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Current status and overview of renewable energy potential in Pakistan for continuous energy sustainability

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ABSTRACT

Unfortunately, Pakistan is facing severe energy crises from the last decade due to increasing population and heavily dependence on the import of the fossil fuels. The electricity breakdown/blackouts was 14–18 h in rural areas and 8–10 h in urban areas. This situation has drastically affected the residential, industrial and commercial sector of the country. Currently, it is a big challenge for the government to sustain the future energy supply of the country. Under these circumstances, the research have been increased for the exploration of renewable energy sources in the country to fulfill the deficit scenario of the country. Fortunately, Pakistan is lying in such a geographical location where potential for all the renewable energy sources exists abundantly viz. solar, wind, biogas production, bio-energy from biomass and feedstock, mini and micro hydel. About 81 million ton/annum biomass production has a huge potential to produce enough bio-energy by employing different technologies viz. combustion, gasification, pyrolysis, trans-esterification process etc. Similarly, available dung from 72 million animals (cows and buffalos) and available poultry droppings from 785 million poultry birds can produce considerable biogas to produce heat and electricity. Pakistan is also blessed with 5.5 Wh m^{-2} d^{-1} solar insolation with annual mean sunshine duration of 8–10 h d^{-1} throughout the country. Wind speed 5–7 m s^{-1} persists in the coastal regions of Sindh and Baluchistan provinces with more than 20,000 MW of economically feasible wind power potential. The worldwide utilization of renewable energy is already on a fast track, however, Pakistan is still lacking in adaptation of these blessed technologies. Therefore, it is a high time that the government should launch a comprehensive program for R&D, commercialization and awareness of the community by incentivizing for the wide scale adaption of renewable energy technologies for the sustainable energy supply of the country in future.

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1. Introduction

Pakistan is a developing country of Asia and its increasing population and industrialization resulted drastic increase in energy consumption [1]. Pakistan's energy sector heavily depends on fossil fuels in terms of primary as well as secondary energy source [2]. The total primary energy supply during 2011–2012 was 64.727 Million Tons of Oil Equivalent (MTOE) in the country [3]. Nearly 87% of total energy was supplied directly or indirectly using fossil fuels such as natural gas, oil, coal and LPG. According to an estimate, around 1% of the total energy supply is being produced from renewable energy sources. The energy mix of Pakistan during 2011–2012 accounts for natural gas as 49.5% followed by oil 30.8%, hydro-electricity 12.5%, coal 6.6%, nuclear electricity 1.9%, LPG 0.5%, and imported electricity 0.1%. The escalation prices of fossil fuels and electricity (Fig. 1) is posing sever energy crises in the country resulting extended periods of electricity breakdown/blackouts of 14–18 h in rural and 8–10 h in urban areas. [4,5]. The electricity shortfall reached between 4000 and 6000 during the last decade. The energy mix of Pakistan for electricity generation is shown in Table 1 [6].

This situation indicates that current indigenous energy sources cannot meet the increasing energy demands and the solution of this problem lies in the energy conservation, energy efficiency and utilization of renewable energy sources for power generation. Various forms of renewable energy sources are being utilized in the developed countries to reduce their dependence on fossil fuels and cease greenhouse gas emissions. Fortunately, Pakistan is also lying in such a geographical location having plentiful potential of renewable energy sources. But unfortunately, very little work has been done in the past to explore these naturally existing renewable energy sources. It is worth mentioning here that Pakistan is suitable country for exploration of different renewable energy sources viz. solar energy (PV and thermal), biogas production using animal dung, poultry droppings and crop residue, wind energy, micro and mini hydel/canal-fall, biofuels (bioethanol/biodiesel) production from biomass, energy production from industrial and municipal waste, geothermal energy, tidal and ocean energies etc. The effective utilization of existing or locally developed renewable energy technologies can play a vital role to meet the current energy deficit of the country. Nearly 2.6 billion population (38% of the global population) depend on biomass [7,8] for cooking and heating applications. In developing countries, the household utilization of biomass in the form of animal dung (cakes), crop roots, agricultural residues and fuel wood [9,10] accounts for almost 7% of the world primary energy demand [11]. Excessive use of fuel wood being an energy source for cooking and heating is increasing the deforestation rate. Almost 70% of the total population is residing in villages using wood for cooking and heating which is also associated with environmental pollution [12]. According to an estimate, 97 million people are living in the rural areas of the country. Out of these, only 46% people have access to electricity although these regions are enriched with energy resources and man power [13]. The developed countries are already playing their leading role for exploration of renewable energy sources. However, the utilization and adoption of renewable energy technologies is at its earlier stage in Pakistan. It is worth mentioning here that many stakeholders in the country are now interested to adopt renewable energy technologies, however, the main hindrance in the wide spread adaptation of these technologies is the high initial cost and lack of knowledge about the selection, operation and maintenance of these innovative renewable energy technologies. Therefore, it is the high time to introduce and equip the stakeholder about the benefits, operation and maintenance of these technologies for promoting on larger scale especially in developing countries.

Due to countless advantages and environmental friendliness of renewable energy technologies over conventional energy sources, these technologies can be used to play a pivotal role in mainstreaming the rural population for their sustainable future. It is the dire need of the time to have an out-of-the-box thinking to use indigenous renewable energy sources. This paper is focused to provide firsthand information about the potential of different renewable energy sources in Pakistan to enable the policy makers for the selection, designing, developing and installation of site specific renewable energy technologies. This will help to promote the adoption and utilization of renewable energy technologies in the country for future sustainability. At the same time, it will also help to reduce carbon emissions and greenhouse gases thus resulting cleaner environment of the country. Keeping in view the increasing energy demand, the Government of Pakistan is already doing its sincere efforts to explore and promote renewable energy technologies and to enhance energy efficiency seeking collaboration with advanced and developed countries.

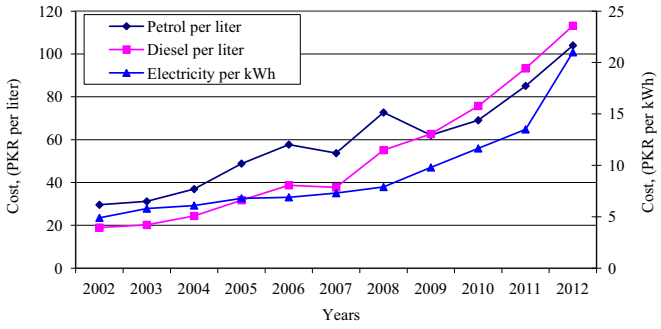

Fig. 1. Increasing prices of fossil fuels and electricity. (Source: [42,14]).

Table 1
Energy mix of Pakistan.

Source	Electricity generation (GW h)	Percent of total generation (%)
Oil	33,568	35.2
Gas	27,656	29
Hydel	28,514	29.9
Nuclear and imported	5531	5.8
Coa	95	0.1
Total	**95,364**	**100**