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Renewable energy sources in power generation in Pakistan

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ABSTRACT

Pakistan, as an underdeveloped and populous country requires an uninterrupted source of energy to keep its development on track and provide its citizens with a reasonable standard of living. Conversely, the country is unable to fulfil its domestic energy requirements and is undergoing an acute energy crisis. Electricity is a sector that has suffered the most from the energy shortages. The gap between demand and supply is met through blackouts and, at times, the country plunges into darkness for more than 10–12 h a day. This crisis, that the country is currently facing, did not occur overnight. The root cause of this debacle goes back in history and can be attributed to decades of mismanagement, poor planning and negligence.

This article provides a comprehensive overview of the electricity sector in Pakistan and the issues it is beset with. In addition, an analysis of the energy policies that the country has announced over the years, as well as the impact that they have had on the electricity sector, is presented. It is concluded that Pakistan's existing energy mix is not sustainable due to the excessive reliance on imported fossil fuels, rising electricity generation cost and increase in power generation related emissions.

This paper develops a roadmap and proposes the energy sources that can fulfil the country's rising energy requirements, whilst being sustainable at the same time. The roadmap identifies and highlights the primary tasks that the country must undertake to reach its vision of meeting its energy needs and integrating renewable energy sources in the power generation.

The recommendations of this paper will provide guidelines to the decision-makers and policymakers, with an insight on how the energy technology and resource development should be carried out, which sources should be given priority and how the issues should be resolved, both in the short and long-term.

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1. Introduction

Energy plays a pivotal role in the formation and sustainment of modern economies. It is central to practically all aspects of human welfare including access to basic necessities, agriculture, health care, employment, education and sustainability. Energy is considered to be crucial to the economy and a central component in a country's success. As a developing country, Pakistan requires a large amount of energy to fulfil its household and industrial needs, as well as to keep the country's development on track. However, the country is struggling to ensure the sustained supply of energy and is currently facing the worst energy crisis of its history [1].

1.1. Objective and structure of the study

The objective of this study is to provide an overview of the prevailing energy situation, present the main challenges and key issues behind the unprecedented energy crisis and to propose practical strategies and policies to address the issue. This paper develops a roadmap and proposes energy sources that can fulfil the country's rising energy requirements, whilst being sustainable at the same time. The roadmap identifies and highlights the primary tasks that the country must undertake to reach its vision of meeting the rising energy needs and integrating renewable energy sources in the power generation. This paper attempts to address the following key questions 1) What are the key factors behind the prevailing electricity crisis? 2) Is the existing generation mix sustainable in the long run? 3) Can renewable energy sources (RES) play a role in mitigating Pakistan's abysmal electricity crisis? 4) Which sources should be given priority and how the issues should be resolved, both in the short and long term?

This paper is structured into 12 main sections. The first half briefly discusses the state of energy, demand forecasts and existing sources of power generation. The following section addresses the origin of the crisis and challenges that the country is beset with. The next part explores the sources and potential of power generation from renewable energy sources. The subsequent section of this study presents the energy policies that the country has implemented over the years and discusses their impact on the electricity sector. Finally, the last part identifies the actions that are necessary to improve the existing energy systems. The recommendations are based on the SWOT analysis, which is conducted to highlight the key challenges and opportunities that exist.

2. State of energy and existing sources of power generation

Pakistan is an underdeveloped and populous country with over 190 million inhabitants in 2014 [2]. The per capita energy consumption is low compared to the rest of the world. The average per person energy consumption is 1/20th of the developed world, 1/9th of the OECD countries, 1/5th of the global average and less than half of the underdeveloped countries, as shown in Fig. 1 [3,4]. According to Asian Development Bank (ADB) the availability of energy is considered an underlying factor behind the low level of consumption [5].

According to Aslam et al. the overall energy consumption in Pakistan has increased in recent decades, like many developing economies, and is expected to follow the same trend [6]. The primary energy supplies have witnessed a soaring growth of over 90% in recent decades, from 34 million tons of oil equivalent (MTOE) in 1992 to 64.7 MTOE in 2012, as shown in Fig. 2 [7]. The indigenous production remained around 45.2 MTOE, leaving a shortfall of 20.5 MTOE to be covered through energy imports [8].

Electricity is the sector that has suffered the most from energy shortages. The country has failed to produce the required amount of electricity to meet the domestic consumption requirements. The gap between electricity demand and supply has been stretched and the shortfall reached 4500 MW in 2010, 6620 MW in 2012 and remained over 5200 MW in 2013, which, on average, constitutes over 50% of the country's total generating capacity of that time (see Fig. 3) [9–11]. The total installed capacity for 2014–15 is 23,928 MW whereas, during the peak periods, the demand is expected to be around 23,242 MW [12]. In actuality, the installed generation capacity perfectly matches with the demand. However, due to issues such as high petroleum prices, availability of indigenous energy sources, circular debt and the transmission and distribution (T&D) losses, the actual generation capacity is expected to remain lower than the installed capacity. The maximum generation capacity is projected to be 18,499 MW, leaving a shortfall of at least 4743 MW during high demand periods [12]. Khalil et al. states that the electricity demand in Pakistan varies on a seasonal basis and peaks during the summer time [13].

The gap between demand and supply is met by blackouts, at times, the country plunges into darkness for over 12–14 h in cities and around 18 h in villages [14]. The deficiency of electricity has caused the industry to cripple. This situation has forced industrialists and agriculturalists to opt for alternative means of electricity generation. According to Pasha et al. self-generation is two and half times more expensive than electricity coming from the grid, and requires additional repair and maintenance costs [15]. Expensive electricity contributes to the higher prices of final product or services. This consequently impacts businesses' ability to compete in the local, as well as international, arena. Many of the businesses were not able to recover from this and eventually had to shut their operations down [5]. Others have shifted their industries to the neighbouring countries [16]. According to BNU [17], the energy crisis has hampered the country's economic growth and has cost Rs. 1272 billion during 2011–12. The economy has witnessed a decline of 2–3% in the GDP [5,18] and 12–37% loss