Solar Mini-Grids for Rural Electrification

A Roadmap to 100% Energy Access for India@75

Shruti Mahajan Deorah & Leena Chandran-Wadia

Observer Research Foundation Mumbai

Ideas and Action for a Better India

SunEdison's 14 kWp mini-grid in Meerwada, Madhya Pradesh

Gram Power installation in Khareda, Tonk dist., Rajasthan

Gram Oorja's 10 kWp mini-grid in Darewadi, near Pune, Maharashtra

A Solar PV plant installed by LREDA in Ladakh

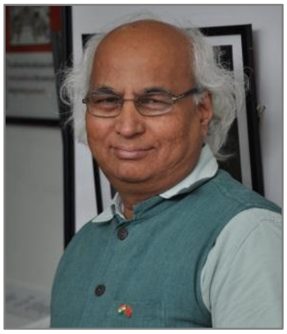
Front cover:

Solar Resource (global horizontal irradiation) map of India — from solargis.info
http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-India-en.png

Kerosene lantern — picture courtesy of Kevin Gessner on Flickr
Solar PV panels — 100 kWp plant at Tangste, Ladakh; picture courtesy of LREDA

Map Legend:

PREFACE



A Revolution Waiting to Happen

Sudheendra Kulkarni
Chairman
Observer Research Foundation Mumbai

SOLAR POWER is India's future. The future is beckoning India. And India must embrace the future with alacrity.

That India is facing a severe power shortage is well known. People and businesses in many countries in the West and the East take 24x7 power supply for granted. In India, growth-crippling power cuts are a common occurrence in most parts of the country. The peak power shortage is growing; in 2013 it is over 10 per cent. In some regions, such as in southern states, it is more than 26 per cent.

The power sector is beset with many problems. About 25% of India's power generation capacity remains unutilised due to fuel scarcity, inefficient equipment and maintenance shutdown. The problem is worsened by huge losses in transmission and distribution. Add to this our country's growing dependence on import of high-cost coal, which continues to be the principal fuel for power generation, and we get a scenario of rising prices of inadequate power from conventional – read, polluting – sources.

The scale of the problems of import burden and pollution gets immensely magnified when we take into account India's huge dependence on oil from alien sources to meet its rapidly growing energy needs.

Obviously, today's crisis-ridden power sector cannot help India achieve her three inter-related goals: double-digit GDP growth rate, which is essential for poverty reduction and large-scale employment generation; socially and geographically inclusive development; and protection of the environment.

The crisis in the power sector is particularly hurtful to the people in rural India, where nearly two-thirds of India's 1.2 billion people still lives. According to the 2011 census, nearly one-third of the country's population – 80 million households accounting for over 300 million people – does not have access to electricity. Most of them live in villages. 77 million of them still depend on kerosene for lighting!

Despite its claims of success, the rural electrification campaign by successive governments has so far made a limited impact on this grim situation. Nearly one-sixth of India's six-lakh villages and hamlets are still not electrified. In many of those villages that are declared as "electrified', not all the households have access to electricity. And of the rural households that do have access to electricity, their actual power consumption remains quite low.

I recall here a book written by V. S. Naipaul, the celebrated Nobel laureate writer. ***'An Area of Darkness'*** it is the title of a travelogue describing Naipaul's travels through India in the early sixties. As far as the unelectrified section of our population is concerned, doesn't India continue to remain, at night, an area of darkness?

• • •

How can India – especially rural India – surmount its power crisis? The answer is self-evident. And it is persuasively presented in this study by my colleagues Shruti Mahajan Deorah and Dr. Leena Chandran-Wadia.

This study makes three forceful affirmations. Firstly, India must make a big push for solar power. Secondly, decentralised generation and distribution, through Solar Mini-Grids, is the way to go. Thirdly, and audaciously, the study argues that the vision of "100% power access" for the whole of India is possible to be realised by 2022, when we celebrate the 75th anniversary of our Independence.

The virtues of solar power are numerous. It is bountiful since the sun god is generous in most parts of India, and for most parts of the year. It is what Mahatma Gandhi, a pioneer of the Green Movement, would have enthusiastically welcomed. It is non-polluting. It promotes decentralised development. Hence, it is critical for both inclusive and sustainable development. Furthermore, with the prices of solar panels falling steeply, and their conversion efficiency soaring, solar power is also becoming increasingly affordable and attractive.

Clearly, as this study insists, it is time for India to be ambitious, aggressive and innovative in harnessing the power of the sun. India's solar energy production is a mere 1 per cent of the total energy demand. In contrast, China is generating 10 per cent of its electricity from renewables, mostly solar. (China is also aiming at full rural electrification using renewable energy by 2015.) The target of the Jawaharlal Nehru National Solar Mission (JNNSM) to generate 20,000 MW of solar power by the end of the 13th Five Year Plan (2017-2022) seems large, given that the current grid-connected installed capacity for solar power is only 1700 MW. However, our progress is slow, and the focus on mini-grids woefully inadequate. This needs to change.

• • •

Although the principal focus of this study is that Solar Mini-Grids can be a boon for rural India, its conceptual framework is also valid for a rapid expansion of solar power in urban India. This point was forcefully made by Shri Pranav Mehta, chairman of the Solar Energy Association of Gujarat, who gave a talk at ORF Mumbai in April 2013 on Gujarat's phenomenal success in converting "Solar Dreams into Reality". (The state accounts for 70 per cent of India's installed solar photo-voltaic capacity.) According to him, installation of solar panels on rooftops must become ubiquitous in both rural and urban India.

Maximum self-reliance in power and energy needs is the only way forward for India.

In this context, India has much to learn from Japan, whose persistent and innovative drive to reduce dependence on foreign energy resources is truly remarkable. All over Japan, technology companies and private investors are installing solar panels on roofs of factories, shopping malls, office complexes and residential buildings. The power so generated is sold either to electric power companies or to decentralised mini-grids.

Clearly, in the years to come, technology will boost decentralized generation and use of solar power in a very big way. Already, nanotechnology promises a dramatic shift from bulky solar panels to 'nanocrystals', which can in the none-too-distant future be painted or printed onto roofs, walls or windows. This can potentially transform every home or building into a giant hi-tech solar power plant. In a country like India, where land is a scarce resource and per capita land availability is low, technological innovation in solar power must receive a strong policy and investment push.

• • •

I heartily congratulate Shruti and Leena for their meticulously researched study. We do hope that this study will help policy- and decision-makers in the Union and State governments to provide greater support to Solar Mini-Grids. In this context, we would especially like them to pay attention to the possibility, alluded to in the document, that the expansion of Solar Mini-Grids through "an assisted entrepreneurship model" could usher in a revolution akin to the Green Revolution by innovative farmers, or the Cable TV Revolution through the neighbourhood cable TV operators, or the Telecom Revolution through the PCO booth operators.

We welcome readers' critical comments and suggestions.

Mumbai, July 2013

EXECUTIVE SUMMARY

Off-grid solutions based on renewable energy sources, particularly Solar Photo-Voltaic (PV), hold great promise to bring electricity to the 80 million or so households that are currently without it (Census 2011). India is very well endowed with solar energy. Solar PV systems scale well with increasing demands and need minimal day-to-day operation. We argue that villages and remote hamlets that are off the main grid can leapfrog into sustainable power access via Solar PV mini-grids as a long term solution rather than as a stop-gap 'till the time the grid comes'. Rural areas that are power starved despite having a grid line can also benefit from grid-interactive versions of these community level power plants. These mini-grids will provide 'Electricity beyond Lighting', which is critical for achieving livelihood enhancement.

In this report, we first analyse the diverse challenges that currently inhibit replication of Solar PV mini-grids across the country, especially when taken up as a business. Viability of 10 kilowatt-peak (kWp) or similar scale systems is very difficult, if not impossible, to achieve. Current subsidy regimes and processes are either insufficient or too tedious. Operational challenges include overheads of reaching remote places, last mile logistics, laying down a localised grid with appropriate metering, payment collection systems, etc. Furthermore, banks are not yet inclined to finance these small scale projects, particularly the local entrepreneurs who lack credit history and collateral. Dearth of trained manpower to install and operate these mini-grids is one of the biggest obstacles to scaling up these systems across lakhs of villages. On the technical side, battery maintenance and replacement is a challenge for solar systems, and one needs creative load optimisation as well as innovations in financing to tackle this cost. We highlight examples of innovations by a few early players to tackle some of these issues.

An Energy Revolution akin to the Green Revolution in agriculture in the 70's needs to be brought about through an enabling ecosystem. It becomes clear that an 'assisted entrepreneurship' model would be apt for Solar PV mini-grids to scale in the country. We believe that the creation of a franchise network of mini-grid operators or distribution agents could be a path to scale. While some existing solar power producers are already playing the role of aggregators, we believe that large companies in the corporate sector could play a major role, leveraging their brand, rural distribution and supply chains, to quickly create and scale out franchise networks.

2022 marks the 75th anniversary of India's independence and it is critical that as a country we muster the conviction to strive for '100% Electrification' to mark the occasion. We believe that the Ministry of Power (MoP) and Ministry of New and Renewable Energy (MNRE) are caught up in their continued focus on grid extension and on expanding grid connected capacities, despite the fact that renewable energy alone can pull the rural areas out of the vicious circle of no power-no development.

We discuss limitations of existing policies and recommend policy incentives to usher the nation on a faster path towards this goal. We suggest that MNRE and MoP come out with a joint policy that creates the enabling framework within which other partners such as industry, entrepreneurs, and non-governmental organizations (NGOs) can contribute. The Ministry of Finance must also be brought on-board. The policy must:

- Empower business models such as franchise networks of companies through an appropriate combination of subsidy, grants and improved access to loan capital;

- Ensure large scale capacity building efforts are put in place to train the thousands of youth who can be employed in this sector – especially entrepreneurs. This is in addition to tens of thousands of technicians that are being sought to be coached under the Jawaharlal Nehru National Solar Mission (JNNSM) Phase II (draft document);
- Provide a majority percentage of capital investment as Central Financial Assistance (CFA). Exhort public and private sector banks to boost capital investment into off-grid solutions. Stimuli could be a combination of guarantee schemes and a separate lending limit for renewable energy;
- Incentivise deployment of CSR funds towards enabling energy access.

An illustrative calculation shows that if 50,000 villages are to be electrified by installing 10 kWp Solar PV mini-grids in each of them, the cost would amount to approximately Rs 15,000 crores. Given that this investment will pay for the cost of power supply for the next 25 years (without counting operation and maintenance costs), this is not a lot of money. It is less than two years of India's annual kerosene subsidy, for example. The government must prioritize allocation of these funds.

We outline a framework for stakeholder cooperation to enable the aggregator and local entrepreneur to scale up deployments and operations quickly. To ensure that there are no gaps in communication or decision making, a 'War room' could be formed for waging this 'War on darkness'. A lean team of empowered individuals, led by a befitting leader, can be put in charge of ensuring the success of the mission, in an accountable and transparent way.

Furthermore, we present a roadmap for achieving this goal in three broad phases:

Phase I: LEARN (up to 2015) – first couple of years have to set the stage, with a clear policy, building public awareness, setting up nationwide capacity building schemes, rolling out incentives to get large companies on board, etc. A quick learning and demonstration could help identify feasible on-ground models, which could then be groomed for speedy execution.

Phase II: SCALE (up to 2018) – the second phase would see scaling up by multiple orders of magnitude. With the business viability proven and large companies prepped, the momentum will pick up. Training of manpower would be stepped up. The pace now would need to support electrification of six thousand villages a year.

Phase III: DELIVER (2018 onwards) – the final dash to the goal would need a massive endeavour from all stakeholders, and readiness on part of state government agencies and financiers alike. An environment with hundreds of aggregators and thousands of entrepreneurs would catalyse tens of thousands of installations per year. Policy regarding grid interactivity could be finalized and implemented starting about this time. A clustered-village-approach would not only speed up the activity, but it would also enable a wider range of (or optimal) solutions via Solar PV-biogas or Solar PV and micro-wind hybrid plants.

The developmental impact of creating thousands of rural entrepreneurs along this path cannot be emphasised enough. A national policy to deploy Solar PV mini-grids for electrification can truly herald a new era of ***Democracy in Energy Access: Power of the People, by the People and for the People.***

TABLE OF CONTENTS

1 Introduction

"Access to modern energy is essential for the provision of clean water, sanitation and healthcare and for the provision of reliable and efficient lighting, heating, cooking, mechanical power, transport and telecommunications services."

World Energy Outlook 2012 International Energy Agency

"Renewable energy has the ability to lift the poorest nations to new levels of prosperity."

United Nations' Secretary-General Ban Ki-moon, 2011

1. INTRODUCTION

'India@75 – The Peoples' Agenda', a grassroots initiative inspired by Prof. C.K.Prahalad and led by the Confederation for Indian Industry (CII), outlines the vision for what India could and should achieve by 2022, structured under 10 broad themes. Of these, the Infrastructure & Urbanization theme includes the goal "All Indians have 24/7 availability of economical and reliable power"[1]. We are, however, far away from this goal with India being home to the largest number of people lacking access to electricity (over 300 million) and clean cooking facilities (over 700 million) in the world. While there are statistics available on households without an electricity connection, it is hard to find numbers that describe the quality of power delivered in homes where it is supplied. Most cities, towns and villages reel under power cuts throughout the year, by means of our indigenous 'load shedding' schemes. Peak load deficit is estimated to be close to 10%. The July 2012 India blackout (on 30th and 31st July) was the largest power outage in world history. It was caused due to record consumption levels by several states (particularly Delhi, Haryana & Punjab) due to a hot summer and delayed monsoon. The outage affected over 620 million people, i.e. about 9% of the world population and approximately half of India's population, spread across 22 states[2]. Although the unreliability of our Transmission & Distribution (T&D) infrastructure is well known, the blackout also highlighted the vulnerability of critical infrastructure services such as railways, airlines, hospitals, etc. Industry too suffered major losses, even though Indian companies have a whopping 35 gigawatt (GW) of private off-grid generation capacity.

While lack of access to modern cooking and electricity supply hinders development, the negatives of using the alternatives are humongous. Adverse health impact of using traditional biomass for cooking and kerosene for lighting are well documented and also discussed briefly in this chapter. The subsidies provided for kerosene (used for lighting) and diesel (used to run generators for backup power), are a huge drain on the Indian economy. The secondary and tertiary repercussions of our energy situation are vast and varied, including a burgeoning import bill of fossil fuels and an ever increasing fiscal deficit.

Our nation faces serious shortages of power already. Despite this, if the economy has to grow at 8-9% for the next 20 years, the installed capacity would have to reach 750-950 GW (Planning Commission 2006) by 2030. Would it be either economical or prudent to grow the existing 140 GW of thermal power capacity manifold? We examine the implications of coal-based power economy later in this chapter.

In this report we pose the following challenge to ourselves – 'Is it possible to achieve the goal of 'Energy Access for All', i.e. for over three hundred million fellow Indians, by 2022, when India turns 75?' and discuss possible solutions.

Renewable energy (RE) technologies – solar, wind, biogas, etc., have come into their own in recent years, and they present a unique opportunity for India to bring light into rural homes in an environmentally friendly way. India's solar power reception is a very high 5000 trillion kilowatt-hour (kWh) per year (theoretical value on total land area). Data emphasizing the potential of other renewable sources of energy in our country continue to pour in. With the launch of the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010[3], India has seen tremendous growth in grid-connected solar capacity. However, the grid has not been able to reach many far flung areas and remote hamlets due to the large distances (and the consequent unviable costs) involved and this situation may not change soon.

[1] http://www.indiaat75.in/document/NVD-India@75.pdf
[2] http://en.wikipedia.org/wiki/2012_India_blackouts
[3] http://www.mnre.gov.in/solar-mission/jnnsm/introduction-2/

Meanwhile solar lanterns and home lighting systems are gaining in popularity and have reached over a million households[4].

Notwithstanding the fact that lighting is the most basic need, it is imperative that any policy intervention in renewable energy focus on providing full-fledged, on-demand, electricity service to the citizens so that economic activity can follow. ***We, at Observer Research Foundation Mumbai, therefore strongly advocate for 'Electricity beyond Lighting', for all Indians and we believe that off-grid community level systems based on renewable energy technologies, particularly Solar Photo-Voltaic (PV), are indispensable to achieve this goal.*** In this document we examine this premise carefully and assess the potential for deployment through replicable/scalable models.

1.1. ENERGY ACCESS FOR INCLUSIVE DEVELOPMENT

The International Energy Agency (IEA) defines modern Energy Access as: *a 'household' having reliable and affordable access to clean cooking facilities, a first connection to electricity, and then an increasing level of electricity consumption over time to reach the regional average.* In a much celebrated 21st century, billions of people across the world lack access to the most basic energy services, thereby stretching the gap between haves and have-nots. As the World Energy Outlook 2012 shows, 1.3 billion people (about one-fifth of the global population) live without access to electricity and 2.6 billion people rely on traditional biomass for cooking, thus bearing the brunt of harmful indoor air pollution on a daily basis. Sub-Saharan Africa and developing Asia account for more than 95% of these people, and 84% live in rural areas.

IEA also predicts that in the absence of concerted action from these nations, nearly one billion people will remain without electricity and 2.6 billion people will continue to live without clean cooking facilities in 2030. It estimates that nearly $1 trillion in cumulative investment – around $49 billion per year – is needed to achieve universal energy access by 2030. The United Nations designated 2012 as the Year of 'Sustainable Energy for All' (SE4All) and their initiative, launched by the United Nations Secretary General's office, has set themselves the goal of Universal Energy Access by 2030. Without access to energy, it is not possible to achieve the Millennium Development Goals.

It is fairly obvious and widely acknowledged that energy access is the sine qua non for economic and social development. Cooking fuels have a direct impact on productivity and health of women and children. Electricity is a fundamental resource that enables education and health services, enhanced agricultural productivity, safe drinking water, information avenues and hence improved market access, increased livelihood opportunities, entertainment, better communication services, etc.

Several studies in the past have proven the correlation between per capita energy or electricity consumption, and various development indicators (see Figure 1). One such research study by the team at the Global Energy Network Institute concludes: *Increasing electricity consumption per capita can directly stimulate faster economic growth and indirectly achieve enhanced social development-especially for medium and low human development countries* (Chi Seung Leung 2005). Another paper from Human Development Report arrives at a much quoted threshold (Gaye 2007): Gaye says that a threshold of annual electricity consumption of 4,000 kWh per capita is required to achieve a Human Development Index (HDI) value of 0.9 or greater. Compare this with India's annual per capita electricity consumption

[4] Census of India, 2011

of 616 kWh for the period 2008-12[5]. No surprise then that India is ranked 136 (out of 186) in the latest HDI 2012 global ranking from United Nations Development Programme (UNDP), barely above the Low Human Development threshold, with an HDI of 0.554[6].

Furthermore, impact of unclean cooking fuels is abhorrent indeed: about 1.3 million deaths are caused due to indoor air pollution every year, as per Global Burden of Disease (GBD) statistics recently published for 2010, thereby making household pollution the second largest killer (after high blood pressure) in India[7]. Globally, noxious smoke from biomass is expected to surpass HIV/AIDS on expected annual number of deaths in 2030[8]. These deaths can and must be avoided, by providing reliable power supply and clean cooking gas as a fundamental right to every citizen of this world.

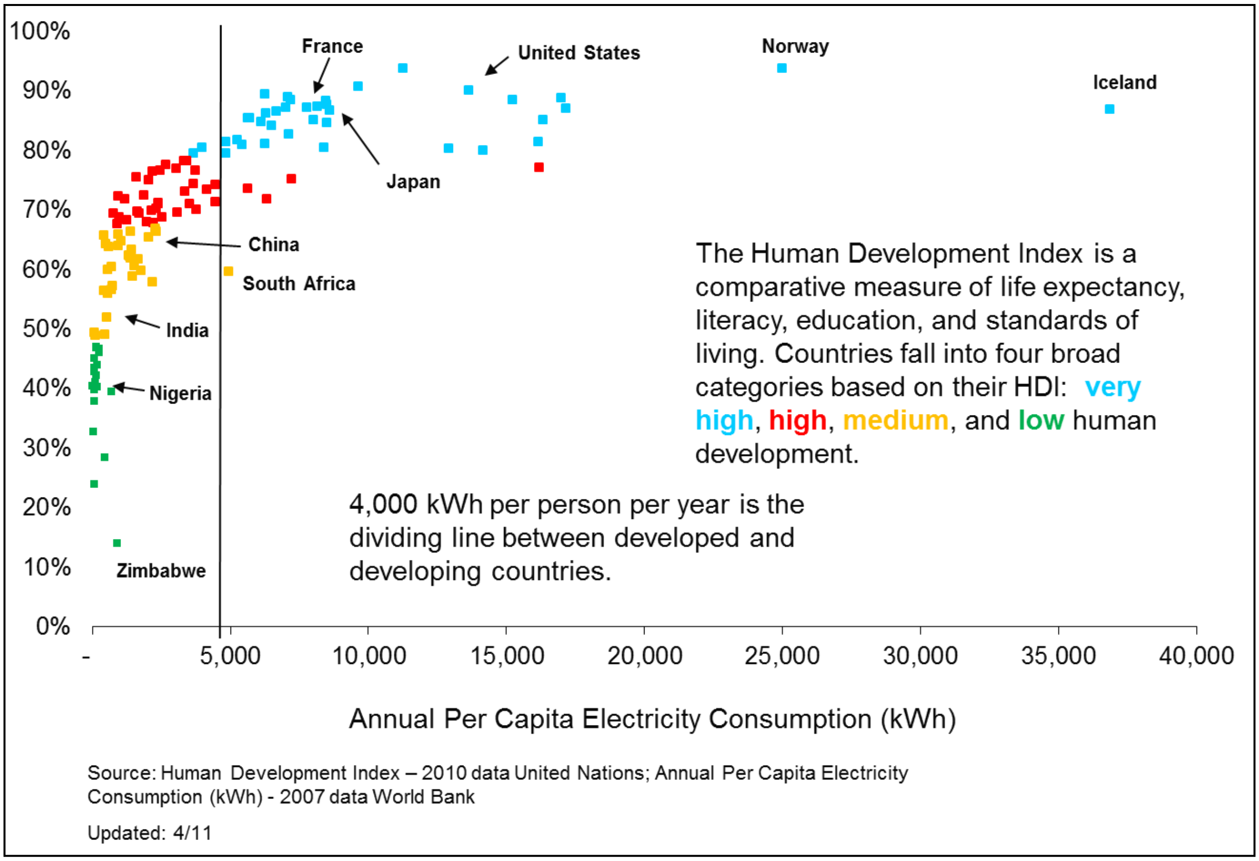


Figure 1: HDI vs. Annual Per Capita Electricity Consumption
Source: *www.nei.org*

[5] From the World Bank website: http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC
[6] http://hdr.undp.org/en/media/HDR2013_EN_Statistics.pdf
[7]www.hindustantimes.com/India-news/NewDelhi/Indoor-air-pollution-kills-a-million-people-every-year-in-India/Article1-1015749.aspx
[8] http://www.worldenergyoutlook.org/resources/energydevelopment/modernenergyforallwhyitmatters/

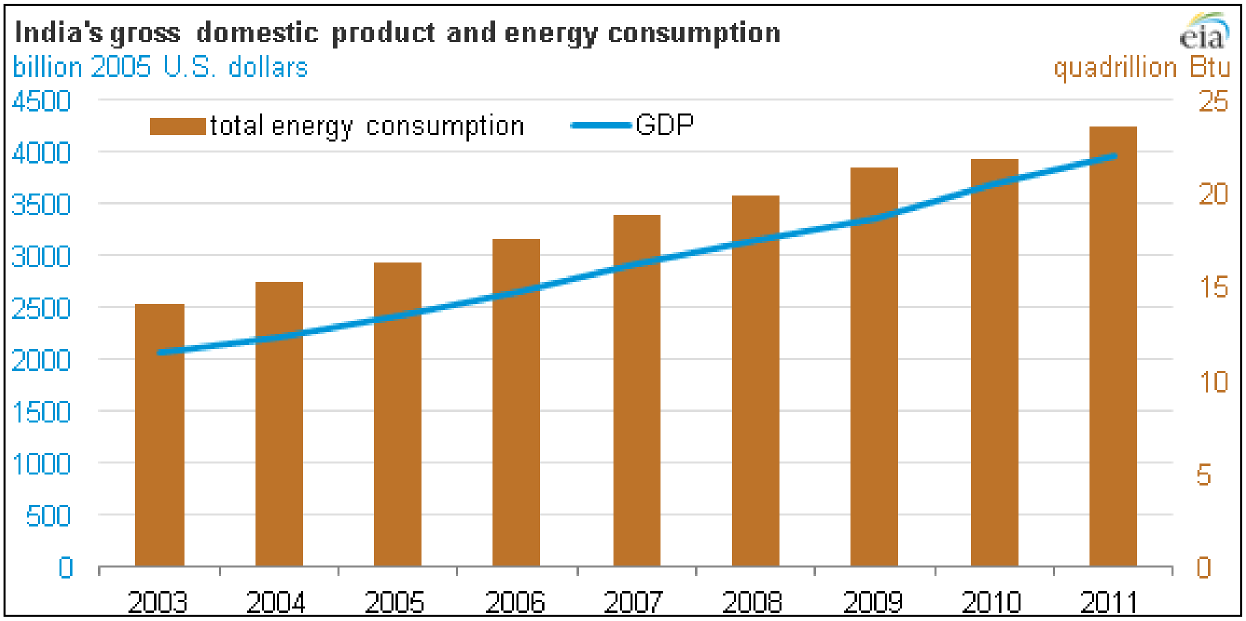


Figure 2: India's GDP and Energy Consumption
Source: *US Energy Information Administration*

As one may expect, India has seen a steady increase in total energy consumption over the last decade, closely linked with Gross Domestic Product (GDP) growth (see Figure 2). But it is clear that this top-line increase is not translating into any significant increase in per capita consumption for the poor.

Inclusive development in India's hinterland will require addressing these intertwined twin challenges – that of reliable electricity supply and modern cooking fuels. The sooner we tackle these, the sooner will we bring the underserved[9] sections of our society on the path to development.

In this report, our focus will be the provision of electricity for every Indian. At a few places, we have used the phrase 'energy access' interchangeably with 'electricity access', setting aside cooking fuels for this discussion. The intention is not to prioritise between the two, but it could be argued that access to electricity will catalyse improved livelihood opportunities which in turn will result in increased purchasing power to procure clean cooking gas.

1.2. Status of Rural Electrification in India

As per the IEA, India has the largest number of people living without access to electricity (Figure 3). With nearly two-thirds of our people relying on traditional biomass for cooking, India also has the largest population lacking access to clean cooking facilities. This is a wake-up call for us. After more than half a century of electrification programs in independent India, nearly one-third of all Indians still live in darkness. Notwithstanding the statistics above, if we were to go by reports from the Ministry of Power

[9] Conventionally referred to as the 'Bottom of the Pyramid' based on C. K. Prahalad's nomenclature.

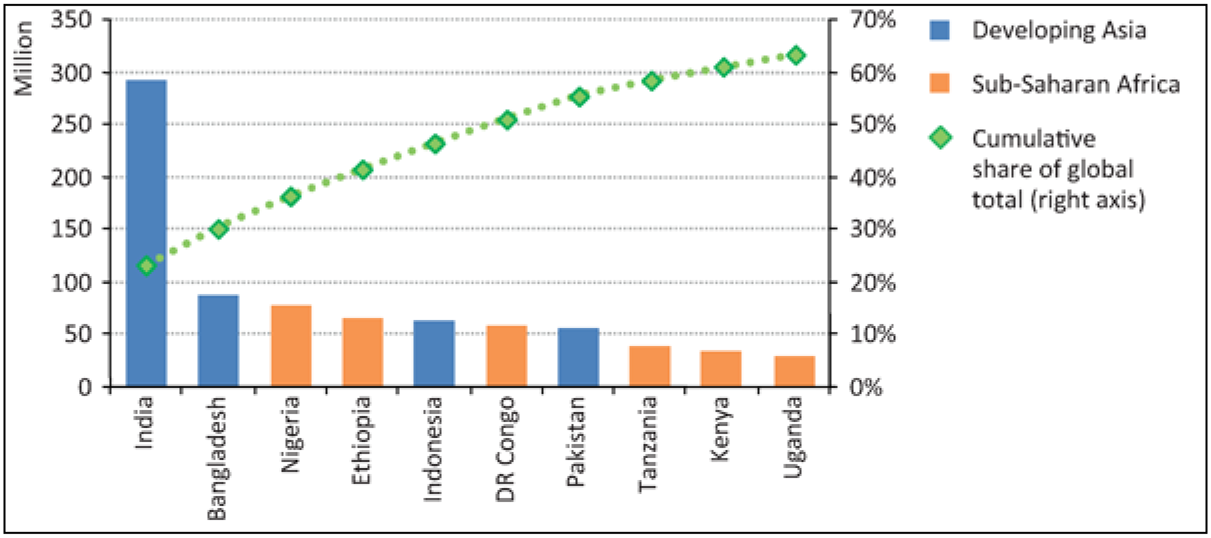


Figure 3: Countries with the largest population without access to electricity, 2010
Source: *www.worldenergyoutlook.org*

(MoP), the country is getting electrified at a stupendous pace. We briefly outline the history of rural electrification and the associated policies below.

The Rural Electrification Corporation (REC), a listed Public Sector Enterprise of Government of India (GoI), was incorporated in 1969 with the main objective of financing and promoting rural electrification projects all over the country. The Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) was launched in April 2005, by the MoP, by merging all on-going schemes and retaining REC as the nodal agency. The RGGVY aimed at electrifying all villages and habitations. It was to provide electrification infrastructure and wherever grid supply is not feasible or cost-effective, Decentralised Distributed Generation (DDG) systems based on conventional as well as non-conventional energy sources were encouraged. What is interesting is that as per the new definition[10] in effect from 2004-05, a village qualifies to be declared as 'electrified' if:

1. Basic infrastructure such as Distribution Transformer and Distribution lines are provided in the inhabited locality as well as the Dalit Basti (hamlet), where it exists.
2. Electricity is provided to public places like Schools, Panchayat Offices, Health Centres, Dispensaries, Community Centres, etc.
3. The number of households electrified is at least **10% of the total number of households** in the village.

This is perhaps the reason why over 93% of Indian villages (5.6 lakh villages out of a possible 6 lakh plus inhabited villages as of March 2012) are labelled as electrified by the Central Electricity Authority (CEA) under the Ministry of Power. However, this definition of electrification does not specify any norms regarding how regular and reliable the power supply needs to be – how many days-per-year or how many hours-per-day of electricity supply constitutes electrification. Consequently, users in rural areas experience poor quality service and can confirm the erratic nature of the power supply. Also, the count of electrified villages stands completely exposed from the numbers that have emerged from the Census: approximately 33% of all Indian households and 45% of rural households do not have access to electricity (Census of India 2011). The states that are lagging behind in providing power to a majority of

[10] http://www.rggvy.gov.in/rggvy/rggvyportal/index.html Rajiv Gandhi Grameen Vidyutikaran Yojana

their residents are: Bihar (83.6%), Uttar Pradesh (63.2%), Assam (62.9%), Jharkhand (54.2%) and West Bengal (45.5%)[11]. Annexure III shows the distribution of states by percentage of population having access to electricity. On top of the map, we overlay some numbers to point out the states with the highest number of unelectrified households, and we see that the worst eight states account for 84% of such households in the country.

Given the skewed definition, it is difficult to locate an accurate statistic for the number of villages and hamlets that have never received power (even if distribution infrastructure was installed), or receive minimal power on an on-going basis. Anecdotally, thousands of villages have never been 'energised', i.e. no power ever reached them after installation of transformers and distribution lines. In addition, there are unelectrified hamlets that are not counted separately in the census and are instead included as part of the parent village. ***According to estimates, there are probably about a lakh (100,000) such villages or hamlets that lack electricity. Of these, 20,000 are located in remote or difficult terrains that cannot be reached by the main grid (CDF IFMR-WRI 2010).***

What is worse is that the primary source of lighting in these areas continues to be kerosene lamps, a well-known and serious health hazard. As per Global Burden of Disease (GBD) report 2010[12], the average household particulate matter pollution in India was 350 micro grams per cubic meter of air, more than ten times the indoor air quality guideline of the United States Environment Protection Agency. As mentioned earlier, well over a million people die each year due to indoor air pollution (primarily caused by kerosene and unclean cooking fuels). Moreover, kerosene costs and subsidies are a huge drain on the economy. Under-recoveries on Public Distribution System (PDS) kerosene are to the tune of about Rs 20,000 crores per year (TERI 2012). In 2010-11, total government assistance (fiscal subsidy plus assistance for under-recoveries) to petroleum companies was close to Rs 44,000 crores. An Off-grid lighting assessment study by the United Nations Environment Programme (UNEP) concludes that 6.7 billion litres of kerosene consumption would be avoided and annual savings of USD 2.8 billion would result from a full transition to energy efficient lighting, such as through solar lanterns (UNEP, en.lighten 2013).

Apart from economic consequences, the environmental impact of consumption of these fossil fuels is well known. India is now the fourth largest emitter of Green House Gases (GHGs) in the world, and while the per-capita emissions are a fraction of that of the developed world, a 7.5% year-on-year growth rate was arrived at in a recent study[13]. Another research points out that kerosene lamps emit 20 times more black carbon than previously thought[14]. Black carbon or soot is a rather potent agent for warming up the air: it is estimated that one kilogram of soot that lingers in the atmosphere for 2 weeks causes as much warming as 700 kilograms of carbon dioxide over 100 years. Thus, eliminating kerosene consumption by households will not only augment health but is also a low-hanging fruit towards reducing global warming in the immediate future. 74 million tonnes of annual carbon emissions are caused due to fuel-based light sources commonly used in developing countries[15].

---

[11] Census 2011 Data, Source of Lighting 2001-2011

[12] http://www.hindustantimes.com/India-news/NewDelhi/Air-pollution-emerging-as-biggest-cause-of-deaths-in-India/Article1-1011240.aspx

[13] http://blogs.wsj.com/indiarealtime/2012/12/04/india-carbon-emissions-at-disturbing-levels/

[14] http://news.illinois.edu/news/12/1210kerosene_TamiBond.html

[15] http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=2704&ArticleID=9407&l=en

1.3. RENEWABLE ENERGY ~~IN~~ IS THE FUTURE

Whilst large sections of our population live in darkness, the country continues to wallow in supply pressure of energy sources. Coal is India's primary source of energy. Even though India has the world's fifth largest coal reserves, the sector is one of the most inefficient with a widening demand-supply gap. Utilisation rates in coal fired power plants have fallen steadily since 2004 due to insufficient fuel supply[16]. Data from the coal ministry shows that coal imports grew by almost 50% year-on-year to 103 million tonnes in FY-12[17]. The country will need to import 165 million tonnes by 2013-14[18]. Several reports, including Integrated Energy Policy (Planning Commission 2006), have pointed out that due to flawed theoretical estimates of total coal resources we as a nation have a false sense of security. However, reserves extractable by current and foreseeable mining technologies are much less, and will run out in about 45 years if coal production continues to increase by 5% each year (IEA 2012). The environmental hazards of indiscriminate coal mining and the resultant displacement of people could be a topic for another report. According to Greenpeace, coal mining threatens over 1.1 million hectares of forest cover in 13 coalfields in Central India alone[19].

Another important trajectory to be aware of is India's total energy needs in the coming decades given an increasing population that is expected to stabilise at about 1.5 billion people by 2050, and the increasing per capita energy consumption accompanying economic growth. Current per capita primary energy consumption of Indians is 600 kgoe (kilogram oil equivalent) per year, whereas the world average stands at 1860 kgoe (RuDiCON 2013). It is estimated that to sustain a GDP growth of 8-9%, demand for grid power will grow at 6% (RuDiCON 2013), and hence by 2030, we will need over 600 GW of installed capacity to meet domestic demand. The Integrated Energy Policy 2006 predicts even higher numbers: 778 GW and 960 GW for 8% and 9% GDP growth scenarios respectively. These numbers could be debated and where we eventually get to is a function of how energy efficient our growth trajectory is. Nevertheless, it is clear that with such a steep increase in total energy demand in the coming decades, national energy security must be given utmost importance.

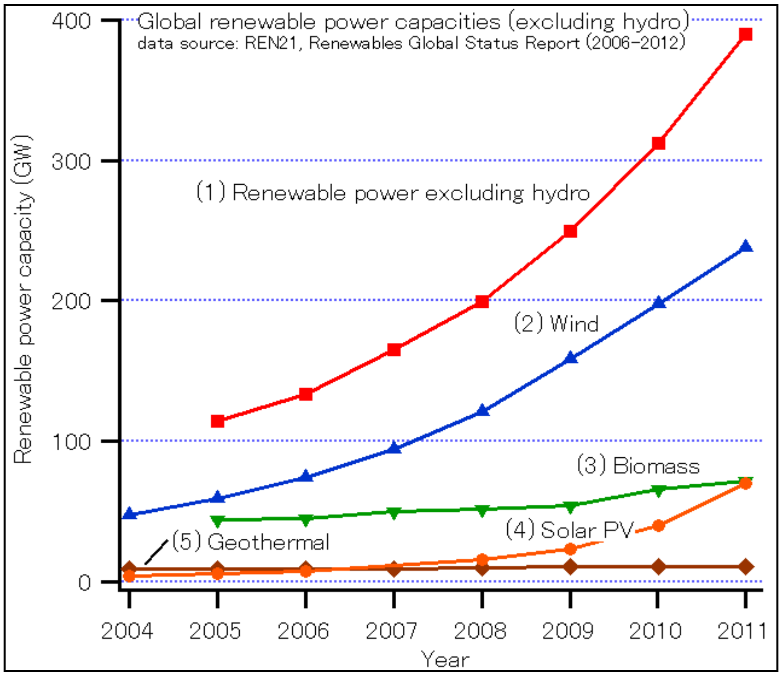


Figure 4: Global Renewable Power Capacity
***Source**: Renewables Global Status Report, REN21*

Globally, trends are indicative of times to come. Rapidly changing economics of coal have led to abandonment of plans to build over

[16] http://www.eia.gov/countries/cab.cfm?fips=IN
[17] http://www.financialexpress.com/news/coal-import-bill-pegged-at-rs.7000-crore-this-fiscal/1052602
[18] http://in.reuters.com/article/2013/04/22/india-coal-import-idINDEE93L0AG20130422
[19] http://www.greenpeace.org/india/en/publications/How-coal-mining-is-trashing-tigerland/

150 coal plants in the US in the past two years. There are talks of shutting down existing thermal power plants. The share of renewables in global electricity generation has been growing, and stands at about 19%, out of which 16% is hydro and 3% is new renewables (wind, solar, geothermal, biomass etc.). However, this 3% is growing very fast. At the end of 2012, worldwide installed capacity of wind energy and solar energy was 282 GW and 100 GW respectively, with wind power growing annually at 30%. Figure 4 shows the sharp growth curve over the last five years, and this curve is about to get steeper, especially for solar. According to a 2011 projection by the IEA, solar power generators may produce most of the world's electricity within 50 years.

Climate change risk is not the only factor driving the march towards renewables; economics has a huge role too. Srinivas Krishnaswamy of the Vasudha Foundation points out in his report (Krishnaswamy 2010) that during the 10th Five Year plan 2002-07, the Ministry of Power incurred an average cost of electrification of Rs 12 lakh per village, whereas MNRE electrified villages at an average cost of just Rs 8.1 lakh per village in the same plan period. Since the remaining unelectrified villages are very remote and scattered, the incremental cost of extending the grid continues to increase sharply. The report also states that at a distance of just 15 km from the grid, coal power is no longer competitive with Solar PV, if one includes the infrastructure, maintenance and distribution costs. Let us note that this analysis was done even before the sharp decline in panel costs over the last 3 years. To compound the grid costs further, the T&D losses in India's distribution network continue to be among the highest in the world, standing at approximately 25% (excluding pilferage & other non-technical losses). This needs to be compared with the world average which stands at a much lower 15%, while the average for the developed nations is a paltry 4-6%.

The salient point to note here is that the cost of generating electricity using fossil fuels is over and above the set-up cost of grid infrastructure. Whereas for Solar PV based power plants there is no additional generation cost for the lifetime of the panels i.e., 25 years, barring battery replacement.

These stunning statistics only underscore the importance of distributed generation of power and of harnessing the power of renewable sources of energy available locally. The use of RE sources has three-fold benefits, (i) of utilising locally available sources of energy, thereby providing more efficient energy conversion and access (ii) of containing emissions of GHGs even as development takes place using the available reliable electricity (iii) of providing a cheaper route to 100% electrification instead of expensive

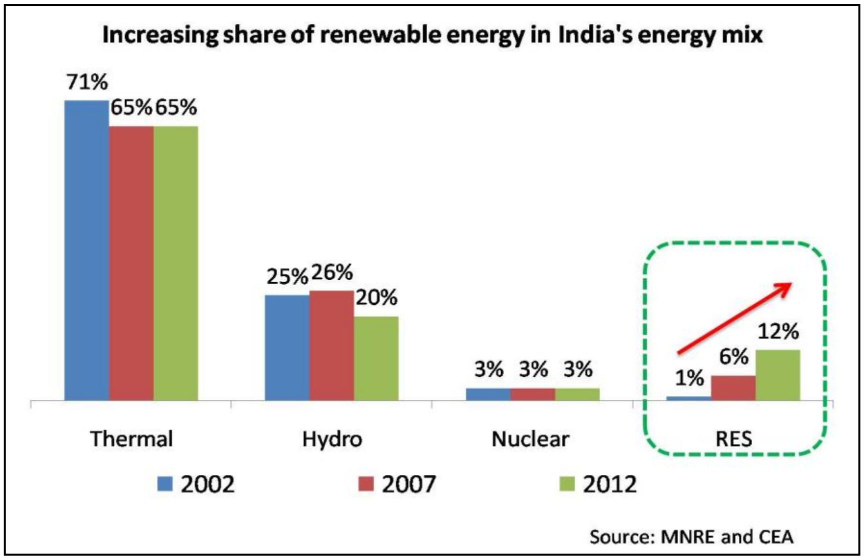


Figure 5: Share of different sources in India's Energy Mix
Source: greencleanguide.com

grid extension.

Renewable energy has taken off in the last few years as one of the fastest growing sectors in India. Between 2005 and 2010, investments in RE in India grew almost 500% (EAI 2012). A quick look at the installed power generation capacity by source type also demonstrates this (Figure 5).

Currently we have about 29 GW of installed capacity based on new renewables[20]. The total potential of power generation from renewable sources, excluding solar, is estimated at about 90 GW, as per the table below from Press Information Bureau, GoI:

Table 1: Estimated medium-term (up to 2032) potential for power generation in the country from RE sources[21]

Resource	Estimated Potential (In $MW_{eq.}$)
Solar Energy	30-50 MW/ sq. km.(1)
Wind Power	49,000(2)
Small Hydro Power	15,000(3)
Bio-Power:	
Agro-Residues	17,000(4)
Cogeneration - Bagasse	5,000(5)
Waste to Energy: - Urban/Municipal Waste to Energy - Industrial Waste to Energy	 2,600(6) 1,300
Total	**89,900** (excluding solar)

$MW_{eq.}$ = Megawatt equivalent

Note: Not all of this potential may be suitable for grid-interactive power for technical and / or economic reasons.

(1) Solar power potential in most parts of the country per square kilometre of open, shadow free area covered with solar collectors.

(2) Potential based on areas having wind power density (wpd) greater than 200 W/m^2 assuming land availability in potential areas @ 1% and requirement of wind farms @ 12 ha/MW. **Revised estimate by C-WET is ~1,00,000 MW at 80 m. height (un-validated).**

(3) Technically feasible potential of all sites upto 25 MW station capacity.

(4) Based on surplus agro-wastes/residues.

(5) With new sugar mills and modernisation of existing ones, technically feasible potential is assessed at 5000 MWe.

(6) Technically feasible municipal waste-to-energy potential estimated for Class-I cities.

It is clear that in order to get to 600-800 GW capacity by 2030, we will have to maximise generation from renewable sources. The coal-based-path is not only climate unfriendly; but also fraught with fuel supply risks. Recently revised estimate by C-WET on wind energy in India pegs the potential at about 100 GW[22]. Assuming we utilize this entire potential by 2030, it would still constitute 12-16% of expected electricity demand. Nuclear energy has its own political and safety constraints, notwithstanding limited

[20] Cumulative achievement up to 31.03.2013, www.mnre.gov.in

[21] http://pib.nic.in/newsite/erelease.aspx?relid=83280

[22] Another recent study by Berkeley labs has revised the wind potential in India to 20 times the current value of 100 GW. However, this has not been recognized by the Indian government yet: http://newscenter.lbl.gov/feature-stories/2012/03/21/wind-energy-in-india/

domestic uranium reserves (IEA 2012). While there are varying estimates of bio-power potential in our country, tapping this potential is dependent on organizing supply chain networks of bio-waste sources, such as agricultural residue or cattle dung.

This brings us to solar energy. India has tremendous potential for generation of solar energy with large tracts of the country receiving radiation levels of 4-7 kWh/m2/day, and 300 clear sunny days per year. Abundant sunshine along with rapidly reducing costs of Solar PV technology and products over the last five years makes for a compelling case. As Table 2 indicates, global average system price ($/W installed) fell by more than half between 2008 and 2012. The trend is expected to continue over the next 5 years also, with cost per installed watt estimated to slide by another 40% (Ron Pernick 2013). ***Our goal of 100% electrification using solar energy is certainly achievable provided we create the enabling ecosystem, discussed in detail in the rest of this document.***

Table 2: Total Installed PV System Prices and Costs of Electricity (Global Average)

Year	System Price ($/W)	LCOE Range (cents / kWh)
2007	$7.20	24-42
2008	$7.00	23-41
2009	$5.12	17-31
2010	$4.55	15-28
2011	$3.47	12-23
2012	$2.58	9-18
2013*	$2.33	8-17
2014*	$2.10	7-15
2015*	$1.89	6-14
2016*	$1.75	6-14
2017*	$1.61	6-13
2018*	$1.49	5-12
2019*	$1.38	5-12
2020*	$1.27	4-11
2021*	$1.17	4-11
2022*	$1.07	4-10

Source: *Clean Edge, Inc., 2013. 2007 through 2012 are actual figures and 2013 through 2022 are estimates. Figures calculated using Clean Edge cost projections and the NREL Levelised Cost of Energy (LCOE) Calculator. ASSUMPTIONS: Discount rate: 4%; Capacity factor: 16-26%; O&M cost: $6-$60/kW.*

The Energy-Water Nexus

Production of electricity consumes a lot of water at various stages of the process – for drilling and mining of coal and other fuels, as well as during the generation process at the power plant. Coal powered plants consume three times as much water as natural gas fired plants. A typical coal plant in India consumes 5-7 cubic metres of water per megawatt-hour (MWh) produced. A few more recently constructed plants are more efficient and might consume 3.5-4 cubic metres per MWh. In the last two decades, water usage for power generation has doubled, and an additional 100 GW coal-fired capacity slated to be added in the 12th Plan will require over 2500 million cubic metres of water per year (Greenpeace 2012).

The recent drought in Maharashtra, the worst in four decades, has brought to the forefront the tussle for water, between farmers and industry. There are several examples of power plants being stalled by farmer protests, a prominent one being the $1.3 billion coal plant in Amaravati by IndiaBulls Power. Maharashtra State Power Generation Co. shut down an 1130 MW plant in February 2013 due to lack of water for the boilers. “Water shortages have prevented construction of 30,000 megawatts of power plants throughout India, 13 percent of current capacity”, as per Naina Lal Kidwai, country head of HSBC Holdings Plc*.

Given over 2200 farmer suicides in India in the last 4 years, primarily due to drought, we as a nation have to get very meticulous about allocation of water resources. Rain water harvesting and distributed power generation from renewable sources will play a crucial role in improved water management.

(Water consumption in manufacturing of Solar PV panels is minimal. However, it is important to note that as in any semiconductor process, hazardous materials require proper handling. Grid connected Solar CSP technology uses a lot of water for cooling towers)

*http://www.bloomberg.com/news/2013-05-21/death-in-parched-farm-field-reveals-growing-india-water-tragedy.html

“We have an opportunity for which the economics are compelling, the moral urgency profound, the development benefits enormous, and the potential leverage game changing.”

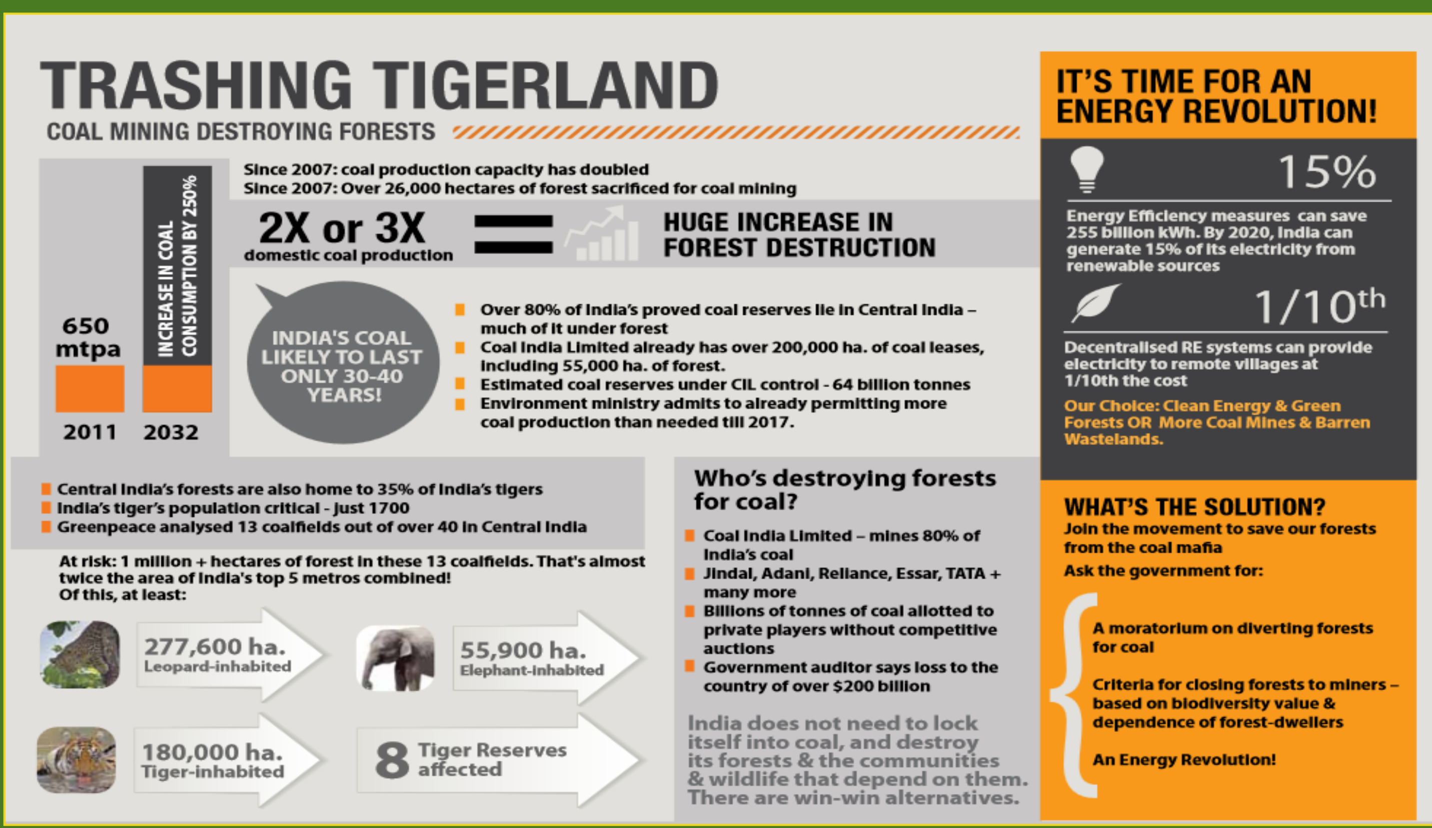
Carl Pope Sierra Club & Harish Hande SELCO-India

Op-Ed: “1 Billion Reasons to Deliver Solar Energy Access for the Poor”

2 Solar Power in India

"Coal shall remain India's most important energy source till 2031-32 and possibly beyond."

Integrated Energy Policy 2006, Planning Commission



Source: www.greenpeace.org

2. SOLAR POWER IN INDIA

As discussed in the preceding chapter the importance of solar energy in India's future energy mix, as the country tries to reduce huge power deficits and provide electricity to hundreds of millions living without it, cannot be minimised. We now quickly summarize the tremendous progress seen in the deployment of grid-connected megawatt (MW) scale solar plants, and then examine the role of off-grid systems.

With the launch of JNNSM under the National Action Plan on Climate Change in January 2010, India has set a target of 20,000 MW of grid-connected solar power by 2020, to be achieved in 3 phases:

1) Phase I (up to 2012/2013) – 11th Five Year Plan & first year of 12th Five Year Plan : Target of 1100 MW;
2) Phase II (2013-2017) – remaining 4 years of 12th Five Year Plan: Target of 3,000-10,000 MW;
3) Phase III (2017-2022) – 13th Five Year plan: 20,000 MW overall.

The corresponding target for off-grid applications is 200 MW by 2013 and 2000 MW by 2020.

The target for grid connected capacity in Phase I has been achieved and in fact surpassed by a large margin. Recent data released by MNRE[23] shows that as of March 2013, a little over 28,000 MW of grid interactive power from renewable sources has been deployed. Of this the contribution of Solar PV is about 1800 MW, while large wind farms have 19,000 MW of installed capacity. The State Governments of Gujarat and Rajasthan have taken the initiative in aggressively expanding capacity for Solar PV and Solar Thermal power plants through state level schemes. More state governments are following suit – Tamil Nadu and Andhra Pradesh have put out ambitious tenders to invite bids for capacities as large as 1000 MW each. All in all, India is seeing a high tide of grid-connected Solar PV.

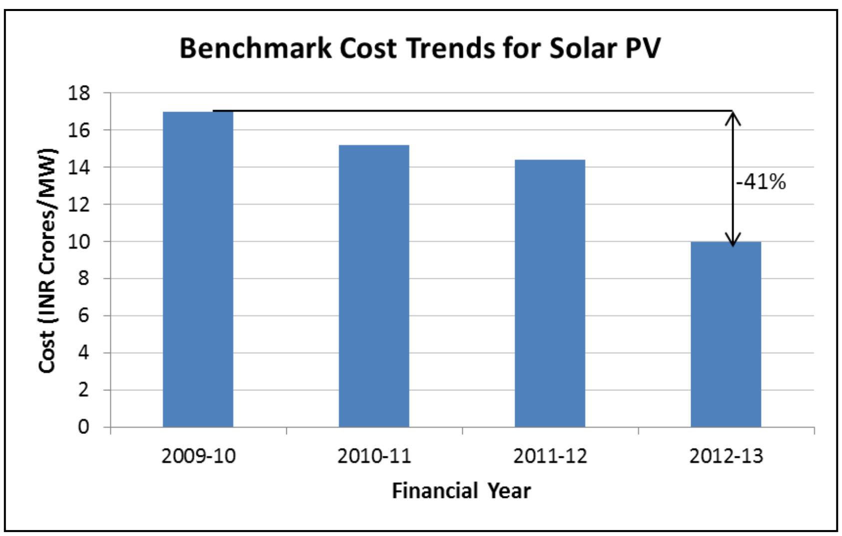


Figure 6: Benchmark Cost Trends for grid-connected Solar PV
***Source**: MNRE*

[23] Data as of 31 January 2013, http://mnre.gov.in/mission-and-vision-2/achievements/

The global trend of declining Solar PV prices has translated into a downward curve for cost/MW installed (Figure 6: over 40% drop in just 3 years) as well as Feed-In Tariffs (FITs) quoted in JNNSM bidding rounds (Table 3). Close to 50% drop between reference and realised tariff was observed in just a couple of years. While industry has mixed reactions towards this bidding trend, overall it has been a substantial driver in putting solar on a fast growth track by instigating several states to initiate State level solar programs.

Table 3: JNNSM Phase I reference price & tariff realised
***Source**: MNRE*

JNNSM Phase I	CERC reference price (Rs/kWh)	Average tariff realized (Rs/kWh)
Batch 1	17.91	11.80
Batch 2	15.39	8.80

Although solar power plants are much 'cleaner' than thermal power plants based on coal for example, this kind of grid-connected capacity does not leverage all the potential benefits of solar energy. Relying on the grid-connected model for rural electrification via solar technologies will continue to incur the high costs of grid extension, high T&D losses and the requirement for large tracts of land for their installation. Figure 7 shows the heavy skew towards grid-connected RE capacity in India so far. Off-grid Solar PV installations in India add up to just about 125 MW (as of March 2013).

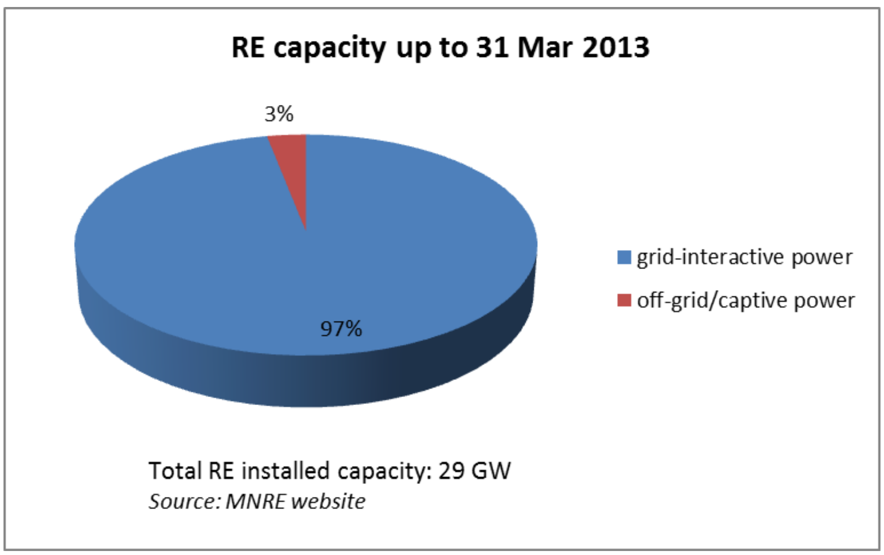


Figure 7: Share of off-grid in total renewable capacity in India

The IEA has estimated Aggregate Transmission & Commercial (AT&C) losses of India's power sector that has put a majority of Distribution Companies (DISCOMs) in a state of perpetual catastrophe. The AT&C losses as defined in the study (IEA 2012) include technical losses during transmission & distribution as well as other financial losses:

- Theft due to illegal tapping of transmission lines & tampering of meters;
- Non-/under-billing by distribution companies;
- Non-payment by consumers;

- Misclassification of consumers resulting in over-subsidising.

Nation-wide AT&C losses were 31% for FY 2010-11, which are humongous. This is equivalent to USD 17 Billion, or 1.5% of India's GDP (in terms of 2010 GDP). One of the main initiatives of the 11th Plan was to reduce these losses through the Restructured Accelerated Power Development & Reforms Programme (R-APDRP), with the following goals:

1. Utilities having AT&C loss above 30%: reduction by 3% per year,
2. Utilities having AT&C loss below 30%: reduction by 1.5% per year.

The budget of this programme is approximately Rs 50,000 Crores (out of which Rs 30,000 Crores would be a grant to the states). The programme covers urban areas with populations of more than 30,000 (or 10,000 in special category states), along with separation of agriculture feeders in 'certain high density rural areas' (Ministry of Power 2008). As is apparent from these statistics and the policy, the T&D infrastructure in the country needs a massive overhaul to rein in the losses of state DISCOMs, and a lot of funds are earmarked for improvements in urban areas.

More grid-connected capacity is good for the country, to slowly bridge the deficits between supply and growth in consumption. However, given the existing unmet demands of urban areas (who pay higher average tariffs vis-à-vis rural), the additional grid-connected power is likely to get absorbed quickly. Thus, it becomes clear that new large scale renewable power that is coming online is unlikely to reach the 300 million people, currently living without any electricity, anytime soon. At ORF Mumbai we believe that just as rural India leapfrogged directly into the new paradigm of mobile telephony, it can do the same with renewable energy by embracing the paradigm of distributed power generation. Off-grid mini-grids[24] using solar energy and potentially its hybrids with bio-gas and micro-wind systems are likely to be the best path forward. Moreover, the developmental impact of privately owned mini-grids in the hinterlands is immense, due to the much-needed employment generation potential.

On July 14 2012, ORF Mumbai conducted a well-attended Roundtable[25] consultation on this important topic of "Off-grid Solar Applications for Rural Electrification". Some of the key observations made by participants at the Roundtable are included within the document but there is also a separate report with many additional details of the discussions in Appendix I.

"From 1982 when MNRE was first set up until 2002-2003, just 3600 MW of grid-connected renewable energy was installed, whereas between 2003 and 2012, 25,000 MW of capacity of grid-connected power has been added" said Shri Gireesh Pradhan, former Secretary MNRE, starting off the deliberations at the ORF Mumbai Roundtable on this positive note. He went on to say, *"The average per capita consumption of power in India is a mere 760 units (kWh), which is less than one-third the world average, while in places like Bihar it can go as low as 160 units per year. Add to this the fact that 37% of households in India have no access to power, and one can see how crucial the situation is for access to power for a large section of our population.* ***Off-grid solar makes a lot of sense****"*.

[24] The draft document of MNRE describing the Phase II policy of JNNSM describes micro-grids as installations of up to 10 kWp and mini-grids as installations of size 10 kWp to 500 kWp per site. However, we do not distinguish between the two. kWp or kilowatt-peak is the rated power of a solar module under standard test conditions (radiation of 1000 W/m2). The actual output is typically lower.

[25] A list of participants at the Roundtable is available in Appendix II.

2.1. ELECTRICITY BEYOND LIGHTING

Solar PV has been successfully harnessed for solar lanterns and small scale household systems (usually referred to as 'solar home systems' or SHS) in villages, tier II and tier III towns. Companies such as SELCO India, Orb Energy, Tata BP Solar and many more have established distribution networks to sell, maintain and service SHS's. A vast majority of these systems provide enough electricity for 1 or 2 LED lights and for charging a mobile handset. A few systems even power a fan. All in all, solar household lighting systems as well as lanterns have been quite successful in replacing kerosene in hundreds of thousands of households across the country.

Going forward however, it is imperative to enable long-term solutions that catalyse economic and social development. Electricity beyond lighting can contribute to this objective in a variety of important ways:

- Household appliances such as fan, TV, radio, mixer, fridge, etc.;
- Water pumping for household and for irrigation purposes;
- Post-processing of agricultural produce including refrigeration of fruits and vegetables and other processing for value addition such as grinding of spices;
- Other non-farm income generating activities;
- Education through the use of computers;
- Tele-medicine, cold storage of medicines;
- Other miscellaneous activities (such as kiosks for market information).

Villagers already recognise some of the above as needs but the others may still be considered aspirational. It has been observed and cited that once people have access to basic electricity, over time they try new applications and become willing to pay for the value they receive. In fact, new income generating activities enabled by access to power slowly increase purchasing capacity of households which are then willing to explore lifestyle enhancing applications. The graph in Figure 8 illustrates this idea well.

> *"Renewable energy technologies can have a direct impact on human development and poverty alleviation in rural areas"*
>
> Harish Hande, CEO, SELCO India

This also suggests that scalability is very important in rural areas i.e., the ability to expand power generation capacity continuously as the standard of living, and correspondingly the requirements, increase. For this, Solar PV based mini-grid is an attractive option as scaling up a Solar PV plant is much easier compared to other technologies.

For the purpose of this document, we will refer to a mini-grid as a Solar PV (or hybrid with micro-wind/biogas) installation of size ranging between one kilowatt to a few tens of kilowatts, sufficient to supply power to a village ranging in size from a few tens of households to a few hundred households.

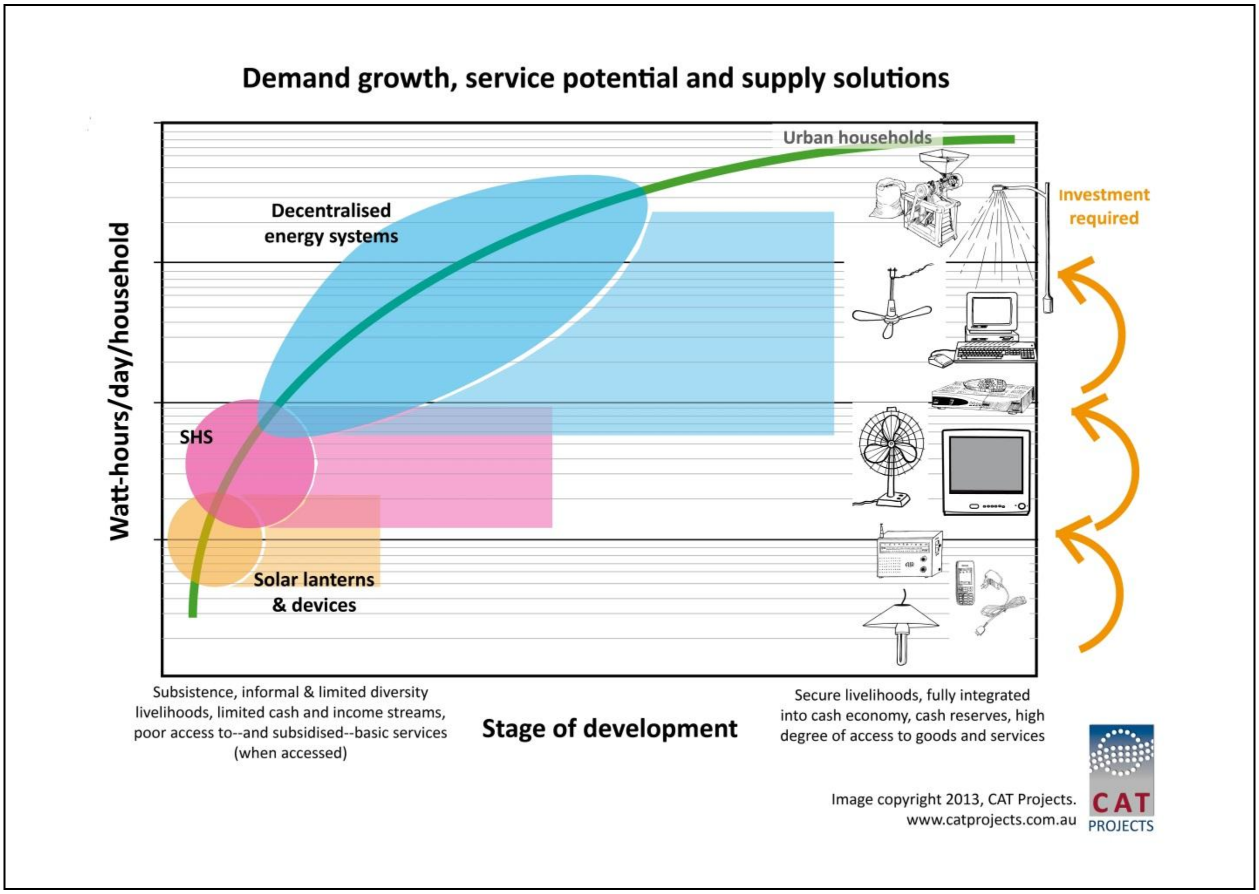


Figure 8: Household demand for electricity vs stage of development
Source: *Provided by CAT projects*

2.2. MINI-GRIDS CAN DRIVE SCALE

A mini-grid offers several implementation benefits over SHS's in a remote village:

- This is just one large system to install, maintain and repair as against hundreds of household systems;
- Although solar based products are continuously evolving to become more user-friendly, it is difficult for laypersons to understand the technology sufficiently to maintain it in their backyard. Therefore it is better that a system is set up at the village level, so that it can be maintained by only a few trained persons;
- Only a single loan needs to be sanctioned by a bank, and the substantial size of the loan is in turn an incentive for the bank's involvement. Household systems are often too small to lend for, and the overheads of administering these too large;

- It is more efficient and easier to expand a mini-grid system in stages as the power requirements of a village increase;
- A larger solar power system can be combined with other sources of energy such as a micro-wind turbine or a bio-gas plant to ensure uninterrupted supply at times of reduced solar energy output, e.g. during the rainy/foggy season. Combining technologies into a hybrid system also reduces battery requirements, with multiple benefits.

Leapfrogging into using renewable sources, specifically solar and its hybrids, entails that system design and ecosystem creation has to be planned carefully so as to make these mini-grids sustainable as the source of power for the long term. In this context, we differentiate our recommendations into two parts, by the current status of the village/hamlet:

A. Grid-connected 'electrified' villages having poor power supply (with <6 hours of supply averaged through the year, now proposed to be covered by JNNSM Phase II);
B. Off-grid un-electrified remote villages and hamlets.

We propose that Category B villages and hamlets be electrified by mini-grids, not just for now but also for the long term future, so that the cost of extending the grid to these places can be saved completely. Our country is faced with a unique opportunity in the evolution of renewable energy technologies – now that these are fairly mature and are continuously evolving towards further maturity and cost effectiveness, they can be deployed as the sole means of electrifying these unreached remote villages and hamlets. Of course such systems must be well designed, deployed and maintained for trouble-free service to the villagers. Provided this is accomplished by smartly designed systems, they will need few maintenance interventions for a couple of decades and we must work towards such solutions.

For Category A villages, mini-grids could be made grid interactive, through smart metering. This would enable two-way flow of power so that excess power produced at the mini-grids can be utilised in other pockets of deficit on the main grid. While smart metering is touted to be the single largest enabler of roof-top PV projects in urban areas worldwide, it could as well be deployed in rural areas in India, to make Solar PV mini-grid systems more profitable. Mini-grids can be considered as aggregated roof-top systems, with better scale and controls. It also helps avoid the T&D losses of bringing power from far-flung large power plants. This is likely not a short term path, but more a longer term evolution of how the mini-grids would fit into the larger picture.

It should be mentioned here that our viewpoint in this regard is different from that of other think tanks. For example, the Centre for Science and Environment (CSE) in its policy recommendations for JNNSM II assumes that the grid will eventually reach everywhere (CSE 2012). Likewise, the ABPS and Shakti Foundation report (ABPS Infra 2011) suggests that the DISCOMs provide a Feed-In-Tariff (FIT) to the Independent Power Producers (IPPs) (also termed as system providers or mini-grid operators), on top of a base tariff collected from the users – a model that presumes grid connectivity of these community level power plants. ***We strongly believe that relying on the grid getting extended everywhere in the country is neither feasible nor necessary at this stage and we firmly advocate against it.***

The goal of deploying mini-grid systems across the country is not without serious challenges. Mini-grids are technology intensive and require fairly large investments up front besides having to handle maintenance and the complexities of payment systems. However, these are known problems to which likely solutions are also being experimented with and developed. Mini-grids also hold out the extremely attractive prospect of creating entrepreneurs and many jobs, and bootstrapping rapid development of local economies.

In the following chapter we discuss some of the challenges, with a view to getting a deeper understanding of the ecosystem. Thereafter, we suggest how these obstacles can be overcome through strategic policy design and partnerships among the different stakeholders. We also highlight some of the innovations made by the early entrepreneurs in this sector.

A mini-grid brings power to a remote village in Madhya Pradesh

For Meerwada village in Guna district of Madhya Pradesh that was notified that it will not be electrified due to forest area laws, life was and dark and difficult until SunEdison adopted the village under the ‘SunEdison Eradication of Darkness’ program. Solar lanterns were distributed in this village of about 70 households and 400 people in 2002-03, but with no subsequent maintenance, they failed within a couple of years. SunEdison then installed a 14 kWp Solar PV plant, entirely funded under their corporate program, in addition to building a community hall, a library and a game area for children. While each family on average had been spending Rs 50/month on kerosene lamps and a few hundred rupees per month for mobile charging, now for a similar amount per month they had the convenience of clean lighting, fans, TV and other electrical appliances. The utilization of the plant quickly increased from an initial 15% to about 70% in a few months as villagers came up with more uses, as stated by Rahul Sankhe, Managing Director, India Operations, at the ORF Roundtable. This project validates the need for providing on-demand-power as well as putting emphasis on scalability. For payment collection and protection from vandalism, a council system was devised, with one volunteer representative for every 10 homes. The participation of the villagers in the planning process and in the council gave the residents a sense of ownership and pride in the project. Community buy-in has been critical to the success of the project, according to Rahul.

Stop waiting for Grid Connectivity:

Solar PV based Mini-grids can deliver ‘on demand’ power sooner.

3

Challenges of Mini-Grid Deployments in Rural India

Horses carry solar panels and other equipment across a mountain pass in Ladakh. Picture courtesy: LREDA

"I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait till oil and coal run out before we tackle that."

Thomas Edison, 1931

3. CHALLENGES OF MINI-GRID DEPLOYMENTS IN RURAL AREAS

Existing policy under the Electricity Act 2003 and RGGVY suggests that for the purpose of rural electrification, an entrepreneur can generate and sell electricity without the requirement of any license. There are several schemes from MoP as well as MNRE that have been instituted with the objective of providing electricity in remote corners of the country. However, both the DDG scheme of MoP and the Remote Village Electrification Programme (RVEP) of MNRE require State agencies to drive the entire process – beginning with identification and approval of villages, to creating Detailed Project Reports (DPRs), and to selecting vendors through competitive bidding. The RVEP is usually referred to as the Remote Village Lighting Programme since 95% of the villages that are claimed to be electrified under the scheme have received only solar household systems (CSE 2012). In addition, there are many villages that are technically electrified but are not receiving adequate power, either due to scarcity of power on the grid or because many households were not connected to the grid to begin with (as mentioned earlier, only 10% households need to have connections for a village to have 'electrified' status). These are covered under the JNNSM's Off-grid and Decentralised Solar Applications policy, which has a provision for 30% subsidy.

So far very few organisations or companies have ventured into electrification at a community/village level. Husk Power Systems (HPS) has the largest number of mini-grids in the country (~90) though these are primarily based on rice husk. Recently, they have started using other renewable energy sources, including solar, for their lighting systems. A few start-ups are establishing DC micro-grids[26] within villages to provide for lighting and mobile charging needs, such as Mera Gao Power (MGP) and Minda NexGenTech. Also SunEdison and Gram Oorja have done a couple of pilots using corporate social responsibility (CSR) funds. Gram Power is a young company which is approaching mini-grids with smart metering and prepaid charging. OMC Power is installing small Solar PV plants but basing the implementation model on daily charging of batteries and delivering to homes. Each one of these companies has innovated in various aspects of implementation, but continues to face serious obstacles to making their business sustainable.

In this chapter, we examine a few critical challenges faced by companies and entrepreneurs, which we organise into the following three broad categories:

A. Sociological challenges;

B. Financial hurdles &

C. Technology related challenges.

3.1. SOCIOLOGICAL CHALLENGES

3.1.1 Coherence of a village or cluster of villages

The residents of a village must come together and agree to either purchase power from an IPP or band together to install, own, safeguard and maintain a collective asset (mini-grid), when in fact they can legitimately expect government to provide grid power. In either situation, they also need to agree to

[26] Here we refer to localized grid systems of size less than 1 kWp as a 'micro-grid'. These are usually DC.

hand over the land that is required for this activity. This is challenging because caste-based issues within the community, familial conflicts, large variations in income levels and suspicion towards external parties make it very difficult to drive a village into collective action. In such a situation, either the locals themselves or a grassroots organisation that may be already working with the villagers on socio-economic development activities can be a good access route for speeding up this process. Business models in which the entrepreneurs are encouraged to treat the land as equity and make the land owners part-owners of the project could be experimented with.

The optimal use of land in a village is also becoming a special challenge in the light of the many interventions that are being put into place by different ministries of the GoI. Non-governmental organizations (NGOs) or other social institutions that have already gained the trust of the community can significantly increase the chances of success for such interventions. They can also assist with capacity building of local youth and adults and also with performing independent audits into the functioning of such projects. Alternatively, the involvement of a strong leader such as the Sarpanch is a reliable way to build consensus in the community. For example, in Manachapada, a small village near Abitghar in Thane district of Maharashtra, Lata Khanjode, who is the Sarpanch of the village, is driving a transformation with the help of a few motivated individuals. She is leading the village and hamlets around it into self-sufficiency through a well-managed cooperative society[27].

Building consensus among villagers can take a long time, especially if any monetary investment is required. There are several cases of payment default that quickly snowball into a community wide issue. However, we are seeing examples of successful pilots where the implementing agency spent time doing the ground work carefully organising the villagers into a trust/cooperative which operates the plant on an on-going basis. For example, in Darewadi, the 10 kWp system built by Gram Oorja in partnership with Bosch Energy, is being run by a trust managed by the villagers. Local involvement in the commissioning of the project has ensured its success. Buy-in of the community and collective responsibility is also critical in preventing vandalism of the system.

The twin issues of whether all villagers are ready to pay for power and their differing payment capacities are a bottleneck while setting up a community level system. At Husk Power Systems for example, co-founders designed the business model such that they set up their plants first in those villages that are prepared to pay for electricity. They only set up the plant in a village where every household pays a connection fee of Rs 200[28]. Each plant typically serves 350-400 households, providing reliable power supply not just for lighting, but also for fans, TVs, radios etc. In addition, they are pioneering the Build-Maintain model by inviting and training local entrepreneurs to invest in and run the plants. Mini-grids built by HPS are now impacting over 200,000 lives.

[27] See http://manachapada.com/ for details of some of the activities they are undertaking
[28] Conversation with Gyanesh Pandey, CEO, HPS

What empowered State Agencies can achieve: CREDA & LREDA shine through

Chhattisgarh has been an early adopter of Solar PV technology. In the year 1992 the very first Solar PV power plant was installed in the state at village Lamni, district Bilaspur. This plant has been working successfully since then. As of May 2012, over 1400 villages have been electrified by Solar PV, benefiting close to 58,000 households. In a state with 44% forest cover, Solar PV emerges as a natural and cost effective solution. Chhattisgarh Renewable Energy Development Agency (CREDA) processes have been streamlined over the years, wherein Village Energy Committees are formed for operations and maintenance (O&M) of installed systems. Cluster technicians are appointed to monitor and maintain the systems by a contractor enrolled by CREDA. Thereafter, CREDA monitors all installations through monthly reports. This three-tier maintenance system has greatly contributed to making Chhattisgarh one of the most successful examples of implementation of RVEP.

Another noteworthy state agency is that of Ladakh – Ladakh Renewable Energy Development Agency (LREDA), established in 1995. Ladakh enjoys 90% subsidy from MNRE due to its status as a special category state. With financial support from the Central Government, the LREDA team has worked extensively to ensure acceptability and proper maintenance of technology in remote reaches of the state. LREDA has sought cooperation of local MLAs whose endorsements result in making the community more receptive to renewable energy technologies. Once there is acceptance, the meticulous quality control processes of LREDA guarantee that the products work well. Several other solar applications are being heavily promoted, such as water heaters, dish cookers, steam cooking systems, irrigation pumps, refrigeration, etc.

LREDA officials unofficially acknowledge that the independence of their organisation and its decision making affords them the nimbleness to experiment and implement quickly. So far LREDA has been able to install 125 standalone Solar PV power plants for villages, institutions and the army, adding up to over 2.5 MW of capacity. This is slated to be doubled to 5 MW in another two years. From 65% in 2010, the share of diesel based generation has dropped to 11% today (primarily due to the installation of 45 MW of large hydro capacity). With continuing emphasis on solar, micro-hydro and geothermal, the share of diesel is expected to drop to a mere 3% by 2015*.

* Presentation: “Role of LREDA in the Renewable Energy Sector”, provided by LREDA team

3.1.2 Availability of skilled manpower

Even when a company owns the asset, several enterprising persons from the village/region must be trained for O&M. This requirement applies to any kind of deployment. Solar systems are still 'technology intensive' and even though they entail minimal maintenance, it can be intimidating for villagers who are unfamiliar with technology.

Additionally, localisation of last mile is very important in a rural supply chain network. Hence, the local technician should ideally belong to the area; understand the language and the needs of the people. This is difficult to achieve given that Solar is a relatively new technology and formal training programmes are not easily available. Availability of trained human resources is a huge gap that needs to be filled with diligence. A massive skill development effort is required by the Central as well as State governments. While the money invested in subsidies is fuelling growth in the grid-connected sector, several vendors are of the opinion that the off-grid market will evolve faster if MNRE and other government agencies invest heavily in capacity building and skill development, instead of subsidies.

Existing solar service providers incur a significant expenditure on in-house training. For example, Harish Hande of SELCO India has invested tens of lakhs of rupees training youth for their manpower as well as training thousands of bank officers to familiarise them with financing schemes for solar systems[29].

Such a process can however be made easier if this need is recognised and a resource pool is created through the government's own skilling initiatives supplemented by the use of CSR funds if necessary. JNNSM Phase II policy has incorporated this aspect in the draft policy document, and we discuss it at length in the following Chapter.

3.1.3 Pricing & Payment Collection

Entrepreneurs who have picked up the mantle of providing electricity in unelectrified and power starved rural areas face the great challenge of having a target group with typically very low payment capacity. In addition, due to prior Government policies, people might expect to pay nominal price for electricity. With household incomes primarily dependent on agriculture, paying for energy is usually limited to the monthly spend on kerosene. Thus it is critical that power producers charge an amount equivalent or less than the cost of kerosene, at least to begin with, so as to wean people away from the fuel.

Payment collection (small amounts from large numbers of families) is a considerable cost to the business, as observed by Husk Power Systems and Mera Gao Power. While it is true that the culture of regular payments takes time to build, an important learning from the field is that payment systems that are aligned to the cash flows of the consumers have a better chance of succeeding[30]. Even if the rates of payment default are high initially they drop over several cycles, once trust is gained and the value of electricity is experienced, as per our conversations with a few mini-grid operators. It is not surprising therefore, that people from villages that have grid connectivity but are currently suffering from severe power cuts, are more likely to pay for power.

Nevertheless, ground realities can be harsh, especially in small villages where herd behaviour can quickly get unfavourable. Two people refuse to pay, fifteen others follow – is a dynamic very difficult to deal with. Therefore, garnering some prior commitment in the form of an initial connection fee is beneficial.

[29] Conversation with Dr Harish Hande
[30] As mentioned by Dr Harish Hande at the ORF Mumbai Roundtable, his biggest learning was when a street vendor told him that a payment of Rs. 300 per month was too expensive, but Rs. 10 per day was fine!

Several companies are experimenting with novel payment collection mechanisms, such as those deploying ‘pay-as-you-go’ solutions. Using one such solution from Simpa Networks, consumers can pre-pay using their mobile phone, while the system keeps deducting credit based on actual usage. A similar solution has been devised by Gram Power, founded by a couple of graduates from University of California Berkeley. Gram Power's smart mini-grid can be adapted for communities from 50 to several thousand homes, and can interface with any form of energy generation—such as solar, biomass or wind. In an innovative pre-paid aggregation model, a local entrepreneur buys bulk energy credit from Gram Power which is wirelessly transferred to his energy wallet. The entrepreneur then sells power to local consumers in small increments, which is loaded on to the prepaid meters installed at their homes. Gram Power has also observed the ‘domino’ effect: as energy demands are met, incomes increase and electricity demands likewise increase[31].

Even when the asset is initially funded by CSR funds or other grant money, it is crucial that some form of payment collection is done on a regular basis to ensure that the asset/service is valued by the community and for on-going maintenance. There have been reports of solar lanterns being distributed free of charge, but were useful only for a few years. Without provisions for maintenance, any technology is destined to fail the community.

Varied Delivery Methods

As innovation in payment collection methodologies, especially pre-paid charging, has enabled better margins for mini-grid operators, various ingenious methods of delivering power are now dotting the scene.

Most common implementation that is taking off is a micro-grid (a system of size less than a kW) that powers low wattage LED lights and a mobile charging point. Many of these are operational in DC mode. Users are happy paying for a couple of lights and a charging point, an amount equivalent to their monthly kerosene budget.

Traditionally, Solar Home Systems (SHS) have dominated the market for a decade now, where individual households purchase a system with a combination of down payment, loan and subsidy.

Solar lanterns that are charged by an operator on a daily basis reduce the complexity of installing and maintaining SHS’s in remote areas. Even larger charging stations are being experimented with. OMC Power sets up mini-grids at telecom towers where it uses excess power to charge portable batteries. These charged batteries are delivered to the nearby village households on a daily basis.

While in this document we focus on the potential of community level mini-grids, due to the heterogeneity of the target market, several off-grid delivery methods will in fact co-exist. For example, for very sparsely populated remote hamlets, it might be more practical to have provision of electricity at just the central market area that serves several hamlets, while solar lanterns fulfil the basic need for lighting at the household level.

[31] http://transition.usaid.gov/press/frontlines/fl_sep12/FL_sep12_YOUTHINNOVATOR_GRAMPOWER.html

3.2. FINANCIAL HURDLES

The market potential of the clean energy industry serving rural underserved households is significant, estimated to be about US $2.11 Billion per year, which comprises of $2.04 Billion for decentralised renewable energy services, and $70 Million for energy products per year (CDF IFMR-WRI 2010). Despite the huge market size, the growth in off-grid systems for energy services has been very limited. In this section, we elaborate on another of the critical hurdles: access to finance.

3.2.1 Overheads of a remote standalone mini-grid

The benchmark costs that the subsidies are based on effectively capture the overall market trends of Solar PV panel prices. Panel prices have dropped sharply over the past three years, pushing down costs/Watt-peak at an astonishing rate. This drop has translated into lower capital costs and hence lower FITs for grid-connected MW scale plants being commissioned under the JNNSM (as mentioned in Chapter 2). Nevertheless, there are a few major differences between grid connected Solar PV plants and an off-grid standalone plant:

- There is no need for a battery in a grid-connected plant as it feeds the generated power into the evacuation grid as and when it gets generated during the day. On the other hand, battery is essential for a standalone mini-grid which stores power for night time usage as well as any additional backup needed;
- 100% power generated gets evacuated in a grid-connected plant, whereas in a mini-grid, some power is bound to get wasted at times when demand is low and the battery is already fully charged. This can go as high as up to 20% if the commercial day load is seasonal, e.g. a flour mill;
- The cost of setting up a distribution network local to the village is also a considerable cost. This includes installation of poles and transmission wires, as well as household meters (this last component might be charged to the villagers directly).

In addition to the issues above, access to remote hamlets in India continues to be challenging due to lack of infrastructure. Transporting materials and manpower to install and maintain a mini-grid in a remote location becomes an effort and cost intensive affair. The demand is sparse and purchasing power even lower.

In the box on the next page, we showcase a sample costing exercise of a typical 10 kWp system. The numbers are representative of a site which has average solar irradiance (e.g. in central India) and have been collated in consultation with a system provider[32].

[32] These might be at the higher end of the spectrum, as admitted by the system provider himself (it assumes high end panels, inverters & batteries which have lower maintenance overheads). However, these are real costs that early entrepreneurs are facing on the ground.

Sample Costing of a remote mini-grid

A 10 kWp system is, on average, sufficient for a village of about 50 households with one or two commercial loads. In addition to meeting the basic electricity needs of households, this size will ensure surplus power for running community level systems such as a flour mill, cold storage for perishables and medicines, etc. If commercial loads are primarily during day time, that would reduce overall battery requirement as domestic loads are skewed towards evenings and nights. Here, we approximate the per-unit cost (Rs/kWh) for capital recovery without any subsidy.

The capital investment has several components – PV modules, inverter, battery, balance of system, mounting structure, laying down the grid, civil work, logistics etc. The benchmark cost assumed by MNRE for the RVEP was Rs 270 per Watt installed, or Rs 2.7 lakhs per kWp. It is important to highlight here that this is on the conservative end of the spectrum, based on our conversations with mini-grid players. This benchmark excludes any supply chain or maintenance costs. It likely also does not take into account losses due to sub-optimal loads. We have several examples of higher on-ground costs. A recent DDG tender by Madhya Pradesh Oorja Vikas Nigam that invited bids with a benchmark price of ~Rs 324/Wp did not attract any bidders. Another recent tender in Dakshinachal, UP, suggested Rs 400/Wp. Actual costs reported by CREDA exceed Rs 500/Wp*.

The off-grid applications scheme under JNNSM provided a subsidy of Rs 150/Wp for mini-grids, but going forward, this would be reduced to Rs 105/Wp**.

The number of units generated and available for sale depend on a number of factors, such as the irradiance of the site, the maintenance of the system, the inverter and battery losses (which is dependent on the quality of components), etc. Notwithstanding higher irradiance levels in Gujarat and Rajasthan, for a typical location in Central India with a couple of months of monsoon, a 10 kWp system could generate about 13,000-14,000 units (kWh) per year. With a system loss of about 12%-14%, we arrive at typical usable output of ~12,000 units annually. The battery is expected to be replaced every 5 years.

Assuming (i) conservative capital investment of Rs 27 lakhs for 10 kWp mini-grid (battery replacement and maintenance costs additional), and (ii) simplistic 25 year loan at 12% per annum – monthly EMI amounts to ~Rs 31,482 ; and yearly instalment of Rs 3.78 lakhs. This implies a cost per unit of ~ Rs 31.5.

Let us add yearly operational and maintenance cost (rent for land, manpower, insurance, admin, part replacement) of ~ Rs 60,000.

- Average cost/unit just to recover actual costs (capex + O&M) ~ Rs 36.5 per unit

Note: the calculation does not include business margins or any losses due to under-utilization of the system

With a subsidy of Rs 105/Wp, a feasible cost of delivery would still be in the range of Rs 25/unit, very expensive relative to the Rs 4-6/unit paid by urban users. This is one of the main reasons why Solar-as-a-Service is being offered in 'packages' of two lights or three lights plus a fan, etc. This approach averts the need for positioning it on a cost per unit basis.

* as cited in CSE's recommendations document for JNNSM Phase II draft

** benchmark costs have been recently revised by MNRE, via an order dated 30th May 2013, discussed in the next section

As we observe, if we present the costs of capital recovery and yearly O&M as a cost/unit, it seems very high. Additionally, this calculation excludes impact of factors such as under-utilisation of generated power or payment default rates (say due to a natural calamity), and assumes clustering of villages for streamlined delivery and O&M. Some other salient points to note:

- The battery costs are significant as they need replacement every 4-5 years. For 100 such sites, i.e. 1 MW in aggregate, the cost would be an extra Rs 2.5 Crores; thereafter 75% of this capex is incurred every 5 years;
- Cost of setting up the mini-grid is non-trivial, especially if one assumes iron poles. Cement (or wooden) poles would minimise these costs, though choice of material depends on climatic conditions, technical specifications etc. Depending on how clustered or spread out the village is, this cost is also quite variable;
- Civil work and logistics costs add up due to the distributed nature of these plants;
- Just the yearly maintenance cost is Rs 5/unit.

Thus, it is clear from the above discussion that when examined from a cost/unit basis; Solar PV mini-grids are not competitive with the conventional grid. However, that is a wrong comparison to make, since these places do not have access to grid electricity, and citizens have spent decades paying for costly kerosene while waiting for the illusory grid power. Rural areas are stuck in a catch-22 situation. Development requires electricity which in turn improves per capita incomes, thereby enhancing affordability. However for private suppliers to provide electricity, reliability of user revenue streams is critical.

Given the nature of the problem at hand and the existing ecosystem, high cost/unit tariffs will be required for providing on-demand electricity. ***A business model for a Solar PV mini-grid is therefore, unviable at current cost structures. Thus, appropriate capital grant or subsidy is a must to make installation of mini-grids feasible even as a social business.***

How can the systems be optimised to operate at better margins? The primary needs of rural households are at night; hence to reduce battery requirement, it is imperative that a commercial load balances consumption during the day. This is one of the crucial factors taken into account by several mini-grid operators, e.g. Gram Oorja, in their choice of villages for installing mini-grids. Commercial loads allow them to have differential pricing as well as a balanced load profile to maximise consumption at the time of generation (during daytime).

Rural consumers pay very high prices for energy access. The current subsidy regime must be supplemented to help reduce tariffs.

The hysteria over tariff

One of the biggest criticisms of RE, in particular Solar, is the cost/unit that the IPPs charge their customers. Most off-grid Solar providers today provide 'package deals' for a flat monthly fee of Rs 100-150, instead of charging the end user a cost per unit as a household on the grid is accustomed to paying. The offering works well for the user as this is the amount that was previously spent on kerosene, for which s/he now has two clean lights and a mobile charging point. However, if one calculates effective cost/unit on these offerings, they are very high. Hence, such arrangements cannot really scale to provide power for other household appliances, as the monthly charges will rise steeply.

On the other hand, a few pilot projects where upfront investment came as a grant are charging ~ Rs 15/unit to cover for operational and battery replacement costs. This might be outrageous if we think that an urban residential consumer is paying Rs 5/unit. Notwithstanding opinions of people who have electricity, villagers seem excited about getting access to power and all the positive change that comes with it. As Carl Pope of Sierra Club sums up well in his article for the RuDiCON 2013 conference: *"It is unconscionable for those without energy to be forced to continue to spend huge portions of their monthly income on dirty kerosene and diesel instead of cheaper and cleaner solar and biomass because we want them to wait for the grid to arrive. A grid that hasn't come for decades, and will not come for decades more".*

We have to look beyond this obsession with cost/unit and maximise supply of electricity to unreached areas in an urgent time-frame. With time, as and when the government starts accumulating significant savings on kerosene and diesel subsidy that money could potentially provide for a Generation Based Incentive (GBI) with a gradual reduction in tariff to the end users.

It is also important to note that grid tariff does not include several hidden costs of environmental degradation, carbon emissions, adverse health impacts, etc. However, in this document, we concern ourselves with existing market price regime only.

3.2.2 Relevance and impact of Subsidies

There have been several schemes for Solar PV systems – first under RGGVY (the DDG scheme) and thereafter released by MNRE, which has resulted in quite some confusion regarding which subsidy is applicable in which case. It can take a while for anyone new to the industry to comprehend the policies and discern which ones are extinct.

Under JNNSM, MNRE has the Off-grid and Decentralised Solar Applications Programme, wherein for Solar PV based household systems, assumptions on benchmark costs are Rs 270/Wp (Watt-peak) including battery and Rs 190/Wp without battery (MNRE 2011). MNRE provides 40% of the cost as Central Financial Assistance (CFA).

For standalone Solar PV plants for rural electrification, MNRE offers a subsidy of Rs 150/Wp installed[33]. However, the process to avail of this subsidy is tedious. First up, the entrepreneur must get the village mini-grid sanctioned. This step itself could take a few months. Then an MNRE representative visits the site to inspect the work done, and prepares a report. Thereafter, once the report is approved, the subsidy is transferred to the nodal office, and the nodal office makes the payment. Overall this appears to be a long process spanning several months, and in a few cases over a year. No surprise then that this particular subsidy has been availed of very rarely, and needs to be overhauled. As per our conversations with industry, we have heard mixed opinions on how fast or slow the disbursement process is. One mini-grid operator praised MNRE's support for disbursement of this subsidy, while another said it takes so long they have to plan and execute without the subsidy.

A crucial point to note here is the benchmark cost. For mini-grids, it was assumed to be Rs 500/Wp (and hence 30% subsidy equalled Rs 150/Wp). This was a supportive benchmark cost, albeit it included 5-year O&M contract and other guarantees. However, recently, the benchmark cost has been reduced to Rs 350/Wp (up to 10 kWp) and Rs 300/Wp for >10 kWp (MNRE 2013). This reduction is being severely criticised by the industry. ***It seems ill-timed, for it acutely compromises the business viability of the few players that are struggling to make AC mini-grids feasible.*** We believe this is a critical phase for mini-grids during which they need more support from the Government. Subsidies could be tapered over time, once the model is adequately validated.

In this context, it is also important to mention an older subsidy scheme by MNRE through its Remote Village Electrification Programme (RVEP): 90% CFA for 'remote un-electrified rural areas'. RVEP was designed to electrify villages and hamlets that were not covered under RGGVY, though technical definition of electrification that mandates setting up of transformer (and other grid infrastructure) ensured that RE systems are considered transitory (a Solar system does not need a transformer, for example). This is also reflected clearly in MNRE's thought process: the 2011-12 annual report states *'The National Rural Electrification Policy, 2006, has clarified that provision of renewable energy based systems in unelectrified villages and hamlets should not jeopardise the rights of such villagers to grid connectivity'.* ***We question this premise and reiterate that community level Solar PV systems should be considered a long term solution.***

As previously mentioned, this subsidy has been given mainly for household level SHS's for lighting purposes. The process entailed preparation of DPRs followed by MNRE approval and competitive bidding, all driven by state nodal agencies. As a result, the scheme has not been fruitful for mini-grids. The RVEP and JNNSM off-grid applications scheme are now slated to be replaced by the 'Energy Access' Scheme under JNNSM phase II (MNRE 2012). It remains to be seen if the implementation methodology is modified, as the older format inhibited success of the scheme.

It must be noted that none of the schemes discussed so far specify any exit strategies for the entrepreneurs/developers should the main electricity grid actually reach an unconnected village or catch up on the deficit in electrified villages and become a viable alternative. This significantly enhances the risk perception associated with such projects not just to entrepreneurs but, more importantly, to potential financiers. This brings us to the next big obstacle.

[33] The document also states 'soft loan at 5%' but a system provider clarified that this is not available.

3.2.3 Access to Capital

A solar mini-grid is an expensive asset, as seen earlier in this chapter, with an estimated average cost of ~Rs.2.5-3 lakh per kW installed. This implies that a system of 10 kWp would need an investment of ~Rs. 25-30 lakhs upfront. To start with, this money could come from various channels:

- Grant from a non-profit organisation/multilateral agency;
- Grant from CSR team of a corporate group;
- Investment by a company;
- Investment by entrepreneurs (one or more);
- Loan from banks or other financial institutions.

Existing loan criteria and processes make it difficult for rural entrepreneurs to avail of individual loans, due to lack of credit history and collateral. Capital is often made available by reluctant banks to English-speaking entrepreneurs with a pedigree. However, vernacular entrepreneurs who drive scale in the hinterland most often do not have access to financing. This slows down the expansion of companies that are willing to try Build-Maintain (BM) models with local entrepreneurs owning the system. For example, Gyanesh Pandey of HPS confirms that financing for local entrepreneurs is a real challenge. HPS started off with Build-Own-Operate-Maintain (BOOM) model, but is slowly shifting gear to BM model in order to scale rapidly. For many such networks to happen, long term asset financing is a necessity. Financial institutions can enable this by making credit available to local youth with repayment plans designed to match the customer's individual cash flow. At the ORF Roundtable, Dr Harish Hande gave credit to the rural banks for already doing this – by customising loan products such as giving 5-year loans to paddy farmers with an annual re-payment plan, to peanut farmers on a bi-annual repayment plan and so on. Dr Hande further illustrated his point with the poignant example of a street beggar who was able to afford a solar lighting system because a bank agreed to finance it based on her daily earnings from begging. Afterwards, she described how happy she was with her new solar system, but how she was even happier with the fact that she now had a bank account. Indeed, after paying off her solar loan she intends to buy a sewing machine so that she can quit begging! ***This case also highlights one of the biggest benefits of the banks being more adaptable namely, that of financial inclusion of the underserved segment.***

In July 2012, RBI extended priority lending to loans sanctioned by banks directly to individuals for setting up off-grid solar and other off-grid renewable energy solutions for households[34]. Hopefully this will give a much needed impetus to public and private banks to lend for Solar PV systems.

Unfortunately, recoveries in priority sectors have shown a poor performance so far. For example, recoveries in the agricultural sector were only 76% in 2008, and by 2011, they had fallen to 73.7%[35]. This is primarily due to short-sighted policies such as loan melas and loan waivers, which encourage the borrowers to default. Thus, it is imperative that lending in the new sectors be managed well, lest it runs the risk of tainting the entire framework.

Multilateral organisations such as the World Bank have also recognised the important role that mini-grids could play in addressing rural India's power deficit. A recently launched pilot programme in UP and

[34] Category 6.6, RBI notification RBI/2012-13/138

[35] Article by R.N.Bhaskar for DNA: http://www.dnaindia.com/money/report_renewable-energy-loans-good-idea-recovery-worry_1765058

Bihar aims to discover a replicable model of Solar PV (or other RE technology) based mini-grids. The key innovation being experimented with is installation of mini-grids to electrify a cluster of villages, to provide economies of scale to vendors. Financial support from the World Bank would be in addition to the 30% subsidy offered by MNRE under JNNSM. The Viability Gap Funding (VGF) component will not be completely front-loaded, but sufficient to boost confidence of debt-providing entities.

Asian Development Bank (ADB) has recently announced the launch of an incubation centre and a specialised venture fund in India dedicated for energy access start-ups, especially mini-grid companies. Whereas the fund is slated to provide the much needed seed capital for these ventures, the incubation centre will train entrepreneurs on how to prepare business models, raise capital, etc. Globally, ADB has formed the Energy for All Partnership whose goal is to bring modern energy to 100 million people by 2015. In 2011 this led to investments of $1 billion. Jiwan Acharya, Project Officer for ADB's Energy for All Partnership, says *"Historically, ADB mainly funded grid extension, but the grid is at its limits, and millions remain without power. ADB is now looking at bringing power directly to communities through off-grid solutions using mature renewable energy technologies"*[36]. Such financial instruments and assistance could provide much needed start-up capital for experimentation and discovery that is currently required for Solar PV based mini-grids.

On the equity front, expectations of financiers are usually very high, to the point of being unrealistic. This is a cause for much discontent amongst the entrepreneurs. Testing and refining business models takes years at a time due to remoteness of locations, building awareness among the consumers, time-varying payment capacity, sparse or low initial demand, etc. This is a tough playing ground, as is evident by the failure of the government to provide these services after decades of investment. Thus, investment horizons have to be much longer than the norm. We need more 'social impact' funds such as Ashoka and Acumen that are content with lower rate of return as compared to commercial funds. Patient capital will go a long way in enabling the fledgling start-ups to discover workable models.

3.3. TECHNOLOGY RELATED CHALLENGES

Optimising technology for local conditions has been the main stay of several breakthroughs in our country. On several occasions, indigenous innovations have tailored new technology to our unique needs. We already see this with the design of household-level systems, the payment collection mechanisms, the monitoring for preventing pilferage etc. Could we do something similar with the core system?

Solar systems are not self-sufficient. Electricity needs to be stored in batteries for night-time usage as well as during monsoons. Specifically, initial demand from a newly electrified village is more concentrated at night (due to lighting needs), and hence storing electricity generated during the day is essential. On the other hand, the notion that no generation is possible during monsoons is false. The generation efficiency typically reduces by 40-50% maximum (except days of very heavy rain). This is because solar photo-voltaic panels can produce electricity from ambient light. In fact, PV systems have higher efficiencies at cool temperatures, and power generation decreases when it gets too hot. However, sharp decrease in production could happen during heavy fog. In renewable technologies, seasonality has to be planned for. Site specific solar radiation data usually gives a fair estimate of the total annual production.

[36] http://www.adb.org/features/focus-sustainable-energy-all

Batteries are not just expensive but environmentally toxic too. In fact, battery costs could be as high as 30% of system cost. It doesn't help that the Indian government levies a significant import duty on batteries, thereby protecting the market for toxic batteries being manufactured domestically.

Battery maintenance and replacement is also the single largest maintenance cost in a Solar PV system. In case of corporate pilots, such as those implemented by SunEdison and Gram Oorja (mentioned earlier in the document), monthly payments by the villagers go into the maintenance corpus, primarily to replace batteries every 5 years. An interesting model is being experimented with in Ladakh where LREDA is considering levying a minor surcharge on conventional grid power to pay for battery replacement in remote areas where Solar PV systems have been installed[37]. It is noteworthy that LREDA has installed large PV systems with large battery banks, for example a 100 kWp system at Vikas, an office site in Leh. Thus, feasibility of large battery banks as the plant size increases has been proven by them.

While research efforts are on-going to find better alternatives to traditional Lead-Acid batteries, Solar PV systems, hybridised with biomass or micro-wind, are also being experimented with. These systems are expected to increase efficiency while reducing the requirements for battery backup:

- Both wind energy and biomass gas can be generated at nights when there is no generation of solar power. They can also provide backup during the rainy season;
- By continuous generation of power through the day and night, battery need is reduced. In addition, battery life could be increased by up to 50% since discharge cycles are less frequent. Since battery cost is the single largest cost component in Balance-of-System (B-o-S) for a Solar PV setup, reducing battery cost can enhance the viability of Solar PV mini-grids;

> *"Everybody now says that technology is available…but it is my belief that this statement should refer to appropriate technology, which is sadly still lacking"*
>
> -Dr. Avinash Patkar,
> Chief- Clean Technology R & D, Tata Power

- Technically, the challenge of designing battery backup remains, because the total output of a RE hybrid system can vary considerably from one season to another. In this respect, it is sometimes preferred to route generated wind power directly to a local circuit for consumption, instead of the battery. This might be efficient to do at the level of mini-grids.

At the ORF Roundtable, Shri Jamshyd Godrej mentioned a study done by Shakti Sustainable Energy Foundation with Lawrence Berkeley labs in the US on the potential for wind energy in India. This report, titled "Reassessing Wind Potential Estimates for India: Economic and Policy Implications" shows that the potential is much higher than was previously thought to be. *"The really interesting thing now would be to see how hybrid systems of wind and solar can be used without storage (batteries)"*, he said.

Notwithstanding the advantages of hybrid systems, critical challenges continue to exist: it is hard to locate good micro-wind sites as wind maps at lower heights (~30 feet) are not readily available; in fact good wind areas are confined to coastal areas rendering solar-wind hybrid practically irrelevant to interior regions. On the other hand, streamlining collection and input of bio-waste for biomass gasifiers

[37] Remarks by Reuben Gergan, LREDA at ORF Roundtable

on a regular basis requires a lot of planning and operations. In Gujarat's 'Gobar banks' initiative, we have seen a successful modus operandi to streamline the biomass supply chain. Something similar, if deployed for wasted agro-residue such as cotton stock and banana stems, could make community level biomass-gasification systems feasible.

Appropriate incentives for hybrid systems could significantly enhance the viability of these village-level systems. However, hybrid systems are not taking off as expected, due to practical considerations and/or lack of adequate subsidies. More investigation is required to gauge the real causes. Currently the subsidy for solar + micro-wind systems stands at Rs 1 Lakh/kW installed (or Rs 1.5 Lakh/kWp for Government / Public / Charitable, R&D, Academic and other non-profit organisations). It is unclear how effective this subsidy process is. MNRE is yet to announce a subsidy regime for solar hybridised with biomass-based systems.

Given the diesel based economy in several rural areas, interesting models of solar backed up with a diesel genset have also cropped up in a few parts of the country. This could be a short term path to significantly reduce diesel consumption (and therefore operating costs), while having a backup to cover deficit during the monsoons, especially in areas not suitable for micro-wind or biomass. Similarly, we already see examples of hybrids of biomass-gasifiers with diesel for captive power generation.

As a slight digression, it is worthwhile to note the dual advantage that comes with a solar system hybridised with biomass, where a part of the gas produced could be used for cooking. That would enable comprehensive energy access for the rural consumers.

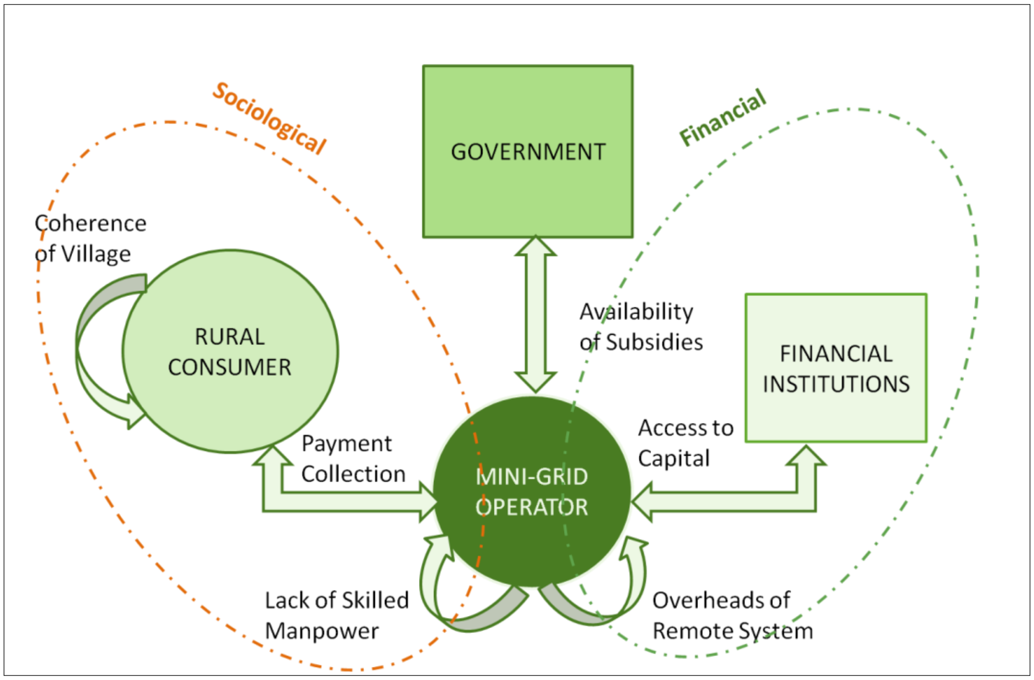


Figure 9: Sociological & Financial Challenges faced by various stakeholders

We conclude this chapter with an interview with Sameer Nair, Director at Gram Oorja, an Independent Power Producer, using Solar PV technology for installing mini-grids. He takes us through the challenges his company faces on a day-to-day level.

Interview with Sameer Nair, Gram Oorja

i. **How and why did you choose to work on mini-grids (over grid connected and other renewable energy solutions)?**

As the name of our company suggests, we were interested in trying to solve the rural energy problems of remote villages. Both Anshuman (co-founder) and I were motivated by a desire to use a commercial framework to do social good. We do work in off-grid.

ii. **How long have you been working in this space and what would you consider are some of your important successes (and failures)?**

The company was incorporated in April 2008 and we were working on the idea for about a year before that. We have been able to establish ourselves as serious players in the rural energy space and all stakeholders from relevant government bodies (MNRE/IREDA etc.), to multi laterals, to players like NABARD are familiar with our work. We would have liked to have scaled up a little sooner than we have been able to.

iii. **What are some of the key challenges you have faced? And continue to face?**

The process of business development and project identification in remote locations is an extremely expensive proposition. For a company like Gram Oorja, the costs to do so can get prohibitive. Also, despite falling costs, projects to provide power over and above basic lighting can be beyond the paying capacity of the end users. Hence government funding is an imperative.

iv. **Are mini-grids viable? Why is the prospect attractive to you? How can it be made more attractive?**

Mini-grids for pure lighting can compete with alternatives like kerosene.
In remote areas, mini grids can also be more cost effective than grid extension. On an absolute basis, these are expensive and beyond the paying capacity of end users at full costs.

v. **Are subsidies the best way to support entrepreneurs like you? If yes, is the subsidy management regime adequate?**

There are multiple subsidy schemes from different ministries (DDG under ministry of power), JNNSM under MNRE and as such the quantum of money purportedly set aside is not insignificant. However, schemes have not taken off because of implementation issues.

vi. **What other kind of support would you like government to provide you with? Are there government processes that you either have difficulties with or you would like to see changed?**

It's important for the different government agencies that are stakeholders to have a common understanding of the problem. Else a lot of effort is duplicated and can lead to confusion in the market.

vii. **What kind of solutions would you recommend for homes within grid connected villages and hamlets that do not have adequate power?**

Decentralised generation with an ability to interact with the grid could in theory be a useful solution. However, in practice without clarity on how grid interactivity can happen technically and without clear understanding on commercial terms of supply (like net metering etc.) this will not take off.

viii. Can you give us a sense of how much local enterprise is being generated as a result of the mini-grid installation in Darewadi?

Currently, the chakki (flour mill) is being used for about 2 months or so. Darewadi villagers are also contributing to make a bore well and use the water for drinking and other purposes.
Our experience is that it is best to work with a local NGO or agency that has a clear idea of how the energy from the mini grid can be utilised for commercial purposes.

ix. What are the challenges to do with Operations and Maintenance?

1) Remoteness makes frequent visits expensive.

2) Lack of qualified technical manpower to handle maintenance issues at remote locations – this is a bit of a chicken and egg problem, the lack of scale makes it difficult to invest in training of local manpower, and the lack of trained manpower is one of the reasons why operations and maintenance becomes expensive and prevents scaling.

3) In some locations, accessibility is often severely restricted for 3-4 months of the year (typically monsoons).

4

Policy Recommendations to Realise the Vision of an Em-POWERed India

"The movement of our masses from Darkness to Light requires no less than a revolution and this revolution is going to rely on the successes of some very disruptive artful models."

Gyanesh Pandey, CEO, Husk Power Systems

"We need a broader perspective on renewable energy which goes beyond merely producing more power or reducing carbon emissions, as is the primary role and understanding in the developed world. For India, it is a developmental imperative."

Deepak Gupta, ex-Secretary, MNRE

4. POLICY RECOMMENDATIONS TO REALISE THE VISION OF AN EM-POWERED INDIA

What we saw in previous chapters is that for the 300 million Indians who are living without access to electricity today, the grid and increased installed capacities are of little significance. Extending the grid to these populations is a difficult and expensive proposition, especially given the current condition of the grid in more accessible areas. For a long term developmental solution, real access to electricity is required and must be provisioned for. With solar energy being an abundant resource in most parts of our country, and the sharp decline in cost of technology in recent years, community level Solar PV mini-grids can be a scalable and low maintenance solution for distributed generation. If combined with biomass gasifier, clean cooking gas can also be made available, resulting in a more versatile system.

Policy mechanisms can address the challenges outlined in the previous chapter to facilitate an ecosystem that can catalyze an Energy Revolution. In this chapter, we list our recommendations on the policy front seeking to cover all the challenges discussed.

4.1. PUT RENEWABLE OFF-GRID SOLUTIONS AT THE HELM OF ELECTRIFICATON AGENDA

As discussed in Chapter 1, the current definition of electrification is grossly inadequate in ensuring a connection to all households as well as an acceptable quality of power supply. Thus, while the electrification rates have been steadily increasing since the launch of RGGVY, a massive number of households (over 77 million) continue to depend on kerosene for lighting. In fact, number of unelectrified households has barely moved in a decade – from 85 million in 2001 to 81 million in 2011 (Census of India 2011). On the other hand, MNRE must be commended for putting out an ambitious target of covering 20,000 villages/hamlets via the newly suggested Energy Access scheme for Phase II of JNNSM in the draft policy. But without other supporting factors such as skill development and easier access to funding, this target might be difficult to achieve. At the time of writing this report, we are awaiting the final policy which would elaborate on the mechanism for implementation, and how it would be different from RVEP, the scheme it is slated to replace. Nevertheless, the responsibility of 100% energy access does not lie with MNRE.

As a nation we need to accept the limitations of the conventional grid policy, and that renewable energy is the way forward to meet the ever increasing energy demands of the nation. The sooner we acknowledge the writing on the wall, the quicker we can embark on the 100% electrification mission. The need of the hour is a joint policy from MoP and MNRE that aggressively tackles electrification through Solar PV (or hybrid) mini-grids. ***Only if MoP accepts off-grid solar power plants as a long term solution, and not just a transitory one 'till the grid arrives', will the right focus be accorded so that they can take the centre stage in the campaign "Energy Access for All".***

> *"Off-grid Solar has such a huge multiplier effect and potential for development that we have to find ways to promote it through policy, and support it as well as we possibly can."*
>
> Jamshyd Godrej, Chairman, CII GBC

The joint policy must be simple and should clearly articulate the role of each ministry/government department. It would ideally aggregate existing set of policies and streamline them. It would also take away the misgivings that are perceived on the multifarious existing policies on distributed power generation. An exit strategy for the entrepreneur, should the grid reach before s/he recovers the investment, would cease to be a matter of concern if there is assurance from MoP/state electricity boards that mini-grids would be integrated with the main grid in such a case.

As issues like corruption, nuclear plants and coal scams capture urban India and the media's attention, an awareness exercise about power woes in the country and how distributed renewable energy could address them would go a long way in building a positive public opinion and putting this issue on the priority agenda. Renewable energy technologies should be highlighted, and the critical role they would play in our country's energy future underscored. A strong campaign by the media and the public will force the policy makers to chart out a way forward in a speedy manner.

While funds are not the only bottleneck, they are perceived to be the biggest one. Below, we do a ballpark exercise for total investment (capex) required for installation of mini-grids across the country:

A 10 kWp system is sufficient for a village of about 50 households, i.e. 200-300 people, based on inputs from existing entrepreneurs. With a cost estimate of Rs 3 lakhs/kW installed, one needs about Rs 30 lakhs for a typical village.

- For 10,000 villages, this would mean Rs 3,000 crores
- For 50,000 villages, this would mean Rs 15,000 crores

(Note this is an over-simplified calculation for illustrative purposes only[38])

Rs 15,000 crore is not a mammoth number, particularly when examined in the context of other spending by the government. A few examples that help us benchmark this number include:

- Annual diesel subsidy: over Rs 90,000 crores[39]
- Under-recoveries on PDS kerosene for the year 2010-11: Rs 19,500 crores (TERI 2012)
- National Clean Energy Fund (NCEF) collection in 3 years 2010-13: Rs 8,000 crores[40]

As we can see, tens of thousands of crores are being spent on various subsidies or are available through the NCEF. It is clear that one year of annual diesel subsidy or a couple of years of kerosene subsidy is all that we need. In particular, the outlay for RGGVY in XIth plan was Rs 28,000 crores, with a goal of electrification of 1.15 lakh villages; out of which DDG got a sanction of Rs 540 crores only. Thus we note that capex per village under RGGVY is very similar in ballpark to the capex amounts for solar mentioned above, except for the distinction that the costs under RGGVY are for setting up infrastructure only. The cost of providing electricity through the conventional grid is over and above this investment. ***On the contrary, the investment in solar mini-grids includes the cost of supply of power for 25 years, which is the life of the panels.***

NCEF was instituted in 2010 by levying a cess of Rs 50/tonne of coal (domestic as well as imported). Whereas NCEF's primary objective is to support research and development for clean energy sector,

[38] Indicative average village size as per conversation with Sameer Nair, Gram Oorja. Distribution of villages by population is available on Census website, but no statistics could be found on villages in our target segment.
[39] http://expressindia.indianexpress.com/latest-news/Diesel-subsidy-for-201314-could-be-capped-at-Rs-6-litre/1076681/
[40] http://www.business-standard.com/article/news-ians/clean-energy-fund-underutilised-lacks-of-focus-experts-113050100326_1.html

enabling universal energy access is an urgent need of the nation that should receive priority attention and funding.

4.2. LAUNCH NATIONWIDE CAPACITY BUILDING AND ENTREPRENEUR TRAINING PROGRAM

The second biggest bottleneck is capacity building at the local level. We saw the importance of educating and getting buy-in of the community in Chapter 3. Members of the community are more likely to succeed in getting this ground-work done. Secondly, even though the main grid reaching a village is a good thing, the socio-economic benefits of a local entrepreneur installing & operating a mini-grid system are much higher. It is not just a livelihood opportunity for one or two households; it builds confidence in the community, especially the youth, who would otherwise migrate to towns/cities to earn wages, straining already burdened resource systems in urban areas.

JNNSM Phase II draft has made a good start by setting a goal of 25,000 village level technicians and initiating courses in engineering institutes as well as Industrial Training Institutes (ITIs) to train manpower for installations and after-sales service. We suggest taking this effort to the next level by training not just technicians, but ***tens of thousands of entrepreneurs.*** An entrepreneurship training program would have to be designed differently – it would include site evaluation, technical, financial, operations and maintenance skills, as well as the knowhow regarding government subsidy schemes. Knowledge of the process is critical and the training could save entrepreneurs who start out on their own a lot of time.

The National Skill Development Corporation (NSDC) was formed in 2008 with the objective of promoting skill development through funding of for-profit vocational training institutes. Operating in a Public-Private-Partnership (PPP) model, it provides incentives for training programmes in 21 focus sectors[41]. However, renewable energy is not a focus area. We recommend that a nationwide training program for RE technologies be drawn out and housed inside the NSDC. This could be designed to work in partnership with FICCI/CII and be executed by the network of ITIs, for example. Organisations such as RUDSETI that are active in addressing unemployment problems in rural areas through entrepreneurship could be leveraged.

Companies such as SELCO and Husk Power who have been training entrepreneurs for the last several years could be invited to design a program to train the trainers, who in turn could be posted at ITIs across the country to kick start a massive capacity building effort. It is very important for this program to reach the interiors of the country. There are over 10,000 ITIs[42], so the potential of this activity is huge. It would be challenging to recruit trainers and thereafter potential entrepreneurs on such a large scale. This exercise can be ramped up over several years, as Solar PV applications continue to percolate into rural and remote areas and the demand subsequently increases.

Appropriate allocation of funds will be required by the Central government to undertake this effort. To conduct such on-site entrepreneur-training programmes, the average cost has been estimated in the range of Rs 150 per person per day. Thus, a 30-day course is about Rs 4500-5000 investment per trainee. Post such training, 70%-80% hit rate of trainees is observed, though 30-40% of those leave mostly within a year[43]. A training scheme of 100,000 entrepreneurs, for example, would need about Rs 50 Crores, though accounting for the churn rate, it would effectively add up to about 80 Crores. This is a simplistic

---

[41] http://www.nsdcindia.org/faq/about-nsdc.aspx#ac
[42] http://dget.nic.in/lisdapp/nvtis/nvtis.htm
[43] Conversation with SELCO Foundation team

calculation which assumes no marketing cost to recruit youth into the program, and no costs to train the teachers. Those costs are likely to be a fraction of this budget.

The impact of enabling rural entrepreneurship would be manifold. ***It would herald a new democracy in energy access – power of the people, for the people and by the people.***

4.3. FINANCIAL INCENTIVES

Given the early days of this industry, and misgivings about policy, financiers have been hesitant to come forward and fund renewable energy projects. Specifically, off-grid Solar PV plants do not present a profitable business model, just yet. In previous chapters, we saw cases where innovations in delivery methods and payment mechanisms have ushered a few early viable models.

In this chapter, we outline a few financial instruments that could go a long way in assisting entrepreneurs either in conjunction with other policy interventions or even in the current broad framework. These ideas are not novel and in fact the second instrument (Interest subsidies) was discontinued by MNRE in 2012. Nevertheless, we present a case for them.

a) A workable capital subsidy

As we saw in Chapter 3, the 30% CFA under Off-grid scheme is insufficient to allow entrepreneurs to charge a reasonable cost per unit to the end users. On the other hand, RVEP, which gave 90% subsidy, was ineffective due to the convoluted implementation mechanism. Therefore, it is clear that the government needs to find a middle path whereby a higher percentage of CFA is provided to implementers (say 50-75%) without compromising on the speed of process. At the same time, it has to ensure appropriate checks and balances so that implementers deliver on their responsibility and end users get the service quality they deserve. For this to happen, government needs to move into the role of a regulator and create a transparent monitoring and regulatory framework. The process of availing the subsidy could still be kept straight-forward while strengthening the technical specifications, on-going monitoring and reporting, and setting up of a complaint redressal cell. This would help reduce the barriers to entry without causing leakages of funds.

b) Interest subsidies

For grid connected projects, it is well known that the success of the project depends on the rate of interest of the loan component. Majority projects in JNNSM Phase I opted for thin film technology instead of PV primarily to avail low interest-rate-loan from US EXIM bank (where the pre-condition was products must be sourced from US based companies).

In a joint study by the Climate Policy Initiative (CPI) and the Indian School of Business (ISB), the impact of rate of interest has been well illustrated (David Nelson 2012). To quote from the executive summary of this report: "*Our financial modelling of actual renewable energy projects in India and elsewhere indicates that the higher cost and inferior terms of debt in India may raise the cost of renewable energy by 24-32% compared to similar projects financed in the U.S. or Europe*".

The study concludes that high interest rate has the highest cost impact on RE projects (see Table 2). For grid-connected projects, the government has acknowledged the need for low interest-rate loans and is now thinking of putting aside some NCEF funds for the same[44].

[44] http://www.energynext.in/ncef-will-be-used-for-low-interest-loans-mnre/

This issue extends to mini-grid financing as well. As per industry sources, assuming 100% loan on capex, cost of interest calculated per unit of electricity generated could be as high as Rs 20/unit[45].

Thus, setting aside a corpus for interest subsidy could go a long way in making these projects more economically feasible.

Table 4: Current and future impact of major issues in RE financing

Source: *CPI & ISB Study: Meeting India's Renewable Energy Targets – the Financing Challenge*

DEBT	COST AND TERMS	**High general Indian interest rate** environment raises renewable project debt cost	VERY HIGH	VERY HIGH
		Longer tenor debt is generally unavailable	MEDIUM	HIGH
		Fixed interest rate debt is rare; market relies on variable rate debt	LOW	HIGH
		Debt is not strictly non-recourse as it is usually offered on a relationship basis	MEDIUM	MEDIUM
		Shortage of debt may raise its cost in the longer term	LOW	MEDIUM
	AVAILABILITY	**Banks limit lending to any one sector** for risk purposes	LOW	HIGH
		Renewable energy debt is often classified within power or energy sectors, which are already nearing sector limits	MEDIUM	HIGH
		Some banks are not lending to renewable projects due to unfamiliarity with renewable energy policy and markets	MEDIUM	HIGH
		Limits on foreign debt may restrict foreign lending	LOW	HIGH
		Technology risk is limiting debt to some technologies	MEDIUM	MEDIUM
		State-level policy, the poor financial condition of the State Electricity Boards, and unfavorable local business environments restrict lending to some states	MEDIUM	HIGH

c) *Bank guarantees*

Financiers are hesitant to make credit available to rural entrepreneurs because they lack conventional credit history as well as collateral. This is a chicken-and-egg situation that has been partially addressed by the Self Help Group (SHG) movement. Cost of servicing a loan in rural areas is also higher. While micro-finance has achieved some success in enabling livelihood opportunities, they are short term loans (usually for up to three years) and with a smaller ticket size. RE solutions need longer term asset financing. Banks do not have an incentive to lend to small scale projects and even though RE solutions have been covered under priority sector lending, it has not translated to multiplication of Solar PV plants. There have been several loan waiver schemes floated by

[45] Conversation with Sameer Nair, Gram Oorja

governments, to the tune of tens of thousands of crores. We do believe that if some of these funds are directed to a loan guarantee corpus instead, banks that are sitting on the fence will be happy to lend, and many more citizens will get benefitted

d) Separate sector limits

Renewable energy loans are usually classified under the power sector, which as a sector has on-going massive funding needs. Thus, the banks maximise the sector limit even before RE projects can be considered. Many banks also restrict lending to RE sector as they do not understand the technology, and thus are more likely to fund conventional power projects. The CPI-ISB report also observed that less than a third of public sector banks and less than a fifth of private banks lend to RE projects (David Nelson 2012).

Making RE a separate lending sector would greatly change this scenario and ensure flow of funds to develop it further. Earlier this year, it was in the news that a separate lending limit for renewables might be encouraged for the banks, which is a very good development. However, at the time of writing this report, there is no confirmation that a separate sector limit has indeed been implemented.

Telecom Towers and the RESCO Model

India has about 500,000 Telecom Towers, out of which about 60% depend on diesel generators due to unreliable power supply. This amounts to sector consumption of 2 billion litres of diesel per year, as per Telecom Regulatory Authority of India (TRAI). The tower providers are now bound by TRAI policy to convert 50% of all rural towers to hybrid power (renewable+grid) by 2015. This conversion project is slated to cost Rs 33,000 Crores, and is partially supported by the 30% off-grid solar applications subsidy by MNRE. Even though the conversion will lead to significant savings over the lifetime of the panels, the tower companies have been hesitant to take such investments on their balance sheet.

A new service model has emerged to capitalise on this opportunity: **R**enewable **E**nergy **S**ervice **Co**mpany, or the RESCO. These providers own and operate the plants and provide renewable power to the towers on per unit or monthly charging basis. Companies such as OMC Power, Bhaskar Solar and several others are jumping into the fray.

'Greening' of rural towers presents a unique opportunity to use these captive power plants as anchor loads; thereafter, the surplus power could be provided to the nearby village(s). This premise was also supported by the Rockefeller Foundation funded SPEED initiative: Smart Power for Environmentally-sound Economic Development. Large anchor loads, whether towers or any other commercial entities, can give a dramatic jump to the economic viability of mini-grids. Especially because these are primarily diesel substitution opportunities, that cost the consumer Rs 20-25/unit. In addition, consumption of generated power during daytime reduces battery requirement. Hence, appropriate incentives to the RESCOs for village electrification could go a long way to catalyse rural development.

4.4. STEER CSR FUNDS INTO ENERGY INFRASTRUCTURE

When the recent legislation mandating 2% of profits into CSR activities (Companies Bill 2012) is implemented, it is expected that thousands of crores of corporate money will flow into several fundamental sectors such as nutrition, health, education, sanitation, rural livelihoods, etc. According to an analysis by the Business Standard, an additional Rs 6,750 Crores[46] will be available for community development.

Few CSR programmes currently have 'Energy Access' on their agenda, even though it is well understood that energy access is a pre-requisite for development. An early example is the work of the Tata Foundation, which has recently teamed up with First Solar to set up pilot mini-grids in a few villages[47].

ORF Mumbai recommends that some sort of impetus be provided to companies so that a portion of the available CSR funds could be deployed towards critical infrastructure such as provision of electricity. This could even take the shape of a national level committee comprising CSR representatives of leading corporate houses, along with pioneer NGOs who already have an established communication channel with rural communities. However, one has to be careful in ensuring the buy-in of the beneficiary community. As mentioned earlier in the report, pilot projects by companies such as Gram Oorja, Sun Edison, etc. have demonstrated that making the community a stakeholder in the operations and maintenance of the mini-grid significantly increases chances of success of the project. This can be accomplished by bringing villagers together as a co-operative/trust to manage the power plant, or ensure that they have a financial stake in the plant.

Additionally, a financial incentive could be provided to companies to channel money into RE installations, such as proportionate Renewable Energy Certificates (RECs) for the generated power[48]. For example if a group funds five hundred 10 kWp systems with a capex investment of about Rs 150 crores, generating about 15,000 units per plant per year, a discounted REC mechanism could be devised to stimulate such investments in the short run.

[46] http://www.business-standard.com/article/companies/ongc-ril-top-list-of-potential-csr-leaders-113010200201_1.html
[47] http://forbesindia.com/article/philanthropy-awards-2012/tata-trusts-outstanding-corpo-rate-foundation/34211/1
[48] One REC represents that 1 MWh of energy is generated from renewable sources

The regime of Purchase Obligation and Energy Certificates

To increase the share of renewable energy in the total generation capacity to 20% by 2020, Renewable Purchase Obligation (RPO) was introduced as a tool by the Government in 2010. Under this policy, State electricity regulatory commissions mandate the percentage of electricity that State utilities and large captive users must derive from renewable sources. For 2012-13, most states announced RPO targets between 3-7%, with a few exceptions such as Maharashtra (8%), Nagaland (8%) and Himachal Pradesh (10%).

The Renewable Energy Certificates (RECs) were launched in 2011, as a mechanism for obligated entities to meet their RPO targets through trading of these certificates. Whilst it is early days to comment on the efficacy of this framework, a few studies have noted that due to seasonal enforcement, volatile supply of RECs and price variation between the two power exchanges, the current market is very inefficient (Sandeep Kumar Gupta 2013).

What could be the relevance and impact of RECs/RPOs on distributed power generation? Currently, aggregation of power from various distributed sources to qualify for REC is not allowed. A few mini-grid operators, such as Yashraj Khaitan of Gram Power, advocate that mini-grids should be eligible for RECs, even when they claim subsidy, to make them more viable as a business. We support these industry recommendations to make mini-grids more attractive as a business, thereby driving faster growth in their deployment.

100% Electrification using Solar PV mini-grids, good for 25 years, will need less than 5 years of Kerosene Subsidies to cover installation costs.

5

A Roadmap to 'Energy Access for all' for India@75

"I suggest that, if India is to evolve along non-violent lines, it will have to decentralize many things."

Mahatma Gandhi, 1939

In this strategy, the sun occupies a center stage, as it should, being literally the original source of all energy.

Prime Minister Dr. Manmohan Singh
Speaking at the launch of National Action Plan on Climate Change, 2008

5. A ROADMAP TO 100% ELECTRIFICATION FOR INDIA@75

In this chapter we lay out one path to achieving the goal of 100% Energy Access. We are not by any means suggesting that this is the only way forward, although we do believe that this path maximises the chances of succeeding within the timeframe of a decade. The path relies on utilizing locally available solar energy as we strive to bring the underserved sections of society on track for economic and social development without exposing the nation to greater fossil fuel import risks.

5.1. A STAKEHOLDER FRAMEWORK TO SUPPORT A REPLICABLE MODEL

Given the tens of thousands of villages in need of electrification, the heterogeneity of the end users, the remoteness of many of these locations and sparse habitations, a franchise model that mobilises local citizens at the front end of the network emerges as a natural implementation model. Since the system installation is technology intensive whereas operations and maintenance are primarily low-tech, Solar PV based mini-grids are particularly well suited for this model.

5.1.1 The Franchise Model

Existing (and new) Independent Power Producers would play a critical role, that of aggregating many smaller players. As mentioned earlier, since these systems are investment intensive, it is best if large players take the onus of providing scale in the deployments, through multiple installations. For corporate houses like Tata, Reliance and several others who are already either in the power generation business or sell products to the rural consumer, it would be a natural market expansion. They could tap into their existing supply chains and leverage their brand name in rural areas. Similarly, if large grid-connected Solar power producers such as Mahindra Solar, Azure, Kiran Energy, etc. could become aggregators of distributed small capacities, it would transform the landscape.

> *"Large industrial houses and other big firms must get involved in the deployment of off-grid renewable energy systems."*
>
> Gireesh Pradhan, ex-Secretary, MNRE

Local entrepreneurs can also become franchisees of these companies, similar to the way in which HPS and Orb Energy have succeeded in creating franchise networks for rice husk based power plants and for Solar PV systems respectively. There is one category of local entrepreneurs already out there who are running diesel generators and operating micro-grids in states like Bihar and UP. These operators need to be converted to Solar PV. The franchisee can operate at various levels of the B-O-O-M (Build-Own-Operate-Maintain) regime. Although they are more likely to be operating these installations, and/or managing the last leg of distribution and payment collection, they may in some cases be willing to put down sufficient investment to own plants too. The latter model can help scale as aggregators won't need to invest as much in every plant directly. On the flip side, it would require the local entrepreneur to have access to funding as well as technical know-how. Two successful models that India has seen namely, the PCO booth revolution and the Cable TV rollout, have shown that if technology can be simplified enough to act as a black box to the last person in the supply chain, it can have an immediate impact on scale up. Agents who are primarily responsible for sale of power and collection of revenues could be great levers for scale. We are already seeing this model with Gram Power, where the distribution agents purchase power credits from the company into their 'wallet' and then wirelessly transfer these credits to end-user smart meters once the user prepays.

The value of the aggregators to the mission and to consumers will be the fact that a clustered approach will leverage efficiencies in supply chain, operations, technology up-gradation and training, and in maintenance cycles making sure that these plants, once installed, run the way they ought to, replacing grid-connected power seamlessly in the eyes of the consumer. On the financing side, there will be fewer touch points for the disbursement of loans, subsidy/grant money, which will make financiers more comfortable and speed up the activity. With the prospect of adequate support and reduced perceived risk, local entrepreneurs will be more enthused to come forward and more people are likely to jump onto the bandwagon. This model also has the added advantage of the potential of creating large-scale employment in rural areas, particularly when the benefits of 'energy availability on demand' begin to be exploited.

5.1.2 The Ecosystem

The full ecosystem that is required to help deliver on the goals of the 100% electrification mission is shown in the framework diagram (Figure 10). This framework envisions cooperation among all stakeholders to evolve a facilitative environment for the aggregators and local entrepreneurs who become the driving force, while the State and Central governments move away from their traditional role of being providers to becoming enablers and facilitators. The roles of the various stakeholders are outlined in detail below:

- The implementing agency can be any of large, medium-sized, or small entrepreneurs working on their own. However, as described in the previous section we believe that small and medium-sized local entrepreneurs can benefit immensely by having the support of large industrial houses playing the role of aggregators in order to leverage scale;
- The support infrastructure consists of several players beginning with the MoP and the MNRE. These Central ministries must come together to announce the mission and support the lofty goal with the enabling framework consisting of the appropriate policy formulations as outlined in Chapter 4;
- NABARD, the Regional Rural Banks and other financial institutions can provide the access to funds which can be given out via a combination of subsidy (disbursed by NABARD), loans (disbursed by banks) and optionally a grant from CSR groups;
- As discussed often, renewable energy systems, particularly hybrid ones, are technology intensive and will require sizeable skill development initiatives to be taken up. These could possibly be coordinated by the NSDC in close co-operation with MoP and the MNRE;
- State Governments and their DISCOMs/RE agencies have multiple critical roles:
    - Provide the regulatory framework in conjunction with the Central Government,
    - Monitor the progress of the mission and take up any and all activities that will contribute towards achieving the goals of the mission. The implementing agencies can be required to send in periodic reports on plant installation and performance;
- Power utilities in the States may not play a role immediately, but they can certainly help in

- Drawing up lists of 'on-paper electrified' villages that can be given go ahead for installation of mini-grids,
- Drawing up policies for grid interactivity of Solar PV plants when necessary.

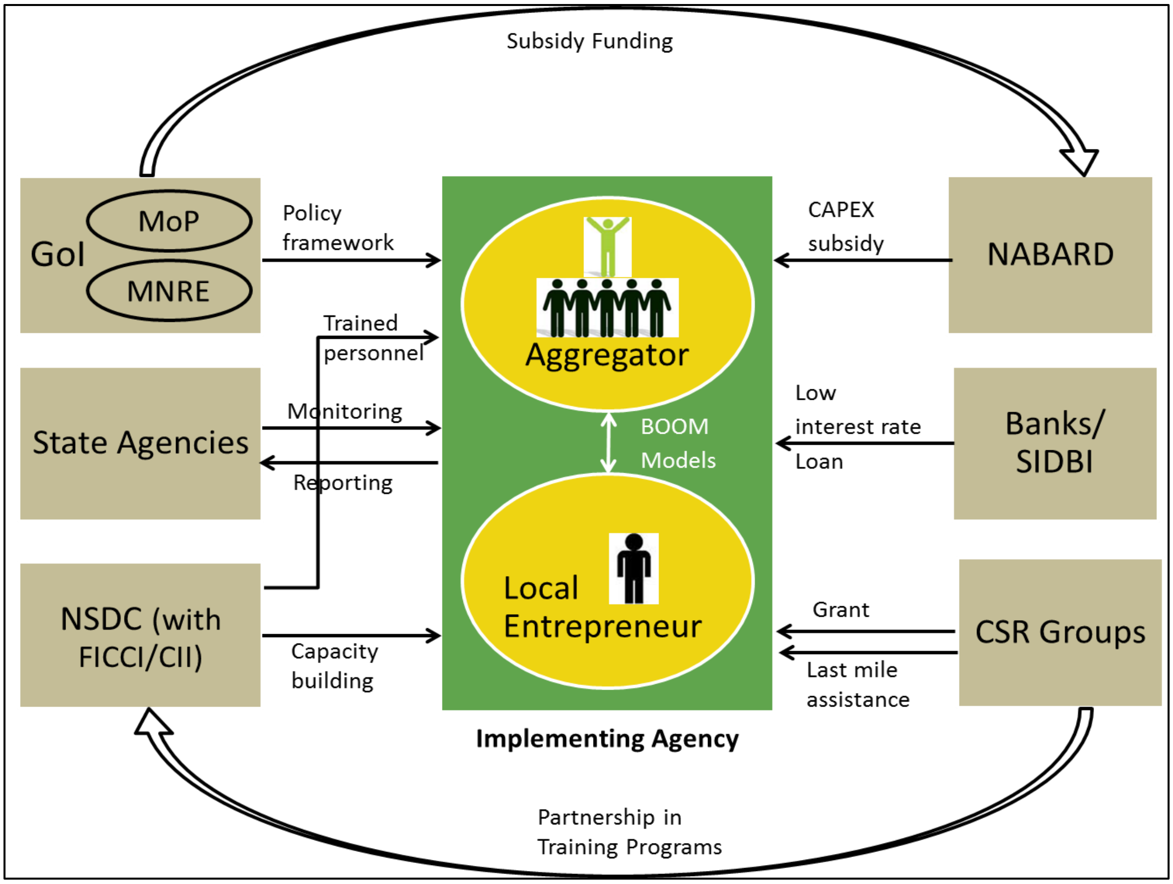


Figure 10: A Framework for Stakeholder cooperation and interaction

5.2. The Roadmap

We incorporate all recommendations as well as the framework presented above to lay out a roadmap to 100% electrification by 2022, when India turns 75. To achieve this, we need a plan as ambitious as the RGGVY, but more practical in its approach, and more conclusive in its impact. A mission equivalent to the Aadhaar would go a long way in providing the requisite push.

We suggest a timeline divided up into three broad phases. This is only indicative and the intention is not to discuss all implementation details in this document. The objective is simply to outline a blueprint that demonstrates that the goal of 100% electrification is indeed achievable.

Phase I (up to 2015): LEARN

The first few years of this plan should gear up the ecosystem to support up to a thousand off-grid Solar PV power plants. An initial phase when the policy is ironed out, a war room set up, the processes streamlined, entrepreneurs groomed and large companies brought on-board would set the stage for large scale deployment of mini-grids. On-ground implementation models must be identified, demonstrated and fine-tuned in this phase. By the end of this time period, large companies ought to have their teams and supply chains in place. This phase will require the following steps:

A. ***Release of joint policy by MNRE & MoP:*** The policy must put Solar PV based mini-grids at the helm of the electrification agenda. The subsidy, loan and grant split must be designed for an encouraging return for the entrepreneur, based on lifecycle-cost analyses that incorporate hidden costs of execution in remote areas;

B. ***Capacity building of local entrepreneurs:*** Nation-wide skill development programmes to train lakhs of entrepreneurs and technicians must be launched. The skilling programmes can primarily target the states with highest numbers of unelectrified households;

C. ***Training of bankers:*** Briefing of public and private sector banks to help them understand the industry, the customers and consumers and eliminate apprehensions for providing RE loans;

D. ***Identification of funding sources:*** Government must identify the avenues from which subsidy and grant funding will be sourced. Ministry of Finance would need to be involved in the decision and there must be a clear time frame for executing the mission. Additionally, Corporate India must be encouraged and assisted with channelling a proportion of CSR funds for these projects;

E. ***Learning & Demonstration (L&D):*** An L&D project must be run in the first couple of years in which existing IPPs are allotted groups of villages for setting up Solar PV mini-grids. This would enable the thrashing out of various implementation related issues as well as streamlining of the ancillary procedures for monitoring and reporting;

F. ***Public awareness:*** Mechanisms for sharing of the goals of the mission, best practices, successes and failures with regard to implementation must be put in place. Evangelising RE technologies and the stakeholders in the space will assist in the acceptability of solutions by end users and the recruitment of enterprising youth into training programmes.

MNRE and MoP, along with the concerned State agencies, could take these initial years to work out the exact processes and streamline them as much as possible.

Phase II (up to 2018): SCALE

In the second phase the efforts must be stepped up by orders of magnitude. This phase will see the mushrooming of mini-grid operators since the business viability is now proven. Large companies will also ramp up mini-grid installations. The pace must be stepped up to support six thousand villages a year. Tasks in this phase will include:

I. ***Routing of subsidy and grant:*** While the subsidy component will in general be routed via NABARD, the routing of CSR funds could now be geared to go from the company to the project implementer directly. It is understandable that corporate groups would like to invest in the regions where they have operations and they can play a large supportive role to help proliferate mini-grids and also help consumers leverage the benefits of access to on-demand electricity;

II. ***Urja Melas:*** In conjunction with state agencies, NABARD could organise 'Urja Melas' – a platform to connect aggregators and financiers with potential rural entrepreneurs, including trained personnel from skill development programmes. Both grant making CSR groups as well as lending agencies such as RRBs and other banks would be invited to participate. These could be organized across the length and breadth of the country, but more intensely in the eight needy states (highlighted in Annexure III);

III. ***Speedy disbursement of subsidy:*** Subsidy instalments should track project execution, and completion could be certified by the State agency. Speedy disbursement of subsidy entitlements is critical for helping implementers take up new locations for mini-grid installation quickly;

IV. ***On-going reporting:*** Aggregators could be asked to report installation and maintenance details to the state agency quarterly or biannually. Monitoring of project sites periodically is important to eliminate fraudulent activity. Either State agencies themselves or a new regulatory body (either at the State or Central level) could take up this task.

NABARD and the state agencies would play a critical role by providing a platform for various stakeholders to connect and coordinate. Monitoring and reporting would ensure on-ground efficacy of the installations.

We note here again that the JNNSM Phase II (2013-2017) draft document mentions a goal of covering 20,000 villages with off-grid electricity generation projects, which is admirable. Nevertheless, we opine that it is critical these villages be provided with scalable mini-grids, and not lighting systems or DC micro-grids that compromise long term sustainability of these solutions. To do this, we need to set the ball rolling in the right direction with appropriate partnership with Ministry of Power and with the requisite ecosystem changes.

Phase III (2018 onwards): DELIVER

The third phase would be the final sprint to the goal. The entire nation goes full steam to wage a war against darkness. With the experience of installing tens of thousands of mini-grids, the policy regarding grid interactivity could be finalized and implemented starting about this time. A clustered-village-approach would not only speed up things, it would result in greater potential for installing Solar PV-biogas or Solar PV and micro-wind hybrid plants.

I. ***Go full steam to cover ground:*** With the on-going ecosystem efforts, by this time, we will have hundreds of aggregators and thousands of local entrepreneurs working towards the goal. The sheer magnitude and pace of this execution will set an example for the world, just as the Aadhaar mission has. Here, a clustered approach could accelerate the pace even further, especially if hybrid plants are installed.

II. ***Hybridization for holistic intervention:*** As discussed in Chapter 3, hybrid systems are a future opportunity. Biomass gasification could complement Solar PV and provide full 'Energy Access' by supplying clean cooking fuel alongside electricity. Micro-wind can be a good option too, for battery reduction/replacement, especially for coastal areas. Hybrid installations would be more efficient for clusters of villages.

III. ***Make the plants grid interactive:*** As previously suggested, in the long run, standalone plants that are installed in power starved areas where grid-line has already reached could be made grid interactive.

The timelines and goals above are very aggressive, and there are a million reasons to dismiss them as infeasible. However, our goal of 100% electrification by 2022 is only a stepping stone to the ‘universal energy access’ goal for 2030 set by the UN. By working towards the ambitious goal for 2022, we will ensure that we will meet the UN goal well in time. Of course to do that, in parallel, the country has to make rapid progress on providing clean cooking gas to the citizens as well.

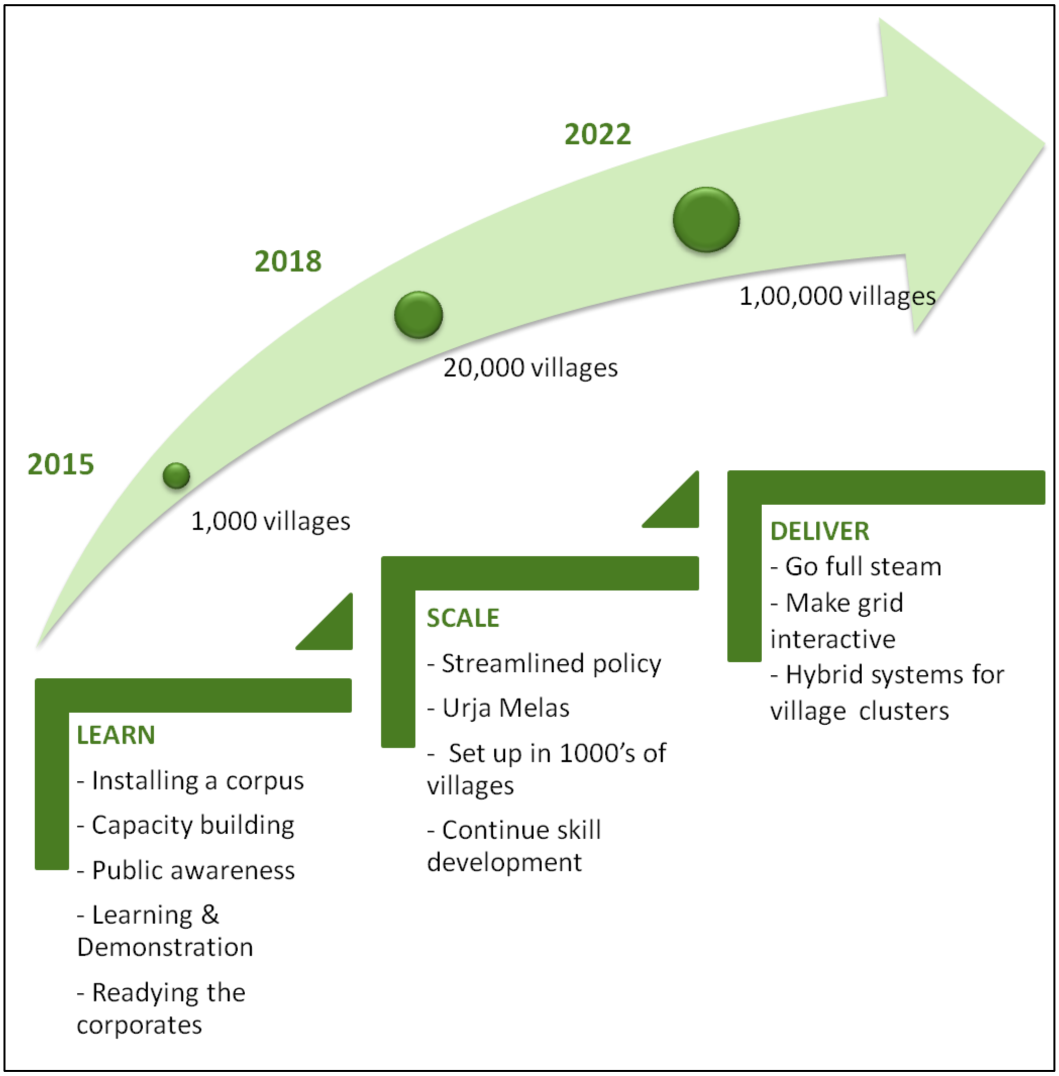


Figure 11: Roadmap to 100% Electrification

A 'War Room' consisting of empowered decision makers must be created to ensure close coordination among stakeholders and speedy implementation.

6. CONCLUSION

Renewable Energy technologies are maturing rapidly and their prices falling steeply, particularly in the case of Solar Photo-Voltaics. This provides India with a newly opened up, huge opportunity – that of deploying a viable yet sustainable alternative to grid connected power in remote villages and hamlets for the very first time. As mentioned by Carl Pope of Sierra Club and Harish Hande of SELCO[49], "We have an opportunity for which the economics are compelling, the moral urgency profound, the development benefits enormous, and the potential leverage game changing." All that remains is for our leaders in government, industry, and in society to grab the opportunity and to act on it.

There are many concerned groups who have been advocating that these 300 million long suffering Indians who still live in darkness are not denied the benefits of grid-connected power (referring to 'on-demand electricity' at a price point available to other, urban, Indians). However, we differ from these groups in that we believe we can make use of this new opportunity to install thousands of standalone as well as grid-connected Solar PV-based mini-grids which can provide 'electricity on-demand' (beyond lighting). The price is albeit higher to start with but this can easily be brought down over time, given the will to design the appropriate subsidy regime. That the grid has not yet reached every village and hamlet is hardly surprising (apart from all other reasons), given the steep incremental costs involved in taking it to ever remote locations. We at ORF firmly believe that it is therefore time to abandon the notion of grid-connected power as the sole route to serving these underserved citizens and turn instead to distributed renewable energy based mini-grids.

Can Solar PV based mini-grids reach electricity to all Indians within the aggressive time frame of less than a decade from today? Admittedly the challenges are enormous, as we have ourselves outlined, but what can undoubtedly make it a reality is the will to achieve it among our country's leaders. However, it appears the MNRE, MoP and State governments are still centred on the goal of grid-connected power. The continued thinking that Solar energy solutions are temporary and that provision of solar home lighting systems are only necessary 'till the time the grid reaches' is only going to delay holistic development.

The political will to steer funds and focus into this long term investment will bring plenty of returns in the form of raised standards of living and increased economic activity resulting in enhanced GDP growth, and economic and social development of backward areas. We are at a historical juncture where darkness can quickly be eradicated from our country once and for all. All that is needed is for this goal to be taken up in mission mode with a lean team that is adequately empowered to deliver on its goals and is made accountable for delivering results. It is entirely up to us to seize the moment.

[49] Op Ed: "1 Billion reasons to deliver Solar Energy Access for the Poor"

7. REFERENCES

ABPS Infra. *Policy and Regulatory Interventions to support Community level Off-grid projects.* Shakti Foundation, 2011.

CDF IFMR-WRI. "Power to the People: Investing in Clean Energy for the Base of Pyramid in India." 2010.

Census of India. *Household Amenities and Assets: Source of Lighting.* Office of the Registrar General and Census Commissioner, 2011.

Chi Seung Leung, Peter Meisen. *How electricity development affects social and economic development.* GENI, 2005.

cKinetics. *SPEED (Smart Power for Environmentally sound Economic Development): an Agenda for Action.* The Rockefeller Foundation, 2011.

CSE. *Centre for Science and Environment's recommendations for the 2nd phase of JNNSM.* CSE, December 2012.

CSE. *Going Remote: Re-inventing the off-grid solar revolution for clean energy for all.* Shakti Foundation, 2012.

David Nelson, Gireesh Shrimali, Shobhit Goel, Charith Konda, Raj Kumar. *Meeting India's Renewable Energy Targets: the Financing Challenge.* CPI-ISB, 2012.

EAI. *India Renewable Energy Guide.* Energy Alternatives India, 2012.

Gaye, Amie. *Access to Energy and Human Development.* UNDP, 2007.

Greenpeace. "Endangered Waters: Impacts of coal-fired power plants on water supply." 2012.

IEA. *Understanding Energy Challenges in India.* IEA, 2012.

Krishnaswamy, Srinivas. *Shifting of Goal Posts. Rural Electrification in India: a Progress Report.* Vasudha Foundation, 2010.

Ministry of Power. *Electricity Act.* 2003.

Ministry of Power. *No.44/1/2007-RE: Guidelines for Village Electrification through Decentralized Distributed Generation (DDG) under Rajiv Gandhi Grameen Vidyutikaran Yojana in XIth Plan.* January 2009.

Ministry of Power. *No.44/26/05-RE (Vol-II): Rural Electrification Policy.* August 2006.

Ministry of Power. "Restructured Accelerated Power Development and Reforms Programme (APDRP) during XI Plan." 2008.

MNRE. *5/23/2009 – P&C: Guidelines for Off-grid and Decentralized Solar Application.* June 2010.

MNRE. "Amendment in the bench mark cost for "Off-grid and Decentralized Solar Applications Programme' 2013-14." *www.mnre.gov.in.* 30 May 2013. http://mnre.gov.in/file-manager/UserFiles/amendmends-benchmarkcost-aa-jnnsm-2013-14.pdf (accessed June 13, 2013).

MNRE. *Jawahar Lal Nehru National Solar Mission Phase II- Policy Document.* December 2012.

MNRE. *No. 5/23/2009-P&C: Continuation of the programme on "Off-grid and Decentralized Solar Applications" for implementation during 2011-12.* May 2011.

MNRE. *No.15/1/2011-12/RVE: Sanction of Continuation of the Remote Village Electrification Programme during 2011-12.* July 2011.

MNRE. *No.5/23/2009-P&C/(SE): Continuation of the programme on "Off-grid and Decentralized Solar Applications" for the 1st Phase of JNNSM, for implementation during the year 2012-13.* June 2012.

MoHFW. "Annual Report." 2009-2010.

NABARD. "No. NB.MCID/ 1063 /Innov.JLG/2009-10: Financing of Joint Liability Groups (JLGs) of Micro entrepreneurs/artisans in Non Farm sector." December 2009.

Planning Commission. *Integrated Energy Policy.* Government of India, 2006.

Ron Pernick, Clint Wilder, Trevor Winnie. *Clean Energy Trends 2013.* Clean Edge, 2013.

RuDiCON. "Distributed Clean Energy: A Roadmap to India's Green Economy." *RuDiCON 2013.* Ekonnect Knowledge Foundation, 2013.

Sandeep Kumar Gupta, Pallav Purohit. "Renewable energy certificate mechanism in India: a preliminary assessment." *Renewable and Sustainable Energy Reviews*, 2013.

Santosh M Harish, Shubha V Raghavan. "Redesigning the National Solar Mission for Rural India." *Economic & Political Weekly*, June 2011: 51-58.

SunEdison. *Meerwada: Bringing Renewable Energy to a Remote Village in India.* MEMC, 2012.

TERI. *A Citizen's Guide to Energy Subsidies in India.* The International Institute for Sustainable Development, 2012.

UNEP, en.lighten. *Off-grid Lighting Assessment, India.* UNEP, 2013.

V K Jain, S N Srinivas. *emPOWERing rural India the RE way: inspiring success stories.* MNRE, 2012.

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AT&C	Aggregate Transmission & Commercial
BM	Build Maintain
BOOM	Build Own Operate Maintain
BoP	Bottom of Pyramid
CEA	Central Electricity Authority
CFA	Central Financial Assistance
CII	Confederation of Indian Industry
CPI	Climate Policy Initiative
CREDA	Chhattisgarh state Renewable Energy Development Agency
CSE	Centre for Science and Environment
CSR	Corporate Social Responsibility
DDG	Decentralised Distributed Generation
DISCOM	Distribution Company
FICCI	Federation of Indian Chambers of Commerce and Industry
FIT	Feed-In Tariff
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GHGs	Green House Gases
GoI	Government of India
GW	Gigawatt
HDI	Human Development Index
HPS	Husk Power Systems
IEA	International Energy Agency
ISB	Indian School of Business
ITI	Industrial Training Institute
JLG	Joint Liability Group
JNNSM	Jawaharlal Nehru National Solar Mission
kgoe	kilo gram oil equivalent
kWh	kilowatt hour
kWp	kilowatt-peak
L&D	Learning and Demonstration
LREDA	Ladakh Renewable Energy Development Agency
MFI	Micro Finance Institution
MGP	Mera Gao Power
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MW	Megawatt
MWh	Megawatt hour
NABARD	National Bank for Agriculture and Rural Development

NCEF	National Clean Energy Fund
NGO	Non-Governmental Organization
NSDC	National Skill Development Corporation
O&M	Operations and Maintenance
OPEC	Organization of the Petroleum Exporting Countries
PCO	Public Call Office
PDS	Public Distribution System
PV	Photo-Voltaic
RE	Renewable Energy
REC	Rural Electrification Corporation
RECs	Renewable Energy Certificates
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RPO	Renewable Purchase Obligation
RRB	Regional Rural Bank
RVEP	Remote Village Electrification Programme
SE4All	Sustainable Energy for All
SHG	Self Help Group
SHS	Solar Home System
T&D	Transmission & Distribution
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VGF	Viability Gap Funding

LIST OF FIGURES

LIST OF TABLES

8. ANNEXURE I – REPORT OF THE ROUNDTABLE HELD AT ORF MUMBAI

A consultative Roundtable on ***"Off-grid Solar Applications for Rural Electrification"*** was organised by Observer Research Foundation (ORF) Mumbai, on Saturday 14th July 2012. The event was attended by stakeholders from every walk of the renewable energy sector – government agencies, financial institutions, power utilities, technology providers, reputed NGOs, research organisations and end users.

ORF Mumbai was also privileged to have the participation of three extremely distinguished guests of honour: Shri Gireesh Pradhan, then Secretary, Ministry of New and Renewable energy (MNRE), GoI; Shri Jamshyd Godrej, noted industrialist, environmentalist and head of CII Green Business Centre; and Dr Harish Hande, Co-Founder and MD of SELCO India and Ramon Magsaysay awardee. Their presentations during the plenary session set the tone for the discussions on a wide variety of challenges surrounding off-grid solar (and hybrid) installations, which were taken up in three sessions.

The context and major themes for discussion were introduced by ORF Fellow, Shruti Deorah, in her opening presentation. Referring to one of the disconcerting statistics thrown up by the Census 2011, Shruti pointed out that ORF Mumbai was advocating scalable models, for the provision of 'electricity beyond lighting' to all these villages, so that people have access to a better quality of life and can engage in income generating activities, such as post-processing of agricultural produce, cold storage, and such. For this to happen it is necessary to set up village level mini-grids systems, typically 5-50KW, which can be expanded to provide more electricity as the usage increases. 'It is for this reason that we are studying distributed off-grid installations involving Solar PV systems and their hybrids with wind energy, biomass and other clean energy sources', she said.

Dr Harish Hande signed off by saying *"Please look at off-grid as the potential for this country to be the soft superpower of this world. It can show how India can be the centre of business models of innovation for the poor. It is much more than a solar product. It is the very fabric of India's development. We need to be very careful about where rural India is going and I am afraid that urban youth are not sensitive to this issue. I believe that off-grid is the solution to get over my fears."*

> *"De-centralised energy has such potential in this country – you can redefine business models that will challenge Starbucks, Walmart or Reliance Fresh. Those are the business models that will be replicable for the four billion people in other parts of the world – Africa, Indonesia or Latin America."*
>
> Dr Harish Hande, MD, SELCO India

Some of the issues discussed at the Roundtable have already been referred to elsewhere in the document. Here we reproduce all the other important points that were brought up by the participants.

8.1. Permissions to set up mini-grids

Shri Pradhan clarified that in terms of policy for the setting up of mini-grids, there were absolutely no hurdles at all. Entrepreneurs need almost no permissions to get started, to which Deepak Gupta's (Shakti Foundation) rejoinder was that this very lack of permissions also meant that there was little or no legitimacy to the work of entrepreneurs in this area.

Land acquisition issues were brought up, but it was generally agreed that land acquisition for mini and micro-grids may not be as much of a problem as for the larger, grid-connected, systems. Shri Pradhan mentioned that renewable energy installations were considered to be benign by MNRE and clearances from the environment ministry were quite easy to get in the past. However, more recently, particularly after the WGEEP report from the Prof. Madhav Gadgil Committee, the environment ministry was being more careful about permissions for larger installations.

8.2. Access to Credit

The difficulties with access to adequate credit for the purchase of renewable energy systems both for individual families – for purchasing solar lighting systems – and for shared resources such as mini- and micro-grids were discussed often. The issue of whether subsidies ought to be made available as capital subsidy or interest subsidy was another hotly debated topic. Dr Hande informed the audience about the little known Differential Rate of Interest (DRI) loans programme, for disbursing low cost loans to rural citizens, that is already in effect but very sparsely used[50]. These loans are available at a subsidised interest rate of just 4%. He pointed out that amazingly enough, of the entire corpus of funds dedicated to the DRI programme, only 1% gets lent out and the remaining 99% goes back to the coffers every year! Dr Hande went on to describe how he was ideologically opposed to the idea of capital subsidies. In his view interest subsidies are definitely preferable and the vastly underused DRI scheme can be a very good avenue to make finance widely available. He further suggested that MNRE could perhaps consider providing a portion or all of its CFA funds to banks instead, to be held as a guarantee against which these DRI loans can be disbursed, for the purchase of renewable energy solutions. He even suggested improvements for incentivising people to pay back, like back-ending the capital subsidy, wherein the last three months of a 36 month loan can be paid for by the government, provided the first 33 instalments were paid back in a timely manner.

Mr G K Ananthamurthy of NABARD, the nodal agency charged with the distribution of subsidies from MNRE for small Solar PV systems, spoke of the wisdom of financing community led projects that have grown organically from within. The easiest way for the residents of a village to get together and work for the common benefit is under the aegis of a cooperative society, as the much heralded example of Amul in Gujarat shows. However, this route is not attractive for renewable energy technologies because they are capital intensive in nature, and banks are unwilling to lend to cooperatives due to the difficulties of establishing legal liability. Mr Ananthamurthy described how NABARD and some Regional Rural Banks (RRBs) in Karnataka were using Joint Liability Groups (JLGs) successfully for financing small groups of enterprising villagers, across a broad spectrum of activities. JLGs are similar to the Self-Help Groups (SHGs) initiated by micro-finance institutions (MFI), but the quantum of loans tend to be much higher than the cap of Rs 50,000 set for MFIs.

[50] This scheme was discontinued by GoI in 2012

Mr Ananthamurthy clarified that NABARD has registered 74 lakh SHGs and 3 lakh JLGs across the country so far. Even assuming that only a portion of these are working well and are credit worthy, operating through these good organisations can result in a huge expansion of lending activity in rural areas, he said. Such groups have the added advantage of being community oriented, which gives them greater local legitimacy and assists them in disseminating knowledge about the benefits of renewable energy. This was seen by NABARD in Karnataka where the deployment of solar home lighting systems in one village led to requests from surrounding villages for similar systems as well.

Shri Pradhan exhorted all the participants to lend their voice to his efforts to lobby the Reserve Bank of India to designate renewable energy as a 'priority lending sector'. Many participants agreed that this move alone could revolutionise the market through the availability of cheaper credit, opening doors to a new phase of growth where financing would be cheaper and more readily available, acting as the catalyst for the 'renewable energy revolution'.

8.3. Energy efficiency of a new generation of devices

Expanding on the need for a complete ecosystem surrounding off-grid renewable energy solutions in the country Dr Hande said, *"Today, the business models are being created mostly by English-speaking entrepreneurs when instead we should be creating eco-system for non-English-speaking rural population, as in the case of the Green Revolution in the 70's"*. Just as in the Green revolution farmers were backed up by an entire eco-system of human resources – people who could install and repair pumps, people selling fertiliser and tractors etc., we need to create the same eco system for off-grid if we are serious about energy services. *"How do we train thousands of technicians, thousands of entrepreneurs to redesign the Solar-based products?"* he asked.

"Solar products are being designed monolithically, as if every poor person has the same needs." He gave an example to illustrate this — an auto-rickshaw driver had come to him with a request for a three-light home solar system, which was too expensive for him. However, the SELCO technician (who is a 4th standard dropout) came up with an affordable alternative. He broke off a part of the roof and installed one single light attached to a solar PV panel that provided light to all three rooms. As it turned out, the customer didn't need three lights; he needed three rooms lit. We also need to design products for better energy efficiency – sewing machines and other income generating products such as basket weaving, silk weaving etc. Even fans must be made more energy efficient so that solar does not become unnecessarily expensive. Industry can play a role here creating more products such as 'Chota Cool' a small (30 litre) refrigerator created by Godrej Industries that does not use a compressor, but instead runs on thermo-electric chips. These are perfect for deployment with a solar energy setup. Such products are essential not just for qualitative improvement in rural lives, but also as a solution for larger problems such as the dearth of cold storage chains for preservation of food.

8.4. Electricity vs. Energy

Mr Deepak Gadhia of MSA Renewtech Foundation made a distinction between electrification and 'energification'. He described how in his experience it has often proven more efficient to fulfil the requirements of his customers without converting the energy to electricity. He gave the examples of a bio-gas plant that his organisation runs in Gujarat, where they are selling the cooking gas to local residents as an energy solution. Mr Gadhia also has to his credit large solar cooking systems in India using Concentrated Solar Power, installed at Shirdi Sai Baba temple and the Balaji Temple at Tirupathi, which are being used to prepare tens of thousands of meals a day. In all of these systems energy is transferred to the kitchens in the form of heat (steam), rather than electricity.

8.5. USE OF APPROPRIATE TECHNOLOGIES AND BEST PRACTICES

Dr Avinash Patkar, Chief- Clean Technology R&D at Tata Power, moderated the session focussed on technology in his typically enthusiastic manner, and deftly directed the conversation towards the salient points underlining this issue. He shared his view that *“everyone now says that the technology is available... but it is my belief that this statement should refer to appropriate technology, which is sadly still lacking.”* It is important to bear in mind the principle that the most important aspect of the technology is how efficiently it is used to meet the customer's requirement. Often, it requires ingenuity and innovation to create a solution that neither the provider nor the customer could have imagined at the outset.

One very significant development in the field of renewable energy in recent times has been the advent of hybrid systems that incorporate two or more different renewable technologies to create one complementary whole. As such, our discussion would have been deficient without touching upon the implications of this. Mr. Ruia of ARCO India, an entrepreneur who installs solar and micro-wind hybrid systems, commented on their feasibility and the encouraging results of their installed systems. Several participants asked the MNRE to devise a subsidy plan for integrated hybrid systems as well, because currently the subsidy framework only includes a subsidy for a hybrid solar and micro-wind system, and as such other hybridizations are not comprehensively covered.

Mr. Rueben Gergan (LREDA) shared his experience of the high cost of maintenance in remote areas, especially when it came to battery replacement. Since this is required once every five years, it can be a significant expense during the 25 year lifetime of the solar panels. He mentioned that LREDA is considering levying a small surcharge on grid electricity to provide for this O&M expense in off-grid areas. Mr. Jamshyd Godrej too had spoken about how batteries are not only the single most expensive component of any renewable system, but also the most environmentally toxic. It would therefore be very good to design appropriate hybrid systems that did away with the need to use batteries completely. More trials with different combinations of solar, wind, biomass and other sources will be needed.

Rueben also described how LREDA, rather ingeniously, teamed up with local MLAs to evangelise solar technology in their areas of jurisdiction. They also ensured the reliability of products deployed on-ground through strict quality control measures.

9. ANNEXURE II – PARTICIPANTS AT THE ROUNDTABLE HELD AT ORF MUMBAI, ON 14TH JULY 2012

Chief Guests

Girish Pradhan, IAS, then Secretary, Ministry of New and Renewable Energy
Jamshyd Godrej, Industrialist and Head, CII Green Business Centre
Harish Hande, Managing Director, SELCO-India

Participants (in alphabetic order)

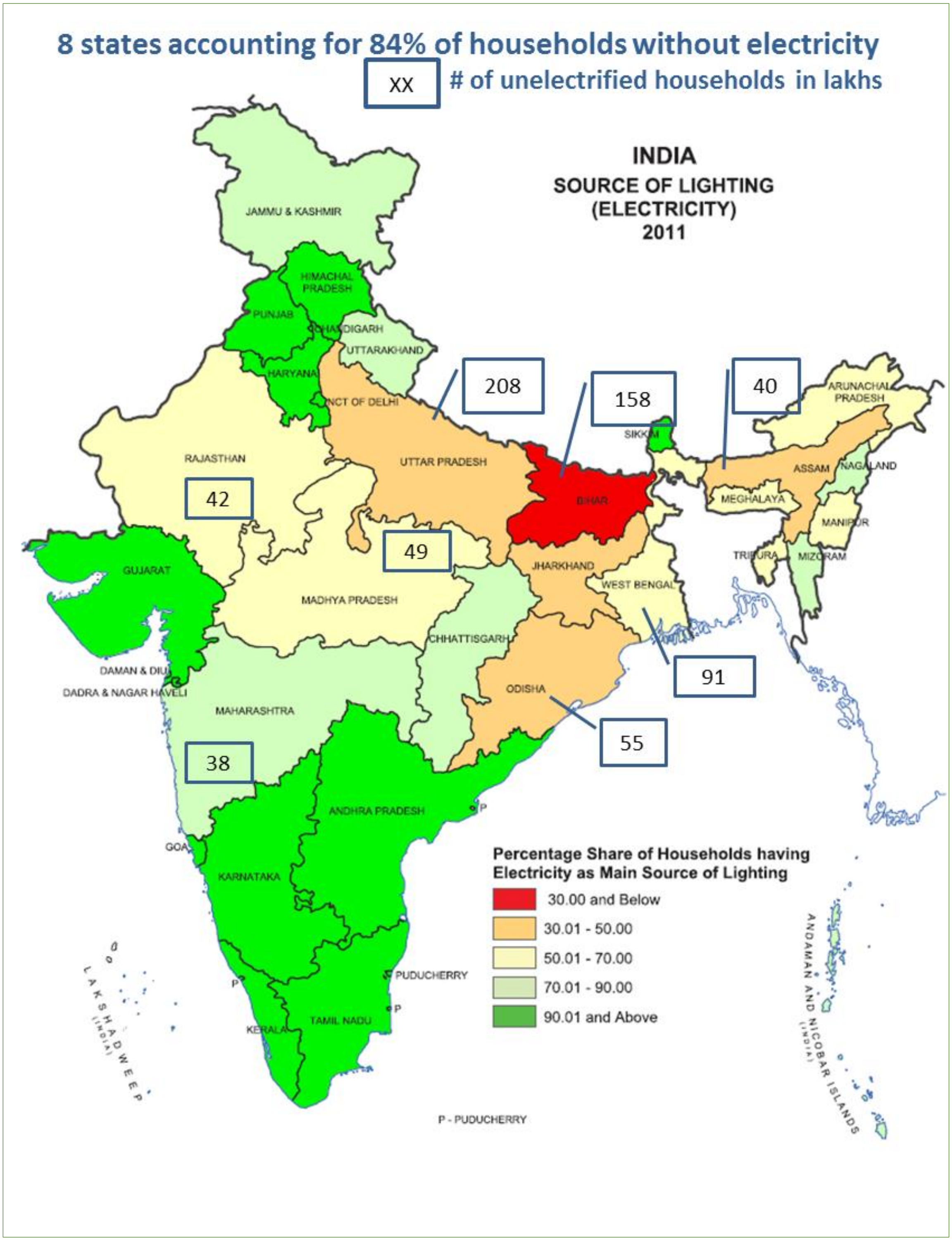
A.V. Murthy, Godrej & Boyce
Akhilesh Sati, ORF Delhi
Alan Rosling, Kiran Energy
Amit Chilwe, MERC
Amit Dhalla, Aarkay Power Systems
Anant Sant, MERC
Anil Dhar, Manachapada Cooperative
Arif Kakpori, Ladakh Renewable Energy Development Agency (LREDA)
Arvind Kumar, Green Light Planet
Arvind Risbud, Myrada
Ashok Deorah, Rotary Foundation
Ashwini Patil, MERC
Avinash Patkar, Tata Power
Dayanand Jadhav, TPM
Deepak Gadhia, MSA Renewtech Foundation
Deepak Gupta, Shakti Foundation
Dhananjay Dakhare, MSEDCL
G.K.Ananthamurthy, NABARD
K. Munshi, IIT Bombay
Karthik Chandrasekar , First Light Accelerator
Kartik Meda, Sympa Networks
Kiran Karande, Sakal
Kunzes Dolma, LREDA
Lata Khanjode, Village Sarpanch and member of Manachapada Cooperative
Mohd Saquib, CSTEP
Meera Sudhakar, CSTEP
N.P. Ramesh, Orb Energy
N.L.Dhage, NPTI
Pradeep Nair, Clinton Climate Initiative
Prajakta Karnik, PTI
Prashant Tondwalkar, Manachapada Cooperative
Praveen Bhasin, Minda Group
Praveen Kulkarni, K K Nesar
R.K.Patil, Bank of Baroda
Rahul Sankhe, SunEdison

Rajendra Ruia, ARCO
Reuben Gergan, LREDA
Rishi Agarwal, Embarq
Rituraj Sharma, NPTI
Rumi Engineer, Godrej & Boyce
S.B.Patil, GEDA
Sally Daultrey, LREDA
Sarang Kale, Kaleidoscope Developers
Saurabh Srivastava, IGIDR
Shantanu Dixit, Prayas
Shawahiq Siddiqui, India Environment Law Offices
Shirish Garud, TERI
Simon Desjardins, Shell Foundation
Sishir Garemella, L&T Infra
Suresh Gurumani, formerly at SKS Microfinance

ORF Participants

Shruti Mahajan Deorah (Co-author of report)
Dr. Leena Chandran-Wadia (Co-author of report)
Kshitij Neelakantan
Dhaval Desai
Sana Noreen Ghazi
Ram Mohan Khanapurkar
Aparna Sivakumar

10. ANNEXURE III – ELECTRICITY AS SOURCE OF LIGHTING (CENSUS 2011)



ABOUT OBSERVER RESEARCH FOUNDATION MUMBAI

Observer Research Foundation (ORF) is a leading non-partisan Indian Think-Tank that seeks to influence public policy formulation. It was established in New Delhi in 1990 by R.K. Mishra, a widely respected public figure, who envisaged it as a broad-based intellectual platform pulsating with ideas needed for India's nation-building. In its journey of twenty years, ORF has brought together leading Indian policy makers, academics, public figures, social activists and business leaders to discuss various issues of national importance. ORF scholars have made significant contributions toward improving government policies. ORF has produced a large body of critically acclaimed publications.

ORF Mumbai was established in September 2004 to study issues specific to India's financial capital. In January 2010, under the chairmanship of Shri Sudheendra Kulkarni, ORF Mumbai selected a broader mandate for research and advocacy in the following six areas: **Education, Public Health, Inclusive Development, Urban Renewal, Youth Development,** and **Promotion of India's Priceless Artistic and Cultural Heritage.** Some of the recent research reports published by ORF Mumbai include:

- "An Urgent Call to improve Mental Healthcare in India: A case study of M.B.Barvalia Foundation's Commendable Work"
- "Time is Running Out: Does Mumbai have Enough Water?"
- "Domestic Violence as a Women's Health Issue: Role of Primary Prevention"
- "Masked Identities: Safeguarding India's Intangible Cultural Heritage"
- "Reforms in Medical Education – to Promote Accessible and Affordable Healthcare for All"
- "Making the Sewer a River Again... Why Mumbai Must Reclaim its Mithi"
- "Moving People: Why Mumbai Needs a Bus Rapid Transport System (BRTS)"

ORF Mumbai's mission statement is: *Ideas and Action for a Better India*. It champions the cause of balanced socio-economic development and a better quality of life for all Indians. It also works towards strengthening India's democratic institutions to become more responsible, responsive and sensitive to the needs and concerns of common people, especially those from the most vulnerable sections of society. Other initiatives of ORF Mumbai include the Maharashtra @ 50 Study Centre, the Forum for India-China Citizens' Dialogue, the Centre for the Study of India's Ancient Knowledge Traditions, and the Gurus of Science Lecture Series.

ACKNOWLEDGEMENTS

It is a great pleasure to be able to thank all the people who have helped us bring out this report. We would like to begin with Dr. Avinash Patkar, Chief- Clean Technology R & D, Tata Power, and thank him for numerous interesting and useful discussions, in person as well as over email. He has provided guidance, reviewed the draft report, and supported us from the earliest time when we embarked on this study. We would also like to thank members of his team, particularly Sydney Lobo, Head- Clean Technology Projects, Tata Power, for their inputs.

We would like to express our gratitude to Shri Deepak Gupta, former Secretary MNRE, for taking great interest in our work and providing detailed inputs on the issues raised in this document. His counsel has influenced our approach to the topic as well as the recommendations we have made.

We are indebted to Mr. Sameer Nair, Director Gram Oorja, for helping us comprehend the nuances of government policy as well as the quantitative metrics of Solar mini-grid installation and operations. His readiness in sharing the experiences of running his start-up has been instrumental in our clear understanding of the on-ground challenges faced by entrepreneurs.

ORF would like to thank the participants at the Roundtable, our Chief Guests Gireesh Pradhan, then Secretary MNRE, Dr. Harish Hande, MD SELCO India, and Jamshyd Godrej, Head CII Green Business Centre, and everyone else for their enthusiastic participation and candid opinions. We would like to particularly thank Mr. Anil Dhar (formerly Vice President, Reliance Industries) and Mr. G.K.Ananthamurthy of NABARD for their support and perspectives. We would also like to acknowledge Lata Khanjode, Sarpanch Manachapada (Abitghar, Maharashtra), for her openness in sharing her learnings from the transformation of her own village.

Special thanks also to Dr. Harish Hande for helping us get valuable perspective on the difficulties of servicing the rural underserved populations. We learnt many a lesson from his insightful accounts of creative solutions to the needs of SELCO's customers.

We would also like to thank Shirish Garud, Sr. Fellow TERI, for taking the time to review the draft report in detail and providing valuable suggestions.

Many thanks to the industry fraternity for several useful conversations: Deepak Gadhia (Gehrlicher Solar India Pvt Ltd), Jigmet Takpa & Reuben Gergan (LREDA), Yashraj Khaitan (Gram Power), Praveen Bhasin (Minda Nexgentech), Rahul Sankhe (SunEdison), Gyanesh Pandey (Husk Power Systems), Deepak Gupta (Shakti Foundation), Damien Miller (Orb Energy), Nikhil Jaisinghani (Mera Gao Power) and Rajendra Ruia (ARCO Industries).

We are grateful to our former colleagues Kshitij Neelakantan (Associate Fellow, ORF Mumbai) and R.N.Bhaskar (Advisor, ORF Mumbai) for their assistance in organizing the valuable ORF Roundtable on the topic of 'Off-grid Solar Applications for Rural Electrification', as well as in shaping the premise of the document.

Finally, we would like to thank our present colleagues, Aparna Sivakumar (Fellow), Dr. Sumedh Kulkarni (Fellow and Programme Coordinator) and Radha Viswanathan (Fellow and Editor), for their timely assistance in bringing out the document.

July, 2013

ABOUT THE AUTHORS

Shruti Mahajan Deorah, Fellow, ORF Mumbai

Shruti's work at ORF is focused on policy analysis and recommendations for Solar energy (and its hybrids) in India. She is passionate about clean energy technologies and their role in combating climate change. Previously, she led Clean Transport and Energy-efficient Lighting programs for the Clinton Climate Initiative in India. She has also held various client management and business development roles with leading companies in the field of internet and mobile advertising.

Shruti has B.Tech and M.Tech in Electrical Engineering from IIT Bombay. She can be reached at shruti.deorah@orfonline.org.

Dr Leena Chandran-Wadia, Senior Fellow, ORF Mumbai

Leena received her Ph.D in physics from IISc Bangalore. Her post-doctoral work was at ETH Zurich, Switzerland. She has been a researcher at several places in India and abroad including NCST Mumbai (now CDAC), EPFL and CERN in Switzerland. More recently she has served as Senior VP and CTO at Netcore Solutions Pvt. Ltd., a start-up company in the space of Mobile Value-Added Services.

At ORF she is engaged in research and advocacy, primarily in the areas of Higher Education and Research but also in Public Health, Sustainable Agriculture and Renewable Energy. She can be reached at leena.wadia@orfonline.org.

Roundtable: Off-grid Solar Applications for Rural Electrification

Participants at the Roundtable organized at ORF Mumbai on 14th July, 2012

Our Chief Guests (left to right):
Jamshyd Godrej, CII GBC
Gireesh Pradhan, MNRE
Harish Hande, SELCO

ORF fellows seen in the background:
Leena Wadia
Kshitij Neelakantan

G.K.Ananthamurthy, NABARD, shares learnings from group lending to villagers in Karnataka

Back cover:
UN Sustainable Energy for All — infographic on 'Universal Access'
http://www.sustainableenergyforall.org/images/banners/accessinfo.jpg

Observer Research Foundation Mumbai
NKM International House, 5th floor, 178, Backbay Reclamation, Babubhai Chinai Marg,
Mumbai 400020. Tel: +91 22 61313800 Website: www.orfonline.org