

# Renewable energy technologies in Balochistan: Practice, prospects and challenges

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## Abstract

Global energy demand is increasing with the rapid urbanization, development, usage of new technologies and expansion of users' net. Many developing countries are facing energy crisis including Pakistan, where energy infrastructure is old and energy sector is facing challenges of supply, demand and distribution. Considering the situation, renewable energy technologies are used across the country including Balochistan province to solve the energy problem. Renewable energy sources, especially solar and wind energy are getting more popular in the province. This paper provides the overview of existing practices of using RE technologies in Balochistan. Moreover, the paper presents the prospects and challenges regarding RE technologies, institutional setup and organizations involved for the dissemination of knowledge and skills regarding RE. In the end, some suggestions are given for effective planning, improvement and use of RE technologies.

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## 1. Introduction

In today's world energy is an important and primary need for the development of a society. Every individual uses energy to fulfil their daily life tasks. It is also needed to meet the basic requirements for a suitable living standard. Due to technological advancement, innovations, increasing population and expansion of users, the demand of energy increased globally. When the supply cannot meet the increasing demand then it takes the shape of a crisis [1]. In Pakistan the demand of electricity increased due to the increasing number of users and the expansion of electricity network to many villages and other areas [2]. It is observed that rise in household income increases the ownership of the appliances which lead to increased energy consumption [3].

The electricity problem in Pakistan turned into a crisis with the load shedding of 8-10 hours per day in urban areas and up to 20 hours per day in rural areas. Such situation highly affected the everyday life, commerce, trade and manufacturing industries thus created economic problems. In Pakistan there are several Independent Power Producers (IPPs) producing around 50% of the total electricity, biggest of them is Hub Power Company (HUBCO) which has a production capacity of 1292 MW [4]. The electricity produced by most of the IPPs is expensive compared to the electricity produced by hydro or nuclear power sources, since IPPs mainly operate on oil, gas or coal-fired plants. Since the public sector do not produce enough electricity to fulfil the demand it needs to procure the electricity generated by IPPs. Considering the economic situation of the country, the government rescheduled the payments to IPPs several times and in current situation there is a circular debt of more than 1.3 trillion rupees in Pakistan [5]. The power production, distribution, management and consumption sides are responsible for the current electricity crisis. The production and the distribution systems are inefficient which includes more than 20% transmission and distribution losses. The power sector over-relies on the thermal power production and the installed capacity of power

production is under-utilized [6]. With the increasing prices of oil, the rates of electricity are also increasing which tends to increase the rate of theft as well [7]. For example, if the transmission and line losses are 20% and the theft loss is 15% then only 65% of the consumption will be billed and rest will be the loss to be carried by the public sector. Considering the production price per unit this situation increases the loss at a high rate.

Population growth and rapid urbanization also increases the energy usage and demand. In Pakistan the total population surpasses 207 million and the annual growth rate is 2.4% [8]. Many of the people living in villages do not possess the land, therefore they migrate to urban areas for the better jobs, wages and to support their families. Rural areas do not provide better education and health facilities which also encourage people to migrate to urban areas. The urban population of Pakistan is increasing at a high rate of 3%, which is highest in the South Asian region [9]. However, a huge majority of the urban population is still living in few major cities including Karachi, Lahore, Faisalabad, Rawalpindi, Peshawar, Multan, Hyderabad and Quetta which creates haphazard situation by putting pressure on the services and infrastructure of the city. The population of these cities is continuously increasing. For example, in 1998, the population of Quetta District was 0.75 million which increased to 2.2 million by 2017 [8] [10].

Renewable energy sector is considerably small in Pakistan. However, concerning the energy crisis and power shortage in the country, public and private sectors started to explore the renewable sources for energy production together with international organizations. Most of the renewable energy in Pakistan comes from hydroelectricity. This study focuses on the existing practices for the use of renewable energy (RE) sources in Balochistan province. Case studies are added to highlight the use of RE. Moreover, the prospects and challenges related to RE and the institutional setup regarding RE is discussed. In the end, conclusion and suggestion are given for the effective planning and improvement of RE technologies in Balochistan.

This paper is divided into 5 sections, first section covers the introduction of the topic by highlighting the energy situation in Pakistan. Second section explains the methodology of the paper. Status of renewable energy in Pakistan and in Balochistan is discussed in third section. Section four includes the results of the online survey, present the case studies and explains the challenges faced by renewable energy sector in Balochistan. The fifth and last section of the paper provides conclusion and recommendations.

## **2. Methodology**

The methodology of this study is divided into two parts. The first part is, the collection of primary data by survey and case studies while the second part presents the secondary data based on the available literature and studies. An online survey was conducted to understand the energy crisis and situation in Balochistan. Questions were asked regarding the outage of electricity and gas, satisfaction of the residents from the energy bills and their knowledge about the energy pricing system, their perception and understanding of renewable energy etc. The respondents also provided valuable insights regarding the use of renewable energy in Balochistan and the organization involved in dissemination of knowledge and providing solutions related to renewable energy technologies. Case studies are also discussed to present success and failure stories of the efforts taken to introduce renewable energy technologies in Balochistan.

## **3. Renewable energy**

### **3.1 Renewable Energy in Pakistan**

There is significant potential to produce renewable energy in many parts of Pakistan including the wind and solar energy. Studies done by National Renewable Energy Laboratory (NREL) of the United States classified the country based on wind power and solar radiation potential. The areas of Sindh, Balochistan and Khyber Pakhtunkhwa have more potential for wind energy while many parts of the country are suitable for the solar power generation [11] [12]. In recent years, several energy projects were started to generate electricity by using renewable sources which includes wind power projects at Jhimpir, Gharo in Thatta District. Twelve (12) of them started commercial production and are connected to the national grid supplying 590.5 MW. Twenty-eight (28) wind power projects are at different stages of the development, and their completion will add another 1397.6 MW electricity in the system. Eight (08) projects having capacity of 445 MW are under construction and expected to be completed in 2018. On the other hand, four

solar power projects with the individual capacity of 100 MW are operational at Quaid-e-Azam Solar Park, Bahawalpur. Twenty-four (24) biogas plants having the total capacity of 817.5 MW are at various stages of the completion and are expected to be completed in 2018-19 [13]. A huge amount of electricity, i.e. 64% is still produced on thermal sources while the total share of renewable energy as of Feb 2018 was 2%. Figure 1 presents the electricity generation by various sources during 2012-13 and 2017-28 [14].

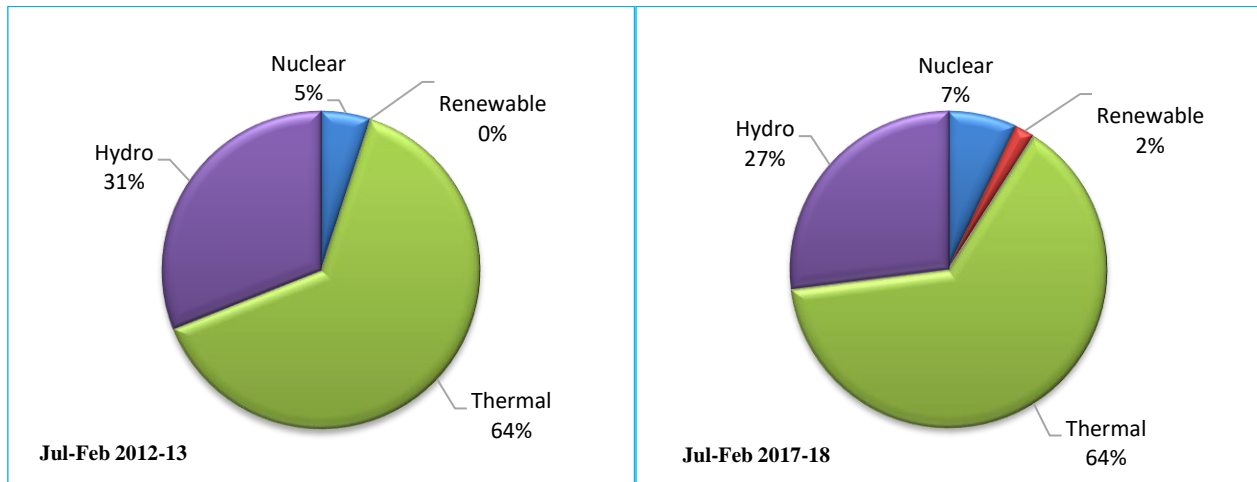


Figure 1. Share in electricity generation  
Source: Ministry of Energy (Power Division)

### 3.2 Renewable Energy in Balochistan

The province of Balochistan is rich in renewable energy (RE) resources, which must be explored for the sustainable development of the province. For remote areas and small power requirements photovoltaic technology is particularly suitable. Balochistan is also the largest province by area, yet, there is low density of population. Majority of its populations is living in villages and rural areas, i.e. 77%. These villages have no easy approach to the roads and are separated by large distances. Several houses in villages have very low requirement of power which varies between 50-100 W. Transmission of power lines for small villages and for very low power requirements is economically not feasible. Use of renewable energy can easily meet the requirements of such houses where electricity is mainly needed for light and fan or for charging mobile phone. This section provides an overview of the solar and wind power in Balochistan.

Solar radiation in Balochistan is highest compared to other parts of Pakistan, as annual average mean daily solar radiation is at 5.9-6.2 kWh/m<sup>2</sup>/day in the province [15]. In view of the growing energy demand the solar energy potential of Balochistan must be fully exploited. Solar energy is a reliable and copiously available renewable energy source. The province has an annual mean sunshine duration of 8- 8.5 hours with an average daily global insolation of 19 to 20 MJ/m<sup>2</sup>/day [16]. These are among the highest solar energy potential values available in the world. The areas where the solar irradiation is highest are ideal for concentrated solar power (CSP) and photovoltaic (PV) systems. In 2016, Government of Balochistan (GoB) signed a Memorandum of Understanding (MoU) with Inter-teck Kuwait Investment Authority to fulfil the energy demands of Quetta city by setting up a solar energy power plant of 50 MW which will be gradually upgraded to 500 MW. Another agreement was signed with CK Solar Korea to establish a 300 MW solar power plant in Quetta. 1500 acres of land is allocated by GoB near Kuchlak, District Quetta for this solar power plant project. The project was aimed to start in December 2014 and to be completed in 2017, however, the updates on this project are not available [17]. Some solar PV projects in Balochistan are mentioned in Table 1.

Table 1. Solar PV projects in Balochistan

Project	Capacity	Status
Solar power project, Kuchlak, District Quetta	300 MW	MoU signed
Teshil Jaffarabad	7.9 kW	Completed
Tehsil Zahri, District Khuzdar	10 kW	Completed
Hospital electrification, District Mastung	14.5 kW	In process
Rural electrification, Tehsil Kalat	41.1 kW	In process
Rural electrification, Tehsil Surab	59.5 kW	In process
Rural electrification, Tehsil Khuzdar	34.3 kW	In process

Wind energy is an imperative renewable source. Beside extended sunshine hours, Balochistan is also blessed with high rate of wind speeds. The available wind velocities data from Pakistan Meteorological Department (PMD) suggests that there is enough wind speed to generate electricity for small power requirements in coastal areas of Balochistan. The mean wind speed must be at least equal to 3 m/s for the minimum efficiency of the wind power turbine. Most of the wind resources are either located on the mountains or along with the coast lines. Coastal areas in Pasni, Makran and Gwadar district provide better conditions and climate for the installation of wind turbines [18]. Pakistan Council of Renewable Energy Technologies (PCRET) has successfully electrified more than 1600 villages along the coastal line of Sindh and Balochistan provinces. The coastal areas of Pakistan have the potential to generate more than 50,000 MW of wind power energy. It is important to manufacture the wind turbines locally to reduce the cost of these projects. In Balochistan, the coastal areas of Lasbela District are more suitable for wind power generation [19]. The estimated statistics of wind zones in Balochistan province at a height of 30m are given in Table 2.

Table 2. Estimated statistics of wind zones in Balochistan at a height of 30m

Parameters	Aghor	Gadani	Gwadar	Hubchoki	Jiwani	Winder
Wind speed (m/s)	5.5	4.9	3.6	5.0	3.7	4.9
Standard deviation	2.7	3.0	2.5	2.6	2.4	9
Wind power density	173.5	170.5	80.4	139.1	78.4	160.7

Source: Pakistan Meteorological Department (PMD)

#### 4. Results and Discussion

As mentioned in the methodology section an online survey was also conducted for this research. In total 102 participants completed the survey and 17 respondents left it incomplete. The results presented here are the responses of 102 respondents from various parts of Balochistan. For electricity all respondents mentioned that they experience load shedding from 2h to more than 8h per day in different areas and localities of the province. While 25% of the respondents experience low gas pressure and outage of gas (43%), mainly in winter during peak hours. The satisfaction level from energy prices is given in figure 2. The respondents are less satisfied with electricity prices compared to gas prices. The survey was conducted before the recent increase of the energy prices in Pakistan. The use of renewable energy is wide spread in Balochistan and more than 19% respondents mentioned that either they use renewable energy at their home or village or they knew someone from their social group who use RE. Some residents of Quetta city use solar PV in their houses to power the house during load shedding hours. According to the results of the survey, these are the areas of Balochistan where solar PV are being used; Sibi, Jhal Magsi, Khuzdar, Hub, Uthal, Zhob, Sherani. Loralai, Khanozai, Chaman, Kalat, Pishin, Panjgur, Dhadar, Bolan and Duki Balochistan. These solar PV are used to meet the electricity needs, farming or agriculture, and to power street lights, etc.

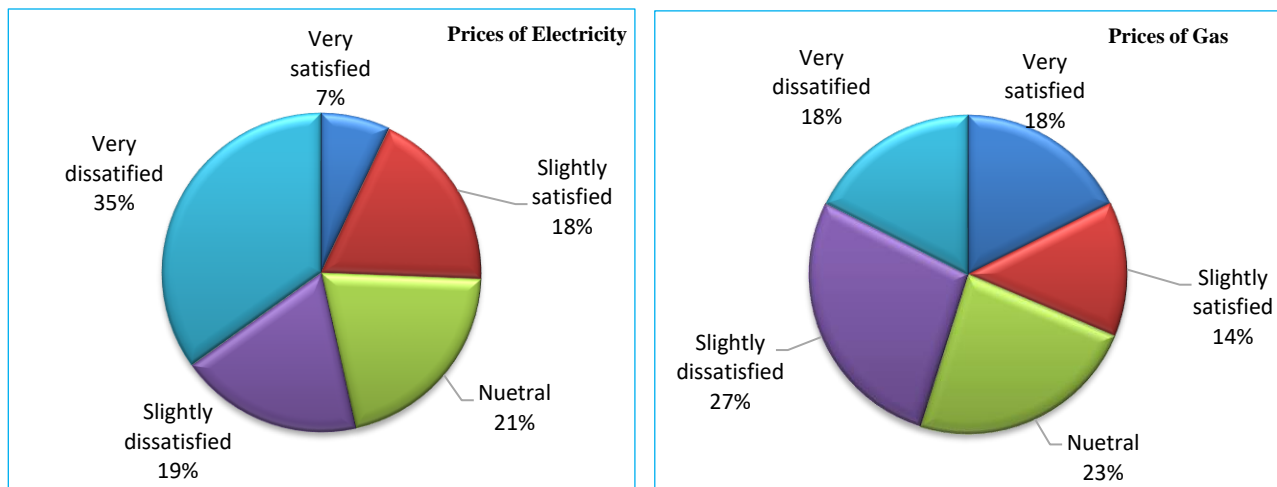


Figure 2. Satisfaction and dissatisfaction of the users from energy prices

#### 4.1 Case Studies

Three case studies are presented here related to the use of renewable energy technologies in Balochistan. Two of these projects were successfully completed while one remained incomplete.

##### 4.1.1 IDSP's University of Community Development (UCD), Quetta

In 1998, Institute for Development Studies and Practices (IDSP) has introduced human resource development courses in order to respond to the pressing needs of remedial initiatives for demystifying existing unjust and exploitative power structures through producing intellectual and practice-oriented potential human resource equipped with knowledge and skills of leadership, development, society, community, politics and economy. The idea of IDSP Pakistan was originally to create a people-centered open learning space to provide opportunities of learning and practice to deprived, marginalized and excluded youth and people to advocate their cause by building up their capacities in social and development fields. The theory and practice-based courses are knitted into a conceptual framework based on study and practice that starts from self, family, community and expands to the world at large.

IDSP decided to build a unique learning space in Quetta to continue supporting communities by education. For this University of Community Development (UCD) was established at Hanna Road Quetta. The UCD is a non-degree awarding and non-formal, open learning institute. It offers theory and practice-based courses for the excluded youth. The UCD campus at Quetta is designed by a renowned Pakistani architect, Ar. Kamil Khan Mumtaz. Two critical aspects of the planning process for construction based on sustainability and renewable energy resources were used in the building of IDSP's UCD campus at Quetta. Although the construction techniques used at UCD are unique of its kind but considering the purpose of this paper, only renewable energy sources used at UCD campus will be discussed.

Passive solar is the modern version of sun-welcoming design, where no fans, pumps or other mechanical devices are used. The large south-facing windows and dark tiles or brick floors are among the basic features of passive solar design. These windows provide enough natural light in indoors while the brick floors or dark tiles store solar heat during the day and release it back at the night. At UCD solar energy is used to heat water during cold winter of Quetta. This hot water is then used in campus buildings and hostels. Many solar water heating systems mainly consist of a water storage tank and a solar collector. Solar collectors used in solar water heating systems are usually mounted on a south facing roof, to heat either a heat transfer fluid, such as a non-toxic antifreeze or water. A water tank, like the one used in electric water or conventional gas heating is used to store the heated water. Moreover, solar PV are installed at

the campus to light the indoor and outdoor areas. The produced solar energy is stored on rechargeable batteries and is also used to operate water pumps used in the campus.



Figure 3(a) and 3(b). Solar Panels and solar water heater installed at IDSP's UCD campus

Wind turbine used at UCD campus produces up to 10 kW of electricity at its optimum wind speed and it has been a successful project for over ten years of its installation. Moreover, biogas plant is also installed at UCD campus to fulfil the demand of cooking needs [20].



Figure 4(a) and 4(b). Wind turbine and biogas plant at UCD campus

#### 4.1.2 Installation of solar water pumps in District Nushki

Azat Foundation Balochistan (AFB) together with National Rural Support Program (NRSP) started “Clean Drinking Water” project with the technical and financial assistance of USAID’s Small Grants and Ambassador’s Fund Program (SGAFP). The project aimed to provide clean drinking water facility to 13 villages of Union Council (UC) Daak and Anambostan of Tehsil Nushki in Balochistan. The project was started in December 2013 and was completed in July 2014. USAID allocated the funds of 11.11 million rupees for the installation of 400 solar water pumps and the construction of water tanks in the selected villages. In total, 400 households (HH) as direct beneficiaries and more than 300 HH as indirect beneficiaries are benefited from the project. The main objective of the project was to reduce the water borne diseases by providing innovative and sustainable infrastructure and to create awareness about safe drinking water and hygiene in the UCs of Daak and Anambostan. Through this project Azat Foundation crafted drinking water schemes functional by using renewable solar energy [21].

Several tube wells of water supply schemes in Balochistan are non-functional either because of some fault in machinery or lack of financial resources on part of community to sustain the fuel (diesel), repair and maintenance

costs. The proposed solution i.e. Solar water pumping will replace the existing diesel engines installed on the tube wells with submersible well pump powered by solar energy.

#### 4.1.3 Renewable energy project at BUITEMS Quetta

In 2005 a MoU was signed between the Chairman of Alternative Energy Development Board (AEDB), Air Marshal (R) Shahid Hamid and Ex-Vice Chancellor, Balochistan University of Information Technology, Engineering & Management Sciences (BUISTEMS), Prof. Dr. Muhammad Abbas Choudhary to establish a Center of Excellence for Renewable Energy and Environment (CEREE) in order to facilitate and support the implementation of off grid energy service supply, based on renewable energy technologies, focusing on Balochistan Province. It was a multimillion project which stated to focus on consultancy services and academic programs to be offered in this regard, but this project came across a failure due to the following reasons.

- The funding from the Federal Government under AEDB was stopped after few years of the project with the change of federal government in Pakistan which stopped the overall workability of the project.
- Two types of wind turbines were installed for the Campus. One was a big wind turbine which was installed behind the BUISTEMS Campus premises in the Takatu mountains. However, it never produced the desired results due to its location issues as well as the design failure. Small wind turbines were installed on the roof top of the Department of Architecture's building (Hall-1), which were operational for shorter period. The batteries and installations are still present, but the project is no more functional due to the lack of maintenance and technical staff.
- The cost of the project increased than the estimated cost of the staff to be hired which also led to the failure of this project.



Figure 5. Small wind turbines still intact to the building of Department of Architecture, BUITESM Quetta

## 4.2 Challenges and institutional framework

There are several challenges regarding the use of renewable energy and sustainable development in Balochistan. For the successful completion of an energy power projects there are several steps in which many stakeholders are involved. The main challenges and hurdles which require immediate attention are described below:

*Public awareness and education:* Public awareness is the first and very important step for the successful completion of any sustainable energy project. The awareness campaigns should be run by public and private sectors by providing necessary information on energy usage, environmental impact and sustainable energy sources. It is also essential, since many people are willing to install solar PV in their houses, yet, they do not have access to the basic information and guidance in this regard. Universities should develop comprehensive programs for the training and education of individuals and the professional who are interested in sustainable development and renewable energy.

*Research & Development:* Significant research is essential before the start of any project. Balochistan is one of the underdeveloped areas of Pakistan and faced unsatisfactory law and order situation in different parts of the province since last few decades. The research & development sector is not much developed compared to other parts of the country. There is lack of technical and professional staff, R&D organizations and lack of financial resources.

In addition to above, the existing infrastructure regarding renewable energy is inefficient. It is essential to encourage private sector to invest in renewable energy sector in Balochistan. Federal government and other related organizations should provide necessary data, training, resources and technology transfer for the development of renewable energy sector. Financial incentives or provision of technology at subsidized price will also encourage more people to adopt RE technologies and fulfil their energy demands without spending a huge amount on power distribution lines to rural and remote areas of Balochistan.

Some of the organizations and institutions involved at present or in past in renewable energy sector in Balochistan are; Alternative Energy Development Board (AEDB), Pakistan Council of Renewable Energy Technologies (PRECT), Pakistan Meteorological Department (PMD), Energy Department Government of Balochistan, Azat Foundation Balochistan (AFB), National Rural Support Program (NRSP), USAID, World Bank and National Renewable Energy Laboratory (NREL) of United States. The role of these organizations varies, since some work for the project execution and completion while the other conduct research and studies to collect viable data to discover the potential of renewable energy in Balochistan.

## 5 Conclusion and recommendations

The following conclusions and recommendations are made based on this study:

- There is substantial potential of renewable energy in Balochistan considering the amount of solar insolation and wind speed in many parts of the province.
- Conventional modes of energy are expensive and cannot meet the energy requirements for long term sustainable development.
- The demand of energy increases with the change of temperature and the effect of weather is directly related to the demand of energy supply so that there is a need of long-term sustainable solution for all seasons.
- The consumers are less satisfied with the energy prices and billing system. By using renewable energy sources, they can control their energy expenses and can still fulfil their energy demands.
- Renewable energy is ideally suitable for the energy requirements of villages and remote areas of Balochistan where energy consumption is very low.
- Public and private sector organizations need to come forward to educate and facilitate people for renewable energy. Since there is a huge lack of understanding regarding the usage and installation of renewable energy technologies. With the public private partnership long term goals can be achieved in terms of renewable energy which will reduce the pressures on the existing energy supply system.

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