management are the main key factors for all developments. Hence focusing in these factors is very important and vital in forming smart cities.

Keywords- Smart grid system, Renewable energy

I. Introduction

A number of factors are contributing to increases in renewable energy production. They include declining costs of electricity produced from renewable energy sources, regulatory and policy obligations and incentives, and moves to reduce pollution from fossil fuel-based power generation, including greenhouse gas emissions. While not all renewable energy sources are variable, wind and solar PV currently dominate the growth of renewable electricity production and their production tries to capture the freely available but varying amount of wind and solar irradiance.

India is at the centre of the global energy stage. It has the third largest energy consumption in the world but per capita electricity consumption is around a third of the world average. Moreover, Indian electricity demand is expected to continue to expand as a result of economic and population growth, along with increased urbanization and industrialization. India is therefore faced with a triumvirate of challenges: how to i) expand access, ii) meet growing electricity demand and iii) integrating renewable energy, all while iv) transitioning to a low-carbon electricity system in order to achieve ambitious economic, social and climate objectives. The Smart Grid is an idea of a better electricity delivery infrastructure. Smart Grid implementations will certainly increase the quantity, quality, and use of information available from advanced sensing, computing, and communications hardware and software. As a result, they help utilities address two of the main issues in today's world: • Environmental concerns. • Power delivery limitations and disturbances.

A. Renewable Energy:

Renewable-energy resources are stand alone or isolated power generation system. But their benefits are significantly enhanced when they are integrated into bigger electric power grids. Each resource is different from the grid's perspective and some are easier to integrate than others.

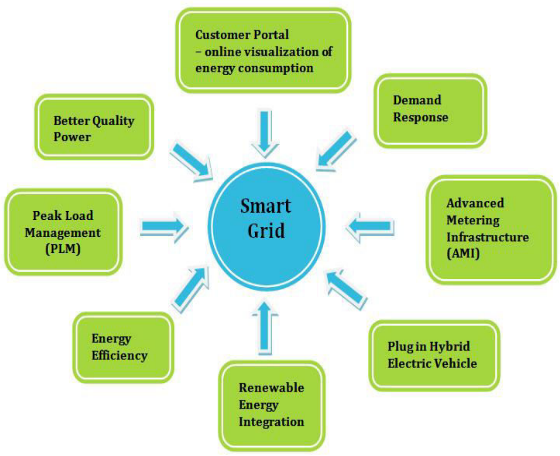

Fig 1. Smart Grid

TABLE 1. CHALLENGING FACTORS AND THE BENEFITS OF SMART GRID TECHNOLOGY

Challenging Factors	**Why Smart Grid Technology?**
Peak shortfalls	India is world's 6th largest energy consumer, accounting for 3.4% of Global energy consumption. Demand for energy has grown at an average of 3.6% per annum there is short fall of peak demand.
Performance Efficiency	The smart grid can improve load factors and reduce system losses. This will reduce the dips in load curves and improves the performance efficiency of entire power system.
Human Error	Error in meter reading, deliberate errors, power theft, faulty meters, and poor maintenance of meter intentional damage has resulted with significant losses. However, automated meter reading would lower recording and other errors thereby reduced commercial losses.
Peak load management	India's supply shortfalls are during peak hours and are persisting for many years. Implementation of demand side management had allowed more "intelligent" load control.
Future energy	India has supported the application of renewable energy – wind energy and solar energy. Nearly 2-3% power generation is considered by renewable energy. MOP has under taken National Solar Mission and set a goal to add 20,000 MW of power by 2020.
Technological leap	Perhaps the most intriguing driver for India is the potential to "leapfrog" into a new future for electricity, as it did with telecommunications. Also, the "smart" in a smart grid is ICT — an area of unique capability in India.

B. Smart Grid Technology in Indian Power Sector:

A smart grid is an electric grid system where all accomplices in the grid system (i.e. Power production, transmission and distribution operations and electricity consumptions). Communicate and work with each other to raise the efficiency and reliability of the grid.

The smart grid is more than simply installing smart meters – by bringing an information technology to the electric grid, we will develop numerous applications that use the devices, networking and communications technology, and control and data management systems.

The smart grid delivers electricity to consumers using two-way digital technology to enable the more efficient management of consumers' end uses of electricity as well as the more efficient use of the grid to identify and correct supply demand-imbalances instantaneously and detect faults in a "self-healing" process that improves service quality, enhances reliability, and reduces costs.

Environmental Impact

Smart Grid development is happening at a very fast pace because of the broad interest of policy makers and utilities in decreasing the adverse effect that energy usage has on the environment. Smart Grids uses technology to drive efficiencies in transmission, distribution, and consumption. As a result, fewer generating plants, fewer transmission and distribution assets are required in order to cater the growing demand of electricity.

II. BARRIERS IN INTEGRATION OF RENEWABLE WITH SMART GRID TECHNOLOGY IN INDIA

Variability in power generation, provided by many renewable-energy sources such as solar, wind, bio-gas etc. is a challenge to electric grid operations. But when used in integration with smart grid as responsive distributed generation can be a profit to system operations if coordinated to relieve stress in the system (e.g., peak load, line overloads, etc.). Smart grid approaches can reduce barriers and facilitate integration of renewable resources. The barriers can be categorized below as technical, financial, business and societal issues.

A. Technical Barriers:

1. Advanced Control Strategies: Solar and wind power plants exhibit changing dynamics, nonlinearities, and uncertainties .Hence smart grid require advanced control strategies to solve effectively. The use of more efficient control techniques would not only increase the performance of these systems, but would increase the number of operational hours of solar and wind plants and thus reduce the cost per kilowatt-hour (KWh) produced.

2. Wind and solar energy are both intermittent resources. Wind behavior changes daily and seasonally, and sunlight is only available during daylight hours. Both wind and solar energy can be viewed as aggregate resources from the point of view of a power grid, with levels that vary within a 10 minute to 1 hour time frame, so they do not represent the same form of intermittency as an unplanned interruption in a large base-load generator.

3. Being flexible to changing technologies require identifying the vital interface between technology components.

B. Business and financial barriers

1. Understanding and communicating the value proposition of a smart grid deployment for each stakeholder in the electricity supply chain is scary.

2. The financial environment risk and reward can challenge business plan for smart grid investments as well as in Renewable energy system.

3. Regulatory understanding and sensitivity to providing an appropriate environment for smart grid investment takes place. Regulatory decisions (or lack of decisions) can create new challenges.

C. Societal Barriers:

1. Strategies need to account for a variety of policy objectives (affordability, sustainability, growth and cultural values).

2. Assigning value to externalities, such as environmental impacts, is difficult, but necessary, in balanced decision-making. Understanding and accounting for the beneficial aspects of smart grid investments as a mechanism for job creation and advancing a technically skilled workforce needs development.

D. Policy and regulation

The current policy and regulatory frameworks were typically designed to deal with the existing networks and utilities. To some extent the existing model has encouraged competition in generation and supply of power but is unable to promote clean energy supplies.

Generally, governments set policy whereas regulators monitor the implementation in order to protect the consumers and seeks to avoid market exploitation. Over the last two decades, the trend of liberalized market structure in various parts of the world has focused the attention of policy makers on empowering competition and consumer choice. The regulatory models have evolved to become more and more effective to avoid market abuse and to regulate the rates of return.

E. Lack of awareness

Consumer’s level of understanding about how power is delivered to their homes is often low. So before going forward and implementing Smart Grid concepts, they should be made aware about what Smart Grids are? How Smart Grids can contribute to low carbon economy? What benefits they can drive from Smart Grids?

Therefore:

- Consumers should be made aware about their energy consumption pattern at home, offices...etc.
- Policy makers and regulators must be very clear about the future prospects of Smart Grids.
- Utilities need to focus on the overall capabilities of Smart Grids rather than mere implementation of smart meters.

III. SOLUTIONS TO OVERCOME THE BARRIERS IN IMPLEMENTATION

A. Enabling distributed generation and storage

Smart grids will change where, when and how energy is produced. Each household and business will be empowered to become a micro-generator. Onsite photovoltaic panels and small-scale wind turbines are the predominant examples; developing resources consist of geothermal, biomass, hydrogen fuel cells, plug-in hybrid electric vehicles and batteries. As the cost of traditional energy sources continues to rise and the cost of distributed generation technologies falls, the economic situation for this evolution will build.

B. Recommendations and Suggestions

✓ Wind power plants exhibit changing dynamics, nonlinearities, and uncertainties .Hence smart grid require advanced control strategies to solve effectively. The use of more efficient control techniques would not only increase the performance of these systems, but would increase the number of operational hours of wind plants and thus reduce the cost per kilowatt-hour (KWh) produced.

✓ Wind is an intermittent resource. Wind behaviour changes daily and seasonally. Wind energy can be viewed as aggregate resources with other renewable energy from the point of view of a power grid, with levels that vary within a 10 minute to 1 hour time frame, so they do not represent the same form of intermittency as an unplanned interruption in a large base-load generator.

✓ Research in technology is still in progress. Hence existing generation and delivery infrastructure (i.e. legacy) of RE systems must be adaptive to work with new technologies.

✓ Being flexible to changing technologies require identifying the vital interface between technology components.

✓ Achieving association across service providers, end-users and technology suppliers is difficult in particularly in growing international market place. Exchange of knowledge and information can allow multiple parties to connect their devices and system for proper interaction, but attaining interoperability is difficult.

✓ Strategies need to account for a variety of policy objectives (affordability, sustainability, growth and cultural values).

✓ Assigning value to externalities, such as environmental impacts, is difficult, but necessary, in balanced decision- making.

✓ Understanding and accounting for the beneficial aspects of smart grid investments as a mechanism for job creation and advancing a technically skilled workforce needs development.

✓ Greater awareness about capabilities of smart grid and there benefits for improving energy-efficiency and renewable resource integration policies.

✓ Research and development activities: the speed with which new ideas and deployment tactics are being generated. Some modern innovation and invention has to be made like recent innovation for power saving method using new type of battery (found out by Harvard University researchers) that could make it economical to store a couple of days of electricity from wind forms and other sources like solar power.

✓ Forecast wind power generation will help TANGEDCO exploit wind potential to the maximum while reducing loss due to backing down of wind mills

IV. BENEFITS OF INTEGRATION OF RENEWABLE ENERGY WITH SMART GRID SYSTEM

Leading characteristics of renewable resources that impact their integration into power grids are their size (generation capacity as compared to other sources of power generation on a system), their location (both geographically and with respect to network topology), and their variability. Renewable integration - reducing our nation's dependence on foreign coal by enabling the seamless integration of cleaner, greener energy technologies into our power network. Normally Renewable resources are connected at the distribution level and as larger resources (wind farms, solar farms) are connected at the transmission level.

Future energy sustainability:

Renewable Energies(RE) are making a significant contribution to climate protection, diversify resources, ease dependence on fossil resources, not produce any type of contamination, domestic energy carriers and therefore contribute to regional value creation and help to secure employment. Hence renewable sources as future energy provide sustainability.

Empowering grid in peak hours:

Integration of more renewable sources and storage support the smart grid with real time information and substituting renewable energy sources whenever possible. Increasing proportion of Renewable sources in generation mix not only improves operational efficiency but reduces peak demands.

Energy management:

Smart metering helps to adopt energy management techniques such as Demand side management at consumer level, demand response usage leads to optimum utilization and results into saving of energy.

A. Role of renewable energy and distributed generation in smart grid

Around the world a change in electricity generation is desired in order to fight climate change and increase energy security. Consequently renewable energies and distributed generation are receiving support and their shares in electricity generation are rising. The increasing renewable generation in an inflexible system is the major challenge for developers and practitioners of smart grid system. The addition of distributed generation to the electrical distribution system has been the key driver in the evolution of distributed system, however distributed generation hardly receives market signals nor participates in system management for two reasons. First, distributed generation is often from renewable sources and therefore prioritized under fixed feed-in tariffs and exempted from market prices. Second, generators in distribution networks are often too small and not equipped with technology and characteristics for system management purposes in balancing markets [2].

B. Technical Challenges

Technological barriers include the challenge of scaling up of immature technologies to commercial level, intermittency and back-up capacity, storage, siting and land use issues. Renewable energy such as wind and solar are known to be variable, (Fig. 2) but are cyclical and they can be predictable.

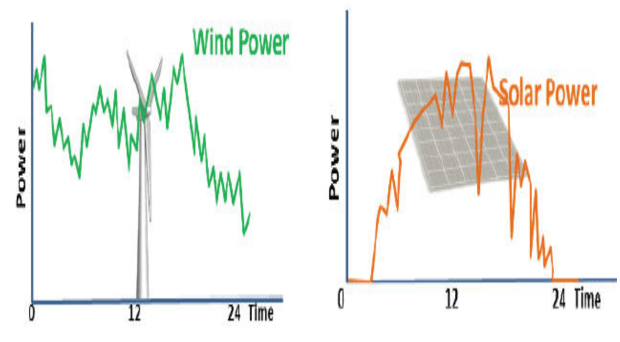

Fig 2. Wind and Solar Energy Intermittency

Functions of Smart Grid Technologies

Smart grid technologies vary widely in cost, applicability, and market maturity. Nevertheless, a carefully integrated set of smart grid technologies can decrease the costs and risks of integrating distributed renewables into electricity systems.

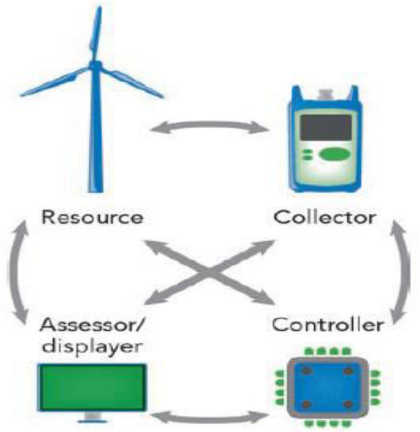

Fig 3. Four Functions of Smart Grid Technologies

The following discussion provides details on the purpose of specific smart grid technologies, their strengths and weaknesses, their current status and other relevant information. We focus on technologies that apply at the distribution level, as these technologies are underutilized and show great potential.

The technologies are presented in order of decreasing technological maturity, with a final section briefly describing bulk power technologies of varying maturity.

V. CONCLUSION

In this paper an attempt has been made to analyze the key challenges in implementing the Smart Grid concept in India. In most of the advanced countries Utilities have made major achievements in terms of productivity, reliability, and efficiency through the use of Smart Grid technology.

Indian utilities are still lagging far behind when compared to other countries. Today their main focus is on providing energy at reasonable price but soon the day will come when the utilities will be focusing on encompassing sustainable use and environmental improvement into their agendas. Integrated system of renewable energy and the smart grid is useful, by which some of the major break downs were prevented as the minor part of northern grid was operating without any disturbances. If this would have been implemented on the complete grid system might be this major black out would have been prevented.

Thus integrating renewable energy into smart grid requires not only new technology but new attitude and operating procedure. Renewable generation has the benefit of enhancing sustainability (reducing environmental impacts), reducing greenhouse gas (GHG) emissions, reducing dependence on local or imported fossil fuels, and increasing energy security through diversification of energy sources. Smart grid technology can control renewable resources to effect changes in the grid's operating conditions and can provide additional benefits as generation of renewable energy in variability assets or when installed at the transmission level.

The Paper involves

- Distributed renewable interconnection technologies with advanced functionality.
- Integration of renewable energy with dispatch able load and storage.
- Electric power systems technologies, controls, and operations that enable high penetration of distributed renewable energy systems.
- Models for renewable energy systems that allow them to be included in the planning and analysis tools.

VI. ACKNOWLEDGMENT

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VII. BIOGRAPHICAL INFORMATION

Dr.I.ARUL was born in Puliangudi in Tirunelveli (D.T), India in 1966. He received his Doctorate in Electrical Engineering and Computer-Information technology in 2013 from Manonmaniam Sundaranar University (M.S), Tirunelveli (District), Tamilnadu, India. He has been active in the area of Renewable Energy and conservation for over 10 years. His current research involves study of the Extraction of Maximum power from Wind Power generating System using Intelligent Controller. He has completed his post-graduation degree M.Tech in Electrical Engineering (2005) and M.Tech in Computer-Information Technology (2010) from Manaonmanaim Sundaranar (M.S) University, Tirunelveli.

In 1988, he joined as an Technical Assistant in Tamilnadu Electricity Board (TNEB), Puliyangudi - Tirunelveli. He has spent over 27 years and got two promotions and presently being as an ASSISTANT EXECUTIVE ENGINEER at the TNEB. He is an active member of Institute of Engineering Technology (IET), London from 2014 and also Member of Institute of Engineers (MIE), Kolkatta, India from 1992. He is an active member of Rotary Club, Courtallam, Tenkasi.

VIII. REFERENCE

[1] Anil K Jain and Toshi Mandloi "Integration of Renewable Energy Sources in Smart Grid Systems, and their constraints" in International Journal of Modern Trends in Engineering and Research (IJMTER) – 2015.

[2] N. Phuangpornpitak and S. Tia "Opportunities and Challenges of Integrating Renewable Energy in Smart Grid System" Eco-Energy and Materials Science and Engineering Symposium (EMSES2012) Energy Procedia 34, 2013, pp. 282 – 290.

[3] Abbasi S.A and Abbasi N "Renewable energy sources and their environmental impact", Publication: - PHI/New Delhi pp. 189-201.

[4] http//www.powergrid.in/national grid.html

[5] Battelle Boulevard Richland "Asia-Pacific Economic Co-operation (APEC) Energy Working" Group May 2011 Report, Pacific Northwest National Laboratory 902, and WA 99352, USA.

[6] Cameron W-Potter "Paper on Building a Smarter Smart Grid through better renewable energy Information" IEEE - 2013.

[7] Wissam Balshe "An introduction to the Smart Grid (White paper)", Sales Application Engineer-2014.