Cost Economics of Solar kWh

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The current levels of dependence on fossil fuels, the need of reducing the carbon emissions associated with energy use and the prospects of developing a new and extremely innovative technology sector, make solar energy increasingly attractive, However higher cost per unit of electricity is the major drawback that have held back this ideal energy source. This paper purports to present, it may not be always cost effective to supply all the energy requirements from the sun but economic feasibility is not always the determining factor in selecting a power generation system. Furthermore, technological advances narrow the cost gap. More over days has passed when the cost of conventional energy was significantly lower than the cost of solar energy. Also today if we compare the price of Traded Electricity during peak hours and cost of Solar KWH we will find days are not far when Solar will be the cheapest source of energy.

he 1973 oil crisis brought "Energy "issues to the forefront. Whether it is Electricity, Gas or alternative source, Energy plays a considerable role in the Socio-Economic development of a country.

Around 90% of world's primary Energy consumption is derived from fossil fuels. India's Primary Energy Consumption is around 524 Metric Tonne of Oil Equivalent (MTOE) as on 2010[4]. The figure clearly shows the increased consumption rate.

It is quite difficult to supply the requisite energy from present major dependable sources of energy. One of the reasons may be availability of conventional fuel and another factor may be present environmental issues. In 2010 the % increase in primary energy consumption is about 9.2% in comparison to previous year. Such high % growth is alarming.

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Solar energy is one of the most prom-



ising of the non-conventional energy sources. The power from sun intercepted by earth is approximately 1.8 x 1011 MW, which is thousand times higher than the present consumption rate on earth of all commercial energy sources. Thus solar power may be an answer for world's energy Security.

Solar potential in India

India is endowed with rich solar energy resource. The average intensity of solar radiation received on India is 20 MW/km square (megawatt per kilo-meter square). With a geographical area of 3.287 million km square, this accounts to 657.4 million MW. However, only 12.5% of the land area amounting to 0.413 million km square can, in theory, be used for solar energy installations. Even if 10% of this area can be used, the available solar energy would be 8 million MW per year. But the efficiency of conversion of solar energy to useful energy is low. Therefore, the energy actually available would be order of magnitude lower than the aforementioned estimates.

In the hottest region of earth, solar radiation flux available rarely exceeds 1 KW/m2 and the total radiation over a day at best about 7 Kwh/m2 [8].

These are very low value from the point of view of technological utilization. The current levels of dependence on fossil fuels, the need of reducing the carbon emissions associated with energy use and the prospects of developing a new and extremely innovative technology sector, make solar energy increasingly attractive.

Towards adopting a sustainable development path various strategies have been adopted by the Govt. of India in the recent past towards promoting energy efficiency, environment protection, pollution abetment in industrial, commercial, transport and agricultural sector. The national action plan on climate change focuses eight key missions leading to sustainable develop-



ltem	Solar PV Power	Solar Thermal Power
Capacity (MW)	1	1
Capital Cost (Rs. in Lac/MW)	1442	1500
Useful Life (Years)	25	25
Tariff Period (Years)	25	25
Capacity Utilization Factor (%)	19	23
Auxiliary Consumption (%)	-	10
Debt : Equity	70% : 30%	70% : 30%
Depreciation	1 st 10 years @ 7% 11 th year onwards @1.33%	1 st 10 years @ 7% 11 th year onwards @1.33%

ment. The National Solar Mission is one of the eight missions to promote ecologically sustainable growth while addressing India's Energy security challenge. One of the mission targets is for the deployment of 20,000 MW of solar power by 2022^[7].

Applications of solar energy

Solar energy is a dilute source. Large areas are needed for collection. Besides, it is obvious that solar energy can be a good source of meeting future energy demands.

On the applications side, the range of solar energy is very large. The generation capacity starts from domestic appliances such as solar cooker, solar water heater, and PV lanterns to the high end of megawatt level solar thermal power plants. Then, in between, there are applications such as industrial process heat, desalination, refrigeration and air-conditioning, drying, large scale cooking (e.g at Tirupati, Andhra Pradesh the food being prepared using Solar cookers), water pumping, domestic power systems, and passive solar architecture. Solar cookers and hot water systems based are gaining popularity in India and to a large extent attained commercial status. Solar energy can be harnessed to supply thermal as well as electrical energy. A solar energy can be harnessed in two ways:

- To use thermal Energy in solar radiation: -Solar thermal technologies ^[6].
- To convert solar energy to Electrical Energy: Solar photovoltaic technology^[6],

Since the accurate information about solar energy resource at a specific location is crucial for designing appropriate solar system; solar energy resource assessment becomes an essential activity of any solar energy program.

Cost of per solar kWh in India

Utilizing solar energy is definitely free, clean, safe, abundant, renewable, but the high initial investment, higher cost per unit of electricity, long-term payback and poor conversion efficiency are some major drawbacks that have held back this ideal energy source.

The terms & conditions for determination of tariff of Renewable Energy for FY-2011-12 was released during September 2010 vide order no. 256/2010 by Central Electricity Regulatory Commission. For calculation of Tariff the commission made a few assumptions. Few of them are as follows.

As per the order the life of Solar PV plant has been accounted for 25 years & accordingly the tariff has been calculated for a 1MW Solar PV Power Project over a period of 25 years. The cost of one unit of solar electricity has been presented. The levellised tariff of Solar Energy has been decided as Rs. 15.39 by Regulatory commission ^[1].

Similarly the cost of Electricity over a period of 25 years generated by solar thermal Power projects has been presented. The levellised tariff of Solar Energy by solar thermal power project has been decided as Rs. 15.04 by Regulatory commission ^[1].

Although the capital cost of solar Power projects is reducing, Solar Electricity still costs more than conventional energy. In order for photovoltaic to be implemented on a significant scale, the cost of solar electricity needs to be substantially reduced.

Approach to minimize cost per solar kWh

Two reasons contribute to this high cost: the need to use large amounts of expensive semiconductor material, and the low conversion efficiency. Scenarios show that solar energy will be, in the long term, the most important energy source, provided that the cost of photovoltaic modules is substantially decreased. The challenge is to reduce the total costs of a photovoltaic system. Some of techno-managerial approaches are discussed as follows:

- The cost essentially derives from the raw material employed in the manufacturing of solar cells, using thinner silicon wafers and higher conversion efficiencies is the nearest path for reaching photovoltaic competitiveness. Innovative manufacturing concepts on a laboratory scale into the full industrial scale, in order to demonstrate technologies that will enable the mass manufacturing of photovoltaic products with a significant reduction in manufacturing costs.
- For instance as per the order of CERC the normative capital cost for setting up Solar Photovoltaic Power Project was Rs. 1700Lakh/MW for FY-2009-10. However as per the order published during September 2010 the normative capital cost for setting up Solar Photovoltaic Power Project was reviewed and finalized to be Rs. 1442Lakh/MW for FY-2011-12. This clearly signifies a reduction of Rs. 258Lakh/MW for setting up a Solar PV project within a span of two years ^{[11][2]}. It may be noted that very recently the commission has prepared a draft Requ-

SOLARPOWER



lation 2012 and the Capital of Solar PV Plant has been decided as Rs. 1000 Lakh/MW.The same will also be retained in final regulation as clarified on 06/02/2012.

- Reducing the need of module surface, being modules – the most significant cost component, could reduce the cost. This may be achieved by adopting the concentrating photovoltaic approach.
- There is a wide gap between the best solar cell efficiencies that are being obtained in research laboratories and those offered commercially by manufacturers. High solar cell efficiencies are beneficial in reducing overall system cost Researchers at the Fraunhofer Institute for Solar Energy (ISE), Germany have achieved a record efficiency of 41.5% for conversion of sunlight to Electricity, thus by overtaking the 40.8% record set by the U.S Renewable Energy Laboratory (NREL) ^[3].
- Accelerate and facilitate the integration of photovoltaic systems in buildings and the electricity network to reduce the cost of photovoltaic systems and become competitive with conventional energy production in the future Liberalized energy market. The success of the photovoltaic penetration in the Japanese market lies with the fact that photovoltaic was considered a building component and integrated since the beginning in the construction.

The cost of the electricity produced by photovoltaic technology is higher than that from conventional fuels. This is a major obstacle for sustained long-term growth of solar technologies, and currently requires massive governmental support to create artificial markets for solar electricity.

The economics of photovoltaic power generation

Photovoltaic efficiency and manufacturing costs have not reached the point that pho-

tovoltaic power generation can compete with conventional coal-, gas-, and nuclearpowered facilities. The cost of solar power is approximately four times that of conventionally (Coal based Thermal Power Station) produced power. There are various factors that affect the cost of producing and distributing conventional electrical power. Due to the wide range of these variables, some applications of photovoltaic power are economically superior to conventional systems.

REMOTE APPLICATIONS

Solar Power can find application in places where purchase or delivery of fuel as well as electricity is a challenge due to geographical location. PV facilities may be located at the point of power consumption. Remote applications include remote telecommunications sites, remote homes and villages (e.g Sundarban area of West Bengal), water pumping, etc. Remote applications can become economically feasible because of the expense of constructing distribution lines and power losses sustained in transmission of conventional power. If a remote site requires a dependable power source or has large loads, a hybrid system may be a better option. This may consist of photovoltaic cells and a diesel generator charging a bank of batteries. In such a hybrid system, the PV cells reduce the amount of fuel consumed.

PEAK LOAD RELIEF

In warm-climate country like India, peak load demands occur on sunny days due to heavy use of air conditioners. This coincides with the productive period for solar photovoltaic power. By locating photovoltaic collectors at the end of a distribution line, a power utility may be able to defer the construction of additional conventional generating capacity as well as defer an upgrade of the distribution line.

GREEN POWER

With interest in green (ecologically friendly) power growing, both consumers and providers of electrical power are turning to the use clean Power in spite of its higher cost. In few states of India it has been made mandatory by regulatory commission the distribution utility has to blend a certain percentage of green power with conventional grid Power. In such cases solar power can stand side by side with other renewable energy sources.

Conclusion

Economic feasibility is not always the determining factor in selecting a power generation system. More over days has passed when the cost of conventional energy was significantly lower than the cost of solar energy. At present the increased price in coal is driving the higher cost of electricity. For instance in eastern India cost of B Grade coal was around Rs. 1750 during 2006-07 which has escalated to Rs. 3350 during 2011-12. The price has almost doubled in a span of just 5 yrs. Also today if we compare the price of Traded Electricity during peak hours and cost of Solar KWH we will find days are not far when Solar will be the cheapest source of energy.

It may not be always cost effective to supply all the energy requirements from the sun but economic feasibility is not always the determining factor in selecting a power generation system.

If we consider a conventional power plant, it depends on fuel that is purchased as a continuous string of payments during the lifetime of the plant. However a solar power plant needs to finance its "fuel costs" through capital investment at the beginning of the project.

The deregulation of the power market in almost all countries of the world led to the emergence of independent power producers and project finance techniques. Even if only a small percentage of its potential put to work, solar electricity generation will be an important pillar in the struggle against "Energy Security" & "Climate change".

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