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Scientific Composite of Solar Energy in Pakistan; Experts' View Point

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Abstract

The scientific composite of energy resources plays foremost role in introducing any technology. In this study, the scientific dimension of solar energy is measured by using in-depth interviews (IDIs). Eighty-five percent (85%) results of the scientific aspect, are found to establish solar energy as the 'Best Alternative Energy Mean' in Pakistan. This study extends the literature on solar energy and features the usefulness of solar energy. This study is beneficial to facilitate the Government of Pakistan to initiate enhanced quality of life and improved business prospects in the new avenues of economic progress.

Keywords: Scientific Composite; Energy Independence; In-depth Interviews (IDIs); Solar Energy; Pakistan (Punjab).

1. Introduction

Energy has been used and its significance established from time immemorial. It has been the foremost essential that has influenced the structure of society in late 20th century. The availability, accessibility and affordability of energy pronouncedly impact people's life standard, the strength of domestic (as well as international) economies, the relations among countries, and the long-term environmental stability; however, it was only two and a half decades ago when the (reciprocal) link between energy and economic development in the international development realm was more concretely established [1]. While energy fuels the economy, economy is also the sponsor of energy systems and of its modules and energy flows [2].

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Fossil fuels remain the main fuels for producing electrical power; however, their depleting reserves and the environmental impact of their burning are increasingly viewed more and more with increased concern. Hence, the energy resource management is framed with its economic, environmental, social, security, resilience, development, and political impact in mind [3] The attainment of desired energy is not only vital for human growth but must for any nation to evade intensive vulnerabilities. While in Pakistan the level of per capita energy consumption is very low (448 kWh as of 2020) [4]. Literature review along with ground realities tell about numerous reasons of energy scarcity of Pakistan ranging from: the Circular Debt, Flaws in Tariff Determination Mechanism, Complex Decision-making Architecture and Inefficient Public Sector etc. The prevailing law and order situation in Pakistan has not favoured for energy development. The areas of Pakistan having immense energy reserves, for instance Balochistan and KPK, have posed challenges to foreign investors. Terrorism and localized threats originating from different grievances are considered as main security issues related to energy security [5] The security situation of the country has badly hampered the progress of exploration and production of petroleum and gas in hydrocarbon rich areas [6]. As stated elsewhere, hydel power remained the mainstay of Pakistan's energy mix until 1990. However, thereafter, the share of thermal-based power generation, consisting of natural gas, residual fuel oil, high-speed diesel and coal, grew disproportionately. By end of FY 2017, total installed generation capacity was 28,399 MW [7], more than 90% of which is connected to the PEPCO system, serving an estimated 92% of the total consumer base of the country. Of the total installed capacity, thermal power generation capacity stood at 18,676 MW, whereas hydel remained stagnant for the third consecutive year at 7,116 MW (including 214 MW generated by private independent power plants), nuclear at 1,142 MW, and renewables at 1,465 MW. Of the thermal power, 6,785 MW was generated from oil, 810 MW from coal, and 868 MW from gas/RLNG. This unbalanced energy mix in Pakistan is the main cause of energy scarcity as far as the insufficient energy supply is concerned. The electricity generation mix of Pakistan mentioned above demonstrates that the share of hydroelectricity in the power mix was central in the early years. Fifty percent (50%) of the total electricity generation had based on hydroelectricity until 1980's but later on it started declining and had reduced to 29.4% in 2010. The development of hydropower could only be seen in the form of Tarbela and Mangla Dams in the 60's and 70's. Further development was totally stopped for the next three decades until Ghazi Barotha Project [8]. The unbalanced energy mix of the country shows that the Government after ignoring hydropower started relying on fossil fuel generation in order to fulfil increasing demand of power in 80's and 90's [9] Since the oil used in fossil fuel-based electricity generation is mostly imported, therefore fluctuations in oil prices in international oil market have transformed the electricity mix to unsustainable and uneconomical one [10]. Thorough review of literature shows that one of the most important factors of energy scarcity is depletion of domestic fossil fuel. Yet while hydropower is continuously being ignored, over dependence on fossil fuels is not only persistent, but also steadily increasing. This over dependence on fossil fuels for power generation, together with other reasons, has led to their fast depletion. For instance, over the next fifteen years the demand for natural gas is expected to increase by 13.27 Bcfd vis-à-vis internal supply of only 2.17 Bcfd [11]. The reason behind this gap between supply and demand of gas is depletion of gas fields [12]. The abovementioned factors of energy scarcity in Pakistan, with depletion of domestic fossil fuels being the most dominating factor highlights the importance of solar energy as an alternate source in Pakistan.

2. Methodology

The study attempts to assess the scientific composite of solar energy utilisation in Pakistan. The available literature focuses much on the significance of technological aspects of any source of energy. However, this study tries to contribute to the current literature on scientific knowledge related to solar energy by utilizing IDIs of solar experts. Following are the variables used in this paper:

- Solar Energy = Independent variable
- Energy Independence = Dependent variable
- Scientific Composite = Mediating variable

2.1. Methods of data collection

In total, 6 experts in solar technology were interviewed based on technological questions so as to showcase the linkage between Energy Security and scientific composition of solar energy utilisation. Some of them were interviewed in person, while others were approached via email, telephone or Skype as per convenience.

2.2. In-depth Interviews (IDIs)

Interviews helped to establish the feasibility of solar energy based on its scientific dimension in Pakistan. Feasibility of solar energy for the achievement of energy security is linked to its scientific strength; thus the assessment of scientific aspects related to solar energy price, and availability in market is needed. Questions were based on price, availability in market, and research funds regarding solar energy utilisation.

2.3. Observations

Data collected through IDIs is documented with an addition of personal observations. It attempts the *question*

'How can scientific composite of solar energy utilisation ensure energy independence?

Purpose of the paper

The purpose of this paper is to evaluate scientific composite of solar energy utilisation in order to achieve energy independence in Pakistan.

Following are the specific *objectives* of this study

- To establish the feasibility of solar energy utilisation based on its scientific composite.
- To represent scientific composite of solar energy utilisation in Pakistan.

Hypothesis

- The feasibility of solar energy for the achievement of energy independence is dependent on its

scientific strength; thus, the assessment of scientific aspects related to solar energy utilisation; price, and availability in market is needed.

3. Findings and Analysis

3.1. Reasons of Energy Scarcity in Pakistan

Experts were asked about the main reason of energy scarcity. Eighty percent 80% experts took corruption, transmission/distribution loss, old system and power theft as the main causes of energy scarcity.

3.2. Best Alternate Source of Energy

Solar experts and practitioners are of the opinion that in Pakistan's case, renewables are the best alternative source of energy. Among all renewables, solar is the most suitable option due to its abundant availability, cost competitiveness, simplicity of technology, cleanliness and sustainability. Eighteen percent 18% transmission and distribution losses is a reason behind gap between supply and demand. Grids that distribute energy to consumers, are decades old. Their distribution capacity was planned as per the population of that time, whereas now the population has increased several times. Even if the plants are generating enough energy, the grids in rural areas particularly are not capable to distribute it. Therefore, there is a need for up-gradation of infrastructure and improvement in the grid system, particularly for transmission and distribution lines, protection equipment, control systems, etc. to reduce system losses and introduce new generation concepts at distribution end. In addition, circular debt, safety, security, capital costs, and long-term maintainability are important factors.

3.3. Potential and Scope of Solar Energy

The experts opined that the potential of solar technology utilisation is significantly high in Pakistan. Almost all of the country receives abundant sunrays. Pakistan has 2.9 million megawatts (2.9 TW) of solar energy potential besides photovoltaic opportunities [13]. Besides some upper part of the country although they also have the potential to generate solar energy and solar thermal power, the entire country receives high solar irradiations. It is placed among the world top solar energy potential countries. However, there are some issues associated with solar energy utilisation. Large centralised installation of the solar panels requires excessive use of land. It has raised concerns for food security. To deal with this hurdle it is necessary to locate non-agricultural sites. In this regard Qazi Zulqadir, indicated that closely two-thirds of the mainland in Pakistan is not utilised due to being infertile [14]. Therefore, this barren land being low-priced is very suitable for solar installation.

3.4. Price of Solar Energy

The experts were also asked about the price factor of solar technology to seek their views. Solar technology is widely considered as an expensive source of energy whereas this research shows that the prices of solar technology are decreasing gradually and becoming increasingly affordable [15]. Pakistan possesses high solar insolation in upper Sindh, south Punjab and several parts of Balochistan. Thus, it is expected that prices of solar technology will continue to drop in the future. The price of solar energy has declined as compared to other energy technologies and it will also decrease in the future becoming the cheapest energy source. Research in

solar technology is bringing the prices down while increasing efficiency. The efficiency of solar panels has improved significantly over time.

3.5. Challenges Faced by Solar Energy

In order to understand the pollution impact of solar energy technology, first, there is a need to understand that in the production of silicon-based solar panels (which constitute more than 90% of worldwide production), there are six processes involved which are as follows.

- Purification of silica sand to get lumps of silica with purity of over 99.9%.
- Formation of silicon crystals (polycrystalline or monocrystalline). This is a very clean technology and causes no pollution.
- Cutting the crystalline lumps into rectangular blocks/ingots. Again, this is a very clean technology and causes no pollution.
- Slicing the ingots into fine wafers using laser technology. This is also a very clean technology and causes no pollution.
- Etching the wafers to produce solar cells. This is also a very clean technology and causes no pollution.

Producing solar panels using a framing technique. This is also a very clean technology and causes no pollution. The only process where there is possible pollution is the first one; where you need to purify the silicon from the silica sand which is a highly energy intensive process. In many countries, coal is used for energy generation. However, if compared the amount of energy that the solar panel will produce over its design life of 25 years, the amount of pollution caused in the production of pure silicon is very minimal. Throughout its 25 years design life, it is pollution free. That is why this is taken as a clean technology. Usually, 15% of generated electricity is lost during conversion from DC to AC current. However, it depends on the quality of the converter being used. Better quality converters are energy efficient but their price is also high. Another factor that affects the energy efficiency is the quality of solar panels itself. Lower quality solar panels are available in abundance in Pakistan. The Government has no policy on monitoring the quality of panels imported or produced locally. The quality depends on: “The type of material used in the manufacturing, Manufacturing process used, Quality control procedures, and Ensuring defective panels are recycled and a few other factors”. Also, the defective stuff is imported into Pakistan, which has a short life. All these factors contribute to the energy inefficiency of the solar panels. For backup and storage, there are many different technologies of batteries in the international market. In Pakistan, consumers opt for the cheapest initial investment. Therefore, he gets poor quality batteries with short life. Lead acid batteries can have a life of over 10 years depending on the type of plates used (tubular or flat), the thickness of the plates, the medium in between (liquid or gel), absorbed mat, and many other points. Using higher features will multiply the life many times with a relatively small additional cost. Thus, such high rated batteries will yield a lower cost over time. Other technologies, like Lithium batteries, have a life of up to 25 years. These are good for industrial uses, but an overkill for domestic use. There is tremendous research work in progress in many countries to bring down costs of energy storage. Further reductions in the cost of storage in the coming years is anticipated.

3.6. User Friendliness of Solar Energy

Following factors make solar energy user-friendly:

- Less maintenance.
- Longer lifetime (20-25 years for solar panel).
- Environment-friendly as it emits zero carbon.
- Safer than conventional energy. No danger of getting an electric shock
- New models are provided with a graphical user interface (GUI) and mobile applications.
- Reduction in energy bills, since inverter/ UPS charging from grid supply, acts as a load during peak time-of-demand and thus increases the consumer bills. Hence, solar technology mitigates the extra billing by charging the inverter during the day and with EV or wind during the night and thus its consumer friendly.

3.7. Support and Recognition from Government

The Government has provided some facilities including tax waiver and customs duty waiver etc. The energy bills for customers will also be reduced when they sell excess energy to WAPDA through net metering. However, solar experts working privately say that more support from Government is required [16]. There is a need to recognize the efforts of solar experts and particularly invest in solar technology as well. It will encourage them to work more enthusiastically and produce fruitful results.

3.8. New Discoveries of Solar Energy

Research and development is a continuous process. Human nature always quests from better to best. It is an R&D process, which has brought down the price of solar technology. Developed countries are intensively investing in the development of solar technology. Governments are providing scholarships in the field of energy development. There are several new developments under process throughout the world, mostly in the fields including nanomaterials, sustainable energy in smart grids in order to improve efficiencies, costs, reliability, space utilization, storage technologies regarding solar technology and solar tracking unit [17]. Since the potential of solar technology is significantly high in Pakistan, almost all of the country receives abundant sunrays, the solar experts, and practitioners are of the opinion that solar energy is the most suitable option due to its abundant availability, cost competitiveness, and simplicity of technology, being clean and sustainable. The Government needs to encourage and facilitate such research in Pakistan.

4. Conclusions

The Experts were asked about the potential and scope of solar technology, challenges being faced by the technology, the support of Government and new discoveries in this field. The Country has high solar potential and posses vast barren land. Thus optimal utilisation of barren land will help in increasing generation. Solar energy is generally considered as an expensive technology but with fast innovations and technological development, solar energy is increasingly becoming more affordable. The Government has given tax waivers

and custom duty waiver on solar energy but much can be done to meaningfully promote it. The effective R&D has brought down the prices of solar energy related technologies while various public and private institutions are constantly working for the improvement and promotion of solar energy.

5. Recommendations

Pakistan has enormous potential for solar energy utilisation but this source has been very limitedly harnessed for the better and long-term benefit of the country. Solar energy is still widely considered as an expensive source of energy in Pakistan whereas this work shows that the prices of solar technology are, in keeping with the international trends, decreasing gradually and becoming affordable in our country too. The important reason is that Pakistan possesses high solar insolation in upper Sindh, South Punjab and several parts of Balochistan. The cost of energy by solar is dependent on the level of solar insolation. If the level of solar insolation is high then the cost of energy will be lower. There is a need to recognise the efforts of the individual scientist and invest in research and development of solar technology. It will encourage them to work more enthusiastically and provide necessary wherewithal innovations and technological breakthroughs.

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