Constraints and Challenges in Deployment of Micro- Grids – A Review

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I INTRODUCTION

According to the 2011 census, an estimate of only around 56% of the rural households has excess to electricity [1]. One of India's major advantages today and going forward is that its RE potential is extensively vast and at the same time it is yet to be tapped. Recent estimates indicate that India's solar potential is greater than 10,000 GW and its wind potential is higher than 2,000 GW [2]. To fully take advantage of India's RE potential over the next few years, however, will require new initiatives from central and state governments — beyond policy and programs currently in place — to support the engagement, participation, and new behaviour of power sector stakeholders including RE industry and developers, grid operators, public and private finance, consumers, and others. In the current debate on the reform of electricity markets, in addition to "stand-alone" generators of renewable energy, the evolution of smart grids, with particular focus on micro grids, gains increasing relevancy. Smart grids enable local platforms (micro-grids) integrating locally and real-time based generation and consumption of renewable energy. The roles of consumers and producers of electricity are no longer clearly distinguished, merging into "prosumers [3]." Nevertheless, micro-grids cannot be considered as isolated commons, but still need to be interconnected with the traditional electricity networks. The potentials of smart grids are not only limited to local micro-grids, but challenge the whole infrastructure of traditional power sector. There has to be no doubt that the evolutionary path toward distributed energy and smart grids is irreversible. In order to survive, future electricity utilities should be enabled to exploit the new business opportunities not stopped by regulatory policies. With the increased adoption of electric vehicles and advanced demand-side technologies such as smart thermostats, load control switches, and home energy management systems, this capability is emerging as a major factor that can enhance the economics of residential micro-grids. Aggregated electric vehicles deployment offers large capacity energy storage in the power system. Plug-in electric vehicles further offer great potential as facilitator of demand response, especially for load shifting, via charging at off-peak hours and discharging at peak hours. The second place is Asia regions; following North America with the Revenue market share over 27.83% in 2016. Europe is another important consumption market of Micro-grid Technology. Micro-grid Technology used in industry including Campus/Institutional Micro-grid, Community/Utility Micro-grid, Commercial/Industrial Micro-grid, Military Micro-grid and Remote Micro-grid. Report data showed that 41.79% of the Micro-grid Technology market demand in Campus/Institutional Micro-grid, 24.24% in Commercial/Industrial Micro-grid, and 21.28% in Community/Utility Micro-grid in 2016. [4].

Micro-grids are now knocking the door of commercial markets, and are simultaneously undergoing. Improvements in techniques, as result of reduction in costs, growing needs and requirements owing to the benefits which might be derived by deployment. The micro-grid with its fast advancement taking place are being preferred as it gives improved reliability and resilience of main electrical grids, by integration of distributed clean energy resources like wind and solar(PV) generation to reduce conventional fuel emissions, and to provide electricity in last mile habitat areas presently not being served by centralized electrical networks. This article elaborates

(a) Micro grid and its advancements
(b) Today's micro-grid challenges and future prospects.
(c) Impact on revenue and expected change in working of Electrical utilities due to future deployment of advanced micro-grids.

It is observed that as of now the world's electricity networks are Likely to undergo a transitional changes, which are Lowering the electricity costs, replacement of decaying infra-structure, improving the resilience and reliability, reduction in carbon emissions to mitigate climate change, and provide reliable power to areas lacking in strong electrical network. However the other factors responsible for fast deployment of micro-grids and the particular solution may differ from place to place. Micro-grids are the answer to complexity of transmission and pit head generations located at very far distances, for enabling the deployment of distributed energy resources which can meet the wide ranging needs of various communities from metropolitan Cities to rural and remote parts of developing countries like India.

In industrialized countries, micro-grids have to face the realities of existing features of gig watt capacity generating units, very long high voltage transmission lines, minimal energy storage, and carbon emitting fossil fuels as a primary energy source, and the deployment of Micro-grids even becomes a bigger challenge in-spite of the more potential and high demand of RE integration and distributed generation there.

II RENEWABLE ENERGY/DISTRIBUTED GENERATION SCENARIO

Stakeholders involved in the road map process were very clear in identifying the key problems constraining the fast development of RE in India. Main among these roadblocks is the absence of a comprehensive and coherent national framework for RE both in the form of regulations or policy. The absence of a long-term vision as well as policy-certainty is holding back much-needed investment in infrastructure and RE integration.

Most importantly, it provides a possibility for electrification of last mile villages which are far from reach of the conventional grid. There is need of re look on need of application of DC micro-grids for rural and urban scenarios in India.

Application in rural areas as community-micro-grid is gaining momentum in India also. For urban scenario, application of the DC-micro-grid concept to attain the goal of a Zero Energy Building (ZEB) is scope of study for researchers in context of smart cities being developed in the country by Govt. of India. The deployment of micro-grids is equally important and will better results to give relief to decaying infrastructure of transmission/distribution and pit head polluting Generation for both rural and urban India [5].

The micro-grid normally consists of radial feeders which are connected to various loads, sources and storage devices. Sources can be in the form of solar PV panels, wind turbines, diesel generators and Combined Heat and Power Plant (CHP) [6]. The loads of the system can be either electrical or thermal. A micro-grid system can also have several types of storage options such as battery, flywheel, fuel cell, super capacitor storage, etc. The radial distribution network is connected to the utility grid through a separation device known as the Point of Common Coupling which is usually implemented as a static switch. The distributed energy sources and loads in the micro-grid network are controlled by the action of the Local Controllers (LC) which is mostly power electronic converters. The Micro-grid as a whole is controlled by the Micro-grid Central Controller (MGCC) which gives command signals to each of the LCs. The highlights of control methods for micro-grid invert and the importance of dynamic security has been discussed. Also, the challenges in the micro-grid for future trends have been discussed [7].

A micro-grid can be defined as a collection of distributed sources, loads and energy storage devices which act a single controllable unit and can operate either in grid connected or Is-landing mode. A more precise definition given by the Department of Energy - US describes it as "A group of interconnected loads and distributed energy resources with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid (and can) connect and disconnect from the grid to enable it to operate in both grid connected and is-landing mode". A micro-grid is "a local energy grid with control capability, which means it can disconnect from the traditional grid and operate autonomously. A micro-grid can be powered by distributed generators, batteries, and/or renewable resources like solar panels. Depending on how it's fuelled and how its requirements are managed, a micro-grid might run indefinitely."

The micro-grid can back-up the grid or operate independently. This makes them very attractive to local communities wishing to actively participate and also take control of their power generation, as well as rural communities looking for economical besides being most robust and independent power supply.

In the continued global shift toward renewable energy generation to counter the effects of climate change, micro-grids enable communities to improve local energy delivery by providing the best of green technologies.

III MICRO GRID CONCEPT AND PRESENT STATUS

A micro-grid has several advantages as compared to a traditional grid. DER penetration on smart micro-grid based energy conservation and optimization solutions could help smart micro-grid planners and operators to adopt effective technologies according to their impacts on micro-grid feeders. Moreover, studying the impact of DER penetration could result in more accurate energy conservation and optimization solutions as, typically, conventional approaches do not take DER impact on energy conservation into account [8]. It opens a gateway for smaller, more efficient distributed generations to be embedded into the distribution network. As the generation is carried nearer to the load centres the losses in bulk power transmission are asthmatically reduced to a huge extent. The concept has drawn much attention worldwide because of the growing concerns in the environmental adverse impacts of sources of generation of conventional power.

A provision for mixed power quality and reliability is presented in a Micro-grid. The concept of micro-grid can also help in load levelling of a certain region. A wide range of energy sources are being integrated, from photo voltaic and wind-power plants to hydro-power and biomass-power plants. Electric vehicle (EV) batteries also are going to be part of the energy supply future. Intelligent control systems coordinate the energy sources, many in conjunction with bio-diesel generators, emergency power units and storage modules, to guarantee the supply of power [9].

(a) Types of Micro grid

Micro-grids can be broadly categorized in three types based on operational frequencies which are as under:

(i) **AC Micro-grid** - An AC micro-grid system may consist of a medium or a low voltage AC distribution network. Distributed sources, storage devices and loads are connected to this AC network with or without a converter depending on the frequency ratings. Native AC generations such as diesel generators, micro turbines and wind turbines can be directly connected to the AC network without any converters. For native DC sources like PV systems, DC/AC converters are normally used. Similarly, AC loads are connected directly while for the case of DC loads, AC/DC rectifiers are required. Even though a great deal of research work is carried out in AC micro-grids, it does have some disadvantages. A few of the major problems in such network include the complexity in control and synchronization issues.

(ii) **DC Micro-grid** - A DC system also brings about other significant advantages solving some of the control issues inside a micro-grid. For instance, synchronization of the distributed generations is no longer required and the controls are directly based on DC bus voltage. Moreover the primary control is much simpler due to the absence of reactive power flow control. And finally, most of the modern appliances also run in DC power, which provides an added benefit.

(iii) **A DC/AC Hybrid Micro-grid** - As the name suggest hybrid micro-grids consist of AC and DC network connected together by multi- bidirectional converters. A hybrid system can reduce the number of AC-DC-AC and DC-AC-DC conversions in individual AC or DC micro-grids. Here, AC sources and loads are connected to the AC network whereas DC sources and loads are tied to the DC network.

(b) Application of Micro grid

(i) **Rural Applications: Community DC Micro-grid** - As per the census of 2011, 46.5% of the rural households and 32.8 % of the total population in India does not have access to electricity. This amounts to around 800,000 villages in rural India [1]. A majority of the rural households rely on non-conventional inexpensive fuel sources for lighting and cooking. And around half of this population use kerosene for lighting purposes. These fuel sources not only causes environmental pollution, they are also known to have serious health implication on prolong use. With a major chunk of Indian population (around 70%) residing in rural areas where electricity supplies is still a big problem, there can be a serious.

(ii) **Urban Applications: Zero Energy Buildings** - Even though most of the urban households in India have access to electricity, it still faces a number of problems. This includes problems of power quality, security of supply and reliability. With an ever increasing demand in peak seasons, power cuts are becoming more and more prominent even in metropolitan cities. And with more concerns of environmental pollution over conventional generations, supplying electricity to an ever increasing urban population becomes a much more challenging task. This is where the concept of Zero Energy Building (ZEB) comes in. Environment and Forest, India [10]

(iii) **Global Micro-grid Market segments by Application**

- Commercial/Industrial Micro-grid
- Community/Utility Micro-grid
- Campus/Institutional Micro-grid
- Military Micro-grid
- Remote Micro-grid

IV CHALLENGES AND CONSTRAINTS OF MICRO-GRID DEVELOPMENT

Challenges and constraints of Micro grid development are closely related to following factors

(a) Future Business Models and Economics
(b) Advanced Micro-grid Technologies
(c) Public Policy: Drivers and Implications
(d) Value for Local and Engaged Communities

Research Priorities for Advancing Micro-grid Deployment As global energy systems shift towards decentralization, consumers are seeking close engagement with providers, and the cost of advanced energy technologies is declining regularly. As these trends become more visible micro-grids have potential to offer benefits to utilities, communities, and industrial customers equally. The micro-grid market is charging up, provoking the regulatory agencies and governments to revise the policies and rules that can enable the cost savings and system-wide benefits of intelligent decentralized systems, while not compromising the risks to utilities and consumers. Communities seek deployment of micro-grid systems due to a variety of factors – such as more reliability in the face of extreme weather events, environmental benefits of local renewable generation, economical way of local cost-management or revenue opportunities, increased autonomy, and few more. However, developing/developed countries the electricity system has been effectively centralized for decades and this has provided us with very reliable electricity, for relatively cheap. Seminar and workshop on the subject are tasked with examining frameworks for advancing technology, business value, and public policy for clean energy micro-grids. The event featured industry and utility leaders, multidisciplinary researchers, and community representatives coming together to discuss factors affecting deployment of smart micro-grids in any energy system and beyond, and specifically plan for future academic research. Building on the conversation taken place in the seminars at [Micro] grids today sought to build linkages between expert researchers, and the industry and utility leaders planning for deployment of micro-grids in global energy networks. The reports on the workshop discussions held worldwide and findings, and aims to develop a road map for research and deeper collaboration on smart micro-grids deployment. The attendees of such seminars explore the economic, public policy, and technical factors affecting deployment, and the implications for both communities and utility companies. Potential Benefits & Opportunities of Community Micro-grids Resiliency Mitigating the impact of power outages due to extreme weather event, including micro-grids at community support centres. Reliability Support for overall electrical grid reliability and maximum customer 'up time' can be offered through micro-grids, at a cost. Sustainable Energy Increased ability to connect and manage intermittent local renewable generation resources, such as solar or wind with energy storage. Economic Leveraging on site distributed generation may have potential to reduce customer costs and raise the overall system efficiency.

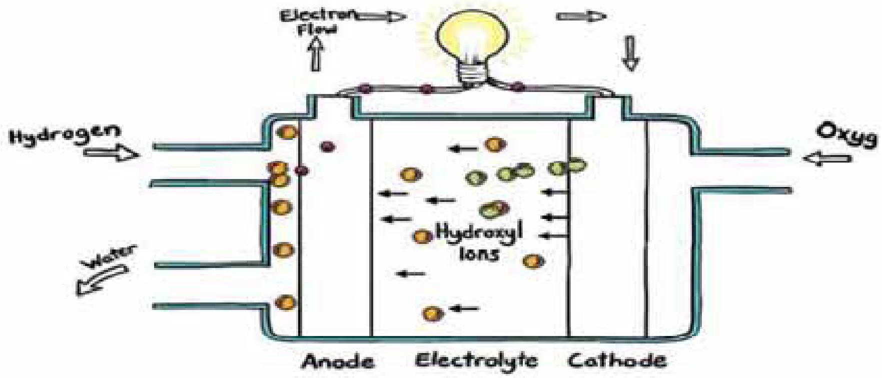

Fig No.1 Conventional Fuel cell

Regulating Renewable and Providing Energy Storage is the need of the hour .One of the inherent benefits of a fuel cell over back up power like DG set or storage batteries is its ability to go beyond just power generation by offering businesses and utilities the capability to also store energy and regulate power flow. This energy storage facility will further support the efficient working of micro-grids of the future. Larger micro-grids have several sources of power generation, normally including renewable solutions in their mix, but due to varying weather conditions, wind and solar cannot provide firm power. In steadying this power supply, fuel cells are ideal [11]. The first steps to develop smart cities are to modernize and optimize the power grid operation. Smart grid allows the integration of sustainable technologies including clean energy sources, reduced air pollution, and accessibility to city services. Energy storage installation among end-users (renewable energy generators, grid operators and distributed generation) is expected to witness larger growth due to smart grid development. The battery energy storage system (BESS) market that had an estimated capacity of 4.9 GW in 2018 and which is expected to reach 22.2 GW by 2023, according to Global Data [11]. The renewable generation integration problem can be investigated under two contexts of large-scale (which attempts to manage the generation of wind and solar farms) [12], and small-scale (which deals with renewable generation at the distribution level). Small-scale coordination approaches mainly focus on various methods of demand side management, such as demand response and energy storage and aggregated electric vehicles [5].

V CONCLUSION

The ability of electric grids worldwide to move from largely central generation to increasingly distributed generation is arguably the most complex systems integration problem of our time. As the standard of living and economic growth of a country is directly related to availability of quality power supply, much of work is needed to be done in order to meet India's growing demands in a much cleaner and environmentally friendly manner. The economics of operation would involve optimal schedule with the diversified generation technologies used for a particular Micro-grid. The key considerations for success of Micro-Grid are development and utilization of safe and dependable communication infrastructure and control strategies. The enabling technologies used in the Smart-Grid will play deciding role in the fast development and success of Micro-grids [13].The adoption of electric vehicles has been increasingly growing in the last few years and is set to continue. International Energy Agency (IEA) data show that the global electric vehicle fleet reached over 5.1 million in 2018 and is expected to grow to approximately 130 million by 2030 [9].The electricity sector is changing rapidly and the grid is changing with it. That will continue no matter what. The question is whether to reinforce and enhance the current grid architecture or to allow the majour change and build new one. [14].

And with an ample amount of renewable potential available in the country, the odds are on the favourable side. The article explores the possibility of incorporating these renewable generations in rural and urban India using the concept of micro-grids as distributed generation. And from the discussions it can be concluded that micro-grids have in fact may gain popularity with adopting technological advancement in the field and making major changes in regulatory policies for making the local utilities to support for enabling more and more integration of Renewable power and adoption of concept of distributed generation to achieve improved reliability and resilience of main electrical grids, and reduction in costs besides fulfilling the goals of reduction in carbon emissions. Basically, a grid-scale battery with a modern power inverter/converter is an instant micro-grid all by itself. Coupling micro-grids to meet demand-side flexibility is a problem that must be solved. This will require new technology, new regulations, and new business models, and the smart grid to perform new tasks it was designed to do but has never done before at scale. Micro-grids are inching their way into the mainstream, though most are being deployed by non-utility vendors for third parties. Growing interest in and regulatory support for community micro-grids—as well as micro-grids designed to bolster the overall distribution system—are opening the door for utilities to play a larger, as yet mostly undefined role in the deployment of micro-grids.

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