THE INDIA

OFF-GRID ELECTRICITY MARKET

Policy Framework, Players and Business Opportunities

European Business and Technology Centre

Alliance for Rural Electrification

Shining a Light for Progress

THE INDIA OFF-GRID ELECTRICITY MARKET
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Contents

Background and scope of this brief

This brief is an output of the cooperation agreement between the European Business and Technology Centre (EBTC) and the Alliance for Rural Electrification (ARE) - a cooperation which aims to facilitate rural electrification competence and technology transfer from Europe to India. This document gives readers a brief overview of the potential of decentralised renewable energy generation in India with a view to stimulate private sector involvement in this sector. While the scope of this study is limited to micro-grids that can distribute locally produced electricity from solar, small wind and small hydro plants, core messages expressed may apply to renewable energy solutions of larger sizes too. This study does not cover off-grid solar based products such as solar appliances, solar water pumps and biomass based solutions.

Summary

India as a rural electrification market has enormous potential. According to the 2011 Census of India, 81 million households or close to 400 million people do not have access to electricity as their 'main source of lighting'. Of these, over 90% residing in rural areas form the biggest market segment for off-grid energy services. In the recent years, *a strong state commitment* has been witnessed to provide electricity for all as demonstrated by national and sub-national policy programs, significant budget outlays and increasing discourse to employ decentralised energy generation technologies for last mile access.

Renewable Energies Overview

Small Hydro Power

In India, hydro projects are classified in two segments of large and small. Small Hydro Power projects (</=25 MW) also called SHPs are under the responsibility of the Renewable Energy Ministry. Large hydro projects are the mandate of the Power Ministry. Hydro (both large and small scale) is an important source of power in India's energy mix. As of 31st of August 2014, all India large hydro power project installations totalled 40.8 GW out of a total installed capacity of 253.4 GW. Small Hydro Power (SHP), on the other hand, has a total installed capacity of 3.8 GW. An estimated potential of 20 GW (this estimate is under upward revision) for SHPs exists in India. The Indian Renewable Energy Ministry has published a database of 6,474 potential state-wise potential sites aggregating in capacity of 19.7 GW.

Solar Photovoltaic Power

Large scale solar photovoltaic (SPV) installations in India have attained near grid parity competing with power plants fired by imported coal on cost per unit basis. In 2010, India launched an ambitious National Solar Mission to augment 20 GW solar capacity by 2022, out of which 2 GW is off-grid focussed. Furthermore, towards end of 2014, the newly elected government revised this target to 100 GW of solar capacity including solar based ultra-mega power projects in the basket. The installed capacity as of 31st of August 2014 is 2.6 GW. In the sub-MW range, with the aid of several state level rooftop policies, solar is being deployed across India. These initiatives will lead to increasing standardisation into ready-to-install solar kits, aggressive marketing, information campaigns, easy availability of PV equipment and credible product guarantees accompanied with proper O&M. Such information and technology availability will also trickle down to the off-grid sector. The off-grid SPV capacity installation as of 31st of August 2014 is 0.2 GW.

Small Wind Power

India's current installed capacity of wind energy is 21 GW which represents the highest proportion in the country's renewable energy mix. This does not take into account large hydro which is not classified under the renewable energy portfolio in India. In the small wind segment, the world market for small wind is still considered to be in its infancy. Most of the growth in this segment has occurred in three countries *viz*. China, US and UK. This however, does not pre-empt scope for small wind market development in India which has tremendous opportunities for collaboration between international players and Indian domestic manufacturers. The current installed capacity for small wind in India is 2.4 MW as of 2013.

Introduction

At the time this brief was written (Nov, 2014), the current national government in India has been in power for six months (Indian general assembly elections were held in April-May, 2014). In this short period, the new government has demonstrated strong intent to accelerate renewable energy (RE) deployment and to reduce dependence on thermal electricity. Three key energy sector Ministries have been put under the independent charge of the Union Minister for Power, Coal and New & Renewable Energy. A number of positive developments are already visible thereof, for example to set up a new dedicated public sector unit for off-grid projects (Bhaskar, 2014) and investments for setting up additional 100 GW each in solar and wind in the next ten years in India (Airy, 2014), and also strong statements from the Minister about plans to make India completely diesel and generator-free within the term of this government (Singh, 2014).

India Macro Indicators – Table 1

Indicator	Figure	Est. Year	Data Source
Surface (km²)	3,287,263	-	CIA Factbook
Population (absolute numbers)	1,236,344,631	2014	CIA Factbook
Population density (people per sq. km)	376.10	2014	CIA Factbook
Share of urban population	368,608,912	2010	Trading Economics
Share of rural population	856,005,415	2010	Trading Economics
GDP (Purchasing Power Parity in bn EUR)*	3749.25	2013	CIA Factbook
GDP per capita (Purchasing Power Parity in EUR)	3,000	2013	CIA Factbook
GDP real annual growth rate (%)	3.2%	2013	CIA Factbook
Human Development Index Value	0.586	2013	UNDP
Rank in Ease of Doing Business (Total 189)	140	2014	World Bank
Share of Official Development Assistance in GDP (% of GNI)	0.1	2012	World Bank
Consumption of electricity per capita kWh/month	917.2	2013	CEA

**Exchange rate used is USD1 = EUR 0.75*

India Indicators for Energy Sector – Table 2

Indicator →		Unelectrified Villages	Electricity Shortage	Per Capita Income*	Rural HHs using kerosene	Number of MFIs
Data Source →		**CEA, 2014**	**CEA, 2014**	**MOSPI, 2012**	**Woodbridge, Sharma & Fuente, 2011****	**Sa-Dhan, 2013**
Region ↓	**State ↓**					
East	Arunachal Pradesh	31,30%	-19.70%	INR 62,213 (EUR 778)	19%	2
East	Assam	3.20%	-32.20%	INR 33,633 (EUR 420)	70%	15
East	Chattisgarh	2.40%	40.90%	INR 46,573 (EUR 582)	37%	8
East	Jharkhand	7.90%	-11.10%	INR 31,982 (EUR 400)	74%	12
East	Manipur	13.40%	3.60%	INR 32,284 (EUR 404)	12%	5
East	Meghalaya	20.20%	12.30%	INR 56,643 (EUR 708)	48%	6
East	Mizoram	14.80%	6.80%		13%	2
East	Nagaland	9.90%	-26.00%	INR 56,116 (EUR 701)	2%	2
East	Sikkim	0.00%	56.60%		6%	2
East	Tripura	3.00%	19.80%	INR 50,750 (EUR 634)	31%	4
East	West Bengal	0.01%	-0.40%	INR 55,864 (EUR 698)	65%	38
North	Bihar	4.50%	-15.30%	INR 24,681 (EUR 309)	89%	21
North	Haryana	0.00%	14.00%	INR 109,227 (EUR 1,365)	9%	9
North	Himachal Pradesh	0.01%	17.80%	INR 73,608 (EUR 920)	2%	1
North	Jammu&Kashmir	1.80%	-29.60%	INR 41,833 (EUR 523)	2%	1
North	Madhya Pradesh	2.90%	5.10%		30%	23

Indicator →		Unelectrified Villages	Electricity Shortage	Per Capita Income*	Rural HHs using kerosene	Number of MFIs
Data Source →		CEA, 2014	CEA, 2014	MOSPI, 2012	Woodbridge, Sharma & Fuente, 2011**	Sa-Dhan, 2013
North	Punjab	0.00%	0.50%	INR 78,171 (EUR 977)	2%	5
North	Rajasthan	9.80%	-8.50%		52%	17
North	Uttar Pradesh	1.30%	-14.80%	INR 29,417 (EUR 368)	75%	22
North	UttaraKhand	0.70%	4.70%	INR 75,804 (EUR 948)	30%	11
South	Andhra Pradesh	0.00%	-15.30%	INR 71,540 (EUR 894)	16%	15
South	Karnataka	2.50%	-14.40%	INR 69,493 (EUR 869)	14%	22
South	Kerala	0.00%	-24.70%	INR 83,725 (EUR 1,047)	20%	11
South	Orissa	18.40%	-0.80%	INR 46,150 (EUR 577)	68%	22
South	Tamil Nadu	0.00%	-6.80%	INR 84,058 (EUR 1,061)	15%	34
West	Goa	0.00%	-7.00%	INR 192,652 (EUR 2,408)	0%	3
West	Gujarat	0.00%	4.10%		20%	17
West	Maharashtra	0.10%	-12.60%		23%	27
	Union Territories ↓					
North	Chandigarh	0.00%	9.60%			3
North	Delhi	0.00%	20.30%	INR 175,812 (EUR 2,198)		9
South	A & N Island	22.20%		INR 82,272 (EUR 1,028)		1
South	Lakshadweep	0.00%				0
South	Puducherry	0.00%	10.20%	INR 95,759 (EUR 1,196)		7
West	D & N Haveli	0.00%	-2.20%			1
West	Daman & Diu	0.00%	-3.00%			0

** Exchange rate used is INR 80 = EUR 1*
*** Data presented is from the 61st round of the National Sample Survey Organisation's 2004-05 Consumer Expenditure Survey*

Indicator Description Box	
Indicator	**Description**
Total Unelectrified	Unelectrified villages as percentage share of inhabited villaged
Electricity Shortage	Energy decifit/Surplus (Requirement - Availability)
Per Capita Income	Net state domestic product per capita at current prices
Rural households using kerosene	Proportion of rural households using kerosene as primary lighting source
Total number of MFIs	Number of micro-finance institutions in that state

Framework for business opportunities in rural off-grid India

According to the 2011 Census of India, 81 million households or close to 400 million people do not have access to electricity as their 'main source of lighting'. Of these, over 90% reside in rural areas. Assuming that this is the off-grid population, it is important to note that the market for rural electrification services is not limited to only this population sub-set. Given the significant power deficit of 5.1% (and peak deficit of 2%; Central Electricity Authority [CEA], 2014) and frequent power cuts and unreliable supply especially in rural areas, there is an additional 'under-electrified' population in need of augmenting grid supply with alternate means.

At the village level, of the total 597,464 inhabited villages as per the 2011 Census of India, 571,123 or 95.6% villages have been electrified. Furthermore, in respect of the current rate of electrification and the 12th Five Year Plan (FYP) (Ministry of Power [MoP] Office Memorandum 44/10/2011-(RE), 2013), it is highly likely that India will achieve 100% village electrification. High diversion between household and village level electrification can be observed due to reasons of definition. The MoP declares a village only as electrified if (i) it has a distribution transformer and distribution lines in the inhabited locality, (ii) electricity is provided to public places in the village, and (iii) the number of households electrified are 10% of the total households in the village.

Thanks to more exposure to decentralised energy combined with increasing incomes and energy aspirations the willingness to pay for decentralised energy services of rural consumers will also go up. Rural people's share of expenditures for energy goods (*e.g.* costs of fuels for cooking, lighting, heating, mobile charging and powering productive loads if applicable) out of available incomes gives a better indication than subsidised tariffs of grid-based electricity. Such figures, which vary from region to region, range from INR 100 – 200 (EUR 1.25 – 2.50) as a monthly flat tariff for basic lighting and mobile charging services and INR 8 – 15 (EUR 0.10 – 0.20)/ kWh in models with consumption based tariffs[1].

Energy Authorities in India – Table 3

Name of Institution	Function	Weblink
Centre		
Ministry of New and Renewable Energy (MNRE)	Nodal Ministry of the Government of India for all matters relating to renewable energy.	www.mnre.gov.in
Ministry of Power (MoP)	The Ministry is concerned with perspective planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, training and manpower development and the administration and enactment of legislation in regard to thermal, hydro power generation, transmission and distribution.	www.powermin.nic.in
Central Electricity Regulatory Commission (CERC)	Electricity regulator at the central level, regulates tariffs of central generating stations as well as interstate generation, transmission and supply.	www.cercind.gov.in
State		
State Electricity Regulatory Commission (SERC)	Electricity regulatory body at the state level. Its main functions include determining bulk and retail tariffs charged to consumers and regulating operations of intrastate transmission.	www.recregistryindia.nic.in/index.php/general/publics/SERCList
State Nodal Agency (SNA)	Promoting use of RE resources at the state level.	www.mnre.gov.in/file-manager/UserFiles/list_sna.pdf
Public Financial Institutions		
Rural Electrification Corporation (REC)	Public infrastructure finance company in power sector.	www.recindia.nic.in
Indian Renewable Energy Development Agency Ltd. (IREDA)	Public financial institution that promotes, develops and extends financial assistance for RE and Energy Efficiency/Conservation Projects.	www.ireda.gov.in

Policy and regulation landscape

The Indian Electricity Act, 2003 consolidates laws relating to generation, transmission, distribution, trading and use of electricity. The Act does not stipulate any provision on the level of tariffs for off-grid rural electrification. The National Electricity Plan (NEP) and Rural Electrification Policy (REP) notified by the Electricity Act provide the overarching framework and targets for 'village electrification' and 'power for all' (MoP, 2011). Since the electricity sector is included in the concurrent list of the Indian constitution, it is administered on central and federal level where the central government is in charge of creating a business enabling environment and of providing funds and the State governments are active on the level of implementation. In order to promote

1. Based on author's interactions with micro-grid players in India.

renewables in electrification, the amended Tariff Policy, 2006 specifies that the states have to set a Renewable Purchase Obligation (RPO) specific to solar with a target between 0.25% – 0.75% for 2014-15 in order to achieve a solar RPO of 3% by 2022. Both MoP and MNRE have guidelines for capital cost and cost of generation from various renewable technologies and their respective flagship programmes for rural electrification such as the following:

a. Decentralised Distributed Generation (DDG) Scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), flagship programme of MoP

In this scheme, 90% of capital cost in implementing decentralised distributed generation (DDG) systems is provided by the central government as grant and the remaining 10% as loan from REC, from state funds or loan from other financial institutions in areas where grid supply is not feasible or cost-effective. Free of cost connections are provided to those consumers who are below the poverty line. Private players place bids on cost of installation and cost of supplying power upon tender invitations from state implementing agencies and are required to maintain the plant for five years.

b. Remote Village Electrification Programme (RVEP), flagship programme of MNRE

This programme supports electrification (basic services of electricity/lighting) of villages that are remote unelectrified census villages and unelectrified hamlets of electrified census villages using non-conventional resources. Most villages electrified through this programme have been done using solar home systems or solar lanterns and very few employ mini-grids. In this scheme, the state acts as the implementing agency to whom the ownership of the plant is transferred after five years of commissioning. The developer is required to maintain the plan until the first five years of operation just as in DDG. In such a scheme, 90% of the cost is borne by the centre and the remaining 10% using state funds or from consumer contributions.

C. Jawaharlal Nehru National Solar Mission (JNNSM)

This national programme focuses only on incentivising solar power and was launched by the previous government in 2010. It initially aimed to deploy 20 GW of grid-connected solar power by 2022 and reducing costs of solar power and achieving grid parity by 2022. It sought to do so in three phases. Currently, the installation targets of this scheme are under significant upward revision to bring it in line with the new government's vigorous push for solar power. The new government has cancelled the planned allocation of 1,500 MW under batch II of Phase II, 2013-17 and has released draft guidelines for 3,000 MW under tranche I of batch II alone (in total three tranches equalling 15,000 MW under batch II of Phase II) (MNRE, 2014).

This programme also has an off-grid component for developing solar applications (including DDG power plants) with a cumulative target of 2 GW till Phase 3 (MNRE, n.d.). Through this scheme, MNRE provides combination of 30% subsidy (on capital cost) and/or 5% interest bearing loans. At least 20% of the cost needs are to be met by promoter's equity contribution or the Renewable Energy Service Companies (RESCOs) itself as margin money. It is possible that this off-grid component may also see some changes in the coming months.

Good times ahead for the renewable energy sector

The Renewable Energy Ministry is taking several steps to make India an attractive foreign direct investments (FDI)[2] hub for this sector. The Ministry is in the process of preparing a draft 'Renewable Energy Act 2015' to establish a comprehensive framework for investment. In addition, promising developments are underway, such as by the Indian Central Bank to give emphasis to off-grid solutions as priority sector and also by the Government who is negotiating a one billion Euro soft loan with KfW[3] for upscaling solar rooftop installations.

2 FDI up to 100% under the automatic route is permitted in RE Sector.
3 KfW is a German government owned development bank.

Key Donors and Financial Institutions active in India's energy access sector – Table 4

Type of Organization	Few Examples
Corporate Social Responsibility (CSR) Funds	Recent Indian legislation mandating corporates to spend 2% of their net profits on CSR activities has led to large corporate funds flowing into key development sectors including energy access
Indian Development Financial Institutions	IFCI, IL&FS, IREDA, NABARD, REC
International Development Financial Institutions	ADB, DFID, GiZ, IFC, KfW, WB, EIB
Equity Funds	Aavishkaar, Acumen, Infuse, Ncubate, Neurus Capital
Global Foundations	Aga Khan, Climate Works, Khemka, Rockefeller, Shell
Regional Rural Banks	Gramin Bank of Aryavart, Prathama Bank
Climate Fund	GEF

** This list is not exhaustive*

Small Hydro Power

Indian Authorities focussing on Small Hydro Power – Table 5

Name of Institution*	Function	Weblink
Alternate Hydro Energy Centre, IITR	Test agency for performance evaluation of SHP plants, training and capacity building centre and hosts a real time digital simulator for SHPs. Using MNRE's sponsorship, AHEC has developed Standards/Manuals/Guidelines adapted for small scale hydro power projects[4].	www.ahec.org.in
Central Board for Irrigation and Power (CBIP)	Dissemination of information regarding recent technological advancements in the disciplines of water resources, dam engineering, tunnels and underground works, rock mechanics, geosynthetics, power and RE.	www.cbip.org
Indian National Hydropower Association (INHA)	Forum for the exchange of views on various aspects of hydro power in India, advocating interests of hydro power fraternity.	www.hydropower.org/companies/indian-national-hydropower-association
Small Hydro Power Division, MNRE	Key policy making authority at the central level	www.mnre.gov.in
United Nations Industrial Development Organization (UNIDO)	Technical support for UNIDO's SHP projects is provided by UNIDO's Regional Centre for Small Hydro Power in Trivandrum (India)	www.unido.org/en/what-we-do/environment/energy-access-for-productive-uses/renewable-energy/focus-areas/small-hydro-power.html

** This list is in no way exhaustive and is selected based on author's review of literature and degree of involvement of various entities in the SHP sector in India.*

4 The complete set (27) of Standards/Guidelines/Manuals can be accessed via the following weblinks: http://www.iitr.ac.in/departments/AH/pages/Publications_Downloads+Standard_and_Guidelines.html and http://www.ahec.org.in/publ/standard/standards_for_small_hydropower_dev.html

With a proportion of about 90% water to wire, hydro power has one of the best conversion rates. SHP requires small capital investment and takes less effort to construct and to integrate into local environments. Since SHPs are site dependent predominantly run of the river, they do not have issues associated with submergence and rehabilitation. The definition for SHP in India allows for rather big projects of up to 25 MW.

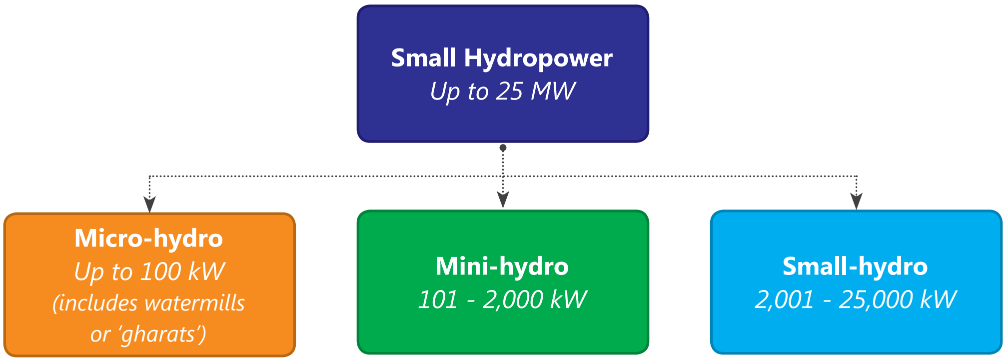


Figure 1: MNRE SHP Classification

Potential

According to present estimations the potential of SHPs in India is about 20 GW while the prospects are more promising as this outlook is under upward revision. MNRE has published a database of 6,474 potential state-wise potential sites aggregating in capacity of 19.7 GW (MNRE, 2014). Most of the potential for power generation is in the Himalayan states as river-based projects and in other states along irrigation canals. It is the objective of the Ministry to utilise at least 50% of the potential and to install a 7,000 MW capacity by 2017.

Policy

The policy environment is positive for SHP in India. The Ministry has announced approval for Central Financial Assistance (CFA) for development of SHP schemes for the year 2014-15 and the remaining 12th Five Year Plan across the following areas:

- identification of new potential SHP sites and preparation of Detailed Project Reports (DPR);
- setting up of SHP projects in the private sector, joint sector and co-operative sector;
- setting up of SHP projects in the government sector;
- financial support for renovation and modernisation of existing SHP projects in the government sector
- developing and upgrading watermills (WMs up to 5 kW) and micro-hydro projects (MHP up to 100 kW) to meet power requirement of remote regions in a decentralised manner to State Government Departments, State Nodal Agencies, local bodies, co-operatives, NGOs and Tea Garden and Industrial Entrepreneurs; and
- financial support for Research & Development (R&D) and capacity building (MNRE Letter No. 14(03)2014-SHP, 2014).

In addition, the central assistance is supported by varying incentives at State level such as a no-entry tax on power generation and tax exemptions for underdeveloped areas in the states of Jammu and Kashmir (Indian Renewable Energy Development Agency [IREDA], 2003).

Selection of specific Business Opportunities for SHP

Remote hydro-rich locations:

Strong economic case as there are many commercial entities such as tea or coffee plantations and other SMEs that are located in remote rural but hydro-rich geographies in hilly regions who, at present, are operating inefficiently because of erratic power supplies. These entities suffer from high operating costs due to high consumption of diesel for captive power generation. Since the MNRE releases the total financial support directly to such entities should they wish to develop such a project through their own financial resources, such entities can form a huge client base of SHP equipment manufacturers and installers.

Himalaya region:

Upgrading traditional watermills in the Himalayan region presents a big opportunity given the central financial assistance and other fiscal incentives such as watermill parts being exempted from Value Added Tax (VAT). According to a survey conducted by the Uttarakhand Renewable Energy Development Agency (UREDA), 15,449 watermills need an upgrade. An upgraded watermill can produce power up to 5 kW enough to power 15-20 families within the diameter of 500 metres[1].

Out of 6,474 sites (equivalent to a capacity of 19.7 GW) 4,143 sites (76.7%) can be used by run-of-river SHP technologies, 379 (8.3%) by existing irrigation dams and 1,952 (15%) by existing canals, falls and barrages solutions (Liu, Masera, & Esser, 2013).

Solar Photovoltaic Power

Solar Power Specific Authorities – Table 6

Name of Institution	Function	Weblink
National Institute of Solar Energy (NISE)	Dedicated unit of the Ministry of New and Renewable Energy, Government of India for development of solar energy technologies and its related science and engineering	mnre.gov.in/centers/about-sec-2/
NTPC Vidyut Vyapar Nigam Limited (NVVN)	NVVN handles bundling of solar power and its sale under National Solar Mission and is the power trading arm of power generation giant National Thermal Power Corporation Limited (NTPC)	nvvn.co.in
Solar Energy Corporation of India (SECI)	Governing body of National Solar Mission	seci.gov.in/content/
Solar Energy Society of India	Indian Section of the International Solar Energy Society (ISES)	www.sesi.in

The attractiveness of solar power has increased considerably as competition and innovation processes have led to a steep fall in electricity generation costs and also to lower risk investment profiles. As a result, in 2013 with a tariff of INR 5.97/kWh (EUR 0.08) near grid parity is deemed to have been achieved by large scale SPV power installations with that of power plants fired by imported coal with INR 5.86/kWh (EUR 0.07); (World Institute of Sustainable Energy [WISE], 2013). This development will positively impact costs for small and medium sized rural off-grid installation costs, especially with an increasing level of scaling up and standardisation into ready-to-install solar kits, aggressive marketing, information campaigns and easy availability of PV equipment.

Policy

India is currently in the second phase of its policy to make solar applications of different sizes work efficiently in the country. After the Jawaharlal Nehru National Solar Mission (JNNSM), which mainly aimed at large scale solar technology across India with a targeted installation of 20 GW in aggregate until 2022, in the second phase this target is under significant upward revision. In addition, this policy also has a dedicated off-grid solar systems component (please see 'Policy and Regulation Landscape' section).

Note on SPV BOS

To make PV competitive in the long run and meet system and delivered energy costs and efficiency target for high PV penetration between 2020 and 2030, there is a need to improve efficiency and life-time and reduce cost of Balance of System (BOS) components (The India Semiconductor Association-National Manufacturing Competitive Council (ISA-NMCC); Report (2008), p. 66-67). For the off-grid case, SPV BOS forms anywhere between 30-50% of the total system cost depending on the system configuration. An even bigger challenge is that while the life of the solar module is predicted to be somewhere in excess of 20 years (taking derating[5] into account), the BOS life is approximately five years. This assumption does not take into account a (very) few international brands which provide a warranty of up to 15 years for electronic devices used in SPV systems. Thus, apart from the requirement of high initial investment, the recurring cost of the BOS[6] also throws up a major challenge in a rural market with low income capacities.

The Indian electronics sector especially has been witnessing a consistent growth in demand without a corresponding increase in the manufacturing base of electronic products. India is still weak in local manufacturing capacities in the inverter segment. The Department of Electronics & Information Technology (DeitY), Ministry of Communications & IT (MCIT) and Government of India (GoI) announced a proposal called Modified Special Incentive Package Scheme (M-SIPS) to provide incentives to promote large scale manufacturing in the Electronic System Design and Manufacturing (ESDM) sector in 2012. These incentives include subsidies for investments in capital expenditure up to 20% in Special Economic Zones (SEZs) and 25% in non-SEZ regions in India. The incentives are available for investments made in a project within a period of 10 years from the date of approval. They are available for units across raw materials including assembly, testing, packaging and accessories and cover 29 verticals of ESDM products including solar PVs.

Technology gap as a business opportunity

The lack of availability of latest technologies and manufacturing, along with the need for innovating at 'global' speed is both a market barrier for large scale uptake of small-scale solar PV projects and a business opportunity at the same time. In modern SPV systems, the hardware has built-in algorithms which define how a solar inverter or a battery-charger behaves in a system that enhances efficiencies. This can come only through multiple iterations in the laboratories coupled with field-testing over long-time periods. A greater part of local manufacturing deals with low-end technologies that have lower system efficiencies. The need is for foreign companies to forge alliances with the domestic industry to accomplish innovations suited to Indian power supply conditions and systems. While this would benefit the case of solar industry in India, it would also enable manufacturers to reap rich returns by participating in the ongoing solar energy market transformation in India.

5 Derating is the process of operating an equipment well inside its rated capacity in order to enhance its life.
6 We have provided one case study each of innovation in inverter and battery application that helps bring the BOS cost down in the 'Case study' section.

Other technology gaps include:

- Good quality, reliable and low cost power convertors which are not easily available for stand-alone hybrid applications, particularly in the 10 kW to 100 kW range;
- Currently available AC off-grid systems can work only with a single point of generation. Hybrid systems combine all sources at a single point. For multiple generation points, good quality bi-directional power convertors which can be distributed at various locations in the network are needed which make a network more flexible and expandable;
- Lead acid batteries have limited cyclic life and require maintenance. Lithium based batteries have higher life expectancies but are more expensive. Flow batteries have much higher life but are even more expensive and the technology has not stabilised yet. Lithium battery prices are coming down and may provide the answer in the medium term for energy access projects.

Small Wind Power

Indian Authorities for Wind Power – Table 7

Name of Institution	Function	Weblink
National Institute of Wind Energy (NIWE)	An autonomous research institution under MNRE, serves as a technical focal point for wind power development in India.	www.cwet.tn.nic.in
Indian Wind Energy Association (INWEA)	Indian association with more than 300 members that works towards removing barriers to wind power development and creation of an enabling regulatory and policy environment.	www.inwea.org
Indian Wind Power Association (IWPA)	Indian association with 1,352 members and works closely with several national industry bodies.	www.windpro.org
Indian Wind Turbine Manufactures Association (IWTMA)	Indian association working to promote and harness wind energy in India.	www.indianwindpower.com

Potential

India's current installed capacity of wind energy is 21.1 GW which is the highest proportion in India's renewable energy mix. The installable potential at 50 m level is calculated to be 49.1 GW based on 0.5% land availability of Himalayan states, North-eastern states and Andaman and Nicobar Islands and 2% land availability of all other states (National Institute for Wind Energy [NIWE], 2014). Further, on the utility scale end, India is also exploring (i) its potential in offshore wind energy over its 7,500 km long coastline; and (ii) replacing older onshore wind turbines that are more than 10-12 years old with more efficient and large capacity machines. India's current repowering potential is approximately 2.8 GW (Global Wind Energy Council [GWEC], 2012).

On the small wind side, it is considered that the world market for small wind is still in its infancy and that most of the growth in this segment has occurred in three countries viz. China, US and UK. This however, does not pre-empt scope for small wind market development in India which has tremendous opportunities for collaboration between international players and Indian domestic manufacturers. India's installed capacity for small wind is 2.4 MW as of 2013 (World Wind Energy Association [WWEA], 2014) and the cumulative installed capacity of wind-solar hybrid systems is 1.6 MW (MNRE, 2014).

Policy

Wind speed data monitoring and turbine model testing

Creating a numerical wind atlas especially when the size of the region is substantial requires a large computational effort. To tackle the issue of insufficient wind measurements, NIWE in association with Riso DTU, Denmark has developed a numerical wind atlas of India. NIWE has been monitoring wind speed and direction data at 790 sites across the country (NIWE, 2014). Furthermore, the MNRE which has been carrying out these wind resource assessment initiatives through NIWE, has launched a new scheme to expand assessment in uncovered areas. Under this scheme which is also to be implemented through NIWE, 40% of the total project cost will be provided from National Clean Energy Fund and the remaining 60% is to be borne together by the concerned SNA and private developer(s) (MNRE, 2014).

The manufacturers have to get their models empanelled with MNRE based on testing/certification for design requirements, power performance and safety functions in accordance with the empanelment procedure evolved by NIWE. Only such empanelled models are eligible for financial support from the government under various schemes.

Small Wind Energy and Hybrid Systems (SWES) Scheme

MNRE has a specialised scheme aimed at technology development and promoting applications of water pumping windmills and aerogenerators/wind-solar hybrid systems called the 'Small Wind Energy and Hybrid Systems (SWES)'. This scheme is valid for the Twelfth Plan Period (2012- 17) and provides financial support for setting up these systems, field trials and performance evaluations, grid connected SWES for demonstration, and R&D (MNRE, 2010). This program aims at boosting the Small Wind Turbine (SWT) market by involving system manufacturers[7].

Business Opportunity

The average size of small wind turbines differs across countries. According to the '11th List of Empanelment of Small Wind Turbines' from 28th of August 2014 the average size of tested and validated SWTs recommended by NIWE for MNRE empanelment (eligibility for government subsidy) is 2 kW (NIWE, 2014). SWTs/aerogenerators can facilitate power generation for remote rural applications for both households and commercial establishments such as small and medium village enterprises and telecommunication towers - a potential that needs to be tapped.

7 List of eligible manufacturers for supply, installation and commissioning of water pumping windmills and the list of approved and tested wind turbines by NIWE can be downloaded using the following MNRE weblink: http://mnre.gov.in/schemes/offgrid/small-wind/

Business model landscape

In India, diesel based micro-grids or stand-alone power generating assets such as diesel generators have existed for decades and fulfil energy needs of relatively well-off rural households, agricultural productive loads, telecom towers and productive loads of other businesses existing in off-grid or 'under-electrified' locations. One of the earliest examples of SPV based mini-grids is the installation of 344.5 kWp system by West Bengal Renewable Energy Development Agency (WBREDA) in Sunderbans that serves 1,750 connections. While the earlier initiatives were all partly or wholly government-led projects with a high proportion of grant to meet the initial cost, today there is a fair representation of non-government players that may be socially or purely profit motivated, such as:

1. First generation entrepreneurs experimenting with different kinds of clean technologies and tariff payment mechanisms (see 'Private sector' section in 'Table 3' for examples).	2. Medium-sized enterprises with an innovative technology that can help to produce a higher energy output per unit cost of installation as compared to other traditional technologies and/or capable of producing power at a previously un-exploitable resource. Examples are: **SheerWind:** This company uses a technology that eliminates the need for massive blades and tower-mounted generators. It works by capturing wind through a funnel and squeezing the wind flow to increase its velocity while channelling it to a ground-based generator. Such a system can generate power from wind speed as low as 2 mph making it profitable to tap many more sites; **Smart Hydro Power:** This company makes use of kinetic hydro power. Kinetic turbines create energy from flowing water and do not require any water head thus lowering infrastructural costs. This also helps open up many more sites which were not possible to exploit using conventional technologies.	3. Large-sized firms who were already in the business of manufacturing components that go in a micro-grid installation, turn-key project implementers or other integrated power companies that have sensed the opportunity in the rural consumer segment. Examples include SunEdison Energy India and Tata Power among others, who have entered this segment either from a Corporate Social Responsibility (CSR) motive or a purely profit motive, being able to benefit from efficiencies emerging in a vertically integrated business.

As the discourse of providing 100% clean energy access at the global and national level intensifies, aided by donor and public grants, social investors and CSR initiatives, this sector is brimming with new innovations (experiments with new technologies and range of business models) aimed at reducing cost of energy delivery to a remote location. Many organisations have published literature aimed at compiling many of these initiatives. In one such effort, Prayas Energy Group, a Pune, Maharashtra-based think tank has compiled a map which shows the geographic location of DDG systems, associated developer, preferred use of technology and number of households served[8]. In the following sections, we discuss some examples of business models and projects driven by private sector, government and 'socially motivated' international organisations.

8 This map can be accessed using the weblink - http://prayaspune.org/peg/publications/item/275.html

Project Examples – Table 8

Entity Type	Entity Name	Scope	Business Model/ Intervention	Partners
Private sector	Gram Power	Families living off the grid or receiving less than 6-8 hours/ day of power supply are given 24x7 electricity with a pay-as-you-go prepaid model. Gram Power is conservatively targeting to reach 200,000 families or 1.4 million people by the end of 2016.	A local entrepreneur buys bulk energy credit from Gram Power at a discount – for 5,500 rupees (EUR 70) of energy credit, Gram Power charges only 5,000 rupees (EUR 62). This credit is then transferred to a wireless energy wallet designed by the company and owned by the entrepreneur. He or she uses this wallet to sell power to local customers in small increments of 20 rupees or more as required, which the pre-paid meter loads and regulates.	
	Mera Gaon Power	Each plant is 240 Wp SPV system which serves basic lighting and mobile charging load for 7 hours a day for about 20 households in villages in Uttar Pradesh. MGP micro-grids are bringing light to about 25,000 people in 222 villages today.	They build, own, operate and maintain recovering cost in about 3 years through tariffs and charge a flat tariff of INR 100/month for the rural households and micro-enterprises that they serve.	
Government (wholly or partly financed by government subsidies)	Karnataka Renewable Energy Development Agency (KREDL)	Micro-hydro systems in Karnataka where the state had identified 1,500 sites in Chikkamagalore, Uttara Kannada, Dakshina Kannada, Hassan, Udupi, Kodagu, and Shimoga districts.	The prospective beneficiary applies online through the KREDL website with a registration fee to install a pico-hydro system in his/her property. This application goes to the project implementers who assist him/her in getting bridge financing and help in system installation.	Technology provider: Prakruti Hydro Labs; Implementer: Nisarga Environmental Technology, Karawali Renewable Energy; Finance: Credit co-operatives like Sharda Souharda Society, Siri Souharda Society.
	Uttarakhand Renewable Energy Development Agency (UREDA) Initiative	Micro-hydro project in Jakhana in Uttarakhand is a self-sustained 100 kW plant utilising the perennial flow of Balgana river providing power to 295 families.	This project received 40% assistance from MNRE as CFA, 8% of the capital cost as land and labour from the Village Electrification Committee (VEC) and remaining funds from UREDA. Members of the VEC have been selected by the villagers based on the population of each powered village. VEC has the authority to penalise defaulters and a regular salary is paid to operators and technicians.	

Entity Type	Entity Name	Scope	Business Model/ Intervention	Partners
Socially motivated international organizations such as DFIs, NGOs, Foundations	Greenpeace	Greenpeace funded project in Bihar with approximately 170,000 USD to demonstrate mini-grid project development within a viable investment, regulatory and community participatory framework.	The model is based on a pre-paid system where each house pays a tariff to fixed energy units per month based on their requirements. They are also charged a nominal amount for this usage which will help in balancing the long term operational and maintenance cost of the micro-grid.	Operation partner - BASIX; Community mobilisation partner - Center for Environment & Energy Development (CEED); Technology Partners - Kripa Solar.
	Indo-German Energy Programme (IGEN) and Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA)	Mini-grid projects in 100 villages will be readily developed; villages will be combined into 4-8 clusters of approximately 15-25 villages each, while each village will get 80-100 connections. Each cluster will be tendered out to the mini-grid operators as an individual project.	Tender cum extensive support package for the bidders. Transaction and development costs will be reduced significantly for the assigned companies. They will be enabled to leverage economies of scale and to operate the mini-grids profitably with an adequate financial return.	INENSUS, Emergent Ventures India and InsPIRE Network for Environment.
	International Finance Corporation (IFC)	India component of IFC project called Lighting Asia.	Through this project IFC gave advisory inputs to its mini-grid clients (among other things) in order to support them in developing scalable and sustainable mini-grids business models in India.	Mini-grid players - Minda Nexgen Tech Ltd. and SunEdison Energy India Private Ltd.
	Mlinda Foundation	150 Wp panels serving 10 households each in Sunderbans region in West Bengal.	Repayment through joint liability account of customers (households and institutions) with NABARD or Union Bank of India. No tariffs are charged and the community is the owner of the pico-grid asset.	
	Rockefeller Foundation	Foundation has committed a fund of 75 USD Million for its initiative 'Smart Power for Rural Development' which aims to electrify 1,000 Indian villages mainly in UP and Bihar between 2014-17.	The initiative provides energy for both lighting and productive use through a financially sustainable method of installing mini-grids. In order to achieve these goals, the Foundation is establishing a new organisation in India that will manage the program and work closely with the wide range of stakeholders critical to developing the eco-system needed to scale up the market.	Energy service companies, telecom tower operators and other 'anchor load' energy customers, investors, NGOs and government agencies.
	MinVayu	100 W individual wind system to a 3 kW community wind system that can be integrated with SPV panels. Manufacturing cost of turbine is Rs 27,000 (EUR 365) for a 350 W machine, a 12 m lattice tower, including the cost of battery banks and inverter if needed.	They use an open source wind turbine that can be locally manufactured and MinVayu trains local participants to be able to build their own systems.	Auroville Green Practices

Case Studies of ARE members

Case Study 1: Small Hydro Power

Service – Proprietary kinetic hydro power plant
System – SMART solution
Generation – 25 kW capacity

SMART HYDRO POWER

Smart hydro Power is a start-up company founded in 2010 based in Germany but with its main activities in Latin America and Africa. One of the company's shareholder is the German development bank KfW. In 2014, the company's main activities are in Zambia, Nigeria, Peru and Colombia. For 2015, India is considered as main market.

The Challenge

While providing basic energy services using solar home systems could still be a viable business model, sustainably delivered full-electrification services is still challenging. This is mainly due to the intermittency in sources like solar and wind. The newly developed hybrid system with hydrokinetic and photovoltaic addresses this need with a solution that focuses both on the generation and distribution of electricity.

The Solution

The SMART solution is built upon a proprietary kinetic hydro power plant which means a hydro turbine that does not require any other infrastructure than an anchor point. It is equally environmental and fish friendly. The turbine generates base load with approx. 8,100 hours a year (95%) only interrupted by cleaning cycles depending on debris impact in rivers or canals. Cleaning is the only service or maintenance required. The turbine might be combined with any other source of electricity to either supply day peak demand or additional capacity during dry season. The turbine feed an energy management system which is based on standard components but adapted to rural needs. While the inverter guarantees a standard generation management, three output lines with different levels of priority guarantee supply to the most important points of demand like health stations or street light circuit and allow the complete usage of the electricity as generated due to an integrated auxiliary load (e.g. water treatment system or ice machine). This does not only take excess electricity productively but technically also helps to stabilise the micro-grid.

The system is completely standardised and modular up to 25 kW capacity. Three single units can be synchronised to build a three phase low voltage grid for rural workshops or food processing plants. So far, the system is employed in Nigeria, Peru, Colombia and Germany.

Source: Smart Hydro Power

Case Study 2: Solar Mini-grids

Service – Solar mini-grids for off-grid rural markets
System – Mlinda
Generation – 500 W- 8 kW capacity

Mlinda is a Paris-based environment organisation working towards sustainable consumption and production. In India, Mlinda is headquartered in Kolkata and one of the flagship projects is rural electrification through solar based mini-grids. To date, Mlinda has installed 180 mini-grids, spanning across households, markets and schools in Sundarbans and Purulia districts, West Bengal. Installed capacity is 58 kW.

The Challenge

The off-grid markets in rural Sundarbans, West Bengal are a hub of commercial activity. The market size ranges from 20 shops to those having more than 300 shops and they are powered by diesel gensets for four hours daily in the evening. Not only is this polluting the fragile ecology of the Sundarbans, but it is an expensive proposition as diesel prices climbing steadily. Some of the local shop owners are finding it difficult to cope with these increasing prices, and finally, have had to switch to kerosene wick lamps.

Source: Mlinda Foundation

The Solution

Not satisfied with this status quo, few shop keepers approached Mlinda to design and develop solar mini-grids for the market space. They decided to give up diesel completely and switch over to a solar facility if it was affordable and resulted in savings. Mlinda conducted an in-depth assessment of the average loads of the market, existing diesel tariffs and paying capacities of the shop owners which in turn informed the technical designs of the market grids and the financial structuring of the same. The capacities of the market based mini-grids ranges from 250 W-8 kW. These are AC systems providing a 230 V 15 Amp supply. System supplies single phase power for lighting, aspirational and productive needs. The sub 2 kW systems are all rooftop mounted and the larger systems are ground-mounted behind the shops. The battery, inverter, MCB is housed within the shops and in larger systems it is housed in a room adjacent to the shops. Installed capacity in Sunderbans is 30 kW and 20 kW are in the immediate pipeline. In the bigger mini-grids, the markets act as the 'anchor load' and the surplus power is supplied to nearby homes (within 1 km) for meeting their aspirational demands. The systems are owned, run and managed by the local entrepreneurs. Mlinda acts as the overall integrator of the ecosystem – facilitating a soft loan for the entrepreneur from banks which they pay over a period of five years in easy monthly instalments, building the capacities of the local entrepreneur as well as taking care of the local repair and maintenance. This switch to a solar-based mini-grid results in minimum savings of INR 1,000 (EUR 12.50) per month.

Case Study 3: Small Wind

Service – Micro Wind for Mini Grids (Rural Communities)
System – INVELOX RDI
Generation – 5 kW wind energy solution

SHEERWIND

SheerWind is a wind energy technology company that provides systems to power to rural communities at market rates. SheerWind's INVELOX™ technology (named for increasing velocity) is a wind funnel system that captures, accelerates, and controls wind before delivering it to the turbine and generator(s) safely and efficiently located at ground level. Generating power from low wind speeds. For the first time in history, multiple turbines can be used in a row or series increasing output capacity for each INVELOX tower. The patented technology captures wind at very low wind cut-in speeds, much lower than what traditional wind turbines require, allowing deployment in close proximity to the region or area requiring power.

The Challenge

Rural communities and remote villages have little to no access to a consistent power source. In many cases, kerosene lamps or diesel generators are the only local source of power. The result is power that can cause significant health issues and is too costly to provide power throughout the day. Wind and solar solutions are precluded from providing localised power due to the requirements to ensure optimal efficiency, and the high cost to transport and commission small scale systems.

The Solution

SheerWind has developed a 5 kW wind energy solution called Rapid Deployment INVELOX (RDI). RDI employs the INVELOX technology to amplify wind speed by a minimum factor of three. The result is a wind energy solution that can provide a consistent power source in poor wind areas, in other words, siting is removed as an obstacle. In addition, the RDI is built on a collapsible aluminium frame with a body of heavy duty fabric. The resulting turbine/generator weighs less than 20 kg. Power from the system exceeds 60%.

RDI employs a wind delivery system and third party generator that can be sourced and constructed locally. The result is power generation that can be built using domestic labour rates with a turbine and generator that can be purchased from an in-country supplier.

Source: SheerWind

Case Study 4: Batteries

Service – Off-grid
System – Up to MWh scale battery systems, depending on system voltage
Generation – Solar

Founded in 1925, Trojan Battery Company (TBC) is the world's leading manufacturer of deep-cycling flooded, absorbed glass mat (AGM) and gel lead acid batteries. With two factories in California and two factories in Georgia, TBC continues to focus on manufacturing the best deep-cycle lead acid batteries in the world.

The Challenge

Batteries in RE applications routinely face PSOC cycling, in which the batteries operate between a low state of charge (SOC) when they are discharged and a high SOC (when they are charged for short time periods), without ever reaching a full charge.

Since batteries need a full recharge after each discharge to achieve optimum cycle life, PSOC cycling significantly reduces the battery's cycle life. Given that PSOC cycling is a fact of life in RE applications, the challenge for Trojan Battery's R&D team was to minimise the impact on cycle life of Trojan's lead acid, deep-cycle batteries in typical RE applications.

The Solution

Trojan's R&D team experimented with many types of carbon in various formulas for more than five years with the objective of developing a solution to address the impact of PSOC cycling. In 2014, Trojan introduced SmartCarbon™, Trojan's proprietary formula which provides improved performance when a battery cycles in a PSOC environment. SmartCarbon™ enhances overall battery life in applications where the batteries are not fully recharged on a regular basis.

Source: Trojan Battery Company

The SmartCarbon™ (SC) high-conductivity carbon formulation is added to the negative active material. Tests have proven that SC increases the PSOC cycle life of Trojan batteries by an astounding 15%.

The innovative SmartCarbon™ technology is available today in Trojan's Premium batteries (T-105RE, L16RE-A, L16RE-B and L16RE-2V), and Industrial batteries (IND9-6V, IND13-6V, IND17-6V, IND23-4V, IND27-2V, IND29-4V and IND33-2V).

Case Study 5: Inverters

Service – Serves any hybrid micro-grid
System – Inverters and MPPT solar chargers
Generation – PV + generator

Studer Innotec is a Swiss manufacturer of high-end inverters, inverter-chargers and MPPT solar charge controllers.

The Challenge

Over the recent years the cost of solar modules has drastically dropped, modifying the solar system cost breakdown: previously amounting to more than 50% of a system cost, the solar module part is now down to 30% of a system cost. With the Balance of System (BOS) now representing up to 70%, its cost is expected to go down too, which means battery, inverter, solar charge controller, all at cheaper price.

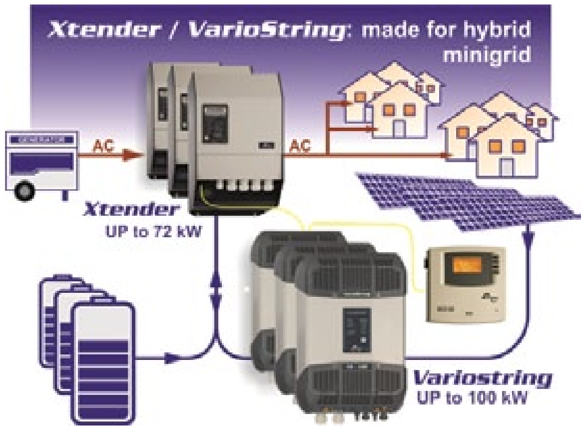
But cheaper BOS does not necessarily mean higher Return on Investment (ROI). More than their price, what improves the ROI is the value added by the electronic components namely the inverter and the solar charge controller. Especially when this added value results in a longer lifetime of the system along with lower operational expenses (OPEX). The challenge is how to improve ROI of solar systems by reducing the BOS cost.

The Solution

Studer Innotec's hybrid inverter called 'Xtender' can help downsize both PV generator and battery. It offers a unique feature that assists AC load to cope with peak load demand and allows downsize backup diesel generator, permitting the system to always operate at full power and highest efficiency.

Studer Innotec designed another product to help reduce the BOS costs. This is a high voltage MPPT solar charge controller that reduces BOS by eliminating expensive wiring for parallel strings, saving wires, connectors, junction boxes, fuses, space and labour. This product is called VarioString, which works up to 900 Vdc on the PV side and charging up to 120 A on the battery side.

The brand behind these two products is Studer Innotec SA, present in India through its sister company based in Bangalore.



Source: Studer Innotec

References

Airy, A. (2014, September 23). PM Modi wants 2 lakh MW more from sun, wind with US help. *Hindustan Times*. Retrieved from http://www.hindustantimes.com/india-news/pmmodiinus/pm-wants-2-lakh-mw-more-from-sun-wind-with-us-help/article1-1267280.aspx

Asia-Pacific Environmental Innovation Strategies (APEIS). Research on Innovative and Strategic Policy Options (RISPO). (2003, March). *Solar photovoltaic minigrids in Sunderbans (India) — a combination of government and community financing. Summary of the Practice*. Retrieved from http://pub.iges.or.jp/contents/APEIS/RISPO/inventory/db/pdf/0022.pdf

Bhaskar, U. (2014, June 16). India to set up two renewable energy firms. *Hindustan Times*. Retrieved from http://www.livemint.com/Industry/TQ0G0KAjZbqYc5UlwI5nwM/India-to-set-up-two-renewable-energy-firms.html?utm_source=copy

Bluth, K. (2014, September/October). A 'Micro' Solution to India's Major Energy Woes. *USAID*. Retrieved from http://www.usaid.gov/news-information/frontlines/youth-mobile-technology/micro-solution-indias-major-energy-woes

Bridge to India. (2014, October 20). Weekly Update: Is India working on a comprehensive "Renewable Energy Act 2015"? *The Bridge to India Blog*. Retrieved from http://www.bridgetoindia.com/blog/weekly-updateis-india-working-on-a-comprehensive-renewable-energy-act-2015/

Central Electricity Authority. (2014). *Load Generation Balance Report 2014-15*. Retrieved from http://www.cea.nic.in/reports/yearly/lgbr_report.pdf

Central Electricity Authority. (2014). *Progress report of village electrification as on 31-08-2014 as per 2011*. Retrieved from http://cea.nic.in/reports/monthly/dpd_div_rep/village_electrification.pdf

Global Wind Energy Council. (2012). India Wind Energy Outlook | 2012. Retrieved from http://www.gwec.net/wp-content/uploads/2012/11/India-Wind-Energy-Outlook-2012.pdf

Government of India. Ministry of Communications & Information Technology. Department of Electronics and Information Technology. (2012, October 22). Notification File No. 8(50)/2011-IPHW. Retrieved from http://cmia-aurangabad.com/events/Attachment2.pdf

Government of India. Ministry of New and Renewable Energy. (2014, March 31). *State Wise Numbers and Aggregate Capacity of SHP Projects (Upto 25 Mw) Potential, Installed & Under Implementation (As on 31.03.2014)*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/SHP-potential.pdf

Government of India. Ministry of New and Renewable Energy. (2014, October). *Draft Guidelines for Selection of 3000 MW Grid-connected Solar PV Power Projects under Batch-II Tranche-I State Specific Scheme*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/Draft-Guidelines-for-Batch-II-Phase-II-Tranche-I.pdf

Government of India. Ministry of New and Renewable Energy. (2014, September 30). *Organisation of 1st Renewable Energy Global Investment Promotion Meet & Expo (RE - INVEST) on 15 to 17 February, 2015 in New Delhi*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/First-Announcement-REINVEST.pdf

Government of India. Ministry of New and Renewable Energy. (n.d.) JNN Solar Mission Scheme/Documents. *www.mnre.gov.in*. Retrieved October 1, 2014, from http://www.mnre.gov.in/solar-mission/jnnsm/introduction-2/

Government of India. Ministry of New and Renewable Energy. National Institute of Wind Energy. (n.d.) Wind Resource Assessment Unit. http://www.cwet.tn.nic.in/. Retrieved October 1, 2014, from http://www.cwet.tn.nic.in/html/departments_wra.html

Government of India. Ministry of New and Renewable Energy. Small Hydro Power Division. (2014, July 2). *Letter No. 14(03)2014-SHP*. Retrieved from http://mnre.gov.in/file-manager/grid-small-hydro/SHP-Scheme.pdf

Government of India. Ministry of New and Renewable Energy. Wind Energy Division. Notification File No. 58/82/2012-WE. Guidelines for Implementation of Wind Resource Assessment in Uncovered/ New Areas under NCEF Scheme and subsequent development.

Government of India. Ministry of New and Renewable Energy. Wind Energy Division. (2010, April 16). Notification File No. 23/1/2009/SWES. Small Wind Energy and Hybrid Systems Programme.

Government of India. Ministry of Power. (2011, July). *Power Compendium - A Compilation of Acts, Rules, Policies, Guidelines 2011 (Updated till 31st March 2011).* Retrieved from http://powermin.nic.in/acts_notification/pdf/power_compendium.pdf

Government of India. Ministry of Power. (2013, September 2). *Office Memorandum No. 44/10/2011-RE*. Retrieved from http://rggvy.gov.in/rggvy/rggvyportal/memo/OFFICE-MEMORANDUM-12th-plan-rggvy.pdf

Government of India. Ministry of Power. Central Electricity Authority. (2014). *Load Generation Balance Report 2014-15*. Retrieved from http://www.cea.nic.in/reports/yearly/lgbr_report.pdf

India Semiconductor Association-National Manufacturing Competitive Council (ISA-NMCC). (2008, September). *Solar PV Industry: Global and Indian Scenario*. Retrieved from http://www.nmcc.nic.in/pdf/isa_nmcc_september2008.pdf

Jain, V., & Srinivas, S. N. (Eds.). (2012). Empowering Rural India the RE Way – Inspiring Success Stories. Government of India. *Ministry of New and Renewable Energy*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/compendium.pdf

Jammu & Kashmir State Power Development Corporation Limited. (2003, October 9). *Government Order No. 211 – PDD).* Retrieved from http://ireda.gov.in/writereaddata/compendium/J&K/SHP-03.pdf

Kasisomayajula, S. (2013). Compressive Study on Importance of Wind Power in India. *American Journal of Engineering Research, 02*(03), 27-35.

Katyal, A. (2012, October). Testing of small wind turbines. *Renewable Energy Akshay Urja*. Retrieved from http://www.indiaenvironmentportal.org.in/files/file/small%20wind%20turbines.pdf

Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, Z. Liu. (2011). *Hydropower. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Liu, H., Masera, D. and Esser, L., eds. (2013). *World Small Hydropower Development Report 2013*. United Nations Industrial Development Organization; International Center on Small Hydro Power. Available from www.smallhydroworld.org.

Ministry of Statistics and Programme Implementation. (2012). *Per Capita Net State Domestic Product at Current Prices.* Retrieved from http://mospi.nic.in/Mospi_New/upload/State_wise_SDP_2004-05_14mar12.pdf

Prayas Energy Group. (2014, August). A Map of Distributed Renewable Energy (DRE) Micro-grids in India. *www.prayaspune.org.* Retrieved from http://prayaspune.org/peg/publications/item/275.html

Rao, P., Reddy, K., Reddy, P. (2013). Design And Development Of Small Wind Energy Systems Is A Soft Path For Power Generation And Environment Conservation For Off Grid Applications In India. *International Journal of Engineering Research and Applications, 3*(3), 194-200.

Sa-Dhan, The Association of Community Development Finance Institutions. (2013). *Microfinance Map of India.* Retrieved from http://www.sa-dhan.net/files/Sa-dhan-indian-map.htm

Singh, R. K. (2014, September 22). Coal India Said to Plan Building $1.2 Billion of Solar Projects. *Bloomberg*. Retrieved from http://www.bloomberg.com/news/2014-09-22/coal-india-said-to-plan-building-1-2-billion-of-solar-projects.html

Woodbridge, R., Sharma, M., & Fuente, D. (2011). *Atlas of Household Energy Consumption and Expenditure in India*. Retrieved from www.householdenergy.in

World Institute of Sustainable Energy. (2013). *Future of Coal Electricity in India and Sustainable Alternatives – Summary.* Retrieved from http://wisein.org/WISE_Projects/final_coal_report.pdf

World Wind Energy Association. (2012). Update | Small Wind World Report. Retrieved from http://small-wind.org/wp-content/uploads/2014/03/2014_SWWR_summary_web.pdf

World Wind Energy Association. (2014). Small Wind World Report 2014. Retrieved from small-wind.org/wp-content/uploads/2014/03/2014_SWWR_summary_web.pdf

List of Abbreviations

Water Mill	WM
Alternate Hydro Energy Center	AHEC
Asian Development Bank	ADB
Central Board for Irrigation and Power	CBIP
Central Financial Assistance	CFA
Corporate Social Responsibility	CSR
Decentralised Distributed Generation	DDG
Department of Electronics & Information Technology	DeitY
Department of International Development	DFID
Detailed Project Report	DPR
Deutsche Gesellschaft für Internationale Zusammenarbeit	GiZ
Development Finance Institution	DFI
Electronic System Design and Manufacturing	ESDM
Five Year Plan	FYP
Foreign Direct Investment	FDI
Global Environment Facility	GEF
Government of India	GoI
Household	HH
Indian National Hydropower Association	INHA
Indian Rupees	INR
Indo-German Energy Programme	IGEN
Industrial Finance Corporation of India	IFCI
Infrastructure Leasing & Financial Services	IL&FC
International Association from Small Hydro	IASH
International Finance Corporation	IFC
India Semiconductor Association	ISA
Indian Renewable Energy Development Agency	IREDA
Karnataka Renewable Energy Development Agency	KREDL
Kilo Watt Peak	kWp
KfW Development Bank	KfW
Mega Watt	MW
Ministry of Communications & IT	MCIT
Micro-Hydro Projects	MHP
Miles Per Hour	MPH
Ministry of New and Renewable Energy	MNRE
Modified Special Incentive Package Scheme	M-SIPS
National Bank for Agriculture and Rural Development	NABARD
National Manufacturing Competitive Council	NMCC
Non-Governmental Organization	NGO
Rajeev Gandhi Grameen Vidyutikaran Yojana	RGGVY
Remote Village Electrification Programme	RVEP
Renewable Energy Service Providing Company	RESCO
Reseach & Development	R&D
Rural Electrification Corporation	REC
Small Hydro Project	SHP
Small Wind Turbine	SWT
Solar Photovoltaic	SPV
Special Economic Zone	SEZ
Ultra Mega Power Plant	UMPP
United Nations Industrial Development Organization	UNIDO
Uttar Pradesh New and Renewable Energy Development Agency	UPNEDA
Uttarakhand Renewable Energy Development Agency	UREDA
Value Added Tax	VAT
Village Electrification Committee	VEC
West Bengal Renewable Energy Development Agency	WBREDA
World Bank	WB

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Alliance for Rural Electrification
Shining a Light for Progress

ARE is an international business association focusing on the promotion and the development of off-grid stand-alone and mini-grid renewable energy solutions for rural electrification in developing countries.

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