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SOLAR DC MICROGRID FOR RURAL ELECTRIFICATION-A CASE STUDY

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ABSTRACT: Currently around 1.5 billion people worldwide live without access to electricity, and without a concerted effort, this number is not likely to drop. Grid extension is often very costly and not feasible in isolated areas. In such situations, electricity mini-grids can power household use and local businesses. The expansion of rural electrification is occurring mainly under the RGGVY (Rajiv Gandhi Grameen Vidhyutikaran Yojona) scheme in India. As among all the renewable sources solar is the most explored one, DC micro grid has become one of the most popular and proposed option for rural electrification. Various policies and delivery models are being implemented on DC micro grid. But Is Dc Micro grid really a viable option for rural electrification? This paper focuses on the various socio-economic and even the technical aspect of DC micro Grid to check its viability and the study is aided by survey reports on the same on various rural villages of India. The paper also tried to integrate the schemes that is introduced for rural electrification with DC micro grid and try to analyze whether DC micro Grid is a sustainable option of rural electrification.

KEYWORDS: Micro Grid, viability, AC vs DC, sustainability

INTRODUCTION

Fossil fuel based power generation with unwanted emissions causing adverse effect with the environment and threatening to the future of the planet. Search for viable and deployable low carbon technologies to meet the growing power demands of global population has become imperative. Role of Scientists and Engineers is to make 'Conventional Energy Sustainable' and 'Renewable Energy Available'. Global warming and Climate change being global problems, must be tackled with global synergy. 'Think Global and Act Local' is the new slogan. Efforts are made by different countries individually and collectively to address this energy related climate change issue. According to International Energy Agency (IEA), about 1.3 billion people worldwide lack access to electricity services with nearly 2.7 billion without clean cooking facilities. 404 million people in India currently do not have access to electricity and the daily average per capita electricity use is about 2 kWh for connected population [1]. Therefore the major challenges in electricity sector are two- fold: a) expanding access to electricity for un-electrified populations where grid has not reached yet, and b) meeting increased demands from sections of grid electrified populations [2]. Increasing energy efficiency is also a major challenge for country's power sector which reports nearly 26 % losses in transmission and distribution.

The availability of electricity in rural India is still a distant dream. When will electricity on a 24x7 basis be available in every corner of the country—irrespective of the rural urban divide? In addition, India's energy crisis may be dealing with the fact that a major share of its rural population is energy poor. Lack of access to modern energy services represents a significant barrier to development.

Today, with easy access to mobile phones, computers and televisions, the need for electricity has become a necessity. Here renewable energy can make a substantial contribution.

It is no longer the 'alternate energy', but a vital part of the solution to the nation's energy needs. In fact, being modular in nature renewable energy systems seem to be the only option for ensuring regular energy supply in a decentralized manner. With the development of renewable energy, energy storage and distributed generation (DG) the micro grid has attracted more and more concern due to its special features. A micro grid consists of a low to medium voltage network of small load clusters with DG sources and storage. Micro grids can operate in an islanded mode or can be connected to the main grid system. Micro grids currently offer various advantages to end- consumers, utilities and society, such as: Improved energy efficiency, improve power quality and reliability, minimized overall energy consumption, reduced green- house gases and pollutant emissions, cost efficient electricity infrastructure replacement .

Recently as the general energy being scarcer, developing clean energy becomes the research focus [3][4]. The solar energy has clean and sustainable use characteristics, so it is prevalent that using photovoltaic electricity. An inspiring account of solar DC mini grid installations being popularized in the villages of Uttar Pradesh and many others to provide electricity during peak hours when electricity is unavailable. But the question here still arises that whether DC source is the best viable option for rural electrification taking into the fact that it has limited capacity.

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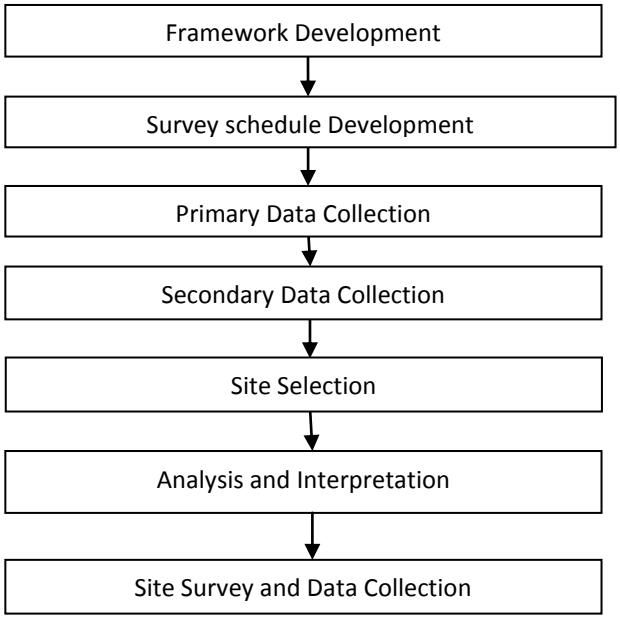
METHODOLOGY FRAMEWORK

The methodology framework has been built for the survey analysis to check the viability of the DC micro grids in practical preface with the rural electrification in villages of India. The methodology framework was based on bottom-up approach. The methodology followed here is case study based on the survey of the localities and the visit of the micro grids. These local, socio-technical survey are investigated by a trans-disciplinary team of researchers and practitioners along with us in order to gain a deep understanding of the diversity of social and technical factors influencing the ways in which the systems work at different levels. This socio-technical research highlights the dynamics between technology and society and how they are mutually influencing and shaping each other. These dynamics create gradual changes in the socio-technical system of technical devices, people, practices, knowledge and other elements, requiring adjustments also by the implementing actors. A range of technical and non-technical factors at various levels are found to be relevant for the implementation, operation, sustenance and further development of the solar micro grid systems. To carry out the study a framework has been developed. The framework consists of the technical, social, financial and institutional/ managerial aspects.



The selection of the states was done after collection on primary data on number of un-electrified villages in each states from MNRE. The state have been selected which has a very poor rate of electrification and three types agencies(out of Government agency, NGO and private agency) have implemented the Solar DC Micro grid and AC mini grid at least before one year. So according to the data analysis Uttar Pradesh and Bihar are the states chosen for the survey purpose. The survey data of this two states are used for the viability check.

ANALYSIS AND DISCUSSION

Electricity is considered to be the best vehicle to carry energy from source to the load. Challenge of today is not only to produce electricity without upsetting nature but to efficiently transmit and utilize the same. Despite massive rural electrification plans, India has nearly 54000 un-electrified villages [1], [5].

In most of the electrified villages not only the connected households are a fraction of the total but power is available on an average of 4 hours per day. This is not acceptable if 'electricity to all' is the motto with all ensured 24x7 power supply. The RGGVY scheme that is trying to implement the same says that the renewable micro-grids can be implemented in a total un-electrified village or villages having access to weak grid where the power supply is unreliable and less than 6 hrs. The total energy required under this scheme for a rural household is 1Kwh/day. This includes the basic lighting provided to the house together with the livelihood activities. According to the new RVEP scheme that is drafted in March, 2012 for rural electrification says that every household eligible for a maximum of 58 W connection (2 light points of 9 W each and 40 W socket). Though DC grids might be a solution to RGGVY scheme of rural electrification but taking RVEP scheme into consideration the limited capacity of this DC Micro-grid raises a question on its viability and sustainability.

Micro grids have gained research interest during the last years. A DC micro grid(capacity < 1.5 kW) is a

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part of power systems which autonomously operate in island mode when the loads are supplied from locally distributed resources. A low-voltage dc micro grid is used to supply sensitive electronic loads, since it combines the advantages of using a dc supply for electronic loads, and using local generation to supply sensitive loads. Micro grid concept widely implemented in rural areas of India .The increase in researches due to benefits of this type of networks including provide the reliability and security of network and loads, high efficiency, environmentally friendly and self-healing. In today's power systems, very large problems including electricity production cost and also reduce of fossil fuel, on the other hand, the increasing pollution created from burning oil and gas and dramatically growth of demands has been increase the greenhouse gases in the air which is considered as a big threat for ozone layer. There are various advantages of Dc micro-grids: a) No frequency/phase control is necessary in dc micro grids, b) Efficiency gains in energy conversion interfaces makes dc systems 5 % to 7 % more efficient than ac systems because the rectification stage is avoided, c) Dc systems are more compact than equivalent AC ones, d) Well designed DC grids can achieve both hardware and operational cost savings over equivalent AC systems, e) Power conditioning and stability control are much simpler in DC systems. But still the survey results in the villages of Uttar Pradesh and Orissa has questioned us in various factors that challenges the viability and sustainability of the DC Micro-grids.

- Cost: The light points generally provided in case of Dc micro-grid is generally 2-3W LED and a mobile charging facility. The operational hours for DC micro-grid seen from the survey results are 4-5hours in average. Taking 3W and 5 hours operational in consideration the energy consumed per day per household is 3*5+3*5(for mobile charging which is optional and not used on a regular basis)= 30Wh. The total monthly consumption per household is 30*30(30 days per month is taken into consideration)=900Wh which is less than the 1Kwh/day/household limit given by the RGGVY scheme. For providing power the revenue charged from the villagers is RS 150/month(might be in a monthly basis for Government agencies or daily / weekly basis for NGOs and private organizations). So the per unit cost of energy provided from DC micro-grid is approximately Rs 150-200. This questions that fact that is it cheap than the kerosene or the petromax alternative which generally cost Rs 75-90/month in average(Results from survey).Doesn't the extra cost putting a burden to the rural villages for their basic demand of getting electrified?

- Local ownership: For making a Dc micro-grid sustainable local ownership can only be the option. The local ownership helps in both operational and maintenance sustainability. This local ownership can be obtained by entrepreneurship driven or community driven model. Arranging micro-finance from different agencies or bank at a low repayment rate and making them invest in the micro-grid causes a successful ownership model. But the question that arises mostly by the local entrepreneur is that "what happens to the micro-grid once the conventional grid intervenes?". The DC micro-grid doesn't have the facility to feed back to the conventional grid once it intervenes. So the total DC system is then a unwanted product for the community and thus questions its sustainability and even the market risk of investment by the local entrepreneurs showing disinterest.

- Presence of Weak grid: Energy Infrastructure is an intense socio-technical system involving several stakeholders with varied and diversified priorities. Wherever there is a weak grid present there also the DC micro grid can be implemented according to RGGVY scheme if the power supplied through the grid is less than 6 hours. But the first question that comes into the mind is "Isn't there a double infrastructure cost associated with this grid which will become not a essential product once the grid improves?" Moreover the DC equipments are costly and not easily available in the local markets. So replacing a damaged DC bulb is not easy for the rural people. Instead they connect a CFL which is available in the local market(results from the survey in rural areas) which consumes much more power than the LED causing overloading and non-functionality of the micro grid.

- Scaling Up: Whenever the question of scaling up arises DC is not a viable option both in terms of limited capacity and technological aspects. The voltage drop in DC distribution wire causes it limitation with 500 m linear distribution beyond which the voltage drop is unacceptable. Moreover the distribution wire have its limitation in which further scaling up is not possible. Even providing more capacity to the aspiring villagers is also not possible with DC plant due to its limited capacity. Moreover the weakest link is battery which is present there in the direct loop for DC micro grid is also a challenge in technological terms because if the battery fails the whole systems collapses. The battery technology still have uncertainty with its maintenance and longevity.

- Livelihood Generation: From the survey of different delivery and institutional models of renewable micro-grids it is seen that the community based micro-grids causing livelihood generation is the most widely successful model for rural villagers not only in terms of acceptance but also sustainability. The livelihood generation model means the use of some appliances in the community centre which causes the economic growth of the villagers. The appliances are all AC run and consumes large power which can't be fed by DC micro grids.

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CONCLUSION

From the above discussion it can be concluded that the DC micro grid challenges can be minimized by using AC mini grid in its place. As AC mini grid has the opportunity to fed back to grid the question of existence of weak grid or grid intervention does not arise at all. Even if the grid intervenes or the quality of power supply improves the power generated from the solar mini grid can be fed back to the grid. During time of power cut the supply can be also taken from the DGs(distributed generators) to make the supply more reliable. As AC doesn't have the limited capacity the question of scaling up does not arises. This will also help in growing interest in the local entrepreneurs. Even livelihood generation is possible in case of AC. The per unit cost can also be addressed by giving a basic supply to the villagers in terms of lighting and charge them a revenue equal to the kerosene used. The villagers aspiring for more energy can be charged accordingly. Moreover the question of availability of DC bulbs in the local market does not arises as CFL can run from AC mini grid. So there is least chance of overdrawing of power. Many successful DC mini grids are running in different villages and well managed by private agencies and NGOs. Moreover the RVEP scheme can only be satisfied by AC mini grid and not by DC micro grid. The theft of power which is a big challenge for AC mini grids are also well addressed in the managerial aspect by providing energy meters and a relay which will cut the power once reached to the threshold value But the conclusion does not mean that DC micro grid should not be implemented. DC micro grid are very successful in hamlets where the number of household is very less and there is no chance of grid extension in the upcoming 5-10 years due to its geographical location.

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