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MODELLING AND ANALYSIS THE FOSSIL AND BIOGAS STATIONS BY USING HOMER SOFTWARE FOR BAGHDAD, IRAQ

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ABSTRACT

In this research paper, two models of different power plants with similar operating capacity were discussed using the Homer Software. One of these stations depends on fossil fuels in its operation, and the other depends on ethanol gas, the biofuel extracted from the fermentation process of Zahdi dates. The estimated location of the station was determined according to the program system in Baghdad Governorate randomly without choosing a specific location. The type of station is a substation that supplies a fixed load. The estimated costs, electrical generation capacity, and the amount of fuel consumption were deduced, in addition to the benefit resulting from reducing environmental pollution due to the combustion of biofuel ethanol gas, which is considered one of the environmentally friendly gases. All these calculations and conclusions were made by using the easy programming of the Homer Software system. The results will be modeled and concluded by program and it give higher power generation for biogas substation about 2,190,000 kw/hr/yr with capacity factor about 50%.

KEYWORDS

Homer Software, Ethanol Gas, Zahdi Dates, Biogas Generator, Diesel Generator, Fossil fuel, Bioethanol.

1. INTRODUCTION

Electricity is a key part of life and hence almost impossible to live without. (Mahmood F. Ahmed.,2024, Raad H. Abed., Nabeel A. ghaydh. 2024) Our everyday routines heavily rely on the use of energy, whether it be at home, school, the neighborhood retail mall, or our place of employment. (Francis Onoroh,.2023, Bolawole F. Ogunbodede1, Anthony C. O Iweka., Akinfolarin Jobi., 2022). Clean energy power generation, appears to be a logical decision given the demands of increasing energy demand and reducing carbon emissions (Al-Kutti, W., Islam., 2019) The date palm tree produces a variety of waste products during its life cycle. United Nations Food and Agriculture Organization reported about 614,584 number of palms in Iraq. On the whole, the seasonal trimming will produce about 25–35 kg of agriculture waste The turning to the renewable energy resources. (Razak. N, Othman, 2010). There is more than one source of bioenergy in Iraq that can be used for the purpose of generating clean electrical energy, comparing these sources with fossil fuels, which is considered the main source of generating electrical energy so far in the country the fossil fuels leads to greenhouse effected global warming. In Malaysia palm oil tree become the main source of biomass to produce the renewable bioenergy .Since the Iraq is rich in palm trees , and after studying the production of the date crop for served years , it was found that the amount of production of the date crop , a type called Al-Zahdi , is the most productive type annually , Therefore it is possible to fixed production rate to ferment the crop and obtain natural ethanol gas , which can be used as biofuel for energy production . To compare and analyze the results in a practical way we used the Homer electrical stations design program (HOMER. PRO) (Sultana ,2017) , (Ahmed Boulal ,2016). Which gives us the opportunity to design two virtual electrical stations for both types of fuel, whether fossil fuels or biofuels, and compare between them in terms of calculating the production capacity of the two stations and the cost and also analyze and conclude the results for power generation during the load period during one year.

2. METHODOLOGY

Biogas may be utilized to generate electricity by direct conversion utilizing biogas-powered prime movers such as engines with internal combustion and turbines that use biogas as a fuel. (Moses J. B. Kabeyi .2022). Because bioethanol is entirely biological, it is regarded as a renewable energy source that contributes to climate change mitigation by lowering carbon dioxide emissions and creating a sustainable environment. We may state that this investigation has led to the following conclusions:

Bioethanol is one of the primary sustainable and renewable energy sources due to its many benefits. The primary benefit of bioethanol is its ability to lessen reliance on fossil fuels by

substituting fuels derived from sustainable plant sources. Increase spending on the expansion and upgrading of bioethanol production facilities to improve the integration of renewable energy sources. Putting in place procedures to encourage the production of bioethanol by legislative actions that assist farmers who provide the raw materials needed to make bioethanol as well as bioethanol. Based on the data available to us about biogas and bioethanol, and after performing a simulation using the Hommer program, The power system is designed keeping operating reserve in mind as a safety margin, To allow the power system to meet the needs of reliable electricity, moreover, it facilitates additional loading Expansion in the future. After simulation, the result will be the following characters such as; Annual Electricity Production, Initial Capital Cost, Excess Electricity, Renewable Portion, Unsatisfied Electricity Load, power shortage, annual fuel consumption, generator operating hours, etc (Rozi L. Berevoianu , 2021., Sharmin Sobhan, 2016).

3. OBJECTIVE

3.1. Ethanol gas production definition theoretical

Bioethanol is concentrated to about 96vol % purity of ethanol productivity of (300-330) liter per ton of date palm (Ghanim,A.,N., 2013). There are two equations derived to describe the kinetic behavior, for ethanol the model was derived as follows (H., Taouda , 2017):

$$\frac{dx}{dt} = \mu_m \times \left(1 - \frac{x}{x_m}\right) \quad (1)$$

$$\frac{dp}{dt} = y_x^p \quad \frac{dx}{d\ (t-\Delta t)} \quad (2)$$

Where, μ_m , The maximum specific growth rate to the fermentation conditions, x, The growth kinetics of biomass, *p*, Ethanol formation , *t,* Time

3.2. Definition of electrical power system theoretical

Mathematical model of diesel generator is giving as follows (Deepak ,2011) ,(Amritpal Singh,2021) :

$$E_{DEG}\ (t) = P_{DEG}\ (t) \times \eta_{DEG} \quad (3)$$

Where , E_{DEG} (t) Hourly energy generated , P_{DEG} (t) , Rated power output , η_{DEG} , Diesel generator with rated power output

HOMER calculates the fuel consumption rate for that time step using the following equation:

$$F = F_0 \cdot Y_{gen} + F_1 \cdot P_{gen} \quad (4)$$

Where , F fuel consumption rate (L/hr) , F_0 generator fuel curve intercept coefficient (L/hr/kW), F_1 $generator\ fuel\ curve\ slope\ (L/hr/kWoutput)$, Y_{gen} capacity of the generator (kW) , P_{gen} output of the generator (kW).

3.3. Definition of electrical power equation for both station in Homer program

HOMER calculates the required output of the generator and the corresponding mass flow rates of fossil fuel and biogas its represented by the points: (HOMER Help Manual., 2015)

1. The biogas (zgas) is a constant, independent of engine output power or fuel mixture.
2. The system always attempts to maximize the use of biogas and minimize the use of fossil fuel.

$$\dot{m}_0 = \rho_{fossil}\left(F_0 \cdot Y_{gen} + F_1 \cdot P_{gen}\right) \quad (5)$$

$$\dot{m}_0 = \dot{m}_{fossil} + \frac{\dot{m}_{gas}}{Z_{gas}} \quad (6)$$

$$\boldsymbol{\dot{m}_{gas} = Z_{gas}\ (\dot{m}_0 - \dot{m}_{fossil})} \quad (7)$$

Where ,

$\dot{m}_0$ $Fossil\ fuel\ flow\ rate$,ρ_{fossil} $Density\ of\ fossil\ fuel$,$\dot{m}_{fossil}$$Fossil\ fuel\ flow\ rate$,$\frac{\dot{m}_{gas}}{Z_{gas}}$ $Biogas\ flow\ rate$,Z_{gas} $biogas$

4. DIESEL GENERATOR MODEL DESIGN BY HOMER SOFTWARE

The following Fig .1 shows model of an electric station based on fossil fuels, designed by default with certain values in the program. The capacity of the electric generator is 500 kilowatts. With electric load value at 165.59 kilowatt hour per day.

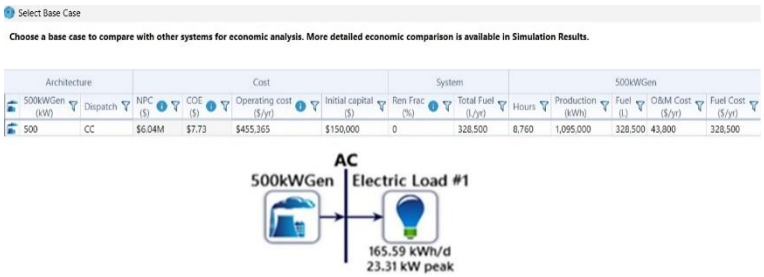

Fig. 1. Model of an electric station based on fossil fuels

4.1. Cost Summary for electric station based on fossil fuels

The chart shown in Fig .2 shows the total cost of the station system in dollar terms, including construction, consumption, and operating system annually. The electric needs 500 kW of generator capacity. operating costs for energy are $455,365 per year. It is the most economical choice for 25 years operating system (Homer program report)

4.2. Electrical Summary Production

Table 1 It shows the amount of annual electrical energy production of a diesel generator that uses fossil fuels, measured in kilowatt-hours per year, based on deductive analysis using the Homer program.

Table 1 Electrical Summary

Quantity	Value	Units
kW h/yr	1,095,000	Electrical Production
kW	Mean Electrical Output	125

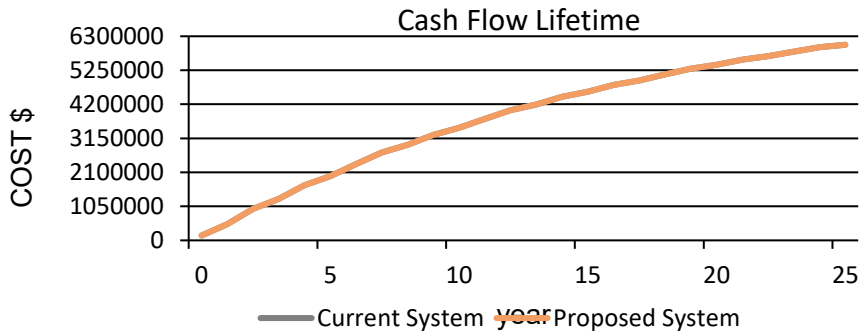

Fig.2. Cost Summary for electric station based on fossil fuels

4.3. Fuel Summary

Table 2 shows the amount of fossil fuel combustion measured in liters used to operate a 500-kilowatt generator. It also shows the amount of specific fuel consumption measured in liters per kilowatt-hour and the amount of electrical production efficiency of the generator during one year and fuel energy entering the system measured in kilowatt-hour per year.

Table 2 Fuel Summary

Quantity	Value	Units
Generator Fuel	Diesel	-
Fuel Consumption	328,500	L
Generator Fuel Price	1.00	$/L
Electrical Production	1,095,000	kWh/yr

4.4. 500kW Generator Fixed Capacity Genset Statistics

In Table 3 we note the annual operating statistics of the 500-kilowatt diesel generator used in the system, where the annual operating period of the generator is calculated in hours per year, and the number of times the generator starts up per year is calculated, as well as the expected operating life of the generator and how many years it takes during the operation system, and also the amount of fixed operating cost measured in dollars per hour and the annual capacity factor of the generator.(Homer program report).

Table 3 Generator Fixed Capacity

Quantity	Value	Units
Operation Time	8,760	hrs/yr
Starts Number	1.00	starts/yr
Life Operation	1.71	yr
Cost	25.0	%
Capacity Factor	22.0	$/hr

4.5. 500kW Generator Fixed Capacity Genset Output (kW)

In Fig. 3 the program shows the amount of electrical energy produced by the diesel generator by making a comparison chart between the working hours during the day for one year to conclude the amount of electrical energy produced per day, which is 200 kilo watt.(Homer program report)

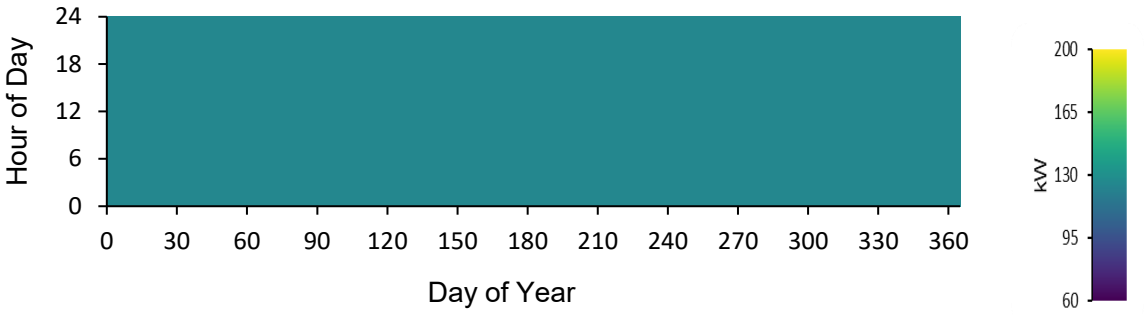

Fig 3. Generator fixed capacity power out put

5. BIOGAS GENERATOR MODEL DESIGN BY HOMER SOFTWARE

In Fig. 4 we show the model designed in the Homer Software for the biofuel station where the ethanol gas produced from the fermentation of Zahdi dates will be used as previously presented and using a biofuel generator with a generation capacity of 500 kilowatts similar to the diesel generator previously used in the first model with a similar load also with a capacity of 165 kilowatt hours per day.

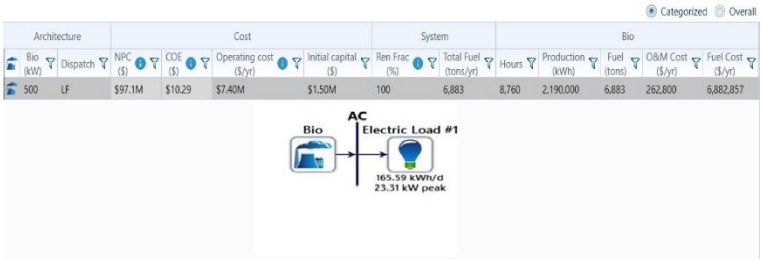

Fig. 4 Model of an electric station based on biofuels

5.1. Cost Summary for electric station based on biofuel

Fig. 5 present a diagram of the annual total cost consumed to establish an electric station based on biofuels, with an estimated cost calculated in the Homer program for a design similar to a fossil fuel station with the same generation value for an electric generator of 500 kilowatts using ethanol as a gaseous biofuel for the electric generator. The generator capacity 500 kW operating costs are currently $7.40M per year.

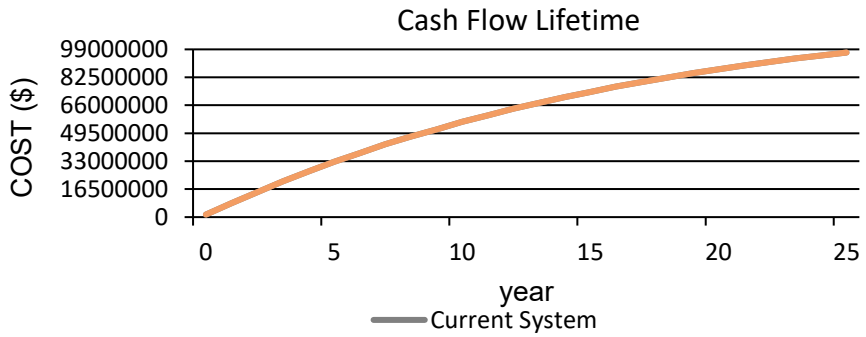

Fig. 5 Cost Summary for electric station based on biofuel

5.2. Generic 500kW Biogas Electrical Summary

Table 4 presents the annual amount of electrical energy produced by the bioethanol gas fuel generator with an estimated production capacity calculated in the program in kilowatts hour per year.

Table 4 Electrical Summary

Quantity	Value	Units
Electrical Production	2,190,000	kWh/yr
Mean Electrical Output	250	kW

5.3. Biogas Fuel Summary

Table 5 shows a fuel consumption in liter value for biofuel ethanol and specific fuel consumption by liter per kilowatt hour, and also give the amount of fuel energy input in kilowatt hour per year, and calculate mean electrical efficiency.

Table 5 Biogas Fuel Summary

Quantity	Value	Units
Generator Fuel	Biogas	-
Fuel Consumption	6,883	L
Generator Fuel Price	1.00	$/L
Electrical Production	2,190,000	kWh/yr

5.4. 500kW Biogas Generator

Table 6 shows the number of operating hours of the biogas generator per year, the number of times it starts up during the year, the operating period for the generator per year, the operating capacity factor, and the total cost of generation in dollars during the year. (Homer program report).

Table 6 500 kW Biogas Generator

Quantity	Value	Units
Operation Time	8,760	hrs/yr
Starts Numbers	1.00	starts/yr
Life operation	2.28	yr
Capacity Factor	50.0	%
Cost	106	$/hr

5.5. 500kW Biogas Generator Output (kW)

The diagram in Fig. 6 shows the relationship between the number of operating hours of the Biogas generator during the days of one year and the results of the calculation of the maximum value of the generation amount given by using the Homer program, estimated at 400 kilowatts per day.

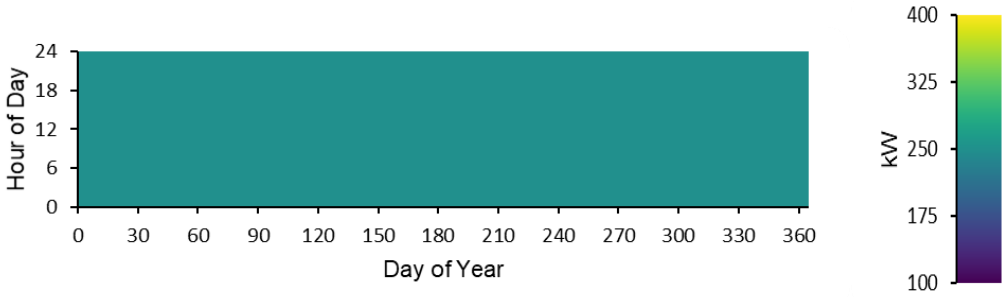

Fig. 6 Biogas Generator Output (kW)

5. CONCLUSION

After using two types of generators with similar generating capacity of 500 kW and two different types of fuel, one fossil fuel and the other bioethanol fuel, and applying them to two stations with similar capacity in the Homer program, the following was concluded: The cost of fossil fuel generator is$455,365 per year is lower than the cost of biogas generator fuel is $7.40M per year , but the electrical generation capacity of the biogas generator is 2,190,000 kWh/yr higher than the electrical generation capacity of the diesel generator is 1,095,000 kw/hr/yr , and also the main external electrical capacity of the biogas generator is higher than the diesel generator, and also the capacity factor of the biogas generator is 50 percent higher than the capacity factor of the diesel generator is 25 percent, so the production efficiency of the biogas generator is higher than the production efficiency of the diesel generator, and also the combustion of ethanol in the biogas generator does not cause environmental pollution, unlike the penetration of fuel in the diesel generator, in addition to the fact that ethanol gas is produced naturally from raw dates.

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