

SOLAR ENERGY IN PAKISTAN – POTENTIAL, CURRENT STATUS AND FUTURE PROSPECTS

By

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ABSTRACT

Renewable energies and especially, solar energy has the definite prospects for development in Pakistan. Solar atlas of Pakistan indicates that the country has huge solar energy potential and it receives highest solar radiations. Solar energy can be used for various off-grid and on-grid applications. Despite having huge potential, the country is lagging behind in exploiting this energy source. Various efforts have so far been done to introduce solar energy applications in different traits of life. But these efforts have so far not been translated into large scale adoption of the technology. The development of solar energy market in Pakistan has faced various barriers which have resulted in slowing down overall progress in solar energy exploitation. But due to recent energy crises, depletion of fossil fuels, global and national climate changes and urge for energy security and sustainable development has greatly pushed the Government of Pakistan to switch over to clean and indigenous energy resources and henceforth, plans and programs are being developed to harness this abundantly available energy resource to supplement the initiatives to meet the energy needs of the country. This paper gives an overview of the potential of solar energy in Pakistan, the barriers in development, viable solar energy applications, previous experience and future anticipated trends in the country.

Key words: *Solar energy, resource potential, applications, barriers, replication,*

INTRODUCTION

Pakistan covers 796,095 square kilometers of land between latitudes 24° and 36° north and longitudes 61° and 76° east. Pakistan is facing severe energy challenges – indigenous oil and gas reserves are running out, energy demand is rapidly increasing, gap between demand and supply is growing, concerns about secure supply of energy are increasing and fuel cost is rising at an unprecedented rate. Present power generation capacity of the country is 19,453 MW, 64 % of which is generated through thermal power plants and 33 % from hydel power plants [1]. Almost 40 % [2] of the population has no access to this very basic amenity. Even present generated power cannot meet the growing electricity demands of present beneficiaries. The government is emphasizing over increasing the power generation capacity. For this purpose the key policy makers are looking towards various options other than thermal and hydel power plants.

The solar technology is much established technology in the world and there is no point of its technical viability. The increased use of electricity has made it even more viable

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and cost effective, as the electricity is getting expensive day by day. The importance of developing solar energy as an alternative energy source for sun-friendly country like Pakistan where sun shines for over 300 days a year could hardly be over-emphasized [3]. It has been evaluated that Pakistan is ideally located in the Sun Belt and due to this fact can advantageously utilize solar energy technologies for energy applications.

SOLAR ENERGY POTENTIAL IN PAKISTAN

Pakistan being in the Sunny Belt and is lucky to have long sunshine hours and high insolation levels and is ideally located to take advantage of solar energy technologies. This energy source is widely distributed and abundantly available in the country. The mean global solar insolation falling on horizontal surface ranges between 450-650 watt per m^2 per day depending upon location of site. This amounts to about 1500-3000 sun shine hours and 1.9 - 2.3 MWh per m^2 per year with annual mean sunshine duration of 8 to 8.5 hours a day and these values are among the highest in the world [3]. Such conditions are ideal for PV and other solar energy applications. We can make use of this freely available and widely distributed solar energy for improving the energy supplies and combating energy requirements.

Availability of sunny days is one of the major parameters that need to be looked into before implementing solar energy projects. Historical data indicates that in most parts of the country, availability of sunny days is between 185 – 290 days in a year. The targeted sites of the project have around 215 sunny days in a year. This renders better prospects for the technology implementation for rural electrification, economical equipment design and better operation [3].

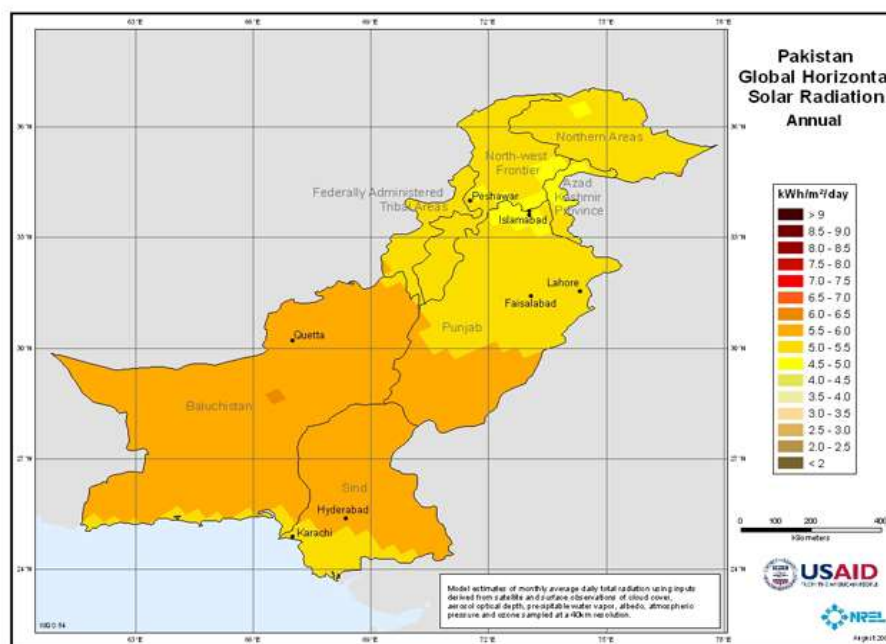


Figure 1: Pakistan Annual Global Horizontal Solar Radiation (Source: NREL) [4]

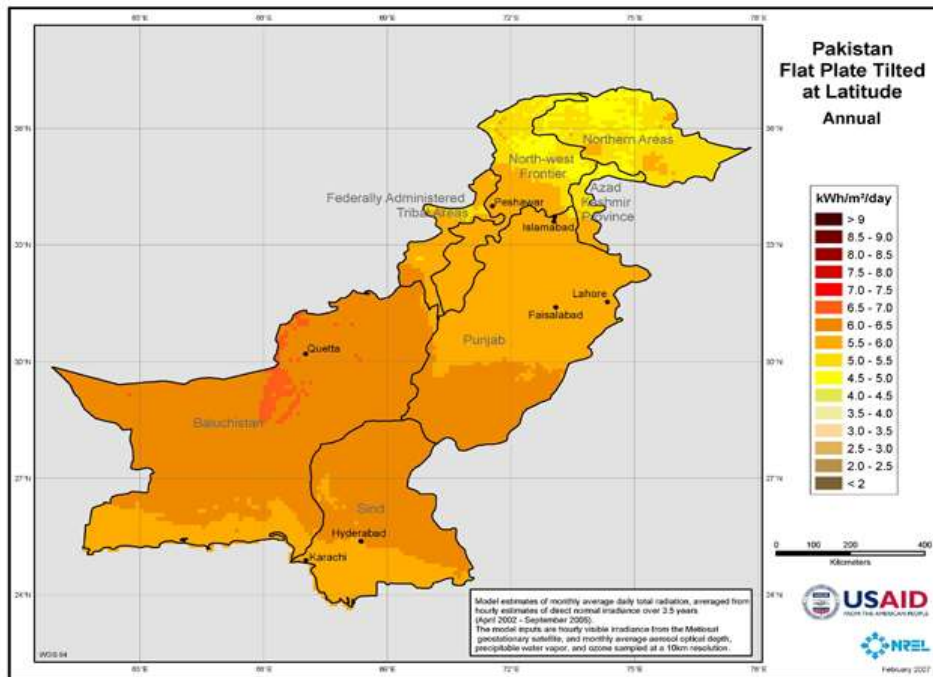


Figure 2: Pakistan Flat Plate Tilted at Latitude Annual Global Horizontal Solar Radiation (Source: NREL) [4]

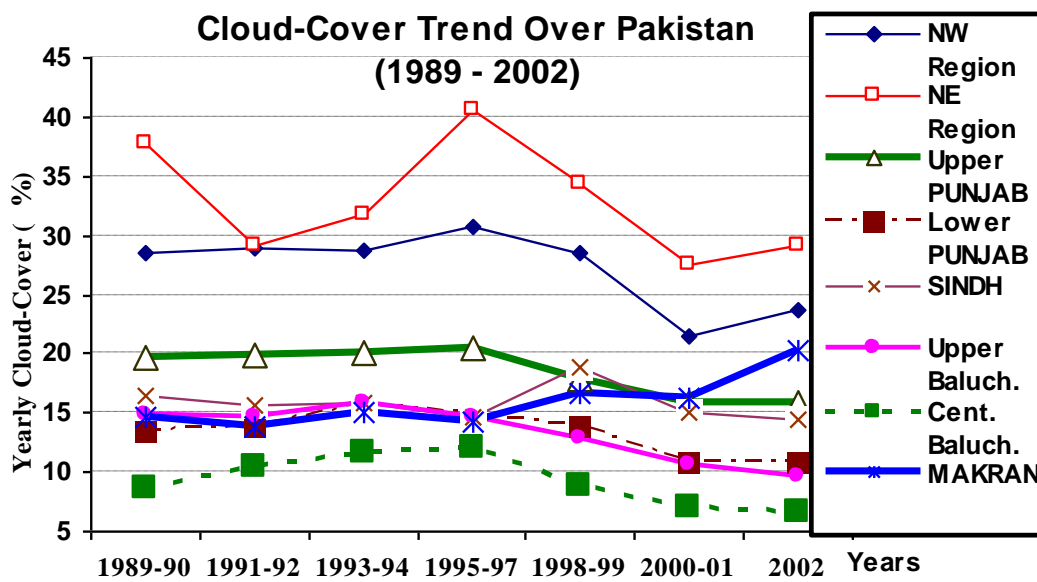


Figure 3: Cloud Cover Trend Over Pakistan [5]

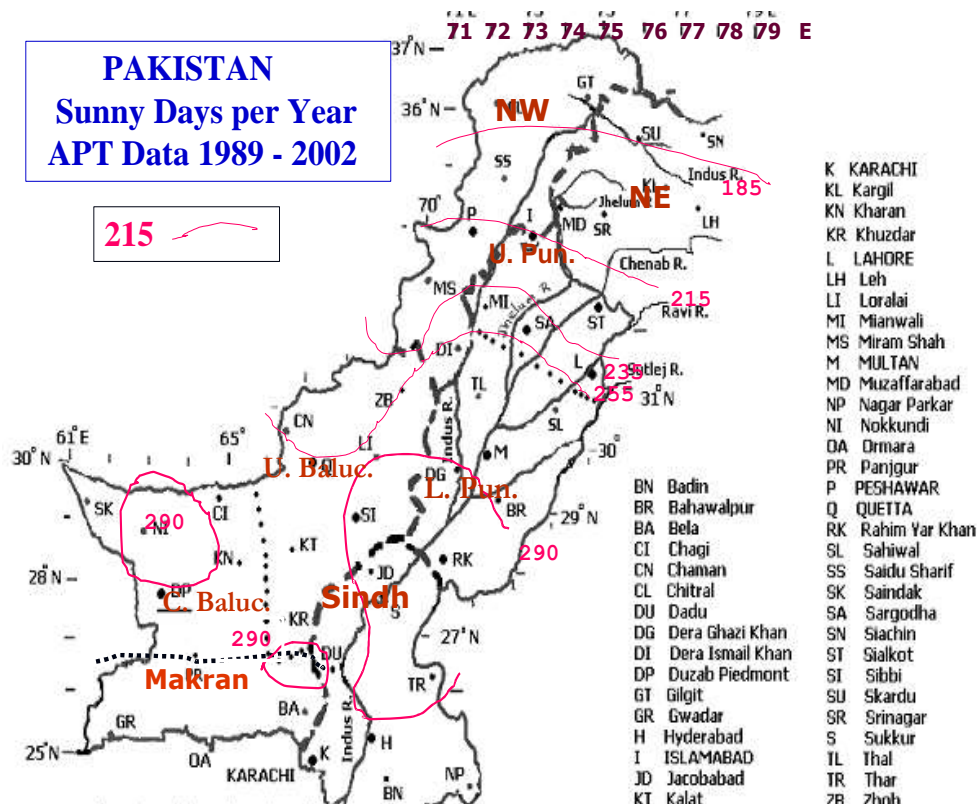


Figure 4: Sunny Days per year in Pakistan [5]

PROPONENT FOR SOLAR ENERGY APPLICATION IN PAKISTAN

The need of electrification of entire Pakistan has become essential for our economic survival. Pakistan still accounts for only 0.5 per cent of the world’s total energy consumption although energy consumption in our country has nearly tripled during the last 20 years or so [1].

Despite this three fold increase in installed electricity generation capacity, less than half of the house-holds are electrified and per capita electricity supply is only 443 kWh per year against 12,500 kWh in the USA and 7,500 kWh in Japan.

There has been lot of talks in the press recently about power deficiency in Pakistan and on poor performance of concerned authorities. Pakistan has about 23,823 MW of installed electric capacity. Thermal plants make up about 68 per cent of capacity, with hydroelectricity making up 30 per cent and nuclear power 2 percent only [1].

Despite abundance of surface water, gas and coal in our country, the potential for harnessing these sources is limited at best and we are opting for costly imported oil for power generation which costs us Rs. 80 billion annually [1].

Under the scenario, electrical power through renewable sources of energy has been fast projected as an attractive option for Pakistan.

In a broadest sense, solar energy supports all life on earth and is basis of almost every form of energy which we use. Amount of solar energy that falls on earth is enormous. It will be surprising to note that all energy stored in earth's reserves of coal, oil and natural gas is just equivalent to energy from only 20 days of sunshine. Yet solar energy accounts for only 1 per cent of global energy sources.

Proponents of solar energy are now convinced that the development and adaptation of solar energy technology in Pakistan can bring a revolution in the life style and living standards of low income people living in the remote areas. While propagating this option they fail to understand that infrastructure, required know-how and limited production levels are the bottlenecks in the mass scale adaptation of solar energy. For years we have been providing incentives and funds for practical demonstration of solar energy, convincing the people for their utilities, educating the masses and developing the pilot scale activities for its promotion but could not achieve a breakthrough as yet due to these limitations.

The role of solar energy has been negligible in the total energy picture of Pakistan. Solar energy technology has so far been used in our country only for demonstration purposes. The experiments in the past in this area were not so successful due to variety of reasons including lack of understanding and handling of this technology.

The solar energy technologies have not been exploited on a large scale for a number of reasons such as, high cost, lack of motivation and inadequate demonstration of effective use of the technology. Recently there is a realization among government circles, about the necessity of using solar energy for the purpose of saving the environment and socio-economic uplift of the peoples living in the remote areas.

Traditional energy sources like firewood, animal dung, and bagasse (the woody residue left-over from crushed sugar-cane) still make up more than half of all energy consumed in the rural areas. There is no denying the fact that solar-generated electricity will improve rural life, thereby reducing the urban migration that is taxing the ability of cities to cope with their own environmental problems. Further, by harnessing solar power for energy in rural areas reliance on firewood would be reduced considerably but question arises that how to bring the know-how for operating such delicate systems in remote areas of the country?

Thar in Sindh and entire Balochistan province is considered ideal for utilization of solar energy. In Balochistan, 80 per cent of the population lives in the rural areas. The population density is very thin and villages are separated by large distances with absolutely no approach roads. About 85 per cent of the villages are yet to be electrified [3].

Light is the only requirement for these houses located in remote areas of the province and the electric requirement for each house is 100 watt at maximum. Extension of grid lines for such small power requirements would certainly be very uneconomical and local power generation could be the best solution. In case, diesel generators are used, transportation of fuel to such remote areas and maintenance is again costly proposition therefore solar energy seems an attractive option for these areas.

Pakistan is ideally located in the sun belt to take advantage of solar energy technologies. This energy source is widely distributed and abundantly available in the country. Balochistan province is particularly rich in solar energy. It has the highest annual mean sunshine duration in the world.

BARRIERS IN SOLAR ENERGY DEVELOPMENT [6] [7]

Low Efficiency of Solar Systems

Further low efficiency of solar cells, non-availability of household appliances that run on low voltages, requirement and maintenance of backup energy sources like batteries for having electricity in night are other potential reasons for which dream of solar electrification in remote areas of our country could not turn into a reality.

High Cost of Solar Applications

The cost of solar energy application is still very high. Economically, payback period of these technologies is very high, which is one of the main reasons of its unacceptability among the general masses. Solar PV system for electrification in remote areas costs around USD 11 / watt (includes complete system). Solar Thermal Power technologies cost around USD 4.5 million / MW. A household level solar cooker costs around Rs. 18,000 and solar water heater of 115 liter capacity costs Rs. 28,000/-. Costs of other technologies are also relatively at higher side. These technologies can not be promoted unless government gives subsidies and special incentives to the end users.

Dusty Environment in Pakistan

To top it all another significant barrier in promotion of solar power in Pakistan which has never been considered by the proponents of solar energy is our dusty atmosphere. Whether it is a photovoltaic type or thermal collector type solar electricity generation unit, the performance of the system directly depends upon obstacle-free contact of sunlight to the system.

Any blockage of the sunlight to the system would certainly decrease the efficiency of the system. In all of our potential areas of Thar and Balochistan where solar power is being considered dust storms are a noteworthy atmospheric characteristic. Therefore a thin layer of dust particles will certainly deposit on photovoltaic device or thermal collector glass thus reducing the sunlight intensity on the system just like clouds and fog which ultimately decreases the performance of the solar system.

Lack of Expertise in System Design

Because of the lack of technical know-how and follow-up, these systems have never been designed appropriately and have not given the required benefits. Now the reason

behind this institutional failure of harnessing solar power in Pakistan is due to the fact that more than optimistic proponents of the solar energy did not take into account the technological barrier of a developing country like ours and disadvantages of solar energy, which certainly outnumber its advantages. In order to keep a balanced perspective of solar power utilization it is pertinent that disadvantages of solar energy must also be mentioned for evaluating the prospects of solar energy use in Pakistan.

Apart from general hurdles of cost effectiveness, collection, conversion and storage of solar energy the other potential bottle neck in promotion of solar power is lack of trained technicians to design, install and maintain solar electric system particularly in country-wide remote areas. Proponents of solar electricity systems for off-grid small villages fail to understand the key fact of illiteracy in our villages. The vital point to consider is that when technically qualified staff of concerned authorities has failed to demonstrate and make pilot scale solar generated system run efficiently, how can we expect that a non-qualified illiterate dwellers of our remote areas will supervise and operate a solar system?

Inability to teach end users

The perception that it is possible to teach ordinary people how solar energy works depends on who you talk to actually. Some may think that solar energy is a field that anyone can readily grasp to a certain extent, depending on what you want ordinary people to do with it. This means that, if you simply want ordinary people to adjust to using solar energy systems that depend on how intelligent people are when it comes to using solar energy systems (particularly home solar energy systems.) The more techie minded among us may claim that there is more to solar energy than the ordinary person could possibly grasp and that to over-simplify solar energy concepts is to diminish the perception of the possibilities that come with use of solar energy and solar energy systems.

The truth is that both perspectives are partially correct. The truth is that no one has all the right answers regarding issues with solar energy usage so it would be unreasonable to expect that we can teach ordinary people everything there is to know about solar energy usage. Actually, what we can reasonably expect from ordinary folk is for them to express an interest in one particular form of solar energy system at a time. The world of solar energy usage was not built in one day, or one week, or one month – it has been in development for more than 100 years now and continuing.

That interest expressed by ordinary folk is actually very crucial if adoption of solar energy applications is to spread and be propagated. If a high-minded techie starts talking in highly technical language about this field, most likely the eyes of ordinary folk will glaze over and they will tune out the message completely. So that is not the best way to help ordinary folk realize that solar energy issues are part and parcel now of modern life in this Earth and that we are all either part of the solution – or part of the problem.

What are the problems now then that we expect knowledge about solar energy and its applications to help solve for us? One issue is sustainable fuel supply – since solar energy is free, overwhelmingly abundant, and definitely useful, then we can reasonably

expect sunlight to serve as a sustainable fuel supply for people now and in the distant future. Another issue is to lessen or even halt dependence on emission-rich fuel supplies (like coal, wood, and fossil fuels) so that the impending global climate changes can be halted and even reversed. This is very important for ordinary folk to understand. If we can convince people, for example, to stop idling their car for extended periods of time and just turn off the car engine if they are going to wait for someone, that will help save on quite a bit of fuel actually. It is the little things that ordinary folk that when summed up result in vast effects on the global population. And this is why it is important to help ordinary folk understand how adoption of solar energy can help them, their local community, and the global community as well – each in its own turn in the process of life.

Social Acceptance of Solar Energy Technologies

This issue has rendered a situation where solar cookers have never been able to pick up in the country. Due to lack of promotion and effective media campaign, questions pertaining to efficiency and effective utilization of solar energies have never been answered.

SOLAR ENERGY APPLICATIONS VIABLE IN PAKISTAN [6] [7] [8]

Seeing Solar Energy Potential in Pakistan, it is envisaged that most of the solar energy applications that are being used around the world are very much practical in the country.

Photovoltaic (PV)

Studies conducted by the World Bank and some national agencies in Pakistan suggest that PV power systems become competitive with conventional energy sources for small power applications such as for telecommunication in remote areas. If installed, about 20 MW PV installations will generate an average 32.195 million kWh of energy annually on a 35% annual plant factor. Since the cost of implementing the option is much higher than the benefits available, the implementation of PV option has not met any considerable success over the years. The manufacturing and assembling of plants and equipment would improve the employment level in the country and reduce solar costs.

Off Grid Applications of Solar Photovoltaic (PV)

Solar Photovoltaic Technologies can be deployed for various off-grid applications as given below:

- Solar street lighting

Street lighting shares around 300 MW of total electricity consumption of the country. It is anticipated that this load would reach to around 500MW in coming days due to new installations in planning and design stages. All such load can be shifted to solar energy. Solar Street Lighting Systems powered through Solar PV modules can meet with this load. The development authorities in the country are exploring the opportunities of this shift. Their planning departments are currently working out prospects for making all new installations of street lighting through solar energy applications.

- Commercial Lighting (Bill Board Lighting, Search Lighting, garden lighting etc.)

Commercial lighting load is increasing as the life style of the people is changing. The provincial and city governments are planning to shift all this much load to solar energy. This renders a potential of around 5 MW for solar PV modules in coming days.

- Solar Water Pumping

The irrigation system in most of the Arid Agricultural Areas is either dependent upon rain or water pumps. This load accounts for more than 1,000 MW. Currently, these pumps are either operated through grid or through diesel generators. The federal and provincial governments are planning to shift this load to solar energy. Efficient solar energy water pumps are available in the market. The companies that are supplying pumps can be contacted for supply of PV modules.

- Rural Electrification

Under Roshan Pakistan Program and Parliamentary Schemes for Rural Electrification, more than 8,000 villages are going to be electrified through renewable energy technologies. A big share out of which would be done through solar home systems powered through solar PV modules. If 80% out of these are electrified through Solar PV module of 80 W capacity, then this accounts for a total load of around 25 MW in coming days.

- Captive Power Generation through Solar PV Application

Government has allowed captive power generation through renewable energies. In this regard, no license or approval from any governmental authority is required. If found economically suitable, then solar PV module can be the best choice for this purpose. It is anticipated that if 100,000 households opt for captive power generation through solar PV modules then this can account for 30 MW requirement for solar PV modules in near future.

On Grid Applications of Solar Photovoltaic (PV)

As like off-grid applications, Solar Photovoltaic Technologies have definite prospects for various on-grid applications. A few of them are discussed below:

- Commercial Power Projects

A huge acreage of land is lying barren in different parts of the country. The areas that are located in most potential areas and where grid is also available, photovoltaic technologies can be deployed for on-grid power generation project. Grid tied power projects of various capacities can be installed in various parts of the country. A few investors are intending to initiate grid tied PV projects of 2 – 5 MW capacity. If one or two successful projects of such capacities are executed, a lot many investors will jump into such projects.

- Net Metering Projects

Government of Pakistan allows the opportunity for net metering to the households, commercial and industrial entities. Under such mechanism a small power producer establishes a power producing facility at its premises. The power generated through this facility is sold to the national grid. In the same time the individual acts like the user as well and purchases the power from the grid. At the end of the month, the individual is liable to net meter his actual consumption and total power generation through his facility. The individual is liable to pay or to be paid the difference of amounts calculated through aforesaid mechanisms. The small investors are eyeing at this opportunity and would be

looking forward to execute such projects in near future. In fact more than 2 projects are already running on this concept. Solar energy would be having the maximum prospects and would see its maximum market share if this concept got popularized. It is anticipated that through such applications, the PV industry would see an annual requirement of more than 50 MW.

Solar Thermal – Electric

Solar thermal technologies collect the sun's radiant energy to create a high-temperature at the source that can be converted into electricity via a number of thermodynamic conversion cycles. Though solar thermal generation system is a proven technology in the USA, Germany and France where such systems have been providing electricity to grid systems on a competitive basis with conventional fossil fuel-fired thermal power plants, no solar power plants exist in Pakistan at present. These technologies are currently in the development and demonstration phase in the country.

Solar Building Technologies

Active heating systems provide hot water for space heating with mechanical assistance while passive heating and cooling systems use little or no mechanical assistance and rely rather on the design of the building to achieve specific thermal requirement goals. The application of solar building technologies is assessed to be high in Pakistan. However, the country does not have building regulations, which support the applications of solar building technologies. The Building Energy Code developed by ENERCON includes a chapter on solar technologies but this document is only for voluntary compliance and has not so far been adopted formally by any municipality.

Solar Water Heaters

According to a Household Energy Survey Study (HESS) Project conducted by the Planning Commission in 1991, water heating in the domestic sector is estimated to have consumed about 145,600 TOE of natural gas. Companies in Pakistan manufacture these devices commercially. This amount of energy and corresponding emissions will be saved for every solar water heater that is installed. The initial investment cost of manufacturing solar water heaters will be higher than that of the natural gas and electric water heaters already available in the market. Consumers experience 10-20% higher prices when they choose a solar water heater instead of a conventional water heater. However, by replacing conventional water heaters with solar water heating systems, significant amount of natural gas will be saved annually. The cumulative potential of GHG emission reduction of the solar water heater option has been projected as 4.10 million tons of CO₂ by 2020. The saving in emissions will arise from reduced natural gas consumption for water heating in the domestic sector.

GLOBAL DEVELOPMENT IN SOLAR ENERGY

The world is rapidly progressing towards developing solar energy technologies for various applications. The global solar energy market indicates that till 2012, more than 102 GW of solar power has already been installed. The investment in this sector is increasing day by day. The world has invested US \$ 244 only in 2012 in the solar energy. The world is targeting that by 2050, 11% of electricity needs should be met through solar energy [9].

STATUS OF DEVELOPMENT OF SOLAR ENERGY IN PAKISTAN

The solar technology is much established technology in the world and there is no point of its technical viability. The increased use of electricity has made it even more viable and cost effective, as the electricity is getting expensive day by day[9]. The importance of developing solar energy as an alternative energy source for sun-friendly country like Pakistan where sun shines for over 300 days a year could hardly be over-emphasized. It has been evaluated that Pakistan is ideally located in the Sun Belt and due to this fact can advantageously utilize solar energy technologies for energy applications[10]. Development of solar energy is being emphasized for both off-grid and on-grid applications. Despite longer period in adopting such technologies, the country is now heading towards right direction and we foresee a huge development in this sector in near future.

Development of Solar Energy for On-grid Applications

The learning curve in wind power sector has helped in devising effective implementation strategy for solar power projects in Pakistan. Government of Pakistan is offering excellent incentives to investors for solar power development in the country. Investors have been offered lucrative fiscal and financial incentives that are of key interest for them to come to this market. Provincial governments, particularly Punjab Government, are also facilitating development of solar power in Pakistan. Though Pakistan started late to develop solar PV power projects, i.e. in 2009, however, now sector is proceeding in positive direction[6].

At present, projects of more than 1500 MW capacity are under development in the country. Out of these, 24 projects of cumulative 763 MW capacity are being developed within the framework of AEDB policies and procedures[6]. NEPRA has announced Upfront Tariff (US Cents 17.006/kWh for North and US Cents 16.306/kWh for South) to attract private sector investment in the sector. Private sector is taking keen interest in developing solar power projects[10].

The developments in the solar sector, the demand for new generation and GoP's plans to harness clean sources of energy have resulted in creating interest from several local and foreign investors for developing solar power projects in Pakistan. There is a huge interest developed for investment in the solar sector.

Development of Solar Energy for Off-grid Applications

Government of Pakistan has initiated several projects to utilize solar energy for electrification of remote areas. Under these projects, each individual house has been given its own solar home system (SHS) and has been made responsible to operate and maintain it. The solar homes systems (SHS) comprise of solar photovoltaic system. Each household in each village has been provided with Solar Panels (40 W, 80 W, & 120 W), CFL Lamps and LED lights. This particular system has been designed to be user-friendly. The user is only required to switch on / off the lighting system as is done in normal home lighting systems [6] [7].

In these remote project areas, houses are mostly 'kacha hut type' and light is their only requirement. Most of the houses consist of one room only. The electric requirement for

each house varies from 50 watt to 100 watt maximum. The system design caters for placement of solar panels on the rooftop or in open un-shaded areas in each house or a set of houses. The Solar panels charge batteries during daylight hours and the stored energy is being used to provide light to homes/streets and operate fans/TV during day and night. AEDB has so far installed 8,000 SHS in remote villages of Sindh and Balochistan provinces through government funding. Most of the systems installed are functioning well and meeting lighting needs of the end customers[6].

The SHS have been replicated in remote areas of Sindh, Balochistan, Khyber Pakhtunkhwa and Azad Jammu and Kashmir under various programmes and projects initiated by NGOs and provincial government departments in some areas where grid electric supply is impossible. The statistics indicate that till to date around 70.5 MW off grid solar PV installations have been done in Pakistan. Most of these are SHS systems [6].

SUSTAINABILITY AND EFFICIENCY OF THE SOLAR ENERGY APPLICATIONS:

Renewable energy, especially, solar energy technologies have come out to be very much effective and a best option for provision of electricity, solution for energy demands of dwellers of these remote areas and other applications including water heating, water desalination, water pumping, street lighting, solar cooking etc. The accomplished projects have proved to be very much effective in this regard and have successfully portrayed prolific utilization of these technologies in project areas.

The technology has faced various problems in communities due to the issue of acceptability. Due to this fact, before deployment of the technology, awareness among the general masses regarding the technology, its use, precautionary measures and system operation and maintenance strategy / criteria is a must. This can also be done effectively by providing the users with small manuals.

Manufacturers in the Market

World renowned solar PV manufacturers have either directly or indirectly already entered into this market. The manufacturers that are currently operative in this market are Suntech China, BP Solar UK, Kyocera USA, GE Germany, Sanyo Japan / China, Q-Cell Germany. These manufacturers are already in supplying their products in this market. Moreover, there are a few more names from China who are not so famous but having their presence in this market due to cheaper product. The efficiency level of the equipment supplied by these companies varies from 13% to 16%.

Replication Potential of the technology and future Projects:

Solar energy has come out to be one of the solutions for meeting dispersed, distributed and stand alone energy applications. The solar energy applications have definite prospects for development in the country. The GoP is eyeing at utilizing solar energy for at least following purposes [6]:

- i. Setting up on-grid power plants; GoP is targeting to introduce at least 1500 MW of solar power into the national grid electricity mix.

- ii. Promoting concept of Net Metering and encouraging the domestic and commercial customers in rural and urban areas to install solar systems at their roof tops to meet their energy needs and supply the surplus electricity to the national grid.
- iii. Running tube wells; GoP is encouraging the farmers to install solar water pumps. For that purpose, GoP is interested to start soft loan and subsidy schemes.
- iv. Street Lights applications; the conventional street lights are intended to be gradually replaced with the solar street light systems
- v. Commercial load; the government is intending to cut power supply for billboard lighting, search lights, outdoor lighting, peripheral lighting and other commercial lightings. Solar energy applications would be promoted to meet with this energy requirement.
- vi. Rural Electrification; the GoP is intending to electrify the remote villages of the country through SHS.
- vii. Using solar water heating systems for heating water thereby saving gas supplies.

CONCLUSION

Solar energy is one of the most promising renewable energy resources in Pakistan. Its abundant availability and country being blessed with such a huge resource provides an opportunity to tap this energy resource to meet energy needs of the country. Solar energy has wider applications which are required to be promoted in different traits of life. Pakistan being energy deficit and energy starved must have to look for alternate solutions for meeting energy needs and solar energy applications come out to be potentially and technically viable for that purpose. The barriers identified in this paper are required to be addressed so that the sector could flourish and solar energy is used for various purposes.

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