International Journal of Renewable Energy Resources 8 (2018) 29-35

LOAD ASSESSMENT OF SOLAR PV SYSTEM: CASE STUDY OF TOR TANG VILLAGE OF BALUCHISTAN

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ABSTRACT
Although significant progress in rural electrification has been made over the provision of electricity services to remote areas over the past two decades, it has also been apparent that most rural areas are isolated in developing countries are electrified through conventional electrification techniques, such as connecting to the grid. Geographic and climatic conditions combined with low growth potential, lower population density and minimum energy demand levels are few reasons due to which rural electrification costs are often unaffordable. The rise in immigration and urbanization rates, especially in developing regions, often supports the government's choice to change direction and improve and expand the urban electrification system. Families in high-altitude areas and remote areas of north western Baluchistan are very poor. They depend on wood for cooking, heating the room and light. This paper presents a study of photovoltaic PV systems without grid connection for the electrification of the village of Tor Tang, Baluchistan, Pakistan (30.55.9 ° N, 69 ° 26.6E). The system is designed to take into account the domestic load and the energy required by the sun. A complete model of the photovoltaic system has been proposed to determine the nominal photovoltaic power necessary to satisfy the requested load. So, a systematic approach to the size and design of these systems are presented. The results show that the unit cost of electricity generated using off-grid photovoltaic systems is lower than the unit cost of conventional energy supplies for residential areas.

Keywords: Demand forecast, Rural electrification, Solar PV, Economic feasibility, Tor Tang Baluchistan.

1. INTRODUCTION

Energy demand is growing rapidly since the beginning of the 20th century due to population growth and lifestyle improvements. As the modernization of the renewable energy sector has become a new consideration in the safety of the energy market, the impact of common energy guarantees has not been eliminated. Above all, in third world countries, the peak of per capita energy consumption is supposed to expand in the coming years. To meet this condition, the development of renewable resource mechanisms such as wind, solar, biomass and hydropower has become an important tool for replacing non-renewable fuel sources (Branco et al., 2017).

More than 1.3 billion people have lack of electricity around the world, mainly in the border areas of underdeveloped countries. Requiring electricity on a regular basis to the grid electricity is very difficult in some areas due to the difficulty of the field and the dispersion of the residents. In these situations, good coverage to provide the connection to electricity are independent systems using sustainable energy resources, since they help the sustainability of special projects by the control of domestic sources, this means moving away from external dependencies and have the tendency to be economical compared to the addition of the normal electricity grid. To achieve electricity in isolated areas, photovoltaic (PV) systems have been widely adopted in recent decades (Aymerich et al. 2016). Since 2008, Pakistan has faced a major electricity crisis that has led to a decline in agriculture, industry and trade. In the last decade, Pakistan's GDP has fallen from 8.0% to 2.0%. Renewable energy technologies can play an important role in the economic growth of any country. Furthermore, the problem caused by the country's energy crisis the use of renewable energy technologies is becoming increasingly important due to the increase in fuel prices. All renewable energies and technologies like solar, wind and biomass are environmentally friendly (Shahzad et al. 2017).

In other sense, appropriate electricity prices play an important role in industrialization, social rehabilitation and poverty reduction. It is currently facing a serious power shortage, which is one of the reasons for the slow industrial growth, turmoil and high unemployment. Pakistan's energy bank consists of thermal power, hydropower and nuclear energy. Thermal energy comes from natural gas and oil power plants. A significant portion of these plants are aging, many of them are single-cycle and have low power production costs (Khalid and Junaidi, 2013). To bring electrification to the rural areas of Baluchistan, solar electrification can play an important role because it is both economic and environmentally friendly. The development of the GDP of the Baluchistan and the improvement of people's living standards are among the basic requirements and demands for energy. Organizations appointed for electricity regulation do not give priority to rural electrification, mainly because they do not directly promote economic recovery and productivity (Zahnd, 2009). The requirement for a global insurgency in the energy sector is important to address the issues of energy security, rapid climate change, global warming and pollution. Depending on fossil fuels in the sector of power generation will increase extremely greenhouse gases emissions that have impact on the climate change. Approximately two thirds of all anthropogenic emissions of greenhouse gases represent power generation sector. Economically efficient, clean and sustainable energy, there is a threatening requirement for a standard shift from conventional energy resources to renewables. Investments in renewable energy infrastructure is the main link between economic growth, climate action and development. To achieve the climate objectives and carbon dioxide emissions, the production of sustainable power generation must be implemented (Barasa et al., 2018).

The deployment of Renewable Energy (RE) technology continues to increase its significance as the Climate change requires more concern and attention in the near future globally. The growth rate of RE varies greatly from region to region and countries. However, renewable energy generation has the largest annual growth rate in 2016, with an estimated 161 GW capacity (Alex et at., 2018). In this way, photovoltaic solar energy represents 47% (RE) capacity installed in 2016, this is the first time it represents an additional power, more than any other renewable energy power generation technology. The decrease in prices and capital expenditures, especially the decrease in the prices of the modules, has increased the competitiveness of photovoltaic technology with traditional energy. Between the first quarter of 2016 and 2017, the cost reduction was approximately 29%, and the installation cost of the fixed-scale and single-axis systems was estimated at $ 1.03 / Wdc and $ 1.12 / Wdc respectively (Zurita et at., 2018). Throughout fiscal year 2015, the capacity sown was 438MW through renewable resources that supported the generation of 802Gwh from solar energy, wind energy and bagasse co-generation. The installed capacity of wind power is approximately 256 MW that generate approximately 457Gwh and we only have one solar power plant installed in Punjab which is Quaid-e-Azam Solar (Pvt) Ltd with a capacity of 100 MW with a generation of 25Gwh. The installed capacity of the joint bagasse generation is 82MW with a generation of 319Gwh. Per day the weather conditions in Pakistan is ideal for generating solar energy with a minimum of eight to nine hours of solar radiation. In addition to photovoltaic opportunities, Pakistan's solar potential is 2.9 million megawatts (Shafqat, 2017).

2. RENEWABLE ENERGY IN PAKISTAN

The production of renewable energy resources in Pakistan has expended to 1568 MW. The identification of the other five wind arcade in Baluchistan perhaps tally thousand MW of pure clean renewable energy to the governmental distribution system. By the ending of this year Production would-be increased to 1870 MW. According to Alternative Energy Development Board (AEDB), wind power generation through alone wind corridor of power generation in Sindh is 938 MW and by the end of this year it would increase to 1,240 MW. Current hydroelectric projects forecast 38% of energy. In Pakistan electricity consumption per capita was 1/5 of the mean electricity consumption per capita in the rest of the world, which means an increase in electricity consumption to improve the living standards of our population. The Private Power and Infrastructure Board (PPIB) has facilitated the completion of new energy projects in the private sector with a capacity of 8,200 MW of electricity. By 2021 PPIB would have completed the private sector energy projects with a production potential of 15,000 MW. Commission Secretary for Planning and Development, Shoaib Ahmed Saddiqui (oct-2018) said that the current leadership have done a lot in electricity generation and the capacity of transmission has improved (Yousafzai, 2018).

Pakistan has a large number of populations which have no access to electricity like other undeveloped countries. However, it is in its transformation period, economic development has assisted to an increase in the power generation demand. The current situation of electricity demand in the Pakistan is 25,000 MW and is expected to increase to 40,000 MW in 2030 (Barasa et al., 2018). The electricity supply is still 18,000 to 20,000 MW, or less than 5,000 to 7,000 megawatts of electricity (Zahnd, 2009). This shortage of electricity has caused power outages in urban areas for 8 to 10 hours, while rural areas experience up to 18 hours of power outages per day (Shah et al., 2018). The situation in rural areas of Baluchistan is even worse, with no electricity supply for many days. Regardless being wealthy in energy originators as natural gas, coal, oil and renewable energy, Baluchistan still cannot get enough electricity. Studies have shown the three main reasons for the shortage of electrification in Baluchistan. First, about 85% of the Baluchistan's population are settled in rural areas, and approximately 90% of settlements do not have electricity (Jatoi, 2006). These are dispersed in enormous and remote areas. Subjoining these zones to the national grid network is costly and uneconomical. Secondly, the order electricity for houses in these regions is just 50W to 100 W (Das et al., 2017).

3. RURAL ELECTRIFICATION IN BALOCHISTAN

Baluchistan is Pakistan's largest province regional wise and is the lowest developed province where most of the inhabitants has no fundamental facilities. According to the 2016-2017 Pakistan Economic Survey, Baluchistan has the highest poverty and lowest literacy figure (Economic survey of Pakistan, 2017). As shown in Figure 1, the status of Baluchistan strategic value because of the length of the coastline. The port city of Gwadar offers the shortest passage to the Middle East and Central Asia. Therefore, Gwadar has excited foreign investment and numerous development schemes (Javaid and Jahangir, 2015). The enlargement of projects over the past ten years has boosted the demand for Baluchistan electricity. Current demand for electricity in the region is around 1650MW, but finite 400-600MW is provided. The huge electricity deficiency will take place in urban areas for 10-12 hours. The condition of power failure is terrible in countryside, where generally 85% of Baluchistan is living at 13.16 million and electricity in rural areas is only available 3-4 hours per day (Siddique, 2016).

Figure 1 Map of Baluchistan (source: Google map)

Shareholders are discouraged to invest in Baluchistan. The lack of legislation, system and the isolation of the area, the short returns of investments, also the unavailability of communication and infrastructure services are the main elements that hinder private funding. In addition, A South Korean company has made no visible development, investing USD 700 in a 300 MW solar farm to be attached to the national grid nearby Quetta. The agreement for the construction of that solar farm was underwrite in December 2013 by the Korean company CK Solar and the government of Baluchistan (Ghafoor et al., 2016).

3.1 Development in Rural Electrification Through Solar PV in Pakistan

Pakistan's outlook on solar power stand negative until in 2006 by the formation of the Alternative Energy Development Board (AEDB). It was established to monitor and encourage the progress of renewable energy in Pakistan. It plans to provide 6968 photovoltaic solar panels in rural villages in Baluchistan and Sindh in future (Zurita et al., 2018). Other major institution that task to encourage renewable energy technologies is Pakistan Commission for Renewable Energy Technologies (PCRET). Figure 2 display the organization of the energy zone, including the federations that supervise and encourage the national progress of renewable energies. In addition, the solar framework has improved significantly, as the government understands the significance of solar energy to preserve the surrounding and improve the socio-economic conditions of inhabitants living in rural areas. In present Pakistan is commercially in favor of solar energy resources due to several capacity features as high irradiation, the efficient administrative framework, encouragements and even the financing accessible in the country (NEPRA, 2016).

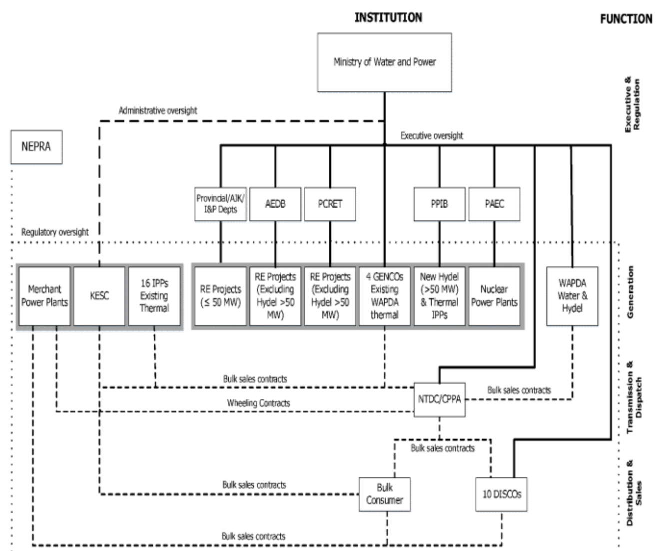

Figure 2 Organization chart of the electricity sector in Pakistan (NEPRA, 2016)

3.2 Circumstances in Solar PV for Rural Electrification

Solar photovoltaic energy is the leading option for remote areas electrification outside the grid because of its ease of fitting, environmental advantages and price efficiency. Although, their distribution for electrification in rural areas of Pakistan is very low, as stated by NEPRA in 2016. State of Industry reported that the number of villages that have no approach to electricity are 40,000 (NEPRA, 2016). Research on the success of rural electrification suggested that powerful coordination between institutions is essential to address the problems that hamper the projects for electrification of rural regions (Urmee et al., 2009). Anyhow, the chronicle of Pakistan has a miserable of deprived institutional plans in 2006, earlier then the foundation of AEDB, in Pakistan none of institution was answerable for developing and arranging renewable energy projects. Although, thereafter the foundation of PCRET and AEDB, institutional systemization between PCRET and AEDB remains low besides the additional key collaborator and ministries (Rehman et al., 2018).

4. CASE STUDY REGION PISHIN BALUCHISTAN, PAKISTAN

Pishin district is in north of Quetta district and fronts Afghanistan on the east and northeast. It includes a series of long valleys (1,370–1,680 m) above sea level surrounded by the Toba Kakar mountains Range to the north. Pishin has four tehsil and one sub tehsil and 38 Union Councils. The population of district Pishin was 736,478 Total, Male 379,122, Female 357,356 (Census, 2017). The maximum average temperature is 24 degree centigrade and minimum 8 degree centigrade. Area wise Pishin rank 18TH in Baluchistan and has an area of 7,819 km. This village is in Barshore which is one of the four Tehsils (sub-divisions) of district Pishin. It is extending over 1700 square km. In general, the sub-division is all mountainous area. These mountains are being intersected by narrow and long valleys. At the northern end of the sub-division the great plateau of Toba Kakar.

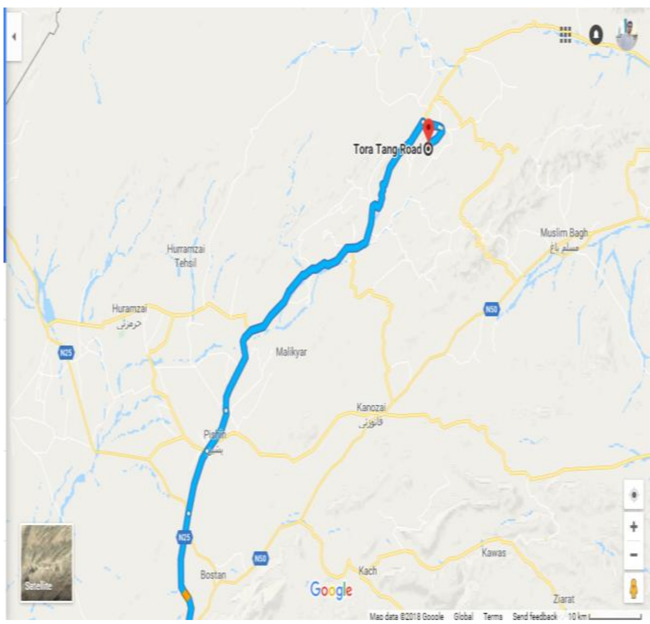

Figure 3 Road from district Pishin to Tor tang Village (source: Google map)

4.1 Site Location (Tor Tang Village)

Tor Tang (Study Region) This region is located at the North-East of the Pishin City at about 70 Km. It will almost take 3hours to reach there because of narrow, rough roads and hilly areas. This village is far scattered in Pishin district deep inside the mountains, the latitude and longitude of Tor tang is 30.55'3 N and 67.26'0' E with an Elevation of 1,555 meters.

Figure 4 Road to Tor Tang village [Google Earth]

4.2 Village Profile

Table 4.1 Village Profile

Province	Baluchistan
District	Pishin
Village	Tor tang
Population	565
Average family size	10
Number of houses	65

5. DESIGNING A SOLAR PV PLANT

The best source of renewable energy is sun which is environmentally friendly and inexhaustible. Pakistan is blessed with large amount of sunshine yearly and the average power of sun is 5.5 kW/m2/day. To supply power for all day for 24 hours, solar exciting battery systems can be implemented. Basically, solar cells modify solar energy and convert it into D.C electricity. In PV module these solar cells are made of semiconductor materials. The power generated from solar PV system can be utilized in useful load and stored in rechargeable batteries. Significantly solar PV can be low price for isolated regions.

5.1. Solar PV cell

The function of PV cells is to generate electricity by converting the radiation of sun directly into electricity using semiconductors that generate photovoltaic effect.

Solar panels consist of huge number of solar cells that contain photovoltaic materials that are used for photovoltaic power generation. Selenide/sulfide, mono crystalline silicon, copper indium gallium, cadmium telluride, polycrystalline silicon, amorphous silicon are materials that are used for photovoltaic cells.

5.2. Battery-Storage

Batteries like, storage batteries, rechargeable batteries or an accumulator type of electrical batteries are the example of storage batteries. These batteries contain one or more than one electrochemical cell and are type of energy accumulators which can be a secondary cell due to its electrochemical reactions that are electrically reversible. These batteries can be found in different unusual size and shapes, ranging from a small button cell to huge megawatt storage system which is used to stabilize the network of electrical distribution. Chemicals with Several unusual arrangements are frequently applied, counting lithium ion polymer (Li-ion polymer), nickel metal hydride (NiMH), lithium ion (Li-ion), nickel cadmium (NiCd) and lead–acid.

5.3. Charge Controller/Regulator

The center of each solar system is Charge controller or sometime called as charge regulator. It is quite important to supervise the power flow inside and outer side of the batteries. It can also control the flowing charge from solar PV panels to the batteries to ensure that the batteries are not overcharged and, it can make sure that the attached loads don't let the batteries to over-discharge to save it from destruction.

5.4. Solar-Inverters

Solar inverters are usually used to recondition the DC output of a solar PV panel into a service frequency AC which can be supplied to a grid. Through involved charger, the backup battery inverters are those that are designed to control the battery charge through an involved charger. It represents energy from battery and send abroad surplus energy to the service grid. These solar inverters can be used for maximum power point tracking and anti-islanding protection.

6. VILLAGE LOAD ASSESSMENT

In this study, village energy load demand has been carefully estimated due to the existing load situation in rural areas. For households owning and using household appliances, the demand of village is estimated. Table below summarizes the estimated needs of a single home. Obviously, demand estimation is a key element of the overall system design and can be further enhanced by combining the user's social information with its benefits.

6.1. Energy Consumption of Village

The total number of monthly average units are 187.1/home, we will take it 190units. As the total number of homes are 65. So, the monthly demand of the village is 12,350 units.

Table 6.1. Electricity calculator for Tor Tang village of Balochistan (for single five room home).

Appliances	Load (W)	No. of quipment	Total load (W)	Average hour/day	No. of days in month	Units/month
	A	B	A*B=C	D	E	C*D*E/1000
CFL lamps	15	10	150	08	30	36
Ceiling fans	75	05	375	08	30	90
Table fan	25	05	125	08	30	30
Washing machine	500	01	500	01	05	2.5
Water pump	500	01	500	01	30	15
laptops	20	01	20	03	30	1.8
Iron	1000	01	1000	01	10	10
Mobile chargers	04	05	20	03	30	1.8
Total			2690			187

7. ANALYSIS-AND-DESIGN OF COMPONENTS

7.1. PV-Panel Design

Total estimated load of Tor tang village is = 25KWe
Duration of operation = 7 Hours.
Therefore, Total Watt-Hour = (25) × (7) = (175) KWhr.
The duration of the solar panel receives solar energy =.7 Hours (9am to 4pm on average basis).
The wattage of solar PV arrangement =.25 KW.
Therefore, for this project solar PV panel of.25,000W is compulsory.
For 150W of solar PV panels, the requirement for constructing (25,000) Watt in parallel will be;
Number of panels =(25000W) / (150W)
Number of panels = (167)
The results that 167 solar panel of (150 -Watt) are required for this project.

7.2. Charge-Controller

For the design of (25KW)
Solar power supply P = I×V
Where, V is the battery voltage,
V= (12 V)
I = current charging.
P = Power supply rating =(25 KW)

Generally the sunshine exist 8 hours per day, the maximum units that can be created by solar PV are 25.X.7=175 kWh, if the valued capacity of solar PV pattern is to create 70%, then daily it can give 122.5KWh, during this period of time as the solar panels are getting rays from the sun we can provide electricity to consumers, minimum 72.5kWh can be distributed without storing directly and for battery bank 50KWh is to be stored.

$I = P / V$

$I = 50000 / 12$

I =(4166Amps)

The important thing for charging controller of the battery bank is 5KA current.

7.3. Capacity of Battery

Capacity of the battery must be 50kWh. For designing the selected capacity of batteries which will be last long, is proposed that just a quarter (1/4) of capacity of the battery will be useful so that it will make battery safe from over discharge. 50000 X 4= 200kWh is the required capacity of the battery. Due to the advancement in technology the storage capacity of the battery depends on A-H which shows the rating and capacity of battery storage. For the calculation of batteries, the quantity of 12V batteries for 500Ah will be 200,000 / (12 × 500) = (34) batteries. In this project the number of batteries will be 34 obligatory to maintain its weight and unnecessary space.

7.4. Inverters

The required load for this solar system 50KWh. The involved size of the inverter must be 10KW for this project. The designed solar panel need pure sign wave inverter of 10 KVA to extend the lifespan of the selected inverter.

8. CONCLUSION AND THE POLICY IMPLICATIONS

The number of unelectrified romote villages are too high which are far away from the national grid. The main problem of romote and scatered areas is that it increeases the loses due to long range transmission lines and it also increases the instalation cost. To defeat all the above problems and issues the sujested green renewable energy of solar PV system backup with rechargable batteries is refered. In this case study of Tor tang village, the load requirement is estimated and favourable to achieve the the load requirement is which is predicted. This system can be applied for the improvement of the household energy demand of the village and natural calamities. For rural electrification, It can be resolved that the solar system is a viable green technology source of energy.

Analyzing precise possible potential in the electrification of rural areas based on the economic viability of solar photovoltaic power generation and solar photovoltaic systems implementation. The paper covers 65 houses of villages Tor Tang, in Balochistan, and has developed a systematic approach to assessing solar PV in the study area. In all regions, the most potential of solar energy has been evaluated, confirming our view that for electrification in Balochistan solar panels are an agreeable option after examining whether the use of photovoltaic solar energy is economically viable. Our research results show that the price of solar photovoltaic power generation is much lower than that of traditional power. Coupled with the economy, the solar photovoltaic system also decreases the annual carbon dioxide emissions by about 126,869.45 tons, if in Balochistan 100% of rural domestic users adopt the solar photovoltaic systems.

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