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Photovoltaic-Biomass Gasifier Hybrid Energy System for a Poultry House

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Abstract: *Availability and sustainability of energy and food production are the biggest challenge facing the world. Find out how to integrate poultry and animal farms with renewable energy technologies will lead to a greater energy security and food production.The main objective of this paper is to obtain the optimal suited configuration of a hybrid renewable energy system from various combinations to meet the poultry house load requirement reliably, economically, continuously and sustainably. This paper presents an optimal design of hybrid solar PV-biomass gasifier system to fulfill the requirements of 250 kWh/day primary loads with 19 kW peak load for poultry house located at El-fayoum governorate, Egypt. Using HOMER simulations, the optimal sizing of solar photovoltaic (PV) and biogas generating system is obtained on the basis of the minimized cost of the obtained energy (COE) generation, HOMER results show that the solution is sustainable and techno economically viable. The simulation results show that PV (12 kW) - biomass gasifier (20 kW) - battery (270 kWh) hybrid system is most economically feasible with a least cost of energy about $0.224/Kwh. Also, this system is characterized by the minimum percentage of carbon dioxide and the other greenhouse gases emissions.*
Keywords*: Biomass, HOMER, Hybrid, Photovoltaic, Poultry House, Renewable Energy.*

I. Introduction

Energy, Economy and environment are the three inter related areas having direct correlation for development of any nation [1]. In the rapidly growing economies of the developing countries the demand for electricity is constantly increasing. Electricity is one of the driving forces in a growing economy and increasing demand puts incredible pressure on the countries' energy infrastructure to match that demand. Depleting oil and gas reserves, combined with growing concerns of atmospheric pollution, have made the search for energy from renewable sources inevitable [2-3].

As well energy plays a crucial role in poultry housing. Where, energy is used for several applications; most importantly for lighting, heating, ventilation and cooling, and running electric motors for feed lines [4]. Therefore, to electrify the previously mentioned house equipments, it is necessary to use a well designed renewable energy systems. Several renewable energy sources, notably wind, waves, tidal, biomass and solar are either intermittent by nature or vary greatly according to time of day or season. In order to achieve reliability, it is necessary to integrate two or more energy sources such as solar photovoltaic, wind, biomass, micro hydro or diesel generators together in an optimal way as hybrid energy system [5].

Poultry products can be considered as one of the most important sources of cheap protein, where the white meat (poultry meat) is very cheap as compared with the red meat (animal meat). In addition to, poultry production is characterized by its high economic return due to its short production cycle, the capital cycle is very rapid in the case of poultry production as compared with the capital cycle in other types of animal production where the production cycle of poultry production takes 7–8 weeks meanwhile the production cycle of bovine takes from 3 to 12 months. Therefore, in the case of poultry production the capital cycle can be repeated 7 times a year. Also, Poultry production needs small area in comparison with other animals. Poultry production can contribute to the solution of the unemployment problem [6-8]. Poultry production can contribute to the state food security policy and strategy. The design of the poultry house based on hybrid renewable energy system is realized by satisfying the load demand, non-linear seasonal variations and equipment constraints. The system's sizing and the design optimization has been done by application of the National Renewable Energy Laboratory's (NREL) software "Hybrid Optimization Model for Electric Renewable (HOMER) version 2.68 betas".

The current situation of energy in Egypt clearly indicates that, the future energy demand cannot be met by traditional energy sources. In coming years it would be a necessity to switch from conventional sources to renewable energy resources to fulfill the energy demand for multiple areas and differing applications. Therefore, coupling of renewable energy with cattle and poultry houses holds great promise for increasing food supplies with natural energy source that does not produce air pollution or contribute to the global problem of climate especially in the food sector. The main objective of the present study is to determine the optimum size of hybrid renewable energy system that able to fulfill the requirements of 250 kWh/day primary load with 19 kW peak load to feed one of the poultry house located at El-fayoum governorate, Egypt.

II. LOCATION

El-Fayyum governorate is chosen as the location of this study. Its Geographic coordinates are; Latitude: 29°18′28″ N, Longitude: 30° 50′23″ E and Elevation above sea level: 40 m [9]. El-fayoum governorate contributes to enhancing the industrial activity through many industries, the most important of which are foodstuffs. It is one of the main producers of meats and dairy products. Poultry field is considered one of the main economic activities in the governorate. Therefore, it is chosen as the site under consideration for the poultry house installation.

III. PV-BIOMASS POULTRY HOUSE SYSTEM DESCRIPTION

Modern poultry house made of steel construction and the average growing season is 55 days. The size of the house is approximately 14 meter by 150 meter which holds 28,000 birds [4]. The average bird density is 0.07m2/bird. Figure 1 shows the block diagram of the suggested photovoltaic-biomass gasifier hybrid system. The main components of the system are namely PV array, biomass generator, battery, inverter and load.

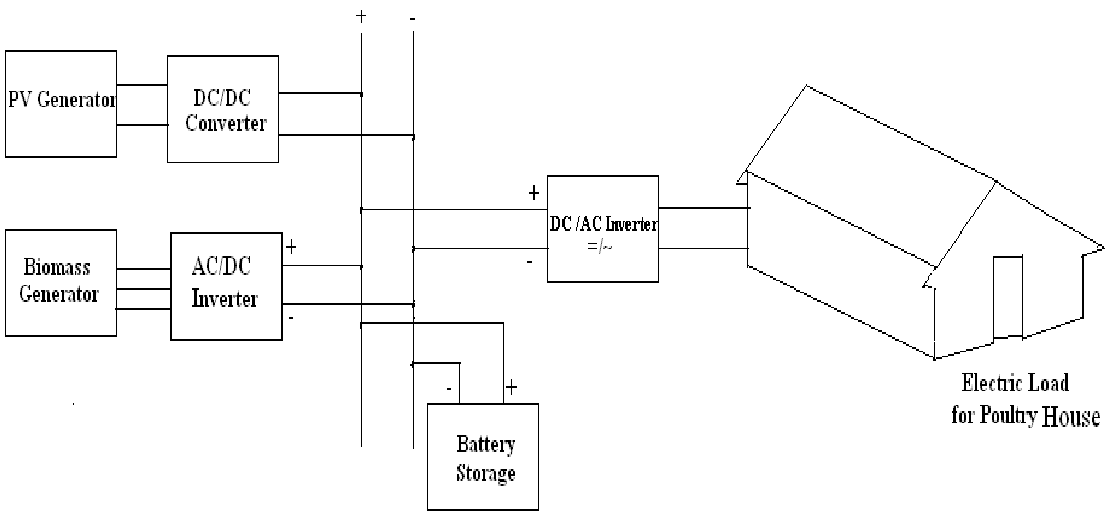


Fig. 1 The proposed block diagram of the standalone PV-biomass poultry house system.

Hybrid renewable energy system is designed based upon the certain important variables to optimize the cost & size effectively. The use of hybrid off-grid electricity depends on the comparative costs, affordability, quality of service, and accessibility of other energy options which are locally available. Therefore, before simulation, certain parameters like solar irradiation, available biomass and load profile must be evaluated.

IV. HOMER SIMULATION

HOMER is used to assist in the design of power systems and to facilitate the comparison of power generation technologies across a wide range of applications. HOMER models a power system's physical behavior and its life-cycle cost, which is the total cost of installing and operating the system over its life span. HOMER allows the modeler to compare many different design options based on their technical and economic merits. Also, it is capable of selecting an optimized hybrid model to serve the given electrical load. In a decentralized electricity generation the COE depends on the selection of various renewable energy technologies and their resources. It contains a number of energy component models and evaluates suitable technology options based on cost and availability of resources. Analysis with HOMER requires information on resources, the data of the component types, their numbers, costs, efficiency, longevity, etc. It compares a wide range of equipments to optimize the system design [10-14]. The following subsections will describe the various input parameters that HOMER requires to model the system: The energy load demand (poultry house) that the system has to serve, the selected energy components to generate electricity, the various energy resources associated to the selected components, and how this hybrid combination operates to serve the loads.

V. METHODOLOGY

5.1 Hybrid Energy System Resources

5.1.1 Solar Radiation

Solar energy has been deemed clean, inexhaustible, unlimited, and environmental friendly. Such characteristics have attracted the energy sector to use this energy source on a larger scale. Solar Profile represents the solar resource data for the location of interest, indicating the amount of global solar radiation that will incident on the PV array. Solar radiation strongly depends on latitude and climate conditions. The monthly average solar radiations are directly taken by HOMER using latitude and longitude of the El-fayoum governorate. Figure 2 shows the solar resource profile considered over a span of one year; it illustrates the monthly global solar radiation of El-fayoum governorate. The average solar radiation for this location is 5.842 kWh/m2/d, and the average clearness index was found to be 0.664. The graph plot in Fig.2 shows that, solar radiation is available throughout the year; therefore a considerable amount of PV power output can be obtained [14].

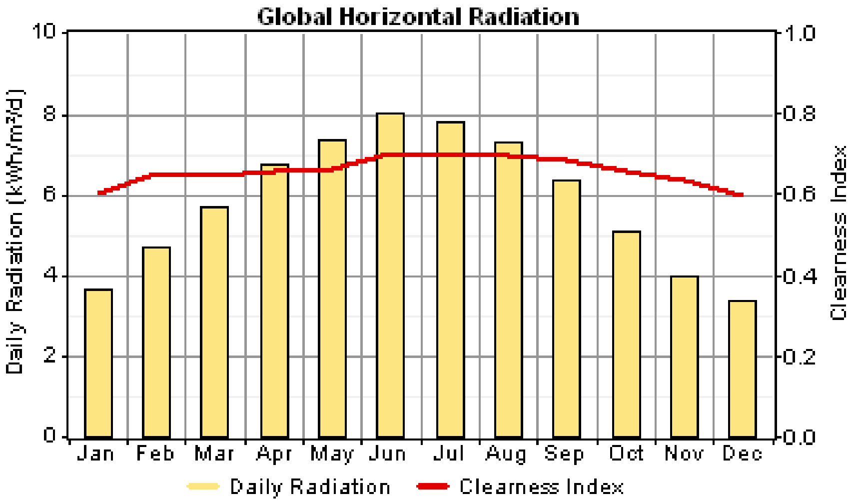


Fig. 2 Global solar radiation of El-fayoum governorate.

5.1.2 Biomass

Biomass represents an important source of energy which includes a large variety of different fuels with different chemical compositions and combustion characteristics. Its utilization as a source of energy is important from an energetic as well as an environmental viewpoint. There are four main types of biomass sources which represent the potential of biomass energy sources in Egypt and include: agricultural residues (dedicated bioenergy crop residues), municipal solid wastes, animal wastes, and sewage sludge. The potential biomass quantity and its theoretical energy content were computed according to statistical reports, literature reviews, and personal investigations. The results show that Egypt produces a considerable amount of biomass with a total theoretical energy content of 416.9×1015J. The dry biomass produced from bioenergy crop residue sources has been estimated at about 12.33 million tons/year, of which 63.75% is produced from rice straw. This source represents the highest percentage (44.6%) of the total theoretical potential energy in Egypt, followed by municipal solid wastes, which could produce 41.7% from an annual amount of 34.6 million tons. Meanwhile, the rest of the total theoretical potential energy could be produced from animal and sewage wastes [15]. Biomass gasifier is considered. Using the produced biogas, a generator is included in the hybrid system to generate electricity. The average data of the available of biomass supply is a bout 8 ton per day.

5.2 System Components

5.2.1 PV Array

The cost of solar electricity with solar photovoltaic (PV) panels has become economically feasible in recent years. A monocrystalline PV 75 Wp, Imp= 4.4A and Vmp = 17V modules is selected in this study. The capital cost and replacement cost for a 1kW PV is taken as $2000 and $2000 respectively. As there is very little maintenance required for PV, only $10/year is taken for O&M costs. Solar PV panels of different capacities are considered,e.g.1,2,3,4,5,5,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,37,38,39 ,40,45and 50 kW for optimization and the lifetime considered is 20 years [16].

5.2.2 Biomass Generator

Biomass gasification converts solid biomass into more convenient gaseous form. This process is done in gasifier mainly comprised of a reactor, where the combustible gas is generated and the gas is made available for power generation/thermal application after the required cleaning and cooling process. The capital and replacement costs are the same $ 628 while M&O cost is $0.08/h. The sizes to consider are 0, 20, 25, 30, 35, and 40 KW and the lifetime is 20 years. Figure 3 illustrates the monthly biomass resource [9].

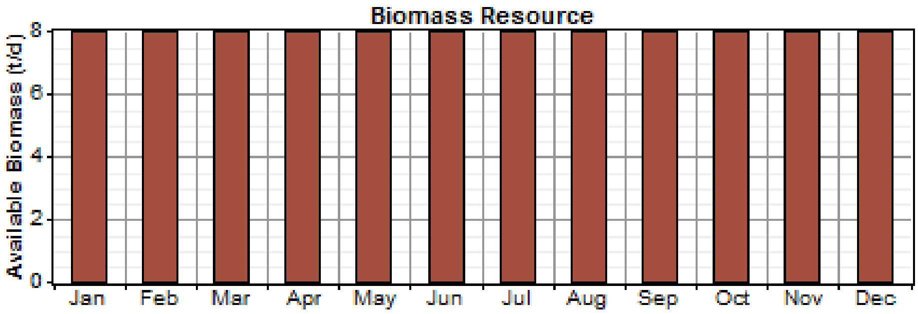


Fig.3 Biomass input in tones/day.

5.2.3 Buttery

Storage battery is essential to make the renewable energy system dependable. The battery bank serves as an energy source entity when discharging and a load when charging. The net energy balance to the battery determines its state-of-charge (SOC). The battery has to be protected against overcharging. It is also necessary to guard the battery against excessive discharge. Therefore, the SOC at any period t should be greater than a specified minimum SOC, SOCmin as given by (1) [5]:

$$1 \geq SOC(t) \geq SOC_{\min} \quad (1)$$

A Trojan T-105 battery is used in this system. The nominal voltage is 24V, nominal capacity is 225 Ah (5.4 kWh). The lifetime throughput is 5 year. The capital cost and replacement costs are taken as $145 [16]. The considered quantities are: 0, 1,2,3,4,5,6,7,8,9,10,20,50.

5.2.4 Inverter

Inverter is an electronic power device that is required in a hybrid system to maintain the energy flow between AC and DC electrical components. The capital cost, replacement cost and O&M costs for 1kW systems, are considered as $700, $550, and $100/year respectively. The lifetime of the inverter is 15 years and efficiency of 90%. The proposed hybrid renewable energy system which consists of a photovoltaic array, biomass generator, storage battery, inverter and load is shown in Fig.4. The estimated lifetime of this system is about 20 years [17].

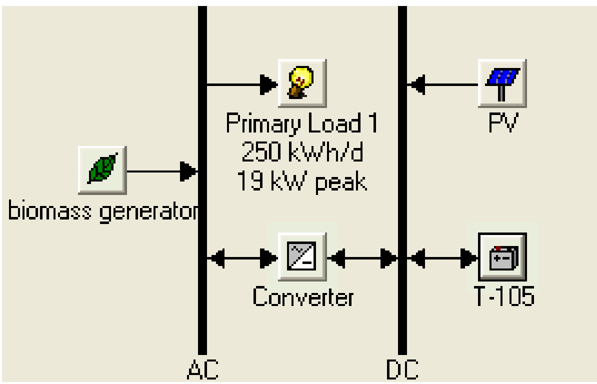


Fig. 4 Schematic of the proposed poultry house hybrid energy system in HOMER code.

5.2.5 Load Estimation:

Birds are very sensitive to their environment and extreme heat or cold will result in greatly increased mortality in the house. Hot and humid weather conditions and poor management practices increase the mortality, reduce the growth and make poultry production to be uneconomical. Heat stress is the major problem in poultry housing. Being a tropical country the temperature reaches over 40°C during summer which is not suitable for poultry housing. Temperature of the poultry houses varies from 25-33°C depending on the growth stage of the birds. The conditioned environment of poultry houses is completely reliant on electricity; power outages will cause changes in temperatures and increasing concentrations of ammonia and germs. Due to the aforementioned factors, security of electricity supply is critical to poultry production; any unexpected loss of power can affect the health and growth and in extreme cases can prove fatal to the birds.

Therefore, optimum temperatures and ventilation are required to maximize productivity. Adequate air conditions are provided through heating and ventilation to attain proper temperature. Therefore, Energy plays a crucial role in poultry production. Energy needs were determined in terms of all actual electrical equipments used in the house. In a typical commercial poultry house, energy is used for several applications; most importantly for lighting, heating, ventilation and cooling, and running electric motors for feed line [10, 18].

Electrical equipments used in the poultry house are presented in Table 1. This Table illustrates the categorized poultry house data; it lists the number of units, voltage, operation periods (hour) and power rating for each equipment.

Table1: Electrical Equipments which are used in the Poultry House.

.**Equipment**	**Number of units**	**Voltage (V)**	**Operation periods (hour)**	**Rated Power (watt)**	**Total power(watt)**
36-inch wall side fan	6	220	24	300	1800
48-inch tunnel fan	4	220	24	1000	4000
Lighting	50	220	24	9	450
Feed line motors	2	220	24	500	1000
Water pump	1	220	12	1000	1000
Total (summer)					8250
Additional winter equipments					
Electrical oil radiator	5	220	12	2000	10000
Pump for heater	2	220	11	500	1000
Total (Winter)					19250

The poultry house is considered to have an average energy consumption of about 250 kWh/d, with a peak demand of 19 kW as indicated in Fig. 4. The daily load profile of poultry house for winter and summer seasons is shown in Fig. 5. Also, a seasonal load profile for poultry house is indicated in Fig. 6. It is observed that the electrical power consumption in winter months is higher than that in summer months due to heating load in these months.

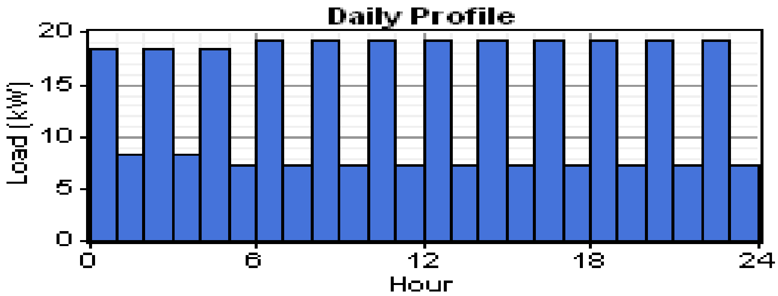


Fig.5 Daily load profile for poultry house.

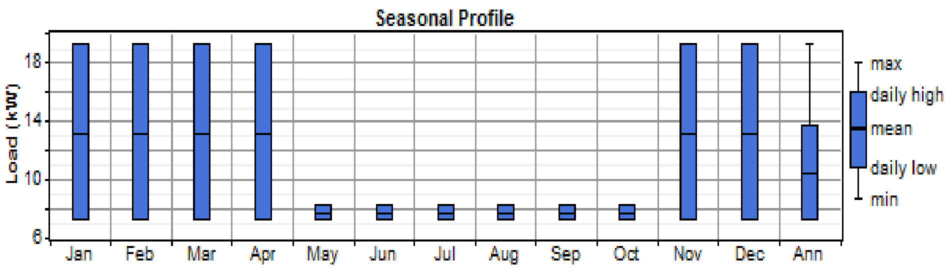


Fig. 6 Seasonal load profile for poultry house.

VI. Economical Model

HOMER's main financial output is the total net present cost (NPC) and cost of energy (COE) of the examined system(s) configurations. NPC analysis is an appropriate gauge or scale for the purpose of economic comparison of different energy systems classification and configuration, the reason is that NPC balances widely divergent cost characteristics of renewable and non-renewable sources. As well, it explores and summaries all the relevant associated costs that occur within the lifetime of the energy project. The economic performance parameters of a photovoltaic-biomass hybrid power system with storage and converter in El-fayoum governorate is calculated through modeling the system. For economic aspect, (NPC) and (COE) of the system are investigated. HOMER uses total net present cost (NPC) to represent the system's life cycle cost. The NPC is calculated by (2) [19-20]:

$$NPC(\$) = \frac{TAC}{CRF} \qquad (2)$$

Where, TAC is the total annualized cost; CRF is the capital recovery factor which can be calculated by the following equation:

$$CRF(\$) = \frac{i(1+i)^N}{(1+i)^N - 1} \qquad (3)$$

Where, N is the number of years and *i* is the annual real interest rate (%).

Cost of energy (COE), which is the average cost per kilowatt-hour ($/KWh) of electricity produced by the concerned system is estimated as in (4):

$$COE(S) = \frac{C_{ann,tot}}{E} \qquad (4)$$

Where, $C_{ann,tot}$ is the annual total cost, $. *E* is the total electricity consumption, KWh/Year.

VII. PV-Biomass System Sizing

7.1 PV Array Sizing

Estimation of the sizing parameters of the PV array is very useful to conceive an optimal and economic PV system.

7.1.1 Estimation the Number of Solar Modules

Estimating the number of PV modules N_{pv} which required for a given daily energy requirement depends on the amount of daily PV energy requirement PV_{wp} and the chosen module peak power $PV_{wp,module}$. N_{pv} can be obtained using the following equation [12]:

$$N_{PV} = \frac{PV_{wp}}{PV_{wp,module}} \qquad (5)$$

7.1.2 Determination the Number of Series Connected Modules

The number of modules Ns to be connected in a series string is determined by the nominal voltage of the module Vn and the chosen DC bus voltage Vpv as given in following equation [12]:

$$Ns = V_{pv}/Vn \qquad (6)$$

7.1.3 Determination the Number of the Modules Parallel-Connected

The number of strings in parallel (N_P) is determined by dividing the designed array output PV_{array} by the selected module output $PV_{wp,module}$ and the number of series modules N_S as indicated in the following equation [12]:

$$N_P = \frac{PV_{array}}{N_S PV_{wp,module}} \qquad (7)$$

7.2 Design of Biomass Generator

7.2.1. Gasification

Gasification can be broadly defined as the thermochemical conversion of solid or liquid carbon based feedstock (biomass) into combustible gaseous fuel by partial oxidation of the biomass using a gasification agent.

The process is carried out at high temperatures of around 800 ºC – 900 ºC. Biomass gasification using air as the gasifying agent, yields syngas which contains CO2, CO, H2, CH4, H2O, trace amounts of hydrocarbons, inert gases present in the air and biomass and various contaminants such as char particles, ash and tars. Fuel Bound organic Nitrogen (FBN) can also be converted into nitrogen oxides (NOx) during gasification [21].

7.2.2 The Suggested Gasifier

Gasifiers are available in different types and sizes. Downdraft gasifiers are one among the fixed bed gasification systems. Downdraft gasification technology has an increased interest among researchers worldwide due to the possibility to produce mechanical and electrical power from biomass in small-scale to an affordable price. The producer gas obtained from a downdraft reactor contains less tar because the gasses are passed through the hot oxidation zone. The downdraft gasifier is also known as Co-Current Moving Bed is shown in Fig. 7. Its fuel is fed from the top and gravitates in the packed bed where it is gasified. Air, oxygen or a mixture of air and steam is fed either from the top or the middle of the reactor and the gasification zones are similar to the updraft reactor. The producer gas is, however, removed from the bottom part of the reactor. Devolatilization of the biomass occurs in the pyrolysis zone, which is heated by convection and radiation from the lower hearth zone. The hearth zone is embedded on top of the reduction zone, to which char is transferred and gasified [21].

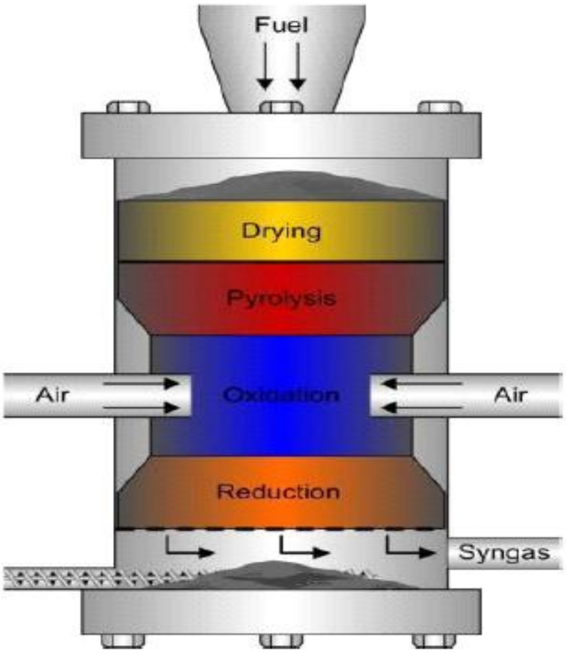


Fig. 7 Down-draft biomass gasifier

7.2.3 Biomass Material

The study focused on the use of agricultural crop residues, specifically maize residues. Maize residues (cobs, leaves and stalks) are abundantly available renewable materials that can be used as an energy source in gasification and combustion systems. Cobs, leaves and stalks are important residues of maize processing and consumption. For every 1 kg of dry maize grains produced, about 0.15 kg of cobs, 0.22 kg of leaves and 0.50 kg of stalks are produced [22]. Maize generates a substantial amount of residues, maize residues consist of the non-edible parts of the plant that are left in the farm after harvesting the targeted crop such as stalks, leaves and cobs. A minimum quantity of these residues are used locally for heating purposes such as water heating, fish smoking, small scale smelting and palm kernel oil processing while a significant quantity is left in the farms to rot. The maize residues available as bioenergy resources were estimated from the annual quantities of the crop produced followed by field verification and the application of the appropriate crop-to-residue ratio as presented in Table 2 [23]. Also, Lower Heating Value (LHV), and moisture content (%) of the maize residues is presented in Table 2.

Table 2: Crop to Residue Ratio, Moisture Content and LHV of Maize Crop.

Commodity	Residue type	Crop to residue ratio	Moisture content (%)	LHV (MJ/kg)
Maize	Maize stalk	1.00	15.5	15
	Maize cob	0.25	8	15

7.2.4 Biomass Fuel Estimation

The amount of maize stalks required to fuel the plant for a year can be estimated using the following procedure:

The annual generated residues in tones, G_A, can be obtained by multiplying Annual Production in tones and Crop to Residue Ratio as it pears (8)[23].

$$G_A = A_P \times CRR \tag{8}$$

where A_p is annual production in tones and CRR is crop to residue ratio. To obtain the Annual Available residues in tons A_A, the annual generated residue in tons G_A, is multiplied by 60% as indicated in (9) [23].

$$A_A = G_A \times 60\% \tag{9}$$

The annual dry maize residues, D_A is given by (10) [23], where MC is the moisture content.

$$D_A = A_A - [A_A \times MC] \tag{10}$$

Similarly, the total energy, ET, in (T J/yr) is given by (11) [23], where LHV is Lower Heating Value of the maize residues

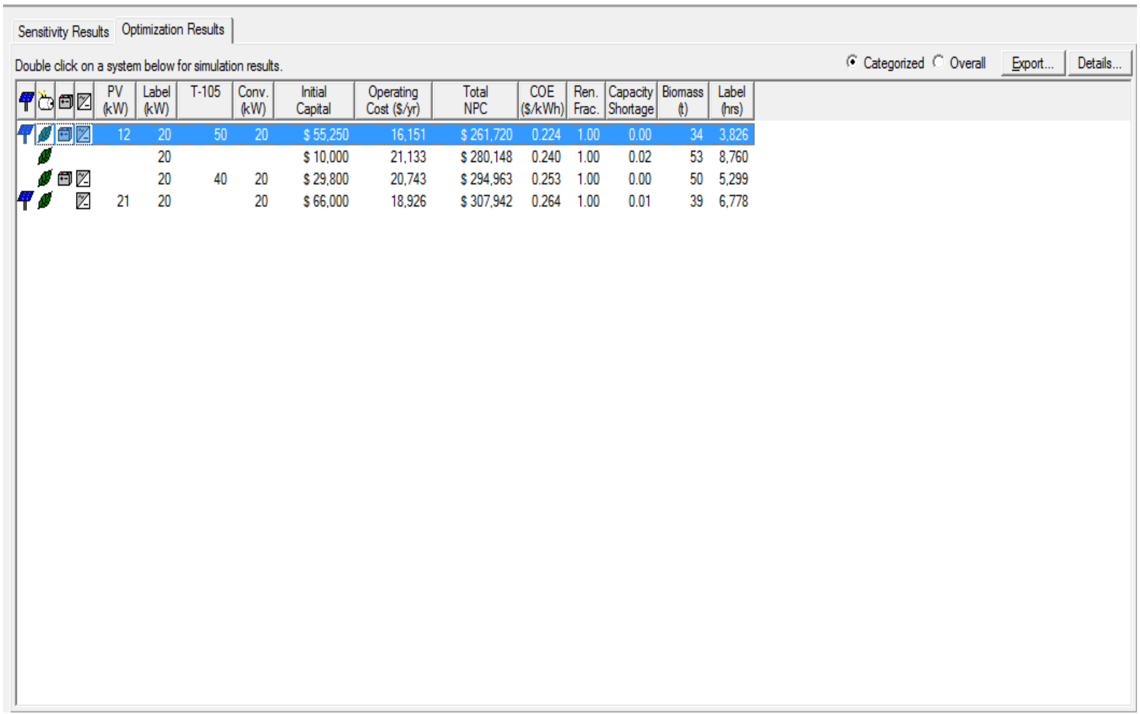
$$E_T = D_A \times \frac{LHV}{100} \tag{11}$$

To obtain the Electricity produced annually, MWh, an average conversion of 1.5 MWh per ton of dry biomass was considered and the final expression is indicated in (12) [23].

$$MWh = D_A \times \frac{1.5MWh}{1tone} \tag{12}$$

VIII. Results And Discussions

The methodology applied provides a useful and simple approach for sizing and analyzing the hybrid systems using HOMER. The output of the simulation helps to choose the optimal system configuration. The aim is to identify a configuration among a set of systems that meets the desired system reliability requirements with the lowest electricity unit cost. HOMER uses the total net present Cost (NPC) and COE as their main selection tools. All the possible hybrid system configurations are listed in ascending order of their total NPC is shown in Fig. 8. Four system configurations are obtained; PV –biomass-battery, biomass, biomass-battery, PV-biomass. The feasible system and economical details of all the configurations of the four hybrid systems resulted from the optimization process are shown in Fig. 8. When these configurations are compared in terms of NPC and COE; the hybrid PV/biomass/battery generation system was found to be the most economically feasible one, which ensures the continuity of power supply and able to fully meet load demands at the lowest possible total NPC of $261,720 and cost of energy $0.224/kWh. Biomass configuration has higher NPC but slightly lower COE ($0.220/kWh) than the optimal configuration ($0.224/kWh). Both the biomass-battery and PV-biomass configurations have higher NPC and COE. The combination of optimal system components are a 12kW PV-Array, 20kW Biomass, 50 T- 105 Battery, 20 kW Inverter. The total NPC, capital cost, replacement cost, operation & maintenance cost, and COE for such a hybrid system are $261,720, $55,250, $96,796, $103,821 and $0.224/kWh, respectively. Figure 9 shows the cash flow summary of each components of photovoltaic-biomass-battery system. The most costs are for the biomass generator and the minimum cost for the PV array.



PV (kW)	Label (kW)	T-105	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage	Biomass (t)	Label (hrs)
12	20	50	20	$ 55,250	16,151	$ 261,720	0.224	1.00	0.00	34	3,826
	20			$ 10,000	21,133	$ 280,148	0.240	1.00	0.02	53	8,760
	20	40	20	$ 29,800	20,743	$ 294,963	0.253	1.00	0.00	50	5,299
21	20		20	$ 66,000	18,926	$ 307,942	0.264	1.00	0.01	39	6,778

Fig.8 Optimization results for the PV and Biomass generator configuration for poultry house.

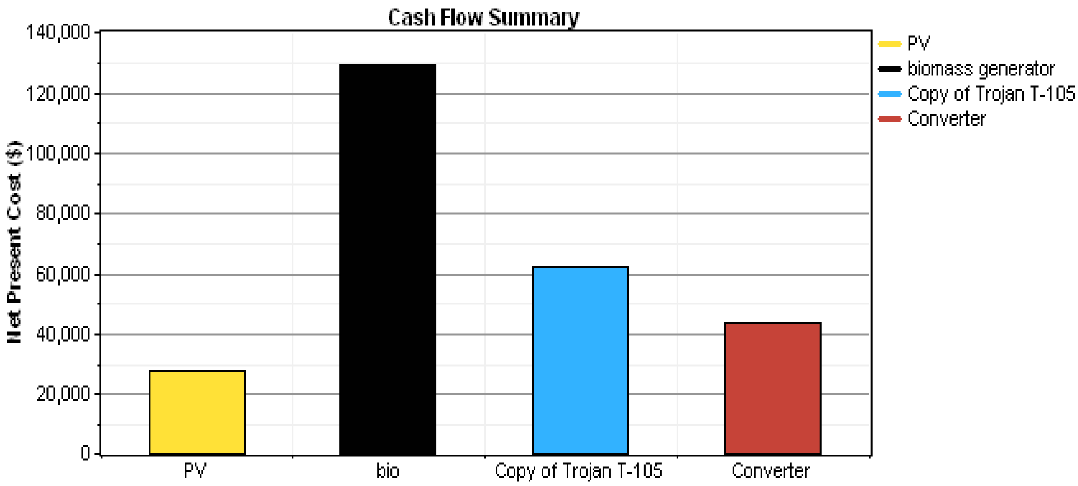


Fig. 9 Cost summary of PV-biomass -battery system

Figure10 shows the monthly average distribution of the electricity produced in kW from the PV and biomass components. If we go towards the electricity produced by that system, it is observed that, the total electrical production of the hybrid system is 102,403 kWh/yr operating for 8760 h/yr. PV array contributes 30,796 kWh/yr of energy which is about 30% of the total energy supplied to the load by the hybrid energy system and biomass gasifier contributes 71,607 kWh/ yr of energy which is about 70% of the total energy supplied to the load by the hybrid energy system. Both the unmet electric load and capacity shortage values equal zero. The consumption is about 91,247 kWh yr and excess electricity is about 8, 68 kWh /yr as shown in Fig. 10. Therefore, the proposed hybrid energy system can supply the poultry house through 24 hour by a reliable power supply throughout the year. Based on the optimization results, it is observed that, during the winter months (from November to April) the biomass energy generator contributes a bigger proportion of energy generation than the PV array. Also, during the summer months (from May to October), the load demand is met nearly by approximate contribution from the PV array and the biomass generator. The COE obtained from the optimal hybrid system is $0.224/KWh. The cost of the different elements of the optimal system configuration is shown in Table 3. The batteries have a low impact on the capital and O&M costs. PV shares the maximum portion of the capital investment. Only biomass generator has the fuel costs.

Table 3**:** The Cost of the Different Elements of the Optimal System Configuration.

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	24,000	7,483	0	0	-4,194	27,289
biomass generator	10,000	29,070	78,255	13,161	-1,452	129,033
Copy of Trojan T-105	7,250	55,653	0	0	-808	62,095
Converter	14,000	4,590	25,567	0	-854	43,302
System	55,250	96,796	103,821	13,161	-7,308	261,720

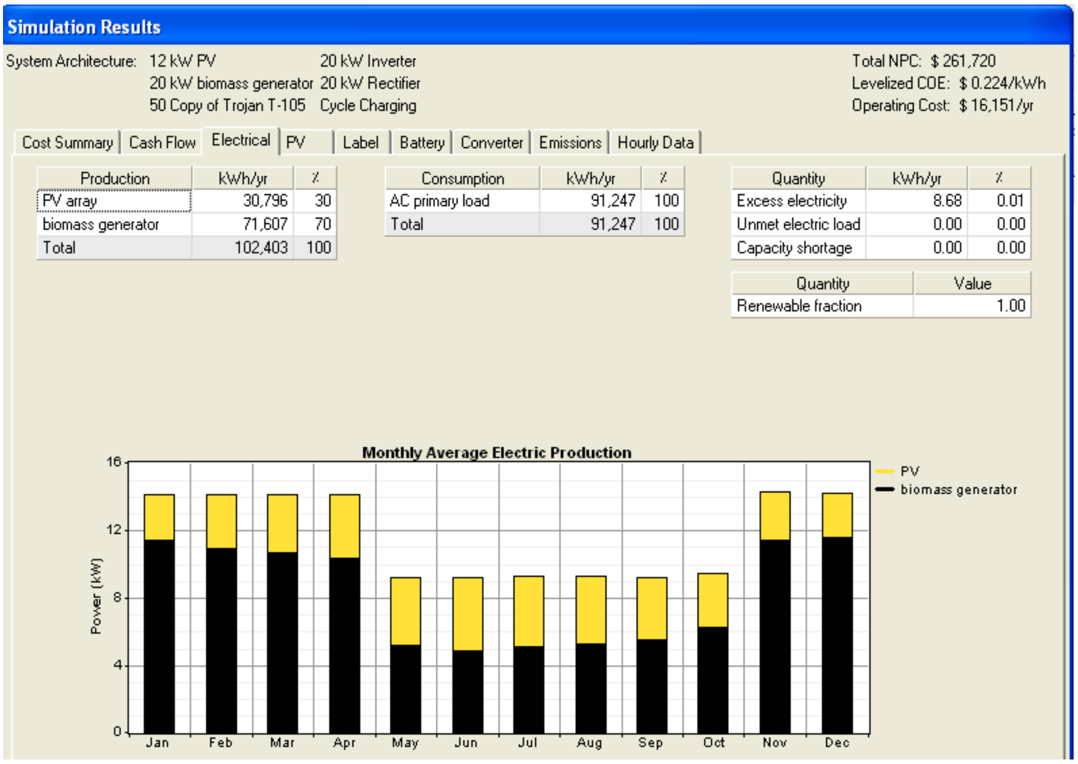


Fig. 10 Monthly average electricity production of the optimal system configuration

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In this study, the emissions from the four energy system configurations were evaluated. A comparison between types of greenhouse gas emission and their quantity within one year of operation for these energy systems is illustrated in details in Table 4. Carbon dioxide, carbon monoxide, unburned hydrocarbons, particular matter, sulfur dioxide and nitrogen oxides are the emitted pollutions. Emission is measured as yearly emissions of the emitted gases in *kg/ yr*. It is observed that, PV-biomass-battery system generates the minimum values of pollution emissions.

Table 4 : A comparisons of the Emissions from Different Configurations of Hybrid Power Systems.

Emission / System	**Carbon dioxide (Kg/yr)**	**Carbon monoxide (Kg/yr)**	**Unburned hydrocarbons (Kg/yr)**	**Particular matter (Kg/yr)**	**Sulfur dioxide (Kg/yr)**	**Nitrogen oxides (Kg/yr)**
PV/Biomass/ Battery	2.16	0.223	0.0247	0.0168	0	1.99
Biomass	3.32	0.342	0.0379	0.0258	0	3.05
Biomass/ Battery	3.14	0. 323	0.0358	0.0244	0	2.88
PV/Biomass	2.44	0.251	0.0278	0.0189	0	2.44

Semines Solar SP 75 PV with 75 Wp (PV_{WP},module =75 W) module was selected for the proposed PV array. This PV module is a mono-crystalline silicon type with nominal maximum power of 75W, each module contains 36 silicon cell connected in series. Table 5 shows the Semines Solar SP 75 PV module electrical specifications. For the daily peak power requirement of 12 kW, if the DC bus voltage V***pv*** is chosen to be 24V, 160 modules are needed to supply the load with required energy. The number of modules to be connected in a series string Ns is obtained to be 2 modules and the number of strings in parallel N_P is equal 80 modules.

Table 5: Semines Solar SP75 Photovoltaic Module specifications

Characteristics	Rating
Maximum power (Pmax)	75 W
Voltage at Pmax	17 V
Current at P_{max}	4.4 A
Short-circuit current (Isc)	4.8 A
Open-circuit voltage(Voc)	21.7 V
Height	1200 (mm)
Width	572 (mm)
Efficiency	15%

The moisture content and the Lower Heating Value (LHV) for the maize stalks are 15.5 and 15 respectively. This implies that for the 24 hours a day that the gasifier will be operating for 365 days in a year, it will consume a 840960 kg maize stalks annually, equivalent to 840.960 tons for the daily peak power requirement of 20 kW contributed by the biomass generator.

IX. Conclusion

Hybrid energy system has the advantage of providing power on a reliable and environmental friendly basis. The main objective is to meet the electricity demand of a poultry house. This can be achieved by making proper utilization of resources like biomass and solar. Also, this work determine the optimal size of a hybrid renewable energy system which able to fulfill the requirements of 250 kWh/day load with 19 kW peak load for a poultry house located at El-fayoum governorate, Egypt. The proposed hybrid system can supply the poultry house for 24 hour by a reliable power supply throughout the year. In this study, a resource assessment and demand calculation have been carried out and the COE has been ascertained for different systems and configurations. The optimization and simulation by HOMER shows that, on the basis of lowest COE and NPC, a combination of PV, biomass generator and battery system has been identified as the cheapest and most dependable solution with a NPC and COE of $261,720 and $0.224/kWh respectively. The complete sizing procedure of the PV system is presented. The number of series connected PV modules is 2, while the number of parallel strings is 80. It is found that, for the 24 hours a day that the gasifier will be operating for 365 days in a year, it will consume 840960 kg of maize stalks. The simulations' results prove that the combination of PV-biomass-battery system configuration is the best solution to guarantee the reliable supply without interruption of the load under the climatic data change.

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