Socio Economic Prospects and Challenges of Solar Potential in Pakistan

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Abstract— Pakistan lies in an area of the world having greater solar radiations. The co-ordinates of the country have solar potential to generate 2.334 million MW electric power. The huge solar potential of the country can play revolutionizing role to overcome the prevailing power shortage in the country. The solar potential can contribute to overcome the power shortage which has an adverse impact on the economy of Pakistan cutting GDP growth by 3%.The solar potential exploitation can reduce the health cost of Country by $ 916.2 billion which will be 21% of GDP in 2050.solar potential exploitation can contribute to electrify the rural population of Pakistan. At contemporary 38% people in Pakistan remain without access of electricity. As per recent report of Water And Power Development Authority WAPDA, over 40000 villages across the country that cannot be provided electricity as it is not economically viable to connect rural areas with Natural grid. Baluchistan's 80% population lives in rural areas 30% of it have no access to electricity. If only 10% diesel pumps in country are replaced by solar pumps 2100 GWh energy can be saved per year and will save Rs.21.6 Billion per year. Exploitation of such gigantic potential yet confronts various impedes in Pakistan. Some of the challenges in this respect are time line and policy uncertainty, Land identification issues, Massive cost of solar energy technology, Transmission issues, on Grid and off Grid issues and unstable and volatile explosive land and order situation in solar potential areas in the country.

Index Terms— Gross domestic Product (GDP), Central Power Purchase Agency (CPPA), Feasibility by Trade And Development Agency (USTAD), On Grid Installation capacity, National Renewable Energy Laboratory (NREL), Solar Map of Pakistan.

1 INTRODUCTION

Pakistan has a potential of 2.9 million MW of electricity per year through photovoltaic and solar thermal system [1]. To overcome the prevailing energy crises in the country, huge investment is needed in this sector, and it has been started on priority basis for it accounts for 65% of the mega multibillion CPEC projects in Pakistan. At contemporary Pakistan, China has allocated huge investment for the development of solar panel plants with the help of International Renewable Energy Agency (IREA), its financed CPEC energy projects, and privet sector is building solar power plant in Baluchistan, Kashmir Punjab and Sindh [2].

1.1 Solar irradiance in Pakistan

Pakistan receives significant level of solar irradiations across the board. Irradiations changes from North to South. The map divides Pakistan into four bends of irradiance-dark orange, ochre, yellow, and fail orange: the irradiations intensity gets increases with depth of color. Highest level of solar irradiance is found in Balochistan, southern Punjab and Sindh. ICT, KPK, PATA and Azad Kashmir receive low level of irradiance [2]. The above-mentioned locations upon sunny belt of Pakistan have sunshine and its rays for longer hours are suitable enough for insolation stages, which may be utilized for installation of solar panel production technologies for sufficient provision of energy supply to the national grid and channels for industrial and rural development.

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It has been indicated that 2.9 million MW of solar panel solar mapping could accrue to the national grid of energy production (NREL, 2012).

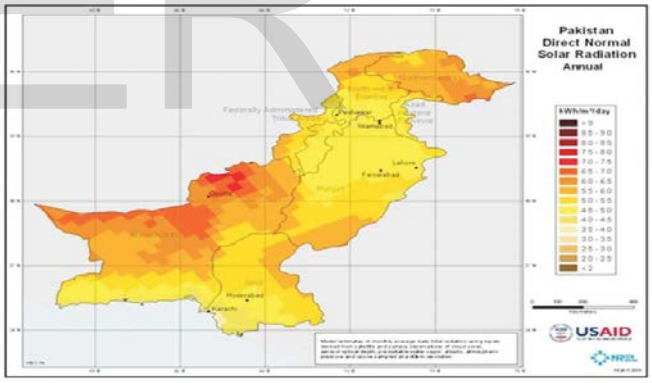

Figure 1: Pakistan Solar Energy Potential [2]

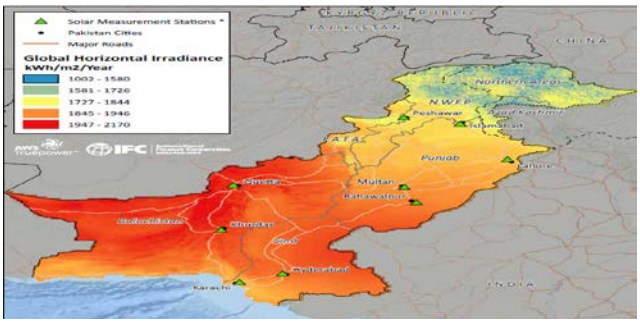

Figure 2: ESMAP solar Measurement stations [3]

The availability of solar panel for all the sectors of economy of Pakistan may be boosted to the overall production of energy infrastructure and its development. The largest province of Baluchistan covers 43% of the total land area of Pakistan has rich resources of sun rays hitting with annual sunshine hours of 8 to 9 a day, falling irradiation of 220 to 270 and insolation of 20 MJ/day constituting among the highest values at global levels. The sunshine irradiation falling on the 43% of whole Pakistan surface, it implies for 24 consecutive days availability, which constitute 80% for Baluchistan. The statistics and suitable conditions are considered near ideality for photovoltaic and energy production through solar panel and solar technologies. The economy of Pakistan can get energy inputs from the naturally gifted sunshine and its irradiation on suitable surface of Baluchistan for rural economy development, domestic and commercial use in marginal and low developed areas, reducing rural poverty, energy access facility to remote areas, provision of minimum level of per capita energy, and overall socio-economic development of its citizens. More than 35,000 villages and marginal locality and communities will get benefits for enhancing their day to day energy based activities and normal business of life at very low costs to them. The demographic characteristics and population distribution nature of rural Sindh, almost all geographic area of Baluchistan can be electrified and benefitted by exploiting irradiance in these areas due to the facts that per capita energy provision has been the lowest in rural Sindh and overall Baluchistan as per WAPDA sources from national pool of energy distribution and production mechanism engineered and formulated for the four provinces in Pakistan. In rural Sindh, about 30% villages are yet to be provided with electricity and around 35% villages are yet to electrify with reduced load shedding hours. In Baluchistan, more than 75% population inhabit rural areas and more than 85% villages in the province are yet to be facilitated with electricity provision and electrification for boosting their levels of living and socio-economic development. The population is sparsely distributed with very void density and very deficient connectivity infrastructure for the least developed province of Pakistan. Thermal power generation is very much expensive in terms of productivity, distribution, transmission lines, wire connectivity, grid connectivity, operating costs, revenue generation, economic efficiency, and optimal production and consumption of electricity.

Solar panel and power technologies has a wide scope and range of opportunities and energy blessings in both off-grid and in-grid application for the broader vision of sustainable development goals, targets of Vision-2015, objectives of CPEC for energy projects and its development, and the following prospects and availability of energy infrastructural opportunities.

i. Provision of electricity through solar power technologies to the marginal peripheries, remote areas, and villages in Baluchistan, rural Sindh, and other areas of Pakistan
ii. Conversion of electricity generation from thermal to solar for household activities, water pumps, mini businesses, and other economic activities
iii. Heating and cooling system conversion to solar panels
iv. Solar energy devices for lightening the roads, streets, LED cell, solar cells, and outdoor lighting facilities
v. Solar metering applications and net metering system
vi. Solar PV technologies and solar thermal technologies for on-grid power projects
vii. Complementary support to existing power generation technologies
viii. CPEC energy projects for solar panel
ix. Solar panel installation at very small-scale levels focusing a single unit in industry, agriculture, and service sector for economic development of Pakistan

Most of the existing and other alternative set of options for energy production are available, but the statistics of suitable volume of irradiation, cost-benefit analysis, accessibility to all the areas and villages of Pakistan, and fast track development in solar energy production technologies for immediate impacts imply for strong likelihood and inclination for Pakistan to exploit and develop the above-mentioned segments and areas of opportunities for the development of overall energy infrastructure through solar power technologies in case of national energy policy for Pakistan.

1.2. On grid installed capacity

Pakistan has inaugurated first ever on grid solar power plant on 29th May 2012 in Islamabad. It was a project that was specially granted by Japan International Cooperation Agency (JICA) under cool earth project, the project was titled "Introduction of cool energy by solar electricity generation system". The project included the installation of 178.08KW PV system for Pakistan Engineering Council (PEC) and Planning Commission (PC) of Pakistan (P block). The combined generating capacity is 356.16 kW both in PC and PEC. This was the first on grade project in Pakistan. The excess production energy by this project relaxes the consumption capacity of both the PC and PEC to sell extra energy to Islamabad Electricity Supply Company (IESCO) for other power consumer at the portal of IESCO. This project was granted by the amount of 480 million yuan, approximating 550 million Pakistani rupees as per exchange rate between Japan currency and Pakistani currency. The project is completed three years, started in 2010, for formal functional to supply solar energy to the consumers. Similarly, in Lahore capital city of Punjab, US consultants installed first ever solar panel system having the capacity of grid linking with 10KW energy production at the site of Beacon house canal side campus. It was a pilot type of project and feasibility study undertaken through Trade and Development Agency (USTAD) for BSS. The feasibility of this project implies for development of PV solar system at micro level to strengthen the case of solar

power generation installation of small scale levels at any part of the country Pakistan [4].

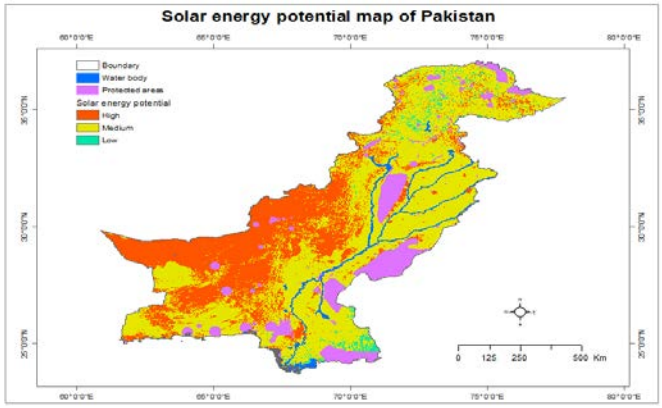

Figure 1 . Solar Energy Potential map of Pakistan [5]

2 LITERATURE REVIEW

In the recent past Pakistan has confronted worst electricity shortage. The load shading adversely imped the social dynamics of life. The Government of Pakistan has took decision to launch two holidays in a week, early shutdown of the markets and power cut off of the industries which adversely affected the business activities and social life of the people.to overcome the worsen power shortage rental power projects has been exercised. Rental power production was oil based projects with the expensive oil prices turned the scenario more complex both for Government (circular debt issue) and customers. The permanent way out to overcome the electricity shortage for that it was mandatory to exploit the renewable energy sources, like solar , wind and hydro potential. In this direction Government of Pakistan has step forward to engineer renewable energy polices first time in 2006.Governament of Pakistan released the policy for Renewable Energy power generation(RE Policy,2006) [6] to deal with solar, wind and small hydro plants having capacity less than 50 MW. Since last five years potential investors has shown interest and momentum in solar, wind and Hydro projects. In last five years solar technology has utilized at a large scale and momentum has seen in the field in the country. At contemporary RE policy of 2006 actively implemented, commercial Operation Date (COD), a publically sponsored 100 MW solar grid connected projects has commissioned on May 2017 by Government of Pinjab. National Electric Power Regulatory Authority (NEPRA) has recently work out to determine Tariff which indicates that interest and momentum has seen to exploit the gigantic solar and other renewable energies potential to generate the bulk quantity of power. As per report of the Alternative Energy Development Board (AEDB) 35 projects are under development within the frame work of AEDB and it policies and procedures with having capacity of 1111.4 MW. At contemporary 8 upfront tariffs for 10 developers has been approved. Out of it 3 projects each with the capacity of 100 MW has signed a power purchase agreement with the public off-taker. National Electric Power Regulatory Authority (EPRA) has granted upfront tariffs for 25-years solar PPA in 2016(shown in Table.1).All the developers were to apply for upfront tariff FIT by 30th Jun, 2016.NEPRA has determined the upfront Tariff/FIT for solar in 2016 as under.

TABLE 1: 2016 SOLAR UPFRONT TARIFF/FIT DETERMINATION BY NEPRA [3]

CATOGARY	>1≤20MW	>20≤50MW	>50≤100MW
Northern Pakistan-Levelized Tariff (US Cents/kWh)	11.5327	11.4460	11.3560
Southern Pakistan-Levelized Tariff (US Cents/kWh)	10.8920	10.8101	10.7251

At contemporary solar technology market has got momentum because many commercial organizations and industries have been turned to opt solar generated electricity because of its lowest cost. In many cities of Pakistan domestic installation of roof top photovoltaic panels expedite used. In 2013 private sector of Pakistan has imported 350MWof solar panels. On the first September 2015net metering system came into effect for projects having capacity less than one megawatt. It has been targeted by Pakistan to add approximately 3000MW of solar power using net metering for at least one million customers. Renewable Energy Policy REP, 2006 empowered the project developers to enter into direct bilateral sale contacts with the end users to sell power generated by them. Renewable Energy RE policy empowered developers to sell electricity directly to utility companies. For direct sell, they are bound to pay wheeling charges using transmission and distribution grid network to deliver power from plant to customers. All these dynamics indicates that development of solar power potential exploitation is in progress in the country.

3 METHODOLOGY

In this section we will discuss in detail the challenges and prospects of the solar potential of Pakistan.

3.1 Challenges

The major challenges identified that confront to exploit the solar potential in country are as under:

3.1.1 Timeline and Policy Uncertainty

No IPP (financed privately) has reached financial close in Pakistan. Central Power Purchase Agency (CPPA) is waiting for a new lower tariff which has delayed the project awarded tariffs under the 2014 and 2015 FIT determination. Investors have lost confidence because of this. NEPRA has made this clear to CPPA that it must honor the given tariffs and has been stable in giving postponements to timelines for developers to come on financial close where government organizations have not cooperated. However, this issue has not been resolved yet at the time of printing. Furthermore, the LOIs issuance by provincial agencies and AEDB was delayed in 2015 because a new tariff was expected. It is expected that this issue will be solved by itself on publication of the 2016 tariff.

3.1.2. Land Identification

The main hurdle for international developers considering entering the Pakistani market is the identification of land for solar plants. It takes plenty of time identifying the suitable land for development, if a local partner is not found who already has land. This is more hindered by an absence of open access to good digitalized maps. To make the process more investor friendly the AEDB and the Government of Sindh are identifying lands for development.

3.1.3. Transmission Issues

In Pakistan the grid interconnection process takes time, this is because NTDC has a number of applications pending for solar projects and due to regulatory uncertainty application processing is not going smoothly. NTDC is required to offer grid interconnection under the 2006 RE Policy, but this is time consuming and expensive process. It is suggested that NTDC is contacted as early as possible and that developers work with NTDC and local consultants to recognize places that are most appropriate for withdrawal of power and that do not need considerable construction of transmission lines.

3.1.4. Massive cost

Two major cost components are present in every power project whether solar or any other, one is called Capex it is the one capital expenditure for initial setting up of power plant, other is called the Opex it is the repeating operation cost for running the plant. The Capex ($/MW) for renewable power plants like solar, wind and hydro is high as compared to fuel based power plants being used and Opex is low for renewable power plants. This is because there is no fuel involved. Both Apex and Opex components with the decided investment return component are finally replicated in the tariff of a specific power project. The first 100MWp of the QASP has a total upfront Capex of $131.15mn ($1.31mn/MWp) and a levellised tariff of US14.15 cents/kWh.

3.1.5. On-Grid issues

1. There is a need for creating and repeating success stories.
2. Good policy and smart FITs feed in tariffs are essential for solar technology to be used.
3. The biggest challenge at this interval is the circular debt and the capability of the utility to pay.
4. The foreign investors are hesitant to come to Pakistan in this current situation of geo political as the local banks do not have the investment capacity to lend the projects.
5. Foreign lenders are unwilling to come to Pakistan because the security condition of the country is also an important threat at this moment.
6. Research & Development and implementation of suitable technology are also a main challenge under the present conditions. No Institution of higher education is ready to take this role.
7. Public sector institutions, private sector and financial institutions also have capacity issues.

3.1.6. Off-Grid issues

38 % of the population of Pakistan does not have access to electricity according to a report published by the International Energy Agency (IEA, 2011) [7]. More than half of the people living in villages are forced to live a life of poverty and social inequality because they do not have access to electricity. Water and Power Development Authority (WAPDA) of Pakistan has estimated that there are more than 40,000 villages in the country that are deprived of electricity as it would not be technically and economically feasible to spread the national grid to the these areas. 6,968 villages of Balochistan out of these total 40,000 do not have electricity. To enhance the sustainable livelihood opportunities and to reduce poverty in these areas renewable energy can be used very effectively. These rural areas require electricity for lighting, heating & cooking, clean drinking water, small commercial and industrial establishments and production usages, e.g., water pumping (irrigation), crop processing, refrigeration, and motive power.

3.1.7. Indigenous production issue

The production of the photovoltaic cell at indigenous level reduces the cost to great extent. A one KW of photovoltaic panel including other components if imported can cost about Rs 500,000 while the cost of crystalline silicon photovoltaic cell panel produced indigenously by National Institute of Silicon Technology NIST is around Rs 375,000.This can, obviously, reduce 25% capital cost if produced locally. Our indigenous solar panel production is very less, so progress in this respect seem very slow.

3.1.8. Import Tax

Excluding the import Tax over the import of the solar panels from China and Germany having the higher efficiencies will decrease the investment cost of solar plants to great extent. Heavy import duty over the import in this respect is an imped to exploit solar potential.

3.1.9. Miscellaneous challenges

Some of the key challenges for introduction of solar energy in off-grid areas are following:

Asymmetric Information

Absence of information stops the reach in villages of Pakistan. Inadequate information is available on both demand and supply. Basic knowledge about the energy requirements of people living in the off-grid village areas is not available. The information about potential customers and their requirements needed by the prospective

investors, microfinance institutions and technology suppliers is inadequate; due to this these areas face difficulty while being served. Similarly, the residents of these areas (clients) are oblivious of the resources which they can use to resolve their energy issues caused by poor physical and social substructure.

Deficiency of Skilled manpower

There is absence of skilled technicians as well as the operations and maintenance is an issue in such distant areas.

Risk Management

Solar energy equipment is a new product in the new market with high cost this produces concern of risk perception. Majority of the population in the rural areas are at or below the poverty line and have inadequate sources to pay their electricity bills.

Volatile Law and order Situation

One of the serious challenges is the law and order situation in both Khyber Pakhtoon Khawa and Balochistan which is unstable, volatile and explosive.

3.2 Prospects of Solar Potential in Pakistan

3.2.1. Job creation Potential

MIT, Stanford University and University of California have recently made a research on Atmosphere/Energy program. The research team made a collaborative global map which demonstrated the anticipated energy mix on each of the examined countries. The study claims that solar potential of Pakistan will produce long term jobs. The jobs are expected to be in the construction sector with 291,110 jobs over 40 years, whereas 239,989 long-term jobs in the operations division [8].

3.2.2. Health Savings

As per research report of MIT, Stanford University and University of California that solar power production will contribute Health positively. The health costs will be reduced by $916.2 billion which will be about 21% of the whole GDP in 2050 [8].

3.2.3. Source of Economy Boast

The power shortage in Pakistan has exceeded the 6000MW mark which has resulted in power outage of more than 12 hours in cities and 20 hours in villages. This has imposed a serious energy crisis in the country. These long load shedding periods have a most important influence on the economy of Pakistan reducing GDP inclination by 3% [9]. To overcome these energy shortages Pakistan has many solar PV opportunities which can be exploited.

3.2.4. Electrification of Rural Pakistan

About 80% of the population in Balochistan lives in villages, the population density is very low and these rural areas are separated by long distances without any roads. Only about 15% of these villages have electricity while 85% are still waiting for electrification. The only requirement of these houses which are located in the far distant areas of Balochistan is light. 100 watt would be enough for each house. For such less power need the extension of the national grid lines would be uneconomical. The best solution would be the local power generation. By providing off-grid solar solutions to these 38% population who do not have access to electricity will increase income generation, decrease health risks by offering health clinics to work in the dark for patient check-up and treatments and for students studying at night. These economically deprived areas will link up with the national markets if off-grid solar electricity is provided.

Solution to load shading reduction

Solar system is source of blessing for those who are connected to Grid but facing load shading 12 to 20 hours both in rural and urban areas. Hybrid solar system for such kind of households is solution, because they can get 40% electricity from solar system and the remaining 60% electricity from Grid to counter worse load shading as an alternate electricity source.

Economic Efficiency

If Diesel pumps are replaced with solar technology it would be cheap way out to counter huge consumptions. If only 10% of 1000,000 diesel pumps are replaced with solar technology, it will save 2160 GWh energy per year which actually saves Rs. 21.6billion per year [9].

Optimization of the power utility

Solar technology is a great opportunity to change Halogen and Sodium Street lights with solar Light Emitting Diodes (LED) for streets. About 2% of total load that is 440MW, that street lights consume [9].If conventional street lights of 200W is replaced with 40W solar LED then 70% of load can be put- off from the Grid. This will reduce losses of the power utility and transmission line losses.

Complementing Industrial demand for energy input

Large on Grid industrial solar power plants will reduce size of the Grid and Diesel used in it by 30% to 40% [9].

Substantial hybrid source for DISCOS

Solar Hybrid plants will reduce cost of installation of the DISCOs Grid to meet the electricity demand.

4 CONCLUSION

Pakistan has massive power generation of capacity 2.334 million MW per year from solar as per MIT, University of California and Stanford University research team report. If these resources are used for electricity generation then it will create jobs and Pakistan can improve its GDP by 3%. Exploiting these resources will also electrify the homes of the 38% population that is deprived of this basic necessity. This will increase the income generation, reduce the health risks providing health clinics to work at night. By converting diesel pumps to solar pumps the country can save 2160 GWh of energy which is worth approximately Rs. 21.6 billion per annum [10]. If solar power generation is used to light up the streets by altering the halogen lamps and sodium lamps with solar powered LED's, the power utility will save 2% of its electricity reducing transmission losses. The major load on the power utility is the industrial load that is around 30%-40%. If the industries are converted to solar power then this load will also be available for the consumer easing the national grid. However, there are many challenges that Pakistan faces like policy uncertainty

and no confirmed tariff from NEPRA. Solar energy equipment is a new product in the new market with high cost this produces concern of risk perception. Majority of the population in the rural areas are at or below the poverty line and have inadequate sources to pay their electricity bills. One KW of photovoltaic panel including other components if imported can cost about Rs 500,000 while the cost of crystalline silicon photovoltaic cell panel produced indigenously by National Institute of Silicon Technology NIST is around Rs. 375,000. This can, obviously, reduce 25% capital cost if produced locally. Keeping in view these challenges Pakistan is facing difficulty to produce electricity by solar. If these challenges are overcome then the country can progress by improving its GDP, reducing the demand and supply gap of electricity and creating job opportunities.

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