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Review

Economic Analysis of the Production of Electricity Generation and Fuel Oil from Different Renewable Resources in Pakistan

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Abstract. Pakistan is in the list of those countries which are facing huge energy crisis chronologically. Capacity of electricity generation from main resources is declining due to improper maintenance. Conventional resources are also depleting with the passage of time causing increase in cost of power generation. Keeping in view of these issues, other renewable resources of power generation should be taken into consideration. Pakistan is an agricultural land therefore, it is rich in some of the renewable resources of energy like biomass e.g., rice husk, wheat straw and domestic plastic waste that can be utilised to produce power by application of certain available technologies. Similarly, use of plastic waste to produce diesel is increasing day by day and its disposal is going to be a great challenge in future. This research is basically an economic review focusing on the cheap cost of electricity and diesel if above mentioned renewable resources are utilised.

Keywords. economic analysis, gasification, pyrolysis, biomass, electricity, diesel

Introduction

Pakistan is in the list of those countries of the world who are facing huge energy crisis. Energy demand and supply gap is increasing in chronological way every year (Amjid *et al*., 2011). Due to the war against terrorism in northern areas of Pakistan, risk of depletion of the energy resources increased tremendously and overall economy of the country is affected very much (Qureshi *et al*., 2003; Noman, 1988). Among various problems in Pakistan, electricity shortfall is the most challenging and major problem which is directly influencing and declining the business opportunities at larger and smaller scales (Jamil, 2013; Siddiqui *et al*., 2008). Local and foreign investors are showing lack of interest for doing investment because of energy crisis. At domestic level electricity short fall is increasing and especially in summer season it increases tremendously (Newsham and Bowker, 2010; Hammer *et al*., 1982). Besides some political reasons, major reason is the decrease in conventional resources of energy. Major resource of electricity in Pakistan is through hydal resources. There are total two major dams "Tarbela Dam' and "Mangla Dam" which are working at their full capacity for contribution in electricity generation (Tariq and van de Giesen, 2012; Myers, 1997; Frost, 1973). Some dams are working at very small capacity and their contribution in electricity generation is not sufficient enough. Due to increase in population, improper maintenance and declining level of water each year in these dams their capacity is decreasing which ultimately leads to great electricity shortfall (Hayat, 2007; Qureshi, 2005). If no attention would be given to these dams, then a great threat of complete depletion of electricity will happen in upcoming years (Kessides, 2013; Kugelman, 2013).

In the light of the above discussion, it is very important to generate power through different resources available in Pakistan. For this purpose, initiative has been taken towards the electricity generation through renewable resources (Sheikh, 2010; Sahir and Qureshi, 2008). Pakistan is considered an agricultural country because 70% of population depends upon agricultural outcome. Therefore, there are variety of renewable resources available in Pakistan in abundant quantity (Amer and Daim, 2011; Mirza *et al*., 2010). Among these renewable resources biomass are of great importance. These biomasses include rice husk, wheat straw and corn cob etc. (Bhutto *et al*., 2011; Mirza *et al*., 2008; Bhattacharya and Salam, 2002). Similarly, other renewable resources include waste plastic, waste wood and waste paper which can be used for fuel production (Batool and

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Chuadhry, 2009; Shekdar, 2009; Batool *et al*., 2008; Khan and Abu-Ghararah, 1991). Huge quantity of food waste and cloth waste is generating per day which can also be used for this purpose. Hence, besides power generation other advantage is effective waste management which ultimately helps in pollution reduction (Sthiannopkao and Wong, 2013; Polprasert, 2007; Dinda, 2004). Although research work has been done for the development of the technology for power generation using these renewable resources but all these technologies are applied at very small scale. Further and extensive research is required in this area for the application on these technologies on massive scale (Sahir and Qureshi, 2008; Berndes, 2002). The major purpose of this review is basically to enlighten the importance of these technologies on the enhancement of overall economy of Pakistan and also its cheaper cost as compared to conventional resources of electricity which reduces a huge burden of consumers for their electricity charges. On massive scale this technology is capable enough to contribute in overall electricity load of Pakistan (Khan, 2015; Khan *et al*., 2015).

Overview of different renewable energy technologies. ***Gasification technology***. In gasification, agricultural waste (biomass) is converted into different gases. These gases are collectively known as producer gas and its composition is given in Table 1 (Fermoso *et al*., 2009). There are two major categories of gasification technology which are "Producer gas production through direct firing" and "production of gases through gasification systems". In direct firing producer gas is generated by direct application of heat in fluidized bed boilers and stocker boilers while in gasification system fixed bed gasifiers and fluidized bed gasifiers are used. Normally direct firing systems are preferred because of its low capital and installation cost. Biomass which serves as a fuel in direct firing systems are burnt for steam production which is used to run steam turbine for electricity production. Basically, biomass is heated in such an environment where it is converted into combustible gas with high energy content in the form of heat, which is further used for different purposes. According to survey reports almost 1232011 tonnes per year of biomass is produced in Pakistan (Mirza *et al*., 2008). Capacity of electricity generation through these systems are between 30-50MW (Laurikka, 2006; Dasappa *et al*., 2004; Morris and Waldheim, 1998).

Table 1. Composition of gasification product

Nitrogen	50-60%
Carbon dioxide	8-11%
Carbon monoxide	17-19%
Methane	14-18%
Hydrogen	13-17%
Gross calorific value	900-1100 kcal/m^3

Production of biogas through anaerobic digestion process. Production of gases from animal dunk/manure provides a great advantage to the rural population in Pakistan. Now a days Pakistan is suffering from a natural gas shortage because of declining gas reserves and chronological increase in population. Biogas usage is not only economical but also helps in reduction of all types of animal waste making clean and green environment. Biogas production requires a lot of field work which includes collection and transportation of animal waste on continuous basis. Biogas is basically a good substitute to a natural gas mostly used at domestic level for cooking and lighting. It is very attractive source for local farmers for additional income. Animal manure is mixed with water in a specific proportions and some settling time is given. Bacteria which are present inside the manure oxidize the organic matter inside manure which results in the production of biogas. Bacteria oxidize the organic matter through digesting them in the absence of air, therefore it is also known as anaerobic digestion. The biogas plant is not only used for energy generation but also its byproduct which is known as substrate is a very good natural fertilizer (Amjid *et al*., 2011; Weiland, 2010 Chen, *et al*., 2008; Gunaseelan, 1997; Nazir, 1991;). Literature reveals that biogas has the potential of producing 23,654 GWH of electricity from 368434650 tonnes per year of manure (Amjid *et al*., 2011). The composition of biogas produced through digestion process is given in Table 2 (Zhang *et al*., 2007).

Energy generation through pyrolysis. Pyrolysis is the thermal decomposition of carbonaceous material in the absence of oxygen to produce char, gas, and a liquid product rich in oxygenated hydrocarbons. In general, pyrolysis is performed using a range of temperatures and residence times to optimize the desired product. The biomass is heated to approximately 500 °C in less than 1 sec and then rapidly cooled to stop the reaction. The liquid product, known as bio-oil, is obtained in yields up to 75% by weight on a dry feed basis. It can also be upgraded to lower the oxygen content and transported using the same trillion-dollar infrastructure used by the oil industry. In addition to being transported and stored at a lower cost than solid biomass, bio-oil

and upgraded oil can be used in applications ranging from value-added chemicals to transportation fuels. Although pyrolysis can produce considerable amount of bio-oils, their direct applications as fuels are limited by the problems of high viscosity, high oxygen content and corrosion, as well as their thermal instability. Therefore, bio-oils should be upgraded using proper methods before they can be used in diesel or gasoline engines (Yang, *et al*., 2007; Mohan *et al*., 2006; Miao and Wu, 2004; Adjaye and Bakhshi, 1995; Shafizadeh, 1982).

Feasibility survey and cost comparison. Cost comparison has been discussed on rice husk, waste wood and domestic plastic waste. Rice husk, and waste wood is discussed for the production of bio-diesel through gasification technique while the cost for bio-diesel production through plastic waste is discussed through pyrolysis process(Lynd, 1996). One unit of electricity requires 0.08 liters of diesel, 1.1 kg of wood and 1.4 kg of rice husk. Currency value used here is Pakistani rupees (PKR) (Mirza *et al*., 2008).

From the comparison in Table 3 it is quite clear that biomass usage for electricity generation is a very good substitute to conventional resources. It is not only less in price but also abundantly available. Here cost comparison is showed both in combination of biomass with diesel for the production of electricity and independent usage of biomass. Independent usage of biomass or in combination with conventional fuel depends upon the circumstances. Due to geographical

Table 2. Composition of biogas from different types of manure

Type of manure	Organic composition	C/N ratio	Dry matter %	Veterinary safety (% of dry matter)	Biogas yield m^3/kg	Physical impurities	Unwanted matters
Pig slurry	Proteins, Carbohydrates Lipids	3-10	3-8	70-80	0.25-0.50	Wood shavings, bristles, water, sand, straw	Antibiotics, Disinfectants
Cattle slurry	Same as above	6-20	5-12	80	0.20-0.30	Bristles, soil, water, straw, wood	Antibiotics, Disinfectants, NH_4^+
Poultry slurry	Same as above	3-10	10-30	80	0.35-0.60	Grit, sand, feathers	Same as above

Table 3. Cost comparison for electricity generation when diesel and biomass used together

Description	Amount of fuel required per unit of electricity	Price of fuel in PKR	Total cost per unit of electricity in PKR
Fuel	----------	----------	----------
Diesel	0.08 liter	72.52/liters	5.8016
Wood	1.1kg	6/kg	6.6
Rice husk	1.4kg	3.5/kg	4.9
Total fuel cost when diesel and wood used together	----------	----------	12.4016
Total fuel cost when diesel and rice husk used together	----------	----------	10.7016
Cost of unit of electricity when only diesel used (1 liter of diesel is equal to 3.5 units of electricity)	----------	----------	20.72

Table 4. Cost estimation for production of fuel oil from plastic waste

Input	Quantity (Input kg)	Rate per kg	Amount Pakistan rupees	Output	Quantity produced (liters)	Rate in Pakistan rupees/L
Plastic	1.00	12.00	12.00	Petrol	0.300	19.50/0.3 = 65
Labor	-------	-------	5.00	Fuel oil	0.600	19.50/0.6 =32.5
Service Charges	-------	-------	2.50	Lube oil	0.100	19.50/0.1 =195
Total	1.00	-------	19.50	------	1.00	------

conditions and some certain constraints in some areas of Pakistan, biomass is not abundantly available or its availability is limited due to some transportation issues. In this case biomass is used in combination with diesel for power generation (Khan, 2015). In Table 4 (Khan *et al*., 2015) cost analysis is carried out for the production of bio-diesel from the domestic plastic waste.

Plastic waste is used because of its readily availability. Further its disposal problem is going to be a bigger challenge so its utilization for useful purpose is very much important. Hence, it is converted into biodiesel through pyrolysis process.

Basis = 1000 Tonnes/day plastic
Fuel oil produced per day = (1000) × (1000) × 0.6 = *600000 L/day
* = kg of plastic is approximately taken equal to liters of plastic for ease of calculation.

Conclusion

From above discussion it is quite obvious that power generation from biomass resources are very cheaper and affordable in price. Energy demand and supply gap can be reduced very easily if initiatives are taken at government level for development of these projects on domestic and industrial scale. These projects are so far applied on small scale so further initiative is required for application of these projects on large scale.

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