SOLAR-POWERED MOBILE TELEPHONY
THE EMERGING MARKET

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Introduction

Today, cell phones have become inseparable parts of our daily lives. Ironically, it was not at all easy for it's inventors to convince the venture capitalists about that in the initial period. No one was convinced of the need for phones being mobile in the days of fixed landline connectivity.

Ever wondered as to how someone reaches you without a miss even when you are in the midst of a large walking mass? The credit goes to the efficiency of carrying the voluminous traffic from one point to another through the innumerable telecom towers placed all over. These towers stay connected with one another owing to an un-interrupted supply of power made available for the purpose.

The problem arises when we move beyond the urban boundaries into the distant semi-urban and rural environs. Little or no-availability of power in such areas is a major challenge. Currently, import-dependent diesel fuel is used for covering up for the lack of regular power supply. Social, economic, and environmental considerations, today, are forcing renewed consideration of renewable energy technologies, especially solar power, to replace diesel.

This article takes a close look at several such core issues with the main focus on increasing people's connectivity and outreach through energy-efficient telecom towers powered by distributed generation in general and solar energy in particular.

Geographical outreach of mobile connectivity

To begin with, let us consider the outreach of mobile phone connectivity at the global level. About 58% of the total world population uses mobile phones. The remaining population—potential mobile phone users—is mainly from the rural areas of developing countries. In India, about 771 million out of 1.15 billion are mobile phone users. India is the world's second largest market for the mobile services. On an average, 19 million new subscribers join this bandwagon every month. Thus, currently, India is being regarded as the world's fastest growing mobile market, far ahead of several other nations.

The vexing issue

The mobile market in India has witnessed phenomenal growth in the last three decades, and though this growth has boosted the India economy, it has also created tremendous pressure on the energy front. This can be gauged from the fact that, annually, about 2 billion litres of diesel fuel are used just to keep this network running. The accompanying cost of such diesel combustion is a whopping ₹70 000 million. That is not all as burning of diesel leads to emissions of greenhouse (GHG) gases. Before we discuss the alternate fuel choices, we need to deliberate on the diesel fuel option.

- Diesel is also prone to adulteration, which ultimately affects the performance of an engine.
- GHG emission is a strong concern.
- Diesel transportation-cum-storage is proving to be a nightmare due to theft and other such issues.

India imports about 80% of its crude oil, which amounts to ₹2 000 000 million, annually. This points to the region's vulnerability, both economically and politically. Despite the concerns, diesel generators are mainly used due to low capital cost.

An alternate fuel option

However, lately, the tide seems to be turning in favour of solar power. Solar cell technology (currently

Courtesy: K Srinivas Reddy

Then and now

As of now, globally, more than 99% of the cell sites use diesel generators as a backup power source. However, there are multiple concerns regarding the use of diesel generators as a backup power source.

- Diesel price is constantly increasing.
- Diesel operated generators entail a huge running cost.

15%–18% efficient) is getting cheaper, whereas diesel is getting costlier. And, in the present context, solar power systems seem to be much more reliable. Thus, slowly, the scenario is turning in favour of the renewable energy sources, which are in abundance in our country, to fuel the telecom towers and, simultaneously, charge the batteries for an un-interrupted power supply.

This article delves into the emerging markets of the solar-powered mobile (telecom) sector.

Prominent power choices for mobile telephony

The geographical outreach of mobile telephony is expanding at a quick pace. A service provider is free to choose the power source to operate a communication base station in a remote area. The choice may depend on the local situation. The following are some of the choices faced by a service provider.

Grid (mains) power

It is possible that a grid is already present in the given area. If not, the grid could well be extended for this purpose. However, it may prove to be very costly and time consuming to put up a grid power connection. Also, huge transmission loss is always a concern. There may be areas where the grid power breaks down regularly. In such situations, battery backup unit is a must.

Diesel generators

A diesel generator could be used in situations where the grid connection is delayed or electricity supply is intermittent. However, a generator needs to be refueled at regular interval. Diesel has to be moved from one place to an other and stored at a given site. Thus, it becomes prone to theft easily. Perhaps the biggest drawback of using a diesel generator is the negative fallout of the GHG emissions. The growing climate change concerns are all pleading for a gradual withdrawal of this pollutant and substituting it with a renewable energy source such as solar.

Solar and wind power

Solar and wind energy technologies have shown some remarkable progress over the last few years. Solar and wind power could be considered as the main choice in the difficult sites, not a supplementary choice. It is now widely believed that these two alternate energy options should be deployed in large numbers.

Is solar power absolutely necessary?

As has been already mentioned, in a number of areas where the supply of conventional power is erratic, diesel generators may continue to be the single most important backup power source. However, the number of solar powered stations may go up considerably by 2020, mainly on account of the following factors.

- The governments of the developing countries are offering special incentives to encourage the use of solar power.
- Diesel is an import dependent commodity, for a developing country like India. This means a huge outflow of foreign exchange.
- Solar technology is getting cheaper and also the field performance reliability steadily increasing.

However, in this context, for solar power to take off significantly, it needs to have a share of a few thousand sites. For Indian operators such as Reliance, Bharti Airtel, Vodafone, and so on, solar power investment is still not the priority. The case is no different for operators in other developing countries. However, this is not to underestimate the growing interest towards the use of solar power.

- Average effective cost of diesel fuel for the emerging-market telecom sites touched $1.90 in 2010.
- About 850 000 cell-site power systems are estimated to have been shipped in 2010.
- Pay back period of an off-grid renewable power plant is set to drop to less than a year in 2014.
- Total 1.9 million mobile telecom sites—the installed base—expected are to be either green power (solar/wind) upgrades or retrofits by 2015.

Key advantages of solar technology

It is quite advantageous to use solar panels for the daily operation of a telecom tower. The following are some of the most important advantages of solar PV technology.

- Fuel, that is, sunlight is available in abundance almost round the year.
- The power producing part, that is, the solar panel does not have any moving part associated with it. Thus, it is easy to maintain the system.
- Solar technology is modular in nature and different system voltages can easily be configured.
- The solar panels last for about 20–25 years.
- Once installed, solar panels need bare minimum maintenance.
- The system uses low maintenance tubular plate batteries, which need to be topped up just twice a year.
- It is pollution free.
- Due to low maintenance requirements, human resource requirement is also very less.

Making a choice

Mostly, the choice is between an on-grid cell site and the one running on solar power. For the developing countries, it is uneconomical to operate a diesel generator with a low load level of 100–200 W/day. Also, transport, storage, and, at times, theft cost of diesel fuel is very high. Compare this to the use of solar power in the capacity range of 500 W and a set of deep-cycle batteries.

The early days of solar power use

The use of solar technology for powering the telecom applications in remote rural areas is not new. In the last 25 years, renewable energy has often been used in telecommunication sites. Today, there are hundreds of sites making use of alternate energy sources like solar and wind power. However, in view of the larger picture, the use of solar or wind powered sites is still very minimal. It is a small fraction of the world's off-grid and poor-grid sites.

In developing countries like India, solar power is just beginning to make an appearance on the mobile telephony

scene. In fact, diesel generators are not the lone choice of power source use at present. In some situations, deep cycle batteries charged on grid, also fit the slot.

Thus, in the case of the traditional power systems, the economies of scale seem to be in place. However, this does not imply a satisfactory state of affairs in all parts of the world. Take, for example, the case of a global system for mobile communication (GSM) base station in an African village. The source of power used for the purpose is still not reliable. Consequently, diesel is still used to keep the sites running. Perhaps, the core solution lies in using solar power for a base station in order to bring down the running costs for such a site. The area-specific use of solar power can be visualized under the following situations.

- Areas that receive conventional power purely on a rotational basis and the time period of the rotated supply last for just a few hours every day.
- Areas (mostly in Africa and Asia), which witness frequent power interruption almost daily.
- Areas, which have good power supply, view deep cycle batteries as the preferred choice. These may be charged using minimal solar energy.
- Areas, which have bad power supply, should view solar power as the first choice.

Grid power, diesel fuel, and other commodities are priced differently in different parts of the world. Renewable energy can, therefore, be very cost-effective in some applications. In general, however, if electrical grid power is available to the cell site, then the wireless operators choose to use it.

Devising the business models

In areas bereft of regular electricity supply, bold telephony players are creating their own unique business models. Solar panels and wind turbines are at the centre of these models. Under its purview, power plant vendors usually facilitate the long-term contracts of 10 years or even more with the operators. Simply put, the power plant supplier can choose the most economical solution on a long-term basis. The solution does not hinge only on the lowest capital cost.

Major green power initiatives

Several initiatives, for the telecom tower, with regard to the use of solar power, are underway. The following is a brief overview.

- As many as 400 telecom towers will be powered by solar panels. According to the available reports, the towers, which will get started in April 2011, in a ₹1200-million project, under the Jawaharlal Nehru National Solar Mission (JNNSM) of the Ministry of New and Renewable Energy (MNRE), will be in Andhra Pradesh, Bihar, and Uttar Pradesh. These will involve state-owned Bharat Sanchar Nigam Ltd (BSNL), GTL, and Indus Towers. The per unit installation cost of a tower is expected to be ₹3 million, wherein the concerned ministry will subsidize about 30% of the tower cost. The BSNL will set up about 25% of these towers.
- Indian telecom infrastructure companies, including Indus Towers, American Tower Company (ATC), GTL, and Viom Networks (erstwhile Tata Quippo), that depend heavily on diesel generators to power more than

0.35 million towers across India, are currently conducting pilot tests on solar, wind energy, bio-diesel, and fuel cell-based equipments and rolling out clean energy solutions strategy.

- While some tower companies are looking at compressed natural gas (CNG) and piped natural gas to power towers, Indus Towers, the largest with over 0.1 million towers in India, may set up 2500 solar towers by September 2011. Indus Towers is a three-way joint venture between Bharti Airtel, Vodafone Essar, and Idea Cellular. It has identified areas in Uttar Pradesh, West Bengal, and Maharashtra where it will deploy solar-powered solutions. Indus Tower's chief executive officer BS Shantharaju expects that the company's diesel consumption to fall by 30% by using renewable energy.
- Viom Networks, which operates more than 38000 towers across India, plans to run more than one-fourth of its towers on alternative energy, within the next two years. It plans to run 2000 towers on solar power alone by 2013. Viom Networks chief executive officer Arun Kapur said that the company has conducted trials on windmills, biomass-based gensets, fuel saver catalysts, fuel cells, CNG, and energy storage platforms in Delhi, Haryana, Kerala, National Capital Region, Odisha, Rajasthan, and Uttar Pradesh in the last two years with considerable amount of success.
- Keeping cost benefits as one of its primary concerns, the ATC conducted trials using solar power in Pune, Maharashtra, and cut its monthly costs of running diesel generator sets, or gensets, by half.
- The ATC is working on increasing the cost benefit by 30%–50% and, thus, scaling up the solution for larger areas. "For this to be a viable solution, the capital costs have to be lower. For solar power, the running cost is low, but it is more expensive in terms of capital investment," said an ATC India spokesperson.
- Tower major, GTL, will use an effective combination of solar and bio-diesel based energy solutions in order to bring down the overall energy consumption by one-fifth, over a period of time.
- Vihaan Networks has created a compact solar-powered tower that draws no power from the electricity grid and can be installed in less than half-a-day without any technical expertise. It requires no air conditioning or shelter and runs on the power of a light bulb, said a company executive. The solution is best suited for rural areas that have 70% of the national telecom tower density, but poor quality of grid power. The suppliers of renewable-energy equipments, such as Acme Tele Power, Tata BP Solar, and Moser Baer reveal the business potential to be $1 billion to start with. This will go up as the next wave of telecom penetration comes from rural locations, where power availability is a major challenge.

Region-specific potential

Africa, China, and India are the three major markets for mobile telephony. Following is a brief account of the existing markets, in these three nations, coupled with the accompanying prospects of switching over to solar energy for power supply.

China

China mobile is the world's largest mobile operator with about 530 million subscribers. This company has set up a sizable number (about 800) of cell sites based on solar power, along western China and Tibet. Luckily, the high altitude has helped in setting up of GSM services using solar panels. Viewed in entirety, the powerful trio of China Mobile, China Unicon, and China Telecom together manage more than 10 000 sites without the use of grid power. The larger objective is to bid goodbye to the diesel-fuel powered sites.

India

The MNRE kickstarted a programme to promote solar power utilization in the mobile telephony sector in April 2010. Under this programme, between 30%–50% of the cost of solar retrofits will be subsidized, implying a favourable situation for this fast emerging application. As per the available market estimates, about 350000 towers are expected to be powered by solar panels. The success of this programme may save up to 2 billion litres of diesel per year. It is equally true that the pace of deploying such systems has been abysmally low—just 3500 sites during 2010. This year may witness about 8500 sites running on solar power. However, all said and done, it is absolutely necessary to continue to get government support in order to maintain the interest of the concerned stakeholders. The incentives involved will be subsidies, tax breaks, and so on.

Africa

Diesel generators, as we have seen, have major problems, and the use of renewable energy, more so solar, has

been irregular when it comes to an application like mobile telephony. The mobile operators in the South African region have been withholding their plans to invest heavily in a large number of remote sites for these reasons. Perhaps a revolutionary change may come about with the recent acquisition of South African telecom company Zain by Bharti Airtel. The accompanying benefit is expected to be by way of sharing a whole lot of experiences with the use of low-power GSM sites in India.

In surrounding sites like Kampala, Uganda in East Africa, car batteries have been used to charge mobile phones. These areas do not have any regular and assured electricity supply. Also, while the urban elite take a fancy for slimmer versions of mobile phones, rural people in Uganda seem to get along well with big size phones. The clear advantages are in terms of size, physical strength, and, importantly, a longer battery backup.

A special solar recharge project by the name of "Motopower" has been launched in Kampala, Uganda. The following are the main objectives of this project.

- Learning of valuable entrepreneurial skills
- Operation of profitable business units
- Generating income

To begin with, about 50 women were chosen to operate their own solar-powered motopower kiosks.

Correlating mobile use with GDP growth

There is a genuine connection between the percentage of mobile phone users and the growth of gross domestic product (GDP). According to a specific study carried out in 2005, an increase of 10 mobile users per 100 people could boost the GDP growth by about 0.6%.

Mobiles roll out numerous services

Mobile phones whether owing their operative origin to solar power or not, have helped to roll out a wide spectrum of services. Table 1 summarizes the most important of services provided by mobiles.

Table 1 Important services provided by mobiles

Services	Service provider/ Beneficiaries	Co-opting organization	Location	Remarks
Revolutionizing socio-economic development in India	Nokia	The Centre for Knowledge Societies	Rural India	The major service sectors Transport Micro-commerce Finance Healthcare Governance Education Infotainment
Renting cell phone minutes	About 260 000 village phone operators (mostly poor rural women)	Grameen's village phone programme	Mongolia	Improving the quality of life
Mobile phone living	Polio-ridden people confined to wheelchairs	Entrepreneurship programme	Nairobi	Phone is connected to a mobile phone network in Kenya and, thus, works like any fixed line phone.
Taking telecommunications closer to people	MTN Publicom	Peoples network	Uganda	These are known as new bike payphones.
Scripting the local language (not familiar with English)	Motorola	Self-help groups	Ethopia	Local language specific characters numbering about 200 developed on the nine keys of the Motorola apparatus
Fighting AIDS under the "Phones for Health" Project	MTN	The US government/ others	Africa	A $10-million scheme launched to combat the menace of HIV/ AIDS.
Use of mobile phone by women		Women's groups for advocacy	South Africa's Kwazulu-Natal province	Reporting the violations of their human rights as well as to assert other constitutional rights

Source Consolidated from multiple channels

Credit via carbon

There is now an incentive for wireless operators to earn carbon credits. Each certified emission reduction (CER) is roughly equivalent to 1 tonne of carbon dioxide. It is obligatory for a carrier to demonstrate that a given site would use a specified amount of diesel fuel per year (up to 20 000 litres), whereby each litre of diesel fuel burnt would change to about 2.69 kgs of carbon dioxide. This is stimulating the interest of the operators across India, Bangladesh, and the Middle East to reduce the dependence of base stations on diesel fuel. This seems to be a sure way of trading off some of the capital cost.

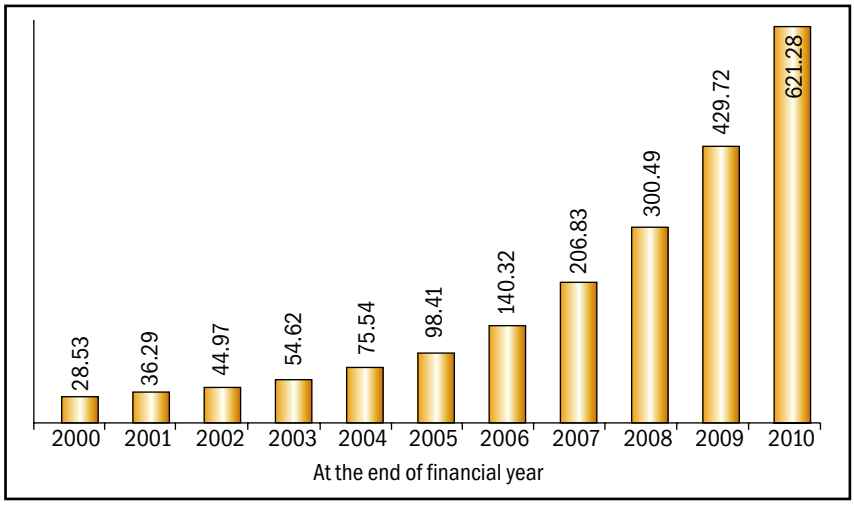

Figure 1 Year-wise increase in subscription rate
Source *Annual Report of the Telecom Regulatory Authority of India (TRAI)*

Growth of mobile subscriber base

Figure 1 shows the year-wise growth, which indicates a whopping addition of about 600 million subscribers in a decade or so.

As per the available estimates, every month, the number of mobile users is growing at an appreciable pace. Table 2 shows the percentage share of rural and urban subscribers being catered to by 15 market players.

As on March 2010, Bharti Airtel led the way with a market share of about 26.46% and has the maximum rural area penetration—48.09 million.

Table 2 Growth of mobile phone subscribers in India

Wireless group	Total wireless subscribers (in millions)		Rural wireless subscribers (in millions)		Market share of wireless rural subscribers (in %)	
	March 210	March 2009	March 2010	March 2009	March 2010	March 2009
Bharti	127.62	93.92	48.09	29.53	25.19	26.46
Reliance	102.42	72.67	21.25	15.13	11.13	13.55
Vodafone	100.86	68.77	36.79	22.33	19.27	20.00
BSNL	69.45	52.14	25.26	19.09	13.23	17.10
Tata	65.94	35.12	13.45	2.66	7.05	2.38
Idea/Spice	63.82	43.02	29.82	17.24	15.62	15.45
Aircel	36.86	18.48	14.00	5.63	7.33	5.05
MTNL	5.09	4.48	0.00	0.00	0.00	0.00
Unitech	4.26	—	1.40	—	0.73	—
Sistema	3.78	0.39	0.54	0.001	0.28	0.00
Loop	2.84	2.16	0.00	0.00	0.00	0.00
S Tel	1.01	—	0.27	—	0.14	—
HFCL	0.33	0.60	0.001	0.004	0.00	0.00
Videocon	0.03	—	0.00	—	0.00	—
Etisalat	0.00	—	0.00	—	0.00	—
Total	584.31	391.76	190.88	111.63	100.00	100.00

Source Annual Report of TRAI

Market share of service providers

At the moment, there are about eight major players (Figure 2) reaching out to the rural and urban subscriber base. Of these, Bharti Airtel commands the highest share of 25.19%, followed by Vodafone, Idea/Spice, BSNL, Reliance, Tata, Aircel.

Figure 3 presents the market share of different networks in the mobile telephony market.

Telecom tower growth pattern in India

A telecom tower is an integral part of a telecom network infrastructure. In fact, it entails considerable build-up cost. At present, there are about 13 major telecom tower companies in the country led by Indus Towers. Table 3 presents the approximate number of towers per company.

Table 3 Mobile phone tower per company

Company	Approximate number of towers
Indus	80 000
Reliance Infratel	31 000
Bharti Infratel	20 000
Quippo Telecom Infrastructure (QTIL)	23 000
GTL	9000
Essar Telecom	6000
American Tower Corp	4000
Tower Vision	3000
Aster Infrastructure	1000
India Telecom Infra Ltd	1000
KEC International	400
Independent Mobile Infrastructure	400

Source TRAI

Greening the telecom sector

There is a growing tendency, on the part of service providers, to switch from diesel to solar power for the following reasons.

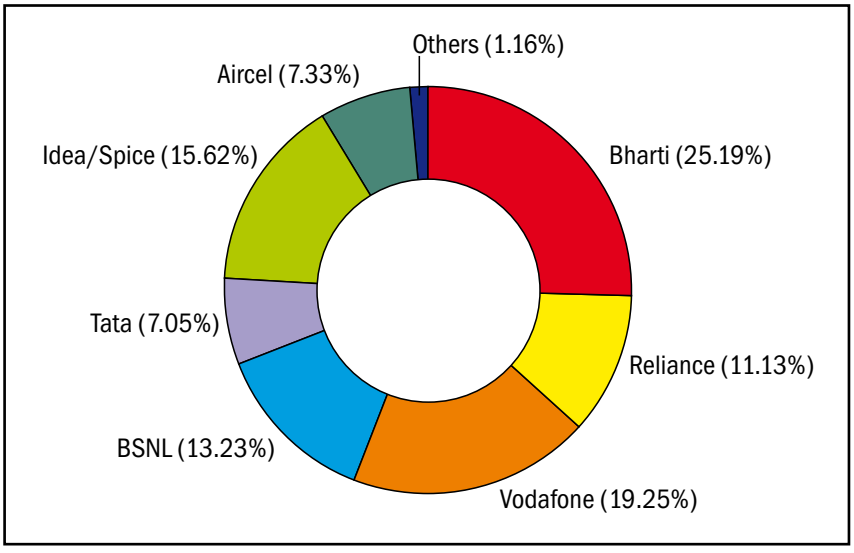

Figure 2 Major players reaching out to the rural and urban subscribers
Source *Annual Report of the TRAI*

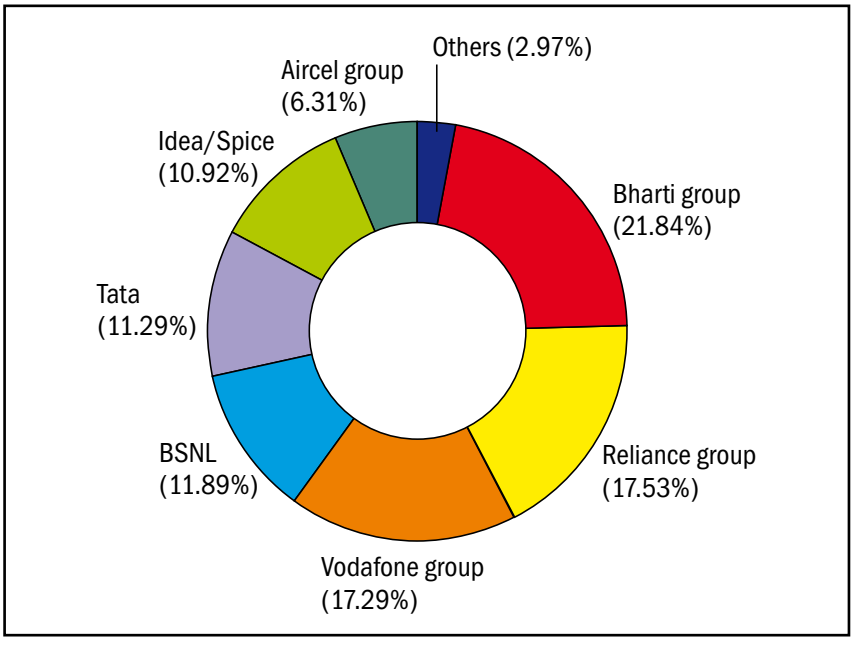

Figure 3 Market share of different networks in the mobile telephony market
Source *Annual Report of the TRAI*

- Reduction in carbon dioxide emission (a dominant contributor to GHG emissions)
- Reduction in the financial burden on the import of diesel
- Reduction in 5 million tonnes of carbon dioxide emissions.
- Saving up to $1.5 billion in operating expenses for the telecom tower companies.

As per the available estimates, the move from diesel to solar and other alternate energy sources like wind may lead to the following gains.

Ironically, till 2007, Airtel was the second largest buyer of diesel after Indian Railways. Currently, GTL Infra, owning 32 500 towers, has started moving from diesel to solar. Likewise, Bharti Airtel has also started a pilot project to evaluate the worthiness of solar vis-à-vis diesel and the resultant savings. According to the MNRE, a total of 250 000 cell phone towers can be energized through solar. Successful realization of this major objective may well transform into an expanded commercial photovoltaic (PV) market.

A telecom shelter

In general, a telecom shelter is made of the following few components.

Active infrastructure

It is also known as a Base-Trans receiver station (BTS). A typical BTS comprises of electronic equipment and telecom switches. The type of equipment depends upon the traffic strength to which it caters. In general, the power requirement of each BTS ranges between 0.9 kW to 1.5 kW. Thus, the total energy requirement of a BTS, on a daily basis, is between 24–36 kWh. The following are the key components of an active infrastructure.

- Spectrum (radio frequency)
- Microwave radio equipment
- Switches
- Antenna
  Transceivers for signal processing

Passive infrastructure

All the peripheral—not directly involved with the communication activity, but is necessary for the operation of a BTS—activities come under this specific category. The passive infrastructure mainly includes the following.

- Building envelope
- Power interface unit
- Power plant
- Diesel genset
- Storage battery
- Air-conditioning unit
- Phase change material

Figure 4 represents the complete infrastructure of a mobile network.

Broad classification of a telecom shelter

Telecom shelters can be broadly classified as the following.

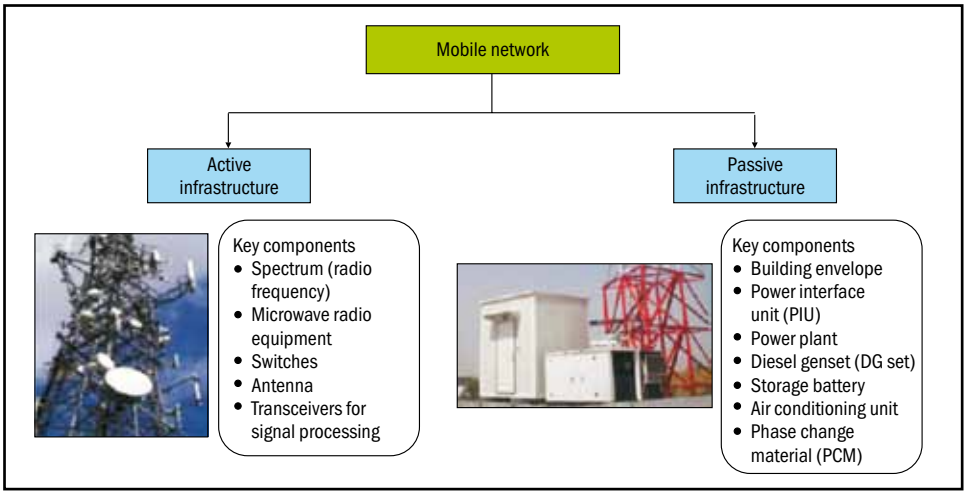

Figure 4 Infrastructure of mobile network

a) Legacy sites

These are existing old sites. The key configuration of such a site is as follows.

- Aircon: 1.5 TR or 2 TR
- Free cooling unit (FCU)
- Diesel genset: 15 Kva or 10 Kva
- PIU and power plant
- Battery bank

b) New sites

Every month, about 2000 new sites are being added to the existing mobile network. The basic configuration of such a new site is as follows.

- Aircon: 0.9 TR
- High efficiency PIU, power plant (~ 92%)
- No phase change materials
- Diesel genset (15 kVA)

The site is either completely run on diesel genset or via an effective combination of DG set and grid power supply. The basic configuration of a telecom shelter varies in accordance with the geographical location and electricity scenario.

TERI's initiative in mobile telephony

The Energy and Resources Institute (TERI) is working on modalities to employ renewables for powering telecom shelters and optimizing the performance for efficient operation. TERI is also proposing to use telecom shelter resources for community benefits by associating it with its flagship programme—Lighting a Billion Lives (LaBL). It has also been proposed to use the telecom shelters for weather forecasting stations, which can be used for intimating the farmers about the weather conditions in time, thereby, helping them increase their yield. TERI is in the process of launching this project on pilot basis with some of the giants in the field.

The TERI-Indus towers project

As of now, there are about 350 000 towers across the country. These are largely dependent on the use of diesel generators for power backup purposes. The accompanying difficulty is in terms of high monthly expenditure on energy usage. As per the industry data, about 30% expenditure of a telecom shelter is attributed to energy cost alone. Thus, the high cost of energy and the risk to the environment is catalysing a gradual shift towards rational use of both the renewable and non-renewable sources of energy. Alongside is a clear recognition to examine the scope for incorporating energy conservation measures to the best possible extent. It was in the backdrop of these two major concerns that Indus Towers asked TERI to carry out a field study on a telecom shelter.

About Indus Towers

Indus Towers is India's leading tower company based in Gurgaon, National Capital Region. It offers specialized services to a whole range of telecom operators in the wireless space besides other wireless service providers, such as broadcasters and broadband service providers. The company has an enviable distinction of being the largest telecom tower company in the world with a portfolio of more than 110 000 towers. It has a marked presence in 16 circles out of a total of 22 circles in the country. Indus Towers is a joint venture of three telecom majors, namely Bharti Group, Idea Group (Aditya Birla Telecom), and Vodafone-Essar Group. A unique feature of Indus operations is its growing commitment towards adopting green power technologies, more so solar power.

Project justification

The TERI-Indus Towers project was undertaken based on the following facts.

- Availability of round-the-clock power supply of a reliable nature continues to be a challenge.
- Desired power quality is still not assured.
- About 30% of the total existing expenses in a telecom shelter is on energy.
- The need of an optimized 'standard design' for future deployment.
- Scope for incorporation of renewable energy technology (ies).

Scope of the work

TERI, after a series of deliberations with Indus Towers, pursued the following few activities.

- Set up the basic configuration of the telecom shelter much like an actual site.
- Test the performance of a telecom shelter with the same operational condition as witnessed at the field stations.
- Determine the performance baseline.
- Create different test combinations to evaluate shelter performance in different configurations.

- Analyse the performance of each combination with baseline performance and demonstrate the energy saving potential.

Installation and demonstration of the telecom shelter

A telecom shelter was set up at a site mutually identified by TERI and Indus Towers within the precincts of TERI Gram. Following this, field operation of this demonstration unit was organized by the company officials. It also involved touching upon the semantics of each and every significant component vis-à-vis the physical and technical specifications, operational details and parameters, measuring instruments and techniques.

Testing and analysis

TERI carried out a detailed performance-oriented analysis of the telecom shelter, much in accordance with the following considerations.

- Energy consumption for 24 hours for different combinations
- Energy consumption (kWh) per kW of BTS
- Impact of DC FCU
- PIU and PP
- Battery and battery cooler
- Phase change material (PCM)
- Diesel generator
- Energy modelling of the shelter

Results and findings

The field evaluation of a telecom shelter helped to understand the schematic operation from several important considerations. Energy consumption dropped from a high of 148 units to just about 109 units, a definite gain of 30%.

Policy-related intervention

The capital cost required for making a smooth transition from conventional to non-conventional sources of energy is substantially large. Thus, at least to begin with, an alluring policy intervention is needed to overcome the inertia. The MNRE has put in place a major policy initiative to encourage the use of green power sources such as solar in the mobile telephony sector. The following are some of the observations in this regard.

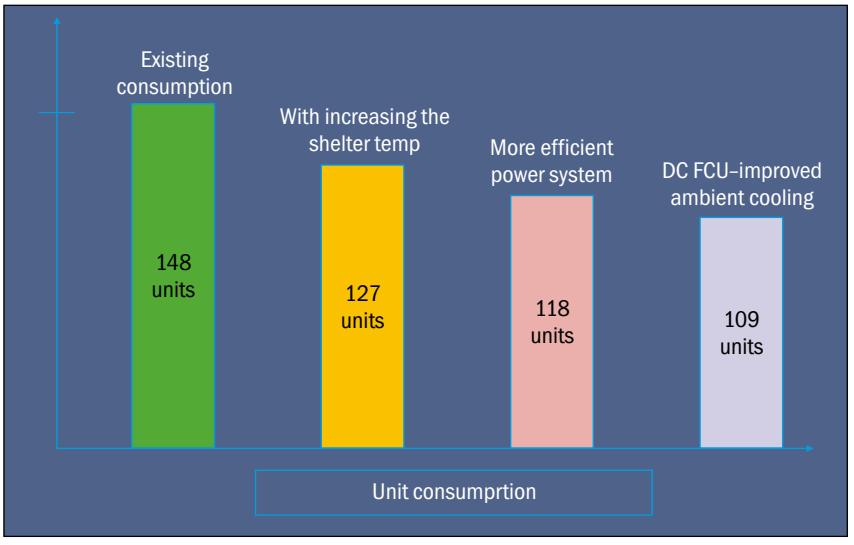

Figure 5 Overall energy saving potential in a telecom shelter
Source TERI

- The government is already giving a subsidy of 30% on the capital cost for each telecom tower. However, it has not been able to force more initiatives towards the use of solar power.
- Perhaps, a progressive subsidy scheme may work well, which simply means increasing the subsidy in direct proportion to an increase in the number of installations.
- At the Delhi Sustainable Development Summit, the Prime Minister said that those who pollute will pay. In accordance with this, the policy framework by the government should not only incentivize green efforts but also penalize those who still continue to use diesel beyond a certain pre-set limit.
- The government should establish a criterion for the use of renewable energy technologies for the telecom towers while allocating 2G or 3G spectrum, in future allocation,
- Funds should be made available through credit from banks, as part of the priority lending sector.

Conclusion

India is now entering a new era of rural mobile telephony. This brings into fold a whole range of issues, challenges, and opportunities, both for the service providers and the solar manufacturers. A true synergy is needed between the assessment of merits and demerits of using various power options, much in accordance with site-specific characteristics and requirements. Also, different solar cell technologies should be put to use. Wherever possible, the combination of solar and wind energy technologies should be tried out to keep the cost of a solar system to a minimum. Simultaneously, efforts should be made to further minimize energy use in telecom towers. After all, even solar power is not cheap. There should also be a heightened impetus on using non-polluting power sources like solar in more ways than one. Social, environmental, and political considerations should be more clearly enunciated and understood in the backdrop of bringing mobile connectivity to the doorstep of every person in the rural areas.

JNNSM
the initial outcomes

Dr Suneel Deambi, Consultant, TERI <sdeambi@airtelmail.in>

For several years, India had an abysmally low solar photovoltaic (SPV) grid-connected capacity of 2.1 MW. However, the build up, in smaller capacities, was adequate, ranging anywhere between 25 kW–200 kWp. Globally, the per unit size of SPV power plants has long crossed the revolutionary megawatt mark. And, this has kept the market experts guessing about a right take-off time for the Indian PV grid power installations. Finally, even in India, the dawn of megawatt-scale grid power generation became a reality, with the formulation of a special scheme, "Generation based incentive" (GBI), by the Ministry of New and Renewable Energy (MNRE). However, under this scheme, only a few power plants were set up. More recently, the much needed boost is being provided by the Jawaharlal Nehru National Solar Mission (JNNSM). This article, very briefly, deals with the initial developments surrounding the JNNSM, which has witnessed a flurry of activities.

Making a beginning

The total aggregated capacity of grid-connected solar projects under Phase-I has been fixed at 1000 MW. Further, in this phase, projects will be selected to provide deployment of both solar PV and solar thermal power projects in a ratio of 50:50 in MW terms. Under this mission, the National Thermal Power Corporation (NTPC's) Vidyut Vyapar Nigam Limited (NVVN) is the officially designated nodal agency for the procurement of solar power. The request for selection (RFS) of

150 MW of SPV projects (of 5 MW each) and 500-MW worth of solar thermal projects (5–100-MW capacity range) was solicited by NVVN from interested project developers on 18 August 2010. Accordingly, the last date for receiving the RFS was 24 September 2010. As per the information made available by the NVVN, a total of 418 RFS were received from the prospective project developers. Out of these, 343 applications were related to PV areas and the remaining 55 belonged to thermal areas. In all, five requests were received for developing combined solar PV and thermal projects. It so happened that the total capacity of the shortlisted projects went beyond the total approved capacity of 650 MW. Thus, it became quite obligatory to invite project proposals along with a clear offer of maximum discount on the Central Electricity Regulatory Commission (CERC)-approved applicable tariff in respect to grid-connected projects for the fiscal year 2010/11. Thereafter, the bids received for the stated purpose were scrutinized.

The enthusiastic response

A total of 300 bids were received from PV-specific project developers. The CERC determined tariff stood at ₹17.91. Majority of the bids submitted to NVVN offered discounts ranging between 300 p–500 p. The NVVN selected 37 companies to develop solar power projects under Phase-I of the JNNSM, based on reverse bidding. The winning bidders offered discounts of about 30%–40% for solar PV and about 20%–30% for solar thermal projects, over the respective CERC-based tariffs. A total of 30 companies will be setting up 5 MW of solar PV projects each, which will be equal to 150 MW. On the other hand, seven companies will set up 470 MW of solar thermal power plants. Among the project developers, Rajasthan seems to be emerging as the preferred destination accounting for 505 MW or an overwhelming 81% of the total allocations of 620 MW made so far under the NSM, including the migration projects.

Analysing the initial outcome

Table 1 shows the allocations made to the project developers vis-à-vis their geographical location for putting up the large-scale, grid-power plants. The CSP-based power plants are much bigger compared to a uniform size of 5 MWp each, for the solar PV projects. According to the opinions of several market experts, the situation is the same for a variety of techno-commercial considerations.

The state of Rajasthan, with immense solar radiation and widespread wastelands, is the favourite among the project developers.

Incidentally, the new entrants outplaced the established players, both in terms of solar PV and solar thermal technology.

It is rather disturbing to note that several of the prominent government entities failed to make it to the final list of 37 companies. These mainly included Engineers India Ltd, Gas Authority of India Ltd, Steel Authority of India Ltd, and Oil and Natural Gas Corporation Ltd.

Courtesy: Knut-Erik Helle

Table 1 Allocation made to project developers vis-a-vis their location for putting up large-scale, grid-power plants

State	Solar CSP allocation (MW)	Solar PV allocation (MW)	Total (MW)	% share in total	Remarks
Andhra Pradesh	50	15	65	10.48	Rajasthan, as expected, gets the highest number of project allocations, both in solar PV and CSP areas.
Gujarat	20	–	20	3.22	
Karnataka	–	10	10	1.61	
Maharashtra	–	5	5	0.80	
Odisha	–	5	5	0.80	
Rajasthan	400	105	505	81.45	Number of states expected to witness megawatt scale power projects is less than one-third of the total number of states in India, thus, indicating a limited geographical spread.
Tamil Nadu	–	5	5	0.80	
Uttar Pradesh	–	5	5	0.80	
Total	470	150	620	~100	

The fast forward

The next most important step is to put a seal of approval on the Engineering, Procurement, and Construction (EPC) contract. It is equally important to achieve the financial closure by the project developers. After the signing of the power purchase agreements (PPAs), the project developers are given 12 months to set up the solar PV projects as against 28 months for the solar thermal projects. It may be possible that, in the beginning, obtaining the desired financial closure may take more than the expected time. This may be due to limited experience of both the project developers and bankers in developing and financing such projects in the country. Thus, the project execution and associated management of the PV projects may not pose any major problems. This is mainly because it is possible to set up the PV projects in a modular fashion having short gestation periods. However, the satisfactory implementation of both the solar PV and thermal projects would rely, to a large extent, on the core strengths of EPC contractors, firmed up for the desired purpose.

As of now, a wide range of activities are underway on the solar front. What is significant is that the Indian Renewable Energy Development Agency (IREDA) has recently sanctioned 98-MW worth of solar PV capacity across 80 projects. This capacity is part of the 100-MW rooftop solar PV and small solar projects under Phase-I of the National Solar Mission. It is important to mention here that these projects are not linked to the projects under the direct purview of the NVVN. Expectedly, there will be a plethora of cross-experiences to learn from, which will definitely benefit a whole range of stakeholders. The day is now firmly in favour of solar energy, but we will have to constantly bring into play the best possible system choice, which is oriented towards a successful field-driven performance.

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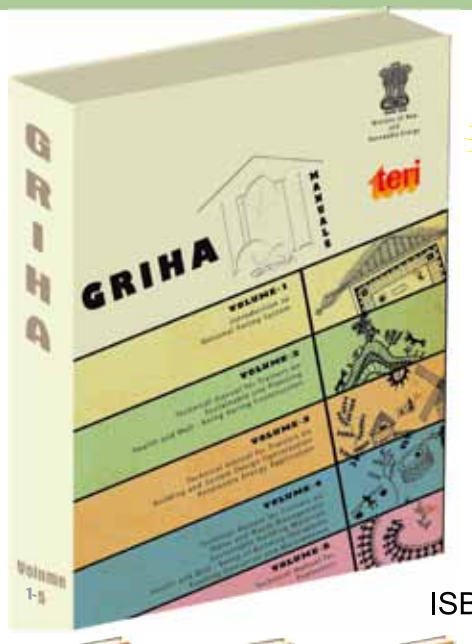

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Rajasthan
THE FUTURE ENERGY HUB OF INDIA

Gopal Lal Somani, President, Era Energy <gopalsomani@eragroup.in>

Solar energy scenario

The growing energy demand in India is mainly met by burning of fossil fuels—coal, oil and natural gas. However, given that these fuels are non-renewable, they have some drawbacks associated with their extensive use. The biggest drawback is the greenhouse gas (GHG) emissions associated with these fuels. The following few are the other concerns associated with such non-renewable fuels.

- Heavy infrastructural costs of exploration and mining
- High cost of production and transportation of these fuels
- Accompanying pollution levels
- Dwindling resources
- Volatility in the prices

Thus, the most viable solution is to migrate to sustainable renewable energy resources.

Courtesy: Knut-Erik Helle

Rajasthan: a classic case of energy transformation

The western part of Rajasthan has become synonymous with the solar energy movement in India. One of the main reasons is the optimum solar radiation that this part of the country receives. It is, however, ironic that despite optimum solar radiation, large-scale solar energy based power generation projects have not taken off, as expected. However, a number of other projects have been initiated and success achieved in the field of solar energy. And, despite the drawbacks, we should take a close look at all those achievements.

To begin with, let us consider some of the facts and figures of Rajasthan's energy potential.

- The western part of Rajasthan is blessed with abundant natural resource.
- It has more than 300 days of sunshine every year and the highest solar radiation in the country. Direct normal irradiance (DNI) is in the range of 2100–2260 W/sq m/year. Jodhpur is popularly known as the 'sun city' of India.
- Wind Power Generation Projects worth 1200 MW are operational in Jaisalmer, Barmer, and Jodhpur districts.
- Additional technical potential of 5000 MW in wind power has been assessed. Under the state wind policy, 2500-MW capacity applications have been registered and projects are in the pipeline.
- The state is also rich in conventional energy resources. It has ample reserves of crude oil, lignite (coal), natural gas, coal bed methane, and so on. The production of crude has started in a big way at Barmer. Cairns Energy, Focus energy, Oil and Natural Gas Corporation (ONGC), Oil India, Gas Authority of India Ltd (GAIL), Indian Oil Corporation Ltd (IOC), and Bharat Petroleum are carrying forward these developments.
- Two 125 MW and three 135-MW capacity lignite coal power plants are in operation and projects worth 2000-MW capacity lignite coal-based power plants at Giral, Barsingsar, and Palana are in the pipeline. Rajasthan Rajya Vidyut Utpadan Nigam Ltd (RVUNL), Raj West, JSW, and Lignite Corporation are responsible for these developments.
- 3 × 37.5 MW natural gas-based power plants are operating at Ramgarh and work on additional 220-MW capacities is in progress.
- The RVPNL has established huge transmission system by setting up 400/220/132-kV network all around. This means good power evacuation arrangements for efficient transmission of power generated from coal, gas, solar, and wind energy based power plants to support development and attract private investment.
- The western part of Rajasthan is sparsely populated and revenue land is available in abundance. The state government provides land at a reserve price.
- Sufficient water from the Indira Gandhi Nahar Project (IGNP)/ Rajiv Gandhi Lift Canal (RGLC) has been reserved and allocated for the development of the power sector.

As is well known, the Middle East is synonymous with oil—a critical natural resource that has made the region one of the wealthiest in the world. Just as oil was a passport to wealth in the 20th century in the Middle East, the energy resource potential of the sun and wind in Rajasthan is the gateway to prosperity. The western part of the state is now poised to be the energy hub of India.

With abundant availability of all types of energy reserves/resources and infrastructure requirements in place, Jodhpur, Jaisalmer, Barmer, and Bikaner districts in the state are some of the best areas in India for development of lignite, gas, solar, wind, and hybrid power generation projects. Rajasthan, thus, has become a preferred destination for investment and future development of power generation.

The state has immense potential for producing clean solar and wind electricity. The development of wind power generation, approaching 1250 MW is proof enough of the potential of wind energy in this state. Further, the state offers optimum solar radiation round the year. This makes it a highly preferred destination for clean energy generation.

The following are some of the solar photovoltaic (PV)/thermal related products having a good market potential in the country.

- Processed raw material for the solar cells
- Large capacity SPV modules
- Thin-film solar cells
- SPV roof tiles
- Inverters
- Charge controllers
- Solar water heaters (based on some advanced technology)
- Roof-integrated solar air heaters
- Solar concentrators for large-scale power generation

At present, the private investors and developers have registered applications worth 15 000 MW. There is keen interest in solar thermal technology in the state, having optimum solar potential in the western part (yearly DNI 2270 KWh/sq m).

A historical perspective

Comprehensive renewable energy policies/laws were enacted in India, time and again, by the concerned ministry. Various state governments also came up with some favourable policy measures as a catalyst for the expected growth. However, significant progress has not been witnessed in large-scale deployment of solar power systems. The following are some of the reasons.

- Prohibitive high capital cost of solar energy technologies being offered by the suppliers across the globe.
- The upfront investment in the technology is very high, thus, impacting solar energy penetration.
- The solar industry was in a nascent stage until recently and, historically, it has not enjoyed the benefits of economies of scale and scope due to its limited size.
- The suppliers of CSP technology are not willing to go in for cost cuts and offer equipment within the expected/affordable limit set by the Government of India. They are still holding inflated capital cost and adjusting the explosive FIT in Spain at

Courtesy: Anab

2007/08 level, even when the market has slowed down considerably.

- Lack of political will and efforts to strengthen our economic competitiveness towards deploying indigenous resources in the development of solar energy systems.
- Subdued focus on setting up mission driven research and development facilities and capacity-building initiatives geared at local resource utilization.
- Lack of availability of trained and experienced manpower to take up the daunting challenge of realizing lower cost of technology implementation.
- Solar energy resource mapping carried out only in the western part of Rajasthan (10 km bandwidth). This is insufficient and needs to be carried out at a macro-level for energy estimation in other parts of the country.
- Globally, manufacturers and suppliers of CSP technology equipments were heavily engaged in the US, Spain, Germany, Japan, and so on, to derive the maximum possible gains, as a result of an explosive FIT policy for long-term support. These resulted in inflating the capital cost, which is unaffordable in India.
- Favourable environment for wind power development in the recent past with tax holiday benefits and tariff support slowed down solar energy development and pushed this technology on the backfoot.
- The 140-MW Integrated Solar Storage Collector (ISCC) technology based Mathania project achieved financial closure and techno-economic clearance was accorded by the Central Electricity Authority (CEA) in 2002. High capital cost on CSP solar block, together with technology constraints proved to be the major deterrents. Thus, the Mathania ISCC demonstration project was put on hold. This weakened the trust and faith of the policy-makers, planners, and the supporters of solar energy in the country.

Key state policy initiatives

To begin with, a state policy to promote renewable energy generation promulgated a special scheme in March 1999. This scheme ended in March 2004 and was replaced by a wind-driven policy in February 2004, followed by yet another revision and replaced by a new policy that continued up to March 2009. The new Electricity Act came into force with effect from June 2003 with fresh updates. The state now has separate policies for the development of wind, biomass, and solar, apart from the State Energy Policy 2010.

The state government has gained sufficient experience with regard to the earlier policies apart from a clear understanding of the impediments associated with the renewable energy use.

In 2007, the Ministry of New and Renewable Energy (MNRE) issued a policy statement highlighting measures to tap about 50 MW of solar power to demonstrate the technology for large scale utilization. The trick of the trade is contained in the feed-in tariff (FIT) mechanism intended to offset the high capital cost involved. However, in the last two decades or so, substantial capacity additions have not been realized in the state.

The following are some of the (known) reasons for the subdued demand.

- The solar technology suppliers have not matched the cost of power to the expected/affordable limit of the Government of India.
- Till recently, the capital cost on concentrated solar power (CSP) remained prohibitive. However, the PV market has collapsed both in demand and price.
- Importantly, the CSP suppliers are reluctant to go in for technology transfer.
- High inflated Engineering, Procurement, and Construction (EPC) cost on solar projects put the investor at high risk. The bankability of the proposals still remains doubtful for the right type of investment decision.

The desirable outcome has been the enactment of the new policy measures in 2010, following a clear recognition of the issues confronting the developers, investors, and the utilities.

A solar-driven economy

A massive initiative to generate solar energy is taking place in the country, particularly in the state of Rajasthan (western part) and Gujarat (Kutch). These two states, with optimum solar radiation and vast wasteland areas, can become the country's preferred solar power locations. It is estimated that an area of 15 000 sq miles with yearly DNI 2200 kWh is sufficient to install 300 000 MW equivalent of CSP plants in Rajasthan. The National Thermal Power Corporation (NTPC) Vidyut Vyapar Nigam Ltd (NVVN) has recently awarded solar projects with a total capacity of about 680 MW. As per the available information, the project developers have already furnished huge bank guarantees and signed the power purchase agreements (PPAs).

Expectedly, very soon, giant solar PV panels and solar concentrating mirrors will dot the 3000–4500 hectare area in Jodhpur, Bikaner, Barmer, Jaisalmer districts of Rajasthan and the Banaskantha district in Kutch.

The government initiatives

As per the existing market reports, majority of the awarded developers under the NVVN Phase I programme opted to install solar power plants (PV as well as CSP) in Rajasthan. The Government of Rajasthan has already facilitated the following for the benefit of the project developers.

- Allotment of land
- Approved power evacuation scheme with a grid interface
- Allotment of water
- Access to required infrastructure

The project activities will now gather momentum, except for the fact that CSP technology suppliers are still unwilling to

support these projects at affordable and viable costs.

The Central Electricity Regulatory Commission (CERC) and the state regulators have further issued Renewable Energy Certificates (REC), regulations, and directives for all the utilities to purchase REC under Renewable Purchase Obligation (RPO) obligations. The CERC has announced the guidelines.

The MNRE, Government of India, the Rajasthan Renewable Energy Corporation, and the Gujarat Industrial Development Corporation are supporting the development of the infrastructure, pursuing an ambitious plan of building a "solar energy park". The larger objective is to support solar industries, developers, investors, entrepreneurs, and solar communities for research and development and implementation of their ambitious solar energy projects.

On 23 November 2009, the Government of India announced the most awaited Jawaharlal Nehru National Solar Energy Mission (JNNSM). It aims to generate 20 000 MW of solar power by 2022. India hopes its solar energy pursuits will not only address its growing

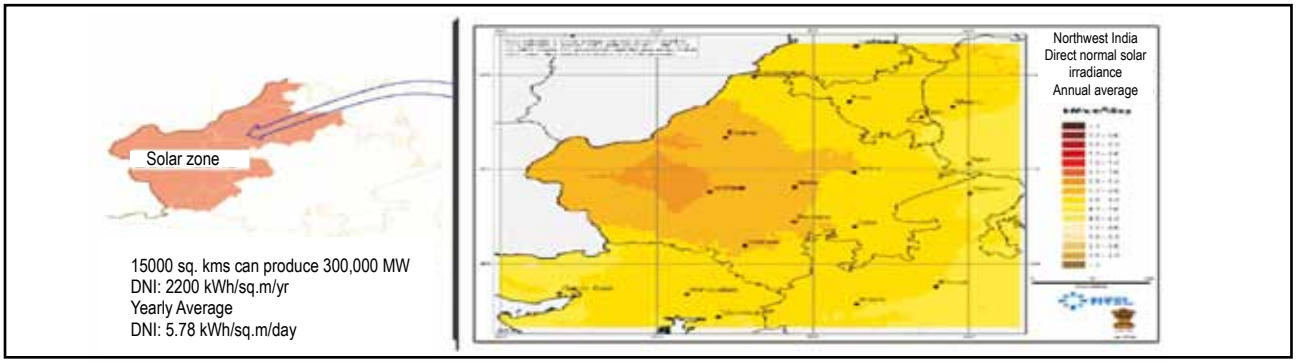


Figure 1 The solar zone of India

Courtesy: Knut-Erik Helle

energy needs, but also create millions of new jobs in next 10 years. It also hopes that solar energy will reduce carbon dioxide (CO_2) emissions by 42 million tonnes during the same period.

The significance of the plan is, that for the first time, solar energy has been identified as a major alternative source of energy to offset some of the energy needs of the country.

The immediate target is to achieve 2000-MW capacity, both for the urban and rural area, via off-grid PV power use. It is intended to put up small capacity, stand-alone, off-grid PV power plants in the range of 10–20 kW for remote village electrification.

The way forward

- For solar energy generation to succeed, India needs to formulate simplified rules and a single window clearance system.
- Intensive efforts are needed to generate solar resource data and solar mapping availability of the same in a public domain. This will encourage setting up of large scale bankable solar energy projects.
- The government should also provide more clarity on its plans for making land available at reserve rates, ensure availability of grid interface facility, and water for solar thermal generation.
- Implement the Mathania Project as the first demonstration research and development project. It has already got the Techno-Economic Clearance from the Central Electricity Authority and achieved financial closure.
- Deploy cost-cutting measures and, thus, provide affordable power to utilities in medium term.
- Sign bilateral arrangements for technology transfer and training of manpower.
- Encourage commercialization of all solar technologies and scalable development, as has been witnessed in the US and the European Union countries. These actions should result in cost cuts.
- The costs of solar equipments have crashed in the recent past. However, currently, the solar energy cost is in the range of ₹14–₹19 for each kilowatt-hour. The capital and installation cost is sure to fall, in case the companies decide and source out the mounting structures, fittings hardware and fasteners, balance of system (BOS), and power block equipments indigenously, and start installing on their own.

As a resident of Rajasthan, I wake up every morning and sleep at night thinking about the significant challenges that we face in our battle to bring about massive solar energy transformation in the state as well as in the country. The following are some of the biggest challenges that we need to overcome.

- Create good jobs and strengthen our economic competitiveness with the help of solar energy development?
- Ensure energy security?
- Protect our natural environment, especially from the threat of climate change?

Solar power offers a viable solution, at least in Rajasthan, to all these challenges. My role, as the leader of a special purpose vehicle (SPV) created by the state government in 1998 to implement the 140-MW Integrated Solar Combined Cycle Project, is rooted in the need to address these critical issues. And, hopefully, through our continuous efforts, we will be able to tap the immense potential of solar energy in India and, particularly, in Rajasthan.

SOLAR CONCENTRATORS

INITIATING RURAL EMPOWERMENT

V K Desai, Founder, TINYTECH <energy@tinytechindia.com>

In today's context, solar energy is being used in diverse areas such as lighting, water pumping, cooking, and so on. Two different technologies, solar photovoltaic and solar thermal, are at work to make this happen. Of late, solar is being used to generate electricity from steam. Thanks to this technology, one can think of distributed generation. As per the initial estimates, a whopping 15 million solar thermal power plants, in the capacity range of 0–10 kW, can be set up in India, which can revolutionize the country's energy scenario. However, the trick of the trade lies in design innovations of such low-capacity power plants.

A historical perspective

The steam engine technology came into being a few centuries ago. In fact, the steam engine helped the British Empire lay its foundations. The primary use of steam engines was in boats, steamers, vehicles, and railways. The technique was also used in war equipments and textile mills. It is quite important to mention here that the steam engine is simpler to operate than a diesel engine. And today, as we are trying to shift from the fossil fuel-based economy to renewable energy-based economy, efforts are being made to convert water into steam with the help of solar energy concentrators. This article talks about one such initiative.

The cost-effective design

RAVIRAJ solar concentrators, a work of V K Desai, founder of TINYTECH Plants, Rajkot, Gujarat, is one such initiative. RAVIRAJ concentrators promise to provide cost-effective, solar steam based power generation technology. Perhaps, the solar power plant incorporating the RaviRaj-32 sq m concentrator, coupled with a steam engine, is the simplest technology of all.

A unique feature of the RAVIRAJ concentrators is the projected outlook for fabricating the concentrators within the village itself. There is no need to construct parabolic or curvature-shaped concentrators. This type of concentrator design needs no bending of the metals. Instead, only straight steel needs to be welded, which seems to be well within the manufacturing range of the villages.

Solar steam-based power plants

The present cost of a solar thermal power plant is about ₹1 000 000 per 10 kW. It will take a month or two to set up a small capacity solar thermal plant. In contrast, a coal-based plants may well mature in not less than three years or so. Thus, the tiny solar power plant may also lead to some cost savings, along with laying a widespread transmission and distribution network.

Applications

It may be possible to operate the following types of products and systems with the help of solar steam based power plants.

- Sugarcane crusher
- Rice huller
- Oil expeller
- Water pump
- Spinning machine

Solar power plants and steam engines may greatly encourage cogeneration with combined heat and power (CHP) application, such as oil milling, sugarcane crushing, rice milling, and so on. This will save a lot of energy and encourage investment in the purchase of generators and motors.

Putting in use other renewable energy sources

Solar energy is not available during night time. One possible way of generating power during night time is by using large volumes of biomass materials, such as agricultural waste, crop residue, forestry waste, and wood waste. It is possible to produce about 20 000 MW of power by using biomass to energize the small capacity power plants and the steam

Table 1 Various type of applications, capacity realization, daily throughput of solar steam power plants

Application	Average estimated throughput per day	Capacity envisaged
Oil extraction	300 litres of oil	7 kW
Sugarcane crushing	10 tonnes of capacity	5 kW
Sugarcane juice boiling	1 tonne of sugar	10 kW
Cotton spinning	20 kgs of yarn	10 kW
Cloth weaving	30 m of cloth	5 kW
Power generation	20 000 MW	In units of 10 kW

engines. Wind energy can also be used for this purpose, thereby, utilizing all forms of renewable energy.

Table 1 showcases the type of applications, capacity (ies) involved, the total capacity realization, and daily throughput with the help of solar steam power plants.

Key technical specifications

The RAVIRAJ range of solar concentrators is designed for high field performance reliability. Following are the main technical specifications of the concentrators.

- The entire concentrator rests on a single central vertical pillar and revolves around the vertical axis. The vertical pillar has fabricated movable base frame. The height of the pillar is about 1.5 m.
- The main beam, supporting the entire concentrator, is 6 m long and supported centrally on a vertical pillar. It is inclined by 10 degrees and revolves on a vertical axis.
- There are 10 cross beams, each 6 m long, at right angle to the main beam and parallel to the ground. All such cross beams are attached to the main beam by pins, so that the cross beams can swing around the pin as a fulcrum.
- Each cross beam carries 36 mirror reflectors, 18 on the left-hand side of the main beam and 18 on the right-hand side of the main beam. Thus, on 10 cross beams, there are 360 reflectors.

Each reflector is of 60 cm x 15 cm. Each reflector has mirror bending device concentrating five to six times and all 360 reflectors focus the reflection on the focal point, just vertically above the central pillar, which is 3 m above from the concentrator frame. The total concentration is about 250 times.

All the 360 reflectors are focused against the sun by hand-operated control wheels. The wheels can be operated by about four people. Focus is to be adjusted manually every 5–10 minutes by the control wheels.

Similarly, the entire concentrator revolves around the vertical axis, operated manually, to track the sun every 5–10 minutes. Manual tracking is done by observing shadow and focus and is quite accurate. All the reflectors, once focused, do not require any change, with respect to cross beams. Only the cross beams are to be swung by control wheels.

The focus is fixed permanently and is independent of any latitude, direction, polar axis, seasonal adjustment, and so on. Thus, any lay person can operate and use the concentrator to generate heat.

The weight of the entire revolving concentrator, including 360 reflectors, is about 750 kg. The entire concentrator is pre-fabricated and can be assembled at site.

At the focal point, the small insulated boiler is placed, which will heat and convert the water into steam. The focal area will be about 0.2 sq m. The reflection area of 360 reflectors is 32 sq m. Thermal power may be up to 10–15 kW and mechanical power up to 2 kW. The approximate cost of solar concentrator, on a per unit basis, is ₹360 000.

The drawbacks

These solar concentrators offer several advantages. However, there are also few drawbacks. These mainly include the following.

- Cleaning of mirrors on a daily basis is required.

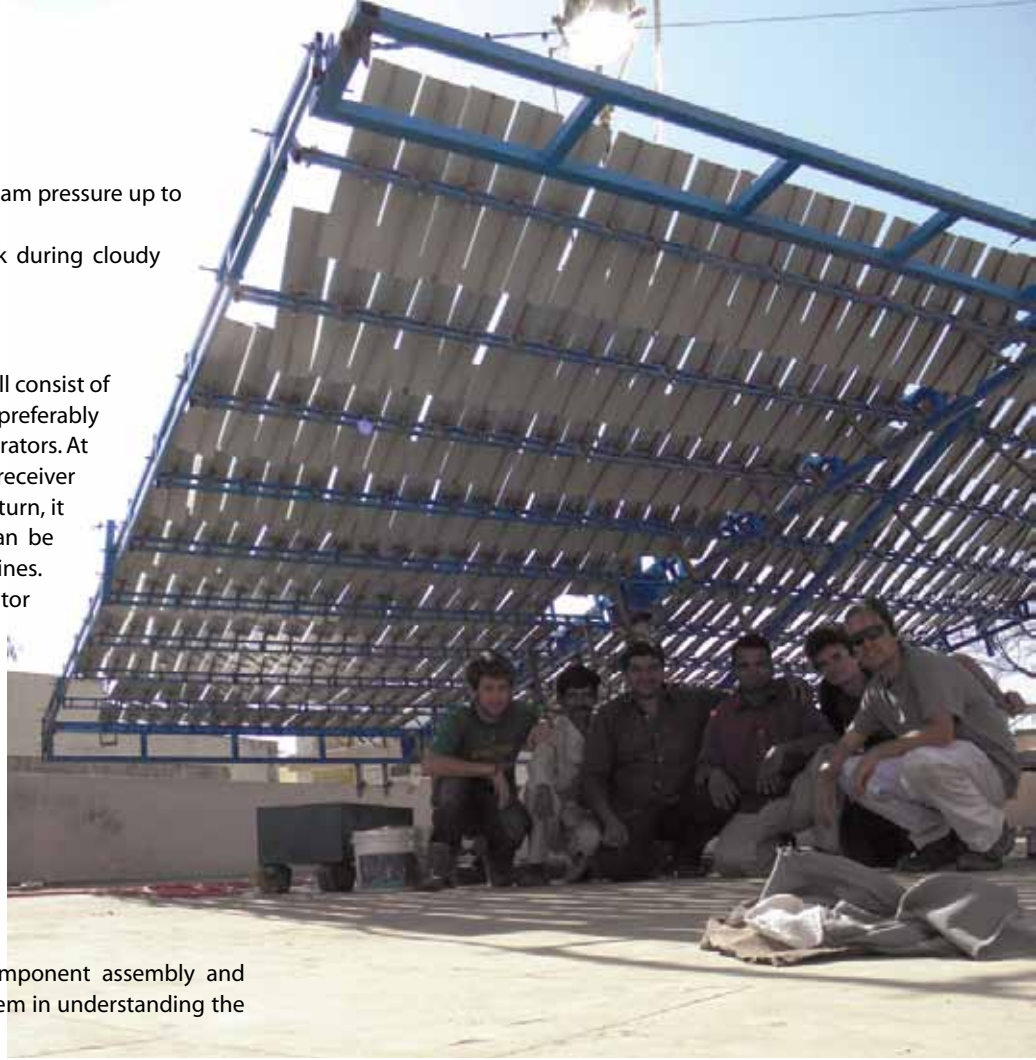
- Sun tracking is manual.
- It takes one hour to build up steam pressure up to 250 psi.
- Solar concentrator fails to work during cloudy and rainy days.

A small power plant

A tiny solar thermal power plant will consist of solar concentrators of 6 m x 6 m size, preferably in modules of three or five concentrators. At the focal point, there will be a heat receiver where steam will be produced. In turn, it will run a steam engine, which can be directly connected to various machines. Steam engine can also drive alternator to produce electricity. For 1-kW power, 16 sq m reflectors are required.

The way forward

The time has come for giving this type of technology innovation a try. To begin with, manufacturers could experiment with small size demonstrations. Rural communities need to be involved right from the stage of basic component assembly and engineering. This may also help them in understanding the key maintenance aspects.



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LINKING ENVIRONMENT AND EDUCATION

Prof. D C Baruah is currently heading the Department of Energy, Tezpur University, Assam. Prior to this, he was a professor at the Assam Agricultural University for about 17 years. He was instrumental in developing energy-efficient farm machinery suitable for local conditions. His interest lies in the field of renewable energy and applications of the modelling technique for energy management and rural energy. Application of solar-biomass hybrid for tea processing, combustion modelling of biomass including biodiesel, and spatial resources assessment through modelling technique, are some of his current areas of research.

Prof. Baruah received his PhD degree from the Punjab Agricultural University, Ludhiana, India. He has authored 25 research papers in different journals covering different aspects of renewable energy and energy management. He was also a distinguished visiting fellow at the University of Nottingham, UK.

In an interview with Arani Sinha, Prof. Barua talks about the linkage between environment and education, and how the Department of Energy, Tezpur University, is trying to strengthen this linkage.

Q. Kindly elaborate on the nature of the energy-related programmes being run in Tezpur University. To what extent do these programmes focus on renewable energy sources?

Tezpur University is carrying out teaching, research, and extension activities in the area of energy through some specific object-oriented programmes. The MTech (Energy Technology) students are expected to learn how to handle conversion, utilization, conservation, and management issues, pertaining to both fossil-based energy system and new and renewable energy system. Similarly, renewables such as solar, biomass, bio-diesel, and small hydropower as well as non-renewable components of energy, relevant to this region, have been the prime areas of research in Tezpur University. Realizing the critical need of awareness on energy conservation and renewable energy, Tezpur University has been regularly organizing training programmes, workshops, and seminars in collaboration with and active