Deploying Renewable Energy Microgrids To Improve India's Electricity Scenario Challenges & Opportunities

D.V. Avasthi1, Gajendra Singh2

Abstract - The paper explains the concept, benefits and features of standalone and smart micro grid systems. The architecture, design, operation and control of the Micro Grid systems in various modes is visualized. An overview of the autonomous microgrid and Smart Grid technology is presented. This is followed by presenting brief account of the Indian electricity scenario and Government initiatives to minimize energy poverty and promote energy equity, energy security and sustainability of energy and environment through the application of micro grid technologies. The younger generation, especially engineers and technologists are sensitized to involve themselves in eradicating energy poverty and strengthen sustainability of energy and environment. And finally, the new paradigms in the Smart grid design and benefits accruing there from including from adaptation of the renewable energy resources and smart grid technology describe the highlights of this paper.

Index Terms — Microgrid architecture, smart grid, renewable energy resources, energy security, energy poverty, power system reliability, power quality, entrepreneurship in energy.

1: INTRODUCTION

Progressive depletion of fuel reserves, constant rise in fuel import bill, increasing demand for electricity and compulsions of Kyoto protocol urging minimization of carbon credits in the environment are exerting irresistible pressure on India to restructure its energy policy. Energy with equity, eradication of energy poverty and freedom from electricity crisis throughout India have become the theme of India's energy policy. Harnessing renewable energy resources instead of dominant dependence on fossil fuels, petrol or oil (Fig 1) are the buzzwords in energy parlance today. The dawn of a new era of electricity generation with dominant share of renewable energy resources such as solar, wind, bioenergy etc., energy conservation and energy efficient technologies seems to be in the offing. The goals for change in the energy basket with higher proportion of renewable energy resources for electricity generation in India by 2022 have already been set as integral part of the new energy policy (Figure 2). The ongoing trend is to enhance productivity through renewable energy resources, and minimize wastages for sustainable growth of energy and eco-friendly electricity for a more productive and prosperous India in the days ahead.

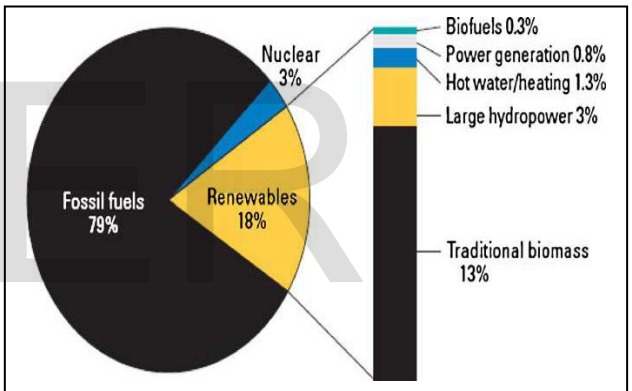

Fig 1. India's dominant Dependence on Fossil Fuels for producing Electricity (to be replaced by renewable resources of energy)

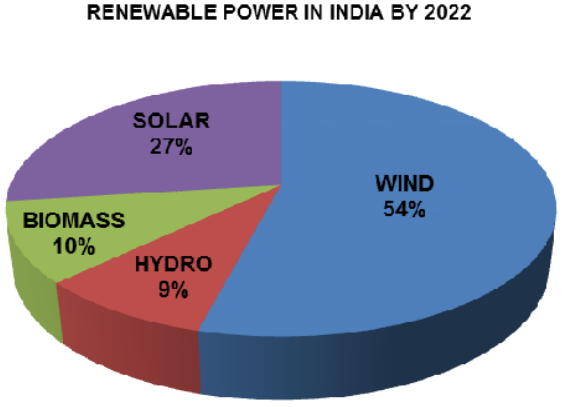

Fig 2. India's Target 2022 for Electricity Generation with Renewable Resources To Modify Its Energy Basket For Sustainability

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2. MICROGRIDS- THE NEW POWER SYSTEM ARCHITECTURE FOR SUSTAINABILITY:

The vision of the country is to strive for energy with equity, eradication of energy poverty and accomplishment of energy security for the whole nation. India is committed to develop infrastructures for providing energy access to all and the creation of autonomous micro-grid systems is just a step forward to accomplish this end (Figure 4). Microgrids can make electricity generation sustainable, reliable, eco-friendly and cost effective and obviate the malady of energy losses in transmission. This, in effect, requires the focus on replacement or retrofitting the traditional hierarchical power systems (Figure 3) with electricity generation, transmission and distribution in difficult areas connected with autonomous microgrid system (Figure4). Creation of renewable energy based autonomous microgrids and their interconnection to form smart grid systems (Figure 5) is preferred in practice to increase the share of environment friendly renewable energy resources for electricity generation. The idea is to promote sustainable energy and environment throughout the country. Replacement of traditional power systems designed with centralized generation and hierarchical transmission (Figure 3) with distributed generation and decentralized transmission is shown in figure (5). These systems are being preferred so that the energy systems become environment friendly, efficient and cost effective in consonance with the energy policy of the country. While standalone microgrids often suit the requirements of rural community or enterprises, the smart grids are designed to integrate resources and services provided by individual microgrid systems. The Smart microgrid systems are designed to allow two way communication between electricity generating stations to address issues relating to security, protection and integrated services to consumers by the electricity utility companies in addition to realizing its prime objective of making electricity services sustainable, reliable, eco-friendly and cost effective and obviate the malady of energy losses during transmission.

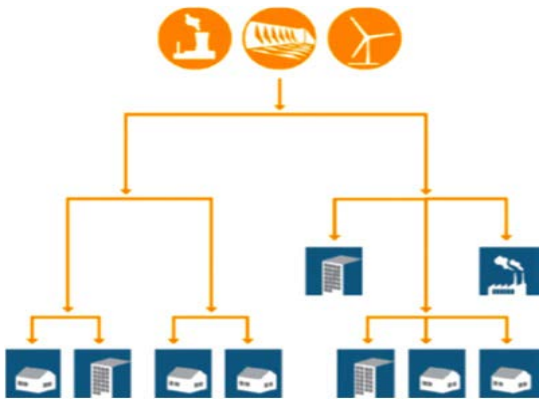

Fig 3. Traditional power system designed with centralized generation and hierarchical transmission

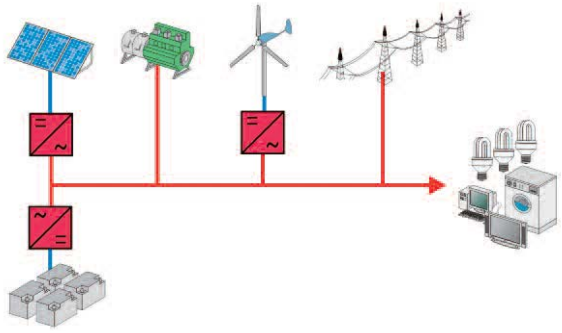

Fig 4. Renewable Energy Resources Based Autonomous Microgrid Architecture Suitable For Remote And Inconvenient Locations.

Smart Grid technology is the quantum leap in merging communication with information technology to enhance grid reliability, and to enable integration of various smart grid resources such as renewable energy, demand response, electricity storage and energy transportation. This technology allows wider competition between utilities enabling greater use of intermittent power resources, establishing the wide area automation and monitoring capabilities needed for both bulk transmission over wide distances and distributed power generation, empowering more efficient outage management, streamline back office operations, aiding the use of market forces to drive retail demand response and energy conservation. Merger of Information and Communication Technology (ICT) with the microgrid technologies has given new dimension to smart grid systems by supporting dynamic real-time two-way energy and information flow, facilitating the integration of renewable energy resources into the grid, empowering consumer with tools for optimizing their energy consumption by introducing Advance Metering Infrastructures (AMI), Virtual Power Plant (VPP) and other such incipient implements. This apart, the use of ICT helps grid system to continuously self-monitor, self-adjust and achieve self-healing functions, so as to monitor all kinds of turbulences, carry on compensations, redeploy the power flow, avoid the intensification of accident and make each kind of different intelligent devices to realize the network communication topologies. The involvement of ICT in the integration of microgrids as illustrated in Figure (5) has created major shifts in the paradigms and challenges in the design of smart grid systems.

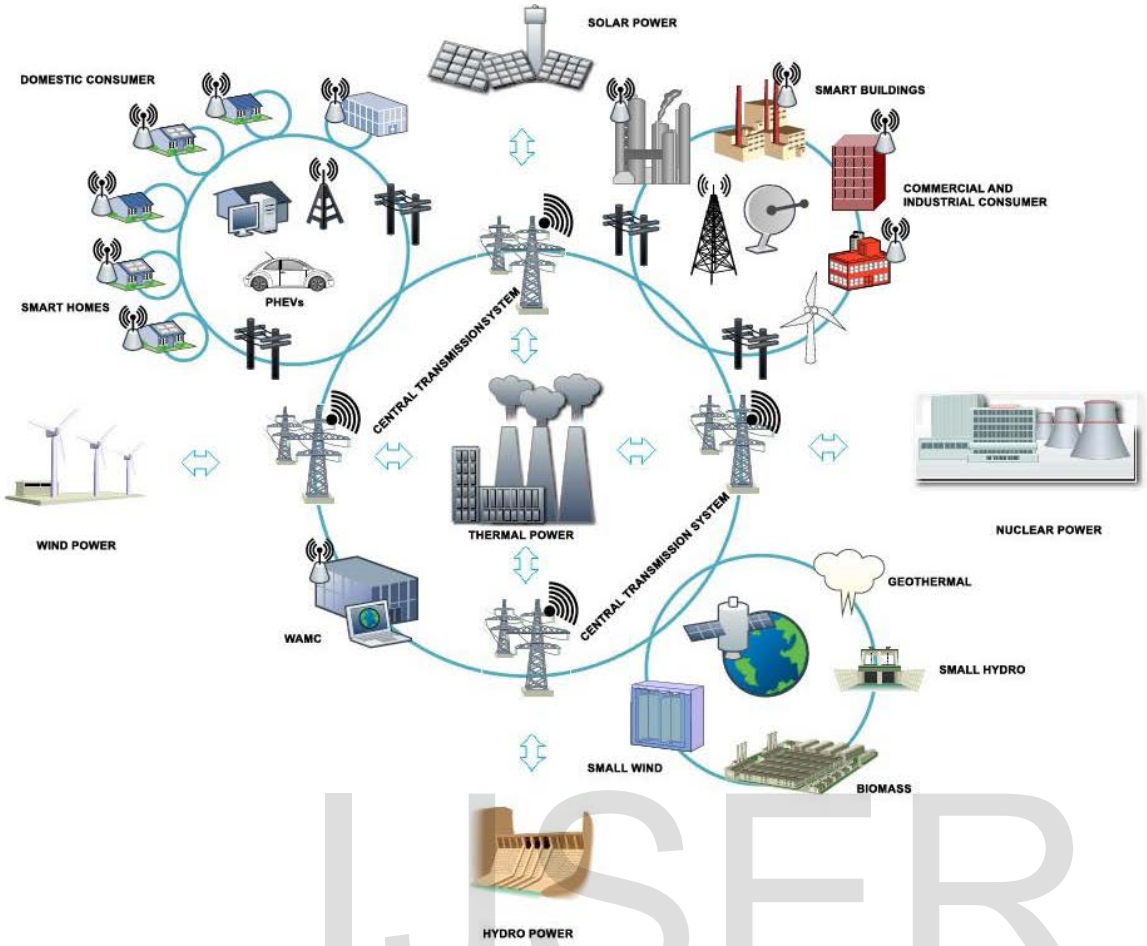

Figure 5. Smart Microgrid Architecture- The Emerging Technology For Power Systems In The Future

3. NEED FOR PUBLIC PRIVATE PARTNERSHIP AND PREPARING NEXT GENERATION ENGINEERS FOR DEVELOPING RENEWABLE ENERGY BASED ENTERPRISES:

The Smart grid systems representing cutting edge technology for electric utilities have given new dimensions to the buzzwords like energy conservation, emission reduction, green energy, sustainable development, safety factor, reduction of T&D losses, optimal utilization of resources etc. etc; The Nation struggles relentlessly to meet electricity demands of the country, both in terms of Energy and Peak Load and usher in an era of energy security and electricity in plenty for all. However, this is too gigantic a task which the Government alone can scarcely perform. Electricity in plenty for all calls for massive efforts for energy conservation and conversion, self-discipline in electricity consumption, people's involvement in establishing power system utility enterprises through public private investment and partnership and the entrepreneurial spirit amongst country's youth for the creation and successful operation of microgrid enterprises. India must prepare its upcoming generation of engineers,

technocrats and businessmen to join hands to develop and operate energy enterprises to save energy starvation and bring prosperity for the masses.

4. GOVERNMENT INITIATIVES FOR RENEWABLE ENERGY BASED ELECTRICITY IN RURAL INDIA:

Energy is on the priority list of the Government of India. Energy is needed for economic growth, for improving the quality of life and for increasing opportunities for development. Some 600 million Indians do not have access to electricity and about 700 million Indians use biomass as their primary energy resource for cooking. Ensuring life line supply of clean energy to all is essential for nurturing inclusive growth, meeting the millennium development goals and raising India's human development index that compares poorly with other developing countries that are currently below India's level of development. Concern to improve this alarming situation has impelled the Government of India to establish the following four full-fledged Ministries, namely, the Ministry of Power, Ministry of Coal, Ministry of Petroleum and Natural Gas and the Ministry of Renewable and Energy Sources. The broad objective of these schemes is to strive for

effective management of electricity generation and the Power Grid and save the country from crippling energy shortages that come in the way of inclusive growth and impede inclusive development of the country. Support Agencies have been created for accelerated development of energy generation, transmission and distribution for rural areas under the

following schemes:

4.1 Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY): The scheme governed by was created to achieve 100% electrification of all villages and habitation in India to provide electricity access to all households; and to provide free-of-cost electricity connection to BPL households.

4.2. Pradhan Mantri Garmodaya Yojana (PMGY): Initially launched in 2000-2001,the Scheme provided additional financial assistance for minimum services by the central government to all states on a 90% loan and 10% grant basis. These included basic services like rural health, education, drinking water and rural electrification. The scheme was later discontinued in 2005.

4.3. Kutir Jyoti Program (KJP):
The Program (KJP) was initiated in 1988-89 to provide single point light connection (60 w) to all Below Poverty Line (BPL) households in the country. It provides 100% grant for one time cost of internal wiring and service connection charges and builds in a proviso for 100% metering for release of grants. The scheme was merged into the 'Accelerated Electrification of One Lakh Villages and One Crore Households' in May 2004 and now into the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY).

4.4. Minimum Needs Program (MNP): The MNP, exclusively targeted states with less than 65% rural electrification (by the old definition) provides 100% loans for last mile connectivity. The program was started in 2001 and was discontinued in 2004-05 on account of certain practical difficulties in implementation.

4.5. Accelerated Rural Electrification Program (AREP): The Program is operational since 2002, provides an interest subsidy of 4% to states for RE programs. The AREP covers electrification of un-electrified villages and household electrification and had an approved outlay of Rs. 560 crore under the 10th Plan. The interest subsidy is available to state governments and electricity utilities on loans availed from approved financial institutions like the REC (Rural Electrification Corporation), PFC (Power Finance Corporation) and from NABARD under the Rural Infrastructure Development Fund (RIDF)

4.6. Rural Electricity Supply Technology Mission (REST): Initiated in September 2002, The Mission's objective was the electrification of all villages and households progressively by year 2012 through local

renewable energy sources and decentralized technologies, along with the conventional grid connection. The Mission has an integrated approach for rural electrification with the objectives to identify and adopt technological solutions and to promote, fund, finance and facilitate alternative approaches in rural electrification and coordinate with various ministries, apex institutions and research organizations for the accomplishment of the declared national objectives.

5. SCOPE, OPPORTUNITIES AND CHALLENGES FOR SMART GRID DEVELOPMENT IN THE INDIAN CONTEXT:

India is endowed with rich natural resources apart from the unique advantage of having a large pool of qualified young technocrats, including experts in Information technology. This gives India the distinct edge to create and develop smart microgrid systems for upgrading its energy status. The Government of India through the Ministry of Power (MoP) acts as umbrella to coordinate activities of different smart grid entities like SGTF (Smart Grid Task Force) and SGF (Smart Grid Forum) launched by it under its aegis with the broad objective to improve generation, transmission, distribution and power quality by the utilities for electricity consumers. Consistent efforts in this direction prepare India to create and develop electricity infrastructures to make India self sufficient in energy. Smart grid innovations and smart grid markets in the country are picking up and hopefully these activities shall cope up with the increase in the energy demand. The Nation has ample scope and opportunities to develop its smart grid infrastructure and it stands third worldwide behind only to the United States and China.

The current active smart micro grid services in India include R-APDRP (Restructured-Accelerated Power Development and Reform Program) to support the modernization of subtransmission and distribution networks including a system of local management and energy metering using IT services and DRUM (Distribution Reform, Upgrades and Management) to establish the framework, institutional capacity and project development. The National Mission for Enhanced Energy Efficiency under the aegis of BEE (Bureau of Energy Efficiency), standardization programs by the BIS (Bureau of Indian Standards) for smart grids, the Central Power Research Institute (CPRI) and Bangalore Electricity Supply Company (BESCOM) pilot project in Electronic City, Mangalore Electricity Supply Company (MESCOM) smart grid project for giving critical sectors un-interrupted supply are only to count a few of the many examples of the on-going smart grid endeavours in India. The engineering fraternity is urged to give a closer look to these endeavours for self-appraisal and make realization of the energy programs more successful through their efforts to make India a prosperous nation.

6. ADVANTAGES AND THE SHIFT IN THE PARADIGMS DUE TO THE ADAPTATION OF SMART GRID TECHNOLOGY- THE NEW CHALLENGES AND OPPORTUNITIES

India is located in the equatorial sun belt of the earth, thereby receiving abundant radiant energy from the sun. The data from India Meteorological Department (IMD) indicates clear sunny weather for 250 to 300 days every year with radiation varying from 1600 to 2200 KWh/sq. m which is comparable with the best solar radiation in the tropical and subtropical regions. Energy from the Sun alone can more than suffice the energy needs of this country and that is reason enough for us to go in for renewable energy resources.

The adaptation of smart grids undoubtedly provide many advantages as depicted in Figure 6 below which inter-alia include new features like high quality power, self-healing, high penetration of intermittent generation sources, multiple generation options, two way metering, consumer participation,

resistance to attacks, and optimization of assets . However, these advantages are not without a price. There is widening of design paradigms which inter alia include exchange of information and protection Of the plant and machinery in the generation, transmission And distribution sections of the smart grid network as reflected below in figure 7.

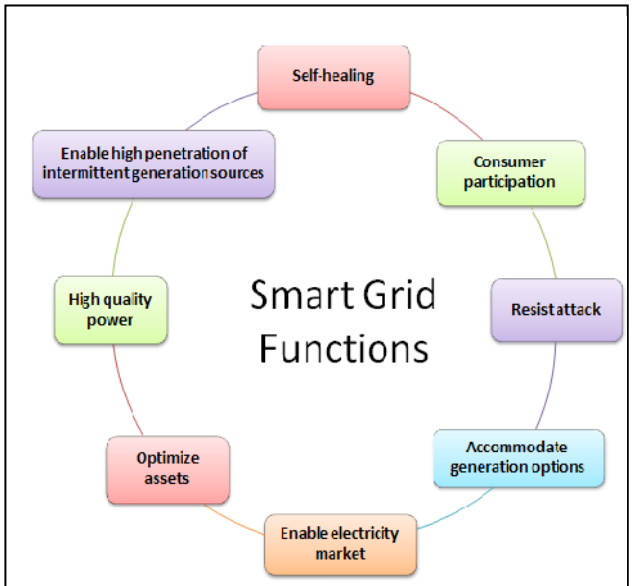

Fig 6. Advantages Of Smart Grids Due To The Additional Functions

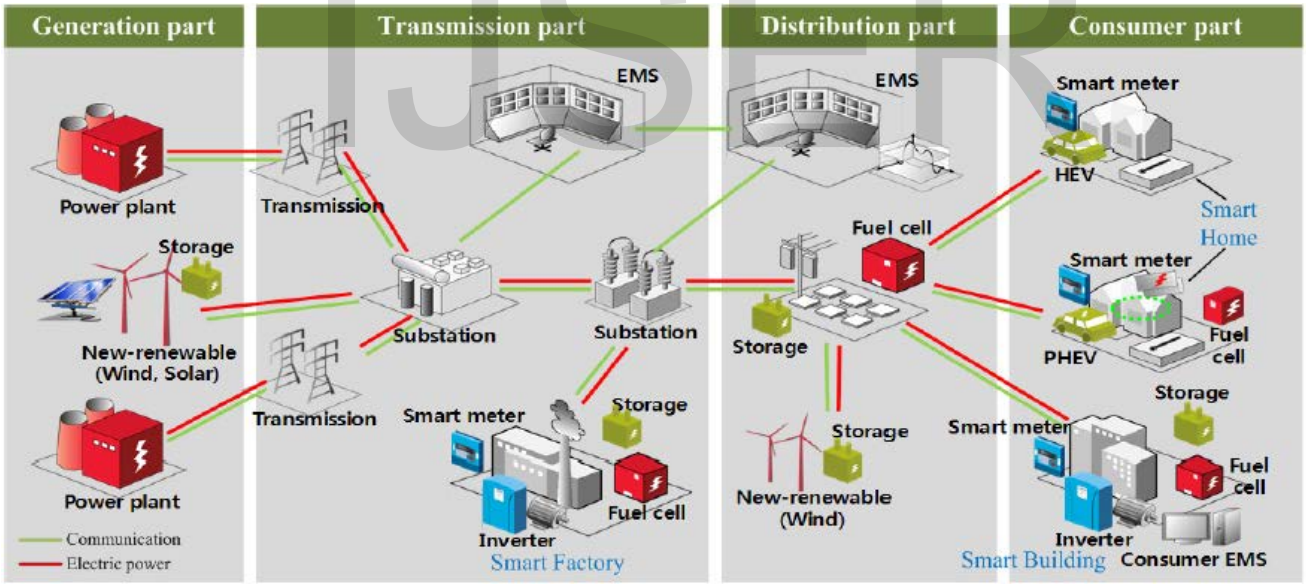

Fig 7. New Paradigms in the Design of Smart grids Such As Exchange Of Information And Protection Of Generation, Transmission And Distribution Sub-Systems

7. CONCLUSION

Smart grid is the emerging technology of the next generation power grid providing new indispensable features including bi-directional flow of electricity, advanced two way metering infrastructure, status information of each section of the grid, self-correction, control with improvements in the power system reliability, security, and efficiency of the electrical system from generation to transmission and to distribution. Adaptation of smart grids would entail versatile design based on interdisciplinary skills and conceptualization of the problems related to practical power systems and a clear understanding of the economically viable solutions. Adaptation of smart grid technologies would require India to develop trained manpower in these technologies and accelerate its pace of unfettered development in order that prosperity can be achieved and sufferings of the common man reeling under the weight of power outages, frequent breakdowns and reliability problems can be ameliorated.

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