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235. Comparative Study of Diesel and Bi-fuel Water Pumping System

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Abstract

Nowadays, energy crisis and volatility of fuel price badly affect the economy of the country, including the agriculture sector of Pakistan. The agriculture sector is the backbone of Pakistan's economy. There is a huge potential of biomass in agricultural countries like Pakistan, which can solve this problem easily.

This research work presents comparative analysis between conventional diesel water pumping system and Bi-fuel water pumps in a village of Mirpurkhas for irrigation. Diesel engine can switch on Bi-fuel blend easily (biogas 90%+diesel 10%) which can use in existing engines with minor modification at low cost.

Annual fuel savings of the proposed system has been estimated as 5,470 litres and annual fuel cost saving Rs.626, 787. The simple and equity payback periods have estimated as 0.3 years. Annual reduction in GHG emissions has been calculated as 6.6 tCO_2.

Therefore, this study concluded that the proposed water pumping system is more economical and eco-friendly than existing conventional diesel pumping system.

Keywords: *Bi-Fuel, Biogas, Water Pumpimg System, RETScreen*

1. Introduction

Pakistan is an agrarian country and the agriculture sector is being contributing 21% share to GDP and employing 44% of the workforce [1].In country, 1.1 million tube wells are installed to fulfil the water necessity for irrigation, where out of which 25% are grid electricity, where 75% are diesel-based [2].
Nowadays, Pakistan is facing the energy crisis by widening supply and demand gap, oil transporting and storage and volatility in fuel price. The Primary commercial energy supply mix during the year 2011-12 did not change much when compared to the previous year. The share of each source was oil: 30.8%, gas: 49.5%, LPG: 0.5%, coal: 6.6%, hydroelectricity: 10.5%, nuclear electricity: 1.9% and imported electricity: 0.1% [2, 3]. The share of the transport sector is 31% in the consumption of energy, which included agriculture diesel consumption. It badly effects on the environment and increment in the fuel taxes indirectly distress economy [3].
The data of carbon emission in Pakistan estimated through econometric technique referring by different theories, from year 1975 to 2010. The result shows that along with all the agricultural technologies, agriculture sector shares largest part in CO_2 emission. [4]
Biogas is an outstanding and economical fuel to both petrol and diesel engines. Dual fuel engine is flexible in switching over Bi-fuel blend to pure diesel and vice versa. The dual fuel engine started on diesel fuel only after that switch to biogas at the required rate [5].
Diesel engines are installed in large quantity for water pumping on irrigated fields, which can easily switch to methane gas by modifying the engine externally only which have; gas choke to regulate fuel and air pipe to inlet the fuel at the suction stroke[5]. It does not require internal modification hence does not use higher capital cost.

As an agricultural and populous country, Pakistan has numerous sources of biomass, which is more suitable for power generation in this meantime. The main sources of biomass are agricultural residues, animal waste and municipal solid waste [6]. In Pakistan, biogas has the potential of 5.97 MTOE annual energy output. [7]
The dairy waste is the substantial area of power generation. The technology uses to dig out energy from cattle and dairy waste through biogas production by using anaerobic or aerobic digestion process. This is well entrenched in our society. The other advantage of this technology is that, it can be used on CHP system and its by-products can be used as fertilizer. The manure produced in Pakistan as shown in Table I.

Headings of tables should be placed above tables, centrejustified. Leave one line space between the heading of the table and the table. Only horizontal lines should be used within a table, and tables should look like the following example:

Table 1.Manure production average data of Pakistan (Aziz et al, Dawn economics, 2013, Pakistan

Year	Dairy Manure produced (Tonnes/year)
2006-07	322,039,500
2007-08	333,044,250
2008-09	344,443,200

Although, installation of large centralized biomass power plants is difficult, so we can overcome this problem by using small power plants. This is the only way to overcome energy crisis at low cost with environmental benefits.

Biogas has proved as one of the best renewable energy sources. Biogas consists of 50-70% methane (CH_4), 30 35% carbon dioxide (CO_2) and traces other gases [8, 9]. Anaerobic digestion involves the degradation and stabilization of organic materials under anaerobic conditions by microbial organisms and leads to the formation of biogas (a mixture of carbon dioxide and methane, a renewable energy source) and microbial biomass. The anaerobic digestion process contains organic matter in a covered tank in the absence of oxygen takes place to produce biogas[10,11].

2. Existing Water Pumping System

Data of wells collected from different departments such as Agricultural Engineering, Sindh Irrigation and some private contractors. After considering different factors, one well selected for analysis, which was operated on diesel fuel with following parameters as in Table.2. In the research village khan was selected for a model with suitability. Diesel price is selected by Government of Pakistan, 2014 that is 114 Rs/litre.

Table 2.Data of water well (Agricultral Engineering Department, Sindh)

Well Location	Khan, Mirpurkhas
Use	Irrigation
Depth (ft)	55
Static suction Head (ft)	50
Total Head (ft)	70
Water demand of Village (gpm)	1000
Delivery pipe (in)	6
Pump (local manufacturing)	Vertical Turbine Pump
Impeller size (in)	7

Table 3.Engine specification (Agricultral Engineering Department, Sindh)

Engine rating	19kw @ 2200RPM
Using	6hr/day in a week
Coupling	connected by V-belt (c-190)
Annual operational hours	2,190
Fuel consumption rate	3lit/hr
Annual fuel consumption	6,570 lit
Annual fuel cost	Rs 748,980
Engine rating	19kw @ 2200RPM
Using	6hr/day in a week

3. Proposed Water Pumping System

This proposed system presented the project idea to switching a diesel engine system to bi-fuel for the

under discussion water pumping system of the selected village. There is a large amount of organic waste being produced and possibly polluting the water supplies due to the presence of parasites and pathogens in the animal dung along with the added responsibility of disposing the waste. Simply using the waste as fertilizer on the field will pollute the water and may transmit diseases, lowering the quality of health on the village. So, it is better to build an anaerobic digester to produce biogas for power and end products for fertilizers.

It is possible to run a diesel engine on a bi-fuel (biogas/diesel) blend, [e.g., 90% biogas, 10% diesel] by using a modified diesel engine. The engine runs by injecting biogas into the engine on the air intake stroke (since the methane does not ignite upon compression). The diesel is injected and ignited, which then ignites the biogas, effectively acting like a spark plug. There is no need to internal modification of CI engine [12].

Biogas can be used in both spark ignition and compression ignition engines. The exact amount needed depends upon the methane content of the biogas. Biogas will not self-ignite in a diesel engine. Therefore, it is necessary to use a little diesel (approximately 10 per cent) to ignite the fuel. The biogas enters the engine via the air inlet system, after the air filter. This needs a small modification to the air intake system. After the conversion, the engine nominal output is not de-rated.
For this purpose use RETscreen4 software, which is available free of cost for economic and environmental analysis.

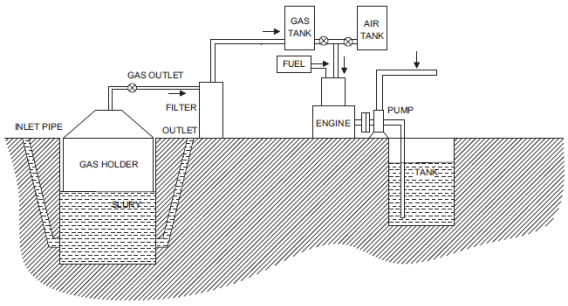
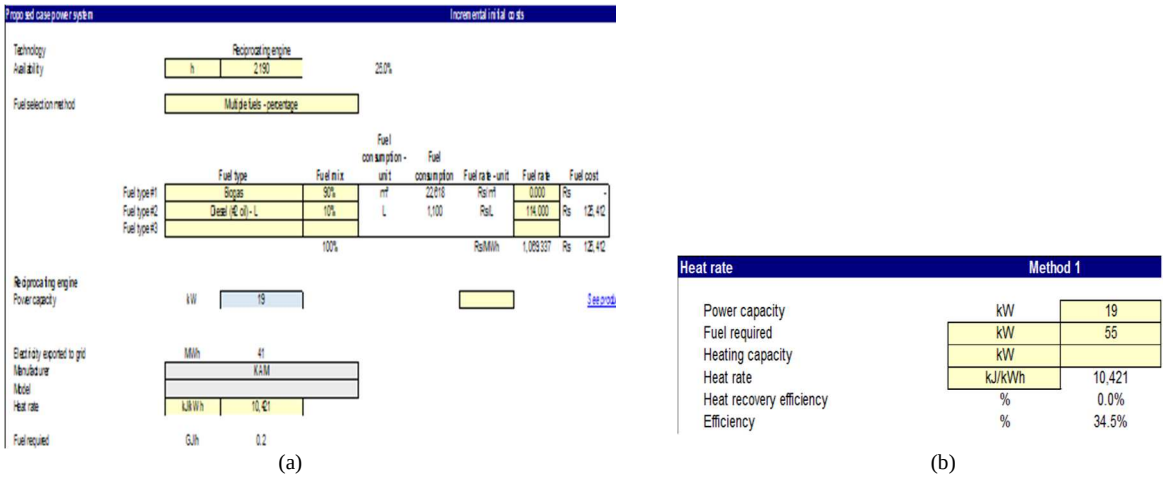


Fig.1. Layout of Bi-fuel water pumping system, source: Gopal et al, Renewable energy source water pumping systems-A literature review

3.1. Fuel Composition and Biogas Production

The 19KW of power engineis installed and annual operational hours are 2190 hrs. The diesel fuel price is 114 Rs/litre (GOP, 2014) as per discussed in existing pumping system. The software calculates the heat rate 10,421kj/kwh at higher calorific value by using fuel rate and power. The annual fuel required is as biogas 22, 618 m^3 and 1,100 litres diesel.



(a) (b)

Fig. 2. Energy Analysis by RETScreen4

The biogas produce by the bio waste, here we only consider dairy waste of the village and the quantity of dairy animals are 100.

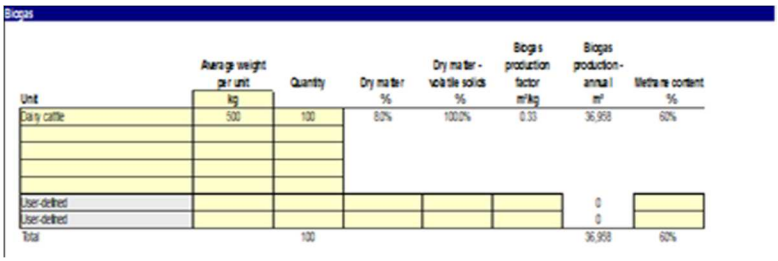


Fig.3. Biogas production evaluation by RETScreen4

3.2. Emission Analysis

Emission analysis of bi-fuel diesel engine by the use of bogus (90%) as an alternate fuel for the proposed water pumping system. The GHG emission factor for diesel is 0.252 (RETscreen). Gases like water vapour, carbon dioxide; methane (CH4), ozone (O3) and nitrous oxide (N2O) into the earth's atmosphere permit the passage of incoming solar radiation but prevent outgoing radiation from earth to space. This effect is similar to a greenhouse of glass, so the phenomenon is called greenhouse gas effect and gases responsible for global warming. The temperature of the earth is being increased about 0.2 to 0.3 degrees Celsius over the last 40 years [13].

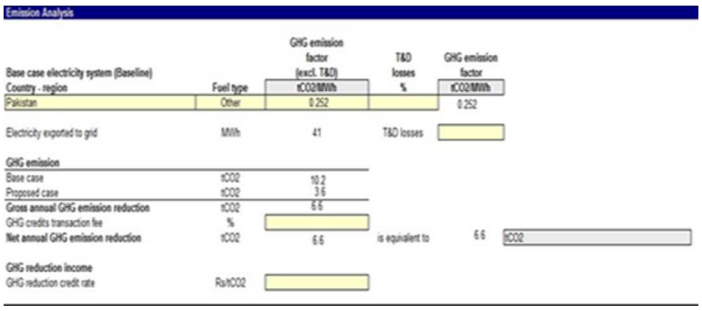


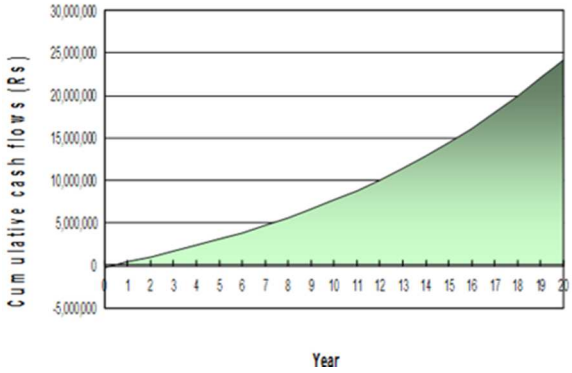
Fig. 4. GHG Emission Analysis by RETScreen4.

3.3. Economic Analysis

This analysis has been done on the basis of financial parameters like inflation rate, project life, initial cost and annual fuel cost. An Inflation rate of 7.9 percent (2014, GOP) is used for financial analysis, which fluctuates according to market prices of general commodities and is evaluated every week. The project life is taken as 20 years, which is the duration over which the financial viability of the project is evaluated. Depending upon the circumstances, digester has a life of 20-25 years. The initial cost of the proposed system (cost of bi-fuel kit and anaerobic digester) is taken as Rs. 140,000 according to the market value (A&J) international, Islamabad. Total annual diesel savings and Total fuel cost saving have been calculated as per the equation 1 and 2.savings, income, and financial viability are evaluated below. Although systems based on these resources have high capital costs as compared to traditional petrol or diesel-based water pumps, over a 20year project life, the analysis indicates that ongoing fuel costs savings for a fossil fuel system greatly be more important. [14,15].

The total annual diesel savings are 5,470 litres and Annual financial savings are Rs. 623,568. Cumulative cash flow is visualized by the cash flow graph as shown in fig. 6. The cash flow is positive as simple and equity payback period is 0.3 years.

Financial Analysis		
Financial parameters		
Inflation rate	%	7.9%
Project life	yr	20
Debt ratio	%	
Initial costs		
Power system	Rs	0
Digester and Ki	Rs	140,000
Total initial costs	Rs	140,000
Incentives and grants	Rs	
Annual costs and debt payments		
O&M (savings) costs	Rs	
Fuel cost - proposed case	Rs	125,412
	Rs	
Total annual costs	Rs	125,412
Annual savings and income		
Fuel cost - base case	Rs	0
Fuel cost saving	Rs	623,568
Total annual savings and income	Rs	623,568
Financial viability		
Pre-tax IRR - assets	%	391.8%
Simple payback	yr	0.3
Equity payback	yr	0.3



(a) (b)

Fig. 5. Financial Analysis by RETScreen4.

4. Result and Discussion

Switching a diesel engine to bi-fuel engine not only provides energy at low cost, but also reduces GHG emissions at the same time. An energy model of biogas production is estimated according to the availability of dairy waste, which is also compared with the diesel fuel. The following results have been obtained to analyse the feasibility of the proposed system.

In the proposed system, diesel oil used 10 % as pilot fuel and remaining 90% biogas used as alternative fuel. The main fuel, biogas is produced by dairy waste, which are available abundantly in that area. Therefore, the precious fossil fuelsmay be saved.

- The annual diesel fuel savings are 5,498 litres, which is beneficial for the environment and reduces the price of oils by reducing the demands.
- In case of Bi-fuel engine, net annual GHG emission reduction is 6.6 tCO2. Therefore, during the entire life of 20 years, the proposed system will be able to reduce GHG emission at 132 tCO2.
- The total annual savings and income from the proposed case is Rs. 626,787.
- Simple payback and equity payback periodor 0.3 years.
- The end-product of the anaerobic digestion system is an organic soil conditioner which can be appliedas fertilizer for agriculture sector.

5. Conclusion

The study leads to the conclusion that the system will be launched on a large scale in the Pakistan, so it can be helpful in the economy of the country as well as environmental protection. It has an advantage over a fully biogas system that is; it can easily switch to the diesel fuel at any time during trouble shootings.The biogas production is more than consumption, hence; it can be used for other purposes. The payback period is also favourable, as less than four months. After the four month period, saving money can lead the prosperity.

It reduces GHG emissions as 6.6 tCO_2. It is a small value, but it will be appreciated at large scale. This is equivalent to 1.2 cars and light trucks not used or 2,851 litres of gasoline not consumed annually.

From the results, It is preferable to these projects where capital cost is less to install the whole system by modifying the engine easily, besidesthe use of bi-fuel pumps

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