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A Report on Relevance of Microgrid for Developing Countries with Specific Reference to India

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ABSTRACT: This paper presents a review on Microgrid structure, its benefits, challenges and application areas from the prospective of developing countries along with a step by step guide needed to plan and build a Microgrid project. Also a brief report has been prepared describing India's journey towards smart Microgrid and the initiatives taken by govt. in this regard. The usefulness of this paper is that it provides a holistic overall view on concepts and implementation issues related to Microgrid in a simple manner which will be helpful for people to understand the topic as well as realise its market potential.

KEYWORDS: Microgrids, Renewable Energy, Photovoltaics.

I.INTRODUCTION

As global warming and other environmental concerns take centre stage worldwide, the focus of government and other key stakeholders are towards looking from alternative sustainable and eco-friendly energy resources. According to a report prepared by IEA [1], the growing demand of energy all over the world will lead to doubling of polluting emissions by 2050 and its effect on human health and ecology will reach critical levels. Our present day trend of generating bulk power in a centralized way from Thermal/Nuclear/ Big Hydropower Projects needs to be changed because each of them have major environmental concerns and instead we should focus to shift the attention towards setting up of more distributed energy resources and stepping up the efforts to integrate Microgrid/ Smartgrid concepts with renewable energy technology for a sustainable future.

Unlike Developed countries in America and Europe who have access to quality and reliable power at almost all times, most of the developing Asian and African countries face power outage frequently and even when they are available, the power quality is very poor mostly in rural areas. These countries have anoutdated power infrastructures due to under-investment in modernizing their grid network and along with poor management, they have led to the reputation of a notorious grid which is unreliable, offers poor quality power, inadequate grid coverage and huge losses in almost every aspect of power transmission and distribution. All this calls for our transformation towards smart microgrids which will provide more reliable & efficient power. Even though they may require huge investments initially but the indirect cost of not having them will deprive people of the developing countries, a chance to lead a better life becausePower is one of the key infrastructures which decides the economic future of any country because the success of business and industry are depended on it.

II.REVIEW ON MICROGRID STRUCTURE

Microgrids are tiny building blocks in the concept of smart supergrids,which in coming decades has the potential revolutionize the power sector by bringing an era of energy revolution just like internet. In absence of a particular standard definition, a lot of literature with varied definition of microgridsare available which keeps evolving but the most cited definitions on this concept of Microgrid are from [2],[3]. Making a similar effort here in this paper, the author defines Microgrid as a self-sustainable energy model which must be able to generate, distribute and control bi-directional flow of power within its comparatively smaller boundary of operation in a coordinated way with focus on

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integration of renewable energy sources for power generation like Solar, Wind, Geothermal, Biomass, Tidal power etc. But theimportant point to note here is that we donot have control over climatic conditions of our surroundings hence most of the above mentioned renewable resources will need to have energy storage systems like fuel cell, flywheel, supercapacitor, super conducting magnetic storage systems and battery bank. Details on these topics can be studied in [4]. For managing the complex operation of a microgrid, we need to have a microsource controller which would control the parameters of the individual microsources while one more Central controller would control the overall system parameters. Issues related to microgrid control are covered in [5],[6]. Also a Microgrid would need to protect itself from probable disturbances in main utility grid during grid connectedmode and be stable enough to handle the internal disturbances beyond tolerance level. Accordingly, protection is needed for a Microgrid in grid connected mode as well as islanded mode and in both of these cases, the protection is different and complex. Literature review concerning the protection issues ofmicrogrid can be seen in [7]. Point of common coupling or PCC serves as a junction betweenmicrogrid and the main grid. The speciality of microgridis that it can function in either of two modes: "Grid connected mode" in which a microgrid may import or export power with utility grid as per self requirementOr in the "Islanded mode" i.e on a standalone basis when it senses any disturbance in the utility grid by isolating itself by switching on to islanded mode of operation by which it continues to feed power to its critical loads. Detailed review and analysis on issues related to control, protection and stability of microgrid operation has been covered by [8].

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III. MICROGRID BENEFITS

Literature pertaining to microgrid benefits can be found in [9].

A. For Utility Grids

i) It will help in reducing feeder congestion and in managing peak load demand on network with options like direct load control and pricing incentives for consumers. *ii)* It will Reduce T&D losses by nearly 3% [10] because in conventional present day system,generation of power is centralized and huge amount of power is lost in transmission and distribution But incase of microgrid where power generation is much closer to loads mostly within local community boundary, these T&D losses will get eliminated to a large extent. *iii)*) If we reutilizing the waste heat in Combined Heat and Power concept then we can increase efficiency to 60-70% as compared to approx.. 25- 40% efficiency in traditional power system [11]. *iv)* Grid Faults which often result in cascading effect leading to massive blackouts can have extremely negative impact oneconomy & essential services. Microgrid can in such situation by operating switching on to the autonomousislanded mode thereby ensuring power to critical loads.*v)* Decentralized supply system will lead to better match of demand and supply [12].

B. For consumers [13]:

i) With most areas in developing countries facing power cuts throughout the year especially during summer season, then renewable energy based microgridwill provides a better backup option with reliable and better quality power with less voltage fluctuation and hence it will improve the lifecycle of most domestic appliances. *(i)*Consumer will have control over energy consumption and he becomes "Prosumer"i.e producer + consumer because he now has the decision making power on whether to import/export power to the grid enabling bi-directional power transfer depending on consumer needs and self-generation*(iii)*Remote area consumers without access to electricity can benefit from standalone microgrids*(v)*Microgrids will also lead to Integration of newclean technologies like hybrid electric vehicles.

C. ForGovernment:

*i)*Moving away from present day polluting generation sources to renewable sources will help govt. ease environmental concerns of local people. *ii)*Since microgrids will be established at community level so it will leads to job creation in the locality &higher economic growth in surrounding regions of project implementation.

IV. CHALLENGES FOR ESTABLISHING MICROGRIDS IN DEVELOPING COUNTRIES

i) Installation of renewable energy sources and the energy storage systems associated with it are very costly and Most of the developing countries including India are very cost sensitive markets But with time as technology advances , there has been a exponential decrease in their prices and moreover with most Govt. providing subsidies for promoting renewable energy, the cost factor has become viable and most of such projects have a pay back period of around 15 years.

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ii) Since Microgrid and renewable energy technologies are comparatively new areas, so there is shortage of skilled hands required for installation, operation, management and maintenance of those projects. With little technical knowledge to operate and maintainthem , it will be difficult for local community members and villages which are the main target markets to adopt them. To solve this problem, the technical engineering & diploma providing institutes nearby the project areas should be trained and promoted to start courses rapidly on such specific skills.

iii) Protection and operational issue are quite challenging ones as compared to conventional power system.

v) Most of the developing countries including Indian government has not yet set dedicated specific standards and regulations for installation of Microgrid projects which is highly needed to ensure uniformity in operation between different private players. Having a standard protocol, will lead to better integrity and synchronization of small microgrids with the bigger utility grid network. Though, IEEE 1547.4 provides a path of standardization but thisneeds modificationskeeping in mind, the local country's individual policies, needs and constraints.

V. STEP BY STEP GUIDE TO ESTABLISH A MICROGRID PROJECT

Step 1) Potential of renewable energy is assessed for local geography so as to decide which renewable resource will be feasible enough to deploy keeping in mind, the interests of local livelihood issues as well. For Example Coastal areas having high and steady wind flow rate can opt for Wind based microgrids, desert regions like Rajasthan can opt for solar and village communities in agricultural dominated states can opt for biomass based Microgrid in addition to either solar or wind or tidal sources.

Step 2) Load demand profileof the local community to be served needs to mapped suitably also keeping in mind the pattern of load variance over a 24 hour period and in different months. Knowledge of varied demand requirements as per different day/season/ month is necessary for prior planning which will help us the ratings of equipment's and size of generation sources.

Step 3) A particular site may be suitable for more than one resources like wind plus solar as well as biomass but which one amongst them will be economical and optimal needs to decided to plan an optimal energy basket: This needs to be done so that the community will be able to meet its present day load demand as well has enough flexibility to incorporate higher future scalability.

Step 4)Before going for an actual installation we need to Design a suitable Model of our system and simulate it to have a rough knowledge of its anticipated behaviour. Optimisation tests needs to be performed on the model.

Step 5) Once a suitable model is designed, then we need to develop a suitable controller which can effectively manage both islanded mode as well as grid connected mode of operation and can coordinate the various issues like bi-directional power exchange with grid and scheduling of generating sources based on local load.

Step 6) Designing a versatile protection mechanism is necessary for Any model because before execution we needto be safeguarded all possible worst case scenarios that might threaten the structures stable operation.

Step 7) Collect information about Govt. rules and regulations related to all issues associated with the project. Adequate knowledge is needed for compliance with local laws and get benefits of subsidies.

Step 8) When the design and planning aspect of the project will pass then the last important step is to perform a financial analysis of the proposed structure & find its pay back period taking into account the subsidy being offered by different local and central govt. for promoting renewable energy.

VI. SCENARIO OF SMART MICROGRID MARKET IN INDIA

In absence of any official survey, no accurate statisticsare available about the no. of households or commercial units in India which are powered by Microgrid protoypes, but a conservative estimate puts that figure around 125,000 [14]. But

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such entities are powered mainly by solar panels and most of them are concentrated to the rural villages of Uttar Pradesh, Westbengal and Bihar having no prior access to electricity and even in these places, its mainly the private small time entrepreneurs who are leading such changes in small scale examples include "Nature tech Infrastructure, Kuvam, MeraGao Power, Husk Power Systems etc and time has proved that they are operating on successfully and the projects are economically viable. More Details about their operation are available in their respective websites. Though small private entities are pre-dominant in this sector but appreciable efforts on a bigger scale have been initiated from very few state government departments like in Bengal and Chhattisgarh, where the state govt.has sponsored big projects like "Sagar Island microgrid" in Bengal. Similarly a detailed Case study onmicrogridsin Bihar has been done in [15].

With each passing day, more and more investors are showing confidence and pumping their money in this sector which has resulted in a tremendous growth rate of this sector and it has bright prospect on contributing towards GDP of the country. A breakup on parameters of a smart microgrid's estimated market has been compiled in the below figure. 1 and its expected to reach $1.9 billion by end of 2015 as per [16]

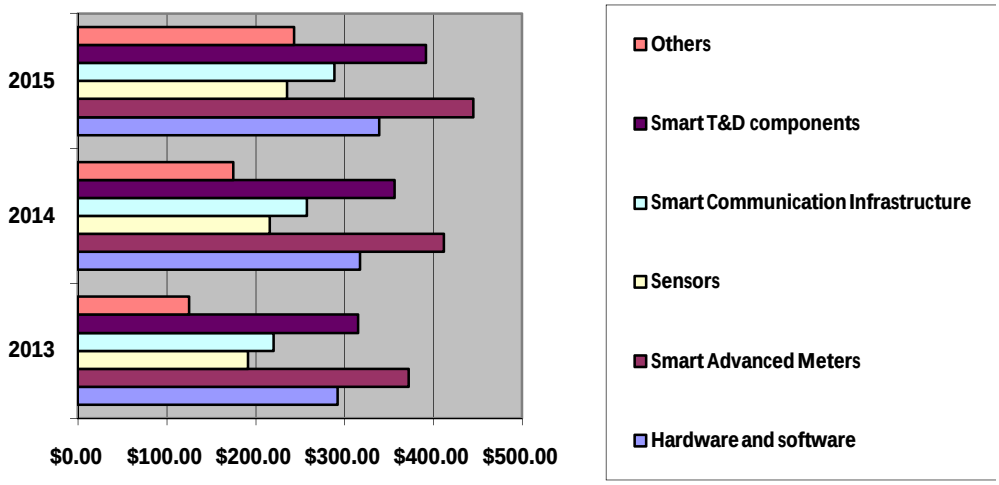

Fig.1 Distribution of smart microgrid market in India [16]

VII. INITIATIVES TOWARDS A SMART MICROGRID MOVEMENT IN INDIA

India is now recognised as a world leader in electronics, software and technology based services and if we are able to leverage this strength then it can help us in promotingsmart microgrids in the country because futuristic power sector initiatives like smartmicrogrids will heavily rely on technology as its partner. There is not much difference between smartgrid and microgrids. Basically combination of many small Microgrid units and making them integrated with technology and sensors for better management will lead to smart grid. We also need to incorporate a few additional features like automated smart control and coordination systems, installation of smart protection systems [17], addition of sensor based smart communication system [18] besides introducing Smarter transmission using synchrophasor technology and Smart distribution systems like advanced metering infrastructure, outage management units, peak load and power quality management, hybrid electric vehicles etc. Details of all these smart grid components has been communicated in [19],[20].

In the last few years, Govt. of India has shown urgency in dealing with power sector and has taken lots of initiatives in this direction of promoting renewable energy and smart microgrids—

a) Institutionalbackbone :Govt along with other stakeholders have set up India smart grid forum-ISGF and Indian smart grid task force-ISGTF consistingof representatives from manyconstituent organizations like Ministry of Power, Department of Science and Technology, Central Power Research Institute , Central Electricity Authority. ISGTF has a further division of many different working groups like WG1 which is for advanced transmission, WG2 which is for

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distribution,WG3 for communications, WG4 for metering, WG5 for consumption and load control, WG6 for policy and regulation, WG7 for architecture and design, WG8 for pilots and business models, WG9 for renewable and microgrids, WG10 for cyber security.

b) Alignment of present govt. policies with smart grid vision by programs like R-APDRP [21], GIS mapping, DeenDayalUpadhaya Gram JyotiYojana, consumer indexing, Smart metering and billing system which are already in progress can be modified and synchronised with state specific requirements.

c) A National Board For Smart Grids has already been established and it has been housed under central power ministry for holding consultation with all involved stakeholders and its scheduled to have statutory powers for managing the entire process of developing and setting up of the necessary regulatory framework.

The vision of Ministry of Power for Indian power sector, is to "Transform the Indian power sector into a secure a, adaptive, sustainable & digitally enabled ecosystem that provides reliable and quality energy for all with active participation from all stakeholders". The document [22] spells out all the mission plans, policies and perspectives of India's smart grid mission along with plans & activities envisioned. A List of microgrid projects currently underway in India along with the technology used and their consumer basesize can be collected from [23].

VIII. CONCLUSION

From the above analysis in previous section its clear how important the role of renewable energy and microgrids are for developing countries and if they are to lift themselves up from clutches of poverty and pollution than they need to invest in this. We recommend that If the govt. makes its mandatory for technical institutes and govt. offices to draw a part or all of their power requirements from self sustaining Microgrid models based on renewable sources, then it would be a great encouraging step.The need of the hour is that all Universities in collaborations withenergy companies shouldjointly come forward to fast track research related to clean energy technologies and integrate the concept of Microgrid and then only a day will come when developing countries too would have universal access to power for their population in a sustainable and environment friendly way.

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