Kurukshetra

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RENEWABLE ENERGY TOWARDS BETTER FUTURE...

GRAMODAY SE BHARAT UDAY ABHIYAN

Prime Minister Shri Narendra Modi speaking at the launch of the "Gramoday se Bharat Uday" Abhiyan in Mhow

"Gramoday Se Bharat Uday" Abhiyan, a nationwide campaign on rural development and social harmony, was launched by the Prime Minister from Dr. Ambedkar's birth place Mhow in Madhya Pradesh on 14th April, 2016. The eleven day programme to commemorate the 125th Birth anniversary of Bharat Ratna Dr. Bhimrao Ambedkar, ended on 24th April 2016, which was National Panchayati Raj Day.

The aim of this campaign is to make nationwide efforts to strengthen Panchayati Raj and through it, boost the social harmony in the villages, promote rural development and foster farmers' welfare & livelihood of the poor.

In his inaugural speech, the Prime Minister recalled that Dr. Ambedkar had fought against injustice in society and his was a fight for equality and dignity.

During the *"Gramoday Se Bharat Uday"* Abhiyan, following programmes were held across the country:

a) **Social Harmony Programme :** In this villagers in Gram Panchayats paid homage to Dr. Ambedkar and resolved to strengthen social harmony in their villages. Dr. Ambedkar's life and his views about national unity were discussed, and literature regarding Dr. Ambedkar was distributed.

b) **Gram Kisan Sabha:** Meetings of farmers were organized in Gram Panchayats. Information regarding schemes in the agriculture sector such as the *Fasal Bima Yojna,* Social Health Card etc, was provided to the farmers and suggestions to improve agriculture were invited from them.

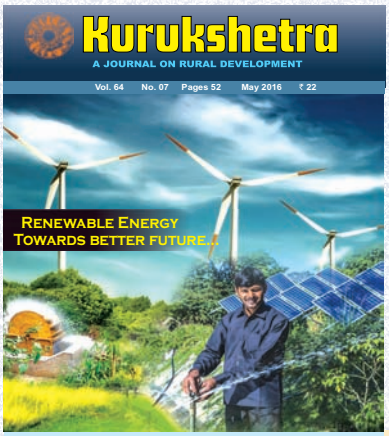
c) Other initiatives such as-*Prabhat Pheri,* Clean Drinking Water and Sanitation Campaign, Cultural Programmes and Sports competitions were organized.

d) Gram Sabhas were held in Village Panchayats to discuss following activities-

❖ Gram Panchayat Development Plan for local economic development ❖ Proper utilization of funds by Panchayats ❖ Safe drinking water and sanitation ❖ The role of women in rural development ❖ Social inclusion including welfare of Scheduled Castes, Scheduled Tribes, Persons with Disabilities and other marginalised groups.

e) **National Meeting of Tribal Women Sarpanches:** was convened on the "Role of the Women Gram Panchayat Presidents in Development of Fifth Schedule Areas". In the meeting, Sarpanches from Fifth Schedule areas of 10 states participated.

f) On the final day of the programme, Conference of Panchayat Representatives was organized at Jamshedpur in which Panchayat representatives from all over the India took part.



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VINOD KUMAR MEENA

COVER DESIGN
ASHA SAXENA

EDITORIAL OFFICE
ROOM NO. 686,
Publications Division,
Soochna Bhawan,
C.G.O. Complex, Lodhi Road,
NEW DELHI-110003
Phone : 011-24362859
E-MAIL : kurupage@yahoo.co.in

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MINISTRY OF I & B, ROOM NO. 48-53,
SOOCHNA BHAWAN, CGO COMPLEX,
LODHI ROAD, NEW DELHI-110 003
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Editorial

Reducing the emissions amidst growing energy demand is a big challenges that India faces today. Renewable energy seems to be the only way out. This is even more so as we are one of the largest importers of petroleum and this is a constant drain on our forex reserves. In this context, present government has rightly focused its attention on harnessing the huge Renewable Energy potential that mother nature has gifted us in the form of sunlight, wind, water streams and biomass.

Revision in the targets of National Solar Mission from 20 GW to 100 GW by 2022, is really a bold and ambitious move. Though it is challenging, but if realised, this step holds the potential of transforming Indian energy scenario. It will help India not only meet its Intended Nationally Determined Contribution (INDC) but also generate millions of job opportunities for its youth. But here the challenges would be in preparing a huge pool of skilled/semi-skilled manpower to manufacture, install and maintain such a large number of solar equipments and then, handling the e-waste likely to be generated in the process.

Other than abundant sunlight, India is also gifted with tremendous wind energy resources. At present, with around 70 per cent share in our total Renewable Energy production, wind energy is the most significant component of India's clean energy sector. Even after final phase of National Solar Mission, it would remain second most important source of Renewable Energy. Most of the wind farms are in rural areas but they source only unskilled labour from those places. Need of the hour is to train the rural youth in those areas for skilled/ semi skilled jobs in this sector.

Other than wind, water can also be a good source of energy specially in Himalayan states and hilly areas such as western Ghat. Small streams can be used to generate electricity by installing small hydro plants. Unlike large hydro, these plants do not have any environmental or resettlement & rehabilitation issues but can be immensely helpful in providing power to those difficult parts which have so far been out of the reach of grid based supply.

Biofuels, with their renewable nature and income generation potential for farmers, are another promising area. Bio-diesel plants like *Jatropha* can be grown in wastelands thus augmenting the farmers' income without jeoparding our food security. Here, awareness generation among farmers and availability of expert guidance would be crucial for success.

India being an agrarian country, we generate huge amount of biomass every year. Usually this goes waste or is burnt inefficiently causing much air pollution. Delhi's air quality is affected very severely every year when farmers in adjoining Haryana & Punjab burn their paddy residue. Through proper management this waste could have been used to generate electrical or thermal power. Energy from biomass can be extracted in several ways e.g. Bio-gasification, Refuse Derived Fuel etc. It would not only be a solution to energy needs of rural India but also contribute to *Swachh Bharat Abhiyan*.

Benefits of Renewable Energy are immense but not without challenges. Government is doing well to create a supporting legal and regulatory environment in several ways such as – Renewable Energy Certificates, Renewable Purchase Obligations, various subsidies etc. But main challenge would come in capacity creation which would require participation of private sector, NGOs, green energy activists and public at large. Aware generation about Renewable Energy is another area that requires urgent attention as it would only create demand for renewable energy solutions and equipments. Nation needs to come together to harness the renewable energy potential that is gifted to us by mother nature.

RENEWABLE ENERGY
PRESENT SCENARIO AND RURAL PERSPECTIVES

Narendra Kumar Mishra

India will emerge as a major country utilizing the roof space for solar rooftop systems on a very large scale. The target of 40 GW roof top solar by 2022 (set by Govt of India) will result in abatement of about 6 crore tonnes of Carbon dioxide per year and will help fulfill the Indian commitment towards its contribution in mitigating the effect of the climate change.

There is now a growing awareness amongst the scientific community and the civil society on the need for a global energy future with distinct departure from past trends and patterns of energy usage. So far the predominant route of energy value chain comprises of generation of steam to rotate turbine, from burning of fossil or nuclear fuels. The energy that is used for generation of power finds its application in various economic activities and house-hold uses.

Economic growth drives the energy demand. But contrary to the trend in other developed and developing countries, total primary commercial energy requirement in India has been falling with respect to the growth in GDP largely because higher energy prices have encouraged efficient use.

However, the energy elasticity of GDP growth in India may not fall as much in the future as rising income levels will encourage life style changes that are more energy intense. Energy is central to reducing poverty and providing vital facilities in the area of health, literacy, governance and equitable growth. However it is not the energy per- se that is used for any activity or process, rather it is energy service that creates value addition.

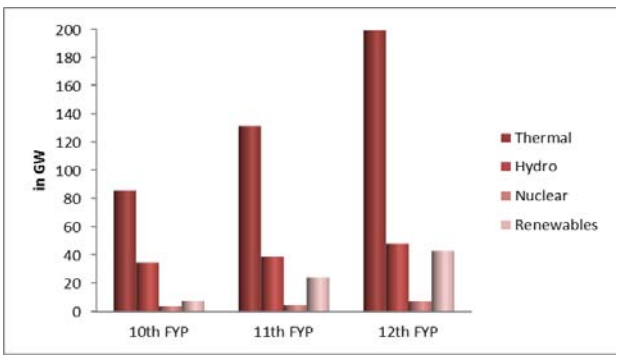
There is thus an undeniable relation between access to high quality energy services with human development and standard of living. Inadequate and unequally distributed energy services create hindrance for employment generation and acts as a constraint to education and health services.

Power Scenario in India

India has the fifth-largest power generation portfolio worldwide. Around 60 per cent of India's current power generation capacity is coal based. The country has been rapidly adding capacity over the last few years with total installed power capacity growing to 272.5 GW. India has grown from being the world's seventh-largest energy consumer in 2000 to the fourth-largest one within a decade. Economic growth and increasing prosperity, coupled with factors such as growing rate of urbanization, rising per capita energy consumption and widening access to energy in the country are likely to further raise the energy demand in the country.

The following figure depicts the installed capacity at the end of the Tenth and Eleventh Five Year Plan (FYP). It also shows the source wise capacity addition plans under the Twelfth FYP-

Figure 1 – Cumulative Installed Capacity (in GW)



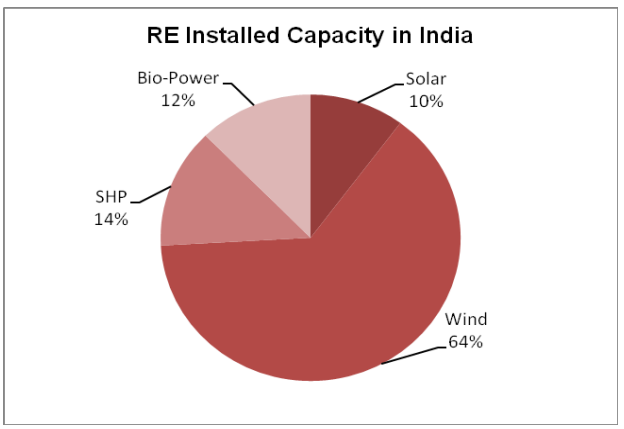
Source: EY Analysis

Renewable Energy (RE) Scenario in India

India's renewable power generation portfolio stands at 35.8 GW out of the total 272.5 GW power generated in the country, as on May 2015. As per the present estimates, India has an estimated RE potential of about 895 GW from commercially exploitable sources. Although the share of RE in the generation mix has been rising over the years, India still has large untapped RE potential.

India has vast RE potential through wind, solar, biomass and small hydro which is concentrated in certain parts of the country. The wind and solar potential is mainly in the southern and western states viz. Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat and Rajasthan. The following illustration summarizes the current split of installed RE capacity in India-

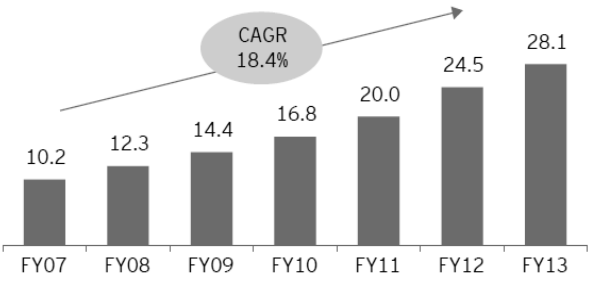
Figure 2 - Installed Renewable Energy Capacity in India (May 2015) [2]



Renewable Energy Targets in India

The Central Energy Authority (CEA) has made an assessment of capacity addition of 32 GW (wind/ solar/small hydro) likely to come up during the 12th Plan (2012 - 2017). The following graph depicts that at the current rate of growth, this target of 32GW of installed RE capacity by 2017, is achievable.

Figure 3 - Growth of Installed Capacity of RE in India (in GW)



Source: MNRE
Note: includes wind, solar, biomass (incl. bagasse) and small hydro. Excludes large hydro.

The following table compares the targets and actual installed capacity of RE in India since the beginning of the 12th Five Year Plan-

To put things in perspective, planned renewable capacity additions during the 12th FYP are almost one- third of the planned conventional energy capacity addition during the same period. In FY 2011 and 2012 the RE installations have exceeded the targets. In FY 2013 and FY 2014

Table 1: RE Targets and Actual Installed Capacity

Renewable Energy	2010-11		2011-12		2012-13		2013-14		2014-15	
	Target (MW)	Actual (MW)	Target (MW)	Actual (MW)	Target (MW)	Actual (MW)	Target (MW)	Actual (MW)	Target (MW)	Actual (MW)
Wind Power	2,000	2,350	2,400	3,197	2,500	1,699	2,750	512	3,000	2,312
Small Hydro	300	307	350	353	350	237	400	54	400	251.61
Bio Power	472	474	475	488	400	472	400	-	520	45
Solar Power	200	27	200	905	1000	754	1,000	75	2000	1117
Total	2,972	3,158	3,425	4,943	4,250	3,162	4,550	641	5,920	3,726

Source: EY Analysis

targets were not met, primarily as a result of decline in wind installations.

A road-map for integrating the envisaged RE production capacity into the electricity grid and its adaption to future requirements was prepared in July 2012 by Power Grid Corporation of India Limited (PGCIL) on behalf of the Ministry of New and Renewable Energy (MNRE). Considering India's RE potential and the target of 175 GW of additional capacity installation by 2022, it is estimated that the RE sector will require significant financing.

Solar power is also a prominent feature in India's Intended Nationally Determined Contributions (INDC) at the recently held Conference of Parties (COP) in Paris, France. India intends to achieve 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030, as one of ways to curb global temperature increase. Given the abundance of solar energy in the country, solar power is going to occupy a considerable share in this goal.

Programme/ Scheme wise Physical Progress in 2015-16 (Up to the month of February, 2016)

Sector	FY- 2015-16		Cumulative Achievements
	Target	Achievement	(as on 29.02.2016)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	2400.00	1773.68	25217.29
Solar Power	1400.00	1788.10	5547.21
Small Hydro Power	250.00	139.05	4194.40
Bio-Power (Biomass & Gasification and Bagasse Cogeneration)	400.00	400.00	4826.53
Waste to Power	10.00	0.00	115.08
Total	4460.00	3720.18	39900.51
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)			
Waste to Energy	10.00	14.13	160.16
Biomass (non-bagasse) Cogeneration	60.00	49.50	652.37
Biomass Gasifiers -Rural -Industrial	2.00 6.00	0.20 8.67	18.15 160.57
Aero-Genrators/Hybrid systems	0.50	0.15	2.67
SPV Systems	50.00	81.00	307.31
Water mills/micro hydel	2.00	0.00	17.21
Total	130.50	153.65	1318.44
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (numbers in lakh)	1.10	0.50	48.48
Solar Water Heating – Coll. Areas (million m2)	-	0.00	8.90

Source: MNRE

Rural Perspectives

The 2011 Census estimates that almost 85 per cent of rural India depends on solid fuels for their cooking needs. This number alone is an indicator of challenges facing various energy policies and programs in India. In case of electricity, although a majority of rural households have a grid connection but the mere extension of grid does not guarantee access to reliable electricity. In India, the rural-urban gap in energy access levels has been significant. This indicates the need and importance of fast tracking access to energy especially in the rural India.

Indian government has also focused its attention on rural clean energy sector by supporting distributed generation in the form of community-based, self-sufficient biomass and solar power. **Government of India is all set to scale up the targets set up for Jawaharlal Nehru National Solar Mission from 20 GW to 100 GW by 2022. National Solar Mission also has an ambitious goal of providing 2 crore solar lighting systems in place of kerosene lamps to rural communities.**

Some of the areas of opportunities in India in the rural electrification are as follows.

- Photovoltaic (PV) home lighting systems & products
- PV Mini-grids
- PV pumping

Low Cost Solar Lanterns

Solar lanterns are increasingly finding applications in the rural areas for lighting purpose with key features such as LEDs, mobile charging, battery back-up etc. These lanterns are environment-friendly and can be immensely useful for children's study besides household and other economic activities. They have a huge potential to replace currently used kerosene lamps thus reducing the subsidy burden of kerosene. However, their price continues to be prohibitively high for the rural population.

Hence, Solar Energy Corporation of India (SECI) has embarked on development of 6 Lakh robust and efficient solar lanterns for distribution in the rural areas of the country. This is with a view to safeguard customers from spurious and unreliable products flooding the market and to have competitive pressure on high prices so as to achieve large scale rapid diffusion of solar lanterns in the rural areas across the country.

Microgrids are modern, small-scale versions of the centralized electricity system. They are very effective for achievement of community-level electrification in remote areas using renewable energy sources and have a low carbon footprint. Microgrids generate, distribute, and regulate the flow of electricity to consumers locally. Microgrids are an ideal way to integrate various renewable resources and allow for community participation in the electricity enterprise.

Ministry of Power is the nodal ministry for the extension of the centralized grid electrification system in the country; it has also been instrumental to promote renewable energy-based mini-grids to electrify remote and far-off areas. **The MNRE started promoting mini-grids under the off-grid electrification programmes during the late nineties and early part of 2000 to cover villages that are unlikely to be covered through grid extension. At that time, the Government of India, estimated that there were around 25000 remote villages which will be difficult to connect through grid-supplied systems. Therefore, renewable energy-based mini-grids or stand-alone systems were considered to electrify these identified remote villages.**

Irrigation Pumps

India's new government led by Prime

Minister Shri Narendra Modi, has announced that it wants to provide electricity to all households by 2019. This is a challenging task, considering that only 55.3 per cent rural households and 67.2 per cent households across the country have access to electricity as per the 2011 Census. 43.2 per cent of rural households and 6.5 per cent urban households use kerosene for lighting and around 30 crore Indians still have no grid power. Another 30 crore have only very unreliable grid power. Most of them live in rural areas.

Most of the rural population depends on diesel and kerosene for energy. Diesel pumps however have three disadvantages. First their fuel is costly; second, they deplete the water table more than necessary by pumping heavily at short intervals and third, they create local pollution and carbon emissions. Agriculture sector consumes a significant portion of overall electricity (20 per cent) in India and irrigation pump sets contribute a significant share (90 per cent) to the overall electricity consumption in agricultural sector.

Solar based pumping systems and solar light and off grid solar panel would be better on all accounts. India is witnessing an increase in solar energy application in agricultural sector. 1,38,267 solar pumps have been sanctioned in the country out of which 34,941 pumps have been installed till date. Rajasthan leads the list followed by Punjab, Madhya and Uttar Pradesh. For drinking water, the government has sanctioned 15,330 solar water pumps, out of which only 200 pumps have been installed.

Solar energy is best options for rural population. Though, renewables have long been seen as a solution to ending energy poverty, but for decades, the products were too expensive and unreliable. All that has changed in recent years. Prices of solar PV have came down drastically and advances in battery and LED lighting technology has created a growing industry that puts power generation directly in the hands of rural citizens rather than an unreliable energy grid.

Solar based electricity and solar based irrigation pumping facility has created livelihood and income generation opportunities for the local population. Reliable electricity in the evening has also improved educational opportunities for village children and has provided much needed safety on the streets after sunset.

Roof Top Solar – Off Grid

A large potential is available for generating solar power using unutilized space on rooftops in buildings and huts. Government is encouraging installations of solar power systems, particularly on rooftops, all over the country including on railway stations and airports. Solar power generated by each individual household, industrial, institutional, commercial or any other type of buildings, can be used to partly fulfill the requirement of the building occupants and surplus, if any, can be fed into the grid. So far, 26 states have notified their regulations to provide Net Metering /Gross Metering facilities to support solar rooftops installations.

India will emerge as a major country utilizing the roof space for solar rooftop systems on a very large scale. The target of 40 GW roof top solar by 2022 (set by Govt of India) will result in abatement of about 6 crore tonnes of Carbon dioxide per year and will help fulfill the Indian commitment towards its contribution in mitigating the effect of the climate change.

A robust national framework for implementation and funding support for states would be critical to achieve these targets. A dedicated nodal agency at the centre to co-ordinate effectively with state level agencies could help. A vast awareness and marketing campaign would be required as well as a significant push in capacity building at the local level for installation, operation, maintenance and repair of such systems. Of course, the state would not have to do everything by itself. In fact, it should not. Instead, it should allow a competitive ecosystem of private companies, investors and banks to do most of the legwork.

In fact, sky is the limit and future indeed is sunny, only if we take the right steps, making effective use of learning from innovative rural projects and initiative.

(The author is working with a leading industry body in the area of Energy & Natural Resources. Email: narendrakumar.mishra@gmail.com)

A SOLAR ROAD FOR RURAL INDIA

Vipin Kumar Yadav, Ravindra Singh

Government is promoting solar energy like never before. Under National Solar Mission, it has set an ambitious target to generate 100 GW solar energy by 2022 (both grid connected and off-grid). Rural India is going to play an important role in this because of the easy availability of open space and land to install solar panels. Yet challenges remain. Lack of trained manpower is one. Skill India will have to play a major role here in training the rural youth.

The sun is setting, sky is changing fast from red to dusky, cattle are returning from grazing land and birds settling in trees for night are making considerable noise…. That is a remote hamlet perched somewhere in rural hinterland of India.

Few moments pass and now village turns quite and calm, engulfed in darkness of night. Jackals have started howling…. But Rashmi is busy. She has a solar lantern and a workbook before her. Homework is still incomplete but bright white light from solar lantern feels much better than the pale light of kerosene lamp.

Solar lantern has made her life and study really easy. Other than good visibility, it is easy to maintain and clean. Old kerosene lamp was a nightmare for Rashmi whenever she had to clean its glass from inside. She would often break it while washing and would be scolded by mother….. sometimes broken glass would injure her tiny hands. Earlier at night, she could never study on open roof as wind would often blow out the kerosene lamp. And then there was always danger of her cloths (or loose hair) catching fire if she ever dozed while studying near that pale lamp.

Solar energy is no less than a boon for the likes of Rashmi, who live in faraway villages with erratic power supply or no supply at all. Solar energy has helped the villages in multiple ways. Rashmi's mother is no less a gainer- she has replaced her earthen heath with a solar cooker.

Most of Indian villages use biomass *chulhas* where cow dung, wood and agricultural residue is used as a fuel. These *chulhas* are a big source of indoor pollution and women cooking on them are the worst affected. Many respiratory diseases and eye related ailments are attributed to the smoke and soot emanating from these *chulhas*. WHO data shows that these traditional *chulhas* are responsible for 13 per cent of total mortality in India, they cause about 40 per cent of all pulmonary disorders, about 30 per cent of cataract incidences and more than 20 per cent each of heart disease, lung cancer and lower respiratory infections.

India being a tropical country, with abundant sunlight most of the year, **solar cooker** can be an easy and convenient replacement for these soot & smoke *chulhas,* bringing immense benefits to health, environment and economy as a whole. Community solar cookers like PRINCE-40, can be used for cooking large number of meals e.g. mid day meals in schools. Solar heater is another device which can be used to warm water, especially in winters and cold areas saving considerable amount of wood.

With development of country, living standards are also improving in villages. This new emerging rural lifestyle, which borrows from urban ways of living, is more energy intensive. Lights, coolers, fans, TV and submersible pumps require much more energy than traditional way of living in rural India. Due to this increased demand, load on feeder lines is increasing and hence the failure of transformers in villages is very common, especially in summers. This leads to total shutdown the of power supply, making life and irrigation of crops both difficult.

Here solar energy can play a very important role as summers also provide the greatest amount of insolation which can be effectively harnessed. Open space, which is main requirement to install solar panels, and difficult to find in urban landscape, is abundantly available in rural area. Other than wasteland and rooftops, farmlands are also being used to install solar panels. Because some crops which can grow in shade, can still be cultivated in the farm under the panels. Further waste water from washing of the panels will be used for irrigation in the same field, thus doubly benefiting the farmers. These solar farms will be a good supplement to grid based supply and may even make **villages Self dependent in energy.**

Even after seven decades of independence, Indian agriculture remains vulnerable to the gods of rain. Last two successive weak monsoons have left our farmers in difficult situation. Boosting irrigation facilities is the solution but erratic and unreliable power supply again becomes a constraint here.

Solar water pump offer the solution. Due to division of land after every generation, 80 per cent of the farmers are small land holders nowadays. Getting new power connection for tube wells is really hard for them. Those who have tube wells, often face the threat of their power supply being disconnected by power distributing company for not being able to pay electricity bills on time. Solar water pump may be best suited to their needs. This combined with modern techniques of irrigation such as drip irrigation, may really prove to be a boon for both – the farmer and fast receding ground water table. NABARD is providing subsidy for solar water pumps.

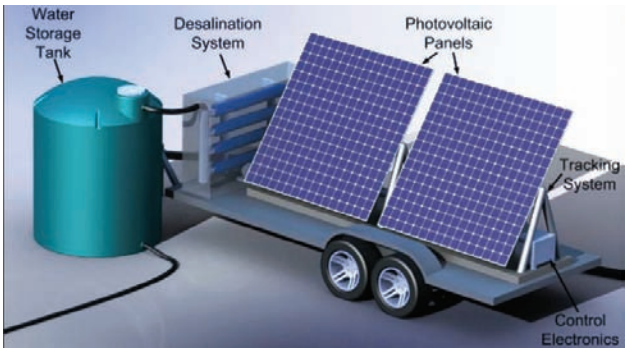
When we think of a farmer, the first image that emerges in our mind is that if a lean man with two bullocks. Though this image remains etched in the popular imagination, it is no longer true as tractors have vastly replaced bullocks. Farm mechanization has taken place at a rapid pace during last three decades. But these equipments cost a lot and mainly big farmers are only able to afford them. Their operation costs are higher as tractors use petroleum fuel which keeps getting expensive every year, thus increasing the input costs of the agriculture. **Tractors equipped with solar panel** may be the solution to this problem. It is not only environment friendly but would also reduce diesel use and thus, our import bills.

Due to small land holdings, expensive diesel and eight months of good sunlight, India is most suited place for these tractors. Small farmers will benefit immensely from this.

Other than this, solar energy can be used in ancillary activities like food processing and dairy. **Solar dryer** is one such application which can be used for drying perishable, semi-perishable and wet processed food material (such as potato chips, leafy vegetables) without contamination. Solar milking machines may help dairy sector.

Man-animal conflicts are often reported from all parts of the country. We often hear the herds of wild elephants straying into farmlands. They cause damage to crops and in return earn the wrath of the land owner, leading to conflict. Innumerable human and animal lives are lost in these conflicts. Though root cause of this problem lies in loss of habitat for wild animals and fragmentation of forest lands but **Solar electric fencing** of fields may solve this problem to a considerable extent, thus reducing the direct conflict.

Pure water is matter of fortune, nowadays. Rapid industrialization and mindless exploitation of ground water has made this problem even more complicated. Several villages complain of ailments related to consumption of contaminated water. Purifying the water using modern techniques such as solar RO seems to be the only solution. Similarly India's 7600 km long coastal boundary line is facing the problem of saline water. Coastal villages are getting adversly affected. By using **solar desalination water plants,** drinking water crises may be overcome effectively.



E-Rickshaws can play vital role in rural connectivity. Thanks to *Pradhanmantri Gram Sadak Yojana*, by now most of the villages are connected by road. And in densely populated regions, average distances from one village to another is 2-3 km. E-rickshaw may be modern *Ikka-Tanga* (Horse Carriage) to ferry passenger towards nearest bus stops or local railway station. At night, all streets and roads can be made safe for women and common man by installing solar lights.

At last, we understand that a vast solar market in rural India will require skilled and semi-skilled pool of manpower to install, maintain and repair solar panels and related electrical equipments. Majority of these job opportunities would be available to rural youth by way of their proximity to the rural solar market. This would also give rise to new entrepreneurs in rural India who would take lead in these projects.

Challenges ahead

Government is promoting solar energy like never before. Under National Solar Mission, it has set an ambitious target to generate 100 GW solar energy by 2022 (both grid connected and off-grid). Rural India is going to play an important role in this because of the easy availability of open space and land to install solar panels. Yet challenges remain. Lack of trained manpower is one. Skill India will have to play a major role here in training the rural youth.

Second challenge is seasonal and daily variations in availability of sunlight. During rains or fog, sunlight is far less, drastically reducing the solar power generation. This variation in power production is also the main hurdle in connecting the solar energy to grid. We will need a huge storage capacity to ensure reliable supply of solar power. Off –grid installations may be more successful but they also need back up power supply in cases of clouds or fog.

Apart from these natural limitations, there is the issue of availability of appropriate technology.

Though India is producing solar PV cells and modules of its own but world class standards are yet to be achieved. Recently announced International Solar Alliance may help in this regard as one of the objectives of this Alliance is to develop new technologies through collaborative efforts. Further private sector must also be engaged in this process. Companies operating in India should design affordable technologies that meet the local demand.

Further cost of solar energy equipments is also a concern. Initial cost of solar installation is relatively high. We know agriculture input costs are already high in farming sector, in such scenario, high prices of solar based appliances may add burden and it may neutralize the mood of farmers towards solar based appliances. Government is trying to solve this issue by providing various types of subsidies but still new cheaper technologies would have to be evolved through R&D to make solar energy attractive and sustainable.

Also, with the expanse of solar sector would arise the problem of managing huge amount of e-waste. We will have to think about this beforehand and include strategies of proper e-waste management in the installation phase itself. Generating public awareness would also be crucial for this.

Renewable energy is the future, not only for India but also for whole world. A lot many initiatives have been taken up at international and national level to promote green energy. At 37,000 MW, renewable energy accounts for close to 15 per cent of the total installed power capacity in the country. It sounds impressive till it is compared to the humongous target India has committed for the Paris climate change agreement - 40 per cent of the installed renewable energy capacity by 2030. Country is aiming to add 175,000 MW of capacity from clean energy sources by 2022, 60 per cent of which would come from solar energy, 30 per cent from wind and the balance from biomass and small hydro. Rural India is integral to the success of these schemes. Also these renewable energy programmes would be able to justify themselves, only when they benefit the last Indian living in the remote hinterland such as – Rashmi.

(Authors have run campaigns on popularising solar appliances among farmers. Email: rsambawat@gmail.com)

INITIATIVES FOR SOLAR ENERGY

Radhika Sharma

The Government of India has recently declared its Intended Nationally Determined Contributions (INDCs) towards realizing the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC). The plan is for reduction in the emissions intensity of its GDP by 33 to 35 per cent from 2005 level, by 2030 and to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030. In order to meet this ambitious target, renewable energy is expected to play a crucial role in our country. India's emission reduction targets are in-line with the National Solar Mission target of 100 GW solar energy by 2022. Out of this 100 GW, 60 GW is to be achieved through grid-connected utility scale solar plants and 40 GW through grid-connected solar rooftop projects. Government of India is speedily moving towards achieving this target by creating a supportive and conducive environment in terms of technology, policy and financial aspects.

Grid-interactive solar power in India stands at 6762.85 MW and solar photovoltaic (PV) systems installed as captive or off-grid units at 313.8 MW. The grid-connected solar power is being commissioned under various Government Schemes. As on 31st Jan 2016, most number of projects is being installed under State solar policies (Table 1). In order to achieve such an aggressive target of 100 GW, Ministry of New and Renewable Energy (MNRE), Government of India has proposed and developed a state-wise plan for this. Also, state governments are proactively proposing and introducing suitable policies and regulations to expedite grid connected solar rooftop capacity addition in the country. Solar Energy Corporation

of India (SECI) has been entrusted by MNRE for implementation of a Grid connected Rooftop pilot project.

Solar Development Schemes and Programmes in India

With around 250-300 sunny days a year nationwide, solar energy's potential in India is immense. The annual radiation varies from 1600-2200 kWh/m², equivalent energy potential to it is about 6,00 crore GWh of energy per year. The Government of India has been able to recognize and utilise this potential through supportive policies and initiatives. It all started with the launch of The National Action Plan on Climate Change (NAPCC) by the Prime Minister's Advisory Council on Climate Change in 2008. The NAPCC comprised of eight missions to map out integrated strategies to develop key national goals from climate change's perspective. National Solar Mission emerged from it and was later termed as Jawaharlal Nehru National Solar Mission (JNNSM). It focused on both solar photovoltaic (PV) and solar thermal technologies. Each programme/scheme/initiative

Table 1: Commissioning status of grid connected solar power projects in India (in MW)

Total MNRE Projects	Under State Policy	Renewable Purchase Obligation (RPO)	Renewable Energy Certificate (REC) Scheme	Private Initiative (rooftop)	Central Public Sector Undertakings	Total Commissioned Capacity (till 31.01.2016)
1503.781	2676.655	150	697.42	100.847	119.51	**5248.213**

at the Central Government's level is explained in details as follows.

Jawaharlal Nehru National Solar Mission (JNNSM)

The JNNSM was launched on 11th January 2010; with a target of 20 GW of grid-connected solar capacity addition by 2022. Its focus is to increase the usage of solar PV and solar thermal technologies majorly in urban areas, commercial and industrial establishments. It aims to reduce the overall cost of solar power generation in India by

(i) a stable and long term policy

(ii) large scale deployment targets

(iii) extensive Research and Development and

(iv) focus on domestic production of raw materials, components and products

It also emphasises on promoting off-grid solar power technology systems for rural households, decentralized off-grid applications such as solar lighting systems, solar water pumps and other solar-power based applications to meet the energy needs of rural India. The capacity addition target is planned in three phases (Table 2).

Table 2: Capacity addition targets for JNNSM

Category	Phase 1-Target Upto 2013	Phase2-Target (cumulative) (2013-2017)	Phase 3-Target (2017-2022)
Utility grid power including rooftop	1,000-2,000 MW	4,000-10,000 MW	20,000 MW
Off-grid Solar applications	200 MW	1000 MW	2000 MW
Solar Collectors	7 million m^2	15 million m^2	20 million m^2

The phase-2 is under process and around 1504.23 MW of grid-connected solar power projects were commissioned in 2015-16.

As part of the phase-2 of JNNSM, "Off-grid and Decentralized Solar Thermal Applications" Scheme (Capital Subsidy Scheme for Installation of Solar Thermal Systems) is continued as a sub-scheme. Under this scheme are solar thermal applications such as solar water/air heating, solar steam generation, solar thermal refrigeration and cooling and solar thermal power pack including hybrid with solar PV.

The cumulative targets of JNNSM for solar capacity addition were surged to 100 GW of solar by 2022, comprising of 60 GW of large and medium scale grid-connected solar power projects and 40 GW of grid –connected solar rooftop projects. The total investment required for accomplishing the goal of 100 GW will be around Rs. 6,00,000 crores. In the first phase, the Government of India is providing Rs. 15,050 crore as capital subsidy. It will be provided for rooftop solar projects for Viability Gap Funding (VGF) based projects to be developed through the Solar Energy Corporation of India (SECI) and for decentralized generation through small solar projects. The Ministry of New and Renewable Energy (MNRE) intends to achieve the target of 100 GW with targets under the three schemes of 19,200 MW. Apart from this, solar power projects with investment of about Rs. 90,000 crore would be developed using bundling mechanism with thermal power

Concept of Renewable Purchase Obligation (RPO) and Renewable Energy Certificate (REC) Mechanism

Renewable Purchase Obligation (RPO) and Renewable Energy Certificate (REC) Mechanism are the two major drivers to achieve the solar capacity addition targets in India. As per Section 86(1) (e) of the Electricity Act, 2003, the State Commission has been mandated to promote cogeneration and generation of electricity from renewable energy sources. In this regard, various State Commissions have put significant emphasis on developing regulations for Distribution Licensees under their jurisdiction.

According to the Electricity Act, 2003 and the amendment to the National Tariff Policy, the State Electricity Regulatory Commissions (SERCs) were mandated to determine a percentage of the power which has to be procured from renewable sources, known as Renewable Purchase Obligation (RPO). In case of solar, RPO

is minimum 0.25 per cent by 2012-2013 which is to be increased to 3 per cent by 2021-2022. But considering the revised target of 100 GW from solar power by 2022, notching up the RPO for each state is significant to achieve the desired capacity addition. An amendment was recently announced in the National Tariff Policy, as per which 8 per cent of electricity consumption by March 2022, has to be from solar.

Renewable Energy Certificate (REC) mechanism is a market based instrument that help entities comply with their renewable purchase obligations (RPO). One Renewable Energy Certificate (REC) is treated as equivalent to 1 MWh. If distribution companies, open access consumers and captive consumers have failed to produce their share of renewable energy, they can purchase renewable power or RECs to meet their obligations.

It is segregated into solar and no-solar RPO thereby aimed at addressing the mismatch between availability of RE resources in state and the requirement of the obligated entities to meet the RPO targets. It can be traded through Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL). REC is traded within the floor and forbearance price as determined by Central Electricity Regulatory Commission (CERC), mentioned in Table 3.

Table 3: Floor and forbearance price determined by CERC (w.e.f. 01.01.2015 – 31.03.2017)

Price	Non-Solar REC (Rs/MWh)	Solar REC (Rs/MWh)
Forbearance	3,300	5,800
Floor	1,500	3,500

Development of Solar Cities Programme

The Solar City Programme aims at reduction in projected demand of conventional energy by minimum 10 per cent at the end of five years, through energy efficiency measures as well as increased renewable energy penetration in the city. The idea is to encourage the local government to adopt clean energy technology interventions. In a Solar City all types of renewable energy based projects like solar, wind, biomass, small hydro,

waste to energy etc. may be installed along with possible energy efficiency measures depending on the need and resource availability in the city. As on 11.04.2016, a master plan for developing solar cities has been constituted for 36 cities in the country.

International Solar Alliance (ISA)

International Solar Alliance is an initiative by the Government of India to accelerate the deployment of solar energy for universal energy access and energy security for the future. The initiative was launched at the Conference of Parties (21st) to the United Nations Framework Convention on Climate Change. The collective aim is to undertake initiatives to reduce the cost of technology and finance for solar projects and to identify financial instruments to mobilize $ 1000 billion worth of investments by 2030 to promote affordable energy. It is an alliance of 121 solar- resource rich countries lying approximately between tropic of Cancer and tropic of Capricorn. India has offered to host ISA at by National Institute of Solar Energy (NISE's) premise and also a contribution of $ 15 million to create as a corpus fund.

Integrated Power Development Scheme (IPDS)

Integrated Power Development Scheme (IPDS) was launched by the Government of India in Varanasi on 18th September 2015. Aim of the scheme was to extend financial assistance against capital expenditure to all state power departments and both State and Private Distribution Companies (DISCOMs) to ensure 24/7 power supply to all. The focus of the scheme is to-

- strengthen the sub-transmission network,
- metering,
- IT application,
- customer care services,
- provisioning of solar panels,
- installation of rooftop solar in all government buildings and
- the completion of the ongoing works of Restructured Accelerated Power Development and completion of the Reforms Programme (RAPDRP)

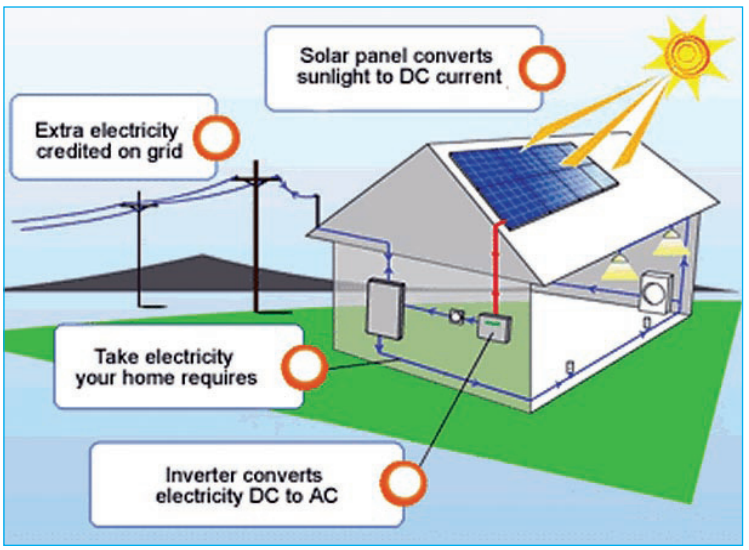
A budgetary support of Rs. 45,800 crores has been provided to the IPDS Scheme for its entire implementation period.

Remote Village Electrification Programme

Ministry of New and Renewable Energy (MNRE) is also focused on the promotion and deployment of solar for decentralized applications such as-

- solar home systems (SHS),
- solar photovoltaic (SPV) power plants,
- small hydropower plants in rural areas,

wherever grid extension is not techno-economically feasible. It also offers energy services for community facilities, water pumping for irrigation and drinking water supply, and livelihood and income-generating economic activities in the village. As per MNRE, till (July 2015), it has sanctioned 13,059 villages/hamlets during the period 2007-14, out of which 11,308 had been completed/ electrified.



Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects in the country commencing from 2014-15 and onwards (i.e. from the year 2014 – 15 to 2018 – 19)

Solar Energy Corporation of India (SECI), a central public sector enterprises under MNRE, would implement the Scheme of developing solar parks each with a capacity of 500 MW and above in all the states of the country. For solar park development, land procurement for solar power projects, infrastructure like transmission system, water, road connectivity etc., would be developed through the State Governments. As on date, 21 states and 33 solar parks of 19,900 MW of capacity have been approved.

Other Schemes and Sub-Schemes to Expedite Solar Deployment in the Country

Amalgamation of Solar Photovoltaic Water Pumping System for Irrigation under the "Sub-Mission on Agricultural Mechanization (SMAM)": Ministry of Agriculture (MoA) and Ministry of New and Renewable Energy (MNRE), Government of India, have introduced solar energy pumping system under the Sub-Mission on Agricultural Mechanization (SMAM). Solar irrigation pump sets for agricultural use have been placed under the list of farm machinery component. The funding pattern is in line with MNRE with capital subsidy being provided for DC pump sets and AC pump sets.

MNRE Lighting Scheme 2016- Capital Subsidy Scheme for Installation of Solar Photovoltaic Lighting Systems: It is a sub-scheme of the off-grid applications scheme 2015-16 and is based on the promotion and dissemination of White LED (W-LED) based solar photovoltaic lighting systems. MNRE has signed a Memorandum of Understanding (MoU) with NABARD to promote solar home lighting systems to rural areas through MNRE-NABARD subsidy and bank linkages.

Off-grid and Decentralized Solar Cooker Programme: As part of the Off-grid and Decentralized Solar Applications (Phase 2, JNNSM), the Off-grid and Solar

Cooker Programme aims at promoting off-grid cooking applications like cooking/baking/frying using Solar Device (Box and Dish Type solar) with Central Financial Assistance from MNRE.

Suryamitra Skill Development Programme: It is a program implemented by National Institute of Solar Energy (NISE) to train 50,000 personnel within a period of 5 years (2015-16 to 2019-20). As on 30.9.2015, about 360 Suryamitras were trained under the scheme.

New loan scheme to promote rooftop solar power projects announced by IREDA: The scheme will provide loans at interest rates between 9.9 and 10.75 per cent to system aggregators and developers.

Pilot-cum-Demonstration Project for Development of Grid Connected Solar PV Power Plants on Canal Banks and Canal Tops: SECI and MNRE provide subsidy to develop pilot-cum-demonstration projects on canal banks and canal tops. As on date, 50 MW of canal tops and 50 MW of canal banks plants have been sanctioned.

Grid-Connected Solar PV Power Projects by Defence establishments and Para Military Forces: It is expected to set up of over 300 MW of grid-connected and off-grid solar PV projects on defense and paramilitary establishments through viability gap funding. It is a sub-scheme under JNNSM (Phase 2/3). The minimum and maximum capacity which can be sanctioned is 1 MW and 20 MW respectively.

Implementation of Scheme for setting up 1000 MW of Grid Connected Solar PV Power projects by PSUs and GOI organizations: Through Viability Gap Funding, a 1000 MW of grid-connected solar to be sanctioned for three years (2015-16 to 2017-18) to be set by CPSUs and other organizations under the Government of India.

Scheme for Decentralized Generation of Solar Energy Projects by Unemployed Youths & Farmers: It is expected that about 10 GW solar projects could be setup under this scheme. A central grant of 4,750 crores has been allocated against this scheme. The subsidy would be eligible for projects with capacity ranging from 0.5 MW to 5 MW.

Way Forward

India is moving forward in adapting to solar energy at a very high pace, but challenges in terms of metering arrangements, standardization and finances are still being worked upon. In order to create favourable conditions for up-scaled and competitive solar energy penetration at both centralized and decentralized levels, more integrated policies and schemes should emerge and thereby create a conducive policy and regulatory framework for speedy deployment of solar energy technology in the country. In order to maintain the pace of deployment, it is essential to focus on the implementation, operation, maintenance and other ancillary services.

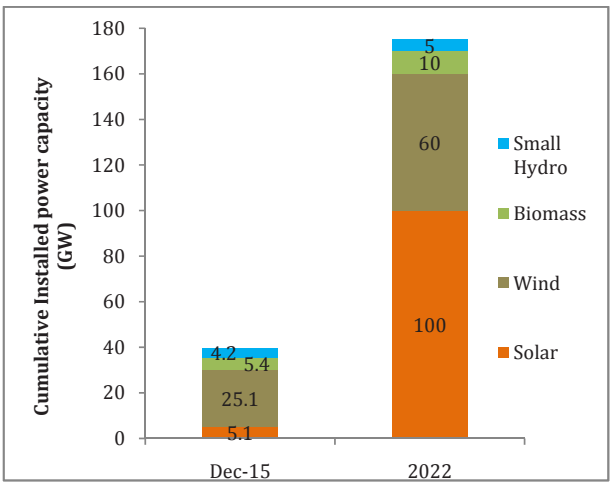
(Author is Research Associate at The Energy and Resources Institute (TERI), New Delhi. Email: Radhika.Sharma@teri.res.in)

RENEWABLE ENERGY & MAKE-IN-INDIA

Kanika Chawla, Shalu Agrawal

Interestingly, many of the large utility scale projects and solar parks, forecasted to add 60 GW of solar capacity by 2022, and the wind power projects would be located in rural or peri-urban areas. Hence, a majority of the jobs created under renewable energy projects, skilled, semi-skilled as well as unskilled, would benefit the rural youth.

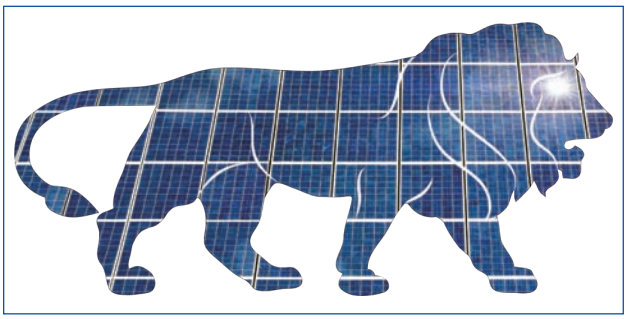
India's Finance Minister officially announced the country's renewable energy target of installing 175 GW of renewable energy (RE) capacity by 2022, in his 2015 budget speech. This ambitious target, along with the recent launch of International Solar Alliance (ISA) spearheaded by India, has made the country a global leader in renewable energy. India's total installed renewable energy capacity stands at close to 40 GW, nearly 22% of the colossal target. The breakdown of current RE capacity and 2022 target by different RE sources is shown in Figure 1.



In order to realise the clean energy goals, the Government of India has launched several schemes such as the Jawaharlal Nehru National Solar Mission (JNNSM), the Biomass Power & Cogeneration Programme and the Small Hydro Power (SHP) Programme, amongst several others. **As the country prepares to scale up renewable energy capacity, it is important to recognise the need for a skilled workforce.**

Job creation potential of renewable energy

Given the population growth rate, India needs to create one crore new jobs every year.



Analysis carried out by the Council on Energy, Environment and Water (CEEW) and the Natural Resources Defense Council (NRDC) estimates that more than 10 lakh full time jobs would be created by the solar deployment industry alone, between now and 2022. Similarly, the wind sector would create 183,500 jobs by 2022, as the wind capacity increases to 60 GW.

Interestingly, many of the large utility scale projects and solar parks, forecasted to add 60 GW of solar capacity by 2022, and the wind power projects would be located in rural or peri-urban areas. Hence, a majority of the jobs created under renewable energy projects, skilled, semi-skilled as well as unskilled, would benefit the rural youth.

Analysing the jobs created in the solar photovoltaic (PV) sector along with the related skills required in every phase of a solar project to reach the targeted 100 GW of solar energy by 2022, suggests that India will need nearly 180,000 skilled plant design engineers and approximately 570,000 semi-skilled technicians for construction, most of whom will be needed to achieve the targeted 40 GW rooftop solar capacity addition. As many as 75,000 highly skilled workers will be needed within 6 years to carry out annual and ongoing performance data monitoring of solar projects totalling 100 GW. An additional 170,000

workers will be needed annually by 2022 to carry out low-skill operation and maintenance functions for the multitude of solar rooftop and utility scale projects.

Distributed RE for rural livelihood and development

The Indian government is also promoting several distributed renewable energy applications, such as solar pumps, wind pumps, solar food dryers etc., which could stimulate the rural economy by providing power for various economic activities.

Currently, lakhs of Indian farmers are waiting for agricultural electricity connections, while 90 lakh diesel pumps are being used for irrigation. Diesel water pumps are both expensive and hazardous to the environment. Solar water pumps could provide cost-effective and reliable irrigation service, even in remote rural areas. The national and state governments are providing several incentives to promote the adoption of solar pumps. Capital subsidy on solar pumps ranges from 30% to 86% of the upfront cost, depending upon the contribution of state governments, with 30% subsidy share contributed by the Ministry of New and Renewable Energy (MNRE). Additionally, there is a subsidy-credit-equity scheme (40:40:20 per cent) for solar pumps, which is being implemented by NABARD.

In addition to solar water pumps, applications such as solar home lighting systems, solar lanterns, biogas plants, etc. could contribute towards income generation through household based economic activities, in addition to fulfilling the basic energy needs and improving the quality of life in rural homes.

Going beyond household energy needs, rooftop solar systems could also provide access to reliable electricity in Primary Health Centres (PHCs) and primary schools in rural areas, which is critical for the last mile delivery of essential community services. Every second rural primary school in India is un-electrified, while close to 33 million people in rural India rely on PHCs that currently have no electricity. A study conducted by CEEW and Oxfam-India, estimates that deploying rooftop solar over PHCs and rural primary schools could contribute towards 6% of the 40 GW rooftop solar target of the country. Manpower requirements for distribution, installation, and maintenance of such distributed renewable energy systems would also lead to creation of local jobs.

Filling the skill gaps

India's skilled workforce has struggled to keep up with other global economic powers. According to Shri Rajiv Pratap Rudy, Minister of State for Skill Development and Entrepreneurship, India's skilled workforce comprises only 2-4 per cent of the labor supply, while other countries such as China, Germany and South Korea maintain far more robust skilled labor forces (47, 74 and 96 per cents, respectively).

The job creation potential of the renewable energy sector is significant, it also brings with it the urgent, and the currently unmet need for skilling. Analysis, based on survey responses from forty solar companies in India, highlights the current unavailability of appropriately skilled manpower for construction and commissioning of solar units as a significant challenge to the solar industry. Similarly, wind sector respondents suggested that the current skilling programmes needed to be made more relevant and accessible, such that companies are assured of the high quality of training. This is where the ambitious renewable energy target of the country interlinks with the

Skill India initiative, which aims to skill 40 crore people by 2022.

In recognition of the need for skill development, National Institute of Solar Energy (NISE) is organizing *"Suryamitra"* Skill Development Program which aims to train 50,000 youths over the next three years, for installation, operation and maintenance of solar projects. The National Certification Programme for Rooftop Solar Photovoltaic Installer (NCPSPI) is aimed at developing skilled and qualified manpower to install rooftop photovoltaic systems throughout the country and is open to technicians, students as well as entrepreneurs. As the government implements these schemes, it will be crucial to develop standardised training programmes that can be implemented through institutes around the country, with training institutes being set up in areas with the most renewable energy potential and upcoming capacity.

Going beyond the need for skill trainings, issues such as access to finance, market information and general awareness amongst the potential customers (which directly determines the bottom up demand), pose significant barriers to entrepreneurs and market players in the renewable energy sector, particularly in rural areas. Addressing these would require an enabling financial ecosystem, resource assessment, common platform for information exchange as well as intensive awareness drives to build confidence and public acceptance for renewable energy applications.

Synergies between different schemes and programmes

During the first Make-in-India Week, focusing on increasing domestic manufacturing in India, the Minister for Power, Coal, and New and Renewable Energy, Shri Piyush Goyal spoke of the need to have end-to-end solar manufacturing in the country. The current annual solar manufacturing capacity in India stands at a meagre 4 GW, cells and modules combined, whereas the annual wind manufacturing capacity stood close to 10 GW. Strengthening domestic manufacturing of solar panels and wind turbines, at competitive prices, would further the objectives of the Make in India initiative while also providing an impetus to the RE industry and creating new jobs for urban and rural youth.

CEEW – NRDC analysis suggests that skilling for research and product development would be essential for scaling up the manufacturing of PV panels and wind turbines. **Similarly, as several new entrepreneurs enter the market, both to manufacture and deploy renewable energy capacity, it will become interesting to view the synergies between the Startup India initiative and the country's renewable energy targets.**

Cooperation could extend beyond just national missions. India's recent pioneering effort to initiate the formation of the **International Solar Alliance (ISA)** brings together 121 solar rich countries on a common platform for cooperation to significantly augment the development, deployment and generation of solar technologies and power. One of the key pillars of the ISA work-plan is to facilitate capacity building for promotion and absorption of solar technologies and R&D among member countries. This resonates with the objectives of the **Skill India** initiative, as well as India's domestic solar target. While the focus of the International Solar Alliance is going to be global, India's domestic solar sector could benefit significantly from its recommendations and capacity building initiatives.

The time for transition to an energy future that has a significant component of renewable energy has come. The political support being extended to this sector is unprecedented. It is now that synergies that have been identified between the various ongoing initiatives, offer the opportunity of scaling up the renewable energy production. Access to high quality and relevant training programmes is crucial along with the support to the domestic solar and wind manufacturing market. Leveraging the synergies between the different government programmes for achieving India's ambitious renewable energy target, could play an important role in furthering the economic development and livelihood security in rural India.

(Authors are researchers at the Council on Energy, Environment and Water (CEEW), a not-for-profit policy research institution. Email: kanika.chawla@ceew.in)

WIND ENERGY: A PROMISING SECTOR FOR RURAL INDIA

Sankalp Ved

Wind Industry has achieved as lot, but the next milestone can only be achieved if the stake of rural sector goes beyond selling mere land. But this cannot be a one way initiative, the Govt. including the local Panchayats and the local set up should also come up with open mind and positive approach and embrace the opportunity.

Humans have used wind energy since ancient times for transportation by sailing ships. Windmills were developed thousands of years ago to draw water for irrigation and grinding grain. Today, with technological advancements, wind power has emerged as an important source of renewable energy. It makes up around 70 per cent of India's total renewable energy production.

In comparison to its benefits, wind power has far less environmental impacts. There are no gas or water emissions, no radiation or solid waste production. Some minor problems are mainly bird kills, turbines make some noise and may affect TV reception nearby.

Wind is likely to remain for years one of the largest sources of renewable energy in India. The Potential for wind power generation for grid interaction has been estimated at about **1,02,788 MW** at 80 m hub-height and the present installed capacity of is 26743.61 MW as on 31 march 2016. In the Financial Year 2015-16 itself, wind power capacity of 3300 MW was added, around 37 per cent higher than targeted capacity of 2400 MW.

Wind Power Programme

To give further fillip to the wind power sector, Ministry of New and Renewable Energy (MNRE) has a broad based Wind Power Programme which aims to catalyze commercialization of grid interactive wind power. Under the programme following steps are taken -

National Wind Resource Assessment

Under this programme, Ministry through National Institute of Wind Energy, Chennai and State Nodal Agencies had installed and monitored around 800 dedicated Wind Monitoring Stations (WMS) of height ranging from 20 m to 120 m throughout the country. Further hundreds of private wind monitoring stations are also operational in the country. Based on the analysis on the data collected from these 700 plus WMS, it is found that 237 stations have economically preferable wind power potential greater than 200 W/m2.

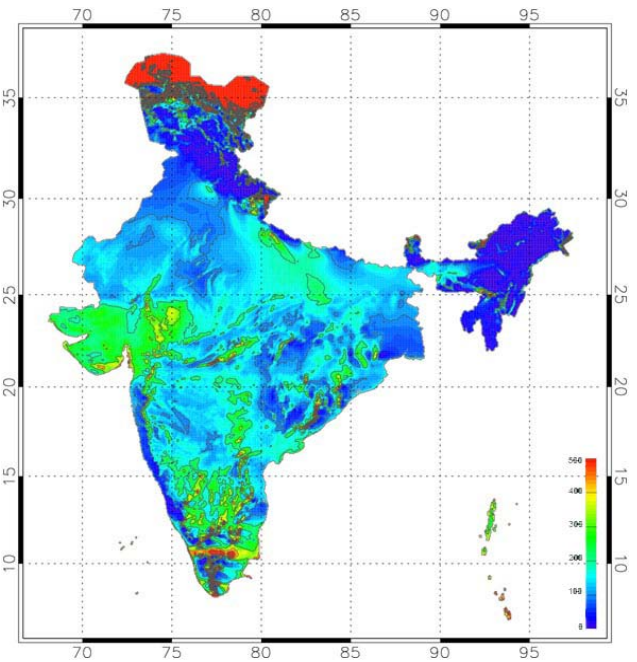


Figure: Wind power density map at 80 m level (Source-NIWE)

Technology

Two types of wind turbines namely stall regulated and pitch regulated are being deployed in the country and abroad for grid-interactive power. The stall regulated wind turbines have fixed rotor blades whereas pitch regulated wind turbines have adjustable rotor blades that change the angle of attach depending upon wind speed. Both technologies have their own advantages and disadvantages

Demonstration Programme

An aggregate demonstration wind power capacity of 71 MW has been established at 33 locations in 9 states. Demonstration projects are implemented through the State Governments, State Nodal Agencies or State Electricity Boards. These projects will be taken up only in those states where commercial wind power projects have not yet been initiated/ taken off.

Manufacturing Base of Wind Electric Generators

Wind Electric Generators are being manufactured in the country by a dozen manufacturers, through (i) joint ventures under licensed production (ii) subsidiaries of foreign companies, under licensed production and (iii) Indian companies with their own technology. An indigenization level up to 70 per cent has been achieved in machines of unit sizes up to 500 kW. The import content is somewhat higher in higher capacity machines.

National Institute of Wind Energy (NIWE)

The National Institute of Wind Energy (NIWE), Chennai was established in Tamil Nadu in 1998 as an autonomous institution under the administrative control of the Ministry of New and Renewable Energy. CIWE main activities include resource assessment and testing & certification.

Promotional Policies

A package of fiscal and financial incentives is available t o boost wind energy such as –

- **Accelerated Depreciation (AD)**: It is a tax benefit scheme that can be availed by anyone who sets up or invests in a wind farm irrespective of the power generated. Under this about 80 per cent of the project cost is paid back if the plant is commissioned before September 30 of the financial year concerned. But from April 2017, the accelerated depreciation tax benefit is slated to be capped at a maximum of 40 per cent. The reason for this decision might have been the fact that the lure of accelerated depreciation led to the setting up of a large number of wind farms across India, but a lot of these farms were not functioning properly after the tax benefit was availed. Average capacity utilisation of wind power projects has been low.
- **Generation Based Incentive (GBI) Scheme:** In 2009, the Ministry introduced GBI Scheme for wind power projects wherein wind power projects not availing the Accelerated Depreciation (AD) benefit are eligible for GBI incentive at the rate if Rs. 0.50 per unit of power fed to the grid subject to the ceiling of Rs. 1 Crore per MW. Idea behind GBI was to broaden investor base, attract FDI, encourage higher generation and transition from investment based incentive to outcome based incentive.
- Concessional custom duty on specified items, exemption from excise duty, sales tax and income tax for 10 years, etc. In addition,
- **Preferential Tariffs :** State Electricity Regulatory Commissions (SERCs) are determining preferential tariffs for wind power. There has been a significant increment in the preferential tariff in several potential states for wind while the cost remained the same or rather reduced in some cases. Just for instance Tamilnadu for the first time came out with tariff of above Rs. 4/unit for Wind projects (Tariff being fixed @ Rs. 4.16/unit) and Rajasthan has announced tariff of above Rs. 6/unit in few classified districts.

- Indian Renewable Energy Development Agency (IREDA) provides loan for setting up wind power projects.

Other Major Policies

In addition to above mentioned Wind Power Programme, government has initiated various other policies to boost renewable energy sector, that also helps wind power sector e.g.-

Renewable Purchase Obligation (RPO)

The Electricity Act, 2003 and National Action Plan on Climate Change (NAPCC) provide a roadmap for increasing the share of renewable energy in total power generation by the way of Renewable Purchase Obligation (RPO). Under this, the Regulatory Commission in each State mandates that Distribution Licensee (power distribution companies (DISCOMs), Open Access Consumer and Captive consumer i.e. those generating and consuming power from captive coal/natural gas power) would generate a certain percentage of their electricity from renewable sources.

Renewable Energy Certificate (REC)

A Renewable Energy Certificate (REC) is a tradable, market based instrument which provides evidence that a generator has produced a certain amount of electricity from a renewable energy resource. One Renewable Energy Certificate (REC) is treated as equivalent to 1 MWh.

REC mechanism helps entities in meeting their RPOs. If distribution companies, open access consumers and captive consumers have failed to produce their share of renewable energy, they can purchase renewable power or RECs to meet their obligations.

Enforcement of REC: There has been conclusive development in the enforcement of REC by various Regulators. In various resent orders they have directed all distribution firms to meet their obligation for buying renewable energy in the past four years, and said they will have to pay a stiff penalty if the backlog of their "renewable purchase obligation (RPO)" is not cleared by March 2017. Few cases are also filed & heard Appellate tribunal in regard of same. There has been a significant growth seen the NON Solar REC purchase in March 16 REC trading section.

Indicators of Growth

All these policies have helped give fillip to wind energy sector, which is visible in following indicators-

Growth in Captive Market: In last five years, share of captive/Group captive wind energy installation in total installation has significantly increased.

Industry indicators: There has been 2-3 fold rise in the resale deals of wind energy projects in last 1-2 years. This clearly indicates the demand in the market which to some extent could not be fulfilled by the new project executers and suppliers. It signifies very good demand in the market for which the available supply is not able to meet the demand.

Some Problems Facing Wind Energy Sector

Though, there has been a lot of talk of maintaining this growth pace but obstacles remain e.g.-

- **Power Purchase Agreement (PPA):** It is a contract between an electricity generator and the power purchaser. The PPA is often regarded as the central document in the development of independent power plants, and is a key in obtaining financing for the project. The delays on the part of state governments and utilities to sign power purchase agreements (PPA) has put developers in a quandary about the future of their projects and this is affecting the growth of the sector.
- Wind machines must be located where strong, dependable winds are available most of the time.
- **Intermittent Nature of Energy** : Winds do not blow strongly enough to produce power all the time. Energy from windmills is considered intermittent. Therefore, electricity from wind farms must have a back-up supply from another source.
- As wind power is "intermittent," utility companies can use it for only part of their total energy needs.

- Wind turbines and its blades are subject to damage from high winds and lightening. Rotating parts, which are located high off the ground can be difficult and expensive to repair.
- Electricity produced by wind power sometimes fluctuates. This can cause difficulties in linking its power to a utility system.
- The noise made by rotating wind machine blades can be annoying to nearby residents.

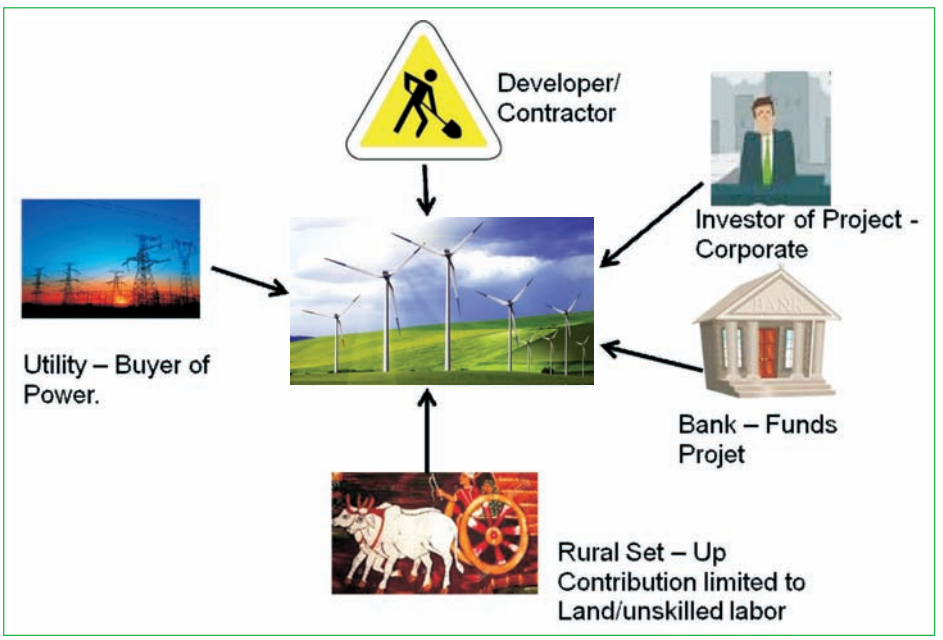
Rural India Push

Wind Energy, with all its benefits, is yet to reach to the bottom of the pyramid and penetrate within the real India that is ***Rural India.***

There are various factors which suggest and indicate the challenges and unexplored opportunities from the context of Wind Energy potential in Rural India.

Current Renewable Business Model: First & foremost important fact is that. Still, 95-96% of Wind energy is being developed at MW scale (grid connected), the cost of which runs into millions. This distances the typical Rural set up (Private or even at Panchayat level) from the direct investment.

Below picture is typical representation of any typical Wind Energy project execution. Someone can correctly argue that, why it is shown as only Wind Energy business model when more or less same is the situation or business model being followed in any industrial setup in Rural area, where the continuation of rural community is limited to only selling land or support with unskilled labor.



There is slight different in normal or routine Industrial setup/factory and Wind Energy setup. And because of this which there is scope and opportunity for involvement of rural communities without hurting the business sentiments from investor's point of view (which is obviously vital for the sustainability of the project). Few of such opportunities are listed below-

Scattered nature of Projects: Unlike any normal industrial set up, Wind Energy Projects are not confined to closed premises but are scattered in nature. This not only make windmills, as well as transmission lines, more exposed in the rural area but also it makes the relationship more delicate. An operating windmill with transmission line passing through a villager's agriculture land both can coexist easily. Now, the opportunity lies in regularising this system to make sure that these no exploitation of either party while achieving maximum financial and operational transparency.

There used to be tradition of acquiring full chunk of land for any wind project. But with recent advancements and growing competition now there is concept of acquiring only "spots" which means only a specific area of land is acquired (along with pathway) in a agriculture field from the farmer and rest is normally left with him to continue farming. This does not makes the farmer 'landless' and also reduces the cost of the investor, it is win-win for both.

Migration from unskilled to semiskilled labour: This is actual challenge and the game changer as well, if

executed even partially if not fully. Though most of companies choose obvious and easy route to adopt only unskilled labour from local area for the plant as they hesitate to train local guys due to time and cost constraint. Some states Governments have announced various promotions and rebates for hiring local skilled labour.

Youth Entrepreneurship: The need of the hour is not only promoting skilled labour but also, encourage the entrepreneurship development in local rural area. Actually business model also promotes this, this is model which does requires a lot of outsourcing and here, local and agile entrepreneurs can participate. Outsourcing may be clearing modules at solar plant, security set up or establishing a customer support set up like a BPO for wind farm etc.

Wind energy and skill India: Above analysis makes it amply clear that skilling rural youth in renewable energy technologies and entrepreneurship is a pre-requisite for getting making rural India a hub of Wind Energy. Here Govt's 'Wind Power Programme' converges with 'Skill India'.

New Real estate Regulator: After passing the Real Estate Bill in both the houses, it not very far from reality that country will have real estate regulators. Since all this is in nascent stage, policymakers have opportunity to bring in provisions for incentivising the wind sector in rural areas in the upcoming policy decisions.

Conclusion: There is no reason that India will not able to reach the ambitious renewable energy targets of current five years plan. Change in Accelerated Depreciation in wind sector can affect only to limited extent and REC market will continue to bear fruit for investors.

Wind Industry has achieved as lot, but the next milestone can only be achieved if the stake of rural sector goes beyond selling mere land. But this cannot be a one way initiative, the Govt. including the local Panchayats and the local set up should also come up with open mind and positive approach and embrace the opportunity.

(Author is a Certified Energy Manager, presently looking after Renewable Energy Business in Ruchi Soya Industries Ltd. Email: sankalp.ved@gmail.com)

SMALL HYDRO-POWER: LIGHTING REMOTE VILLAGES

G. K Rathnakar

Water is not just a liquid, essential for our survival but a good source of environment friendly, affordable and clean energy as well. The water flowing down a natural gradient can be used to turn turbines to generate electricity known as 'hydroelectric power'. With its abundant water resources, today India is the 7th largest producer of hydroelectric power, with an installed capacity of 42,783 MW. This is 14.35 per cent of total utility electricity generation in India. In addition 4,274 MW small hydro power units are installed as on 31 March 2016. In this article we will deal with small hydro power only.

Hydro power projects are generally categorized in two segments i.e. small (less than 25 MW) and large hydro (more than 25 MW). While Ministry of New and Renewable Energy is responsible for small hydro projects, the large hydro power is dealt by Ministry of Power. Small hydro power projects are further classified as-

Class	Station Capacity in kW
Micro Hydro	Up to 100
Mini Hydro	101 to 2000
Small Hydro	2001 to 25000

Advantages of Small Hydro Projects (SHPs)

The small hydro projects normally do not encounter the problems associated with large hydro projects such as-

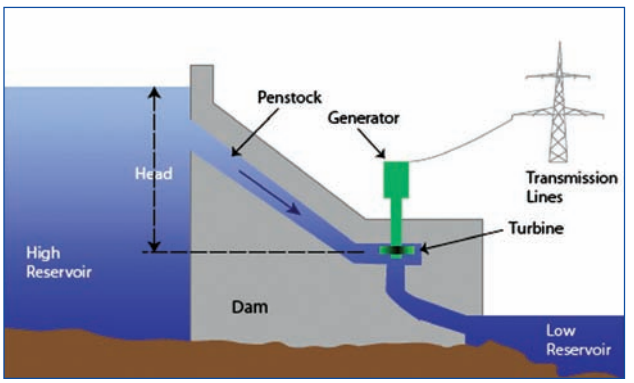
- Small hydro projects are normally run-of-river and no dam is constructed
- These projects do not encounter the issues associated with large scale hydro projects of deforestation, resettlement and rehabilitation
- The projects have potential to meet power requirements of remote and isolated areas
- The plants have long useful life and the generation cost is almost inflation free
- The plants are beneficial to environment as they substitute thermal power thereby reducing carbon emissions
- These projects have the potential to turn around economic activities in local areas, villages and remote areas

These factors make small hydro power as one of the most attractive renewable source of grid quality power generation. With the advancement of technology, it is now possible to set up economically viable low head small hydro projects on existing canals and fall structures, dam outlets and small streams spread through the country.

Constraints in setting up SHP projects

Growth in the SHP sector is relatively slow. The reasons for the slow progress may be-

- The difficult locations where SHP projects are normally set up
- Short working season in hilly areas
- Involvement of private and forest land in setting up of SHP projects
- The risks due to natural calamities in setting up SHP projects are high
- Sometimes the developers face resistance from local residents
- The SHP projects are governed by the State policies and the potential sites are allotted by the State Governments to private developers. Often there are delays in land allocations.
- Delay in clearances including land acquisition, forest clearance, irrigation clearance etc



- Inadequate evacuation facilities for power generated from SHPs

The estimated **potential** for power generation in the country from small hydro power plants is about 20,000 MW. Most of this potential is in Himalayan States as river-based projects and in other States on irrigation canals. Government is trying to promote this sector through various schemes and incentives, which are listed below-

Small Hydro Power Programme

It has been recognized that small hydropower projects can play a critical role in improving the overall energy scenario of the country and in particular for remote and inaccessible areas. The Ministry of New and Renewable Energy is encouraging development of small hydro projects both in the public as well as private sector. Though, the SHP programme is now essentially private investment driven. Projects are normally economically viable and private sector is showing lot of interest in investing in SHP projects. The viability of these projects improves with increase in the project capacity.

The focus of the SHP programme is to lower the cost of equipment, increase its reliability and set up projects at the most promising locations. The Ministry's aim is that at least 50 per cent of the potential in the country is harnessed in the next 10 years.

Water Mill Programme

It was observed that the traditional Water mills are operating at a very low efficiency of around 15 to 20 per cent. A large number of Water mills have been found in disuse. Under the Water mill programme of the Ministry, new designs of water mills have been developed with efficiency 2 to 3 times that of the traditional Water mills both for mechanical application as well as for generation of electricity. This will improve the productivity of Water mills and supply of electricity to remote localities. This is basically a scheme which is directly benefiting the local people living in the difficult remote and hilly areas of Himalayan & sub Himalayan region of the country.

National Mission on Small Hydro

A draft was released last year on National Mission on Small Hydro by the Govt of India. The Mission will be a joint initiative of the Government of India and State Governments to enrich remote and rural areas in power generation. **It would give unique opportunity of entrepreneurship development, livelihood opportunities in rural areas and would be an effective tool to achieve round the clock power to all. Mission recognises that small / micro hydro projects and watermills have the potential to provide sustainable economic growth to village community along with livelihood and agro/ cottage/ small industrial activities.**

Draft attributes the sharp increase in installed capacity of SHP projects during 10th and 11th plan to the participation of private sector. However, this situation has changed is recent past. The Private sector is no more finding SHP sector attractive enough to make investments.

Reasons for this are –

- The costs of projects have gone up and tariff given to the power generated from SHP projects is no more attractive. The present cost per megawatt of small hydro projects is now touching about Rs. 8.50 crore to Rs. 9..50 crore per MW which was around Rs 5- 6 crore per MW a few years ago.
- Low rate of average pool power purchase rate in hydro rich states
- Non-sale of Renewable Energy Certificates in the open market
- Long implementation time
- Multi departmental statutory clearances associated with the projects including land acquisition, forest clearance, irrigation, fisheries, district administration, local panchayat, clearance etc.
- With only the large rivers in the country being properly mapped, hydro power producers have to rely on insufficient data on water geography and rain flow on the other rivers

The objective of the National Mission on Small Hydro is to address issues responsible for decline of SHP sector in the country and to regenerate interest of private sector to make investment in this renewable energy sector. Technological

innovation, new methods of civil construction, standard designs and automation can be helpful in arresting the increase in cost of projects.

Manufacturing capabilities

The current manufacturing capacity for small hydro equipment is of about 1500 MW per year. About 70 per cent of the capacity is used for export. All major equipment manufacturers of Europe are represented in India. Small hydro is technically matured sector with an experience of about 120 years. The equipment used in small hydro projects is normally over 80 per cent efficient.

Monetary Incentives for small hydro projects by MNRE

State	Public Sector	Private Sector
North-Eastern States & Special category states of J&K, HP and Uttarakhand	Rs.7.50 crore per MW, limited to Rs.20 crore per project	Rs.3.5 crore per MW, limited to Rs. 20 crore per project.
Other States	Rs.1.50 crore per MW limited to Rs.5 crore per project	Rs.1 crore per MW limited to Rs. 5 crore per project

Modified Hydro Electric Turbine – A Success Story of a Farmer

Author, a farmer himself, lives in a hilly region of Karnataka, having many natural water streams. A 100 feet stream flows right through my backyard and thus thought of generating electricity from this struck my mind. With no technical knowledge or guidance available, I started experimenting by myself through trial and error method. After years of self learning and mistakes in experiments, I managed to generate electricity for my own domestic needs.

Modified Hydro Electric Turbine, developed by the author, in action

Another model of Modified Hydro Electric Turbine

I kept improving the turbine and started manufacturing it for others as well on their demand. So far, I have set up over 360 turbines in Dakshina Kannada, Chikmagalur, Kadagu and Hassan districts of Karnataka. National Innovation Foundation was very helpful in bringing my innovation to outer world. Finally best moment of my life came when I was awarded by then Hon'ble President of India Dr APJ Abdul Kalam for my innovation.

Some advantages of Modified Hydro Electric Turbine are-

- Water is not exhausted, it can be used for agriculture applications
- Minimal maintenance (after 2.5 -3 years)
- Low noise level
- Cost efficient
- Can generate AC power which can be used directly

For sustainable operation over a long period, it is recommended to form a self help group in the village who would look after operation and maintenance of the turbine and electrical system.

(Author is an innovator and proprietor of Turbo – Turbine Lights, Chikmagalur, Karnataka. He was awarded by the President of India for his innovation. Email: turbojpr@gmail.com)

BIOFUELS – A NEW AVENUE FOR FARMERS

Salman Zafar

India has a tremendous biomass potential which could easily be relied upon to fulfil most of our energy needs. An estimated 5 crore metric tonnes of liquid fuels are consumed annually in India, but with the actual biomass potential and its full utilization, India is capable of generating almost double that amount per annum.

The term 'Biofuel' refers to liquid or gaseous fuels for the transport sector that are predominantly produced from biomass. A variety of fuels can be produced from biomass resources including liquid fuels such as ethanol, methanol, biodiesel, Fischer-Tropsch diesel, and gaseous fuels such as hydrogen and methane.

The **first-generation** liquid biofuels are made from sugar, starch, vegetable oils or animal fats using conventional technology. The basic feedstocks for the production of first-generation biofuels come from agriculture and food processing. The **second-generation** technologies use a wider range of biomass resources – agriculture, forestry and waste materials. **Third-generation** biofuels may include production of bio-based hydrogen for use in fuel cell vehicles, e.g. algae fuel, also called oilgae.

Globally, liquid biofuels are most commonly used to power vehicles, heat homes and for cooking. Biofuels offer many benefits including sustainability, less greenhouse gas emissions, regional development, wasteland agriculture and security of supply.

The **biomass resource** base is composed of a wide variety of forestry and agricultural resources, industry residues and municipal solid and urban wood residues. The **forest resources** include residues produced during the harvesting of forest produce, fuel wood etc. Some forest resources also become available through initiatives to reduce fire hazards and improve forest health.

The **agricultural resources** include grains used for biofuels production, animal manures and crop residues derived primarily from corn and small grains (e.g., wheat straw). A variety of regionally significant crops such as cotton, sugarcane, rice and orchards can also be a source of crop residue. Municipal and urban wood residues are also widely available.

Other advanced biofuel feedstocks include non-plant sources such as fats, manure and the organic material found in urban waste. In addition, algae production has great promise because algae generate higher energy yields and require much less space to grow than conventional feedstocks. Also, algae would not compete with food crops for land and could be grown with minimal inputs using a variety of methods.

Jatropha Plant

Biofuel Feedstock

First-generation biofuels (produced primarily from food crops such as grains, sugar, beet and oil seeds) are limited in their ability to achieve targets for oil-product substitution, climate change mitigation and economic growth. Their sustainable production is under review, as is the possibility of creating undue competition for land and water used for food and fiber production.

These concerns have increased the interest in developing biofuels produced from non-food biomass. Feedstocks from **ligno-cellulosic materials** including cereal straw, bagasse, rice husk, forest residues and purpose-grown energy crops such as vegetative grasses and short rotation forests. These second-generation biofuels could

avoid many of the concerns facing first-generation biofuels and potentially offer greater cost reduction potential in the longer term.

Forest Resources

Primary

- Logging residues from conventional harvest operations and residues from forest management and land clearing operations
- Removal of excess biomass (fuel treatments) from timberlands and other forestlands
- Fuel wood extracted from forestlands

Secondary

- Primary wood processing mill residues
- Secondary wood processing mill residues
- Black liquor

Tertiary

- Urban wood residues — construction and demolition debris, tree trimmings, packaging wastes and consumer durables

Agricultural Resources

Primary

- Crop residues from major crops — corn stover, small grain straw and others
- Grains (corn and soybeans) used for ethanol, biodiesel and bioproducts
- Perennial grasses
- Perennial woody crops

Secondary

- Animal manures
- Food/feed processing residues
- Tertiary
- Post-consumer residues and landfill gases

In countries like India, human demand for food and feed oilseed crops (e.g. soybean, sunflower) exceeds supply, so it is not desirable to divert large quantities of these crops for biofuels **However large wasteland areas are available that might be cultivated with non-conventional oilseed species that are not consumed by humans but can withstand such rugged conditions, e.g. Pongamia and Jatropha**. In recent years, juice from sweet sorghum (*Sorghum bicolor*) stalks is emerging as a viable source for bioethanol production. Sweet sorghum grows rapidly, is photosynthetically efficient due to its C4 metabolism, and is widely adaptable.

The Government of India approved the National Policy on Biofuels in December 2009. The biofuel policy encouraged the use of renewable energy resources as alternate fuels to supplement transport fuels (petrol and diesel for vehicles) and proposed a target of 20 percent biofuel blending (both bio-diesel and bio-ethanol) by 2017. The government launched the National Biodiesel Mission (NBM) identifying *Jatropha curcas* as the most suitable tree-borne oilseed for bio-diesel production.

Bioethanol or Cellulosic Ethanol

Cellulosic ethanol (or bioethanol) technology is one of the most commonly discussed second-generation biofuel technologies worldwide. The largest potential feedstock for bioethanol is lignocellulosic biomass, which includes materials such as agricultural residues (corn stover, crop straws, husks and bagasse), herbaceous crops (alfalfa, switchgrass), short rotation woody crops, forestry residues, waste paper and other wastes (municipal and industrial). Bioethanol production from these feedstocks could be an attractive alternative for disposal of these residues in developing countries such as India. Lignocellulosic feedstocks do not interfere with food security and are important for both rural and urban areas in terms of energy security reason, environmental concern, employment opportunities, agricultural development, foreign exchange saving, socioeconomic issues etc.

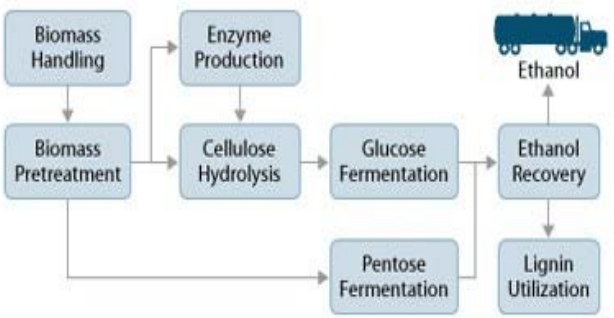
The production of ethanol from lignocellulosic biomass can be achieved through two different processing routes. They are:

- Bio-chemical – in which enzymes and other micro-organisms are used to convert cellulose and hemicellulose components of the feedstocks to sugars prior to their fermentation to produce ethanol;
- Thermo-chemical–where pyrolysis/gasification technologies produce a synthesis gas ($CO + H_2$) from which a wide range of long carbon chain biofuels, such as synthetic diesel or aviation fuel, can be reformed.

Compared with the production of ethanol from first-generation feedstocks, the use of lignocellulosic biomass is more complicated because it contains polysaccharides. These polysaccharides are more stable and the pentose sugars are not readily fermentable. So polysaccharides must first be hydrolysed, or broken down, into simple sugars using either acid or enzymes.

Ethanol from lignocellulosic biomass is produced mainly via bio-chemical routes. The three major steps involved are pretreatment, enzymatic hydrolysis and fermentation. Biomass is pretreated to improve the accessibility of enzymes. After pretreatment, biomass undergoes enzymatic hydrolysis for conversion of polysaccharides into monomer sugars such as glucose and xylose. Subsequently, sugars are fermented to ethanol by the use of different microorganisms.

Schematic of a Biochemical Cellulosic Ethanol Production Process



The world's largest demonstration facility of lignocellulose ethanol (from wheat, barley straw and corn stover), with a capacity of 25 lakh litres, was established by Iogen Corporation in Ottawa, Canada. Many other processing facilities are now in operation or planning throughout the world.

Biodiesel

Biodiesel in India is mostly produced from the oils extracted from the seeds of *Jatropha*, mainly because of the fact that edible oil is scarce and the country already depends on huge quantity of imported oils for edible purposes. **Apart from *Jatropha*, *Pongamiapinnata*, Mahua, Neem and Castor are also considered as good source of non-edible oil-based biodiesel in India.** In Western countries, biodiesel is typically made from vegetable oil (rapeseed oil, sunflower oil and palm oil), animal tallow and used cooking oil. Rapeseed oil has 82 percent of the share of the world's biodiesel feedstock followed by sunflower oil, soybean and palm oil.

Jatropha is a genus of nearly 175 species of shrubs, low-growing plants, and trees. However, discussions of Jatropha as a biodiesel plant actually means a particular species of the plant, *Jatropha curcas*. The plant is indigenous to parts of Central America, however it has spread to other tropical and subtropical regions in Africa and Asia. *Jatropha curcas* is a perennial shrub that, on average, grows approximately three to five meters in height. It has smooth grey bark with large and pale green leaves. The plant produces flowers and fruits in winter or throughout the year depending on temperature and soil moisture. The *curcas* fruit contains 37.5 percent shell and 62.5 percent seed. *Jatropha curcas* can be grown from either seed or cutting.

By virtue of being a member of the *Euphorbiaceae* family, *Jatropha* has a high adaptability for thriving under a wide range of physiographic and climatic conditions. It is found to grow in almost all parts of the country up to an elevation 3000 feet. *Jatropha* is a perennial plant, suitable for all soils including degraded and barren lands. It occupies limited space hence is highly suitable for intercropping. Extensive research has shown that Jatropha requires low water and fertilizer for cultivation, is not grazed by cattle or sheep, is pest resistant, is easily propagated, has a low gestation period and has a high seed yield and oil content. It also produces high protein manure.

Pongamiapinnata or *Karanj* is another promising non-edible oil seed plant that can be utilized for oil extraction for biofuels. The plant is a native to India and grows in dry places, far in the interior and up to an elevation of 1000 meters. *Pongamia* plantation is not much known as like *Jatropha*, but the cost effectiveness of this plant makes it more preferred than other feedstock. *Pongamia* requires about four to five times lesser inputs and gives two to three times more yield than *Jatropha.* This makes it quite suitable for small farmers in India. However, *Pongamia* seeds have about 5-10 percent less oil content than *Jatropha* and the plant requires longer period to grow as the gestation period is about 6-8 years for *Pongamia* against 3-5 years in *Jatropha*.

There are three major steps in biodiesel production:

(i) plantation—production of oil seeds,

(ii) oil extraction—production of straight vegetable oil (SVO), and

(iii) trans-esterification— production of biodiesel.

Biorefinery Prospects in India

Biorefinery is analogous to the traditional petroleum refineries employing fractional distillation process for obtaining different fractions or components from the same raw material, i.e. the crude oil. Biorefinery involve the integration of different biomass treatment and processing methods into one system, which results in the production of different components from the same biomass. This makes the entire chain more viable economically and also reduces the waste generated.

India has a tremendous biomass potential which could easily be relied upon to fulfil most of our energy needs. An estimated 5 crore metric tonnes of liquid fuels are consumed annually in India, but with the actual biomass potential and its full utilization, India is capable of generating almost double that amount per annum. These biomass estimates only include the crop residues available in the country and essentially the second-generation fuels since the use of first-generation crop based fuels in such food-starved nations is a criminal thought.

Currently, there are various technologies available to process such crop-residues and generate value products from them. However, essentially, they all revolve around two main kinds of processes, either bio-chemical or thermo-chemical. The bio-chemical process involves fermentation to produce ethanol or trans-esterification to produce biodiesel. Alternatively, the thermo-chemical processes involve heat-based processes like combustion (to produce heat), gasification (to produce gas) or pyrolysis techniques (to produce liquid fuels). These products can be used as such, or could be further processed to generate high quality biofuels or chemicals.

Biorefineries can help in utilizing the optimum energy potential of biomass wastes in India and may also help in climate change mitigation to a certain extent. Biomass can be converted, through appropriate enzymatic/chemical treatment, into either gaseous or liquid fuels. The pre-treatment processes involved in biorefining generate products like paper-pulp, solvents, acetate, resins, laminates, adhesives, flavour chemicals, activated carbon, fuel enhancers, undigested sugars etc. which generally remain untapped in the traditional processes. The suitability of this process is further enhanced from the fact that it can utilize a variety of biomass resources, whether plant-derived or animal-derived.

(Author is the CEO of BioEnergy Consult and Founder of Doha-based EcoMENA. Email: salman@bioenergyconsult.com)

BIOMASS ENERGY: SCOPE IN INDIA

Martand Shardul, Shilpa Mohan, Mohd. Asim Mirza, Devender Singh, M.K. Pandey

At present, based on learnings from National Biomass Cookstoves Initiative (NBCI), the government is implementing *Unnat Chulha Abhiyan* (UCA) during the 12th Five year plan period. This scheme has an overall target of 24 lakh family type cookstoves and over 3 lakh community cookstoves.

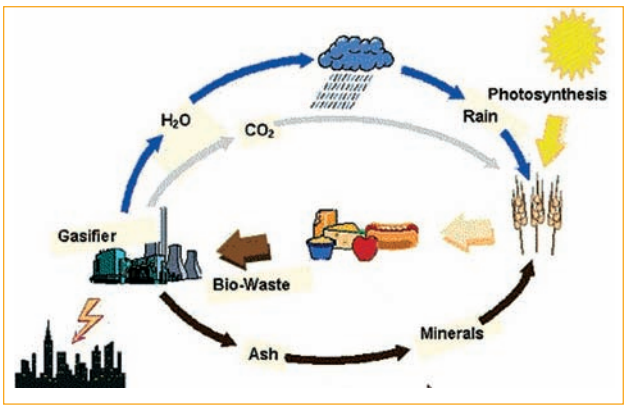
Thousands of years back, man invented three stone fire and even today in the 21st century, over 2.6 billion people globally depend on traditional cookstoves for cooking. A majority of them - over 70 crore people, live in India. The traditional burning of solid biomass such as firewood, crop residue, coal and charcoal in poorly ventilated space, is a source of indoor air pollution (IAP). Another major source of IAP is the kerosene wick lamp which is used as primary source of lighting in over 25 percent of the rural households. IAP is linked to almost 40 lakh global deaths and over 2 lakh annual deaths in India alone. Incidentally, a majority of those who are exposed to IAP are women and the accompanying children. The soot emanating from traditional cookstoves and the kerosene wick lamps is a major source of black carbon, an aerosol which is a catalyst for climate change. A majority of those who lack access to clean cooking and clean lighting live in rural and remote areas of the country where poverty is a common trait. Hence, the lack of clean energy access has social, economic and environmental implications.

Addressing the energy access challenge – biomass as a source of energy

Post industrialization, fossil fuels such as coal, kerosene and Liquefied Petroleum Gas (LPG) have become preferred fuel sources for electricity generation and cooking. However, these fuels are non-sustainable and cannot be replenished. **Fossil fuels make the country dependant on imports and at the same time fuel price fluctuation make the poor vulnerable. Hence, there is an immense thrust on tapping renewable energy sources such as the biomass energy for cooking and electricity generation.**

The common sources of biomass energy are wood, food & agricultural waste and landfill gases. In its raw form, the most prevalent use of biomass energy is for cooking in rural households. It is also worth mentioning that a majority of rural homes practice cookstove stacking and fuel stacking. This implies, households that have access to LPG fuel also often possess traditional cookstoves and biomass fuel such as woodchips and crop residue.

In 2006, in compliance with Section 4 and 5 of the Electricity Act, 2003, Rural Electrification Policy of the government provisioned for renewable energy based decentralized electricity generation and distribution so as to facilitate access to electricity to every household. This led to emergence of several renewable energy service companies (RESCOs) that are using biomass such as rice husk, which was earlier considered a waste, for decentralized electricity generation and distribution. In addition, several micro small and medium enterprises undertake biomass based captive power generation to meet their electricity needs in rural areas. **Unlike fossil fuels, biomass absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Therefore, it does not add carbon dioxide to the atmosphere.**



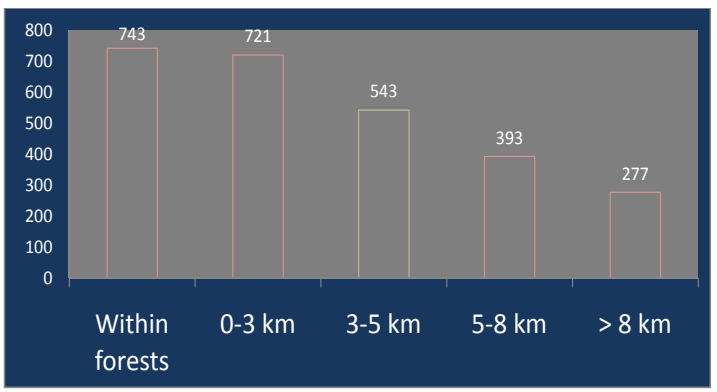
Current status of biomass energy

As per recent Energy Statistics report of the government, it is estimated that India has a biomass power potential of 17,538 MW and a potential of another 5000 MW from bagasse based cogeneration in sugar mills. The states of Punjab (3172 MW), Maharashtra (1887 MW) and Uttar Pradesh (1617 MW) are estimated to have highest biomass power potential in the country. As of 31st March 2014, biomass power constitutes 12.66 percent of the total installed renewable based power generation capacity. Further, it is reported that India has a cumulative installation of off-grid/decentralized biomass energy systems of over 500 MWs.

Challenges in usage of biomass energy

As per the India State of Forest Report 2011, forest and tree cover in India is estimated to be around 24 per cent of the geographical area of the country. Energy sector and forests are closely linked at local levels as wood fuel is key source of energy in rural areas. As per statistics presented in (FAO, 2005), in 2005, over 41.5 lakh tonnes of fuel wood was removed from forests. Similarly, it is estimated that close to 27 per cent of total firewood consumed is from forests. The inefficient usage of biomass fuels such as wood from forest has severe implications on the biodiversity and green cover of the country. It is estimated that the per capita consumption of fuel wood is higher for communities that are living closer to forests (Figure 1).

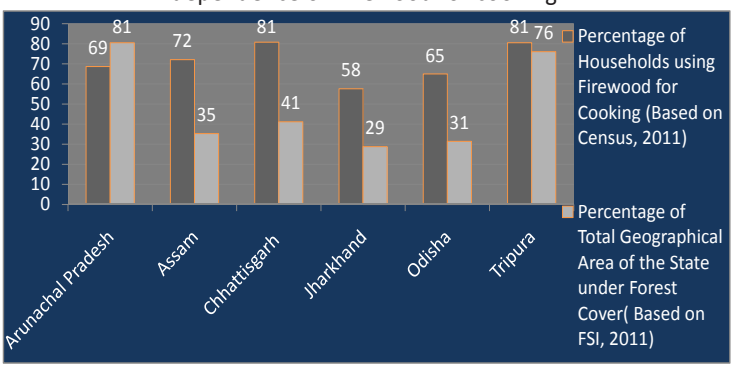
Figure 1: Per capita consumption (in Kgs) of fuel wood in relation to distance from forests



Source: Adopted from Pandey, 2002

A mapping of Census of India 2011 data reveals that states having higher forest cover have more number of households that are reliant on solid biomass for cooking (figure 2).

Figure 2: State wise data for forest cover and dependence on firewood for cooking



Source: Adopted from MoEF and TERI, 2013

From the above, it is evident that forest degradation is a serious challenge emerging from un-sustainable consumption of firewood by households and enterprises. Also, direct usage of firewood has been characterized with energy inefficiency and environmental hazards.

National schemes for promoting usage of biomass energy

Owing to the above, both sustainable biomass supply and efficient usage of the biomass energy source are among priorities for the government.

Sustainable Supply of biomass from forests: In the past consumption of biomass from forests has been reported to exceed the overall demand. Further, over extraction of biomass from forests can lead to irreversible consequences on the climate and local ecology. Hence, the Ministry of Environment, Forest and Climate Change (MoEF&CC) has been promoting social forestry in the country. Some of the key programs/schemes are mentioned below:

Acts such as the Indian Forest Act, 1927, the Forest Conservation Act 1980 and The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 emphasize on the role of forest conservation and rights of the forest dwelling communities.

The government has also been promoting social forestry through various means. Government's programs/schemes such as National Afforestation Programme (NAP), Joint Forest Management (JFM) and the Green India Mission (GIM) focus on enhancing the green cover and the quality of forests in India by involving the communities, Panchayats and the Civil Society in the process.

Efficient usage of the biomass energy source: Efficient use of biomass energy at household level and in enterprises, for thermal and power needs, can tremendously reduce the overall energy demand and consequently, the financial burden for energy services on the end user. To realise this, India has been promoting a range of interventions at various levels. Some of the key schemes have been highlighted below:

- **At household level:** Government's earliest scheme for introducing efficient usage of biomass for cooking commenced during the Sixth five year plan with the launch of National Programme on Demonstration of Improved *Chulha*. Around 8.12 lakh Improved *Chullahs* (ICS) were installed then. Almost all previous programs of the government have missed on facilitating market based mechanisms for ICS in rural India. In 2009, a National Biomass Cookstoves Initiative (NBCI) was launched by Ministry of New and Renewable Energy (MNRE) to augment usage of ICS. **At present, based on learnings from NBCI, the government is implementing *Unnat Chulha Abhiyan* (UCA) during the 12th Five year plan period. This scheme has an overall target of 24 lakh family type cookstoves and over 3 lakh community cookstoves.**
- **Power Generation through biomass gasification:** MNRE promotes setting-up of biomass gasification based power generation plants by a range of stakeholders including Self-Help Groups, Civil Society Institutions, Panchayats, Cooperatives and the private sector. The government has also provisioned biomass gasification based decentralized power generation and distribution for rural areas and for captive use by enterprises. In order to promote adoption of the technology, government provides central financial assistance/subsidies to the institutions that set-up such units. At present, there are provisions to install hybrid power systems that combine biomass gasification based power generation with other sources of power generation. State governments such as the Uttar Pradesh government has introduced their own polices to further facilitate the attainment of the goals of the Central government.
- **Biomass based Grid Interactive Power Generation Systems and Cogeneration**: Biomass such as sugarcane bagasse, de-oiled cakes, rick husk etc is used for generation of power that can be fed into the central grid system. Also, several sugar mills are currently using bagasse for cogeneration in order to meet their power requirements.
- **Biomass Briquetting**: The government also promotes the usage of biomass pellets or biomass briquettes for industrial and households purposes. Briquetting allows for efficient use of fuel for thermal processes.

In addition to the above, research institutions, civil society institutions, multi-lateral and bi-lateral institutions have been undertaking numerous

Traditional cookstove

Improved cookstove

Augmenting access to improved biomass cookstoves in India: The Energy and Resources Institute (TERI's) interventions and partnerships

As part of Project Surya (http://www.projectsurya.org/), TERI in partnership with University of California, San Diego crated evidence for the effectiveness of forced draft ICS. Based on primary research conducted in Uttar Pradesh, Project Saurya documented the effectiveness of forced draft ICS towards climate change mitigation and established that natural draft ICS has no substantial health and environmental benefits. Later, as part of DFID-TERI partnership, TERI facilitated creation of market value chain for ICS in rural India. As part of the development cooperation, over 40,000 forced draft ICS were disseminated through independent micro-enterprises operating in rural areas. This partnership also led to roll-out of Integrated Domestic Energy Systems (IDES) which includes forced draft ICS, solar lighting and mobile phone charging point (http://labl.teriin.org/technologies.php). Further, to augment sales of ICS, Project Surya piloted the Carbon Credit Pilot Project (cleancooking.org) with an aim to provide climate credits to end users based on their actual usage of ICS which was tracked using smart IT enabled solutions such as the SootSwap.

projects to create evidence for viability of biomass as an energy source and to enhance efficiency of biomass based technologies (Box 1). For example in case of the Improved Chullahs (ICS) technology, unavailability of both enterprise finance and consumer finance restricts adequate technology research, and also limits adoption of the technology by end users at last miles. Adoption of any new technology has its own realisation time. **However, majority of the ICS manufacturers who are small players focus only on retail sales and de-prioritize after-sales-service. Therefore, poor consumers who have limited disposable incomes lose confidence on ICS technology the moment it goes out of order. Also, any single ICS product model might not match with requirements and preferences of any two communities. This is aggravated due to range of factors such as difference in their food habits and difference in primary fuel type (hard wood, wood twigs, crop residue, dung cake or a mix of two or more fuel) used for cooking**. All of these call for participation of the development sector in the clean cooking space.

Beyond energy access

The biomass energy sector presents ample opportunities for job creation in India. As per MNRE's Human resource development strategy for Indian RE sector report, estimated that 35,000 people were engaged in employment through biomass on-grid systems in 2009. The report also projected employment of 60,000 and 1 lakh people by 2020 in biomass on-grid under moderate and high growth scenarios respectively. It further projected employment of 63,000 people by 2020 in the biomass gasification sub-sector. **However, biomass gasification based electricity generation and distribution companies in rural areas have been facing acute skills crunch. While there are ITI level courses for solar energy in India, there isn't any curriculum recommended by the government for biomass gasifier sector. To address this challenge, Bihar based Husk Power Systems (HPS) has set-up Husk Power University, a captive institution for skills building of local youth.**

Way forward and conclusion

Using a mix of energy sources has become necessary, to meet the growing energy demand of the country, in this context biomass energy has a big role to play in the coming years. At present there is a dire need to formulate policies for facilitating research and skills development in the area of biomass energy. Unlike solar technologies, because of under-developed markets, biomass-based technologies, such as the ICS require participation of development agencies, government institutions, civil society, and the business. At the same time, it is important to map the existing biomass potential of the country and integrate it into the mainstream energy system.

(Authors are from The Energy and Resources Institute (TERI), New Delhi. Email: Martand.Shardul@teri.res.in)

RURAL WASTE TO ENERGY & SWACHH BHARAT

Suneel Pandey

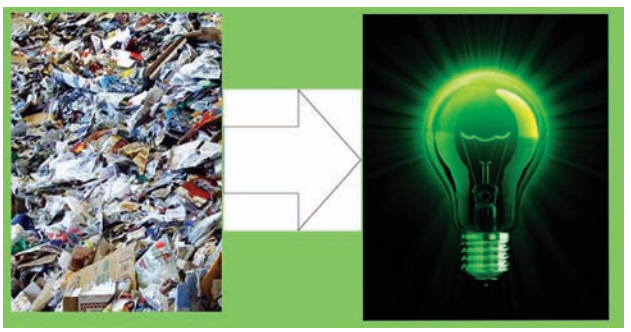
The funds required to establish, operate and create rural entrepreneurship can partly come from *Swachh Bharat Abhiyan* (SBA) (rural) and also from Corporate Social Responsibility (CSR) funds available from the corporate sector in the country. At the later stages of project implementation on rural waste to energy, a competition somewhat similar to clean city can also be initiated with villages implementing these projects in order to keep them clean.

The issue of solid waste management, till now, was not so much of a problem as per capita consumption of materials and hence, per capita generation of solid waste was much lower among rural populace as compared to the urban. Moreover, the rural population was also diffused and most of the solid waste generated was essentially organic in nature (food waste and agri residue), which was either composted or used as fodder. There was very less usage of packaged materials and hence, very little packaging waste generation.

Situation is however fast changing in rural, more so, in rural-urban areas, where use of packaged materials is growing and the waste composition is also becoming complex. This can no longer be handled by simple processing techniques like composting but requires more robust and locally available waste processing options to deal with the solid waste without polluting the environment.

As of now, it is estimated that rural India is generating liquid waste (greywater) of the order of 1,500 to 1,800 crore litres and solid waste (organic/recyclable) 3 to 4 lakh metric tonnes per day respectively. The production of energy from such waste, especially solid waste, will depend upon the specific treatment processes, seasonal variations etc. Important physical parameters are the size of the constituents and the density and moisture content of the waste. The important chemical parameters are the fixed carbon content, calorific value, VS (volatile solid) contents, Carbon to Nitrogen ratio (C:N ratio), toxicity and inert fraction present in waste.

In addition to solid and liquid waste, the rural areas also generate agri-residues and forestry biomass waste, which can be utilised for energy generation. A study carried out by The Energy and Resources Institute (TERI) on availability of biomass for energy generation in selected districts reveals that there is surplus biomass available in rural areas which can be effectively used for energy generation. For example, the survey estimated that there is 54,600 and 70,000 tonnes of annual surplus biomass from agricultural and industrial sources in Pune and Thane districts of Maharashtra.



Technology option for energy generation from waste in rural areas

Different waste processing technology options, which are commercially viable in Indian conditions and can be used at the scale from 50 kg/day to 1.5-2.0 tonnes/day, can be deployed in rural areas include:

1. **Anaerobic (without air) digestion or biomethanation process and using it for-**

a) Thermal application (e.g. cooking)

b) Power generation

c) The residue of the process can be stabilised and used as manure

2. Processing waste into refuse derived fuel (RDF) and using it for-

a) Thermal application (e.g. cooking mid-day meals in schools)

b) Power generation by burning RDF

3. Use of waste in gasifiers to convert it into producer gas and use it for power generation

These technology options are describes below.

Anaerobic digestion

Solid and liquid wastes consist of both organic and inorganic constituents, and the degradation of the organic constituents can take place in the presence or absence of oxygen (air). When microbial degradation of organics takes place in the absence of air, the process is known as 'anaerobic digestion' or 'biomethanation'. This results in the production of biogas, which contains methane, carbon dioxide and traces of other gases.

Anaerobic digestion occurs naturally in swamps, waterlogged soils and rice fields, deep-water bodies and in the digestive systems of animals. Anaerobic processes can take place in a reactor such as digester vessel, covered lagoon or landfill in order to recover the methane gas (as biogas), which can be used for power generation. Waste, which contains particulate organic material (waste sludge, food waste, vegetable waste, etc.), must first be solubilised by the action of extra cellular enzymes that are produced by the hydrolytic bacteria. The solubilisation of particulate material is relatively slow and takes time. The process can be sometimes hastened by chemical solubilisation or leaching.

After solubilisation, in next phase, wastes containing soluble organics will require short retention times for achieving high treatment efficiency to produce methane rich biogas using acidogenic and methanogenic bacteria. The typical food waste or vegetable waste having moisture content of 45 per cent or more, is an ideal waste to be processed anaerobically as the process requires easily biodegradable waste with high moisture content.

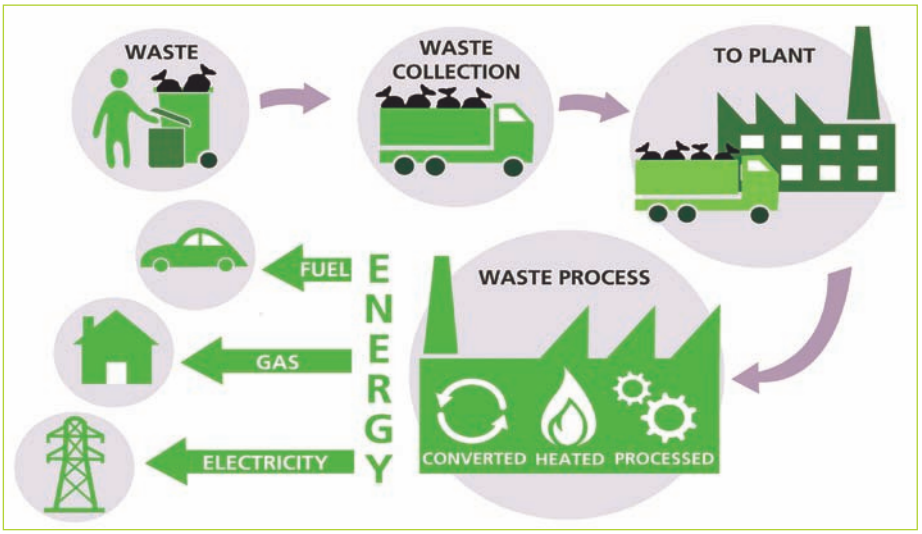
Typical composition of biogas can range from 45 to 65 per cent methane which can be used both for thermal as well as electrical applications. The leftover residue, as stated earlier, can be used as manure.

Refuse Derived Fuel (RDF)

Refuse Derived Fuel (RDF) commonly refers to solid waste that has been mechanically processed to produce a storable, transportable, and more homogeneous fuel for combustion. The typical processes involved in producing waste to RDF pellets include following steps:

- Drying to reduce moisture content
- Size reduction
- Screening
- Pneumatic separation for the removal of non-combustible materials
- Mixing with additives
- Pelletisation

The waste is pre-processed to remove incombustible materials, thus increasing the calorific value of the fuel. The incombustible materials are removed using various mechanical methods for example, ferrous metals are removed using magnetic separators; glass, grit, and sand is removed through screening. Some systems utilize



air classifiers, trommel screens or rotary drums to further refine the waste.To reduce the cost of producing RDF, one can also look at producing waste fluff instead of palletisation which adds to the cost, but pellets can be stored for longer time and can be transported easily. Good candidate wastes for producing RDF include agri residues, hard woody waste, waste plastics, paper, rags, leather and such organic waste which are not easily biodegradable and have low inherent moisture content (typically in the range of 10%).

RDF can be co-fired with fossil fuels in existing industrial (e.g. boilers in sugar mills or paper and pulp industry which are often located in rural areas) or utility boiler, or it can be used as the sole or primary fuel in specially designed "dedicated" boiler for producing either heat or power or both. Co-firing of RDF has the obvious advantage of capital cost savings since a new boiler is not required. However, RDF as the primary fuel burning in a dedicated boiler has become more common, since the dedicated boiler can be designed to accommodate some of the characteristics of RDF that can otherwise cause operating problems in existing boilers designed for conventional fuels.

The processed RDF can also be used as fuel in cooking mid-day meals for the schools. Biomass based briquettes or pellets are already being used as fuel in such scheme in suitably designed stoves. Use of this fuel comes out to be cheaper than using LPG and thus reduces the cost of cooking. The gross calorific value of RDF with binder is in the range of 4000-4500 Kcal/Kg and without binder 3000-3700 Kcal/Kg.

If power generation through use of RDF is considered as an option in rural settings, it is suggested to use "hub and spoke" model wherein RDF processing is in semi-mechanised manner in decentralised locations, preferably close to the source of waste. This would not only ensure that the cost of processing is less

Table : Suitability of different waste-to-energy technologies for India

Technology	Advantages	Disadvantages	Applicability for India
Anaerobic digestion or Biomethanation	• Can be small scale with no external power source requirement • Totally enclosed system; modular construction possible • Odour and visible pollution reduced	• Highly capital intensive • Requires high degree of biodegradable material	Recommended only with segregated waste
Refuse Derived Fuel (RDF) burning	• Fuel produced has high energy content • Fuel is convenient to store and transport	• High energy consumption for crushing and drying of waste • High inorganic content reduces the effectiveness of fuel • Favourable in areas having lower rainfall • May require gas clean up to avoid toxic emissions	Recommended for Indian conditions. Indian projects are presently using waste fluff (step before pelletisation) thus reducing the cost of production. Solar drying is also an option to reduce pre-processing cost
Gasification	• Can be small scale with modular design • Closed system with no smell, odour • Less expensive gas clean up system than incinerators	• Net energy recovery might be affected by excessive moisture • No commercial model on waste as yet	Technology adaptation for waste feedstock required, therefore not recommended

Source: Compiled by TERI

but also transportation cost of waste is minimized and power generated in this manner can be easily transported and stored.

Use of Gasifiers

Conventional incineration uses air for combustion and oxidation reactions whereas gasification operates in a partial oxidation mode (gasification). The consequence of this is that flue gas streams from incinerators are at a high volume, requiring major investment for gas cleaning equipment, whereas pyrolysis and gasification produce more concentrated syngas (synthesis gas) which can be cleaned in significantly lower volume (and lower cost) equipment. Typical output of gasification process can be:

- Produce syngas that is cooled and cleaned prior to the direct generation of electricity with gas engines.
- Produce a transportable fuel, either as a solid char that is subsequently combusted to generate energy conventionally, or clean methanol/ hydrogen for use as fuel, or bio-oil that can be used as a low-grade fuel.

Typical wastes which can be gasified are again similar to one which are subject to RDF processing, viz. agri residues, hard woody waste, waste plastics, paper, rags, leather and such organic waste which are not easily biodegradable and low inherent moisture content (typically in the range of 10%). Use of biomass based gasifiers also has found application in mid-day meal preparation for thermal application. Coal based gasifiers were extensively being used by Ceramic clusters in Gujarat and industry found it to be cheaper than using LPG. The issue to be addressed in using gasifiers however, is to develop environmental standards and protocols for the sector and scaling out of the technology diffusion.

Recommendations

Based on above summary of technological options, it can be said that:

- Producing RDF from source segregated waste and use in already existing boiler or dedicated boiler holds promise and the technologies are commercially available
- Biomethanation must be considered a high priority for waste-to energy projects in rural areas due to the combination of cost, technology, effectiveness and environmental benefits.
- Gasification has a distinct promise, and although there are limitations to its uptake, these can be solved as the technology matures.

Swachh Bharat Abhiyan

To make these projects effective, their long term operation and maintenance needs to be ensured. **The rural youth can be trained to manage these projects and can thus get livelihood out of keeping the rural areas clean and managing waste scientifically and also generating energy in the process of managing waste. This will also be in accordance with Swachh Bharat Abhiyan (SBA) launched by the Prime Minister, which attempts to ensure that India becomes clean and affordable and sanitation services are provided and used by all.**

The funds required to establish, operate and create rural entrepreneurship can partly come from SBA (rural) and also from Corporate Social Responsibility (CSR) funds available from the corporate sector in the country. At the later stages of project implementation on rural waste to energy, a competition somewhat similar to clean city can also be initiated with villages implementing these projects in order to keep them clean. A suitable recognition at the village Panchayat level will keep them motivated in the long term and help sustaining these initiatives.

(Author is Director, Green Growth & Resource Efficiency Division, The Energy and Resources Institute. Email: spandey@teri.res.in)

BIOGAS : A CLEAN ENERGY ALTERNATIVE

Virendra Kumar Vijay, Ram Chandra, Vandit Vijay, Bhaskar Jha, Abhinav Trivedi

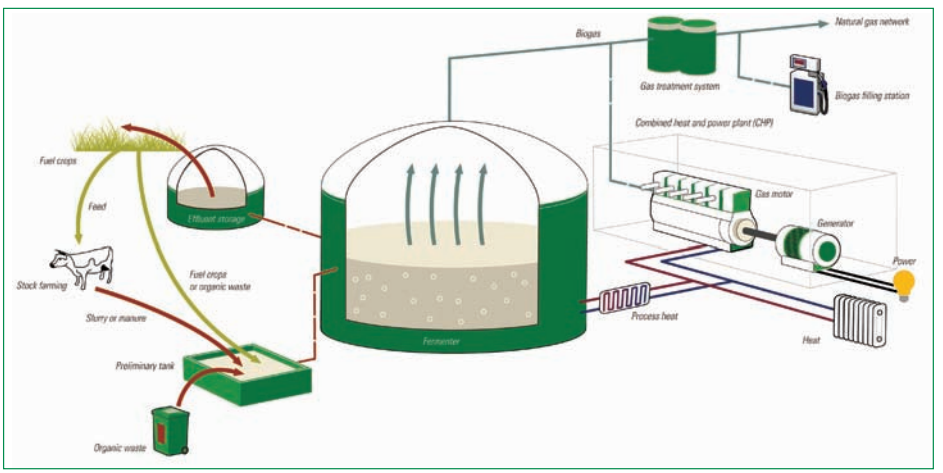
The Ministry of New and Renewable Energy had also started a scheme "Biogas based Distributed/Grid Power Generation Programme" with a view to promote biogas based power generation, especially in the small capacity range. Biogas based power units can be a reliable decentralized power generation option in the country.

Deteriorating quality of life in urban hubs of India, especially in cities like Delhi, shackles our overall growth potential. "Delhi wakes up to air 5 times worse than safe standard", was reported by Times of India on the Christmas this year. Delhi has been ranked the most polluted city in the World. The cases of paddy straw burning in Punjab and Haryana during paddy harvesting season, further deteriorate the air quality in Delhi and northern part of India. This burning increases pollution level many folds. NASA has been alerting about the same since last few years. This alarming raise in air pollution is a grave health concern for us all, forcing the government to take drastic steps like 'Odd-Even' scheme in Delhi.

Furthermore, our huge import bill for petroleum is a constant drain on our forex reserves. The world is now looking to green energy technologies for the future. Renewable energy is an excellent solution for this problem. Our mother nature is full of miracles and has very simple solution for such big problems like Renewable Natural Gas (RNG) or Biogas.

Biogas is produced from anaerobic digestion (without oxygen) of any organic material. Generally, biogas consists of methane (50–70%), carbon dioxide (30–45%), traces of water vapor and hydrogen sulfide (H_2S). Biogas can be utilized for cooking, lighting, power generation and automotive fuel. For automotive fuel application, raw biogas needs to be upgraded to natural gas quality. This means carbon dioxide (CO_2), hydrogen sulphide (H_2S), ammonia, particles and water (and sometimes other trace compounds) have to be removed so that the product gas has a methane content of more than 90% by volume. This upgraded gas is generally referred to as **Biomethane**. This upgraded gas or Biomethane is bottled at pressure of 200 bar, referred as **Bio–CNG**. The Bureau of Indian Standards had already issued a standard for Biomethane to be utilized for transport application.

Biogas production from various available biomass resources, is a viable option for our country as it is environment friendly, clean, cheap and versatile fuel. Harnessing such a resource will promote rural industries, agriculture, dairy and animal farming in a sustainable way. Also it will help regulate environmental cycles effectively as nutrients such as nitrogen, phosphorus and potassium are conserved in the process in the slurry and can be returned to the soil. Digested slurry is also a good source for several micronutrients like zinc, iron, manganese and copper**. It has been observed that use of slurry as fertilizer has many advantages as compared to farm yard manure. Weed seeds in the substrates are destroyed completely during the digestion process and is richer in nutrients compared to farm yard manure.**



India has the largest cattle population in the world. The cows and buffaloes stand at 29.96 crore, and contributes 58.5% of total livestock population in the country. Biogas Development and Training Centre, research team at **IIT Delhi estimated the total biogas generation potential in India is nearly 50,000 million cubic metre annually.** This calculation includes biogas from dairy farms, municipal solid waste, crop residue and agricultural waste, vegetable market, food waste, community toilets, wastewater sludge, industrial waste (including distilleries), dairy plants, pulp and paper, poultry, slaughter houses, sugar industries (excluding wastewater). This estimate is equivalent to 30,000 million cubic metre per year of upgraded biogas which can be utilized as Bio – CNG for vehicles. The upgraded and bottled biogas can be utilised as a vehicle fuel or as a cooking fuel substituting CNG. This amount of upgraded biogas can replace 86.8% of petroleum fuel used in transportation and 83.4% petroleum fuel in cooking sector.

The National Capital Region itself has potential to produce nearly 800 million cubic metre of biogas per year from its own available bio–waste resources, i.e. cattle dung, slaughter waste, sewage treatment plant waste, municipal solid wastes, vegetable fruit market waste, food leftover and kitchen waste etc. **This quantity of biogas if upgraded to Bio – CNG quality, can produce nearly 350 million kg of CNG per year, which can run more than 5,000 buses and 2 lakh cars.**

At present Delhi NCR alone has more than 8 lakh CNG vehicles and 325 CNG gas stations. Bio – CNG can easily be implemented as a transport fuel with this infrastructure. Small sewage treatment plants installed at housing clusters across the city will provide a potential source for replacing CNG in vehicles for local transportation in various cities.

The Biogas Development and Training Centre (BDTC) at IIT Delhi is supported by Ministry of New and Renewable Energy (MNRE), Govt. of India under **National Biogas and Manure Management Programme (NBMMP)** for providing technical training and publicity support for quality implementation of biogas programmes. **At IIT Delhi a passenger car testing on Bio – CNG is going on. This vehicle has already covered 40,000 km run on upgraded biogas and exhaust emissions were found lower than petrol/diesel and similar to CNG. Also, existing CNG vehicles need not to undergo any modification and are to be compatible to Bio–CNG.** The water scrubbing based biogas upgradation and compression/ bottling system developed at IIT Delhi is now patented. This technology promises a green and low cost fuel for automobiles and various thermal applications. Thus, biogas has a potential in India towards achieving energy sustainability using locally available organic wastes, which may also help in reducing greenhouse emissions and supplying good quality bio-fertilizer for farmers.

Biogas & Swacchh Bharat Abhiyan

IIT Delhi is planning to develop a small household aesthetic and compact model of biogas digester which will be of the size of domestic refrigerator or washing machine, where household generated kitchen waste and food leftover material can be converted into biogas. This may supplement LPG for cooking as minor changes in the burner stove design make it compatible for both LPG and biogas. The burner can run on both fuels, depending upon availability. This may help us to save at least 10–15% of LPG consumption in households.

Not only in the capital but in most of the cities, waste management issues are becoming important for municipalities and consuming most of their budget. The waste is heaping up like mountains and we do not have a fool proof solution to it. This problem can be combated by segregating biodegradable waste and then subjecting to household biogas plants/entrepreneurial system of biogas. Nowadays, in rural areas some persons are not willing to touch and handle cow dung. This is one of the reasons for non–functioning of many biogas plants. This situation can be overcome if entrepreneurial based biogas system is promoted in rural areas where a large biogas plant is setup in the village and gas is distributed through pipeline. This will ensure proper management of dung and waste collection, biogas and bio–manure distribution to every household by the entrepreneurs on nominal charge basis.

In such a way waste management can become self-reliant by providing energy and bio-fertilizer. Such initiatives taken by people to utilize the waste generated by them will help in keeping

the environment clean, green and disease free by which everyone can contribute to the Prime Minister's vision and mission of Swacchh Bharat Abhiyan.

National Biogas and Manure Management Programme (NBMMP)

The Ministry of New and Renewable Energy (MNRE) introduced the National Biogas and Manure Management Programme (NBMMP) in 1981. It's a Central Sector Scheme, which provides for setting up of Family Type Biogas Plants mainly for rural and semi-urban households. The aim of the NBMMP is to specifically utilize biogas energy in order to address the deficiency in adequate cooking energy sources in India. The government views biogas technology as a vehicle to reduce rural poverty and as a tool in it's drive for rural development. The most important instrument in the promotion of biogas technology is the provision of allowances paid towards the investment costs which benefit the farmers directly. The extent of this sum is defined by the size of the plant, the social category of the user and the relevant part of the country where the plant being promoted is located.

Over 48 lakh small biogas plants of family sized (1 cubic metre onwards) for cattle manure are installed so far against a potential of 1.2 croe. The Central Financial Assistance (CFA) on biogas plant provided under National Biogas and Manure Management Programme is shown in Table 1.

Biogas based Distributed/Grid Power Generation Programme

The Ministry of New and Renewable Energy had also started a scheme "Biogas based Distributed/Grid Power Generation Programme" from 2005–06 with a view to promote biogas based power generation, especially in the small capacity range. **Biogas based power units can be a reliable decentralized power generation option in the country.** In order to promote this route of power generation, specifically in the small capacity range (3 kW to 250 kW), based on the availability of large quantity of animal wastes and wastes from forestry, rural based industries (agro/food processing), kitchen wastes, etc. The central financial assistance for such projects will be limited to a maximum of

Table: Central Financial Assistance (CFA) on biogas plant provided under National Biogas and Manure Management Programme

Sl. No.	Region of India	CFA on 1 m^3 plant, INR	CFA on 2–6 m^3 plant, INR
1.	North Easterm States, Sikkim (except plain areas of Assam) and including SC and ST Categories of NE Region States.	15000.00	17000.00
2.	Plain areas of Assam.	10000.00	11000.00
3.	Jammu & Kashmir, Himachal Pradesh, Uttrakhand, Niligiri of Tamil Nadu, Sadar Kurseong & Kalimpong Sub-Divisions of Darjeeling, Sunderbans (W.B.) and Andaman & Nicobar Islands.	7000.00	11000.00
4.	Scheduled castes / Scheduled Tribes of other than NE Region States including Sikkim & other Hilly States / regions as given in Sl. No.3.	7000.00	11000.00
5.	All Others	5500.00	9000.00

Rs 30000 to 40000 per kW depending upon capacity of the power generating projects in the range of 3 kW to 250 kW of different rating limited to 40% of the plant cost.

Ministry of New and Renewable Energy, Govt. of India is contemplating National Biogas Mission for setting up of 1 crore biogas plant by 2022. Already a task force has been constituted by the Ministry, which is working on preparation of Mission Document. This will be an initiative for utilizing all kind of bio–waste for biogas production for cooking, power generation and automotive fuel, for providing energy security and promoting organic agriculture in the country.

(Authors are from Centre for Rural Development and Technology (CRDT), IIT Delhi. Prof Virendra Kumar Vijay is head of CRDT and General Secretary, Biogas Forum, India. E–mail: vkvijay@rdat.iitd.ac.in,vkvijay14@gmail.com)

SOLAR DISH COOKER FOR COMMUNITY COOKING

Prof. Ajay Chandak, Gulu Advani

India has 1.2 million rural schools where Mid-Day-Meal scheme is operational. This is world's biggest and most successful effort in the direction of RTE (Right To Education). Fuel used in these schools to cook Mid Day Meals is mostly firewood or in few cases LPG. However providing LPG to most of remotely placed schools is a big task. Asian and African countries are blessed with ample Sun and Switching over to 'Solar Cooking', can help to resolve the issue to large extent.

Ministry of Human Resource Development in India had budgeted Rs. 3000 crores for community solar cookers for 5 lakh schools in 12th five year plan.

Individual or family sized cookers have limited use because of limitations of space and cooking timings, but the community cooking does have huge market potential, especially in country like India. Temples, old age homes, residential schools, hostels, hotels, public health centers, mid-day-meal schemes in schools, Border Security Forces are the primary areas where community cooking is in practice on a very large scale and many million meals are prepared on daily basis. PRINCE-40 solar paneled concentrator primarily developed for community cooking promises great solution for such needs.

SK-23 Community Dish Cookers

Prof. Ajay Chandak designed a simple dish cooker of 2.30 m diameter with 4 m^2 aperture area, referred as SK-23. These were well received by the society as well as state government especially in rural areas.

It is capable of cooking mid day meal for 50 students in just one hour. These systems are cooking meals for more than 25000 students, saving 54 tons of LPG equivalent i.e. around 150 tons of carbon emission reduction per year.

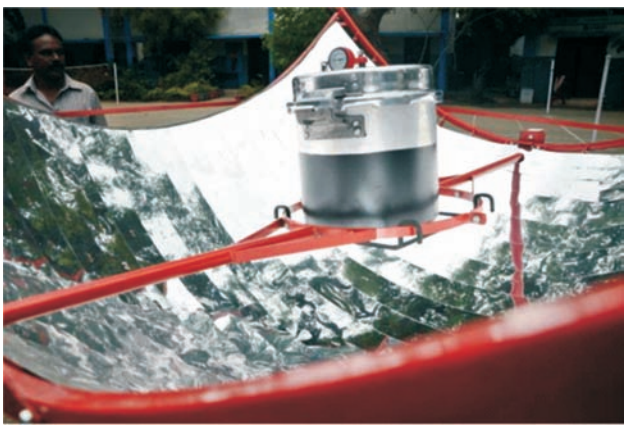
Even though SK-23 community dish cookers were highly successful, large scale dissemination of the technology was difficult, as the dish of 2.3 m diameter was fabricated in single piece, and was very difficult to transport. Transportation cost was also substantially high and expert installation team is needed. For these reasons the promotion of the systems could not go beyond state of Maharashtra.

Development of PRINCE-40 Concentrator

Realising limitations of SK-23 concentrator dish, Prof. Chandak developed new compact design named as PRINCE-40. This innovation utilizes a special geometry where all construction members of the dish are of same geometry and hence it is possible to design the dish as knock down assembly, which can be assembled at site. This design solved the transportability issue of SK-23, however this design also needs expert team for installation. This is a square paraboloidal dish. The design was acknowledged as best innovation in renewable energy at a national event Innovation 2009. PRINCE-40 solar concentrators are better in terms of performance than SK-23.

Feedbacks from users were encouraging and brought to notice other positive side effects like protecting cooks from the smoke and additional time they have for other works. Improved taste was other motivation for the users. Hostel management and cooks are happy because it not only saves time and money but also protect eyes from smoke and fire.

It is encouraging to see that even tribal women were involved during assembling of the community cookers.



PRINCE-40 Solar Cooker

Development of Segmented Dish Version of PRINCE-40

Fabricated version of PRINCE-40 solar cooker has 42 structural strip members which are bolted together to form structure of dish. Reflectors are tied on this dish structure. Installation for these systems required some skill and this restricted the promotion of fabricated version of PRINCE-40 solar cookers in local region. Authors came up with a geometry in which the fabricated dish is replaced by sheet metal panels. These 8 panels form the same geometry of fabricated dish keeping center open. Open center allows passage to wind and prevents toppling of the solar cooker. In new design reflectors are factory fitted and hence this makes the design truly DIY (Do It Yourself) kit.

Cooking time	
5 kg rice	60 minutes
100 eggs	80 minutes
5 kg potatoes	60 minutes
3 kg pulses	60 minutes

PRINCE-15 and PRINCE-40 solar cookers were used by a Dutch team in world's first ever solar trek in Nepal. These solar cookers proved their worth even at elevation of 4000 mtrs and also established fact that they are easy to transport and assemble even in hilly terrain of Himalayas.

Many corporate for their CSR projects and charitable organizations like Rotary are finding these solar cookers most suitable for installations in rural schools.

Use of PRINCE-40 Beyond Cooking

Efforts were made by the authors to develop new applications. For developing autoclaving applications a collaborative project was carried out with a team of doctors from Government Medical College Dhule. All clinical autoclaving tests were carried out by the doctors, for one month, for sterlisation of surgical tools and accessories. Separate tests were also conducted to neutralize biomedical waste. All the tests showed 100% acceptance and complete sterlisation.

Use of solar concentrator for sterlisation can prove to be very useful, especially in rural public health centers, where availability of the power is very uncertain. It is possible to sterilize the autoclave with contents, when sun is available, and store the ready autoclave for 2-3 days.

PRINCE-15 and PRINCE-40 Solar Cookers in First Ever Solar Trek in Nepal

Conclusions

New DIY (Do It Yourself) kit design of PRINCE-40 paneled solar concentrator has potential to make wonders in community cooking in all remote and tribal areas where access to clean fuel like LPG is not good. Solar cooking is cleanest method and food tastes great. Community solar cookers will not only save precious petro fuels and firewood but also will reduce emission to large extent. Solar cooking is hygienic for cook as well as for the users.

Applications like water distillation and bakery can be practiced as micro enterprise to generate revenue for rural folks.

One small version of the square dish is already available as PRINCE-15, as domestic dish cooker of 1.5 m^2. These can be promoted in rural areas for cooking for families especially in areas where cooking fuel like firewood, LPG, Kerosene etc. is scare. In desserts of Rajasthan, Kutch and Ladakh these domestic as well as community solar cookers are no less than blessings.

Technology needs financial support from governments and by other means like carbon funding, to improve viability of the projects. Widespread demonstrations and pilot projects are also needed for the prospective users to get first hand feel of the system. Entrepreneurs need to be developed to have wider network of manufacturers and dealers to improve availability of the new designs.

(Dr. Ajay Chandak is Professor at SSVPS BSD College of Engineering, Deopur, Maharashtra and Gulu Advani is Director, Elektromag group of industries, Mumbai. Email: renewable.consultant@gmail.com)

BAREFOOT WOMEN SOLAR ENGINEERS OF INDIA

Bunker Roy, Anu Jain

Supported by the Ministry of New and Renewable Energy (MNRE), twice a year, the Barefoot College team along with a network of non-profit partner organizations called SAMPDA, identifies non-electrified remote villages in various States of India. They meet with the village elders and share the vision of solar electrifying their village by training two village women, preferably grandmothers to become solar engineers.

I never knew that it was acceptable for women to stand among a group of men, let alone look at and speak to them. I was taught to always look down and stay quiet," says 40-year-old Bacchi Devi from Bihar.

"Even though I have not gone to school or college, I am now sure that I can do something important and useful with my hands," says 45-year-old Malamma from Karnataka.

"I have become stronger in my mind. I plan to learn the alphabet using my iPad because I believe that if I try, I can learn anything," says 35-year-old Jansiya from Bihar.

What is common amongst these smiling and assertive women? They live in remote Indian villages, have attended school for just a handful of years, were married off when they were very young and have always struggled to make their ends meet.

And… they all are Solar Engineers, also know as **'Solar Mamas'** trained at the Barefoot College in the dusty village of Tilonia in Rajasthan. They know how to:

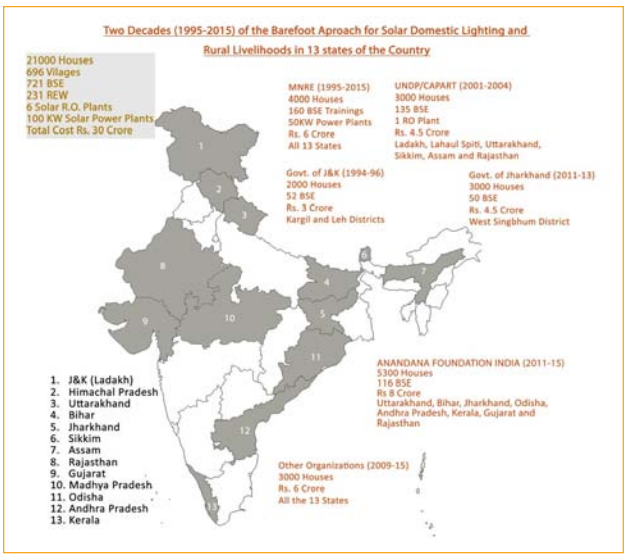
- Use a soldering iron to solder various parts such as capacitors, resistors, diodes on breadboards
- Handle complex charge controllers and inverters
- Install solar panels and link them to batteries
- Build solar lanterns along with their batteries
- Set up an electronic workshop in their village to assemble, conduct repairs to the solar equipment.

Additionally, they are headed back to solar electrify their villages and earn a salary every month to maintain the solar equipment.

The Barefoot College Story

In 1965, Bunker Roy, when he was still studying in St Stephens College, volunteered to spend the summer working with famine-affected people in one of India's poorest states. This life-changing experience culminated in a personal mission to fight poverty and inequality. Between 1967 and 1971 he worked as an unskilled labourer digging wells for drinking water in Ajmer District. In those impressionable years living with the poor he decided to start a College with a difference. He launched Barefoot College seven years later in Tilonia, Rajasthan as a voluntary, community-based organisation managed and operated by the villagers themselves drawing inspiration from the life style and work style of Mahatma Gandhi.

The wisdom of the elders became a foundation for this grand experiment of grafting together



formal urban learning with rural wisdom and knowledge. This continues to allow for the voices of the rural poor to be at the heart of creating their own solutions.

This guiding philosophy also explains the organisation's name. All over the world, the rural poor walk barefoot and college is a universal symbol for education and development.

The Barefoot Approach

The Barefoot College's model prioritizes a holistic approach towards innovative grassroots programs for the rural poor. It has proven over the last four decades that people everywhere, especially in the rural villages have the ability to rise above the limitations of extreme poverty and to live a life of dignity and self-respect. Also, **educational qualifications are not imperative to acquisition of skills that can create a positive change in one's communities.**

The Barefoot Approach believes in demystifying technology and placing it in the hands of the rural poor. This ignites the capacity and capability of communities such that they can utilize the expertise to improve their lives.

It also stresses respect for five "non-negotiable" values: equality, collective decision making, decentralisation, self-reliance and austerity. Respect for all permeates the college.

Barefoot Approach

Learning to Install Solar Panels

The teacher is the learner, and the learner is the teacher.

The Solar Electrification Program

Supported by the Ministry of New and Renewable Energy (MNRE), twice a year, the Barefoot College team along with a network of non-profit partner organizations called SAMPDA, identifies non-electrified remote villages in various States of India. They meet with the village elders and share the vision of solar electrifying their village by training two village women, preferably grandmothers to become solar engineers. The women would have to leave their homes for six months and stay in Tilonia to undergo the intensive training.

Trust is the key to the success of this venture. The local partner organisations play the crucial role of building relationships with rural communities, where one rarely ever sees a reason for a woman to travel outside her village. All questions are answered and all fears and put to rest:

- No, we cannot take men trainees instead of the women because there is no guarantee that a man will not leave for greener pastures once trained; whereas a woman will stay in the village and participate in advancing the community.
- Yes, your village women have the capability to learn how to assemble, install and maintain solar equipment.
- No, the women do not need to know how to read and write to become a solar engineer.

- Yes, the women have to stay the entire six months to complete the training.
- Yes, the women will return to the village. They will not run away.

Under this community ownership model, each family, irrespective of their economic level would contribute a certain amount on a monthly basis to maintain the solar equipment installed in their home. This amount is decided and collected by a village committee formed for this program. A part of these funds is disbursed as salary to the women solar engineers and the rest is utilized for spare parts, repair and replacing the battery, once in every six years.

Success also hinges upon the commitment made by the community members. All decisions including selection of women trainees, forming a village committee and collection, disbursement and management of funds must be done in a transparent and collective manner to ensure community ownership of the program.

Every six months 20-30 Indian women are trained under this program. Simultaneously, 35-40 women from the international sector are

Learning Solar Component Names

selected and undergo the training. They are taught through repetition, trial and error. Various parts and their functions are taught through colour codes, hand signals and drawings. One on one attention is provided to teach soldering. Students set up charge controllers as many times as it takes them to remember how it is done right. A pictorial book lists every step clearly. The solar trainers were all trainees at one point in time. They too grew up in a village, did not go through

Women Solar Engineers at Work

the formal education system and persevered to become trainers.

In addition to the solar training, a co-curriculum named Enriche supports the women's aspiration to transform themselves, and their communities, beyond solar electrification. Focusing on the areas of education, enterprise and empowerment, it provides the participants with knowledge, skills and tools in the following eight areas: Livelihood, Micro Enterprise, Basic Digital Literacy, Women's Reproductive Health and Nutrition, Financial Inclusion, Self Awareness, Human and Civil Rights and Environmental Stewardship.

The Government of India, Ministry of New and Renewable Energy funds the training of the Solar Electrification program in India. The Barefoot College also seeks funding from several private and corporate donors for solar equipment. The Indian Technical and Economic Cooperation Division (ITEC) of the Ministry of External Affairs funds the airfare and training costs of the international group. Their equipment is funded by multi lateral agencies along with other donors.

Immediate Impact

As of March 2016, the Barefoot College has been instrumental in training 721 Barefoot Solar Mamas from India. These engineers from 13 states (Andhra Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh Jammu & Kashmir, Jharkhand, Kerala, Madhya Pradesh, Odisha, Rajasthan, Sikkim, Uttarakhand) have lit a total of 21,000 homes in 696 villages from darkness into light.

In addition to the above, 486 Barefoot Solar Mamas belonging to 334 villages of 75 countries have been trained to electrify over 17,000 homes. Some of these countries are Afghanistan, Bhutan, Colombia, Ethiopia, Fiji, Guatemala, Malaysia, Mali, Philippines, Sierra Leone and Zanzibar. Solar Mamas have been trained from 40 of the 47 Least Developed Countries identified by the UNDP.

Long Term Impact

Education

The solar electrification extends the daylight hours thereby providing extra hours for household tasks, work and education. These communities have a much greater propensity to open night schools with assistance from local non-profit organisations. The solar lanterns enable the children busy with household activities such as cattle grazing or farming during the day to attend school at night. Several adult literacy programs have also been initiated. The phone charger in the solar equipment has led to an increase in cell phone usage along with other electronic media facilitation.

Gender Equality and Empowerment

The ability of illiterate women to acquire intricate technical skills and serve their community as a solar engineer has a powerful impact on the social status of all women in the village. The multi-cultural experience gained during the six-month training in a positive environment broadens their thinking, enhances their self confidence and hones their inter-personal skills.

The Enriche co-curriculum learning gives them the tools to translate their new livelihood activity into better living standards. Awareness and information about human rights adds dynamism to their attitudes. The women start on the path towards empowerment and they - being the true architects of a society - take the village along with them.

Socio-Economic Benefit

The villages selected by the Barefoot team are typically so remote that they have a very minimal prospect of being included in the traditional power grid. Solar energy not only results in financial savings in expenses such as kerosene and batteries, it also results in considerable time savings that can be utilized in other areas such as livelihood and education.

Environmental Impact

The solar electrified villages experienced considerable reduction in air pollution, fire and health hazards. Additionally, communities that previously relied on using firewood saw significant reductions in deforestation and land degradation.

International Expansion

Committed to expand and scale up Barefoot College's proven rural development model, the organisation has received support to open regional training centers in Africa, Latin America and South Asia. The first center in Zanzibar opened in August 2015 and has trained its first batch of solar mamas.

Personal Story

Kamala Devi is Rajasthan's first barefoot solar engineer from the village of Sirunj.

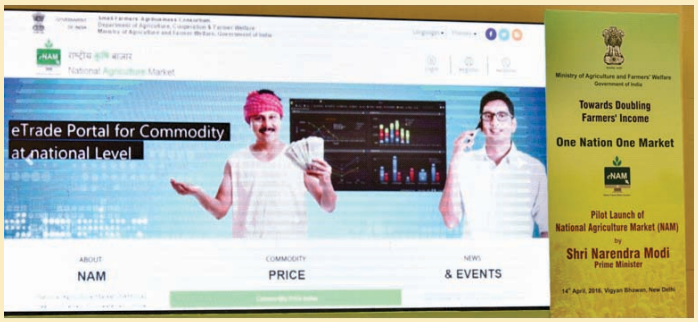
Kamala Devi at Work

If you ask her, if she has any dream yet to be fulfilled? "Yes," she said, "I want every child, especially girls, to be educated and empowered so that they can become economically independent and lead meaningful lives."

(Bunker Roy is founder and director of Barefoot College, Tilonia, Rajasthan. He was selected for Time's 100 most influential personalities in 2010. Anu Jain is a volunteer at Barefoot College. Email: bunker.roy1@gmail.com)

NATIONAL AGRICULTURE MARKET LAUNCHED

The National Agriculture Market was formally launched by the Prime Minister with the launch of the pilot of e-NAM, its e-trading platform on 14 April 2016. The initiative is expected to usher in transparency which will greatly benefit the farmers and be a turning point for the agriculture community.



21 mandis in 8 states have joined the National Agriculture Market. By September, 2016 two hundred mandis will be included and by March, 2018, the number will be five hundred eighty five.

This project will operate through an online portal which is being linked to the mandis of the States. Its software will be provided to all the participating states free of cost. An expert will be deployed for one year in every sharing mandi so as to facilitate the smooth functioning of the portal. Under this Project, Government of India is providing a grant of Rs. 30 lakhs to the proposed agriculture mandis of the states. The farmers will be provided farmer helpline services round the clock for obtaining information related to this portal.

Integration of agri-markets across the country through the e-platform is seen as an important measure for overcoming the challenges posed by the present agri-marketing system namely –

- fragmentation of states into multiple market areas,
- each administered by separate APMC,
- requirement for multiple license for trading in different APMCs,
- multiple levy of mandi fees,
- licensing barriers leading to conditions of monopoly,
- poor quality of infrastructure and low use of technology,
- information asymmetry,
- opaque process for price discovery,
- high level of market charges, movement controls, etc.

Various steps are being taken to double the farmers' income in the next 5 years. For the first time in India, "one nation and one market" is being developed and this market status will be elevated to the status of international market.

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