Energy Access through

Rural Electrification and Renewable Energy

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Preface

Power is the life blood of a developing economy. India is currently in a state of burgeoning economic development. But the power scenario in India still has a long way to go. The government policies are well in place to take care of the power requirements of the country at a macro level. However, the issue of Energy Access at the grass root level still remains a cause of major concern. We believe that a lot of work can be done in this regard and hence we decided to formulate the 'Initiative on Sustainable Energy Access' (ISEA) and take up the preparation of this report.

Energy Access is about making accessible to the common man electricity, heat, or other forms of energy. Often referring to the situation of people in the developing world, lack of energy access also implies any quality of life issues relating to this lack of access. The rural parts of the country still remain largely devoid of an efficient power infrastructure. Research and policy implementation at this level can strengthen the power position of the country at the ground level.

Rural India is the backbone of India's economy. Nearly 70% of India's population lives in villages and agricultural is the main support for their livelihood. It is, therefore, ironical that India's rural population shares a much larger burden of poverty as well as energy poverty. For realization of India's ambitious dream, ensuring inclusive growth would be essential. Alleviation of rural energy poverty in India has to be an important component of such inclusive growth agenda.

With vast diversity of our rural population in physical, social, cultural, educational, and economic background, the solution would need to be developed on case by case matching with the peculiarities of a particular region. Eradicating energy poverty requires that adequate infrastructure is put in place so that power can reach the corners of the country. Moreover, this power must be clean enough to be environmentally acceptable, affordable by the people and also feasible to implement. Most of these criteria are satisfied by Renewable Energy. Also, renewable energy can be implemented in a distributed format which makes it more suitable for providing power to areas with difficult geographical accessibility. This report looks at the providing energy access to the rural part of the country through renewable energy.

This report is a comprehensive effort, at macro level, to make an assessment of the current scenario of energy access to the rural population, what should be our objectives and targets to remove the rural energy poverty and how we can meet the challenges encountered and accomplish this stupendous but important task. In such effort, the report identifies the vital role renewables offer, especially the solar energy. The report has looked at a lot of policies and case studies and tried to correlate those with the data about their implementation. The report also looks at new technologies and emerging solutions. We would consider this research a success if the inputs from this report can be useful in getting further insights into the power problems of the country.

The 'Initiative on Sustainable Energy Access (ISEA)' was formed by PFC in association with WEC-IMC with resourceful members from companies and organizations related to power and energy. The preparation of the report was coordinated by Technofin Consultants Pvt. Limited based on inputs provided by the members of the Core Group constituted for Initiatives for Sustainable Energy Access.

Core Group of ISEA
April, 2010

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Core Group of Members of Initiative on Sustainable Energy Access

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1. Introduction

Energy is a basic necessity for human activity and economic and social development. Yet global strategies for how to meet this basic need for the world's rapidly growing population are sorely lacking. Lack of energy services is directly correlated with key elements of poverty, including low education levels, restriction of opportunity to subsistence activity, and conflict.

Energy Access & Energy Poverty

Access to energy services is a key component of alleviating poverty and an indispensable element of sustainable human development. Without access to modern, commercial energy, poor countries can be trapped in a vicious circle of poverty, social instability and underdevelopment.

During the past twenty-five years, electricity supplies have been extended to 1.3 billion people living in developing countries. Yet despite these advances, roughly 1.6 billion people, which is one quarter of the global population, still have no access to electricity and some 2.4 billion people rely on traditional biomass, including wood, agricultural residues and dung, for cooking and heating. More than 99 percent of people without electricity live in developing regions, and four out of five live in rural areas of South Asia and sub-Saharan Africa.

Despite advances in areas such as rural electrification, the number of people lacking access to energy services has remained relatively constant due to increases in population. The total number of people without electricity has fallen by fewer than 500 million since 1990. Without modern energy services, millions of women and children face debilitating illness or premature death; basic social goods like health care and education are more costly in both real and human terms, and economic development is harder to perpetuate. The services that energy enables, such as electricity, can create conditions for improved living standards, especially in areas of public health, education, and family life.

Energy Poverty is a term for a lack of access to electricity, heat, or other forms of Power. Often referring to the situation of peoples in the developing world, the term also implies any quality of life issues relating to this lack of access.

Energy poverty is distinct from fuel poverty in that access is more of a problem than affordability. Energy poverty exists when the required infrastructure is not in place for energy delivery, most often electricity. Fuel poverty, on the other hand, exists when people do not have the ability to pay for energy, most often heating materials.

According to the Energy Poverty Action initiative of the World Economic Forum, "Access to energy is fundamental to improving quality of life and is a key imperative for economic development. In the developing world, energy poverty is still rife. Nearly 1.6 billion people still have no access to electricity, according to the International Energy Agency (IEA)."

Because most economic studies on global poverty focus on the provision of finance and education to create economic activity, the role energy services play in alleviating abject poverty and promoting sustainable development has not been clearly identified.

Although it is clear that people demand more energy as their incomes rise and that increased use of modern energy by households is a key element in the broader process of human development, the shift from traditional to modern energy sources - the energy ladder - is not a smooth one. As per capita incomes increase, the transition to commercial energy sources, which include natural gas, petroleum products and electricity, does not simply represent a substitution of more convenient and expensive fuels for cheaper traditional fuels. Commercial energy sources also permit the use of modern technologies that transform the entire production process at the factory level, in agriculture and within the home. The resulting increase in productivity generates higher incomes and increases the ability of people to explore and develop their capabilities.

Electricity allows tasks previously performed by hand or animal power to be done much more quickly with electric powered machines. Electric lighting allows individuals to extend the length of time spent on production and hence on income producing activities. It also allows children time to read or do homework and access to television and film, which opens rural residents to new information that can instill the idea of change and the potential for self -improvement. Modern liquid fuels permit modern modes of transportation that cut the cost, both monetary and in time, of travel to nearby towns where, again, individuals are exposed to different ways of doing things and different views. Faster and cheaper transportation can increase the reliability of supply of modern fuels, reducing the need to maintain supplies of firewood as a back up and facilitating movements up the energy ladder.

India’s Economic Development and Energy

India is perceived to be an Emerging Global Economic Tiger. Irrespective of the extent of materialization of the above perception, this has thankfully led to an accelerated developmental effort in vital sectors of economic growth, namely, infrastructure, energy, agriculture and social sectors.

There seems to be a deep-rooted realization that inclusive growth in all sectors is pre-requisite for translation of the aforesaid national dream into reality. It is, therefore but natural that such inclusive growth agenda in Energy sector has attracted the focused attention of the planners and all concerned stake-holders.
A comprehensive look, at the state of rural energy sector involving an analysis as to what extent the rural energy needs are being met (or not being met); how the unmet needs can be met and the vital role the renewable energy is poised to play in this major task, is a first but vital step in the direction of achieving objective of inclusive growth in energy sector.

UN Millennium Development Goals

The Global community identified certain goals to be achieved for global development which are included in the **Millennium Declaration** adopted by 189 nations and signed by 147 heads of state and governments during the **UN Millennium Summit** in September 2000.

The Millennium Development Goals (MDGs) are eight goals to be achieved by 2015 that respond to the world's main development challenges. These are as follows:

Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a Global Partnership for Development

In support of the MDGs, the UN Development Program's work centers upon "six thematic practice areas, selected because of developing country demand: poverty reduction, democratic governance, sustainable energy and the environment, crisis management, ICT, and HIV/AIDS." Access to energy is a component part within UNDP's approach to sustainable energy. UNDP's priorities on sustainable energy involve: (a) strengthening national policy frameworks, (b) promoting rural energy services, (c) promoting clean energy technology, and (d) increasing access to financing for energy.

Sustainable energy for poverty reduction

Sustainable development will only happen if poverty is tackled and the environment is protected. It is a false dilemma to say that we either tackle poverty or we save the planet. Poverty can be tackled without costing the Earth. Crucial to both is the rapid expansion of clean, sustainable and renewable energy.

There is now a growing consensus amongst policy makers that energy is central to reducing poverty and hunger, improving health, increasing literacy and education and improving the lives of women and children.

Some 1.6 billion people in the world, more than a quarter of humanity, have no access to electricity and 2.4 billion people rely on wood, charcoal or dung as their principal source of energy for cooking and heating. This fuel is literally killing people. Two and a half million women and children die each year from the indoor pollution from cooking fires.

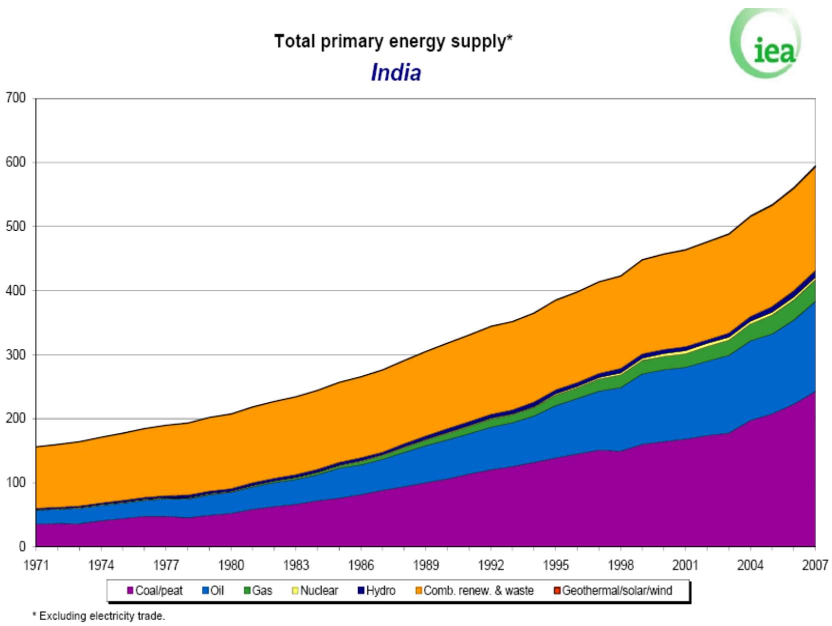
The poor face another threat, paradoxically because of the over consumption of energy. Industrialized countries' excessive fossil fuel consumption is driving climate change, and the poor are bearing the brunt because poverty makes them the most vulnerable and least able to cope. Thousands have already died and millions more made homeless due to extreme weather events. The Intergovernmental Panel on Climate Change described Africa, the world's poorest region, as "the continent most vulnerable to the impacts of projected change because widespread poverty limits adaptation capabilities".

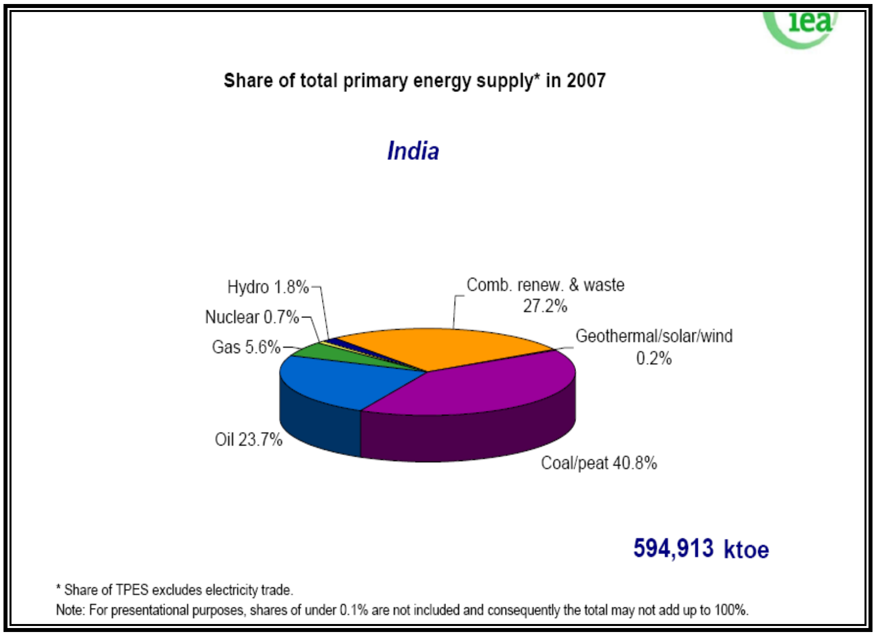
The rapid expansion of clean and sustainable energy offers a win-win for the poor and the environment. For the poor, particularly the rural poor, without basic energy services, renewable energy is often the cheapest option. For industrialized countries a massive uptake of renewable energy will help to achieve the dramatic emissions cuts needed to avoid climate change. The growth of renewable energy is both necessary to provide energy services without choking the planet and to create the economies of scale necessary for a global expansion of renewable energy.

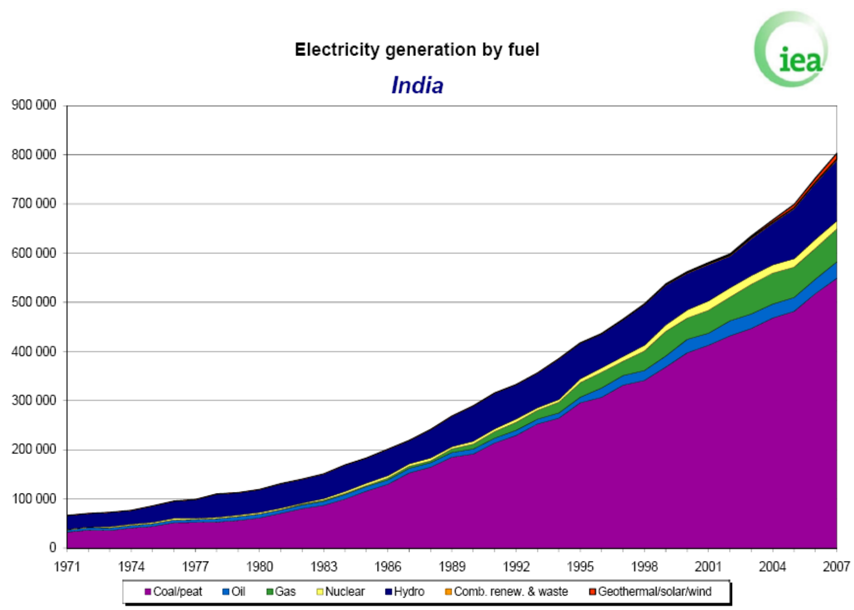
Sustainable, clean energy can play a key role in reducing the huge burden of poverty and environmental degradation around the world. In order to maximize the role of clean and renewable energy in poverty reduction significant steps forward must be made to:

- implement strategies which will allow access to clean energy for the world's two billion poorest people in ten years
- greatly expand global renewable energy markets to create economies of scale

- stimulate clean and renewable energy markets in developing countries to increase energy options available for sustainable development




Share of total primary energy supply* in 2007
India
Hydro 1.8%
Nuclear 0.7%
Gas 5.6%
Comb. renew. & waste 27.2%
Geothermal/solar/wind 0.2%
Oil 23.7%
Coal/peat 40.8%
594,913 ktoe
* Share of TPES excludes electricity trade.
Note: For presentational purposes, shares of under 0.1% are not included and consequently the total may not add up to 100%.


Electricity generation by fuel
India
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
0
1971 1974 1977 1980 1983 1986 1989 1992 1995 1998 2001 2004 2007
Coal/peat Oil Gas Nuclear Hydro Comb. renew. & waste Geothermal/solar/wind

Projections for Electricity Requirements by MOP

Year	Billion kWh		Installed Capacity (GW)	
	8%	9%	8%	9%
2006-07	700	700	140	140
2011-12	1029	1077	206	215
2016-17	1511	1657	303	331
2021-22	2221	2550	445	510
2026-27	3263	3923	655	785
2031-32	4793	6036	962	1207

2. Rural India and Energy

Energy Poverty Is Universal

As per one estimate, globally, 1.6 billion people (1/3 humanity)[1] have no access to electricity; 80% of energy poverty is in rural areas of developing world.
Worldwide, more than 3 billion[2] people depend on dirty, harmful solid fuels to meet their basic energy needs like cooking. Some 2.4 billion[2] people rely on traditional biomass i.e. wood, agricultural residues and dung cake for cooking and heating. The Indian situation is no better.

India

With its large rural population of (70% of the total population) living in villages and being poor, India is one of the worst affected developing countries suffering from energy poverty. As per the data of 2004 (which might have only changed marginally as a result of various initiatives taken by the Govt.), 26% villages (56.5% households)[3] had no access to electricity; An ambitious scheme launched in 2004, Rajiv Gandhi Grameen Vidyuteekaran Yojana (RGGVY) targets to achieve 100% village electrification by 2012 (originally by 2010).

Energy Poverty impacts in several ways

Social Dimension: Energy poverty is the main reason for rural poverty which in turn, give rise to health issues, Up to 95% of rural energy needs are being met by inefficient burning of fuelwood, dung cake and plant wastes and is used for meeting the basic needs of cooking, heating and lighting, there being nothing left for productive use. These result in high pollution levels in low income dwellings with consequent health issues propping up.

Economic Dimension: Lack of affordable and reliable energy restricts the income levels and industrial/commercial activity leading to economic stagnation or slow growth.
Environmental Dimension: In the absence of affordable modern energy, there is no alternative to the manner of use of energy natural sources, which results in huge pressure on the environment in general.

Complexity of Energy needs of rural India

The energy needs of rural India, as seen in totality, are much more complex and are unlikely to be fully or substantially addressed by 100% village electrification.
Such complexity is the result of large population, majority being poor with no capacity to pay for the cost of energy and the only energy in use i.e. fuel wood for cooking being availed without any financial cost personal human labor, the grid extension to the villages, even if materializes, would be of limited help as there is

large gap between supply and demand, quality and timing of supply to the rural areas, high T&D losses and large component of hidden cost involved in such supply, which would justify use of local energy resources than to rely on grid power for the rural population.

This has been dealt in more details subsequently. The following list out the Rural Energy Demand Composition

Rural Energy Demand Composition

- Domestic
  - Cooking
    - Biomass
    - Kerosene
    - LPG
    - Grid Electricity
    - Renewables
  - Lighting (including street lighting)
    - Kerosene
    - Grid Electricity
    - Solar
  - Other Uses
    - Grid Elecricity
    - Renewables (Solar, Biomass etc.)
- Agricultural
    - Grid Electricity
    - Renewables
    - Animal/Human Energy
- Industrial/Commercial (including institutional and Govt.)
    - Grid Electricity
    - Captive Generation (Diesel/Kerosene/Petrol)
    - Rnewables
- Transport
    - Diesel/Petrol
    - Grid Electricity
    - Animal/Human
    - Coal (very limited in railways)

- About 75% of Energy in Rural India required only for Cooking and Lighting, largely met by locally available bio mass and kerosene, supplemented by electricity from grid.
- 75% use biomass (firewood), 10% use dung-cake and only 5% use LPG for cooking
- 50% use kerosene and 48% grid electricity for lighting.
- Agriculture is second largest rural energy demand , Electricity and Diesel are the main sources
- Human and Animal Energy is major source for domestic, agriculture and several other requirements. Women and Energy have strong relationship in rural India. Drudgery of women and children, Health Issues due to inefficient use of biomass and lack of ventilation

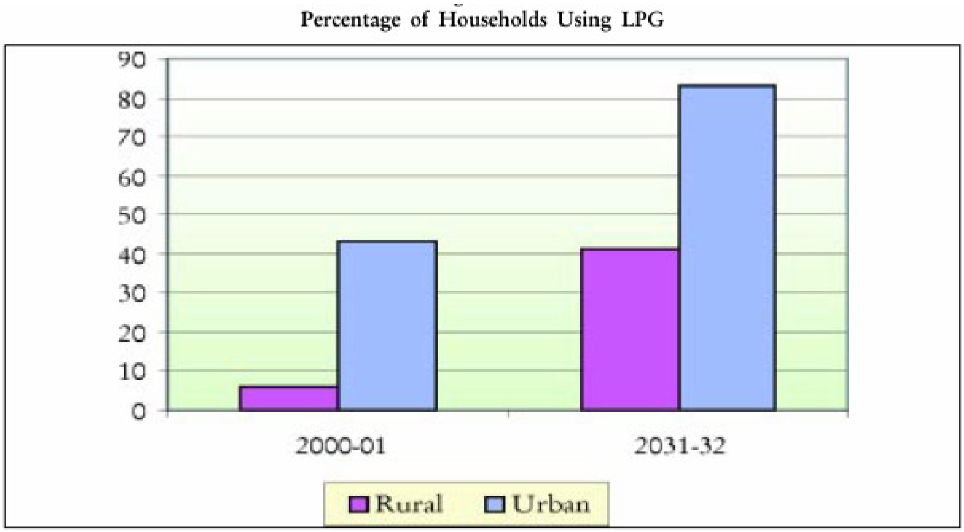
The Rural Poor

The Economic Poverty and Energy Poverty seem to be going hand in hand. It is difficult to make a conclusive determination which one drives the other.

Let us take a look at the typical characteristics of the rural poor household. These are:

- The family consists of more than 5 members.
- It has no or limited land or livestock as its assets.
- It has limited or no other assets or equipment, it may be living in a self built Kachcha (temporary) house.
- It has no access to electricity, either no grid connectivity or not being able to afford the cost thereof.
- It depends on water from, hand pump, pond or well, irrespective of whether the water is fully potable or needs some treatment for making it fit for drinking.
- It depends on rudimentary cooking processes and equipment, typically the three stone chulha (cook stove).
- The family survives on a single or two persons working as daily Wage Labor.
- It is substantially dependent on natural resources and hence is sensitive to earning shocks.
- It may be spending up to 70% of the budget on food expenditure, mainly rice and other staples, unlikely to provide the minimum essential nutrients.
- The energy needs are predominantly met by women folk (who may at times be assisted by young children) for fetching wood, biomass or dung and making dung cake for cooking and other needs. Thus, Women and Energy have strong relationship in rural India in arranging and using energy.
- Drudgery of women and children can be well imagined who need to collect biomass on their heads almost on daily basis to be able to cook their daily food.

Thus, there is no time or energy left with them for to pursue income generating activity or education.



Energy Poverty and Rural Health

Access to modern energy has vital contribution in the success of efforts for eradication of poverty. However, while planning and providing for the energy needs of the rural masses, due consideration will have to be given to address the challenges of concerns for health and ecology

As per WHO estimates, 1.6 million People die from adverse effects of indoor pollution each year or 1 person every 20 seconds.

- A large rural population has to depend on wood, dung cake, agricultural residue and coal to meet their coking and heating needs, which they burn indoors over open three stone chulhas (cook stoves) or like. The smoke has no escape and women and children are trapped with it while meals cook. The fine concentrated particles (Black Carbon) travel deep into lungs and become source of chronic respiratory diseases, lung cancer, pneumonia etc. These particles are also one of the major sources for global warming.

Therefore, clean energy alternatives have to be developed, especially for developing countries. Some of very simple means of achieving this of some extent need only efforts to promote amongst the rural poor as these are simple to be handled by the rural uneducated and do not cost a fortune. For example, improved chulhas (cook stoves) with induction exhaust can be used on large scale amongst rural population which will benefit as under:

- It will improve efficiency of combustion and thereby CO2 emission and fine carbon particulate matter.
- It will increase heat utilization per kg of biofuel, thereby saving of labor in collection of biofuels as also economy in use of such fuels.

3. Barriers to Energy Access for Rural Masses

The barriers or constraints to Energy Access to Rural Masses have their origins in economic, social, technological and financial limitations coupled with inadequate focus by the planners, Governments and national and international development organizations on the issues involved.

Some of the major barriers to Energy Access for Rural Masses are:

Geographically dispersed villages
Long distances and widely disbursed village populations have made it extremely difficult and expensive to provide access to grid electricity for the Rural Masses.

Inadequate focus on local resources
There is need for increased focus to explore the local energy resources due to perceived inhibitions of cost, suitability of available technologies and appropriate organization to optimize use of such local resources.

Inadequate financing structures
While the investments involved were perceived to be too huge to be met by the Govt. resources, appropriate financial models need to be developed to tap these resources through innovative private sector investment and PPP models.

Inadequate Interest of private sector
Viability of private sector investment needs to be facilitated by the Govt. though an appropriate mix of:

- Subsidies & Grants
- Incentives
- Policy of Tariffs and Risk Sharing

Unsustainable initiatives
In some cases, the initiatives for decentralized energy systems have not sustained due to various reasons and this has created mistrust in the planners, policy and decision makers to pursue these and other initiatives for decentralized energy systems.

Need for better monitoring

Implementation of rural energy schemes requires to be continuously monitored. The schemes need to be appropriately modified from time to time to ensure that poor people are not deprived of electricity after connection due to issues of affordability or under conditions of extreme hardship like natural disasters, draughts, floods, etc, which may affect their meagre earnings. It needs to be appreciated that some of the existing energy sources like fuel wood for cooking is procured by the rural poor without any financial cost or in another words, the energy is available free of any cost. If these poor people are to be provided access to modern energy, distributed or grid, the planners have to simultaneously work out a scheme which provided an opportunity for these people to increase their earning and until such time to ensure that they are able to bear higher financial burden than that required to meet their minimal cost of kerosene etc. for limited domestic lighting etc.

Ineffective targeting of subsidies

The rural poor may also be seen using fire wood or coal instead of cleaner fuels like kerosene, LPG etc. due to affordability or availability issues. There is also a perception that the subsidized kerosene provided by the Govt. for the rural poor may also be cornered by the vested interest for adulteration of other fuels or for other uses. Hence these never reach the poor for their needs. It may also be possible that some of the poor prefer to sell the kerosene allotted to them for money so that some of their other needs can be met as the requirement of energy can in any case be met by fire wood which they are able to procure from natural resources free of any cost.

Affordability of Energy cost

Most of the rural population is so poor that they have no potential to bear the partial or total capital cost for availing any energy connection or capital equipment. Nor are they capable of meeting the expenses of capital maintenance or repairs. With almost no financial resources that can be spared for such contingent requirements and with no education or training even to take care of very minor day to day repairs or maintenance. In fact, in some cases, it has been observed that where the financial model was worked out to require a very meager operating cost from such poor population could not be sustained which resulted in discontinuance of the energy service to such poor or in some cases the abandonment of the scheme itself.

Remote locations

India is geographically a very large area and the villages are widely dispersed, with difficult approach and high transportation cost for any energy supply to these areas. Often the population of the small villages may not be enough to economically justify the extension of the grid connection. Such areas are perhaps best served with the distributed energy generated from locally available resources, like solar, biomass, small hydro etc. However, a suitable financial structure with subsidy element and also organizational requirements for operation and maintenance of such schemes would need to be tailor-made, depending on the peculiarity of each village or a group of villages in close proximity.

Availability of ready to use technology.

In cases where extension of the grid to remotely located villages or village clusters may not be economically viable, they will need to be served with energy from distributed generation from locally available resources. However, the availability of right technology for meeting such needs is huge challenge. The technology will need to be not only affordable from considerations of capital investment, but also simple and reliable so that the rural population, with a little training can manage operation and maintenance without allowing loss of faith therein of the local population. .

Solar Energy, Biomass and Micro/Mini Hydro systems seem to be appropriate for such distributed generation. There have been several initiatives at the Govt. level, by NGOs, by Private Sector organizations and even by groups of individuals globally and several of them in India as well. These initiatives will need to be validated and evaluated from the considerations mentioned above and if feasible replicated at suitable locations with appropriately structured financing arrangements.

Energy crops competing with food crops

Bio-fuel also seems to be an alternative for meeting the energy requirements of remote villages, where other sources are not practical. There is an evolving controversy about the use of bio-fuels as these are perceived to be competing with the food crops as the use of land for the food crops would be the first priority. However, as per one study, there are enough degraded lands for growing the bio-fuel crops without in any way affecting the land for food crops. Further, there are technological developments which facilitate a productivity enhancement by several times of the conventional method, which would free up the corresponding land for cultivation of bio-fuels. Similarly, the pressure on water for growing some of such fuel-crops is also considered to be much lower compared to the other crops. Nonetheless, the commercialization of these technologies and availability of degraded lands where fuel crops could unquestionably be grown would require a detailed study and documentation to be of practical utility for the planners and developers/investors.

Crops presently used for production of bio-diesel are Jatropha and Karanj, which require minimal water as compared to food crops. As regards, the land requirement, there have been wide variations in productivity of these crops (Jatropha) but by developments in cultivation of these crops (Jatropha) some of the countries have made large strides in enhancing productivity. which would facilitate substantial reduction for such crops.

Funding Gap

Energy needs of the poor are small but small amounts of energy can make tremendous difference to the quality of life of the poor. However, even to meet these small energy needs for the large poor rural population of the world, despite all the talks and initiatives, there have been wide gaps between availability of financial resources vis-a-vis the requirements. An estimated $ 435 billion required for providing electricity to all. An estimated $ 135 billion required to convert 50 % of biomass for cooking into clean bio mass use.

Ability to pay

Ability and willingness to pay is a mojor concern and is a critical issue for bridging the funding gap.

Sustainability of Renewables

Global increase in fossil fuel prices would make some of the renewable energy initiatives as more viable.

Subsidies

Subsidies are more acceptable now than ever before. Capital Subsidies are provided under various schemes of the Govt. including RGGVY, VGF and MNRE schemes. Operating cost subsidies are also being recognized as a means of rural energy development. These schemes have, however not been able to substantially alleviate the Energy Poverty amongst rural population.

4. Government Initiatives

The Govt. of India as well as the State Govts. have taken several initiatives to meet the energy needs of the rural population. Some of these initiatives are discussed below.

RAJIV GANDHI GRAMEEN VIDYUTIKARAN YOJANA (RGGVY)- Ministry of Power, Govt. of India

This is a major national effort to universalize access to electricity – 57% of rural households were without access in 2001. The programme launched in 2005 targets and achievements :

- 1, 00,000 un-electrified villages.
- 78 million rural households in un-electrified and electrified villages.
- Provides 90% capital subsidy. 100% capital subsidy for electrification of Below-Poverty-Line (BPL) rural households.
- 44,000 villages electrified. Another 22,000 villages covered under intensive electrification. About 2 million connections given.
- USD 1.5 billion invested. Another USD 6.75 billion provided.
- National programme for Franchisee development launched. Franchisees in place in 14 states, covering 63,000 + villages.
- Generated employment for villagers and improved consumer services.
- Resulted in significant improvement in revenue collection - in some cases more than 100%.

The programme has been in operation ever since its launch in 2005 and has helped in a major way in rural electrification of India. The program has achieved electrification of about 83% un-electrified villages by December 2009. Notwithstanding the progress in village electrification through extension of the grid, the availability of modern energy for the rural poor masses is still perceived to be a distant dream due to inadequate electricity generation and issues of affordability for the rural poor.

Integrated Rural Energy programme (IREP).

IREP aims at promotion of an optimum mix of both conventional and non-conventional energy sources in selected blocks in the country. Central Sector Component - Provides grants for support staff in the IREP project cells at the State and Block levels, training of the staff and extension work. State Sector Outlays - Utilized for the implementation of IREP Block Energy Plans. IREP is no longer in effect. The program is learnt to have been of limited success primarily due to the State not having been able to allocate necessary financial resources for the scheme.

National Biogas & Manure Management Programme

The National Biogas and Manure Management Programme' (NBMMP) aims at promotion of indigenously developed simple-to-construct and easy-to operate family type biogas plants.

Cumulative Installations to over 41.2 lakh biogas plants for providing clean cooking /lighting fuel to over 4 million rural houses has been achieved by March 2009. Potential for such biogas plants has been estimated to be 120 lakh installations.

Table 3.1	National Biogas and Manure Management Programme (NBMMP) State wise estimated potential and cumulative achievement for family type biogas plants till 31st March, 2008 and Targets and Achievements during 2008-09			
State/Union Territories	**Estimated Potential**	**Cumulative achievement as on 31/3/08**	**Target and Achievement during 2008-09***	
			Target	**Achievement**
Andhra Pradesh	1065000	433414	18000	12510
Arunachal Pradesh	7500	2545	150	-
Assam	307000	63642	3000	6000
Bihar	733000	125488	200	-
Chhattisgarh	400000	25499	3000	1972
Goa	8000	3828	50	34
Gujarat	554000	395552	8000	3101
Haryana	300000	51314	1500	1032
Himachal Pradesh	125000	45225	150	-
Jammu & Kashmir	128000	2261	50	24
Jharkhand	100000	3079	500	301
Karnataka	680000	400614	10000	4250
Kerala	150000	117227	3000	2393
Madhya Pradesh	1491000	266389	16000	12851
Maharashtra	897000	753831	15000	12261
Manipur	38000	2128	100	-
Meghalaya	24000	5111	300	134
Mizoram	5000	3670	200	100
Nagaland	6700	3123	200	200
Orissa	605000	232190	4000	1062
Punjab	411000	88344	8000	7470
Rajasthan	915000	67080	100	-
Sikkim	7300	6331	200	166
Tamilnadu	615000	213015	1500	693
Tripura	28000	2587	200	-
Uttrakhand	83000	8179	500	502
Uttar Pradesh	1938000	416998	3000	1065
West Bengal	695000	285462	11000	13736
A&N Islands	2200	137	0	-
Chandigarh	1400	97	0	-
Dadra & Nagar Haveli	2000	169	0	-
Delhi	12900	678	0	-
Puducherry	4300	573	100	-
KVIC and Others			16000	1800
TOTAL:	**12339000**	**4025781**	**124000**	**101529**

*Figures are being flurried up

Table: Achievements under National Biogas and Manure Management Program

Solar Thermal Applications in Rural Areas

Solar thermal demonstration programme to promote different types of solar cookers, special demonstration and pilot projects of solar dryers and solar stills, and demonstration scheme for North-East, Islands, Jammu & Kashmir and Sikkim for solar water heating systems has been implemented The programme also provides financial support to the manufacturers of solar cookers for obtaining BIS approval.

Under the programme, central financial assistance at the rate of Rs.1, 500 per dish

Table 3.2	Physical Progress of Implementation of Remote Village Electrification Programme (as on 31.03.2009)					
S. No.	State	Total Villages Sanctioned	Villages Completed	On going Villages	Total Hamlets Sanctioned	Hamlets Completed
1.	Andhra Pradesh	0	0	0	13	
2.	Arunachal Pradesh	297	246	51	1	
3.	Assam	1986	255	1701		
4.	Chhattisgarh	588	399	189		
5.	Gujarat	38	35	0		
6.	Haryana	0	0	0	286	194
7.	Himachal Pradesh	21	1	20	1	
8.	Jammu & Kashmir	235	130	105		
9.	Jharkhand	477	449	23		
10.	Karnataka	22	16	2	57	14
11.	Kerala	0	0	0	607	558
12.	Madhya Pradesh	274	118	137		
13.	Maharashtra	353	256	94		
14.	Manipur	237	191	46	3	
15.	Meghalaya	97	27	70		
16.	Mizoram	20	20	0		
17.	Nagaland	3	3	0		
18.	Orissa	306	74	232		
19.	Rajasthan	327	219	84		
20.	Sikkim	0	0	0	13	13
21.	Tamil Nadu	0	0	0	184	
22.	Tripura	62	60	2	693*	341
23.	Uttarakhand	655	472	130	63	34
24.	Uttar Pradesh	250	79	3		
25.	West Bengal	1177	1171	6	9	2
	TOTAL:	**7425**	**4254**	**2895**	**1930**	**1156**

Notes:

19 projects in Madhya Pradesh, 3 in Maharashtra, 24 in Rajasthan, 3 in Karnataka, 53 in Uttrakhand,5 in Jharkhand and 168 in U.P and 145 hamlets in Tripura have been cancelled by State Governments as they were taken up for grid electrification.

cooker and Rs.15, 000 for community solar cookers is provided. For box type solar cookers, an incentive of Rs.200 for ISI mark and Rs.100 for other solar cookers is provided to the promoter. As of March 2009, Cumulative Installations for demonstration solar thermal power plants is 6.57 lakh units

Solar Photovoltaic Programme for rural areas

Solar Photovoltaic (SPV) technology enables direct conversion of sunlight into electricity. Photovoltaic systems have emerged as viable power sources for various applications such as lighting, water pumping, traffic signals, telecommunications as well as stand-alone and grid connected power generation. They are increasingly being used to meet the electrical energy needs especially in hilly areas, forest regions, deserts, islands, far flung villages, unmanned locations and other areas which require reliable and uninterrupted power supply.

The Cumulative Installations for SPV lighting systems, mostly in rural areas, as of March 2009 is 14 lakh.

Remote Village Electrification

The Remote village electrification (RVE Program) initiative during 10th plan aimed at providing basic lighting / electricity facilities to renewable energy sources in remote villages and hamlets which are not electrified and where grid connectivity is either not feasible or not cost effective. The total number of such villages and hamlets so far electrified is 2,300. Nearly, 4 lakh households in 4,237 remote villages and 1142 remote hamlets have so far been provided with solar home lighting systems.

Table: Achievements under Remote Village Electrification Program

Village Energy Security Program

The Village Energy Security Test Projects (VESP) aim at meeting the total energy requirements, such as cooking, lighting and motive power of villages, with full participation of the local communities, including women. The projects are environment-friendly and create avenues for local employment and improve the quality of life. The activities envisaged under these projects are: Preparation of a Village Energy Plan, including assessment of resources, energy services required and configuration of energy production systems; formation of a village energy committee; creation of a village energy fund; plantations and installation of energy production systems; operation & maintenance; and capacity building including training.

The energy production systems could comprise improved chulhas; biogas plants based on dung / oil cakes or leafy biomass; biomass gasifiers coupled with 100% producer gas engines; and, biofuel based engines run on 100% Straight Vegetable Oils (SVO) for lighting and biofuel based pump sets for meeting the motive power requirements. Energy plantations are an integral part of these projects.

The projects involve village-level planning and implementation in order to meet the total energy requirements of the village mainly through local biomass resources. The energy services are to be owned and maintained by the village community. The projects involve active community participation and have considerable potential for local employment generation.

MNRE provides 90% of the project cost for meeting the total domestic and community energy requirements using new and renewable energy systems. The balance 10% of the project cost is to be mobilized by the community. Cumulative no. of installations so far under the scheme is 37.

Biomass based distributed power generation program

Biomass power projects with an aggregate capacity of 703 MW through 102 projects have been installed. Fuels used in such projects are rice husk, Prosopisjuli flora and agricultural residues. The Indian biomass power projects are characterized by a number of innovative features such as use of diverse range of biomass materials in the same boilers and use of air-cooled condensers, etc.

The promotion of biomass-based power generation in the country is encouraged through conducive policy at the State and Central levels. The MNRE provides the capital subsidy for biomass and bagasse cogeneration projects. Fiscal incentives such as accelerated depreciation, concessional import duty, excise duty exemption, tax holiday for 10 years etc. were continued during the year.

Jawahar Lal Nehru Solar Mission

While launching the National Action Plan on Climate Change on June 30, 2008, Hon'ble Prime Minister of India recognized the central-stage that the Sun, being the original source of all energy, occupies. In pursuance thereof, the Jawahar Lal Nehru National Solar Mission was launched on 11th January, 2010

The main objectives of the Mission are:

- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To ramp up capacity of grid-connected solar power generation to 1000 MW by 2013; an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled – reaching 10,000MW installed power by 2017 or more, based on the enhanced and enabled international finance and technology transfer. The ambitious target for 2022 of 20,000 MW or more, will be dependent on the 'learning' of the first two phases, which if successful, could lead to conditions of grid-competitive solar power. The transition could be appropriately up scaled, based on availability of international finance and technology.
- To create favorable conditions for solar manufacturing capability, particularly

- To promote Solar thermal for indigenous production and market leadership.
- To promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022
- To deploy 20 million solar lighting systems for rural areas by 2022

Introduction of Feed-In Tariffs for Renewable Energy

- India, in September 2009, embarked on the strategic move for use of Feed-In tariffs for harnessing its vast renewable energy potential.
- Central Energy Regulatory Commission (CERC) on September 16, 2009, announced the system for Feed-In Tariff both for Solar and Wind Energy.
- The initiative is also expected to also support the National Action Plan on Climate Change, which calls for 5% of electricity generation from renewable sources by 2010, which needs to be increased by 1% per year for the next 10 years.
- It is, however, to be seen whether this initiative is able to generate the desired interest amongst the investors, especially as the Feed-In Tariffs are to be decided by CERC individually for each project, which are to be worked out using certain principles as brought out in CERC's notification. This is different from most jurisdictions where Feed-In Tariffs are specified and remain in force for certain period of time and are technology specific.
- It is however to be noted that the policy with regard to the tariffs including feed in tariffs in the states is in the jurisdiction of the State Energy Regulatory Commissions (SERCs), and they can decide on the same with a view to attract long term attract of the investors. However, these SERCs have generally announced policies applicable to limited periods of up to 5 years perhaps in anticipation of falling cost of renewables and more definitive and reliable information being available for long term costs and tariffs for the renewables.
- Some of the salient features of Indian Feed-In Tariff System are that it:
- Includes all renewables.
- Tariff based on cost of generation plus profit (19%RoE)
- Contract Term: 13 years
- Contract Term for Solar PV and Solar Thermal: 25 years
- Contract term for hydro (< 3 MW): 35 years
- Wind Tariffs based on resource intensity
- First review within 3 years, except for Solar PV, which begins after 1 year
- To ramp up capacity of grid-connected solar power generation to 1000 MW within three years – by 2013; an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled – reaching 10,000MW installed power by 2017 or more,

based on the enhanced and enabled international finance and technology transfer. The ambitious target for 2022 of 20,000 MW or more, will be dependent on the 'learning' of the first two phases, which if successful, could lead to conditions of grid-competitive solar power. The transition could be appropriately up scaled, based on availability of international finance and technology.

- To create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
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- To deploy 20 million solar lighting systems for rural areas by 2022.

5. Approach for meeting rural energy needs

In the previous chapters, an attempt has been made to outline the magnitude of the task of meeting the rural energy needs of India's rural population as various initiatives that have so far been taken. Where as a subjective judgment of the efficacy of various initiatives can be attempted, but to be able to chart out a way forward on a scientific basis, a structured approach, perhaps some sort of modeling technique, would need to be evolved.

With several variables playing a major role, it would be an easy task to develop a fool-proof model which would cater to all possible situations, but it would certainly help to establish the desirability and effectiveness of most of the initiatives taken so far as also those that may come for consideration in future.

Some of the factors in such critical appraisal of the initiatives for meeting rural energy needs would involve aspects of:

- Moving to the next stage from pilot/demonstration projects
- Contribution in meeting the extent of rural energy needs
- Use ABC classification based on magnitude of potential of each initiative to meet the rural energy needs
- Prepare a detailed plan for selected initiatives to achieve specific time bound targets for meeting the extent of rural energy needs, complete in terms of resource mobilization (financial, human resource etc.), organizational, monitoring etc.

The Ultimate Goal

The Ultimate goal of all policies and research is simple - to meet 100% of energy needs of rural India:

- in the shortest possible time
- at an affordable cost; and
- in environmentally sustainable manner

The above is an ambitious statement and should also keep in view considerations such as:

- Targets for rural energy poverty alleviation in short, medium and long term
- Identification of appro00000000priate sources of energy
- Identification of appropriate technologies

- Where to find the resources financial, technological and organizational

Major Considerations

Some of the major considerations in defining the Vision for meeting rural energy needs of India as also the underlying objectives would be addressed through answerers to the questions like:

- How do we strengthen our rural economic competitivess and ensure creation of good rural jobs?
- How do we make our rural population self reliant and empowered?
- How do we reduce the arduous human labor so prevalent in our rural population, more particularly for the women and the children?
- How do we protect are natural environment?

Limitations of Present Initiatives

There seems to be near total reliance to meet the rural energy needs though 100% electrification of the villages though extension of the grid supported by distributed generation in a limited way using renewable sources of energy. This is unlikely to achieve the desired results and provide satisfactory responses to all the questions mentioned above. Some of the limitations are:

- Target to achieve 100% Village Electrification, which was originally to be completed by 2010, may not be completed even by 2012.
- Huge costs involved for expansion of grid to all the far flung rural areas
- Against tariff of Rs 3/- (approx.), actual of supply Rs 9/- per kWh
- As distance from grid increases cost of expansion of grid increases by about Rs 1 per km per kWh.(figures to be checked?_
- Poor revenue collection: Rs0-10 p.m. (poor) and Rs. 0-130 p.m. (others)
- Sustained thru redistributive policies, tariff cross-subsidies, financial relief to loss making utilities.
- Rural supply low priority, first in power cut.
- Rural electrification more in deficit states and less in surplus ones
- 13 hours of rural supply considered adequate for irrigation pumps
- “Rural” equated to agricultural; casualty education (schools and children)
- 91% of 0.7 million primary schools in rural areas
- 62% of 28,000 integrated schools (combining primary and secondary) in rural areas
- Overall, about 87% schools in rural areas
- Of 41.2 million enterprises (other than crop and plantation related), 25.81 million (61.3%) in villages; account for 51% employment.

Remaining Gaps

Despite the several initiatives mentioned above, there are large gaps between the demand (including the unrecognized demand) and availability of power. Rural electrification program through grid extension alone will certainly be insufficient to meet the demand and would need to be substantially augmented by other by other forms of energy supply and use.

Relevance of Renewables

To bridge the gaps, renewables can play a very important role, including:

- Potential to create large no. (net) of jobs especially in rural sector
- Revenue Neutral or even better (savings v/s cash investment)
- Benefit to sectors like Construction, Professional Services, Farming, Trucking and Transport, Metal Fabrication etc.

Reliance entirely on Renewable Energy sources would not be practical in the short and medium term, despite claims of falling costs, and the rural households would need to be provided with an adequate share of relatively lower cost energy from conventional sources.

A comprehensive integrated rural energy development program combining both conventional and non-conventional energy sources, optimized for blocks of rural population, to be evolved.

Nonetheless, the long term planning must hover around meeting most of the energy needs of rural India from Renewable Sources of energy. The grid extended to villages could perhaps at some time in future, be used to plough back the energy generated from such renewable sources to the grid rather than from the grid.

7. Renewable Energy

In the context of other forms of energy service and use to augment the grid extension, especially for the rural population, Renewable Energy is poised to play a major role. Unlike in the past when these resources were perceived to too expensive to be of any practical use, several forms of renewable energy are fast coming into the viability zone, especially when adverse effects of fossils are taken into account on human health and ecology.

Vast Potential

The Renewables have huge potential to meet the entire energy requirement of the world as evident from the following:

- As per some studies, less than 1% of earth's deserts can meet the world's energy demand using CSP technology and covering 4% of the world's deserts with photo voltaic cells could supply the entire world's energy.
- Wind energy can also theoretically meet 15 times the world's energy requirement.

Global Outlook

Global Investments in renewable power generation rose from $ 28 billion in 2004 to $ 71 billion in 2006 [3](New Energy Finance)

The global renewable energy market is doubling every three years.

Public Investments in R&D, subsidy schemes that favor renewables, and the probability of a future global carbon market, are all for fuelling the cleantech boom.

While driven by supportive public financing and regulation, the challenge of mitigating energy poverty can offer significant commercial opportunities for investors in the area of renewables.

Major Renewable Energy Resources

The major renewable energy sources in commercial use include:

- Solar
- Wind
- Biomass
- Small Hydro

Initiatives in India

India is fast emerging as the World's clean energy hot spot. The total demand of electrical energy in India is projected to be shooting up to 240, 000 MW by 2012 and the Govt. has rightly recognized the need to supplement a significant portion of additional generation from renewable energy resources. As much as 18% of additional generation capacity commissioned during first three years of the Tenth plan came from renewables. It is estimated that by 20, 000 MW will be contributed by renewables. A major part of investment in renewable energy sector has come from private sector which is very encouraging for the future of this sector.

In the 11^{th} Five Year Plan (2008-2012), India's renewable energy market is expected to reach an estimated US $ 19 billion with an investment of US $ 15 billion to add 15000 MW of additional renewable capacity. The Govt. of India has planned a subsidy support system of approximately US $ 1 billion in Govt. funds.

India has realized the major role that Renewable Energy can play in meeting the challenges of energy security and climate change though:.

- Proactive role of State Govts.
- Emerging IT solutions for emission reduction
- Innovative Microfinance Schemes
- Clean Transport
- Carbon Markets
- Corporate Interest in Rural Renewables

The National Action Plan on Climate Change envisages that the central and state energy regulatory commissions ensure procurement of a stipulated minimum percentage of grid based power from renewable energy industry.

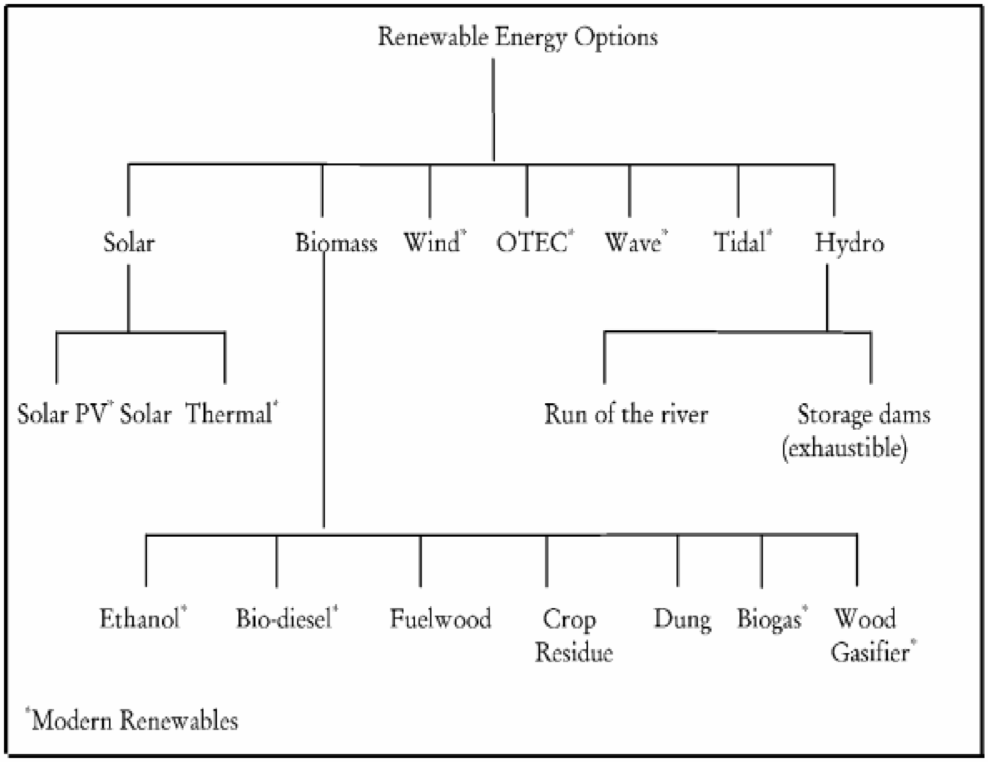
Potential and achievements in various form of renewable energy are brought in the following table.

S.No.	Source/system	Estimated potential	Achievement as on 31 October 2009	
I Power from renewables				
A	Grid-interactive renewable power	(MW)	(MW)	
1	Wind power	45 195	10891.00	
2	Bio power (agro residues and plantations)	16 881	816.50	
3	Bagasse cogeneration	5 000	1241.00	
4	Small hydro power (up to 25 MW)	15 000	2519.88	
5	Energy recovery from waste (MW)	2 700	67.41	

6	Solar photovoltaic power	—	6.00	
	Sub total (A)	84 776	15541.79	
B	Captive/combined heat and power/distributed renewable power	(MW)	(MW)	
7	Biomass/cogeneration (non-bagasse)	—	181.37	
8	Biomass gasifier	—	108.37	
9	Energy recovery from waste	—	37.97	
	Sub total (B)	—	327.71	
	Total (A+B)	—	15869.50	
II	Remote village electrification	—	5554 villages/hamlets	
III	Decentralized energy systems			
10	Family-type biogas plants	120 lakh	41.42 lakh	
11	Solar photovoltaic systems	50MW/km2	120 MWp	
i.	Solar street lighting system	—	82 384 nos	
ii.	Home lighting system	—	510 877 nos	
iii.	Solar lantern	—	767 350 nos	
iv.	Solar power plants	—	2.39 MW	
v.	Solar photovoltaic pumps		7247 nos	
12	Solar thermal systems			
i.	Solar water heating systems	140 million m2	3.12 million m2	
ii.	Solar cookers		6.57 lakh	
13	Wind pumps		1347 nos	
14	Aero generator/hybrid systems		0.89 MW eq	
IV	Awareness programmes			
16	Energy parks	— 511 nos		
17	Aditya Solar Shops	—	284 nos	
21	Renewable energy clubs	—	521 nos.	
22	District Advisory Committees	—	560 nos.	

Table: Potential and realization of various forms of renewable energy

Renewable Energy Options



India presently generates 13,878 MW (as in Aug 2009) of grid interactive power from renewable sources including wind, solar, small hydro, biomass and bio-gas cogeneration, which accounts for 9% of total installed generation capacity. The 11th five year plan targets 14,000 MW of grid interactive and distributed renewable power by 2012, which means 10% contribution of renewables in power generation capacity by 2012.

If Renewable Energy has to contribute effectively in our medium term and long term energy mix, leapfrogging of initiatives needed taking clue from international trends as well as the successful pilot and demonstration projects in the country. Nature has been magnanimous in provision of RE resources like solar, wind, biomass and small hydro to India. The challenge for India is to mainstream renewable based power generation.

8. Solar Power- the bridge to future

Irrespective of the international debate of climate change and negotiations amongst nations on price on carbon and commitment to the extent of carbon reduction, for an energy safe future which also takes care of the health concerns of the population, it is inevitable to focus on policies that will accelerate deployment of clean technologies like solar that make a real difference in fighting climate change, As per an estimate, solar and other renewable energy resources can, with the right policies in place, can play an increasing significant role in meeting the electricity needs of that country, which shows solar energy replacing a large part of coal based energy generation by 2020. The situation of energy needs and availability of clean energy resources offer similar possibilities for India.

While national and international politics will continue to play its role in shaping policies towards solar energy, educating the public and the media is vital. The solar industry needs to address this as a challenge rather than creating more business and more profit and these efforts need to be supplemented by NGOs and other institutions/organizations concerned with the ill-effects of climate change on one side and meeting the energy needs of the rural masses on the other.

Salient features of Solar Energy:

- the cleanest
- most abundant
- inexhaustible
- most predictable of all renewable energy sources

Potential

Against total equivalent energy consumption of 21.8 TW by 2030[1], total solar radiation intercepted on earth 173, 000 TW of which 120, 000 TW reaches earth's surface i.e. solar energy potential is about 8000 times (800000%) of total global energy requirement in 2030. It offers viable solution for rural energy needs (at least in part).

Solar Energy Technologies

Solar Photo Voltaic: This technology is based on conversion of light energy from solar radiations falling on a photo voltaic cell directly into electric energy, which can either be stored in storage batteries and used as required or can directly be used as electricity for any purpose like lighting, heating, running a motor or other appliances or for any chemical processes. The photo voltaic cell uses the property of some semi conductor materials to convert light energy into electrical energy.

The advantages of Solar PV are:

- It can generate power through Centralised Systems – Grid connected or Stand Alone.
- It can produce power through Decentralised Distributed Generation (DDG) Distributed Generation, for Street Lights, Lanterns etc
- Direct solar radiation can produce some electricity under less than ideal condition, low sun angles and overcast sky.
- Offers modularity and scalability, large units more prone to clouds
- Clouds may cause spikes, up to 20 MW manageable

Solar Thermal

Sun light can be used by its conversion into heat energy though

- Passive System- through building systems
- Active System: CSP

Concentrated Solar Power (CSP)-

It is also termed as Concentrated Solar Thermal Power (CST), Solar Thermal Electricity Generation (STEG)

The technology uses heat from the sun to generate electricity in much the same way the conventional thermal power station. The sun's rays are focused on a central receiver containing a mineral oil or other thermal carrier. As this liquid gets heated up (reaching temperatures as high as 400C-600 C), it passes though a heat exchanger and generates steam, which is then used to drive a steam turbine. With the present state of technology development and costs involved, the areas having solar insulation levels of 2000-2500 kWh.m-2 are better suited for the technology.

As in any thermal power plant, water is required for raising steam using solar heat. Since the high levels of solar insulation are predominantly in arid areas, this is matter of concern. However, water consumption can be reduced by as much as 90% using dry cooling, which however would result in higher price by about 10%. Water is also required for washing of parabolic mirrors for maximum performance, but the amount of water required is less than that required for steam.

As per an estimate, based on CSP, less than 1% of the world's deserts could generate enough energy sufficient for the world. The power so generated can be economically transmitted via 3000 kms or more using HVDC and 90% of world's population lives within 2700 km of desert.

Integrated Solar Combined Cycle (ISCC)

Another possibility CSP offers is in its integration with Gas based Combined Cycle Power Plants (typically known as Integrated Solar Combined Cycle (ISCC) Power Plants. Conceptually the disadvantage of solar based energy generation being not available when sun is not available is taken care by ensuring generation though natural gas, the available solar heat during day time can be utilized for augmenting power generation in steam cycle with scaled up stem generators and Steam, Turbines would help in achieving lower cost of generation from high cost natural gas.

Storage – the USP of CSP technology

The concept seeks to address the biggest limitation of solar power- its non-availability when there is no sun. The heat collected during day can be fed into storage tanks – using a medium like molten salt to hold the heat. When needed, that heat can be released to generate steam to run the turbines.

Generation from Solar Plant with storage can be shifted to match the utility system load profile. It allows solar to provide power when it is needed most. As a result Storage CSP Plants are able to achieve higher annual efficiencies up to +50%. Such peaking power has a high commercial value. Adding storage and extra collector field to serve it pays off when there is good feed-in tariff or good peaking power price.

Other Salient features

- The concept of CSP technology is based on creation of high temperature, which generates steam or hot gases for STG or GTG.
- Best suited where high direct solar radiation
- Flexible- storage, backing by other fuel use
- Suitable for peaking energy or for extended hours of generation.
- Generally, each installation tailor-made
- Some options are: ISCC, Direct Steam, Lineal Fesnal Reflectors for lower cost, Molten Salt for storage (freezing a challenge).
- Capability to produce lowest cost, commercial scale bulk electricity
- Capability to dispatch as needed.
- Cost reduction likely by mass production, economy of scale, reduction of risk premium and risk mitigation costs; When 5000 MW solar capacity achieved, solar generation cost and fossil cost may converge as per CSP industry.

Limitations of Solar Energy

Solar Energy is perceived to be prone to several limitations for being incorporated as a mainstream energy resource for rural energy needs. These are briefly analyzed below.

Capital cost

Though initiatives for solar power generation were taken back in 1980s in USA, the use of solar energy has not for become commercially popular due to several constraints. The biggest of such constraints has been the capital investment involved in such projects. Though it is difficult to pin pointedly mention these costs but till about a year back these were perceived to be as high as Rs. 25 to 30 cr. Per MW of installed capacity.

In the recent past, say last one year, with the technological advancements and increasing population of solar power installation, the perceived costs have substantially come down. So much so that for some of the CSP projects in USA, taking into account the state tax credit provision, the expected tariff by 2012 would match with the peak load tariff of grid power.

Technological Obsolescence

As mentioned above, the technologies for solar power generation in the recent past have changed very fast which have helped in bringing down the capital investment and consequently the cost of power from such projects. Such fast changing technological scenarios is likely to continue at least in the next few years. While technological advancements are most needed and are welcome to move towards acceptable and affordable cost of power from such resources, especially the resources are poised to play a major role in meeting the total energy requirements of the world, the technological obsolescence is often perceived to be a hurdle in commercial use of such energy as this may lead to apprehension in the equipment being able to be continuously serviced after obsolescence of a technology on one side and postponement of decision for installations in anticipation of future availability of more useful (like proven methods of storage for CSP projects) technology and lower costs. The impact of technology obsolescence on continued serviceability of the equipment however does not seem to be so grave as the technology is not perceived to be so complex for the purpose. Also, in some cases, it may be possible to replace the more efficient equipment which would get developed in future with better technology with a fraction of capital cost, may be when the existing equipment needs replacement in any case or the cost benefit analysis otherwise justifies such replacement. As regards with the postponement of decision for setting up projects in anticipation of future lower costs, this needs to be addressed by the govt. policies. Since the process of technological improvements is a continuous one, decision for setting up projects should not be allowed to be postponed on such ground. One way to address this constraint would be by govt. providing for long term tariff commitment for such plants based on prevailing capital costs time to time. A right step has been taken up CERC by notifying tariff for PV based and CSP based solar power plants that may be set up 2012.

Availability of Water

While for PV based generation, no large scale requirement of water envisaged (except perhaps for washing of mirrors due to high dust levels) for CSP which require steam generation in a thermal plant as also cooling water requirement, water availability is a major consideration for citing of CSP based solar power projects. While water requirement constraint puts CSP based power projects at par with fossil based thermal power project, an additional limitation for CSP based projects is that as per the prevailing economics there need to be located in areas of high solar level of about 2000-2500 kWh per m2 per year. Such areas are predominantly in deserts where water availability becomes scarcer. However, in some of the deserts like in Rajasthan, water supply linkages have been established, like Indira-Gandhi project etc. Also, as an alternative to water cooling, air cooling is also a proven technology which have an adverse effect on power availability from the plant which means sacrificing the net efficiency to some extent.

Availability of Land

It seems extensive land requirement is a common constraint for most renewables in vogue presently including wind, biomass, solar, hydro, etc. In case of solar power projects however, whether the land availability is a constraint or not will depend on case by case. This will need to be examined from the conflict if any with alternative land use where the plant is to be located from other considerations like solar insulation, off take of power, etc.

Without getting into the details of actual citing difficulties if any experienced (for want of relevant feed back in this regard), it is logically expected that the desert areas which are having high solar insulation levels may not pose much constraint from land availability consideration as desert areas are largely consideration as desert areas are largely neither densely populated nor cultivated.

9. Other renewable energy resources

Biomass Energy
Biomass is a major source of energy especially in rural areas. However, it is being used in an inefficient and un healthy manner with the consequent adverse impacts of depleting forest reserves and human health with all its consequences on the socio-economic status of the rural population. Biomass includes fuels like wood, agro-waste, bagasse, rice husk, animal ding etc.

Advantages of Biomass Energy
There is an immediate and immense need for better use of biomass. Good biomass for energy could:

- diversify energy supply at reasonable cost,
- improve trade balances,
- provide rural income and employment,
- reduce GHG emissions from fossil fuels.

Use of biomass for energy would be bad if;

- GHG emission reduction is not achieved.
- Biodiversity loss though Land Use change is not controlled/monitored through suitable safeguards.
- Suitable Safeguards not used for tackling food insecurity, overuse of water and mismanagement of soils.

Global Potential for Better Use of Biomass for Energy estimated at 25 to 30% of Global Energy Supply by 2050.Use of biomass for energy is associated with direct and indirect Land Use Change emission. The impact needs to be monitored and controlled.

Indirect Land Use Change emission can be controlled by

- Using residues and wastes
- Promoting more efficient energy conversion
- Using land "set-free" from higher yield crops
- Using abandoned or degraded land not in competition with food, feed or fibre production
- multi year crops
- multiple cropping scheme (agro forestry)
- land based algae
- more efficient conversion:

- CHP
- Next generation biofuels
- Integrated bio-refineries

With Carbon Capture Sequestration (CCS), sustainable bio-energy could, in long term, achieve reduction in atmospheric CO_2 levels

Major Mile stones in better use of bio energy would be

- In the first phase mainly being used for electricity and heat, less for transport.
- CCS will push (2050) shifting biomass use to road, ship and aviation fuels.
- Biomass for energy cultivation of potential crops on low carbon land could help sequestion of atmospheric carbon in soil and could reduce deforestation process thorough economic development alternatives and access to modern energy.
- Use of good biomass will also help in:
- GHG emission reduction
- Maintenance of biodiversity
- Energy Security
- Low Social Trade Off

Biomass in India

India being tropical with good sun and rain is ideal for bio-mass production. The availability of biomass in India is estimated at about 540 million tonnes per year covering residues from agriculture, forestry, and plantations. Principal agricultural residues include rice husk, rice straw, bagasse, sugar cane tops and leaves, trash, groundnut shells, cotton stalks, mustard stalks, etc. It has been estimated that about 70-75% of these wastes are used as fodder, as fuel for domestic cooking and for other economic purposes leaving behind 120–150 millions tones of usable agro industrial and agricultural residues per year which could be made available for power generation. By using these surplus agricultural residues, more than 16,000 MW of grid quality power can be generated with presently available technologies. In addition, about 5000 MW of power can be produced, if all the 550 sugar mills in the country switch over to modern techniques of co-generation.

Technologies for biomass based energy generation

- Gasification
- Pyrolosis
- Direct Combustion

One of the perceived limitation of biomass is the requirement of land especially clash with the land requirement for food crops. It is estimated that the total land requirement for use of good biomass is 16 mmn hectares where as the total available degraded land is about 100 mm hectares. Such criticism therefore, would be misconceived.

Examples and Success Stories

There are several success stories of good biomass in the country. One such example is Impunia grass based bio mass plant at Jhansi (100kW). 18 such projects planned to be replicated: It is given to understand that cost of power is comparable with grid power.

Limitations of Biomass as energy source

Another perception seems to be that bio mass energy projects may use up the agriculture, plant residues and other bio products which would otherwise be used as organic (compost) manure. Looking into the totality and macro level picture, the constraint even if real is much amplified. Such material would constitute a very small percentage of the total bio mass energy materials.

Wind Energy

Both offshore and onshore wind energy are suitable for generation of power and are being used, although offshore use is yet to pick up in a major way due underlying higher costs. However, some countries are moving forward with their plans for offshore wind energy.

Offshore Wind Energy

- Expanding to grow leaps and bounds in next decade.
- Globally, Offshore Wind Energy potential estimated at 45 GW by 2020.
- Growth likely be led by Europe supported by North America and Asia.
- Growth so far has been slow, due to various reasons, including higher cost.
- In last eight yrs grew from 70 MW to 1.5 GW.
- In Eorope, Onshore Wind Projects are struggling to find land and higher capacity factors leading to Govts being pressured to provide incentives to Offshore Wind Projects.
- Asia to tap Offshore Wind market by 2014.
- China, with its 9000 miles of coast line, well poised to tap Offshore Wind Energy; China’s potential of Offshore Wind Energy estimated at 750 MW; has one operational Offshore Wind Project and two more in planning stage.
- Higher capital cost getting weighed out by low running cost, longer lasting turbines, high and steady volumes.

Wind Energy in India

Wind energy has emerged as the most promising renewable energy technology for generating electricity. The wind power programme covers survey and assessment of wind resources, implementation of demonstration and private sector projects and promotional policies. A total wind power capacity of 10,242 MW has been

established up to March 2009 in the country. India is now the fifth largest wind power producer in the world, after USA, Germany, Spain and China
The onshore wind power potential has been estimated at about 48,500 MW, assuming 1% land availability in potential areas for setting up wind farms @12 ha/MW in sites having wind power density greater than 200 W/ sq. m at 50 m hub-height.

The Ministry has sponsored a project on Preparation of Indian Wind Atlas to CWET, Chennai in association with Riso National Laboratory, Denmark. 1485 MW installed capacity was added during 2008-09, taking the cumulative installed capacity to 10,242 MW. Wind energy potential and installed capacity are shown in Table 5 and 6.

A package of incentives which includes fiscal concessions such as 80% accelerated depreciation, concessional custom duty for specifi c critical components, excise duty exemption, income tax exemption on profi ts for power generation, etc. is available for wind power projects. Many States have also announced renewable energy purchase obligations, which also catalyses the growth in the wind power generation.

In 2007-08, MNRE initiated a new demonstration scheme on Generation Based Incentive to promote higher effi ciency in wind electricity generation to attract a large number of independent power producers into the wind sector, who do not avail the benefi t of accelerated depreciation. The scheme is limited to a capacity of 49 MW. The investors, apart from getting the tariff as determined by the respective State Regulatory Commissions, would get an incentive of 50 paisa per unit of electricity for a period of 10 years provided they do not claim the benefi t of accelerated depreciation.

Advantages of Wind Power

- abundantly available
- environment friendly

Disadvantages of Wind Power

- High Investment,
- Non-uniform wind velocity
- Large Area requirement.

Small Hydro

Ministry of New and Renewable Energy has been vested with the responsibility of developing Small Hydro Power (SHP) projects up to 25 MW station capacity. The estimated potential for power generation in the country from such plants is about 15,000 MW. Most of the potential is in Himalayan States as river-based project and in other States on irrigation canals. SHP projects are economically viable and consequently private sector has started investing in such projects. The viability of these projects improves with increase in the station capacity.

Of the estimated potential of 15,000 MW of small hydro power in the country, 5415 potential sites with an aggregate capacity of 14,292 MW have been identified. The Ministry is providing financial support to the States for identification of new potential sites and preparation of a perspective plan for the State for development of small hydro potential. The Ministry is supporting 142 SHP Projects in the government sector aggregating to 266 MW capacity in 23 States/ UTs. So far, a total of 77 projects aggregating to a capacity of 148 MW have been commissioned and the other projects are at various stages of execution.

The Ministry aims to double the current growth rate that leads to a capacity addition of 500 MW per year with total installed capacity of 4000 MW by the end of 11th Plan. State Nodal Agencies provide assistance for obtaining necessary clearances and allotment of land at potential sites.

10. Recommendations

The Process

The extreme poverty of India's rural masses is closely linked to energy poverty. The process of eliminating rural energy poverty cannot be over simplified and would need to be evolved on case by case basis after detailed analysis of reliable data to be collected for the purpose.

The standard approach invariably being sought by the public and even by social groups is that the Govt. should ensure it. Such demand or expectation, apart from being not feasible due to various resource constraints, is also not practical for long-term sustainability of the measures. This view is also supported from the feedback of pure Govt. oriented initiatives internationally.

Equally deficient is the pure "Market Approach". The Market Approach here essentially means there is demand in the market for a product or a service (in this case the electricity or other forms of energy) and the investors come forward to meet this demand for profit. Some reformists may push the argument that for long term sustainability, the Market Approach would only work, which sounds good but in reality is limited by:

- There is no concern for social equity.
- There is lack of concern for environment.
- It lacks of long-term vision.
- There is lack of focus on R&D.

In the context of meeting the vast energy needs of India's poor masses, it is inevitable that the Govt. shall have to do some hand-holding till the operation, by whatever alternative, becomes sustainable.

In fact, the task is so gigantic that concerted efforts would be essential by the Govt. and private sector and it would not be difficult to identify the areas in which each should make major strides. There are also areas where PPP framework can draw on the strengths of the govt. and private sector and at the same time deal with the limitations of the initiative by govt. or private sector alone.

Though a preliminary exercise has been attempted in this section to identify the way forward to accomplish the vision for meeting the rural energy needs, but these would need to be further refined by deliberations and consultations with the experts in each subject and various stake-holders.

The approach to meeting the rural energy needs has been outlined through a series of recommendations. These recommendations, will try to answer the following questions in the sections that follow:

- Meeting the rural energy Demand: What are the preferred avenues to meet rural energy demand portfolio?
- Policy level initiatives: What are the areas requiring Govt's policy intervention?
- Financing, Incentives and Subsidies: What are the financing alternatives, including the aspects of subsidies and incentives?
- Other Areas: What are other support areas to be strengthened for a sustainable rural energy program?

Meeting the Rural Energy Demand

India is a large country geographically as well as population wise. The villages, for which the issues of 'Energy Access' and 'Energy Security' are to be addressed, are geographically dispersed, remotely located with difficult terrain and physical access, large variations in size from few 100's to a few 1000's of population, have wide variations in terms of availability of local energy resources, some are located near to exciting grid and some far away, large variation in education levels, large variation in social structure, customs and beliefs and several other factors which could have a bearing on the package of energy sources which could best suit a village, a cluster of villages or an entire district.

Meeting energy needs for such target population with complex characteristics would require a deep understanding of the relevant factors and designing a solution through an appropriate combination of energy resources. Therefore, the recommendations briefly outlined below, should not be construed and viewed as providing a generalized solution in all situations and will need to be validated and customized as required to meet the requirements in each case.

Rural Energy Demand Portfolio- Domestic

Cooking

Unlike several other components of domestic rural demand portfolio, which largely remain unfulfilled like domestic light energy requirements of cooking, the cooking needs have to be met by whatever means and whatever implication as the basic need to satisfy hunger has to be met. While it may appear to be deceptively consoling that the demand is being met, it offers the biggest challenges for meeting the energy needs of the rural poor, as the prevailing resources being used for cooking pose major threats to the environment and the rural health as brought.

Drudgery is involved even in meeting the basic energy requirements as woman and children need to work hard in collection of firewood. Women spend upto 6 hrs a day in household chores, while the young children stay with them.
Inefficient use of biomass in the traditional stoves coupled with insufficient ventilation causes severe health hazard and most of it affects woman and female children.

Traditional biomass can have a variety of negative health impacts, especially when it is burned indoors without either a proper stove to help control the generation of smoke or a chimney to draw the smoke outside. Women and children are particularly exposed to the effects of indoor air pollution, as it is they tend to cooking fires. The use of biomass may also promote higher spending on medical care and may diminish the ability of people living in poverty to work productively. These effects are reinforced to the extent that users of biomass are less likely to boil the water they drink, for reasons of cost or custom. In so far as the use of bio mass in urban areas promotes deforestation, reliance on biomass may also tend to increase its future cost, further diminishing the living standards of people living in poverty.

The strategy to meet the energy needs for cooking for rural masses needs to focus on:

- Reduction of arduous human labor, especially of women and children by providing alternative sources of energy and improved use of existing sources.
- Transformation of cooking into a less unpleasant safe and healthy.
- Provision of safe water for domestic purpose.

Challenges associated in the achievement of above objectives include:

- Cooking is largest component of rural energy needs and yet highly neglected.
- Large poor population gets cooking fuel (firewood/ dung-cake) almost without any cash expenditure and have no capacity to pay for the capital cost or running cost.

Any scheme to support cooking needs of rural poor through Renewables or combination of fossil fuel and Renewables need take into account the following:

- No incremental burden of cash flow on the rural household (especially poor)
- Adaptable technology keeping in view the relatively lower level of education and users being largely women.
- Social and cultural prejudices
- Sustainability and continuity.

Replacement of firewood and dung cake by LPG though not impossible, seems impractical due to reasons such as:

- LPG already being heavily subsidized and further subsidizing may pose bigger challenge for the govt. without which it may not be affordable.

- Difficult to manage regular supply for far flung areas.
- It is extremely difficult to ensure fuel security with LPG as neither can one manage without fuel for cooking nor have a readily available alternative that would be feasible for the rural poor.

Use of fire wood and dung cake can be reduced only gradually, Some of the options that may be tried include:

Solar cooking

This clean energy can be instrumental in reversing rural energy poverty and health hazards of pollution due to burning of fire wood/ dung cake in conventional manner. A common example is solar cooker or solar stove.

However, popularizing such schemes would require a considerable effort on the part of the govt. who would need to do promotion, education and handholding of the backward, uneducated and poor villagers; many of them may even resist these schemes due to their prejudices, cultural and religious beliefs or myths.

Setting up Govt. supported / facilitated large solar cooking centers, which will provide limited varieties of cooked food (like bread and rice) for the rural masses at prices comparable to what they already spent. This could also help in provision of some minimum nutrition to the poor, elderly and children by optimizing the food quality. The food for work, mid day meals and such other programs can be starting points for such initiation.

Over a period, rural masses may adopt distributed solar cooking as a main process of cooking reducing the load on biomass and also availability substantially additional time for the women and children to do other more productive things. What is needed is a major demonstration effect by initiating the process through feed back from users to dispel any social or health related prejudices and beneficial aspects without putting pressure on their cash flows.

Good Biomass

Biomass use for cooking purposes in rural areas may be through Family type biogas plants or Community Biogas plants. Biomass use for the rural population can be for cooking, manure production, power generation, water pumping etc. and the combination of uses would need to be decided from case by case.

Policies that directly target better way of biomass use should be promoted including:

- Use of better stoves that have greater combustion efficiency.
- Encouraging sustainable management of biomass fuels such as wood. The management and use of fuel wood resources should be transferred as much as

possible to local communities: the transfer of ownership and land title of forest areas to local communities can help to ensure the sustainable use of these resources.

- Processing biomass and coal to make them cleaner; for example, converting them to charcoal and biogas or smokeless coal and coal gas. In general, the environmental pollution from the final use of processed solid fuel is less than from the raw forms. New sources of pollution are created by processing—for example, at the kiln, but these would not affect the poor as much as the direct combustion of raw biomass or coal.

Some of the main challenges for biomass based Decentralised Distribiuted Generation (DDGs) are:

Fuel Supply Challenges

The issues relating to fuel supply involve one or more of the following questions:

- Is a fuel supply really available?
- How the fuel is to be collected?
- What are the biomass fuels?
- Would DDG be economical?
- How to handle the shocks in availability and prices of fuel?

These questions may appear to be simple but any of these may pose a serious threat to the sustainability of the DDG scheme.

The solutions to these problems would evolve with each situation but some of the alternatives include:

- Developing by biomass fuel so that bio mass fuel can be utilized for DDGs. This could be done through Energy Plantations. Growing fuel wood for running power plants either directly or after gasification can save the coal or gas used for generating power. Since the country's energy needs are growing, imports of coal and LNG are also likely to grow. Fuel wood plantations can help improve energy security. The scope for such plantations is substantial. For example, if 10 million hectares of wasteland can be converted to fuel wood plantations with a sustained yield of 200 Mt of wood per year, it would obviate the need for some 200 Mt of domestic coal. Moreover since wood is a renewable fuel, no net carbon emission takes place. Thus all compensatory afforestation should be made in the form of energy plantations to improve India's energy security.
- Collaborate with related industries who are the users of biomass fuel which will help in reducing the shocks of availability and prices of biomass fuels.

Other than the fuel supply and prices, challenges of need for proper targeting and administration of subsidies also are very real. It has been the experience that not only the capital costs subsidies but also the operating cost subsidies may be necessary for certain very poor sections of rural population without which rural energy generation and supply is not likely to be sustainable in the long term.

Since we are concerned about the rural masses, another challenge is the non-availability and shortage of skilled operators and management personnel. Suitable programs for training of the local population to handle as much as possible of the technical and managerial requirements need to be evolved.

As mentioned earlier, 41.2 lakh family type bio gas plants have been installed by Mar 2009 providing plain cooking and lighting fuel and also producing at the same time he bio gas manure for agricultural use. It is however, noted that the pace of installation for such plants is slowing down as evident from the fact that of the 41.2 lakh plants, only about 1 lakh plants were installed in 08-09. This is notwithstanding the fact that the total potential for such plants in the country is essential to be 120 lakhs. As per MNRE report, it is heartening that more than 95% of such plants are functional, as brought out based on a study conducted.

The DDGs based on biomass have, however, progressed slowly. RGGVY Scheme provides for a massive target for DDGs. (any technology). However, almost no DDGs have come up so far under the scheme. While the reasons for slow progress in thin regional would need to be gone into, from interaction with some knowledgeable people it is gathered that the guidelines issued for setting up such plants have not evinced much interest. Possible reasons for this could be inappropriate risk-reward format and excessive rigor in the process of project awards. These need to be addressed.

Meeting Rural Energy Demand - Lighting (including street lighting)

Presently, village households meet their lighting energy requirements using kerosene predominantly and to a limited extent by grid electricity. Street lighting would only be available depending on availability of electricity from the grid. In a limited way, solar PV is also used for domestic lighting and street lighting.

Use of Kerosene for domestic light is fraught with several limitations, including the adverse impact on health from kerosene fumes, apart from the very high level of Govt. subsidy and adverse ecological impact due to dependence on the fossil resource. Price and availability shocks due to highly fluctuating international crude oil prices are also relevant.

The high level of subsidy makes this fuel highly susceptible to misuse by diversion to other needs thereby limiting its availability to the target population.

In a country like India, where in most parts of the country for a good portion of the year sufficient amount of solar insulation is available, solar home systems which cater to the minimal lighting and other household requirements of rural population seems to be most appropriate notwithstanding the immense use of storage batteries for such gadget which are perceived to be environmentally not desirable. This is so at least in the interim (say 10 to 20 yrs) till alternative renewable sources of energy become abundantly available at affordable cost.

A large no. of Solar Home Systems (SHSs) have been installed in the country under various subsidized schemes of the Govt. While this small step has the potential of changing the quality of life of all the village population substantially by enabling education for the children, possibility of income generation for women, etc. the effectiveness of these schemes needs to be continually monitored. From informal discussions with knowledgeable people, apprehensions have been expressed about the dismal performance of these schemes. Such perception comes from the fact that several of such household lanterns and SHSs are provided with poor quality batteries (to keep the cost low), which go dead within a short period and are not replaced either due to non availability of good quality batteries or lack of funds with the poor rural population for replacing such batteries. If this is indeed so, it has several adverse outcomes including:

- Loss of faith of the village population in these gadgets which may lead to their unwillingness to adopt any such schemes in future.
- Reverting back to use of kerosene with all its adverse health and environment impact.
- Total loss of the funds invested by the govt. in such schemes for subsidizing the capital investment in such schemes.

Such schemes should ensure high quality of batteries (any other critical spare parts) which are vital for long term operation of the units. Possibility of linking a guaranteed life of the battery with the capital cost of the unit could be explored, which even though may push up the capital cost and therefore, the subsidy element, will at least provide intended benefit. Alternatively, the capital cost to be paid to the manufacturers may be linked to a certain cumulative output from the unit, which would require that the manufacturer also assumes the responsibility of recharging the units. In any case, a continuous monitoring through feedback from user groups by an independent agency is a must.

Other renewable source of energy that can be effectively used for such rural lighting /other household needs are DDGs based on biomass, solar PV or solar thermal, which could be supplemented by grid electricity to the extent of its availability. Suitability of a particular type of system would need to be evolved on case to case basis for a village or cluster of villages, depending on socio-economic conditions, availability of resources for renewable energy, grid connectivity etc.

Several successful case studies are available for DDGs using different renewable sources of energy including biomass (fuel wood, dung cake, agricultural waste, rice husk etc.) solar PV and solar thermal.

Some of the technologies, like CSP, although not much tried in India so far, seem to offer advantages over others in terms of long term costs, environmental friendliness and possibility of extended working even after sun sets in, using storage . The suitability of these, however, need to be evaluated for each situation and considering the energy needs, availability of technology as well as necessary organization for installation operation and an maintenance of such units over their lifetime.

Meeting Rural Energy Demand -Agricultural

Agricultural energy requirements, being intermittent and irregular would, normally, not be suitable for stand-alone dedicated generating solution from most Renewables due to high capital cost and limited time of use for irrigation purposes. Therefore, agricultural loads are perhaps best served by the grids, mini grids or decentralized distributed generation (DDGs). Serving agricultural energy loads by DDG would also require energy management of energy demand by staggering the loads at different times as much as possible for optimizing the generating system capacity.

Off-grid Energy

For off-grid energy, Technology Selection is the most important but not the only consideration. Others are:

- Commercial Considerations: Licensees are not willing to supply electricity to remote villages due to high level of losses, cost of service and poor recovery rates
- Grid extension may be less expensive but availability of sufficient energy, cost of energy service etc. may justify off grid Energy provision.
- Poor Customers: ability to pay for connection and supply; extent of subsidy requirement and sustainability of financing structure.
- Reliability of supply, skills for operation and maintenance
- Evidence is clear that remote communities provided with any type of off grid electricity have achieved marked improvement in their welfare.

Advantages to household

Shift from traditional (kerosene based) to modern lighting

- Suitable for schools, health centers, water supply systems, communication facilities, micro-enterprises
- Overall economic benefit

Figure 4 brings out the elements of a sustainable off-grid electrification project.

Challenges

- Development of a sustainable service delivery model for improving rural electricity supply through renewable energy based distributed generation and supply
- Availability of an Appropriate Business Model

Following areas need specific attention to enhance the penetration of off-grid systems for rural population:

- Regulatory Support
- Exploring opportunities for international co financing

Distributed Generation

Grid Extension may be uneconomical for electric utilities where the distance to the consumer is high, where the households are dispersed and density of demand is low, or where consumption per consumer is low. In such cases, it may be better to provide off-grid electricity service to the consumers.

Off-grid electrification is based on distributed generation solutions such as stand-alone photovoltaic systems, battery charging stations, minigrids powered by sun or wind, and isolated systems based on diesel, hydropower, or biomass.

RGGVY also has recognized the need for off-grid electrification and has made exclusive provision of funds (Rs 520 crores) for such schemes for the X plan period. The guidelines for setting up of these DDG projects have also been issued. It is understood, however, that projects pursuant to these guidelines are yet to be taken up. It is also learnt these guidelines are perceived to be much stringent and may need to be reviewed to enable substantial progress of DDGs under RGGVY. The key driver of improved access to off-grid electricity services has been an emphasis on local participation.

Community or locally based approaches in project selection and project management are essential for the success of energy supply options located in the niche between the two extremes of small systems for individual consumers (like family type biogas plants) and large network schemes that cover wide areas (like being linked too the national or State grid). Relevance of Community programs is also borne out in the following situations:

Choice of energy service.

Decentralization of decision making to local communities is essential if they are to signal their energy service needs. Poor communities must usually choose between different supply options but also between different community -based rural infrastructure interventions, such as health and maternity posts, schools, water supply and sanitation, culverts, and energy supply. Furthermore, they must decide on the scope, mix, and sequencing of these investments. Empowering local communities to assume the responsibility of making these choices can reveal their willingness to pay as well as the quality of services they require

Community based management.

Community groups such as Cooperatives can assist (i) in the delivery of energy services to the poor; (ii) in billing and collection; (iii) organizing local labor to

provide maintenance services which in-turn can increase local employment, encourage local entrepreneurship, and reduce costs.
Notwithstanding the above, it is extremely important that the management of the assets is performed in a business-like manner. This would require insulation of day to day operations from political interference; transparency of operations, and prices covering not only the cost of operation and maintenance, but also contribute to a fund to pay for future capital replacement. From interaction with some experts involved in DDGs, it is learnt that DDGs which have been successful so far are facing this problem of finding funds even for relatively small requirements as while the original capital cost was funded by a subsidy but there is no such provision for capital replacements and the scheme also did not specifically envisage the operating revenues taking care of the same.

Designing sound DDG projects is far from an exact science. The combination of high cost of service; poor customers; and newer, less familiar technology options often makes it a more complex task.

Designers of off-grid electrification projects are responsible for a range of critical decisions that affect sustainability. These decisions include technology choice, ensuring affordability, social safeguards and environmental considerations, as well as taking advantage of opportunities to initiate and enhance productive activities and institutional applications. Project designers must also consider ways to use appropriate business models, determine necessary regulatory actions, and explore opportunities for international co-financing.

Rural areas of developing countries are much more suitable for using distributed generation, which would be a very effective source of energy for those who can access the technology. So the efforts of the Govt. need to be concentrated in proving the right technology. Govt. policies and support should focus on this practical and affordable solution for rural energy by canalizing international and national financing to develop this alternative and supplement it by appropriate technological initiatives.

In areas where there is no electricity grid, there should be minimum clearances/ permissions required for setting up a Distributed Generation (DG) system. Supply companies/entrepreneurs should be free to set-up micro-grids and recover revenues from customers. This is already provided for in the Electricity Act 2003. Each state should clearly define guidelines to facilitate this process.

A critical issue in distributed generation for rural electrification is the cost recovery and the implementation mechanism. Different policy experiments for implementation of DG in different regions should be attempted. The village panchayat aided by the state energy agency and technical experts should decide the appropriate technology option (biogas, biomass gasification, wind-diesel, micro-hydel, bio-oil engine) for their village.

For isolated systems it is beneficial to link the DG system to an industrial load (cold storage, oil mill etc.) to improve its load factor and hence its economic viability. The capital subsidy should be based on the annual generation, and should preferably be in the form of an annualised subsidy to be provided based on actual generation.

These projects can be set-up by panchayats, independent power producers or renewable energy service companies. A mechanism of bidding can be used to obtain the annualised subsidy level sought for sustainability. For example, if it is decided to electrify a village using a dedicated producer gas engine and biomass gasifier, bids may be obtained for the support required annually for the concession period per kWh of actual generation. The project would then be given to the lowest bidder. Such a programme would require actual tracking of annual generation. This is feasible using existing technologies of remote monitoring and would add only incrementally to the system cost.

Synergising Grid connectivity and Distributed Generation would be an effective option for optimization of use of grid electricity as well as the Renewables, where grid connectivity is already provided.

Where grid connectivity is already provided or needs to be provided based on an objective cost-benefit analysis, such grid supply in rural areas may be augmented by Distributed Generation would result in:

- Grid working as balancing sink/source
- Partial supply from grid lowering the overall cost of power
- Reduced risk for developers/investors

To sum up, Distributed Generation would facilitate:

- Market Transformation,
- Environmental Benefits,
- Reduced cost of electricity for the consumers,
- Supply diversification and grid security and
- Socio-economic benefit to society.

Policy Level Initiatives

As mentioned earlier, the Govt. has taken a no. of policy initiatives and has allocated a large amount of funds to address the high level of "energy poverty" in the rural population of India which is a major hurdle in achievement of the national goal of poverty alleviation. These initiatives have contributed in mitigation of energy poverty amongst rural masses but in a limited manner. No doubt know, the subject has attracted the continuing attention of the planners, which in turn has provided the much needed fillip to the efforts to find solution to the gigantic problem through technology development & innovations, new mechanisms for financing and subsidy administration, newer forms of organization structure at all.

The outcome of these efforts, however, appears to be far from desired and at this pace the objective of alleviating rural energy poverty may remain a distant dream. The need is not only to accelerate the energy sector reforms in all the areas, but to objectively review the policy initiatives linking these to specific time based targets which are supported by a detailed plan to achieve it through provision of all necessary resources, technological, manufacturing, organizational, human resource development, R&D, financing, project planning and monitoring including a mechanism of automatic mid course correction.

Though such a comprehensive policy document would require a detailed study and research on all related aspects of the problem, some relatively obvious areas requiring attention are as follows.

The current dominant development model is focused in achieving macro-economic growth, resulting in predominant attention to large scale energy infrastructure to provide energy for growth. Much more attention and investment is needs towards supply of local energy services for poverty reduction in rural communities. National development strategies will need to be oriented towards local energy delivery (local grid, fuel distribution, renewable energies, etc.) along side large scale infrastructure development.

There exists a large funding gap in providing energy access for the poor which has not been seriously addressed by existing financial mechanism, political will and commitment of the govt. It is needed that investment in energy is prioritized as critical for development of the sectors.

The cost of delivering energy to meet the need of poor people is only 2.85% of total global energy investment. The govt. should raise the issue of meeting the energy needs of the poor in international forum for allocation of funds through international aid, multilateral financing, climate change financial mechanisms which need to be supplemented by the appropriate own of funding by the govt. as well as catalyzing funding by the private sector.

To attract necessary investment from Private Sector, appropriate, transparent and less cumbersome subsidy mechanisms, other financial incentives and clear long term tariff policies need to be in place.

These mechanisms for subsidy administration should ensure that these reach the target population and are sustainable till the desired long term goals also attained.

One of the reasons for failure of off grid and decentralized distributed generation schemes is their poor sustainability for various reasons including assured fuel supply, availability of spare parts & capital equipment replacement, availability of necessary skills for operation and maintenance, price shocks of inputs and vulnerability of the poor sections in capability to pay even the marginal operating cost due to variation in their income. Some of these factors which are not attributable to the beneficiary consumer groups, result in mistrust setting in the minds of the poor about the intent and capability of the planners and the govt. in the providing them with the required power. This, therefore, leads to the necessity of a long term continuing monitoring arrangements to ensure operation of these off grid and DDG schemes and the organization involved, preferably independent and in pvt. sector should be provided with some funds so that these installations do not come to stop for want of minor amount. The compensation to such organization should be on the basis of defined targets of either energy supply, plant availability or a combination thereof. This could apply to the large no. of solar lanterns and SHSs distributed with the Govt. subsidy.

Small energy system installed to provide electricity to small villages or communities are often abandoned soon after their installation. Similarly, large numberof projects for the dissemination of efficient stoves have not changed the use of three stoves from being in common place. These are caused by faulty design of the schemes with lack of understanding of the problems associated with poverty and threshold cash flow, lack of technical capacity and institutional support.

Apart from companies, small and big, private sector also includes small farmers and local traders, who may be looking for investment opportunities in small local businesses, who could also consider potential business opportunity in energy supply. They could also reach the rural poor more effectively than conventional large energy invertors and govt. This, however, would require strong long term commitment from govt. through regulations, incentives (subsidies) and support for local capacity and energy literacy amongst energy consumers.

With a view to socio economic equity of the rural population with their urban counterparts, the govt. needs to embark on a program that seeks to achieve:

- Electricity, whether from grid or otherwise for each household (instead of electrification of each village)
- Adequate energy availability for all rural needs: domestic, farm, industries, education and all other community activation.

Planning for energy supply to rural population

A comprehensive data collection exercise should be undertaken, which should, inter-alia, include the following:

- A complete socio-economic and survey of the rural population including physical mapping of each village, its population (with sex wise and age wise break up), economic status, education status, etc.
- A complete survey and mapping of energy resources including fossil, wind, solar, biomass, tidal, geothermic and any other with full details on intensity of solar insulation, seasoned variation, wind velocities, availability of various types of biomass like firewood, dung cake, agro-waste, rice-chunk etc.

Rural households would need to be provided with an adequate share of relatively lower cost energy from conventional sources. Reliance entirely on renewable energy sources may not be practical in the short and medium term, despite claim of following prices.

The outcomes of RGGVY and the newly developed pilot projects under Village Energy Security Programme to identify and work out detailed plans for successful projects that can be replicated to provide the needed energy to the rural masses.

Coordination is also called for between the rural electrification programs, telecom and road connectivity initiatives and certain social sector programs. Bundling of services is likely to achieve greater success and is more likely to yield sustainable structures that are replicable through separate franchises.

Detailed target based planning for the share of each source of energy taking all relevant factors into account with strategic plans to mobilsation of resources financial and human.

A national level task force comprising energy professionals, bankers, bureaucrats with authority for close monitoring of execution of plans and any mid course corrections based on specific new information, if any available.

Decentralized Energy Planning

It is needed to change the existing mindset which seems to be focusing on large capacities being set up from fossil fuels. This will facilitate:

- Efficient utilization of resources, especially the locally available resources and more equitable sharing of benefits.
- Formulation of plans and their implementation with the involvement of local people and institutions.

Focus on Renewable Energy

For meeting the rural needs effectively, shifting of focus on renewable energy is a prerequisite due to the following considerations:

- Despite extension of the grid to villages, rural energy demand cannot be adequately met due to large gap between energy generation and existing demand (even without taking into a/c the unmet rural energy demand)
- It would not be economically and technically justified to extend the grid to certain remote, low density villages located across difficult terrains
- The domestic fossil reserves have a limited potential to serve before these get exhausted (about 50 yrs.) and imported fossils are constrained by highly fluctuating international prices.

Some suggestions for promotion of renewable energy for rural needs are briefly outlined below:

Power Regulators must seek alternative incentive structures that encourage utilities to integrate wind, small hydro, cogeneration etc., into their systems.
All incentives must be linked to energy generated as opposed to capacity created.
Respective power Regulators should mandate feed-in laws for renewable energy where appropriate as provided under the Electricity Act and as Price subsidy for renewables may be justified on several grounds. A renewable energy source may be environmentally friendly. It may be locally available making it possible to supply energy earlier than possible through a centralized system. It may also provide employment and livelihood to the poor.
The environmental subsidy for renewables could be financed by a cess on non-Renewables and fuels causing environmental damage. All price subsidies should be linked to outcomes. Thus, for example, giving a capital subsidy on a wind power plant provides encouragement to set-up a power plant but does not provide any additional incentive to generate power. Instead a price premium on feed-in tariff for wind power into an existing power grid ensures outcome for the outlay.

For grid connected renewables, Regulatory Commissions (RC's) should provide feed-in laws to permit renewables to supply electricity to the grid as when it is produced without any restriction. RC's should ensure that the renewables are given a tariff at least equal to the avoided cost of generation.

Biomass

Support Jatropha, Karanj and other similar species, with incentives. Since the end objective is to promote bio-diesel and significant research is still needed to establish viable germ plasms and genotypes for bio-fuel plantations, it is recommended that the parallel route based on industrial oils be pursued immediately through a reduction in import duty to 5% or even to nil for specific rural locations for high FFA vegetable oils for conversion to bio-diesel.

Trans-esterification facilities set up by importers of industrial oils may also be given TTRCs. Encourage direct and local sale of bio-diesel where feasible. This can begin with the metro towns. As a green fuel make bio-diesel free of excise and levies charged on fossil fuel-based diesel. Bio-diesel and/or blends of bio- diesel should be sold with full disclosure and priced differently from pure fossil fuel based diesel. Modernization of use of biomass as energy input by suitable technology interventions. Ensure that the lands to be used for cultivation of bio plantation do not adversely affect the food crops and water availability for such crops.

Biogas plants have been promoted for families with 5 or more cattle head to obtain 2 to 3 cubic metre of gas per day. The estimated potential is 14 million plants. This leaves out the dung of all those who have fewer animals and also wastes the surplus gas that may be produced in warmer months. The real potential of biogas is thus in community level plants. To encourage private or community entrepreneurs to set these up, they need to be provided land and finance. Also to have the willing participation of all the cattle owners in the community requires an appropriate operating strategy.

Family Size Biogas Plants: If fuel efficient cooking utensils and methods, with which 60% to 70% energy can be saved, are used than even a biogas plant with one or two cattle heads can provide the bulk of required energy for a family's cooking. This would avoid the institutional complexity of operating community level biogas plants. Compact and monolithic biogas plants suitable for one, two or three animals are now available. Trials with small biogas plants and energy efficient cooking should be carried out to examine their acceptability.

Ethanol

Aggressively support alternate routes to ethanol such as cellulosic ethanol and low water intensity crops such as sweet sorghum. Raise sugarcane yields and divert increased cane output for ethanol production. Promote grain-based alcohol to the extent possible especially from spoilt grains. Remove barriers to import of ethanol for all end-uses. Like equity oil seek ethanol acreage in Brazil – the world's cheapest producer of ethanol.

Thus, the following policies are recommended:

- Set import tariff on alcohol independent of use and at a level no greater than that for petroleum products.
- Require that oil companies may blend upto 5% of ethanol with petrol but do not mandate oil companies to do so.

- Price ethanol at its economic value vis-à-vis petrol but not, in any event, above its import parity price.
- Companies in India such as Praj Industries and International Crops Research Institute for the Semi- Arid Tropics (ICRISAT) have developed commercial varieties of sweet sorghum.
- To encourage alternate routes to ethanol, such production may be procured at the full trade parity price of petrol for 5-7 years instead of being purchased at its true economic value based on calorific content duly adjusted for improved efficiency.
- As a green fuel, however, government may wish to waive all or part of the excise and levies charged on petrol to the extent that it contains ethanol. However, bulk of the benefit must be passed on to the consumer.
- Petrol pumps must declare if they are selling blended petrol and price it differently.
- Incentivize cellulosic ethanol with investment credits as detailed above

Financing, Incentives and Subsidies

The biggest challenge for meeting the energy needs of the rural population is perceived to be the rural population is perceived to be the ability to mobilize financial resources and that too in a manner so as to facilitate sustainability and affordability to the rural poor, who may not have enough earnings even for their survival (literally) or who spend all their time and energy (particularly the women and children) to collect the required biomass for cooking as this can be done without incurring any cash expenditure.

The problem gets further complicated when the energy needs of the rural population are sought to be met through renewable energy as the capital cost of renewable energy generation equipment at least at the present junction, needs to be moderated with due consideration to other relevant factors.

The higher capital investment per unit of energy delivered is also to a great extent delivered is also to a great extent attributed to the fact that renewable in general are not suitable for base load operation. This is not intrinsic to generation method but also to the perceived inability to store energy inexpensively. However molten salt technology which stores energy as heat and covers it to electricity on demand is a prime method to overcome this limitation. Another argue in favor of high capital cost of renewables is justified on the grounds of capital cost and complete time over especially in case of nuclear power plants.

The strongest argument in favor of renewable is perhaps the pollution caused by the fossils. It is often heard that if the price we pay per KWH of electricity (or for a litre of petrol) included the cost of addressing the lung disease and long term damage to our skys and oceans, the math would be changed completely in favor of

Renewable. Society's desire to continue to mine, process and burn coal and oil would be gone in the blink of an eye.

As per another perception, the cost of coal and oil far exceed their price with tax payers absorbing many of their hidden costs of these resources including e.g. special infrastructure for transportation, health costs, mercury contamination of fish and people and asthma attacks. Once a coal plant is built, the costs are just beginning, but with the solar plant, once it is built, the electricity is free (in terms of fuel cost).

Notwithstanding the above harsh truth the other harsh truth is that this does not provide the necessary financial resources especially as the society cannot change overnight and we cannot afford to continue with the misery of rural masses as well as their socio-economic disparity due to lack of modern energy.

The funds requirement is so enormous that no single of financing could meet it. Therefore, it is imperative that all possible sources of financing are tapped. And maximizing allocation through grant funds, loans, equity investments. The need for appropriate security structure would also be kept in view looking into the large gap between financing needs and repairing capacity of the rural poor, there is an acute requirement for evolving innovative financing solutions with or without the involvement of the govt. , domestic financial institutions, multilateral and bilateral organization, NGOs, social groups, etc.

Investments in generation, transmission and distribution needs to meet the rural energy demand can be funded in various ways, such as:

- Normal project funding mode.
- One or more Govt. agencies or a multilateral/ bilateral agency subsidizing the capital.
- Micro financing arrangements.
- Other innovative schemes, including combinations of above.

Project Financing

The project financing envisages the funding of capital cost of the project through a combination of equity and debt. The distribution of equity and debt components is decided on case by case depending on the strengths of the project and equity investors and invariably is subject to the approval of the lenders for the debt component with regard to security structure.

The main sources for funding of equity and debt components are:

- Equity
    - Govt. or Govt. institutions
    - Small Private Sector

- Small Traders/Investors at local level
- Large Corporates

- Debt
  - Govt. Institutions
  - Multilateral/ Bilateral
  - Commercial Banks
  - Govt. support required to develop bankable financing structures

Financing through grant fund

Through various schemes of the govt. and/or multilateral / bilateral financing institution, grant funds are provided to subsidize the capital investment. Such financing is almost the norm for renewable energy based generation schemes. While the mode of financing is critical in providing the needed energy to the rural power, especially through renewables, the structuring of the financing schemes are very critical for sustainability and attainment of the long term objectives. There are repeated instances when the schemes set up through subsidy are soon abandoned for various reasons and these need to be addressed in formulation of the schemes.

Energy Pricing Policies

As much as possible, energy prices should reflect the full costs of supply. If subsidies are needed, they should ensure that service providers have a financial incentive to meet the demand of subsidized consumers. When a cross-subsidy mechanism is used between categories of users, it will also create a disincentive to serve those who do not pay full costs.

Although energy pricing mechanisms should in principle seek to internalize the costs of pollution that result from energy use, these environmental taxes should not make the energy on which the poor rely unaffordable. For example, a tax on commercially available charcoal, coal briquettes, or kerosene may be largely borne by the poor.

Subsidies should be designed in such a way as to reinforce the commercial orientation toward reducing costs and improving service. In most cases this will mean focusing on reducing the cost of the initial investment, thereby increasing the number of people who have access to the energy service, rather than continuously subsidizing the recurrent cost of operation.

Subsidies and Incentives

Subsidies are almost universal in the energy sector at all stages of economic development. It should be borne in mind that the costs of adjustment in moving to privatization and reforms with economic regulation can be high, much of this burden falling on the poor people. To be poverty-sensitive, any such move should therefore include a safety net.

Subsidies may be used:

- to assist poor households in obtaining or affording a minimum level of service (that is, in the form of a consumer, or consumption, subsidy, such as a low charge for very low levels of household electricity consumption)
- to cover wholly or in part the cost of connecting the poor (that is, a capital subsidy or first-cost subsidy).

Subsidy mechanisms

General Price subsidies.
Keeping electricity utility prices and the prices of kerosene, diesel, and LPG below costs for all residential consumers is a widely used and easily administered subsidy mechanism, and the predictability of the benefit received is fairly high for the poor who have the subsidized service. The coverage of this subsidy can be high for a network service (for example, electricity), however, and it is not well targeted. Across-the-board subsidies can also create a distorted price regime, resulting in wasteful consumption practices among households.

Lifeline subsidies.
These subsidies to electricity are restricted to an initial block of consumption, perhaps equivalent to a basic need level. The coverage of this mechanism is equal to the share of connected households among the poor. Since consumption grows with income, the targeting improves as the size of the initial block decreases.

Merit-based price discounts.
These may be provided based on some normative measure of poverty, for example, reduced prices to those living in slums and public housing. These subsidies are difficult to target well and can be very distorting. A cap placed on the volume of discounted con-sumption, like a lifeline subsidy, can minimize the impact of price distortion, particularly if the cap is set below the typical consumption level. However, establishing these normative poverty measures and administering them can be expensive and at times impractical.

Burden limit.
Here the total payment for service is limited, based on an income test or similar measure of energy spending as a share of household income. This mechanism has low coverage of the poor and is not well targeted, because of a weak correlation between per capita household income and the share of household income that goes to energy spending. The burden limit mechanism is probably the most

distortionary of utility subsidy mechanisms, although the distortionary effect is confined to thosehouseholds that receive support in contrast to the distortions created by an across-the-board subsidy, which affect every consumer. Placing a cap on per capita or total household consumption of utility services that counts toward the burden limit, or using consumption norms to fix the level of utility expenditures for the purpose of subsidy can significantly reduce the distortionary effect.

Noncollection

This refers to non-enforcement of disconnection for unpaid bills, allowing illegal connections to continue. This occurs when governments pressurize utilities not to disconnect households that do not pay their bills. Coverage of this mechanism is low. There are significant pricing distortions associated with this scheme, since the effective price of the utility service is below cost for many consumers even if the notional price is set properly, resulting in inefficient consumption.

Cash transfers and general cash benefits targeting poor households.

This mechanism is the least distortionary because households can spend the cash support as they wish. While it can involve significant fiscal cost, there is no direct financial burden for utilities or other consumers.

Easing first-cost constraints

Two fundamental elements of energy pricing influence a poor household's decision to obtain and use a particular energy service. The first is the up-front connection and equipment cost of using the energy service, for example, the cost of grid connection and home wiring or of a kerosene/LPG stove, and the service deposit. The second is the per unit price of using the service; that is, the electricity price per kilowatt-hour or cost of kerosene per liter. Poorer people often pay more per unit of energy used simply because they cannot cover the initial capital costs of obtaining the energy supply (and/or the necessary conversion equipment).

High first costs significantly constrain the ability of the poor to shift to modern energy services. The indivisibility or "lumpiness" of many energy systems means that the initial cost for improved energy services may often be a multiple of a poor household's monthly income. There is clearly a need to break these payments into smaller installments and spread them over a reasonable timeframe. These constraints are addressed through:

Utility-credit.

Electric companies could allow customers to pay connection costs over several monthly payments on their electricity bills. By charging interest to the consumer, the utility can make a profit on this activity, provided they are able to cut off the consumer for nonpayment. This provides the utilities with an effective form of collateral.

Providing subsidies for technical assistance

It is also important to consider ways in which the costs of a particular energy development can be reduced, and not just be a subsidy to the providers of finance. Providing subsidized assistance for the training of equipment manufacturers or for independent on-site feasibility studies appears to be particularly effective in reducing costs to the user, and in reducing the risks to the investor.

Subsidy evaluation criteria

Coverage.

The extent to which the poor are being reached. Obviously, if the poor are not using the subsidized service, coverage is inadequate. The environmental subsidy for renewables could be financed by a cess on non-renewables and fuels causing environmental damage. This could help in increasing the coverage.

Targeting.

Targeting refers to the share of the subsidy that goes to the poor. If a large share of the subsidized energy product is actually consumed by the middle class and the rich, targeting is inadequate. Capital subsidies linked to investment should be restructured to link these outcomes. All price subsidies should be linked to outcomes. Thus, for example, giving a capital subsidy on a wind power plant provides encouragement to set-up a power plant but does not provide any additional incentive to generate power. Instead a price premium on feed-in tariff for wind power into an existing power grid ensures outcome for the outlay.

Predictability.

Predictability refers to the extent to which the poor can count on the subsidy each month.

Distortion.

Distortion refers to the extent of pricing distortions and unintended side effects. Subsidies may exacerbate supply bottlenecks and create disincentives for private businesses to deliver energy services to poor consumers. For example, subsidizing kerosene may prevent consumers from switching to non-subsidized LPG, or may encourage the diversion of kerosene supplies to other market uses, such as transportation. In another example, electricity subsidies for agricultural users in India have led to the illegal use of subsidized electricity for nonagricultural use, such as small industries. The objective is to minimize distortion.

Cost- effectiveness.

Cost effectiveness takes into consideration the impact of direct or indirect cost of the subsidy. The objective should be to minimize costs. High costs of providing the subsidy may place a direct burden on the budget, and although a cross-subsidy may minimize cost, it would increase the distortions and create disincentives to supply.
There are sustainable models for energy services delivery to the poor with clear focus on energy poor with long term program involving capacity building, appropriate technology and affordable financing. Some examples are:
Administrative cost:The goal should be simplicity and ease of administration, and should seek to eliminate the potential for graft, corruption, and rent-seeking behavior.

Subsidies for the Weaker Sections

Subsidies designed to benefit weaker sections of the society remain poorly targeted and result in serious price distortions and malpractices. Most of the LPG subsidy is actually benefiting the rich and the upper middle classes. A large part of the PDS kerosene is used for adulterating diesel and burned in standby generating sets. Agriculture and household subsidies on electricity provide the basis for theft of power by industrial and commercial consumers.

Micro financing

Providing consumer credit through micro-finance institutions (MFIs) may sometimes be a feasible way of easing first-cost barriers. These institutions often standardize small loans to individual households or groups, often targeting women within the poorest households. Unlike traditional financial institutions, they can be more flexible with collateral policies. An additional benefit of this approach is that it is consumer-led, which makes it more likely that an affordable solution will be identified. A drawback of the approach, however, is that most micro finance institutions have found it difficult to refinance themselves through commercial sources, and remain dependent on the extension of donor and government loans.

Need for Financial Innovation

Public and Private sector investors need to innovate financing models to support sustainable energy availability for the rural population through grid and distributed generation including optimized use of renewable energy.
Meeting the energy needs of rural population can offer significant commercial opportunities for Investors.

Other Recommendations

Institutional Arrangements, Enterprise Management New Technologies etc.

While finding enough financial resources is the biggest challenge for setting up new energy ventures, creation of the right structure of institutions/enterprise is perhaps equally big challenge for the sustainability of these ventures. For individual/family bases gadgets, small and medium DDG projects, involvement of the local people in managing the enterprise is very important, providing professional approach in the management of these ventures and ownership are equally important for the long term sustainability of these ventures.

In view of unavoidable substantial capital subsidies in some of the renewables based systems for the rural masses, involvement of Govt. organization or representatives would be necessary but this should be supported by the involvement of the local village population who should have their emotional and if possible a nominal financial stake in these ventures for their long term sustainability. Other forms of organization structures bases on success stories of similar project ventures would also merit consideration

Private participation

Looking into the magnitude of financing requirement it is well recognized that involvement of the private sector is very important.

However, Restructuring and regulation of energy utilities has to be carefully designed so that the poor benefit and are not disadvantaged, as can happen if service is withdrawn because of their inability to pay the unsubsidized or even the subsidized prices of the private supplier. Private participation in ownership and/or operation of energy sector entities can have positive short- term and long-term impacts on the poor.

Private owners and operators can improve the operating efficiency of the energy production, transport, and supply chain, thereby reducing the cost of providing the service. Effective regulation will be needed to ensure that cost reductions are passed on to consumers. Private ownership will require cost-covering tariffs. If tariffs are initially below cost, they will need to rise, to the short-term detriment of all consumers. In the medium term, such changes will generate the funds needed to pay for enhanced investment and maintenance, and hence, should result in improved services for all.

Private operators have been found to be more responsive to service delivery obligations and consumer needs. Private operators will have incentives to contain their costs by reducing "non-technical" losses (that is, theft). Private operators will typically be able to obtain large-scale injections of capital and, if the regulatory environment is stable, have the ability to make the best use of that capital. This will allow systems to be expanded and should minimize supply shortages. Private ownership may sometimes lead to a short-term decrease in employment in the affected industry, but the resulting improvement in service reliability or cost should lead to longer-term increases in the job creation that accompanies growth.

The scale and distribution of benefits of privatization will depend on the form of privatization chosen. A variety of mechanisms can be employed to involve the private sector in the energy sector. For example, in a management contract the private operator may be paid a flat fee to improve enterprise management. The incentive under the terms of such a contract to in- crease sales or to improve billing and collection is weaker than with a lease, however, which allows the operator to keep the collected revenues and pay a lease fee to the government. A concession with investment obligations, a BOT (build, operate, and transfer) scheme, or a divestiture would make the private operator responsible for deciding upon investments, delivering stronger incentives than would a lease to minimize the costs of the capital investment that is a crucial determinant of the final price of infrastructure services.

New technologies

There are several new technologies in renewable sector, which are at various stages of development. These clean sources of energy seem to be considerable potential and need to be developed for their commercial deployment at a faster rate. Some of these are:

Hydrogen Energy

Hydrogen is a clean energy carrier with potential to replace liquid and gaseous fossil fuels. The MNRE has been supporting R&D on different aspects of hydrogen energy covering hydrogen production, storage and utilization, and fuel cell technologies through research, scientific and educational institutions, national laboratories, universities, industries, etc to make the evolving hydrogen energy and fuel cell technologies more efficient, convenient, safe and reliable, apart from making the sector cost-competitive.

Research on hydrogen production through various methods using using solar energy, and microbial and gasification routes of biomass are under various stages of development.

In view of the low density of hydrogen, its storage in a compact and efficient manner is a major technological challenge and thrust area for research.
Hydrogen can be used in internal combustion engines and fuel cells for motive power production and electricity generation. A no. of research projects in the area of utilization of hydrogen energy in internal combustion engines, catalytic combustion cookers for domestic, industrial and community applications etc have been undertaken by academic institutions as well industrial R&D centers.

Chemical Sources of Energy - Fuel Cell

Fuel cell is an electrochemical device that converts chemical energy of hydrogen directly into electricity and heat without combustion. Fuel cells are emerging as a clean and efficient technological option for stationary, transport and portable applications. Fuel cell power systems can be used as uninterrupted power supply (UPS) systems, replacing batteries and diesel generators.

The emphasis of research has been on further improvements in fuel cell related processes, materials, components, sub-systems and fuel cell systems.

Geothermal Energy

The energy generated by heat stored beneath the earth's surface that can be tapped for generation of electrical energy or for other direct uses like green house, space heating, refrigeration, etc.

In India, various resource assessment studies/ surveys have shown the existence of 340 hot springs in the country, most of which are low temperature hot water resources and can be best utilized for direct thermal applications. Only some sites are suited for electrical power generation.

Tidal

Among the various forms of energy contained in the seas and oceans, tidal energy, has been developed on a commercial scale. Technologies for harnessing other forms of energy from seas and oceans are still under development. France, Russia, China, Canada, United Kingdom and Korea are some of the leading countries, which are making use of tidal energy on commercial basis.

India has a long coastline but the estuaries and gulfs where tides get pronounced becoming suitable for moving turbines is very few. The tidal power potential sites in India are in the Gulf of Kutch, Gulf of Cambay in Gujarat and the Delta of the Ganges in West Bengal. In order to develop and harness tidal energy for power generation, the MNRE is implementing a programme on tidal energy.

Integrated Gasification combined cycle

As the name suggests the technology has evolved by combining the processes of "gasification" and "combined cycle". Gasification is the process of converting solid or liquid fuels in gaseous forms under controlled conditions, which facilitates removal of polluting components like sulfur, etc. from these fuels, thereby making available clean gaseous fuel for generation of power in a "combined cycle power plant".

The term combined cycle connotes the process of power generation by expanding compressed high temperature gaseous fuel in a gas turbine and the exhaust heat which has good of energy is used for raising steam in a heat recovery, steam generation, to be expanded in a steam turbine for generation of power. The process results in fuller extraction of energy from the fuel and consequently in high thermal efficiency.

It would thus be evident that IGCC technology would enable generation from power from fuels which are considered to be highly polluting unsuitable for use in any other manner from environmental consideration. The technology, therefore, is most suitable for refinery residues like visbreaker, LSHS, petroleum coke, etc, as also coals having high levels of polluting components like sulfur. The refinery residues, especially from refineries using high percentages of sour crude, would contain high percentage of sulfur which may go up to 8%. The gasification process separates sulfur from to the extent of 99.9% in elemental form which is saleable in commercial market, thus converting highly polluting fuel into most benign one. Some people also support gasification of normal coals but the refinery residues would rank higher in the merit order for adoption of IGCC technology.

As regards the cost of power generation for IGCC technology, because of substantial additional investment in gasification equipment as also increased auxiliary power consumption in operation of such gasification equipment, the cost of power generation for IGCC, would be marginally higher than corresponding costs for coal based generation as the cost of refinery residual fuels, after for variation in calorific value, would be substantially lower than that of coal. With the present stage of IGCC technology, the plant availability levels in IGCC plants, especially of large capacity, say 300 MW and above would be marginally lower than the corresponding coal based power plants.

This source of power generation may not by itself offer any specific advantage for rural energy needs but would be an important avenue for augmenting a total power generation and an the same time containing pollution however govt. policy essential for promoting this technology or else the polluting refinery residue would their use in unorganized sector industries with their consequent impact on pollution and human health.

Some Successful Case Studies

Saradi Test Project in Dehradun District of Uttarakhand

Saradi, situated on a hilltop, at an altitude of 1200 meters above mean sea level, is a remote, tribal-dominated and forest fringe village with 106 households at a distance of about 70 Kms. from Dehradun. Saradi test project was completed in all respects and dedicated to the villagers in November 2008. Two gasifi ers, each of 10 kW capacity have been installed and commissioned on 25th May 2008 and 7th November 2008 respectively. The project was implemented by Uttarakhand Biofuel Board (Forest Department, Govt of Uttarakhand). The biomass gasifi ers meet the daily requirement of domestic lighting in the households, community hall/school lighting, street lighting and other entertainment activities. Each household has been provided with two light points and one power point for domestic lighting and entertainment. One oil expeller installed in the project, is being operated on 10 HP motor for extraction of oil from Jatropha seeds. In addition, the villagers also make full use of oil expeller to extract oil from mustard. The oil extracted from Jatropha seeds is being used by the villagers as raw material to operate their diesel engine pump sets directly for irrigation purpose. With the availability of electricity in the village, the quality of life of the villagers has improved drastically and villagers are happy as they have installed television sets in their houses for entertainment and children are able to study at night in a proper light. The fear of wild animals has reduced, as 10 streetlights have been installed in the village, which provide adequate illumination during night. The villagers have decided to use the power generated for many other applications, such as, fl ourmill, chaff/fodder cutter machines and water pumps. The VEC has undertaken plantation of Jatropha in 7 hectares land, which would provide biomass for running the gasifi ers and oil seeds for running the oil expeller. Biogas plants have also been installed in the village for meeting their cooking requirements.

Electricity & Energy Services provided by 50 kW Biomass Gasifi er in Distt. Araria, Bihar

Decentralized Energy Systems India Pvt. Ltd. (DESI Power), Bihar has set up biomass gasifi er based Employment and Power Partnership for electricity supply, energy services and job creation in rural areas of district Araria, Bihar to promote socio-economic development of villages through the provision of electricity and energy services. The 50kW biomass gasifi er and balance of systems are provided by Netpro Renewable Energy (India) Pvt. Ltd. Baharbari Oudyogic Vikas Swavalambi Sahkari Samity Ltd. (BOYS), a local cooperative which owns and operate the plant. All the villagers are members and benefi ciaries. They have set up micro-enterprises and other energy services such as Mini Rice Mill–7.5 kW; Aatta

Chakki–7.5 kW; Chura Mill–3.5 kW; Battery Charging Station–2.0 kW; Mini Work Shop–10.0 kW, Irrigation Pumps (nos. 06)–21.0 kW; Briquetting Machine–8.5 kW; two Fish Ponds; and Organic farming. DESI Power has imparted capacity building and trained trainers among benefi ciaries to operate the micro enterprises. The sources of funds for the four projects are equity from a local society, DESI Power and a German social-investor apart from subsidy from MNRE with commercial loan from ICICI Bank / IFMR Trust.

Rice Husk based Gasifi er Technology provides Electricity to households in Distt. West Champaran, Bihar

Samta Samriddhi Foundation, uses rice husk based gasifi er technology to produce electricity using 32 kWe (40kVA) producer gas engines that deliver electricity as a "pay-for-use" service to households at village Tamkuha, Dhanaha Block; village Madhubani, Rupahi Blocks; Bhitaha, Distt. West Champaran, Bihar. Samta Samriddhi Foundation has partnered with Ganesh Engineering Works, Buxar to successfully produce highly cost effective down-draft gasifi ers in which the rice husk undergoes "bio-mass gasifi cation" (controlled incomplete combustion) to produce a combustible mixture of gases (mainly producer gas) that runs a CNG engine to drive an alternator and produce power. The gasifi ers cost are 30% cheaper than similar gasifi ers. Samta Samriddhi Foundation provides power to clusters of 500-700 households in rural areas within a radius of 1.5 kms at an affordable price for 5-8 hours everyday. The charges are no more than two third of the savings in price of Kerosene usage. Only CFL or LED lighting is allowed. In the daytime power is provided to local enterprises as well as a mini rice mill of 500 kg/hr capacity. The rice mills setup by Samta Samriddhi Foundation mill the paddy free of cost. They produce 50-60% of the plant's husk requirement in just about 6 hours of operation per day and hence reduce dependence on outside sources for husk. Monthly charges of electricity are collected in advance and are facilitated by a Gram Urja Samiti in each village.

Success story of Micro Hydel Project in village Yangthang of (Khaltse Block) in district of Leh of Ladakh region installed by Directorate of Science and Technology (IREP) J & K State.

Khaltse is a very remote village of district Leh which is 15 kilometres from Saspol and 75 kilometre from Leh, located on the road leading to Himsshok village. Ladakh is situated in the Indus valley region of Ladakh range of Karokram Mountains within a complex network of Himalayan Mountains. It lies between 32 degree 25 minutes to 36 degree latitude having hilly terrain surrounded by large ranges. Minor ranges exhibit no pattern in terms of the direction of alignment. These ranges are drained by number of rivers which eventually ends up in the River Indus. Some of the peaks surrounding the village rise beyond 16000 feet and are permanently snow covered. 25 KW Micro Hydel Project was formally commissioned on 19.06.2008 at a cost of Rs. 16.21 Lakhs on Yangthang stream The project was completed within a period of one year and remained on trial before it was formally commissioned. The project provides electricity to 35 households. The area was devoid of electricity except few households were having solar units for lighting 2-3 CFL tubes. The Village Level Energy Committee was constituted which has taken up the responsibility of management, maintenance and repair after the project was handed over to the Committee. Two grassroot engineers were trained for running the project. This hydropower has the least impact on the environment. Each beneficiary contributes Rs. 50/- per month which is shared among the two grassroot engineers. Beyond the lighting the Village Energy Committee plans to install local industry for processing agriculture crops steel works, irrigation etc. Presently they have to go to Leh for Milling and other services. The village also has a small wool processing unit at home level, which could be augmented with power spinning machine which will enable them to process a larger quantity of wool and spinning a pashmina can also be done at home.

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Abbreviations

MDG: Millennium Development Goals

HIV: Human Immuno Deficiency Virus

AIDS: Acquired Immuno Deficiency Syndrome

EU: European Union

GW: Giga watt

MT: Metric Tonne

RGGVY: Rajiv Gandhi Grameen Vidyuteekaran Yojana

T&D: Transmission & Distribution

LPG: Liquefied Petroleum Gas

Govt.: Government

WHO: World Health Organization

NGO: Non Governmental Organization

PPP: Public Private Partnership

VGF: Viability Gap Funding

MNRE: Ministry of New and Renewable Energy

BPL: Below Poverty Line

USD: United States Dollar

IREP: Integrated Rural Energy Program

NBMMP: National Biogas and Manure Management Programme

BIS: Bureau of Indian Standards

ISI: Indian Standards Institution

SPV: Solar Photo Voltaic

RVE: Remote Village Electrification

VESP: Village Energy Security Test Project

SVO: Straight Vegetable Oil

MW: Mega Watt

CERC: Central Energy Regulatory Commission

SERC: State Energy Regulatory Commissions

RoE: Return on Equity

kWh: Kilo Watt Hour

OTEC: Ocean Thermal Energy Conversion

CSP: Concentrated Solar Power

RE: Renewable Energy

TW: Tera Watt

PV: Photo Voltaic

DDG: Decentralized Distributed Generation

CST: Concentrated Solar Thermal Power

STEG: Solar Thermal Electricity Generation

HVDC: High Voltage Direct Current

IEA: International Energy Agency

DNI: Direct Normal Insolation

ISCC: Integrated Solar Combined Cycle

ENEA: Energy and Sustainable Economic Development

PPA: Power Purchase agreement

GHG: Green House Gas

CCS: Carbon Capture Sequestration

CWET: Center for Wind Energy Technology

SHP: Small Hydro Power

UT: Union Territory

CCPP: Combined Cycle Power Plant

LNG: Liquefied Natural Gas

SHS: Solar Home System

DG: Distributed Generation

R&D: Research and Development

RC: Regulatory Commission

TTRC: Tradable Tax Rebate Certificates

ISPP: In Situ Propellant Production

FFA: Free Fatty Acid

ICRISAT: International Crops Research Institute for the Semi- Arid Tropics

MFI: Micro Finance Institutions

PDS: Public Distribution System

BOT: Build Operate Transfer

ROE: Return on Equity

UPS: Uninterruptible Power Supply

LSHS: Low Sulphur Heavy Stock

REDP: Rural Enterprise Development Project

DESI: Decentralized Energy Systems India Pvt

CFL: Compact Fluorescent Lamp