Diyala Journal of Engineering Sciences

ISSN 1999-8716
Printed in Iraq

Second Engineering Scientific Conference
College of Engineering –University of Diyala
16-17 December. 2015, pp. 277-286

OFF-GRID ELECTRICITY GENERATION WITH HYBRID RENEWABLE ENERGY TECHNOLOGIES IN IRAQ: AN APPLICATION OF HOMER

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ABSTRACT: - The current power system in Iraq used fossil fuels that effect an environmentally, also the power generated does not cover the power demand. In the other hand, to reduce the gap between the generation and the power demand suggested renewable energy alternative sources adding to power system, renewable energy is zero pollution. The purpose of this proposal is to find the preferable hybrid technology combination by a hybrid renewable energy resources for electricity generation to satisfy the electrical needs in a reliable manner of an off grid choosing small town, Bald Ruz in the state of Diyala, Iraq as case study. Three renewable resources, namely, solar photovoltaic systems, wind turbines, with natural gas generator are considered. The software used HOMER that offers optimal solution from the types of resources. The proposal estimates COE of energy of the optimized system is $0.998/kWh for stand-alone and $0.2/kWh for hybrid grid system.

The PV system represents around 42% of power production small percentage for wind turbine that reaches to 6%.

KEYWORDS: Hybrid system, Renewable Energy, Off-grid, Power Generation, HOMER, Iraq

Abbreviations

1- COE: Cost of Energy
2- Km: Kilometre
3- RES: Renewable Energy Sources
4- GHG: Green House Gases
5- NPC: Net Present Cost
6- O&M: Operation and Maintenance
7- SPV: Sola Photovoltaic
8- DG: Diesel Generator

1. INTRODUCTION

Still many people around the world without access electricity(about 1.3 billion In 2010)[1]. The freedom greenhouse gas is the main difficult to the sustainability of the earth and it really affects humans, animals and plants[2]. Carbon dioxide is released into the atmosphere due to increase using fossil fuel for electricity generation, that will effect on environmental and also global warming that encouraged to study friendly energy for example wind, PV, micro hydro and Biomass systems[3][4]. Solar and wind are consider important example for renewable energy resource that offer economically and clean energy competitive the original power generation[4].

In Iraq, the power generation is not meet the power demand for many reasons like the wars, administrative corruption and the collapse of the transmission lines that happen because some persons continue explosion transmission lines that take long distances make it susceptible for targeting. For all these reasons construction hybrid system offer successful substitution, renewable energy is available in Iraq like solar energy – sunshine is available most the annual as average is 5 kWh/m^2 see in fig.(1)–wind energy also around 5.36 m/s in Balad Ruz our zone target addition to Biomass and Hydro systems (the data is depend on national renewable energy laboratory national solar radiation database and NASA surface meteorology and solar energy wind speed at 50m above the surface of the earth for terrain similar to airports, monthly average values over 10 year period)[5].

The absence of reliable electricity supply considers one of the main problems to Iraq's economic and social development electricity supply. Although a important increase in grid-based electricity size in latest years (in 2011 peak net daily production was around 70% higher than 2006), it is quiet far from being enough to meet demand. IEA estimate that the net size available at highest in 2011 was around 9 GW compare with 15GW net size required estimated to meet peak demand, as result around 6 GW need more available capacity – an increase of around 70% see Fig.(2). Increasing numerous building generation capacities is the immediate priorities find other resources for the power sector in Iraq.

The solar resources are available in Iraq. Even though the Middle East's greatest solar irradiance is farther south Iraq's average solar irradiance is similar to that in north Africa[6].

2. MODEL EVALUATION

The renewable energy hybrid and off-grid models have been established using HOMER to explore the influences of renewable energy sources on the current power grid.

This segment presented required data collection method and the simulation software used in this paper to improve the hybrid model with the measured performance metrics.

2.1. Data Collection

The data have been collected from national renewable energy laboratory solar radiation database, NASA surface meteorology and solar energy [5] for the location of Balad Ruz and position of the coordinate (33°42′N 45°05′E). Daily mean solar radiation data for twelve months and mean wind speed data have been collected from the NASA [5] as shown in Tables (1) as a sample data.

2.2. Simulation Software

HOMER pro version 3.3.1.0 [7] has been used in this paper to investigate the possibility and cost analysis relationships of numerous renewable energy sources. HOMER models a power systematic performance plus its life-cycle cost which allows the modeler to compare many design options based on their technical and economic advantages. It can estimate design choices both for off-grid besides grid-connected power systems for remote, distributed and stand-alone applications. Inputs to HOMER have load data with renewable source data.

3. HYBRID RENEWABLE ENERGY SYSTEM

In this paper the optimization power system investigated the strategic impacts of renewable energy, a model has been developed and simulate with HOMER to identify the operating characteristics of different renewable energy sources with available power grid. This paper to calculate the cost of different hybrid systems and compares their performances built on performance advantages; cost analysis and the optimization of the system have be performed then ending by recommendation. The solar and wind energy in this study must been integrated by a on-grid system. The hybrid system contains of an electric load, renewable energy sources (wind and solar) and additional system components for example, grid with converter.

3.1. Electric Load

In this analysis there is a typical load profile considered depends on Balad Ruz town for average monthly load demands. Daily load demand is shown in Fig.(3) in which the 00:00 Am to 12:00 pm time period has been experiment as peak demand. The electric load has a seasonal variation in February and March as peak months with August during summer while to June requires fewer loads during winter which is shown in Fig.(4). The annual average for the electric load is 21,628 kWh/day and the annual peak load is 21,740 kW of the data collected. but in this study, the power peak is 1955.05KW.

3.2. Renewable Energy Sources

3.2.1. Solar Energy

Data of daily solar radiation were imported into HOMER by internet to compute daily radiation and monthly clearness index average values. Fig.(5)shows that solar radiation is high between May to August. The average annual clearness index is 0.635 and the average daily radiation is 5.43 KWh/m^2/day. Fig.(5)shows the daily radiation and the clearness index curve over the total year. Considering the radiation variation, the sensitivity analysis is done with three values around the mean radiation.

3.2.2. Wind Energy

The hourly wind speed data (m/s) were imported into HOMER,. Fig.(6) shows the monthly average wind speed is 5.36 m/s for a year. Wind speed is high at midyear (June) arrived to 6.12 m/s and minimum speed at January (4.66 m/s). the source of this information is NASA Surface that download at 8/12/2015 for 10 years periodic and wind speed at 50 m above surface of earth as shown in Fig.(7).

3.3. Hybrid System Components

The main components of the grid-connected hybrid system are wind turbines, PV panels and a power converter. In economic analysis the number of units that used performs the capital costs, replacement and O&M costs, and the operating hours have to be defined in HOMER in order to exam the system.

3.3.1. Photovoltaic

The early photovoltaic arrays installation cost can varies from $2.00 to $4.00 per watt[8]and[9]. So for an optimal solution, a 1.0 kW stand-alone PV array has installation cost $2030 assumed, but for O&M cost is considered to be practically zero. The photovoltaic sizes arrays are varied 1kW - 4 kW.

3.3.2. Wind Turbine

For this project the XL1R AC wind turbine has been used which is factory-made by Bergey Wind power [10]. The installation, capital and O&M cost of this turbine are respectively $ 17500, $15000 and zero.

3.3.3. Power Converter

A converter is necessary to exchange AC-DC or DC-AC. A 1.0kWconverter the installation costs is $800, replacement cost is $700 and O&M cost is measured practically zero.

3.3.4. The Grid

This projected system has two simulation ways, the first is stand alone and the second a grid-connected system in which the grid acts as a backup power component.

4. RESULTS & DISCUSSION

In this study, to estimate the performances of changed hybrid systems, need measured optimal systems performance and the sensitivity analysis using HOMER simulation tools. To categorize an optimal hybrid system, the wind /PV/grid-connected system can be diverse assuming the electricity stable at 0.3$/kWh[3]. Fig.(8) demonstrate the projected system stand-alone, but Fig.(9) demonstrate project Hybrid system for comparing purpose, developed with HOMER.

4.1. Optimization Results

Simulations have been guide considering different values used for solar radiation, wind speed and power provided that extra flexibility in the experiments. The optimization results - consider for 4.5 KWh/m^2/day for solar scale average power with wind speed average 7 m/s in- stand-alone is shown in Fig.(10). It is seen that, a stand-alone built power system is economically extra feasible with a minimum COE of $0.998/kWh-is more economic result comparing with ($0.2) COE for gird system- and a minimum total NPC of $ 67.7M.

Hybrid grid with grid electricity price (0.3$/kWh) has best optimum NPC ($20.2M), COE ($0.2) operating cost ($1.55M)with initial cost ($278,960)have achieved from the presented in Table(2) comparing with stand-alone system; though the economic performance of a PV-wind system is nearly similar to the wind only system. So the difference is because the wind energy resource abundance and the cost of the solar array modules being more than wind turbine generator. However, in this case electricity price is more than usual. So, it is required to behave further studies with extra and useful data. It's clear from table (2) observed that a PV-wind system Hybrid system is more economical compared to the stand-alone system.

Summary of the cash flow in Fig.12 is demonstrations that in the optimized stand-alone system most of the cost operating category and replacement are required for the generator component adding to fuel cost that reach to $20 M while for capital most cost is for the PV system and without any fuel cost. So it can be stated that most of the cost is due to generator component whereas renewable energy sources needs less spending which is one of their greatest useful features.

The average electric energy production for every month for annually is shown in Fig.(13). The total solar produces 4,514,930 KWh/year, the wind turbine produces 655,770kWh/year and the grid products4,702,214kWh/year. In this system the PV array penetration is 57.19%, the wind turbine penetration only 8.31% of the total energy production. Further analysis need to be undertaken to increase the contribution of wind array modules.

4.2. Sensitivity Results

Sensitivity examination is a measure that checks the model sensitivity when change the parameters value of the model and change the model structure. So the analysis is suitable to support decision making or the improvement of the recommendations from the model. In this proposal, the sensitivity examination has been consider to study the sound effects of variation for wind speed and the solar radiation, then to sort suitable recommendations in developing a hybrid energy renewable system. The system has been simulated built on the three sensitivity variables; solar irradiation, wind speed, PV capital cost and grid electricity price with changed NPC, COE and RF values have been done experiential as system outputs.

HOMER simulates all the schemes in their respective primary definite search spaces. Simulation is accepted for each possible system mixture and organization for a period of one year. The sensitivity variable for solar irradiation is set as G (4.5, 5,5.43, 6) kWh/m with wind speed v (4.7, 5, 5.36, 7) m/s then the grid electricity price p (0.3, 0.2, 0.4) dollar. A total of 144 sensitivity cases were run for every system structure. The Fig.(13) shown the hours per day for PV power in annual that show maximum hours from April to August.

5. CONCLUSION

As conclusion the result considered at the economic model of hybrid renewable energy sources then optimized energy system of hybrid renewable was developed manufacturing cost which includes a Bergey Excel 1-R wind turbine, with 1kW PV module. Investigational results demonstrate that the COE of energy of the optimized system is 0.2/kWh for hybrid grid system while the standard electricity is estimated at 0.3/kWh. In this paper the PV array spreading 57.19%, the wind turbine spreading only 8.31% of the total energy construction. Adding renewable resources to stand-alone or grid system reduces global warming as well as plays an important role in emerging climate-friendly maintainable power systems for coming soon.

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Table (1): Monthly average solar Global Horizontal Irradiance (GHI) and wind speed data

No.	Month	Clearness Index	Daily Radiation (KWh/m^2/day)	Average (m/s)
1	January	0.594	3.150	4.660
2	February	0.622	4.110	4.980
3	March	0.620	5.185	5.240
4	April	0.617	6.190	5.390
5	May	0.646	7.180	5.750
6	June	0.672	7.733	6.120
7	July	0.668	7.535	5.880
8	August	0.680	7.072	5.790
9	September	0.704	6.276	5.570
10	October	0.645	4.588	5.310
11	November	0.610	3.408	4.840
12	December	0.547	2.682	4.750

Table (2): optimization results comparing between stand-alone and Hybrid grid

	Optimization cases	Stand-alone	Hybrid grid
Architecture	PV (kW)	3000	100
	XL1R	200	
	Grid (KW)	X	999,999
	Label (kW)	550	X
	Converter (kW)	100	50
	Dispatch	CC	CC
Cost	COE ($)	0.998	0.2
	NPC ($)	67.7M	20.2M
	Operating cost ($)	4.57M	1.55M
	Initial capital ($)	9.35M	278,960.
system	Ren Frac (%)	11	1.6

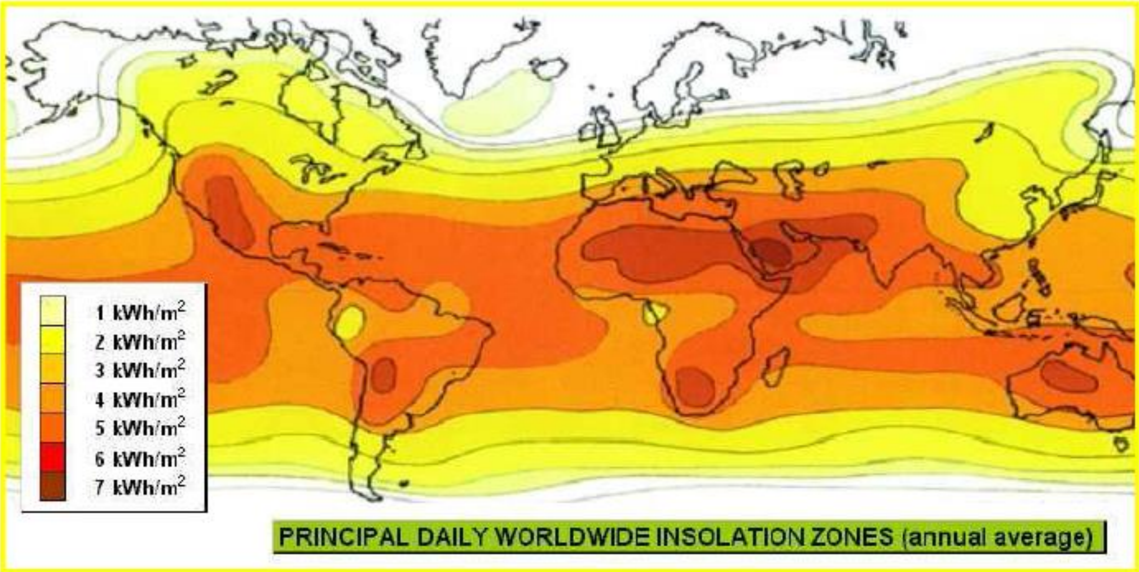

Fig.(1): Daily worldwide insulation zones

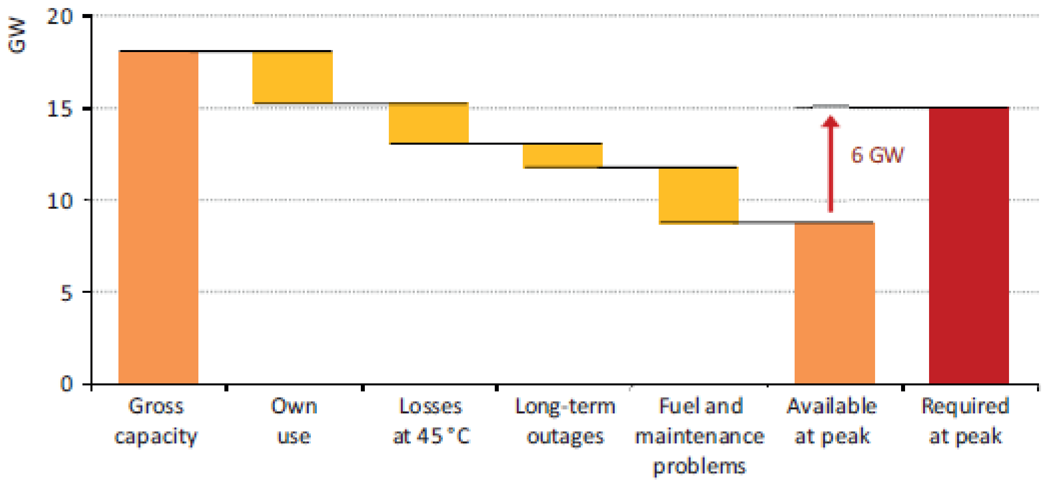

Fig.(2): The difference generation in Iraq between gross installed and available peak capacity, 2011[6]

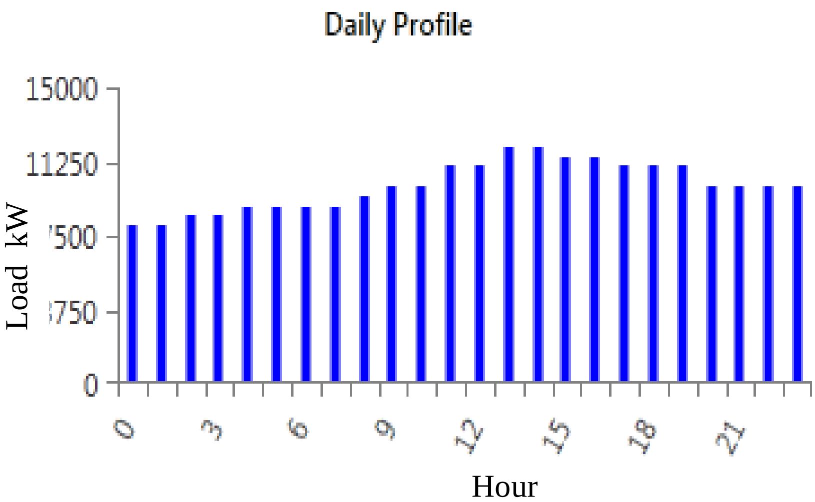

Fig.(3): Daily load profile

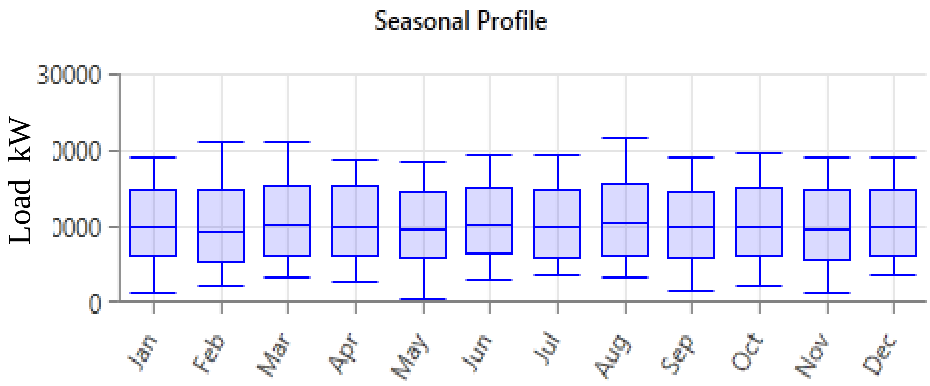

Fig.(4): Monthly load variations

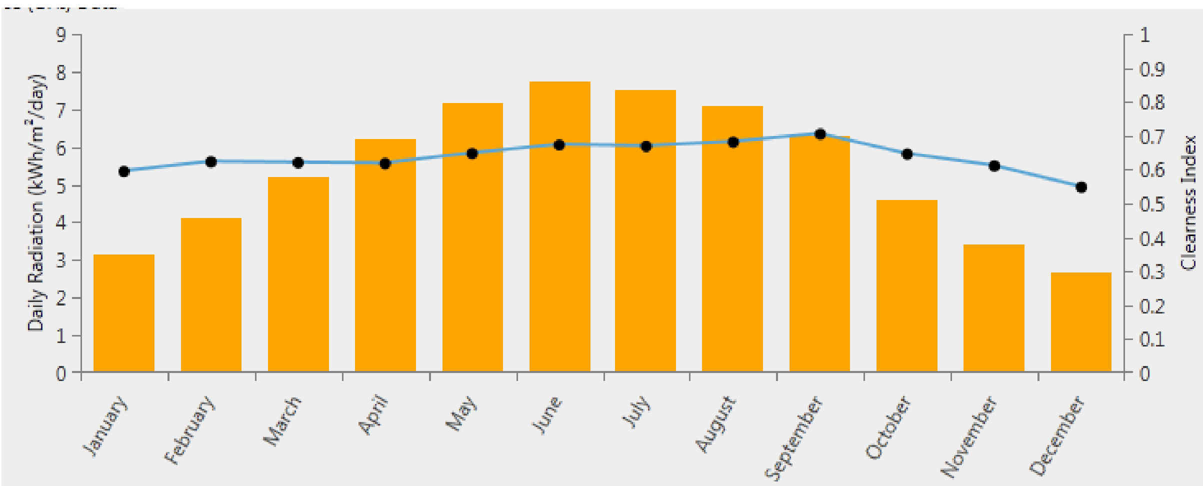

Fig.(5): The Daily solar radiation by clearness index

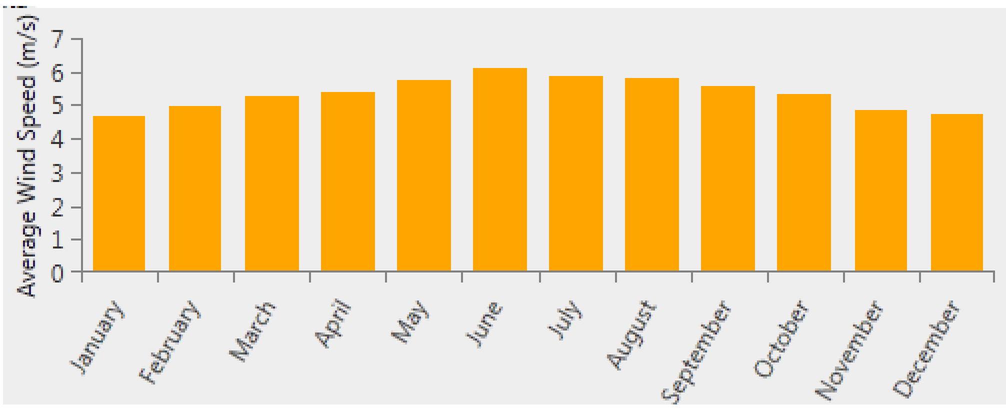

Fig.(6): Monthly wind speed variations

Downloaded at 8/17/2015 11:26:42 PM from:
NASA Surface meteorology and Solar Energy database.
Wind speed at 50m above the surface of the earth for terrain similar to airports, monthly averaged values over 10 year period (July 1983 - June 1993)
CellNumber: 123225
CellDimensions: 1 degree x 1 degree
CellMidpointLatitude: 33.5
CellMidpointLongitude: 45.5
AnemometerHeight: 50

Fig.(7): information of data source for wind speed

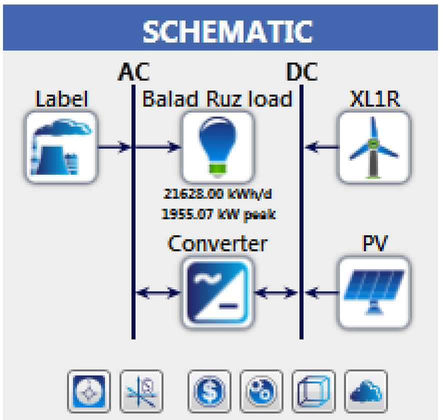

Fig.(8): HOMER stand-alone renewable energy system

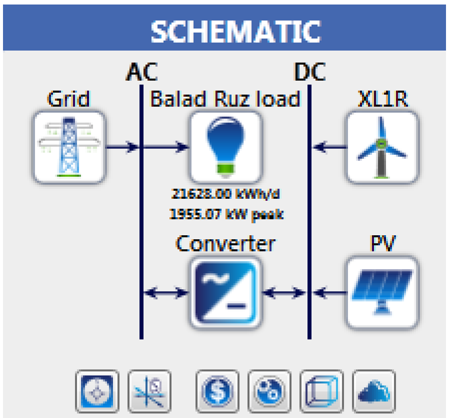

Fig.(9):HOMER Hybrid renewable energy system

Architecture					Cost				System
PV (kW)	XL1R	Label (kW)	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)
3,000	200	550	100	CC	$1.02	$67.9M	$4.58M	$9.35M	9.7
3,000	200	550	100	CC	$1.01	$67.9M	$4.58M	$9.35M	10
3,000	200	550	100	CC	$1.02	$67.9M	$4.58M	$9.35M	9.9
3,000	200	550	100	CC	$0.998	$67.7M	$4.57M	$9.35M	11
3,000	200	550	100	CC	$1.02	$67.9M	$4.58M	$9.35M	9.7
3,000	200	550	100	CC	$1.01	$67.9M	$4.58M	$9.35M	10

Fig.(10): Best optimum results for stand-alone system

Architecture					Cost				System
PV (kW)	XL1R	Grid (kW)	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)
100		999,999	50.0	CC	$0.200	$20.2M	$1.55M	$278,960	1.6
100	100	999,999	70.0	CC	$0.217	$21.9M	$1.55M	$2.06M	2.8
	100	999,999	50.0	CC	$0.218	$22.0M	$1.58M	$1.83M	1.2

Fig.(11): Best optimum results for Hybrid- grid system

Fig.(12): Cash flow summary

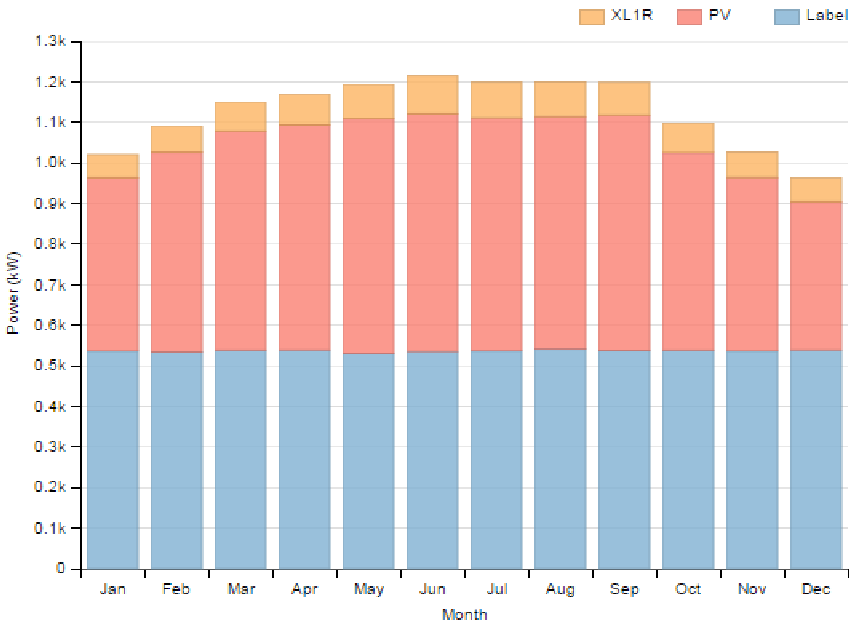

Fig.(13): Electrical production for every month per year

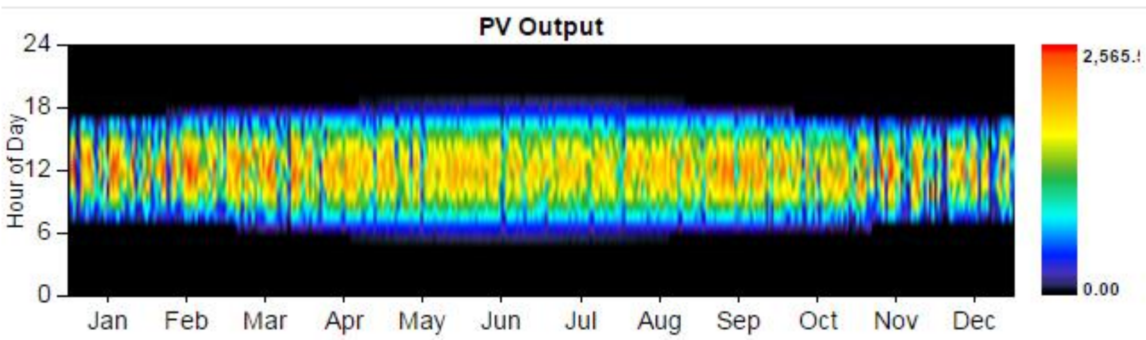

Fig.(14): Hours of day for PV output power for annual

توليد الكهرباء بدون الشبكة الوطنية مع استخدام تكنولوجيا الطاقة البديلة الهجينة في العراق باستخدام تطبيق HOMER

عمار عيسى إسماعيل
مدرس مساعد، كليه الهندسة ، جامعة ديالى

الخلاصة:
نظام القدرة الحالية في العراق يستخدم الوقود الحفري التي توثر على البيئة وهذه القدرة لا تلبي حاجه القدرة المطلوبة للاستهلاك. ومن ناحية أخرى استخدام الطاقة البديلة توفر قدرة إضافية لتقليل الفجوة بين التوليد والمتطلبات وهذه الطاقة لا تنتج إي تلوث للبيئة. الغرض من هذا البحث المقترح إيجاد أفضل مزيج من مصادر توليد متعددة بدون استخدام ألشبكه الوطنية حيث تم اختيار مدينه بلدروز الواقعة في محافظه ديالى في العراق كنموذج للدراسة. سوف يستخدم ثلاث أنواع من الطاقة البديلة هي الطاقة الشمسية, طاقه الرياح وطاقه الديزل. المقترح خمن طاقةCOE 0.998 دولار لكل kWh للنظام القائم بذاته بينما 0.2 دولار لكل kWh لنظام الشبكة ألهجيني. يمثل نظام PV نسبه 42% من القدرة المنتجة بينما نسبه قليله من تورباين الرياح الذي يصل إلى 6% من القدرة المنتجة.