FRIEDRICH EBERT STIFTUNG

CUTS International

BASK RESEARCH FOUNDATION

Green Growth and Energy Transformation

Project Design for Decentralized Renewable Energy Integration in Rajasthan

1. Background to the Project Design

India is one of the fastest growing economies of the world. Hectic efforts are being put by Central and State Governments to accelerate economic growth. At the same time it is also recognized that growth has to be inclusive and sustainable.

Energy is the engine of growth for any economy, much the same for India. India's energy consumption has witnessed a significant increase in the recent past due to increasing population and the corresponding increase in economic activities. This combined with the recent boost given to the manufacturing sector will continue to lay pressure on the existing energy sources that are available in limited quantities within the country. Therefore, sustainable path to growth must encompass sustainable, cleaner and efficient provision of energy. This necessitates an enabling policy framework, its proper implementation and favorable response from various sectors of the economy and civil society. In other words, it requires an inclusive and collective decision making and a common stake of society at large.

The inclusive nature of the process would take into account concerns of all affected sections and would provide good measure of legitimacy to the outcomes. To serve this purpose, in April 2016, Green Growth and Energy Transformation (Grow-GET) project was conceived by CUTS International in collaboration with Friedrich-Ebert-Stiftung (FES) India with an aim to create social coalitions comprising relevant stakeholders in the states of Rajasthan and West Bengal and subsequently at a national level with an aim to move towards a more sustainable, green and clean growth.

1.1. Seed Community – Need and Purpose

Seed Communities were formed in the backdrop of an acknowledgement that change does not happen automatically. It is also not an outcome of technological advancements or mere facts and figures alone. Further, it cannot also be just brought by government policies alone and hence what is indeed needed is a rainbow societal coalition that can do the following:

- Formulate a vision of a future (a promise), where the interests of key constituencies converge
- Identify the structural drivers ("game changers") which can bring about this vision
- Identify a potential platform for a discourse alliance between key constituencies
- Lay the platform for the discourse alliance with a Change Narrative which credibly explains how the game changers bring about the vision by translating facts (research, policies) into emotionally powerful stories (myths, experiences)
- Translate discourse into action by inviting potential allies to support **catalytic projects** designed to unleash structural game changers.

Here it may be pertinent to explain what constitutes a Catalytic Project. The following aspects are crucial ingredients of Catalytic Project:

- It should be capable of being scaled up
- It should be transformative i.e. it should be able to unleash structural game changers. In other words a catalytic project should be able attract other significant actors to also drive it
- It should be exemplified as a change narrative
- It should become a nucleus for social coalition, and
- It should create a platform for discourse alliance

Further, for Catalytic Project to be successful key allies need to be mapped and their motivations need to be assessed. Key allies can be broadly categorised into three types namely natural allies i.e. those who are already convinced or are the 'champions' of cause in case, transactional allies i.e. those who need incentives to come on board and transformative allies i.e. those whose interests do not align naturally and are generally averse to change. They can also be referred to as 'spoilers'.

After identifying the allies and assessing the nature of alliances, the strategic conclusions are drawn to assess whether an alliance around the project is strong enough to make it a workable project or not. If the project has significantly higher number of transformative allies then there appears a greater difficulty in implementing such a project. Further once the implementable projects have been identified, the strategy to co-opt each of the allies needs to be thought of.

1.2. Identification of Project Idea in Rajasthan

After following the above process, the Seed Community in Rajasthan identified and vetted a project idea on **'Solar Rooftop for Education'**. Some of the points justifying the project idea are enunciated below:

- Even though the economy of scale may be not as much as in the commercial and industrial consumers, there is a high potential of political, commercial and social buy-in for Solar Rooftop for School education in Rajasthan. This is because, as per DISE data, there are nearly 1 lac schools in the state, both government and private. While most of these schools have buildings, roughly about 45% of them are un-electrified
- Along with the provision of electricity through solar rooftop, there is also a scope of introducing renewable energy education in the school curriculum so that children, teachers and even parents become brand ambassadors of renewable energy solutions

- The intervention can also catalyse rural market for solar products thus bringing down costs and increase awareness

- It can serve the social commitment of the state in providing enabling conditions for learning environment in schools

- This can also be a step towards popularising environment friendly solutions to meet basic needs even outside the immediate area of application

- It can contribute to better human development record in the state, particularly in areas where electricity is not available

- Once the provision of power is ensured in the schools, it can also create a base to introduce ICT education in schools

- Since schools usually operate during day time, the expenses on storage could be avoided thereby making the model more feasible

- There are also many corporate foundations with considerable interest in providing financial resources to enable quality education in schools

- There is also a potential for creation of local jobs in renewable energy through the intervention

- Other relevant stakeholder could also be interested in the project. These would include Department of Education, Rural Development, NABARD, Private schools, Government schools, Human Resource Ministry, Women and Child Department, and Ministry of New and Renewable Energy, amongst others

- Further, it was felt that Members of Parliament and Members of Legislative Assembly could also be interested parties and their development funds could be leveraged towards the said project. This will also increase their electoral popularity at the constituency level

- Even content developers for curriculum can also be structural game changers in this process

While the above reasons were not exhaustive, they indicated sufficient reason to take up this project for implementation. However, it was felt that there could be a need to bring the discoms on board especially in the context of grid connected locations

1.3. Scoping Exercise:

A scoping exercise was also undertaken for vetting of the project idea on the ground. This exercise was undertaken by CUTS International directly in select clusters of four districts

namely Udaipur, Chittorgarh, Bhilwara and Jaipur while the assessment of the district of Sawai Madhopur was presented by Shri Hari Prasad Yogi, Member of the Seed Community, Rajasthan.

Amongst others, the following three important elements having bearing on this Project Design came up during the scoping exercise.

- First, it was felt that there is a need to change the name of the project from 'Solar Rooftop for Education' to 'Solar for Education'. This is because insufficient and unreliable power at household level also diminishes extended learning environment for children and hence households should also be included.

- Secondly, It was realised that solutions for 'Solar for Education' can be provided through a number of technologies available for the Decentralised Renewable Energy interventions and hence are 'Solar for Education' is essentially a subset of larger Decentralised Renewable Energy (DRE) domain.

- Thirdly, it was also felt that essentially the challenges to the higher uptake of DRE pertain to awareness, finance and policy and hence there is a need to target these areas in a methodical and structured manner.

To facilitate an interaction on key bottlenecks for higher uptake of Solar Solutions for DRE the following forums were organized.

- **Forum for Grassroots** – Aimed to bring the grassroots beneficiaries on a common platform and give them an opportunity to articulate local problems as well as solutions through informal group discussions

- **Forum for Finance** – Aimed to bring the banks, CSR foundations, donors and project developers on a common platform so that focused discussion on challenges in financing could be understood

- **Forum for Policy –** Aimed to identify policy gaps in the DRE space with a focus on Solar for Education

- **Forum for Awareness-** Aimed to disseminate the findings obtained during the course of the project with all the relevant stakeholders

1.4. Key technical observations recorded during forums

- ***Enabling Policies for New Entrepreneurs***

The current MNRE **'Guidelines for Off-Grid and Decentralised Solar Thermal Application Schemes**' published in 2014 are quite restrictive for new entrepreneurs to apply for empanelment as a Channel Partner with MNRE. Earlier new entrepreneurs could operate as a 'distributing partners of channel partners'. However, the recent guidelines make it mandatory

that the new entrepreneurs who directly cater to the customers should apply for empanelment as a channel partner. The project developers registered as channel partners with MNRE are entitled to the capital subsidies. The get empaneled by MNRE after they get themselves accredited with the rating agencies approved by MNRE which is based on the technical and financial strength of the entity. If the entity scores low on one of the two criteria, then its rating goes down. MNRE hasn't opened any opportunity for empanelment after the new scheme in 2014. Because of this some of the well-meaning entrepreneurs have been left stranded for 3 years now. Also, the concept of ratings by agencies like CARE and CRISIL are not suited to last mile energy access entrepreneurs whose revenue are supported by organic sales rather than Government tenders. This restricts participation of new players in the market.

- ***Incorporating Performance-based parameters to rate Channel Partners***

Financial and technical capacity rating of an enterprise by ratings agencies such as CRISIL and CARE is a mandatory norm of MNRE. Unfortunately, simplistic and standardized approach of the rating agencies does not do justice for off-grid enterprises. For example, one enterprise might be mostly working on Government projects, its balance sheet boasting of massive capacities and string cash flows. Against this an enterprise directly engaged at last mile, investing in building a sustainable ecosystem for energy access with organic sales will fare very poorly. Secondly, off-grid space suffers because of poor tracking of projects delivered. Hence, small enterprises with much better track records of delivering quality services and solutions are not able to leverage any value. This needs to change for the sector to improve and generate better value for all.

- ***Subsidy should be linked to only solar generation and not on allied appliances***

The '**Central Financial Assistance (CFA) of MNRE for Off-grid and Decentralized Solar Applications Programme'** published in 2014 provides a capital subsidy (of INR/ Wp) for pre-defined solar home systems and power packs. This limits application flexibility for the user and inhibits innovation. It is felt that Capital subsidy could be better utilised if it is given only solar on generation and storage (modules, battery bank and controller / inverter). Also, higher subsidy can be allocated to this wherein user is free to choose applications and bear full cost for same. For quality awareness purpose, maximum load and maximum energy consumption per day can be recommended.

- ***Star Rating mechanism for solar projects to ensure quality***

Solar PV systems are typically said to have a life of 25 years. For off-grid applications, systems are unlikely to last that long. This is simply because modules and electronics for small scale project are not built on highest quality components. To expect a design life of 25 years is over ambitious. A more practical design life expectation would be 10-15 years. This will be big step up from 2-3 years achieved on the ground. MNRE describes technical specifications for various components. It is felt that regulation and ecosystem to ensure quality of products post the

testing and certification stage is largely absent. What gets tested isn't necessarily sold as it is. There is a need to ensure compliance beyond certification stage. Secondly, test certificates imply adherence to minimum standards. This means the manufacturers and engineers have no incentive to improve their product beyond the minimum technical standards required. It is felt that a rating systems is designed to distinguish between quality of products based on parameters such as efficiency and life cycle expectancy, protections etc. This will enable the customers to distinguish between premium and non-premium products in a fare and transparent manner. Financing institutions and Government departments can also follow such criteria to improve as guide for their investments

- ***Allowing flexibility in installation of capacities in Mini-Grids***

Following areas are identified as challenges when it comes to current mini-grid policy:

Capital Subsidy: Currently MNRE and State Nodal Agencies (SNA) are providing capital subsidy for projects. This means that project developers end up deploying much higher capacities based on projected loads 5 years down, in order to avail maximum subsidy benefit in the present. This leads to highly under-utilized capacities and secondly by the time loads do grow, there is significant degradation in capacities. Very often project developers are unable to meet growing community needs because financial incentives are not available to add new capacity. It is felt that financial incentives or subsidies are structured to allow for addition of capacity at a later stage also.

Grid Standardization: For grid interactive mini-grids, it is imperative that minigrid infrastructure complies with National Grid Standards. Hence it is felt that Transmission and Distribution infrastructure shall mandatorily comply with Grid standard wherein public funds are sought, but same shall be 100% subsidised through Rural Electrification schemes. It is felt that all T&D infrastructure be considered as National Asset. In places where infrastructure already exists, and there is a value proposition in DRE intervention, funds shall be made available for up-gradation of infrastructure as required.

Connection Fee: Connection costs and complexity can vary a lot depending on the point of injection. It is proposed that capacities shall be defined corresponding each injection point. This shall help assist in justifying connection costs. It is also proposed that connection costs are borne through suitable schemes rather than pushing the burden to project developer. In the absence of sufficient data, suitable and alternative options of sharing or subsidizing costs need to be explored.

Energy Tariffs: In order to promote inclusive development and equal opportunities it is imperative that all consumers are able to access quality energy services at same costs as their counterparts in rural or urban electrified areas. Difference in viable tariffs and proposed tariffs shall be bridged via Viability Gap Funds.

Generation based Incentives: Unfortunately, many sponsored DRE projects suffer from poor performance. It is felt that in order to ensure accountability of project developers / EPC

contractors, they shall be compensated by generation based incentives. Incentives may be defined for minimum service delivery, and additional benefits may be provided for exceeding minimum expectations. Such contract can be structured for a period of 5 to 10 years. This will ensure accountability, and also allow for innovation in the space. Project developer concerns can be addressed by ensuring swift and transparent transfer of their dues on regular basis. Automation, Artificial Intelligence and block-chain technologies can potentially address such challenges. Finally, it is felt that there is a need for pilots in the space in order to understand technical, operational and financial challenges in Indian context. This shall allow for evidence based policy.

1.5. Key non-technical observations

- School authorities and management have little idea on techno-financial aspects of solarisation and evaluation of proposals by project developers. There is also lack of awareness even at the household level on these aspects.

- There is also a need to create more consumer awareness on design aspects of solar installation.

- Communities from surveyed locations are by and large willing to contribute both in terms of money as well as maintenance. The local peoples' representatives can play a significant role in mobilizing the community for such a role. Such community participation can bring down the cost of the installation as well as increase awareness and longevity of the project. Some of the peoples' representatives seem confident of mobilizing an amount close to 15-20% of the project cost. It may be noted here that in one of the project locations, the 'highest government district functionary' has already institutionalized community participation as a norm for most public works. With regards to community perception, concerns emanated mainly on one count i.e. with increased awareness if communities opt for installations at house hold level, the upfront cost for installation will be a deterrent despite subsidy. However, it must be mentioned here that there is a divided house on this issue with the majority agreeing that consumers will be able to pay up the upfront cost as quality of grid supplied electricity is very poor, unreliable and intermittent. The billing amounts also don't represent actual consumption as they are improperly attributed due to inefficiencies in the system.

- It has repeatedly been highlighted that even though banks are mandated to extend loans for solar installations, the actual compliance is low in areas where need is high. This is due to high compliance costs for recovery of loans and inadequate manpower in the banking system. A proposition was thus put forth that a tripartite agreement between a bank, technology provider and a third party (NGO) can help in scaling up solarisation of villages. This proposition has already been cross-vetted informally by number of bankers though with a caveat i.e. MNRE maintains list for specific project developers and hence banks or their local branches may not be willing to have a tripartite agreement with a technology provider which is not part of that list. This has an impact on restricting new players in the market.

- Programme running solely on Government funding without any ownership of the community can not only become largely unsuccessful and unsustainable but can also send a negative message to the community on the potential of innovative interventions. A case in point is many dysfucntional solar systems installed on several Atal Seva Kendras which are meant for providing hundreds of Government to Citizen (G2C) and Business to Citizens (B2C) services in rural and peri-urban areas. Since these centres see a rather overwhelming turnout of local people to avail the essential services, the dysfunctional solar systems and delayed services due to non- provision of electricity has made a negative impression on people about the utility of solar solutions. It may be noted here that this is largely due various factors such lack of **people participation**, **availability of local maintenance and lack of vendor accountability mechanisms,** amongst others.

- There is also lack of awareness and coordination within the banks on the mandate for solarisation. Banks also have limited understanding on technical aspects of technology

- All green energy projects qualify under Priority Sector Lending (PSL) as per Reserve Bank of India Guidelines. However, banks tend to only extend PSL for agriculture pumps since it is explicitly provided for. It may also be due to the fact that it is linked to a productive activity. It was observed that unless a financing is linked to livelihood activity banks are usually unwilling to lend to rural and poor consumers unless there is guarantee of recovery or bank guarantee.

- There are also views that capital subsidy should be transferred to interest subsidy to spur demand.

It may be noted that the above mentioned procedural and policy bottlenecks are not exhaustive. There are and can be several other issues. Therefore, an attempt has been made to present a road map (project design) for strategic integration of DRE in the state of Rajasthan. This has been dealt in the next section.

2. How to plan strategic integration of DRE in Rajasthan

This section lays out roadmap for optimization of off grid and on-grid solar solutions in the backdrop that Government is fully committed to providing electricity to all households and ensure 24x7 access to quality power. The document aims to map the potential for integrating DRE in energy planning and power infrastructure investments. This is done by defining process for comparing cost of investments and benefits for DRE interventions on case to case basis. The document maps generic clusters having different load profiles with most suitable DRE technologies while considering Government mandate and plan of action. Attempt is made for convergence of Government Schemes to reduce and optimize the burden on the ex-chequer. In doing so, the document also highlights challenges in implementation, policy design and also discusses potential solutions.

Please note that since there is no current mandate for energy requirements for agriculture segment, analysis for same has been omitted from the purview of this document. Although, same arguments shall hold true for meeting the energy needs of agriculture sector also.

Even though the term DRE has been used several times in this document, it is not explained before what are the prevalent technologies deployed by the market. Therefore, the following paragraphs briefly describe some of the common technologies available in the DRE space.

2.1. Types of common technological solutions available in the DRE space

This section briefly describes some of the common solutions and technologies deployed in the market.

- **Decentralized Solar Systems** are typically customized solutions designed to meet energy requirements of a household, business or a facility. The solutions are available for both DC and AC applications. The solutions consist of a solar module, battery bank and a charge controller or a power conditioning unit.
  Decentralized solar systems are modular in nature, easily customizable and typically easiest to deploy in remote and difficult terrains. But, despite the modularity, they lack flexibility to respond to increasing energy demands. Hence, they are considered most suitable for basic loads. Although system can be designed for high power consumption loads also, but managing surge loads and designing optimal solutions which can provide ensure reliable power 365 days a year is a major challenge. Energy efficiency and surge load management plays a major role in viability of such solutions.

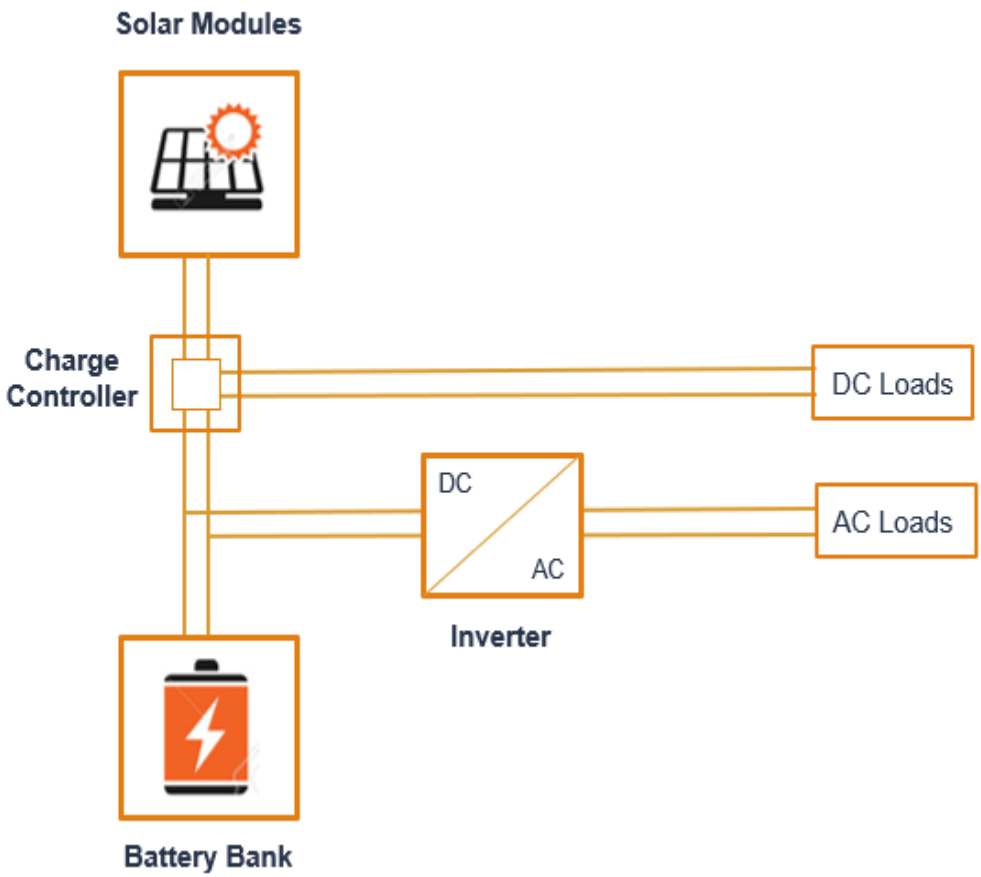

Figure 1 Single Line Diagram-Decentralized Solar System

- **Decentralized Energy Storage,** for the purpose of this document, is basically a battery based energy storage system. Typically designed to provide power back-up in case of grid failure, such solutions are common in a country like India, given the reliability of grid power. Lead acid batteries have traditionally dominated the battery segment, but they are considered as critical pain point because of their maintenance requirements, slow charging, short life cycle and environmental impact.
  Globally, Lithium ion batteries are becoming increasingly popular because of their long lifecycle, extremely low maintenance and fast charging capacity. Such energy solutions also have the capacity to provide aggregated demand response services to the main grid, and hence aid in improving grid stability.

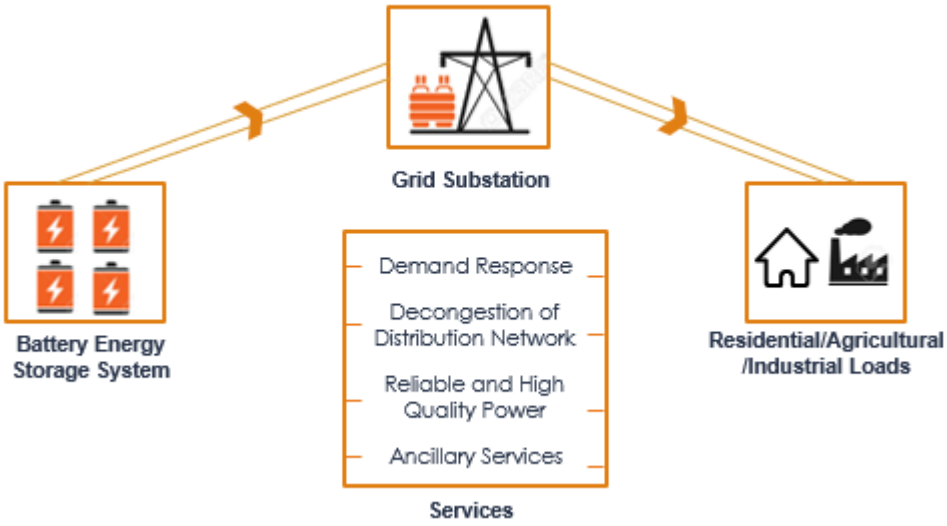

Figure 2 Energy Services

- **Off-grid Microgrids,** are solutions designed to provide energy as a service, in a manner similar to the main grid. Microgrids may include solar, wind, biomass, micro-hydro, diesel / gas based generation or even multiple sources for energy generation. Along with decentralized generation source, a microgrid shall almost always include distribution infrastructure and energy storage. Suitably designed microgrids have the capacity to almost completely replicate the main grid and provide energy as a service, along with desired flexibility. Unlike decentralized solar systems, microgrids can be easily designed to incorporate more load handling capacity at a later stage. Also, if designed for eventual grid integration, microgrids can play pivotal role in energy transition and inclusion.

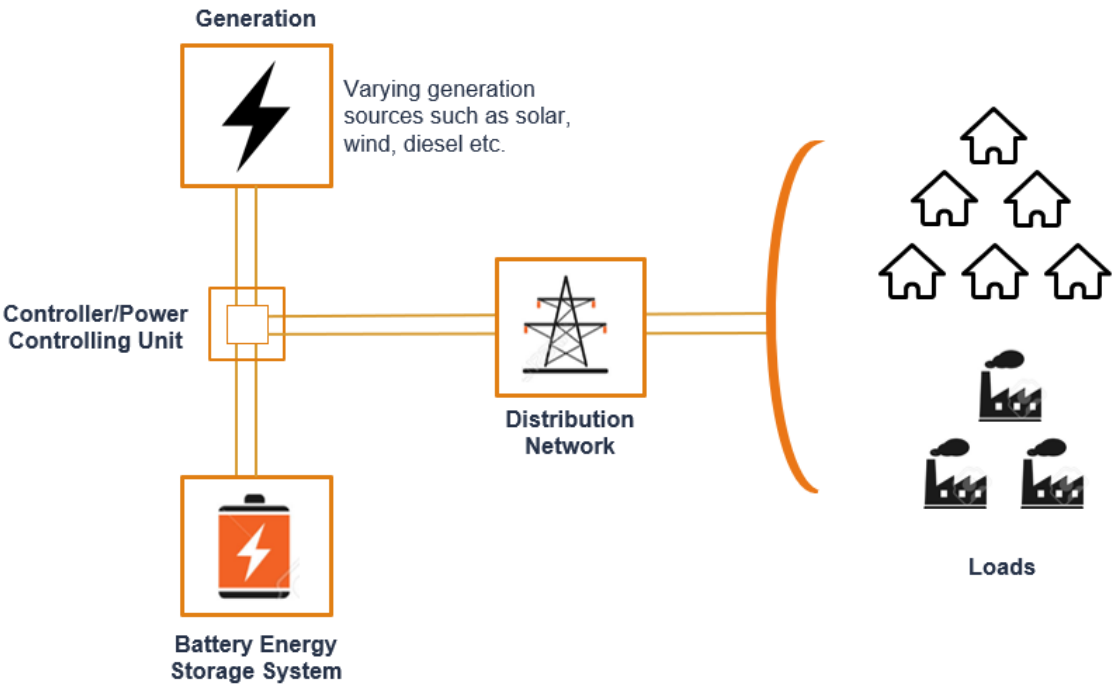

Figure 3 Single Line Diagram- Off- grid Microgrids

- **Advanced (Grid-Interactive) Microgrids,** are microgrids with automated controls systems and AI based management systems. While Advanced Microgrids can be deployed to bridge energy deficit and improve reliability, they have the potential to offer much larger value when strategically deployed to defer infrastructure investments, improve grid stability and add resilience to the grid. With the ability to also operate in islanding mode, microgrids are often the solution of choice for critical facilities such as hospitals, military applications and data centers, etc.

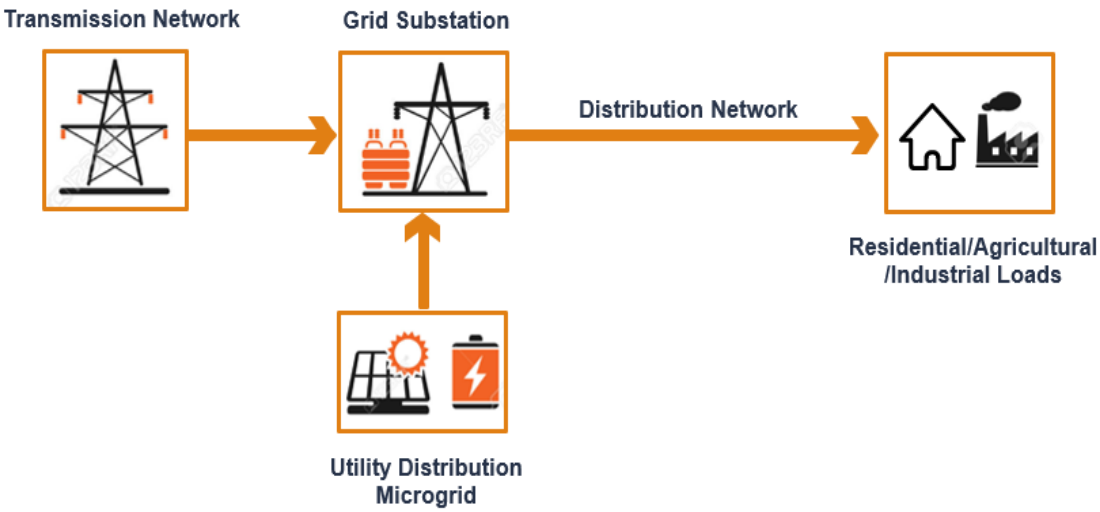

Figure 4 Single Line Diagram-Advanced Microgrids

- **Solar PV Rooftop Systems: They** offer a unique value through tail-end generation and consumption. Depending on local load pattern, decentralized solar solutions can aid in reducing day time peak demand and decrease congestion in the network by promoting local generation and consumption.

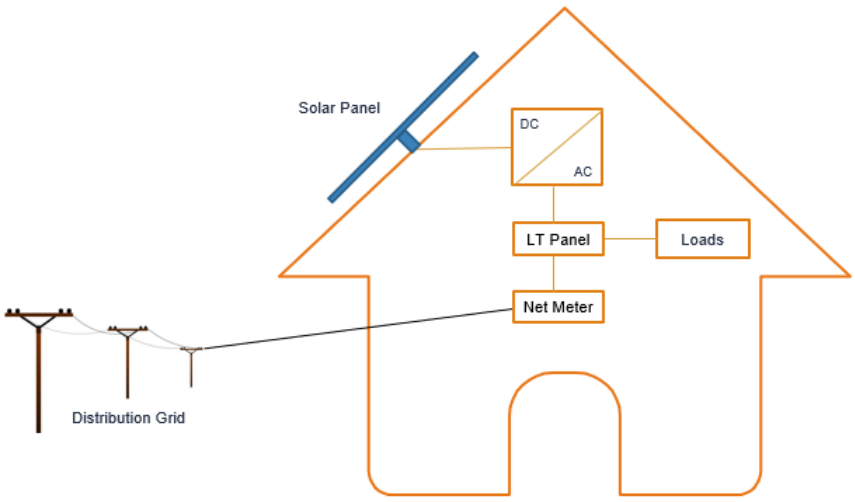

Figure 5 Solar PV Rooftop

2.2. Value based DRE Integration in Energy Planning

This section explores integration possibilities of various DRE technologies based on demographic parameters, local energy needs and cost-benefit analysis of traditional approach vs DRE. The section also attempts to scope such possibilities while considering Government

initiatives and attempts to scope (and suggest) convergence of public schemes for electrification and improvement of electricity supply.

2.2.1. Location type: Off-grid clusters

Key characteristics

Remote location, relatively low population density, absence of commercial, livelihood and institutional loads, low household consumption and low willingness to pay.

Possible Solutions

Grid Electrification

Grid electrification is the default solution for ensuring 24x7 access to electricity, under schemes such as DDUGJY or SAUBHAGYA. Once transmission and distribution infrastructure is set-up, it provides access to potentially low cost and reliable power. But cost of setting up the distribution infrastructure escalates with increase terrain difficulty and remoteness. Project cost may depend on number of parameters, and some of the key parameters are listed below:

a. Population density

b. Soil properties and geography

c. Load or demand profile

d. Distance from closest feeder line

e. Availability of feeder capacity and capacity in upstream infrastructure

Any addition of capacity required in the upstream infrastructure will typically make grid extension financially non-feasible and technically challenging. Apart from that, ensuring quality and reliability of power through the traditional approach for remote regions is very difficult. Low voltage supply and fluctuations are often a key concern for consumers in remote rural villages. Such poor supply adversely impacts energy linked livelihood and income generating activities.
Extension of grid electricity is typically the cheapest approach to increase flexibility of the grid. But with escalating costs for setting up the infrastructure in remote regions, alternative approaches offered by DRE technologies can aid in optimizing investments of public funds while ensuring access to better quality power.

Decentralized Solar Systems

Modularity and extreme decentralization of home system technologies provides for extremely cost-effective energy solution especially in sparsely populate regions. But at the same time, these solutions are unable to meet long term energy aspirations of the local communities as they are unable to provide energy for high power consumption or respond to escalation in energy demand. Along with lack of last mile service support, reliability during bad weather conditions is also a key concern.
While such solutions are often provided by State Nodal Agencies for off-grid villages at highly subsidized prices, we suggest that such solutions shall be deployed for only those villages where it is not feasible to set up local distribution network because of techno-commercial challenges.

Off-grid Microgrids

Microgrids offer the capacity of scalability to respond to growing energy demand. Also, unlike Solar Home Systems, they can be designed to cater to commercial, institutional and livelihood loads with rather ease. Hence, they shall be considered as the preferable solution wherein setting up a local distribution network is not a major challenge and grid is unlikely to reach in medium term or long term scenario.
Historical initiatives to facilitate energy access, under rural electrification schemes, have had only small degrees of success. This can be attributed to multiple challenges. Firstly, such microgrids have been traditionally designed to cater to basic loads for fixed number of hours. While this is a step up for the local communities, it is typically non-sufficient to contain their aspirations. Hence, the demand of grid electrification becomes inevitable. Secondly, high cost of operations and maintenance in the last mile, poor revenues and inability to respond to growing energy needs and aspirations imply that long term sustainability and acceptability of microgrids is always questionable.
To address these challenges, microgrids need to be designed to provide energy as a service, with the ability to grow their capacity to respond to growing energy aspirations over the years. Providing energy-as-a-service as per SERC norms, with the necessary flexibility and reliability, is also extremely critical. If microgrids can replicate the grid in terms of affordability, reliability and flexibility of energy as a service, their acceptance is likely to be high.

2.2.2. Location type: Electrified clusters with low electricity consumption and poor supply of electricity

Key Characteristics

Variable population density, presence of basic livelihood or economic activities with low dependence on energy, possible presence of public facilities like schools, PHC, banks etc.

Possible Solutions

Improving Grid Supply

If it is assumed that Indian power sector has very low energy deficit, there are 2 main reasons for poor and unreliable supply of electricity at the last mile: (a.) Lack of capacity in Distribution or transmission infrastructure continuous and parallel load management for all feeders, (b.) DISCOMS curtailing supply to reduce incurred losses.
For the purpose of this document, we shall assume that DISCOMS have all the intentions for ensuring 24x7 access to electricity. Hence, in an event where same is not being delivery, it can be assumed that over loaded infrastructure is the key reason for the inability of the DISCOM to ensure 24x 7 electricity downstream. Hence, to resolve this issue, upgradation or addition of power infrastructure is the traditional approach. In the event, upgradation of infrastructure is considered, different variables dictate cost of upgradation or addition of new infrastructure. Such a decision provides an opportunity to undertake a cost-benefit analysis between the traditional approach vs a Decentralized Energy Resource designed to manage additional capacity or bridge the energy deficit. Even though upgradation of infrastructure is long term asset, its cost and expected utilization subsequent to projected load growth dictates the soundness of the investments planned.

Solar Home Systems / Decentralized Energy Storage

Promoting solar home systems or energy storage units are likely to most cost effective measure for boosting energy sufficiency, with least financial of burden on the exchequer. Such decentralized household solutions can be encouraged through various schemes and incentives designed to boost the market. In past, various capital subsidy and financing schemes have been promoted for Solar Home Lighting systems by MNRE.
In regions where grid stability is a challenge, especially because of difference in generation peaks and demand peaks, energy storage solutions can play a pivot role in smart demand-supply management. Such solutions, when aggregated, can have significant impact on overall power quality while reducing the need to invest in grid infrastructure.
Getting DISCOMS on boards to facilitate integration of decentralized energy resources and ensuring availability finance for same are major road blocks.

Advanced (Grid-interactive) Microgrids

Given their potential to respond to grid requirements, advanced microgrids are often best suited to manage **variability** in the grid. By providing demand response and islanding services, microgrids can operate as Virtual Power Plant, improving grid stability by facilitating peak load shaving and managing generation peaks. Such services are extremely critical for grids with high concentration of variable power capacity such wind and solar. Microgrids can also potentially offer a more viable and novel approach for handling more loads without investing in upstream capacity handling infrastructure.

2.2.3. Clusters with High Energy Consumption

Key Characteristics

Inductive loads with high power consumption, need for extremely reliable and high quality power, industrial and institutional loads, possible day time peaks.

Possible Solution

Advanced Microgrids

Unless demand in a cluster with intensive energy consumption is projected for slow growth, investments in power infrastructure shall always be mandatory. However, investments in Microgrids can strategically considered on followings basis:

A. Improve reliability of power and resilience of the grid: Back-up power solutions are a norm for critical industries and institutions. Diesel generators acquire the major chunk of market share when it comes to back-up solutions for industries and institutions. Now Diesel Generators have high operational cost, complex to maintain and they occupy prime real estate. Microgrids-as-a-Service can be introduced wherein storage and back-up needs can be aggregated, while assuring extremely reliable power to the users.

B. Microgrids can vastly improve resilience of the grid, help in peak shaving of demand and hence improve the life of power infrastructure (like transformers) also. Hence, in areas where load profile consists of high day time and / or night time demand peaks, microgrids can prove to be the most cost effective solution.

C. If major upgradation in power infrastructure are required, microgrids can significantly defer the need for such investments at marginal costs. Viability and deferment period shall depend on projected growth in local demand for power.

3. Removing the Road Blocks for DRE

To realize the true potential of DRE in medium and long term energy planning, and energy transformation of the state, we need to address some critical technical, financial and policy barriers. This section highlights challenges for respective DRE technologies which have already been discussed in this document, and attempts to make recommendations to provide resolution for the challenges. All recommendations are designed with an objective of unleashing the value of DRE technologies over a long period of time, positioning them as valued assets, while also attempting to suggest an ecosystem of transparency, accountability and fair monetization of services.

3.1. Decentralized Solar Systems

Lack of after sales service support is one of the key challenges because of which decentralized solar home systems have been maligned for more than 2 decades. Despite stringent contracts between the government agencies and product vendors, service support at the last mile continues to be dismal. Some of the key reasons behind this are: (a.) Inability to monitor system performance in remote rural villages, (b.) Lack of awareness at household level among the users, and (c.) extremely high operations and maintenance cost at the last mile.

Technology Recommendations

Cost for lithium ion battery packs have fallen by more than 60% in last 2 years, and the industry is further projecting significant cost reductions. Now even though, lithium ion packs continue to be significantly more expensive than lead acid batteries, their application shall be promoted for remote rural villages because of their long life cycles and low maintenance requirements. Lithium ion packs are also more environment friend and non-hazardous. Their fast charging capability implies that systems can be designed for much faster charging without the need for high autonomy. In such a scenario, system can be optimized by increasing solar capacity instead of battery pack, to ensure power availability during poor weather conditions. If grid electrification is projected to be unviable after a period of 4-5 years, provision shall be made for replacement of batteries, refurbishment and upgradation.
It is further recommended that all system shall include remote monitoring functionality, and the data hence received from the systems shall be linked to public platforms to facilitate efficient monitoring, enabling complaint registration through the system hardware itself, and also to reduce the transaction cost for systems financed by banks.

Financial Recommendations

Solar Home Systems also have a significant market demand even in electrified areas, with poor supply condition. But, in order to realize their full potential in rural underserved villages with low ability to pay for the upfront cost of the systems, end consumer finance plays a crucial role. In the past, poorly structured subsidies and lack of support from financial institutions have throttled the market demand. To facilitate market uptake of decentralized energy solutions, financing has be de-risked for the banks. RBI shall encourage disbursement of small loans through suitable incentives, while banks also need to develop a positive attitude towards small loans as they are the tools for effective financial inclusion.
For the consumers, financial subsidies shall also be structured as interest subsidies, rather than as capital subsidies. This shall improve the efficiency of disbursement of subsidies, while

ensuring that the burden for delays in subsidy disbursements don't get transferred to the banker or the consumer.

Other Recommendations

Incentives and subsidies are designed with an objective of encouraging markets. Even so, such instruments often distort the markets, throttling innovation. For example, there is a need to relook at the technical recommendations laid out by MNRE to allow flexibility of use and customization by end users. It is also recommended that to promote fair markets, MNRE should focus on build consumer awareness and grievance redressal mechanisms, rather than empaneling channel partners.

Special case: DRE Solutions of Public Facilities

Public facilities like schools, healthcare centers, aagnanwadies, etc are the backbone of delivery of basic services to the last mile underserved communities. Often, the capacity of such facilities is hampered by lack infrastructure and power. Hence, decentralized energy resources are central to the effective delivery of basic services in remote and rural villages. While diesel generators have been the traditional choice, their operational cost and difficulties in diesel procurement make them an unviable solution. Solar Photo-voltaic based DRE solutions have been a popular choice in the recent years because of the failing prices, but operations and maintenance remains a concern here also.

Key recommendations to improve quality of service, optimize expenditure and ensure operations and maintenance accountability are as below:

A. Tenders shall be designed based on OPEX model, where in incentive for the project developer shall be linked to performance of the systems. Minimum service standards shall be defined, and string penalties shall be integrated in case the project developer fails to meet these standards.

B. Integrated request for proposals should be invited. These proposals shall consider energy efficiency along with solar power packs. This shall open the room for innovation and efficiency measures to be taken by the project developer.

C. Payment guaranties shall be ensured, along with safeguarding interests of project developer if system is damaged because of mishandling or tampering.

D. To ensure bankability, term of the contract can be kept at 5 years.

3.2. Off-grid Microgrids

Off-grid microgrids have strong potential to provide cost effective solution in remote regions, but have suffered from poor social acceptance because of traditional approach. Tampering and over-utilization is a common concern, especially since cost of operations and maintenance can be extremely high for remote villages. Below, some strategic recommendations are explored to resolve some of the pain points.

Technology Recommendations

To ensure social acceptability of microgrids, they need to be designed to replicate main grid in terms of affordability, flexibility and reliability. Otherwise, microgrids shall always be

threatened by grid extension, and socio-political forces shall demand for same. This of course is fair in terms of social equity and equal opportunity. But this also means that we need to design microgrids to provide 24x7 reliable access to the communities, without restricting their energy or power consumption. Hence, microgrid shall be designed to meet domestic and commercial energy needs as per demand. Microgrids shall also be designed for scaling capacity as local energy demand evolved. While at the same time, to ensure fair and democratic access to energy services, same needs to be metered and energy prices need to be mandated as per SERC norms.
The often-cited challenge of collection of dues can be addressed through pre-paid metering. This shall provide consumers with better flexibility for their energy expenditure, while reducing their transaction cost. Smart pre-paid metering can also potentially reduce operational costs for the project developers, while also enabling them to track energy behavior of their consumer base. Remote monitoring of asset performance and energy transactions shall be mandated to enable transparency and accountability.
It is also recommended, depending on possibility of grid arrival in future, microgrids are designed with grid ready architecture. This shall enable seamless grid integration in the event of arrival of the main grid.

Financial Recommendations

Once it is established that a Microgrid is to be designed to provide 24x7 energy access, with necessary demand flexibility and capacity to scale with growing demand; although difficult, it isn't impossible to design contracts for the project developers to ensure adherence to minimum energy reliability. This is of course assuming tariffs shall be regulated as per SERC norms and gap funding shall be provided by concerned State agency.
In such an event, there is a strong scope of convergence of schemes under Rural Electrification Schemes such as Saubhagya, wherein, distribution infrastructure can be completely subsidized by State agencies. It is strictly recommended that wherever public funds or subsidies are deployed, grid infrastructure should be mandated as per National Grid Code, and duplication of infrastructure shall be strictly discouraged. This shall also enforce mandatory grid integration, and hence suitable exit strategies for microgrid developers.
It is to be noted that once the distribution infrastructure is installed as a State asset, competitive bidding can be facilitated for energy generation, storage, electronics, operations and management. This significantly reduces risk and financial exposure of the developers, and it can potentially ensure suitable institutional financing for the developers once the payment guaranties have been ensured.
It is recommended that a strategic shift is made for moving towards OPEX based or similar models to ensure transparency and reliability, while also providing developer an automatic framework for addition of power capacity as the need arises. Suitable penalties shall be built in to ensure that the developer is held accountable for shortcomings in service quality and inability to meet consumer energy needs.

3.3. Decentralized Energy Storage

In India, storage industry for small scale residential and commercial applications is estimated to be at a scale of 15-20 GW by 2020. Cost effective grid integration and evolution of fair market mechanism can help unleash the potential of decentralized energy storage. Aggregation mechanism can have significant impact on decongestion of networks, integration of renewable energy and peak demand shaving while managing the surplus energy generation. Such technology solutions have minimal requirement of state incentives, and can be quickly commercialized for scale if necessary regulatory mechanisms are in place.

Technology Recommendations

The evolving storage technology and the falling prices offer a great opportunity for behind the meter energy management. There is need for development of intelligent management tools (software) for demand charge management and interoperability with the grid; with such tools in the hands of developers, complex energy storage systems will become predictable, manageable and repeatable. The software with interoperability across different OEMs can provide developers with a means to easily integrate the latest and greatest hardware, further driving down costs and ultimately enabling economies of scale.

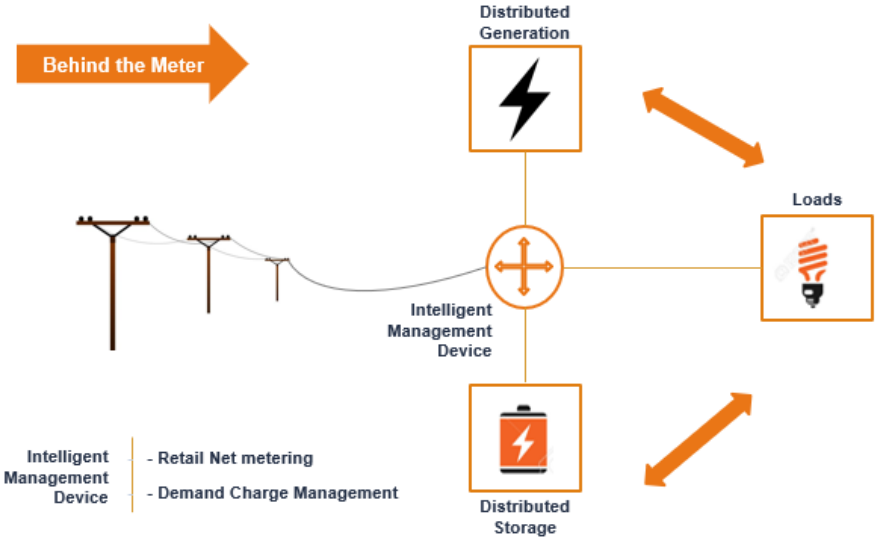

Figure 6 Behind the meter Storage

Financial Recommendations

Unleashing decentralized energy storage potential shall require implementation of time of day based tariffs and fair monetization of demand-response services. Presently, three financing models have dominated the market- shared savings, lease and models based on power purchase agreements. The first two lack clear and predictable customer pricing and revenue streams for financial partners. While the PPA model of distributed generation have seen success in the market, however the generation plus storage are still relatively new and require proper structure in order to offer clear value proposition.
Apart from these, EMI based options to consumers can also be explored, cheaper financing and adoption can be pushed by integrating traditional finance. For example, such solutions can be financed through Home Loans or Home Upgradation Loans.

3.4. Advance Microgrids

If strategically integrated into energy planning, Advanced Microgrids can potentially facilitate significant cost reduction in infrastructure investment, enable better integration of renewable energy and increase resilience of grid to natural disasters, unscheduled outages and cyber-attacks. These microgrids can also be potentially integrated into Disaster Management Planning, as they can ensure that critical services like communication and healthcare don't get effected during adverse conditions. Smart controls systems and communication technologies can sense disturbances in the main grid or provide demand response action by going into Islanding Mode as and when required. They can also provide ancillary services such as VAR support, frequency regulation and peak shaving. But most importantly, when strategically implemented, Microgrids

can save millions of dollars by deferring investments required in infrastructure upgradation, and by reducing the load on existing infrastructure and hence extending its life.

Technology Recommendations

To realize full potential of services offered by Advanced Microgrids, it is important that grid integration infrastructure and protocols are standardized. The standards on grid integration of RE are defined by CEA, it allows for unidirectional flow of power into the grid and there's no provision of utility scale storage integration. The scope is limited to feeding power into the grid only, while advanced microgrids scope themselves with additional features of demand response, islanding, voltage and frequency regulation etc. The anticipated standards for grid integration and interoperability of advanced microgrids should allow for

1. Integration of DRE plus storage
2. Smart Controls for grid management
3. Demand Response

While the CEA guidelines gives the liberty to follow recognized international standards in case national standards are unavailable, the challenge lies in modification of those standards as per Indian scenario. For example, IEEE standards for interoperability of microgrids are designed for grids operating on 60Hz frequency, in order to adopt them for Indian projects, we need to modify them for 50Hz frequency.

Financial Recommendations

To promote scaling of Advanced Microgrids, it is important that fair financial evaluation mechanism is developed to account for savings from infrastructure investments, energy efficiency and de-congestion of infrastructure. At the same time, market mechanisms shall facilitate fair monetization of ancillary services such demand response, peak shaving, frequency regulation, VAR support and cold start. Also, Advanced Microgrids shall be considered as long-term assets and hence suitable financial mechanism need to be evolved to finance such assets.

4. How to bring discoms on board

In India, advocacy for renewables needs to start at the discom level. Once the discoms are on board, it won't be a difficult proposition. To be able to do that, the following process could be adopted:

- First, there is a need to determine the RPO targets and how is the discom fulfilling that, for instance, it is important to determine where is it currently buying electricity from. Once that is done it will help to determine what would be the cost for discom till 2022 (as per RPO targets) and if it is buying from outside the state then how can this amount be saved by discom by building domestic capacity?

- The cost needs to be estimated holistically, not just taking into account the reduction in losses at discoms end, but also reduction in Deviation Settlement Mechanism (DSM) penalties (for under drawl or overdrawl vis-à-vis projection)

- Thereafter, there is a need to create a push for solar through a strong data base justifying the need. This can be done in the following manner:

- Prevailing RE prices and payback period to be identified in case of each consumer category
- Only solar will not be a successful model because the power deficit occurs during the day peak as well as the night peak. That's why there is a need to club solar solutions with DSM and energy efficiency measures

- Need to consider current situation of discoms and identify which consumer category is a major cause for heavy losses to discoms

- Then, there is a need to club Solar solutions with Energy Efficiency (EE) measures. For this purpose, Load research needs to be done i.e. identifying what is the volume of non-energy efficient equipment and how much load can be reduced by introducing 5 Star EE equipment.

The above will give an estimate of energy savings potential in a state for a defined period which will reduce the day peak and night peak of the state. The solar intervention can reduce the day peak and the DSM and EE intervention can reduce the night peak. This will reduce the overall losses of the discoms. The domestic sector's tariff is already below the discom's 'Average Cost of Supply'. Therefore, it is a beneficial proposition for discom to introduce solar + EE intervention in case of domestic sector as the discom will save on its power purchase cost. This will also have a direct impact on tariff and tariffs will go down. With these savings, the discom can invest in the network for power evacuation. Also the discom can be provided support from project management consultants who can provide support in building a strong data based assessment of project feasibility. Each state has its own diagnostic problems, network problems and financial problems. Once an analysis of all these is done, appropriate solutions can be designed.

5. Conclusion

While universal electrification in India definitely seems like an achievable goal, reliability and quality of power continues to be a concern. Some of the challenges faced by 24x7 Power for All mission are as below:

- Supply continues to be constrained, and low voltage considerably constraints livelihood and commercial opportunities.

- Transmission and distribution losses for Indian utilities are monumental, and they are further stressed by grid expansion into remote villages.

- Utilities are stressed by high losses and increasing debts. The situation is further stressed by providing services to low paying consumers. There is no financial incentive or advantage for utilities to supply quality power to our villages.

- Billing in remote rural villages continue to be a major concern for the consumers.

- Tariff models are typically not suited for poor household. Fixed costs, despite subsidized unit rates, put financial burden on the poor.
- Highly subsidised tariffs do not promote conservation of energy or energy efficiency.
- With current loads and consumption levels, very often, enough revenues are not generated even to sustain the infrastructure.

In the rapidly changing energy landscape, DRE has an increasingly important role to play. DRE and energy access enterprises can potentially bring the following values to the table.

- Better understanding of energy needs of the community, and hence generation capacities can be better optimised.
- Scale capacities to respond to community needs.
- Innovation in metering and business models, enabling affordable and democratic energy access
- Help manage and reduce T&D losses for the discoms
- Leverage local operational efficiencies, allowing for more sustainable growth.

Further, with rapid grid expansion, it is becoming more and more imperative that Discoms and DRE players work together to provide affordable and quality energy services to consumers.

An inclusive policy is likely to leverage efficiencies and capacities of Discoms and DRE players, improving overall efficiencies and allowing DRE project developer to scale technologies from prevalent capacities and commercialise their technologies. In such an event, DRE is expected to add a larger value to the National Grid which shall have ever increasing RE contribution.

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