Journal of Engineering Research

Volume 6 | Issue 1 Article 11

2022

Economic and Environmental Investigation of Renewable Energy Sources for Micro-grids coastal areas

Samir Dawoud

Vol. 6, No. 1 – 2022 Journal of Engineering Research (ERJ)

Economic and Environmental Investigation of Renewable Energy Sources for Micro-grids Coastal Areas

Samir M. Dawoud

Electrical Power and Machine Engineering Department, Faculty of Engineering, Tanta University
Emails: *sameer_dawood @f-eng.tanta.edu.eg*

Abstract- The standalone power generating units in Marsa-Alam coastal areas depend on fossil fuel to feed electrical loads. This causes many side effects like green gas emissions and high fuel costs, which leads to weak economic growth in this region. While the global interest increases to utilize renewable resources due to several benefits and renewable technologies in solar energy and wind turbine. The objective of this article is to design a tecno-economic and feasibility study of using hybrid renewable energy systems (HRES) over conventional resources. Eight different types of models including solar photovoltaic (SPVs) /wind turbines (WTs)/ power converter /diesel/battery are designed using HOMER software. The key factors are used to make the decision such as net present cost (NPC), net Levelized costs of energy (LCOEs), the renewable fraction (RF), load demand, availability of the HRES and greenhouse gases emissions. The lifetime and capacity of WTs, SPVs, converter, and battery, nominal discount rate, are used to decide the best optimal solution of HRES. These analyses compared the performance of the micro-grid and showed that the optimal micro-grid is techno-economically feasible based on LCOEs. The LCOEs and net present cost (NPC) of optimum source ($0.224/kWh and $103M) are the least compared to the other hybrid source configurations.

Keywords: ***cost of energy, HOMER, renewable energy sources and greenhouse gas emission***.

I. INTRODUCTION

The potential of using clean energy in Egypt is a good solution for the abundant wind and solar resources. feeding the remote areas has become an issue very pressing for some countries which cannot connect all power grids to the whole country, especially in coastal areas. The electricity generation from fossil fuels such as natural gas, fuel oil, and coal represents a problem in the future because increased carbon dioxide (CO2) emissions affect the environment negatively. For solving the emission problem, a great interest in renewable energy sources (RES) such as solar and wind energy. Hence, investigating the replacement of efficient energy conversion methods for example renewable energy sources as a clean method in the forms of wind, solar, and so forth with conventional methods is of paramount importance [1-3]. Using renewable resources to get electricity will help to protect the local environment and reduce the generation price compared to the standard methods. The developments of a hybrid micro-grid, which contains WTs, SPVs, power converters, power storage units and diesel engines have become the practical solution to provide energy for remote areas [4-8].

The utilization of renewable micro-grid energy gives the environmental benefits within the decreasing CO2 pollution, using several renewable micro-grids to make hybrid energy systems, which off-grid or grid-connected sources could supply more benefits by decreasing CO2 emissions [9-11]. In Extension, the utilization of renewable micro-grids in coastal areas could help to reduce operating costs through a reduction in fuel consumption, a rise in system efficiency, and reduced amounts of emissions [12,13]. The authors in [14] applied a meta-heuristic model for minimizing the generation costs in the hybrid sources. In [15] a search algorithm was implemented for the sizing of hybrid SPVs, wind, battery (batt), and diesel (dies) units. In reference [16] an anti-colony optimization technique was implemented for resizing the optimization of the renewable resource. The different methods for optimizing the hybrid micro-grid size were examined in [17]. In [18] the design for the SPVs/WTs hybrid home system was optimized by a genetic algorithm with developing the storage battery. The capacity for the different isolated micro-grids has been optimized by different techniques in [19]. The techno-economical optimizations of the isolated (SPVs/WTs/ diesel/ battery) were done considering the total unsupplied energy [20].

In this paper, the renewable energy micro-grid of the new cities was used in Egypt by assessing SPVs systems with WTs to decide the economic system, taking into estimation the environmental impacts. The optimum combinations of SPVs, WTs, power converter (Conv), batteries, and diesel considering have the lowest LCOEs. Eight micro-grids of (SPVs/WTs/dies/conv/batt), (SPVs/WTs/dies/conv), (SPVs/ diesel/conv), (SPVs/dies/ conv/ batt), (WTs/dies/ conv/batt), (WTs/dies), (WTs/dies/ conv) and (diesel only) had been suggested to feed the electrical power in Marsa-Alam within the red sea Egypt. The investigation of using a diesel unit with the hybrid sources and comparing the LCOEs of these micro-grids with the diesel-only system was considered. HOMER software calculates the LCOEs, net present cost (NPC), and environmental issues.

II. SYSTEM DATA COLLECTION

A. *Load Profile*

The actual load information has been collected through the existing site, while solar resources and wind power resources are available, and the summary of technical details accurately by the database NASA. Two kinds of electrical loads were identified accurately, The first quite loads are industrial loads. It is identified to be 6.31567 MW as a peak load and daily energy consumption to be 62868.48 kWh. Figure 1 shows a daily profile of industrial loads. The second load is a domestic electrical load that illustrates the town housing units. Figure 2 shows a daily profile of a domestic load. The proposed hybrid micro-grid will supply a load of 2.10522 MW as a max load and 20956.16 kWh as daily energy. HOMER software operates 8760 hourly in a year, using an hourly load demand.

B. *Solar power resource*

Average monthly irradiation data in a rural small town in Marsa Alam, Red Sea (Egypt) Africa, which is found a latitude at 23°57.2' N and a longitude at 35°34.1' E are obtained from (NASA) database for the year 2021, this area receives yearly average radiation of 5.94 kWh/m^2/day [21]. Table 1 show the average solar data in a month for the study area. The clearness index may be measured by the clarity of the atmosphere. It is a fraction of irradiation that is forwarded through an atmosphere to stand off the surface of the world.

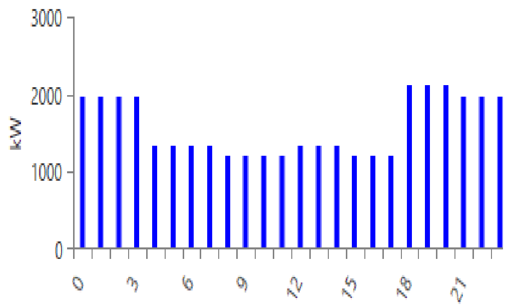

Fig. 1. The daily profile of industrial load.

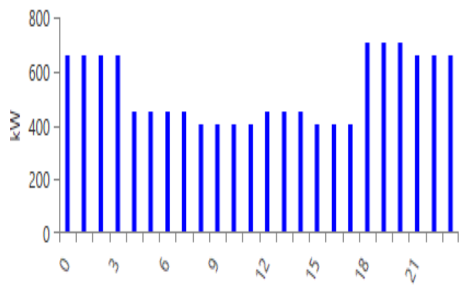

Fig. 2. The daily profile of the domestic load.

Table 1. Average values of meteorological data.

	Solar Irradiation (kWh/m^2/day)	Temperature (°c)	Wind Speed (m/s)
Jan.	4.540	19.29	5.080
Feb.	5.390	19.430	4.870
Mar.	6.170	21.650	5.070
Apr.	6.910	25.010	5.000
May	7.080	28.330	4.600
Jun.	7.450	30.380	4.670
Jul.	7.190	31.560	4.430
Aug.	6.600	31.850	4.360
Sep.	6.090	30.710	4.330
Oct.	5.160	27.750	4.190
Nov.	4.510	24.090	4.140
Dec.	4.150	20.920	4.750

C. *Wind energy resources*

The wind speed is gotten from the NASA database for the year 2021. Table 1 show the common monthly wind speeds data from the NASA website, the average wind speed for the study area is 4.62 m/s.

D. *Costs and technical specification*

Tables (2-6) give the costs of all components which show the details of the technical specifications of SPVs, WTs, power converters, battery banks, and diesel units respectively. All data were collected to run HOMER software of 25 years project lifetime with a discount rate of 8 % and an inflation rate of 2 % [22, 23].

Table 2. The cost and technical details of spvs [24]

Model name	**Schneider Conext CoreXC 680kW with Generic SPV**
Peak power	680 kW
Dreating factor	96%
Ground reflection	20%
Operating temperature	45 °c
Efficiency	17.30%
Capital cost	500$/kW
Replacement cost	400$/kW
O &M cost	$10 /year
Lifetime	25 years

Table 3. The costs and technical details of WTS [6]

Model name	**WTs 10 kW**
Rated power	10 kW
Hub height	50 m
Capital cost for 10 kW	$9000
Replacement cost for 10 kW	$8000
O &M cost	$16/year
Lifetime	30 years

Table 4. The costs and technical details of power converters[4]

Rated power	**1 kW**
Capital cost	800$/kW
Replacement cost	600 $/kW
O &M cost	$5/year
Efficiency	90%
Lifetime	15 years

III. HYBRID SYSTEM MODELLING

The main feature of a hybrid micro-grid is to contain more than two renewable generations of technology to prove their operating characteristics and to higher efficiency more of one source. This feature results from the competence of HRES to require merits of the complimentary seasonal characteristics of suitable renewable sources in Marsa Alam, Red Sea (Egypt). Figure 3 shows the configuration of hybrid SPVs/WTs/ dies/conv/batt source by HOMER software. HOMER simulates a procedure of hybrid system by calculating energy balance with step time of a year for the whole-time step that compares electric loads and energy that a model might feed in that time.

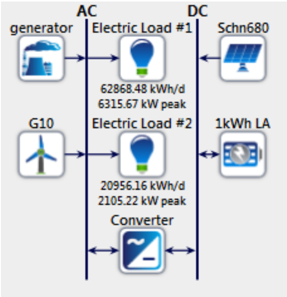

Fig. 3. The configurations for a hybrid SPVs/WTs/dies/batt system.

Table 5. The costs and technical details of the storage batteries

Model name	**Generic 1kWh Lead Acid**
Nominal capacity	83.4 Ah
Nominal capacity	1kWh LA
Roundtrip efficiency	80%
Min. State of charge (SOC)	40%
Float life	10 years
Max. Charge rate	1 A/Ah
Max. Charge current	16.7 A
Capital cost	$300
Replacement cost	$275
O &M cost	$10/year
Lifetime throughput	800 kWh

Table 6. The costs and technical details of diesel

Model name	**kW Cummins**
Rated Power	1600 kW
Lifetime	20000 h
Min. load ratio	30%
Capital cost	$405.57
Replacement cost	$383.43
O &M cost	$0.03/hour
Fuel cost	$1/L

IV. Results and Discussions

The choice of variables includes the SPVs arrays capacity, WTs, diesel units, converters and the No. of battery banks used. In a list, HOMER performed a calculation of energy balance for every feasible system configuration in line with NPC and LCOEs in very increasing order. The optimum source is beloved at the highest of this list, which has the smallest amounts of expensive LCOEs and NPC.

Table 7. Operation results of the two loads

Total load (MWh/d)	83.824
SPVs (kW)	10000
Wind Count	1300
Diesel (kW)	8000
Battery (kWh)	5000
Converter (kW)	5000
COE ($/kWh)	0.224
NPC (M$)	103
RF (%)	41.7
Total Fuel (L/Y)	4,394,644

A. Modes of Operation

Table 7 shows the obtained result of the total load 83.824 MWh/d and the cost of energy of the hybrid system is 0.224 $/kWh. The renewable fraction is 41.7 % which is a high value when hybrid SPVs used with WTs. Table 8 shows the sensitivity analysis results in the variation of one load. The first type of load, which are industrial loads, represent the subsequent loads (workshops, equipment, shiploads, and few mechanical loads) and therefore the second load is a domestic load, which represents both loads (lighting, power loads, light current, and external lighting). This load is considered a fixed value, But the sensitivity analysis of an industrial load changes its value by 20% higher or lower than a known value that had gotten.

The total load is studied in three cases, and the system has studied reliability through the HOMER program. In the first case, which can be estimated the total loads are identified to be 83824kWh as required daily energies consumption. The second case is that the higher 20 %. The total load can be estimated to be 96398kWh per day required energy consumption. The third case is that the upper 20 %. The total loads can be estimated to be 71250kWh as daily required energy consumption as shown in Table 8. The LCOEs of the hybrid source are $0.224/kWh for 83.824 MWh/d, $0.273/kWh for 96.398 MWh/d and $0.221/kWh for 71.25 MWh/d.

Table 8. The sensitivity analysis results of load variation

Load (MWh/d)	96.398	83.824	71.25
SPVs (kW)	10000	10000	8000
Wind Count	1300	1300	1300
Diesel (kW)	9600	8000	6400
Battery (kWh)	5000	5000	5000
Converter (kW)	5000	5000	4000
COE ($)	0.273 $	0.224 $	0.221 $
NPC ($)	123 M$	103 M$	83.3 M$
RF (%)	37.5	41.7	44.8
Total Fuel (L/Y)	5,416,473	4,394,644	3,502,683

B. HOMER optimization results

From the optimization results shown in Table 9, the optimal configuration is the hybrid (SPVs/WTs/ dies/conv/batt) source, consisting of 10,000 kW of SPVs arrays, 13000 kW wind, 8000 kW of the diesel units, 5000 kW for power converter, 5000 kW of batteries. The LCOEs of the hybrid source are $0.224/kWh; it is the smallest LCOEs compared to the other sources configurations. The cost of (SPVs/WTs/dies/conv) is $0.275/kWh, (SPV/ dies/conv) is $0.305/kWh, (SPVs/dies/conv/batt) is $0.310/kWh, (WTs/ dies/conv/ batt) is $0.328/kWh, (WTs/dies) is $0.337/kWh, (WTs/dies/conv) is $0.416/kWh and (dies) is $0.445/kWh. NPC of the optimal micro-grid method is $103 M, which is that the least NPCs compared to the other source configurations (SPVs/WTs/dies/conv) is $107M, (SPVs/ dies/ conv) is $119M, (SPVs/dies /conv/batt) is $120 M, (WTs/dies/conv/batt) is $128 M), (WTs/dies) is $131 M, (WTs/dies/conv) is $161 M, (dies) is $174M.

Renewable energy fraction (RF) of optimum source is 41.7 %. The RF of optimum source is that the highest RF in comparison with the other sources configurations (SPVs/WTs/dies/conv) is 36.6%, (SPVs/ dies/conv) is 29.1%, (SPVs/dies/conv/batt) is 33.9%, (WTs/dies/conv/batt) is 18.3%, (WTs/dies) 11.3%, (WTs/dies/conv) is 4.3%, (dies) is 0%. The whole consumed fuel amounts of optimum model is 4,394,655 L/year, which is that the average amounts of a fuel consumed per year. Additionally, the whole consumed amounts of diesel fuel for optimum model is that the smallest amount comparison with the other sources configurations (SPVs/WTs/dies/conv) is 4,745,464 L/Year,(SPVs/dies/conv/batt) is 5,297,319 L/Year, (SPVs/ dies/conv) is 4,908,348 L/year, (WTs/dies /conv/ batt) is 6,110,628 L/year, (WTs/dies) is 6,625,362 L/year, (WTs/dies/conv) is 8,070,787 L/year and (dies) is 8,680,756 L/year.

C. *Cost summary by each component*

Table 10 shows a summary of NPC for diesel units, WTs, SPVs, battery banks, and the power converters system. the diesel unit has the highest NPC ($84,028,190.00) is compared with the opposite source components and, this can be attributed to high values of fuel costs ($56,811,975) consumed by diesel units. On the opposite hand, NPC of WTs ($1,023,658.74) is the least NPC within the optimum source.

D. *Cost summary by the cost type*

Table 11 shows the summary of every cost type of the optimum HRES. The replacement cost ($10,380,622.47) is less than a capital cost ($12,414,569.60). Additionally, there is another style of cost called salvage cost, which passes the value of ($970,968.63) within the optimal source.

E. *Electric summary*

Table 12 shows an electricity production of optimum HRES for a month, it can say that the entire yearly electricity production is 49,832,640 kWh/year of the optimal source. From this total yearly electricity production, 20,428,590 kWh/year (41 %) of SPVs arrays, 11,671,669 kWh/year (23.4 %) of WTs, and 17,732,382 kWh/year (35.6 %) of diesel unit. Additionally, the capacity shortage of the optimal source is 0.921 % and excess electricity of 18,965,280 kWh/year (38.1%). In general, the surplus produced electricity by optimal sources always exists, which might be employed by the shape heating and cooling loads, which could improve the reliability of the source.

Table 9. Compared between configuration hybrid sources

System	LCOEs ($/kWh)	NPC ($)	RF (%)	Total Fuel (L/Y)
SPVs/WTs/dies/Conv/batt	0.224	103 M	41.7	4,394,655
SPVs/WTs/dies/Conv	0.275	107 M	36.6	4,745,464
SPVs/dies/Conv	0.305	119 M	29.1	5,297,319
SPVs/dies/Conv/batt	0.310	120 M	33.9	4,908,348
WTs/dies/Conv/batt	0.328	128 M	18.3	6,110,628
WTs/dies	0.337	131 M	11.3	6,625,362
WTs/dies/Conv	0.416	161 M	4.3	8,070,787
Dies	0.445	174 M	0	8,680,756

Table 10. The NPC of optimal HRES for each component

Component	Cost ($)
SPVs	$6,292,751.65
Generator	$84,028,190.00
Converters	$5,822,099.72
Wind turbine	$1,023,658.74
Lead Acid battery	$3,795,232.31

Table 11. The costs of optimum HRES different

Cost type	Cost ($)
Capital	$12,414,569.60
Replacement	$10,380,622.47
Operation & maintenance	$24,569,368.32
Fuel	$56,811,975.24
Salvage	($970,968.63)

Table 12. Electricity production of optimal source

Component	kWh/yr	%
SPVs	20428590	41
Dies	17732382	35.6
WTs	11671669	23.4

V. TECNO-ECONOMIC ANALYSES OF OPTIMAL HRES

A separate techno-economic analysis of every component (diesel units, WTs, SPVs, battery banks, and, power converters system) within optimum HRES is as follows:

A. *Techno-economic analysis of SPVs*

From the hybrid source (SPVs / WTs /dies/conv/batt) The SPVs array power output is dependent on the quantity of radiation striking SPVs array surfaces, which are connected in serial and/or parallel to make arrays. The SPVs array power output in HOMER software can be calculated as the following equation:

$$P_{pv} = F_{pv} * C_{pv} (\frac{G}{K}) \tag{1}$$

where, C_{pv} is that a rated capacity for SPVs array (kW); G is that the global radiation of SPVs array surface (kWh/m^2); and value of K is 1 kW/m^2 and F_{pv} is that SPVs derating factor. The derating factor (96%) is employed in this paper taking into consideration the negative effect of wiring loss, shading, dust cover, ageing supported SPVs costs and therefore a designation of hours/days SPVs power output has been shown in Fig. 4, the most of SPVs output power is in a daytime around six AM to six PM. Additionally, the common SPVs power output is 2,332 kW of overall rated capacity (10,000 kW) and the capacity factor is 23.3 %. The operation time of SPVs per year is 4,395h.

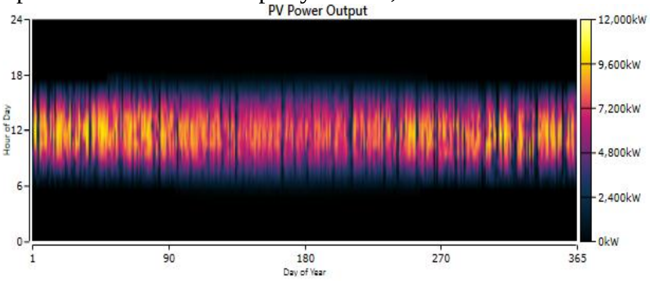

Fig. 4. The designation of hours/days SPVs power output

B. Techno-economic analysis of WTs

The output power of WTs in every time stage is obtained using HOMER software. Moreover, it evaluated a wind speed at hub-height through the following equation:

$$V_{hub} / V_{anem} = Ln(Z_{hub} / Z_o) / Ln(Z_{anem} / Z_o) \quad (2)$$

Where V_{hub} and V_{anem} are a wind speed at the hub height of WT (m/s) and wind speed at anemometer height (m/s) respectively. Z_{hub}, Z_{anem} and Zo are hub-height of the WT (m), anemometer height (m) and surface roughness length (m) respectively. In the title of hours/days WT power output in Fig. 5, the average output power of WTs is 1,332 kW of 13 GW total rated capacity (with a capacity factor of 10.2 %), distributed for 24 h. Also, the operation time of the WTs per year is 6,280 h. Figure 6 shows the designation for WT power output of hours/days.

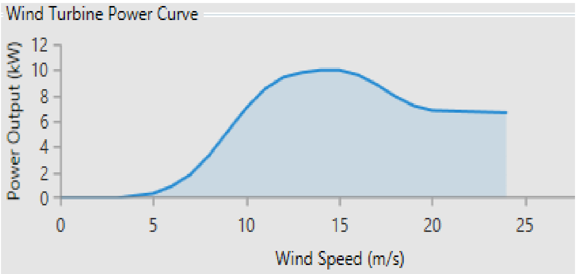

Fig. 5. The WTs power output curve

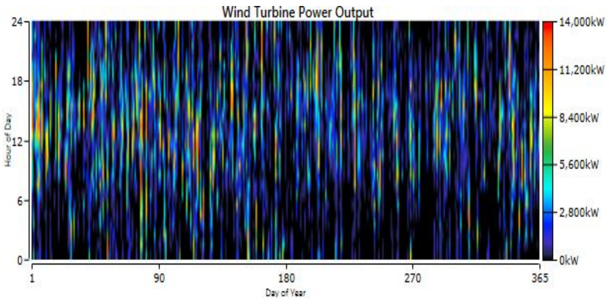

Fig. 6. The designation for WT power output of hours/days

C. Techno-economic analysis of power converters

The yearly inverter energy output is 6,216,897 kWh while the yearly input energy to the inverter is 6,544,102 kWh with the losses of 327,205 kWh/year. The operation time of a converter as an inverter is 3,902h in a year. Rectifier; that converts AC to DC power, as presented by designation of hours '/days power output of a rectifier. The rectifier energy output is 186,255 kWh/year and the yearly input energy to a rectifier is 206,950 kWh with power losses of 20,695 kWh/year. Also, the operation time of power converters as a rectifier per year is 1,564 h.

D. Techno-economic analysis of battery banks

The maximum power of the battery bank is calculated at any step time by HOMER. Two self-regulating factors could limit the lifetime of battery banks in HOMER software; the battery float life and a lifetime throughput. The battery bank lifetime can be calculated by the subsequent equation:

$$B_{bl} = \begin{cases} N_b * \frac{L_{tb}}{A_{tb}} & \text{if limited by throughput} \\ B_{fl} & \text{if limited by time} \\ min(N_b * \frac{L_{tb}}{A_{tb}}, B_{fl} & \text{if limited by throughput and time} \end{cases} \quad (3)$$

where, B_{bl} is that a battery storage life (year); N_b is the number of storage batteries; L_{tb} is the battery lifetime (kWh); A_{tb} is the annual storage battery throughput (kWh/year) and B_{fl} is the storage battery float life (year). Figure 7 previews the monthly profile of storage battery SOC. Therefore, the designation profile of the hours/days of storage batteries. The energy output of storage batteries is 452,717 kWh/year and the energy input of storage batteries is 564,892 kWh/year with power losses of 113,073 kWh/year with storage depletion of 899 kWh/year. Additionally, it can be noted that SOC for storage units is about 100% year-round, and also the lifetime for storage batteries is ten years.

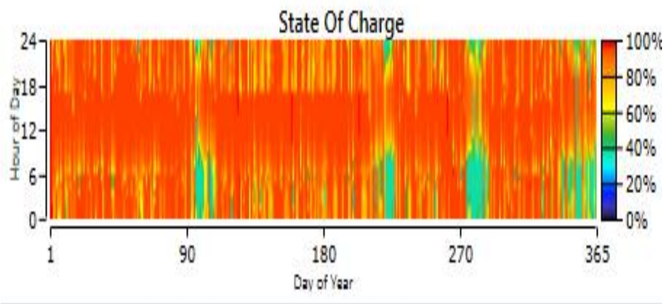

Fig. 7. The profile of storage battery SOC

E. Techno-economic analysis of Diesel units

The diesel unit lifetime is different from lifetime inputs of countless other components, it is specified non-cutting-edge years, but hours of operation. This is dependent on the operation hours of diesel. It is estimated using HOMER in step with the subsequent equation:

$$G_{l,y} = G_{l,h} / N_{h,g} \quad (4)$$

Where $G_{l,y}$ is an expected lifetime of diesel unit (year); $G_{l,h}$ is the diesel unit lifetime (h); N_{hg} is amounts of hours the unit operates for one year (hour/year). The diesel fuels curve describes the quantity of fuel that a unit consumes to supply wattage. HOMER software assumes that the fuel curve of the diesel unit is presented in Fig. 8.

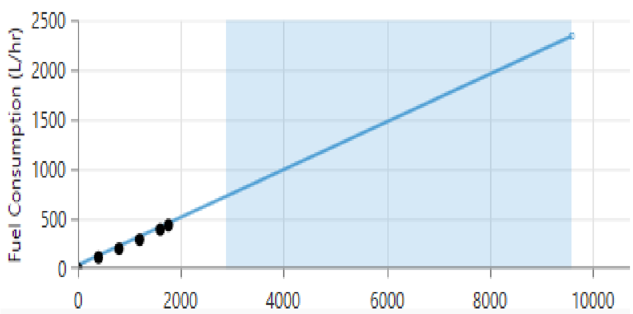

Fig. 8. The fuel consumption curve of a diesel unit

$$F = F_o * Y_g + F_1 * P_g \quad (5)$$

where F_o is that the intercept coefficient of diesel fuel curve (L/hour/kW); F_1 is that the slope of fuel curve (L/hour/kW); Y_g is the diesel unit rated capacity (kW) and P_g is that the electrical output power of the unit (kW). The designations of generator power output presented in Fig. 9. The electrical production of diesel units is 17,732,382 kWh/year. The operation time diesel unit of the optimal micro-grid is 4,692 h/year in 455 starts per year, which illustrates the smallest amount time of an operation is compared to SPVs/WTs/dies/conv is 6,793 h/year, SPVs/dies/conv is 5,294h/year, SPVs/dies/conv is 5,598 h/year, SPVs/dies/conv/batt is 5,214h/year, WTs/dies/conv/ batt is 6,521h/year , WTs/dies is 7,374 h/year , WTs/dies/ conv is 8,631 h/year and dies 8,631h/year. Additionally, the overall consumed amounts of fuel are 5,297,319 L/year and therefore a lifetime for diesel unit is 3.57 years.

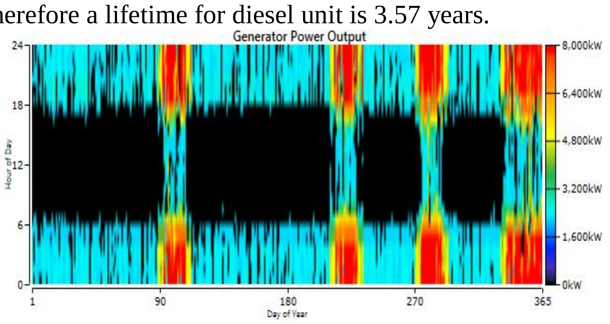

Fig. 9. The designation of hours/days of diesel unit power output

Table 13. The greenhouse gases amounts of optimal source and diesel unit (kg/year)

	Optimal source	Diesel
Carbon Dioxide	11,527,547	19,156,430
Carbon Monoxide	57,218	95,085
Unburned Hydrocarbons	3,164	5,258
Particulate Matter	510	847
Sulfur Dioxide	28,169	46,812
Nitrogen Oxides	9,932	16,505

F. Greenhouse gases emissions

According to environmental protocols, there are penalties on emissions, HOMER uses these penalties and adds its cost to the cost of the project. The values of these penalties for Carbon dioxide is 15 $/ton, Carbon monoxide is 10 $/ton and Nitrogen oxide is 7 $/ton. Table 13 gives the total greenhouse gases that contain carbon dioxide, carbon monoxide (CO), unburned hydrocarbons, particulate matter, nitrogen dioxide, and sulfur oxides, which were free for the optimal source. Greenhouse gas totals were designed using the well-known HOMER software. Greenhouse gas has many evil effects on humans and the environment; first for humans, it reasons respiratory problems, stops the transport of oxygen to the body of the organ and produces bores. Second, the environment wind-up in atmospheric reaction causing acid precipitation. A good reduction within the quantity of CO2 and other emissions may be gotten throughout a lifetime of optimum hybrid source, as compared with the other sources' configurations. Moreover, the hybrid SPVs/WTs/dies/conv/ batt source is the foremost environmentally friendly model compared to the diesel-only source. Table 13 shows the greenhouse gases amounts of optimal source and diesel units.

VI.CONCLUSIONS

From the analyses of this article, it may be concluded that the hybrid SPVs/Converter/diesel micro-grid is a solution for the environmentally friendly small town in Marsa Alam, Egypt. According to the obtained results, the combinations of WTs, SPVs, battery banks, power converters, and diesel units are the optimal hybrid micro-grid with the capacities of 13000 kW, 10000 kW, 5000 kWh, 5000 kWh, and 8000 kW respectively, is the optimum source according to LCOEs and NPC. The LCOE and NPC of optimum source ($0.224/kWh and $103 M) is the least compared to other hybrid source configurations (SPVs/WTs/dies/conv of $0.275/kWh and $107M), (SPVs/ dies/conv of $0.305/ kWh and $119M), (SPVs/dies/ conv/batt of $0.310/kWh and $120 M), (WTs/dies/conv/ batt of $0.328/kWh and $128 M), (WTs/dies of $0.337/kWh and $131 M), (WTs/dies/conv of $0.416/kWh and $161 M), (dies of $0.445/kWh and $174M) respectively. In addition, the achieved RF is 41.7%, which is the highest RF fraction in compared with the RF of other sources configurations. Additionally, an optimal HRES configuration is ready to scale back the significant amounts of greenhouses gas emission, which has poor effects on humans and the environment. Furthermore, it is the foremost environmentally friendly configuration in this paper. Finally, the separate techno-economic analyses of every component (SPVs arrays, WTs, converters, and diesel units) within optimum HRES are administrated. With the rapid development within the renewable energy industry, LCOEs is reduced and then could be applied for identical work widely in any other community within Egypt. To realize the goal that the Egyptian environmentally friendly within the near future become. Also, the identical work may apply to other sites within the world. The increasing renewable energy penetration in rural regions reduces operating costs through the decrease in fuel consumption, increasing efficiency, and reduced amounts of emissions of the micro-grid.

REFERENCES

[1] Aly, Abdelmaged M., et al. "Design of micro-grid with flywheel energy storage source using HOMER software for a case study." 2019 International Conference on Innovative Trends in Computer Engineering (ITCE). IEEE, 2019.

[2] Helal, Ahmed, Rasha El-Mohr, and Hussien Eldosouki. "Optimal design of hybrid renewable energy source for electrification of a remote village in Egypt." CCCA12. IEEE, 2012.

[3] Wu, Qing, et al. "Optimization Design And Simulation Of Micro-grid In Amdjarass Town, Chad." E3S Web of Conferences. Vol. 118. EDP Sciences, 2019.

[4] Diab, Fahd, et al. "An environmentally friendly factory in Egypt based on the hybrid photovoltaic/wind/diesel/battery source." Journal of Cleaner Production 112 (2016): 3884-3894.

[5] Salisu, Sani, et al. "Assessment of technical and economic feasibility for a hybrid PV-wind-diesel-battery energy system in a remote community of north-central Nigeria." Alexandria Engineering Journal 58.4 (2019): 1103-1118.

[6] Dawoud, Samir Mohammed, et al. "Feasibility study of the isolated PV-wind system in Egypt." Advanced Materials Research. Vol. 1092. Trans Tech Publications Ltd, 2015.

[7] Shezan, SK A., et al. "Performance analysis of an off-grid wind-PV (photovoltaic)-diesel-battery hybrid energy system feasible for remote areas." Journal of Cleaner Production 125 (2016): 121-132

[8] Ibrahim, Mostafa M., et al. "Performance analysis of a stand-alone hybrid energy system for desalination unit in Egypt." Energy Conversion and Management 215 (2020): 112941.

[9] Abu-Elzait, Sohad, and Robert Parkin. "Economic and environmental advantages of renewable-based microgrid s over conventional micro-grids." 2019 IEEE Green Technologies Conference (GreenTech). IEEE, 2019.

[10] Dong, Jun, et al. "Research on Economic Operation Strategy of CHP Micro-grid Considering Renewable Energy Sources and Integrated Energy Demand Response." Sustainability 11.18 (2019): 4825.

[11] Holdmann, Gwen P., Richard W. Wies, and Jeremy B. Vandermeer. "Renewable energy integration in Alaska’s remote islanded micro-grids: economic drivers, technical strategies, technological niche development, and policy implications." Proceedings of the IEEE 107.9 (2019): 1820-1837.

[12] Jung, Jaesung, and Michael Villaran. "Optimal planning and design of hybrid renewable energy systems for micro-grids." Renewable and Sustainable Energy Reviews 75 (2017): 180-191.

[13] Rezk, Hegazy, Mohammad Ali Abdelkareem, and Chaouki Ghenai. "Performance evaluation and optimal design of stand-alone solar PV-battery system for irrigation in isolated regions: A case study in Al Minya (Egypt)." Sustainable Energy Technologies and Assessments 36 (2019): 100556.

[14] Fesanghary, M., and M. M. Ardehali. "A novel meta-heuristic optimization methodology for solving various types of economic dispatch problem." Energy 34.6 (2009): 757-766.

[15] Hamanah, W. M., M. A. Abido, and Luai M. Alhems. "Optimum Sizing of Hybrid PV, Wind, Battery and Diesel System Using Lightning Search Algorithm." Arabian Journal for Science and Engineering 45.3 (2020): 1871-1883.

[16] Qayyum, Nabeeha, et al. "Optimization Techniques for Home Energy Management: A Review." 2019 2nd International Conference on Computing, Mathematics, and Engineering Technologies (iCoMET). IEEE, 2019.

[17] Okhuegbe, S. N., C. Mwaniki, and M. F. Akorede. "Optimal Sizing of Hybrid Energy Systems in a Micro-grid: A Review." Proceedings of Sustainable Research and Innovation Conference. 2019.

[18] Nagapurkar, Prashant, and Joseph D. Smith. "Techno-economic optimization and environmental Life Cycle Assessment (LCA) of micro-grids located in the US using genetic algorithm." Energy Conversion and Management 181 (2019): 272-291.

[19] Dawoud, Samir M., Xiangning Lin, and Merfat I. Okba. "Hybrid renewable micro-grid optimization techniques: A review." Renewable and Sustainable Energy Reviews 82 (2018): 2039-2052.

[20] Mrollahi, Mohammad Hossein, and Seyyed Mohammad Taghi Bathaee. "Techno-economic optimization of hybrid photovoltaic/wind generation together with energy storage system in a stand-alone micro-grid subjected to demand response." Applied energy 202 (2017): 66-77.

[21] http://eosweb.larc.nasa.gov/sse/2021

[22] Pawar, Nagorao, and Pragya Nema. "Techno-economic performance analysis of grid-connected PV solar power generation system using HOMER software." 2018 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC). IEEE, 2018.

[23] Dawoud, Samir M., et al. "Reliability study of hybrid PV-wind power systems to isolated micro-grid." 2015 Sixth International Conference on Intelligent Control and Information Processing (ICICIP). IEEE, 2015.

[24] Aziz, Ali Saleh, et al. "Energy management and optimization of a PV/diesel/battery hybrid energy system using a combined dispatch strategy." Sustainability 11.3 (2019): 683.

[25] Aziz, Ali Saleh, et al. "Energy management and optimization of a PV/diesel/battery hybrid energy system using a combined dispatch strategy." Sustainability 11.3 (2019): 683.