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Off-grid Energy Development in India: An Approach towards Sustainability

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Abstract

The paper carries out a critical evaluation of existing approaches to the off-grid/decentralised energy development in India and proposes a sustainability framework based on a decision hierarchy. An exhaustive review of policies and programmes is complemented with a statistical analysis of project level information available from secondary sources. The results of the analysis have been validated through select field visits and a stakeholders' workshop. The major findings of the study suggest that successful decentralised interventions are critically contingent upon certain key determinants i.e. choice of technology, scale of the project, type of policy support, role of community, economic linkages and type of investment. While the analytical results corroborate with the findings of many other studies, some of them point to interesting and new perspectives to explore. One such finding is related to the community participation in off-grid projects. Contrary to the established wisdom on role of communities, our analysis suggests that in practice the reality of capacity constraints among communities, local level conflicts and elite capture subvert the established premise on community participation. The decision hierarchy proposed for off-grid energy services has been linked to certain enabling methods at each stage of decision-making and is expected to address the key sustainability dimensions of off-grid energy interventions.

Keywords: Off-grid electrification; sustainability; field insights; analytical framework.

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1.0 Introduction: Off-grid access to modern energy services

Energy is considered as a primary and critical input for sustainable human development. Current energy access[1] statistics reveal that about 1.4 billion people (i.e. 22 % of the global population) do not have access to any form of modern energy services, of which 612 million (about 38 %) live in South Asia (IEA, 2010). IEA projections also warn us that if current trends persist, more people are likely to slip into the energy poverty trap in 2030 than now (IEA, 2009). Access to energy has been strongly linked to achieving Millennium Development Goals (MDGs) and has become an important policy goal for developing economies of the world. The recent Vienna Energy Forum (VEF) held during 21-23 June 2011, has reiterated the crucial importance of energy access in meeting sustainable developmental goals.

The conventional approach to addressing the energy access challenge primarily rests on expanding the grid and creating new sets of distribution network infrastructure. However, the grid extension solution does not always fix the problem and is often neither financially viable nor environmentally benign (Rogers et al, 2006; Lhendup, 2008; IEA, 2010). Given the limitations of centralized grid extension approaches, off-grid solutions based on small scale decentralized renewable energy systems are increasingly emerging as preferred alternatives in many parts of the world. These interventions are also favoured being resource efficient and less capital intensive.

Unfortunately, the 'increasing returns of adoption[2]' of centralized generating facilities often act as a deterrent to the small scale decentralized projects to be taken up at the desired scale (Woodman and Baker, 2008). It is argued that small scale electricity generation systems are gradually being 'locked out' from our economic, political, legal and social construct (Watson et al, 2007) or at best are restricted to playing a peripheral role. Massive expansions of thermal power plants have undermined the need and importance of decentralised energy generation in many countries.

[1] Access to modern energy services is defined by International Energy Agency (IEA) as household access to electricity and clean cooking facilities (i.e. clean cooking fuels and stoves, advance biomass cook stoves and biogas systems).

[2] The growth of a particular system creates network externalities. These network externalities are a special kind of increasing returns of adoption. Brian Arthur identifies five major sources of increasing returns with adoption i.e. learning by using, network externalities, scale economies in production, informational increasing returns and technological interrelatedness.

For project developers of decentralized energy systems, some inherent constraints are likely to arise because of high upfront costs, 'thin' rural markets3, difficulty in arranging institutional finance and ambiguous government policies. More specifically on the policy front, the existing responses are limited to pilot scale implementation models and do not have a clear framework to mainstream decentralized systems in the national planning process (Hiremath et al, 2009). A greater challenge to promote and accelerate the off-grid process in developing economies is linked to inadequate capacities at the community or village level to effectively operate and maintain the infrastructure. Studies point that capacity building efforts are central to wider replication of these systems (Clemens et al, 2010, World Bank, 2011).

Nevertheless, there has been renewed interest shown by many countries in the world in the decentralized regime of power production through small scale facilities. For developed countries, the attraction to micro generation technologies is because of their potential to become future energy technologies4 (IEA 2002; Pehnt et al, 2006; Sauter and Watson, 2007). Developing countries are increasingly looking forward to it not as an isolated form of energy provision, but in the overall context of community life and as an integral component of other rural improvement efforts (Kaygusuz, 2011). Recently, improvements in the legal and regulatory conditions and creation of fertile policy space have been giving new directions to off-grid energy development in developed and developing countries alike.

The review of literature on off-grid energy systems reveals that there is a dearth of studies with integrated frameworks of analysis. Most of the studies either focus on techno-economic assessments or present policy narratives without adequate attention to local contexts and key determinants shaping the development trajectory of these projects. To bridge the gap, this paper attempts an integrated evaluation of factors that are expected to determine the business case for off-grid projects. The geographical focus is on India and the data for our analysis comes from the documented experiences of a large number of off-grid projects, field visits and interactions (both telephonic and direct) and participatory stakeholder consultations.

[3] The concept of market thinness indicates a situation where in general the number of buying and selling offers is small.

[4] For instance, the UK Department for Trade and Industry envisages meeting 40-50 percent of energy needs from micro-generation energy technologies (Burton and Hubacek, 2007).

Rest of the paper is structured as follows. The next section presents the current state of off-grid energy systems in India. Section third traces the genesis and major policy drivers shaping the off-grid energy development in India. Major challenges and complexities of off-grid energy development are identified in section four by drawing evidences from the scientific literature as well as from Indian experiences. The fifth section critically examines the sustainability dimensions of off-grid electricity projects deployed in India over the past couple of decades. In section six, we draw lessons from the earlier discussion to propose an approach to framing a business model for decentralized/off-grid energy interventions in the country. Section seven concludes the paper.

2.0 The Indian context

India, being one of the fast growing economies of the world, is on the horns of the 'trilemma' of meeting the goals of economic development, environmental sustainability and technological leapfrogging. The electricity requirement projections indicate that the country requires 800,000 MW of electricity by 2031-32 – an increase of 437.90 % from the current level of 182689 MW – to sustain the current growth momentum of the country (Planning Commission, 2006). Further projections caution that the peak power deficit could rise to 70,000 MW by 2017 (McKinsey and Company, 2007).

The challenges are much more pronounced and complex when it comes to providing energy access to the millions of people lying at the 'bottom of the pyramid'. Very recently, the 12th Five Year Plan (2012-17) Approach Paper of the Government of India highlights the energy access concerns especially for poor habitations and suggests looking beyond the conventional approaches to address the problem (Planning Commission, 2011). Latest available figures reveal that there exist about 11,000 un-electrified remote villages and hamlets in various parts of the country. The National Sample Survey Organisation (NSSO)'s 61st Round Survey (July 2004 – June 2005) (MoSPI, 2006) shows that the use of kerosene continues to be the primary source of lighting energy for 44 per cent of rural India. More importantly, the Survey reveals the presence of large variation in energy access levels among the States in India. The electricity use statistics of NSSO 61st Round Survey indicates that while the use of electricity in rural areas is highest in Punjab (96 % of the households), it is lowest in Bihar (10%).

In order to emphasize the significance of electricity access in the development context of a region, we have attempted establishing a link between an 'access to electricity' indicator with the Human Development Index (HDI) for 17 States representing 92 percentage of the country's population. The NSSO 61st Round Survey provides data on the electrification status of sample rural households surveyed for each State and we have used the statistic of '% of sample rural households with electricity as source of lighting' as the 'access to electricity' indicator. It is evident from Fig. 1 that there exists a strong link between human development status of a State and its level of electrification. The correlation produces two clusters of States at two extremes, one with States having poor electrification rates coupled with poor HDI indices and the other with States having both higher electrification rates and higher HDI levels.

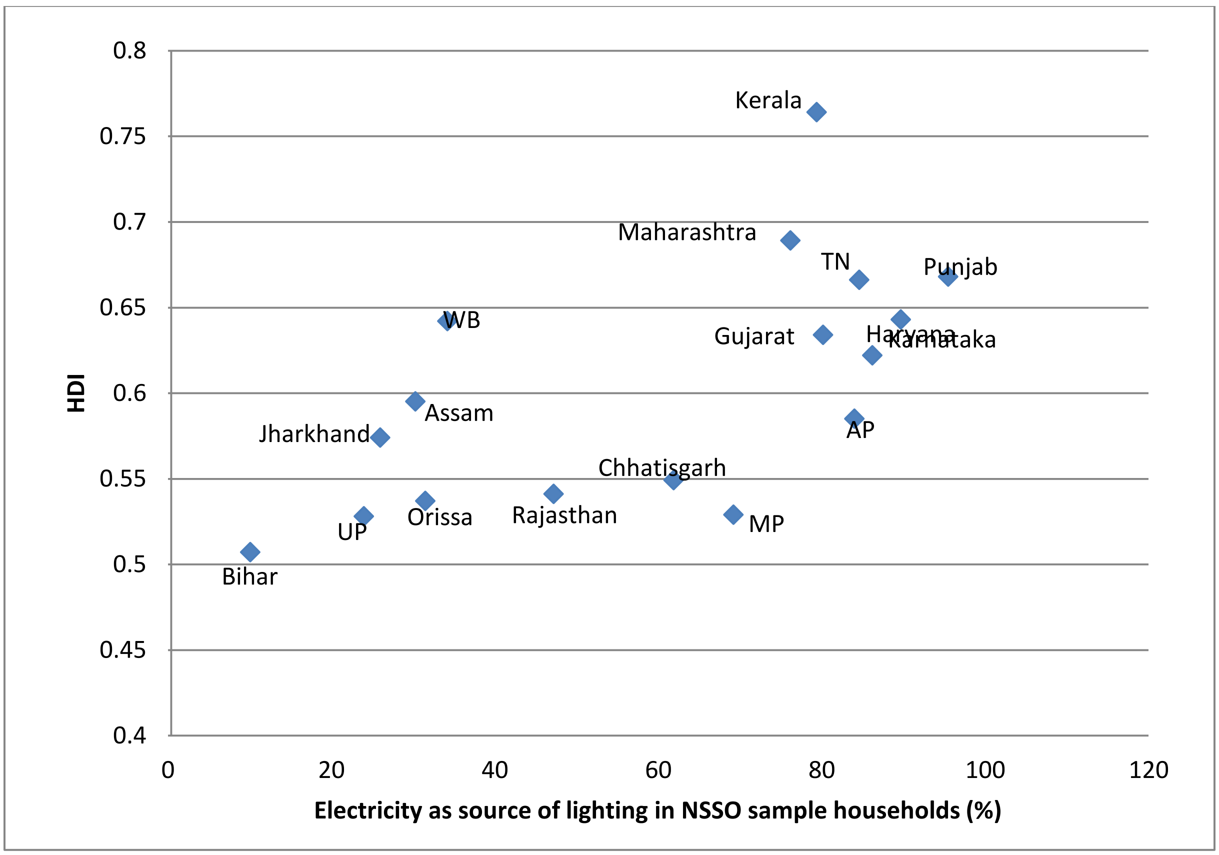

Fig. 1: Drawing a link between electricity access and the Human Development Index (HDI) in major states of India

At the national level, there are a number of policies and programmes of the Government of India (GoI) to promote off-grid electricity solutions to address the energy access challenge. The most important piece of legislation in this regard is the Electricity Act 2003 with specific provisions relating to rural electrification through off-grid modes. Further, the Integrated Energy Policy (IEP), 2006 of the Government of India reiterates that traditional biomass will be the primary fuel for rural areas of the country for a long time to come thereby indicating the need to focus on decentralised energy options. The Gokak Committee on Distributed Generation in its report asserts that decentralised renewable energy systems should be used even in areas where grid connectivity exists for the effective management of rural power distribution (Gokak Committee, 2003). Apart from macro level policy statements, a set of specific schemes and programmes[5] are also under operation to mainstream off-grid energy systems in the country. The most recent initiative in this direction is the Jawaharlal Nehru National Solar Mission (JNNSM) with its 2022 target to produce 2000 MW of off-grid power by optimizing the available solar resources of the country.

There have been a number of off-grid technologies developed, tried and inducted in India over the years. Sectoral applications of decentralised energy technologies consist of agricultural, domestic, industrial, and commercial use in both rural and urban areas. Multiple technologies such as combustion and gasification of biomass, micro-hydro, solar photovoltaic, aero generators, waste to energy bio-fuel gasification plants are used at different scales and sizes. However, biomass gasification, micro-hydro and wind have been the predominant technologies used so far in the country (Hiremath et al, 2009).

It is interesting to present the cumulative picture of off-grid energy deployment in India in recent times (Fig. 2). The portrayal of cumulative status of off-grid energy development in India demonstrates the unevenness in the annual capacity addition as reflected in the year-to-year fluctuating total cumulative capacity. It is possible that such a growth pattern is due to project level discontinuities and failure in significant numbers. It is thus worth exploring this phenomenon at a more disaggregated level and our paper makes an attempt in this

[5] E.g. Remote Village Electrification (RVE) Programme, Village Energy Security Programme (VESP) of Ministry of New and Renewable Energy (MNRE), GoI and Decentralized Distributed Generation (DDG) programme of Ministry of Power (MoP), GoI.

direction on the basis of a database of rural off-grid projects in India created from available secondary sources.

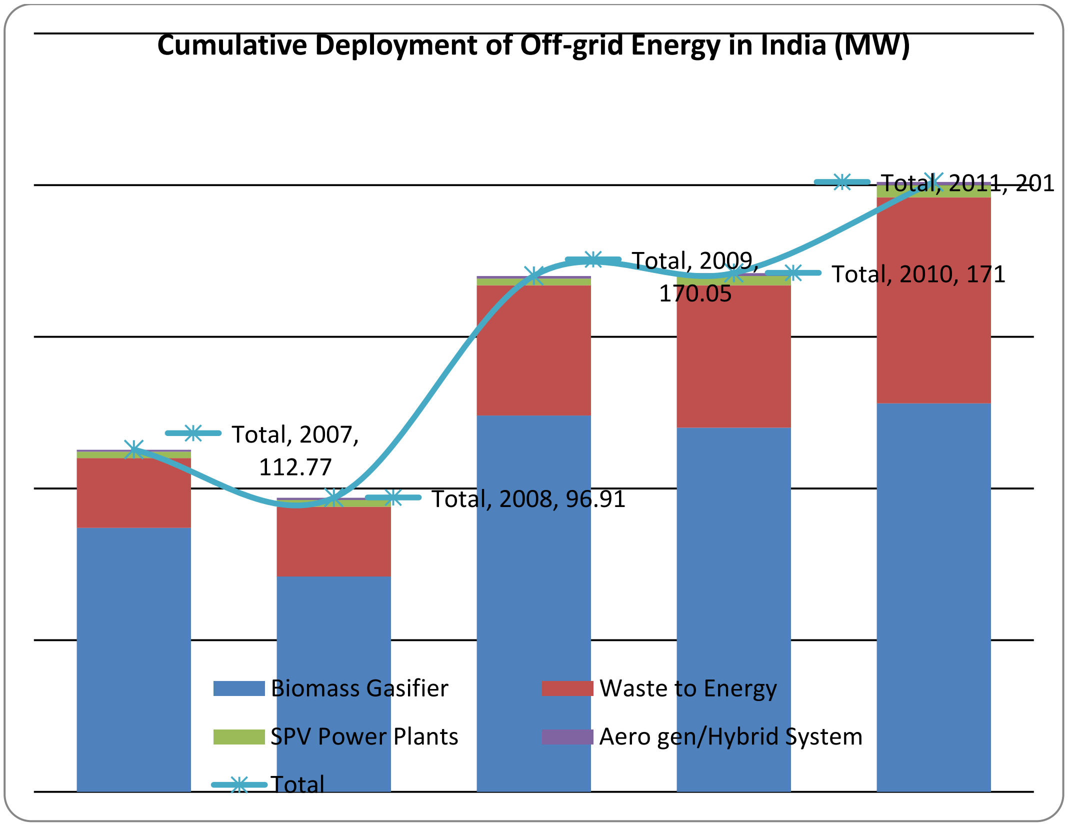

Fig. 2: Cumulative deployment of off-grid/decentralized renewable energy systems in India, 2007-11

3. Off-grid energy development in India: genesis and policy drivers

The early idea to promote and develop renewable energy in India, besides hydro energy, was mooted in the wake of global oil shocks in late seventies. An independent ministry to that end was created in 1992 – initially named as Ministry of Non-conventional Energy Sources and then rechristened as Ministry of New and Renewable Energy (MNRE) in 2006 –to accelerate the growth of renewable energy in the country. Besides, and despite the

Government of India's Ministry of Power (MoP) being at the helm in the federal system to look after rural electrification, the MNRE has been tasked from time to time to address electrification concerns in remote and far flung villages of the country (Bhattacharya, 2006).

Before the enactment of the Electricity Act 2003, rural electrification was carried out in a limited fashion and mostly bundled with other rural development programmes (Siddiqui and Upadhyay, 2011). The very first effort was undertaken during Fifth Five Year Plan (1974-79) under the banner of the Minimum Needs Programme (MNP) in which central financial assistance was made available for electrification of remote rural villages. This was followed by the Rural Electrification Supply Technology (REST) Mission, 2002 with an objective of 'Power for All by 2012'. Renewable energy based decentralised generation technologies were for the first time considered under the mainstream rural electrification efforts. During the same time, the first focused attempt by the GoI through Gokak Committee (2003) recognised the potential role of decentralised energy options in addressing India's rural electrification challenges. The efforts to mainstream renewable energy based off-grid energy systems culminated with Rajiv Gandhi Grameen Viduytikaran Yojana (RGGVY) in 2004 with its special focus on Decentralised Distributed Generation (DDG) schemes. The major Central government programmes promoting off-grids in India and with specific targets to electrify remote villages of the country are the Remote Village Electrification Programme (RVE) and the Village Energy Security Programme (VESP) of MNRE, and the Decentralised Distributed Generation (DDG) schemes of MoP. While the RVE programme seeks to meet only the lighting requirements of far flung remote villages, the VESP projects are designed to provide for the total energy needs of rural communities. The DDG schemes, on the other hand, intend to provide electricity to those villages where population is more than one hundred.

The enactment of the Electricity Act (EA) 2003 opened up new vistas for off-grid energy development in India by scrapping the licensing requirement for electricity generation and distribution in rural areas. The Rural Electrification Policy (REP), 2006 also makes explicit provisions for off-grid energy development in India. It envisages a minimum lifeline consumption of 1 kWh per household per day as a merit good by 2012.

Even though not designed for off-grid energy development per se, the off-grid application component of JNNSM envisions generating 200 MW by 2013 which would eventually be increased to 2000 MW by 2022 by utilising solar energy sources. The off-grid component of the JNNSM constitutes setting up small utility scale power plants in the rural areas and providing solar lanterns to households. The implementation of the Mission's off-grid component continues to be under RVE of MNRE. The 11th Five Year Plan is also ambitious about the development of decentralised/off-grid renewable energy based systems in the country. The Plan document envisions a physical target of producing 1000 MW of distributed off-grid renewable energy with a proposed outlay of 21000 million INR. Furthermore, for renewable energy based rural applications, there is an outlay of 22500 million INR in the 11th Five Year Plan.

A detailed mapping of all the Central government policies and programmes is presented in Annexure – I. Initiatives are also being taken at the provincial level in the form of State level policies to promote renewable energy with specific provisions for decentralised energy systems. A compilation of extracts of State level policy provisions for decentralised energy development is presented in Annexure II.

The generic organizational framework for all the public sector programmes is illustrated in the figure below (Fig. 3). In majority of cases the financial assistance comes from the MNRE/MoP at the Centre. The State Renewable Energy Development Agencies (SREDAs) act either as project implementers or as project monitors; often, NGOs or State Forest Departments have taken up this role. Technical support comes from the associated technology partners. In majority of cases, a Village Energy Committee (VEC) is formed to look after the O & M of the project. The DDG schemes operate with a slightly different organizational arrangement. In case of DDGs, the Rural Electrification Corporation (REC) acts as the Nodal Agency (NA) and a three tier monitoring mechanism ensures quality checks.

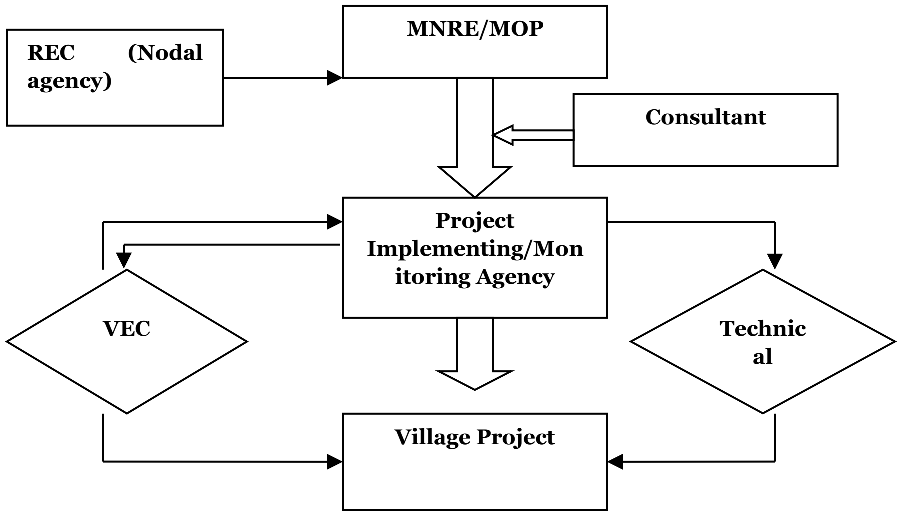

Fig. 3: Simplified organizational framework of major publicly supported off-grid/decentralized programmes

4.0 Complexity and challenges of off-grid energy interventions: need for an integrated approach

Despite the recent emphasis on supportive policy environment, multiple challenges continue to obstruct up-scaling and replication of decentralized energy systems as a means to off-grid electricity access. Studies have identified barriers operating at different levels and scales (Velayudhan, 2003; Chaurey et al, 2004, Radulovic, 2005, Miller and Hope, 2007) and have argued for an integrated approach encompassing the technical, financial, implementation and regulatory aspects (Hiremath et al, 2009; Kumar et al, 2009). Others argue that the analysis of distributed energy generation requires a systems theoretic approach where technical characteristics are viewed in broader strategic contexts and interwoven in a larger socio-economic setting (Gordijn and Akkermans, 2007).

It has also been argued that rural applications of renewable energy systems face multiple sustainability challenges related to technology, economics and community participation and that there is a dearth of literature explaining 'what exactly matters for sustainability of off-grid projects' (Hong and Abe, 2011). Kumar et al (2009) point out that installation of off-grid systems in the country generally focus on the technical components with scant attention to the long term sustainability of the project. Sustainability of project interventions have been linked to social acceptance (Sauter and Watson, 2007; Wolsink, 2011) and locally based decision making processes (Burton and Hubacek, 2007). It is further argued that three critical factors contribute to the successful implementation of rural electrification models i.e. sense of ownership, affordability, and post-commissioning support (ECN, 2005). Assessing the sustainability considerations of renewable energy technology intervention in South Africa, Brent and Rogers (2010) argue that the complex interactions between technological, economic, social, ecological and institutional sub-systems require trans-disciplinary understanding.

A recent World Bank study (2011) on VESP projects in India indicates that many of the identified problems are due to poor knowledge about local institutional contexts. Cust et al (2007) are convinced that even economically viable projects fail simply because the importance of organisational structure and institutional arrangements of those projects are not adequately appreciated and suggest aligning economic incentives with the institutional arrangements. This has also been reiterated by Mulder and Tembe (2008) in a study of the rural electrification processes in Mozambique. Mulder and Tembe argue that dynamics of institutions play a critical role in access to energy by poor and institutional quality to a greater extent determines the effectiveness of economic and technical solutions.

It is evident from the above discussion that mainstreaming renewable energy based off-grid energy systems in rural settings is challenging and requires nuanced understanding of a whole gamut of factors operating at different scales. Moreover, and equally important, is the issue of local sustainability impacts of renewable energy interventions which has not been adequately examined in the existing literature.

Significantly, the need for an integrated approach to formulating off-grid energy programmes is recognized at the policy level in India. This realization seems to have evolved over time and the experiential learning gained from the implementation of a particular off grid energy programme has typically fed into the formulation of the succeeding programme. For instance, RVE, which is one of the earliest programmes in the field of off-grid energy development in India, recognises the role of local institutions and emphasizes on the vertical co-ordination among institutions at different scales. The approach to integration has been taken up to the next level in the succeeding programme i.e. VESP, which, inter-alia, stresses on local level community participation and recognises the need for firming up institutional arrangements at the local level. Thrust is also placed to capture inter-regional variations with regard to resource availability, energy requirements, and social cohesion among local communities. The programme went a step ahead in focussing on the need for enhancing productive activities through micro-enterprise developments in project localities. Even more progressive is the DDG scheme of MoP which explicitly recognises carbon credits from off-grid energy systems as potential inducement for private investors to foray into the rural energy business.

However, despite policy level attempts to coalesce factors in a holistic fashion in the ambit of programme designing and implementation, there still seems to exist some missing links and an incomplete understanding of the sustainability dimensions of decentralized/off-grid energy interventions in rural India. The next section highlights the key anomalies and gaps in the existing approaches.

5. Sustainability dimensions of decentralized/off-grid energy interventions

In order to gain further insights on the operationalization aspects of off-grid/decentralized energy development in India, we examine three key ingredients i.e. policy support, rural energy markets and community participation. The emphasis here is to identify gaps and inherent contradictions hindering the sustainability of off-grid/decentralized energy interventions in India.

a. Addressing policy inadequacy and institutional constraints

A critical evaluation of the policy statements suggests that the problems besetting the development and promotion of decentralized/off-grid energy in India may largely be due to a lack of policy focus and certain ambiguities in the existing policy framework. To start with, the review of policy documents and legislative pronouncements in India reveals a diluted and mixed articulation of what is meant by either a decentralised or an off-grid energy system. Accordingly, a varied and loose interpretation seems to have been adopted, mostly drawing from the experiences and industry practice[6]. Secondly, policies are often found to be ambiguous on technology choice and there is evidence from the field to suggest inappropriate technology selection[7]. Third, financial arrangements for promotion of decentralized energy systems have been found to be not based on any valid logic – such as, the emphasis on capital component of a project with scant attention to its O&M costs.

Often, juxtaposing a policy or programme with the existing legal and political institutions have led to confusion. For instance, as per the 73 Constitutional Amendment Act, village panchayats are responsible for providing drinking water and street lights in the villages. In case of off-grid energy based village electrification, panchayats are hardly found to pay for the service offered by the decentralized energy facilities (World Bank, 2011). This raises debates regarding the provisioning of basic village level services through off-grid energy systems and the role and contribution of village level constitutional entities.

Organizationally also, there seem to be lack of co-ordination between MoP and MNRE in implementing two key off-grid rural electrification programmes i.e. DDG and RVE. As per the design principles of these two programmes, the Rural Electrification Corporation (REC) is supposed to maintain the liaison in order to avoid any kind of implementation hurdles. The current arrangements do not reveal any such co-ordination (Siddiqui and Upadhaya, 2011).

A comparison of India's off-grid energy programmes (Table 6; Annexure III) reveals some key differences in their operational features. On the finance front, for instance, all programmes except for JNNSM have a capital subsidy component, which is 90 % the total project cost. Under JNNSM scheme, MNRE provides 30 % of the benchmark costs as capital subsidy and 50 % of the benchmark costs (150 INR/Wp) is eligible for a loan at 5 % interest per annum with the user making a down payment of 20 % of the benchmark cost. Differences can also be observed in the matters of technology preferences, energy applications and recognition of carbon financing benefits. On technology front, while solar

[6] Even the current literature on the topic does not offer a consistent definition and several terms e.g. decentralised energy, distributed energy, off-grid systems and standalone systems are used interchangeably to connote on-site production of energy at a small scale. An oft cited definition is that of IEA, which defines distributed generation as 'a generating plant serving a customer on-site or providing support to a distribution network and connected to the grid at distribution level voltages'.

[7] Siddiqui and Upadhaya, (2011) find despite having abundance biomass availability, villages are electrified through solar powered systems .

has been the preferred technology in RVE and JNNSM, VESP on the other hand emphasizes on biomass based technology. On the other end, DDG is neutral in technology selection matters. Similarly, comparing on the basis of energy applications reveals that the design principles of all the programmes except VESP target to meet lighting needs. The VESP on the other hand intends to provide the total energy needs of the users. Finally, there also exist differences in carbon benefit recognition from projects. Except DDG of MoP, no other programme explicitly mentions the benefits of carbon financing schemes.

Policies and regulation at the State level are mostly designed to propel grid-interactive renewable energy with very little focus on decentralized or off-grid renewable energy systems. As is the case at the level of central ministries, the policy documents at the State level provide no clarity on what constitutes 'off-grid renewable based energy systems'. Some of the central regulatory guidelines seem to have not been considered in true spirit by the States (e.g. safety and security standard specifications of EA, 2003 have been grossly unheeded by state agencies). Expectedly, political compulsions have often driven policies (e.g. subsidies on kerosene) against the stated goals of the government.

From the above, it appears that there is a critical need for strengthening policy and institutional arrangements at all levels of energy governance to capture the associated dynamism of the sector's growth and development. It is also felt that there is a need to bridge the regulatory gaps by bringing in place an effective regulatory screening mechanism, streamlining administrative processes and getting rid of market barriers. In a dynamic context, where technology leapfrogs and liberalization process fast alters the operational dynamics of the sector, the need of the hour is to create more accommodative policy space to support new innovations and to move in a sustainable development trajectory.

b. Promoting rural energy markets and off-grid entrepreneurship

Certain economic and strategic factors have created a possible niche for business communities to foray into rural energy markets in India. Private efficiencies and entrepreneurships are believed to have the potential to upscale the rural energy business through decentralised energy interventions. A rural energy entrepreneurship is often distinguished from the standard entrepreneurship as it often starts as a social enterprise. At the international level, REDCO Alliance and Energy Access Foundation (EAF) have been pivotal in catalysing the rapid growth of rural energy business in many countries.

There exist enormous opportunities for small and medium scale investors to engage themselves in decentralised clean energy business in emerging economies like India. Bairiganjan et al (2010), for instance, estimate the business potential of such services at around 94 billion INR per year. This unlocking of rural energy markets has been made possible due to the changes in the legal and regulatory landscape governing the decentralised sector, which has created the required legal and regulatory space for private entrepreneurs. The enactment of EA 2003 and consequent withdrawal of the licensing requirements for generation and distribution of electricity for rural areas has been the key legal enabler driving the private enterprise in the sector.

A significant part of rural energy entrepreneurial activity is happening with large-scale dissemination and installation of solar home systems (SHSs). SELCO in India has been the forerunner in making a successful social enterprise model through its SHSs intervention. By leveraging the model of micro-financing and rural banking through innovative financial modalities, SELCO has been able to install more than 115000 SHS in different parts of India so far. Other noteworthy examples are the successes achieved by the Husk Power System (HPS) and Saran Renewables operating in remote rural parts of the States of Bihar and Uttar Pradesh.

However, it appears that the policy makers and planners have not able to adequately appreciate the role and potential of private business in rural energy services. High transaction costs of accessing government support have been a key inhibiting factor for private entrepreneurs, and to address this, the information exchange between government and private players needs to be further enhanced. Non-uniformity of State policies and provisions on certain key strategic matters are also limiting the growth and development of off-grid energy systems in the country.

c. Building community capabilities

Community participation is unequivocally considered crucial for effective deployment of off-grid energy projects. The dominant decentralised energy models prevalent in India revolve around the premise of strong community involvement in project management. Considering the rich diversity of the country, needs and capabilities of communities would differ significantly across regions. Project implementation and operation modalities, when critically linked to community level engagement, need to be contextualised at the local scale and take explicit account of the diverse sources of heterogeneity within and among communities. Community level heterogeneity has significant implications for engineered processes towards achieving community ownership of projects. The capacity building component of existing off-grid energy programmes need a deeper and more participatory approach to community mobilization than is often observed in practice.

6.0 Project level decision-making for sustainability - insights from the field

While the above section highlights the key sustainability dimensions of off-grid/decentralised energy development in India from a macro level perspective, the present section goes into the project level evaluation and strives to understand the basic conditions that have largely shaped off-grid project viability on a sustained basis in the country. Based on secondary sources, the evaluation covers 74 cases of off-grid/decentralized project interventions from India8 that include a range of technologies such as biomass, solar, micro-hydro, small wind and hybrid systems. There is considerable variation among the projects in terms of geographical locations, use of technology, size of the plants, tariff structures, ownership and management arrangements, etc.

In order to 'ground truth' the desktop research on the above off-grid cases, we conducted field visits to six project sites and investigated the fundamental conditions shaping the project operation and management. The details of the field sites and key operational attributes of the projects are presented in the following table.

[8] The information collection and analysis is carried out under a specific methodological framework. The initial activity was the scoping exercise of case profiles of off grid energy interventions by mining all the possible secondary information. This was followed by some select field visits and a series of expert interviews, both direct and telephonic. In order gain further insights at a collective level, a participatory workshop was conducted and preliminary findings of this study were presented and discussed with different stakeholder representatives in the workshop.

Project name	Technology	Size of the Plant (kW)	Ownership	Funding
Rampura	Solar	8.7	Community	Non-govt.
Radhapura	Biomass	10	Community	Govt.
Tamkuha	Biomass	33	Private	Private
Amthagouda	Micro-hydro	20	Community	Non-govt
Karlapeta	Micro-hydro	25	Community	Non-govt
BERI	Biomass	1000#	Government	Mixed

Table 1: Key features of visited field sites

Cumulative capacity

A statistical profile of the database of selected cases is presented in Table 2 with information related to the type of technology, size of the plant, implementing entity, source of finance, and energy applications. A majority (53%) of the projects are based on biomass gasification technology and mid-sized plants, ranging between 11 to 50 kW, constitute more than 50 % of the cases. There is variety in terms of project implementing entities (e.g. VECs, NGOs, state nodal agencies and in some cases private business entities) but in majority of cases either VEC or NGO is the implementing agency. Though private entrepreneurship is believed to possess lot of potential in the rural energy business, the database has only 10% of cases implemented by private entities. We categorize the source of funding into three major groups i.e. government, non-government and mixed. Nearly half of the cases in the database have funding from non-government sources. On the basis of energy applications, the database has 40% of the selected cases demonstrating clear income generating links.

Technology	%	Plant Size	%	Implementing Agency	%
Biomass Gasification System	52.7	Less than or equal to 10 kW	24.3	VEC & NGO	66.2
Micro-hydro	24.2	11 to 50 kw	51.4	State Agency	23.0
SPV & others	23.1	Above 50 kw	24.3	Private Company	10.8
Source of Funding	**%**	**Policy Link**	**%**	**Income Generating Link**	**%**
Government	37.8	States with Policy Links	62.5	With links	39.2
Non-government	48.6	States without any Policy Link	37.5	No links	60.8
Mixed	13.5				

Table 2: A statistical profile of selected case study projects

A key challenge in preparing the database for analytical work was to identify each project's current operational status. This was an intensive exercise and we have largely relied on expert information to categorize projects as operational, partially operational and non-operational. The database has 61% of cases under the operational category, which allows us to take the analysis to the next level of identifying key determinants.

Going by the discussion presented in earlier sections of this paper, operational viability of off-grid projects in the Indian context are largely determined by policy support, social acceptance in the form of community participation, linkages with income-generating opportunities, and technological appropriateness. To incorporate the policy dimension to our database, we took the geographical location of each off-grid case and mapped the project to State-specific decentralized/renewable specific policies (or elements of it)[9]. It was found that in 62.5 % of cases, there exists some kind of policy support to promote and develop off-grid energy development in the concerned State. This percentage figure goes up to 67% if we consider only those projects which are currently operational; more interestingly, nearly 60% of the projects currently non- or partially operational seem to have suffered because of lack of policy support.

The critical role of policy support in determining the success of a project was strongly emphasized in our interactions with project developers during the ground truthing exercise. The consensus is that macro-economic policy enunciation must be strengthened with local mechanisms for continuous monitoring and accountability frameworks, specifically for government owned and operated projects. Further, the interactions with stakeholders reveal that regulatory uncertainty and vacuum can be stifling to the growth of these projects and that the current paradigm of ad hoc and piecemeal dispensation to regulation produces sub-optimal outcomes. Policies at the local level are perceived as major determinants of project outcomes and often developmental policies integrative of off-grid elements form the policy foundation for many of the off-grid energy systems. The flip side of this is that in-congruencies in the local governance structures act as impediments to project development.

It is generally accepted that the success of off-grid/decentralized energy systems largely depends on the ability of such projects to generate local income generating opportunities. Our case-based analysis supports this proposition and the field visits made it clear that often people prioritize livelihood opportunities over other energy needs. For instance, in Radhapura, energy requirement for irrigation purposes are given high preference over lighting needs. Even in projects run by private initiatives such as husk power systems operating in UP and Bihar, there is every effort to create additional sources of income through the project intervention.

Another crucial element which has been prominently highlighted in the literature is with regard to community participation in project activities, which in some cases is expected to culminate with community ownership of the project. In the current paradigm of off-grid

[9] Even though it is hard to find any specific policy operating at the state level to promote decentralized based interventions, policy 'strings' can be traced in other provincial policies (mostly state specific renewable energy policies) specifying the need and importance of decentralized energy development in the state.

systems in India, largely dominated by government funded schemes, community participation has been assigned a significant role in project management. Such a premise, however, seems to be challenged in practice by the reality of capacity constraints among communities, local level conflicts, and 'elite capture'. In our analysis of the 74 case studies, only a fourth of the operational projects are characterized by community participation and the remaining are largely led by private enterprise. Interestingly, the majority (55%) of the non- and partially operational cases in our database also do not have community participation; hence, it would be erroneous to make any straight-forward conclusion regarding the role of communities. From our ground-truthing exercise covering six projects, we found that in two cases – Radhapura and BERI – there is evidence to suggest that community participation has failed its premise. While in Radhapura societal conflicts have inhibited community participation, the BERI project operational in Karnataka has experienced a shift from community-led management to a professional management body. On the other hand, the success of private initiatives like HPS in Bihar suggests that there are viable alternatives to community participation in off-grid project design.

Unlike community participation, the database gives reason to link more definitively a project's source of funding with the project's long-term viability. For operational projects as well as the other category of non- and partially operational projects, government funding has clearly not been fortuitous in the majority of cases. The reason may be found in the soft-budget syndrome identified in public finance literature. With guaranteed funding and lax monitoring, government funded projects are said to operate under soft budget constraint conditions, which inevitably leads to weak budgetary discipline by project developers and implementers. Moreover, a majority of public funded projects grossly fail on after sale service and poor maintenance structures.

It can be discerned from the diagram below (Fig.4) that size of the plant impacts the success of the project. It appears from the analysis that there is a minimum defining size which can have definite impact on the success of the project. Projects with a mean size more than 20 kW are found to be more viable indicating that very small sized plants may not be able to fulfill the basic energy needs of a community, especially in a dynamic context when such needs grow and change over time.

	Technology		Size		Funding Source		Community Participation		Income Generating Linkage		Policy Linkage	
Case Types	Biomass	Otherwise	< 10 kW	>10 kW	Govt.	Non-govt., and Mixed	Exists	Not Exist	Exist	Not Exist	Exist	Not Exist
Operational (61 %)	47	53	22	78	24	76	24	76	47	53	67	33
Non-operational and Partial Operational (39 %)	79	21	28	72	59	41	45	55	28	72	41	59

Table 3: Distribution of case profiles based on operational status (%)

Next step in the analysis is to examine the comparative position of both the groups i.e. operational as well as non- and partially operational in a holistic manner. Figure 4 reveals some interesting insights. Operational projects are found to be dominantly spread across all the variables save community participation. This indicates that projects that are operational are often large sized, with primary source of funding from non-governmental agencies and having strong income generating and policy links. Comparatively, the performance of non-operational and partially operational cases on the six key variables appears to be skewed with weak policy support, minimal income generating links and modest community participation.

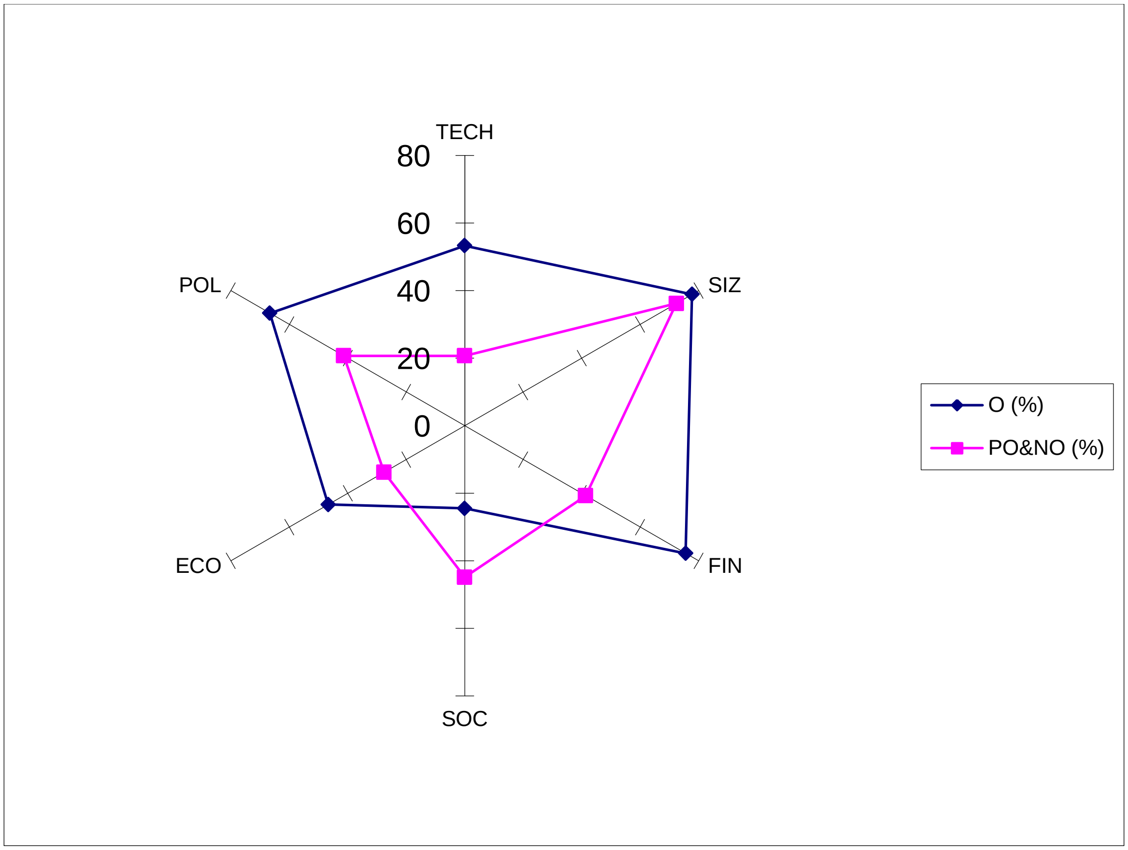

Fig. 4: Comparative performance of Operational and Non-operational and partially operational cases on key sustainability dimensions

7.0 Business models for off-grid energy systems

The above analysis makes it clear that successful off-grid interventions are based on much more than techno-economic assessment. A meaningful business model would need to factor in the whole set of constituent elements such as choice of technology, scale of the project, type of policy support, role of community, income linkages and funding sources. The integration, moreover, would need to feature in a dynamic framework that is able to account for multiple interacting drivers at different scales of the social, economic and institutional context in which the intervention is planned.

It is proposed here that the business case for an off-grid intervention should start by looking at the local context. A useful approach may be to distinguish between the set of determinants that are generally context dependent and those which are context neutral. Choice of technology, social acceptance and ownership, and economic linkages are essentially context specific outcomes in the project cycle of an off-grid intervention. At a more macro level and as exogenous influences, we have policy support and institutional financing.

Considering technology choice to be partially neutral and to some extent driven by external determinants, the choice of intervention would primarily be determined by two crucial locally embedded elements i.e. strength and ability of local community structures and economic linkages. In terms of a conceptual framework, community structures can have two extreme forms i.e. one deeply cohesive, well organized and having genuine interests to participate in the project operation and management, and the other largely disorganized, fractured, sabotage prone and passive to the project matters. Economic linkages can have similar characterization with two extreme types: one with easy market access, vibrant local economy, and the other remote and opportunity constrained. Figure 5, with its four quadrants, not only captures the combinations of these extreme varieties of the two context dependent determinants, but also allows us to contextualize in terms of intermediate combinations with varying degrees of heterogeneity. Such contextualization, in turn, establishes the need for a non-uniform and context-relevant approach to decision-making in off-grid energy interventions.

Figure 6 presents a decision hierarchy or 'tree' for sustainable off-grid energy projects. It consists of six essential stages and, importantly, decisions arrived at each stage are fed into the next stage in the process.

Given the framework of Fig. 5, one can possibly map the various contextual reference points to a continuum of off-grid energy services ranging from one extreme of that of a 'merit' good to the other extreme of fully marketable services. Once the nature of services is identified, the next step in the hierarchy is about the decision on the scale of project intervention. This can be facilitated through a baseline assessment of the specific context for its energy needs and productive potential; the dynamic character of the context may be introduced through the technique of scenario building and future scenarios may range from the most plausible to a 'surprise'.

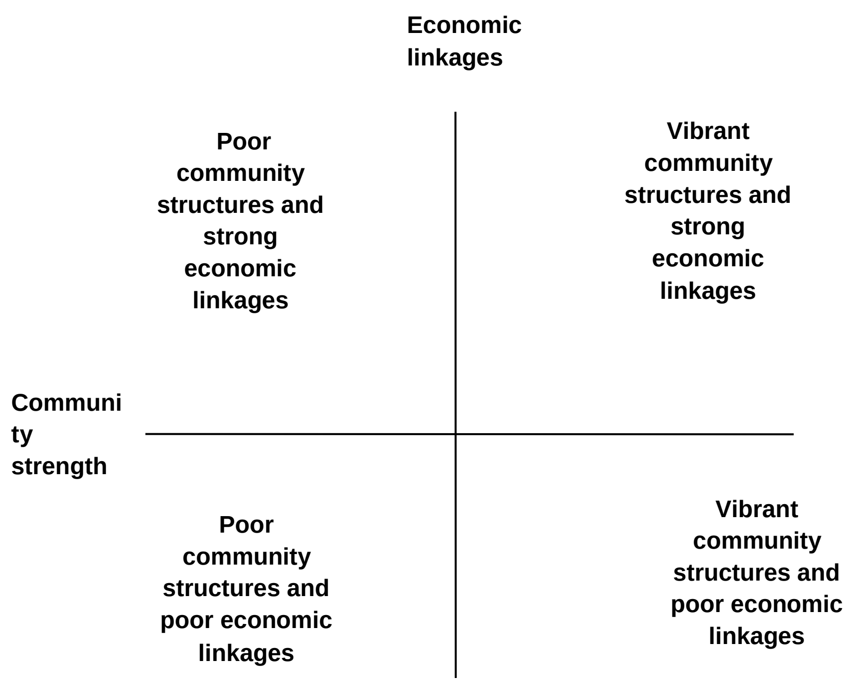

Fig.5: A graphical exposition of possible combinations of community structures and economic linkages

Step three in the decision tree is the evaluation of appropriate technology, which would require the application of the multiple criteria technique. The criteria would include resource availability, local supply chain, community capabilities, policy strength, scale of the intervention, and other supporting factors. An appropriate multi-criteria decision tool considering the above identified factors can decide on the appropriateness and relevance of technology type/s with respect to the context and scale. Following the multi-criteria analysis, alternative technology types can be made subject to cost effectiveness analysis to arrive at a final decision on technology selection.

The final stage of decision making involves issues related to finance and the choice of an appropriate financing mechanism. Here, we would need to refer back to the mapping done in stage one, in which the context defines the nature of off-grid energy services to be provided. It is hypothesized that the choice of finance would be determined by the characterisation of the off-grid energy service. If the context defines the services to be fully marketable, one would expect private investment to be forthcoming given the appropriate policy support. On the other hand, if the context is such that the off-grid energy services are best viewed as a 'merit' good, it would be justified to expect public investment in the project. In between these two extremes, off-grid energy services would require a mixed form of financing which may be linked to varying gradients of transition depending on the dynamism of the context.

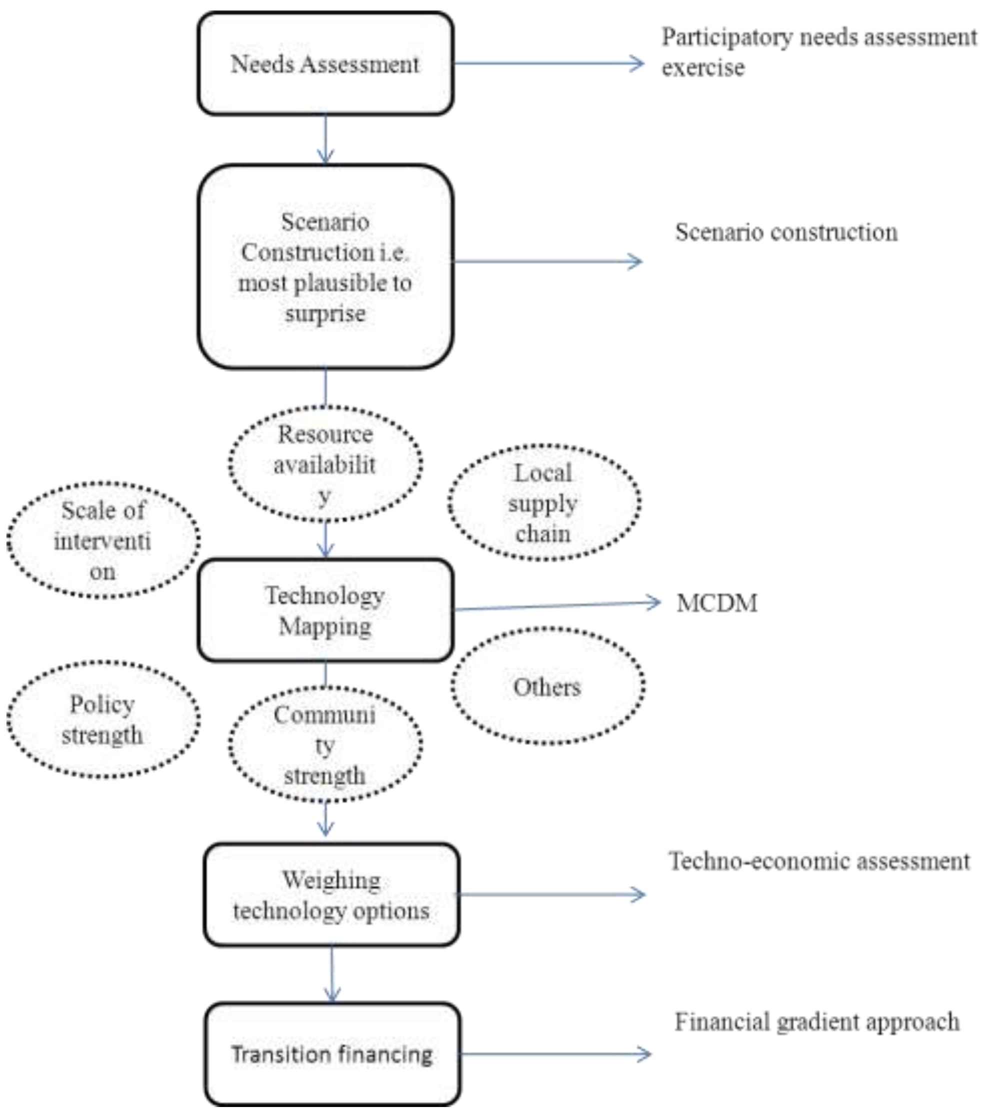

Fig. 6: Decision hierarchy of the proposed framework

8.0 Conclusion

Despite efforts at all levels i.e. government, donor agencies, and private players, multiple challenges continue to obstruct up-scaling and replication of decentralized energy systems as means to off-grid electricity access. The problem seems to lie in overemphasising the techno-economic angle of development of these systems without adequate attention to other critical determinants. Of late, though policies and programmes have started increasingly recognising the complexity and multi-dimensionality of challenges in mainstreaming renewable energy based decentralised interventions, they are falling short of addressing core sustainability concerns. The present analysis reveals that operational viability of off-grid projects in the Indian context are largely determined by policy support, social acceptance in the form of community participation, linkages with income-generating opportunities, and technological appropriateness. The key pointers coming out of our analysis are that: a) macro-economic policy instruments must be aligned with local accountability mechanisms, specifically for government owned and operated projects; b) at the project level, key choices related to technology selection and scale of intervention need to emerge from an understanding of the context; c) the context itself is a variable depending on community structure and local economy; and, d) financing of a project may be linked to the nature of energy services defined by the context.

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Annexure – I

Programme/ Policy	**Key Elements**
The Gokak Committee Report, 2003	- Decision between grid extension and distributed generation should be based factors such as distance from exiting grid, load density, system losses, and load management. - Appraisal process of distributed generation schemes should consider the accrued socio-economic benefits. - Considering the poor quality of grid supplied power in many villages, such villages should be encouraged to have distributed generation facilities.
The Electricity Act, 2003	- Prescription for a National policy on standalone systems for rural areas and non-conventional energy systems "The Central Government should notify a national policy permitting stand alone systems (including renewable energy and other non-conventional systems) for rural areas" (Section 4). - Obligation of the State Government to supply electricity to all areas including villages and hamlets (Section 6). - Exemption of license on recommendation of State Government for local Authority, *Panchayat* Institution, Co-operative society, Franchisees. - No licensing requirement to generate and distribute electricity in rural areas (Section 14: Eighth Proviso)
Rural Electrification Policy, 2006	- For villages and habitations where grid connectivity would not be feasible or not cost-effective, off-grid solutions based on standalone systems may be taken up..." (Para 3.2). - District Committees would be formed at the district levels to facilitate rural electrification projects both stand-alone systems and grid extension and local management projects. - Exempted person under eighth proviso of Section 14 of EA, 2003 would be free from the purview of Appropriate Commissions in matters pertaining to determination of tariffs and universal supply obligations applicable to licensees (Para 8.5). - Provisions of Act relating to technical standards and safety measure shall continue to be applicable (Para 8.5). - The retail tariffs for electricity supply by persons exempt under eighth proviso to section 14 would be set based on mutual agreement between such person and consumers (Para 8.6). - Given the micro-enterprise nature of the projects, it is presumed that competitive market forces ensure reasonable prices reflecting actual costs (Para 8.6). - Benefits of financial assistance or subsidies by the government should be fully passed on to the consumers (Para 8.6). - Special enabling dispensation for standalone systems up to 1 MW (Para 8.8). - Institutional arrangements for back up services and technical support to systems based on non-conventional sources should be created by State Governments (Para 8.9)

Table 4: Recent policy landscape governing the off-grid energy development in the country

Annexure - II

State	Specific Policy	Relevant Policy Element
Arunachal Pradesh	*Small Hydro Power Policy, 2007*	- The project classifications in the policy speak about the standalone systems. The Category III projects i.e. projects having installed capacities of 100 kW shall be designed on standalone mode dedicated to a village or habitat directly distributing power to the households without high tension systems.
Chhattisgarh	*Policy Directives and Incentives for Small Hydel Projects, 2002*	- One of the eligibility conditions is that "If the applicant/company shall be providing benefits of the plant to un-electrified villages and the schemes envisages wheeling for this purpose; preference shall be given to such applicant/company.
	Energy Policy of Chhattisgarh Government	- One of the objectives is to electrify all villages/Majras - The policy also says that villages located in remote tribal areas where conventional electricity is not possible, non-
Himachal Pradesh	*Policy on Small Hydro and Other Renewable Source of Energy, 2006*	- One of the considerations is to " provide decentralised energy supply for households, agriculture, industry, and commercial purposes in the remote and tribal areas
J & K	*Policy for Development of Micro-Mini Hydro Projects, 2011*	- The main objective of the project is to provide a solution to the energy problems in remote and hilly areas where extension of grid system is un-economical or un-viable
Kerala	*Renewable Energy Policy*	- One of the objectives of the policy is that "decentralised and micro-level power generation through renewable energy
Karnataka	*Karnataka Renewable Energy Policy, 2009-14*	- One of the objectives speaks about producing power through decentralized and micro level power generation renewable energy sources to provide energy supply to agriculture, industry, commercial and household sector".
Punjab	New and Renewable Sources of Energy Policy – 2006	- One of the objectives is to "provide decentralised energy supply for agriculture, industry, commercial and household sector

Rajasthan	*Rajasthan Solar Energy Policy, 2011*	- Specific mention about decentralised off-grid solar applications - Mention about state's consideration for incentives to promote decentralised and off-grid solar applications
Uttarakhand	*Uttarakhand State Government Policy for Harnessing Renewable Energy Sources, 2008*	- One of the objectives of the policy is to "provide decentralised energy supply to agriculture, industry, commercial, and household sector. - State government should support and promote to harness the biomass based decentralised energy production in the state

Table 5: State policies with provisions for off-grid energy development

Annexure – III

Program	Eligibility Condition (s)	Physical target	Achieve ments	Responsi ble Ministry	Techn ology Prefere nces	Energy Applic ations	Decisions on Tariffs	Implementing Agency (Project)	Ownership Structure of the project	Financial Arrangement	O & M	Recognition of Carbon Finance
RVEP, 2003	Villages with a populatio n of 100 inhabitant s	To electrify about 10000 remote villages	6446 remote villages and 1587 remote hamlets have been electrified so far.	MNRE	Most adequa te energy techno logy (no clear guideli ne). Howev er 95 % of the village s electrif ied are throug h solar photov oltaic system s	Lightin g	PIA	State Nodal Agencies	Community	90 % of the capital subsidy from MNRE	State Implementin g Agencies. Financial grant includes a five year Annual Maintenance Contract with the supplier	Not recognized as such

VESP	Village should be a minimum of 50 and maximum of 400 HHs	To electrify remote and inaccessi ble 1000 villages and meet the total energy needs of villages	700 kW of capacity has been created and 79 VESP projects have been sanctioned.	MNRE	Bioma ss & Bioene rgy is prioriti zed	Total energy require ments of cookin g, electric ity and motive power	VEC and project implement ing agencies will decide tariff	Govt. Deptt (e.g. Forest Deptt.) NGOs	Village Energy Committee/ community ownership	One time grant upto 90 % of the project cost subject to Rs 20,000 per beneficiary. Rest as equity contribution in terms of cash or kind (User charges)	O & M Support fund to cover 2 years of operation and management . It shall be 10 % of the total project cost	Possibility of carbon finance is partially recognized.
DDG, 2009	More than 100 HHs	No clear guideline	No informatio n available	MOP	Techn ology neutral but a hierarc hy is sugges ted	Lightin g	Tariffs will be decided by the implement ing agency	SREDAs/State Deptt./State Utilities/Identi fied CPSUs	State Governmen t	90 % of the project cost as subsidy and rest 10 % will be arranged by the implementing agency	Cost of spares for five years after commissioni ng (excluding the cost of consumables and labor) is included as the project cost	Yes, through bundling up of projects

JNNSM , 2009-10	Various off-grid solar photovoltaic systems/applications up to maximum capacity of 100 kWp per site. For mini-grid, a maximum capacity of 250 kW will be supported	The programme will be a part of the RVEP and targets to electrify 10000 remote villages	33 MW has been sanctioned by Jan 2011. 300 villages have been electrified and 7000 HHs have been provided home lighting systems.	MNRE	Solar	Lighting/electricity/power, heating /cooling	No clear guideline	State Nodal Agencies/ Akshay Urja Shops	Community	MNRE will provide 30 % of the benchmark costs as capital subsidy and 50 % of the benchmark costs (Rs 150/Wp) will be eligible for a loan at 5 % per annum. The user must pay a down payment to the tune of 20 % of the benchmark cost.	Warranty of five years	Implicit recognition is there

Table 6: Off-grid energy development program and their key features

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Disclaimer

The views expressed in this report are those of the authors and do not necessarily represent the views of the institutions they are affiliated to or that of the funding agencies.

OASYS South Asia project

The Off-grid Access Systems for South Asia (or OASYS South Asia) is a research project funded by the Engineering and Physical Sciences Research Council of UK and the Department for International Development, UK. This research is investigating off-grid electrification in South Asia from a multi-dimensional perspective, considering techno-economic, governance, socio-political and environmental dimensions. A consortium of universities and research institutes led by De Montfort University (originally by University of Dundee until end of August 2012) is carrying out this research. The partner teams include Edinburgh Napier University, University of Manchester, the Energy and Resources Institute (TERI) and TERI University (India).

The project has carried out a detailed review of status of off-grid electrification in the region and around the world. It has also considered the financial challenges, participatory models and governance issues. Based on these, an edited book titled "Rural Electrification through Decentralised Off-grid Systems in Developing Countries" was published in 2013 (Springer-Verlag, UK). As opposed to individual systems for off-grid electrification, such as solar home systems, the research under this project is focusing on enabling income generating activities through electrification and accordingly, investing decentralised mini-grids as a solution. Various local level solutions for the region have been looked into, including husk-based power, micro-hydro, solar PV-based mini-grids and hybrid systems. The project is also carrying out demonstration projects using alternative business models (community-based, private led and local government led) and technologies to develop a better understanding of the challenges. It is also looking at replication and scale-up challenges and options and will provide policy recommendations based on the research.

More details about the project and its outputs can be obtained from www.oasyssouthasia.dmu.ac.uk or by contacting the principal investigator Prof. Subhes Bhattacharyya (subhesb@dmu.ac.uk).

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