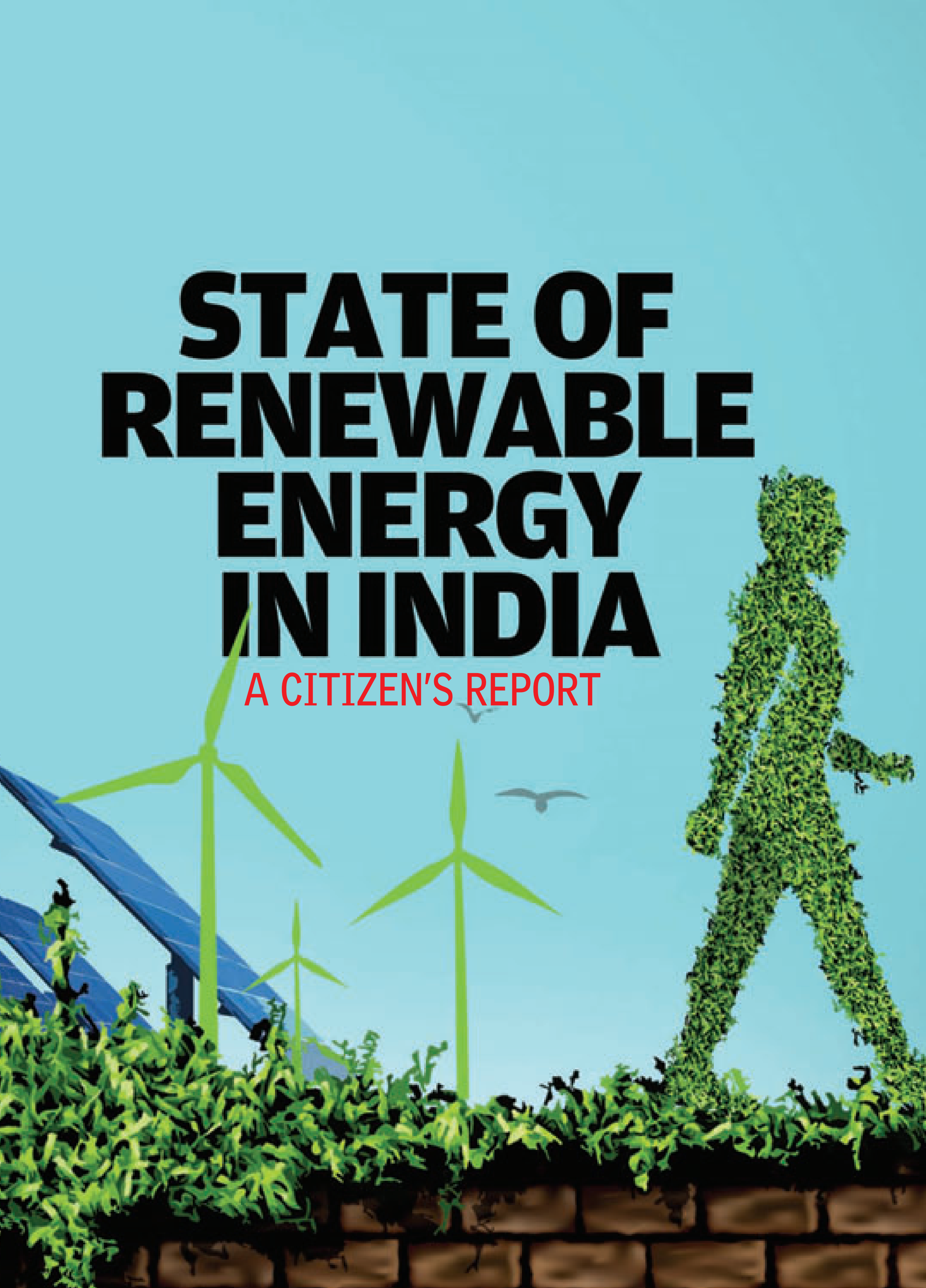
STATE OF RENEWABLE ENERGY IN INDIA

A CITIZEN'S REPORT



STATE OF RENEWABLE ENERGY IN INDIA

A CITIZEN'S REPORT

CENTRE FOR SCIENCE AND ENVIRONMENT

Authors: Chandra Bhushan, Nayanjyoti Goswami, Aruna Kumarankandath, Kanchan Kumar Agrawal and Joel Kumar

Editor: Kaushik Das Gupta

Design: Chaitanya Chandan and Vivek Bhardwaj

Cover design: Ajit Bajaj

Layouts: Kirpal Singh and Surender Singh

Production: Rakesh Shrivastava and Gundhar Das

Research and edit support: Ankur Paliwal, Aparna Pallavi, Kumar Sambhav Shrivastava, Jyotika Sood, Sayantan Bera, M Suchitra, Archana Yadav and Snigdha Das

Photo contributors: Chinky Shukla, Jonas Hamberg, Meeta Ahlawat, Benudhar Sutar and Leena Gupta

SHAKTI SUSTAINABLE ENERGY FOUNDATION

We are grateful to Shakti Sustainable Energy Foundation (www.shaktifoundation.in) for its support. However, the views expressed and analysis in this document does not necessarily reflect views of the Foundation. The Foundation also does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.

We are grateful to Swedish International Development Agency for institutional support.

ISBN: 978-81-86906-75-0

Price: ₹690

Maps in this report are indicative and not to scale.

Citation: Chandra Bhushan, Nayanjyoti Goswami, Aruna Kumarankandath, Kanchan Kumar Agrawal and Joel Kumar, 2014, *State of Renewable Energy in India: A Citizen's Report*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-29955124, 29955125, 29953394
Fax: 91-11-29955879
E-mail: cse@cseindia.org
Website: www.cseindia.org

Printed at Multi Colour Services, New Delhi

Foreword

Renewable energy has arrived. In matter of a decade, it has grown from a fringe player to a mainstream actor in the energy sector.

In the past ten years, installation of renewable energy for electricity has grown at an annual rate of 25 per cent. It has reached 30,000 MW as of January 2014. During this period, wind power installation has grown ten times and solar energy has grown from nothing to 2,500 MW. Currently, renewable energy accounts for about 12 per cent of the total electricity generation capacity and contributes about 6 per cent of the electricity produced in the country. Renewables, therefore, produce more than twice the amount of electricity produced by all nuclear power plants in the country. In 2012-13, the electricity produced by renewables was equivalent to meeting the per capita annual electricity requirement of about 60 million people. More than a million households in the country, today, depend solely on solar energy for their basic electricity needs.

The growth of renewable energy has changed the energy business in India. It has, in many ways, democratised energy production and consumption in the country. Before the renewable sector became a significant player, the energy business was all about fossil fuel-based big companies and grid-connected power—they dominate even today. But today there is an alternate energy market in which thousands of small companies, NGOs and social businesses are involved in selling renewable energy products and generating and distributing renewables-based energy. This trend is likely to accelerate because of two key policies of the government.

The first is the Electricity Act, 2003. The Act has opened up the rural electrification market to decentralised distributed generation systems. It promotes decentralised generation and distribution of electricity involving institutions like the panchayats, users' associations, cooperative societies and NGOs in rural India not under the purview of distribution companies. In addition, private developers are free to set up renewable energy based generators and sell electricity to rural consumers.

The second impetus to decentralized renewables comes from rooftop solar policies of state governments. States like Gujarat, Andhra Pradesh, Uttarakhand, Karnataka, and Tamil Nadu have policies to promote solar energy generation from rooftops of residential, commercial and industrial buildings. The response to these policies has been highly encouraging. Although the results of this policy are likely to be realized slowly, the stage for re-inventing electricity generation with power from rooftop installations has been set. In the coming years we could see thousands of energy producers feeding the grid or supplying electricity to consumers through local mini-grids. We could also see millions of consumers generating their own electricity and feeding the surplus to the grid. The fact is we are just beginning to realize the potential of the renewables to open up the energy market and democratise energy generation and consumption.

Performance Downturn

But all is not well with the renewable energy development in the country. In the past two years, renewable energy development has taken a backseat. Installation of renewable energy has gone down significantly in 2012-13 and 2013-14, compared to 2011-12. In 2011-12, about 3,200 MW of wind power was installed. But installation came down to 1,700 MW in 2012-13 and less than 1,246 MW in 2013-14 (till January, 2014). Solar power installation too has suffered. In 2011-12, 906 MW of solar power was installed. In 2013-14 (till January 2014) only 523 MW have been installed.

The status of off-grid renewable energy is even poorer. There has been little effort by the Ministry of New and Renewable Energy (MNRE) in the past few years to take off-grid solutions to the country's unelectrified villages and hamlets. The decade-long Remote Village Electrification Programme (RVEP) was stopped in 2012. Under RVEP, solar home lighting solutions were distributed in about 10,000 villages and hamlets. The programme suffered from poor service delivery and corruption. It is anybody’s guess how many of the villages electrified by RVEP still have electricity or how many households are still using the solar home lighting systems they have received through the programme. MNRE had to come out with an energy access programme to replace RVEP. The programme envisaged installing mini-grids for rural electrification. But this programme has not taken off so far.

Policy flip-flop

The past two years were a complete wash out for the renewable energy sector in India. Investment in renewables went down from US $13.0 billion in 2011 to US $6.5 billion in 2012. This was largely because of policy uncertainty—some say paralysis—within MNRE.

Let's take the case of the solar energy. After successfully implementing the Phase 1 of the Jawaharlal Nehru National Solar Mission (JNNSM), nothing significant happened on Phase 2 till the beginning of 2014. The delay of more than a year brought about stagnancy in the solar industry.

In addition, MNRE announced that states will have to deploy, as part of their renewable purchase obligations (RPOs), about 60 per cent of JNNSM Phase 2's target of 10,000 MW of solar energy by 2017; the central government will support only 40 per cent of the installation. But in January 2014, MNRE announced its plans to install four Ultra Mega Solar Power Plants (UMSPP) of 4,000 MW each—all these four plants will be put up by the Centre. If these UMSPP are installed, they alone will meet most of JNNSM's targets. Bearing in mind that government programmes are about targets, if Centre is going to meet the bulk of the target, why should states be interested in doing more!

MNRE also did major flip-flop on wind power. Government incentives have played a major role in the wind industry's growth. Till the end of 11th Five Year Plan (FYP), the industry could avail of both accelerated depreciation (AD) and generation-based incentives (GBI). Then all of a sudden at the beginning of the 12th FYP, both subsidies were removed. This led to major reduction in investments in the sector. The removal of subsidies, though, was not the only reason for the fall in investments: lack of proper grid infrastructure to evacuate power and delays in payments by state utilities have compounded the wind industry's problems.

MNRE has now announced a Wind Mission to ramp up installation of wind power in the country. It now proposes to bring back both GBI and AD incentives (GBI was reintroduced in 2013-14). But the question is how long will this industry survive on AD and GBI? Is there a long-term sustainability plan for the wind sector?

The biomass sector is in big trouble as well. Under the 12th FYP, a National Bioenergy Mission was announced to provide 20,000 MW biomass power by 2022. The mission will promote plantations to achieve its targets. But the fact is about 60 per cent of the country’s grid-connected power plants that run on biomass have either shut down or are on the verge of shutting down. Out of about 118 projects in the major states—Andhra Pradesh, Chhattisgarh, Maharashtra, Tamil Nadu and Rajasthan—nearly 72 have shut down. The reason: rising cost of biomass due to competition within the biomass power industry and from other industries like cement and brick kilns. Now biomass industry wants an increase in tariffs. But should we pay more for power just because we want biomass power or should biomass power remain in the fray, only when it is economically efficient. If cement and brick kilns can utilise surplus biomass more efficiently and outcompete biomass power in the market, then they should be utilising this feedstock, not biomass power plants. Affordability of energy is as important as promotion of renewable energy.

It is quite clear that long-term policy perspective and policy certainty is the key for the sustained growth of the renewable energy sector. The experience of the past few years show that major changes in policy and practice are required to make renewable energy a real solution for meeting the energy needs of the country.

Agenda for change

Develop an integrated policy and plan for the renewables for 2050: Policies and plans to develop renewable energy have been haphazard. Two key levels of integration are missing: one, integration of the renewable energy sector with conventional energy sources and the other, integration of different sources of renewable energy themselves.

Currently India has five separate ministries for the energy sector: Ministry of Coal, Ministry of Petroleum and Natural Gas, Department of Atomic Energy, Ministry of Power and the MNRE. These ministries are only concerned about their own turf. There is a huge scope for synergies between different energy sources that can enhance economic efficiency as well as meet the energy needs of the country. For instance, the growth of grid-connected renewable energy will depend on the stability of the transmission grid and need for balancing power in the grid. This can only happen if there is integration between quick startup power sources like hydropower and gas and intermittent power sources like wind. Such synergy can only be developed if plans for each energy source are devised keeping interlinkages in view.

Similarly in the MNRE itself, each wing is concerned with its own territory. The ministry has a sub-sector approach and vision. The solar wing has a national solar mission to ramp up solar installation by 22,000 MW by 2020. The bioenergy wing is working on a national bioenergy mission. The wind energy division does not want to be left behind. So, it has proposed a national wind mission to reach 100,000 MW wind power installation by 2022. We should not be surprised if there is an announcement of a small hydropower mission as well. The fact is ministry does not have a vision for a holistic development of the renewable energy sector. This is leading to inconsistent policies, opportunities for interlinkages between various sources of renewable energy are missing and the ministry is not utilising its limited resources optimally.

For reasons of economic efficiency, better utilisation of infrastructure and environmental protection, India needs a long-term policy to integrate the different sectors of energy. This policy should specify the role of renewable energy in addressing the needs of energy access and energy security.

Be ambitious: Installation of renewable energy in India, especially grid-connected solar and wind, has always exceeded government targets and expectations in the past. In fact, one can argue that government has been quite pessimistic about the role of renewable energy in meeting the energy needs of the country.

The Integrated Energy Policy, 2006 had projected that in the most optimistic scenario, by 2031-32, India will have 30,000 MW of wind and 10,000 MW of solar power. The policy had put its faith in the biomass sector and had projected installation of 50,000 MW biomass power based on plantations and production of 15 million tonnes of bio-diesel and ethanol every year, by 2031-32. The expert group that wrote this report, projected 11 future energy scenarios for the country and estimated that renewable energy would contribute only 0.1–5.6 per cent of the total primary energy consumption in the country by 2031-32.

The 12th Five Year Plan (FYP) document has projected a fourfold increase in the installation of renewable power by 2021-22. But despite renewable power reaching 100,000 MW by 2022, the share of renewables in total commercial energy use will remain under 2 per cent in 2021–22. According to the plan document, the share of renewables in electricity generation will rise from around 6 per cent in 2012 to 9 per cent in 2017 and 16 per cent in 2030.

The resource allocation in the 12th FYP reflects the priority accorded by the government to renewable energy. The total plan outlay for the energy sector during 2012-17 is ₹10,94,938 crore. The outlay for the MNRE is ₹33,003 crore or about 3 per cent of the total plan outlay for the energy sector plan. The amount allocated to the Department of Atomic Energy—that contributes barely 2.5 per cent of total electricity production in the country—is ₹66,590 crore—more than double that of the MNRE.

Both the Integrated Energy Policy and the 12th FYP are not ambitious enough. While the Integrated Energy policy had projected 30,000 MW wind power installation by 2031-32, wind installation in the country has already reached 20,000 MW. Solar installation too will exceed the projections by many times.

The fact is the price of renewable energy (especially solar) is coming down and the price of fossil fuels is going up. India is, today, more and more dependent on imported fossil fuels and this dependency is growing every year. As per the 12th FYP, by 2021-22 imports will meet as much as 36 per cent of all the commercial energy demand in the country. India will depend on imports to meet 82 per cent of its crude oil and 27 per cent of its coal requirements by 2021-22.

The fact also is that climate change is palpable and is now hurting India's poor. India cannot ignore climate change and will have to start putting plans in place to reduce carbon emissions. All these require that we must be more ambitious about renewable energy.

Renewables are expensive compared to fossil fuels today but will be cheaper tomorrow. The benefits of moving to renewables are immense – energy security, climate protection, reduced pollution and health benefits for people.

Renewables for energy access: India has done well on grid-connected renewable energy, but has lagged behind on decentralised solutions. The biggest social and economic impacts of renewable energy will be in providing clean energy to the energy poor. Presently 400 million people in the country have no access to electricity and hundreds of millions more get electricity for only a few hours. Decentralised renewable energy can provide basic energy access to all. This can be done by adopting a cluster-based approach.

The government needs to incentivise setting-up of small renewable energy plants with the same model it employs for grid-connected large solar or wind plants. These mini-grid projects should be provided with a feed-in-tariff (FiT) or Viability Gap Funding (VGF), like grid-connected projects. The difference between what consumers in the villages are willing to pay (say equivalent to the replacement cost of kerosene) and tariff discovered through the bidding mechanism can be financed through VGF or FiT. Entrepreneurs should be encouraged to decide their own mix of renewable energy to achieve the lowest price for a pre-defined service quality. Such projects can be made grid interactive. When the grid reaches villages, the mini-grids can be used to export power to the grid, as well as import from it depending upon growing needs or deficits.

This programme cannot be driven by MNRE. It will only succeed if states drive it. MNRE, however, will have to setup the regulatory framework, operational and performance guidelines and secure resources to support states in implementing this programme.

If operationalised, this model will revolutionise the way power is produced and consumed in India. Thousands of renewable energy based mini-grids can promote millions of small businesses and social entrepreneurs to create local jobs and build local economies. And, this will bring down the price of renewable energy too.

From subsidy to grid-parity: Renewable energy has grown in the country on the back of government subsidies, incentives and tax exemptions. Though these incentives are very important to jump-start the sector, there must be a long-term plan to progressively reduce subsidies and allow renewable energy to reach grid-parity. Reverse bidding has done very well in the solar sector and subsidies have reduced over time. The solar example can be emulated in other renewable energy sources like wind. Similarly, subsidies should incentivise performance and not physical achievements. In this regard, the move to reintroduce Accelerated Depreciation for the wind sector must be thought through carefully. Accelerated depreciation benefits given to other renewable energy sectors should also be evaluated.

Rationalise and enforce RPOs: RPO was amongst the policy measures used to mandate renewable procurement by state electricity boards, open access and captive consumers. Most states introduced their own targets in 2010, but none of them have enforced this mandate. In fact, Rajasthan Electricity Regulation Commission has reduced its RPO target from 8.5 per cent to 6 per cent. Tamil Nadu Electricity Regulation Commission reduced its RPO target from 14 per cent to 9 per cent—this, despite the state utility drawing 9.5 per cent of its electricity from renewables.

There must be a guideline for states to fix RPOs. Currently, different states have different thumb-rules to fix RPOs. Secondly, there is a need to enforce RPOs. This will give big impetus to the growth of the sector and also lead to development of renewable energy in all parts of the country, not just in a few regions.

Green norms for renewable energy: Renewable energy projects can have major ecological impacts if they are installed without proper environmental assessment and management. For instance, the impact of wind power on forest ecology can be very high. However, wind projects are being installed in forest areas without going through any environmental impact assessment (EIA). So far, 4,000 hectares of forests have been diverted for wind power development and majority of this is only in two states, Maharashtra and Karnataka. Many of these wind power projects are coming up in the eco-sensitive Western Ghats.

Similarly, small hydro projects (SHP) are exempted from EIA. Multiple SHP on a single river can completely destroy a river's ecology. Guidelines for setting aside ecological flow for rivers and undertaking cumulative impact assessment, therefore, become very important. Large solar projects too have environmental impacts—they are land and water intensive. These issues should be addressed before setting-up large solar plants.

There is now a growing consensus within the environmental community about the necessity of proper environmental regulations for the renewable energy sector: it should be subjected to the EIA process. Today, renewable energy is small. But it will grow. If we don't have environmental safeguards now, the ecological impacts of this 'clean' energy source might become unmanageable.

Lastly, renewable energy must benefit the local community. Communities must have the first right over the electricity from renewables and they must benefit from the installation of renewable energy on their land.

These we think are the ways ahead for the sustainable growth of renewable energy in India.

Chandra Bhushan

CONTENTS

1

GRID-CONNECTED SOLAR

Need to move beyond short-term targets

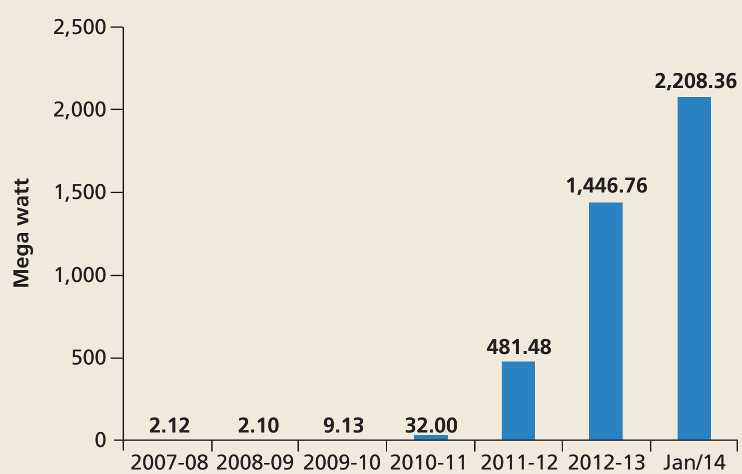
1. Introduction

Solar power has grown exponentially in India in the recent past. The country's cumulative installed capacity grew from mere 2.12 megawatts (MW) in 2007-08 to 2,208 MW in January 2014 (see figure 1: Solar installed capacity).[1] Such growth can be attributed to two major mission mode policy frameworks namely Gujarat Solar Power Policy (GSPP) and Jawaharlal Nehru National Solar Mission (JNNSM) introduced in 2009 and 2010 respectively.

Solar power in the country has grown on the back of government subsidies and schemes. However, in the past year, both the central and state governments have failed to operationalise their schemes. This has led to a slowdown in the solar industry. Only 523.49 MW was added between April and January, 2014 while the target for the financial year is 1,100 MW.[2] In addition, the solar manufacturing sector has collapsed due to imports of cheap solar panels from China and the US.

The grid-connected solar policy of the country, as it stands today, comes across as highly haphazard and unplanned. The government has failed to give policy certainty to investors, manufacturers and financiers. The central government is caught up in the 20,000 MW target that it has set under JNNSM forgetting the larger vision for solar power development in the

FIGURE 1: SOLAR INSTALLED CAPACITY

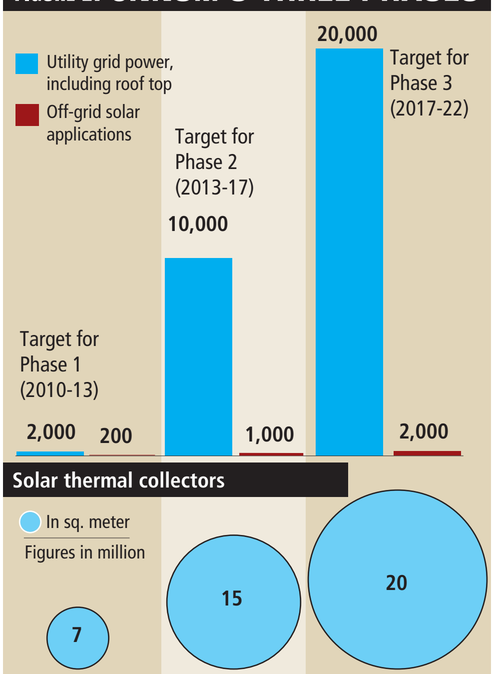


Source: Ministry of new and renewable energy

JNNSM TIMELINES

- **24-Feb-10** Launched eight missions as part of the National Action Plan on Climate Change - National Solar Mission being one of them
- **16-Jun-10** Guidelines of Schemes under Jawaharlal Nehru National Solar Mission were introduced
- **Aug-10** NVVN* started the process of selection of new grid solar power projects comprising of 150 MW of Solar PV and 470 MW of solar thermal capacities
- **Oct-10** PPA was signed
- **24-Aug-11** NVVN invited Request for Selection (RfS) from interested developers for 350 MW solar PV projects
- **Jan-12** PPA was signed
- **Dec-12** Draft Guideline for Phase II were released
- **Oct-13** Document for 750 MW Grid Connected SPV Projects under Phase-II Batch-I of JNNSM for Viability Gap Funding subsidy

FIGURE 2: JNNSM'S THREE PHASES



*NTPC Vidyut Vyapar Nigam
Source: Compilation from various MNRE sources

country. What India needs today is a long-term vision for solar energy. It needs a roadmap that clearly defines the role of solar energy in meeting the twin challenges of energy access and energy security. The roadmap must show the way towards reducing costs (and expanding installation) and developing the solar industry in the country. This means development of manufacturing capability to generate employment, enhanced R&D capability and reduced dependency on imports.

TABLE 1: INSTALLATION

Capacity added by various schemes (As on July 31, 2013)

Projects	Capacity (MW)
RPSSGP*/GBI**Scheme	91.80
State Policy	1170.40
JNNSM	595.05
RPO/REC	335.99
Other projects	15.13
Total	**2,208.36**

*Rooftop PV & Small Scale Power Generation
** Generation Based Incentive
Source: Ministry of new and renewable energy

2. Policies and performance

I. The Central Government: From JNNSM to UMSPP

The Jawaharlal Nehru National Solar Mission (JNNSM) was launched as part of National Action Plan on Climate Change to increase penetration of solar energy in India. Under JNNSM, the target is to install 20,000 MW of grid-connected solar power by 2022 (see figure 2: JNNSM's three phases). These targets comprise a mix and match of solar photo voltaic (SPV) and concentrated solar power (CSP) technologies, predominantly grid connected and commissioned either on ground or on rooftops.

JNNSM Phase I

Under JNNSM Phase I, 1,000 MW (500 MW SPV and 500 MW CSP) of solar projects were auctioned to companies using reverse bidding (companies quoting the least feed-in-tariff were selected). As solar power is more expensive than conventional power, in Phase I the costly solar power was bundled with cheaper unallocated coal power from the National Thermal Power Corporation (NTPC) and sold to the distribution companies at lower price.

Phase I received an overwhelming response from the private sector and the average tariff quoted was 25-43 per cent lower than the benchmark tariff of the Central Electricity Regulatory Commission (see table 2: Tariffs in JNNSM Phase I). As of July 2013, 445 MW of SPV had been commissioned whereas CSP languished at 50 MW. There are several reasons for CSP's failure ranging from technology immaturity to financial constraints to delay in raw material supply (specifically heat transfer fluid) to lack of Direct Normal Irradiation (DNI) data.[3] "But the failure has more to with the individual company's stability and not with the technology," Tarun Kapoor, Joint Secretary, Ministry of New and Renewable Energy (MNRE) said at a stakeholder's round table discussion organised by the World Bank in September 2013.

TABLE 2: TARIFFS IN JNNSM PHASE I*

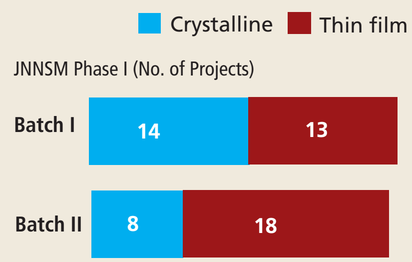
JNNSM Phase I		CERC Benchmark Tariff	Lowest Tariff Quoted	Average Tariff Quoted	Reduction
Batch I	CSP	15.31	10.49	11.48	25.02%
	SPV	17.81	10.85	12.16	31.72%
Batch II	SPV	15.39	7.49	8.77	43.01%

** All figures are in ₹/kWh Source: Draft JNNNSM Phase II Document, Ministry of New and Renewable Energy*

JNNSM's phase I mandated domestic content requirement (DCR), which meant developers had to buy locally manufactured modules if the SPV project was designed around crystalline silicon technology. However, this rule was not applicable to projects with thin film technology as India did not have enough players and experience in this sophisticated technology.[4] As a result developers chose cheaper imported thin film module options and 50 per cent of SPV projects used thin film in Batch I of JNNSM Phase I. This figure rose to almost 70 per cent in Batch II (See figure 3: Thin film scores). This impacted the domestic SPV manufacturers severely. Most of the Indian SPV module manufacturing capacity is in a state of forced closure and debt restructuring with very few takers for their products.[5]

FIGURE 3: THIN FILM SCORES

Various technologies in JNNSM Phase I



Source: Ministry of New and Renewable Energy

In JNNSM's Phase II, 60 per cent of the targets have to be met by states. MNRE has transferred this responsibility to them

JNNSM Phase II

The announcement for Phase II of the JNNSM was delayed by almost a year. MNRE announced the draft guidelines of JNNSM's Phase II and invited comments from stakeholders in December 2012, almost a year after the Power Purchase Agreements (PPA) were signed for Batch II, Phase I.[6] Phase II targets installation of 9,000 MW of solar capacity between 2014 and 2017.

Many changes have been proposed in Phase II. Firstly, the responsibility of meeting the targets has been shifted to the states. State governments will set up 60 per cent of the 9,000 MW target under Phase II. Also, as CSP elicited a lukewarm response in Phase-I, SPV's share has been hiked to 70 per cent in phase II (See table 3: Technology targets).

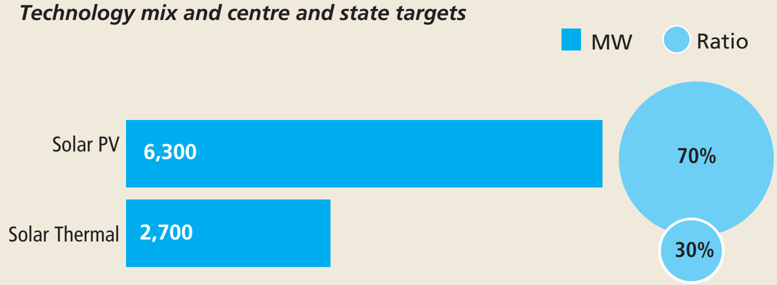
The most significant change in the Phase II is the introduction of Viability Gap Funding (VGF) as a capital subsidy to promote solar installation. Establishment of Solar Energy Corporation of India (SECI) to oversee implementation and facilitation of solar energy projects including achievement of JNNSM targets is another important development of this phase (see box: What is SECI).

Under the VGF model, developers will be asked to reverse bid for project—developer asking for the lowest viability gap fund will get the project. The upper limit for VGF is 30 per cent of the project cost or ₹ 2.5 crore per MW, whichever is lower.

SECI will administer and monitor VGF. It will buy power from the developers at a tariff fixed at ₹ 5.45/kWh fixed for 25 years (without accelerated depreciation benefit to the developers). SECI will sell this power to utilities at a fixed rate of ₹ 5.50/kWh for

TABLE 3: TECHNOLOGY TARGETS

Technology mix and centre and state targets



Technology	Centre		State	
	Ratio	MW	Ratio	MW
Solar PV	40%	2520	60%	3780
Solar Thermal	40%	1080	60%	1620

Source: Draft JNNSM phase II reference document, December 2012

SOLAR TECHNOLOGY

India receives nearly 3,000 hours of sunshine every year. This is equivalent to 5,000 trillion kWh of energy.[1,2] The 35,000 sq km expanse of Thar Desert is sufficient to generate anything between 700 gigawatts (GW) to 2,100 gigawatts.[3] The country's irradiation map (see: Horizontal Irradiation Map of India on page 171) shows that although solar radiation Rajasthan gets is one of the highest globally, northern Gujarat and parts of Ladakh, parts of Andhra Pradesh, Maharashtra and Madhya Pradesh also receive fairly high radiation compared to many parts of the world. Both solar photovoltaic (SPV) and concentrated solar power (CSP) are suitable for Indian conditions.

SPV technology has grown phenomenally throughout the world with cumulative installation of over 100 GW as of December 2012 with Germany, Italy and US leading the charge.[4] India is also poised to join the leaders with a target of 20 GW by 2022, a quantum jump from the present level of 2.08 GW.

They are of two types of SPV technology — crystalline silicon cells and thin film cells, based on the type of semiconductor and the process followed to manufacture them.

CSP technology has four variants: solar tower (ST), solar dish (SD), parabolic Trough (PT), and fresnel Reflector (FR). Unlike SPV technology which works on global irradiation, CSP technology works only on direct normal irradiation (DNI). Therefore the technology is limited only to places with high DNI. Globally, CSP technology is at a nascent stage with only 2.5 GW of installed capacity. In India, there are 15 projects in various stages of development. Couple of these are pilot projects. Besides, one 50 MW plant is currently in operation.

25 years. In October 2013, MNRE released the request for proposal (RFP) to select 750 MW SPV projects through competitive reverse bidding on VGF. This 750 MW has been divided into two parts – 375 MW will be installed with DCR and 375 MW without DCR.[7]

Renewable energy analysts fear VGF might lead to inefficient solar projects.[8] There is no way to ensure quality, notes an analysis by Bridge to India, a Delhi based international consultancy on solar power projects. "This mechanism not only has potential to derail policy motives but will also sow seeds of doubt about developer's intentions in minds of lenders," says Mohit Anand, senior consultant, Bridge to India.[9] Kapoor of MNRE, though, clarifies, "VGF is one of the financing options we are trying out as we tried bundling in JNNSM's first phase. Besides, it is only for 750 MW of projects. We may try other financing models like generation based incentives (GBI) in the coming batches. We have also put in safeguards."

Ultra Mega Solar Power Plants

On January 29, 2014, MNRE announced the setting up of the first Ultra Mega Solar Power Project (UMSPP) in Sambhar, Rajasthan. This is the first of the four such 4,000 MW projects that MNRE plans to install. The other three would come up in Khargoda in Gujarat and Ladakh and Kargil in Jammu and Kashmir.[10] The rationale is that investing in big plants will reduce the cost of SPV power from the current ₹ 7-8 per kilowatt-hour (kWh) to ₹ 5 per kWh over the next seven to 10 years.

Six public sector undertakings (PSUs) have come together to develop and operate the Sambhar UMSPP. Responsibilities among the PSUs have been divided, as is the equity share. Bharat Heavy Electricals Ltd will supply equipment; SECI will sell electricity; Rajasthan Electronics and Instruments Ltd will look into operation and maintenance; Sambhar Salt Ltd will make available 8,000 hectares of surplus land it has in Sambhar; Power Grid Corporation will look into power evacuation; and Satluj Jal Vidyut Nigam will be in charge of project management.[11]

The project will be completed in seven years, and will cost ₹ 30,000 crore. This is excluding the cost of land, and transmission and distribution (T&D) infrastructure. When fully functional, the plant is expected to generate 6,400 million kWh of electricity annually for 25 years, and offset carbon dioxide emissions by over four million tonnes per year.

The project will be set up in phases. The first phase aims to achieve 1,000 MW by the end of 2016. The remaining 3,000 MW will be through tenders to different developers to develop projects of 500 MW each.

The UMSPP will be funded through VGF, which means the government will pitch in to meet a portion of the capital cost to make the project viable. The government will provide a VGF of ₹ 1,000 crore from the National Clean Energy Fund for the first phase.[12] MNRE has also approached the World Bank for loan assistance of USD 500 million for implementation of first phase of 750 MW of Sambhar UMSPP.[13]

The four UMSPP of 16,000 MW that MNRE plans to install will cost more than ₹ 1.2 lakh crore (excluding the T&D infrastructure costs), and require 35,000 ha of land. If all these UMSPPs come up, then the country will surpass the 20,000 MW target of JNNSM. But the question to ask is should we be investing in large and expensive solar power

WHAT IS SECI

The ministry of new and renewable energy (MNRE) has set up a private limited company owned by the government to take over the supervision of the implementation and execution of the JNNSM. This company has been named the Solar Energy Corporation of India (SECI). The SECI will assume the same responsibilities as that of the NTPC Vidyut Vyapar Nigam Ltd in the first phase.

Anil Kakodar, former chairman of the Atomic Energy Commission, heads SECI. Today, the authorised capital of SECI is stated to be ₹ 2,000 crore with a total of two crore equity shares of ₹ 1,000 each as per the information furnished to the ministry of corporate affairs. The subscribed capital of the "company" is stated to be ₹ 600 crore with a total of 10 lakh equity shares. Several officials of the MNRE are directors or nominated directors in the company. As and when the officials retire, they cease to be directors and new ones are appointed.

Despite being incorporated two years back, there is still no clarity on exactly what functions and specific responsibilities the company will fulfill.

When a separate entity to govern solar energy in the country was envisioned a few years back, there were talks of an autonomous commission on the lines of the Atomic Energy Commission. However, what finally emerged was something absolutely different; a company incorporated under section 25 of the Companies Act, 1956. Therefore there is, till date, no clarity on the level of autonomy this company will get or whether the MNRE would be the parent body with the company under it.

Last year, the first board meeting of the company was held; going by the minutes of the meeting, SECI "may" do almost everything under the sun for the solar sector. From "setting up mini grid based on hybrid" to linking "up with housing developers to develop integrated architectural designs that incorporate water heating, air-conditioning and refrigeration as well as electricity systems based on solar power", from managing "security fund to provide support to the solar power project developers" to the almost ridiculous prospect of acting "as a wholeseller/ distributor or devise some scheme so that solar products are available in the market net of subsidy".

Is the purpose of an agency which was originally conceptualised as an autonomous body to implement the solar schemes of the government, to be a wholeseller/ distributor of solar products? Till date, the specific responsibilities and the level of autonomy of SECI continue to be a mystery.

The high cost of solar power generation is proving to be the major hindrance in the development of the sector especially for the states

plants that will feed to a leaking grid (the T&D loss in the country was 24 per cent in 2011-12) or should we be investing in solar projects that gives energy access to millions in the country?

II. State Policies: From exuberance to paralysis

In February 2009, Gujarat announced its solar policy— the most ambitious solar policy of the country. Under Gujarat State Solar Policy (GSSP), the state set a target of installing 500–3,000 MW of solar power by 2014. By March 31, 2013, the state had an installed capacity of 852.31 MW of solar power with PPA signed with 77 companies.[14]

Under GSSP, project developers are given a fixed feed-in-tariff (FiT) for 25 years. The Gujarat Electricity Regulatory Commission (GERC) fixes the tariff and accelerated depreciation benefits are allowed under the Income Tax Act and Rules. This policy was launched with a tariff of ₹ 13 per kWh for the first 12 years and ₹ 5 per kWh for the following 13 years for SPV projects (See table 4: Tariffs in Gujarat).

In July 2013, the Gujarat Urja Vikas Nigam Limited (GUVNL), the holding company for power generation, transmission and distribution in Gujarat, petitioned GERC asking the regulator to re-negotiate tariffs for already-installed projects. GUVNL claims that the capital cost of ₹ 16.5 crore per MW used to calculate the FiT is too high and therefore the debt equity ratio considered at 70:30 actually does not reflect in reality.[15] GERC rejected this petition on grounds that it had to be filed 60 days from the date of order.[16] GUVNL then filed the same petition with the Appellate Tribunal. At the time, this publication went to press, the tribunal was holding hearings on the petition.

Gujarat has not announced a new phase of solar development. D J Pandian, the state's secretary for energy and petrochemicals, says GUVNL has been resisting any further solar deployment because profitability has been severely impacted by high FiTs committed by PPAs of earlier projects.[17]

What has happened in Gujarat is happening in almost all states (see table 5: State solar policies). Many states announced ambitious solar energy targets but are now finding it difficult to meet those targets because of either financial constraints or policy uncertainties.

Tamil Nadu's solar policy that came into force in 2012 and set an aggressive target of 1,000 MW by 2013. In December 2012, the state called for bids for allocation of 690 MW with a benchmark tariff of ₹ 6.49 per kWh with a price escalation of 5 per cent every year for the first 10 years. But the response from developers was lukewarm. In August 2013, the state government's consultative paper on determination of solar tariff talked of reducing tariff to ₹ 5.78 per kWh without any escalation assuming that the capital cost of SPV installation is ₹ 7 crores per MW.[18] A tariff petition by CERC on January 7, 2014 lowered the capital cost of SPV plant to ₹ 6.12 crore per MW. Such confusion on benchmark cost determination combined with constraints on evacuation capacity, and challenges in combining solar power with wind—a resource the state is blessed with—has meant Tamil Nadu's solar policy has not elicited much interest from

TABLE 4: TARIFFS IN GUJARAT

	SPV	CSP
Projects done by January 28, 2012	₹ 15 for 12 years, ₹ 5 for next 13 years	₹ 11 for 12 years ₹ 4 for next 13 years
Projects done after January 28, 2012	₹ 9.98 for 12 years, ₹ 7 for next 13 years	₹ 11.55 for 25 years

Source: Gujarat solar policy, 2009

TABLE 5: STATE SOLAR POLICIES

Gujarat has been the leader in solar installations in the country. But expansion of the solar sector has been stopped in the state because of the high feed-in-tariffs committed to earlier projects. Other states had ambitious targets for solar deployment but are now finding it difficult to meet them because of financial constraints and policy uncertainties. The states are also finding it difficult to sustain solar policies because their power utilities are in poor financial condition.

States like Rajasthan and Tamil Nadu, which have high targets of solar deployment, can't even afford conventional power.

Gujarat

Introduced (year) : 2009

Tariff: Feed-in-tariff fixed by GERC

Current scenarios: Further expansion has been stopped because the state cannot afford additional solar installations

Target (MW)	Completed (MW)
500-3,000 by 2014	860.40

Rajasthan

Introduced (year) : 2011

Tariff: A tariff-based competitive bidding process

Current scenarios: No development on state projects. All projects under JNNSM

Target (MW)	Completed (MW)
600 by 2017	666.75 (493.5 under JNNSM)

Odisha

Introduced (year) : 2011

Tariff: A tariff-based competitive process/reverse bidding process

Current scenarios: Alex Green, who was awarded the project of 25 MW SPV has to complete the project by end of 2013

Target (MW)	Completed (MW)
25	15.50

Andhra Pradesh

Introduced (year) : 2012 (target)

Tariff: A tariff-based competitive process/reverse bidding process

Current scenarios: Invited bids with a benchmark tariff of Rs. 6.49/unit in April 2013. No allocations finalised

Target (MW)	Completed (MW)
1,000	92.90

Madhya Pradesh

Introduced (year) : 2012

Tariff: A tariff-based competitive process/reverse bidding process

Current scenarios: The state's discom signed PPAs for 225 MW of PV projects with five project developers. Welspun was awarded 130 MW of SPV installation, highest capacity ever awarded to any Indian company

Target (MW)	Completed (MW)
200	195.32

Tamil Nadu

Introduced (year) : 2012

Tariff: A tariff-based competitive process/reverse bidding process

Current scenarios: Invited bids in January 2013. No allocations finalised

Target (MW)	Completed (MW)
3,000 by 2015	31.82

West Bengal

Introduced (year) : June 2012

Tariff: No details available

Current scenarios: No details available

Target (MW)	Completed (MW)
100 by 2017	7.05

Karnataka

Introduced (year) : 2011

Tariff: A tariff-based competitive process/reverse bidding process

Current scenarios: 80MW have been awarded

Target (MW)	Completed (MW)
200 by 2016	31.00

Chhattisgarh

Introduced (year) : 2012

Tariff: No allocation process announced

Current scenarios: Projects amounting to 225 MW are pending PPAs and may be signed in three to four months. The delay in signing PPAs is due to the local discom reportedly sitting on a power surplus.

Target (MW)	Completed (MW)
500-1,000 by 2017	5.10

Uttar Pradesh

Introduced (year) : 2013

Tariff: A tariff-based competitive process/reverse bidding process

Current scenarios: Issues letters of intent for 230 MW in August 2013, commissioning expected after 6 months of land acquisition

Target (MW)	Completed (MW)
500	17.38

Source: Compiled from various state policies and MNRE. projects completed as on January 31, 2014

SPO targets have been thrust on discoms, open access consumers and captive generators apart from their general renewable purchase obligation targets

developers. Projects have not been allocated so far and there is likelihood of another benchmark cost revision.[19]

Recently, Tamil Nadu imposed a six per cent Solar Purchase Obligation (SPO) on its bigger customers from 2014. This was done to promote solar energy in the state. However, litigation against the move has put a spanner in the state's intentions.

Similarly, Andhra Pradesh's Solar Power Policy, declared in 2012, set a target of 1,000 MW in the first phase with the benchmark cost of ₹ 6.49 per kWh. Though PPAs for 60 MW have been signed, the deployment of large-scale solar power plant looks bleak until the cloud of political uncertainty in the state lifts.

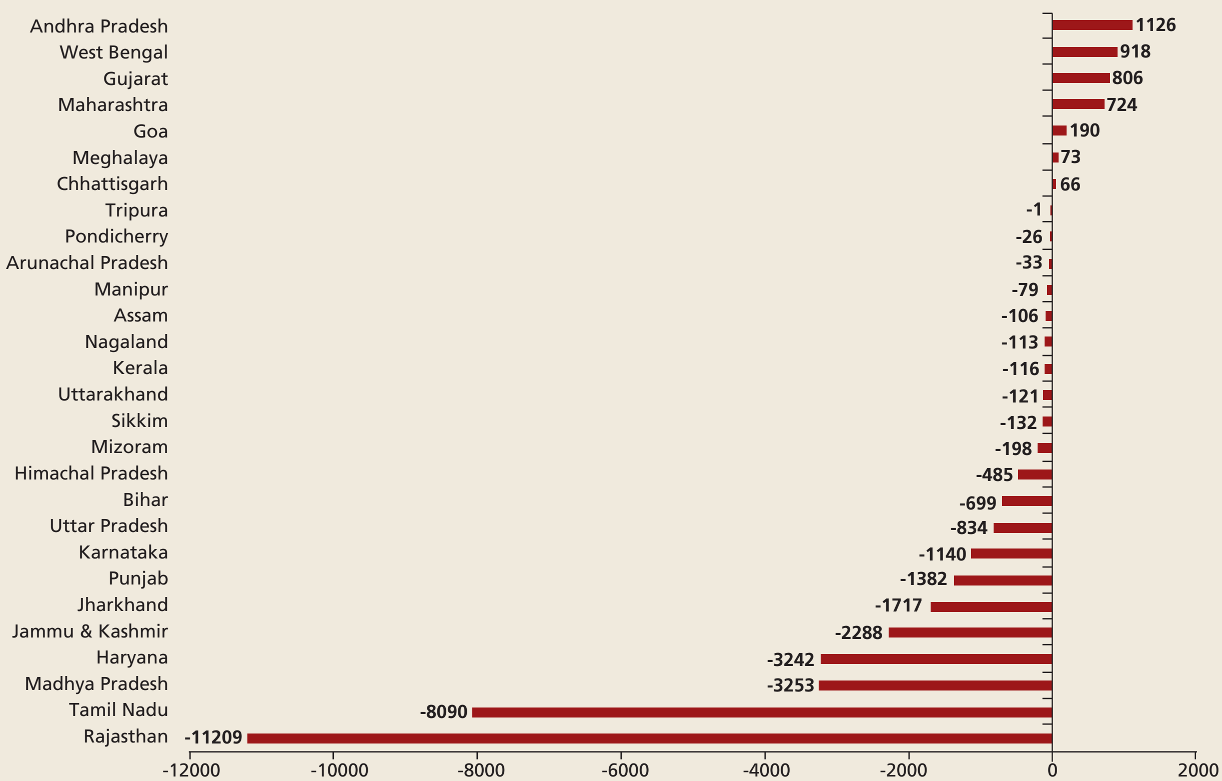
States are finding it difficult to pay for expensive solar energy largely because their power utilities are in poor financial condition (Figure 4: Cash-starved utilities). States like Tamil Nadu and Rajasthan which have high solar energy targets can't afford even conventional power. Even Gujarat is finding it hard to sustain more solar energy in its energy mix. On top of financial and policy barriers, under the Phase II of JNNSM, MNRE wants states to install 6,000 MW under the Renewable Purchase Obligation mechanism. Six thousand MW of solar power for the states is a heavy burden to carry, as at a tariff of ₹ 7 per KWh, this would entail a cost per year of about ₹ 7,000 crore on state utilities.

III. Solar Purchase Obligations: No enforcement

The National Tariff Policy set solar energy purchase obligation (SPO) target at 0.25 per cent in 2012-13. This will be extended to 3 per cent by 2022. Accordingly, state power

FIGURE 4: CASH-STARVED UTILITIES

State-wise net internal revenues (₹ crore) for 2009-10



Source: Planning Commission, 'Annual Report 2011-12 on the working of State Power Utilities and Electricity Departments', October 2011 departments—barring Sikkim and Arunachal Pradesh—have set SPO targets ranging from 0.13 to 1.0 per cent for 2013-14. Discoms, open access consumers and captive generators can fulfill SPO obligation by setting up own solar power, by signing PPAs with solar independent power producers and buying the power through open access route, and by buying Solar Renewable Energy certificates (Solar RECs).

If the SPO is properly enforced then meeting the JNNSM target would not be difficult. However, the track record with the general renewable energy purchase obligation (RPO) is far from promising. There has so far been little enforcement of the RPO as state power utilities are not able to fulfill it and states are loath to fine their own, already heavily indebted, entities. The centre, through MNRE, has not been able to push states to enforce the RPO. MNRE cannot take action by itself, as energy is a concurrent subject under the Constitution of India.

IV. Solar Renewable Energy Certificates: No demand

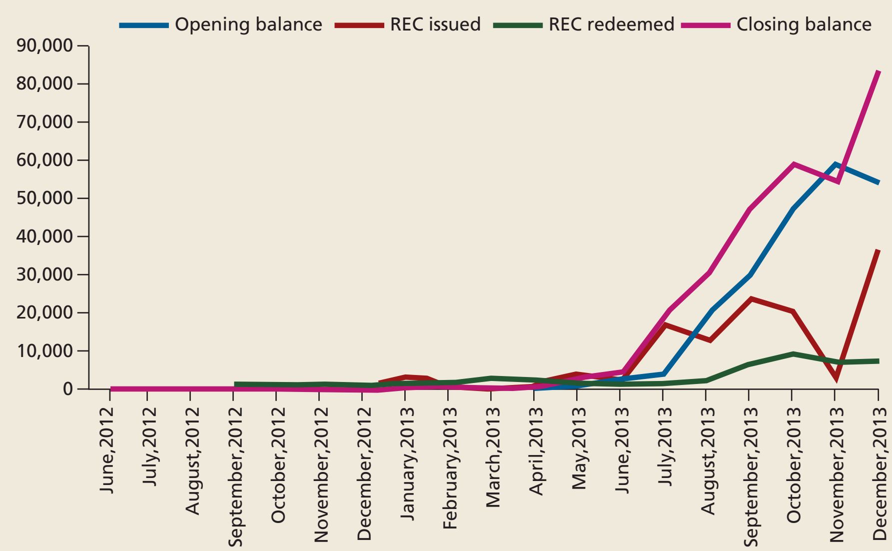
The main objective of the solar REC is to help obligatory entities in different parts of the country to fulfill their SPO irrespective of whether sites they operate in have sufficient solar irradiation or not. One megawatt hour (MWh) is considered as one unit while providing RECs. These certificates are tradable in both the energy exchanges in the country: Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL). Once it is issued, a solar REC must be traded within two years.

In absence of mandatory SPO, obligatory entities are under no compulsion to buy solar REC. In fact, this has already had a bearing on the solar REC market. Consequently, the cumulative solar REC inventory is increasing whereas there is no proportionate redemption (see figure 5: Solar goes to energy exchange). Another major reason for low redemption is significantly high floor price of solar REC (₹ 9.30 per kWh) in comparison to current estimated cost of generation of solar power in the market in the range of ₹ 6.49 per kWh to ₹ 7.87 per kWh. A few obligatory organisations buying solar REC to meet SPO are doing so at the floor price of ₹ 9,300 per REC.

Solar RECs have been trading at the floor price of ₹ 9,300 per certificate since June 2013 which is higher than the cost of generation of solar power

FIGURE 5: SOLAR GOES TO ENERGY EXCHANGE

Solar REC inventory is increasing without proportional redemption



Source: Indian energy exchange website

The trend is expected to improve slightly. Chhattisgarh has started imposing penalties on obligated entities for failure to meet their RPO.[20] The acute power shortage Tamil Nadu government has forced the government to impose an SPO of 3 per cent in 2013 and 6 per cent in 2014 on all its high transmission (HT) customers. Failure to meet this target will mean a penalty equivalent to the forbearance price of solar REC. Solar developers have welcomed the move as it would kickstart solar development in the state; they estimate the state will generate 3 GW of solar power 2015. However, a recent order by an appellate tribunal in January 2014 set aside the SPO on grounds that HT customers are not obliged to buy solar power under SPO.

3. Manufacturing sector: From boom to bust

Solar cell and module manufacturing has suffered big losses in the past few years. Currently, 80 per cent of the Indian manufacturing capacity is in a state of forced closure and debt restructuring with no orders coming to them. In 2011, India had an installed manufacturing capacity close to 900 MW for solar cells and almost 2,000 MW for solar modules. There were 19 cell makers and over 50 module makers registered with MNRE. Today there are no statistics on how many of these manufacturers has survived the onslaught of cheap imported modules.

While JNNSM gave a fillip to solar power generation in the country, the mission failed to achieve its other key objective: developing domestic manufacturing for solar cell and module. DCR clause of JNNSM phase 1 was restricted only to crystalline silicon technology. As per MNRE guidelines, developers were allowed free imports of thin-film modules since India only had one thin-film module producer, Moser Baer.[21,22] Restricting DCR to cyrstalline modules led to import of cheap thin film modules from China and the US. Under JNNSM Phase I, 60 per cent projects were thin film-based—the global market share of such cells is only 14 per cent.[23] Since most states did not have any DCR clause, thin film dominated projects in states like Gujarat as well. So, the purpose of promoting domestic manufacturing through DCR clause was defeated.

But the fact is that developers cannot be faulted.

Choice between thin film and crystalline silicon panels depends on several parameters which ultimately impact the cost of generation. Cost is the

The US has filed a complaint with the World Trade Organization against the domestic content requirement of JNNSM's Phase I in February 2013, and again in February 2014 against the same provision of Phase II

THE MODULE FACTOR

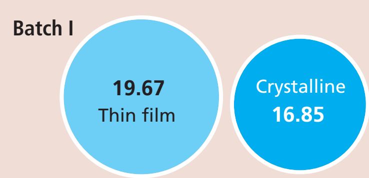
Which technology is more efficient: crystalline or thin film?

It has been more than a year since all the plants in Batch I of Phase I of JNNSM have been commissioned. The power generation figures from April 2012 to March 2013 show that the average Capacity Utilisation Factor (CUF) reported by developers using thin film is higher compared to that of crystalline. Temperature has a more detrimental impact on the performance of crystalline compared to thin film and a majority of Batch I projects are located in Rajasthan.

So it is not surprising that thin film developers have achieved higher CUF on an average.

UTILISATION FACTOR

for Solar PV projects under JNNSM in 2012-13



Average Plant Load Factor 2012-13 (%)

Source: CSE analysis

first factor. According to a CERC petition, (SM/353/2013 {Suo motu} dated January 7, 2014), the average cost of crystalline silicon solar module is US $0.709 per watt, while that of thin film is US $0.606 per watt.

The second factor is efficiency. Though thin film is less efficient compared to crystalline silicon module in laboratory condition (25° C), it performs better at higher temperature because of its low temperature coefficient (see box: The module factor). This means, difference in performance parameters between thin film and crystalline silicon becomes insignificant at high temperature zones like Gujarat and Rajasthan where most solar plants have been installed.

Land requirements are the third factor governing selection of panels. CERC's petition considered 5 acres (2 hectares) per MW for crystalline silicon module to arrive at the capital expenditure of solar power plant. Though thin film requires more land per MW in low temperature zones, both technologies have almost same land requirement in high temperature zones.

The fourth factor is degradation of solar modules. Though the temperature coefficient of thin film modules is less as compared to that of crystalline silicon, thin film degrades fast at high temperatures compared to crystalline silicon. Therefore, thin film module might give similar or a somewhat higher efficiency at initial stages in high temperature zones, use of these modules has a significant bearing on the life of a power plant. This has already been noticed in JNNSM Phase I projects commissioned in Rajasthan. However, this does not bother project developers who feel secure because of the warrantee clause provided by module manufacturers.

JNNSM Phase I's domestic content requirement was only applicable to crystalline technology. Developers were allowed imports of thin film modules. So cheap imports of thin film from China scored over domestic crystalline in JNNSM Phase I

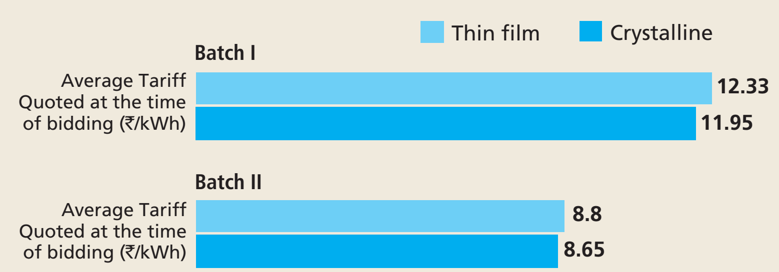
Financing is the fifth factor. Financing of projects and manufacturing have merged into a single issue thanks to banks such as the US Exim Bank and the Overseas Private Investment Corporation (OPIC). These banks have been giving low-interest loans to project developers with a mandate of using modules supplied only by American manufacturers.[24,25] Indian banks, in contrast, are more or less reluctant to provide loans and in cases where they do, they demand a higher interest.

These factors combine to make thin film the preferred technology for the project developers. This was reflected in the competitive bidding in batches I and II of JNNSM Phase I. Developers with thin film quoted more as compared to that of crystalline technology (See figure 6: Competitive bidding).

Developers claim that DCR may prove counter-productive. They believe sustainable development of manufacturing facilities in the country requires a far more long-term and integrated outlook.

FIGURE 6: COMPETITIVE BIDDING

Average Tariff Quoted at the time of bidding (₹/kWh) in Phase I for all technologies



Source: CSE analysis

There is a need to relook at the issue of solar manufacturing in the country. Indian solar PV manufacturers are too small and lack critical technologies to compete with major global manufacturers. While Germany and USA are leaders in SPV technology, China has driven the market through massive production capacity. To compete with the likes of the US and China, India will need a robust policy support to attract large private sector investment and technology transfer in solar manufacturing.

4. The predicament

There has been a slowdown in deployment of solar power in 2013-14. Only 523.49 MW was added between April 2013 and January 2014 while the target for the financial year is 1,100 MW.[26] This slowdown is primarily due to factors like delay in JNNSM phase II allocation, complete halt of solar projects in Gujarat due to lack of finance and policy uncertainty in states like Andhra Pradesh and Tamil Nadu. There has been some movement, though, in the past few months: under JNNSM Phase II auctioning process for 750 MW has started and MNRE, along with the Ministry of Heavy Industries and Public Enterprises and the Ministry of Power, has announced the setting-up of the first UMPP in Rajasthan.

India's solar policy seems to be more experimental than a well-thought out policy to address issues of energy scarcity and energy security. Policies to lower the cost of generating solar power also seem haphazard

But despite the movement on JNNSM Phase II and announcement of UMSPPs, the grid-connected solar policy of the country comes across as highly haphazard and unplanned. Take the case of JNNSM Phase II and the DCR clause. The 750 MW under the Batch I have been divided into two parts—375 MW will be installed with DCR and 375 MW without DCR. There is no rationale for this except that MNRE is undecided on the DCR issue and wants to please both manufacturers and the developers at one go.

Similarly, from FiT during Phase I of JNNSM, MNRE has decided to move to VGF for Phase II. It is a different matter that capital subsidies for renewable energy has been abandoned in favour of some kind of generation based incentive in almost all parts of the world as capital subsidies were shown to be inefficient.

The spur-of-the-moment nature of planning in MNRE can be gauged from the fact that till mid 2013 MNRE was shifting the burden of setting-up solar power plants to the states. Under JNNSM Phase II, 60 per cent targets were to be met by the states. Then in late 2013, MNRE decided to set four UMSPPs of 16,000 MW along with other central ministries. The current solar policy environment seems more like an experiment rather than a well thought policy designed to address India's power crisis.[27]

The fact is solar power remains a risky and expensive option and MNRE's policies have not been able to convince Indian banks to lend for solar power development. Unlike regular corporate finance, which is based on an evaluation of a company's financial performance, project finance involves lending to 'standalone' assets. This means lenders only have access to cash flows from a particular asset—in this case solar power installations or utilities.[28] Local banks have been reluctant to provide financing because policies have not been stable and they fear the cash-crunched utilities will not be able to pay for the FiT. Developers say there is an acute shortage of long-term project finance. Lenders have not developed the technical capability to assess risks associated with a solar power project and are hesitant to finance these projects.

The process of aggressive bidding has added fuel to the fire. Reverse bidding has reduced the final benchmark tariff after discount for SPV in Phase I from ₹10.95/kWh to ₹ 5.45/kWh in Phase II with VGF. This is a 50 per cent reduction in price per kWh in a span of three years and does look amazing. But it raises concern about sustainability.

Lenders claim that low tariff rates quoted and the subsequent PPAs are insufficient to make the projects financially viable. Also the power developers are cash constrained and highly leveraged because of the slow and infrequent payments from the State Electricity Boards, which are suffering heavy losses.

The question is what does JNNSM want to achieve? To meet the target of 20,000 MW by 2022 by any means or to create a sustainable market condition which allows for development of solar power to solve the country's energy crisis. The present approach certainly is not thinking about long-term development of solar power.

Way Forward

India is energy scarce and has a price sensitive market. But it is also blessed with abundant solar irradiation which can be harnessed effectively to mitigate energy scarcity to a large extent. All this can happen only if the country has a visionary policy framework for long-term development of solar energy.

I. Develop a long-term integrated vision for solar energy

India must develop a long-term vision (for, say, 2050) for solar energy. The role of solar energy in meeting the twin challenges of energy security and energy access must be clearly defined.

There should be a roadmap that shows ways to reduce costs, helps expand solar installations and has guidelines to develop the solar industry in the country. This means development of manufacturing capability to generate employment, enhanced research and development capability and reduced dependency on imports.

We need to rethink our deployment strategy and have a long term vision for solar power in India

II. Optimal land use policy

Solar energy is very often land intensive. But, it does not need any extra land if it installed on buildings and existing structures like canal or dams. The country's solar policy must consider optimal use of land. Presently most of the bigger projects are using large tracts of land (the 4,000 MW USMPPs will use 8,000-10,000 hectares). There is a need to shift focus from land to buildings. This means rooftop installations and integrated solar outfits must become a priority for the development of solar energy in the country. Also when land is used, instead of acquiring it, land should be leased from farmers. They should gain from solar projects through lease rents or through benefit sharing. It is important that local population receives direct benefit from large scale power installations. Such benefits could include access to energy from solar installations, employment and community development measures.

III. Quality control

Bringing the cost of generation down to the level of grid parity is important, but not at the cost of quality. Currently, the inspection, testing and certification infrastructure for solar panels is poor. Also, the standards must be suitable for Indian site conditions. The country must develop standard and protocols along with inspection, testing and certification infrastructure to institutionalise quality management systems in the solar industry.

IV. Generate irradiation data

The country lacks solar irradiation data and this is a major bottleneck for site selection. After prioritising lands in order of least social and ecological impact, the government should incentivise private sector to monitor global radiation there. It should then make this data available to developers.

V. Financing

Payment security is the key element in financing solar projects. Long term PPAs signed between SECI and the project developers in JNNSM phase II are definitely bankable, but there is a catch. Due to VGF and accelerated depreciation of up to 80 per cent, the project developer actually recovers the entire equity investment in the first year itself. Therefore the risk of the project shifts to the debt funder from the second year onwards. Failure of several projects in the JNNSM phase I and absence of a strong policy framework to ensure strong quality and site selection mechanisms are some real cause of concerns for commercial banks to finance such projects. Though the PPAs are bankable (as they are signed by SECI), it is highly risky for the banks to assume that project will be operational for at least the tenure of the loan period, if not the entire lifecycle of 25 years.

Incorporating quality and site selection issues within policy framework will ensure that development banks and government funding institutes will not mind funding projects of independent power producers (IPPs) till they gain the confidence of commercial banks. Public sector organisations like state utilities may opt for public private partnership (PPP) model to setup large scale solar power projects. PPPs are also a good way to apportion risk between public and private partners to create bankable project.

VGF prompted bids for 2,170 MW in the first batch of JNNSM Phase II for the 750 MW offered. It just proves that developers are looking for financial options for deployment of solar projects in India

VI. Enforce SPOs

In the JNNSM Phase II, SECI has taken the responsibility to buy solar power from all power developers at ₹ 5.45 per kWh and sell them to the utilities at ₹ 5.50 per kWh. This cost does not include open access charge and has to be paid by the obligatory entities (final off-takers). SECI will sign PPAs for 25 years with the developers which would be a bankable document. However, the challenge is whether there would be buyers available for the solar power generated since no state is implementing the SPO targets levied on them. SPO targets in fact exist from 2011-12, but have never been fulfilled by any state. Therefore, SECI's ability to sell power to the obligatory entities is a big question mark. The only solution to the problem is mandating SPO in every state with penalty clause equivalent to solar REC floor price in case of failure.

REPORTS FROM THE GROUND

Every day a sun day

Asia's largest solar park generates 224 MW electricity everyday

A view of the Charanka Solar Park

Rows of photovoltaic cells spread over nearly 2,000 hectares in a small village in Rann of Kutch showcase Gujarat's solar programme. This is Asia's biggest solar park. Named after the village in which it is located, Charanka Solar Park has so far attracted 21 solar developers who generate 224 MW of electricity every day—more than 200 MW generated by Golmund Solar Park in China's Qingzai province.

The park has attracted investments of almost ₹ 4,000 crore, apart from the ₹ 550 crore spent on infrastructural costs and land acquisition. The Gujarat government intends to increase the plant's capacity to 590 MW, with a 50 MW expansion planned by 2014-end. The park can also generate 100 MW of wind power and two turbines of 2.1 MW capacity have been commissioned. This makes Charanka the world's biggest solar-wind hybrid park.

The Gujarat government plans to increase the park's capacity to 590 MW, with a 50 MW expansion planned by the end of 2014

DISCONTENTED LOT

Charanka residents, mostly dairy farmers, say the village has a more-than 500 year old history of human settlement. A check-dam was also demolished by the project proponent. According to a Gujarat State Petroleum Corporation (GSPC, the petroleum company is one of the developers in Charanka) engineer a small natural pond has now been expanded. GSPC has provided an above-ground tank for the village, but that remains non-operational. Acquiring a natural water body for the solar park is, according to Mahesh Pandya of the environmental organisation Paryavaran Mitra, against court orders in Gujarat: new projects are not allowed to take over natural ponds, which are seen as wetlands.

DEVELOPERS – CHARANKA SOLAR PARK

Name of party	Technology	Capacity (MW)	Commissioned (MW)
ZF Steering Gear	PV*	5	5
NKG Infrastructures Ltd.	PV + TPV**	10	10
Alex Astral Power	TPV	25	25
SEI Solar Power Gujarat Pvt. Ltd.	PV	25	25
GSPC Pipavav Power Corporation	PV	5	5
GMR Gujarat	TPV	25	25
Surana Telecom & Power	PV	5	5
Corner Stone Energy	TPV	5	0
Solar field Pvt. Ltd.	TPV	20	20
E. I. Technologies Pvt. Ltd.	TPV	1	1
Emami Cement	PV	10	10
Gujarat Power Corporation Ltd.	PV	5	5
Roha Energy	PV	25	25
Sun Clean Renewable	PV	6	6
Saumya Constructions.	PV	2	0
Avtaar Solar	PV	5	0
AES Solar	PV	15	15
Lanco Infrastructures Pvt. Ltd.	TPV	15	15
Palace Solar	PV	15	15
Yantra e Solar Pvt. Ltd.	TPV	5	0
Universal Solar	PV	2	2

**PV - Photovoltaic technology **TPV - Thin film photovoltaic technology*
Source: Gujarat Power Corporation Limited

POWER GENERATION AT CHARANKA

Month	Power generated (in MWh)
Mar-12	21,538.77
Apr-12	30,078.52
May-12	29,526.00
Jun-12	30,005.80
Jul-12	19,004.00
Aug-12	18,875.00
Sep-12	24,504.00
Oct-12	32,967.00
Nov-12	29,867.00
Dec-12	30,292.00
Jan-13	32,123.00
Feb-13	30,260.00
Mar-13	35,826.00
Apr-13	35,988.00
May-13	37,724.00
Jun-13	28,080.00
Jul-13	21,186.00
Aug-13	24,433.00
Sept-13	28,548.00
Oct-13	32,105.00
Nov-13	29,956.00
Dec-13	31,461.00

In the financial year 2012-13, Charanka generated 343.33 million units at a plant load factor of 18.31 per cent.

According to the site engineer of the Gujarat Power Corporation Limited (GPCL), about 50 MW of capacity is based on thin-film technology, the rest works on PV crystalline technology. However, another official report puts the figure of thin-film at 106 MW and PV crystalline at 125 MW. Of the 21 developers the park harbours (See table: Developers-Charanka Solar Park), projects of 19 are complete. GPCL provides the infrastructure and acts as a nodal agency. Water for the projects comes from a canal and a large human-made pond.

An investigation by researchers from the New Delhi-based Centre for Science and Environment revealed that only a few projects use trackers—devices that turn the modules towards the sun— and most projects use fixed structures. Indigenous technologies were almost non-existent—Tata BP was the only visible Indian supplier of solar modules. The Gujarat government is planning another park.

The park is spread over 2,000 ha and has received investments of almost ₹ 4,000 crore

Solar plant saves water

Gujarat State Electricity Corporation (GSECL) runs a 1 MW solar power plant on a 750 metre stretch of the Sardar Sarovar Canal System, It's location meant the project did not require land acquisition. The Sardar Sarovar Narmada Nigam Ltd, which owns and maintains the canal network on the Narmada river, supports GSECL in running the project. Multinational engineering outfit Sun Edition developed the polycrystalline project for GSECL and the US-based company MEMC manufactured the solar panels. All this cost GSECL ₹ 17.71 crore. This capital cost seems high for a 1 MW project, but it required special steel structures. In fact, the construction cost is quite low for a pilot project. More importantly, the project will save 9 million litres of water from getting evaporated every day. The canal top project was commissioned on March 28, 2012. Preliminary studies show the plant's yield will be 2.47 per cent higher than conventional PV solar power plants. The project is a precursor to other solar utility projects on the Sardar Sarovar Canal. It is estimated that 2,200 MW of solar power generating capacity can be installed by covering only 10 per cent of the 19,000 km canal network with solar panels. This would also mean that 4,400 hectares can be potentially conserved and about 20 billion litres of water saved every year.

The plant is located on 750 m long Narmada branch of the Sardar Sarovar Canal near Chandrasan village in Mehsana district.The picture was taken before the construction began in September 2012

The 1 MW canal top project was estimated to produce 1.53 million units of electricity every year. In the financial year 2012-13, the plant exceeded the estimation and generated 1.612 million units of power at a plant load factor of 20.35 per cent

The project site is a mere five minutes drive from Govindpura village in Mehsana district. The village residents had no problem with the project, but they also had no idea about it before its inauguration

The plant was commissioned on March 28, 2012. Gujarat Chief Minister Narendra Modi inaugurated the project on April 24, 2012

Overcoming data issues

Concentrated solar power plant innovates to surmount data problem

The 50 MW parabolic trough using concentrated solar power plant in Jaisalmer, Rajasthan

On August 13, Godawari Green Energy Limited (GGEL), a flagship company of the HIRA group, received the commissioning certificate for 50 MW Concentrated Solar Power (CSP) plant in Nokh village in Rajasthan's Jaisalmer district. The CSP plant that features parabolic trough had begun supplying electricity to the grid on June 5, 2013.

Unlike many other CSP projects (see table: CSP projects in India), GGEL faced no financial issues. Bank of Baroda conducted extensive evaluation of the project before disbursing loan.

The lenders did have some apprehension since CSP technology in India is fairly new and there is little experience in setting up these plants in India. The bank appointed energy consultants Mott MacDonald to scrutinise the project and based on their evaluation the project was allocated funds.

GGEL managed to address a major problem faced by CSP projects. Developers of such projects usually complain that lack of reliable Direct Normal Irradiance (DNI) data hinders completion of projects. Information provided by the Ministry of New and Renewable Energy does not reflect the reality on the ground. DNI is the amount

CSP PROJECTS IN INDIA

Project	Programme	Size of Technology	Location	Status
ACME Solar Power Tower	JNNSM migration phase	2.5 MW Solar Tower (Suppose to come to 10 MW)	Bikaner, Rajasthan	Functioning but with reduced capacity
Entegra	JNNSM migration phase	10 MW Parabolic Trough	Rajasthan	May be cancelled - Company Could Not get financing
Dalmia Cement	JNNSM migration phase	10 MW Sterling Dish producer of technology	Rajasthan	May be cancelled - Has moved headquarters
IIT-Bombay test plant	Unknown	1 MW Linear Fresnel	Solar Energy Centre, Gurgaon, Haryana	Commissioned
Abengoa demonstration plant	Unknown	1-3 MW Parabolic Trough	Solar Energy Centre, Gurgaon, Haryana	Commissioned
Lanco Solar 'Diwakar'	JNNSM Phase 1	100 MW Parabolic Trough with 4 Hour Storage	Askandra, Jaisalmer, Rajasthan	Delayed
KVK Energy Ventures	JNNSM Phase 1	100 MW Parabolic Trough	Askandra, Jaisalmer, Rajasthan	Delayed
Reliance Power (Rajasthan Sun Technique)	JNNSM Phase 1	100 MW Linear Fresnel	Dhursar, Jaisalmer, Rajasthan	Delayed. Was to be commissioned in Dec 2013
Corporate Ispat Alloy/ Abhijeet	JNNSM Phase 1	50 MW Parabolic Trough	Nokh, Jaisalmer, Rajasthan	Delayed
Godawari Green	JNNSM Phase 1	50 MW Parabolic Trough	Nokh, Jaisalmer, Rajasthan	Commissioned
Aurum	JNNSM Phase 1	20 MW Parabolic Trough	Mitrala, Porbandar, Gujarat	Delayed
MEIL Green Power	JNNSM Phase 1	50 MW Parabolic Trough	Pamidi, Ananthapur, Andhra Pradesh	Delayed
Cargo Solar	Gujarat Solar Policy	25 MW Parabolic Trough with 9 Hour Storage	Kutch, Gujarat	Delayed
Sunborne Energy Services	Karnataka Solar Policy	10 MW	Karnataka	Won bidding in end April 2012. Commissioning in 30 months from signing PPA*
Atria Power Corporation	Karnataka Solar Policy	10 MW	Karnataka	Won bidding in end April 2012. Commissioning in 30 months from signing PPA*

**Power Purchase Agreement; Source: Compiled from various sources*

FIRST CSP PLANT TO BE COMMISSIONED IN INDIA UNDER JNNSM

Location: Village Naukh, Jaisalmer, Rajasthan	Commissioned **August 2013**	**Land Used: 160** hectares	Reduction of 118,214 tonnes of CO_2 every year
Capacity : **50**MW	**17280** receiver tubes	Commissioned in 29 months from the date of signing of PPA	600 jobs created
Project cost: Approximately ₹ **800** crores	**480** solar collector assemblies having 161,280 mirror segment	Claims 110 million units of annual clean electricity generation (effective 25% PLF)	December generation - 3,255,200 units @ a PLF 8.75%

Concentrated sunrays generate steam to produce electricity

To compensate for data uncertainty, the Godawari plant increased the mirror area to harvest more heat energy

of solar radiation received per unit area by a surface perpendicular to the sun rays. The lack of data means that almost every company has to redesign plants.

To compensate for the uncertainty of DNI data, the 50 MW plant increased the mirror area to harvest more heat energy. Instead of the 80 loops required (theoretically) for 50 MW of power, the plant put up 120 loops of mirror, reported an official.

Barely a month's delay

Actual commissioning of all CSP projects is required 28 months after the power purchasing agreement (PPA) is signed. But there was a month's delay in commissioning the Jaisalmer plant. This was because the structures had to be changed to be in tune with the plant's location. The parabolic trough structures required high precision fabrication. Engineering procurement and construction contractors, Jyoti Structures, took up a major portion of fabrication. This work took a little more time than anticipated. No other CSP project has been commissioned in India so far—and most are not scheduled to be completed in near future. Developers complain that a commissioning period of 28 months is over ambitious, given their lack of experience.

2

WIND ENERGY

WIND ENERGY

Need to re-energise with environmental norms

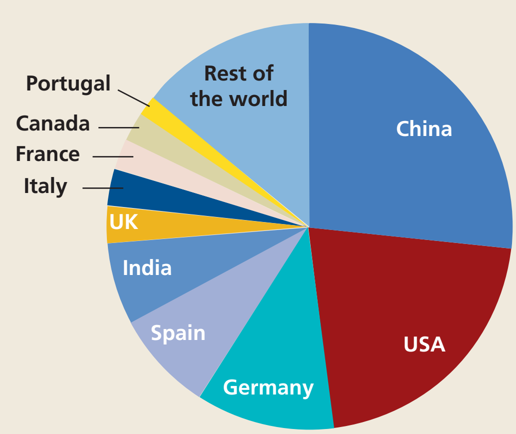
1. Introduction

Wind energy accounts for about 67 per cent of the total renewable energy capacity installed in India. At the end of December 2013, the total installed capacity of wind power was 20,149.5 megawatts (MW).[1] Presently, India stands fifth in terms of cumulative wind power capacity—after China, USA, Germany and Spain. The global installed capacity of wind power had reached over 2,82,000 MW by 2012 end.[2] The top 10 countries account for about 86 per cent of the total share; India's contribution was about 7 per cent (see figure 1: Wind power installation, globally).

The wind energy sector's growth, which was bullish till 2011-12, has been declining since 2012-13. Withdrawal of major incentives such as Accelerated Depreciation (AD) and Generation Based Incentives (GBI) in the beginning of 12th Five Year Plan led to this decline. The government reinstated GBI in 2013-14 and there is major push from investors to reinstate AD as well.

Recently, the Ministry of New and Renewable Energy (MNRE) has proposed a Wind Mission to achieve a target of 100,000 MW wind power by

FIGURE 1: WIND POWER INSTALLATION, GLOBALLY



Source: Global Wind Statistics -2012; Global Wind Energy Council (GWEC)

Studies carried out by the Lawrence Berkeley National Laboratory in the US estimate the country's wind power potential to be as high as 3.1 million MW at a hub height of 120 m

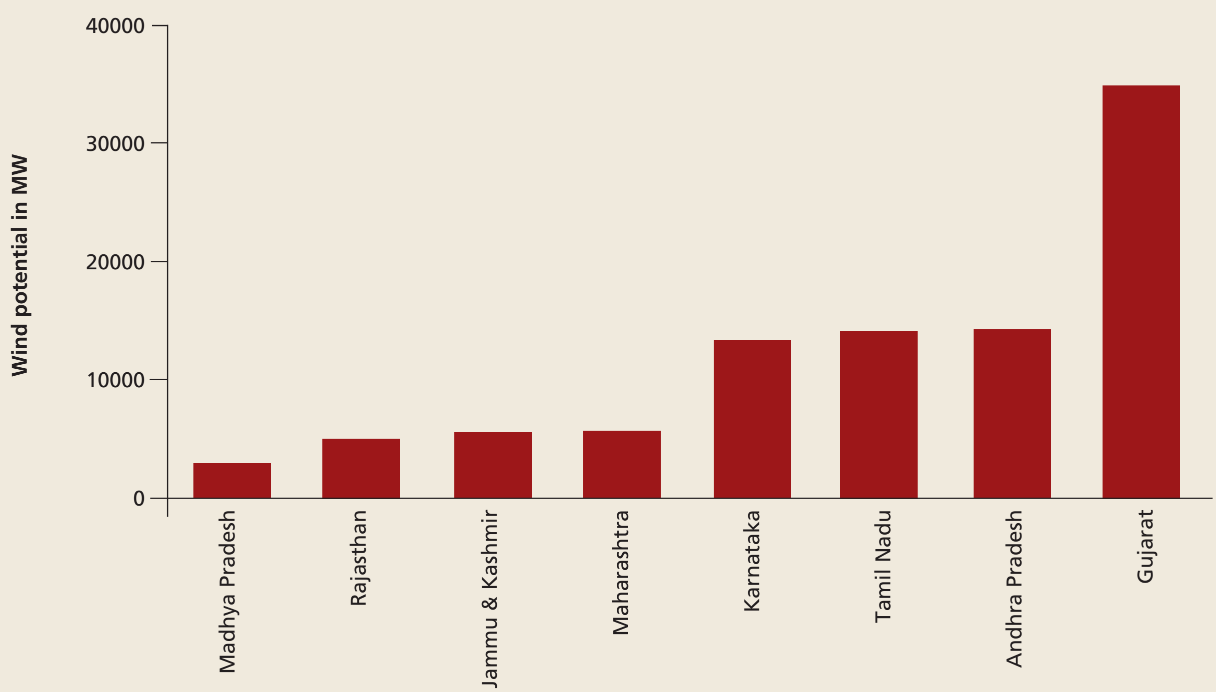
2022. But this ambitious mission can only be successful if it is based on a long-term vision on the role of wind energy in India's energy mix. Bottlenecks related to power evacuation, power balancing, grid discipline and wind forecasting need to be unclogged for sustainable growth of the sector. Similarly, an action plan must be put in place to reduce the cost of wind power to achieve grid-parity. Subsidies can't be the only tool to spur the large-scale growth envisaged by the ministry. Lastly, increasing concern on environmental impacts of wind power can no longer be ignored. As the sector grows, impacts on environment are going to be bigger and bigger and need to be plugged right away through adequate policy and regulatory framework.

2. Wind power potential in India: Discovering more out of the thin air

Advances in turbine technology and studies exploring wind resources have opened up the immense potential of wind power in the Indian subcontinent. Centre for Wind Energy Technology (C-WET) has assessed India's wind power potential as 102,778 MW at 80 metres height considering 2 per cent land availability.[3] This is up from the earlier estimate of approximate 49,130 MW at 50 metres with the same land availability.[4] According to C-WET, Gujarat has the highest wind potential in the country followed by three southern coastal states, Andhra Pradesh, Tamil Nadu and Karnataka (see figure 2: Wind potential in different states).

In the past few years, other research organisations have estimated wind power potential using different models for mapping the country's wind resource. In one such study, the Lawrence Berkeley National Laboratory (LBNL), USA assumed a turbine

FIGURE 2: WIND POTENTIAL IN DIFFERENT STATES



Source: C-WET (http://www.cwet.tn.nic.in/html/departments_ewpp.html) density of 9 MW per sq km and a capacity utilisation factor of 20 per cent to estimate the country's wind potential. The study reckoned the wind potential of the country to be 2 million MW at 80 meter hub-height or 3.1 million MW at 120 meter hub-height.[5]

However, studies such as the one conducted by LBNL need to be validated with actual measurements at sites. Once validated, their findings may have significant bearing on India's overall energy strategy.

MNRE has proposed a Wind Mission to achieve an ambitious target of 100,000MW wind power installation by 2022

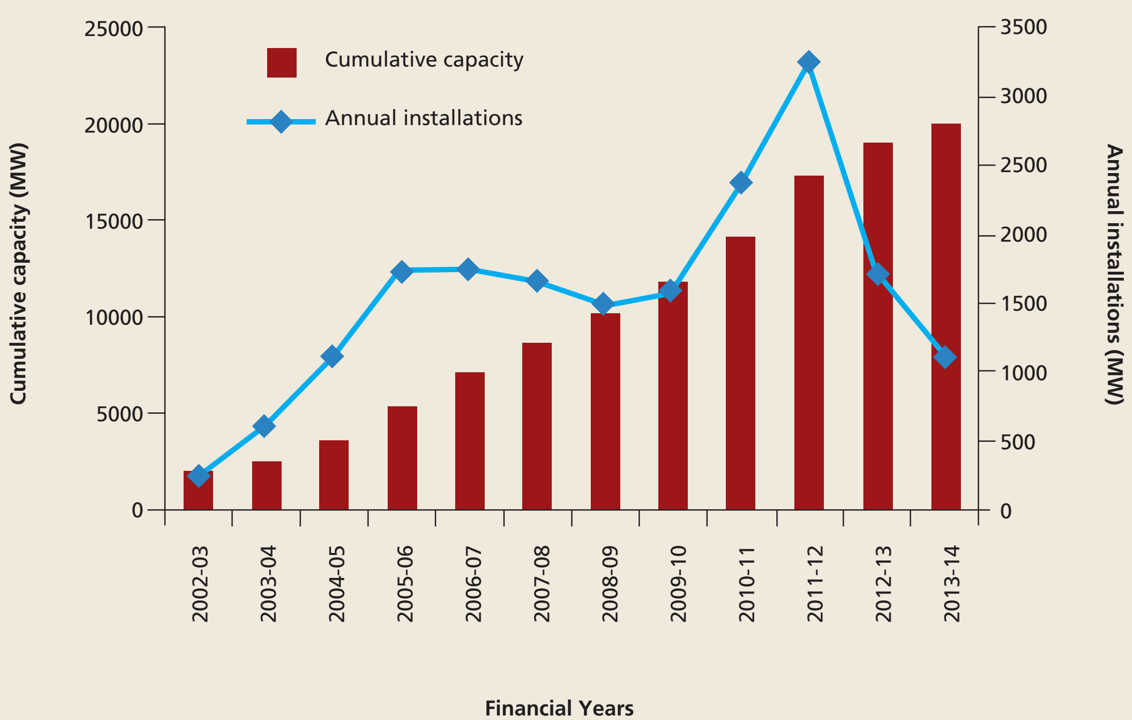
3. Growth of wind power: A rollercoaster ride

Wind power in India has grown at a cumulative annual growth rate of 26 per cent from 2002-03 to 2012-13 (see figure 3: Growth of wind power). The installation of wind power has always exceeded government targets. In the 10th (2002-07) and 11th (2007-12) Five-Year Plans (FYP), against targets of 1,500 MW and 9,000 MW, 5,427MW and 10,260 MW of wind power was installed. This prompted the government to set ambitious plans for growth of wind power in the 12th FYP (2012-17). The plan set a target of 15,000 MW. However, growth was sluggish in 2012-13 and 2013-14. This is largely due to the removal of subsidies, including AD and GBI, in the beginning of the 12th FYP. This has prompted MNRE to go into the mission mode. A Wind Mission has been inaugurated to develop a long-term sustainable policy framework to accelerate the wind sector's growth.

The Wind Mission

The Wind Mission has an ambitious target of 100,000 MW wind power installation by 2022 (see table 1: Wind mission targets). As per the mission's concept paper, the aim is "to create a long term stable policy framework that minimises risks and costs of wind

FIGURE 3: GROWTH OF WIND POWER



Source: MNRE (http://mnre.gov.in/file-manager/UserFiles/Presentations-NWM-09012014/Alok-Srivastava-JS-MNRE.pdf)

TABLE 1: WIND MISSION TARGETS

Wind Power Category	Phase 1 (2012-2017)	Phase 2 (2017-2022)
Utility-scale On-shore wind	20,000 MW	50,000 MW
Off-Shore wind	1,000 MW	10,000 MW
Distributed wind	100 MW	1,000 MW

Source: MNRE, Wind Mission concept note circulated during National Consultation workshop held on 9th Jan, 2014

power deployment while sharing such reduced costs and risks appropriately, amongst all relevant stakeholders through an inclusive process". As part of the mission, MNRE would coordinate between various central and state government agencies.

Wind mission also envisages enhancing manufacturing capacity of indigenous wind turbines. Development of wind zones as per wind resource and assessment of transmission infrastructure have also been accorded priority. The mission also aims at coordination between regional and state level agencies to operate with large scale intermittent sources connected to the grid.

Meeting the targets of the wind mission mean that the country will have to install about 25 per cent of all the wind turbines that are currently installed, globally

The target of installing close to 80,000 MW in the next eight years is daunting, to say the least. The maximum that the country has installed in any given year is about 3,000 MW. Meeting the targets of wind mission implies that the country will have to install

GOING OFFSHORE

Should India be investing in large-scale offshore projects?

India's long coastline of 7,600 km gives it a high offshore wind power potential. United Nations Convention on Law of the Sea gives India exclusive rights over its Exclusive Economic Zone (EEZ), an area up to 200 nautical miles from coastline, to develop offshore wind energy. India released its offshore wind draft policy in May 2013.[1] The policy proposed an Offshore Wind Energy Steering Committee (OWESC) headed by the Secretary, MNRE, to frame policy framework for offshore wind energy development. It also proposed formation of a National Offshore Wind Energy Authority (NOWA) to act as the nodal agency for offshore wind projects in the country. NOWA's primary task will be to carry out resource assessment and surveys in the EEZ, enter into contracts with project developers for development of offshore wind energy project in the country's territorial waters (12 nautical miles), and act as a single window agency for project clearances. However, NOWA will only be a facilitator for getting clearance; application and procedures for clearance will be dealt by the ministries/departments concerned.[2] Though various studies suggest immense wind energy potential along the coast, none of them have concrete data on offshore wind potential of the entire coastline. A MNRE presentation uses a study by World Institute of Sustainable Energy (WISE) to estimate Tamil Nadu's offshore wind energy potential at 1,27,000MW at 80 m height.[3] However, the question to ponder is whether it is worth investing in offshore when the country has not even harnessed a fraction of its on-shore wind potential. This is also because the cost of offshore wind is currently ₹12-18 crores per MW in comparison to ₹6 crores per MW for on-shore wind.[4]

10,000 MW every year. In other words, India will have to install about 25 per cent of all the wind turbines that are currently installed, globally.[6]

In addition, the target includes installation of about 11,000 MW of offshore wind power. Considering that there has not been even 1 MW of offshore wind installed so far and the costs are high, one has to question the wisdom of setting such high targets (see box: Going offshore)

4. Incentives and subsidies: Will they remain the main drivers?

Wind industry in India has grown on the back of subsidies, incentives and tax exemptions. Presently, following incentives and exemptions are provided to the wind industry:

- Generation based incentives provided by the central government.
- Preferential feed-in tariff in 13 states under long-term power purchase agreement.
- Income tax exemption on earnings from the project for 10 years.
- Concessional customs duty (5 per cent) on some components of wind power machinery.
- Hundred percent foreign direct investment (FDI) is allowed in wind power sector.
- Value-added tax (VAT) at reduced rates from 12.5 per cent to 5.5 per cent in some states.
- Wind operated generators and its components manufactured domestically are exempted from excise duty.
- Exemption from electricity duty levied by state governments

However, three key incentives have seems to have propelled wind power development in India: accelerated depreciation (AD), generation based incentives (GBI) and preferential tariff.

Accelerated depreciation and generation based incentive have propelled growth of wind power in India. Their withdrawal led to dramatic fall in wind power capacity additions

I. Accelerated Depreciation

In the 10th and 11th FYP, the Centre (under the Income Tax law) allowed wind power investors to avail 80 per cent AD if the project is commissioned before September 30 or 40 per cent if commissioned after that date in a financial year.[7] AD effectively allowed investors to recover their equity in the first year itself by writing-off taxes. This policy did give a boost to investments in the wind power sector. But it also led to poor capacity utilisation factor for the turbines (See box: The Indian wind power sector's capacity utilisation factor). This was because the incentives were for installing wind power and not generating wind energy; investors were more interested in tax benefits through AD and not in earning money by selling power.

The AD benefits were availed only by those companies that were making profits—either on their own or through their sister concerns. Independent power producers (IPPs) were not able to avail AD benefits; it was also of little use in drawing FDI.

On April 1, 2012 the 80 per cent AD benefit was withdrawn. Instead, a new AD policy was introduced under which the wind industry was allowed an additional 20 per cent AD in the first year; this is in addition to the 15 per cent AD given to wind power projects in the first year.

But despite this, the traditional investors in wind power—profit-making companies and high net-worth individuals—have reduced their investments. There is a growing demand to reinstate AD benefits and MNRE is lobbying with the Ministry of Finance to reinstate these benefits.[8] But reinstating AD benefits without proper check and

THE INDIAN WIND POWER SECTOR'S CAPACITY UTILISATION FACTOR

The capacity utilization factor (CUF) of Indian wind power sector is low as compared to other countries. Table below shows the maximum CUF has remained on average between 17% -19% as analysed using three different methodologies below.

Year		up to 2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Installed capacity (MW) Cumulative		5350.77	7092.82	8756.14	10241.04	11805.64	14154.84	
Installed capacity (MW) Year wise			1742.05	1663.32	1484.9	1564.6	2349.2	3196.7
Power Generated (BU)			9.547	11.413	13.334	18.188	18.735	23.353
Methodology I	CUF (%)		20.4%	18.4%	17.4%	20.3%	18.1%	18.8%
	Average CUF				18.9%			
Methodology II	CUF (%)		18.6%	17.2%	16.5%	19.4%	17.1%	17.6%
	Average CUF				17.7%			
Methodology III	CUF (%)		17.7%	16.6%	16.1%	18.9%	16.6%	17.1%
	Average CUF				17.2%			

Source: Data from MNRE. Analysis by CSE

Methodology I: It is assumed that the wind capacity installed in the year is not contributing to any power generation. So, CUF is based on cumulative installed capacity of previous year and power generated figures of the year.

Methodology II: It is assumed that only 30 per cent of the wind capacity installed in the year is contributing to power generation at full capacity; the remaining 70 per cent is not contributing to any power generation. For calculating CUF, the installed capacity assumed is the sum of the cumulative installed capacity of previous year plus 30 per cent of the capacity installed in the year.

Methodology III: It is assumed that the entire capacity installed in a particular year has come equally in 12 months. So, one-twelfth of the plant installed in the year has been assumed to produce power for the entire year, another one-twelfth for 11 months, another one-twelfth for 10 months and so on. CUF has been calculated based on the cumulative installed capacity of the previous year plus the contribution by capacities installed equally in 12 months.

In the above three methodologies, it is observed that the average CUF of wind power in years 2006-07 to 2011-12, varies between 17 per cent and 19 per cent. In January 2014, in a meeting organised by MNRE, Joint Secretary, MNRE responsible for wind power announced that wind sector in India is achieving CUF to the range of 21-22 per cent.[1] However, the data put out by MNRE in the public domain does not support this.

The wind turbines which have come before 2010 are mostly at the hub height of 50 m. The new wind turbines are coming up at the height of 80 m; this is expected to increase the CUF. However, the specific data related to 80 m hub height is not available and the available data doesn't reflect the increasing CUF trend.

balances in place, to ensure high performance from a wind turbine during its entire lifetime, might backfire.

II. Generation Based Incentives

In order to include different category of investors and also to incentivise higher efficiencies, Government of India (GoI) announced a GBI scheme in 2009 for grid connected wind power projects. A GBI of ₹ 0.50 was announced for every unit of wind power produced and fed to the grid. The maximum incentive that could be availed under this scheme was ₹ 62 lakh per MW.

This incentive is over and above the preferential tariffs given by the different state governments. However, this incentive was not applicable to projects availing AD benefits. The GBI scheme was introduced to draw investors away from AD benefits. The policy worked and GBI drew substantial interest, especially from IPPs. Between March 2010 and October 2012, 2021.29 MW capacity of wind projects had availed themselves of the GBI benefit, while 1,830.43 MW projects availed AD benefits.[9]

As the market started moving towards GBI and drawing IPPs, GoI thought the sector is ripe enough to be driven by market forces and removed all fiscal incentives on April 1, 2012. This policy move backfired. Installations dipped to 1,700 MW in 2012-13, compared to 3,164 MW in 2011-12.[10] This led GoI to bring back GBI in the 2013-14 budget with an allocation of ₹ 800 crore (sufficient to support GBI for 800 MW wind power).

However, this GBI got the Union Cabinet's nod only in August 2013.[11] As per MNRE, the incentive is applicable to all wind power producers who had installed wind turbines from April 2012.

III. Preferential Feed-in-Tariff

Wind industry in India enjoys preferential feed-in-tariff similar to several other countries. As of now at least 9 states have declared feed- in-tariff for wind power (see table 2: Preferential tariff for wind power).

Although Central Electricity Regulatory Commission (CERC) issues benchmark tariff every year, state regulators decide feed-in-tariff of their own. These are lower than the CERC benchmark. Different states have fixed tariffs based on the capacity utilisation factors (CUF) wind turbines are likely to achieve. For example in Tamil Nadu, where wind velocity is high for around six months a year, wind developers can achieve higher CUF compared to other states. Therefore, developers can make profits in Tamil Nadu at a lower feed-in-tariff which is not possible in other states and hence tariffs are higher in other states compared to Tamil Nadu.

In fact, there are no takers for wind power in some states which offer a feed-in-tariff higher than Tamil Nadu. For example, the Maharashtra State Electricity Distribution Company Limited (MSEDCL) had objected to Maharashtra Electricity Regulatory Commission's (MERC) move to increase feed in tariffs for wind power projects on the ground that it is already high, compared to that in other states.[12] However, MERC

Several states have announced preferential feed-in-tariff as per the wind density zones. They vary from ₹ 3.51 in Tamil Nadu to ₹ 5.92 in Madhya Pradesh

TABLE 2: PREFERENTIAL TARIFF FOR WIND POWER*

State	Tariff (₹/kWh)
Andhra Pradesh	4.70
Gujarat	4.15
Karnataka	4.20
Madhya Pradesh	5.92
Maharashtra	WPD 200-250 W/m^2 : 5.81 WPD 250-300 W/m^2 : 5.05 WPD 300-400 W/m^2 : 4.31 WPD >400 W/m^2 : 3.88 * WPD in W/m^2 means wind power Density in Watt per Square metres
Rajasthan	5.46 (for projects in Jaisalmer, Jodhpur and Barmer districts) 5.73 (for other districts)
Tamil Nadu	3.51

** In 2013-14; Source: Compiled from different states regulatory commission websites* overruled MSEDCL's objection and passed an order (no 6 of 2013, dated March 22) that set a maximum tariff of ₹ 5.81 per unit of wind power (For Wind Zone 1 with wind power density of less than 200-250 watt per square metres).[13]

Despite being a major manufacturing hub, research and development in India is limited. Multinationals setting up units in India are largely dependent on their counterparts abroad for innovations

5. Manufacturing in India

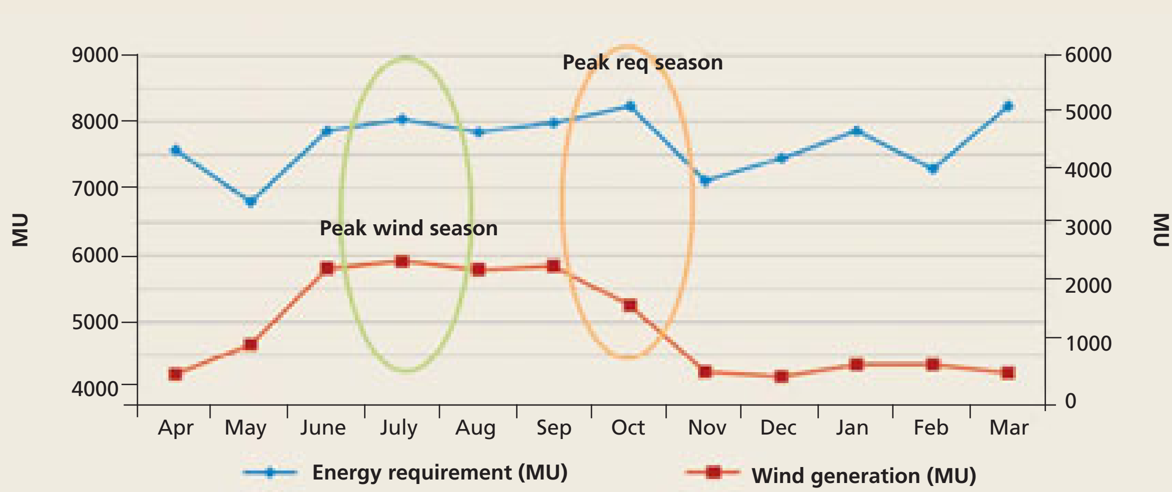
Low manufacturing costs, custom duty exemptions on imports of certain components required for wind turbines and a host of other financial benefits given to manufacturers have made India a lucrative wind turbine-manufacturing hub. Currently, India has an annual production capacity of over 10,000 MW.[14] There are presently 19 manufacturers registered with Centre For Wind Energy Technology (C – WET) offering wind turbines ranging from 250 kW to 2,500 kW.[15] Wind turbine manufacturers in India now export wind turbines and blades to Australia, Brazil, Europe, USA and a few other countries. International companies with Indian subsidiaries source over 80 per cent of their components from India.

Despite being a major manufacturing hub, research and development (R&D) in India is very limited. Multinationals setting up units in India are largely dependent on design specifications and innovations from their counterparts abroad. This means India doesn't have a competitive advantage on the technology front in the wind sector.

Wind turbine manufacturers have been accused of cartelisation and driving up project costs[16]. They have been accused of opaque pricing and for failing to provide capital expenditure break-ups of projects to regulatory commissions.[17]

Competitive bidding for wind power has been receiving stiff opposition from the wind industry. Rajasthan's wind policy for 2012 announced that the state will determine feed-in-tariff for wind energy through competitive bidding.[18] In line with this policy, Rajasthan Renewable Energy Corporation Limited (RRECL) released "request for proposal" during first week of February, 2013 to install 300 MW of wind power capacity in the state. The tariff was to be determined through competitive bidding. But this met with stiff opposition from wind industry and was eventually withdrawn.

FIGURE 4: DISCORD BETWEEN NEED AND GENERATION
Wind generation and demand in Tamil Nadu



Source: Central Electricity Authority (www.cea.nic.in/reports/powersystems/large_scale_grid_integ.pdf)

Competitive bidding leads to market price discovery and possibility of price reduction. Countries like Brazil, China and the US have introduced competitive bidding in wind. However, such bidding without a robust policy framework for quality control may lead to project failure as intense competition will force developers to quote unviable tariff and compromise on quality and technology.

There is a need to bring in transparency in the pricing structure of the wind turbines and introduce incentives and competition to reduce the price.

In wind rich states, wind generation is maximum during May to September, while peak demand is in November to January and then again in March to May

6. Issues and challenges: Making wind sustainable

I. Addressing variability and integrating wind power

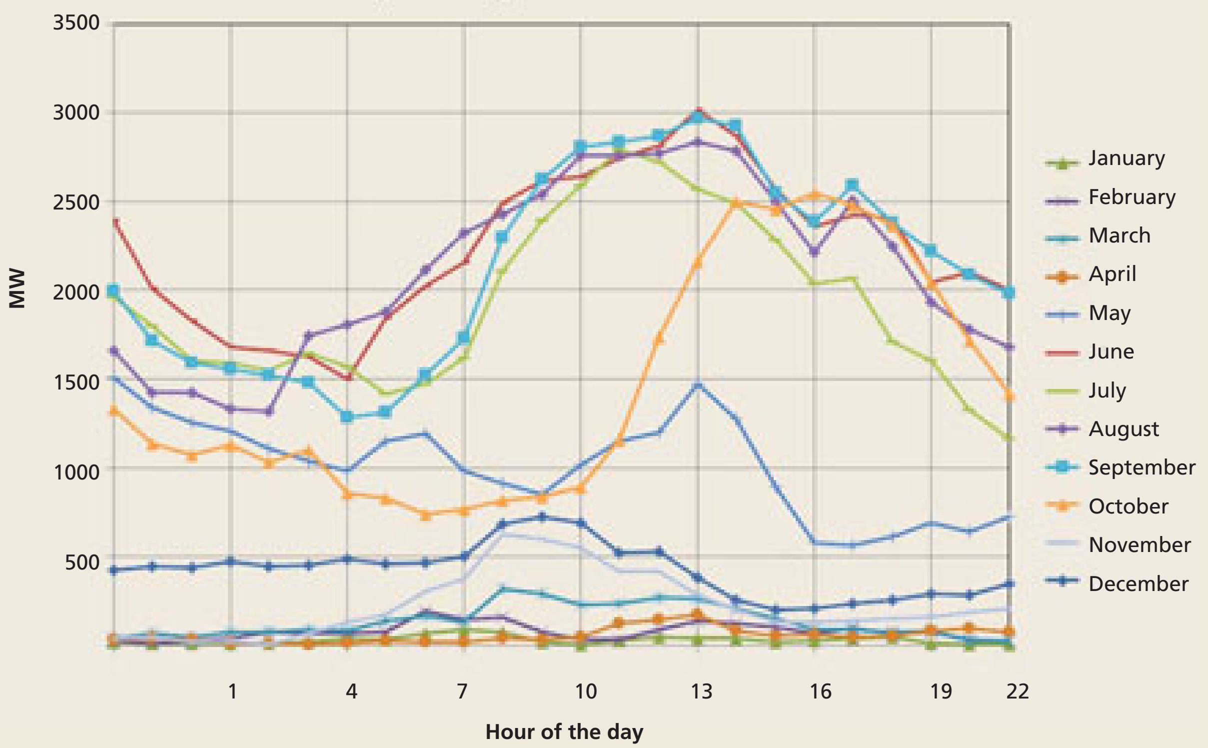
Wind power generation mainly depends on wind speed and availability. Although there is no control over wind speed and availability, wind does exhibit certain monthly patterns, which can be used to plan power evacuation from wind farms. In India, wind flow is usually most active from May to September.[19]

In high wind potential states like Tamil Nadu, wind power is able to contribute to peak power requirement for only four months. In the remaining eight months, peak power demand does not match the peak wind power generation (see Figure 4: Discord between need and generation).

Daily wind generation pattern and peak demand also do not match in Tamil Nadu (see figure 5: Daily mismatch). The daily wind generation pattern in Tamil Nadu shows a huge variability at different hours of the day in all months. In general the trend is that

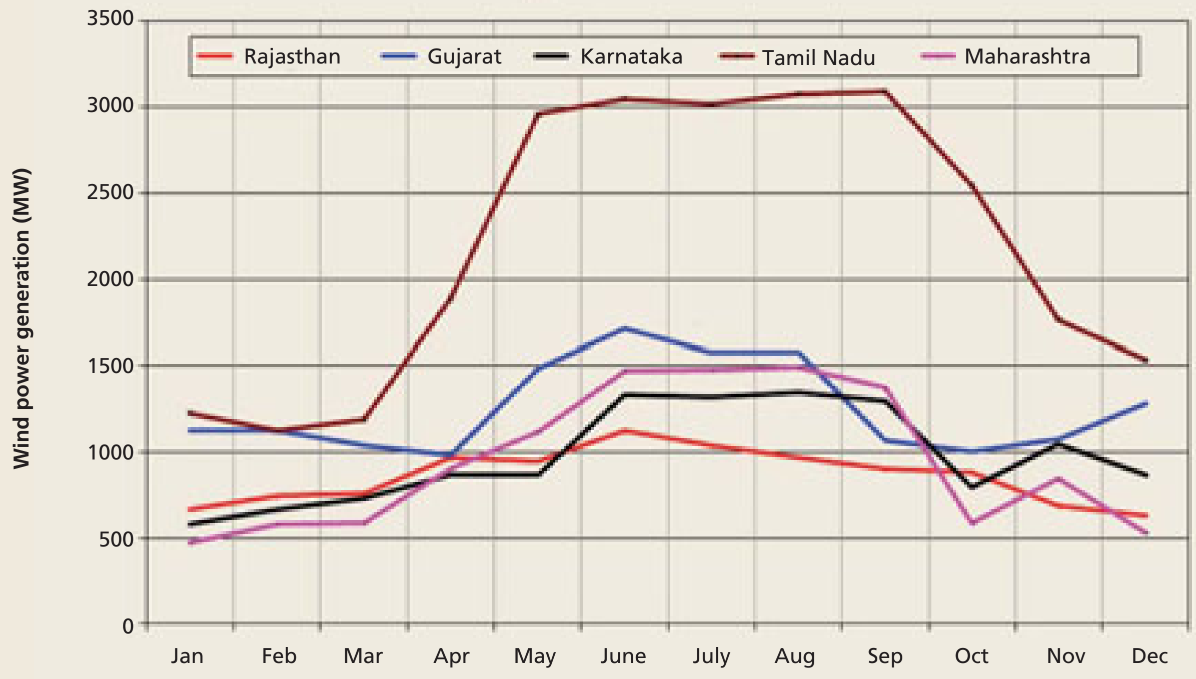
FIGURE 5: DAILY MISMATCH

Typical daily wind generation pattern and demand curve in Tamil Nadu



Source: Report on Green Energy Corridor, Power Grid Corporation of India Ltd.

FIGURE 6: STATE WISE MONTHLY PEAK WIND GENERATION PATTERN



Source: Report on Green Energy Corridor, Power Grid Corporation of India Ltd.

generation from wind power is more during afternoon (16:00 hours) and late night (01:00 hours) while demand peaks during morning and evening.

The Tamil Nadu example illustrates the fact that seasonal as well as daily variations in wind power generation do not match the typical seasonal and daily demand patterns. This seems to be the case in all wind rich states. The wind generation pattern of wind rich states show that generation is maximum during May to September, while the peak demand seasons are in November-January and March-May (see figure 6: State wise monthly peak wind generation pattern). Therefore, using wind power to address the peak power demand does not work out. Using wind power to meet the base load demand is also an issue because it is not reliable and generation fluctuates rapidly. The load pattern exhibits similar trend during all the seasons, hence availability of wind power in any particular season does not seem to balance the power availability and load curve. There is, therefore, an urgent need to address the issue of wind power variability and integrating wind power with other sources of electricity. Many proposals have been put forth to address this issue.

Wind power generators find forecasting a challenge. They argue wind flow is highly variable and dependent on locally contingent factors

i. Balancing wind power

Balancing wind power with hydropower is an option to address variability. For example, the demand curve of Tamil Nadu remains almost flat throughout the day, while wind generation pattern peaks during the afternoon. This variability can be managed by supplementing wind with hydropower at times of the day when wind power generation is lean.[20]

However, there are practical challenges in doing this in the country because wind and hydropower sites are located far apart from each other and, more significantly, power situation in the country does not allow the luxury of supplementing one renewable energy resource with another.

ii. RRF mechanism

A far viable solution is the Renewable Regulatory Fund (RRF), which was set up to make power from renewable energy sources more acceptable and compatible to the grid. This mechanism requires wind energy and solar energy generators to forecast and schedule their power output on a daily basis. A wind power generator has to maintain generation output within an error limit of ±30 per cent or face penalties.

In January 2013, CERC issued an order requiring projects to start such forecasting and scheduling from July 1, 2013. However wind power generators find forecasting a challenge. They argue that wind flow is dependent on highly variable and locally contingent factors. Wind industry, therefore, went to Delhi High Court against the CERC for implementation of RRF mechanism. There was litigation against the forecasting requirement elsewhere too. The Madras High Court has ordered a stay on the full implementation of RRF on a petition filed by the wind developers. The court though has ordered wind projects to continue forecasting and scheduling generation. It has only stayed the collection of penalties.

Scheduling wind power generation and settling financial transactions based on penalties need proper coordination between multiple agencies.

The Central Electricity Authority (CEA) report, "Large Scale Grid Integration of Renewable Energy Sources – Way Forward" offers a way out. CEA has emphasised the establishment of Renewable Energy Management Centers (REMCs) to forecast renewable power. It also proposes that REMCs work closely with State Load Dispatch Centre (SLDC) for maintaining grid balance.

Low capacity wind turbines installed 10 to 12 years ago occupy some of the best wind sites in India

iii. Grid Management

Grid enhancement and management is key for integration of wind power. Wind power, being variable and intermittent, stresses the grid. Large-scale wind integration may introduce new patterns in the flow of power which could cause congestion in the transmission and distribution networks. To address these issues, planning for the grid and planning for wind power must go hand in hand.

Wind turbines are generally located in remote areas and are far away from concentrated load centres. Integrating such wind farms with the state/national grid, therefore, requires planning evacuation capacity well in advance. This is also necessary because wind plants have low gestation period compared to transmission infrastructure development. For example, presently the Tamil Nadu Electricity Board doesn't give approval for installing wind turbine unless grid has reached the site concerned. The wait for grid to reach the pooling point takes far more time than expected. All this calls for integrated planning amongst developers of transmission infrastructure and wind power.

Similarly, concentration of large number of wind turbines in one geographical region has serious implications for grid supply and management. This is especially so since sudden fluctuations from wind farms can cause an upheaval in the entire grid, leading to grid failure. This problem can be solved by spreading the installation of wind power across the country as well as by developing a robust transmission network to evacuate this power. In this regard, MNRE and Powergrid Corporation of India Limited

(PGCIL) have planned a dedicated green energy corridor to evacuate renewable energy from regions rich in such energy and feed into other regions. This will eventually reduce the risk of national/regional grid failure in case of sudden fluctuation of wind energy as well as ensure better distribution of wind energy throughout the country.

The integration of wind power also requires better forecasting of wind power generation. This means that the country will soon have to set-up state-of-the-art centralised forecasting centres, which will have to be integrated with supervisory control and data acquisition systems. The country will have to start planning for bulk storages devices to store power during periods of low demand and supply to the grid when there is a surge in demand.

As wind power installation increase in the country, grid management will become even more important.

Vehicles carrying huge components of wind turbines and other machinery require wide roads. When these roads cut through forests and hills, they fragment ecosystems, opening up wildlife habitat for human exploitation

II. Repowering

Commercial wind power generation in India began in 1986. Wind turbines installed more than 10 to 12 years ago (< 500 kW) occupy some of the best wind sites in India. Such low capacity turbines need to be replaced with more efficient, larger capacity machines. An immediate benefit of repowering the old turbines is that more electricity can be generated from the same site.

About 1,380 MW of wind turbines have been installed before 2002 (see table 3: Old turbines). Considering a minimum repowering factor of two, India's current repowering potential stands at approximately 2,760 MW.[21] In Tamil Nadu, about 60 per cent of small wind turbines (<400 kW) installed before 2000 are operating at capacity utilisation factors (CUF) ranging from 10 to 15 per cent (mostly 50 meter hub height), whereas the new wind turbines with improved efficiency can operate at a much higher CUF (in the range of 27 to 32 per cent at 80 to 120 meter hub height)

However, the repowering agenda is not moving ahead because of lack of policy guidelines and incentives. For instance, feed- in-tariff to be given to the repowered turbine is a major concern. The position of state electricity boards, for example that of the Tamil Nadu Generation and Distribution Corporation Ltd. (TANGEDCO), is that the tariff applicable to the old turbine should continue. This is a major disincentive to invest in new and high-capacity turbines. Similarly, land ownership is fragmented in most existing wind farms wherein a single wind farm has many owners who might own just one wind turbine. In such a scenario, repowering cannot happen for one turbine; it has to happen for the entire farm. There is no government policy that incentivises all owners to come together and agree to repower the entire farm. Evacuation of extra power generated due to increase in installed capacity is another issue that needs to be addressed.

TABLE 3: OLD TURBINES

State wise wind turbine installations before 2002

State	Total capacity (MW) installed before 2002
Tamil Nadu	809.8
Maharashtra	247.8
Gujarat	175.1
Andhra Pradesh	86.7
Karnataka	28.9
Madhya Pradesh	22.6
Rajasthan	4.1
Others	5.1
Total	1380

Source: Consolidated Energy Consultants Ltd. (CECL)/Ministry of New and Renewable Energy (MNRE)

III. Environment impacts due to non-regulation

In a country like India, where population density is very high, a wind power project may cause significant impacts if it is set up in an area occupied by, or close to, human settlements. When operational, wind turbines generate noise and shadow flicker which can disturb nearby communities. Projects on forest land can impact local biodiversity; those on hilly areas exert higher impacts on forests, wildlife and water resources, compared to projects located in the plains.

The status of wind power as 'green energy' may give it an unofficial stamp as being less disturbing, but roads and power lines still have to be built for the project. These activities disrupt the environment.

Vehicles carrying huge components of wind turbines and other machinery such as cranes require wide roads. When these roads cut through forests and hills, they fragment a single continuous ecosystem. Such linear fragmentation opens up wildlife habitats for human exploitation (poaching, timber removal and encroachment by farm land) and also creates problems in spread of flora. It disturbs movement of animals. Water catchment areas are cut through to make roads leading to changes in the hydrology of the area. Streams change course, get blocked or silted.

Linear intrusions can have significant impact depending on the nature of the project. A 10-hectare (ha) road or power project can have a much larger impact than a 10-ha square used for a non linear infrastructure project. Though power lines mostly constitute of overhead cables and can allow vegetation growth beneath them, installing power lines does require axing down large trees. Electrocution by power lines is a major concern for wildlife with reports of elephants being killed and deaths of endangered bird species. In Gujarat over 150 flamingos deaths have been reported as a result of electrocution by power.[22]

Wind power projects are not covered under the Environment Impact Assessment (EIA) notification and are, therefore, exempt from EIA. Wind power is also categorised as "green" by a majority of the State Pollution Control Boards.[23] Such projects are rarely scrutinised—only if there are complaints against them. They receive Consent to

76 per cent of the total forest diverted for wind power projects is located in just two states, Maharashtra and Karnataka

MNRE ON WIND PROJECTS' ECOLOGICAL IMPACT

In October 2013, MNRE released a report, 'Developmental Impact and Sustainable Governance Aspects of Renewable Energy Projects'. The report focuses on wind and solar projects.

The report recommends that solar and wind energy projects should be developed in environmentally non-sensitive areas. It recommends zonation of the country into go-green (no objection), go slow and no-go regions. The zonation will be based on factors such as ecological sensitivity and the region's wind potential. The demarcation will also consider the optimal use of land at wind farm sites to sustain other livelihood activities. It will also have to be sensitive to requirements of local communities. The report recommends new wind projects in go-green areas. However, the report has not recommended EIA process for the wind power development.

It emphasises that the onus of local welfare should fall on the RE project developer. The report also suggests benefit sharing arrangements with the local community or the village panchayat. It recommends that the project developer take care of the power needs of local communities.

Establish (often called 'No objection certificate') and Consent to Operate for five years from state pollution control boards without much scrutiny. The Consent to Operate is usually extended for another five years if there are no complaints against a project.

The detrimental ecological impacts of unregulated wind power development is now well established. The Western Ghats Ecology Expert Panel Report (WGEEP) chaired by ecologist Madhav Gadgil recommended EIA for wind power.[24] The panel noted that forest clearances for wind power projects had been secured by misrepresentating facts. Recently, MNRE has come out with a report which looks at the environmental aspect of wind power development. The report, however, has rejected the idea of EIA for wind projects (see Box: MNRE on wind projects' ecological impact).

Forest diversion: A large number of wind power projects are coming up on forest land, mostly in Karnataka and Maharashtra. According to the MoEF database, the total forest area diverted for wind power project till January 2014 is about 4188 hectares (ha) for 75 projects (both approved and in principle clearance). About 76 per cent of forest diversion has taken place in just two states, Karnataka and Maharashtra (see table 4: Exploiting forests).

In 2004, ministry of environment and forests issued guidelines on forest clearances for wind projects. But adherence to these guidelines has been quite poor

TABLE 4: EXPLOITING FORESTS

Forest diverted for wind power

States	Forest Area Diverted (Ha)	Percentage
Andhra Pradesh	227.0	5
Gujarat	417.6	10
Himachal Pradesh	34.3	1
Karnataka	1857.7	44
Madhya Pradesh	320.5	8
Maharashtra	1331.7	32
Total	**4188.9**	**100**

Source: As per Ministry of Environment and Forests online database accessed on 4th Feb, 2014

In different states, the forest area diverted varies from 0.9-1.9 ha/MW of wind capacity installed. On an average, about 1.5 hectares of forest land is diverted per MW of wind capacity. Therefore about 2,886 MW of wind capacity has come up in forest areas. It has been observed that 38 per cent of the wind power installed in Maharashtra has come up in forest areas; while 43 per cent of such power in Karnataka has come up in forest areas.

As the biggest environmental impact of wind power is in forest areas, the process of forest clearances becomes

TABLE 5: EASY DESTINATION

Percentage of wind capacity installed in forest area in different states

State	Ratio ha/MW	Total forest area diverted (ha)	Corresponding wind capacity installed (MW)	Achievement (MW) (as per MNRE till Jan 2014)	% wind power capacity in forest land
Andhra Pradesh	1.2	227	188.7	648	29%
Gujarat	0.9	417.6	484.2	3384	14%
Karnataka	1.9	1857.7	1001.0	2312	43%
Maharashtra	1.0	1331.7	1323.9	3472	38%

Source: As per Ministry of environment and Forests (MoEF) online database accessed on February 4, 2014 important. Any project set up in a forest area requires a forest clearance, regardless of its inclusion under the EIA notification. The majority of wind power projects that have received forest clearance require more than 40 ha. The MoEF is the only statutory authority to issue forest clearance for such projects. It has been observed that clearance is issued in some such projects in just 10 days. This gives rise to speculation about the rigour followed by the ministry while awarding clearances to the projects in question.

In 2004, the MoEF issued guidelines on forest clearances for wind power projects; these guidelines incorporate afforestation and forest value paid into CAMPA (Compensatory Afforestation Fund Management and Planning Authority) funds.[25]

The guidelines prohibit wind power projects in natural parks, sanctuaries and national heritage sites. They also stipulate "safe distance" of 300 meters from the nearest village habitation in "normal circumstances", but these circumstances are not described. Overall, adherence to these guidelines have been quite poor.

IV. Land and Benefit Sharing

In many countries landowners and affected communities are compensated through the benefit sharing mechanism. This is sometimes done voluntarily and at other times mandated by law. For landowners (usually farmers), this is a rental agreement like any other. Unlike projects in India, where land is acquired for an one-time compensation, the mechanism hinges on sharing profits of the wind farms with communities whose lands are used for such farms. Benefit sharing mechanism ensures sustained livelihoods for these communities.

Many long-drawn conflicts between local communities and project developers can be resolved at the project planning stage by involving landowners or affected people in sharing benefits of schemes.

Countries such as Germany have made rapid strides in forecasting wind power. India lags far behind

Recommendations and Way Forward

I. Zonation of wind resources should be carried out on priority basis. It is of strategic importance not only in the short term but also in the long term. Zonation will help to identify 'go' and 'no go' areas in forest and ecologically sensitive areas for wind power development. It would help in fixing of suitable tariffs as per wind density thereby enabling viability of wind turbines in different wind zones. The following steps can be followed:

- Identification of potential area followed by district level mapping of wind energy potential with the help of C-WET and other related agencies.
- Based on feasibility study, detailed EIA needs to be carried out to assess the overall impact of wind farm.
- Exclude sensitive areas as indicated by EIA study, while planning wind farms.
- Develop Environment Management Plan (EMP) for each wind farm location.
- EMP should be mandatory before a project receives Consent to Establish and Consent to Operate.

II. EIA should be carried out until proper zonation studies are put in place. The EIA studies should be carried out for every project coming in forest areas irrespective of size.

III. A national policy should be developed to integrate various renewable resources such as wind power, solar power, hydropower and biomass to balance the intermittency of renewable energy resources. This hybrid of energy would help balance grid and enable more wind power intake into the grid.

IV. Repowering should be carried out on old wind farm locations which are more than 15 years old so that some of the most resourceful wind sites are utilised to their maximum capacity. A special policy can be designed by MNRE, wherein the best repowering sites are chosen after proper estimations and are incentivised with cheap loans from IREDA.

V. The most feasible way to manage grid is proper implementation of RRF mechanism. Countries such as Germany have made rapid progress in forecasting. However, India is far behind. Adequate expertise and technology upgradation needs to be developed in forecasting and scheduling wind power to manage its intermittency. REMC needs to be set up across all wind rich pockets to encourage quick deployment and enable better management of wind energy generation.

VI. Wind industry needs to stand on its own feet and should no longer be dependent on incentives. Currently the industry gets GBI. Restoring AD could have detrimental impact on efficiency of wind power generated. As most of the states have low wind zones, restorating AD might encourage developers to set up more wind farms in low wind density zones to avail tax benefits. Hence, GBI should be encouraged over AD to encourage utilisation of high wind resource areas.

VII. Research and development (R&D) in wind sector is poor in India. As most technology is imported into India, there is little encouragement for in-house research. Government and industry need to develop substantial R&D capabilities within the country to suit the needs of the country's wind power sector. This can also help keep costs under control.

REPORTS FROM THE GROUND

Wind creates havoc

Wind farm destroys green cover in Andhra Pradesh

A hill top is removed for installing a windmill

For two decades people from eight villages in the Kalpavalli region in Andhra Pradesh's Anantapur district laboured hard to turn a vast expanse of wasteland into a forest. But the effort seems to have gone waste as the green cover was destroyed to set up wind farms. German company Enercon through its subsidiary Enercon (India) Ltd, has set up a 50.4 MW wind energy project in the area under the title 'Nallakonda wind farm'.

Over 20 years ago, the Kalpavalli region used to resemble a desert. Hilly terrains, dried streams and tanks, and hard surface bereft of top soil marked the landscape. Then came the turnaround. A voluntary organisation and village residents brought to life a thriving wilderness on 2,833 hectares (ha) in Kalpavalli, marked as revenue wasteland. The area boasted 264 floral and 105 fauna species. Wild boars, black bucks, foxes and porcupines could be found in the forests. Kalpavalli provided livelihood to about 400 families.

Windmill intervention

Kalpavalli completely changed after Enercon's entry. The state government allotted 28 ha to Enercon Wind Farms

(Madhya Pradesh) Pvt Ltd at a cost of ₹62,500 a ha. Apart from this land, the company used 79.3 ha for building roads.

The company got the permission from the district administration to set up the windmills after the Non-conventional Energy Development Corporation of Andhra Pradesh (NEDCAP) sanctioned the project in 2004. According to the company, wind monitoring studies have been undertaken by NEDCAP, and the Ministry of New and Renewable Energy notified the location "as a proven windy site to encourage private sector investment".

The result has been devastating. Vegetation cover has been removed and hilltops cut for installing windmills. Deep cuts of three to four metres have been made on the slopes to develop roads, but without any retaining walls, leading to massive soil erosion. The company has developed roads ranging 10 m to 50 m in width. The deep cuts have damaged pasture routes, making it impossible for sheep and cattle to climb up the hills. About 50,000 sheep and 6,000 cattle from 20 villages, some as far as 20 km, would browse and graze on these hills, according to C K Ganguly, chairperson of Timbaktu Collective, a voluntary organisation based in Chennekkothappalli, 20 km from Kalpavalli, that started eco-restoration of wasteland in the region in 1992. Village residents allege the company did not take the necessary permission for road construction.

Creating rift

Enercon started its installation work after entering an agreement with the Kalpavalli Mutually Aided Tree Growers Society, formed by village residents in 2008. The company paid ₹20 lakh as compensation to the society most of whose members were part of the initiative to regenerate the forest. Alleges Gopal K, a member of Timbaktu collective, "Enercon caused a deep divide in the local community. It has also paid off villagers and local politician". The company has bought 1.6 ha for the village community for building a school.

State biodiversity board chairperson, R Hampaiah, says, "It's true that this was revenue wasteland. But it has been regenerated and has a forest which is common property". People resisted initially, but now everybody keeps quiet because of the money involved, he says.

While the company has completed its project, the Kalpavalli Mutually Aided

Kalpavalli 20 years earlier (top) and after forest regeneration (bottom)

Enercon paid ₹20 lakh to the Kalpavalli tree growers' society for the damage done by its wind mills. Aggrieved parties say the cost of damage is ₹20 crore

Tree Growers society maintains it has been misinformed. "Enercon said it would use only the existing paths and take only a little space for installing the windmills," says Roddam Pothenna, director of Kalpavalli Society, also a watchman of the windmill company. "Had we known the extent of damage, we would not have signed the agreement."

Mushtikovila tank, which used to irrigate paddy, has been silted because of soil erosion and roads interrupting streams, say villagers. The tank, a roosting ground for painted storks and other birds, is 1-1.5 km from the wind turbines. Transmission lines run close to the tank.

Brewing conflict

Nallakonda wind farm is now owned by Tadas Wind Energy Limited. A case against the company has been filed in the National Green Tribunal by Kalpavalli Mutually Aided Tree Grower's Society, Timbaktu Collective and Society for Promotion of Wastelands Development, which helped Kalpavalli's eco-regeneration.

One of the contentious issues is the amount of compensation for the ecological damage. While Enercon has paid ₹ 20 lakh as compensation, calculations by the aggrieved parties show the actual cost of damage is at least ₹ 20 crore. Society for Promotion of Wastelands Development had also objected to the wind energy project's claim to sell carbon credits under the Clean Development Mechanism (CDM). However the project was registered by CDM in 2013.

Deep cuts made on hill slopes for roads have caused massive soil erosion

Wind loses power

How wind energy majors lost interest in Tamil Nadu

Tamil Nadu has the highest concentration of wind farms in the country

The breeze seems to have reversed in the country's wind energy capital. Wind energy majors, which were investing full throttle in Tamil Nadu, are moving to Karnataka, Andhra Pradesh and Maharashtra. This at a time when Tamil Nadu reels from a huge power deficit of 2,500 MW. At least eight to 10 hours daily power cut is routine.

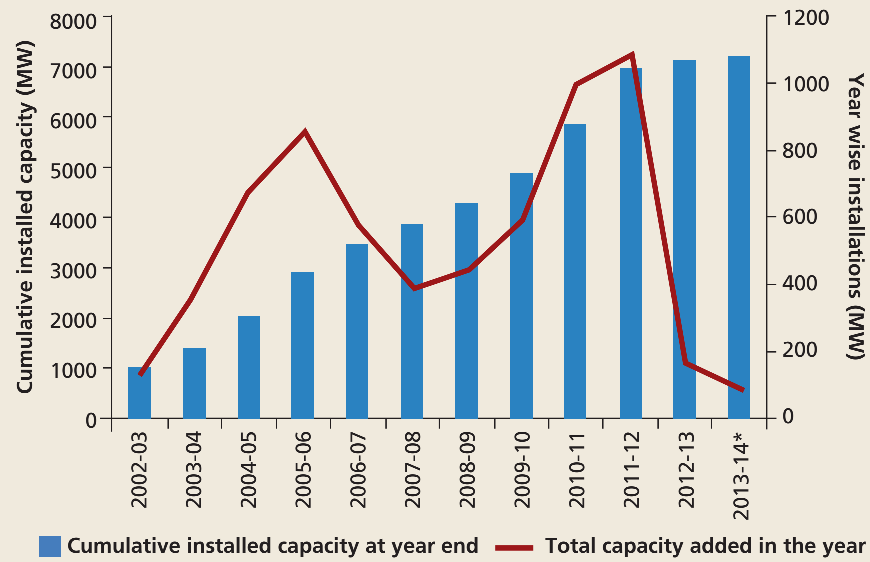
The state has some of the best windy sites in India and its installed wind energy capacity by end of 2013 was 7,200 MW, about 35 per cent of India's 20,200 MW installed capacity. Tamil Nadu's targets adding a capacity of 5,000 MW during the 12th Five Year Plan. But this target seems unlikely.

Developers are upset over delayed payments for electricity supplied, inadequate transmission infrastructure and withdrawal of incentives

Wind power developers are upset with the Tamil Nadu Electricity Board (TNEB) over delayed payments for the power supplied. They are also annoyed because of inadequate transmission infrastructure. Their frustration escalated after the Centre, in April 2012, withdrew the incentive of 80 per cent Accelerated Depreciation in the first year, allowing developers to defer income tax payments. "Why should developers continue investing in the state when there is noth-ing to pull them back?" asks K Kasturiranagan, chairperson of the Indian Wind Power Association, a national organisation of wind developers.

The result: a sharp dip in the power generation capacity addition in the state. In 2012-13, only 174 MW was added compared to the previous fiscal's 1,083 MW addition, figures of the Indian Wind Turbine Manufacturers' Association (IWTMA) show (see figure: Rise and fall of

FIGURE: RISE AND FALL OF WIND POWER ADDITION



** Till December 2013; Source: Ministry of New and Renewable Energy*

Till the first half of 2012-13, only 174 MW capacity was added in the state, compared to 1,083 MW in the previous fiscal

wind power addition). Earlier, Tamil Nadu attracted investment of ₹ 7,000 crore in wind energy every year. But the current fiscal is likely to close with an investment of merely ₹700 crore, a drop of about 90 per cent, as per the IWTMA.

Preferred wind power destination

Most of the state's southern districts—Kanyakumari, Tirunelveli, Thoothukudy, Theni and Coimbatore—are very windy. During Southwest monsoons, winds at a speed of 18-25 km per hour blow from the Arabian Sea through four major gaps in the Western Ghats—Palghat, Shencottah, Aralvaimozhi and Kambam passes (see map: Wind passes in Tamil Nadu).

Most wind farms are located close to these passes. Muppandal, with about 3,000 windmills in Aralvaimozhi, is Asia's largest windmill cluster. About 80 per cent of the wind energy is produced from April to September.

The Centre started promoting commercial generation of wind energy in 1993 with incentives such as accelerated depreciation, concessional custom duty on certain components of wind electric generators, excise duty exemption, 10 years' tax holiday on income generated from wind power projects, and loans from the Indian Renewable Energy Development Agency and other financial institutions.

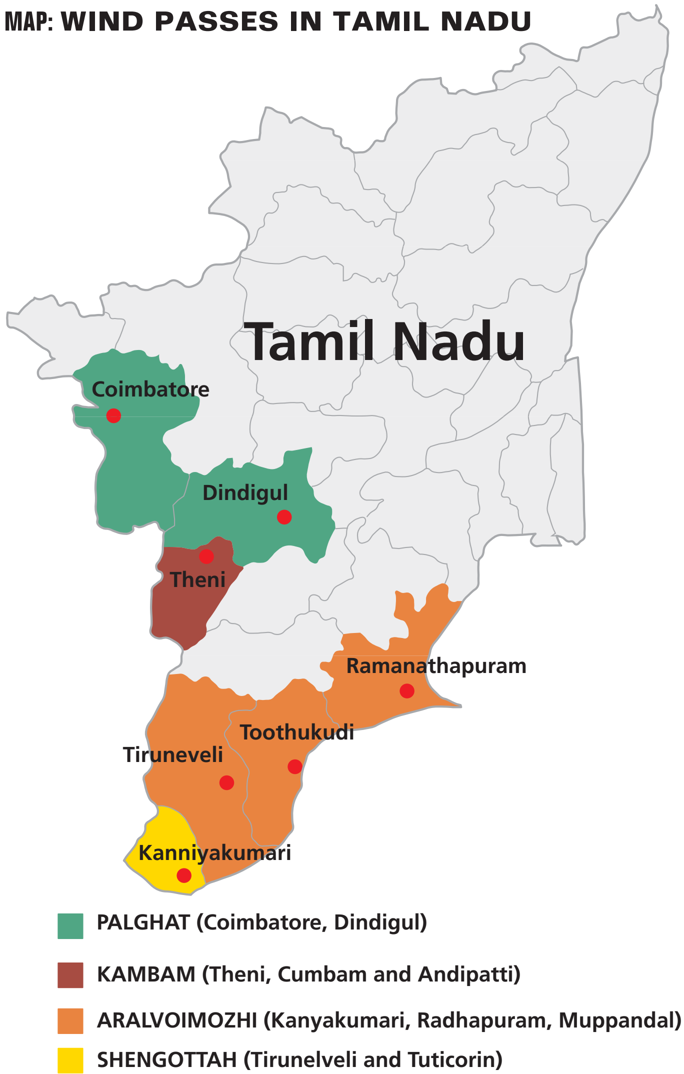
TNEB offered to wheel power from sites where industries have installed windmills. The developer would give five per cent of the energy generated as wheeling charge.

Banking of energy is just like banking of money. Developers can deposit excess power to the state electricity grid and withdraw, when required. For this too, the charge is five per cent of what is deposited. Unlike other states, Tamil Nadu allowed investors to buy private land directly. It soon became the most sought-after destination for private developers, with generation capacity increasing as well. Interestingly, the state government's share in wind power generation is minuscule at 19 MW.

As the earlier estimates of wind potential in Tamil Nadu was already exhausted, it led to downfall of wind capacity additions during 2006-08.

However revised potential estimation encouraged new capacity additions. "More wind power can be generated at higher altitude because wind speed increases with height," points out S Gomathinayagam, director of the Chennai-based Centre for Wind Technology, an autonomous organisation under the Ministry of New and Renewable Energy. Though the state has exceeded its estimated wind energy generation potential of 5,374 MW at 50-metre height, the predicted potential at 80-metre height is 15,000 MW," he says. According to him, the state can go for 10,000 MW of additional capacity, provided the grid capacity is increased. But the ailing TNEB is unable to do this.

MAP: **WIND PASSES IN TAMIL NADU**



Lack of grid infrastructure

The gestation period of the windmills is two to three months, but the power evacuation works require at least six months to an year for completion. Due to sudden spurt in windmill growth there has been a mismatch between installation of windmills and power evacuation.

"While we generate electricity, consumers are power-starved. There is no proper evacuation and transmission facility for power from pooling stations to reach the consumers," says Kasturirangan.

Developers complain that at the peak of the windy season when they expect revenues to maximise, TNEB disconnects some windmills from the grid, leaving significant generation capacity unutilised. Officials at Tamil Nadu Generation and Distribution Company (TANGEDCO) and Tamil Nadu Transmission Company (TANTRANSCO), which are parts of TNEB, say some machines are disconnected from the grid during peak generation because there is a possibility of grid collapse due to high energy penetration.

Developers say they pay ₹ 35 lakh as infrastructure development charge to TNEB for a 1-MW windmill. The amount should have been spent on laying transmission lines. "But the board diverts the money for repayment of debts," alleges Kasturirangan. TNEB, which is responsible for installing substations and transmission lines, is making huge losses and is debt-ridden. So despite sharp growth in the installed wind power capacity, the Board could not develop adequate infrastructure.

TNEB's financial mess

As per the power purchase agreement signed with producers, the board should pay the wind power suppliers within 30

By replacing old turbines with taller ones, the state can enhance its wind potential by nearly 10,000 MW. But it will also have to increase its grid capacity

TABLE: LOSS MAKING OUTFIT

Tamil Nadu Electricity Board's revenues

Year	Average cost of supply (₹/unit)	Average rate of realisation (₹/unit)	Loss per unit (₹/unit)
2005-06	3.52	3.07	(-)0.45
2006-07	3.55	3.10	(-)0.45
2007 08	4.00	3.19	(-)0.81
2008 09	4.86	3.13	(-)1.73
2009 10	5.09	3.11	(-)1.98
2010 11	5.55	3.43	(-)2.12
2011 12	6.12	3.73	(-)2.39
2012 13	5.98	3.79	(-)2.19

Source: http://www.tangedco.gov.in/linkpdf/tarrev-faq.pdf

As per power purchase agreement with wind power producers, Tamil Nadu Electricity Board should pay power suppliers within 30 days of their raising sales invoice. But the cash-starved board does not do so

days of raising the sale invoice. But it does not make payments on time owing to its financial mess.

TNEB has been making losses over the years. The average rate of realisation has been always less than the cost of supply ever since 2005-06. The loss per unit in 2005-06 was ₹ 0.45 which increased over the years to ₹ 2.39 in 2011-12 (see table: Loss making outfit).

The deficiency in revenues over the year has forced TNEB to borrow from financial institutions and has led to the total accumulated debt at ₹ 45,000 crores. All this has crippled the financial state of Tamil Nadu electricity Board and it is unable to pay to wind power generators on time. "Every project is being executed with equity and loan arrangement," says K Venkatachalam, chief adviser, Tamil Nadu Spinning Mills Association. Most of the wind power projects are funded through bank loans with 70 per cent debt. With the TNEB in financial crisis, irregular payments lead to wind mill owners struggling to pay off their loans. This further discourages any new investment.

Low wind resource utilisation

Wind technology has undergone tremendous changes. Modern wind machines with taller towers and larger rotors are more efficient. They have 80-metre tower height and 80-metre rotor diameter. The old ones had 30-40 metre height and 40 metre rotor diameter. Hence repowering which is replacing the old inefficient turbines with modern new ones would make best use of wind potential in the state.

About 800 MW of the turbines in Tamil Nadu's best wind sites have come up before 2002. They need to be replaced with modern windmills. But repowering is a complicated issue. The first issue is micrositing norm of 5DX7D. According to this, the distance between two windmills in a single row should not be less than five times the diameter of the bigger rotor, and the distance between two rows should not be less than seven times the diameter of the rotor. This means all the windmill owners within a plot have to agree for repowering.

Most of the wind turbines have power purchase agreements signed at different times with the TNEB. Developers would need a no-objection certificate from the TNEB and pay infrastructure development charges once again. Despite this, the connection will not be considered new because the plot is the same.

This means the developer will be paid old tariff of ₹ 2.75/kWh as per Preferential Tariff order issued by the Tamil Nadu Energy Regulatory Commission for wind mill commissioned prior to 15 June 2006. The current tariff is ₹ 3.51/kWh for wind turbines installed after 31 July 2012. This does not make sense, say developers.

A local body's way

A Tamil Nadu Panchayat invests in wind energy

Awareness about wind power is very high in Tamil Nadu

Odanthurai Panchayat in Tamil Nadu's Coimbatore district had a taste of green energy back in 1996 when it installed solar street lighting. So when its ever-increasing population required bigger energy plans, it could take the next step in 2006: invest in a wind mill, even though this was not something panchayats are known to do.

Odanthurai could do it because of three reasons. One, its president had an exposure to developments in the renewable energy sector through energy fairs and training programmes. Two, government advisers readily guided it on the use of renewable energy. Three, the Tamil Nadu Electricity Board offered power banking option. The major drive towards renewable energy happened between 2001 and 2009, under the leadership of its panchayat president, Rangaswamy Shanmugam.

Odanthurai bought a 350 kW windmill from a Suzlon wind farm, 140 km from the panchayat, for ₹1.55 crore. It pooled some money and loaned the rest from a bank

Odanthurai is located close to the wind farm regions of Tamil Nadu. Shanmugam decided to take advantage of this. He formed a committee consisting of panchayat members and advisers from the government to advise on utilisation of solar and wind energy on a large scale.

The panchayat committee initially planned to install a hybrid system of solar and wind energy because a government scheme provided 90 per cent subsidy to the hybrid system. As the system was withdrawn, the panchayat decided to invest in wind mill.

Wind power company Suzlon had built a wind farm near Maivadi, 140 km from Odanthurai. In India's wind farm regime, turbine manufacturers take care of all aspects of wind farm development —starting from land acquisition, commissioning to operations and maintenance.

Willing bank, enterprising borrowers

Odanthurai panchayat purchased one of Suzlon's windmills of 350 kW capacity. It

The panchayat estimated it would repay the loan in six-seven years by selling electricity and earn a cool ₹ 6.5 lakh a year after repayment

ODANTHURAI PANCHAYAT WINDMILL FACTS

Panchayat	Odanthurai panchayat located near to Mettupalayam town in Karamadai block of Coimbatore city. It is about 40 kilometers north of city
Wind mill	In 2006, panchayat purchased a 350 kW wind turbine in Maivadi (140 kilometres from Odanthurai) developed by Suzlon
Concept behind investment	Wind turbine would feed power to the grid. Panchayat would avail banking and net metering facility provided by TNEB. Panchayat could meet their electricity requirement through this facility and earn revenue from excess power sold to the grid
ECONOMICS	
Cost of wind turbine	₹1.55 crores
Source of fund	₹40 lakhs from panchayat savings. ₹1.15 crore through a commercial loan from Central Bank of India at 8.5% interest
Repayment of loan	Wind turbine can produce 6.75 lakh units a year. This is sold at ₹2.90 to TNEB. The total revenue amounts to ₹19.575 lakhs. Revenues from the sale of electricity produced in the period 2006-2013 directly went to bank as repayment of loan
Post loan repayment	Panchayat self electricity requirement 4.5 lakh units/year. Remaining 2.25 lakhs units of power sold to the board at ₹2.90 generating revenue of ₹6.525 lakh rupees a year

Source: CSE visit to Odanthurai and Maivadi

The windmill transformer house of Odanthurai Panchayat

cost ₹1.55 crore. The panchayat pooled in ₹40 lakh. The rest was obtained as a commercial loan from the Central bank of India. The loan is paid from the earnings from sale of electricity to the Tamil Nadu Electricity Board board.

The panchayat's windmill produces about 0.67 million units of electricity a year. This power is purchased by the electricity board at ₹2.90 per unit. So the revenue generated from the sale of power is about ₹19.6 lakh per annum.

The state electricity board allows banking of power produced by wind mill. The power produced by wind mills is fed to the grid and is credited to the power producer's account, which can be availed later. Hence the Odanthurai panchayat can avail their banked power as per their requirement. The remaining unutilised power can be sold to the grid. The panchayat estimated it would repay the loan in six-seven years. After paying back the loan, Odanthurai Panchayat could earn close to ₹8 lakh per year after meeting its own public electricity requirements.

Today, Odanthurai is a role model of self-sustained development, attracting the attention of policy makers and renewable energy enthusiasts. But it is a model yet to emulated by others.

3

SMALL HYDRO POWER

SMALL HYDROPOWER

Need for environmental assessment, regulations

1. Introduction

Small hydropower plants (SHP) are the oldest form of harnessing power in India. The first SHP installed was a 130 kW plant at Darjeeling in 1897. A few other plants such as Shivasundaram in Mysore (2 MW, 1902), Galgoi in Mussoorie (3 MW, 1907), and Chaba (1.75 MW, 1914) and Jubbal (50 kW, 1930) near Shimla are reported to be still functioning.[1] However, after independence (and till very recently), India's main thrust had been on large hydropower. But with growing resistance from people who get displaced from inundated areas, the attention has shifted towards SHP using run-of-the-river (ROR) design as well as towards canal-based projects.

There is no globally acceptable definition of SHP. Different countries have defined different capacity limits for SHP. SHPs in developed nations have a range of 1.5 to 20 megawatts (MW) whereas the capacity of such plants in developing nations varies between 25 MW to 50 MW (see figure 1: Capacity limit for SHP). In India, hydropower plants with capacity of less than 25 MW are considered SHP. Interestingly, hydropower projects with capacity up to only 25 MW are considered renewable power source in India; there is no justification available why hydropower projects more than 25 MW are not considered renewable.

The Ministry of New and Renewable Energy (MNRE) estimates the potential of SHP to be about 19,750 MW in 6,474 sites, spread across the country. Arunachal Pradesh, Chhattisgarh, Himachal Pradesh, Jammu and Kashmir, Karnataka and Uttarakhand have the maximum potential. As of

FIGURE 1: CAPACITY LIMIT FOR SHP (MW)

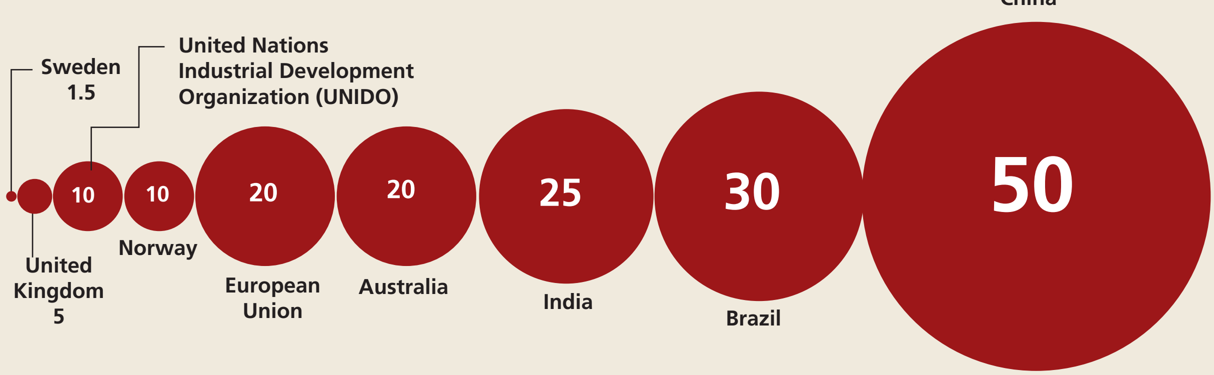
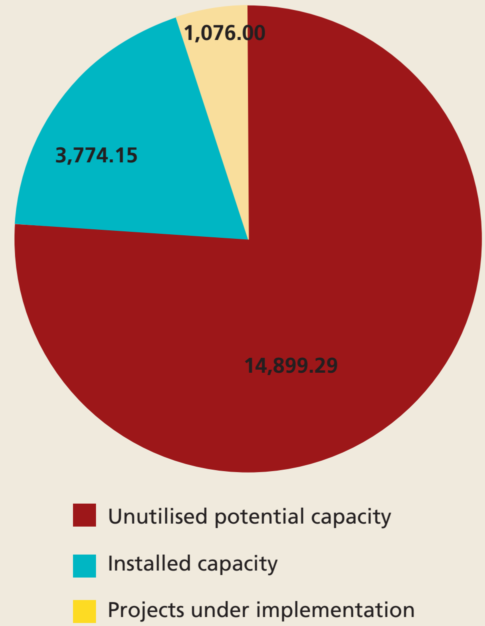


FIGURE 2: SHP IN INDIA (MW)



Source: Ministry of New and Renewable Energy

January 2014, the installed capacity of SHP was 3,774.15 MW and projects of another 1,076 MW were under different stages of implementation (see figure 2: SHP in India).[2]

Power generation from SHP is cheaper compared to several other renewable sources and such power can be easily connected to the grid. SHP can also be implemented as a standalone generator with a distribution system to provide electricity to people in remote and hilly locations where grid extension is techno-economically not feasible. SHP, however, has high environmental impacts compared to other renewable sources. The impacts which are perceived to be of critical importance are ecological (on aquatic flora and fauna), physical (on water quality, sediment carrying capacity, erosion, groundwater quality and recharge, soil and geology), and human–induced (such as interference with drinking and agriculture water availability, solid waste generation and socio-economic factors).[3]

The versatility of SHP, grid connected or based on remote electrification, and the low cost of generation makes it a potentially useful source of power in India

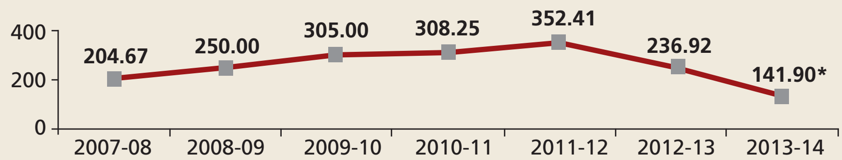
In the past few years, the environmental impacts of SHP have come under greater scrutiny from government agencies, judiciary and NGOs from across the country.

In response to a public interest petition filed by Western Ghats Environment Forum, which questioned the decision of the government to set up 137 SHP at various places in Western Ghats in Karnataka's Uttara Kannada district, the state's High Court in April, 2011 directed the projects in question to stop work till further orders.[4] In early 2013, the Karnataka High Court put a blanket ban on the construction of new SHPs in the Western Ghats.[5]

In Uttarakhand, the debate on the environmental impacts of hydropower development has led to setting-up of an inter-ministerial group (IMG) by the Ministry of Environment and Forests (MoEF) to look into issues related to ecological flows in the Ganga (See: For a healthy river). Ecological flow is the minimum water flow that should be released from hydropower projects in the river to maintain the ecosystems and sustain livelihoods dependent on the river. Uttarakhand proposes to setup 69 hydropower projects with a capacity of 9,020.3 MW on the Bhagirathi and Alaknanda basins — the two main tributaries of the Ganga in Uttarakhand. MoEF has also declared an eco-sensitive zone in Uttarkashi district along the 100-km stretch of Bhagirathi River where no hydropower plants would be allowed.

The debate on the ecological impacts of hydropower was further accentuated by the Uttarakhand floods of June 2013. In August 2013, the Supreme Court directed MoEF to constitute an expert body to conduct a detailed study as to whether hydroelectric power projects, existing and under construction, have contributed to environmental

FIGURE 3: SHP INSTALLATION IN INDIA (MW)



** Installed till January 2014* *Source: Ministry of New and Renewable Energy*

degradation in Uttarakhand. The expert body was also mandated to analyse if hydroelectricity projects in Uttarakhand contributed to the June 2013 flood tragedy in the state. The expert body's report is awaited.

The development of SHP has suffered during 2013-14 because of various reasons including environmental issues, policy uncertainty, delays in project clearances and grid and power evacuation issues. In 2011-12, about 352 MW SHP was installed; in the first ten months of 2013-14, only 142 MW was installed (see figure 3: SHP installation in India).

India needs to look at SHPs afresh. There is an urgent need to develop a holistic policy that addresses financial viability of SHPs and sets environmental standards and norms for them, while also promoting the use of such hydropower for energy access.

Although MNRE provides subsidies for development of small hydropower, the responsibility to drive growth is entirely that of state governments

2. Policies and subsidies

Hydropower development in India has been primarily promoted by government investments. But in the past 10 years or so, both states and the centre have encouraged private sector investment. Encouragement to SHP has been in the form of capital subsidies and assured feed-in-tariff. Because SHP is considered a renewable source of energy, it does not need to go through mandatory environmental clearances and the Environmental Impact Assessment (EIA) process.

I. Central government

Responsibility for hydropower development in India has been divided amongst two central ministries. Large hydropower (more than 25 MW) is handled by the Ministry of Power whereas SHP is handled by MNRE.

MNRE encourages SHP development in both public and private sectors and financial subsidies in almost equal measure are provided to both grid-interactive and decentralised projects: ₹ 1.2 crores for the first MW and ₹ 20 lakhs for subsequent MW for plants set up in states other than Jammu and Kashmir, Himachal Pradesh and those in the country's north east.[6] The latter will receive higher subsidy of ₹ 2 crores for the first and ₹30 lakhs additional for subsequent MW of small hydro installation. This capital subsidy will be disbursed in two installments, the first after purchase of electro-mechanical equipment and the next after the project is commissioned.[7]

The exemption from EIA means SHP projects in India are being constructed without any detailed environmental assessment. India also does not have a policy or guidelines for ecological flow for hydropower projects.

MNRE, as a promoter agency, has not put out any policy or guidelines for managing the environmental impacts of SHP. In October 2013, MNRE released a report, 'Developmental Impact and Sustainable Governance Aspects of Renewable Energy Projects'. The report discusses the environmental and socio-economic impacts of renewable energy projects in India and recommends steps to be undertaken for its sustainable development. However the report is silent on the issue of SHP.[8]

II. States Policies

Twenty-four states have policies to encourage private sector involvement in SHP (see table: State policies for small hydro). Most states have given incentives, over and above those given by the central government, to promote SHP. However, very few state government have looked at the environmental issues related to SHP and mandated green norms or guidelines.

Himachal Pradesh (HP)

Himachal Pradesh and Karnataka are the leaders in SHP deployment

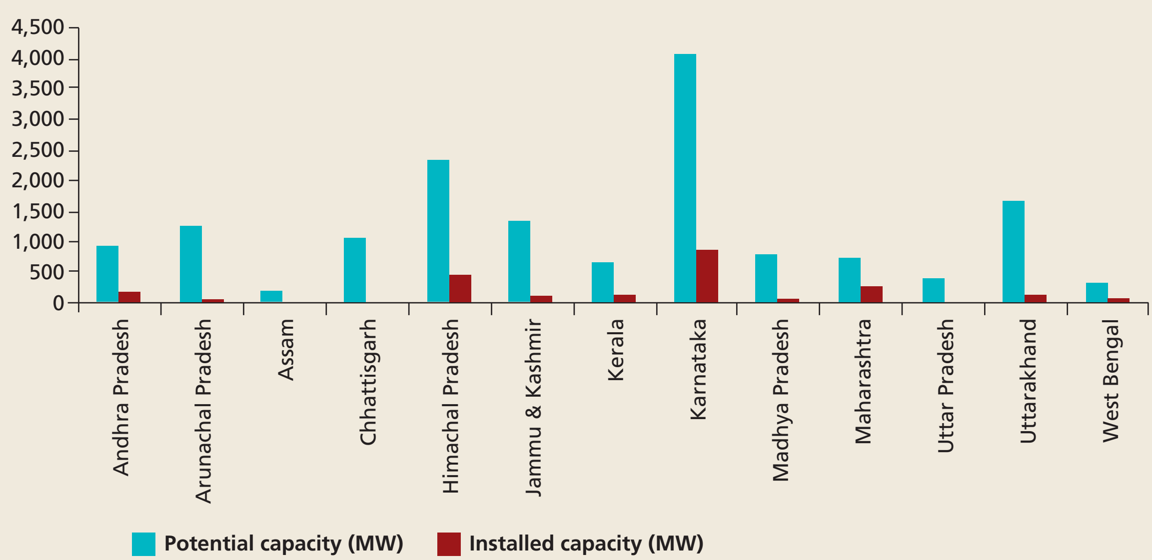
HP has a potential of 2,398 MW in 531 sites, but only quarter of that has been utilised as of March 2013. The ₹ 2.50 per kwh tariff offered by the state is one of lowest tariff for SHP in India. Projects lower than 2 MW capacity are reserved for development by residents of the state. Also, no independent power producer is allowed to have more than three projects. Himachal is the only state with norms for minimum ecological flow:15 per cent of the average of the water flow in the three leanest months (anytime between October and February).[9] However, this ecological flow norm has been criticised as too low to maintain proper ecological balance in the river.[10]

Karnataka

Karnataka with an untapped potential of 3,177 MW spread over 694 sites has the highest SHP potential in the country. Sixty-five projects worth 201 MW are currently under implementation.[11] The Karnataka electricity regulatory commission has set SHP tariff at ₹ 3.40 per kWh for a 10-year period from the date of signing the power purchase agreement (PPA).[12]

Karnataka Renewable Energy Policy (KREP) aimed to add 4,200 MW by 2014 of which 600 MW was dedicated to SHPs, requiring ₹ 2,700 crores of investment.[13]

FIGURE 4: STATES WITH POTENTIAL FOR SHP DEVELOPMENT



Source: Ministry of new and renewable energy annual report 2012-13

Karnataka Renewable energy Development Limited (KREDL) had to identify potential sites for canal based projects and then offer them for development under Public Private Partnerships following Build Own Operate Transfer mechanism.

KREP recognises the environmental impact of SHP projects and states that only projects with capacity less than 5 MW will be permitted in Western Ghats regions/forest areas. The Karnataka Renewable Energy Policy 2009-14 further says: "Mini hydro project proposals which do not involve diversion of the water flow resulting in drying up the stream/river stretch will be considered for development." But the policy document does not mention regulating ecological water flows.

There has been a spanner in SHP deployment in Karnataka. Many projects violated environmental norms and project development has been stalled following a high court order dated February 20, 2013.[14]

Uttarakhand

The state boasts of a large untapped potential of about 1,500 MW of SHP. Its renewable energy policy released in 2008 aimed to achieve 1,000 MW of electricity from renewable sources out of which 600 MW were to be achieved through SHP.[15] Uttarakhand, like Himachal Pradesh, has a clause stating that SHP up to 5 MW of capacity has to be developed by residents of the state only. It also has a clause stating no developer shall be allowed to have more than three projects.

Currently, there is no regulation in Uttarakhand regarding minimum ecological flow for SHP as well as large hydro projects. There is a general understanding that 10 per cent of the water flow calculated during the lean period should be left in the river stream at the time of the project design and approval, but adherence to this rule is questionable as there is nothing in writing.

Uttarakhand, one of the leaders in small hydropower deployment, has no regulation stipulating ecological flows. There is an unstated understanding that 10 per cent of water flow, calculated in the lean period, be left aside at the time of project design. However, developers very often go back on this understanding

Jammu & Kashmir (J&K)

J&K has almost 1,500 MW of SHP potential but has developed around 150 MW only. The state released a "Policy for Development of Micro/ Mini Hydro Power Projects" in 2011. The state has an extensive network of canals and streams, which its government wants to tap by promoting SHP through a bunch of incentives: assistance in identifying sites, open access and priority dispatch to the grid, land on 40 years of lease at premium of ₹ 1 per square meter, 10 per cent subsidy on capital investment and 3 per cent subsidy on term loan interest. However, such encouragement is only for plants with capacity equal and less than 2 MW.

Recently, the government floated tenders for 23 SHP projects in seven districts of the state with a total capacity of 35.7 MW.[16] J&K State Hydroelectric Projects Development Policy, 2011 considered development of plants with capacities ranging from 2MW to 100 MW separately, but is silent on any environmental norms or ecological flow regulations.[17]

Chhattisgarh

Chhattisgarh has an installed capacity of just 27 MW but has an untapped potential of 1,100 MW. The state gives several incentives to promote non-conventional energy such as public private partnership, open access, land leasing facility and bunch of financial incentives to entrepreneurs interested in setting up renewable energy projects. Its policy, however, is silent on environmental norms or ecological flow regulations.

STATE POLICIES FOR SMALL HYDRO

States	Sale of Power and Tariff	Water Royalty	Incentives	Ecological Flow Regulations
Arunachal Pradesh	₹ 2.09/kwh is the tariff for 2013-14 fixed by Arunachal Pradesh State Electricity Regulation Commission. The producers can sell power to third parties through a PPA 10 paise lower than the tariff	5-10 per cent of power generation is to be supplied to the state as free power	State government will allow 50 per cent share of Carbon Credit under CDM Tribal entrepreneurs, with projects up to 5 MW capacity, are exempted from supplying free power to the state government	There is no e-flow norm in the state hydro policy. But, it says that the developer needs to pay an amount at the rate of 1 paise per unit of power sold to the state government for raising local area development fund
Chhattisgarh	The state electricity board will buy surplus power @ ₹ 2.25 per unit after captive consumption or sale to third party		No electricity duty payable for 5 years CREDA may cancel the allotment of site in case of non execution of project within time limit set	There is no e-flow norm in the state policy
Himachal Pradesh (Up to 5 MW)	HP state electricity board (HPSEB) to purchase power @ ₹ 2.50 per unit Third party sale within the state is allowed where cost of generation is above ₹ 2.50 per unit	No royalty for plants up to 5 MW for first 12 years, 12 per cent for next 18 years and beyond at 18 per cent of the power generation to be given for sale within the state	As per MNRE/HP government For new projects - Upfront premium exempted for projects up to 2 MW Above 2 MW and up to 5 MW - ₹ 45,000/- per MW with ceiling of ₹ 75,000/-	Minimum flow of 15 per cent of the average of the water flow in the three leanest months for all small hydro projects
Himachal Pradesh (Above 5 MW)	Developers are free to sell power on merchant tariff rates State government/HPSEB to have right of first refusal on sale	12 per cent of power generation to be given to the state for first 12 years of operation for free, 18 per cent for next 18 years and 30 per cent	Government land if required, for power projects shall be allotted on lease for 40 years @ premium of ₹ 1 per sq. m	
Jammu & Kashmir	Open access and priority dispatch of power to the grid	Exempted for first 10 years After 10 years, 12 per cent of power should be free to sell to the state	Micro projects exempted from income tax No entry tax on power generation, transmission equipment and building material for projects	The policy is silent on any environmental norms or ecological flow

Continued…

			10 per cent capital subsidy for plants of less than 2 MW capacity	
Uttarakhand	Projects allocated on the basis of bidding on tariffs	Micro and mini projects are exempted from all royalties	No entry tax on generation, transmission equipment & building materials for project	Although specified nowhere, projects are asked to leave 10 per cent of the lean flow in the river stream
	Uttarakhand Power Corporation Limited (UPCL) have the first right to purchase produced power	SHPs have to pay 18 per cent of the electricity generated as royalty from the 16th year of operation		
		Sale to other Parties, 12 per cent of net Energy wheeled		
Karnataka	₹ 3.40 per kWh for the first 10 years	The state government has waived the levy of water royalty on small hydro projects with a generating capacity up to 20 MW	Exempted electricity tax for a period of 5 years to captive consumers	There is no mention of any regulation on ecological flows. However, the Karnataka Renewable Energy Policy 2009-14 says: "The Mini Hydro Project proposals which do not involve diversion of the water flow resulting in drying up the stream/river stretch will be considered for development."
			Issued orders exempting non-conventional energy projects under Sec. 109 of Land Reforms Act for the purpose of acquiring lands through Karnataka Industrial Areas Development Board	
			Extended the option of selling power to third party	

Source: Compiled from all states' SERC Tariff Guidelines, State Hydro policy, MNRE Website and IREDA

Arunachal Pradesh

The state released its SHP Policy on January 24, 2008 to encourage private sector participation in SHP generation. The policy document suggested allocation of projects to the private developers on Build Own Operate Transfer basis for a period of 50 years. The policy has a clause requiring developers to finance and execute relief and rehabilitation.

The state has 1,300 MW of SHP potential out of which only 100 MW has been tapped so far.

In a speech in Arunachal Pradesh in 2008, the Prime Minister pledged a package of ₹ 550 crores to electrify villages on the border of the state.[18] Till December 2012, out of the 1483 un-electrified villages in the state, only 425 have been electrified through SHP.

3. Drivers and Barriers: Economics and Environment

I. Reducing incentives and increasing risks

SHP is an attractive investment for developers due to several reasons. It is a proven technology with high capacity utilisation factor—45 per cent in Himachal Pradesh, Uttarakhand and North Eastern States and 30 per cent in other states — as compared to other renewable energy sources. It also has a long operating lifetime of 35 years and beyond—it scores over other renewable technologies in this respect too.[19] Moreover, levelised cost of energy (LCOE) of SHP is also significantly lower, compared to many competing technologies like solar, wind and thermal coal.[20] Then there is capital subsidy and other incentives offered by the state governments. These reasons propelled an average annual growth of 10.5 per cent in SHP installations between 2006 and 2012. About 360 projects were installed during these seven years–on an average about one SHP project every week *(see figure 5: Growth in capacity and numbers).*

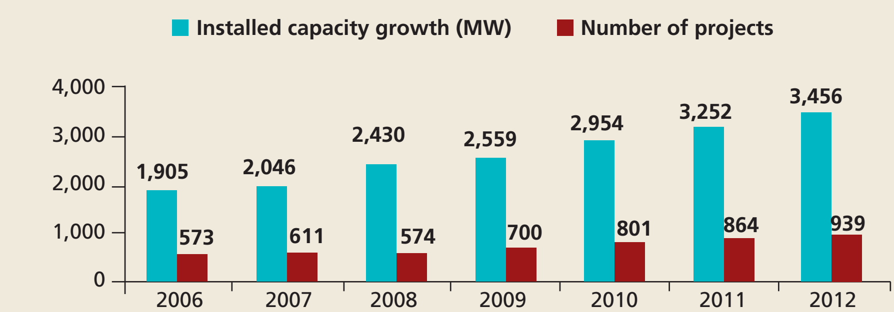
However, the trend has reversed in the past one year. From April 2013 to January 2014 only 142 MW worth of SHP was installed. The total SHP investment was merely US $0.6 billion out of the total of US $6.5 billion invested in renewable energy in 2012.[21] Developers attribute the slide to political uncertainty, policy dilemma, delay in getting project clearances, environmental issues, problems in grid interconnectivity, power evacuation issues, and low feed-in-tariff rates offered by many states. Non-availability of sufficient hydrological data is another hindrance in taking investment decisions on SHP projects. Flow figures are usually outdated and based on estimates rather than any actual long-term measurements.

Despite having good potential for small hydropower, Jammu and Kashmir and Chhattisgarh have some way to go in developing this renewable energy

i. Bureaucratic holdup

Though SHP is the cheapest in terms of LCOE, its gestation period is longer compared to other renewable sources like solar and wind. A SHP plant can be constructed in 30 to 36 months where the pre-commissioning period lasts around 20-24 months. Procedures like feasibility studies, detailed project report, clearances from various government departments including gram panchayats villages near the project site delay SHP ventures significantly. While these clearances are important, lack of a clear timeline for these procedures hampers the growth of the sector. Developers complain that acquiring these clearances from various departments requires much effort and consumes a lot of time.

FIGURE 5: GROWTH IN CAPACITY AND NUMBERS



Source: Compiled from MNRE annual reports

One consultant working on SHP projects in Uttarakhand and Himachal Pradesh revealed on the condition of anonymity that even after getting clearances and no objection certificates, the panchayats and government departments refuse to acknowledge the same at a later date. In some instances, developers had to restart the procedure from scratch. He claims that these bureaucratic hassles are derailing the growth of SHP in the country.

However, the complaints of the villagers are opposite. Villagers affected by SHP projects in Uttarakhand, complaint that the pradhan (head of the panchayat) had given clearance without any consent from villagers—the headman is alleged to have been bribed.[22]

What is clear is that a time bound, transparent and accountable clearance system is urgently needed for the SHP sector.

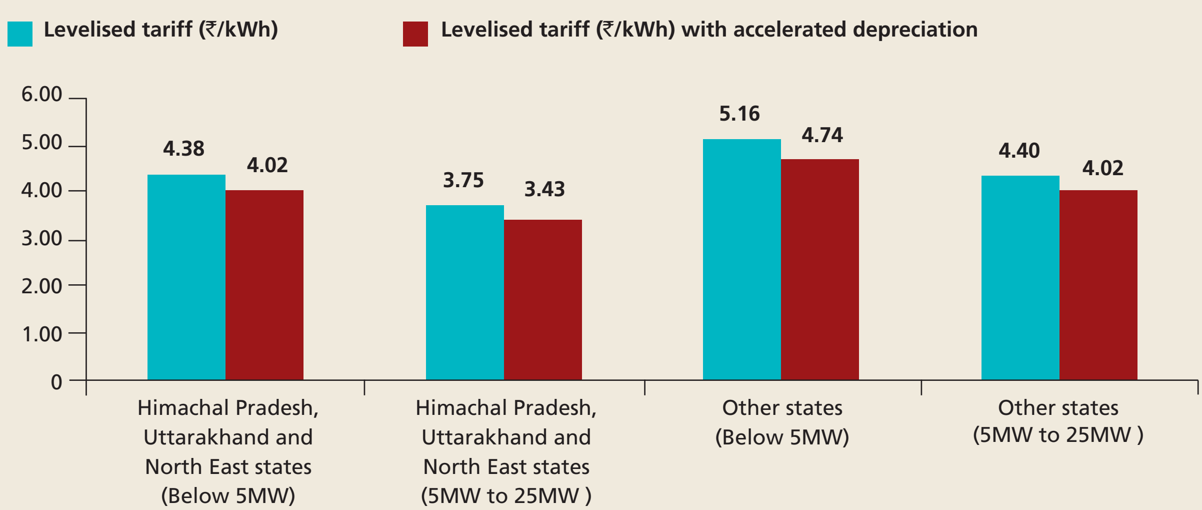
Procedural delays and reducing incentives are the major impediments in SHP development

ii. Costs and tariffs

It is a matter of concern that equipment prices for SHP are not going down due to the limited number of players in the sector. These players are relatively inexperienced entrepreneurs with limited investment capabilities.[23] Commercial banks and private investors are also reluctant to invest in the sector due to increasing risks. Governmental financial institutions namely, Indian Renewable Energy Development Agency (IREDA), Power Finance Corporation (PFC), Rural Electrification Corporation (REC) provide loans for setting up of SHP projects and there is no participation from private equity investors.[24] SHP sector is also exposed to the ceiling clause (The exposure ceiling limits would be 40 per cent of capital funds in the case of a borrower group for the power sector for lenders).[25] Like all power projects, financial health of the state electricity boards raises the level of uncertainty of SHP projects.

SHP developers also complain about the low tariffs offered by many states.[26] The Central Electricity Regulatory Commission (CERC) has decided two benchmark tariffs for hydro power plants, one for those with capacity less than 5 MW and the other for those

FIGURE 6: CERC LEVELISED TARIFF RATES FOR SHP



Source: CERC – RE tariff regulations FY 2013-14 with capacity higher than 5 MW, which are reasonably high (see figure 6: CERC levelised tariff rates for SHP); most of the state regulators allow tariffs way below these benchmark costs.[27] The viability of many projects suffer after fulfilling requirements of royalty charges and free power mandates imposed by states.

SHP has the option of selling power through Renewable Energy Certificate (REC) as well as availing Certified Emission Reduction (CERs) apart from the feed-in tariff. RECs and CERs are tradable certificates that help developers earn extra income. In November 2013, non-solar REC certificates traded at ₹ 1,500 per REC which is the floor price in the trading exchanges and the trading price has remained consistent since August 2012.[28] There are a total of 25 registered SHP projects with a capacity of 222.5 MW for REC mechanism.[29] However, low REC trading rates and noncompliance of the renewable purchase obligation (RPO) by states has meant that REC mechanism has failed to promote large scale uptake of SHP projects.

On similar lines, the Clean Development Mechanism (CDM) also has died because of oversupply of CERs in the market. The price of the CERs stood at Euro 0.35 on December 9, 2013.[30] Fifty nine SHP projects with a total capacity of 540.45 MW are registered under United Nations Framework Convention on Climate Change (UNFCCC) with a combined annual carbon dioxide emission reduction of 1.91 million tonnes.[31] Uncertainty of UNFCCC in the future has completely upset the CDM framework and CERs available are next to nothing for SHP developers.

SHP projects can have major ecological impacts, still they are not required to do an Environmental Impact Assessment

II. Without environmental due-diligence

SHP plants have been viewed as environmentally benign, and are categorised by MNRE as renewable technology.[32] As against coal based thermal power, SHP has no carbon dioxide emission, its fuel source is infinite and is available for free of cost. Water pollution from SHP is also very minimal and largely occurs only during the construction phase. Rehabilitation and resettlement issues related to SHP are also small, compared to large hydro projects.

However, SHP can have major impacts on the local environment. As all renewable energy projects are exempted from EIA requirement in India, not many studies have been done to assess the environmental impact from SHP: either on a single project basis or on cumulative projects basis.[33]

SHP plants can have major impacts on the river ecology by disrupting the development and growth of aquatic flora and fauna, by impacting water quality and sediment carrying capacity of the river, by interfering with drinking and agriculture water availability, and by polluting water through improper solid waste generation.

SHP plants often re-route water through pipelines and tunnels to increase pressure and remove silt, leaving long stretches of a river dry. A single SHP plant has a relatively less impact on the surrounding area. However, multiple SHP plants are now being constructed in cascade design on river basins across the country. At least 44 projects are planned on Karnataka's Nethravati river and its tributaries.[34] Uttarakhand's Alaknanda and Bhagirathi basins have 69 hydropower projects under operation, construction or development phases here. These include 40 SHP projects.[35] With multiple projects on the same tributary, a river can run dry for many kilometres with only intermittent ponds behind dams before the water goes into a diverting tunnel and penstock. This practically kills a river.[36] For example, Kaliganga I (4 MW) and Kaliganga II (6 MW), in Uttarakhand, use 400 m and 2 km tunnels respectively. The desilting tank of Kalinganga

SHP AND RURAL ELECTRIFICATION

SHP can provide cheap power for rural electrification with excellent flexibility in operation due to quick up and down time. This advantage associated with SHP make it suitable for lending support to the local grid at peak loads as well as for stand-alone applications in isolated remote locations. Therefore promotion of SHP offers a practical solution to the issues of inadequate, poor and unreliable power supply in rural areas.

According to paper by Cust, Singh and Neuhoff[1], small hydro can supply power for rural electrification at ₹3-6 per kWh. For example, projects like Ramgad and Karmi in Uttarakhand have achieved capacity utilisation of more than 50 per cent and provide 24 hour electricity to villages. There are many SHP projects in remote and hilly areas where the operation and maintenance (O&M) is carried out by the local community. The Amthaguda project in Odisha run by the non-profit Gram Vikas is one such venture. All villagers (67 households; 380 people) in the area were involved in constructing and managing the system. Such projects create a sense of responsibility and ownership amongst local people in rural areas.[2]

However, many such projects face problem of low capacity utilisation. This is mainly due to low demand from rural customers. This is evident in the Putsil hydropower project in Odisha. Here the demand is much lower than supply and the project is underutilised. But such underutilisation also provides opportunity for setting up rural enterprises like rice mill, chura mill, fabrication shop, ice making factory, cold storage, drinking water and filtration units. It also provides opportunities for irrigation amenities, educational institutes and entertainment activities.

Innovative designs of water mills are being developed for not just the mechanical purposes of milling of grain but also for electricity generation of 3-5 kW. MNRE provides various incentives for upgrading these water mills. Uttarakhand has installed over 300 such watermills. Nagaland has also set up micro-hydels for rural electrification.[3] Karnataka has installed around 700-800 pico-hydel plants.[4]

SHP becomes a practical solution to the inadequate, poor and unreliable power supply in rural areas

II project starts form tail-race of Kaliganga I. These projects have left a long stretch of the river dry.[37]

SHP projects are also coming up in dense forest areas like Western Ghats. In these areas, there is also the issue of linear intrusion. Linear intrusion refers to the impact of access roads and transmission lines to, and from, multiple SHPs, leading to forest fragmentation. It causes species isolation and disrupts movements of animals. Muck disposal regulation is another issue ignored by many developers. Dumping sites are often made available in forest areas; they should not be allowed in the first place.

All in all, there is an urgent need to look at the environmental impacts of SHP and institutionalise processes to minimise these impacts. The key regulatory reforms required include setting-up ecological flow standards, institutionalising EIA and framing clear guidelines for environmental management practices like muck-disposal and afforestation.

Way Forward

There is an urgent need to develop a holistic policy that takes care of financial viability of SHPs, sets environmental standards and norms for them and also facilitates their development to ensure the country's energy security.

- Capacity development is the key to success of scaling up the country's SHP programme. There is a need to train project developers, facilitators, financial institutions and community members. All this would lead to better understanding of issues pertaining to SHPs and encourage sustainable development.
- As far as environmental norms are concerned, there is no way of knowing a project's impacts unless there is no EIA requirement. Therefore, SHP plants above 1 MW capacity should be included under EIA notification 2006 as Category B projects.
- A minimum ecological flow rule should be set in place for all SHPs in case of canal based design. Centre for Science and Environment recommends that 50 per cent of the average flow calculated during the lean season and 30 per cent of the flow in monsoon should be set aside as ecological flow. This parameter should be publicly monitored. There should not be any dams for RoR projects.
- Forest diversion should be taken into consideration while approving SHP projects. Forest diversion due to road construction and linear intrusion should be factored while calculating total forest diversion. Forest clearance should be given only after ascertaining the total forest diversion by a project. There should be strict monitoring of the afforestation conditions required from the developer.
- Clearance given by the fisheries departments should not include the clause of introduction of invasive species into the river ecology.
- Developers should have muck disposal plans and state government should have rules for muck disposal by SHP projects. State Pollution Control Boards should monitor muck disposal by SHP developers.
- There should be an assessment of the infrastructure constructed for SHP projects. There have been cases where larger than required infrastructure has been created to increase power production capacity in future.
- Benefits from the projects must be shared with the local communities. These include first right to power, local employment and share of profits through community development activities.
- A carrying capacity study over a river basin should be undertaken for all the rivers before there is more hydropower development.

Given the recent floods in Uttarakhand, it has become indispensable that we assess environmental impacts of small hydropower

REPORTS FROM THE GROUND

Devious split

In Karnataka, project developers split large hydropower projects to take advantage of incentives for small hydropower ventures

The Rithwik hydropower plant (above) and AMR hydropower plant are shown by Greenko as one large project

Developers are passing off single projects as two smaller ones to avoid EIA and avail subsidy

In rainforests in Karnataka's Hassan district lie two mini hydel projects on the Nethravati river. They promised more than 37 megawatt (MW) electricity. This was till the state's high court saw through the deception of Maruthi Power Gen, the project developer.

The two projects in question, the 18.9 MW Hongadahalla project and 19 MW Yadakumari project, are actually one entity. The split was designed to avoid the Environmental Impact Assessment (EIA). When it comes to generating hydroelectricity, no clearance is required under the Environment (Protection) Act, 1986, if the installed capacity is less than 25 MW. Viewed as a single entity, Hongadahalla and Yadakumari projects require 8.38 hectares (ha) of forest land. Individually, they need 4.18 ha and 4.20 ha respectively. A project requiring more than 5 ha of forest land has to be scrutinised by the Forest Advisory Committee of the Union Ministry of Environment and Forests (MoEF). The split meant that Maruthi required clearance from the state government and a final clearance by the MoEF's regional office.

Besides in Karnataka, small hydro projects, or SHP, get a higher tariff—₹3.40 per kilowatt-hour (kWh)—compared to large hydropower project—₹2.30 per kWh. SHP developers are also eligible for subsidies from the Union Ministry of New and Renewable Energy (MNRE)—₹2 crore for the first MW and

₹20 lakh for every subsequent MW. This has led some of them to pass off one large project as two small ones.

Greenko's project on the Nethravati river in Dakshin Kannada district is another case in point. Greenko claims it has installed two projects: 24.75 MW AMR in Perla village and 24.75 MW Rithwik in Shamburi. But an investigation by Centre for Science and Environment researchers shows the two projects are actually one.

Circumventing rules

Bengaluru-based conservationist Sanjay Gubbi, one of Maruthi Power Gen project's critics, says, "Maruthi Power's project area is full of multi-layered forests, lofty trees, epiphytes, climbers, gushing streams. It is home to tigers, elephants, hornbills, the Travancore flying squirrel, the Nilgiri marten and many other wildlife species." Working in such an ecologically rich area would have required the company to comply with environmental regulations, but it decided otherwise.

Maruthi Power Gen secured forest clearances in 2009 with the then deputy conservator of forest of Hassan district stating that "no rare/endangered/unique

In Karnataka, a small hydro project can get a tariff of ₹3.40 per kilowatt-hour compared to ₹2.30 per kilowatt-hour for a large project

TWO PROJECTS ON PAPER, ONE ON GROUND

Project	Area	Stated capacity/ Actual capacity (MW)	Issue	Status
Pioneer Genco: Ranganathaswamy/ Shivasamudram	Cauvery basin, Shivasamudram village, Chamrajnagar district	24.75/49.5	Pioneer built a dam and diversion big enough for a 50-MW project but set up a 24.75-MW capacity turbine house. With an oversized dam and penstock, the company is now planning to build another project.	First plant is complete; second plant is pending approval with the State Board for Wildlife (as the plant project is less than 10 km from a wildlife sanctuary). Proponent contends they are two projects. The State Forest Department objects, stating the plant needs an EIA as it is one project.
Maruthi Power Gen: Yadakumari/ Hongadahalla	Nethravathi river, Yadakumari village, Hassan district	18.9/37.9	Maruthi Power Gen received approval to set up two projects in the same area, but it began building a joint dam and tunnel for both the projects and planned to have only separate turbine sheds.	The project is now stalled because of orders from the Karnataka high court to stop all projects in the forests of the Western Ghats. The project proponent wants to continue because of huge investments already made.
Greenko: AMR/Shamburi	Nethravati river, Bantwal, Perla (AMR) and Shamburi (Rithwik) villages, Dakshin Kannada district	24.75/49.5	Two separate dams were projected on paper, but on the ground it is just one dam that stretches over the entire Nethravati river (approximately 2 km), which has dried up on one side.	Both the projects have been commissioned and are operating.

Rejecting MNRE's position, the Karnataka High Court ruled that projects having same tunnel and same penstock built on the same river cannot be deemed as two different projects

species of flora and fauna are found in the entire block and (the land) is not prone to soil erosion"—this despite the fact that the region receives 6,000-8,000 millimetre of rainfall on an average every year. In the same area, the forest department has put up a board, with the picture of a tiger, which reads that the Western Ghats is one of the 18 biodiversity hot spots. The developers even managed to get an approval from MNRE stating that if the hydro projects are located in two different power houses, they are treated as two different projects.

The Karnataka high court, in contrast, ruled that projects having the same tunnel and same penstock built on the same river in the same forest cannot be deemed as two different projects. The Maruthi Power Gen project has now been stopped because of the court's stay on projects in the forests of Western Ghats.

In February 2013, the deputy conservator of forests filed another declaration for the project (the first declaration was filed in 2009). It included a long list on the region's biodiversity. The declaration stated "these forests include areas of unique flora and fauna with rich biological diversity and genetic resources, apart from many medicinal herbs and shrubs. Some of flora unique to the region are *Hapea wightiana*, *Holigama grahmi*, *Mesua ferrea*, *Cedrela toona*, *Machulus macrantha*, *Canarium strictum*, *Vateria indica*, *Garnecia indica*, *Flinkingera nodosa*, *Umboltia brunonis*. Some of the unique fauna include 91 species of birds of which 14 species are endemic to the Western Ghats, such as wood pigeon and Malabar Parakeet. The area is also home to Schedule-I mammals such as slender loris, tiger, lion-tailed macaque and flying squirrels."

The AMR hydropower plant from downstream

For a healthy river

Government committee sets environmental flow norms for hydel projects

The 330 MW Shrinagar hydropower project on Alaknanda river in Pauri district of Uttarakhand

In July 2010, the Centre commissioned a consortium of seven Indian Institutes of Technology to prepare a Ganga River Basin Management Plan. To facilitate the consortium's study, the Union Ministry of Environment and Forests formed an Inter-Ministerial Group (IMG) in December 2012, headed by B K Chaturvedi, member, Planning Commission. The group presented its recommendations to the ministry in March 2013 on regulations for hydropower development and environmental flow (e-flow) for hydropower plants.

The report analysed projects on the Alaknanda and Bhagirathi river basins. The report found that 69 projects with a total installed capacity of 9,020.30 MW have been proposed by various

The committee was set up to ensure that hydropower projects do not affect the health of rivers

TABLE 1: E-FLOW NORMS
recommended by IMG

Time of the year	e-flow recommended by IMG
October – November	25 per cent
April – May	25 per cent
June – September	20 per cent
December – March	30 per cent for average water discharge; 50 per cent for rivers that have discharge less than 5 per cent of the high season flow during winters

Source: Report of the Inter-Ministerial Group (IMG) on environmental flow regulations for Ganga, March 2013

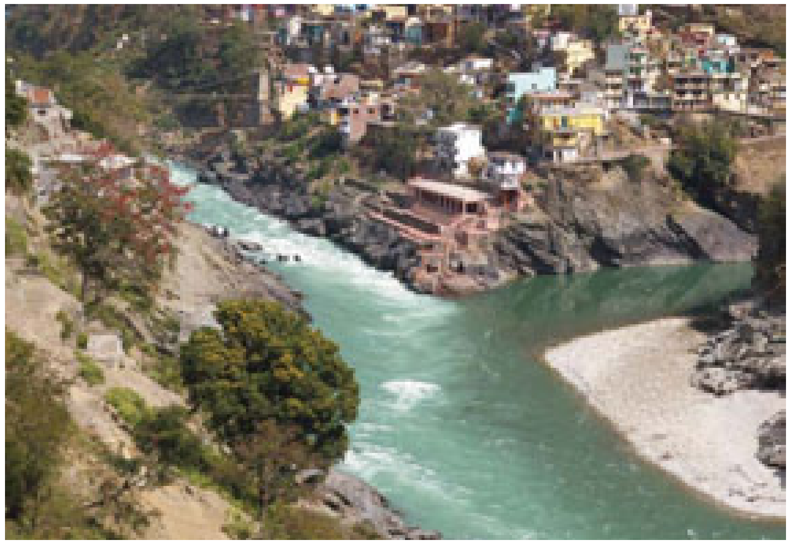
The IMG report stated that 69 hydropower projects have been proposed on the river basins of Alaknanda and Bhagirathi, both tributaries of the Ganga

TABLE 2: SHP PROJECTS COVERED IN IMG STUDY

River Basin	Name of the Project	Installed Capacity (in MW)	E-Flow Regulation
OPERATIONAL			
Bhagirathi	Pilangad	2.25	10% of the lean flow
	Agunda Thati	3.00	
	Bhilangana - Swasti	22.50	
	Bhilangana - Polyplex	24.00	
Alaknanda	Badrinath II	1.25	10% of the lean flow
	Jummagad	1.20	10% of the lean flow
	Birahi Ganga	7.20	10% of the lean flow
	Debal	5.00	
	Rajwakti	3.60	
	Rishiganga	13.20	
	Vanla	15.00	
	Urgam	3.00	10% of the lean flow
UNDER CONSTRUCTION			
Bhagirathi	Asiganga I	4.50	10% of the lean flow
	Asiganga II	4.50	10% of the lean flow
	Suwarigad	2.00	10% of the lean flow
	Limchagad	3.50	10% of the lean flow
	Kaldigad	9.00	10% of the lean flow
	Balganaga II	7.00	
	Jalandharigad	24.00	0.3 cumecs e-flow
	Jhalakod	12.50	15% of the lean flow
	Kakoragad	6.00	0.3 cumecs e-flow
	Kotbudhakedar	12.50	
	Siyangad	11.50	0.3 cumecs e-flow
Alaknanda	Kaliganga I	4.00	10% of the lean flow
	Kaliganga II	6.00	10% of the lean flow
	Madhyamaheshwar	15.00	10% of the lean flow
	Bhyunderganga	24.30	
	Birahiganga I	24.00	0.72 cumec e-flow
	Dewali	13.00	
	Kaliganga	5.00	
	Khiraoganga	4.00	
CLEARANCE STAGE			
Bhagirathi	Asiganga III	9.00	10% of the lean flow
	Bhilangana IIA	24.00	10% of the lean flow
Alaknanda	Melkhet	15.00	
	Rambara	24.00	
UNDER DEVELOPMENT			
Bhagirathi	Bhilangana IIB	24.00	
	Bhilangana IIC	21.00	
	Pilangad II	4.00	
Alaknanda	Birahiganga II	24.00	
	Urgam II	3.80	

developers on the Alaknanda and Bhagirathi river basins. The report concluded that if all the projects were to come to fruition, 81 per cent of the Bhagirathi river and 65 per cent of the Alaknanda river would be affected.

IMG analysed 29 large hydel plants (with a capacity above 25 MW) and 40 small hydel plants (capacity below 25 MW). Of the 40 SHPs—with a combined capacity of 442.3 MW—12 plants (101.2 MW) are operational, 19 (192.3 MW) are under construction and nine (148.8 MW) are in the process of attaining clearances.



Alaknanda and Bhagirathi confluence at Devprayag in Uttarakhand and take the name Ganga

Balanced approach

The committee's objective was two-fold: recognising the economic importance of the projects and ensuring that these projects do not affect the health of the rivers. The committee tried to ensure that the e-flow of rivers is maintained to fulfil the water needs of the people, especially during winter when the river flow is naturally less.

The report stresses on a balanced approach keeping in mind the economic, social and cultural needs of the people.

- The e-flow norms should be such that they do not increase the cost of power generation to the extent that electricity becomes unaffordable for the consumer, rendering hydropower projects unviable
- The e-flow norms should mimic the river's natural flow
- The e-flow norms should be adopted by various hydro projects and should not be limited by technology

Himachal Pradesh is the only state which has e-flow regulations. The Himachal Pradesh Pollution Control Board has set 15 per cent of the minimum flow observed in lean season as e-flow. In Uttarakhand, there is unwritten understanding that 10 per cent of the water flow calculated in the lean period be left aside during project design. Developers of some projects (see table 2: SHP projects covered in IMG study) do adhere to this understanding. However, since there is nothing in writing many go back on this understanding.

TABLE 3: IMPACT OF E-FLOWS
On tariff and power

River basin	Power loss (%)	Increase in levelised tariff (%)
Alaknanda	11-23	13-30
Bhagirathi	8-20	10-23

Source: IMG report on environmental flow regulations for Ganga, March 2013

IMG simplified the e-flow norms with minimum variations. The regulations would reduce power generation by eight to 23 per cent and increase the tariff (to maintain the return on investment) by 10 to 30 per cent (see table 3: Impact of e-flows). All IMG members did not agree on these recommendations. Sunita Narain, director general of Centre for Science and Environment and one of the members, proposed a 30 per cent e-flow for May to October and a 50 per cent e-flow for November to April, claiming that would be economically viable.

Himachal Pradesh is the only state which has e-flow regulations

Rejoicing in power

A micro hydel project in Odisha gets community support

Villagers in Putsil transport transmission lines for electricity

The 14 kilowatt micro hydel project in Putsil village meets the power demands of a remote village where the grid power is not feasible

In Putsil village in Odisha's Koraput district is a micro hydel project that uses water from the Kodramb stream, running close to the village. Kodramb is a tributary of the Karandi river. The stream provides water for paddy cultivation, the main agricultural activity of the local population.

The 14 kilowatt (kW) micro hydel project was commissioned in August 1999 by the Koraput-based Integrated Rural Development of Weaker Section in India (IRDWSI), a non-profit that helps the rural poor improve their livelihood options. The non-profit also identifies decentralised energy options for achieving development in remote regions.

Detailed project reports estimated a total power demand of 5.64 kW for the entire village (see table 1: Power demand). When the project was conceived, it was recognised that grid power will not reach this remote village. During a feasibility study, it was estimated that the demand for electricity would require a 12 kW micro hydel project for the first seven to eight years and a 20-25 kW project in the next 20.

Plant design

The project had to be designed to operate with the lowest stream flow to ensure year-round electricity supply. The dry season in the region extends from February to April. For the power plant design, a flow rate of 50 litres per second (l/s) was required, which would have affected irrigation during the dry season. The villagers deliberated the matter and concluded that they were over-irrigating their fields. They decided to let the power plant draw water at night, while continuing with their irrigation during the day. The discharge from the plant is diverted back into the stream via a tail-race channel.

Trained villagers

The power station is about a kilometre from the village and is operated by two trained villagers.

The plant operates for three hours in the morning and four hours in the evening. During this time, each household in the village receives electricity to suffice the household load of 60-70 Watt, which is transmitted to the village via a kilometre-long low-voltage transmission line laid underground.

Although the initial estimate of the project was ₹ 19,30,000, the actual cost turned out to be lesser (see table 2: Project cost). Funds for the project came from various sources. To promote ownership, the people of Putsil also contributed. Around 12.5 per cent of the project cost were borne by the villagers themselves who offered labour while the project was set up.

A worrying mismatch

The plant has been functioning since 2000. In its initial years, it generated only four to five per cent of its total capacity. "Consumption was low and the power plant was taking time to stabilise with the periodic water flow," says Benudhar Sutar, director, Desi Technology Solutions, the energy consultant which helped IRDWSI set up the project. However, after the third year of its installation, the plant's capacity utilisation factor improved to 15 per cent. This was because of the introduction of commercial loads. "As of today, the plant generates about 22 per cent of its rated capacity," Sutar adds. This means that over the past 14

The water diversion pipeline used in the project (top); assured electricity motivates children to study (below)

years, an average of nine per cent of the annual power generation has been dumped due to a mismatch in demand and supply (see table 3: Power generation).

Moreover, the plant generates when the flow of the stream is strong. This can be any time of the day. But the plant lacks a battery bank. So electricity generated during times of the day when demand is lean cannot be stored.

TABLE 1: POWER DEMAND

(a) Domestic demand	
3x20 W lamps per household	60 W
Provision for Radio/Cassette	10 W
Total demand by all 72 households (70 W x 72)	5040 W
(b) Street lighting	
15 lamps x 40 W	600 W
(c) Milling	
Grinding machinery	3000 W
Total night time power demand	5640 W
Total day time power demand	3000 W

ENERGY POVERTY STATUS IN ODISHA

Installed capacity (as on December 2013)
7,381.80 MW

Annual per capita electricity consumption (2011-12)
1,145.8 kWh

Total households
9,661,085

Unelectrified households
5,506,820

FOR LIGHTING

Households depending on kerosene
5,342,580

Households depending on solar energy
38,645

FOR COOKING

Households using firewood, crop residues, cow dung etc
8,656,332

Unelectrified villages
17,895

Source: Census 2011, Central Electricity Authority

The villagers recognise that they would need bulk cash to replace major components of the plant in a decade or two. They have started planting cash crops to raise funds

Operation and maintenance

The supplier of equipment for the plant provided training along with a set of tools to a select group of personnel from the village. Prior to the commissioning of the plant, all families in the village were educated about the project. They were given lessons on the judicious electricity use and also given lessons in caring for the plant.

Over the past 14 years, the annual maintenance expenditure of the plant has been ₹ 15,000, on average. The villagers saved ₹ 3 lakh in labour cost out of the total allocated cost of ₹ 13.5 lakh. There are three operators in the village who are on rotational duty for 10 days each in a month. They earn about ₹ 150 to ₹ 200 per month.

The villagers are aware of the bulk cash they would need after a decade or two to replace the major components of the hydro plant. This has prompted them to start saving—people in Putsil are planting cash crops to raise money. Moreover, to take care of recurring maintenance, the village residents have contributed to a savings account which now amounts to about ₹ 700,000.

TABLE 2: PROJECT COST (In ₹)

Feasibility Study	35,000
Civil Construction	3,50,000
Pen Stock	3,12,000
Turbine	70,500
Electronic Load Controller	2,60,000
Transmission Lines	2,57,000
Generator	49,000
Consultancy	1,31,000
Transport and Travel	1,60,000
Coordination	73,111
Total Cost	**1,697,611**

TABLE 3: POWER GENERATION (In kWh)

Year	Generation	Utilisation	Dump Load
2000	16,954	15,179	1,775
2001	15,729	14,300	1,429
2002	16,856	15,148	1,708
2003	15,239	14,230	1,009
2004	17,052	15,629	1,423
2005	23,450	16,560	6,890
2006	24,290	22,057	2,233
2007	24,710	24,066	644
2008	22,750	21,060	1,690
2009	23,590	21,720	1,870
2010	23,940	23,173	767
2011	24,430	23,055	1,375

High incentives

Women are the main beneficiaries of such rural electrification. Women no longer have to rush home from the fields to cook before dark. Kitchen appliances running with electricity have taken care of back-breaking work such as pounding and grinding of cereals. Villagers have also installed a 3-HP rice mill in the village.

Earlier, people used to go to bed by 7 pm to save on kerosene. Now they can attend to household chores at leisure, watch television at the village's community centre and also undertake other recreational activities. Children take interest in their studies as they no longer have to study by candlelight, the quality of cooking has improved. There has also been an increase in income-generating activities with the setting up of the rice mill. Most families now generate an additional income of ₹10,000-12,000 in a year.

For domestic use, electricity is supplied from 6 pm to 10 pm and from 3 am to 6 am. Electricity is again supplied from 6 am to 8 am to run the rice mill. The early morning power supply was demanded by the women so that they could complete their household chores before leaving for the field. During marriage, childbirth, serious illness and festivities, power is supplied as per requirement.

4

BIOMASS POWER

BIOMASS POWER

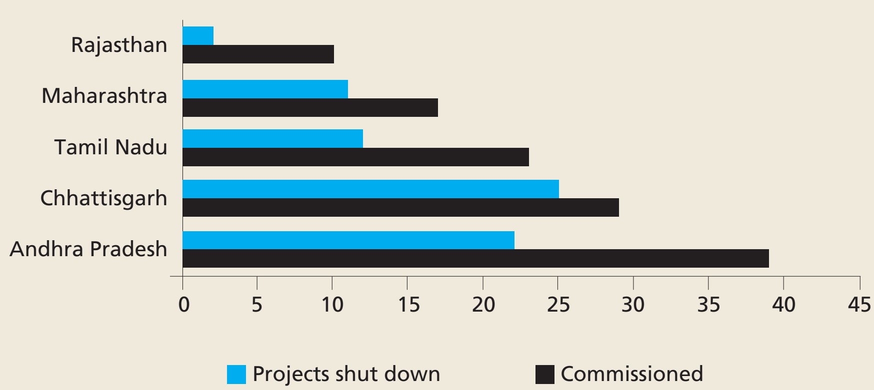
Transition from large to small

1. Introduction

The Ministry of New and Renewable Energy (MNRE) reckons that the over 500 million tonnes of agricultural and agro-industrial residues (collectively called biomass) generated every year in the country has energy potential equivalent to about 175 million tonnes of oil.[1] The ministry further estimates that at least 150–200 million tonnes of this biomass goes waste. This waste can generate 15,000–25,000 MW of electrical power at typically prevalent plant load factors.[2] A recent report from the Central Statistics Office estimates the potential of biomass power as 17,538 MW. The report also estimates that an additional 5,000 MW can be obtained from bagasse based cogeneration—sugar mills doubling up as power plants.[3] MNRE believes that more than 70,000 MW electricity can be generated from biomass grown on wastelands, road sides and on plantations along railway tracks.[4] In other words, the total electricity generation potential from biomass in India could amount to nearly 100,000 MW.

The installed capacity of grid-connected biomass power in the country—as of January 2014—is, however, only a tiny fraction of this potential: about

FIGURE 1: POOR STATE OF BIOMASS POWER PLANTS



Source: Information received from Indian Biomass Power Association

NATIONAL BIOENERGY MISSION

Taking cue from India's National Action Plan on Climate Change in 2008, MNRE has plans to initiate the a National Bioenergy Mission in association with state governments and other stakeholders to promote biomass related projects in the country.[1]

The ministry appointed a consultant, Dalkia Energy Services, to develop a road map for the commercial biomass projects, to chart out a way to utilise surplus agro-residues and develop energy plantations. The mission aims to increase the share of biomass power in the energy basket by creating right policy conditions for its diffusion across the country as quickly as possible. The suggested roadmap takes a two-phase approach with five years for each phase spanning the 12th and 13th Five Year Plans (2012- 2022). Phase I would be dedicated to policy and regulatory interventions. It will also identify wastelands in the states that can be dedicated for plantations. The second phase would aggressively create conditions for scaling up biomass energy facilities in the country.

The mission sets targets for scaling up biomass energy in the country. Its overall target is 20,000 MW of biomass projects by 2022. The plan presumes about 1,253 MW of biomass projects have been installed in the country. So the roadmap shows a target for 18,747 MW of biomass projects. Phase I aims to install 5,697 MW of projects and Phase II would develop 13,050 MW of biomass projects. These include various kinds of biomass projects like agro residues and waste, plantations, urban and industrial wastes and waste from dispersed systems. Dedicated plantations will be assigned for a capacity 5,625 MW of the projects.

OVERALL TARGETS FOR 2022 (IN MW)

Biomass	Independent Power Producers	Tail End	Off Grid	Cogeneration	Purified Gas	Thermal/ Cooking Purposes	Refrigeration	Total
Agro Residue/ Waste	5,100	2,550	400	2,300	0	0	0	10,350
Plantations	3,800	1,150	175	700	0	0	0	5,825
Urban/ Industrial Wastes	1,050	175	850	0	0	0	0	2,075
Wastes from Dispersed Systems	0	0	145	0	130	122	100	497
Total	**9,950**	**3,875**	**1,570**	**3,000**	**130**	**122**	**100**	**18,747**

Source: Anonymous (December 2011, Bio-energy Road Map, an initiative by MNRE, Bioenergy India Newsletter, Ministry of New & Renewable Energy and United Nations Development Programme for India

1,285 MW of biomass based power and another 2,513 MW of bagasse-based cogeneration.[5] Grid connected large-scale biomass power plants are facing serious problems in getting assured feedstock supply: rapid increase in prices, deteriorating quality and logistical issues related to regular supply of biomass to the plants have rendered large numbers of plants unviable. In Chhattisgarh, 25 of the 29 biomass plants have closed down. In Andhra Pradesh, 22 out of the 39 commissioned plants have shut down (see figure 1: Poor state of biomass power plants). In fact, it is estimated that as much as 60 per cent of all the grid-connected biomass plants are not operating.

Despite the failure of the grid-connected plants, MNRE proposed a National Bioenergy Mission in 2011 to ramp up biomass power generation by 20,000 MW by 2022. Out of this, 10,000 MW would be grid-connected (see box: National bioenergy mission). It plans to increase grid-connected biomass power by raising feedstock in plantations (see box: Issues with plantation). The mission also intends to push development in this sector through mandatory use of the renewable purchase obligations. These would be backed up with tariffs and generation-based policy incentives.[6] The mission has not yet been approved, but it has also not been shelved.

ISSUES WITH PLANTATION

MNRE has mooted plantations as a way out of the feedstock problem.[1] The ministry reckons 5,000 MW of power can be generated by using dedicated plantations on 2 million hectares (ha) of forest and non-forest land.[2] But does India have land for such plantations? And also, is plantation the best way to produce power?

The land efficiency of biomass projects is very poor. Making 2 million ha of land available to produce 5,000 MW of power would be both economically and socially inefficient In a thickly populated country like India (population density of 382 persons per sq. km). Solar power is much more land efficient. A solar power plant with a capacity equivalent to 5,000 MW biomass plant will only need about 100,000 ha—20 times less land.[3]

In addition, plantations are likely to be energy, water and chemical intensive (they will use fertilisers and pesticides), putting a question mark on the environmental sustainability of these projects.

In an ideal situation the CO_2 generated from the plantation-based biomass power station will be consumed by the greenery grown for future use in the station. So the net impact of CO_2 emissions, in such a situation, will be nil. However, this is not likely to happen because plantations are resource-intensive. They have issues pertaining to energy use, water use and use of fertilisers and pesticides—to grow feedstock for biomass projects. Agro-waste needs to be transported to biomass plants on a regular basis, generally by trucks running on diesel, a non-renewable polluting fuel resource. In reality then, a plantation-based biomass project is not likely to be carbon neutral.

In recent times, one project backed by a US-based company has acquired land for plantations dedicated to biomass power. The website of the energy major, Clenergen notes that the company has a sublease agreement for 5,000 acres (2,000 ha) in Valliyur, Tamil Nadu and another agreement to sublease for 4,000 acres (1,600 ha) near Tuticorin in the same state. The company intends to establish plantations that will support a 32 MW biomass power plant.[4] This would mean 113 ha of land per MW, less than MNRE's estimation of 400 hectare per MW, but a sizeable area nevertheless.

The International Institute for Environmental Development raised the issue of land acquisition for plantations in its briefing paper of 2011.[5] According to the paper, Clenergen had acquired about 11,500 ha of land, globally by 2011.[6]

Water is one of the key requirements for a successful plantation and an increase in plantations would increase demand for irrigation water in a region. Plantations will stress already water-scarce areas. They will draw away water resources from food crops towards fuel crops. Over-extraction of water could lead to further degradation of groundwater resources.

Meanwhile, the industry is increasingly getting disinterested in biomass power plants. The 12th Five Year Plan (FYP) envisages an addition of 400 MW in grid-connected biomass based power generation.[7] But as of January 2014, it has added only 120.5 MW. In fact in 2013-2014 (till January 31, 2014), only 22 MW was installed. So there are strong grounds to rethink the approach towards large-scale biomass plants.

2. Issues and challenges

I. Rising raw material prices

The biomass power sector in India is currently hamstrung by rising prices of agro-waste due to the rising demands of the sector itself. In the past few years, the price of biomass has increased substantially; in some cases by as much as 50 per cent (see table 1: Cost of biomass). Projects are closing down because developers cannot afford to run power plants at the feed-in-tariff allowed by the regulators. States are unwilling to revise their tariffs to countervail the rise in prices, developers claim.[8]

Rising demand from cement industry and brick-kilns is another reason for high agro-waste prices. Units in these industries have started replacing fuel like furnace oil and coal with biomass as the later is cheaper and there is not much difference in

TABLE 1: COST OF BIOMASS*

State	Type of fuel	2010	2012
Maharashtra	Rice husk	1600-1920	2800 – 3200
	Prosopis juliflora	1575-1695	2625 – 2825
	Groundnut shell	1620-1710	2700 – 2825
	Mung husk	1320-1380	2200 – 2300
	Coconut waste	720-810	1200 – 1350
Andhra Pradesh	Rice husk	1320-1380	2200 – 2300
	Maize shanks	1200-1320	2000 – 2200
	Prosopis juliflora	1140-1380	1900 – 2300
	Sawdust	900-1260	1500 – 2100
Rajasthan	Prosopis juliflora	1200-1500	2500 – 2600
	Mustard/ Cumin husk	1200-1320	2000 - 2200
Madhya Pradesh	Rice husk	1800-2100	3000 - 3500
	Maize shanks	1200-1320	2000 – 2200
	Groundnut shell	1620-1700	2700 – 2850
	Prosopis juliflora	1440-1500	2400 – 2500

** In ₹; Source: Information provided by MNRE and Indian Biomass Power Association*

Feed-in-tariffs allowed by state regulators have not kept pace with the rise in biomass prices. This has put developers of biomass plants under severe economic stress

calorific values compared to conventional fuel. A survey of biomass price and supply, commissioned by the Rajasthan Renewable Energy Corporation Ltd, shows that brick kilns are th biggest competitors to biomass power plants.[9]

The survey shows kiln owners were purchasing biomass at ₹2,000- ₹ 2,500 per tonne in 2010-11—cheaper than coal which cost ₹ 3,511-₹ 3,865 per tonne. Industry claims biomass prices have been rising by 30-40 per cent every year due to rising demand from biomass plants as well as cement and brick industries.

II. Reducing government subsidies

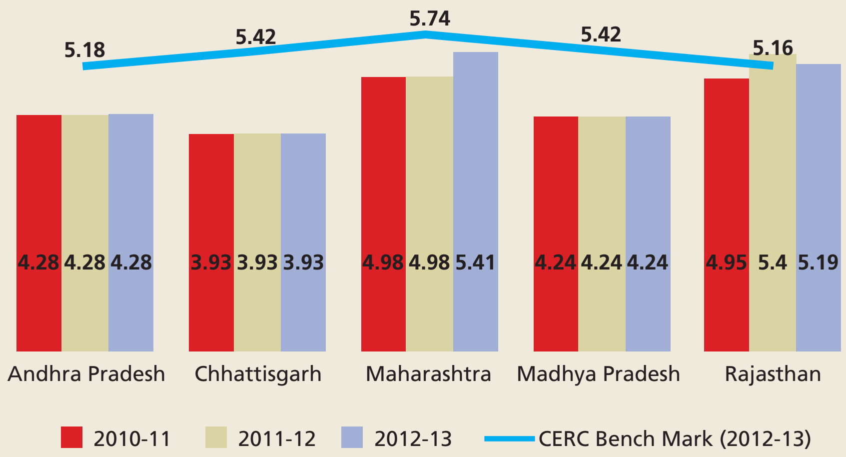
MNRE supported grid connected biomass power plant (combustion technology) through a capital subsidy scheme in the 11th FYP.[10] This subsidy along with preferential tariff given by different states led to installation of grid-connected plants during the plan period. However, MNRE has discontinued capital subsidies in the 12th plan.

The ministry now provides capital subsidy to only those biomass power plant that run on gasification technology and have a capacity limit of 2 MW. Grid- connected biomass gassifier projects that have an assured flow of feedstock and annual maintenance contract with supplier of equipments for five years receive a central assistance of ₹ 1.50 lakhs per 50 KW. The scheme also supports grid-connected boiler turbine generators projects for tail end generation. MNRE policy, therefore, has made a transition from large to small-scale grid-connected biomass power plants whose primary focus is on tail end generation.[11] The scheme has also given importance to off-grid distributed generation for rural electrification.

The preferential tariffs given by the states, however, do not reflect the increase in the biomass prices. The states also do not follow the Central Electricity Regulatory Commission's (CERC's) tariff guidelines; their tariffs are lower than the commission's

FIGURE 2: NOT FOLLOWING CERC

Biomass tariff fixed by states against CERC benchmark (₹ per kWh)



Source: Renewable Energy Regulatory Framework of MNRE and annual tariff orders of Central Electricity Regulatory Commission for Renewable Energy

benchmark (see figure 2: Not following CERC). Tariffs in Rajasthan, though, are closer to the benchmark and have been revised annually. This is one reason that plants in the state are doing somewhat better than those in Andhra Pradesh and Chhattisgarh.

3. Environmental and economical issues

In December 2009, the EIA notification was amended. The amendment required environmental clearances only from biomass plants with more than 15 MW capacity. Projects in the 15 to 20 MW range are considered category B projects. They are subject to jurisdiction of State Environment Impact Assessment Authorities. Plants above 20 MW are deemed category A projects; their EIA is handled by the Ministry of Environment and Forests.[12]

The 2009 amendment to the EIA notification allows use of coal, lignite or petroleum in biomass power projects; but the use of these fossil fuels should be limited to 15 per cent of the fuel-mix.[13] However, there is a real danger of biomass plants using more coal than allowed. In fact, over-use of coal in a biomass plant has already been reported in Raipur, Chhattisgarh

There are strong reasons for bringing biomass plants under the ambit of environmental regulations. Depending on its feedstock, a biomass plant may pollute air through particulate matter, nitrogen oxide and sulphur oxide from stacks. Currently, developers are expected to submit ambient air quality within a 10 km radius in various locations to measure impact.[15]

Storages with large amounts of agro-waste—for fuel-security—in plants are basically like large landfills. A plant that uses 600 tonnes of biomass everyday could have month's stored waste amounting to18,000 tonnes—basically, slowly decomposing biological matter. Unless properly managed, run-off of water from the waste, called leachate, can escape into groundwater or streams. This leachate could be high in pesticides, nitrogen, phosphorous biochemical oxygen demand, chemical oxygen demand, phenols, tannins/lignins and metals. All this can harm the ecosystem.

Biomass plants are allowed to mix 15 per cent coal, lignite or petroleum. But some plants are using fossil fuels far more than the permitted amount

Way Forward

The main challenge for biomass power projects is that increasing costs of biomass are not reflected in tariffs set by states. So project developers are unable to pay market prices for their feedstock. When biomass resources are not available locally, projects are unable to sustain their operations over a long period, while cement and brick kiln industries that use biomass as feedstock are able to purchase biomass at a higher price because it makes more economic sense to them. Promoting large-scale grid connected biomass projects by regularly increasing the tariff in line with increasing biomass prices, is not economically prudent. Cement and brick industries will muscle out biomass industry in the long run. However, small-scale biomass industry is largely dependent on locally produced biomass and not subject to price vagaries to a great extent. Therefore, the government should rethink the deployment of large-scale biomass projects and scale up the establishment of off-grid distributed generation and village electrification. Such plants are also viable option for grid-connected tail end generation.

The transition of MNRE's subsidy from large-scale grid connected biomass to small scale off-grid and tail end generation is a positive step. However, the scheme has failed to draw large scale institutional investment to the sector for several reasons. These include issues related to electricity distribution policy in rural areas, problems associated with tail end generation and grid connection, inadequacies of the feed-in-tariff mechanism for off-grid generation and lack of avenues for local skill development.

The transition from large-scale grid connected biomass projects to small-scale off-grid ventures should be backed by strong institutional and financial mechanisms

- **Electricity Distribution:** Though the Electricity Act, 2003 permits generation and distribution of electricity in un-electrified rural areas it is silent about distribution and feeding excess electricity back to the grid in electrified villages. The Act should be amended to correct this anomaly. The Rural Electrification Policy should have provision for electricity distribution through mini-grids in rural areas. These mini grids should be connected with the grid. Such interconnection will require development of appropriate codes and guidelines.
- **Tariff:** The feed-in-tariff mechanism or generation based incentives should be incorporated for grid-connected as well as for off-grid projects with mini-grids. These incentives should be subjected to periodic review by state regulators for adjustment against feedstock price.
- **Biomass:** Biomass is available only during harvesting period, usually this is about two to three months in a year for a single crop. Developers should encourage villagers to undertake multiple cropping. This will reduce the need to store biomass for a long time. Microbial activity makes storing biomass a difficult task and adds to operation and maintenance costs.
- **Coal blending:** State environmental authorities should regularly monitor if biomass plants are adhering to coal blending rules. They should appoint third party Independent Verification Agency (IVA) for such verification and regular reporting.
- **Environment:** Though biomass power plants below 15 MW capacities do not require environmental clearance, guidelines must be in place for disposal of wastes like *char* and contaminated water. Pollution control board should monitor *char* and water disposal in plants.
- **Institutional and financial support:** There is much sense in transition from large-scale grid connected biomass projects to small-scale biomass projects in electricity starved but biomass-rich rural India. But the approach should have strong institutional and financial backing.

REPORTS FROM THE GROUND

A profitable waste

Punjab farmers burn straw after harvest that causes pollution. It is time to exploit the potential of this agro-waste

PHOTOGRAPHS: MEETA AHLAWAT / CSE

Farmers following mechanised agriculture complain that rice straw is a major problem

Plumes of smoke arising from the fields is a common sight in Punjab during rice harvesting season. In the months of October-November, it almost asphyxiates anyone who ventures out of house, be it a village or city. The reason: paddy stubble burning.

Burning of rice straw remains emits pollutants such as carbon dioxide, methane, carbon monoxide, nitrogen oxide, sulphur-oxide and large amount of particulate matters, which adversely affect human health and the environment. In 2013, the magnitude of stubble burning was so high that it received international attention. The National Aeronautics and Space Administration (NASA) in the US released a satellite image showing large number of agriculture fields on fire in Punjab.

Farmers in the state complain that rice straw is a huge problem for them because they follow mechanised agriculture to increase farm worker productivity. "When you harvest rice by a combine harvester, it leaves a significant length of straw on the field," says Rajinder Kumar Sama, a farmer from Punjab's Abohar district. So the crop residues in combine-harvested fields are burnt.

Besides, explains Sarabjit Singh from Ghanaour village in Patiala district, both wheat and rice are long-duration crops. With a short period available between rice harvesting and wheat plantation, burning is the easiest and quickest way to get rid of rice straw.

Singh adds that increasing labour cost is another reason farmers prefer setting fire to their paddy fields after harvesting is over.

After China, India is the world's largest producer of paddy. The country produced 99 million tonnes of paddy with roughly 130 million tonnes of straw in 2012-13. Of this, about half was used as animal fodder. The rest was mostly burned in the fields, though a small amount was consumed by brick kilns, and paper and packaging industry. Despite such huge amounts of rice straw generation, farmers in the country are yet to realise the potential of this agro-waste in terms of manure and as a profitable raw material for various industries.

Where's the profit?

Sama says on an average one gets about two tonnes of rice straw per acre (0.4 hectare). "The combine harvester owner or operator charges an additional ₹850 per acre for harvesting the leftover portion which is of no use to us," says Sama. It cannot be fed to the cattle. Also, the thick and sharp straw easily blunt the blades of fodder cutter, he says.

Sama adds that in his area only brick kilns buy rice straw, but they are limited. Besides, selling rice straw to kilns is not profitable. "They pay us ₹600-₹700 per tonne, which means we get ₹1,200 to ₹1,400 per acre. Now subtract ₹850 rental cost of the combine harvester and transportation cost of ₹300, which is borne by the farmer, from the amount. All we get is between ₹50 and ₹250. Where is the profit?"

Daljeet Singh, another farmer from Patiala says, "Of late, power companies are approaching us to buy rice straw. They are offering between ₹500 and ₹700 a tonne. Last year, the paper and

Burning of paddy fields after harvesting to burn the paddy stubble emits gases which adversely affect environment and human health

Wheat and rice are long duration crop. With little gap between rice harvesting and wheat plantation, burning is the easiest way to get rid of rice straw

In 2012, Punjab Biomass Power Ltd—the lone rice straw power plant in the state—generated 12 MW of power from rice straw. It helped farmers reduce pollution

packaging industry had bought straw for ₹1,400-₹1,700 a tonne." That was a one-off deal though. In the absence of assured returns, farmers find stubble burning an economic way of managing the agro-waste.

Back in soil

Every year about 12 million tonnes of rice straw is burned in Punjab. According to O P Rupela, former soil microbiologist at the International Crops Research Institute for the Semi-Arid Tropics, this leads to nutrient loss from the soil which is equivalent to US$18 million worth of urea. Rupela, along with scientists from Punjab Agricultural University, has developed a simple and rapid composting technique to convert huge piles of rice straw into organically rich soil. It takes about 45 days to prepare this rice straw compost which helps conserve nitrogen and other nutrients contained in the straw, he says.

The compost contains 1.7 to 2.1 per cent of nitrogen, 1.5 per cent phosphorous and 1.4 to 1.6 per cent potassium. It helps improve crop yield by 4 to 9 per cent. "But the farmers found it labour-intensive," says Rupela.

Power industry offers a way out

For the past two years, people in villages in the radius of 25 km around Ghanaour village of Patiala are witnessing relief from choking air during harvesting seasons. Complaints of respiratory problems have also reduced. This is attributed to hundreds of farmers who decided to sell their rice straw to a power company, Punjab Biomass Power Ltd (PBPL) in Ghanaour. The company's

Every year, about 12 million tonnes of rice straw is burned in Punjab agents had approached the farmers to harvest the straw for a dividend in cash. The proposal was luring enough, but farmers had strict time constraints. The company offered its own machinery to harvest and collect straw on time so that farmers do not get delayed for the next crop. Farmers agreed. In 2012 PBPL generated electricity from the 12 MW plant while helping farmers reduce the pollution levels considerably (see box: Rice straw to power).

S Y Mehta, plant head of PBPL, says, "A 12 MW rice-straw power plant typically needs 120,000 tonnes of stubble, which can be collected from about 15,000 farmers." Power sector pundits say energy demand in Punjab may increase by 50 per cent by 2030 and, as Mehta says, power production from rice straw is a good way to meet the demand. If enough biomass power plants are set up, they will provide a new source of income to farmers.

But the power industry pays less to farmers than the paper packaging industry. Mehta says paper and packaging industry needs straw in small amounts and hence is spoiling the market. "Our straw requirement is 350 to 400 tonnes a day. We pay about ₹900 a tonne for non-basmati rice straw and ₹1,500 for basmati straw as it has high calorific value," Mehta says, adding that prices may increase as the market becomes competitive. Mehta hopes PBPL, which is currently incurring losses, will be able to make profits in two to three years. With several applications, increasing demand and competitive prices, it seems farmers have no dearth of options for managing the agro-waste. However, convincing them about economic viability of the

A group of scientists in Punjab has developed a simple and rapid composting technique to convert huge piles of rice straw into organically rich soil

A 12 MW rice straw power plant needs 12,000 tonnes of stubble. That can be collected from 15,000 farmers

RICE STRAW TO POWER

Punjab Biomass Power Ltd is the first of the nine rice straw power plants coming up in Punjab. This 12 MW plant near Ghanaur village in Patiala district is functioning for the past two years. It uses rice straw (not husk that is widely used as an expensive commercial fuel) for producing electricity. Every day the plant consumes 350 to 400 tonnes of straw and produces 40 to 50 tonnes of ash.

Agents appointed by the company approach farmers to harvest their rice straw. The harvesting is followed by cutting, baling and transporting the bales to company depots where it is stored. The plant, set up at a cost of ₹80 crore, is based on the simple principle of combustion. It has a furnace, a boiler and a steam turbine. There are also a set of machines that cut open the bales and shred the straw into small pieces to ensure uniform combustion. The shredded straw is then fed into the boiler using a conveyor belt. A conventional steam turbine then generates electricity. An electrostatic precipitator to collect ash ensures minimal atmospheric pollution. Although there will be some emissions from combustion, the project is eco-friendly and aims to earn substantial carbon credits.

What about the ash produced by the plant every day? S Y Mehta, head of Punjab Biomass Power Limited (PBPL), says, "We are trying our best to find ways of utilising the ash by selling it for production of bricks and other construction materials." For the time being, a contractor has been hired who dumps the ash in landfills or depressions created at brick kilns.

Apart from combustion, Mehta informs, there are other technologies to produce power from rice straw, such as anaerobic digestion (biogas), pyrolysis (bio-oil) and gasification (sygas). The last two are under research and development as they are not economically viable, Mehta adds. The power generation company has signed an MoU with the Punjab State Power Corporation for selling electricity at ₹5.18 per unit. The other rice straw plants which are in the inception stage will supply electricity at ₹5.83 per unit. It now plans to introduce a rice straw power plant in Bihar.

The 12 MW Punjab Biomass Power Plant Ltd uses rice straw to produce power

options could be a challenge.

Rupela says farmers will give up burning rice straw only if they receive a lucrative incentive. He has a suggestion: policy makers can devise a plan to offer incentives to farmers to stop the polluting stubble burning and later credit the incentives through carbon trading.

Coal in biomass

Raipur's clean biomass power plants use coal on the sly

Agrawal Renewable Energy Plant in Raipur

On October 15, 2010, the regional officer of Chhattisgarh Environment Conservation Board (CECB) R K Sharma visited Tilda industrial area in Raipur unannounced. He noticed thick smoke rising from the premises of a renewable energy project. On paper the 8.5 MW power plant, Agrawal Renewable Energy Plant, uses rice husk, a cleaner alternative to coal, to produce electricity. The electrostatic precipitator (ESP), an emission control device, installed in the plant was tripping frequently. On probing further, Sharma discovered that the plant was using coal as fuel.

During the time, Raipur had at least 10 power plants based on biomass, considered a carbon neutral fuel with zero emission. Three reasons dictated the use of biomass in the district. One, a state government order of 2007, which prohibited commissioning or expansion of coal-based thermal power plants in critically polluted Borjhara, Urla and Siltara tehsils of Raipur. Two, the state provides financial benefits like accelerated depreciation, concessional import duty, excise duty and tax holidays to promote biomass-powered plants and buys energy from these plants at preferential tariffs. The third reason is carbon credits; none of these plants could have applied for carbon credits by using only coal as a fuel.

A day after the CECB official discovered that Agarwal Renewable Energy plant was using coal, CECB issued a show cause notice to the plant for non-compliance. In reply, the company said the share of coal in its fuel mix was only 25 per cent. To qualify as a renewable energy project for government schemes, the fuel

Many biomass plants were commissioned due to tax incentives like accelerated depreciation, tax holidays and preferential tariff

TOO LITTLE HUSK FOR POWER

In Chhattisgarh, 27 biomass-based plants were producing 237 MW in 2011. On the surface, things look fine. But even a basic calculation proves there may not be enough rice husk to produce this much power.

According to an analysis by Centre for Science and Environment, 1.5 tonnes of biomass is required for generating 1 MWh of power. Assuming that the Plant Load Factor (PLF) for biomass plants is 46 per cent and that these plants consume coal and biomass in the proportion of 25:75, at least 1.07 million tonnes of rice husk is required to generate 237 MW (F grade Indian coal and rice-husk have almost same calorific value—3,000 kcal/kg). However, in 2009-10, the state produced just 1.1 million tonnes of rice husk. Close to half of the rice husk produced is consumed by solvent extraction plants (plants where oil is extracted from plant products) and brick kilns. This means there is not enough rice husk to meet the demand of biomass power plants.

Close to half of the rice husk produced in Chhattisgarh is consumed by solvent extraction plants and brick kilns. This means there is not enough rice husk to meet the demand of biomass power plants

ratio of a biomass plant could be 15:85 or 25:75 (lesser number indicates percentage of coal). The ratio depends on the year the plant is commissioned. On October 24, CECB officials inspected the plant again, and found that 90 per cent of the fuel used by the plant was coal and only a small portion was biomass. They also found that most of the pollution abatement equipment, including ESP, was not functioning properly. The plant was ordered shut for the next two months.

Ground reality belies paper claims

The Agrawal RE Project was commissioned in July 2006. It is common knowledge in Raipur that biomass plants use coal on the sly as their primary fuel. Industry sources admit that the Agrawal RE project is not an one off case. Another power plant by Maa Usha Urja Ltd (MUUL) in Siltara was found faltering in 2010. CECB officials say during an inspection in December 2011, they found 70 per cent of the fuel burnt in the plant was coal when the plant was allowed to burn only 25 per cent. For reasons that could not be verified, no action was taken against the plant.

The deep rooted malaise became more apparent when a Centre for Science and Environment surveyor visited more such plants, posing as a student. "The boiler in the plant is of 400 tonne fuel capacity. Husk is not available throughout the year. So we burn 150 tonnes of rice husk. Rest is coal or *dola char* (waste from the sponge iron industry)," said the officer in charge of the boiler at the biomass-based power plant of Shree Nakoda Ispat Ltd, in Siltara tehsil of Raipur. This means around 63 per cent of the fuel used in the plant is fossil. The plant is permitted to use only 15 per cent coal. The 12 MW plant was commissioned in April 2009.

A supervisor responsible for preparing the fuel mix at the Godavari Power and Ispat Limited in Siltara said that the ratio (of rice husk and coal) is not fixed. "Every day we are given a new ratio. Generally, it is 50:50," he said. This plant was commissioned in November 2010.

"A severe shortage of husk for biomass plants leading to a steep increase in its prices," says a Raipur-based CDM consultant. Paddy cultivation in the state has been declining. The state government figures show that in 2005-2006, it was 7.52 million tonnes, which dropped to 6.16 million tonnes in 2009-2010. Husk accounts for 15-16 per cent of paddy. Yogesh Agrawal, president of Chhattisgarh Rice Millers' Association, says 30 per cent of the husk produced in the state is used by solvent plants and 20 per cent by brick kilns.

In 2005-2006, when commissioning of biomass power plants began in the state, the price of husk was around ₹850 per tonne. Today it costs between ₹2,000 and ₹2,300 per tonne. Coal is available at ₹850 per tonne from the government allocated coal blocks.

5

WASTE TO ENERGY

WASTE-TO-ENERGY

Futile without efficient waste segregation

1. Introduction

Waste management is a major problem in Indian cities. With the country's urban population growing 31.8 per cent between 2001 and 2011, 377 million people now live in cities, generating 110,000-150,000 tonnes per day (TPD) of municipal solid wastes (MSW).[1,2] Urban and industrial waste is a potential source of energy to generate electricity. Though the Ministry of New and Renewable Energy (MNRE) estimated 4,000 MW of potential from these wastes in 2012, the waste-to-energy programme is in the doldrums because of inefficient waste management and poor environmental performance.[3]

A Supreme Court judgment has put severe strictures on deployment of waste-to-energy projects based on MSW. Following major concerns about waste management and environmental hazards of MSW projects—and the subsequent failure of such projects—the Supreme Court in 2007 ruled that energy extraction from MSW cannot be promoted until five pilot projects (promoted till then by MNRE) operate successfully without violating environmental laws and causing pollution. But these projects have been bedeviled by severe environmental, technical and operational concerns. Several complaints have been registered against a 16-MW plant in New Delhi's Okhla area for exceeding pollution levels. On January 14, 2014, the Delhi Pollution Control Committee issued a show cause notice to the Okhla waste-to-energy plant for violating air pollution control norms.[4] In fact, the first MSW project setup in Vijayawada by M/s Sriram Energy Systems Ltd closed down due to technical faults, apart from environment problems. Another 5 MW project in Lucknow shutdown due to operational issues, and lack of organic content in the waste, just a few months after it was initiated.[5,6]

Municipal Solid Waste Rules, 2000 which could have given a fillip to waste-to-energy projects has been ignored by the urban local bodies. A Comptroller and Auditor General (CAG) of India report of 2008 highlights major lapses in implementation of the rules both at central and state levels. Waste-to-energy remains a futile exercise without a scientific and efficient waste management programme backed by a strong coalition between citizens and municipalities. The sector requires a policy that emphasises strict adherence to environmental rules and standards and has roadmaps for developing technology and sustainable business models.

2. How much waste, how much energy

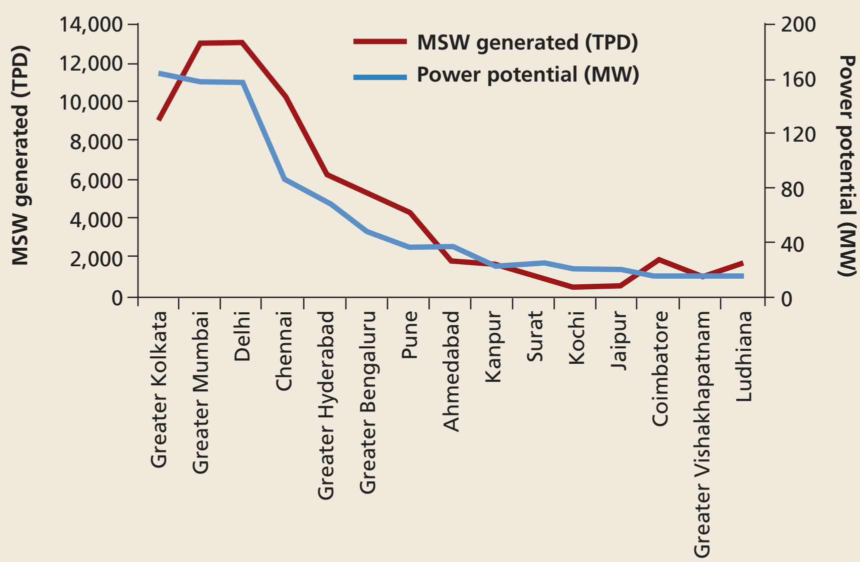
In 2004-2005, the Central Pollution Control Board (CPCB) with the help of National Environmental Engineering Research Institute (NEERI) studied waste generation in 59 cities, including 35 metros and 24 capitals.[7] This study showed New Delhi, Greater Mumbai, and Chennai to be the biggest waste generators in the country: 5,922 TPD, 5,320 TPD and 3,036 TPD respectively. It also estimated the per capita waste generation rate based on population of cities. The report says that cities with less than 0.1 million population generated between 0.17 – 0.54 kg per capita wastes per day while cities with population ranging from 0.1 million to 2 million generated between 0.19 to 0.59 kg per capita per day. Cities with more than 2 million population generated the highest per capita waste – 0.22 – 0.62 kg per capita per day.

Since then, other studies have shown that waste generation has at least doubled and the cities have changed ranks in terms of amount of waste they generate. A recent study sponsored by Waste to Energy Research and Technology Council (WTERT) found that Kolkata is the largest waste generating city in India tossing about 11,520 TPD, followed by Mumbai at 11,124 TPD and then Delhi with a slightly lower figure of 11,040 TPD.[8] The per capita generation of wastes is also different and varies from 0.2 kg per day in Kohima (Nagaland) to 1.2 kg per day in Thiruchirapally (Tamil Nadu) among a list of 366 cities with a population of more than 100,000. According to the WTERT study, the average per capita waste generation in urban India is about 0.498 kg per day—this translates to 129,593 TPD for all of urban India.

The Municipal Solid Waste Rules, 2000, which could have given a fillip to waste-to-energy projects in the country has been ignored by local bodies

Asit Nema, Director, Foundation for Greentech Environmental Systems, a non-profit, estimates the total MSW to be in the range of 113,000 TPD to 151,000 TPD.[9] Another professional in the sector, Sanjay Gupta, Independent Adviser and Consultant, Water, Sanitation and Livelihoods, suggests MSW generation to be 115,000 TPD with a per capita waste generation in cities between 0.2 to 0.6 kg per day.[10] He estimates annual increase of 1.3 per cent in urban waste generation in the next few years.

FIGURE 1: POWER POTENTIAL AND CALORIFIC VALUES



Source: RK Annepu, January 2012, Sustainable solid waste management in India, Waste to Energy Research and Technology Council (WTERT), Columbia University, New York

Comprehensive data about waste in the country is, however, hard to come by. Such data is also significant because the composition of the wastes varies from city to city. It differs in terms of the compostable, recyclables and inerts. This directly impacts the potential of waste for composting, recycling and energy generation. For example, Chennai generates 6,118 TPD solid wastes. This is about half of what Kolkata generates. Yet a comparison of the electricity generating potential of wastes in the two cities shows Chennai (149 MW) has more potential than Kolkata (129.9). This is because the calorific value of wastes generated in Chennai (10.9 MJ/kg) is twice that of Kolkata (5 MJ/kg). Such links with calorific value of wastes and their power potential can be observed in other states too (See figure 1: Power potential and calorific values).

3. Issues and challenges

I. The financial predicament: Inadequate subsidies, low tariffs

MSW projects are expensive. A 300 TPD MSW project based on biomethanation technology can cost ₹100 crore (see table 1: Cost of MSW technology). Similarly, a 300 TPD MSW project based on combustion can cost ₹ 37- 65 crore. The cheapest option is sanitary landfills with gas recovery, but such landfills require huge amount of land which is becoming scarce in most cities.

MNRE has a scheme to give capital subsidies to waste-to-energy projects (see table 2: Financial assistance). MNRE also provides a 50 per cent subsidy for preparing the project proposal, subject to a maximum of ₹ 1 lakh per project.[11] It also grants financial assistance on other expenses made by the state nodal agencies (SNAs) towards administrative charges and setting up training and awareness programmes. SNAs implement the schemes in the states on behalf of MNRE.

Despite being an expensive proposition, the MNRE outlay for promoting the waste-to-energy programme for 2013-2014 is a mere ₹ 38 crore.[12] And, MNRE proposes to use this small fund to support energy recovery from all three types of wastes: urban wastes, industrial wastes and MSW.

Sustainable financing and poor support from MNRE has been a persistent grouse of developers. "MNRE announces schemes but there are always budgetary constraints. Top priority is given to household biogas digesters. The allocation for medium to large

Comprehensive data about waste is necesssary because waste differs in content. This has a major bearing on its calorific value and ultimately power generation potential

TABLE 1: COST OF MSW TECHNOLOGY

Technology	Capital Cost for 300 TPD waste handling***	Space required for 300 TPD waste handling
Mass burn with energy recovery	₹ 37 – 40 crore	0.8 hectares*
RDF followed by energy recovery	₹ 65 crore	NA
Biomethanation followed by energy recovery	₹ 100 crore	2 hectares*
Sanitary Landfills (including gas-to-energy recovery)	NA	36 hectares**

Source: Asit Nema, Technological and systemic challenges in municipal solid waste treatment and policy options for sustainable development in the sector, Foundation for Greentech environmental systems, Delhi, February 2013
** Based on actual installations*
*** For areas away from coast (can be more in coastal areas). This is estimated on the basis of a filling depth of 7 m and Landfill life of 15 years.*
**** In India, on an average about 900,000 people will generate about 300 TPD waste*

TABLE 2: FINANCIAL ASSISTANCE

Wastes/Processes/Technologies	Capital Subsidy
Power generation from municipal solid waste	₹2.00 crore/MW (Max. ₹10 crore/project)
Power generation from biogas at sewage treatment Plant or through biomethanation of urban and agricultural waste/residues including cattle dung or production of bio-CNG	₹2.00 crore/MW or bio-CNG from 12000 cubic metre biogas/day (Max. ₹5 crore/project)
Biogas generation from urban, industrial and agricultural wastes/residues	₹2.00 crore/MW (12000 cubic meter biogas/day with max. ₹5 crore/project)
Power Generation from biogas (engine/ gas turbine route) and production of bio-CNG for filling into gas cylinders	₹1 crore/ MW or bio-CNG from 12000 cubic metre (Max. ₹5 crore/project)
Power generation from biogas, solid industrial, agricultural waste excluding bagasse	₹0.20 crore/MW (Max. ₹1 crore/ project)

Source: Anon, 2012, Programme on Energy from Urban, Industrial and Agricultural Wastes /Residues during 12th Plan period, Union Ministry of New & Renewable Energy, Government of India, http://mnre.gov.in/file-manager/offgrid-wastetoenergy/programme_energy-urban-industrial-agriculture-wastes-2013-14.pdf

Developers say estimates used to set tariffs do not match the reality. For example, operation costs of the Okhla waste-to-energy plant was estimated to be ₹ 2.51 per kWh. It is ₹ 7 per kWh now

scale plants is very limited. All applications have to be routed through respective SNAs and it is an open secret that things do not move easily. Genuine entrepreneurs suffer a lot," says Murali Krishna, Chairperson, Village Vision India, an energy services consultancy. Krishna believes that, "Either the subsidy should be increased or there should be higher prices for power / gas." A higher selling price of gas/power will assure financial viability for projects and bankers will come forward to finance them. The government should offer such price support until the developer breaks-even, Krishna says.

For the New Delhi's Okhla waste-to-energy project, tariff was fixed at ₹ 2.49 per kWh for the first year and from second year onwards the developer was sanctioned ₹ 2.83 per kWh.[13] But says Ashok Mandal, CEO of Jindal Ecopolis, which runs the Okhla project, "When the Okhla project was conceived, its operation costs were estimated to be ₹ 2.51 per kWh. But the current operating cost is ₹ 7 per kWh. The assumptions were wrong. We get more material that is unfit for incineration." He also adds that "The costs that were assumed to set the tariff were extremely modest when the project was conceived compared to what we eventually incurred. Capital costs of the plant were assumed to be about ₹ 170 crore. However, with cost of technology rising during the project's implementation period, expenses shot up to about ₹ 270 crores."

The company had counted on the sale of carbon credits, which were about 15 Euros per tonne of CO_2 in 2008. However, the prices have come down to less than a Euro of late. "On top of that, the central nodal agency for the Renewable Energy Certificate (REC) market is also unsure if we should be counted as renewable energy suppliers. We have registered for the REC mechanism, but we are yet to be accredited. We are also yet to receive the ₹ 10 crore subsidy under the MNRE programme, even though it has been three years since the plant has been commissioned," he adds. Krishna of Village Voice advocates a generation based incentive and argues that tariff be fixed on a case-to-case basis. He also calls on the ministry of agriculture to extend subsidies to biogas slurry

TIPPING FEE IN SWEDEN AND THE US

Sweden has a financially viable model for treating and disposing solid wastes. The model has been replicated in several countries in the European Union and countries like US to address the growing problem of waste disposal. Economic incentives and taxation policies have also helped in promoting good waste management practices in these countries.

To begin with, a big driver for waste to energy facilities to operate is the high charge (gate fee or tipping fee), levied by landfills in order to dispose the waste.[1] The municipality or developer bringing in waste to landfills is charged on a per tonne basis. This fee helps cover the cost of landfill maintenance. These countries also charge a landfill tax.

The idea of this tax is to keep the gate fee at the landfill high in order to reduce the flow of waste to landfills, which may be owned by the private developers or municipalities.[2]

The high gate fees charged by landfills have led more than 80 plants in the US to reduce the amount of waste they send to landfills.[3] In the US, the state of Washington charged the highest landfill gate fee: US $142 per tonne in 2013.[4] The charges vary from state to state. Sweden charges much higher for landfilling because it has a landfill tax. which the US does not have. Sweden's average landfilling charge was equivalent to roughly US $212 per tonne (US $150 landfill fee and US $62 landfilling tax).[5]

Waste processing and treatment facilities like waste to energy plants, compost plants and anaerobic digestion plants do not attract taxes from the Swedish government. Developers charges tipping fees to cover operating costs of their facilities. An average tipping fee of US $84 is charged in the Sweden for waste management facilities other than land disposal. These projects generate revenue through the sale of electricity, and heat energy for district heating network. In countries, like Sweden, landfills are the most expensive method of waste disposal, while anaerobic digestion is by far the cheapest way to rid of wastes.

based fertilisers. "All agriculture and horticulture departments should buy organic fertilisers from the biogas producers. This will not cost the exchequer extra as there are several subsidies for organic fertilisers, such as vermicompost and synthetic fertilisers. Biogas slurry based fertilisers from waste-to-energy plants should also be brought under the same scheme," he adds.

Mandal of Jindal Ecopolis believes that municipalities must pay waste management charges to MSW projects to make them financially viable. Presently, depending on the municipality, wastes are either delivered free of cost or for a small price from the developers. In many developed countries, municipalities pay waste management charges to the developers to manage as well as to recover energy from these wastes (See box: Tipping fee in Sweden and the US).

Developers want municipalities to pay them waste management charges

II. The necessity of segregation

Municipal solid waste can come from residential, commercial and institutional sources. These wastes include food wastes, paper, cardboard, plastics, textiles, leather, wood, glass, metals, ashes, bulky items such as consumer electronics, white goods, batteries, oil, tires, hazardous wastes from households such as paints, cleaning agents, waste containing mercury and motor oil, and e-wastes such as computers, phones and TVs. Debris from construction sites are also found in municipal solid wastes.

In India, MSW is not segregated in an organised and scientific manner. This waste should be properly segregated for the smooth functioning of waste-to-energy plants. Firstly, when plastics and chlorinated compound find their way to boilers of waste-to-energy plants they release dioxins, furans and hydrogen chloride which are toxic to the environment. Secondly, segregating materials unfit for burning—bricks, stone, glass,

RELUCTANT MUNICIPALITIES AND POLLUTION CONTROL BOARDS

Why MSW rules, 2000, were never implemented

The MSW Rules, 2000, puts onus on the municipalities and pollution control authorities for proper waste management. Every municipal authority has to set up a waste processing and disposal facility, and prepare an annual report. State governments and Union Territory Administrations have the overall responsibility of enforcing these rules in metropolitan cities and within territorial limits of their jurisdiction. Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB) are required to monitor compliance of standards pertaining to groundwater, ambient air, leachate quality, and compost quality including incineration standards.[1]

The rules require that waste processing and disposal facilities must be monitored once every six months. Existing landfill sites must be improved, and landfill sites for future use identified. It stipulates that biomedical and industrial wastes should not be mixed with MSW. It asks municipalities to encourage people to segregate wastes. Vehicles for transportation must be covered and MSW must be processed in such a way as to reduce burden on landfills. Biodegradables have to be processed by composting and landfilling is only recommended for wastes that are non-biodegradable, inert, or are not suitable for recycling. The MSW rules, 2000 have guidelines for maintenance of landfill sites and for processing techniques such as composting, treated leachates, and incineration.

No municipality or local body has complied with these rules.[2] There is a clear lack of an established system for collection, transportation, treatment, and disposal. The lack of coordination among outfits that collect, transport, treat, and dispose wastes is another drawback.

In 2008, a Comptroller and Auditor General (CAG) of India report, Performance Audit on “Management of Waste in India” came down heavily on different agencies for tardy implementation of the MSW rules. The audit examined CPCB and the MoEF at the central level. It also examined 24 state pollution control boards, state departments for urban development, forest departments, municipalities, districts and hospitals. The report criticised data collection by state nodal agencies, urban local bodies and municipalities. It urged the CPCB and MoEF to collect, analyse and generate waste-related data on a periodic basis in order to make effective policy decisions. The CAG recommended a mechanism to incentivise collection of waste at source. It asked the MoEF to devise policies based on the polluter pays principle: waste generators would pay for sustainable disposal of waste.

Subsequently, the Ministry of Environment and forest (MoEF) set up a committee to identify strategies to manage wastes in India. The committee came up with a report in 2010 saying that local bodies responsible for proper disposal of urban waste are over-burdened with other priorities and therefore waste disposal is relegated to the end of the priority list.[3] The report suggests the following reasons for poor operation and maintenance:

a. Inadequate finances
b. Multiplicity of agencies for operation and maintenance
c. Inadequate training of personnel
d. Lack of performance monitoring
e. Inadequate emphasis on preventive maintenance
f. Lack of management
g. Lack of appreciation by urban local bodies for facilities set up for the use and safety of the community

The MoEF report noted that many cities lack legally notified landfill sites for dumping solid wastes. This leads to open dumping and burning, jeopardising public health. In municipalities, solid waste management tasks are amongst the many responsibilities assigned to the health department. The personnel-starved department finds it hard to manage waste. This is compounded by vagueness over many aspects of solid waste management: roles of the health department and the engineering department of the municipal corporation are not clearly defined.[4]

More than five years have passed since the CAG report and three years have passed since MoEF identified the core issues related to inefficient waste management. But CPCB and MoEF have not initiated much action regarding data collection and capacity building. Local municipal corporations are also yet to respond.

ceramic pieces, leather and rubber—imposes burden on plants, who have to send these rejects to landfills.

Sorting non-industrial waste is largely in the hands of the unorganised sector. The rag pickers seeking recyclables for their livelihood, tend to segregate only those materials which fetch them good returns in the recycling market. This means waste-to-energy plants get badly segregated feedstock making it very difficult for energy developers to assess accurately the financial viability of their projects. More importantly, unsegregated waste puts a question mark over the technical feasibility of waste-to-energy plants in the long run.

The Ministry of Environment and Forests has laid down rules on segregation, proper collection and transportation, but it has not been implemented (see box: Reluctant municipalities and pollution control boards). There is no regulatory link between waste management and power generation. Hence, waste management and power generation does not complement each other except for receiving financial benefits under the Clean Development Mechanism and getting capital subsidy under the MNRE.

III. Meeting environmental norms

The MSW Rules, 2000 mandate that waste disposal facilities like landfills must obtain necessary clearances from the Ministry of Urban Development and relevant state authorities. Waste-to-energy projects must comply with acts and regulations pertaining to air quality, water quality, noise levels, storage of hazardous material, groundwater in order to obtain clearance.[14]

Such regulations are necessary because operations of waste-to-energy plant are known to pollute the environment. To begin with, transporting waste to the power plant involves vehicular exhaust emissions. It is necessary to mention that transporting wastes to the plant has to go on a continuous basis in order to keep it running. Secondly, primary storage pits generate leachate (liquid waste) that is dangerous for the soil and ground water. Thirdly, firing of fuel in a boiler generates several pollutants like carbon monoxide, nitrogen dioxide and sulphur dioxide. Besides, when plastics and chlorinated compound find their way to the boilers of waste-to-energy plants, they lead to generation of dioxins, furans and hydrogen chloride which are toxic to the environment. After the incineration process, the ash from the boiler can adversely impact the environment as well.[15] Development projects require Environmental Clearance (EC), which is given on basis of an Environmental Impact Assessment study. The process is mandated by the Environment Impact Notification, 2006. All common MSW management facilities have been categorised under item 7(i) of the notification. Disposal facilities like landfills and incinerators are categorised under item 7(d) of the same notification.

Despite the rules and regulations in place, there have been a series of protests against waste-to-energy projects in India for polluting the environment. In many cases, the siting of these projects have been poor. The Timarpur-Okhla waste management project, (16 MW capacity incinerator), is situated right next to a residential colony. There are hospitals and other institutions nearby as well. Apart from the citizens who are impacted due to the project, strong opponents of waste-to-energy projects are also waste pickers. It has been proven through earlier unsuccessful experiments in Timarpur (1989) and Vijaywada that Indian waste cannot be incinerated as it contains more than

Waste-to-energy plants release several toxins when they are fed unsegregated waste. Use of such waste also puts a question mark over the long-term feasibility of such plants

50 per cent of organic material which is high in moisture and low in calorific value. Hence, high proportion of plastics, paper and cardboard are usually added for the incinerators to function; but these are precisely the materials which the informal sector recycles. Hence, these facilities are seen as a threat to the livelihoods of this informal sector of workers.[16] Not only do they cause pollution due to the inclusion of recyclable calorific waste material, they also rob off the livelihoods of the waste pickers in the city. After several rounds of protests from various citizen groups, the Delhi Pollution Control Committee handed a show-cause notice to the Timarpur-Okhla incinerator plant in New Delhi in January 2014 with regard to its pollution problem.

Way Forward

Poor handling of MSW by agencies concerned has made sustainable treatment of such waste a difficult task. If the quality of MSW as feedstock remains poor, regulations are not followed and local expertise is not developed, the waste to energy market may remain untapped. In the nutshell, waste to energy is not worth unless waste management is made effective and efficient at the first place.

I. **Know the waste:** As per the recommendation of CAG in 2008, CPCB and MoEF must conduct a study jointly to collect, analyse and generate waste-related data for all municipal bodies of designated cities and towns. A mechanism should also be developed for periodic updates of these studies to make effective policy decisions.

Waste-to-energy plants have been dogged by allegations of pollution

II. **Segregate the waste:** It is important to segregate waste at the collection point for effective disposal, recycling or power generation. This is the most difficult aspect of effective waste management and can be possible only if citizens of the country understand their social responsibility and actively participate. To initiate such social transformation, a mechanism based on incentives and penalty should be worked out for segregation of waste at the source. In accordance to the CAG report, CPCB / MoEF should devise policies based on the polluter pays principle where waste generators would pay for sustainable disposal of waste. An incentive should be given to the waste generator for proper segregation or a penalty should be imposed if waste is not adequately segregated.

III. **MSW power plant economics:** The power generated from MSW is a derivative of effective waste management. Therefore, the cost of MSW power plant should not be considered without factoring in social costs related to health and hygiene, environmental protection, cleanliness and beautification of cities / towns. The waste-to-energy technology not only produces power, but also reduces the quantum of waste to the tune of 60 to 90 per cent for disposal. This result in less requirement of land at landfill sites, less transportation cost due to reduced disposable waste and less environmental pollution.

IV. **Environmental protection:** The MSW power plants must comply with acts and regulations pertaining to air quality, water quality, noise levels, storage of hazardous material, groundwater in order to obtain clearance. State-of-the-art pollution control technology must be employed. Waste handling and waste disposal by these power plants must comply with the MSW Rule-2000.

REPORTS FROM THE GROUND

Power of separation

Segregated municipal waste is being used for power generation in Pune

A woman collects segregated dry and wet waste

Waste collectors now enjoy better livelihoods and have improved working conditions

Shoba *thai* used to be a waste picker collecting recyclables from dump sites around Prabhat Road in Pune to make a marginal living. Her economic condition improved in 2005 when the Kagad Kach Patra Kashtakari Panchayat (KKPKP), a union of waste pickers, waste dealers and recyclers, launched a pilot programme in collaboration with the city's municipal corporation where waste pickers were integrated in door-to-door waste collection (DTDC) work.

This paved the way for the formal institution of SWaCH in 2007, a wholly-owned workers' cooperative as a Public Private Partnership to undertake such work. SWaCH (Solid Waste Collection and Handling or, officially, the SWaCH Seva Sahakari Sanstha Maryadit, Pune) is India's first wholly-owned cooperative of self-employed waste pickers/waste collectors and other urban poor. It is an autonomous enterprise that provides front-end waste management services to Pune residents. The cooperative is authorised by the Pune Municipal Corporation (PMC) to provide DTDC and other allied waste management services.

SWaCH members like Shobha *thai* collect garbage from citizens' doorsteps and deposit it at the designated PMC collection points. The interesting part about their work is that they are expected to collect segregated rather than mixed waste. Their waste carts also have a partition to help transport the waste in segregated form. "All the households have been requested to give segregated waste, but few do so. This makes my job harder as I have to segregate dry and wet waste," says Shoba *thai*.

Each member collects waste from 150 to 200 households, charging ₹10 to ₹40 depending on the area. They can also sell the recyclables. PMC has mandated that at least ₹10 is collected monthly from each household for the service. A citizen's helpline helps households access the services or lodge complaints. "The members are now enjoying better livelihoods with assured income," says Manisha of SWaCH. "They also have better working conditions, thanks to improved equipment provided by PMC," she adds.

The city has 9,000 waste pickers—SWaCH works with 2,300 waste pickers and contracts with 400,000 households in Pune. Hotels and households provide 125 tonnes of organic waste, and another 50 tonnes comes from *mandi*s.

Some of the waste goes to the city's decentralised biogas plants, a brainchild of Sanjay Nandre of Enprotech Solutions who wanted to show municipalities the feasibility of decentralised waste management. He helped Thane Municipal Corporation build a 5-tonne per day project for a housing complex in Thane: The Hiranandani housing complex on Gorbhundar Road, Thane, consisted of 10,000 flats at the time of commissioning the plant. Impressed by the Thane project, the Pune municipality, in 2009, decided to set up the city's first biogas plant in Model Colony.

Segregated waste

The 17 biogas plants operational in the city today process only wet waste. They require properly segregated waste. The plant takes a small portion of segregated municipal solid waste and a large portion of hotel waste as feedstock. Hotels, being commercial enterprises, have been instructed to provide segregated waste to

Pune residents have been requested to segregate dry and wet waste. But many do not comply, making the collector's task difficult

A MODEL BIOGAS PLANT

IN Pune, all biogas plants have the capacity to take in 5 tonnes of wet waste every day. Waste comes in daily between 10 am and 2.30 pm by hotel and *ghanta* trucks arranged by the Pune Municipal Corporation (PMC). The trucks empty the waste at collection unit.

The waste is passed on to the shredder with the help of two employees. At this stage, the employees pull out any waste that is unfit for the biomethanation process, such as paper and inerts. Only organic waste enters the shredder. It is even good to avoid certain inedible biodegradable objects like banana stalks and mango seeds, which reduce the quality of the waste.

The shredder turns the solid waste into a semi-solid state. In this state, the waste is passed on to the scum remover where particles that are unfit for processing such as oil are separated. The waste settled at the bottom is sent to the anaerobic digester for building the culture. A culture is prepared in the digester before injecting waste for biomethanation. It is built by adding cowdung and poultry droppings.

The process of anaerobic digestion produces biogas, largely constituted by the methane. After this process, waste in the digester, the slurry material is dried. It is high in nutrient and is used in the PMC gardens; the remaining is sold in the market.

The biogas is transferred to a scrubber which helps in the removal of hydrogen sulphide. The clean biogas is now transferred to a gas balloon, which pumps the gas to the biogas engine whenever power generation is required.

Pune municipality has employed the public-private-partnership model to set up biomethanation plants. The municipality provides the capital cost to set up the project

the waste collectors. Hotel wet waste is considered to be of good quality for biomethanation. The objective is to be able to feed these plants with municipal solid waste from households, which requires proper segregation at source (see box: A model biogas plant). These plants are set up amid residential areas to reduce the cost of transportation. The plants are usually fenced with high walls; there is little smell outside the plant area and a uninformed passerby would barely even notice a waste processing unit in the vicinity.

The economics

The municipality has employed public-private-partnership model to set up these plants. PMC provides the capital cost and land to set up the project. In 2010, the projects cost ₹55 lakh to ₹60 lakh, including all physical infrastructure. Currently, the capital costs are pegged between ₹70 lakh and ₹90 lakh. Each plant employs four to five persons. The operation and maintenance of a plant is contracted for five years, which can be renewed. It costs at least ₹75,000 per month and annually escalates at 10 to 15 per cent rate depending on the project. These projects cannot be on a revenue based model as they are not financially viable.

On an average, a typical 5 tonnes per day (TPD) biogas plant occupies 500 to 600 square metres. Such a project produces about 300 cubic metre biogas per day to generate electricity from a 40 kW gas engine. The electricity is not sold to the grid. Instead, it is used to light 145 to 250 streetlights in the neighbourhood. The other output is slurry waste which is high in nutrients and is used as fertiliser.

About 80 per cent of the waste that the plants receive can be used for biomethanation. There are rejects in every case. "However, the current level of segregated waste is high compared with other cities in India. This is good for biomethanation projects in Pune. But most of it comes from hotels. We should get more waste from residents," says Suresh Rege, chairperson of Mailhem

Biogas plants take municipal solid waste and hotel waste as feedstock

The slurry waste from a plant's digester is rich in nutrients and can be used as fertiliser

Engineers Pvt Ltd, which offers solutions for treatment and disposal of solid and liquid biodegradable organic waste.

Door-to-door collection of waste and awareness seems to be pushing segregation practices. "We should shove unsegregated waste back to people," says Rege. PMC, on its part, encourages good disposal practices through incentives. It gives rebate on property tax—an annual 10 per cent rebate is given if rainwater harvesting/solar/composting is being done by property owners.

A setback

The work to segregate waste received a setback in June 2013 when the only landfill in Pune was closed as the municipality was looking for sustainable options of treating waste. "The landfill was set to be fully closed by June 2014," says Sanjay Gawade, Assistant Commissioner, Solid Waste Management department of PMC.

At the dumpsite a refused derivative fuel (RDF) plant has been set up, which burns municipal waste to generate electricity. The plant was set up by Hanjer Biotech. According to PMC, the plant is working to its optimum capacity of 1,000 TPD while the company claims to be processing more than 1,200 TPD. The RDF plant claims to have the capacity to take in mixed waste. Organisations like SWaCH, involved in enabling segregation practice, see this is a setback.

According to a report by Nagrik Chetna Manch, Pune, "As Hanjer is capable of processing mixed garbage, the municipality has neither compulsion nor incentive to ensure segregation at source, mandatory as per current rules and regulations. The capacity of Hanjer plant would go up by about 25 to 35 per cent if it gets only wet segregated garbage."

Residents of nearby areas report of pollution as a result of this plant. The Nagrik Chetna Manch claims to have tested mercury levels in manure from a composting plant also operated by Hanjer. The non-profit claims this is 32 times the acceptable level set under the Schedule 4 of MSW (Handling and Management) Rules 2000. The plant continues to operate at the claimed capacity, using more than 65 per cent of Pune's solid waste.

Biomethanation plant produces electricity and fertiliser apart from managing the MSW. But segregation is the key for its success

The Okhla landfill

DELHI'S DEBRIS

New Delhi is the third largest waste generator in India after Kolkata and Mumbai. According to estimates, the city throws more than 11,500 tonnes of municipal solid waste every day. It has run out of capacity to manage such large amounts and is resorting to steps that are unsustainable. Rather than addressing the larger issue of waste management—promoting controlled waste generation and encouraging household level segregation—the municipality is counting on short-term measures that are exacerbating the situation. The Timarpur-Okhla waste-to-energy plant is a classic example of how the city is grappling with the issue. Situated amid hospitals, institutions and a large residential complex, the plant incinerates solid waste to convert it into electricity. Built at a cost of ₹270 crores, the plant treats nearly 2,000 tonnes of waste everyday to generate electricity. Its operation cost is now way beyond the agreed electricity tariff. The waste, it receives, has more material unfit for incineration, and the amount cannot be predicted till household level segregation is not practiced. The plant faces losses. A bigger concern here is that pollution levels are crossing the limits, a serious threat to health and environment

The plant received Delhi Pollution Control Committee's approval in late 2011, and started trial runs on January 3, 2012. Resident Welfare Associations say it generates large amounts of harmful gases, heavy metals and dioxins, which are associated with cancer, birth defects, hormonal disorders, respiratory ailments and skin infections. Residents in the area and environmentalists are trying in court to get the plant closed because of the problems associated with the pollution

Waste that is unfit for incineration—inerts and plastic—is transported back to the landfills from the plant. Waste workers scrounge through open dumps to pick out the recyclables that can be sold in the market. Typical waste workers earn ₹30 to ₹150 per day with which they manage their livelihood

More than 500 trucks dump waste at the treatment plant daily. Trucks also carry ash from the plant and dump it in the Okhla landfill. Almost one-fifth of the waste generated in Delhi is transported daily to the plant for treatment

Haji Colony is just 100 metres from the incinerator plant. The photo shows residents living next to the entrance of the plant through which waste is delivered. The primary reason for the location of the plant is to reduce the cost of transportation. Most of the raw material is being sourced around south and southeast Delhi. The Municipal Corporation of Delhi handles the transportation who have contracted the job to private waste management companies like—Delhi Waste Management, ABG Enviro, Metro Waste, Ramky and Delhi MSW Solutions. The plant receives about 26 tonnes waste per hour

Farhad Parveen, resident of Haji Colony, suffers from severe asthma. "It is difficult to live here amidst dust and harmful gases. Trucks filled with waste from different parts of the city are dumped here, which emits bad stench. The situation worsens in the morning and late evening, leaving many like me gasping for breath," she says

6

DECENTRALISED RENEWABLES

Can they eradicate India's energy poverty?

1. Energy Poverty: A perennial issue

India has failed to provide clean and affordable energy to a significant part of its population. According to the Ministry of Power, 18.5 million rural households are still to be electrified in India.[1] Fifty nine million households were electrified during 2001 to 2011, but most of them receive less than six hours of electricity per day.[2] Lack of clean cooking fuel in rural India aggravates the already grim situation. Presently, about 700 million Indians use biomass such as dung, agricultural waste and firewood as the primary energy source for cooking.[3] Inefficient methods of biomass burning are known to cause severe health hazards and environmental pollution in rural India.

The government of India has taken several steps to address energy access issues in rural India, without much success. Its biggest programme is the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY). Introduced in 2005, this flagship programme of the government claims 82 per cent success in electrification of un-electrified villages and 84 per cent success in intensive electrification of electrified villages (see table 1: The flagship programme).[4] But these claims are belied by the fact that more than 77.5 million households (about 400 million people) continue to rely on kerosene for lighting.[5]

Clean cooking fuel programmes initiated by the Ministry of New and Renewable Energy (MNRE) have, similarly, failed to provide clean cooking energy to a sizable section of India's rural population. The Census data, 2011

TABLE 1: THE FLAGSHIP PROGRAMME

Status of Rajiv Gandhi Grameen Vidyutikaran Yojana (as on January 31, 2014)

Electrification of Un-/De-Electrified villages		Intensive Electrification of Electrified villages		No. of Connections to Rural Households including BPL	
Coverage in No.	Achievement in No. (%)	Coverage in No.	Achievement in No. (%)	Coverage in No.	Achievement in No. (%)
117,704	96,891 (82.3 %)	356,393	300,096 (84.2 %)	41,138,452	23,317,792 (56.7 %)

Source: Website of the RGGVY http://rggvy.gov.in/rggvy/rggvyportal/plgsheet_frame3.js (As viewed on 16/2/2014)

TABLE 2: COOKING FUELS IN INDIAN HOUSEHOLDS

India	Rural	%	Urban	%
Firewood	104,963,972	62.5	15,870,416	20.1
Crop residue	20,696,938	12.3	1,139,977	1.4
Cowdung cake	18,252,466	10.9	1,356,862	1.7
Coal, Lignite, Charcoal	1,298,968	0.8	2,278,067	2.9
Kerosene	1,229,476	0.7	5,935,113	7.5
LPG	19,137,351	11.4	51,285,532	65.0
Electricity	118,030	0.1	117,497	0.1
Biogas	694,384	0.4	324,594	0.4
Any other	1,040,538	0.6	155,521	0.2
No cooking	394,607	0.2	402,358	0.5
Total	167,826,730	100	78,865,937	100

Source: Census of India, 2011

Rural electrification has been extensively done through grid extension. Decentralised distributed solutions have been viewed as temporary solutions in India

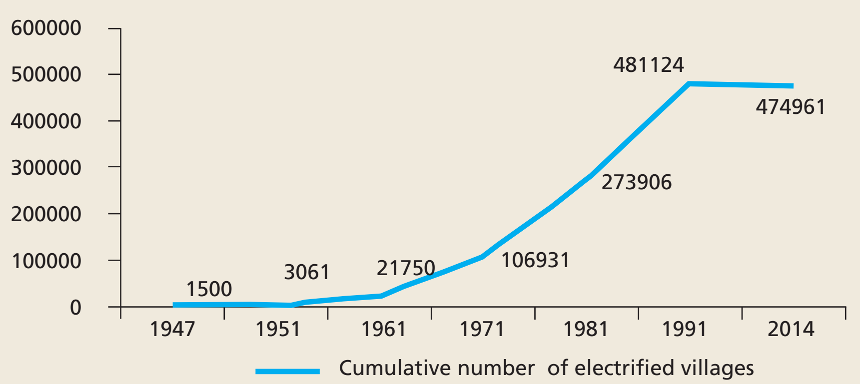
shows that 86 per cent people in rural India still use biomass as cooking fuel (see table 2: Cooking fuels in Indian households).

2. Programmes: saga of failures

In India, rural electrification has evolved by extending the grid to un-electrified villages or by providing off-grid home lighting systems to remote villages where extending the grid is not techno-economically feasible. In the 1950s and 1960s, state electricity boards were, by and large, electrifying towns and cities—despite universal service obligation being one of their mandates. Growing financial constraints of state utilities and rising demand for rural electrification forced the government take US assistance to set up the Rural Electrification Corporation (REC) in 1969.

However, REC took a very narrow approach to rural electrification. Guided by a flawed definition, the programme focussed on taking electricity to villages without taking care to ensure electricity to individual households in rural India.[6] The exponential growth curve of village electrification is, therefore, misleading (see figure 1: A misleading high). It does not depict the actual picture of energy access in India's villages. The graph's downward slope between 1991 and 2004 is a function of the change in definition of village electrification. Many villages that were deemed electrified were downgraded to a 'de-electrified status' because the definition of rural electrification changed in 2004.

FIGURE 1: A MISLEADING HIGH



Source: Improving Electricity Services in Rural India, Working Papers Series - paper no 30, Page 13

Since 1974, the government has embarked on several programmes to address village electrification. But all of them have failed to provide universal access to electricity (see timeline: A futile tryst with electricity).

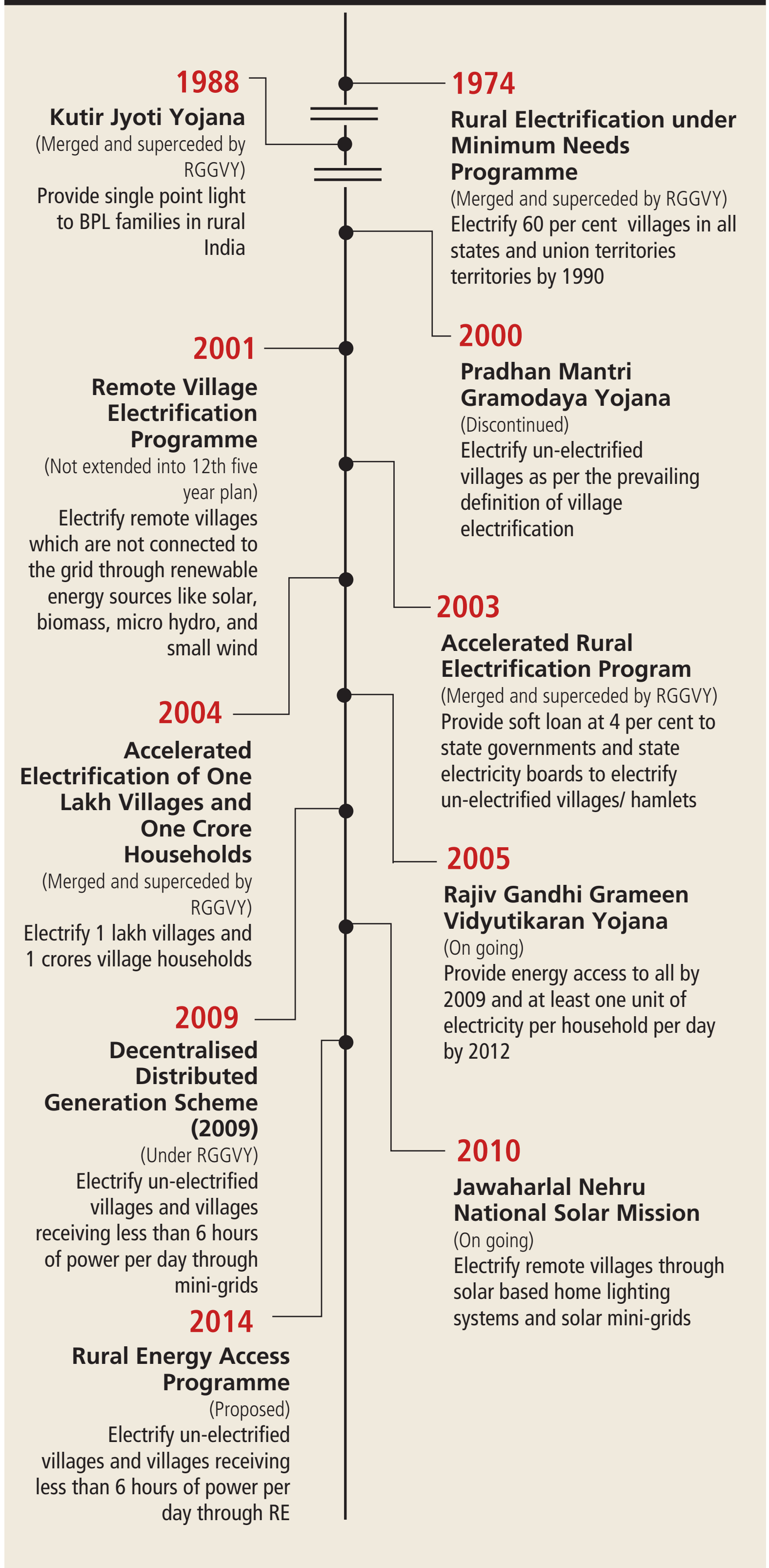
I. Rajiv Gandhi Grameen Vidyutikaran Yojana

RGGVY was set up in 2005; it superceded all other programmes run by the Ministry of Power through REC or state governments. The programme aimed to provide electricity to all and improve rural electricity infrastructure by 2009.[7] The centre provides 90 per cent capital subsidy to states for overall costs of the project. It also arranges for the balance 10 per cent: as soft loans.

A capital subsidy of ₹ 5,000 crores was approved for the last two years of the 10th plan period ending March 2007, ₹ 28,000 crores was allocated in the 11th plan period and ₹ 23,397 crores was sanctioned in the 12th plan period.[8] As of January 31, 2014, RGGVY has involved 576 projects, covering 96,891 un-electrified villages, more than 300,000 partially electrified villages and 19.76 million BPL households. The total project cost has come to ₹ 28,767.3 crores (see figure 2: The flagship programme's beneficiaries).[9]

Electricity supply, however, continues to be poor. Rural consumers get electricity for less than six hours a day.[10] Rural households still use kerosene for basic lighting even though villages in which they are situated are electrified on paper. The mismatch between the programme's claims and ground realities is corroborated by Census data of 2011. According to the Census, 77.5 million households still use kerosene for lighting at night. So, RGGVY not only failed to fulfill its objectives for 2009, it also failed to provide electricity to individual households under the programme.

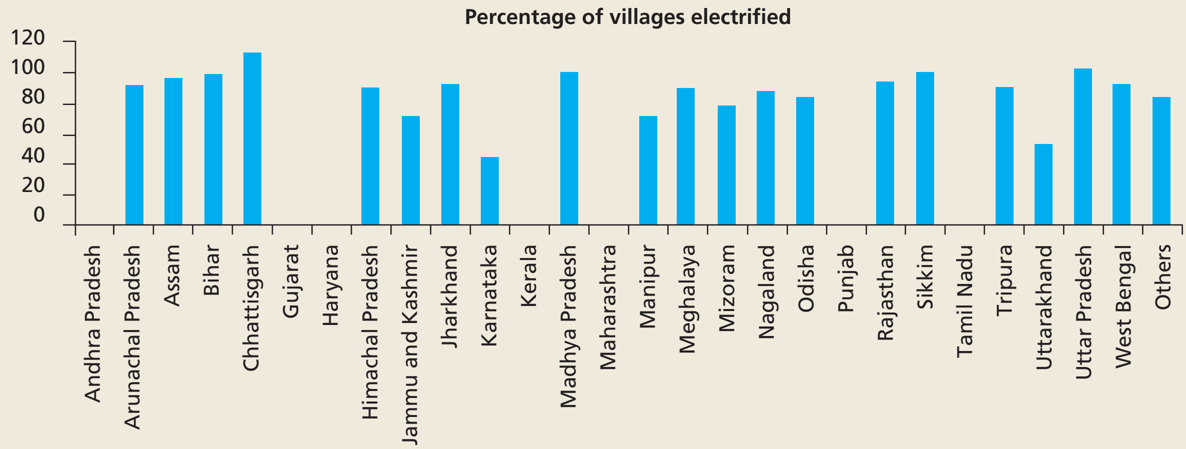
A FUTILE TRYST WITH ELECTRICITY



Source: Compiled from various sources of MNRE and MoP

FIGURE 2: THE FLAGSHIP PROGRAMME'S BENEFICIARIES

Percentage of villages electrified by RGGVY as January 2014



Source: Website of the RGGVY, Projects so far, http://rggvy.gov.in/rggvy/rggvyportal/plgsheet_frame3.jsp as seen on 20/2/2014

Given the scope for setting mini-grids under RVEP and RGGVY, very few projects exist on the ground

II. Remote Village Electrification Programme

There are several villages in hilly and remote areas where extension of grid is neither technically feasible nor economically viable. In 2001, MNRE identified about 18,000 such villages and hamlets to provide them basic lighting services using renewable energy applications.[11] It designed the Remote Village Electrification Programme (RVEP), that year, to reach electricity to these villages by 2012, using off-grid renewable technology.[12] However as of June 2013, MNRE could achieve a little more than half the stated target (10,154 remote villages and hamlets) a total outlay of ₹ 715 crores.[13]

The programme did not have a long-term vision of rural electrification. It did have a provision for setting up community-based power plants, but very few states actually did so. Instead, they sought temporary solutions: most RVEP projects have been set up using solar home lighting systems that includes a 37 Watt-peak (Wp) module, two 11 W CFLs and a battery. RVEP has been beset by several problems: beneficiaries have not developed a sense of ownership over the home lighting systems, several of them have been riddled with faulty equipment and several others have not been able to get proper maintenance services for the lighting systems.[14] Rampant corruption has also crippled RVEP in several areas. Monitoring is poor or, at several places, non-existent. The programme has been suspended in the 12th plan and is likely to be superceded by the proposed Rural Energy Access Programme (REAP).[15,16]

III. Decentralised Distributed Generation under RGGVY

While RGGVY was responsible for village electrification through grid extension, RVEP was mandated to provide village electrification through renewable energy based off-grid solutions. RGGVY's inability to achieve energy access to all by 2009 forced the government to rethink another project under the flagship programme. The government had also, perhaps, anticipated RVEP's failure in achieving its target of electrifying 18,000 villages by 2012. In order to reach out to villages that cannot be electrified through grid extension, the Ministry of Power launched the Decentralised Distributed Generation (DDG) scheme in 2009. DDG has a budget of ₹ 540 crores to set up community-based power plants for villages either using diesel generation sets or renewable energy based mini-grids. The programme provides 90 per cent capital subsidy on project costs. Every household will receive a 76 W load as per DDG.

Rural Electrification Policy, 2006 (REP) had a mandate to provide one unit per day to all households. RGGVY promised to fulfill this mandate by 2012.[17] However, 2012 has come and gone and the objectives are nowhere near fulfilment. Of the 10,154 remote villages and hamlets electrified under the RVEP, most were provided with basic lighting services for six to eight hours a day through solar-based individual home lighting. The programme's architecture was ill-suited to meet the mandate of REP.

RGGVY also failed to provide electricity to rural consumers for six to eight hours a day in most cases. Therefore, the DDG scheme was modified in April 2013 to cover electrified villages that receive electricity for less than six hours a day.[18] Other modifications included increasing the per household load provision from 76 W to 200 W. The scheme also allows setting up projects in remote villages where only solar home lighting systems were issued under RVEP.[19]

However, four years since its inception, DDG has found few takers. Only 85 projects have been commissioned under the programme out of the 639 project proposals that have been received till January 2014.[20] All projects have been commissioned in Andhra Pradesh. So far, ₹ 26 crores has been released for these projects so far as against the sanctioned amount of ₹ 277 crores .

The grid has reached the majority of the villages in the country. However, the supply is barely six to eight hours a day

IV. Off-grid solar applications scheme under JNNSM

The Jawaharlal Nehru National Solar Mission was launched in 2010 to develop solar technology both on large-scale mode and for off-grid applications. The first phase of the JNNSM, which had an off-grid component of 200 MW with primary focus on energy access in rural areas, has achieved its target: 252 MW have been installed (by 2013 end). Apart from solar-based mini-grids and home lighting systems, off-grid solar applications like solar lanterns, solar streetlights, and solar water pumps were also included under the off-grid subsidy scheme of JNNSM.

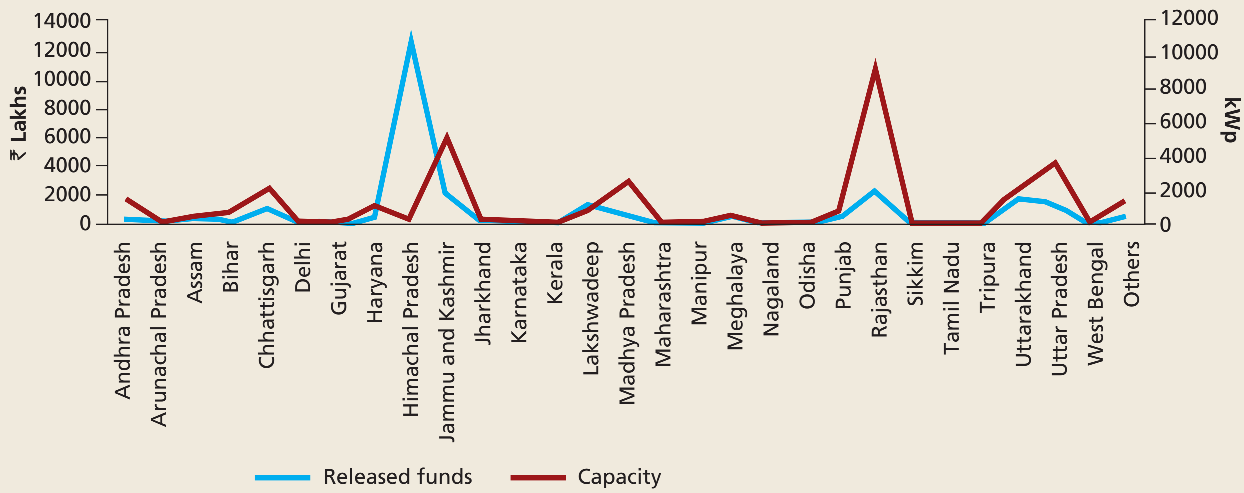
The programme provides 30 per cent capital subsidy calculated on benchmark costs declared by MNRE from time to time. The programme also has provision for soft loans up to 50 per cent of the project cost. The balance has to come as an upfront user contribution.

An analysis of the JNNSM's first phase shows that only a small percentage of its subsidies benefited rural households. In its first year, projects benefiting rural households comprised only about 27.5 per cent of JNNSM's achieved targets; 40.6 per cent of the projects were directed to institutions and the rest were taken up by the private sector, including banking institutions, telecom companies, industrial units and theatres in urban and semi-urban centres.[21] The difference between the national solar mission's objectives and their implementation is stark. Uncertainty about subsidies and the time consuming disbursement process led most channel partners away from the programme's targeted beneficiaries: rural consumers.

It is also important to note that benefits of the off-grid component of JNNSM's first phase have not gone to states that suffer acute energy poverty. And quite significantly, Himachal which received the highest subsidy performed very poorly in terms of capacity installation (see figure 3: Not for the energy poor).

FIGURE 3: NOT FOR THE ENERGY POOR

Statewise funds released and capacity installed in the first phase of JNNSM



Source:http://greencleanguide.com/2011/05/18/states-wise-cfa-and-capacity-of-off-grid-solar-installations-under-the-jnnsm-2010-11/

Implementation of JNNSM has strayed away from its objectives. Only a few portion of the off-grid subsidies have actually been utilised by rural households

V. Rural Energy Access Programme

In mid 2012, MNRE drafted a new scheme, Rural Energy Access Programme (REAP) to supercede RVEP.[22,23] Similar to DDG, REAP also targets villages that are either un-electrified or are electrified but receive less than six hours electricity per day.[24] The scheme aims to cover 20,000 villages. Each household would receive two to five light points and one to three plug points based on its requirement and shall be connected through micro- / mini-grids.[25,26] The micro- / mini-grids shall receive capital subsidy up to 90 per cent of the benchmark costs decided by MNRE from time to time. The programme also will encourage private sector participation through competitive bidding process.

The irony is that there is hardly any major difference between DDG and the proposed REAP programme except that the former comes under the preview of MoP while the latter falls under MNRE. This kind of overlapping of programmes will create conflict which will eventually end up in disorderly execution of the programmes. The objectives, strategies, and the targeted beneficiaries are similar in both the programmes. However, the proposed REAP has some riders such as ‘star rating’ to differentiate product / system performance, online disbursal of subsidies and IT enabled monitoring systems.

3. Crux of the problem

I. Definition of village electrification – faulty premise

Defining village electrification in the country has always betrayed a lack of seriousness. Prior to 1997, a village was deemed electrified if electricity was used within its revenue area for any purpose. In October 1997, the definition was changed somewhat and a village was considered electrified if electricity was used for any purpose in residential areas within the revenue boundary of the village. According to the latest definition of village electrification in India, which came into effect in February 2004, a village is considered electrified, if the following three conditions are fulfilled:

TABLE 1: DDG, JNNSM (OFF-GRID) AND PROPOSED REAP PROGRAMMES AT A GLANCE

DDG Scheme (RGGVY)	Off-grid distributed generation (JNNSM)	Proposed REAP Scheme (MNRE)
Scope ● Un-electrified villages and their hamlets where grid extension is not possible and villages receiving less than 6 hours of electricity a day ● Priority to villages where grid extension shall take around 5-7 years	**Scope** **Power plant** ● In urban and rural areas ● Maximum capacity of 100 kWp / site with battery storage ● Maximum capacity of 500 kWp/ site W/O battery storage **Mini-grid** ● Maximum capacity of 250 kWp / site	**Scope** ● Un-electrified villages and villages receiving less than 6 hours of power per day
Mandate ● 6-8 hours of electricity/day for 25 days/month ● Mini-grid that should be grid compatible ● Population > 100/village or hamlet		**Mandate** ● 7 street lights per 100 households ● Set up service centers in every village ● Village not considered electrified if powered by solar home lighting systems ● Tariff to be decided by state nodal agency (SNA) ● Mini-grid that should be grid compatible
MoP assistance ● 90 per cent capital subsidy ● 10 per cent soft loan from REC	**MNRE assistance** **Capital subsidy** ● 30 per cent of benchmarking cost ● 90 per cent of benchmarking cost for special category states **Interest subsidy** ● Soft loan @ 5 per cent	**MNRE assistance** ● 90 per cent central financial assistance (CFA) for mini-grid for 10-250 KW range and micro-grid up to 10 kW range. ● CFA for load up to 58W per household.
	Benchmarking cost **Solar lighting** ● CFLs upto 300 Wp – ₹ 270 ● LEDs upto 300 Wp – ₹ 450 **Power plant with battery** ● 1 – 10 kWp - ₹ 190 ● >10 – 100 kWp – ₹ 170 **Power plant without battery** ● Up to 100 kWp – ₹ 100 ● >100 – 500 kWp – ₹ 90 **Micro-grid** ● Up to 10 kWp– ₹ 350 **Mini-grid** ● >10 – 250 kWp – ₹ 300 **Solar water pump** ● Upto 5 kWp – Rs. 190	
Funding structure ● 60 per cent in proportion to project progress ● Balance 40 per cent split over 5 years @ 8 per cent per year ● Cost of providing power at the end of FY based on recovery from the villagers	**Funding structure** ● Developers contribution 20 per cent ● Routed through regional rural banks and accredited channel partners	**Funding structure** ● Funding in 3 stages routed through SNA ● 1st stage - 30 per cent CFA upfront ● 2nd stage – 30 per cent CFA after commissioning ● 3rd stage – 40 per cent CFA after successful operation for one year
Technologies ● Diesel Power Generation ● Renewable Generation (Micro hydro, biomass, wind, biofuels, biogas, solar PV, hybrid Systems)	**Technologies** ● Only solar ● With required test certificates after accreditation	**Technologies** ● All RE technologies ● Solar home lighting systems if other technologies are not feasible ● 10 years warranty for SPV system

Source: Programme documents of JNNSM, DDG and proposed REAP from MNRE

i. Basic infrastructure such as distribution transformers and distribution lines are provided in the inhabited locality as well as one dalit *basti*/hamlet
ii. Electricity is provided in public places like schools, panchayat office, health centers, dispensaries and community centers
iii. The number of households electrified is at least 10 per cent of the total number of households in the village.

It is apparent that definitions of village electrification prior to 2004 completely ignored the issue of energy access. The 2004 definition breaks new grounds in talking about establishing a distribution network within a village and addressing energy access issues: it talks of extending energy access to 10 per cent of village households. However, even this definition dilutes the objective of providing electricity access to every rural household. Energy access to every household and 100 per cent electrification cannot be achieved until the definition of village electrification is changed.

II. Cost economics – negative economic rent

Extending the grid to rural and remote areas requires huge capital expenditure, but net revenue returns are negative. Usually cash crunched utilities do not show any interest in serving rural people even though they receive a capital subsidy of 90 per cent through government schemes. This is because operation and maintenance costs of rural electricity systems are more than revenues from electricity.

Even when a village is connected to the grid, rural poor get the least priority in terms of distribution schedule of utilities

Even if a village is connected to the grid, rural poor get the least priority in power distribution schedule of utilities. The country's energy shortage and peak demand shortage are 4.3 and 4.2 per cent respectively.[28,29] Therefore, utilities optimise revenue by giving priority to customers in towns and cities while people in villages suffer frequent outaged.

III. Topography – extension of grid not feasible

Grid extension is not possible in some villages because they are located on hilly terrains and their population is dispersed. These villages essentially need sustainable off-grid solutions. However, such solutions should not be limited to basic lighting. Programmes for off-grid solution have to factor in population growth, future demand, economic activities and growth of aspirations in rural areas. Currently, however, the off-grid programmes do not have adequate foresight to address these aspects.

Way Forward

I. Definition: First things first: India needs to redefine village electrification to fulfill the basic objective of energy access in reasonable time. A programme's success should be measured in terms of the number of households electrified rather than the number of village electrified.

II. Policy: Off-grid distributed generation is being considered actively in various parts of the world as a possible way to take electricity to people in rural areas. Policy makers in India are also thinking along similar lines and are revitalising off-grid decentralised distribution through programmes like DDG, JNNSM and newly proposed REAP.

However, these programmes must complement, and not compete against, each other. An integrated policy framework should be in place for them to co-exist. There is no point in having two separate programmes, DDG and REAP, that compete with each other. They could complement each other. If DDG is taking care of villages with more than 100 households only, REAP should focus on villages or hamlets that have up to 100 households. Similarly, JNNSM should consider only individual home lighting systems, solar lanterns, solar pumps, rather than concentrating on renewable energy based distributed generation with micro- / mini-grids.

III. Subsidy: The overall cost of renewable energy solutions is high, compared to conventional energy sources. In order to make renewable energy work for the rural and marginalised poor, government will have to provide some form of financial support. Decentralised distributed systems like, solar home lighting systems, street lights, water pumps, are essential for the objective of rural electrification, driven largely through capital subsidy. But in the current capital subsidy regime, deciding the right amount of subsidy is a a challenge for policy makers: high subsidy encourages unscrupulous business while low subsidies discourage serious and passionate entrepreneurs. It has also been observed that capital subsidy to the tune of 90 per cent does not foster a sense of ownership among beneficiaries. Therefore, policy makers must get away from capital subsidy and propagate incentive-based mechanisms like feed-in-tariff or generation based incentives to encourage project developers. Interest based subsidy, like soft loan, is also a good way to finance projects.

IV. Awareness: Lack of technical knowledge often leads to abuse and ultimate failure of solar home lighting systems. Such failures are quite common. A survey by researchers from the Centre for Science and Environment revealed that beneficiaries shift back to kerosene if a component in the solar home lighting system require repair and maintenance—instead of getting the system repaired. It is important there is a service network at hand to attend technical problems.

V. Quality Control: Products meant for remote locations should be robust in quality so that after sales service issues are minimal. Currently, however, quality control in off-

A village may be considered to be electrified with just 10 per cent of the households having connections. Hence, even if 100 per cent of the villages are electrified on paper, only a fraction of the households could have received connections

MINI-GRID

The term 'micro-/mini-grid' refers to a system where one or more generators and, possibly, energy storage systems are interconnected to a distribution network not connected to the main grid. This off-grid distributed generation is often termed as 'micro/ mini-grid' and is used extensively in the context of electricity access in rural and peri-urban areas.

Micro/mini-grid has become a buzzword in the developing world in recent years. A lot of emphasis has been given to sustainable development of mini-grid models in order to address electricity access issues in rural areas. Although there are several mini-grid models, none of them has been proved commercially viable. Several factors like tariff regulation, feed-in-tariff, interaction with the main grid, operations and maintenance stand in the way of viability of these mini grid models.

Mini-grids were originally intended for villages where the grid has not reached or shall never reach. However, this limitation was removed in 2013 when the DDG programme allowed establishment of mini-grids in electrified villages receiving less than six hours of electricity in a day.

grid solutions is a big challenge. Developers often use poor quality products to reduce capital or production costs and then sell their products at competitive rates. There has to be a mechanism in place to ensure quality control. Quality control measures like star rating programs for products and systems should be developed and best practices from different parts of the world emulated to ensure better quality.

VI. Mini-Grid: Government policies must push for grid ready mini-grid models to serve rural consumers where grid power is available for less than 15 hours in a day. The following aspects need to be considered to ensure the model's sustainability:

i. Size: The mini-grid should be designed in such a way that it is capable handling increasing electricity demand. Adding further generating capacity on to a mini-grid in future will not be much of a problem, if the distribution and control system are designed adequately at the beginning itself to take care of additional loads in the future.

ii. Standards: The mini-grid and the distribution system must follow standards for electricity transmission and distribution at standard voltage levels of the grid. Wiring of houses must be in accordance with building codes to ensure safe use of electricity in rural areas.

iii. Models: As of now, mini-grid developers receive 90 per cent capital subsidy. However, this approach affects sustainability if the developer, having received the subsidies, does not show interest in the project's operation and maintenance. Instead, the developer must be engaged over a longer period and possibly work as a distribution franchisee of the utility operating in the region. Rural consumers should pay the mini-grid developer at rates charged by grid power utilities in the nearest electrified village. The balance, the difference between the cost of generation and the tariff charged to the consumer, could be paid by the government either as feed-in-tariff or as generation-based incentive. The developer should also be given soft loans routed through development bank / government financial institution / commercial banks and mini-grid should be considered under the priority sector lending.

The Ministry of Power and the Ministry of New & Renewable Energy need to avoid overlapping of policies

Moreover, the mini-grid policy must have clear guidelines on feed-in-tariff, tariff regulation and grid interconnection. These are vital for the success of the programme. The policy must have guidelines to judiciously calculate the cost of generation. This should be the basis of calculating feed- in-tariff. The policy also should provide guidelines for developing the required grid interconnection codes for micro / mini-grids.

iv. Finance: Although Reserve Bank of India has included off-grid lighting applications for rural areas under the priority lending for commercial and rural banks, micro and mini-grids are yet to receive such approval. This is a significant bottleneck for mini-grids development in the country. Absence of banker's confidence on the commercial viability of mini-grid is an issue for priority lending. Therefore, soft loans from development banks including the government financial institutions is the only answer until the confidence of the commercial banks is built up.

REPORTS FROM THE GROUND

Biogas rediscovered

People in Vidarbha innovate to make biogas viable

While biogas schemes fail elsewhere in Maharashtra, Vidharbha farmers make plants work

When Vijay Ingle of Chittalwadi village in Akola district decided to install a biogas plant at his dairy in 2010, everyone in his village thought the project was doomed. Biogas had failed to take off in Maharashtra's Vidarbha region despite the government promoting it as the cleanest and cheapest fuel for over three decades and offering subsidies for setting up the plant.

Besides, no one had heard of a biogas plant installed about half-a-kilometre from the house; it is usually set up in the backyard, close to the kitchen.

In neighbouring Tandulwadi village of Buldhana district, farmer Shyamrao Deshmukh had faced similar scepticism. As their joint family grew, the Deshmukhs had to relocate their cowshed to the village outskirts, about half-a-kilometre away. To cut down the growing expenses on liquefied petroleum gas (LPG), Shyamrao Deshmukh decided to set up a biogas plant in the cowshed. He, too, found himself surrounded by people asking him to give up the project. The two farmers, however, stuck to their resolve and made the plants work. The success turned critics into believers.

In Vidarbha, farmers setting up biogas plants do not have large number of cattle. This disproves the official theory that cow dung scarcity was what failed the plants earlier

Today, Chittalwadi has 15 working biogas plants. Tandulwadi has four. Several others also plan to install biogas plants and have applied for subsidies.

So far, officials had cited cow dung scarcity in Vidarbha as the reason biogas was not drawing a crowd, despite subsidies. But farmers setting up biogas plants in these villages do not own large numbers of cattle, disproving the official theory. They have found innovative solutions to the challenges that prevented farmers from accessing biogas.

Back to original plan

While struggling to overcome problems involving distance, Deshmukh approached scientists at Dr Punjabrao Deshmukh Krishi Vidyapeeth, an agriculture university in Akola that offers extension services. He was advised to install telescoping PVC pipe to build pressure in the gas tank and put the pipeline below ground with a gentle gradient for unhindered flow of gas to the kitchen. He was also told to install equipment for removing moisture from the pipeline. Deshmukh realised that to install the pipeline he would have to shell out more than the cost of the entire plant and lower his kitchen floor by around 60 centimetres.

Before deciding to give up, Deshmukh decided to go back to his original plan. He already had constructed a 2-cubic metre (cum) digester tank at ₹ 9,000 and installed a rubber pipe used for drip irrigation. Instead of laying it underground, he took the pipe to his house by securing it to tree branches overhead. It cost Deshmukh ₹ 1,000. To trap moisture, Deshmukh twisted the pipe into a loop at the source and secured it in that position; being heavier than gas, moisture settles within the loop and flows back into the digester. “Moisture, which the university official had warned would be the problem, has not troubled me so far,” Deshmukh says. The plant provides enough gas to cook for his family of six all year round.

Sindhutai Tayade adds cow dung slurry to her plant through the feeder

Success lies in bifurcation

Ingle too had approached the university for guidance but to no avail. Then he approached an agriculture input dealer, who suggested that he use rubber tubes used in LPG cylinders. “My brothers and I had spent ₹ 1.75 lakh for constructing four 6 cum digester tanks,” says Ingle. “Installing that kind of a pipe would have cost us another ₹ 1.4 lakh, which was impossible.” Like Deshmukh, Ingle used a drip irrigation pipe, running overhead. But he bifurcated it at the source with a T-section.

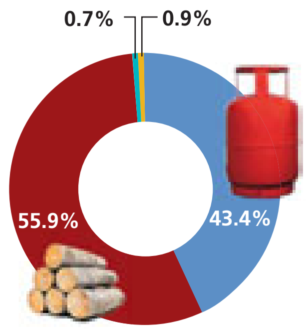
One branch carries the gas to the house, while the other heads vertically downwards to a nozzle. “I open it once a week to drain out moisture,” he says. Apart from providing enough gas for cooking and heating bath water for 22 people, Ingle’s plant also provides enough gas for extra cooking for about 100 people three to four times a year during festivals, processing of 100 litres of milk products in the dairy every day, and lighting the cattle shed. “We are left with surplus gas and plan to install a generator to supply power to the house,” says Ingle. His joint family now saves ₹ 80,000 per year on LPG cylinders. Most of the 15 farmers in Chittalwadi who used Ingle’s innovation own not more than three to four heads of cattle.

“Initially, we were reluctant as the conventional biogas plant design requires

FUELS USED FOR COOKING IN MAHARASHTRA

Total no. of households

23,830,580



- Firewood, cowdung cake, crop residue, coal
- Liquefied petroleum gas
- Biogas
- Other fuels

Source: Census 2011

Vijay Ingle stirs the slurry in the biogas digester tank

a large amount of dung," says Sindhutai Tayade, who owns four heads of cattle. "But when we found that Ingle's plant works just by using dung from 10 to 12 animals, that too on alternate days, we thought it could work for us too."

Milind Ingle, another farmer from Chittalwadi, was surprised to find that dung from his three cows was more than enough for his family of three.

The innovations are fast spreading to nearby villages where people are rediscovering biogas. Manohar Kokate of Shirla village in Akola says some 50 biogas plants were installed in the village in the 1980s when the government introduced biogas under a national project. Most of these plants closed down within a decade after cattle numbers dwindled in the arid region. Now, with the government introducing the smaller Deenbandhu model of biogas plant and innovations by several farmers, people want biogas again, Kokate adds.

Farmers now require guidance to make innovations

Government must step in

Farmers feel that guidance for installing biogas plants and associated innovations is a pressing need. One area of improvement is transporting gas from a distance. In most villages, with families multiplying, cattle sheds are located away from the homestead. "The gas pressure is influenced by distance, topography, as well as the number of twists and turns in the pipeline," says Ingle. "What works for one may not work for others. It took me two months to work out how often I need to feed dung to the plant to maintain uniform gas pressure. Also, there is no guidance on the kind of pipes to use. Metal and PVC pipes are expensive and need to be laid underground," he adds.

The government should also raise the subsidy bar, says Ingle. The current subsidy of ₹ 8,000 is for a 2 cum plant, which generates just enough gas for cooking. To meet all domestic fuel needs of a family of five to seven members, one needs a 6 cum tank.

With rising LPG prices and firewood getting scarce by the day, the number of farmers willing to go for biogas is on the rise in Vidarbha. All they need is a little support from government and financial institutions.

Budgeting power

Four Rajasthan villages get micro-grid solar power using an innovative pre-paid meter that detects theft

A 5.5 kilowatt solar micro-grid in Neechli Babhan in Rajasthan's Pali district

Innovative pre-paid meters help people use electricity judiciously

It looks no different from the regular electricity meter, but its innovative version is changing the way people use electricity and pay for it. Neechli Babhan, a small village in Rajasthan's Pali district, has a smart meter installed in 80 of its 150 houses. The smart meter forces people to use electricity diligently.

The device is an innovation by a company started by engineering graduates, Yashraj Khaitan and Jacob Dickinson: Gram Power. It gives real time information about the credit left, just like a pre-paid mobile phone does, says Mohan Singh, a daily wager. It also shows the number of hours an appliance can be used. "We have only ₹ 30 left," pitches in his 10-year-old daughter. "Please get it recharged before we run out of credit," she tells her father, happily showing off that she can read the meter. Mohan phones Udai Singh who recharges smart meters in the hamlet.

Within 10 minutes, he is in Mohan's house with an instrument of the size of a mobile phone, called dongle. He enters 100 on it for the ₹ 100 that Mohan pays him, takes it close to the smart meter and presses a button. The meter makes a 'click' sound and shows ₹ 130 as balance. The ₹ 100 recharge can help Mohan light an 8 Watt CFL for 400 hours.

A SMART MICRO-GRID

LOCATION

Neechli Babhan village, Pali district, Rajasthan

Size

5.5kW

Households

80

Tariff paid by consumer*

₹34/kWh

Implemented by

Gram Power

Funded by

Multiple sources

Energy services

Lighting, fan, television

Grid connection

Not present

* As per calculation by CSE

The electricity comes from a 5.5 kW solar micro-grid set up on the roof of a school. Neechli Babhan is off the main grid because of its rocky terrain. The power generated through solar panels is stored in batteries, which make electricity available 24 hours a day. The plant has generated about 4,600 units until September 2013. A capacity utilisation factor of 16 per cent can be observed from the plant's generation.

The micro-grid is also power theft-proof. All smart meters in the village are wirelessly connected and can be controlled online. If somebody hooks a wire on a distribution line, the meters detect it and that line shuts immediately.

Idea for change

In 2008, still in their twenties, Khaitan and Dickinson met while studying engineering at the University of California, US. Khaitan belongs to Jaipur. He knew that back home, villages without power were underdeveloped. Besides, power distribution companies in the state were facing two major problems—theft and bill payment default.

Khaitan spoke to Dickinson about it. The two started thinking how the situation could be improved. Massive penetration of mobile phones in remote parts of the country gave them the cue. They completed their course, came to Jaipur and started Gram Power.

After months of research, smart meter was born. In 2012, Gram Power installed smart micro-grids in four villages in Rajasthan. It employed people like Udai Singh who recharge smart meters and get 10 per cent commission on each recharge. Gram Power holds intellectual property rights on the meter. Now the company plans to install it in 21 more villages in the state.

Gram Power charges ₹ 3,500 for one connection. This is non-refundable. The connection includes a smart meter and two 8 Watt CFLs. However, the meter is not the consumer's property.

Gram Power, a micro-grid technology provider, has installed pre-paid smart meters in Pali district of Rajasthan

"The pre-paid system ensures that there is no payment default," says Khaitan. He set up the system in Neechli Babhan in mid-2013. Before that, people either used kerosene or Solar Home Lighting System (SHS). Many prefer micro-grid over SHS because it is cheaper and takes more load. A regular 37 Wp (Watt-peak) SHS costs ₹ 11,000. It is difficult for people to pay the amount. Unlike SHS, which gives only two CFL points, micro-grid can reach almost every room of a house. The recurring cost of battery replacement of SHS every five years is another deterrent. In many villages, SHSs are lying unused because people could not arrange money to replace batteries, which cost ₹ 4,000 each.

For necessity, not for comfort

Smart micro-grid works very well till people consider electricity as a means to illuminate their houses. No sooner do they expand its use, charges shoot up. Lighting an 8 Watt CFL for an hour costs 25 paise. So if a family uses two such CFLs for six hours a day, the monthly expenditure would be ₹ 90. But if they want to run a ceiling fan or a television, power becomes expensive. Consider this. It costs ₹ 2.50 to run a 70 Watt ceiling fan for an hour. So if a family wants to sleep comfortably in the night and use fan for six hours, it would cost them ₹ 450 in a month.

The amount can give people of Neechli Babhan, comprising mostly daily wagers, many sleepless nights. It is because of the expense that women of the village still gather under a big neem tree during the day. "We save money to use fan in the evening when our children study," says Savita Rawat.

Service is another challenge. There have been times when Gram Power has taken 10 days to repair meters. "We have trained vendors to fix small problems. In case of big problems, we send people from our head office. But big problems are few and far between," says Khaitan.

He admits the rates are steep. The cost of power generation in micro-grids below 10 kW, including power storage is ₹ 28 per unit. A back-of-the-envelope calculation by Delhi-based Centre for Science and Environment (CSE) shows that consumers in Neechli Babhan pay about ₹34 per unit. "That is why we developed a pre-paid system. People can budget their power," says Khaitan. "This is the best we can do, else the model will be financially unviable for the company," he adds. He hopes to recover the cost of micro-grid installation in five years.

Capital challenge

The capital cost of the smart micro-grid was ₹25 lakh. Gram Power availed 30 per cent subsidy from the Union Ministry of New and Renewable Energy (MNRE) on capital cost for off-grid system. The company collected ₹2.8 lakh from households as connection charge. The rest was raised through private investors. "Low government subsidy makes it difficult for us to make financially viable projects and still supply electricity at a low rate," says Khaitan. "Better funding mechanisms are needed. Banks should provide low interest loans to developers working in off-grid areas," he says.

Raza Ahmar, director, solar off-grid in MNRE, admits that high tariff is a problem in off-grid models. "But we still do not have an off-grid model that can satisfy everybody. Giving high subsidy is not the answer," he says.

One way to make off-grid models financially viable is to set up small industries in one area and create a productive power load. This way tariff can be cross-subsidised for the poor. But not many people want to set up industries in off-grid areas.

Another big challenge for micro-grid developers is the fear of their grid being rendered useless once main grid reaches its area of operation. "My system is compatible with the main grid," says Khaitan. It can be connected to the main grid and serve as the distributor.

Developers fear that their micro-grids may be rendered useless once the main grid reaches their area of operation. As of now, there is no policy to integrate micro-grids with the main grid

Solar power is stored in batteries and distributed among consumers

RAJASTHAN'S ENERGY POVERTY

Installed capacity (as on December 2013)

14,059 MW

Annual per capita electricity consumption (2011-12)

927.4 kWh

Total households

12,581,303

Unelectrified households

4,151,830

FOR LIGHTING

Households depending on kerosene

3,887,623

FOR COOKING

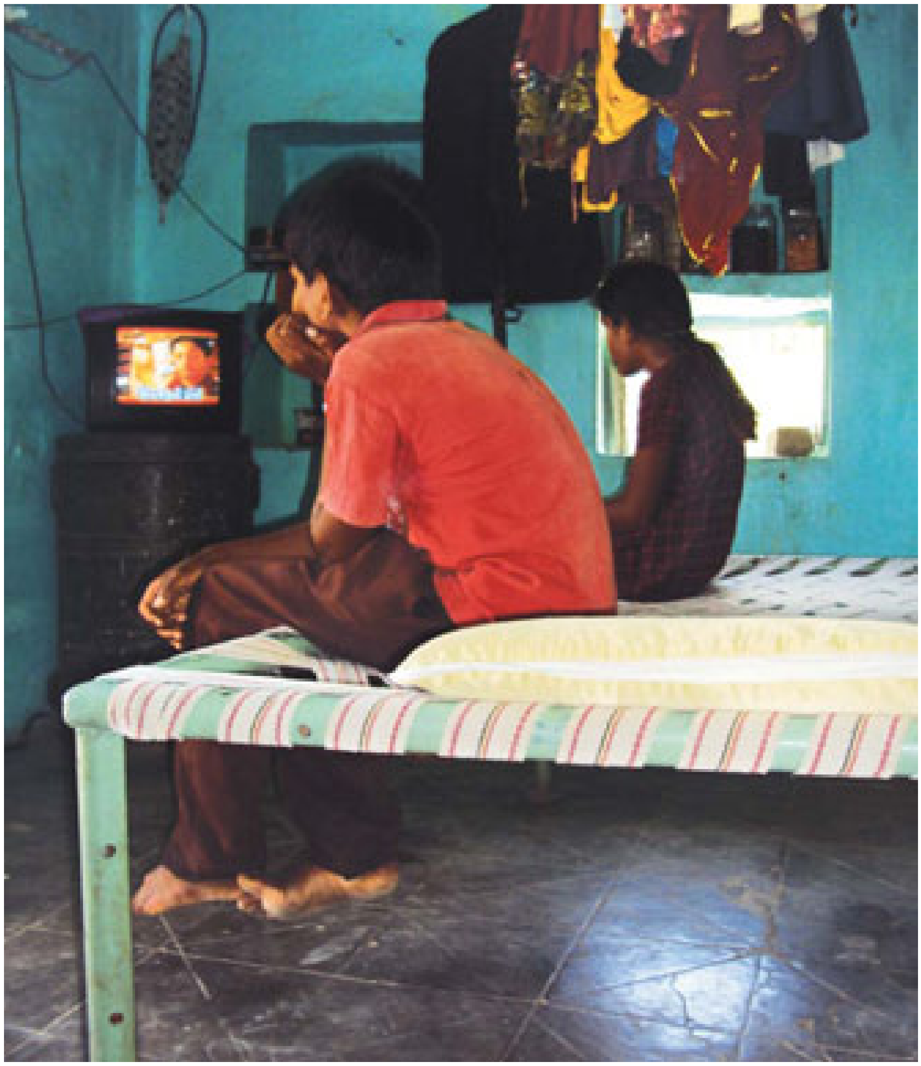
Households using firewood, crop residues, cow dung, coal

9,700,185

Unelectrified villages

4,151,830

Source: Census 2011, Central Electricity Authority



People in Neechli Babhan can now watch TV because of round-the-clock electricity supply by the micro-grid

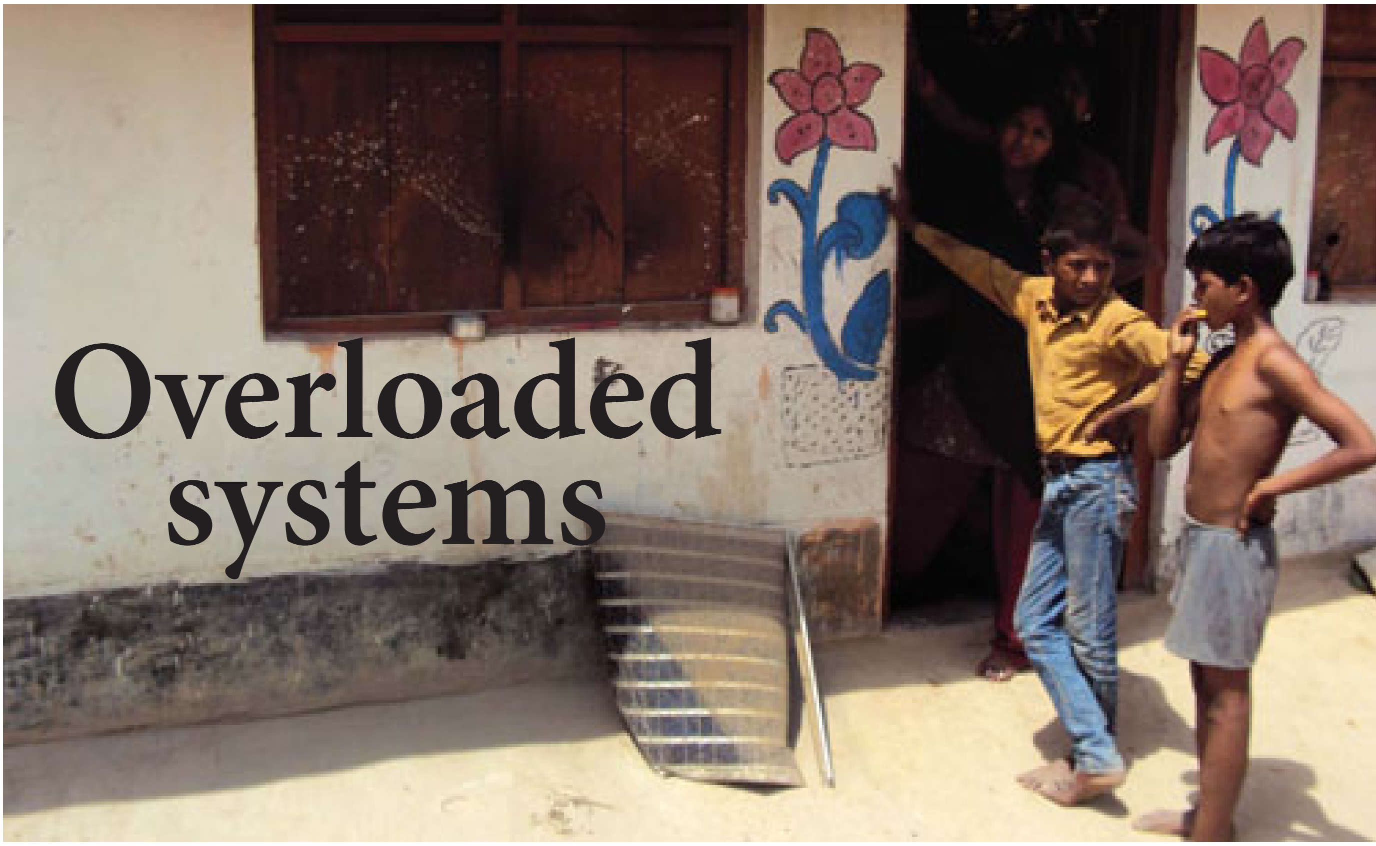
Workable model

In April 2013, Forum of Regulators (FOR), a group of consultants, endorsed a model, called distribution franchise, for electricity distribution in off-grid areas. The state electricity regulator decides tariff based on power generation cost of the developer. But the consumer is charged the conventional tariff.

The distribution company pays the difference to the developer. For example, the regulator decides the tariff as ₹ 15 per unit. The consumer pays the conventional tariff, say ₹ 5, to the developer. The distribution company pays the difference of ₹10 to the developer. This will save the state electricity regulator cost of setting up infrastructure.

"It is a workable model, but it is yet to be proved successful," says Ashwin Gambhir, policy researcher with Pune-based non-profit Prayas Energy. "It is important for main grid to reach small areas because many developers charge unfair tariff from the poor and do not want the grid to reach their areas of operation. This model will help both the parties," says Balwant Joshi of ABPS infra, Mumbai-based consultancy which prepared the report for FOR.

Overloaded systems



A bank's experiment to provide solar home lighting system faces challenges

Aryavart Gramin Bank partnered with Tata BP to provide solar home lighting systems to rural consumers on short-term credits

In 2008, when Shrinand Lal bought a Solar Home Lighting System (SHS) it seemed a boon for his family of seven. "It lit up the evening and my children could study," says his wife Kamlesh Rani. The family, which lives in Madeenpur village in Uttar Pradesh's Barabanki district, was the beneficiary of Aryavart Gramin Bank's scheme that provides SHS on credit. For 50 families in the village not connected to the grid, Aryavart's scheme has come as a blessing.

Within four years of its inception in 2006, the bank had a client base of 370,000 farmers who use Kisan Credit Cards (KCC)—which provide short-term credit to farmers during the cropping season—and about 27,000 teachers who have accounts with it. The scheme earned the bank, then with branches in Lucknow, Barabanki, Farrukhabad, Hadoi, Kannauj and Unnao districts of Uttar Pradesh, the distinction of being the first bank in India to receive carbon credits under the Clean Development Mechanism (CDM). It has also been recognised internationally: in 2008, the London-based Ashden Trust awarded the bank the International Global Green Energy award, one of the world's leading green energy prizes.

Drawing on its base of captive customers, Aryavart roped in Tata BP, currently known as Tata Power, which is accredited by the Union Ministry of New and Renewable Energy (MNRE) to supply SHS (see box: Financing solar home lighting systems). On its part, the company provides an extended warranty of 10 years for solar panels and five-year warranty for batteries. This reassured the rural clients who often lack a well-coordinated maintenance apparatus. According to the company, its local dealers have qualified mechanics on hand, who install the systems. "For proper

FINANCING SOLAR HOME LIGHTING SYSTEM

Aryavart provides a loan for up to 95 per cent of the system cost and the rest is collected from the user as down payment. The loan, offered at an interest rate of 12.5 per cent per annum, can be repaid in monthly or half-yearly installments, within five to seven years, depending on the product.

The bank then negotiates a reduction in the price of the systems with Tata BP. For example, the Venus 1 model (two 9 W CFLs, a 37 Wp panel, 12 V - 40 Ah battery), originally costing ₹ 14,500, was negotiated for a price of ₹ 13,650. This includes ₹ 650 as value-added tax. Out of this, the Union Ministry of New and Renewable Energy (MNRE) gives out a subsidy of ₹ 3,996 per system.

The customer deposits a down payment of ₹ 750 to the bank and the rest is credited to Tata BP by the bank. This amount, ₹ 8,904, is repaid with a monthly installment of ₹ 200 with 12.5 per cent interest in five years. The project has proved to be a successful venture for Tata BP since they do not have to worry about credit repayment. Till March 2012, around 55,560 customers have been given SHS.

PRICE OF THE SHS MODELS

Model	Panel	Luminaire	Battery Capacity	Price
Venus 1	37 Wp	2 x 9 W CFL	Tubular 12 V 40 Ah	₹ 14,500
Venus 2	74 Wp	4 x 9 W CFL	Tubular 12 V 40 Ah	₹ 27,000

Source: Tata BP

In many villages, solar home lighting systems are not operational due to lack of coordination among bank, service providers and consumers

installation and maintenance, the company partners with a local dealer who takes care of installations and maintenance," says S M Jafar, regional manager of Tata BP. Solar Power Systems (SPS) is one such dealer in Lucknow, which has trained 'business facilitators' in areas where the systems have been delivered. "We pay the facilitator a monthly salary of ₹ 3,000 and the beneficiary pays them service charges when the system is out of warranty," says Manoj Gupta, manager, SPS.

But all is not well with the scheme. "The panel was kept on the roof. It developed cracks and then shrunk," says Kamlesh Rani. The family is back to buying kerosene and does not know whom to contact. According to Jafar, the warranty was only on performance, not on breakage of systems.

Beer Singh, another resident of the village, who availed the scheme, says the SHS's battery has deep discharging problems. "Only one CFL works and that too only for two hours," says Sarita, his wife. Singh purchased a new lamp but that too failed. Singh has not paid his dues for several months now.

Mohmad Rizwan of nearby Tikaitganj village, complains, "What is the use of the system, if I still have to purchase kerosene for lighting? All the promises that the bank made about services were hollow," he lashes out. Rizwan has not heard of any technician trained by Tata BP in the area. He has paid all the installments.

No ownership

Company officials blame the battery problems on the overloading of the system. "A 37 Wp (Watt-peak) SHS has been designed for lighting about five hours a day. People have been told to not run television and fans for long hours together. But they don't pay heed," says Jafer. He explains, "There is a charge controller that cuts off power when the battery is about to go into reserve mode.

The beneficiary does not understand this and removes the charge controller, and directly connects wires of the panel with the battery. This exerts pressure on the battery. The charge finishes completely and the battery goes into deep discharge mode. The only way to get the battery fully discharged then is to leave the system untouched for two to three days."

But many beneficiaries say they use the system only for lighting and even then the SHS battery runs out. Says Gajraj Singh, Shrinand and Kamlesh's neighbour, "To begin with, the system not only powered CFLs for at least five hours, but also a fan for two hours. But that was only for a year-and-a-half. We are now back to using kerosene." Singh has not complained to the bank because of his pending dues.

Defaulters galore

Defaulting is a major problem across Aryavart's operational area. Till mid-2012, its branch at Kursi (25 km from Lucknow) had 14 villages, including Madeenpur, in its service area where it had provided about 1,000 SHSs. Only 300 had paid their complete installments while some others had time to complete the five-year loan period. "On an average, there were 20 per cent defaulters," complained Anwer Husain, Chief Manager (finance) of Aryavart Gramin Bank, Lucknow.

Satya Prakash, who lives in nearby Gondwa village, had paid all his installments, but was still denied good service. Prakash was unaware of the complaint book in the bank where beneficiaries could register their complaints.

Ravindra Kumar Trivedi, Aryavart's manager in Kursi, blames the beneficiaries for their problems. "There is a complete lack of ownership among beneficiaries. They think that since the bank has given them the system, it is the bank's responsibility to knock on their doors to check for all problems," Trivedi says. "Until the beneficiary reports problems, how would the bank come to their aid?"

Ramkumar Singh, another beneficiary from Madeenpur, does not agree. He had put in a complaint with Trivedi and was assured the services of a technician sent. "But the technician never arrived", says Singh. Madeenpur is just three kilometres from Kursi. According to the bank's system every branch is supposed

ENERGY POVERTY IN UTTAR PRADESH

Installed capacity (as on December 2013)
14,275 MW

Annual per capita electricity consumption (2011-12)
449.9 kWh

Total households
32,924,266

Unelectrified households
20,808,136

FOR LIGHTING

Households depending on kerosene
20,380,121

Households depending on solar energy
164,622

FOR COOKING

Households using firewood, crop residues, cow dung, coal, etc
26,602,807

Unelectrified villages
30,802

Source: Census 2011, Central Electricity Authority

Shrinand Lal's solar home lighting system has lit up evenings for his family of seven

The bank is working to expand its solar business and to also improve the after-sales service

to keep a separate complaint register for SHS to note the complaints but none of the two branches at Gondwa (in Hardoi district) and Kursi that researchers from Delhi-based Centre for Science and Environment (CSE) visited had the register.

The technicians have problems with their service conditions. A local technician, who had been trained by Tata BP, on conditions of anonymity says he had not been paid his salary for a year. "I get around three to four calls every day but I have a large area of around 50 villages to cover. I cannot spend my own money to pay for the conveyance," he says.

Success stories and future plans

But not all are unhappy. The SHS in the house of Ramdulare Singh, the pradhan (village head) of Tikaitganj is working fine. He purchased the system around 2008. "I have paid all my dues," he says. He uses two CFLs for three or four hours a day and sometimes watches TV for an hour. "I try not to overload the system," he says.

Aryavart embarked upon its next phase of development in the SHS sector using its earnings from carbon credits. In 2010-11 the bank earned US$ 77,536 (nearly ₹ 35 lakh) as carbon credits. It has a six-year deal with Micro Energy Credit, a US-based company that applies for credit with the UN Framework Convention on Climate Change on its behalf. Micro Energy Credit takes 20 per cent of the profit.

To begin with, Aryavart Gramin Bank is organising camps in rural areas to popularise SHS. It plans to engage more channel partners and business facilitators. The bank is also using the funds to devise ways to develop the service delivery mechanism, the key grouse of most consumers. Many villagers have complaints about the SHS they purchased and the problems with insufficient after-sales services, as CSE discovered when they visited Barabanki and Hardoi districts in Uttar Pradesh.

Beneficiaries often connect the wires of the panel directly with the battery, exerting pressure on it

The hazy sun

Maintenance issues and corruption dog Assam's off grid solar programme

Assam has received the largest amount of funding from MNRE for RVEP

In Laphaichuk village, a visit by Indeswar Bhuiyan is a cause of excitement. As soon as the 44-year-old social worker enters this Mising tribe hamlet in Assam's Sunitpur district, a crowd surrounds him and demands solar electricity. Bhuiyan works with Chairduar Rural Development Centre (CRDC), an NGO engaged in implementing the Remote Village Electrification Programme (RVEP) in Sunitpur.

Assam, a state where 80 per cent villages are not connected to the grid, is leader in implementing the programme, which works through village electricity committees (VECs) and NGO facilitators such as CRDC (see box: Remote electrification in Assam).

Assam has received the largest amount of funding from the Centre for implementing RVEP. More than 1,700 villages in the state have benefited from the programme, which targets basic electricity facilities through renewable

REMOTE ELECTRIFICATION IN ASSAM

SUBSIDY: Ninety per cent of benchmark cost of ₹12,500 set by the Union Ministry of New and Renewable Energy. Remaining 10 per cent shared equally between state agency and beneficiary.

PLAYERS: Assam state agencies (Assam State Electricity Board targets 1,057 villages, Assam Energy Development Agency targets 920 villages and the forest department targets 162 villages), village electrification committee (VEC) and facilitating NGO.

IMPLEMENTATION: An NGO creates awareness and helps village residents form a VEC, which then makes an agreement with one of the state agencies, deposits its monetary share and receives the solar home lighting system. Third party monitors employed by the state agencies check whether systems have been installed and are working properly.

ENERGY POVERTY IN ASSAM

Installed capacity (as on December 2013)
1,140 MW

Annual per capita electricity consumption (2011-12)
249.8 kWh

Total households
6,367,295

Unelectrified households
4,005,029

FOR LIGHTING

Households depending on kerosene
3,934,988

Households depending on solar energy
50,940

FOR COOKING

Households using firewood, crop residues, cow dung, coal, etc
5,151,142

Unelectrified villages
8,525

Source: Census 2011, Central Electricity Authority

sources for areas where grid extension is not feasible. About 2,200 villages in the state still do not have the facility.

Laphaichuk is one such village. With the sun beating down, the people of the village tell Bhuiyan that they have to travel several km just to charge a mobile phone. They argue they can save ₹300-400 a month on kerosene expenses if solar electricity reaches the village. Bhuiyan gives them a patient ear and promises to put their case before Assam Energy Development Agency (AEDA). The autonomous agency of the Assam government is in charge of extending RVEP in Sunitpur. As of March 2012, the agency had delivered about 33,830 solar home lighting systems (SHS) in 730 remote villages in Assam.

Kutum, about a km from Laphaichuk, in Sunitpur district is one of them. In 2010, each of the 121 households in the village received a solar home lighting system (SHS), consisting of two CFLs, a battery and a charge controller. The market price of the system was ₹13,476. The Union Ministry of New and Renewable Energy (MNRE) gave a 90 per cent subsidy and the rest was equally shared between the beneficiary household and the state government.

Residents of Kutum are proud of their possession but are at a loss when repair and maintenance issues arise. Phaniram Kutum, for instance, had to spend ₹200 repairing the circuit board inside the charge controller within a few months of purchasing the SHS. The local technician trained by the company said he knows only how to connect the components but nothing about internal repairs. Ideally, Phaniram is entitled to free maintenance, as per the purchase agreement, but the nearest service centre is 17 km away.

Many RVEP beneficiaries in Kutum have been dogged with problems related to maintenance of their systems. First-time solar electricity users, like Tupuni Pegu, a mother of three, do not know that batteries need to be replaced after five years. Pegu asked the Centre for Science and Environment's (CSE) researcher, "Can you repair my system? The lights go off after an hour." The SHSs have a longer running time on a bright, sunny day. Sonti, another Kutum resident, has no idea where to take the systems for repair. When told the batteries will need to be replaced after five years and will cost ₹3,500, Sonti retorts, "In that case I will go back to kerosene."

Too ambitious

Kutum received its SHS equipment under RVEP, which targeted covering 2,139 villages between 2007 and 2011 in Assam. Phanindra Sarma, former head of the energy division at the Assam Science Technology and Environment Council (ASTEC), who monitors solar projects in the state, believes the programme was too ambitious. "It entailed supplying more than 123,000 systems in four years. The programme was implemented hurriedly without the required maintenance network in place. There is no awareness regarding replacement of batteries."

"Which company will go to geographically dispersed villages to honour maintenance contracts?" asks Sarma. "The only way out is to develop skills of local entrepreneurs," he adds. Other experts say households have not been informed of the necessity of replacing the distilled water in batteries every six months and about the correct angle (30 degrees) at which panels should be placed and the processes to clean up the solar panels.

Mrinal Chaudhuri, AEDA's additional director, agrees. "We should train technicians at Regional Industrial Training Institutes to make the programme technically sustainable," he says. The agency is encouraging villages to create a corpus to finance replacement batteries.

In Kalajhar village in Darrang district bordering Bhutan, 89 families have collected ₹1.5 lakh in two years. The fund will finance battery replacements as and when the households need.

Corruption galore

Success stories are rarer and the problems stiffer where the Assam State Electricity Board (ASEB) runs RVEP. Till December 2011, the board had provided solar electricity to 1,019 villages as against the target of 1,057 villages. But its achievement has been marred because of technical issues, and more importantly, by rampant corruption. An energy consultant who has worked closely with the Assam government says, "ASEB is into conventional grid electricity and has no experience in renewable energy. Because the renewable energy wing (AEDA) did not have the manpower or network, a major chunk of the programme went to ASEB." The consultant who did not want to be named adds, "ASEB has organised only five training camps with 125 people. This means just one technician for over 400 households".

All state agencies implementing the programme are required by MNRE to employ third party monitors to track the performance of solar systems. These

Many beneficiaries of the programme have no idea about where to take the solar home lighting systems for repair

Each of the 121 households in Kutum village has solar home lighting systems. But most are beset with problems

A household in Kutum village with home lighting system

Experts allege that the subsidy scheme breeds corruption with facilitating NGOs, electricity board engineers and even village electrification committee officials sharing the spoils

monitors, in turn, employ local youth to carry out field surveys. A field coordinator, who has supervised the programme in over 90 villages, explained how corruption takes root while distributing SHS. Sometimes, the list of beneficiary households is forged. Say, in a village with 100 households, 70 opt for the solar scheme. The remaining 30 are persuaded to apply for the systems with an offer of a bribe. Later, these 30 SHSs are sold in the market or find their way across the border to Bangladesh or Bhutan. The booty, says the supervisor who did not want to be named, is shared between the facilitating NGO, the VEC president and secretary, and engineers from the electricity board.

At times the NGO, the VEC president and secretary come together and overcharge the households. Say, for a system where the beneficiary household should pay only ₹ 500, the households are charged ₹ 3,000. The supervisor also notes that sub-standard SHS are purchased by the state agency. Even though MNRE has a list of suppliers and the purchases are made through a tender, quality standards are often not adhered to.

The NGOs or the VEC have little or no financial incentive within the programme. Bhuiyan of CRDC says the monetary incentive of ₹ 1,500 per village does not cover all costs.

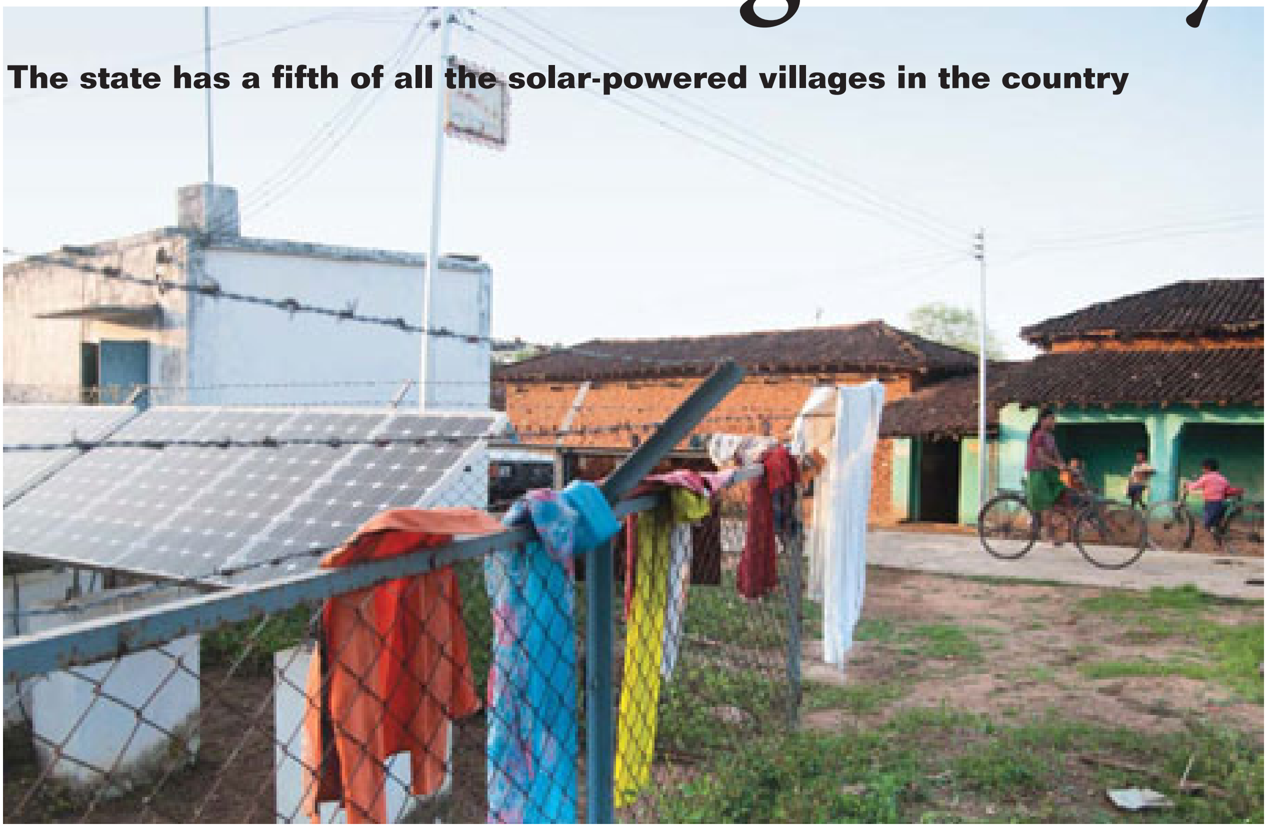
There are other kinds of corruption. Kakla Bari in Barpeta district was connected to grid electricity in 2010 and a year later received 94 SHS and three street lighting systems in clear violation of the Central government rules that subsidised solar equipment are meant for remote villages not connected to the grid. When the CSE team visited Kakla Bari in end-November 2011, it could locate only four SHSs. People of the village said they were sold to nearby villages for anything between ₹ 3,500 and ₹ 8,000.

Chinmoyi Sharma, managing director of North East Renewable Energy Pvt Ltd and a distributor of Tata BP, laments, "Being an early player we burnt our fingers." Sharma's firm supplied 3,459 SHSs during 2007-08 in Dhubri and Dhemaji districts. But during inspection, the systems could not be traced. "They were either sold off by NGOs and VECs or by the poor families. So ₹ 3 crores of my money got stuck," says Sharma. Now, suppliers get inspection certificate during the installation and not months later.

Sharma blames the heavy subsidy for the problems, be it NGOs overcharging households, or together with the VEC selling solar lights across the border. Chauduri of AED, however, says many corruption problems have been taken care of. He elaborates: "Initially, beneficiary lists were fudged and households were overcharged. All payments by VEC are now made through bank drafts. We also issue receipts to each beneficiary household so that they cannot be cheated. The gram panchayat, together with the VEC president/secretary and the block development officer or circle officer, authenticates the list of households. We also have strict quality standards."

The Chhattisgarh way

The state has a fifth of all the solar-powered villages in the country



The last power blackout Deba village experienced was in 2010

Tucked away in the Barnawapara wildlife sanctuary of Chhattisgarh is a small village, Deba. The national power grid is yet to reach there. But there is no interruption in the scheduled power supply to its 75 households.

While power cuts are frequent in grid-connected villages across the state, the only time Deba residents experienced a blackout since they started receiving electricity some seven years ago was in October 2010. The blackout was caused by a powerful lightning. It hit the power transmission cables and damaged the inverter of the solar power plant, recalls Phool Devi, in her 40s. The government officials replaced the inverter within two weeks and the village was illuminated again just before Diwali.

Unlike other states, Chhattisgarh ensured that installed solar systems remain functional by taking care of repair and maintenance issues

The 4 kilowatt (kW) solar power plant, which uses photovoltaic cells to tap solar power, generates 28 units (1 unit = 1 kWh) of electricity a day. It is sufficient to light all houses and lanes of Deba with CFLs (compact fluorescent lamps) for seven hours without fail: from 4 am to 6 am and from 6 pm to 11 pm. Devi says the solar power plant, installed by the Chhattisgarh Renewable Energy Development Agency (CREDA) in 2003, has been a boon to the village residents who had always relied on kerosene lamps and lanterns.

"Now that the village has streetlights, I do not fear snakes or wild animals in the night," Devi says with a grin. She is happy that her children now study even after nightfall.

Deba is one of the 50 villages and hamlets dotting the dense Barnawapara forest that are benefiting from the solar

As of June 2013, about 1,500 remote villages in Chhattisgarh have received electricity through micro-grids

power plants installed under the Remote Village Electrification Programme (RVEP) of the Union Ministry of New and Renewable Energy (MNRE). The programme, as the name suggests, aims to electrify villages and hamlets in remote and difficult areas such as forests, hills and deserts of the country, which are not feasible to be linked with the national grid, using renewable energy. Solar power is popular for such electrification due to its abundance and simple plug and play nature of the technology.

But solar off-grid projects under RVEP have been reported to be not so successful across the country, Chhattisgarh being the only exception. With assured illumination to 1,400 remote villages, the nascent state boasts of being home to over one-fifth of the solar-powered villages across the country, reckon MNRE officials.

Tanushree Bhowmik, programme director (energy) of the United Nations Development Programme-India, says renewable off-grid projects tend to fail in most remote villages because of lax monitoring and poor maintenance of installed systems. Though states are responsible for installation and maintenance of off-grid power generation systems, most lack the intent to monitor. There have been reports of systems getting stolen or lying defunct in several states, she adds.

Chhattisgarh went the extra mile to ensure that installed solar systems remain functional. In 2003, CREDA installed Solar Home Lighting Systems (SHS) in 500 villages. It also set up micro-grids wherever possible and introduced a standardised operation and maintenance system for solar power.

TABLE 1: MICRO-GRIDS OF CREDA

Implemented under the Central government programme till June, 2013

District	No. of Villages/ hamlets	Beneficiary	Un-electrified villages
Raipur	0	0	0
Gariaband	128	4,265	0
Baloda Bazar	22	1,535	0
Mahasamund	5	165	0
Rajnandgaon	51	1,401	0
Durg	0	0	0
Balod	0	0	0
Bemetara	0	0	0
Kabirdham	67	2,795	0
Bilaspur	50	1,216	0
Mungeli	45	2,413	0
Raigarh	12	552	0
Korba	238	9,142	0
Janjgir-Champa	1	62	0
Sarguja	15	721	0
Balrampur	2	306	0
Surajpur	42	2,066	0
Jashpur	183	7,262	0
Koria	123	6,354	0
Dhamtari	41	1,911	0
Kanker	114	3,179	0
Kondagaon	5	324	0
Jagdalpur	44	2,037	5
Sukma	4	430	125
Dantewada	215	8,562	36
Narayanpur	9	170	131
Beejapur	23	1,100	109
Total	**1,476**	**57,968**	**406**

Source: Chhattisgarh Renewable Energy Development Agency

Initial hiccups

SHS is an assembly of 37 Wp (Watt-peak) solar panels, cables, an inverter, a battery and two 11 Watt CFLs. "More than half of the panels got stolen within a year. Some even sold them off or mortgaged them for money," says S K Shukla, director of CREDA. A survey in 2004 showed that of the 617 solar panels installed in tribal hostels, ashrams and primary health centres, 500 were stolen. This is when CREDA opted for micro-grids.

"Micro-grids require more investment from the state exchequer because the subsidy by MNRE is limited to ₹ 18,000 per household covered by the micro-grid. But they prevent theft and require minimal maintenance," Shukla adds.

As per the estimates of CREDA, a solar module of 37 Wp costed about ₹ 14,000 when the projects were being implemented. Factor in the 90 per cent subsidy by MNRE and each module costs the state ₹ 2,750. Compare this with the cost of setting up a micro-grid (solar photovoltaic power plant and transmission cables) per household, which is approximately ₹ 25,000. The state shells out about three times more for a micro-grid than a solar home lighting system. CREDA installed its first micro-grid in 2004.

Status of micro-grid implementation

As of June 2013, 1,476 remote villages, including 622 hamlets, in Chhattisgarh have received electricity through micro-grids. The total capacity (including micro-grids and solar-powered water pumps and street lights) adds up to 3,066 kW, serving about 58,000 households in the state. Such installations have also been set up in tribal hostels (1,633), rural health centres (446) and remote police camps (256). Rest of the villages and hamlets, where houses are scattered, have been provided with solar home lighting systems. "It is not feasible in scattered villages to invest in wiring for long distances," says Shukla.

The state depends on funds under RVEP. Since 2001, when the programme was first initiated by the Centre, the state has received about ₹ 34.35 crores under the programme from the Centre. Although, it is claimed that the funds from the Centre cover up to 90 per cent of the capital cost, the ground realities are far from this.

CREDA uses standard specifications while setting up micro-grids in remote villages. "There are so many projects on the ground that a certain standard design for the micro-grid has been evolved out of the experience. Currently CREDA follows these specifications but can differ as per the village," says Sanjeev Jain, chief engineer, CREDA.

CREDA designs micro-grids to support two 11 Watt CFLs which is the norm suggested by MNRE. Although the system specifications set by MNRE are met in the process, the benchmark cost that is set by MNRE does not match with the actual costs (see tables 1 and 2: Basic specifications for solar micro-grids and Cost of setting up a solar micro-grid). In many cases, the benchmark of MNRE only matches with the system cost. That

CHHATTISGARH'S ENERGY POVERTY

Installed capacity (as on December 2013)

6,865 MW

Annual per capita electricity consumption (2011-12)

1,319.6 kWh

Total no. of households

5,622,850

No. of unelectrified households

1,555,435

FOR LIGHTING

No. of households depending on kerosene

1,304,501

No. of households depending on solar

50,605

FOR COOKING

No. of households using firewood, crop residues, cow dung, coal

4,976,222

No. of unelectrified villages

1,188

Source: Census 2011, Central Electricity Authority

TABLE 2: SPECIFICATIONS FOR SOLAR MICRO-GRIDS

Capacity (kWp)	Households	Proposed load per household (in Watt)	Maximum connected load (in Watt)	Street lights	Battery bank
1	10	60	600	3	300 Ah / 40 V
2	20	60	1200	6	600 Ah / 48 V
3	30	60	1800	9	800 Ah / 48 V
4	40	60	2400	12	600 Ah / 96 V
5	50	60	3000	15	800 Ah / 96 V
6	60	60	3600	18	1000 Ah / 96 V
8	80	60	4800	24	800 Ah / 120 V
10	100	60	6000	30	1000 Ah / 120 V

Source: Chhattisgarh Renewable Energy Development Agency

TABLE 3: COST OF SETTING UP A SOLAR MICRO-GRID

Capacity (kWp)	System cost (₹) (lakh)	Cost of control room (₹) (lakh)	Cost of fencing (₹) (lakh)	Cost of public distribution network (₹) (lakh)	Operation and maintenance for 5 years (₹) (lakh)	Total project cost (₹) (lakh)	Net cost per watt (₹) (lakh)	Benchmark of MNRE —cost per watt (₹)
1	2.23	1.80	0.24	2.08	0.69	7.04	704.00	315
2	4.68	2.25	0.36	4.16	1.38	12.83	641.50	315
3	7.15	2.70	0.48	6.24	2.07	18.64	621.33	315
4	9.56	3.00	0.56	8.32	2.76	24.20	605.00	315
5	11.80	3.40	0.60	10.40	3.45	29.65	593.00	315
6	14.67	3.75	0.72	12.48	4.14	35.76	596.00	315
8	18.02	4.25	0.80	16.64	5.52	45.23	565.38	315
10	22.60	4.80	0.86	20.80	6.9	55.96	559.60	315

Source: Chhattisgarh Renewable Energy Development Agency

TABLE 4: PROJECTS SET UP BY CREDA

Details of a few projects under the CREDA model. The state government of Chhattisgarh had to chip in for a significant part of the costs

Site	No. of households	Capacity (KW)	Cost of PP (₹)	Cost of PDN (₹)	Total (₹)	Share of MNRE (₹)	Share of GoCG (₹)	Per cent share of MNRE
Surve	43	3	13,68,000	4,09,066	17,77,066	7,74,000	10,03,066	43.55
Bimalta	60	5	23,54,000	6,56,057	30,10,057	10,80,000	19,30,057	35.87
Dokarmana	51	4	19,01,000	5,46,829	23,57,829	9,18,000	14,39,829	38.93
Hirvadoli	40	4	19,01,000	2,84,888	21,85,888	7,20,000	14,65,888	32.93
Tapara	34	3	13,68,000	2,84,655	16,52,655	6,12,000	10,40,655	37.03

Source: Chhattisgarh Renewable Energy Development Agency

The cost of infrastructure like control room, fencing and public distribution network are not included in MNRE subsidy

means, the cost of other capital infrastructure, such as control room, fencing and public distribution network, has not been included.

When compared with the net cost of the project, the benchmark cost is only between 32-44 per cent of the net cost. A 90 per cent subsidy on these costs suggests that only 28-36 per cent of the actual net project cost is being covered by the Central government (see table 3: Projects set up by CREDA).

Maintenance and servicing

CREDA envisaged a three-tier system for maintenance and servicing. An operator was chosen from each solar-powered village to clean solar modules every day and repair them if there was wiring glitch. For this, he charges ₹5 from each house a month. For regular maintenance of batteries and inverters and for fixing technical problems, CREDA enrols an operation and maintenance contractor, who appoints a cluster technician for every 10-15 villages. The technician directly receives a payment of ₹ 25 per household per month from the state government. This is equivalent to the subsidy that the Chhattisgarh government provides to families below the poverty line in grid-connected areas for availing one unit of electricity a day.

"The technician files a monthly

Most households now require more than lighting that was first provided to them

monitoring report for every solar installation. The solar equipment that are not working and the problems associated are also recorded," says Shashi Dwivedi, an operation and maintenance contractor.

The third tier is managed by CREDA, which monitors all installations through the monthly reports and replaces equipment in case of major breakdowns like the one that happened in Deba.

"Not many states have asked for large-scale solar system connections like in Chhattisgarh," says Moola Ramesh, deputy general manager of Tata BP, a leading solar equipment manufacturer in the country, now known as Tata Power. Even states that install solar systems hardly seek maintenance, he adds.

Lighting is not enough

Though solar power provides illumination, its limited capacity does not meet the demand of complete electrification. Consider this. Kaya Bara, the village neighbouring Deba in Barnawapara sanctuary, has a 3 kW solar power plant that generates 24 units of electricity a day. Till two years ago it was sufficient to light 45 households in the village for eight hours a day.

Now with three TV sets in the village, the load on the grid has increased and residents get light barely for two hours a day. The operator, Monu, blames those who own TV sets for the load-shedding as a TV set can gobble up the entire 24 units of electricity in just a couple of hours. But there is no let up in their use. Rather, more residents in Kaya Bara are planning to buy TV sets and other electrical equipment like fan and water pumps.

Discontent with limited electrification is palpable across solar-powered villages. Take Kalaar Baahra, a tribal hamlet in Dhamtari for instance. Each of the 15 houses in it has a solar home lighting system. In 2010, the government declared it electrified. Residents still demand link to the grid, just half-a-km away.

Though solar power provides illumination, its limited capacity does not meet the demand of complete electrification

Illumination is not sufficient, says Itwarin Bai, in her 50s. She likes the solar panel on her rooftop, but she is jealous of the people living in a village just half-a-km away who have access to the grid. "*Bada bijli matlab bada aamdaani*, (grid electricity means more income)," she says. "Solar-powered pumps are very expensive. We cannot afford them. If we have access to the grid we can buy the regular water pumps and grow vegetables even in summers like people in the neighbouring village. We can also draw water when the level dips," Bai explains.

Limiting energy services

Villagers in Mohda say they would prefer the grid electricity over the electricity that is being supplied by solar panels since the panel only provides electricity for a maximum of one to two hours in a day. This was because the generation was below the rated capacity.

Some villagers say they would prefer grid electricity over what is supplied by the solar micro-grids

The plant was designed to cater to 70 households in 2004. Currently, there are around 180 households in the village, with more connections. But the supply has not been enhanced beyond 4 kW. Now 700-800 people live in the village.

In Mohda, the capacity was not enhanced as the Central government programme does not have scope for enhancing the capacity and the state government resources are limited. Increase in capacity has to be able to balance the growing demand, which is currently lacking in the model.

The limited supply of electricity does not suffice the lighting needs of the beneficiaries of the village. Therefore, they continue to buy kerosene for lighting. An average household spends ₹ 15 per litre of kerosene through his ration card, which allows two litres, and ₹ 25 per litre for the remaining four to six litres that is still required for lighting. On the whole, the household spends ₹ 150 to ₹180 a month for lighting through kerosene and spends ₹ 5 per month for lighting through solar. Wood is still used for cooking purposes.

A few km away, another village called Bar, located within the Bar-Nawapara Wildlife Sanctuary, also had installed a 4 kW micro-grid. But it was generating just 5 units of electricity per day against the claim of 16 units per day. This was too little for people who relied on solar pumps for growing vegetables.

The Centre now plans to resettle people of Bar in a neighbouring grid-connected area as part of its plan to shift people living within wildlife sanctuaries to outside areas. The households do not oppose the move because they look forward to the grid connection in the new village along with other benefits—about two hectares of farm land, ₹50,000 and a house for all the families.

CREDA has electrified many villages. But most other states have not been able to follow suit. The observations in the villages visited were that one to two hours of electricity used for just lighting is not an adequate solution for the issue of rural electrification. Households continue to use kerosene, though in reduced amounts, for lighting. Another issue is that once the micro-grids are installed, these villages are deemed electrified on government documents, no matter whether micro-grids fulfill needs of the people or not. These villages then are not eligible for any other sources of electricity. In village Rawan, after an installation of 7 kW micro-grid, the village is not getting grid extension.

Pitfalls and way ahead

Managing the load is more important than the total capacity because only 30 per cent of the capacity is being utilised currently. Very often, households

Just watching TV trips the voltage in villages in Chhattisgarh, and this happens at least once a day

overload the lines, and it trips the voltage. This happens at least once a day, so a lot of generated electricity goes without being utilised.

Demand is growing and peaking, but the plants are not designed for peak demand. Inverter and system sizing is based on 10 years ago, which is completely different from the situation today. This is largely because people now use the power for applications other than lighting. Their aspirations have increased and the current model of electrification does not take this into consideration.

Researchers from Delhi-based Centre for Science and Environment (CSE) found that the plants were operating at only one-third of the capacity. This is largely because of two reasons. First, overload and voltage trips leads to frequent plant shutdowns. By the time the operator reaches for checks, there is no electricity for a while. The operators are paid on the basis of number of days of operation rather than operation on an hourly basis. Seondly, systems were designed for taking only lighting needs into consideration and without factoring in aspirational needs and increasing population.

Capacity enhancement is not able to balance the growing demand. When a system is installed, it has to be many times oversized which involves huge capital costs anticipating the demand for one and half year. Even the Census data for the villages are around 10 years old. They do not have demographic data about how many mobile phones, TVs, fans and lights are in the villages to estimate the demand.

Now, there are discussions on how to reform the system to meet the increasing electricity needs of the households. One of the ideas is to involve the private sector, and provide tariff for every unit of electricity that has been consumed by the households.

Under this model, the consumers are charged for electricity but at a rate lower than the actual cost of generation. This gap will be provided by the state to make the model viable.

Aspirations of people have increased, but the current model of electrifying rural households does not take this into consideration

Out of option

Exhibition Road, Patna: cheap, substandard solar panels for desperate consumers

Solar equipment stocked at a bylane in Patna's Exhibition Road

Daily wager Bijendra Sao is fussing about at Exhibition Road in Patna to shop for his daughter's dowry. The doting father wants the best that he can afford—a solar panel that can power two compact fluorescent lamps (CFLs) and a table fan. What better gift to give in a state that faces perpetual power crisis. And what better place to shop for but the India's biggest off-grid solar market that does an annual business of ₹ 500 crores.

Sao is spoilt for choice here. This one-kilometre road has numerous narrow bylanes that cater to the energy needs of people with all pocket sizes. Solar lanterns and streetlights, besides panels of all makes and sizes, are hoarded in matchbox-sized shops. A 75 Wp (Watt-peak) panel can cost anywhere between ₹ 2,500 and ₹ 10,000 here.

After half an hour of hectic negotiations, Sao pays ₹ 3,200 for a 75 Wp panel that has a two-year warranty. He is lucky, for a warranty is hard to get with under-wattage panels. Under-wattage panels are those that do not give as much power as they promise. A 75 Wp panel of a standard brand would have cost at least ₹ 7,000.

The flourishing solar market is the result of a grim reality Bihar faces. The state needs 3,500 MW, but supplies only 1,595 MW through self-generation and by procuring it from other states, says Rajmohan Jha, deputy director of Bihar Renewable Energy Development Agency (BREDA). The shortfall makes the state a perfect market for off-grid energy products, he adds. "Bihar gets 300 days of good sunlight in a year. It has off-grid photovoltaic potential of 7,300 MW," says Sudhir Kumar of World Institute of

Solar Energy (WISE), a non-profit in Pune. No wonder, Bihar has quietly replaced the expensive diesel generated power option with solar energy and become the third largest solar user in the country, according to Census 2011.

The state government, however, has shown little interest in encouraging solar energy and has never initiated a programme for off-grid solar power. In 2011, it formulated a renewable energy policy which approved 175 MW grid-connected solar projects. But the policy has no clarity on off-grid solar. "This is why few entrepreneurs have shown interest," says Harish K Ahuja of Moser Baer, solar panel manufacturer. No work was undertaken till June 2012 under the Centre's Remote Village Electrification Programme (RVEP), initiated in 2001. The programme promises its beneficiaries subsidised rooftop off-grid solar systems. "If a government programme promises subsidised solar equipment, people with low purchasing power will not have to buy under-wattaged equipment," says Ahuja.

Happy with little

Trying to compete at the thriving Exhibition Road market, companies are taking solar equipment closer to villages. Every block in all the 38 districts of the state has its own small Exhibition Road, says Ramadheer Singh, retailer, Jandaha block in Vaishali district. Every shop, be it for clothes or stationery, stocks solar equipment. "Panels manufactured by TBP are the cheapest and sell the most, despite being underwattaged and without warranty," says Bachchu Singh, retailer at Jandaha. A 75 Wp TBP panel, which sounds similar to that of the well-known Tata BP, may give only 30 Watts of power. Yet, it gives tough competition to Tata BP that offers a 20-year warranty.

"I don't care if the panel gives me less power than it promises. It suits my pocket and I get as much power as I require," says daily wager Saroj Kumar, living in Jagdeeshpur village in Vaishali. A good quality panel is beyond his reach (see table: Cost of branded panels). Earlier, Saroj used to pay ₹100 every month for a diesel generator to illuminate a 10 Watt CFL for four hours and to charge his mobile phone. This works out to ₹ 83 per unit, perhaps the highest per unit energy cost in the country. At present, Saroj's panel is working well. But not all have such happy stories to narrate.

When Rakesh Rai bought a cheap solar panel in Jagdeeshpur for ₹ 3,500 a year ago, it could light a CFL and at times a table fan. Six months later, the CFL gives dim light for less than an hour. "The panel is not charging properly," he says. Rai is back to using kerosene for light, spending around ₹ 200 a month. "I cannot complain because I bought the panel knowing it was of poor quality."

Substandard choice

Solar market in Bihar is flooded with underwattaged panels made in Hyderabad and Mumbai. "We tell companies what we need—cost, wattage and warranty years. We can choose the brand name. It could be your name, for instance," says a dealer, requesting

COST OF SOLAR PANELS

Brand name	Cost* (in ₹)	Warranty (in years)
Sharp	9,000	20
CEL	8,500	10
Waree	6,700	10
Tata BP	6,500	20
Luminous	6,500	10
Reliance	6,000	10
Plaza	4,800	10
Surana	3,200	5
Fusion	3,000	2
TBP	2,400	No warranty

** Cost is for a 75 watt solar panel*

ENERGY POVERTY STATUS IN BIHAR

Installed capacity (as on December 2013)
2,198 MW

Annual per capita electricity consumption (2011-12)
133.6 kWh

Total households
18,940,629

Unelectrified households
15,834,365

FOR LIGHTING

Households depending on kerosene
15,607,078

Households depending on solar
113,644

FOR COOKING

Households using firewood, crop residues, cow dung, etc
17,349,616

Unelectrified villages
23,211

Source: Census 2011, Central Electricity Authority

A garment shop in Jandaha, Vaishali, has hoarded the much in-demand solar panels

Solar market in Bihar is flooded with inferior equipment. Bad experience with solar power can lead to misconception that solar energy is faulty

anonymity. Hyderabad-based Surana Ventures is one such company, he says. Incidentally, the Union Ministry of New and Renewable Energy (MNRE) has accredited Surana Ventures to make panels under the Jawaharlal Nehru National Solar Mission.

Fifty per cent of the state's solar market is captured by those who make inferior equipment. A retailer in Patna can sell 50 cheap panels even on a bad day. In the past five years, Tata BP's monopoly over Bihar's solar market has dropped by almost 70 per cent, says Piyush Agrawal, dealer at Exhibition Road market.

"Consumers are being duped. If they know that a 75 Wp panel gives only 40 Watt power, they will buy a good quality 40 Wp panel at almost the same price with warranty," says Agrawal. "In villages, retailers push for underwattaged panels because they get high margins," says Amrendra Kumar, senior sales executive at Tapan Solar Energy Pvt Ltd, a Delhi-based solar equipment manufacturer that sells its products in Bihar.

Bad experiences with solar power can lead to the misconception that solar energy is faulty, fear some renewable energy experts. "This may affect its acceptance in future," worries Manish Ram, renewable energy analyst with non-profit Greenpeace India. It recently released a report that presents Bihar as a model state for decentralised renewable energy systems. Ram says government should ensure that all panels adhere to the standards set by MNRE. "But the standards apply only to panels supplied under government programmes. Thus, we have no control over the market," says an MNRE official on condition of anonymity.

Those who have the money buy good quality panels. Raj Kumar runs a confectionery shop from his house at Salha village in Vaishali. A year ago, he bought an 80 Wp Luminous panel with a 10-year warranty for ₹ 6,000. It lights a 15 Watt CFL in his shop and two 10 Watt CFLs and an 18 Watt fan at home. "It is good to buy panels with warranty. At least I can get it replaced if it stops functioning. It also gives the promised power," he says.

Power shortage in the state has worked to profit some others. Jagdeep Kumar of Araria village in Vaishali is not very rich. He thought of a novel idea that could earn him some bucks. After saving money for two years and borrowing some from friends, he bought six 80 Wp Tata BP panels and created a small grid on his rooftop. The grid brightens up the lives of 50 households every evening. For four hours, each house can light an 8 Watt CFL. Jagdeep charges them ₹ 75 every month. He expects to recover the ₹ 1 lakh installation cost in about five years.

At present, what Bihar desperately needs is a strong policy push that provides off-grid energy solutions, says Kumar of WISE. Without it, cheap solar markets like the one at Exhibition Road are the only hope for the power-starved state. Good or bad, it's what people in the state have learnt to depend on.

Look at the sun

Promotion of solar water pumps requires a sustainable model

By shifting to solar pumps from diesel powered ones, many residents of a village in Bihar's Nalanda district saved about ₹ 50,000 in 2012

"Peter takes away all our money," say farmers in Bihar, bristling with anger. They want to get rid of Peter but can't. Peter is the diesel pump used widely in the state for irrigation due to power shortage. The three horsepower (HP) pump consumes a litre of diesel (₹ 50) in an hour. In 2011, the state government initiated a pilot project, offering an economical and sustainable alternative for free—solar-powered pumps. But its faulty implementation marred hopes of eliminating noisy Peter.

Under the pilot project, Bihar's minor irrigation department, along with Delhi-based Claro Energy Pvt Ltd, fitted 34 community tube well pumps with solar panels in Nalanda district. As per the agreement, Claro maintains the pumps while the department looks after the underground water channel. A solar community pump (of 7.5 HP) caters to 20 to 30 fields.

By shifting to solar pump from Peter, many residents of Gonkura village saved about ₹ 50,000 in 2012. But the happiness was short-lived. Between January and May 2012, only few fields in Gonkura received water. "PVC pipes that run from the pump through the fields have holes. Consequently, some fields get over flooded while some get less water," says the pump caretaker. He cycled 13 km 20 times to lodge a complaint with the minor irrigation department, but to no avail.

Another problem is that some pipes do not reach farmers. They run for 200 metres, while fields are farther away. "We may have to supplement irrigation with Peter," rues a resident demanding quick repair and extension of pipes.

Farmers, meanwhile, point out that the pump had reduced their input cost considerably. "We have to pay only ₹ 5 per *kattha* (about 125 square meters), per irrigation cycle to water fields," says a resident of Gonkura.

An unsubsidised 3 HP solar pump (worth ₹ 4.5 lakh) has negligible recurring cost, while a diesel pump (₹ 70,000), assuming it runs five hours a day, has an annual recurring cost of ₹ 80,000. The cost of the solar pump can be recovered in four years, while for diesel the spending never ends.

When asked why the pilot was started if the pipelines were faulty, Kartik Wahi, CEO of Claro, said, "We were not aware of it." Vidya Bhusan, assistant engineer (tube well), state minor irrigation department, says the authority is aware of the situation. "The project is an experiment. We are planning to overhaul the water channels."

Experts believe that solar pumps have very good potential in states like Bihar, Jharkhand and West Bengal where there is enough groundwater

Avinash Kishore, a senior fellow at the International Food Policy Research Institute in Delhi, says solar pumps have a massive potential in states like Bihar, Jharkhand and West Bengal where there is enough groundwater. "These states practise less irrigation because of power shortage. They mostly cultivate kharif and rabi crops. The pump can help farmers grow summer and cash crops, and save money," adds Kishore, who has written a paper on solar-powered pump irrigation and India's groundwater economy.

But the pilot project's poor implementation has limited the potential of the solar pump, he adds. The state auditor general, in a 2008 report, states: "Almost all underground distribution systems of tubewells were partially damaged due to substandard work of laying of pipes."

A more serious challenge is the subsidy on diesel. This may prevent people from buying solar pumps in future. "Diesel cannot be done away with immediately," says a state government official, requesting anonymity. Kishore points out that in contrast with diesel the disbursement of subsidy on solar has been patchy. As a result, farmers are buying diesel at market price.

Rajasthan: less water, big goals

Despite water scarcity, Rajasthan is actively pushing for solar pumps. Its horticulture department provides 86 per cent subsidy on pumps, while the rest is borne by the farmer. Till mid-2013 the department had installed 1,725 pumps, and was planning to install another 3,000 by the end of the year. There are certain

Diesel pumps like Peter require never-ending expenditure, while the cost of solar pump can be recovered in four years

conditions for selecting the beneficiary: those who practise horticulture on a minimum of 0.5 hectare (ha), have tubewells or farm ponds (*diggi*) to store rain or canal water, and drip irrigation system. "These conditions may limit the use of pumps," believes Nidhi Tewari, policy researcher with International Water Management Institute (IWMI). Less than 10 per cent of farmers in Rajasthan practise horticulture and fewer have the drip irrigation system. "Many farmers are not even aware of solar pumps and government makes no effort to reach them," says Ajay Jakhar, president of Bharat Krishak Samaj. Kishan Das of a village in Sri Ganganagar is one of them. He grows mustard and wheat on his small farm. "For irrigation I use water from the Indira Gandhi Canal, but the supply is decreasing. Earlier, water was released weekly, but now it is done fortnightly," says Das who neither has a *diggi* nor a drip system.

According to the horticulture department, the solar pump is meant "only for progressive farming and promotion of cash crops and saving water". Rajendra Singh Khichar, agriculture research officer at the Directorate of Horticulture in Rajasthan, asks, "What is wrong if solar pumps encourage farmers to invest in drip irrigation and *diggi*?" The state in addition provides 90 per cent subsidy on drip irrigation and 50 per cent on *diggi*s.

Kishore contends that linking drip irrigation system with solar pump may not ensure its use. "Many farmers buy the drip to get the pumps but do not use it. They use the pump for running sprinklers which is a less water-efficient technique." In some areas where water table is low, farmers use high-capacity motors. "Solar pumps should not be promoted in such areas because when farmers get free energy, they over exploit groundwater," says Kishore. "Irregular power and high diesel cost actually deter exploitation of groundwater in these areas," he adds.

Besides water availability, the demand for solar pumps is also guided by cropping seasons. In states like Uttar Pradesh, Bihar and Madhya Pradesh, where 80 per cent of energy demand is in winters, the use of solar pumps will remain restricted due to cloud cover or fog, points out Jakhar. "Solar has its limitations, but low water discharge is sufficient during winters as requirement is less," says Wahi of Claro. In such a situation, diesel could be used to supplement irrigation, adds Kishore.

Solar pumps should not be promoted in water-scarce areas because farmers tend to overexploit groundwater

Sorting out money

The biggest hurdle in widening the use of the solar pump is its cost. A 3 HP solar pump costs ₹ 4.80 lakh (see table: Price of solar water pumps). Even after subsidy, the amount the beneficiary has to pay, as in the case of Rajasthan, is high. "High capital subsidy is difficult to sustain. It leads to gold plating of appliances by companies to increase margins and cost remains high," says Kishore. In many cases, the government does not disburse the subsidy amount to the companies on time, adds Amarjeet, vice-president of Claro. "We have raised money from unsecured loan sources at high rates of interest which is piling up."

It is due to such reasons many

PRICE OF SOLAR WATER PUMPS

Pump capacity	Panel size required	Cost of the total system (₹ Lakh)
1 HP	900 Wp	2.25
2 HP	1,800 Wp	3.25
3 HP	2,700 Wp	4.50
4 HP	4,000 Wp	5.50
5 HP	4,800 Wp	6.50

Source: Various developers

POLICIES AND PROGRAMMES IN INDIA

The solar water pumps are being promoted nation-wide under the Jawaharlal Nehru National Solar Mission (JNNSM). Earlier, the Union Ministry of New and Renewable Energy (MNRE) had a programme specific to solar water pumps. Since 2009, the solar mission has superseded the programme. The programme, now under JNNSM, provides a mix of capital subsidy and a soft loan on expenditure towards solar pumps. An individual can obtain a maximum of a 5 kWp battery-less system under the programme. For this, the individual gets a 30 per cent subsidy on the capital cost and a soft loan at 5 per cent for 50 per cent of the cost. This leaves the consumer to pay 20 per cent of the system's cost. A few states have decided to chip in their funds to supplement the Central subsidy.

PUNJAB: The state government has announced 40 per cent subsidy on purchase of solar pumps to encourage farmers for using these pumps for irrigation. A solar pump costs nearly ₹ 2.5 lakh in the open market. But under the subsidy plan, a farmer only has to pay 30 per cent of the cost. The rest 40 per cent (₹ 1 lakh) and 30 per cent (₹ 75,000) is borne by the state government and the Centre, respectively.

TAMIL NADU: The Tamil Nadu government plans to distribute 2,000 solar pump sets at subsidised rates to farmers in 2013-14. The Agriculture Department will distribute the 2,000 pumps of 5 HP fitted with solar tracking device during 2013-14. Each unit is estimated to cost about ₹ 5 lakh and the state government will provide 80 per cent subsidy—₹ 4 lakh. The farmers will bring in the balance for which they can obtain loans from cooperative banks.

Small and marginal farmers get 100 per cent subsidy for setting up drip irrigation and other micro irrigation facilities. Other farmers get a 75 per cent subsidy. The Tamil Nadu government has also announced plans to distribute 500 solar powered irrigation pump sets in the Cauvery delta districts where it will provide an 80 per cent subsidy.

RAJASTHAN: Rajasthan presently gets 30 per cent of funds for the scheme from the Centre and 56 per cent from the National Agricultural Development Programme and the state's own resources. The state expects to get ₹ 148 crores from the National Clean Energy Fund for installation of 10,000 solar pumps during 2013-14.

Lack of economic options for farmers is fuelling the growth of players who provide solar pumps at low costs

entrepreneurs are exploring other financing models. Claro is in talks with NABARD to work out a financing mechanism. The banking sector, however, is reluctant because of lack of experience in the field. "Some past experiments with renewables have failed because of high default rate. This affects the bank's portfolio," says an official of a rural bank requesting anonymity. Farmers say they default because their income is seasonal and insufficient. "Solar pumps have an advantage. Their use is linked to increase in farm income which will help people pay. Banks need to show confidence for such projects to take off," says Wahi.

In April 2012, Bihar's minor irrigation department rejected NABARD's proposal of connecting tubewells with solar, saying the technology is costly. Lack of economic options for farmers is fuelling the growth of new players that provide low cost solar pumps. Take for instance Navneet Sharma in Rajasthan's Bikaner district. He sells a 3 HP pump at ₹ 1.60 lakh which includes the cost of four batteries for power backup, something the state government-empanelled companies do not cover. Seeing such low cost options, a farmer in Sri Ganganagar has filed a public-interest petition in the Rajasthan High Court against empanelled companies for selling expensive pumps. By 2012, Sharma had installed 30 pumps. While farmers using Sharma's pumps have reported little problems, some companies have raised questions regarding product quality.

Sharma says, "We cannot afford to supply substandard material because we operate in a local market. We procure material from the place others do. It is just that we bargain, ensure timely payment and do not have incremental costs of standardisation." Like empanelled companies, Sharma also gives 25 years of warranty. He asks, "What is the guarantee of the quality of equipment supplied by empanelled companies?"

There are no local testing facilities in most states for solar pumps

An empanelled company has to send its products for testing to the lab of the Union Ministry of New and Renewable Energy. "These companies send the best product to get the approval. What is actually installed could be substandard," says Krishna Bhambhoo, a dealer of Waaree, a solar panel manufacturer, in Rajasthan. "There are no local testing facilities. The verifying team generally sees if the pump is running," says Tewari of IWMI.

Khichar, however, defends that quality cannot be compromised as there are quality inspections before the despatch and installation of the material.

Grid *v* solar

It is often argued that solar pumps may find it difficult to gain ground in areas where subsidised electricity is in good supply. But experts say this is a rarity in most parts of the country.

They advocate use of solar pumps although they are expensive because the installation cost of grid is high. According to the Rajasthan horticulture department, an investment of ₹ 700 crores in solar pumps can save the installation cost of grid in 70,000 farms. Farmers can recover the cost of the pump within a year.

A major reason behind the promotion of solar pumps is poor financial health of state discoms and a long pending list of farm connections. "The hours of power supply are also limited," says Tewari.

In Bihar, however, use of solar pumps may face competition from electric pumps. Last year, the state announced the Bihar Agriculture Road Map under which a separate 1,500 MW power grid will be set up exclusively for agriculture. This makes the state's stand on clean energy confusing. To make solar pumps successful in agriculture, the government needs to clearly define policies, says Kishore.

Some companies send their best product to the government laboratories for test and approval, but actually install substandard pumps

Powered by husk

Off-grid biomass plants light up villages; experts demand clarity on tariff regulation

Two 32 kW off grid biomass gasification units in Sahebganj means the village gets electricity in the evening and businesses like the teashop (above) are doing well

It is 10 pm. Too late by village standards. But the four benches around Mote Singh's tea stall are occupied. People are chatting and sipping tea. About a year ago, the stall in Sahebganj village, in Bihar's Muzaffarpur district, used to be empty by sunset. Singh's fortune has been illuminated by a 15 Watt CFL. The village has an electricity grid but supply is negligible. "Managing with kerosene lamp was expensive," says Singh, the sole earner of a family of five, who used kerosene to light his house, which cost him ₹ 250 a month.

In June 2011, life changed for many in Sahebganj as they started getting electricity every day from 6 pm to 12 pm. The residents thank Husk Power Systems (HPS), a company in Patna that has installed two off-grid biomass gasification plants with 32 kW capacity each in the village. These plants convert solid biomass into gas which is then used to generate electricity (see box: How biomass gasification works). Each plant uses 300 kg of rice husk a day to power 40 per cent of the households in Sahebganj.

HPS charges ₹ 50 per household a month for a 15 Watt connection for six hours a day. Money is collected in advance. Plant operators say village residents require power for only six hours. By mid-2012, HPS had set up 80 such plants of varying capacities across Bihar.

When small is better, almost

With big grid-connected biomass plants suffering from feedstock issues, the Union Ministry of New and Renewable Energy (MNRE) is pushing for small off-grid plants. "They need less biomass and villages prefer selling that to developers because they get electricity. Transmission and distribution losses also reduce," says D K Khare, director of biomass gasification, MNRE.

Although most experts hail the HPS model, there are a few critics. Sunil Dhingra, senior fellow at Delhi-based NGO, The Energy and Resource Institute, says developers are charging unreasonably due to unregulated tariff for off-grid energy solutions. A back-of-the-envelop calculation by researchers from the Centre for Science and Environment shows that HPS charges ₹18.51 per unit from consumers in the village. This is when an average urban consumer pays ₹ 4 per unit for conventional energy. "States should decide on a reasonable tariff. Some of it should be subsidised," suggests Dhingra. For instance, if the government decides ₹10 per unit as tariff and the cost of generation is ₹ 13, the balance (₹ 3) should be subsidised, he says.

Ratnesh Yadav, co-founder of HPS, clarifies: "We operate in a market where if we charge irrationally someone will replace us," he adds. People of Sahebganj are happy with the tariff. "It is cheaper than kerosene and diesel," says Sohan Ram, who has a 30 Watt connection. For diesel operated energy, a 15 Watt connection costs ₹ 100 for four hours. Despite large-scale availability of biomass and the subsidies provided by MNRE, the power developers are charging high tariffs, says Dhingra. The ministry gives capital subsidy of ₹ 15,000 per kW and ₹ 1 lakh per km for a transmission line of up to 3 km. Going by this, if HPS—which claims that its 32 kW plant costs ₹ 18 lakh—avails the maximum subsidy, then 45 per cent of its cost is subsidised.

The developer differs. "It costs me ₹7 for generating a unit of power," says Yadav. Comparing off-grid renewable energy solutions with grid-connected conventional power to calculate per unit cost is irrational, he adds. "Our tariff is inclusive of transmission and service cost, which is not present in grid-connected power. The latter is hugely subsidised."

Greenpeace India, which advocates the HPS model, proposes an alternative: the government should set up small distribution networks (mini-grids) in villages. "It can enter into a power purchase agreement with the developer to buy power at a preferential tariff from the developer and collect the standard tariff amount from the consumer," says Manish Ram, renewable energy analyst with Greenpeace India. Suppose, the government is buying power at ₹ 10 per unit from the developer, it can charge ₹ 4 per unit from the consumer and subsidise the rest over a period of time until they eventually reach grid parity (the point at which the cost of renewable energy equals the cost of utility power from conventional sources). Later, the mini-grids can be interconnected with the main grid.

But an MNRE official, who wished to remain anonymous, says HPS is charging what people can pay. The debate is useless because the Electricity Act exempts developers from taking any licence to provide power in rural areas. "The Act also says tariff should be decided by the electricity regulatory commission after consultation with the consumers," says Ashwini Chitnis, senior

Critics say developers are charging unreasonably due to unregulated tariff for off-grid energy solutions

People would prefer uninterrupted electricity supply if tariff is reasonable

researcher, Prayas Energy in Pune. The developer should not be given free hand, she adds.

HPS says it consulted Sahebganj residents before deciding the ₹ 50 tariff. Decentralised distribution guidelines of the Union Ministry of Power say tariff in an off-grid village should not be more than that in the neighbouring grid-connected village.

Ram, along with rest of the residents of Sahebganj, says he would prefer uninterrupted full-day supply of electricity, if tariff is reasonable. But developers say this would increase generation cost which will have to be passed on to the consumer. "If a developer runs the plant for the whole day, an optimum load needs to be maintained. If tariff increases, people may reduce power consumption. The unused power is a cost to the developer," says H S Mukunda, senior scientist at the Indian Institute of Science, Bengaluru. To match the extra load, small industries can be set up in a cluster of villages, he adds. The developer may then charge higher tariff from the industry and lower tariff from domestic users. "Such an experiment is yet to happen," says Sangeeta Kohli, professor at IIT-Delhi, who has worked as a consultant with biomass power developers.

Employment generation is the key to increase acceptance among people for off-grid energy solutions

Government no-show

In 2012, the World Bank published a report on the status of MNRE's Village Energy Security Programme (VESP) under which off-grid biomass plants were set up across India. The report, India: Biomass for Sustainable Development, states that since 2005, when VESP started, only 45 of the proposed 95 projects have been commissioned. Most of the commissioned projects were closed for long periods because of poor after-sales service. Other reasons include inadequate training and lack of interest among people in operating the plant and supplying biomass due to absence of incentives. VESP was discontinued in 2009. N P Singh, director of biomass, MNRE, says projects failed because people did not take responsibility.

Kohli says to increase acceptance among people for off-grid energy solutions, employment generation is the way to go. Yadav of HPS agrees. He says, "We have employed women to make incense sticks out of char, a by-product of biomass gasification." Of the total biomass used in a gasifier, 40 per cent converts into char.

Technological glitches

A major problem in the gasification process of biomass is the production of tar and wastewater. The gasifier runs best on woody biomass because light biomass, like rice husk which is used in most plants in Bihar, can choke the reactor where combustion takes place.

Rice husk has the highest content of ash (20 per cent) among all the agricultural residues of the gasification process. If this husk is burnt at the regular temperature of 1,000°C in the gasifier, the ash will produce clinkers that will jam the reactor. To avoid clinkers, temperature needs to be lowered at 850°C, but this drop in temperature results in more tar.

To reduce tar, briquetting technology has to be used. "If husk is made into briquettes of appropriate size, say 5 cm by 5 cm, it will reduce the surface area of biomass which is inversely proportion to tar production," explains Mukunda. Briquettes also increase the density of husk, facilitating its flow inside the reactor. In its original form, husk gets stuck inside the reactor. Despite the positives, developers stay away from briquetting machines because they increase operation cost by 30 per cent.

Yadav of HPS says, "We regularly clean our system and mix the tar with char." Inside the gasifier, water is used to clean the gas of impurities by cooling. Impurities either condense or get dissolved in water. This water can be used for a month in the system, after which it becomes saturated with impurities. "It needs to be treated before letting it out of the system," says Mukunda. With no checks in place, plants often avoid it.

For HPS, efficiency is not a priority. Most of the existing plants are based on the basic technology with 65 per cent efficiency. "Technology with up to 85 per cent efficiency is costly and requires skilled and expensive manpower," says Yadav. A 35 kW plant with 85 per cent efficiency would cost ₹ 30 lakh. "Our priority is to give employment to village residents, who may not be able to operate plants based on a sophisticated technology," he adds.

HOW BIOMASS GASIFICATION WORKS

Biomass gasification is the conversion of biomass into a combustible gaseous mixture. In a reactor, commonly known as the gasifier, biomass undergoes chemical reactions under controlled air supply. First, drying of biomass takes place in the uppermost part of the gasifier. Biomass is heated at 90°C to 100°C to remove its moisture. Then pyrolysis takes place, where dried biomass gets heated from 300°C to 400°C and volatile combustible matter is released. This leaves behind a carbon residue called char. The volatile combustible matter contains non-condensable gases and condensable oils like tar. In the third step of oxidation, controlled oxygen is provided which burns the volatile matter and char. When all the oxygen is consumed, a reducing atmosphere is created. In the reduction zone, the carbon dioxide and water vapour produced in the oxidation process get reduced to carbon monoxide, hydrogen and methane which essentially form the producer gas. Water is used to cool and clean the producer gas. Cleaning takes place through condensation. The gas is further cleaned through filters. Finally, the gas is fed into a gas engine which converts it into electrical energy.

Gasifiers with up to 85 per cent efficiency are available in the country. But some developers are reluctant to use the technology because they are costly and require skilled labour

Bon appetit with sun

Enter the world's largest solar kitchen

Solar panels at the kitchen of Brahma Kumaris World Spiritual University in Shantivan, Rajasthan. It is the biggest solar kitchen in the world

The brightly lit kitchen at the headquarters of the Brahma Kumaris spiritual university is filled with aroma of *dal* and rice being boiled in steam cookers. Lunch time is an hour away. Chefs dressed in spotless white are working in tandem to ensure that the food is cooked to perfection.

Spread across 7,000 sq m, the kitchen has over 15 such cookers with capacities of 500-1,000 litres, and many deep pans for cooking vegetables. The food is to be served to an impressive 15,000 diners.

There are bigger kitchens but none that runs on solar energy. Built in 1998, this solar kitchen is at the headquarters of Brahma Kumaris World Spiritual University (BKWSU) in Shantivan, 18 km from Mount Abu in Rajasthan.

The kitchen, where vegetarian meals for 38,000 people can be cooked at one go, uses solar energy in the form of steam generated on the roof of a building next to the kitchen. Its roof is an interesting sight. After climbing stairs of the four-storey building, one is greeted by a wall that says, "Welcome to solar world." The roof has 84 shining parabolic concentrators, each looking like a huge dish made of reflecting concave mirrors. Every dish is 9.6 sq m and

The kitchen serves meals to 15,000 people every day

The kitchen saves around 200 litres of diesel and 1.2 tonnes of carbon dioxide emissions in a day

has 520 pieces of special white glass imported from Germany.

These dishes are arranged in pairs with one placed higher than the other. A rotating support adjusts the dishes automatically according to the sun's position so that it can reflect and focus maximum sunlight on receivers.

Made of high-grade steel, these receivers are situated three metres from the centre of the concentrators. A strong beam of reflected sunlight from the concentrators heats up the receiver. The temperature reaches up to 500°C at its focal point. These receivers are attached to pipes running along the row of concentrators. The temperature of the receiver heats the water inside the pipes and steam is generated.

This steam travels through insulated pipes to the kitchen. The cooking vessels have perforation at their base to facilitate entry of the steam. The entire solar installation generates 3.6 tonnes of steam every day which is used for preparing food and drinks. About 50 kg of rice can be cooked within 12 minutes.

"It saves around 200 litres of diesel and 1.2 tonnes of carbon dioxide emissions in a day.

Around 50 kg of rice can be cooked in the kitchen in 12 minutes

The 1 MW solar thermal power project produces heat that can be stored for as long as 16 hours so that it can be used after sunset

The kitchen also saves 184 kg of LPG every day," says Aneta Loj, research and development coordinator, India One Solar Thermal power project at BKWSU. The kitchen and the roof have been designed by Switzerland-based Wolfgang Scheffler, regarded as the father of solar community kitchens, with BKWSU's renewable energy department.

Having taken care of the cooking fuel, BKWSU is planning to fulfil its electricity needs through solar energy. It is building a one MW solar thermal plant on 22 ha using the technology used in the kitchen. Construction of the project, called India One, is under way.

Metal structures painted bright yellow stand on the ground. Pieces of mirrors are being fitted on large parabolic metal structures, each of 60 sq m inside the workshop on the campus. About 260 such concentrators will be required to generate enough steam to power one MW of turbine to generate electricity.

At the centre of every concentrator a camera will be fitted to monitor whether the focus of the sunray on the receiver is accurate. The receiver, in this case, can heat up to 1,200°C and is integrated inside a heavy iron drum. The hollow of the drum has a spiral of heat-exchanger pipes wherein water will flow. On heating, the water will turn into steam which will be compressed to run the turbine.

A big advantage of this project is that the heat produced can be stored for as long as 16 hours so that it can be used after sunset to generate electricity. The stored heat can be between 250°C and 450°C. "We are using cast iron to store the heat," informs Loj of India One, adding, "If we combine the storage system, the actual capacity of the plant becomes 3.2 MW."

According to Loj, the project cost is ₹ 25 crore, 60 per cent of which is funded by corporates. The rest is jointly borne by the Union Ministry of New and Renewable Energy and the German government, which provided the technology. Loj says the project's objective was to develop technology suitable for India. BKWSU's solar thermal power project can be replicated elsewhere in the country.

A biogas plant being constructed in Valsad district. There is an acute shortage of masons and supervisors

Gujarat's biogas travails

Plants built by Gujarat government agencies in poor shape, cooperatives fare somewhat better

In 2001, Gujarat's Agricultural Industrial Corporation built a small biogas plant in Phulji Sagan's house. The plant lies broken and unused. "The burner of the gas stove rusted in six months and broke down one day. We did not know from where to get a new burner. The pipe also started leaking," says the resident of Kosamadi village in Gujarat's Dangs district. "We did have cow dung, but could not use biogas because there was no technical help from the government, and quickly switched to firewood. Even that is getting scarce now," says Sagan who has seven cows.

His experience with biogas plants typifies that of several farmers in Gujarat. The National Biogas and Manure Management Programme (NBMMP) began in 1981-82 in Gujarat. About 95 per cent plants are about the size of the one in Sagan's house: 2 cubic metres (cum). Such a plant

In Anand district, the slurry taken out of the tank is used as manure

DWINDLING INTEREST

Year-wise target for setting up biogas plants in Gujarat

2001-02	8,057
2002-03	7,301
2003-04	7,814
2004-05	6,974
2005-06	5,201
2006-07	8,324
2007-08	8,270
2008-09	5292
2009-10	9,050
2010-11	3,876
2011-12	2,589

requires 50 kg dung and water in equal proportion every day. The gas output is enough for a family of five, like Sagan's, which should have at least four cattle. On a conservative estimate, a cow or a buffalo drops 12-15 kg of dung every day.

Gujarat Agricultural Industrial Corporation (GAIC), the nodal agency to implement the programme in the state, had built 420,686 family-sized biogas plants as of March 2012. The estimated potential in the state is 554,000 plants. But the corporation's targets have been coming down in the past few years (see 'Dwindling Interest'). "Construction costs are a big deterrent," says Mahendra Patel, former assistant manager of the corporation. A plant like the one in Sagan's house, that used to cost about ₹ 18,000 five years ago, now costs between ₹ 28,000 and ₹ 30,000. Patel attributes this to the increase in the price of construction material.

Inadequate support

The Ministry of New and Renewable Energy (MNRE) offers a subsidy of ₹ 4,000 for a 1 cum plant and ₹ 8,000 for a plant with a capacity between 2 and 4 cum. It offers an additional subsidy of ₹ 1,000 for a 2 cum plant if it is linked to the toilet in the house. The Gujarat government also gives a subsidy of ₹ 4,000 for such a plant. But all this is not enough.

"Village residents find it difficult to arrange the remaining ₹ 16,000-₹ 18,000. What makes matters worse for beneficiary is the fact that the subsidy amount comes only after construction of the plant and a two year delay is a norm," says Vinod Gandhi, a GAIC field supervisor in Valsad district.

Those who can pay use biogas as a supplementary source of cooking. They have LPG connections. "However, even big farmers want biogas in their house because LPG prices are increasing," says Arvind Patel, a farmer from Lambhel village in Anand district. Patel has an LPG connection, which cost him ₹ 1,100 and refilling—once every month—costs ₹ 450.

Most villagers want GAIC to revert to the system when the corporation used to provide construction material against the subsidy amount. That way village residents got ₹7,000-8,000 upfront. The rest was given after the completion of the plant. This eased pressure on the farmer to arrange the material. Family members gave labour in most cases.

This scheme was discontinued in 2011. GAIC did not offer any reason. J N Tuwar, the corporation's director, skirted the issue and also said that there are no plans to give village residents loans for setting up biogas plants.

Poor maintenance

GAIC provides one cookstove after the biogas plant is built. But since biogas has moisture and sulphur, knobs, burners and pipes start rusting. "Knobs and pipes break in two or three months and the stoves do not last more than two years. Spare parts are not available, neither at the local market nor at the GAIC centre," says Anjara Patel of Lambhel village in Anand district. Many beneficiaries like him have not used biogas for five to six months just because spare parts for stoves were not available.

GAIC field supervisors and district heads of biogas programme, who do not want to be named, say there are no technicians to take care of maintenance issues pertaining both to stoves and the plants. Usually supervisors and masons double up as technicians. "A supervisor's job is to find beneficiaries and ensure the construction of a quality biogas plant. A supervisor generally has six-nine trained masons under him. But now only few supervisor and masons are left in the field," says Ishwar Patel, a supervisor in Sabarkantha district who was on strike demanding wage revision.

Wage issues

Supervisors get ₹ 1,000 for building a plant though wages were increased to ₹1,500 three years ago. They are given ₹500 at the completion of the plant. And, the remaining ₹ 500 is given in installments of ₹ 125 over four years. A supervisor makes about 15-20 plants every month. Their monthly earnings of ₹ 8,000- 12,000 are not enough to continue in the job. A mason gets ₹ 2,500 for a 2 cum plant which he takes around a week to build. A mason can make four to five plants in a month. So his monthly income comes to around ₹10,000-12,000. "But of late, the masons are not finding regular work because of high construction costs. Also, they get paid better in cities. That is why many have quit biogas projects," says Ameer Pancha Kotariya, a field supervisor in Junagadh.

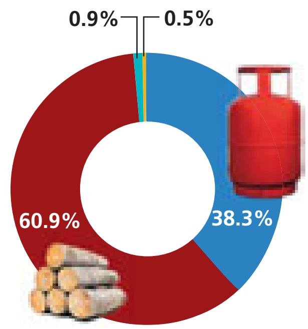
"Supervisors are not paid for going to meet beneficiaries and educating them about using the plants," Kotariya adds. So there is little motivation to remain in the profession. In Anand, for example, only eight of the 28 supervisors are left. There are 17 supervisors in Junagadh but only half work. In Sabarkantha, supervisors like Patel are on strike since the past two years demanding better pay. Some supervisors try to build more plants than they actually can to earn more money,

FUELS FOR COOKING IN GUJARAT

Total households

12,181,718

Type of cooking fuel used



- Firewood, cowdung cake, crop residue, etc
- Liquid petroleum gas
- Biogas
- Other fuels

Source: Census 2011

A kitchen in a Junagadh village that uses biogas

A dairy cooperative in Surat that also manages cow dung bank

compromising quality. There are other problems. Black soil in regions like Valsad caves in during monsoon. So plants break if they do not have a strong cement base—which is usually the case.

Some dairy cooperatives provide construction material to farmers, arrange for technicians and also store spare parts

Success stories

Some dairy cooperatives in Gujarat have shown ways to overturn problems dogging NBMMP in Gujarat. These cooperatives are the implementing agency of GAIC programme. For example, Vasundhara dairy, in Valsad, Navsari and Dangs districts of South Gujarat has built about 8,000 plants between 1994 and mid-2013. Valsad alone has 4,800 plants. "The dairy collects the subsidy from the beneficiaries and provides them construction material. It also gives an interest-free loan of ₹ 4,000. The cooperative deducts ₹ 200-300 from monthly payments to the beneficiary for milk. In this way, the loan amount gets paid back in about a year and a half," says Kalavati Ben, director, Pardi taluk, Vasundhara dairy in Valsad.

"In case the village residents have complaints with the plant or stoves, they report the problems to the manager of the village's *doodh mandali* when they visit the milk collection centre to give milk. The *mandali* manager communicates the problem to the main office, which arranges for technicians. The service is free. The cooperative also keeps stoves and spare parts," says Kalpana Patel of Parvasa village in Valsad district.

Patel has a 2 cum biogas plant built by the dairy cooperative in 2009-2010. The plant did have some problems including rusting but the dairy cooperative took care of them.

Modified biogas plants

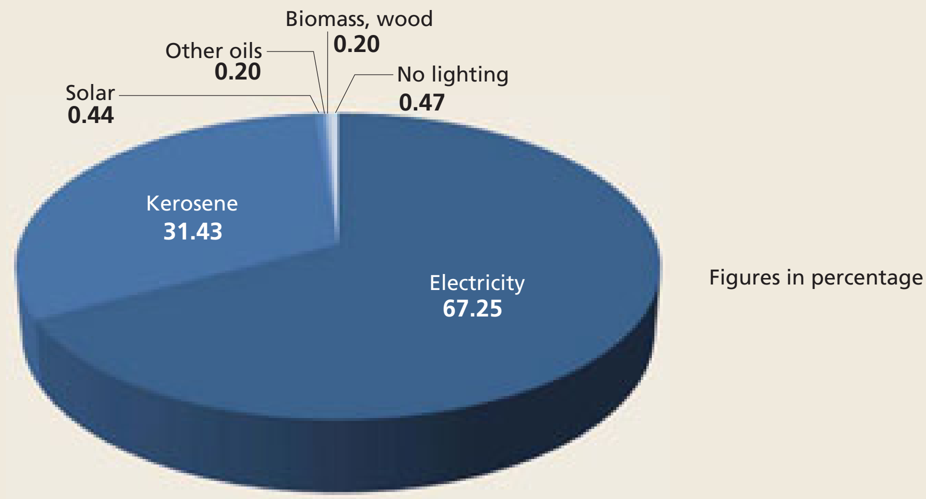
There are other initiatives. Sardar Patel Renewable Energy Research Institute in Anand has tried to modify biogas plants. The institute's researchers changed the material and design of the inlet pipe. The straight cemented structure was changed to PVC pipe in a slanted position. This prevents dung from choking in the pipe. The slanted inlet means less water is required to take the dung to the dome. The modified design requires 80 per cent less water. This also means the dung stays longer in the dome leading to 30 per cent more production of gas.

STATISTICS

Energy access and renewable energy at a glance

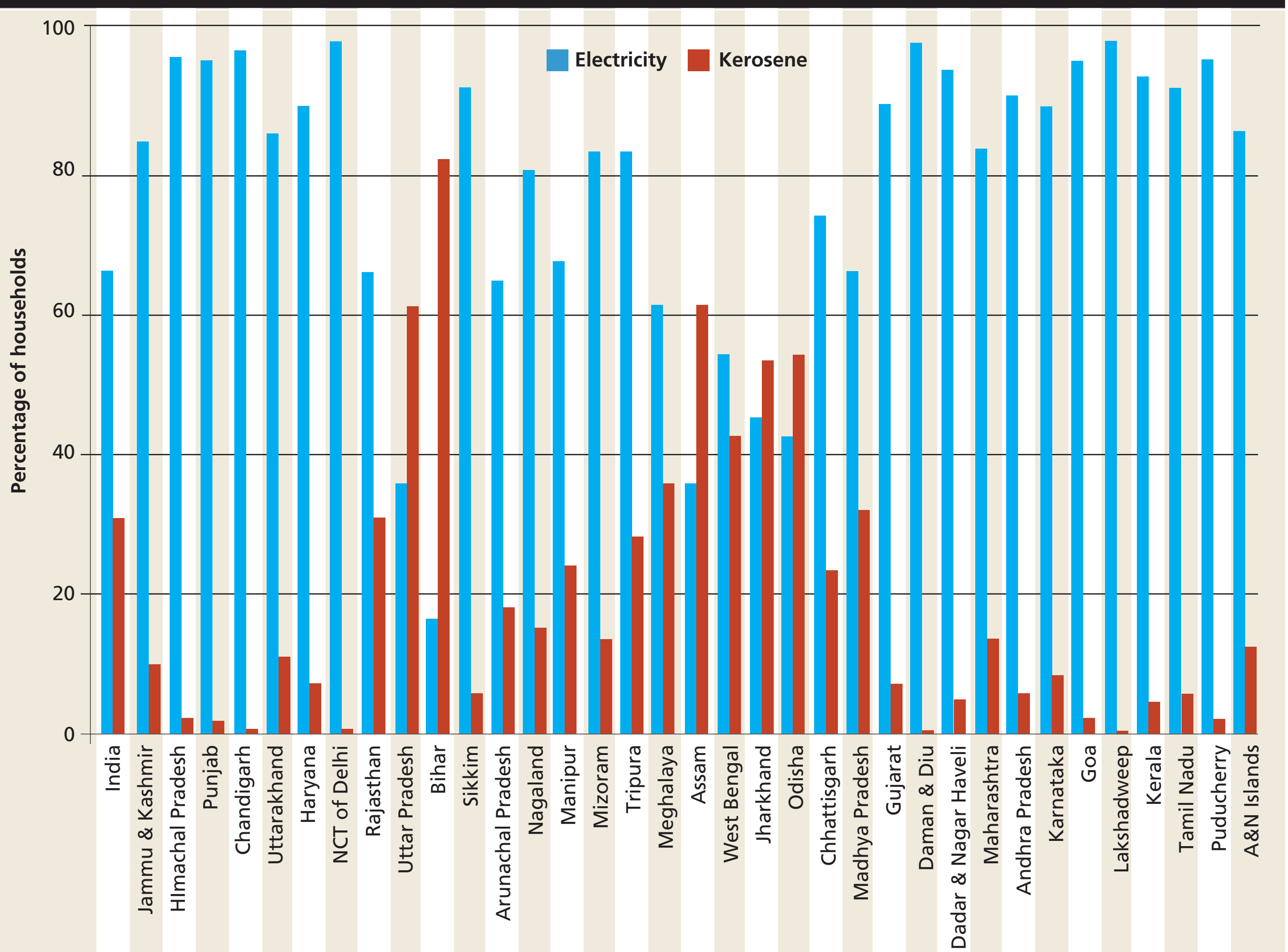
Energy Access

SOURCES OF LIGHTING FOR HOUSEHOLDS IN INDIA



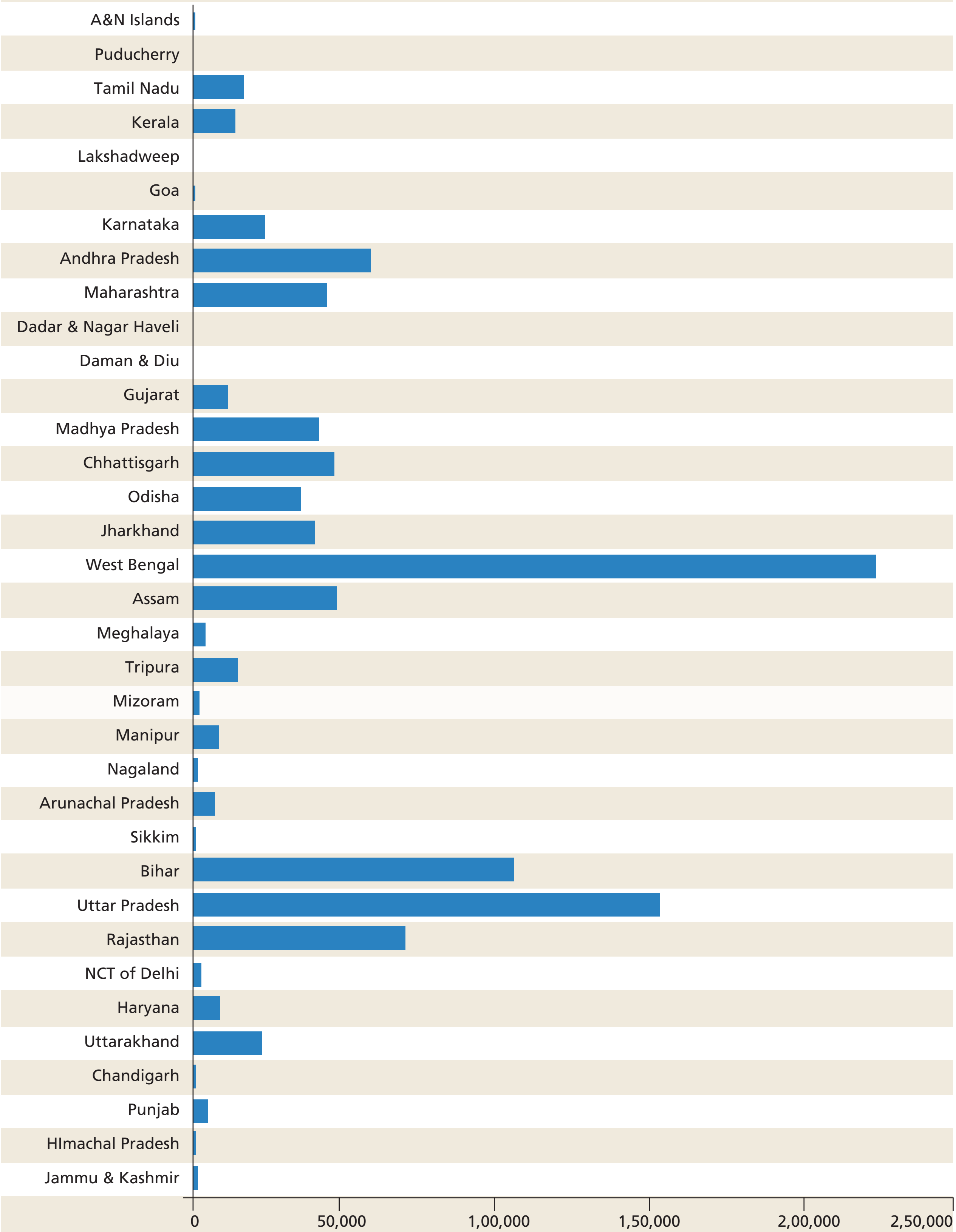
Source: Census of India, 2011

SHARE OF HOUSEHOLDS USING ELECTRICITY AND KEROSENE FOR LIGHTING



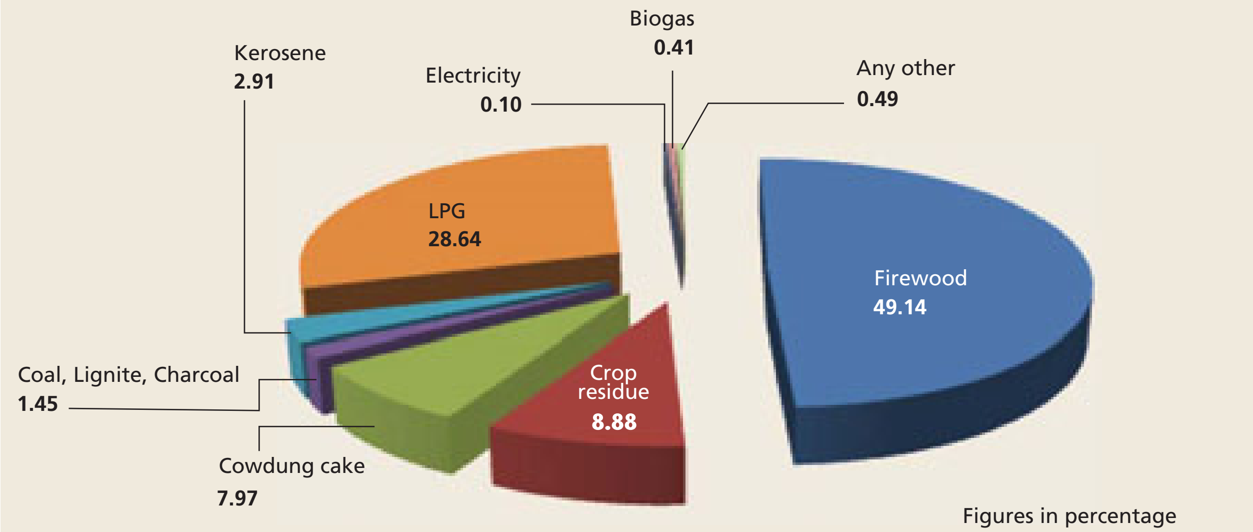
Source: Census of India, 2011

HOUSEHOLDS IN STATES USING DECENTRALISED SOLAR FOR LIGHTING (No.)



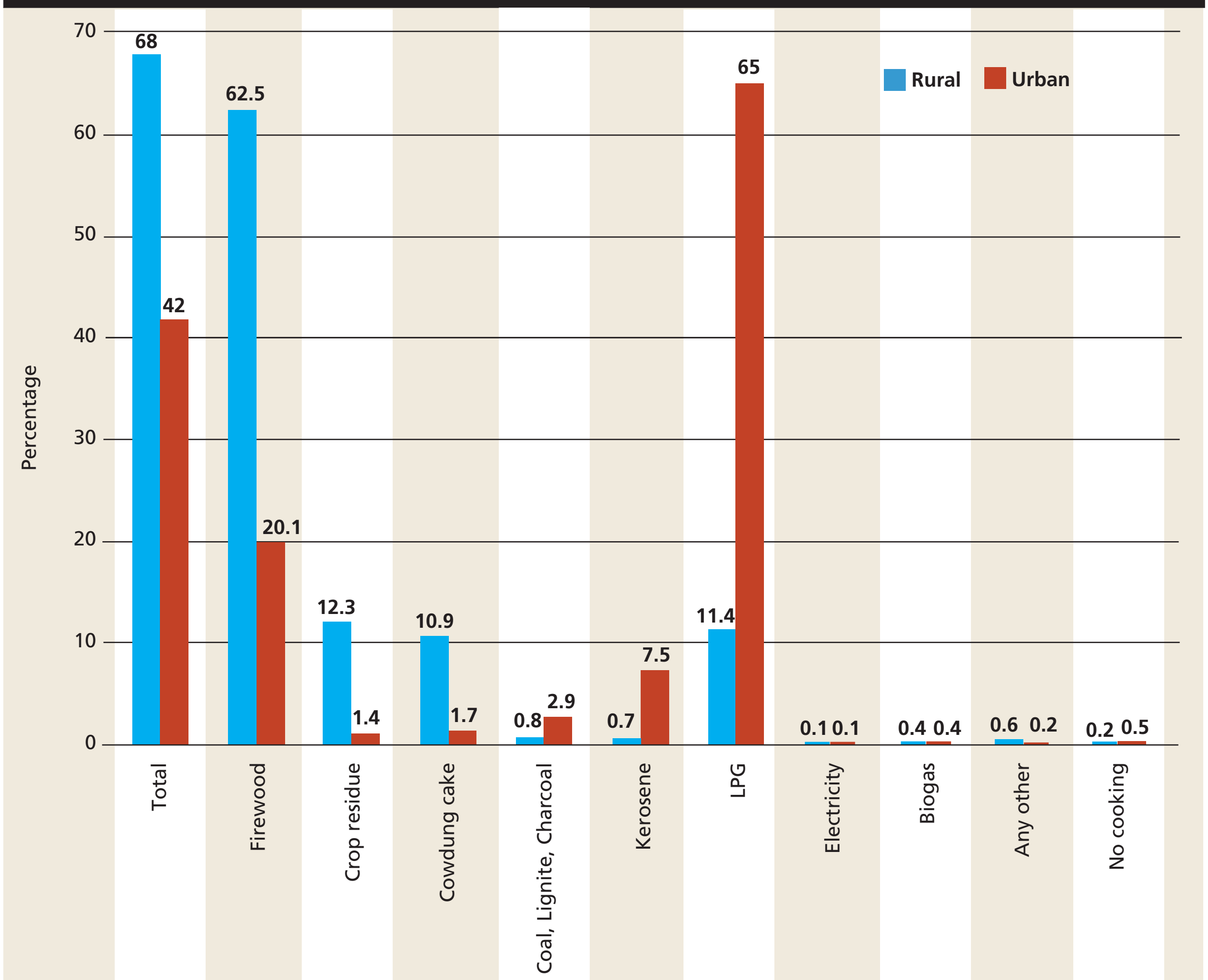
Source: Census of India, 2011

SOURCES OF COOKING FUELS FOR HOUSEHOLDS IN INDIA



Source: Census of India, 2011

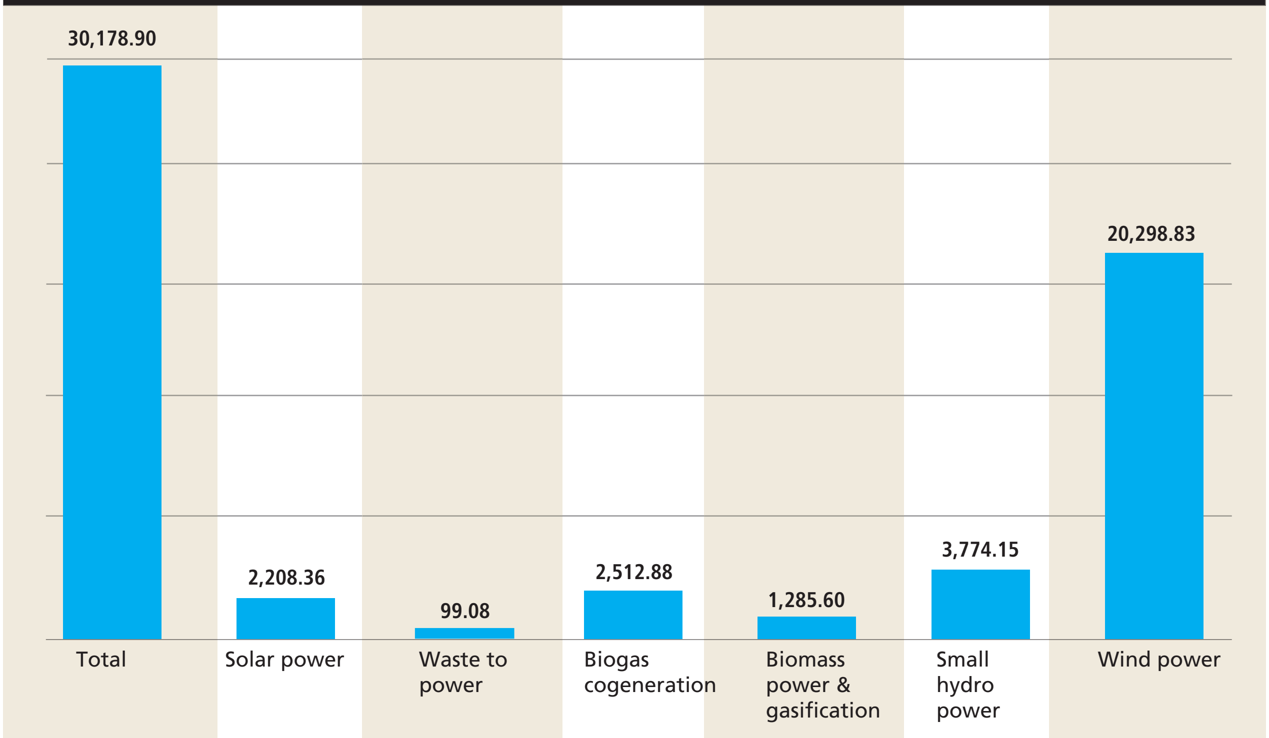
COOKING FUEL USAGE IN URBAN AND RURAL HOUSEHOLDS IN INDIA



Source: Census of India, 2011

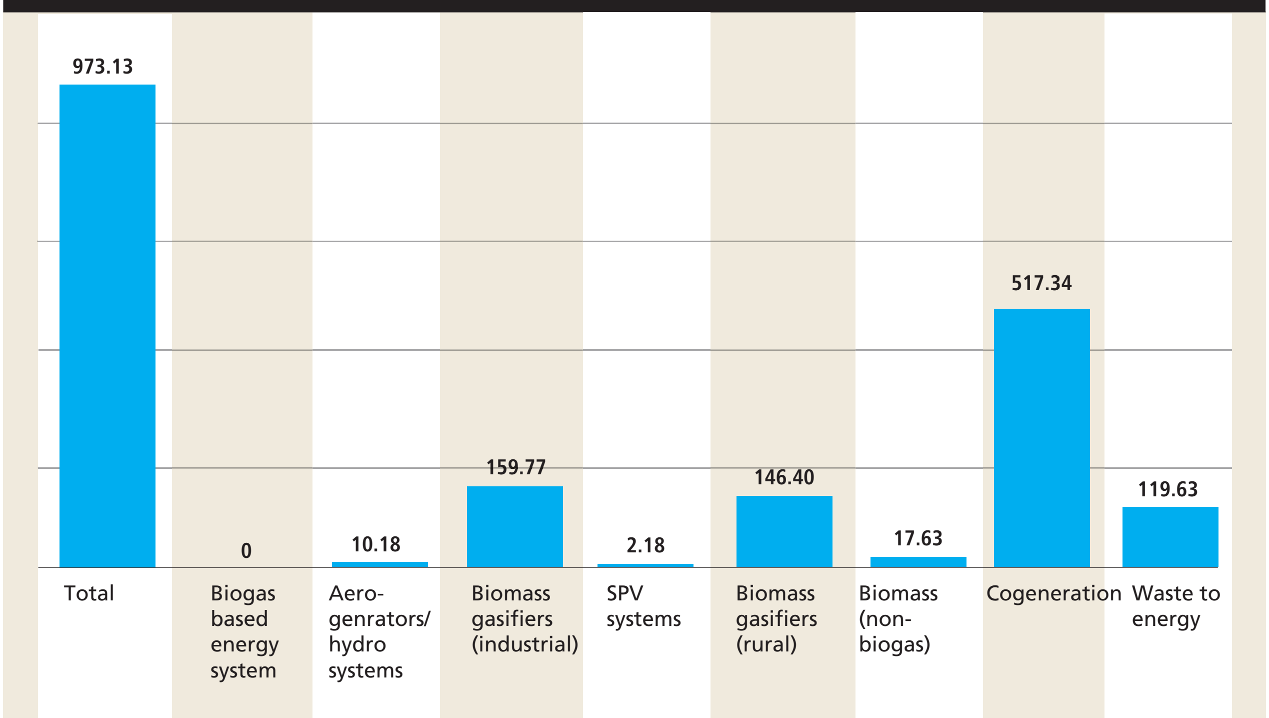
Renewable Energy

GRID-CONNECTED RENEWABLE ENERGY IN INDIA (MW)



As on January 31, 2014 Source: Ministry of New and Renewable Energy

OFF-GRID/CAPTIVE RENEWABLE ENERGY IN INDIA (MW)



As on January 31, 2014 Source: Ministry of New and Renewable Energy

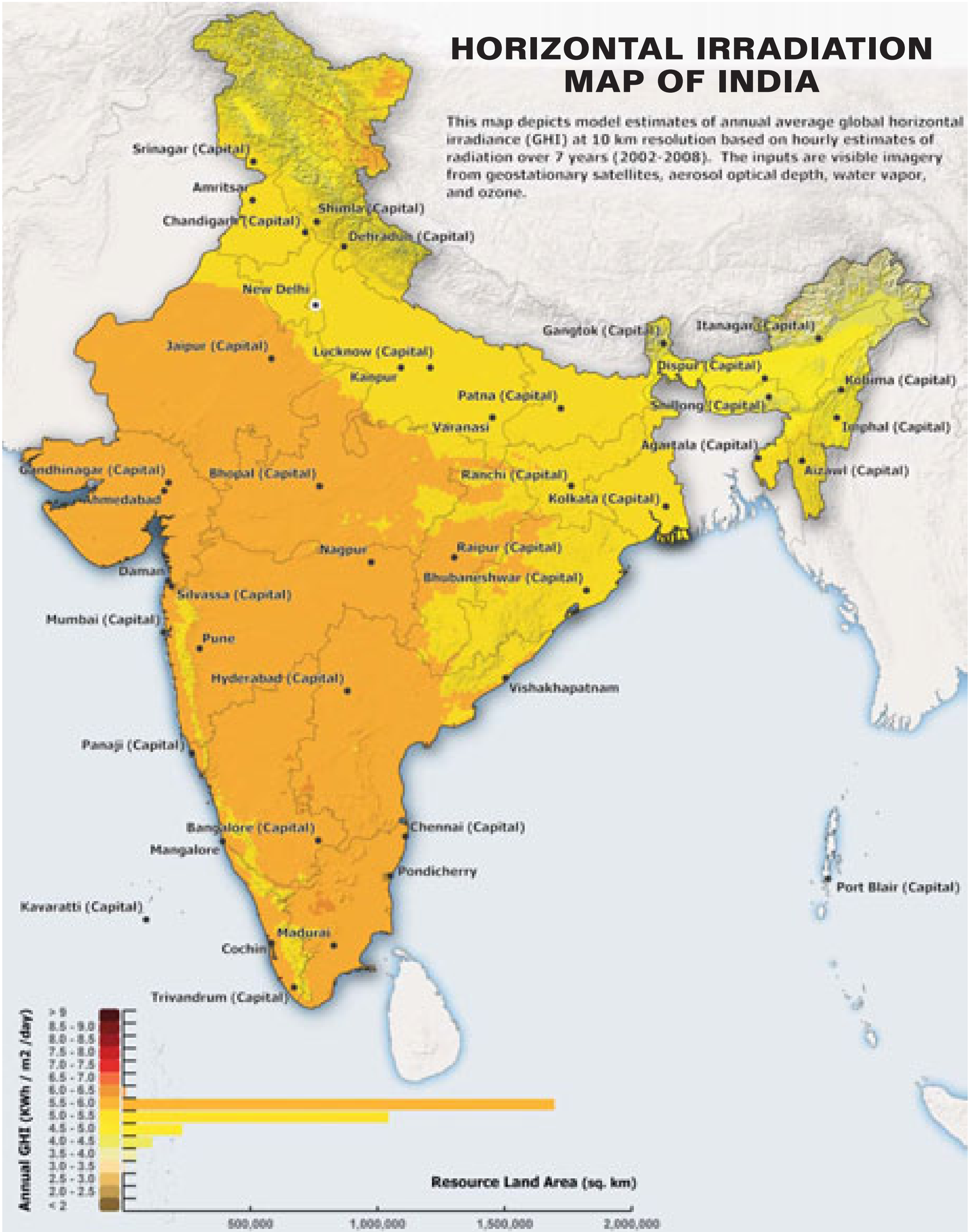
12th Five Year Plan

TARGETS FOR RENEWABLE ENERGY

Programme	Proposed 12th plan targets
Grid-interactive Renewable Power(MW)	
Grid Interactive Solar	10,000
Grid Connected Wind	15,000
Other Renewable Sources	5,000
Total	**30,000**
Off-grid/Distributed Renewable Power (MWe)	
Cogeneration from bagasse	2,000
Solar Off-Grid Applications	1,000
Waste to Energy	200
Bio Gas Based Decentralised Power	50
Others (Biomass Gasifiers, Micro-hydel)	150
Total	**3,400**
Renewables for Rural applications (Cooking)	
Biogas Plants (million)	0.7
National Biomass Cookstoves Programme (million)	3.5
Solar Cookers (Box type + Dish type)	3.5
Solar Cooking in schools for mid-day scheme (Schools in lakhs)	5.0
Renewable Energy for Urban, Industrial and Commercial Applications	
Solar Water Heating Systems (million sq.m of collector area)	6
Solar Air Heating System (sq m.)	-
CST based systems for community cooking (sq.m.)	50,000
CST based system for air-conditioning (125 systems, 30TR)	40,000
CST based systems for process heat (225 systems, 250 sq.m. area each)	53,750
Solar Cities	
New Solar Cities in addition to existing target of 60 cities and pending liabilities.	15
Model and Pilot Solar Cities.	-
Green Townships	25
Tourist/Religious/ Important Places	150
Alternate Fuel Vehicles (in numbers)	**2,75,000**
Power Generation from Hydrogen	
Stationery Power Generation (KW)	4,000
Hydrogen/H-CNG Stations (nos)	10
Demonstration projects for Hydrogen/H-CNG vehicles	500
Power Generation from Fuel Cell	
Stationery Power Generation (KW)	10
Back- up units for telecom towers (MW/nos)	10/2000
Fuel cell Vehicles	100

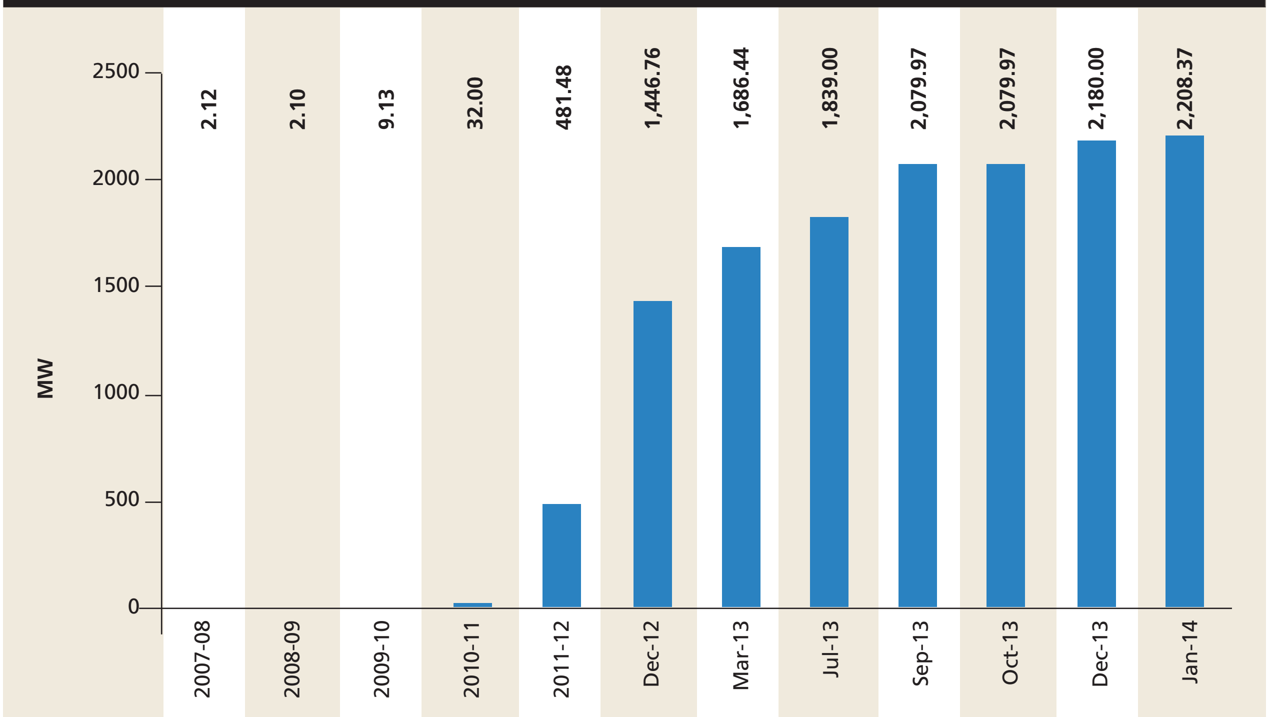
Source: Twelfth Five Year Plan (2012–2017), Economic Sectors - Volume II

Solar



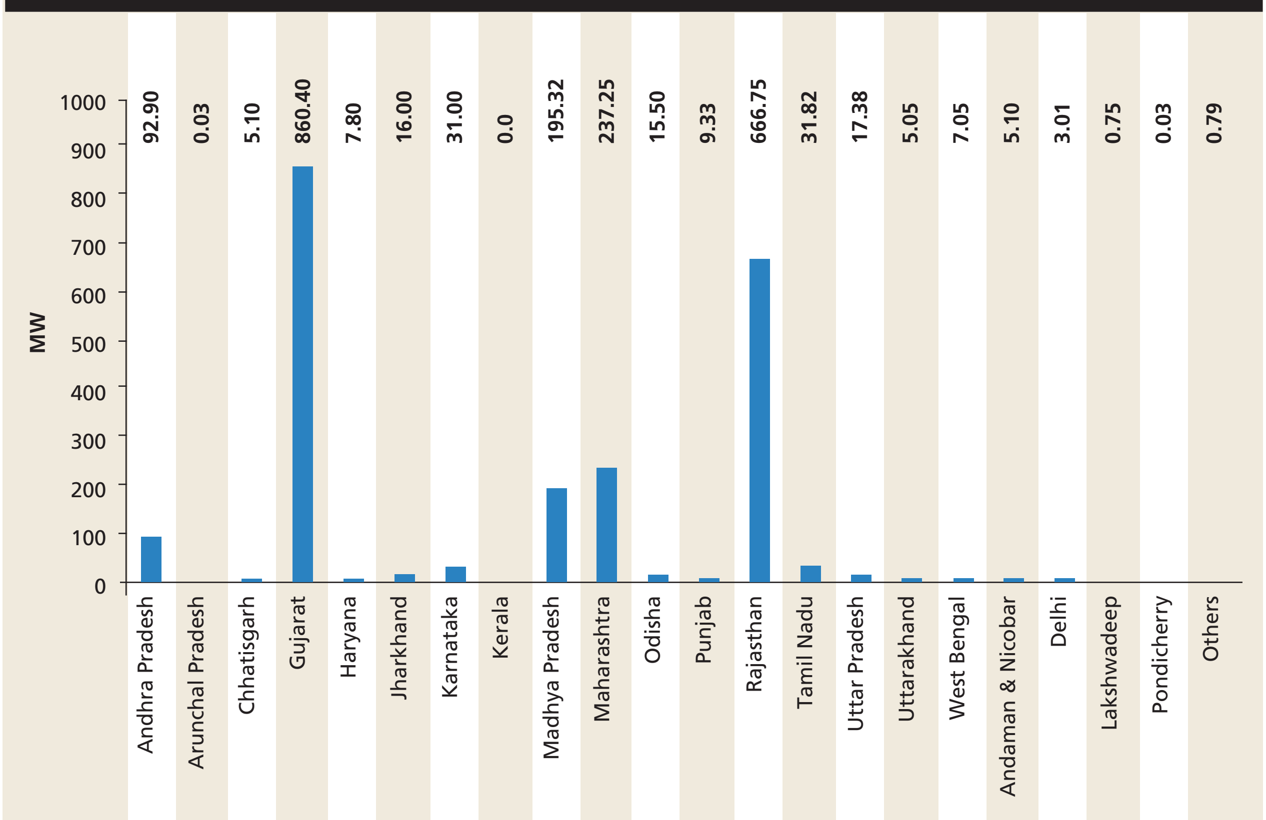
Source: Ministry of New and Renewable Energy and National Renewable Energy Laboratory

CUMULATIVE SOLAR INSTALLED CAPACITY



Source: Ministry of New and Renewable Energy

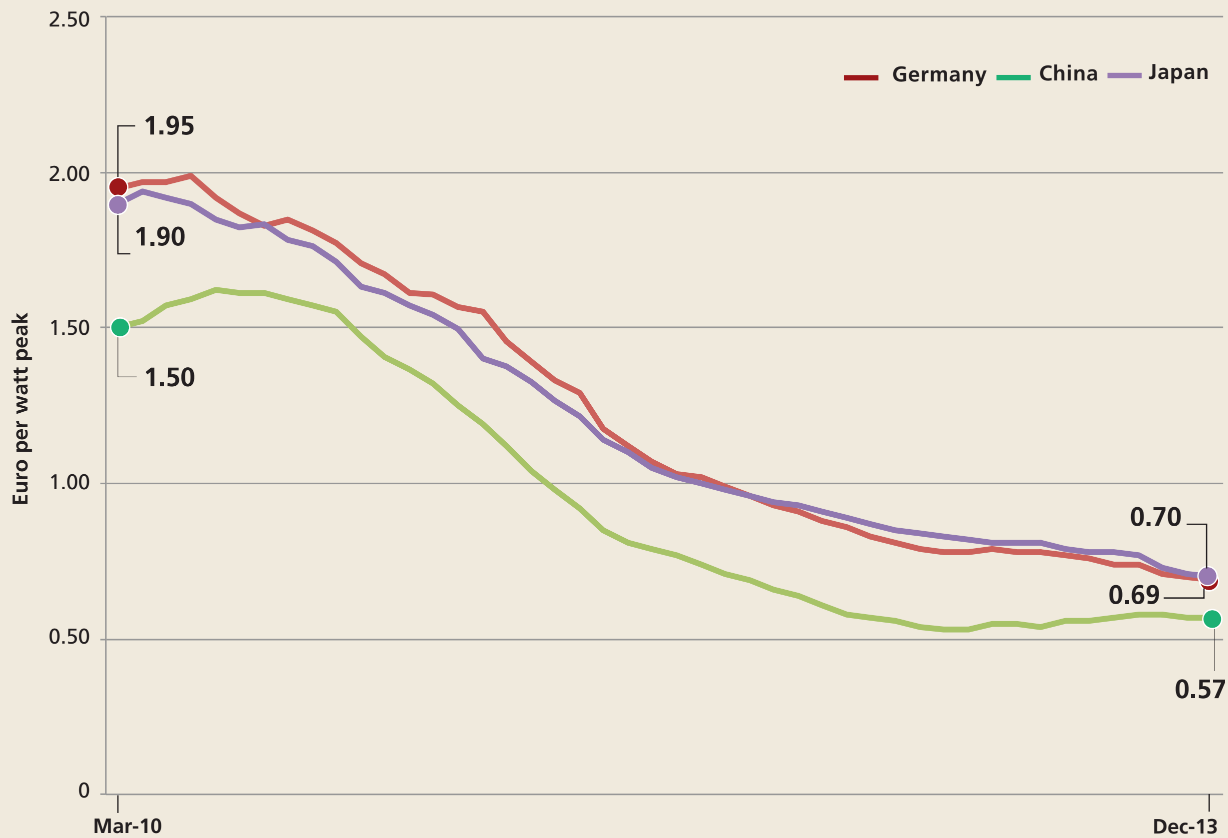
SOLAR INSTALLED CAPACITY BY STATE



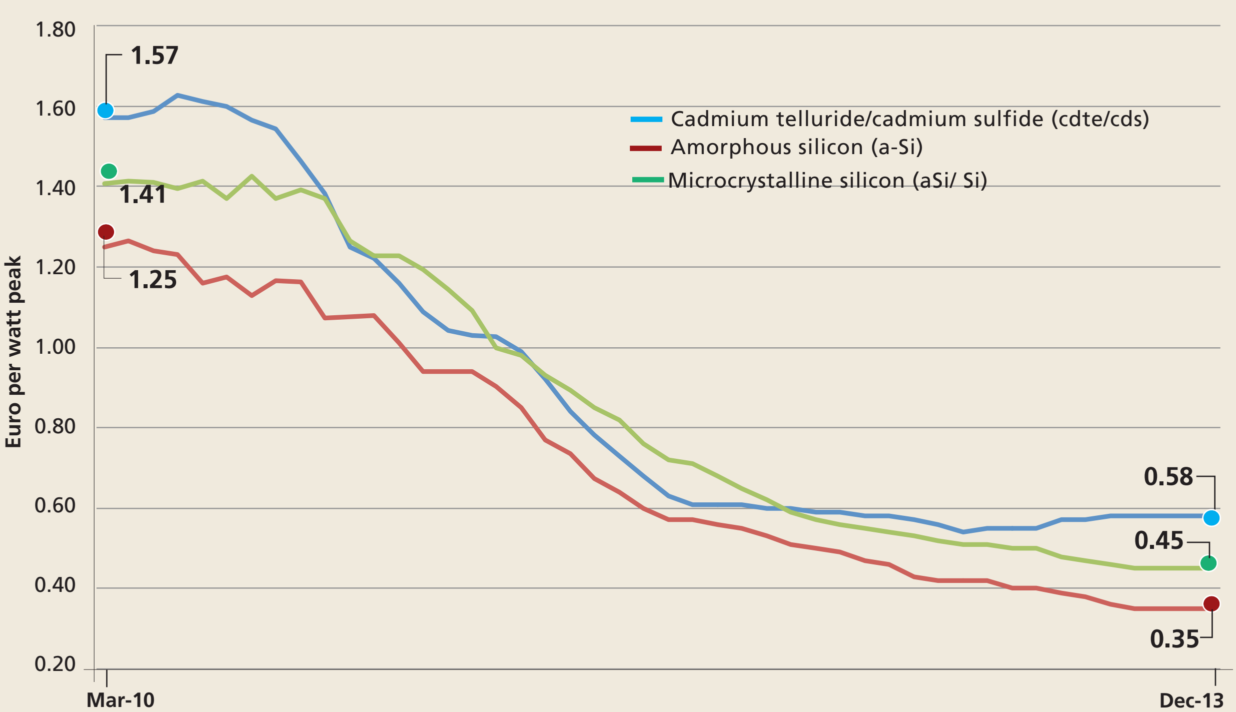
*Source: Ministry of New and Renewable Energy * As on January 31, 2014*

PHOTOVOLTAIC PRICE INDEX

Crystalline modules



Thin film modules



Source: Price Index, PVXCHANGE http://www.pvxchange.com/priceindex/Default.aspx?template_id=1&langTag=en-GB as accessed on February 3, 2014

DETAILS OF BATCH I PHASE I PROJECTS IN JNNSM

Bidder Company Name	State	Tariff Signed (₹)	Technology	Technology source	Capacity (MW)	Date of Commissioning	2012-13 Net Power Exported (kWh)	CUF (%)
Mahindra Solar One Pvt	Rajasthan	11.89	Crystalline	Indian	5	03-Jan-12	9,301,353.90	21.24
SunEdison Energy India	Rajasthan	12.39	Thin Film	Foreign	5	01-Jan-12	7,578,333.48	17.30
Viraj Renewables Energy Pvt.	Rajasthan	12.37	Thin Film	Foreign	5	05-Jan-12	9,258,642.80	21.14
Northwest Energy Pvt Ltd.	Rajasthan	12.38	Thin Film	Foreign	5	07-Jan-12	9,940,330.00	22.69
Punj Lioyd Infrastructure Ltd.	Rajasthan	12.73	Thin Film	Foreign	5	08-Jan-12	7,036,596.00	16.07
Azure Power (Rajasthan) Pvt. Ltd	Rajasthan	11.94	Thin Film	Foreign	5	01-Jan-12	8,184,111.00	18.69
Indian Oil Corporation Limited	Rajasthan	12.54	Crystalline	Indian	5	02-Feb-12	7,137,501.00	16.30
Amrit Energy Pvt. Ltd	Rajasthan	12.75	Crystalline	Indian	5	02-Feb-12	9,329,283.00	21.30
Alex Spectrum Radiation	Rajasthan	12.49	Thin Film	Foreign	5	21-Feb-12	9,039,387.25	20.64
Greentech Power Pvt. Ltd	Rajasthan	11.70	Crystalline	Indian	5	08-Feb-12	8,559,249.40	19.54
Precision Technik Pvt	Rajasthan	12.76	Crystalline	Indian	5	22-Mar-12	4,115,067.30	9.40
Khaya Solar Projects Private Ltd.	Rajasthan	11.50	Crystalline	Indian	5	28-Jan-12	7,763,650.50	17.73
Vasavi Solar Power Private Ltd.	Rajasthan	11.65	Crystalline	Indian	5	02-Feb-12	7,466,277.00	17.05
Saidham Overseas Private	Rajasthan	11.75	Crystalline	Indian	5	30-Jan-12	7,853,928.00	17.93
DDE Renewable Energy	Rajasthan	11.55	Crystalline	Indian	5	14-Feb-12	7,056,009.00	16.11
Finehope Allied Engineering	Rajasthan	11.65	Crystalline	Indian	5	07-Feb-12	7,931,451.00	18.11
Newton Solar Pvt. Ltd	Rajasthan	11.70	Crystalline	Indian	5	09-Feb-12	6,824,403.00	15.58
ElectroMech Maritech Pvt	Rajasthan	11.60	Crystalline	Indian	5	01-Feb-12	7,579,036.00	17.30
Oswal Woollen Mills	Rajasthan	12.75	Thin Film	Foreign	5	10-Jan-12	8,820,936.30	20.14
Maharashtra Seamless	Rajasthan	12.24	Thin Film	Foreign	5	07-Jan-12	9,229,197.70	21.07
FireStone Trading Pvt. Ltd	Maharashtra	10.95	Thin Film	Foreign	5	Awaited		
Karnataka Power Corporation*	Karnataka	11.69	Crystalline	Indian	5	25-Jun-12	5,701,414.00	17.60
SAISUDHIR Energy Ltd	Andhra Pradesh	12.00	Thin Film	Foreign	5	05-Jan-12	9,171,600.00	20.94
Electrical Manufacturing Co. Ltd.	Uttar Pradesh	12.49	Crystalline	Indian	5	04-Mar-12	6,731,911.00	15.37
Welspun Solar AP Pvt. Ltd	Andhra Pradesh	12.64	Thin Film	Foreign	5	01-Jan-12	9,198,000.00	21.00
CCCL Infrastructure Ltd	Tamil Nadu	12.70	Thin Film	Foreign	5	29-Mar-12	7,743,913.00	17.68
Aftaab Solar Pvt. Ltd	Orissa	12.72	Thin Film	Foreign	5	07-Feb-12	8,189,900.00	18.70

MW - MegaWatt,kWh - kiloWatt hours, CUF - Capacity Utilization Factor - calculated for the period of 1st April 2012 to 31st March 2013 based on number of days in the period from the date of commissioning, CUF calculated for 9 months*

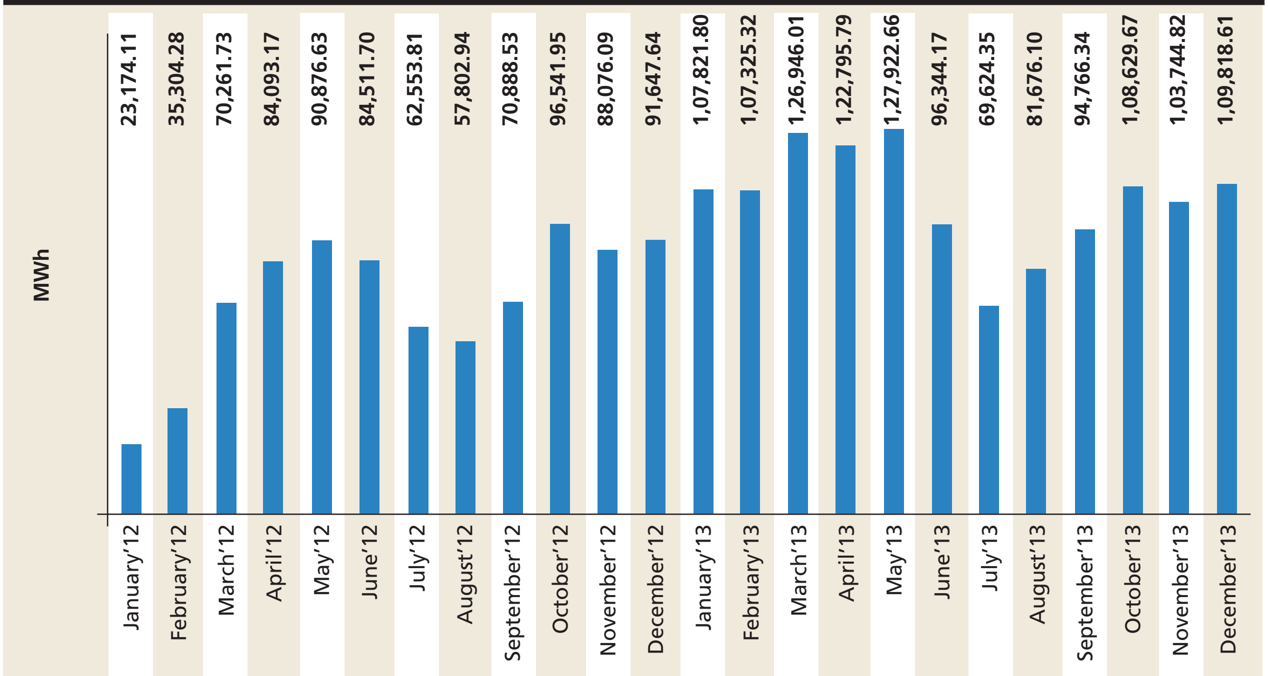
Source: CSE Analysis and information received through Right to Information (RTI) from NTPC Vidyut Vyapar Nigam Limited

DETAILS OF BATCH II PHASE I PROJECTS IN JNNSM

Company	State	Tariff Signed (₹)	Technology	Technology source	Capacity (MW)	Date of Commissioning/ Remarks
Welspun Solar AP Pvt Ltd.	Rajasthan	8.14	Thin Films	Foreign	15	22-Jan-13
Welspun Solar AP Pvt Ltd.	Rajasthan	8.05	Thin Films	Foreign	15	31-Jan-13
Welspun Solar AP Pvt Ltd.	Rajasthan	7.97	Thin Films	Foreign	20	19-Feb-13
Mahindra Suryaparakash Pvt. Ltd	Rajasthan	9.34	Thin Films	Foreign	20	20-Feb-13
Mahindra Suryaparakash Pvt. Ltd	Rajasthan	9.34	Thin Films	Foreign	10	20-Feb-13
Solarfield Energy Two Pvt. Ltd.	Rajasthan	9.34	Thin Films	Foreign	20	20-Feb-13
Azure Solar Pvt. Ltd.	Rajasthan	8.21	Thin Films	Foreign	15	12-Feb-13
Azure Solar Pvt. Ltd.	Rajasthan	8.21	Thin Films	Foreign	20	13-Feb-13
Fonroche Saaras Energy Pvt. Ltd.	Rajasthan	9.10	Thin Films	Foreign	15	21-Jan-13
Fonroche Rajhans Energy Pvt. Ltd.	Rajasthan	9.10	Thin Films	Foreign	5	23-Dec-12
Green Infra Solar Farms Projects Ltd.	Rajasthan	9.44	Thin Films	Foreign	20	30-Jan-13
Green Infra Solar Projects Ltd.	Rajasthan	9.39	Thin Films	Foreign	5	24-Dec-12
Gail (India) Ltd.	Rajasthan	9.32	Crystalline	Indian	5	18-Feb-13
Sh. Saibaba Green Power Pvt. Ltd	Maharashtra	8.73	Thin Films	Foreign	5	11-Feb-13
SEI Solar Power Pvt. Ltd	Rajasthan	9.28	Thin Films	Foreign	20	11-Feb-13
Pokaran Solaire Energy Pvt. Ltd	Rajasthan	7.49	Crystalline	Indian	5	24-Feb-13
Sai Mathili Power Co. Pvt. Ltd.	Rajasthan	8.28	Thin Films	Foreign	10	26-Feb-13
NVR Infra. and Services Pvt. Ltd.	Rajasthan	9.16	Crystalline Thin Films	Indian Foreign	10	25-Feb-13
LEPL Projects Ltd.	Rajasthan	8.91	Crystalline	Indian	10	26-Mar-13
Sunborne Energy Raj. Solar Pvt Ltd	Rajasthan	8.99	Thin Films	Foreign	5	26-Mar-13
Symphony Vyapar Pvt. Ltd.	Rajasthan	8.48	Crystalline	Indian	10	27-Feb-13
Lexicon Vanijiya Pvt. Ltd.	Rajasthan	8.69	Crystalline	Indian	10	26-Feb-13
Jackson Power Pvt. Ltd.	Rajasthan	8.44	Crystalline	Indian	10	1-Mar-13
Jackson Power Pvt Ltd.	Rajasthan	8.74	Crystalline	Indian	10	26-Feb-13
Enfield Infra. Ltd.	Rajasthan	9.16	Crystalline	Indian	NA	Not yet commissioned
Essel MP Energy Ltd.	Maharashtra	9.27	Thin Films	Foreign	NA	Not yet commissioned
Saisudhir Energy Ltd.	Andhra Pradesh	8.22	Thin Films	Foreign	10	24-Jul-13

Source: CSE analysis and information received through Right to Information (RTI) from NTPC Vidyut Vyapar Nigam Limited

GUJARAT SOLAR POWER GENERATION



Source: State Load Dispatch Center, Gujarat

SOLAR RPO TARGETS FOR STATES

States	2011-12	2012-13	2013-14	2014-15
Andhra Pradesh	0.25%	0.25%	0.25%	0.25%
Assam	0.10%	0.15%	0.20%	0.25%
Bihar	0.25%	0.25%	0.50%	0.75%
Chhattisgarh	0.25%	0.50%		
Delhi	0.10%	0.15%	0.20%	0.25%
JERC (Goa & UT)	0.30%	0.40%		
Gujarat	0.50%	1.00%		
Haryana	0.00%	0.05%	0.75%	
Himachal Pradesh	0.01%	0.25%	0.25%	0.25%
Jammu and Kashmir	0.10%	0.25%		
Jharkhand	0.50%	1.00%		
Karnataka	0.25%			
Kerala	0.25%	0.25%	0.25%	0.25%
Madhya Pradesh	0.40%	0.60%	0.80%	1.00%
Maharashtra	0.25%	0.25%	0.50%	0.50%
Manipur	0.25%	0.25%		
Mizoram	0.25%	0.25%		
Meghalaya	0.30%	0.40%		
Nagaland	0.25%	0.25%		
Orissa	0.10%	0.15%	0.20%	0.25%
Punjab	0.03%	0.07%	0.13%	0.19%
Rajasthan	0.50%	0.75%	1.00%	
Tamil Nadu	0.05%			
Tripura	0.10%	0.10%		
Uttarakhand	0.03%	0.05%		
Uttar Pradesh	0.50%	1.00%		
West Bengal	0.25%	0.30%	0.40%	0.50%

Source: Ministry of New and Renewable Energy

Wind

STATE-WISE & YEAR-WISE WIND POWER INSTALLED CAPACITY (MW)

State	Up to March 2002	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2008-10	2010-11	2011-12	2012-13	Total
Andhra Pradesh	93.2	0	6.2	21.8	0.45	0.8	0	0	13.6	55.4	54.1	202.15	447.7
Gujarat	181.4	6.2	28.9	51.5	84.6	283.95	616.36	313.6	297.1	312.8	789.9	208.28	3074.59
Karnataka	69.3	55.6	84.9	201.5	143.8	265.95	190.3	316	145.4	254.1	206.7	201.65	2135.2
Kerala	2	0	0	0	0	0	8.5	16.5	0.8	7.4	0	0	35.2
Madhya Pradesh	23.2	0	0	6.3	11.4	16.4	130.39	25.1	16.6	46.5	100.5	9.6	385.99
Maharashtra	400.3	2	6.2	48.8	545.1	485.3	268.15	183	138.9	239.1	416.5	288.55	3021.9
Rajasthan	16.1	44.6	117.8	106.3	73.27	111.75	68.95	199.6	350	436.7	545.7	613.95	2684.72
Tamil Nadu	877	133.6	371.2	675.5	857.55	577.9	380.67	431.1	602.2	997.4	1083.5	174.58	7162.2
Others	3.2	0	0	0	0	0	0	0	0	0	0	1.1	4.3
Total	1665.7	242	615.2	1111.7	1716.17	1742.05	1663.32	1484.9	1564.6	2349.2	3196.7	1699.86	19052

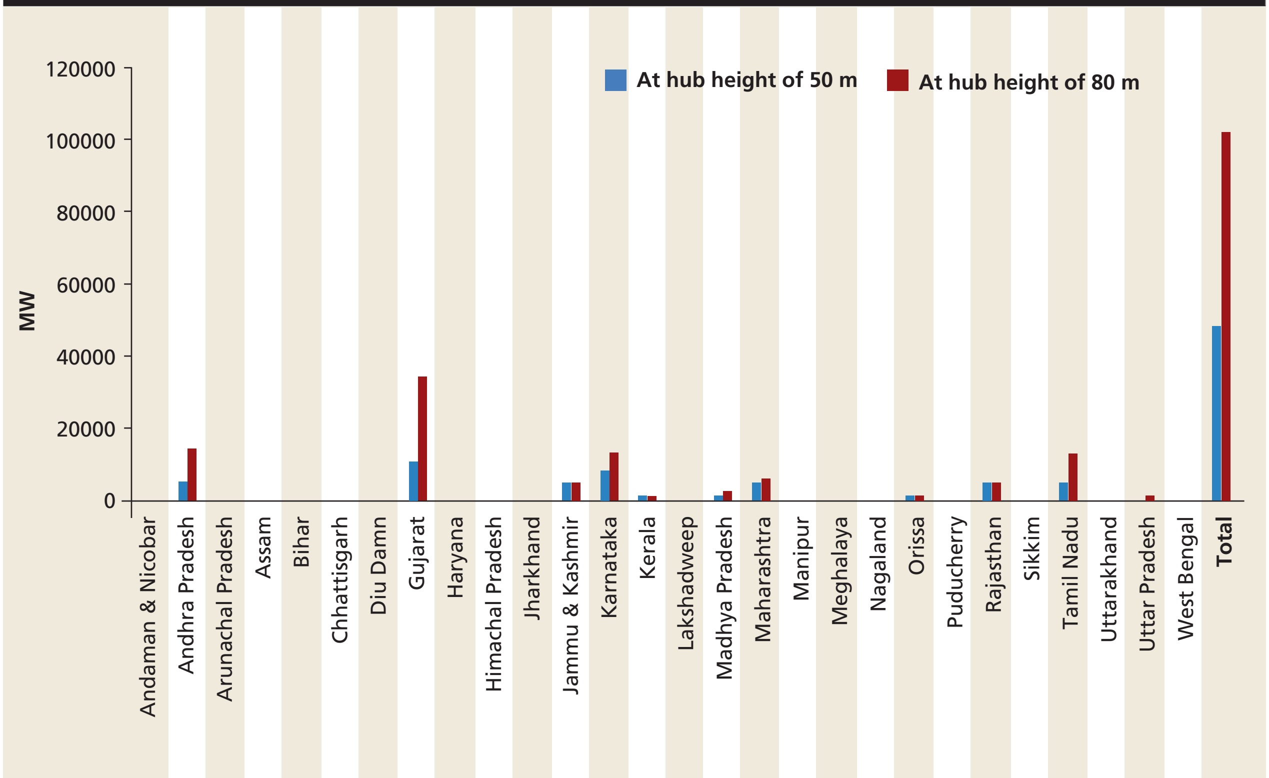
Source: Ministry of New and Renewable Energy, http://mnre.gov.in/file-manager/UserFiles/wp_installed.htm

STATE-WISE CUMULATIVE WIND GENERATION IN BILLION kWh

State	Up to 2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Cumulative
Andhra Pradesh	0.8	0.111	0.101	0.333	0.106	0.076	0.122	1.65
Gujarat	1.618	0.455	0.851	2.104	2.988	2.881	4.181	15.077
Karnataka	2.344	1.397	1.84	1.723	2.895	2.825	3.279	16.303
Kerala	0.047	0	0	0	0.065	0.065	0.07	0.246
Madhya Pradesh	0.33	0.07	0.069	0.003	0.082	0.09	0.13	0.775
Maharashtra	3.44	1.714	1.804	2.207	2.779	2.692	3.296	17.931
Rajasthan	0.921	0.532	0.682	0.758	1.127	1.387	2.42	7.826
Tamil Nadu	15.414	5.268	6.066	6.206	8.146	8.72	9.855	59.675
Total	24.914	9.547	11.413	13.334	18.188	18.735	23.353	119.483

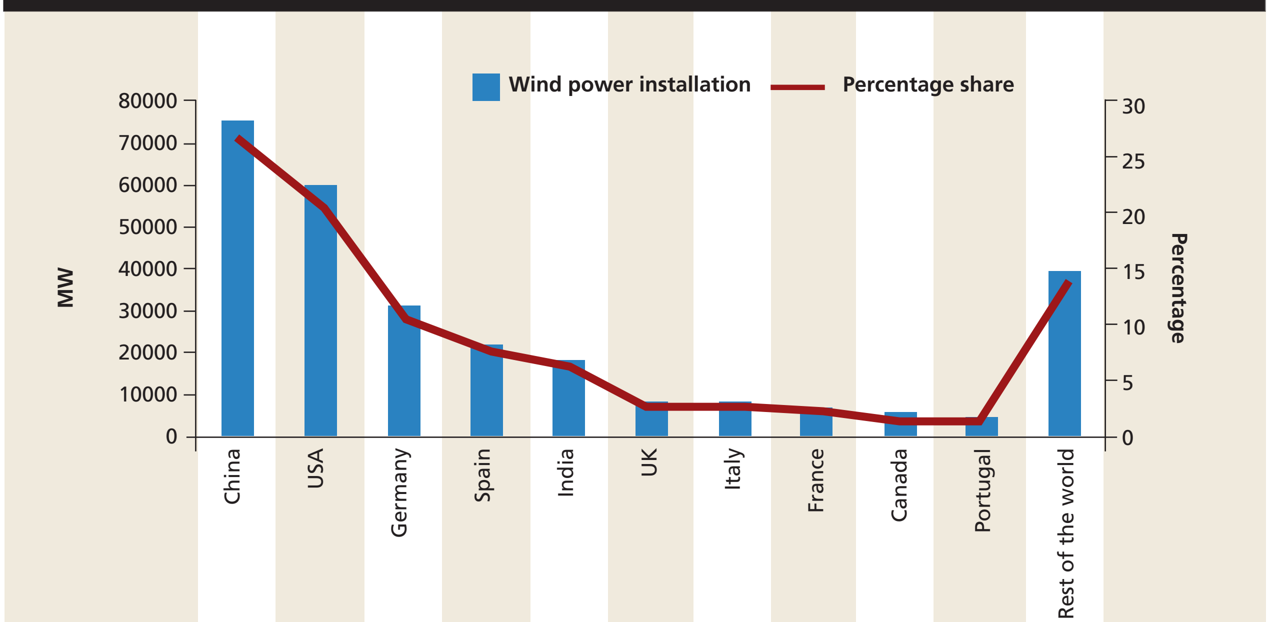
Source: Ministry of New and Renewable Energy, http://mnre.gov.in/file-manager/UserFiles/wp8.htm

WIND POTENTIAL IN DIFFERENT STATES



Source: CWET http://www.cwet.tn.nic.in/html/departments_ewpp.html

COUNTRY WISE WIND POWER INSTALLATION



Source: "Wind Energy Statistics 2012". Report. Global Wind Energy Council.

MANUFACTURER WISE WIND TURBINE INSTALLATIONS

Manufacturer	Turbines (No.)	Total (MW)	Percent share of MW
Suzlon	6502	7785.49	40.979
Wind World (Former EIL)	5615	4071.19	21.429
Vestas Wind	1605	1919.85	10.105
RRB Energy	2544	1117.5	5.882
Regen Powertech	588	882	4.642
Gamesa Wind	747	662.3	3.486
NEPC-Micon	1306	325.115	1.711
Inox	159	318	1.674
Pioneer Wincon	892	243.1	1.280
NEPC-India	999	233.75	1.230
Shriram EPC	627	156.75	0.825
Southern Windfarms	615	138.375	0.728
GE Energy	88	137.7	0.725
Leitner Shriram	79	118.35	0.623
Global Wind Power	102	95.25	0.501
ABAN-Kenetech	231	94.71	0.499
Kenersys India	43	86	0.453
AMTL- Wind World	333	83.94	0.442
Das Lagerwey	293	71.72	0.378
CWEL	272	68.7	0.362
WinwinD	67	67	0.353
BHEL Nordex	263	61.8	0.325
Pioneer Asia	52	44.2	0.233
Nedwind-Windia	59	30.25	0.159
Elecon	73	28.1	0.148
Textool-Nordtank	70	22.25	0.117
REPL- Bonus	83	20.51	0.108
RES - AWT	80	20	0.105
Sinovel Wind (China)	10	15	0.079
Tacke	26	14.35	0.076
Wind Power	29	9.57	0.050
Micon (Pearl)	99	8.91	0.047
Sangeeth - Carter	25	7.5	0.039
Himalaya	28	5.36	0.028
Ghodawat Energy	3	4.95	0.026
SIVA	19	4.75	0.025
BHEL	33	4.28	0.023
India Wind Power	13	3.25	0.017
Kirloskar	8	3.2	0.017
Chettinad	4	2.4	0.013
JMP-Ecotecnia	10	2.25	0.012
Pegasus	9	2.25	0.012
Mitsubishi	6	1.89	0.010
Danish Windpower	12	1.8	0.009
Windmatic	30	1.65	0.009
Garuda	1	0.7	0.004
NAL	1	0.5	0.003
Wind Master	1	0.2	0.001
Total	24747	18998.7	100

Source: http://www.windpowerindia.com/index.php?option=com_content&view=category&layout=blog&id=17&Itemid=71

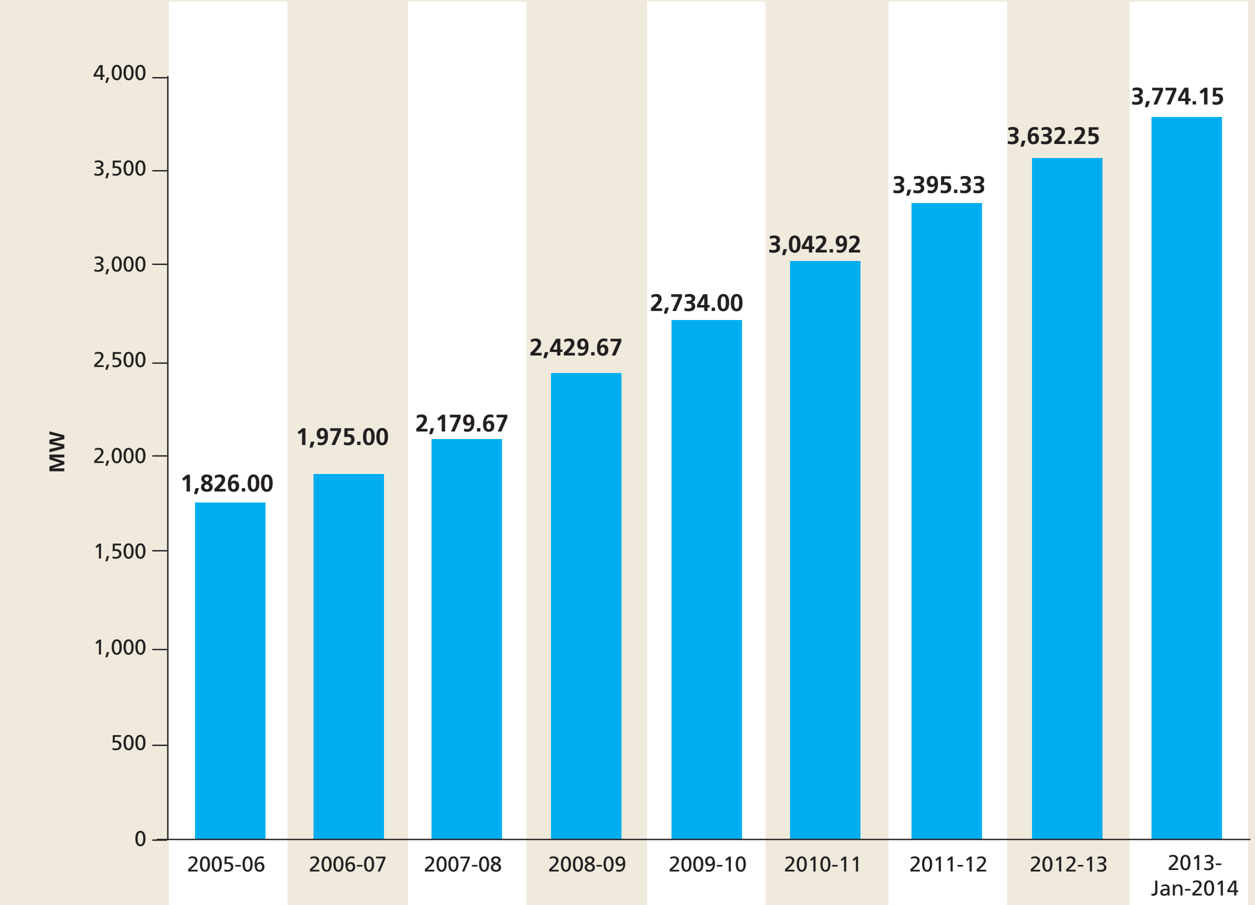
Small hydropower

SMALL HYDRO STATE-WISE POTENTIAL AND INSTALLED CAPACITY

States	Potential (MW)	Projects Installed (MW)
Andhra Pradesh	978.40	219.03
Arunachal Pradesh	1,341.38	103.91
Assam	238.69	31.11
Bihar	223.05	70.70
Chhattisgarh	1,107.15	52.00
Goa	6.50	0.05
Gujarat	201.97	15.60
Haryana	110.05	70.10
Himachal Pradesh	2,397.91	587.91
J&K	1,430.67	130.53
Jharkhand	208.95	4.05
Karnataka	4,141.12	963.76
Kerala	704.10	158.42
Madhya Pradesh	820.44	86.16
Maharashtra	794.33	299.93
Manipur	109.13	5.45
Meghalaya	230.05	31.03
Mizoram	168.90	36.47
Nagaland	196.98	28.67
Orissa	295.47	64.30
Punjab	441.38	154.50
Rajasthan	57.17	23.85
Sikkim	266.64	52.11
Tamil Nadu	659.51	123.05
Tripura	46.86	16.11
Uttar Pradesh	460.75	25.10
Uttarakhand	1,707.87	174.82
West Bengal	396.11	98.40
A&N Islands	7.91	5.25
Total	19,749.44	3,632.25

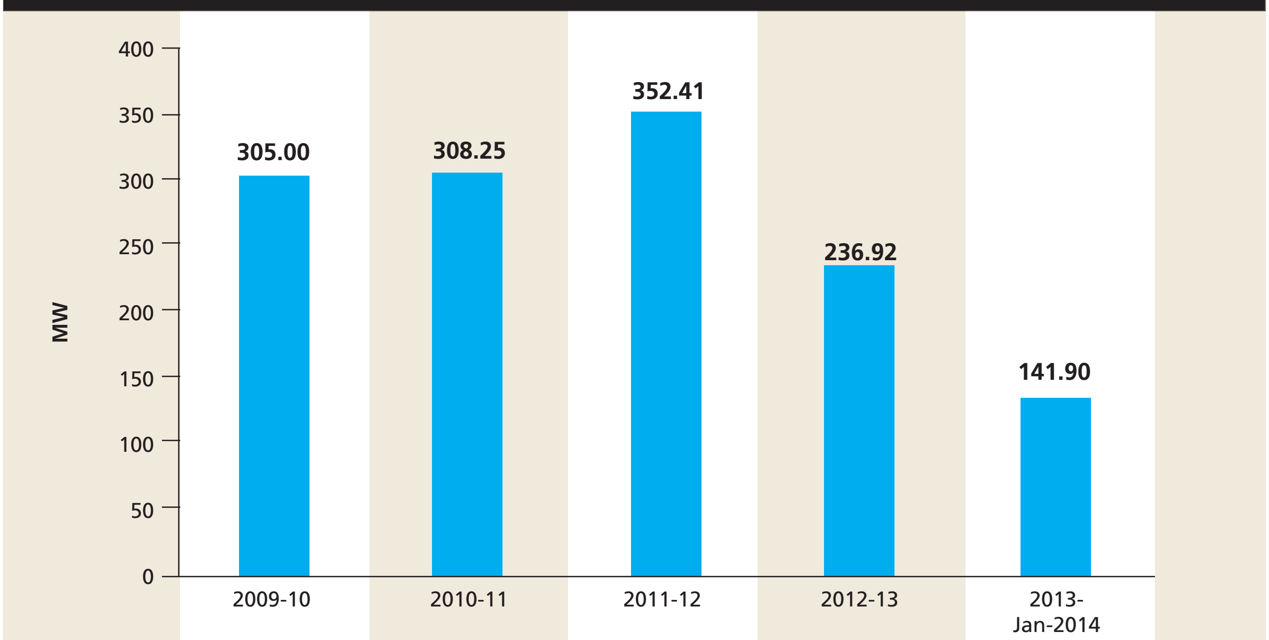
Source: Ministry of New and Renewable Energy Annual Report, 2011-12

CUMULATIVE SHP INSTALLED CAPACITY



Source: Compiled from Ministry of New and Renewable Energy Annual Reports

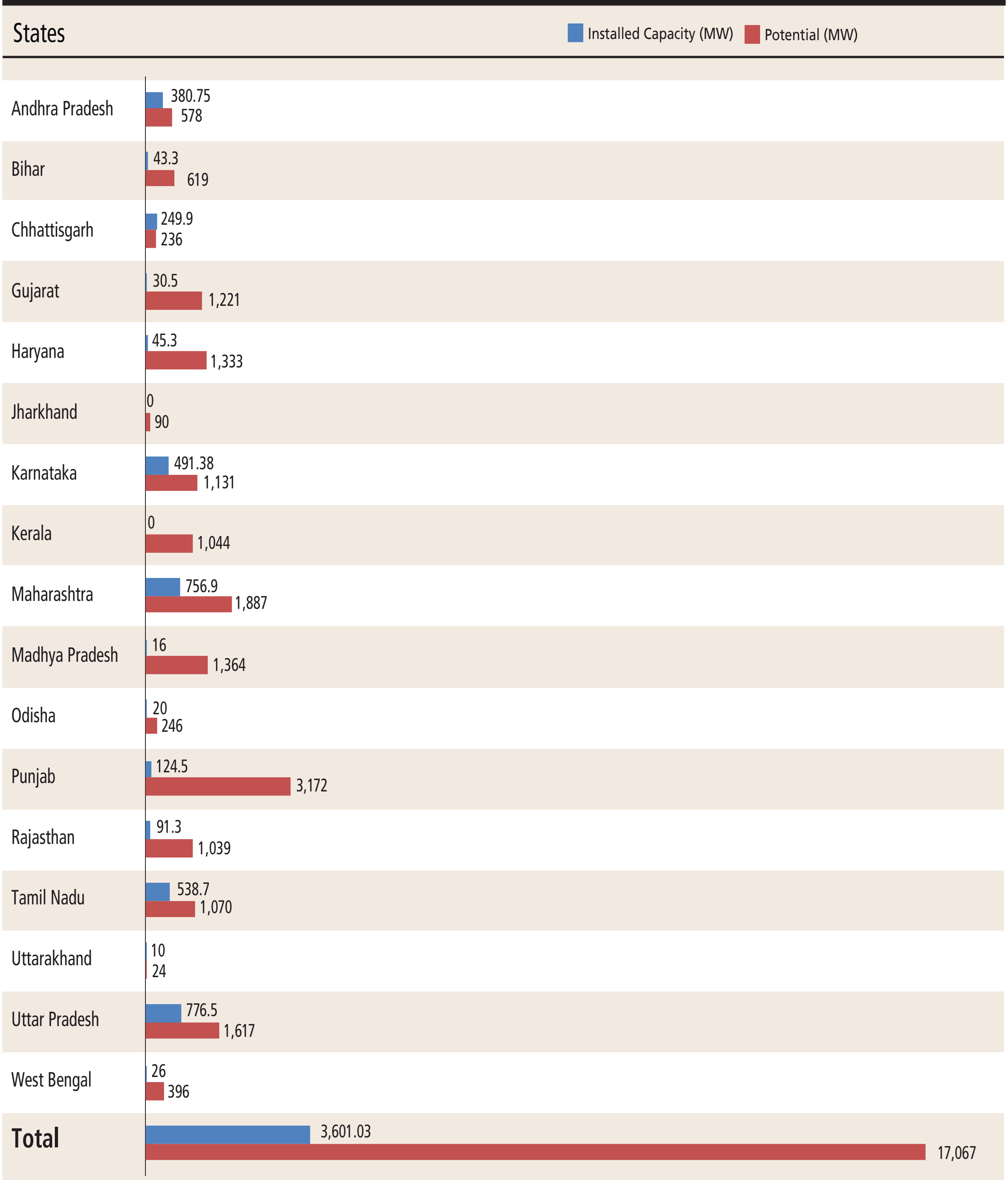
SHP INSTALLATIONS EVERY YEAR



Source: Compiled from Ministry of New and Renewable Energy Annual Reports

Biomass

BIOMASS PROJECTS INSTALLED



Source: Ministry of New & Renewable Energy, Data Portal of India
Link: http://data.gov.in/dataset/state-wise-installed-capacity-grid-interactive-renewable-power

POTENTIAL AVAILABILITY OF AGRICULTURE BASED BIOMASS

In tonnes

Biomass	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	2000 -01	2005 -06	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12
Rice husk	37.1	37.3	36.5	40.2	40.9	39.8	42.5	45.9	48.3	49.6	44.5	47.7	43.6
Wheat straw	73.5	74.3	76.3	79.6	87.5	83.3	92.7	92.2	104.5	107.3	107.5	114.3	N.A.
Maize cobs	2.7	2.4	3	2.9	2.7	2.8	3.6	4.4	5.7	5.9	5	6.4	4.8
Pearl millet straw	11.4	7.8	14.8	8.3	12	9	12.5	12	16.6	14.8	10.8	16.7	15.2
Sugarcane bagasse	80.4	84.7	76	75.8	90.9	93.4	97.7	93	114.9	94.1	96.5	111.9	112.9
Coconut shell	1.3	1.4	1.5	1.6	1.8	1.9	1.7	2	2	1.4	1.7	N.A.	N.A.
Coconut fibre	1.6	1.7	1.9	2	2.2	2.3	2.1	2.4	2.4	1.7	1.8	N.A.	N.A.
Coconut pith	2.4	2.5	2.8	2.9	3.3	3.4	3.1	3.6	3.6	2.5	2.7	N.A.	N.A.
Groundnut shell	2.5	2.4	2.9	2.6	2.7	2.6	2.1	2.6	3	2.4	1.8	2.5	1.9
Cotton stalks	22.3	23	22.6	22	23.7	27.3	28.6	55.5	28.2	28.2	30.4	33.4	36
Jute sticks	13.1	3.3	2.8	2.7	2.7	2.7	3.2	3.2	2.9	2.7	2.7	2.6	2.7

Source: Indian Council of Agricultural Research,
Link: http://www.indiastat.com/table/power/26/biomasbiogas19852012/452705/21926/data.aspx

STATE-WISE TARIFF FOR BIOMASS PROJECTS IN INDIA

States/UTs	Tariff fixed by the commissions for biomass power (₹/ kWh)
Andhra Pradesh	4.28
Bihar	4.17
Chhattisgarh	3.93
Gujarat	4.40 (with AD)
Haryana	4
Jharkhand	5.53 (Aircooled) & 5.31 (Water cooled with 3% escalation variable cost
Karnataka	3.66 for first 10 years & 4.13 from 10th year
Kerala	2.8 (escalation at 5% for 5 years)
Maharashtra	4.98
Madhya Pradesh	3.33 to 5.14 for 20 years
Odisha	4.87 with 3% escalation
Punjab	5.12 (escalation 5%)
Rajasthan	4.72 (water cooled) & 5.17 (air cooled)
Tamil Nadu	4.50 - 4.74
Uttarakhand	3.06
Uttar Pradesh	4.38 (escalated at 4 paise per year)
West Bengal	4.36 (for 10 years)

Source: Ministry of New & Renewable Energy

Waste-to-energy

COMPOSITION OF WASTE IN 59 CITIES IN INDIA

City	Compostables (%)	Recyclables (%)	Higher calorific value (Kcal/kg)	Moisture content (%)
Kavaratti	46.01	27.2	2242	25
Gangtok	46.52	16.48	1234	44
Itanagar	52.02	20.57	3414	50
Daman	29.6	22.02	2588	53
Silvassa	71.67	13.97	1281	42
Panjim	61.75	17.44	2211	47
Kohima	57.48	22.67	2844	65
Port Blair	48.25	27.66	1474	63
Shillong	62.54	17.27	2736	63
Shimla	43.2	36.64	2572	60
Agartala	58.57	13.68	2427	60
Gandhinagar	34.3	13.2	698	24
Dhanbad	46.93	16.16	591	50
Pondicherry	49.96	24.29	1846	54
Imphal	60	18.51	3766	40
Aizwal	54.24	20.97	3766	43
Jammu	51.51	21.08	1782	40
Dehradun	51.37	19.58	2445	60
Asansol	50.33	14.21	1156	54
Kochi	57.34	19.36	591	50
Raipur	51.4	16.31	1273	29
Bhubaneswar	49.81	12.69	742	59
Thiruvananthapuram	72.96	14.36	2378	60
Chandigarh	57.18	10.91	1408	64
Guwahati	53.69	23.28	1519	61
Ranchi	51.49	9.86	1060	49
Vijaywada	59.43	17.4	1910	46
Srinagar	61.77	17.76	1264	61
Madurai	55.32	17.25	1813	46
Coimbatore	50.06	15.52	2381	54
Jabalpur	58.07	16.61	2051	35
Amritsar	65.02	13.94	1836	61
Rajkot	41.5	11.2	687	17
Allahabad	35.49	19.22	1180	18
Visakhapatnam	45.96	24.2	1602	53
Faridabad	42.06	23.31	1319	34
Meerut	54.54	10.96	1089	32
Nasik	39.52	25.11	2762	62
Varanasi	45.18	17.23	804	44
Jamshedpur	43.36	15.69	1009	48
Agra	46.38	15.79	520	28
Vadodara	47.43	14.5	1781	25
Patna	51.96	12.57	819	36
Ludhiana	49.8	19.32	2559	65
Bhopal	52.44	22.33	1421	43
Indore	48.97	12.57	1437	31
Nagpur	47.41	15.53	2632	41
Lucknow	47.41	15.53	1557	60
Jaipur	45.5	12.1	834	21
Surat	56.87	11.21	990	51
Pune	62.44	16.66	2531	63
Kanpur	47.52	11.93	1571	46
Ahmedabad	40.81	11.65	1180	32
Hyderabad	54.2	21.6	1969	46
Bangalore	51.84	22 43	2386	55
Chennai	41.34	16.34	2594	47
Kolkata	50.56	11.48	1201	46
Delhi	54.42	15.52	1802	49
Greater Mumbai	62.44	16.66	1786	54
Average	**51.30**	**17.10**	**1751.20**	**47**

Source: Report on Management of Municipal Solid Waste, Central Pollution Control Board, Link: http://www.cpcb.nic.in/divisionsofheadoffice/pcp/management_solidwaste.pdf

POTENTIAL OF WASTE-TO-ENERGY GENERATION

City	MSW generated (TPD)	Calorific value (MJ/kg)	Power potential (MW)
Greater Kolkata	11,520	5	129.9
Greater Mumbai	11,124	7.5	186.6
Delhi	11,040	7.5	186.8
Chennai	6,118	10.9	149
Greater Hyderabad	4,923	8.2	91
Greater Bengaluru	3,344	10	74.9
Pune	2,602	10.6	61.8
Ahmedabad	2,518	4.9	27.9
Kanpur	1,756	6.6	25.9
Surat	1,734	4.1	16.1
Kochi	1,366	2.5	7.6
Jaipur	1,362	3.5	10.7
Coimbatore	1,253	10	28
Greater Visakhapatnam	1,194	6.7	18
Ludhiana	1,115	10.7	26.8
Agra	1,021	2.2	5
Patna	945	3.4	7.3
Bhopal	877	5.9	11.7
Indore	867	6	11.7
Allahabad	815	4.9	9
Meerut	804	4.6	8.2
Nagpur	801	11	19.8
Lucknow	743	6.5	10.9
Srinagar	713	5.3	8.5
Asansol	706	4.8	7.7
Varanasi	706	3.4	5.3
Vijayawada	688	8	12.3
Amritsar	679	7.7	11.7
Faridabad	667	5.5	8.3
Dhanbad	625	2.5	3.5
Vadodara	606	7.5	10.1
Madurai	543	7.6	9.2
Jammu	534	7.5	8.9
Jamshedpur	515	4.2	4.9
Chandigarh	486	5.9	6.4
Pondicherry	449	7.7	7.8
Jabalpur	380	8.6	7.3
Bhubaneswar	356	3.1	2.5
Nashik	329	11.6	8.5
Ranchi	325	4.4	3.2
Rajkot	317	2.9	2
Raipur	316	5.3	3.8
Thiruvananthapuram	308	10	6.9
Dehradun	247	10.2	5.7
Guwahati	246	6.4	3.5
Shillong	137	11.5	3.5
Agartala	114	10.2	2.6
Port Blair	114	6.2	1.6
Aizwal	86	15.8	3
Panaji	81	9.3	1.7
Imphal	72	15.8	2.5
Gandhinagar	65	2.9	0.4
Shimla	59	10.8	1.4
Daman	23	10.8	0.6
Kohima	20	11.9	0.5
Gangtok	19	5.2	0.2
Itanagar	18	14.3	0.6
Silvassa	11	5.4	0.1
Kavaratti	5	9.4	0.1
Total	**81,407**		**1,292**

Source: RK Annepu, Sustainable solid waste management in India, Columbia University, New York, January 2012; Link: http://www.seas.columbia.edu/earth/wtert/sofos/Sustainable%20Solid%20Waste%20Management%20in%20India_Final.pdf

CURRENT STATUS OF SELECT SOLID WASTE-TO-ENERGY PROJECTS

Project developer	Type of project	Location	Capacity (MW)	Year of commissioning	Grid connection	Current status *
Sriram Energy Systems ltd	Power generation from MSW	Vijayawada, Andhra Pradesh	6	2003 - 04	On-grid	Shut down technical fault with engine
Vijayawad Municipal Corporation with Sriram Energy Systems	Power generation from vegetable market wastes, sewage sludge and slaughter house wastes	Vijayawada, Andhra Pradesh	0.15	2004 - 05	Off-grid	Shut down technical fault due to low calorific value of feedstock
SLT Power & Infrastructure Projects	Power generation based on poultry litter	Nalgonda, Andhra Pradesh	3.5	2007 - 08	On-grid	Working
Raus Power	Power generation based on poultry litter	East Godavari, Andhra Pradesh	3.66	2008 - 09	On-grid	Working
Shravana Power Projects	Power generation based on poultry litter	Ranga reddy, Andhra Pradesh	7.5	2010 - 11	On-grid	Working
Surat Municipal Corporation	Power generation at sewage treatment plant	Surat, Gujarat	0.5	2003 - 04	Off-grid	Working
Surat Municipal Corporation	Power generation at three sewage treatment plants	Surat, Gujarat	3	2007 - 08	Off-grid	Not Working
Jain irrigation systems ltd	Power generation from vegetable market wastes	Jalgaon, Maharashtra	3	2009 - 10	On-grid	Working
Ramky Enviro Engineers	Power generation from cattle dung	Ludhiana, Punjab	1	2004 - 05	On-grid	Working
GK Bioenergy	Power generation from poultry litter	Namakkal, Tamil Nadu	1.5	2005-06	On-grid	Working
Subhashri Bio Energies Private Limited	Power generation from poultry litter	Thiruchengode, Tamil Nadu	2.5	2006-07	On-grid	Not yet setup
Ramky Enviro Engineers with Chennai Muncipal Development Authority	Power generation from vegetable market wastes	Chennai, Tamil Nadu	0.25	2005-06	Off-grid	Shut down inconsistent feedstock quality
Asia Bio-Energy Ltd	Power generation from MSW	Lucknow, Uttar Pradesh	5	2003-04	Off-grid	Shut down Insufficient feedstock
Jindal urban & infrastructure ltd	Power generation from MSW	Okhla, New Delhi	16	2011-12	On-grid	Working

** Based on telephonic conversations with developers by CSE researchers*
Source: Ministry of New & Renewable Energy

SANCTIONED MSW PROJECTS UNDER MNRE

Project developer	Project location	Capacity (MW)	Technology	Project cost (₹ in crores)
M/s East Delhi Waste processing Company (P) Ltd., New Delhi (Promoted by DIAL, IL&FS Energy Dev. Co. Ltd. (IEDCL) and SELCO International Ltd.)	Gazipur, Delhi	12	Combustion	155.42
M/s Srinivasa Gayatri Resource Recovery Limited	Village Mandur, Bangalore	8	Combustion	70.33
M/s. RDF Power Projects Ltd.	Chinnaravulapally village, Bibinagar Madal in Nalgonda District, A. P.	11	Combustion	114.11
M/s. Delhi MSW Solutions Ltd. (promoted by Ramky Enviro Engineers Ltd.,Hyderabad)	Bawana, Delhi	24	Combustion	268.27
M/s. Rochem Separation Systems (India)	Pune	10	Gasification	90
M/s. Solapur Bio-Energy Systems Pvt.	Solapur	3	Biomethanation	40.89

Source: Press Information Bureau,
Link: http://pib.nic.in/newsite/PrintRelease.aspx?relid=94202

Decentralised renewables

COMPLETE STATUS OF REMOTE VILLAGE ELECTRIFICATION PROGRAMME

State	No. of villages and hamlets sanctioned	No. of villages and hamlets reported to be completed	Central Financial Assistance Released (₹ In lakhs)
Arunachal Pradesh	298	297	1,584.08
Andhra Pradesh	13	13	1,46.97
Assam	2,192	1,883	11,580.1
Chhattisgarh	682	568	3,435.97
Delhi*	0		24.96
Goa	19	19	10.24
Gujarat	38	38	88.88
Haryana	286	286	276.42
Himachal Pradesh	22	21	251.88
Jammu & Kashmir	471	349	7,819.99
Jharkhand	720	493	6,877.2
Karnataka	79	30	174.98
Kerala	607	607	340.65
Madhya Pradesh	623	515	3,465.16
Maharashtra	353	340	3,629.7
Manipur	240	240	2,329.19
Meghalaya	163	149	863.85
Mizoram	20	20	144.75
Nagaland	11	11	100.817
Orissa	1,743	950	5,788.85
Rajasthan	430	382	2,811.46
Sikkim	13	13	16.64
Tamil Nadu	184	131	433.76
Tripura	1,029	842	4,989.38
Uttarakhand	818	594	2,414.34
Uttar Pradesh	507	184	3,808.86
West Bengal	1,210	1,179	8,075.5
Total	12,771	10,154	71,484.577

Source: Ministry of New & Renewable Energy,
Link: http://www.mnre.gov.in/schemes/offgrid/remote-village-electrification/

IMPLEMENTATION OF NATIONAL BIOGAS AND MANURE MANAGEMENT PROGRAMME (NBMMP) FOR FAMILY TYPE BIOGAS PLANTS (in No.)

States/UTs	2007-08		2008-09		2009-10	
	Target	Achievement	Target	Achievement	Target	Achievement
Andhra Pradesh	18000	10725	18000	10825	13699	18000
Arunachal Pradesh	150	200	150	250	162	200
Assam	2550	3700	3000	7500	10450	5000
Bihar	100	182	200	200	200	300
Chhattisgarh	1500	2100	3000	3118	3433	3700
Goa	75	21	50	34	31	50
Gujarat	8000	8301	8000	5842	10556	10000
Haryana	1000	1048	1500	1347	1422	2000
Himachal Pradesh	150	179	150	246	245	300
Jammu & Kashmir	110	50	50	72	155	1000
Jharkhand	200	536	500	824	1030	1000
Karnataka	4000	3933	10000	7822	10323	16000
Kerala	4500	3044	3000	5151	4085	3500
Madhya Pradesh	15000	7642	16000	14077	15114	16000
Maharashtra	13000	18635	15000	15461	11235	8000
Manipur	100	-	100	-	-	50
Meghalaya	200	525	300	725	825	600
Mizoram	100	100	200	100	50	200
Nagaland	200	231	200	425	605	500
Odisha	4000	3895	4000	2332	5296	7000
Punjab	1500	4573	8000	9695	7250	16000
Rajasthan	25	90	100	92	176	100
Sikkim	200	372	200	447	555	240
Tamilnadu	1500	1773	1500	1761	1740	1500
Tripura	300	38	200	159	47	100
Uttar Pradesh	4000	3946	3000	2019	3252	4500
Uttarakhand	400	825	500	1104	1225	900
West Bengal	8500	12175	11000	16300	16748	15000
Delhi/ New Delhi	-	1	-	1	-	-
Puducherry	100	-	100	-	5	50
KVIC	15000	NA	16000	NA	NA	19000
Total	**104460**	**88840**	**124000**	**107929**	**119914**	**150790**

Source: Ministry of New & Renewable Energy, indiastat.com

IMPLEMENTATION OF NATIONAL BIOGAS AND MANURE MANAGEMENT PROGRAMME (NBMMP) FOR FAMILY TYPE BIOGAS PLANTS (in No.)

States/UTs	2010-11		2011-12		2012-13		
	Target	Achievement	Target	Achievement	Target	Achievement (upto January 2013)	Estimated funds for the year (₹ in crores)
Andhra Pradesh	18000	16275	16000	15346	10488	12000	12
Arunachal Pradesh	200	175	100	150	14	100	0.167
Assam	5000	6732	4900	6581	4335	6000	10.02
Bihar	300	350	1000	3285	-	-	-
Chhattisgarh	3700	3832	4000	4779	1254	4000	4
Goa	50	18	50	65	21	100	0.1
Gujarat	10000	6105	7000	2631	2482	5000	5
Haryana	2000	1379	1700	1819	929	1500	1.5
Himachal Pradesh	300	445	500	426	243	300	0.3
Jammu & Kashmir	1000	114	200	136	193	200	0.2
Jharkhand	1000	913	500	750	150	500	0.5
Karnataka	16000	14464	13000	12363	8778	12000	12
Kerala	3500	3941	2600	3483	2047	2500	2.5
Madhya Pradesh	16000	16742	14000	12415	6584	12000	12
Maharashtra	8000	21456	13000	22220	9262	12000	12
Manipur	50	-	50	-			
Meghalaya	600	1275	1000	1390	170	500	0.835
Mizoram	200	100	200	100	461	1000	1.67
Nagaland	500	1171	1000	1325	396	500	0.835
Odisha	7000	6050	7000	7186	2828	7000	7
Punjab	16000	23700	18000	14173	6735	10000	10
Rajasthan	100	275	500	498	73	500	0.5
Sikkim	240	358	200	635	136	200	0.33
Tamilnadu	1500	1493	1000	1531	391	1000	1
Tripura	100	89	200	117	68	500	0.835
Uttar Pradesh	4500	4603	5000	4759	1282	2500	2.5
Uttarakhand	900	2082	2000	2114	687	1100	1.1
West Bengal	15000	17000	16000	19986	7135	12000	12
Delhi/ New Delhi	-	1	-	1	--		
Puducherry	50	-	100	-	--	--	--
KVIC	19000	NA	21000	NA	NA	NA	
Total	**150790**	**151138**	**151800**	**140264**	**77019**	**125000**	**133.576**

Source: Ministry of New & Renewable Energy, indiastat.com

SOLAR OFF-GRID AND DECENTRALISED APPLICATIONS UNDER PHASE 1 OF JAWAHARLAL NEHRU NATIONAL SOLAR MISSION (in No.)

State/UTs	Lanterns	Home lighting system	Street Lights	Water Pumps	Stand alone plants (kWp)
Andaman & Nicobar	6296	468	390	5	167
Andhra Pradesh	41360	8350	6454	613	871.595
Arunachal Pradesh	14433	18945	1071	18	17.1
Assam	1211	5890	98	45	910
Bihar	50117	6572	955	139	775.6
Chandigarh	1675	275	898	12	0
Chhattisgarh	3311	7254	2042	240	12186.72
Delhi	4807	0	301	90	332
Goa	1093	393	707	15	1.72
Gujarat	31603	9231	2004	85	374.6
Haryana	93853	56364	22018	469	864.25
Himachal Pradesh	23909	22586	8058	6	601.5
Jammu & Kashmir	44059	62133	5806	39	308.85
Jharkhand	23374	8658	620	0	480.9
Karnataka	7334	44439	2694	551	294.41
Kerala	54367	32995	1735	810	214.39
Lakshadweep	5289	0	1725	0	1090
Madhya Pradesh	9444	3590	9198	87	1983
Maharashtra	68683	3442	8420	239	913.7
Manipur	4787	3865	928	40	216
Meghalaya	24875	7840	1273	19	50.5
Mizoram	9589	6801	431	37	241
Nagaland	6766	1045	271	3	1050
Orissa	9882	5163	5834	56	84.515
Puducherry	1637	25	417	21	0
Punjab	17495	8620	5354	1857	281
Rajasthan	4716	124402	6852	4501	4013
Sikkim	23300	10059	504	0	150
Tamil Nadu	16818	7885	6350	829	609.77
Tripura	64282	32723	1199	151	365
Uttarakhand	64023	91326	8568	26	280.03
Uttar Pradesh	62015	206245	124828	575	3470.46
West Bengal	17662	140034	8726	48	889
Others	125797	24047	9150	0	8070
Total	**939862**	**961665**	**255879**	**11626**	**42157.61**

Source: Data portal of India
Link: http://data.gov.in/dataset/state-wise-cumulative-installation-spv-systems-upto-31st-march-2013

References

1. Grid-connected Solar

1. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision- 2/achievements/*
2. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision-2/achievements/*
3. Ankur Paliwal (May 2013), Sun block, Down to Earth *http://www.downtoearth.org.in/content/sun-block*
4. Anonymous, Down to Earth, http://www.downtoearth.org.in/node/40129 as accessed on January 14, 2014
5. Centre for Science and Environment (August 17, 2012), The US is using climate finance to kill the Indian solar panel industry: CSE, *http://www.cseindia.org/content/us-using-climate-finance-kill-indian-solar-panel-industry-cse* as accessed on February 4, 2014
6. Ministry of New and Renewable Energy (December 2012), Jawaharlal Nehru National Solar Mission Phase II – Policy Document, New Delhi
7. Solar Energy Centre of India (October 2013), Request For Selection (Rfs) Document for 750 MW Grid Connected Solar Photo Voltaic Projects Under JNNSM Phase II Batch-I, New Delhi
8. Ankur Paliwal & Abhinav Goyal (May 3, 2012), Solar mission phase II: viability gap funding not the best way to subsidise solar photovoltaic plants, say analysts, Down to Earth, *http://www.downtoearth.org.in/content/solar-mission-phase-ii-viability-gap-funding-not-best-way-subsidise- solar-photovoltaic-plant*, as accessed on June 21, 2013
9. Bridge to India (October 10, 2013), Weekly Update: Draft Guidelines for Batch One of Phase Two of The NSM Released, Serious Concerns Remain, http://bridgetoindia.com/blog/?p=1601, as accessed on June 21, 2013
10. Special Correspondent (November 11, 2013), More ultra mega solar plants on anvil, The Hindu, *http://www.thehindu.com/business/Industry/more-ultra-mega-solar-plants-on-anvil/article5339822.ece* as accessed on February 3, 2014
11. Sanjay Mehdudia (January 29, 2014), BHEL, 5 PSUs to set up 4,000 MW solar plant in Rajasthan, The Hindu, *http://www.thehindu.com/business/Industry/bhel-5-psus-to-set-up-4000-mw-solar-plant-in-rajasthan/article 5630430.ece* as accessed on February 3, 2014
12. Press Trust of India (November 11, 2013), Govt to roll out 4 solar ultra mega power projects; groundwork underway in Sambhar, Times of India, *http://timesofindia.indiatimes.com/home/environment/developmental-issues/Govt-to-roll-out-4-solar-ultra-mega-power-projects-groundwork-underway-in-Sambhar/articleshow /25600067.cms*, as accessed on February 4, 2014
13. Ben Willis, (February 10, 2014) India seeks World Bank loan to kick-start 4GW 'ultra mega' PV project, PV-Tech.org, *http://www.pv-tech.org/news/india_seeks_world_bank_loan_to_kick_start_4gw_ultra_mega_pv_project*, as accessed on February 11, 2014
14. Gujarat Energy Development Agency (March 2013), Solar Power Projects Installed, *http://geda.gujarat.gov.in/project_single.php?project=26* as seen on June 18, 2013
15. Gujarat Electricity Regulation Commission Petition (May 28, 2013), Tariff for procurement of power by the Distribution Licensees and others from Solar Energy Projects
16. Anonymous (August 19, 2013), GERC rejects GUVNL's petition seeking solar tariff cut, Business Standard, *http://www.business-standard.com/article/companies/gerc-rejects-guvnl-s-petition-seeking-solar-tariff-cut-113081901241_1.html* as accessed on October 19, 2013
17. DJ Pandian, India Solar Summit, April 21, 2012
18. Tamil Nadu Electricity Regulation Commission (August 2013), Consultative Paper on "Comprehensive Tariff Order on Solar Power", Chennai
19. Anonymous (December 11, 2013), Tamil Nadu to come up with solar power tariff soon, Business Standard, *http://www.business-standard.com/article/economy-policy/tamil-nadu-to-come-up-with-solar-power-tariff-soon-113121101119_1.html* as seen on February 5, 2014
20. Anonymous (July 2, 2011), SAIL, Jindal Steel threatened with fines for clean-power lapses, Live Mint, *http://www.livemint.com/Industry/1508QtZ1MfEOJ2FW6iakyN/SAIL-Jindal-Steel-threatened-with-fines-for-cleanpower-lap.html*, as accessed on July 3, 2013
21. Interview with B Bhargava, director, MNRE, Delhi, September 2011
22. Moser Baer has a line of Amorphous Silicon (A-Si) module production which counts as a thin-film technology
23. Council on Energy, Environment and Water & Natural Resources Defense Council (April 2012), Laying the Foundation for a Bright Future: Assessing Progress Under Phase 1 of India's National Solar Mission', *http://www.nrdc.org/international/india/national-solar-mission-ph1.asp*, New Delhi
24. Craig O'Connor (December 10, 2010), 'Financing Renewable Energy: The Role of Ex-Im Bank', presentation of US Ex-Im Bank at SolarCon Hyderabad
25. Interview with PNC bank representative (Ex-Im Bank's Indian partner) at SolarCon Hyderabad, December 10, 2010
26. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision-2/achievements/*
27. Raj Prabhu, Mercom Capital Group, Indian Solar Market Update – 2nd Quarter 2013, *http://mercomcapital.*

com/indian-solar-market-update-2nd-quarter-2013 as accessed on November 21, 2013

28. Deepto Roy (March 14, 2011), Project finance challenges for Indian solar power, MY Law, *http://www.mylaw.net/Article/Project_finance_challenges_for_Indian_solar_power/#.UdJlMjswdQM* as accessed on July 2, 2013

Box: SOLAR TECHNOLOGY

1. Ministry of New and Renewable Energy, Solar, *http://mnre.gov.in/schemes/grid-connected/solar/*
2. Prof Prabhu *et al*, Evaluating the Future of Indian Solar Industry, IIMB, *http://tejas.iimb.ac.in/articles/75.php* as accessed on December 3, 2013
3. IRACST (June 2013), Utilization of solar energy as an constituent of green energy anticipated for green environment in India, International Journal of Research in Management & Technology, ISSN: 2249-9563 Vol. 3, No.3
4. Gaëtan Masson et al (May 2013), Global Market Outlook – For Photovoltaics 2013-17, European Photovoltaic Industry Association

2. Wind Energy

1. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision-2/achievements/*
2. Global Wind Energy Council (February 2013), Global Wind Statistics 2012, Brussels, Belgium, *http://www.gwec.net/wp-content/uploads/2013/02/GWEC-PRstats-2012_english.pdf*
3. Centre for Wind Energy Technology, Estimation of Installable Wind Power Potential at 80 m level in India: The revised figure of 102,778 MW remains to be validated with real time data *http://www.cwet.tn.nic.in/html/departments_ewpp.html*
4. Centre for Wind Energy Technology, Wind Resource Assessment Unit, *http://www.cwet.tn.nic.in/html/departments_wra.html*
5. Amol Phadke et al, (2012), Reassessing Wind Potential Estimates for India: Economic and Policy Implications, Lawrence Berkeley National Lab, A U.S. Department of Energy National Laboratory Operated by the University of California, United States
6. The global annual installed wind capacity between 2009 and 2012 was about 40,000 MW. Global Wind Energy Council (February 2013), Global Wind Statistics 2012, Brussels, Belgium, *http://www.gwec.net/wp-content/uploads/2013/02/GWEC-PRstats-2012_english.pdf*
7. Indian Renewable Energy Development Agency, MNRE Scheme for Implementation of Generation Based Incentives (GBI) for Grid Interactive Wind Power Projects, New Delhi, *http://www.ireda.gov.in/forms/contentpage.aspx?lid=744*
8. Dr. Farooq Abdullah (January 9, 2014), Ministry of New and Renewable Energy, National Level Consultation on National Wind Energy Mission, New Delhi
9. India Wind Energy Outlook (2012), Generation Based Incentive, Page 15, *www.indianwindpower.com/pdf/GWEO_2012.pdf*
10. Special Correspondent (May 6, 2013), Call to implement generation-based incentive for wind energy, The Hindu, Chennai, *http://www.thehindu.com/news/national/tamil-nadu/call-to-implement-generationbased-incentive-for-wind-energy/article4689078.ece*
11. Ramesh M (August 3, 2013), Cabinet clears 'generation-based incentive' for wind power projects, The Hindu, Chennai, *http://www.thehindubusinessline.com/industry-and-economy/cabinet-clears-generationbased-incentive-for-wind-power-projects/article5019072.ece*
12. Kanchan Kumar Agarwal (February 21, 2013), Power utilities oppose hike in wind tariff price, Down to Earth , *http ://www.downtoearth.org.in/content/power-utilities-oppose-hike-wind-tariff-price*
13. Maharashtra Electricity Regulatory Commission (March 22, 2013), Determination of Generic Tariff for the fourth year of the first Control Period under Regulation 8 of the Maharashtra Electricity Regulatory Commission (Terms and Conditions for Determination of Renewable Energy Tariff) Regulations, 2010, Case No. 6 of 2013, Mumbai, *http://www.mercindia.org.in/pdf/Order%2058%2042/Order_6_of_2013_22_March_2013.pdf*
14. Alok Srivastava (January 9, 2014), National Wind Mission: Objectives & Scope, presentation of Ministry of New and Renewable Energy at National Level Consultation on National Wind Energy Mission, New Delhi *http://mnre.gov.in/file-manager/UserFiles/Presentations-NWM-09012014/Alok-Srivastava-JS-MNRE.pdf*
15. Centre for Wind Technology (October 10, 2013), Revised list of models and manufacturers of Wind Turbines – "Main List", Chennai, *http://www.cwet.tn.nic.in/Docu/RLMM_Main_List_dated_29.10.2013.pdf*

16 Anonymous (June 8, 2012), TANGEDCO official says wind turbine manufacturers cartelization driving up capital costs for projects, Panchbhutta, *http://panchabuta. com/2012/06/08/tangedco-official-says-wind-turbine-manufacturers-cartelization-driving-up-capital-costs-for-projects/*

17. Anonymous (June 15, 2012), Windmill makers in Tamil Nadu accused of opaque pricing, IBN Live, Chennai, *http://ibnlive.in.com/news/windmill-makers-in-tamil-nadu-accused-of-opaque-pricing/266165-62-128.html*
18. Energy Department, Government of Rajasthan (July 2012), Policy for promoting generation of electricity from wind – 2012, Jaipur, Rajasthan, *http://www.rrecl.com/PDF/Notification-Wind%20Policy,%202012.pdf*
19. Power Grid Corporation of India (July 2012), Report on Green Energy Corridors - Transmission Plan for Envisaged Renewable Capacity, Gurgaon, Haryana *http://indiaenvironmentportal.org.in/files/file/Report-Green%20Energy%20corridor.pdf*
20. Anonymous (January 9, 2014), Report on Green Energy Corridors - Transmission Plan for Envisaged Renewable Capacity, presentation of Ministry of New and Renewable Energy at National Wind Energy Mission, New Delhi, *http://mnre.gov.in/file-manager/UserFiles/presentation-01082012/Presentation%20on%20Green%20Energy%20Corridors%20by%20Y.K.Sehgal,%20Power%20Grid.pdf*

21. Venkatesan R Iyengar et al (October 2011), RePowering Wind Farms in India, RE Feature October 2011, Volume 5 Issue 2, *http://mnre.gov.in/file-manager/akshay-urja/ september-october-2011/EN/RePowering%20Wind %20Farms.pdf*
22. AnkurPaliwal (December 13, 2011), Killing ground, Down to Earth, *http://www.downtoearth. org.in/content/ killing-ground*
23. Anonymous (February 7, 2013), Find the Law Inconvenient? Exempt Yourself From It!, Campaign for Survival and Dignity, Forest Rights Act, New Delhi, *http://www.forestrightsact.com/statements-and-news/132-find-the-lawinconvenient-exempt-yourself-from-it*
24. Government of India (August 2011), Report of the Western Ghats Ecology Expert Panel Part I, Submitted to Ministry of Environment and Forests, *http://moef.nic.in/ downloads/public-information/wg-23052012.pdf*
25. Ministry of Forest and Environment (May 2004), Guidelines for diversion of forest land for non-forest purposes under the Forest (Conservation) Act,1980- For projects utilizing Wind Energy thereof, *http://mahafca.com/ pdf/Handbook-36.pdf*

Box: GOING OFFSHORE

1. Ministry of New and Renewable Energy (2013), Draft National Offshore Wind Energy Policy, New Delhi, *http://www.indiaenvironmentportal.org.in/files/file/draft -national-policy-for-offshore-wind.pdf*
2. Anonymous (August 14, 2013), Draft National Offshore Wind Energy Policy presentation of Ministry of New and Renewable Energy, New Delhi, *http://mnre.gov.in/file-manager/UserFiles/presentations-offshore-wind-14082013/JS-MNRE.pdf*
3. Anonymous (August 14, 2013), Draft National Offshore Wind Energy Policy presentation of Ministry of New and Renewable Energy, New Delhi, *http://mnre.gov.in/file-manager/UserFiles/presentations-offshore-wind-14082013/JS-MNRE.pdf*
4. Ken Silverstein (January 29, 2014), European Union Fanning Offshore Wind Energy in India, IEEE Spectrum, New York, United States of America, *http://spectrum. ieee.org/energywise/energy/renewables/european-union-fanning-offshore-wind-energy-in-india*

Box: THE INDIAN WIND POWER SECTOR'S CAPACITY UTILISATION FACTOR

1. Farooq Abdullah (January 9, 2014), Ministry of New and Renewable Energy, National Level Consultation on National Wind Energy Mission, New Delhi

3. Small Hydropower

1. Manoj Kumar Kesharwani (October 2006), Overview of Small Hydro Power Development in Himalayan Region, Himalayan Small Hydropower Summit, Dehradun
2. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision-2/achievements/*
3. Chandra Bhushan, Jonas Hamberg and Abhinav Goyal 2013, Green Norms for Green Energy: Small Hydro Power, Centre for Science and Environment, New Delhi
4. Anonymous (April 20, 2011), Bangalore High Court stalls 8 mini hydro power projects in Karnataka in Western Ghats, Panchbhutta,*http://panchabuta.com/2011/04/20/ bangalore-high-court-stalls-8-mini-hydro-power-projects-in-karnataka-in-western-ghats/* as accessed on February 4, 2014
5. Divya Gandhi (May 23, 2013), Mini-hydro projects still a major threat to Western Ghats, The Hindu, *http:// www.thehindu.com/news/national/karnataka/minihydro-projects-still-a-major-threat-to-western-ghats/article 4740215.ece*, as accessed on October 23, 2014
6. Ministry of Renewable and New Energy, Small Hydro Power, *http://mnre.gov.in/schemes/grid-connected/small-hydro/* as accessed on July 18, 2013
7. Ministry of Renewable and New Energy (December 2009), Small Hydro Power Programme for the Year 2009 and subsequent 11th 5-Year Plan, *http://mnre.gov.in/file-manager/grid-small-hydro/shp_scheme.pdf* as accessed on December 20, 2013
8. Ministry of New and Renewable Energy (September 2013), Developmental impacts and sustainable governance aspects of renewable energy projects, *http://mnre. gov.in/file-manager/UserFiles/report-on-developmental-impacts-of-RE.pdf* , New Delhi *as accessed* on January 27, 2014
9. The usage of three lean months seem to be standard; it is however not mentioned in the hydro power policy of the state: See clause xxxiv *http://ireda.gov.in/writereaddata/ compendium/HP/HPpercent20percent20SHPupper cent20toper cent205per cent20MW-03.pdf*
10. Chandra Bhushan, Jonas Hamberg and Abhinav Goyal 2013, Green Norms for Green Energy: Small Hydro Power, Centre for Science and Environment, New Delhi
11. Karnataka Renewable Energy Development Limited, New/ Under Process Small Hydro Projects, *http://kredlinfo.in/hydrostat.aspx* as accessed on December 11, 2013, Bangalore
12. Karnataka Electricity Regulatory Commission (December 11, 2009) Determination of Tariff in respect of Renewable Sources of Energy, Bangalore
13. Karnataka Renewable Energy Development Limited (December 2009), Karnataka Renewable Energy Policy 2009-14, Bangalore
14. Jay Mazoomdaar (May 18, 2013), Karnataka Sets An Example, Tehelka, *http://www.tehelka.com/karnataka-sets-an-example/* as accessed on December 21, 2013
15. Government of Uttarakhand (2008) Policy for harnessing renewable energy sources in Uttarakhand with private sector/community participation, Dehradun
16. Press Trust of India (December 12, 2013), J&K govt floats RFQ for setting up of 23 mini hydro power projects, The Economics Times , *http://articles.economictimes.indiatimes.com/2013-12-12/news/45123354_1_jk-govt-rfq-kashmir-energy-development-agency* as accessed on December 27, 2013

17. Jammu and Kashmir Energy Development Agency, Energizing the State by Hydro Power, Policy for Development of Micro/Mini Hydro Power Projects-2011, Srinagar
18. Press Information Bureau (January 2008), Key Features of the Prime Minister's Speech at Itanagar & Major Announcements, *http://www.pib.nic.in/newsite/ere-lease.aspx?relid=35068*
19. Central Electricity Regulator Commission (February 2013), Renewable Energy Tariff Regulations FY 2013-14, New Delhi
20. World Bank (2010), Unleashing the Potential of Renewable Energy in India, New Delhi
21. Frankfurt School of Finance & Management, UNEP and Bloomberg New Energy Finance (2013), Global Trends in Renewable Energy Investment 2013, *http://www.fs-unep-centre.org*
22. Interviews conducted by the CSE researcher - Jonas Hamberg
23. S.D.B. Taylor et al (2005), Sustainable markets for small hydro in developing countries, IT Power, UK
24. Dr P. Saxena (October 2006), Overview of Small Hydro Power Development in India, Himalayan Small Hydropower Summit, Dehradun
25. Reserve Bank of India, Clauses 2.1.1 –Ceilings, Master Circular – Exposure Norms, Reserve Bank of India, *http://www.rbi.org.in/scripts/BS_ViewMasCirculardetails.aspx?id=8130#a8* as visited on December 27, 2013
26. Kapil Kalra (October 2013), Small Hydro Power Development: Promise and Potential; Risks and Challenges of L&T Infrastructure Finance Company at Le Meridien Hotel, New Delhi
27. Central Electricity Regulator Commission (February 2013), Renewable Energy Tariff Regulations FY 2013-14, New Delhi
28. Indian Energy Exchange, REC Market Data, *http://www.iexindia.com/marketdata/recdata.aspx*, as accessed on December 10, 2013
29. Renewable Energy Certificate Registry of India (December 2013), RE Source & Unit wise break up (10-12-2013), , *https://www.recregistryindia.nic.in/index.php/general/publics/Rec_Source_Wise_Breakup* as accessed on December 10, 2013
30. Point Carbon, *http://www.pointcarbon.com/* as accessed on December 10, 2013
31. SHP Projects, UNFCCC, *http://cdm.unfccc.int/Projects/projsearch.html* as accessed on December 10, 2013
32. Ministry of Renewable and New Energy, Small Hydro Power, MNRE further classifies plants up to 100 kW as 'micro-hydro' and plants between 100 kW and 2 MW as 'mini-hydro', *http://www.mnre.gov.in/schemes/grid- connected/small-hydro/* as accessed on April 2, 2013
33. Chandra Bhushan, Jonas Hamberg and Abhinav Goyal 2013, Green Norms for Green Energy: Small Hydro Power, Centre for Science and Environment, New Delhi
34. Government of India (March 2013), Report of the Inter-Ministerial Group on Issues Relating to River Ganga, New Delhi
35. Government of India (March 2013), Report of the Inter-Ministerial Group on Issues Relating to River Ganga, New Delhi
36. T Abbasi and S A Abbasi (2011), Small hydro and the environmental implications of its extensive utilization, Renewable and Sustainable Energy Reviews, Puducherry
37. Site visits by CSE researcher in Uttarakhand, January 2013

Box: SHP AND RURAL ELECTRIFICATION

1. James Cust et al(2007), Rural Electrification in India: Economic and Institutional aspects of Renewables
2. Dipti Vaghela (October 2006), Powering dignity - mantra and micro hydro, Himalayan Small Hydropower Summit, Dehradun
3. Dr P. Saxena (October 2006), Overview of Small Hydro Power Development in India, Himalayan Small Hydropower Summit, Dehradun
4. Ministry of New and Renewable Energy and United Nations Development Programme for India (2012), Empowering Rural India the RE Way – Inspiring Success Stories, New Delhi

4. Biomass Power

1. Ministry of New and Renewable Energy (2011), Annual Report of the Ministry of New & Renewable Energy 2010-2011, New Delhi
2. Ministry of New and Renewable Energy (2011), Renewable Energy Booklet, New Delhi
3. Ministry of Statistics and Programme Implementation (2013), Energy Statistics 2013 (Twentieth Issue), Central Statistics Office, New Delhi
4. Tasneem Abbasi and S.A Abbasi (November 2009), Biomass energy and the environmental impacts associated with its production and utilization, Renewable and Sustainable Energy Reviews, Puducherry
5. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision-2/achievements/*
6. Bioenergy India Issue 9& 10 (July – September 2011 & October – December 2011), Ministry of New and Renewable Energy, New Delhi
7. Planning Commission (2012), Draft Twelfth Five Year Plan 2012 – 2017, Economic Sectors, Volume II, New Delhi
8. Ankur Paliwal (September 30, 2012), A looming biomess, Down to Earth *http://www.downtoearth.org.in/content/looming-biomess*
9. Dalkia Energy Services Ltd (March 2011), Biomass fuel supply study in the state of Rajasthan, Rajasthan Renewable Energy Corporation Ltd., *http://www.rrecl.com/PDF/Biomass%20Fuel%20Assesment%20Report%20_main%20Report.pdf*
10. Ministry of New & Renewable Energy (2010), Scheme for Implementation of Grid interactive Biomass Power and Bagasse Cogeneration Projects during 2010 - 11 and remaining period of the 11th Five Year Plan, *http://mnre.gov.in/file-manager/grid-biomass/grid-ipgp.pdf* as accessed on February 14, 2014

11. Ministry of New & Renewable Energy (January 2014), Continuation of Biomass Gasifier programme from 11th plan to 12th plan period, *http://mnre.gov.in/file-manager/offgrid-biomass-gas-schemes/biomassgasifier-prohramme-for-12th-five-year-plan.pdf* as accessed on February 14, 2014
12. Ministry of Environment and Forests, http://moef.gov.in/citizen/specinfo/emp.html as accessed on February 15, 2014
13. Ministry of Environment & Forests (November 2009), The Gazette of India, New Delhi
14. Kumar Sambhav Shrivastava (November 28, 2011), Raipur's clean power plants using coal on the sly, Down to Earth *http://www.downtoearth.org.in/content/raipurs-clean-power-plants-using-coal-sly* as accessed on February 18, 2014
15. Ministry of Environment & Forests (December 2009), Amendment, EIA Notification 2006, The Gazette of India, New Delhi

Box: NATIONAL BIOENERGY MISSION

1. Ministry of New and Renewable Energy and United Nations Development Programme for India (December 2011), Bio-energy Road Map, an initiative by MNRE, New Delhi

Box: ISSUES WITH PLANTATION

1. Ministry of New and Renewable Energy (2012), Annual Report of the Ministry of New & Renewable Energy 2011-2012, New Delhi
2. Ministry of New and Renewable Energy (2012), Annual Report of the Ministry of New & Renewable Energy 2011-2012, Chapter 5, *http://mnre.gov.in/file-manager/annual-report/2011-2012/EN/Chapter%205/chapter_5.htm* as accessed April 24, 2013
3. Assuming that biomass plant is operating at 80% plant load factor and solar plant is operating at 20% plant load factor. Also assuming that 1 MW solar installation requires 2.5 ha land.
4. Clenergen, Energy Crop Plantations, *http://www.clenergen.com/clenergen-india/energy-crop-plantations* as accessed April 22, 2013
5. International Institute for Environment and Development (August 2011), Biomass energy: Another driver of land acquisitions? , London, United Kingdom
6. Sharachchandra Lee et al (December 2010), Jatropha plantations for biodiesel in Tamil Nadu, India: Viability, livelihood trade-offs, and latent conflict, Ecological Economics

5. Waste-to-Energy

1. Hoornweg, Daniel et al (July 2012), What A Waste: A Global Review of Solid Waste Management, The World Bank, *http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/07/25/000333037_20120725004131/Rendered/PDF/681350WP0REVIS0at0a0Waste20120Final.pdf*
2. Asit Nema (February 2013), Technological and systemic challenges in municipal solid waste treatment and policy options for sustainable development in the sector, Foundation for Greentech environmental systems, New Delhi
3. Ministry of New and Renewable Energy (2012), Annual Report of the Ministry of New & Renewable Energy 2011-2012, New Delhi
4. Jayshree Nandi (January 14, 2014), Delhi Pollution Control Committee hands showcause notice to Okhla Plant, Times of India, New Delhi *http://timesofindia.indiatimes.com/home/environment/pollution/Delhi-Pollution-Control-Committee-hands-showcause-notice-to-Okhla-plant/articleshow/28724711.cms*
5. Kurian Joseph (2007), Lessons from Municipal Solid Waste processing initiatives in India, International Symposium , MBT, *http://www.swlf.ait.ac.th/UpdData/ International/LESSONS%20FROM%20msw.pdf*
6. P.U. Asnani, Solid Waste Management, Indian Institute of Technology, Kanpur, *http://www.iitk.ac.in/3inetwork/html/reports/IIR2006/Solid_Waste.pdf*
7. Central Pollution Control Board (2006), Waste generation and composition, *http://www.cpcb.nic.in/wast/municipal-wast/Waste_generation_Composition.pdf* as accessed on December 15,2013
8. RK Annepu (January 2012), Sustainable solid waste management in India, Waste to Energy Research and Technology Council (WTERT) Columbia University, New York, United States of America, *http://www.seas.columbia.edu/earth/wtert/sofos/Sustainable%20Solid%20Waste%20Management%20in%20India_Final.pdf*
9. Asit Nema (February 2013), Technological and systemic challenges in municipal solid waste treatment and policy options for sustainable development in the sector, Foundation for Greentech environmental systems, New Delhi
10. Sanjay Gupta (February 2013), Solid waste generation in India – myths and realities, International Conference on Waste, Wealth and Health Organised by IIWM, Vigyan Bharati & MPCST, Bhopal
11. Ministry of New & Renewable Energy (2012), Programme on Energy from Urban, Industrial and Agricultural Wastes /Residues during 12th Plan period, New Delhi, *http://mnre.gov.in/file-manager/offgrid-wastetoenergy/ programme_energy-urban-industrial-agriculture-wastes-2013-14.pdf*
12. Ministry of New & Renewable Energy (2012), Programme on Energy from Urban, Industrial and Agricultural Wastes /Residues during 12th Plan period, New Delhi, *http://mnre.gov.in/file-manager/offgrid-wastetoenergy/ programme_energy-urban-industrial-agriculture-wastes-2013-14.pdf*
13. Delhi Electricity Regulatory Commission (January 20, 2011), Petition for adoption of Tariff and approval of energy purchase entered between Timarpur Okhla Waste Management Company Private Limited and BSES Rajdhani Power Limited, for purchase of 16 MW of power

by BSES on Long-term basis from power station to be set up at Okhla, New Delhi – Petition No.18/2010, *http://www.derc.gov.in/ordersPetitions/orders/Misc/2010/TOWMCL.pdf*

14. Waste Processing Company Private Limited (December 2006), Environmental Impact Assessment of Integrated Municipal Solid Waste Processing Facility in Okhla, New Delhi, Submitted to Delhi Pollution Control Committee
15. Waste Processing Company Private Limited (January 2008), Environmental Impact Assessment of Integrated Municipal Solid Waste Processing Complex in Ghazipur, Delhi, Submitted to Delhi Pollution Control Committee, East Delhi
16. Anonymous (October 24, 2011), Waste Pickers Protest CDM Incinerator in Delhi, Global Alliance for Incinerator Alternatives, *http://www.no-burn.org/-1-9*

Box: TIPPING FEE IN US AND SWEDEN

1. Matt Williams (December 2011), Waste-to-energy success factors in Sweden and the United States, http://www.acore.org/wp-content/uploads/2012/04/WTE-in-Sweden-and-the-US-Matt-Williams..pdf
2. Matt Williams (December 2011), Waste-to-energy success factors in Sweden and the United States, http://www.acore.org/wp-content/uploads/2012/04/WTE-in-Sweden-and-the-US-Matt-Williams..pdf
3. Solid Waste Association of North America, Waste-to-Energy Facilities Provide Significant Economic Benefits, Silver Spring, Maryland, United States of America *http://swana.org/portals/Press_Releases/Economic_Benefits_WTE_WP.pdf*
4. Anonymous (2013), Landfill tipping fees in USA in 2013, Green Power Inc, *http://www. cleanenergyprojects.com/Landfill-Tipping-Fees-in-USA-2013.html*
5. European Environment Agency (March 5, 2013), Typical charge (gate fee and landfill tax) for legal landfilling of non-hazardous municipal waste in EU Member States and regions, *http://www.eea.europa.eu/data-and-maps/ figures/typical-charge-gate-fee-and*

Box: RELUCTANT MUNICIPALITIES AND POLLUTION CONTROL BOARDS

1. Government of India (2000), Municipal Solid Waste (Management and Handling) Rules, New Delhi
2. Sunil Kumar, Akolkar et al (July 2008), Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: An Insight, Central Pollution Control Board and National Environmental Engineering Research Institute, New Delhi
3. Ministry of Environment & Forests (March 2010), Report of the Committee to Evolve Road Map on Management of Wastes in India, New Delhi
4. Ministry of Environment & Forests (March 2010), Report of the Committee to Evolve Road Map on Management of Wastes in India, New Delhi

6. Decentralised Renewables

1. Rajiv Gandhi Grameen Vidyutikaran Yojana, Physical and Financial progress of RGGVY, status as on 15.12.2013, *http://rggvy.gov.in/rggvy/rggvyportal/plgsheet_frame3*.jsp as accessed on 28th December 2013
2. Census of India, 2001 and 2011, New Delhi, *http://censusindia.gov.in/*
3. Planning Commmission, Power & Energy, New Delhi *http://planningcommission.nic.in/sectors/index.php?sectors=energy*
4. Rajiv Gandhi Grameen Vidyutikaran Yojana, Physical & Financial Progress of RGGVY Projects Under Implementatio (State-wise), *http://rggvy.gov.in/rggvy/rggvyportal/plgsheet_frame3.jsp* as accessed on February 14, 2014
5. Census of India, 2011, New Delhi, *http://censusindia.gov.in/*
6. V Modi (2005), Improving Electricity Services in Rural India, Working Papers Series No 30, Page 20, Center on Globalization and Sustainable Development, Columbia University, New York, USA
7. Rajiv Gandhi Grameen Vidyutikaran Yojana, Launch of the scheme in the 10th plan, *http://rggvy.gov.in/rggvy/rggvyportal/index.html* as accessed on February 14, 2014
8. Rajiv Gandhi Grameen Vidyutikaran Yojana, RGGVY Scheme of Rural Electricity Infrastructure and Household Electrification, *http://rggvy.gov.in/rggvy/rggvyportal/office_memo_mar05.htm* as accessed on February 14, 2014
9. Rajiv Gandhi Grameen Vidyutikaran Yojana, Physical & Financial Progress of RGGVY Projects Under Implementation (State-wise), *http://rggvy.gov.in/rggvy/rggvyportal/plgsheet_frame3.jsp* as accessed on February 20, 2014
10. Anonymous (April 2011), Rajiv Gandhi Grameen Vidyutikaran Yojana Social Survey Report, Madhubani District, Bihar, Greenpeace India and Sakhi
11. Note: A major difference between the DDG programme and RVEP is that, the latter would cover hamlets and remote villages with less than a hundred households too.
12. Maharashtra Energy Development Agency, Rural Village Electrification, *http://www.mahaurja.com/RE_RVE_Program.htm* as accessed on February 20, 2014
13. Ministry of New and Renewable Energy (January 2014), Achievements, *http://www.mnre.gov.in/mission-and-vision-2/achievements/*
14. Chandra Bhushan and Joel Kumar (2012), Going Remote: Re-inventing the off-grid solar revolution for clean energy for all, Centre for Science & Environment, New Delhi
15. Ministry of New & Renewable Energy (March 2012), Draft scheme of the village lighting programme, New Delhi
16. Veena Sinha (August 13, 2013), 'Energy Access Programme', presentation of Ministry of New & Renewable Energy at Conference on Scaling up mini-grids for rural electrification, Centre for Science & Environment, Raipur, Chhattisgarh

17. Ministry of Power (August 23, 2006), Rural Electrification Policy, New Delhi, *http://powermin.nic.in/whats_new/pdf/RE%20Policy.pdf*
18. Rural Electrification Corporation of India (April 1, 2013), Guidelines for village electrification through Decentralised Distributed Generation under RGGVY in the XI plan, Annexure to order no. 44/01/2007-RE dated 1st April 2013, *http://www.recindia.nic.in/download/Amend_DDG_Guidelines_010413.pdf*
19. Minister of New & Renewable Energy (November 30, 2012), Remote Village Electrification Programme, Press Release, *http://pib.nic.in/newsite/PrintRelease.aspx?relid=89777*
20. Rural Electrification Corporation of India (January 2014), DDG: Status of Sanctioned Projects, *http://www.recindia.nic.in/download/DDG_MIS%2031.01.2014%20.pdf*
21. Chandra Bhushan and Joel Kumar, 2012, Going Remote: Re-inventing the off-grid solar revolution for clean energy for all, Centre for Science & Environment, New Delhi
22. Ministry of New & Renewable Energy (March 2012), Draft scheme of the village lighting programme, New Delhi
23. Veena Sinha (August 13, 2013), 'Energy Access Programme', presentation of Ministry of New & Renewable Energy at Conference on Scaling up mini-grids for rural electrification, Centre for Science & Environment, Raipur, Chhattisgarh
24. Ministry of New and Renewable Energy (March 2012), Draft Programme for Providing Basic Lighting Facilities in Remote Unelectrified Census Villages and Unelectrified Hamlets of Electrified Census Villages through Renewable Energy Sources, New Delhi
25. Veena Sinha (August 13, 2013), 'Energy Access Programme', presentation of Ministry of New & Renewable Energy at Conference on Scaling up mini-grids for rural electrification, Centre for Science & Environment, Raipur, Chhattisgarh
26. Ministry of New and Renewable Energy (December 2012), Jawaharlal Nehru National Solar Mission Phase II – Policy Document, New Delhi
27. Rajiv Gandhi Grameen Vidyutikaran Yojana, Definition of Electrified Village *http://rggvy.gov.in/rggvy/ rggvyportal/index.html* as accessed on February 20, 2014
28. Central Electricity Authority (January 2014), Power Supply Position (Provisional), New Delhi *http://www.cea.nic.in/reports/monthly/gm_div_rep/power_supply_position_rep/energy/Energy_2014_01.pdf* as accessed on February 20, 2014
29. Central Electricity Authority (January 2014), Peak Demand and Peak Met (Provisional), New Delhi, *http://www.cea.nic.in/reports/monthly/gm_div_rep/power_supply_position_rep/peak/Peak_2014_01.pdf* as accessed on February 20, 2014

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Ph: 91-11- 40616000 **Fax:** 91-11-2995 5879
E-mail: cse@cseindia.org **Website:** www.cseindia.org

ISBN: 978-81-86906-75-0 **Price:** ₹690