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Improving Power Production in Biogas Based Electrical Power Generation Using Simplex Optimization Techniques

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Abstract: The inconsistence power supply in our country Nigeria has arisen as a result of not having capable power generation system. This power failure experience in our country can be overcome by improving biogas electrical power generation using simplex optimization technique. This can be done in this manner, characterizing the network understudy, designing a mathematical model from the characterize network understudy, determining the generated biogas electric power, designing a MATLAB Simulink model for improving biogas electrical power generation using simplex optimization technique and comparing the percentage of optimized biogas electrical power generated to the conventional one. The result obtained is 5.4KW for optimized electrical power and 0.5KW for conventional biogas electrical power at the same volume of biogas $3.6m^3$. With this result obtained it shows that optimized biogas electrical power generates better biogas electrical power than the conventional method.
Keywords: Improving, power generation, optimization.

INTRODUCTION

The improvement of Biogas technologies will assist sustainable development and provide a solution to electricity problem in Nigeria. In this sense, optimization algorithms constitute a suitable tool for solving complex problems in the field of renewable energy systems. Some authors have reviewed different types of models such as renewable energy models, emission reduction models, energy planning models, energy supply-demand models, forecasting models, and control models using optimization methods [1].

In mathematics, optimization is the discipline concerned with finding inputs of a function that minimize or maximize its value, which may be subjected to constraints [2]. Rentizelas *et al*. [4] proposed an optimization method for multi-biomass energy conversion applications taking into account various technical, regulatory, social and logical constraints. PSO has also been applied for the optimal location and supply area for biomass-based power plants where the maximum electric power generated by the plant is considered as a constraint [5]. Vera [6] applied a nature in spired algorithm for the optimal location of a biomass power plant with the aim of providing the best profitability for investors. Reche [3] presented a binary PSO-based method to accomplish optimal location of biomass-fuelled systems for distributed power generation with forest residues as biomass source, and the results outperformed those obtained by a GA when maximizing a profitability index taking into account technical constraints.

Many researchers are continuously proposing and applying new methods in improving Biogas power generation. For this reason, this paper presents Linear Programming optimization method to improve the Biogas electrical power generation.

METHODOLOGY

This research paper develops a linear Programming optimization of biogas electrical power generation for Ade-Oyo community in Ibadan Oyo state with the aims to improving electricity access of the area using pig dung. This system was designed calculating the daily energy generated for biogas to establish the futures of the network understudy from the empirical data collected. The biogas electrical power mathematical model is formulated and simulation was performed using.

MATLAB/SIMULINK

Table-1: Collected empirical data from Ade-Oyo at Ibadan in Oyo state

Number of pigs	Volume of digester(m^3)	Volume of biogas(m^3)	Generated electric energy(Kwh/d)	Generated electric power(Kw/d)
50	6	3.6	11.6	0.5
100	12	7.2	23.2	1
150	18	10.8	34.9	1.5
200	24	14.4	46.5	2
250	30	18	58.2	2.5
300	36	21.6	69.8	3
350	42	25.2	81.4	3.5
400	48	28.8	93.1	4
450	54	32.4	104.7	4.5
500	60	36	116.3	5
550	66	39.6	127.9	5.5
600	72	43.2	139.6	6
650	78	46.8	151.2	6.5
700	84	50.4	162.8	7
750	90	54	174.5	7.5
800	96	57.6	186.1	8
850	102	61.2	197.7	8.5
900	108	64.8	209.4	9
950	114	68.4	221	9.5
1000	120	72	232.4	10

Mathematical Linear Programming Optimization of Biogas

To design a mathematical model from the characterize network understudy.
Maximize Z= 0.5X1 + X2 + 1.5X3-------------------------1
ST
50X1 + 6X2 + 3.6X3 <= 0.5---------------------------------2
100X1 + 12X2 + 7.2X3 <= 1--------------------------------3
150X1 +18X2 +10.8X3 <=1.5-------------------------------4
Where X1 is Number of pigs
X2 is volume of digester
X3 is volume of biogas
Z is the power output

The mathematical model for improving biogas electrical power generation using simplex optimization technique

To determine the generated biogas electric power

```
>> % Optimized mathematical model for improving biogas electrc power
% generation using simplex optimization technique
% Maximize Z = 0.5X1+1X2+1.5X3
% Subject to 50X1+6X2+ 3.5X3<=0.5
%             100X1x+12X2+7.5X3<=1
%             150X1+18X2+10.8X3<=1.5
% Where X1 is the number of pigs
%       X2 is the volume of digester
%       X3 is the volume of biogas
      f=[-0.5;-1;-1.5];
      A=[50 6 3.5;;100 12 7.5;150 18 10.8];
      b=[0.5;1;1.5];
      Aeq=[0 0 0];
      beq=[0];
      LB=[0 0 0];
      UB=[inf inf inf];
      [X,FVAL,EXITFLAG]=linprog(f,A,b,Aeq,beq,LB,UB)

Optimization terminated.

X =

    0.0000
    0.0000
    0.1333


FVAL =

   -0.2000
```

The optimized biogas electric power z is 0.2KW when the volume of biogas is $0.1333M^3$. To find the increase in biogas electric power when the volume of biogas is varied to $3.6M^3$

Then, recall equation 1 which is the mathematical model for improving biogas electrical power generation using simplex optimization technique and substitute 3.6 for X3

Recall Maximize Z= 0 + 0 + 1.5x3.6-------------------------1

Z = 5.4KW biogas electric power generated.

To design a MATLAB Simulink model for improving biogas electrical power generation using simplex optimization technique.

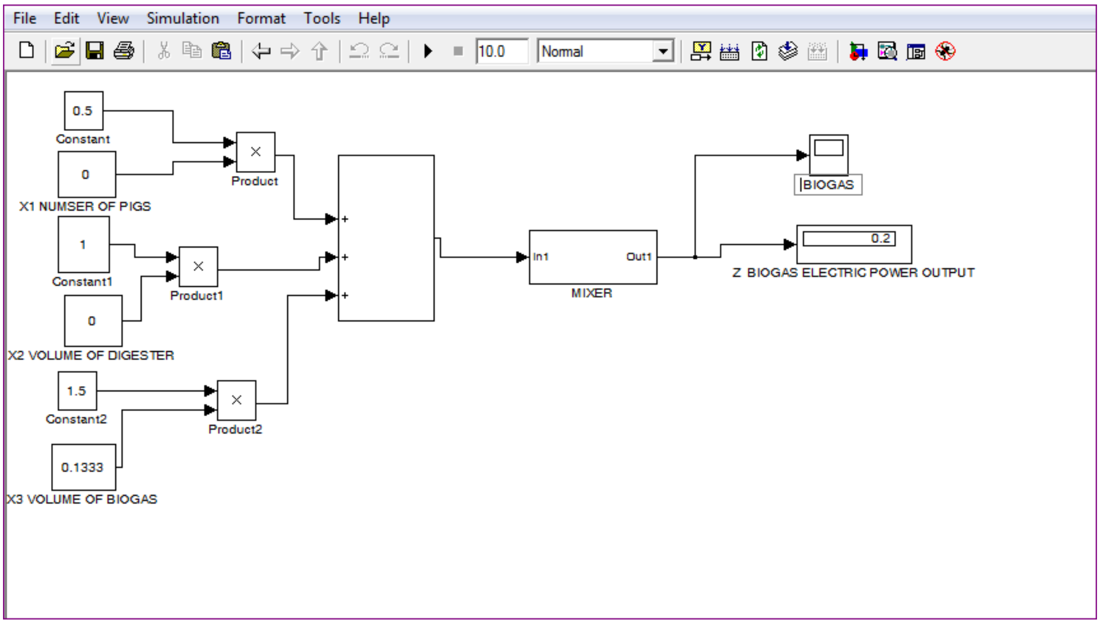

Fig-1: designed MATLAB Simulink model for improving biogas electrical power generation using simplex optimization technique.

Fig 1 shows designed MATLAB Simulink model for improving biogas electrical power generation using simplex optimization technique. The result obtained is biogas electrical output of 0.2KW from the conventional approach.

To compare the percentage of biogas electrical power generated in optimization to the conventional one.

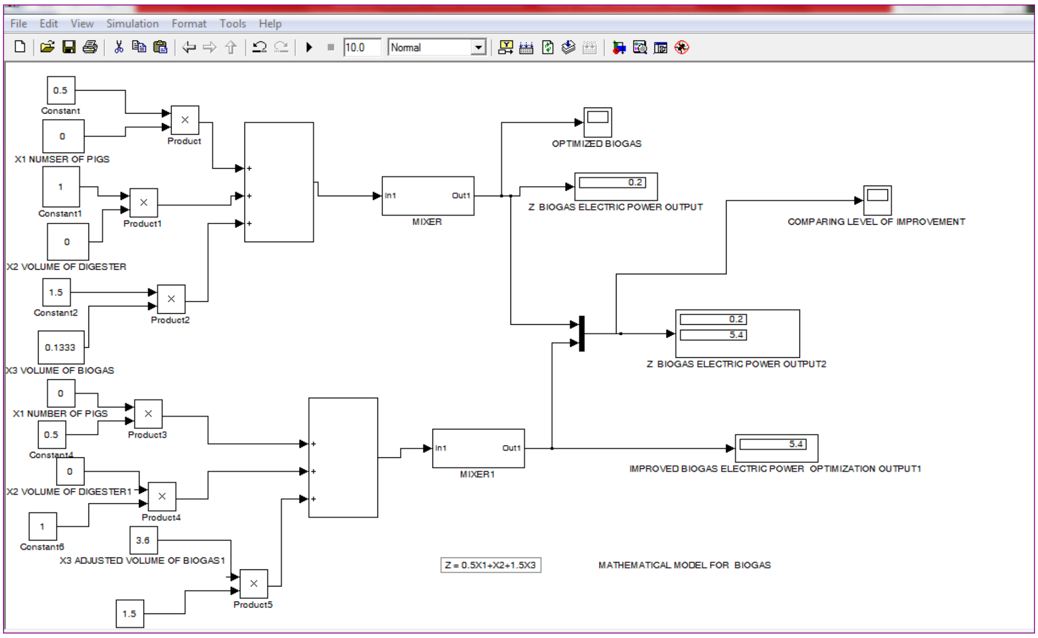

Fig-2: comparing the percentage of biogas electrical power generated in IV to the conventional one

RESULTS ANALYSIS

Table-2: Comparing optimized electrical biogas power output when volume of the biogas is 0.133m^3 and 3.6m^3 respectively. Biogas is 0.133m^3 and 3.6m^3 respectively

No of pigs dung	Optimized electrical biogas power when volume of biogas is 0.133m^3.	Optimized electrical biogas power when volume of biogas is adjusted to 3.6m^3.
50	0	0
100	0.3	6.2
150	0.1	5.1
200	0.2	5.4
250	0.2	5.4
300	0.2	5.4
350	0.2	5.4
400	0.2	5.4
450	0.2	5.4
500	0.2	5.4
550	0.2	5.4
600	0.2	5.4
650	0.2	5.4
700	0.2	5.4
750	0.2	5.4
800	0.2	5.4

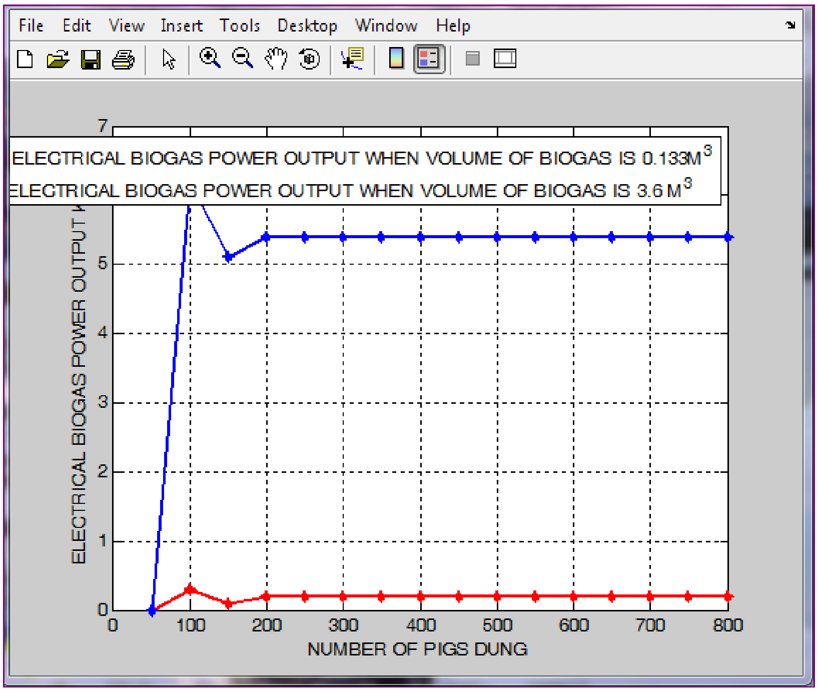

Fig-3: Comparing optimized electrical biogas power output when volume of the biogas is 0.133m^3 and 3.6m^3 respectively

Table-3: Comparing optimized electrical biogas power output with the conventional method when volume of the biogas 3.6m^3 respectively

Number of pigs dung	Optimized electrical biogas power when volume of biogas is 3.6m3.	Conventional electrical biogas power when volume of biogas is 3.6m^3.
50	0	0
100	6.2	0.7
150	5.1	0.3
200	5.4	0.5
250	5.4	0.5
300	5.4	0.5
350	5.4	0.5
400	5.4	0.5
450	5.4	0.5
500	5.4	0.5
550	5.4	0.5
600	5.4	0.5
650	5.4	0.5
700	5.4	0.5
750	5.4	0.5
800	5.4	0.5

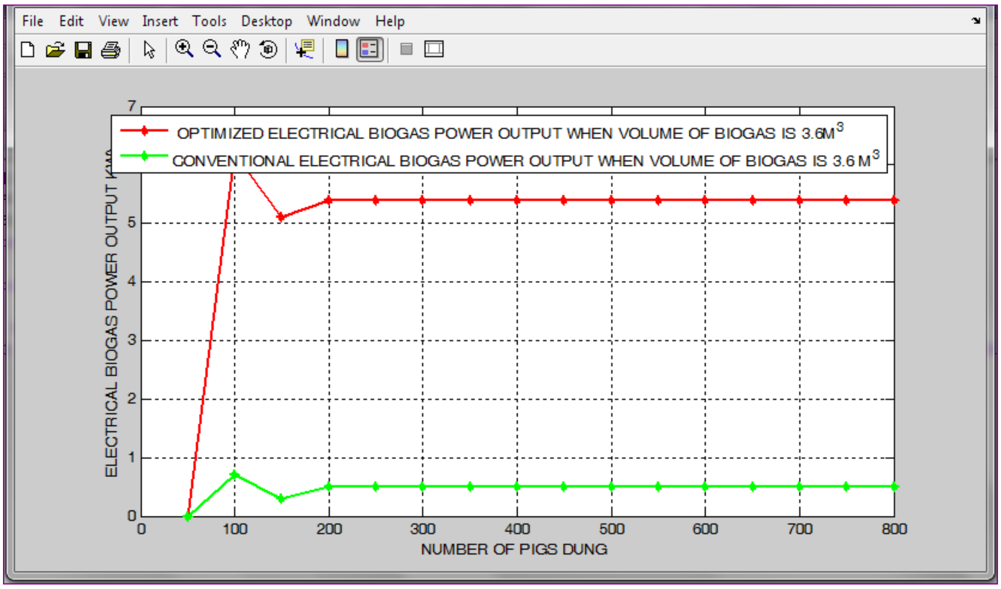

Fig-4: Comparing optimized electrical biogas power output with the conventional method when volume of the biogas 3.6m^3 respectively

DISCUSSION OF RESULTS

The simulation result is presented in Fig 2-4. This shows that the biogas electrical power increase and stabilize in biogas electrical power output of 5.4kw, when the biogas volume is increased to 3.6m^3.

Its shows the relationship between the Biogas electrical Power output, Optimized electrical biogas power when volume of biogas is 3.6m3 and Optimized electrical biogas power when volume of biogas is adjusted to 3.6m^3. The Biogas electrical Power output after processing the dung of 50, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750 and 800 fattening pigs are 0.5KW/d, 1KW/d, 1.5KW/d, 2KW/d, 2.5KW/d, 3KW/d, 3.5KW/d, 4KW/d, 4.5KW/d, 5 KW/d, 5.5 KW/d, 6 KW/d, 6.5 KW/d, 7 KW/d, 7.5 KW/d, and 8 KW/d respectively while Optimized electrical biogas power when volume of biogas is 0.133m^3 are 0KW/d, 0.3KW/d, 0.1KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d, 0.2KW/d and .Optimized electrical biogas power when volume of biogas is adjusted to 3.6m^{3}are 6.2 KW/d, 5.1 KW/d, 5.4 KW/d, 5.4 KW/d, 5.4 KW/d, 5.4 KW/d, 5.4 KW/d, 5.4 KW/d, 5.4 KW/d, and 5.4 KW/d.

Fig 2 shows comparing the percentage of biogas electrical power generated in optimization to the conventional approach. The result obtained is an electrical biogas of 5.4Kw when $3.6m^3$ volume of biogas is used in the optimized model. This is unlike when same volume of biogas is used in the conventional approach as shown in table 1 that gave an electrical biogas power of 0.5KW.

Fig 3 shows comparing optimized electrical biogas power output when volume of the biogas is $0.133m^3$ and $3.6m^3$ respectively. The result shows that there is an increase in biogas electrical power output of 5.4kw when the biogas volume is increased to $3.6m^3$.

Fig 4 Comparing optimized electrical biogas power output with the conventional method when volume of the biogas is $3.6m^3$. This shows that the Biogas power output increase with optimized electrical than conventional method.

The result obtained is 5.4KW for optimized electrical power and 0.5KW for conventional biogas electrical power at the same volume of biogas $3.6m^3$. With this result obtained it shows that optimized biogas electrical power generates better biogas electrical power than the conventional method.

CONCLUSION

The inconsistency in power generated can be overcome by improving biogas electrical power generation using simplex optimization technique. This can be achieved by characterizing the network understudy, designing a mathematical model from the characterize network understudy, determining the generated biogas electric power, designing a MATLAB Simulink model for improving biogas electrical power generation using simplex optimization technique and comparing the percentage of optimized biogas electrical power generated to the conventional one.

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