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Techno - Economic Study of Hybrid Renewable Energy System for Remote Area in Sinai

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Abstract The presence of energy and water is essential for the development of remote communities. In addition to, the high cost of fossil fuels and grid extensions led to the use of renewable energy sources in remote areas. Therefore, this paper aims to investigate the techno-economic study of hybrid photovoltaic/wind/diesel/ battery/backup generator system to satisfy the electrical energy needs for a community consisting of 15 families in Tor Sinai city. Furthermore, supplies clean potable water using Ultra Violet and ozone generator technologies for well-water disinfection. In the present study, HOMER software is utilized to estimate the performance of the system. Furthermore, it is used to evaluate the optimal configuration according to net present cost and sensitivity analysis. The results revealed that the optimal configuration of the hybrid system consists of one wind turbine about 7.5 kW, 10 kW photovoltaic panels, 2.8 kW diesel generator and 20 batteries (360 Ah). The system is able to meet the load demand of 11 kW. The system net present cost is 113, 256 $ and the cost of energy is 0.179 $/kWh. Additionally, the system with lowest net present cost is considered as the optimum system and the most naturally friendly system in comparison with the other configurations.

Keywords Hybrid system, PV/wind/diesel/battery/backup generator system, Techno economic analysis, Sensitivity analysis

1. Introduction

In the most recent decade, expanding of power interest is identified with the development of industrialization and nonstop increment of the populace. Notwithstanding, the rebate of the customary vitality assets of fossil fuels on a worldwide and high cost of network expansion. The conventional vitality adds to the expanding in the outflows of greenhouse gasses (GHGs), carbon dioxide, (CO_2). Egypt is considered as one the biggest oil and normal gas buyer in Africa. The nation expends more than 20% of aggregate oil utilization and more than 40% of aggregate dry normal gas utilization in Africa in 2013 (EIA, 2015). In this way, it is key to hunt down option assets in Egypt, particularly for remote areas. Consequently, clean and renewable sources of energy and related innovations are being looked for, created and executed around the world. Renewable resources contributions to electricity supply with zero or low harmful emissions. There are clusters of alternative sources of energy, for example, wind, solar, geothermal, tidal, wave, and biofuels. The reliance on one wellspring of renewable energy (solar or wind energies) can't satisfy the stack need in view of the perspective variety and low accessibility of these assets. Accordingly, no less than two or more sources of energy are utilized to satisfy these prerequisites. These sorts of structures are named Hybrid Renewable Energy System (HRES). The (HRES) is made out of one renewable and one customary energy source or more than one renewable with or without traditional energy sources [1]. The usages of these sources utilized for power supply as a part of remote areas which are a long way from the distribution network. Besides, the hybrid power systems considered monetarily practicable and in some cases focused on grid expansion.

Tsuanyo et al. [2] introduced modeling and optimization of hybrid PV systems for off-grid applications without battery stockpiling. The technical-economic model was utilized to optimize the design and the operation of the hybrid systems by their most diminished Levelized cost of energy (LCOE). The optimization method was applied to two investigations cases: identical Diesel generators and Diesel generators with various sizes. At the same load profile, the outcomes exhibited that the (LCOE) of optimized hybrid solar PV/Diesel was (0.289 €/kWh for the hybrid system with identical Diesel generators and 0.284 €/kWh for the hybrid system with various sizes of Diesel generators). Jamel et al. [3] presented a survey investigation of the advances in the combination of solar thermal energy with conventional and non-conventional power plants. Juan et al. [4] represented a mathematical model for stochastic simulation and optimization of small wind energy systems. The effect of the wind speed variability and load uncertainty in the system reliability was investigated. From the outcomes, an addition of 25% in the capacity of the battery bank was required to accomplish a reliability level of 90%. A novel load administration technique for the optimal use of hybrid renewable energy system was debated in Zaragoza, Spain [5]. The results revealed that the used load administration technique permitted improvement of wind power usage by shifting controllable loads to wind power crests. In addition to, increasing the state of the charge in the battery bank, and diminishing the operating time of the diesel generator, when compared to a case without load administration. Maouedj et al. [6] studied the techno-economic feasibility of PV - wind hybrid system. The proposed system supplied the electricity to a small house in Adrar, Algeria, with average daily energy utilization of 3205 Wh/day. The system was composed of 750W PV solar panels and 900W wind turbine.

The configuration of (PV/Wind/Diesel/Battery) was examined in various areas [7 – 12]. Diab et al. [9] utilized HOMER software to provide an exhaustive feasibility and a techno-economic estimation of hybrid system. The study was done to fulfill the electrical energy requirements for a naturally friendly factory in New Borg El Arab city, Egypt, and the city encompassed the manufacturing plant. The outcomes revealed that the optimal configuration of the hybrid system was comprised of 100 kW of wind turbines, 60 kW of PV arrays, 40 kW of diesel generators, 50 kW of power converters and 600 batteries as per the net present cost and cost of energy. A Feasibility study of stand-alone hybrid renewable energy systemwas explored by utilizing HOMER software [12]. The outcomes demonstrated the system could address clients issue in the remote area. Furthermore, the wind turbines gave about 34% of the yearly aggregate electricity production while PV conveyed around 26%. The proposed system reduced the utilization of fossil fuel by around 70 % compared with diesel generator only. Bilal et al. [13] proposed an approach for designing a stand-alone hybrid energy system by minimizing the Levelized cost of energy (LCOE) and the CO_2 emission. The genetic algorithm was utilized in the study. The outcomes uncovered that increasing of the LCOE implies the diminishing of the CO_2 emission.

The purpose of the present paper is to make a specialized outline of an optimum hybrid renewable energy system to achieve sustainable development of the remote area in Tor Sinai city. This target can be accomplished by optimizing hybrid energy system with minimizing the life cycle cost while ensuring dependable reliable system operation, diminishing the emanations from conventional power plants by utilizing renewable vitality. Notwithstanding, diminish the high cost of supplying power to remote region and sanitizing ground water to utilize it as drinking water.

2. Collected data

Tor Sinai was picked as a case study for the present work. Tor Sinai has some main characteristics such as; away from the electricity grid, suitable solar radiation, appropriate wind speed and underground water sources. The estimated loads profile, wind energy, solar energy resource, costs and technical details summary were collected precisely from an accepted sources to run the Homer software.

2.1. Estimated loads (loads profile)

The system supplies the required electrical load which is estimated to cover 15 families amid the four seasons. These electrical loads ought to be supplied by the produced vitality incorporates local apparatuses (Refrigerator, Washing machine, Radio set, TV, Ozone generator, Ultraviolet , Lamps, fans and water pump). The estimated monthly load profile during the year for 15 families is shown in Fig.1. From Fig. 1, obviously there is a different peak during the day for every season. The highest daily peak in the four seasons is found in summer at 20 hours. In addition to, the lowest loads in the four seasons are between hours 1 to 8. Homer is capable of producing the electrical load's values for a whole year, utilizing this loads profile and adding random variability factors, known as day-to-day variability and time-step-to-time- step variability [15]. In the present study, they are taken as 10% and 20% respectively. The present study utilizes hourly load profile and adding a day to day variability factor about 5% and time step to time step about 10%. The monthly load profile amid the year is gotten from the HOMER software is appeared in Fig. 2. From the figure, it can be seen that the maximum load demand is in months June, July, and August. On the other hand, in January, February and December is the lowest load demand.

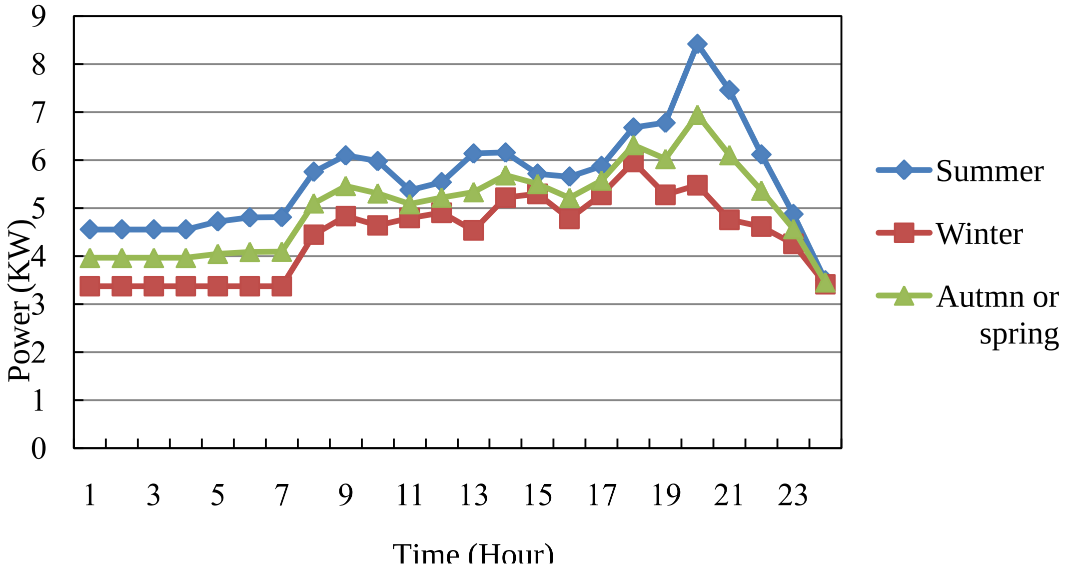


Figure 1: Load profile during four seasons

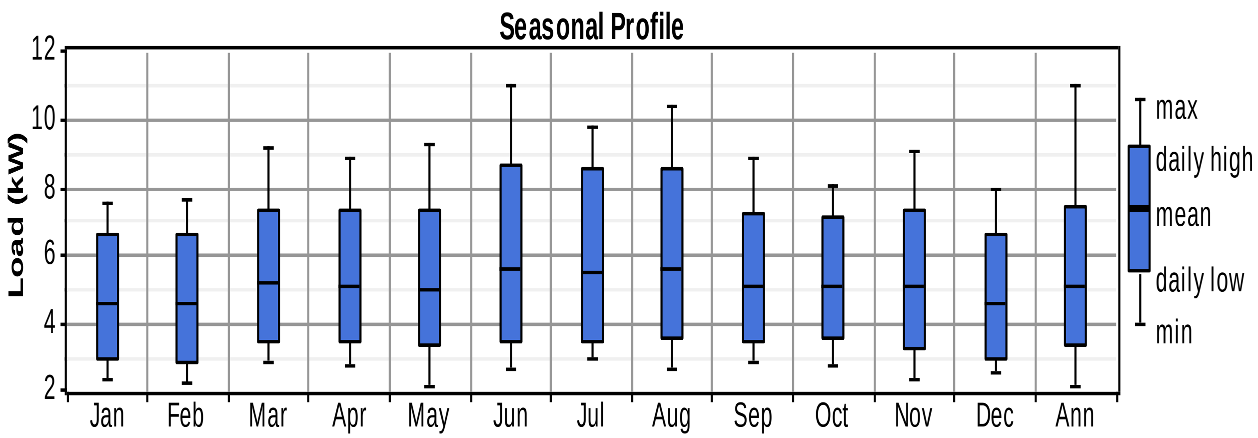


Figure 2: Seasonal load profile

2.2. Solar energy

The site of Tor Sinai is located at 28.24 of latitude and 33.59 of longitude. The average monthly data of the solar radiation is acquired from the European Commission, Joint Research Centre Institute for Environment and Sustainability Renewable Energies Unit [16].The yearly average solar radiation in the site is almost 6.62kWh/m^2/day. Fig.3 demonstrates the monthly solar radiation and solar radiation's clearness index values. The clearness index is defined as a dimensionless number somewhere around 0 and 1 and it is a measure of the clearness of the atmosphere. From Fig. 3 it is clearly obvious that June has a greatest radiation amid the year.

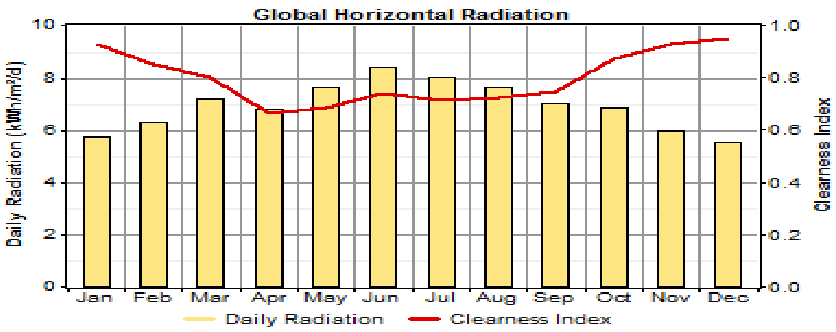


Figure 3: Homer results of radiation profile along the year, Tor Sinai.

2.3. Wind resource

Regarding the average monthly wind speed data in Tor Sinai it is in between 6/2012 – 10/2015 based on every day observations from 7 am to 7 pm local time [16]. This Monthly wind speeds for Tor Sinai are appeared in Fig.4. From this figure it is seen that August has the most noteworthy wind speed during the year.

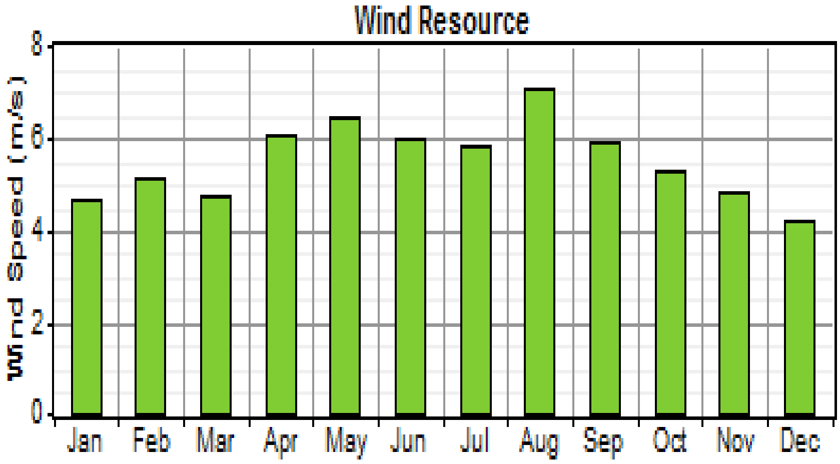


Figure 4: Monthly wind speed data, Tor Sinai

3. Modeling with HOMER software

For micro power systems design the HOMER program is utilized. The program allows comparing different design options based on their technical and economic profits. The program could perform three essential assignments; simulation, optimization, and sensitivity analysis. There are some inordinate parameters which are used by HOMER to make optimization,for example,project lifetime and annual real interest rate. These parameters are utilized to simulate diverse system configurations to optimize the net present cost (NPC), life cycle cost and cost of energy (COE). The optimization results are listed according to total net present cost, and considers the cost of energy to acquire the optimal results of different system configurations [17]. In the present study, there are some inputs to HOMER program such as; hourly mean wind speed, hourly total solar radiation, and load data. The technical specifications and cost details of diesel generators, wind turbines, photovoltaic modules and power converters are added to the program. Additionally, the system controls, economic parameters, and system imperatives are likewise added.The utilized percentages of the control parameters during the optimization in the present study are; maximum annual capacity shortage 10%, the least renewable fraction 75%, operating reserve as a percentage of solar power output 20 % and the wind turbine 80 %. Furthermore, the annual real interest rate is 3 % and the lifetime of the project is 20 years.

4. Mathematical modeling and simulation

The hybrid energy system model with a lifetime of 20 years is simulated with the HOMER software. The system involves the following parts; wind turbine, solar PV panels, battery bank and diesel generator. The model inputs and technical details of each component in the system under study are represented in tables from 1 to 5.In the present work, the photovoltaic derating factor is 80% taking into consideration the negative effects of wiring losses, shading, dust cover and aging. The specifications of the utilized wind turbine with startup speed (cut in) 3 m/s. The nominal capacity of batteries is 360 Ah, and minimum state of charge is 30%. Fig.5 shows the configuration of the hybrid energy system under consideration as simulated in HOMER software.

Table 1: Costs of the PV module [18]

PV system	
Model name	Crystalline
Peak power	1 kW (4× 250W)
Efficiency	15%
Capital cost	3000$
O&M cost	2% of the capital cost
Life time	25 years

Table 2: Wind turbine specifications and cost [19]

Wind turbine	
Model name	BWC Excel-R
Rated power	7.5kW
Capital cost	27000 $
O&M cost	172 $/y
Life time	20 year

Table 3: Battery costs data [19]

Trojan L16 p	
Voltage	6V
Capital cost	300$
Replacement cost	300$
O&M cost	20$/year

Table 4: Diesel generator cost data. [19]

Diesel generator	
Size	2.8 kW
Capital cost	1200 $
Replacement cost	1000 $
O&M cost	0.05 $/hr
Life time	15000 Operating hours
Minimum load ratio	30 %

Table 5: Converter cost data [18]

Converter	
Size	8 kW
Capital cost	180 $/kW
Replacement cost	125$/kW
O&M cost	1.8 $/kW
Life time	10 years
Efficiency	92%

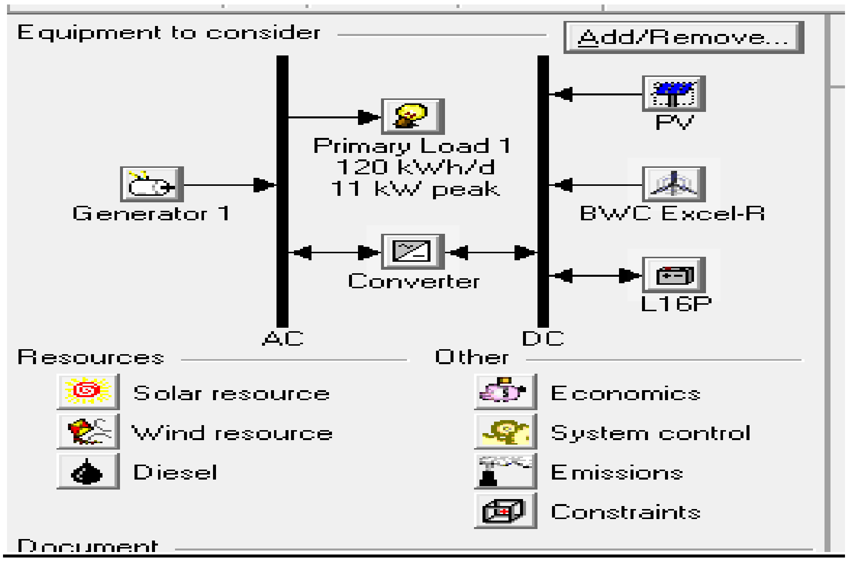


Figure 5: HOMER diagram for hybrid system

The revenues include income from selling power to the grid and any Salvage value that occurs at the end of the project lifetime. The total net present cost is calculated according to equation:

$$C_{NPC} = \frac{Cann;tot}{CRF\,(i;\,Rproj)} \qquad (1)$$

Where,

Cann; tot is the total annualized cost ($/y) which includes capital, replacement, O&M and fuel costs, i is the annual real interest rate (the discount rate), Rproj is the project lifetime, and CRF is the capital recovery factor, calculated by equation:

$$CRF\ (i,\ N) = \frac{i(1+i)N}{(1+i)N-1}$$

Where, i is the annual real interest rate and N, is the number of years.

Levelized cost of energy (COE)is the average cost per kilowatt hour ($/kWh) of useful electrical energy produced by the system, and it is calculated by equation number (2).

$$COE = \frac{Cann;tot}{Eprim,Ac+Eprim,DC} \qquad (2)$$

Where,

Cann,tot is the total annualized cost ($/year), $E_{prim},_{AC}$is the AC primary load served and $E_{prim},\ _{DC}$ is theDC primary load served (kWh/year).

To calculate the output power from the PV array equation (3) is used:

$$P_{pv}=F_{pv}.C_{pv}.\ (G/K) \qquad (3)$$

Where,

F_{PV} is the PV derating factor; C_{PV} is the rated power of the PV (kW); G is the solar radiation incident on the surface of the PV (kWh/m^2); and K is the peak solar intensity at the earth surface, at the equator 1 kW/m^2.

The produced power from wind turbine is depending on the incoming hub-height wind speed at standard atmospheric conditions. The real electrical power delivered is calculated from equation (4).

$P_{wout}= P_w.\ A_w\ .\eta_w$(4)

Where,

A_w the total swept area of turbine (m^2) and η_w the electrical efficiency of wind generator and other electrical components connected.

Storage level capacity for a battery should not exceed the minimum allowable capacity E_{min}. The following equation described the relation between $E_{min}$and battery discharge depth:

$$E_{min} = EBN.\ (1\text{-}DOD) \qquad (5)$$

Where,

E_{min} is minimum allowable capacity of battery bank; EBN is the nominal capacity of battery bank and DOD is the depth of discharge.

The generator's fuel consumption in (L/h) as a function of its electrical output could be represented as follow:

$$F = F_0.\ Y_g + F_1.P_g \qquad (6)$$

Where,

F_0 the fuel curve intercept coefficient (L/hour/kW); F_1 the fuel curve slope (L/hour/kW); Y_g the rated capacity of the generator (kW) and P_g the electric output of the generator (kW).

5. HOMER Optimization Results and Discussion

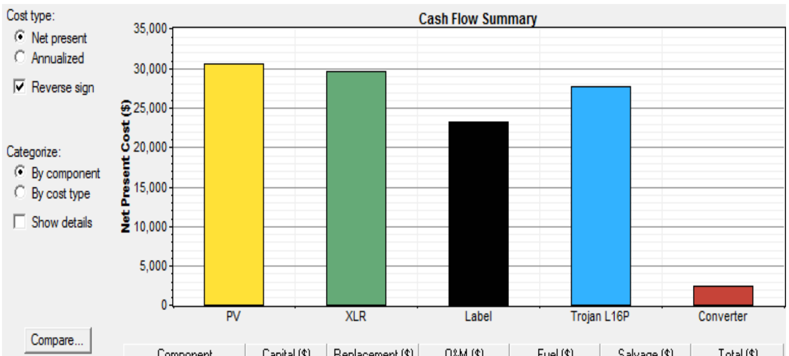
During the progress of the optimization procedure the optimization variable which has an ideal quality is resolved. The optimal systems configurations as per NPC and COE are illustrated in table 6. From the table, the optimum system is the first system at the top of this rundown which has the minimum costly COE and NPC. It can be seen that the net present cost and cost of energy for the ideal system (PV/wind/label/battery system) is 113,256$ and 0.179$/kWh individually. It is considered the reduced NPC and COE in comparison with other system arrangements.

Table 6: The summary of optimization results

PV (kW)	XLR	Label (kW)	L16P	Conv. (kW)	Disp. Strgy	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
10	1	2.8	20	8	LF	$ 65,640	3,198	$ 113,215	0.179	0.76	0.05
	3	2.8	20	8	LF	$ 89,640	3,312	$ 138,921	0.223	0.81	0.09
20		2.8	50	8	LF	$ 77,640	5,096	$ 153,448	0.239	0.75	0.02
10	2		60	8	CC	$ 103,440	4,523	$ 170,733	0.279	1.00	0.09
	4		100	8	CC	$ 139,440	5,622	$ 223,074	0.365	1.00	0.10
30			200	8	CC	$ 151,440	9,119	$ 287,110	0.441	1.00	0.01

5.1. Cost summery

The aggregate expenses of every component of the hybrid power system comprise of PV panel, wind turbine, diesel generator, batteries and converter including capital cost, substitution, O&M, fuel and salvage costs are represented in Fig.6. From this figure the aggregate capital cost of the system during the lifetime of project (20 years) is 65,640$, substitution cost 23,303$, O&M cost 15,725$, fuel cost 13,233$ and salvage value 4,645$. The total cost for all the system amid the lifetime is 113,256$. Notwithstanding, the cash flow summary of the different equipment and cost type in the studied system, is illustrated in Fig. 7. The figure exhibits that the initial capital cost of a component is considered the total installation cost at the start of the project. The diesel generators have the largest O&M cost during the project lifetime contrasted with alternate components and even contrasted with their capital and replacement costs as appeared in Fig. 7.



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	30,000	0	2,975	0	-2,492	30,484
BWC Excel-R	27,000	0	2,559	0	0	29,559
Generator 1	1,200	5,112	4,025	13,233	-435	23,135
Trojan L16P	6,000	17,447	5,951	0	-1,719	27,679
Converter	1,440	744	214	0	0	2,398
System	65,640	23,303	15,725	13,233	-4,645	113,256

Figure 6: Total cost sheet (NPC) of optimal system configuration

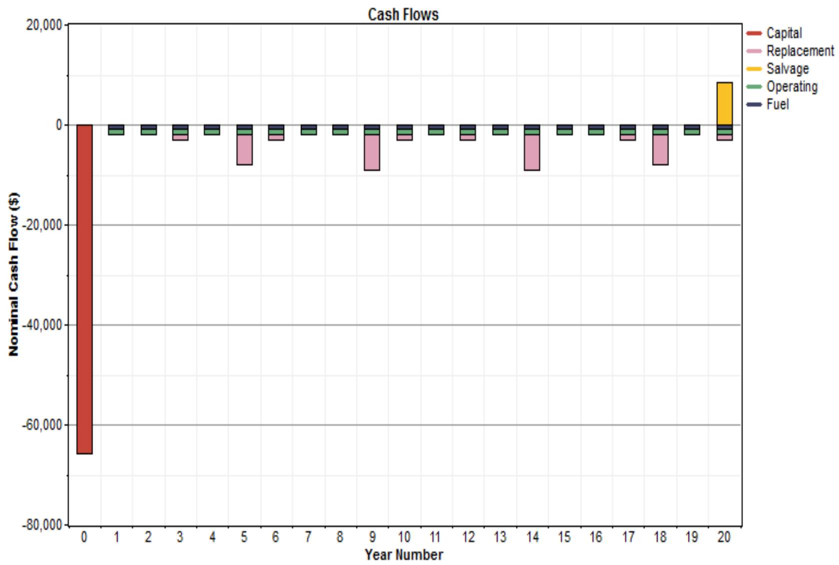


Figure 7a: Cash flow diagram of the system by component

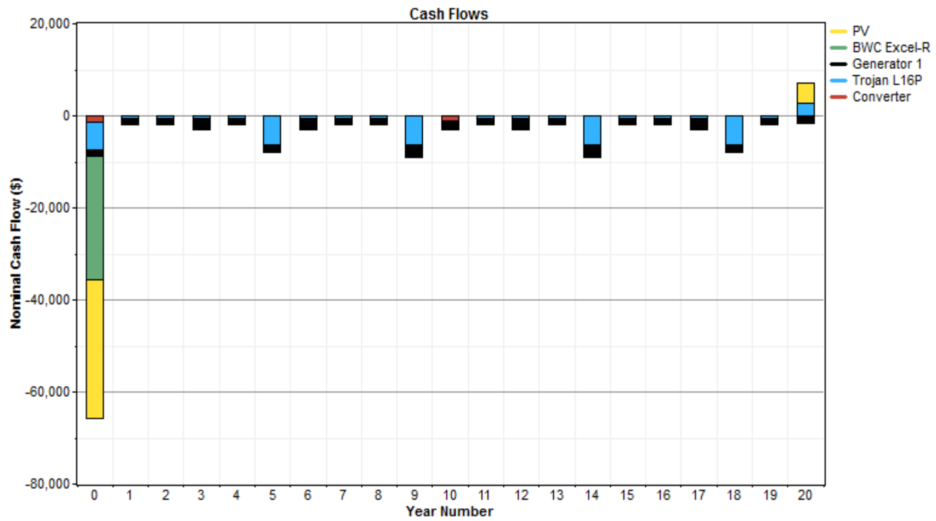


Figure 7(b): Cash flow diagram of the system by cost type

Production	kWh/yr	%
PV array	21,875	41
Wind turbine	18,687	35
Generator 1	12,941	24
Total	53,503	100

Consumption	kWh/yr	%
AC primary load	42,541	100
Total	42,541	100

Quantity	kWh/yr	%
Excess electricity	6,925	12.9
Unmet electric load	1,259	2.9
Capacity shortage	2,291	5.2

Quantity	Value
Renewable fraction	0.758

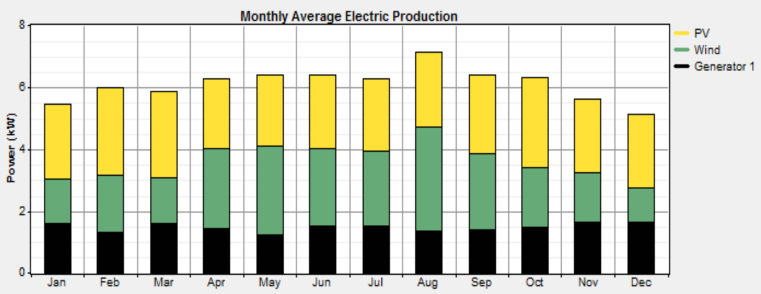


Figure 8: Monthly electricity production from all components of the system

5.2. Electricity summary

The monthly electricity production from all parts of the optimum hybrid renewable energy system appears in Fig. 8. The figure demonstrates that the load in December, January and February is low and electricity productions are overabundance than the load demand. This overabundance in electricity production is utilized for charging batteries to be used amid evening or when the wind speed and solar radiation is too low. In addition, the aggregate annual electricity production from the upgraded system is 53,503kWh/y. The PV modules give around 41% of the aggregate yearly electricity output, 35% from a wind turbine, and 24% from a diesel generator. The capacity shortage is 5.2% (2,291kWh/y) and the abundance electricity is 12.9% (6,925kWh/y). Therefore, the abundance electricity created by the hybrid system dependably exists, which could be utilized by the dump loads in remote areas in the form of heating or cooling loads this would enhance the system quality.

6. Sensitivity analysis

The investigation which is used to study the effect of impact progress of various parameters, for example, solar radiation, wind speed and diesel price on the net present cost is called the sensitivity analysis. For Tor Sinai city the investigated solar radiation and wind speed are appeared in tables 7and 8. At the wind speed 5.53m/s and diesel price 0.2 $/L the optimal NPC for various solar radiation are represented in table 7. The table demonstrates that for higher solar radiation the COE has a minimum value. The data in table 8 shows the optimal NPC for different wind speed at solar radiation 6.64kWh/m^2/d and diesel price 0.2 $/L. This table shows that for higher wind speed the COE has a minimum value. Moreover, table9 demonstrates the investigated optimal NPC for different diesel price at solar radiation 6.64kWh/m^2/d and average wind speed 5.53 m/s. This table shows that for higher diesel prices the COE has a maximum value. Consequently, the optimum system occurs at high solar radiation, wind speed, and low diesel price.

Table 7: Effect of solar radiation on the optimal NPC and COE

solar radiation(kWh/m^2/d)	optimal NPC $	optimal COE $/kWh
4.5	124,279	0.197
5.5	126,541	0.195
6.5	113,215	0.179
7.5	113,483	0.178
8.5	124,245	0.178

Table 8: Effect of solar radiation on the optimal NPC and COE

Wind speed (m/s)	optimal NPC $	optimal COE $/kWh
3.5	153,448	0.239
4.5	142,564	0.225
5.5	113,215	0.179
6.5	107,851	0.172
7.5	83,964	0.133

Table 9: Effect of solar radiation on the optimal NPC and COE

Diesel price$	optimal NPC $	optimal COE $/kwh
0.15	109,956	0.174
0.2	113,215	0.179
0.3	119,710	0.189
0.35	122,946	0.194
0.4	126,147	0.200

7. Conclusions

Techno - economic study of hybrid renewable energy systems consisting of PV modules, wind turbine, battery bank and back up diesel generator is investigated in the present work. Simulation and optimization of the hybrid

PV/Wind/Diesel/Battery system for Tor Sinai has been achieved by using HOMER software. Daily and seasonal load curve of 15 families are estimated. The maximum load required for these families is about 11 kW. The obtained results from HOMER software simulation showed that a hybrid energy system consisting of PV panels with 10 kW, 1wind turbine 7.5 kW, 2.8 kW diesel generator and 20 batteries (360 Ah) can supply the electric energy for load demands. The obtained system is considered as an optimal hybrid energy system configuration according to net present cost. The NPC of the optimal system configuration is (113,256$) and COE is (0.179$). The hybrid (PV/Wind/Diesel/Battery) system is more economic and reduced the CO_2 emission.

References

[1]. Mohammad Rozali, N.E., Wan Alwi, S.R., Abdul Manan, Z., Klemes, J.J., Hassan, M.Y.,Optimal sizing of hybrid power systems using power pinch analysis. Journal of Cleaner Production 71, 158e167, 2014.

[2]. David Tsuanyo, Yao Azoumah, Didier Aussel and Pierre Neveu," Modeling and optimization of batteryless hybrid PV (photovoltaic)/Diesel systems for off-grid applications ",Energy, a Vol. 86, pp. 152-163, May 2015.

[3]. Jamel, M.S., Rahman, A.A., Shamsuddin, A.H., 2013. Advances in the integration of solar thermal energy with conventional and non-conventional power plants. Renewable Sustainable Energy Review 20, 71e81.

[4]. Juan M. Lujano-Rojas, Rodolfo Dufo-López and José L. Bernal-Agustín,"Optimal sizing of small wind/battery systems considering the DC bus voltage stability effect on energy capture, wind speed variability, and load uncertainty",Applied Energy, a Vol. 93, pp. 404-412, December 2011.

[5]. Juan M. Lujano-Rojas, Cláudio Monteiro, Rodolfo Dufo-López and José L. Bernal-Agustín,"Optimum load management strategy for wind/diesel/battery hybrid power Systems", Renewable Energy, a Vol. 44, pp. 288-295, February 2012.

[6]. R. Maouedj, A. Mammeri, M.D. Draou and B. Benyoucef, "Techno-economic analysis of a standalone hybrid photovoltaic-wind system. Application in electrification of a house in Adrar region", International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES15, Vol. 74, pp. 1192-1204, 2015

[7]. Abdelhamid Kaabeche and Rachid Ibtiouen,"Techno-economic optimization of hybrid photovoltaic/wind/diesel/battery generation in a stand-alone power system", Solar Energy, a Vol. 103, pp. 171–182, March 2014.

[8]. Rachid Belfkira, Lu Zhang and Georges Barakat, " Optimal sizing study of hybrid wind/PV/diesel power generation unit", Solar Energy, a Vol. 85, pp. 100–110, November 2010.

[9]. Mei Shan Ngan and Chee Wei Tan, " Assessment of economic viability for PV/wind/diesel hybrid energy system in southern Peninsular Malaysia ", Renewable and Sustainable Energy Reviews, a Vol. 16, pp. 634-647, October 2011.

[10]. D. Saheb-Koussa, M. Haddadi and M. Belhamel, " Economic and technical study of a hybrid system (wind–photovoltaic–diesel) for rural electrification in Algeria", Applied Energy, a Vol. 86, pp. 1024-1030, December 2008.

[11]. Fahd Diab, Hai Lan, Lijun Zhang and Salwa Ali, "An environmentally friendly factory in Egypt based on hybrid photovoltaic/wind/diesel/battery system", Journal of Cleaner Production, pp. 1-6, July 2015.

[12]. Fazia Baghdadi, Kamal Mohammedi, Said Diaf and Omar Behar,"Feasibility study and energy conversion analysis of stand-alone hybrid renewable energy system", Energy Conversion and Management, a Vol. 105, pp. 471-479, August 2015.

[13]. B. Ould. Bilal, V. Sambou, C.M.F Kébé, P. A. Ndiaye and M. Ndongo,"Methodology to Size an Optimal Stand-Alone PV/wind/diesel/battery System Minimizing the Levelized cost of Energy and the CO_2 Emissions", Energy Procedia, a Vol. 14, pp. 1636-1647, December 2011.

[14]. https://ec.europa.eu/jrc/en

[15]. J. Kelleher, J.V. Ringwood, A computational tool for evaluating the economics of solar and wind microgeneration of electricity, Energy, Volume 34, Issue 4, April 2009, PP. 401-409.

[16]. http://www.windfinder.com/
[17]. Tom lambert, Pqul Gilman, and Peter Lilienthal, "Micropower System Modeling with HOMER ", Integration of Alternative Source Energy, 2006.
[18]. Ramin Hosseinalizadeh, Hamed Shakouri and Mohsen Sadegh Amalnick," Economic sizing of (PV-WT- Fc) renewable energy system (HRES) for stand – alone usages by an optimization-simulation model: Case study of Iran", Renewable and Sustainable Energy Reviews, a Vol. 54, PP 139-150, November 2015.
[19]. Vincent Anaychukwu Ani and Bahijjahtu Abubakar. "Feasibility Analysis and simulation of Integrated Renewable Energy System for Power Generation: A Hypothetical Study of Rural Health Clinic", Journal of energy, 7 pages, 2015.
[20]. Shiplu Sarker, "Feasibility analysis of a renewable hybrid energy system with producer gas generator fulfilling remote household electricity demand in Southern Norway", Renewable Energy, a Vol 87, PP 772-781, November 2015.
[21]. Aminul Islam, Md. Shahjahan, R.H. Khan, A. Kashem and K.N. Babi," Feasibility Study of Renewable Energy Resources and Optimization of Hybrid Energy System of Some Rural Area in Bangladesh", International Journal of physics , a Vol. 3, PP 216-223, 2015.