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The Potential and Environmental Benefits of Developing Renewable Energy Strategy: A Comparative Analysis of Pakistan and Developed Countries

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Abstract

Renewable energy is being developed globally to overcome the depletion of natural resources and mitigating the global issue of climate change. The increasing energy crisis and environmental concerns make renewable energy more critical for a sustainable future. Renewable energy technologies have a great potential across the globe. Pakistan being a developing country is continuously facing energy crisis and an emphasis on industrialization is increasing carbon emissions. Renewable energy development provides necessary solutions, particularly in developing countries where energy demands have to be met through an economical and environmental friendly way. This paper explores the significance and potential of renewable energy development in developing countries i.e. Pakistan and how it can contribute to reduce the environmental impacts for mitigating climate change. It argues that the current policy measures and infrastructure is inadequate to implement renewable energy technologies, also discussing various renewable energy sources. The critical review of the literature and case-based experiences has been used as an overall approach to this paper. It will help in exploring renewable energy strategy and its implementation in developing countries in comparison to developed economies. It concludes with an integrated and comprehensive policy recommendations and possible solutions to develop a strategic approach to renewable energy.

Keywords: Renewable energy, Climate change, Developing countries, Energy crises, Policy

1.1. Introduction

Renewable energy is being developed globally to overcome the depletion of natural resources and mitigating the global challenge of climate change. The types of energy usage and how we use them are major factors in order to move towards a sustainable society. Pakistan is a developing country and has faced major challenges in energy production for the last couple of decades. There was an acute energy shortage in Pakistan since 1990's. There are regular and problematic power outages in Pakistan especially

in the summer months. Since 1990's, there has been lot of pressure to introduce new technologies and capacities to be brought on line to overcomes energy shortage such as renewables. No one can deny the effectiveness of these technologies upon the modernization of industry and the standard of life. Over the last many decades, Pakistan has found that its energy policies are controversial with some limitations.

This paper will provide a strategic framework and policy guidelines that will allow developing near and longer-term objectives for renewable energy. The overarching framework will look into the most suitable renewable energy sources and low-carbon technologies. The objective of this paper is to look at how renewable energy technologies can be implemented and help meet increased energy demand and crises in Pakistan, keeping in view the environmental benefits of it. This paper starts with the conventional sources of energy in Pakistan, introduction of renewable energy technologies in general and in developing countries**,** taking Pakistan as an example. It also explores environmental impacts of renewable energy in order to reduce carbon emissions. Then it presents a comparative analysis with selected developed countries for its implementation. Finally, conclusions and recommendations have been made with policy guidelines for the government to mainstream renewable energy.

1.2. Conventional Energy Resources in Pakistan

Major part of the energy in Pakistan is being generated through conventional sources. In 2005-06, a capacity of 6463 megawatt (MW) has been installed with hydroelectric resources (Mian and Nayyar, 2009). The Mangla and Tarbela are the biggest dams, located in the North part of Pakistan on two different rivers Jhelum and Indus respectively (Haq and Abbas, 2007). There is also a plan for the use of natural gas, nuclear energy, hydroelectricity and renewable technologies to meet energy demand in Pakistan. No country can significantly progress without proper and efficient means of energy. The economy of any country grows with the energy consumption and the energy sources deplete with the passage of time. If the country is facing energy shortage, then it will become a disaster for the whole economy including businesses and the society.

Unfortunately, the same is happening in Pakistan, because of less energy resources and the policy makers not utilizing renewables properly in this part of region in spite of having excessive natural resources for renewable energy production. Pakistan even lacks in conventional energy resources and the demand of energy is increasing rapidly due to high population. There is a huge gap between demand and supply of energy in Pakistan. Pakistan is not able to fulfill its energy demand and will be facing huge conflicts and more deficits about energy in the coming years. The key solution that needs to be implemented is a shift from traditional energy resources to the more environmental friendly and sustainable renewable energy resources (Duffey and Poehnell, 2001). Electricity is being generated in Pakistan mainly from natural gas, hydro and oil up till 2009 as shown in the Figure 1(International Energy Agency, 2011). There is almost no electricity generation from renewable sources of solar, wind, geothermal, biofuels and waste.

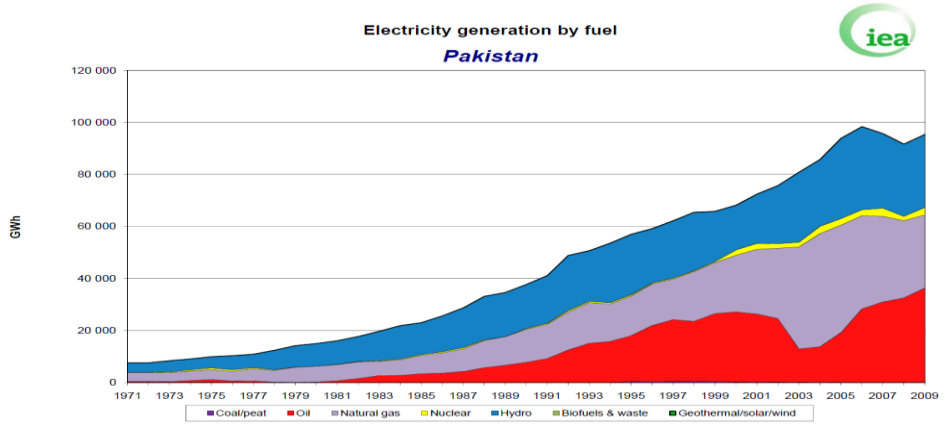

Figure1: Electricity Generation by Fuel in Pakistan (IEA, 2011)

1.3. Renewable Energy Technologies

Renewable energy refers to the energy that occurs naturally and repeatedly in the environment and does not run out unlike the conventional energy from fossil fuels (The Carbon Trust, 2012). By utilizing a range of technologies, renewable energy is produced from renewable sources, mainly for the purpose of replacing the current limited resources associated with fossil fuels as well as in finding economical and sustainable sources of energy. Renewable energy technologies have many long term benefits including energy security, job creation, business opportunities, sustainable development and prevention of global warming (Tükenmez and Demireli, 2012). Renewable energy can cover a wide range of natural energy sources of biomass, geothermal, hydropower (waves, underwater current and flowing water from higher ground), solar (sunlight & sun heat) and wind (Altawell, 2011). Renewable energy developments face a range of socio-technical barriers that require effective strategies in the areas of financial incentives, infrastructure enhancement, regulation reforms, community-centered developments, technology development, workforce investments, information and education programs (Martin and Rice, 2012). These technological interventions have significant environmental impacts which are important to understand the environmental benefits associated with them. By understanding the current and potential environmental issues associated with each renewable energy source, future steps can be taken to effectively avoid or minimize these impacts.

1.4. Renewable Energy in Developing Countries

Developing countries need to promote the use of renewable energy to ensure access for their population to modern and reliable energy supplies. This form of energy can play a vital role in poverty alleviation and encourage sustainable development (Kane, 2007). The inaccessibility of adequate energy sources is one of the biggest challenges being faced by many developing countries in the world. The limited availability of commercial forms of energy reserves in developing countries makes renewable energy very attractive and an important contributor in the future (Khatib, 1993). There is a vast of literature on the potential benefits and prospects of renewable energy technologies in developing countries but it lacks in its implementation which is the real problem. Developing countries, such as Pakistan, may be able to make efficient and considerable progress towards meeting the increasing energy needs of society with a focused program of renewables electricity transmission. It is only possible if projects of renewable energy are encouraged by the policy makers. As per ground realities, there are more constraints and problems in utilization of the solar and wind energy technologies in Pakistan.

According to the report by US National Renewable Energy Laboratory (NREL) it is estimated that the total theoretical potential for installed wind capacity for utility-scale operations of about 130,000 MW, a land- based, large and a wind energy component seems to be possible in principle for future energy production (Hand and Baldwin, 2012). For wind energy technologies, efficient industries are necessary to make blades and turbines for the implementation of wind energy technologies. Similarly in the case of photovoltaic cells, the market should produce these technologies with high impact to improve the quality of life. The renewable industry is not mature and considered to be expensive, so it needs more investment by developed countries (including other sources of capital investment) for the utilization of solar technology with natural resources of sun. In the case of biomass energy, the same problem of under-developed industry and expensive energy technologies exists. Developing countries need to establish their market first. Local populations and the private sector are often insufficiently involved in the implementation of renewable energy projects with a lack of awareness (Kane, 2007). Some developing countries like India and Malaysia are progressing at a good pace by introducing stable industries and effective policies for these renewable energy technologies.

1.5. Environmental Impacts of Renewable Energy

Climate change is an issue, no country can ignore. According to the International Energy Agency (IEA), production from oil and gas reserves will fall by around 40-60 % by 2030. Competition for fossil fuel resources has become a source of international tension and potential conflicts. Even if fossil fuel supplies were infinite, climate change is another compelling reason for an urgent switch to renewable energy (Tükenmez and Demireli, 2012). The global energy sector is responsible for contributing around two-third of world's greenhouse gas emissions. Implementing renewable energy technologies along with the integration of energy saving measures is the best way to achieve carbon emissions reduction (Tükenmez and Demireli, 2012). Renewable energy technologies are supposed to be clean sources of energy and optimal use of these sources of energy reduce environmental impacts, produce minimum secondary wastes and are also sustainable based on current and future economic and social needs. They also provide an excellent opportunity for reducing carbon emissions and mitigating climate change by substituting conventional energy sources (Martin and Rice, 2012).

The impact of climate change on Pakistan is drastic in comparison to the role it plays in causing it (Malik et al., 2012). Pakistan is estimated to have raised carbon emissions from 76 million tons in 1990 to 200 million tons in 2006. It is estimated that CO_2 emissions with an average increase of 6.5% annually will grow to 482 million tons by 2020 (Malik et al., 2012). Energy based emissions are a major source of greenhouse gases and environmental pollution. Technological interventions can provide solutions along with energy saving and efficiency strategies in public and private sectors of Pakistan (Malik et al., 2012). There is an urgent need to implement alternative sources of energy and the urgency of the issue is also connected to the global climate change. By using certain types of renewable energy, it is possible to balance greenhouse gas (GHG) emissions associated with fossil fuels, such as CO_2, which is one of the main causes of global warming (Altawell, 2011). There is an increasing trend of GHGs in different areas (energy, agriculture etc.) of Pakistan till 2050. It is possible to reduce CO_2 emissions by 40% from the Business As Usual (BAU) scenario by employing cleaner energy technologies (Khan, 2011). Present policy instruments have flaws and climate change is low on the priority agenda and thus remains unimplemented (Sheikh, 2008).

It is unfortunate that Pakistan's government is not serious about an energy future that is sensitive to the climate change challenge as per its energy plan of 2030 (Mian and Nayyar, 2009). Pakistan is facing a serious energy crisis and will be unable to meet energy demand and thinking about environmental impact of fossil fuels based energy is out of question at the moment. The energy from renewable sources can respond to both of the strategic issues if they are taken seriously. Greenhouse gas emissions are directly related to climate change and some of its impacts on Pakistan include rise in sea level, GDP decrease, un-seasonal rains, temperature rise, decrease in crop yield, diseases, social inequalities and glacier melting (Khan, 2011). Renewable energy can offer significant environmental, social and economic benefits for sustainable development. For these reasons, renewable energy is becoming more attractive from an economic and a strategic point of view because it is produced under local control; the use of renewable energy ensures increased security of supply and can result in greater energy price stability for businesses, making it easier to predict future energy costs (The Carbon Trust, 2012).

1.6. Current State of Renewable Energy in Pakistan

Pakistan has historically seen itself as energy poor country and its energy policies have seen huge political problems. There have not been positive achievements in renewable energy development. The performance of the Pakistan Council of Renewable Energy Technologies (PECRT) has been quite poor and it has not been able to complete anything more than minor demonstration projects (Mian and Nayyar, 2009). In May 2003, Pakistan set up an Alternative Energy Development Board (AEDB) and it developed a draft of renewable energy policy that aims to encourage investment in various renewable energy technologies. It has set several ambitious targets that renewable energy resources should be 10% of primary commercial energy supply by 2015 and 2% of all investment made in the energy sector should be

dedicated to the development of renewable energy technology base in Pakistan (Mian and Nayyar, 2009). The government of Pakistan has promised to promote energy efficiency and renewable forms of energy at all levels in order to achieve self-reliance in energy in its National Environment Policy which was developed in 2005 (Government of Pakistan, 2005). The government of Pakistan has implemented various energy policies between 1985 and 2002 for employing renewable energy resources but none provided a sound framework for the implementation of projects. Unfortunately these policies failed to attract private sector confidence and investment opportunities (Khattak et al., 2006).

There are very small activities of renewable energy production in Pakistan and there is significant research carried out in this area with lack of implementation. Pakistan may be able to make significant progress towards meeting the expected higher energy demand with a focused program of energy conservation, energy efficiency and renewable energy technologies. The energy plan for 2030 includes a major commitment to the development of renewable energy technologies. The Clean Development Mechanism (CDM) has been in Pakistan for last few years to help in implementing major projects. There has not been much top level government support and commitment on renewable energy technologies. The sources like wind, solar, geothermal, oceans, biomass and fuel cells technology can be used to overcome current energy shortage in Pakistan (Chaudhry et al., 2009).

1.7. Renewable Energy Resources in Pakistan

The importance of renewable energy resources cannot be ignored for the progress of developing countries. For many decades, Pakistan has not shown significant progress in renewable technologies. Photovoltaic technology is not very common in Pakistan, even in 2013. Solar photovoltaics, wind turbines and hydro turbines in Pakistan are usually imported from developed countries. Renewable energy resources such as wind and solar are abundant in Pakistan and show significant technical potential to meet energy needs, but the development of renewable energy technologies is facing many social, economic, technical, institutional and informational barriers (Yazdanie, 2010).

Photovoltaic (PV) is a promising technology that may allow the generation of electrical power on a very large scale. Worldwide photovoltaic production was more than 5GW in 2008, and is expected to rise above 20GW by 2015 (Atwater and Polman, 2010). Photovoltaics could make a considerable contribution to solving the energy problems that our society is facing. There are many types of solar cells being studied, mainly named as 1^{st}, 2^{nd} and 3^{rd} generation solar cells to help increase efficiency and reduce cost. One of the most challenging problems to harvest light as much as possible is being taken under the field of plasmonics. The energy resource of hydropower is a well known energy technology in Pakistan and there is a lot of potential in the field of hydro projects. On a small scale, hydro power of few megawatts can be established to specific sites and location in Pakistan. Hydro-potential is estimated to be about 50,000 MW out of which 6595 MW has been developed over the past 50 years (Haq and Abbas, 2007). Pakistan is a country which is blessed with highest solar insulation around the globe. Maximum solar radiations and intensities are observed in central Punjab, usually an average intensity of 5.5 KW/m^2 has been found on a daily basis (Mian and Nayyar, 2009). This potential of solar energy can be used to produce enough electricity which can be provided to off-grid communities in the Northern hilly areas, the Southern and Western deserts of Pakistan. There is similar intensity of sun in the region of Balochistan, which makes this technology efficient and energy productive. Wind energy is a very significant area where Pakistan can get benefits and utilize it in efficient manners. In Pakistan, there are some regions in the mountainous and hilly areas which have the potential for wind energy generation, also for wind farms. The urban areas of Pakistan usually generate over 55,000 tons of solid waste daily. This solid waste can be utilized for conversion of biomass energy (Boyle, 1996). The Government of Pakistan (2006) has also produced a summary of the potential and current state of renewable energy in Pakistan (see Table 1).

Table 1: Potential and Status of Renewable Energy in Pakistan (Government of Pakistan, 2006)

Resource	Potential	Status (2006)
Hydro	The total hydroelectric potential in Pakistan has not been fully investigated, but conservatively estimated to be 45,000 MW. This consists of all sizes of hydropower plants.	Pakistan has an installed hydroelectric capacity of 5928 MW of large (>250 MW), 437 MW of medium (>50 MW and <250 MW), and 253 MW of small to micro (<50 MW) plants, mostly in the northern parts of the country. This amounts to 6,608 MW of total capacity.
Wind	Commercially exploitable wind resources exist in many parts, especially in southern Sindh and coastal Balochistan, with monthly average wind speeds exceeding 7-8 m/s at some sites along the Keti Bandar- Gharo corridor.	No commercial wind farms in operation. Some micro-wind turbines pilot tested for community use.
Solar: Photovoltaic (PV) and thermal	Much of Pakistan, especially Balochistan, Sindh, and Southern Punjab receives abundant solar irradiation on the order of over 2 MWh/m^2 and 3,000 hours of sunshine a year, which is at the highest end of global insulation averages.	Negligible use in niche applications. No significant marketing of rooftop PV or household and commercial thermal systems.
Biomass: Bagasse, rice husk, straw, dung, municipal solid waste	Pakistan's large agricultural and livestock sector produces copious amounts of biomass in the form of crop residues and animal waste, such as bagasse, rice husk, much of which is currently collected and used outside the commercial economy as unprocessed fuel for cooking and household heating. In addition, municipal solid waste produced by a large urban population is also available.	Sugar mills in the country use bagasse for cogeneration purposes and have recently been allowed to sell surplus power to the grid up to a combined limit of 700 MW. No other significant commercial biomass-based technology is presently employed for energy production in the country beyond experimental deployment of biogas digesters, improved cook stoves, and other small scale end-use applications.

1.8. Comparative Analysis with Developed Countries

There has been significant research conducted on the potential of renewable energy technologies in Pakistan which seriously lacks in its implementation and currently, it is a matter of governance. This section provides a comparative analysis of Pakistan with leading developed countries in the field of renewable energy. It will help Pakistan learn lessons and best practices on how renewable energy can be a mainstream part of the energy strategy. In order to promote an effective and sustainable development of renewable energy, Chinese government has formulated a series of policies on renewable energy development, including laws, regulations, economic encouragement, research and development, industrial support and government renewable energy model projects (Peidong et al., 2009). Denmark has converted their present energy systems into a 100% renewable energy system. It is concluded that such large-scale renewable energy development is possible if the government develops strategies for integrating renewable in coherent energy systems influenced by energy savings and energy efficiency measures (Lund, 2007). Primary supply of energy is not sufficient to meet present demand of society. So, being an under developed country, Pakistan is facing a serious challenge of energy deficiency in all walks of life.

Observations based on reviewing the climatological cycles, geological set up, industrial activities, geographical position and rural activities; there are bright prospects for the implementation of various

renewable energy resources which include micro, macro and mega level projects in hydal, wind, solar and biomass. Even these renewable energy resources can aid to standardized life of urban areas in this region. In comparison with developed countries, France has a feed-in tariff of EUR 8.2 c/kWh to 2012, which will then decrease (UK Energy Research Centre, 2006). Germany is very much progressive in renewable energy technologies around the globe. Germany has Renewable Energy Sources Act that gives priority to power dispatch and grid access. It is regularly amended to adopt feed-in tariffs to market conditions and technological developments. For wind energy, an initial tariff applies for up to 20 years and then reduced to a basic tariff of EUR 5.02 c/kWh. The initial tariff is EUR 9.2 c/kWh for onshore wind and 15 c/kWh for offshore wind from January 2009. The combined subsidy from consumers and government is EUR 5 billion per year - for 7.5% of its electricity (Global Wind Energy Council, 2008). Similarly, Denmark has a very wide range of incentives for renewables technologies, particularly for wind energy. It has a sort of 'Green Certificate' scheme which transfers the subsidy cost to consumers.

If there is a drop in wind intensity, back-up power is brought from the Nordic power pool at the same rate. Similarly, any surplus wind power that is sold to the pool at the prevailing price which is sometimes zero. The net effect of this is growing losses as wind capacity expands. Similarly**,** Italy legislated to provide EUR 18 c/kWh on a quota system for wind power technology in 2008 (European Commission, 2008). Spain has different levels of feed-in tariffs depending on the technology used either solar, wind or other renewables. In European countries, the tariffs for renewables are adjusted usually every four years. Greece has a feed-in tariff of 6.1-7.5 c/kWh whereas Netherlands relies on exemption from energy taxes to encourage renewable technologies (European Wind Energy Association, 2011). The UK has Feed-in-Tariffs (FiTS) and Renewable Heat Incentives (RHIs) to encourage solar technology. Meanwhile a specific indication of the cost increment over power generation from other sources is given by the 4.5 - 5.0 p/kWh market value for the Renewables Obligation, by which utilities can cover the shortfall in producing a certain proportion of their electricity from renewables by paying this amount and passing the cost on to the consumer (Laughton, 2002). Sweden subsidies renewables, principally large-scale hydro by putting tax on nuclear capacity, which works out about EUR 0.67 cents/kWh from 2008. For wind, there is a quota system requiring utilities to buy a certain amount of renewable energy by purchasing certificates (Global Wind Energy Council, 2008). Similarly, in a developing country like India, 10 out of 29 states have feed-in tariffs, e.g. 2.75 times the tariff for coal-generated power in Karnataka, plus a Federal incentive scheme paying one third of the coal-fired tariff (Settle, 2013). Small-scale PV input is encouraged by high feed-in tariffs even in different European countries.

1.9. Conclusion and Recommendations

Renewable energy is an underdeveloped subject in Pakistan. It is because of the lack of motivation, government support and leadership at a political level. There has been some interest by researchers to explore renewable energy resources to meet the energy demand. It seems like different bodies have started talking about renewable energy in Pakistan but it is in its very early stage and it will take a lot of time to be in full implementation. It is the time to act now on urgent basis. There is a huge gap between policy interventions and the implementation. Energy savings and efficiency are a big part of the answer and the development of renewable energy is another. There are various research and development institutions and national/international agencies in Pakistan working in the area of renewable energy which is a positive sign. But it is very hard to see how Pakistan will arrange funds to invest in capital intensive renewable energy projects. It is quite appropriate that renewable energy technologies and the targets at national and provincial level form part of a successful energy strategy. This study has made a novel contribution in order to develop improved understanding of renewable energy development in Pakistan detailing what actions must be taken to overcome massive energy crises in an environmental friendly way, also mitigating the challenge of climate change. It is expected that following recommendations and policy guidelines would be helpful for the improvement of renewable energy development in Pakistan:

- It is evident that sufficient renewable energy resources exist in Pakistan. The main lesson learnt is that current policy objectives will not meet the desired goals and additional policy measures are required to meet renewable energy development in Pakistan at national, provincial and local level with good governance. Feed-in-tariffs (FiTs) and Renewable Heat Incentives (RHIs) can be effective policy tools to drive this agenda.
- There is a need for a regulatory framework and support mechanism to encourage renewable energy in both domestic and non-domestic sectors, including public and private sectors. Mainstreaming climate change into strategic decisions at all levels will be effective.The main aim of the energy policy should be energy savings, improvement in energy efficiency and then renewable energy implementation strategy. The government as prominent energy consumer should lead by example.
- Learning the lessons and best practices on renewable energy production from developed countries with collaborative approach identifying what has worked and what didn't work and why.
- It needs a comprehensive and well defined national energy policy looking into meeting the energy demand through renewable energy sources with ambitious, but realistic targets and strategies to meet those targets. Investment in renewable energy technologies will construct the pathway for a secure and continuous supply of energy to the society and a possible research theme in future.
- There is a huge gap between renewable technology researchers and the industry. There should be linkage between these two and all key stakeholders must be engaged in the process. The government should develop customer friendly policies to facilitate the renewable energy market. The education sector should also conduct training and development programs on renewable energy technologies to develop public ownership and skilled workforce.

1.10. References

Altawell, N. (2011). Renewable Energy: Brief General Introduction. *Center for Energy, Petroleum and Mineral Law and Policy (CEPMLP)* – Dundee University.

Atwater, H.A. and Polman, A. (2010), "Plasmonics for improved photovoltaic devices", *Nature Materials*.

Boyle, G. (1996), *Renewable Energy - Power for a Sustainable Future*, Open University, UK.

Chaudhry, A., Raza, R. and Hayat, S. (2009). "Renewable energy technologies in Pakistan: Prospects and challenges", *Renewable and Sustainable Energy Reviews*, Vol. 13**,** No. 6-7, pp. 1657-1662.

Duffey and Poehnell. (2001). *Hydrogen production, nuclear energy and climate change*, Vol. 22, No.3, CNS Bulletin.

European Commission, (2008). Italy – *Renewable Energy Fact Sheet, European Commission (EU)*, Brussels, Belgium.

EWEA .(2011). Annual Report 2011 - *The European Wind Energy Association (EWEA)*, Brussels, Belgium.

Global Wind Energy Council (GWEC), (2008), *Annual Report, GWEC*, Brussels, Belgium.

Government of Pakistan, (2006). *Policy for Development of Renewable Energy for Power Generation, Ministry of Water and Power*.

Government of Pakistan, (2005). *National Environment Policy, Ministry of Environment*, Pakistan.

Hand, M.M. and Baldwin, S. (2012), *Renewable Electricity future study: Renewable Electricity generation and storage technologies*, National Renewable Energy Laboratory (NREL), USA.

Haq, I and Abbas, S.T. (2007), Sedimentation of Tarbela and Mangla reservoirs; *Pakistan Engineering Congress, 70th Annual Session Proceedings*, Pakistan.

International Energy Agency, (2011). *Electricity generation by fuel in Pakistan: IEA Energy Statistics***.**

Khan, M. A. A. (2011). *National Economic & Environmental Development Study (NEEDS)*, ENVORK: A Research and Development Organization.

Khan, A.N., Ghauri, B.M., Jilani, R. and Rahman, S. (2011). "Climate change: Emissions and sinks of greenhouse gases in Pakistan", *Symposium on Changing Environmental Pattern and its impact with Special Focus on Pakistan,* Lahore, Pakistan.

Kane, M.M. (2007). "An African view: renewables in Senegal", *Proceedings of a conference organised by the European Office of the Konrad-Adenauer-Stiftung and the East West Institute*, 28 February, Brussels, Belgium.

Khatib, H. (1993). "Renewable energy in developing countries", *International Conference on Renewable Energy - Clean Power 2001*, 17 - 19 November 1993, London, UK.

Khattak, N., Hassnain, S. R., Shah, S. W. and Mutlib, A. (2006), "Identification and Removal of Barriers for Renewable Energy Technologies in Pakistan", *International Conference on Emerging Technologies (ICET)*, pp. 397-402.

Lund, H. (2007). "Renewable energy strategies for sustainable development", *Energy, Vol*. 32**,** No. 6, pp. 912-919.

Laughton, M.A. (2002). Renewables and the UK Electricity Grid Supply Infrastructure, Platts Power in Europe.

Martin, N. J. & Rice, J. L. (2012), "Developing renewable energy supply in Queensland, Australia: *A study of the barriers, targets, policies and actions", Renewable Energy*, 44**,** pp. 119-127.

Malik, W., Shahid, H., Zafar,R., Zaheer Uddin, Wazir, Z., Anwar, Z., Khattak, J.Z.K. and Ali, S.S. (2012). "Role of Pakistan in Global Climate Change through Greenhouse Gas Emissions (GHGs)." *Research Journal of Environmental and Earth Sciences*, Vol. 4, No. 11, pp. 996-1001.

Mian, Z. and Nayyar, A. H. (2009). Pakistan and the Energy Challenge, Chernobyl +20: *International Perspectives of Energy Policy and the Role of Nuclear Power*.

Peidong, Z., Yanli, Y., Yonghong, Z., Lisheng, W. and Xingprong, L. (2009). "Opportunities and challenges for renewable energy policy in China", *Renewable and Sustainable Energy Reviews*, Vol. 13**,** No. 2, pp. 439-449.

Paziorek, P. (2007). "Renewables and development: the German perspective", *Proceedings of a conference organised by the European Office of the Konrad-Adenauer-Stiftung and the East West Institute*, 28 February, Brussels, Belgium.

Sheikh, A.T. (2008). "Challenge of Climate Change: Pakistan's carbon emissions continue to grow at an increasing rate", *Daily DAWN*, Pakistan.

Settle, K. (2013). *India Combats Energy Poverty through Renewable Sources*, India.

The Carbon Trust. (2012). *Making sense of renewable energy technologies*. London, UK.

Tukenmez, M. and Demireli, E. (2012). "Renewable energy policy in Turkey with the new legal regulations", *Renewable Energy*, Vol. 39, No. 1, pp. 1-9.

UK Energy Research Centre. (2006), The costs and impacts of Intermittency, *UK Energy Research Centre*, UK.

Yazdanie, M. (2010). "Renewable Energy in Pakistan: Policy Strengths, Challenges & the Path Forward", *Energy Economics and Policy*, ETH Zurich, Switzerland.