SSRG International Journal of Electronics and Communication Engineering Volume 7 Issue 5, 10-18, May 2020
ISSN: 2348 – 8549 /doi:10.14445/23488549/IJECE-V7I5P103

Simulation Design of hybrid System (Grid/PV/Wind Turbine/ battery /diesel) with applying HOMER: A case study in Baghdad, Iraq

AHMAD AL-SARRAJ [#1], Hussein T.Salloom[*2], Kareem K.Mohammad[#3], Saad M.Mohammadghareeb[#4]

[#1] *Ministry of higher education and scientific research, Iraq-Baghdad*

[#2] *Al_Nahrian Unversty, Iraq-Baghdad*

[#3] *Al_Nahrian Unversty, Iraq-Baghdad*

[#4] *Al_Nahrian Unversty, Iraq-Baghdad*

Received Date: 12 April 2020
Revised Date: 11 May 2020
Accepted Date: 14 May 2020

Abstract:
The purpose of the presented paper is to simulate a hybrid power system for most urban constructions, which is technically feasible and economically optimal with a significant role in supporting clean energy and protect the environment from toxicity emissions. With a vision to promote clean, renewable energy resources, photovoltaic also wind turbine has been joined with the grid-connected building. Two systems have been modeled (with sell back and without sell back price); the comparative analysis and the optimal system configuration have been examined to support a hybrid optimization model for electric renewables (HOMER). The results indicated that the hybrid system with sellback property was the optimal solution (Grid, PV, Battery, Wind Turbine) that produced 61.6 kW/yr. The logic has been established with the case study due to the practical datasheets placed in Iraq.

Keywords: *Hybrid System, Homer Program, Clean Energy, Energy Automation.*

Abbreviations

1- HOMER: hybrid optimization model for electric renewables.
2- RE: renewable energy.
3- RES: renewable energy sources.
4- MESCA: Modified Electric System Cascade Analysis.
5- DDTE: the design, development, testing, and evaluation
6- $n_{mp,STC}$: The efficiency of the PV cell in standard test circumstances [%]
7- Y_{PV}: The rated power output of the PV cell in standard test circumstances [kW]
8- A_{PV} : The surface area of the PV cell [m^2]
9- $G_{T,STC}$: The radiation at standard test circumstances [1 kW/m^2]
10- Y_{pv}: The rated capacity of the PV array, meaning its power output in standard test circumstances [kW]
11- f_{pv} : The PV panel derating factor [%]
12- G_T : The solar radiation incident on the PV array in the current time step [kW/m^2]
13- $G_{T,STC}$: The incident radiation at standard test circumstances [1 kW/m^2]
14- α_p : The temperature coefficient of power [%/°C]
15- T_c : The PV panel temperature in the current time step [°C]
16- $T_{c,STC}$: The PV panel temperature under standard test circumstances [25°C]
17- TAC: total annualized cost
18- CRF: capital recovery factor
19- (r): discount rate
20- (n) : project lifetime in years

21- NASA: National Aeronautics and Space Administration
22- O/M: Operation & maintenance

I. Introduction

According to growing concerns about global warming and environmental toxic waste, numerous nations agree to reduce carbon emission to the atmosphere due to the Kyoto protocol. According to the previous protocol agreement, the release of carbon must be reduced by 50% by 2050. As a result, several nations attempt to have special attention to this aspect by employing environmental-friendly resources like less emission energy resources. Implementation of renewable energy resources might be valuable with a view to eliminating environmental problems. [1].

Recent trends continue for increasing electric usage averages and decrease the solar photovoltaic (PV) costs in the market for residential solar power systems. Understanding the analysis of the political, financial, and technical decisions is valuable for informing that support society's transition to cleaner energy. HOMER The hybrid energy system modeling software is applied here to model local energy use for Baghdad-Iraq's research center. Sensitivity analysis is considered one of the unique properties of HOMER, which can compare the effects of many variables. This functionality makes the software ideal for reviewing their factors that define the cost-effectiveness between grid-only and grid/PV/wind turbine for local power systems. The study investigates the elements that affect the economics of those systems [2].

Power grids across Iraq and other nations worldwide have been suffering greater than before from power outages. Thus, energy regulations and policies should require reappraisal across the world. Most of these crises have been directly associated with climate change (increases in environmental &natural disasters), aging infrastructures, volatilities in the market place based on (financial, wars, rumors of wars, and threats of terrorism) also raised demand/loads for electrical power consumption [3]. Iraq suffers from a shortage of power usage, and the effects of wars and terrorist processes led to collect all efforts to find ways to improve power energy production.

Nonetheless, utilize batteries supposed to be an important key for low energy storage. According to weather conditions, the fluctuation of renewable energy sources, batteries need to store energy produced in the non-consuming range or for surplus energy times [4].

HOMER software is used to accomplish the ideal system with a hybrid traditional/RE system connection. The hybrid system consists of PV, wind turbine, grid, batteries, and power converter. Initially, planned and optimized the system to reach all needed standards. Then, deep analysis for all technical, economic, and Environmental details are investigated and debated. Lastly, a comprehensive sensitivity analysis is implemented to examine the impacts of changing different system performance elements. These elements have a direct effect on the system performance and the utilized management system. All possible scenarios are designed and debated in the study [5].

Nowadays, plenty of literature is being worked on hybrid systems and their applications. In the literature survey, different configurations have been analyzed; such as HOMER software have been used by L.halabi et al (2017) to design the whole system and analyze operating performances for various PV penetration levels to precisely quantify the behavior of PV integration[6]. L.Olatomiwa et al. (2016) reviewed and covered different configurations of the hybrid renewable energy systems for electric power generation. The energy Management strategies were given Special attention to use in smart grids. Fuzzy logic systems were also implemented to achieve Energy management Strategies [7]. F. Baghdadi et al. (2015) discussed the effectiveness of hybrid PV–Wind–Diesel Battery configuration based on hourly measurements of Adrar climate (southern Algeria). The hybrid configuration has been well developed to ensure higher fuel saving while the objective is maximizing renewable electricity use [8]. S. Bahramara (2016) propose and evaluate the advantages of combing renewable energy technologies to reach the energy needs of a wastewater treatment facility due to conventional activated sludge system in the city, which is located in a specific water-stressed area of Sub-Saharan Africa [9]. Cost analysis is debated due to the features of solar radiation exposure in South Korea by Mohammed H. Alsharif (2017) and investigated an independent solar power system to provide heterogeneous cellular networks within required energy sources [10]. N. AzierohArman et al. (2015) proposed a separated energy storage system that covers great energy density storage systems and great power density storage systems to investigate an expected rising supplies. numerous simulation results validate the efficiency of the indicatedmethod throughout HOMER program [11]. The finest hybrid technology group from a mixture of renewable energy resources is presented by

Sen and C. Bhattacharyya (2014) to meet the electrical required in a reliable manner of an off-grid remote village, Palari, in the state of Chhattisgarh, India. Using HOMER, the study detects the optimum off-grid choice and compares this with traditional grid extension [12]. H. Kim et al. (2014) found that the most economically feasible hybrid system is a grid-connected wind turbine photovoltaic battery converter hybrid system by inspected the economic, environmental, and technological feasibility of hybrid systems at Jeju the Island in South Korea[13]. MESCA method has discussed by H. Zahboune et al. (2016), for finding the ideal of a standalone hybrid PV/WT power system with battery storage, The optimum design is chosen depending on the hourly meteorological data. The MESCA method can be applied to find the optimum scheme and be employed to size the hybrid system [14]. HOMER software was utilized by H. Shahinzadeh et al. (2016) to conclude the size of electrical resources in a microgrid, which has interactions with the power market [15]. The optimization process of energy costs of a grid-connected hybrid Photovoltaic (PV)/ Battery/Grid is presented by Alghamdi et al. (2018). The example in the Brazilian Amazon area is applied as an optimization. The system performance and optimization effects are certified by applying(HOMER) [16].

According to the previous literature review works, many studies were accomplished to find the ideal design, explore the potential or investigate the techno-economic feasibility due to various aspects and comparison analysis; however, HOMER can be played a productive role in achieving these objectives.

The presented case study investigated the suitable management system, comprehensive techno-economic with environmental aspects have been analyzed where a detailed sensitivity analysis is applied to investigate the impacts of main factors at on-grid connection.

II. HOMER

In the HOMER review, the hybrid renewable energy technology (RET) system is configured, followed by a techno-economic analysis. The analyses are determined by the system's technical features and the life-cycle cost (LCC) of the system. The LCC contains the initial capital cost. It compares a wide range of equipment with different constraints and sensitivities to optimize the system design, cost of installation, and operation costs over the system's life duration. HOMER achieves simulations to meet the specified demand utilizing alternative technology possibilities and resource availability. Due to the simulation results, the ideal suited configuration is elected [17].

III. Site description

Baghdadis the capital city of Iraq; Baghdad exists in the middle of Iraq. This case study presented one station in a specific location in Baghdad, which is named(nonrenewable energy research center)that is located in the university of Nahrain with a latitude and longitude 33.16E /44.22N. It is the main center of scientific studies and experimental researches.

IV. System configuration

The hybrid system consist of (grid-solar-wind-diesel) has been investigated in this case study shown in Fig 1. The system involves of wind power system, photovoltaic (PV) system, an inverter, diesel generator, and the load required. The electric power is produced by the PV cells with wind turbines (WT) to meet the power required.

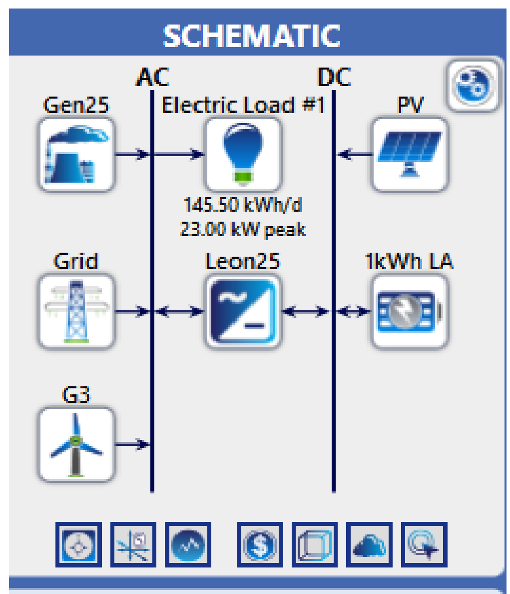

Fig 1.shows the configuration system for the case study

IV. *A. load profile*

In this study, the average electrical load of the center was calculated by the canter's administrators. It was observed that the maximum electric load recorded was in the summer period. At the same time, winter is the lowest level of electric load. On the other hand, the average daily electrical base lıne load was about 145.5 kWh/Dover a full year, while 23 kW was recorded as the maximum for electric load Fig 2.

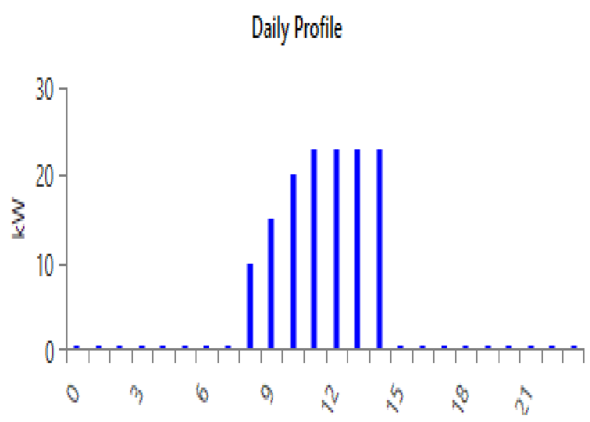

Fig 2. Shows the daily electrical load

IV.*B.SolarEnergy Resources*

NASA Surface Meteorology and Solar Energy Irradiance data have been utilized in this research; due to the exact site latitude and longitude, the average level of solar radiation for the site is 5.02 kWh/d shows in Fig3.According to data from homer.

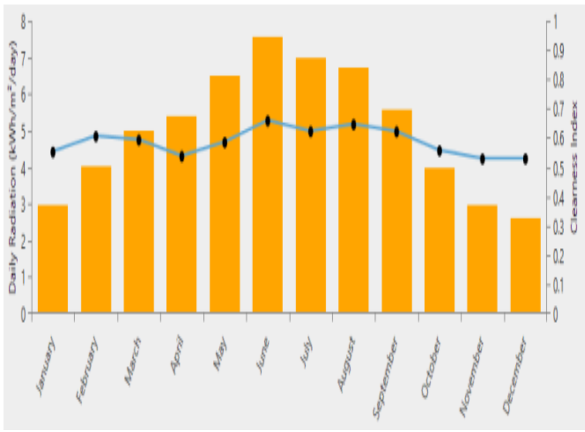

Fig 3. Shows the solar irradiance with clearness index through the year on the exact site

IV.*C. wind energy supplies*

NASA Surface Meteorology data of wind speed applied by this paper depend on the site latitude and longitude. The annual average wind speed has been calculated as 5.37 m/s according to data from NASA indicates in Fig 4, which are extracted from HOMER.

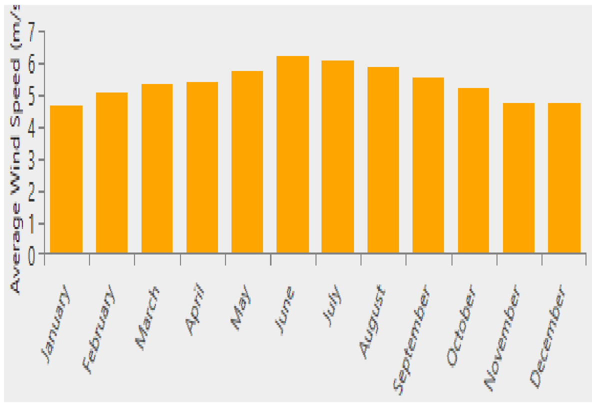

Fig 4. Indicates the average wind through the year on the exact site

IV.*D. Economic*

Renewable energy Projects need a relatively long-term time duration in current studies, 20-30 years assumed in most projects. The study proposed a project span of 25 years.

IV.*E. PV Panels*

In the presented study, the capital costs of solar cells, the replacement costs, and the yearlyO&M cost per 20 kW capacity were estimated to be $12,000, $12,000, and $200 per year. The values depend on a report of local markets. The lifetime of a PV cell was supposed to be 25 years. A derating factor of (80%) was applied to calculate the electric generation from each PV cell. This factor decreases the cell's productivity by 20% to estimate the changing effects of temperature and external circumstances, like dust, on the cells. In the case of solar cells, this factor reflects that as air temperature rises, there is a reduction in the power efficiency of 0.5%/C°. This study supposed that all cells were considered fixed and tilted at 33.28°, which is close to the site's latitude. The ground reflection was supposed to be 20%.

IV.*F. Wind Turbine*

One Generic 3 kW Wind turbine is utilized in this study; a model is proposed to clarify the analysis. The setting costs of wind turbines, replacement costs, and yearly O&M costs of a turbine are estimated to be $2,000, $2,000, and $180. These values were also dependent on local market prices; the height of the wind turbine's hub and lifetime were assessed to be 17 m and 20 years, respectively.

IV.*G.Converter*

Due to this study, Leonics, 25 KW converter has been designed; the study assessed the beginning installation costs, replacement costs, and yearly maintenance costs were $8,000, $8,000, and $20 per 25 kW. Twenty-five years of a lifetime for a converter was proposed, and a converter's efficiency is assessed to be 96%. The rectifier input is intended to be 80%.

IV.*H.Diesel generator*

One Diesel generator is configured to satisfy the load demand; as a rule, if there is no power output from the PV cells and status of the grid in an outage, initial and replacement expenses in this study are evaluated to be $12,500 and $12,500 respectively for Generic 25kW Fixed Capacity Genset, the maintenance cost assumed to be 0.750 $/h. The charge of diesel is proposed to be1.0$/L on the presented site.

IV.*I.Batteries*

24 Generic 1kWh Lead Acid type batteries are employed in the presented sites (Al-nahrain renewable energy center). Each cell comprises a nominal voltage 12V and nominal capacity 1 KWh.initial, and replacement costs were considered to be $7,000 and $7,000 respectively, with ten years duration lifetime.

IV.*J.Grids*

This paper assumed two cases, one with sellback and the other without sellback, and investigate the differences in the optimization results; the cost assumed to be$0.10/kW to buy power from the grid according to the power statistics revealed by the Iraqi ministry of electricity information system of power exchange. Furthermore, $0.5/kW if sellback property is applicable, if the price of selling power to the grid would be achieved. The renewable energy field is anticipated to gain great profits during the advancing policy, which recently being introduced.

V.Implemented operating strategies

Three important operating strategies were achieved with presented hybrid renewable energy(RE) system, which named as Load Following (LF) and Cycle Charging (CC), combined dispatch (CD) strategies. In the LF strategy, a diesel generator is designed to provide the loads only in the absence of PV powerproductivity, whereas the PV arrays provide the load and charge the batteries due to surplus electricity. Otherwise, diesel generators were utilized to satisfy the required loads and at the same time charge the batteries in the CC strategy. LF strategy appears to be a productive strategy, as it helps to decrease the surplus energy and the total NPC(net prices costs), to avoid making presumptions and constraints about the upcoming netload, the Combined Dispatch strategy utilizes the existing net load to control whether or not to charge the battery by the generator. It applies the Cycle Charging dispatch strategy when the net load is declined and the load Following dispatch strategy when the net load is inclined. By Cycle Charging during periods of declined netload, the Combined Dispatch helps avoid using the generator at declined loads. By Load Following during periods of inclined netload, the Combined Dispatch permits the generator's continued use. According to this flexibility depend on high and low loads, the Combined Dispatch can accomplish better than load Following or Cycle Charging in the energy access situations[18].

VI. Optimization and simulation results

VI.*A. Optimized results*

The technical, economic, and environmental analysis has been investigated, and the existing hybrid system PV/wind turbine/Battery/grid has been examined. In both cases (with grid sell back price and without). Although both case prices analysis has been compared with grid alone which is illustrated in Fig.5.6, the result included the sensitivity study used for observing the impacts of variations and increasing demand through the years of the project. Facilities of (HOMER) are employed in the simulation. Both case's net present cost (NPC) and cash flow chart have been illustrated below. Table1 3.Indicated the cost summary, and (Table 2, 4) showed the electrical production for each component of both cases systems:

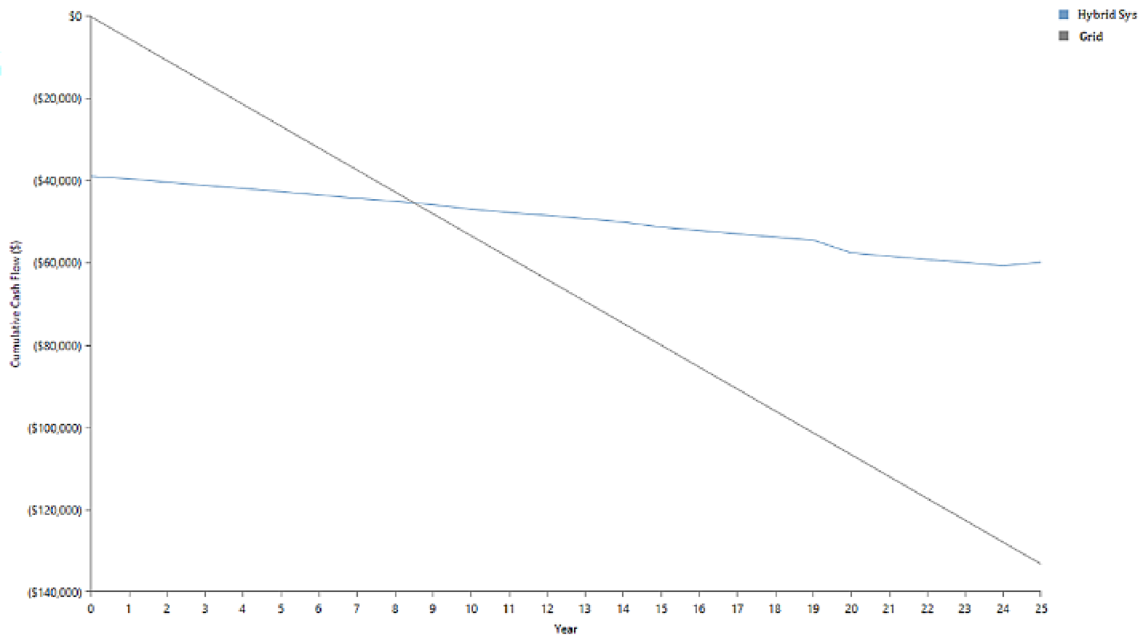

Fig 5. Indicates the cash flow changing of the project through 25 years with sellback property

The line graph above shows the changes between the cash flow and the project duration expanded from (0-25) years. According to the line graph, there is a significant drop in the gridline through the years, comparison with the hybrid system line that drop-down slightly with small fluctuation through the years (18, 19, 29) respectively, In addition to that there is meeting point cost between the two lines in the year of (8). An important incline in the hybrid line compared with grid line in the year of 24 that incline point means the system starts the payback gain costs from the proposed project.

Table 1. Illustrates the summary cost details for the hybrid system with sellback property

component	Capital($)	Replacement($)	O&M($)	Feul($)	Salvage($)	Total($)
Generic 1kWh Lead Acid	$300.00	$265.03	$12.93	$0.00	($35.93)	$542.03
Generic 3 kW	$2,000.00	$637.61	$14,100.43	$0.00	($304.43)	$16,433.62
Generic flat-plate PV	$28,287.50	$0.00	$1,218.96	$0.00	$0.00	$29,506.46
Grid	$0.00	$0.00	($5,205.53)	$0.00	$0.00	($5,205.53)
HOMER Cycle Charging	$200.00	$0.00	$129.28	$0.00	$0.00	$329.28
Leonics MTP-413F 25kW	$7,700.00	$0.00	$62.21	$0.00	$0.00	$7,762.21
PV Dedicated Converter	$500.00	$212.14	$64.64	$0.00	($39.93)	$736.85
System	$38,987.50	$1,114.78	$10,382.91	$0.00	($380.29)	$50,104.91

The electrical production from the system has been illustrated in the table see (Table.2) below for every module of the presented hybrid system with sellback property:

Table 2. Indicates the electrical production for the presented hybrid system

Production	KW/yr.	%
Generic flat-plate PV	61,614	83.2
Generic 3 kW	2,749	3.71
Grid Purchases	9,690	13.1
Total	74,053	100

Otherwise, the details of the hybrid system without sellback property have been analyzed below:

Fig 5.Illustrates the changes between the cash flow and the project duration expanded from (0-25) years. According to the line graph, there is a significant drop in the gridline through the year's comparison with the hybrid system line. The line of the hybrid system declined also. In addition to that, there is a meeting point of the two lines near the year of (12) compared to the previous project which the meeting point occurred in the year of (8). Moreover, the stability has been started in the hybrid system line after the year (24), which means that the system began to return the payback costs.

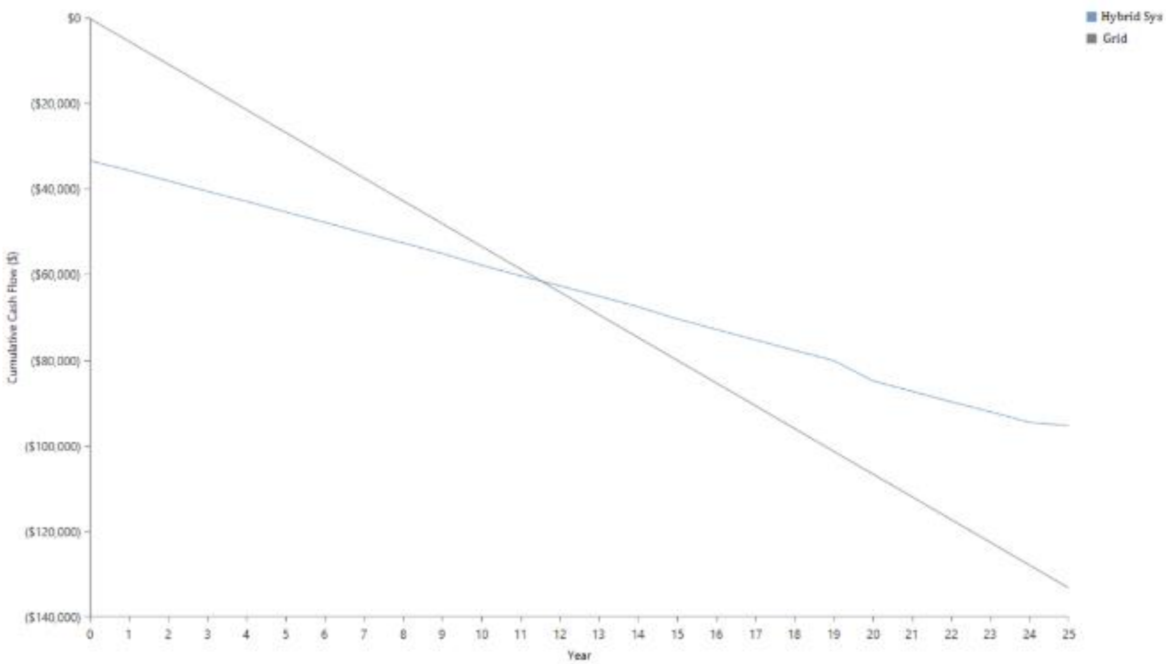

Fig 6. Indicates the cash flow changing of the project through 25 years without sellback property

Table 3. Shows the summary cost details for the hybrid system without sellback property

component	Capital($)	Replacement ($)	O&M($)	Feul($)	Salvage($)	Total($)
Generic 1kWh Lead Acid	$300.00	$265.03	$12.93	$0.00	($35.93)	$542.03
Generic 3 kW	$2,000.00	$637.61	$14,100.43	$0.00	($304.43)	$16,433.62
Generic flat-plate PV	$23,182.43	$0.00	$998.97	$0.00	$0.00	$24,181.40
Grid	$0.00	$0.00	$16,227.63	$0.00	$0.00	$16,227.63
HOMER Cycle Charging	$200.00	$0.00	$129.28	$0.00	$0.00	$329.28
Leonics MTP-413F 25kW	$7,217.75	$0.00	$58.32	$0.00	$0.00	$7,276.07
PV Dedicated Converter	$500.00	$212.14	$64.64	$0.00	($39.93)	$736.85
System	$33,400.18	$1,114.78	$31,592.18	$0.00	($380.29)	$65,726.86

The electrical production from the system has been illustrated in the table see (Table.4) below for every module of the presented hybrid system without sellback property:

Table 4. Indicates the electrical production for the presented hybrid system

Production	KW/yr.	%
Generic flat-plate PV	55,461	78.4
Generic 3 kW	2,749	3.89
Grid Purchases	12,553	17.7
Total	70,763	100

According to homer, the PV efficiency for both cases under the standard test conditions calculated by this formula [18]:

$$n_{mp,STC} = \frac{Y_{PV}}{A_{PV}\, G_{T,STC}} \quad (1)$$

Also, HOMER utilized the next equation to compute the output of the PV array:

$$P_{pv} = Y_{pv} f_{pv} \left\{\frac{G_T}{G_{T,STC}}\right\} [1 + \alpha_p (T_c - T_{c,STC})] \quad (2)$$

Total net price costs (NPC) cover all expenses and profits throughout the project's lifetime, with reduced cash flows in the future. The total NPC involves the system components' capital cost, the replacement cost of components that happens through the working period, and the maintenance cost. Moreover, The NPC considers any recovery costs of components, which is the remaining value of the system components after the operating period of the system, then NPC is calculated as follows:

$$NPC = \frac{TAC}{CRF} (3)$$

CRF can be calculated, as the equation:

$$CRF = \frac{r(1+r)^n}{(1+r)^n - 1} \quad (4)$$

Nevertheless, HOMER adopts all expensesincrease at the same rate and employs a yearly real interest rate rather than a nominal interest rate.

VII. Conclusion

HOMER has implemented an evaluation of cost optimization of electricity production. Two cases are debated of hybrid systems; HOMER is the tool utilized to analyze the system's technical and economic feasibility. Then, HOMER is applied to optimize the Nano renewable energy research center's electricity production, which is located in Baghdad. The ideal solution was a hybrid system with sellback property (Grid, PV, Wind Turbine, Battery) that produced 61.6kW/yr from PV arrays. The size of PV installed and the PV output power is based on the building's specified area. However, other renewable energy such as Wind turbine produced 2.7 KW/yr, the grid purchases 9.6KW/yr. The total from the system has been recorded as 74 KW/yr. Moreover, the result indicates a significant difference between both hybrid systems in the factors of total system price and the cash flow line through the project's life. The study recommends activating the sellback property with hybrid systems for crucial economic and production results.

VIII. ACKNOWLEDGMENT

The writers would like to give thanks for support and motivation from the nano renewable energy research center staff located at AL- Nahrain University, Iraq-Baghdad, for their facilities to accomplish this paper.

References

[1] Hossein, S., Majid, M., Hamid F., Gevork, B., "*Optimal Sizing and Energy Management of a Grid-Connected Microgrid using HOMER Software.*" Smart Grids Conference (SGC), 20-21 Dec. 2016, Graduate University of Advanced Technology, Kerman, Iran.

[2] Nathan, J., Peter L., Timothy S., "*Modelling distributed premises-based renewables integration using HOMER*." Grid-Interop, 2011.

[3] Jeffrey, A., David, G., Tianlu, G., "*Affordable Mobile Hybrid Integrated Renewable Energy System Power Plant Optimized Using HOMER Pro*." North American Power, ieeexplore.ieee.org, 2016.

[4] Hoarcă, C., Nicu, B., Bădiţă, A., "*Design of hybrid power systems using HOMER simulator for different renewable energy sources*." ECAI International Conference – 9th Edition, 2017.

[5] Laith, M., Saad, M., Mehdi, S., Ben, H., "*Energy management for a grid-connected hybrid renewable energy system*." ieeexplore.ieee.org, 2017.

[6] Laith, M., *"Performance analysis of hybrid PV/diesel/battery system using HOMER: A case study Sabah, Malaysia."* Energy Conversion and Management, 144, 322–339, 2017.

[7] Lanre, O., Saad, M., Ismail, S., Moghavvemi, M., "*Energy management strategies in hybrid renewable energy systems*." Renewable and Sustainable Energy Reviews, 62, 821–835, 2016.

[8] Fazia, B., Kamal, M., Said, D., Omar, B., "*Feasibility study and energy conversion analysis of standalone hybrid renewable energy system."* Energy Conversion and Management, 105, 471–479, 2015.

[9] Bahramara, S., Moghaddam, M., Haghifam, M.., *"Optimal planning of hybrid renewable energy systems using HOMER: A review*." Renewable and Sustainable Energy Reviews, 62, 609–620, 2016.

[10] Mohammed, H., "*Optimization design and economic analysis of energy management strategy based on photovoltaic/energy storage for heterogeneous cellular networks using the HOMER model. Solar Energy*", 147, 133–150, 2017.

[11] Azieroh, N., Logenthiran, T., Woo, L., "*Intelligent Energy Management of Distributed Energy Storage Systems in Microgrid*." IEEE Innovative Smart Grid Technologies, ieeexplore.ieee.org, 2015.

[12] Heetae, K., Seoin, B., Eunil, P., Hyun, J., Chang, "*Optimal green energy management in Jeju, South Korea e On-grid and off-grid electrification*." Renewable Energy, 69, 123-133, 2014.

[13] Hassan, Z., Smail, Z., Goran, K., Petar, S., Mohammed, E., "*Optimal hybrid renewable energy design in an autonomous system using Modified Electric System Cascade Analysis and Homer software*." Energy Conversion and Management, 126, 909–922, 2016.

[14] Abdulrahim, H., Alghamdi, S., Carlos, H., Marciano, C., Ramon, Z., "*Review of Cost Optimization of Electricity Supply by Using HOMER and a Case Study for a Big Commercial Customer in Brazilian Amazon Area*." Springer, 2018.

[15] Rohit, S., Subhes, C., "*Off-grid electricity generation with renewable energy technologies in India: An application of HOMER."* Renewable Energy, 62, 388-398, 2014.

[16] Anurag, C., Saini, P., "*A review on Integrated Renewable Energy System based power generation for standalone applications: Configurations, storage options, sizing methodologies and control*." Renewable and Sustainable Energy Reviews, 38, 99–120, 2014.

[17] Available at [http:\\www.homerpro.com]. At [www.homerenergy.com/products/pro/docs/latest/_system_control.html]

[18] Harsha D N, Arjun M S, Niranjan Kumar V S, Tejendra Prasad, "Planning and Design for a Singapura Village in Karnataka for Self Energy Generation with Utilization of Sustainable Technologies" SSRG International Journal of Mechanical Engineering 1.6 (2014): 27-31.

[19] Rijuta S.Bapat, Vasant A.Mhaisalkar, Rahul V.Ralegaonkar "Techno-Economic Analysis of Sustainable Energy Management Techniques – A Case Study" International

Journal of Engineering Trends and Technology 65.3 (2018): 168-175.

[20] Karuna Nikum, Rakesh Saxena, Abhay Wagh "Performance Analysis of Battery Banks with PV-Wind Connected Hybrid Distributed Power System", International Journal of Engineering Trends and Technology (IJETT), V29(4),177-182 November 2015.

[21] Mulugeta Tadesse, Chernet Merkneh "Design of Solar PV Underground Water Pumping System for Household Water Consumption in Bilate Basin, Ethiopia" International Journal of Engineering Trends and Technology 68.2 (2020):49-56.