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# Pakistan's progress in solar PV based energy generation

Hadeed Ahmed Sher [a,*], Ali F Murtaza [b], Khaled E Addoweesh [a], Marcello Chiaberge [c]

[a] Department of Electrical Engineering, King Saud University, Riyadh, Saudi Arabia
[b] Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Turin, Italy
[c] Department of Electronics and Telecommunication Engineering, Politecnico di Torino, Turin, Italy

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ABSTRACT

Solar PV has been a cornerstone for the energy policy makers around the globe. It is because the environmental effects of solar energy are low as compared to the conventional energy sources. It is free and virtually inexhaustible. Developed countries have long been in the business of using solar energy for energy generation. However, for the third world countries like Pakistan, the use of solar energy for power generation is a relatively new experience. In recent months, Pakistan has shown a paradigm shift in its renewable energy policy and invested on mega power plants based on solar PV system. This paper reviews the recent exponential rise of using solar energy for power generation in Pakistan. The results of this paper will not only help in understanding and hence, curbing the power crisis in Pakistan, but will also be relevant to the other countries of the third world.



**Contents**



## 1. Introduction

Pakistan has seen a bitter taste of recent energy crises in the form of violent mob protests in major cities across the country. The change in international oil markets has had a constant pressure on the national economy and with the fluctuating prices of furnace oil, the per unit cost of electricity also oscillates and under such circumstances, the inflation rate is also difficult to control. The dependence of furnace oil for electricity generation has costed Pakistan a lot of financial burden. In 2001 the share of power sector in consuming petroleum products was 37.8% which is now 40.82% mainly because the number of electricity consumers have increased from 17.9 million to 21.7 million [1]. The recent energy crisis in Pakistan has forced the policy makers to bring a paradigm shift in Pakistan's energy policy. A good solution to reduce the dependence on imported furnace oil is to invest in Renewable Energy (RE) technologies. Several countries have successfully installed the RE based power sources to deal with their growing energy demand [2,3]. Various forms of RE sources are used in the modern world. As far as Pakistan is concerned there has been a lot of work explaining the possibilities of using RE sources that includes biomass, wind, hydel solar, etc. [4–9]. This paper, however focusses on utilizing solar energy for coping the energy crisis.

Solar PV is among the prominent renewable energy sources. They are highly valuable when it comes to the environmental aspects. They does not produce greenhouse gases, improves the quality of water resources and if used as distributed power system, reduces the cost of transmission lines [10]. The work done by [11]

* Corresponding author.
*E-mail address:* hsher@ksu.edu.sa (H.A. Sher).

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shows that solar PV is among those renewable energy technologies that is sustainable when it comes to the constraints like green house gasses emissions, life cycle cost and net energy ratio. This substantiality is evident from the fact that the total installed capacity of PV around the globe has exceeded 100 GW [12]. Most of the installed PV systems are in Europe, where solar plants cumulatively produce more than 70 GW. Third world countries like Pakistan, despite having an abundance of sunlight almost throughout the year, are far behind in the use of solar PV systems. Recently, the policy makers in Pakistan have decided to use sunlight to harness energy in the form of electricity. The inclusion of solar PV in the energy mix will not only produce employment opportunities, but will also boost the research activities, industrial progress and hence new markets will emerge [13]. With the huge economic burden on Pakistan, there is a need to shift from the expensive furnace oil based power generation to cheap sources of electricity generation. This paper will evaluate the use of solar PV plants in Pakistan and is being set out in the following order.

- It explains the present state of energy generation and consumption.
- It then discusses the solar PV sites selected for the establishment of solar parks.
- It explains the organizations involved in the dissemination of solar PV technology.
- The recent developments in the use of solar PV are discussed.
- It argues about the paradigm shift in energy policy of Pakistan.

## 2. Present state of energy in Pakistan

Pakistan is currently facing an average deficit of 4500–5000 MW in supply and demand of electricity [14]. The present state of energy is very stiff and controlled power outages (usually termed as load management by the utility officials) are usually adopted by the utility to control the peak demand of various areas. The electricity demand growth is expected to be 5–6% over the next ten years, which demands the injection of new sources of electricity generation in addition to the already installed power plants. The conventional national energy reserves like gas and crude oil (30% requirement of oil is fulfilled by domestic oil rigs) are also at the edge of their limit as far as the confirmed reserves are concerned [15]. Energy consumption is directly related to the national progress. In fact, the national progress can be seen as a function of energy consumption as shown in Fig. 1 [16].

It is visible from Fig. 1 that in 2006 the GDP has seen high values because of high energy consumption per capita, while in 2008–2009 it has seen the negative impact primarily because of less energy consumption. It is pertinent to mention that 35% of electricity

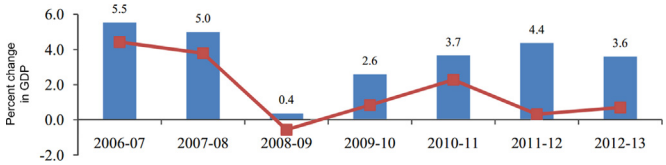


**Fig. 1.** GDP as a function of energy consumption per capita [16].

**Table 1**
Indo-Pak comparison of electricity generation W. R. T sources [16].

| 2012 | Gas (%) | Furnace oil (%) | Coal (%) | Hydel, nuclear, import (%) |
|---|---|---|---|---|
| Pakistan | 29 | 35.0 | 0. | 19 |
| India | 9.2 | 0.8 | 71 | 35.7 |

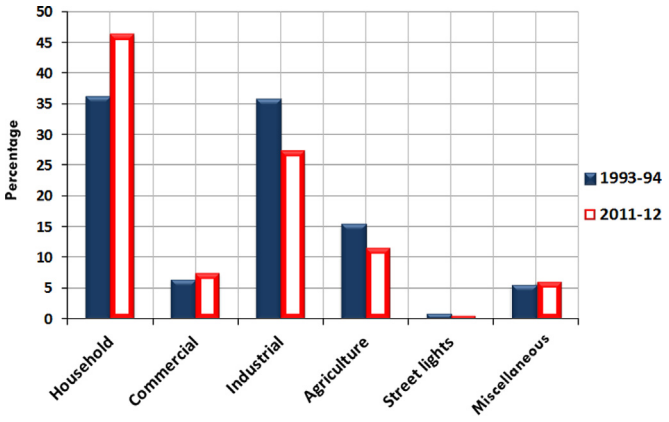


**Fig. 2.** Sector wise percentage consumption of electricity in Pakistan [16].

generation in Pakistan is based on furnace oil and 29% is through natural gas, which is way high compared to the neighboring India as shown in Table 1 [16]. This certainly means that Pakistan has a very high percentage of electric power generation through conventional sources. The consumption of electricity in different sectors of daily life has seen dramatic changes too, as shown in Fig. 2

In view of authors, the household load as well as the load in the agriculture sector can be greatly shifted to the PV system because of the availability of sunlight.

## 3. Solar sites in Pakistan

Pakistan receives an average irradiation of 5–7 kWh/m$^2$ a day in 95% of its land [10]. Fig. 3 shows the four season solar irradiation distribution in Pakistan [17]. It can be seen that the vast deserts of Sindh, Cholistan desert of Punjab and Balochistan offers exquisite possibilities of installing mega solar PV power plants. In these areas the sun shines in the range of 2300–2700 h per year [18]. In [19] the authors have evaluated the most suitable sites for solar PV systems, keeping in view the monsoon weather. The authors of [19] concluded that District Multan and Dera Ghazi Khan are best for installing the solar PV power plants. These districts are located in southern Punjab along the provincial boundary of Balochistan and Punjab. It is also visible that out of four provinces of Pakistan, Balochistan, Sindh and Punjab receive above 5 kWh/m$^2$/day in all four seasons. Almost half of north-west frontier, and Federally Administrative Tribal Areas (FATA) receive 5 kWh/m$^2$/day and above solar irradiation round the year. This makes it feasible to use solar PV systems for energy harnessing. It should be noted that vast area of Balochistan is remote and it is not practical to connect far flung villages with national grid. The solar irradiation however, make solar PV an ideal candidate for electrifying these villages. Similarly, the villages in the desert of Sindh and south Punjab are ideal candidates of rural electrification using solar PV.

## 4. Organizational level efforts

Historically the statistics show very encouraging start when in 80s Pakistan installed about 18 PV sites that generate a cumulative 440 kW, however, this progress was not sustained due to lack of expertise and technical issues related to their maintenance [20,29]. In June 1983, Kyocera donated a 6 kW in order to electrify a village named Kankoi in Pakistan [26]. Some authors believe that due to lack of marketing instruments the project was flopped [27]. Later in 90s, departments were established to work in the field of RE technologies. During the first decade of 21$^{st}$ century Pakistan established two