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OPTIMIZATION OF HYBRID SOLAR PV/ DIESEL SYSTEM FOR POWERING TELECOMMUNICATION TOWER

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ABSTRACT

The contribution of renewables hybrid energy systems to the fast development in several isolated areas far from the main utility grid is significant. However, the supply of these isolated areas with their needs of electricity by the renewable energy source can have interruptions because of climatic changes which must take up into consideration when designing these systems. This paper discusses the design and analysis of a hybrid system to supply Telecommunication Tower with 10kW power in Al-Buraimi, Oman. The article is providing optimization solution for using PV/Diesel Generator Hybrid Power Systems using the Homer software. The simulation model has been utilized to estimate the best improvement results in the light of proficient energy system for the predefined load. The results indicated that the PV exhibit appraised limit is 50kW. The results show that the sun-powered energy use is an appealing alternative to starting cost of 143.402$, the net present expense of the system is 324.569$, and the energy cost is 0.29 $/kWh. In correlation with a diesel generator, the system energy cost 0.584$ and the standalone PV system energy cost was 0.344$. The usage of the Hybrid system for powering telecommunication tower in Al-Buraimi, Oman is the best optimization system based on the energy cost.

KEYWORDS: *HOMER Software, Optimization, Telecommunication tower, hybrid system.*

I. INTRODUCTION

Energy sources are divided into two general categories; the energy that reaches the earth from the outer space known as the incoming energy, and the energy that already exists on or within the earth which is called capital energy. Solar energy is included in the incoming energy, while fossil fuels, geothermal energy, and nuclear power are considered to be capital energies. The utilization of solar energy is very attractive, because it is non-depletable source of energy, and it is pollution free, which is a critical consideration. Although the solar radiation intensity shows up rather debilitate when compared to the fossil fuels energy. In the long haul, the cost of fossil fuel based energy era may increase, and the costs of renewable energy diminish because of the development, streamlining, and expanded productivity [1& 2].

The solar radiation is changed to electricity in solar PV applications. The most widely recognized strategy for doing this is by the utilization of silicon sunlight based cells. The solar module which comprises of a few solar cells electrically connected to a base plate which is the force producing unit.

The clusters which comprise of the PV change gadgets are the significant parts of a PV system. The gadgets interconnections and bolster power molding hardware which changes over the DC to AC and gives controlled yields of voltage and current. Controller, which naturally deals with the operation of the aggregate framework and the discretionary stockpiling for standalone (non-network) systems [3 & 4].

The power systems consistent quality and accessibility are essential for most telecommunication applications. Most systems are in remote areas with constrained access and frequently with compelling climate conditions (wind, snow, ice) part of the year. Therefore, PV systems are progressively being utilized to supply power for telecom applications. Hybrid systems are employed to decrease starting expense, especially at the peak power demands [5].

Telecommunications stations require growing amounts of electricity supplies. The power source, in general, is from the grid and the rest is from burning of fossil fuel such as diesel fuel. These sources contribute to emission of greenhouse gasses (GHG) with the attendant adverse environmental effects. What the reduction of the GHG resulted from the telecom sector called as the greening of telecom. Green Telecom minimizes the energy consumption by using renewable energy sources and eco-friendly consumables. The need to reduce the cost of operations of the telecom network and to expand the network into rural areas where power availability is poor has led to the enhancement of green telecom [6 & 7].

This study aims to design and estimate the cost of supplying a telecommunication station with electricity using hybrid system in Al-Buraimi-Oman. The study used Homer software to define and select the optimum parts of the hybrid system. This work is a part of Sohar University Renewable Energies team efforts to raise awareness of the use of renewable energies in various aspects of public life in the Arab Gulf countries and Iraq [8- 33].

1.1.The study location

Al-Buraimi is a city in Oman in the Middle East, where the solar energy is found to be the highest globally. Al-Buraimi lies between the longitude and latitude of (24˚ 15’N, 55°45E). It is very hot, with temperatures reaching 48°C in the summer season. Also, Al-Buraimiclimate remains dry and scalding all over the year. Therefore, the usage of solar PV technology is suitable for producing electricity in the northern parts of Oman and in the desert areas [33].

Figure 1. Al-Buraimi-Oman – a top view from Google Earth [33]

II. ENERGY ANALYSES

2.1 Solar Radiation Profile for Al-Buraimi-Oman

Fig. 2 shows the solar radiation intensity profile over one year for Al-Buraimi. In this study, the solar resource data for Al-Buraimi, Oman was obtained from the average of NASA Surface Meteorology, solar energy website [33]. The data was collected for latitude 24° 15' North and longitude 55° 45' east. It has been observed that the delay radiation ranges from 3.937 kW/m^2/d to 6.420 kW/m^2/d and the highest radiation was in May. The clearness incident fields lay between 0.520 to 0.631. The average daily radiation and average clearness incident are 5.141kW/m^2/d and 0.561 respectively [34].

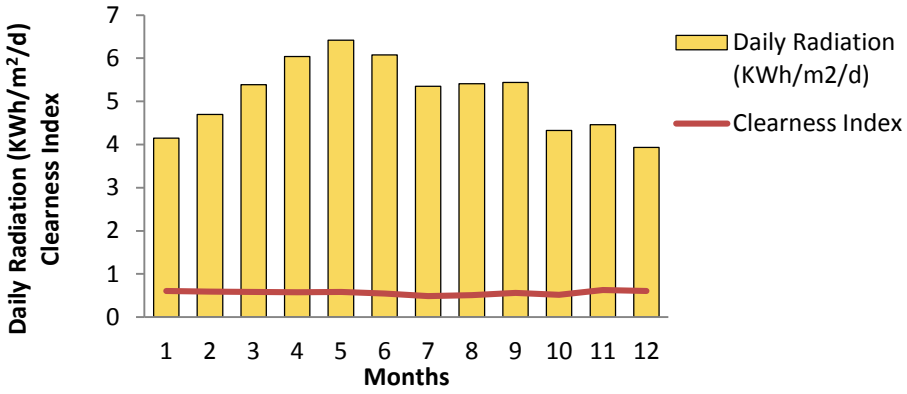


Fig. 2: Solar radiation profile

2.2. Load profile

The load profile which is based on a hypothetical apartment has been assumed as a base load of 10 kW occurs throughout the day and night. The total daily load average is 240kWh/day, with a peak power, equals to 19kW.

III. COMPONENTS OF THE PROPOSED HYBRID SYSTEM

Depending on the project location, a hybrid system was chosen to power the telecom station. The selected system consists of a solar PV module and a diesel generator. Solar energy is the most abundant green energy supply while the diesel generator was taken to confirm continuous supply of power. Hence, the components of the proposed systems were:

1. Solar Photovoltaic system.
2. Diesel Generator.
3. Storage devise.

IV. INPUT PARAMETERS

4.1. PV Array Data

The PV array simulation declared that the capital cost was 180$ and the replacement costs was 140$. The maintenance cost was considered about 10$/yr which is a low value. The lifetime for this system was estimated about 25 years and a derating factor of 90% was selected as Fig. 3 declares.

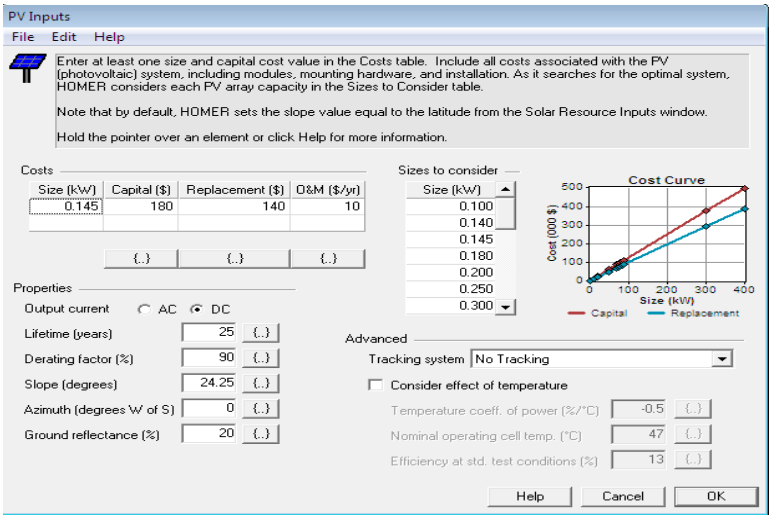


Figure 3. Photovoltaic solar input

4.2. Storage Device:

A storage device is needed for the proposed hybrid system. The model defined that the energy from solar panels can be stored in a battery to be used whenever the solar radiation is low or when the solar cells electricity generation is not enough. This condition can be found during cloudy or rainy days. Also, the battery can be used as an energy source during the night period, as well as it is used to store the excess energy. The description of the selected battery is given below:

Battery type: Hoppecke 12 OPzS 1500
Nominal Capacity: 1500Ah
Nominal Voltage: 2V
Number of batteries: 100 batteries
The batteries considered by HOMER in the simulation as Fig. 4 represents.

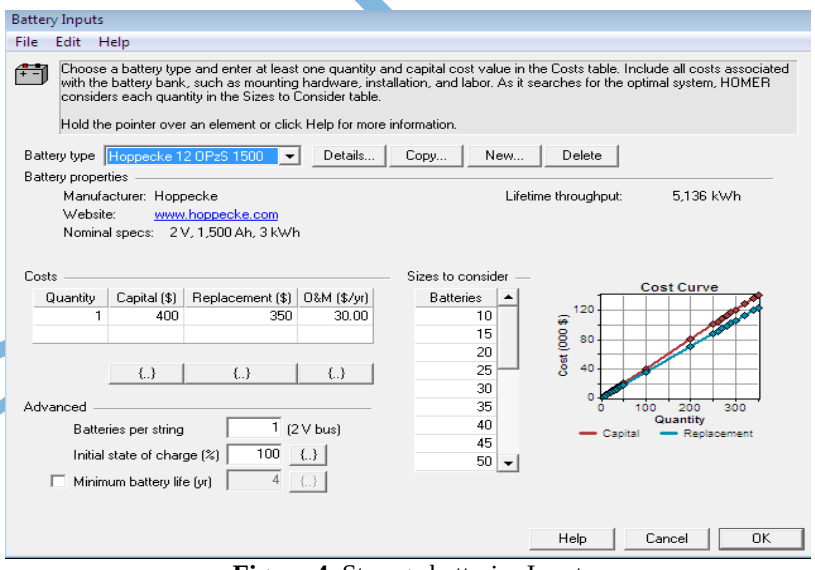


Figure 4. Storage batteries Input

4.3. Diesel Generator:

For power supply without interruption, a 20kW diesel generator must be used. The PV system works together with the generator to fulfill the load demand. Fig. 5 shows the generator considered by HOMER in the simulation.

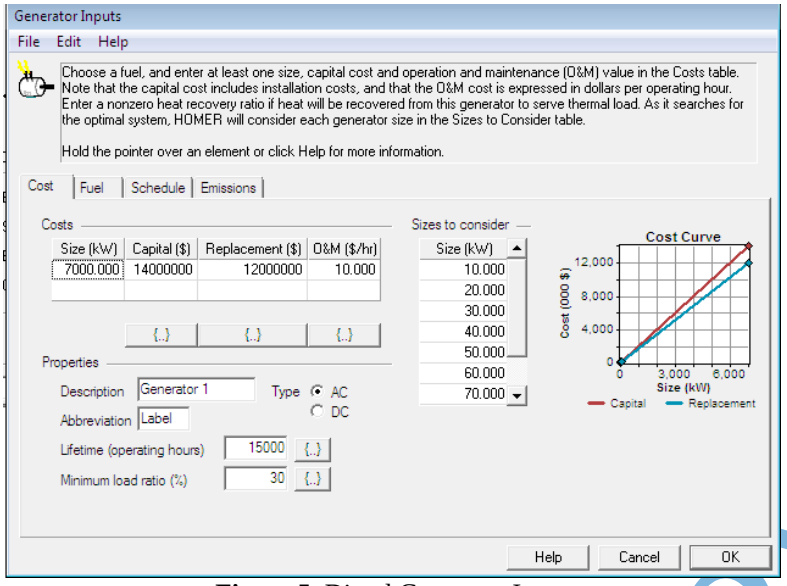


Figure 5. Diesel Generator Input

4.4. Inverter Data

Fig. 6 illustrates the inverter input as simulated by HOMER. The selected inverter size was 6 kW and its efficiency was about 95%.

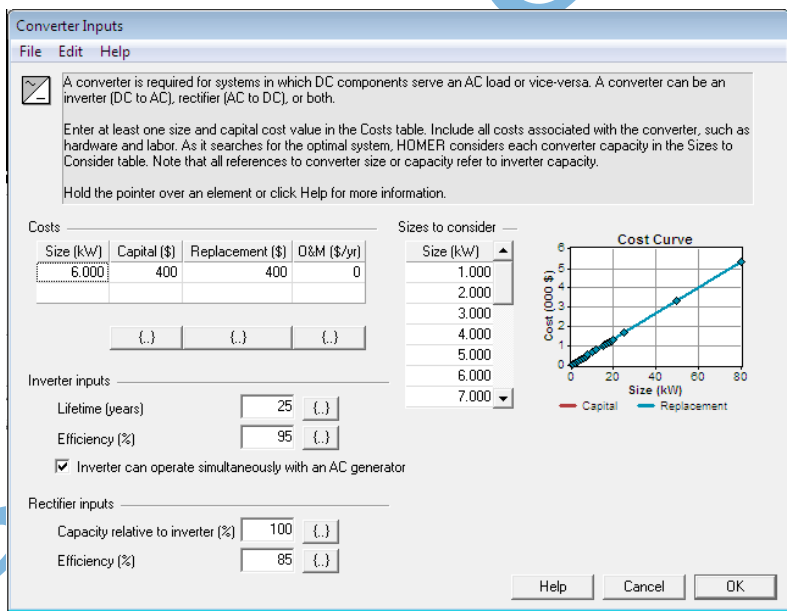


Figure 6. Inverter Input

V. COMPLETE MODEL OF HYBRID SYSTEM

Fig. 7 represents a complete model of the proposed hybrid system consisting of a solar PV module and a diesel generator. As the generating schemes contributing to the hybrid operation, storage device and converter for storing and conversion of power produced from the solar panel.

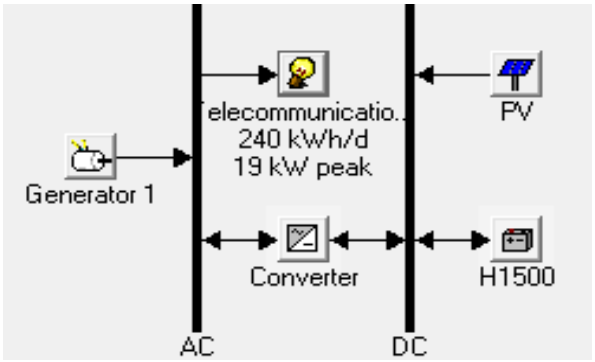


Figure 7. Complete Model of Hybrid System

In addition to Hybrid system, two other systems have been optimized. These systems were based on powering the telecommunication tower with a standalone PV system, and the other proposed system was using diesel generator as shown in Fig.8 and Fig.9, respectively.

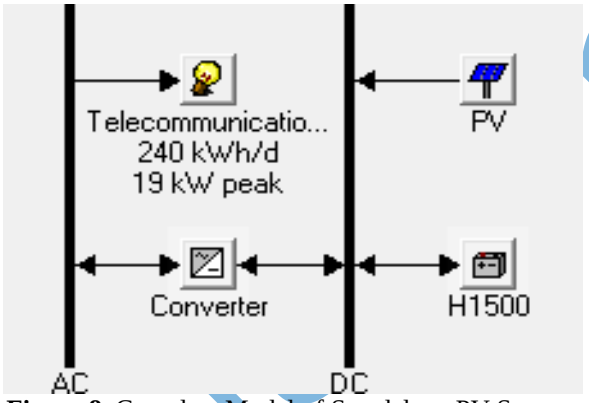


Figure 8. Complete Model of Standalone PV System

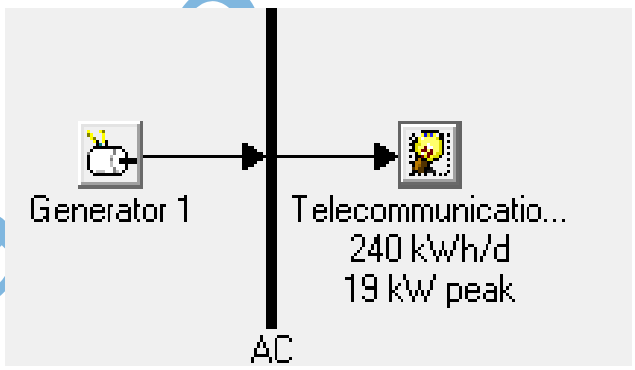


Figure 9. Model of Diesel Generator

VI. SIMULATION RESULTS

Renewable energy systems design depends too much on the system location, so the designing of such a system is complicated. The study deals with the design of hybrid power system for the remote rural place named Al-Burami in Oman. The study was conducted to evaluate the economics associated with the designed hybrid system. In this study, each of the schemes participating in hybrid system i.e. solar PV and Diesel generator was modeled by HOMER. The climatic input parameters used were drowned from NASA data. The hybrid system economics was estimated. The hybrid system cost of produced energy (CoE) was affordable for the people living in that rural region. HOMER software simulation results showed that:

Hybrid PV/diesel system as shown in Fig. 10:

Minimum cost per kWh (COE) of Hybrid system is 0.29$.

Total Net Present Cost (NPC): 32,456.9$.
Operating Cost: 1,417.2$/yr.
Initial Capital cost of the system: 14,340.2$.

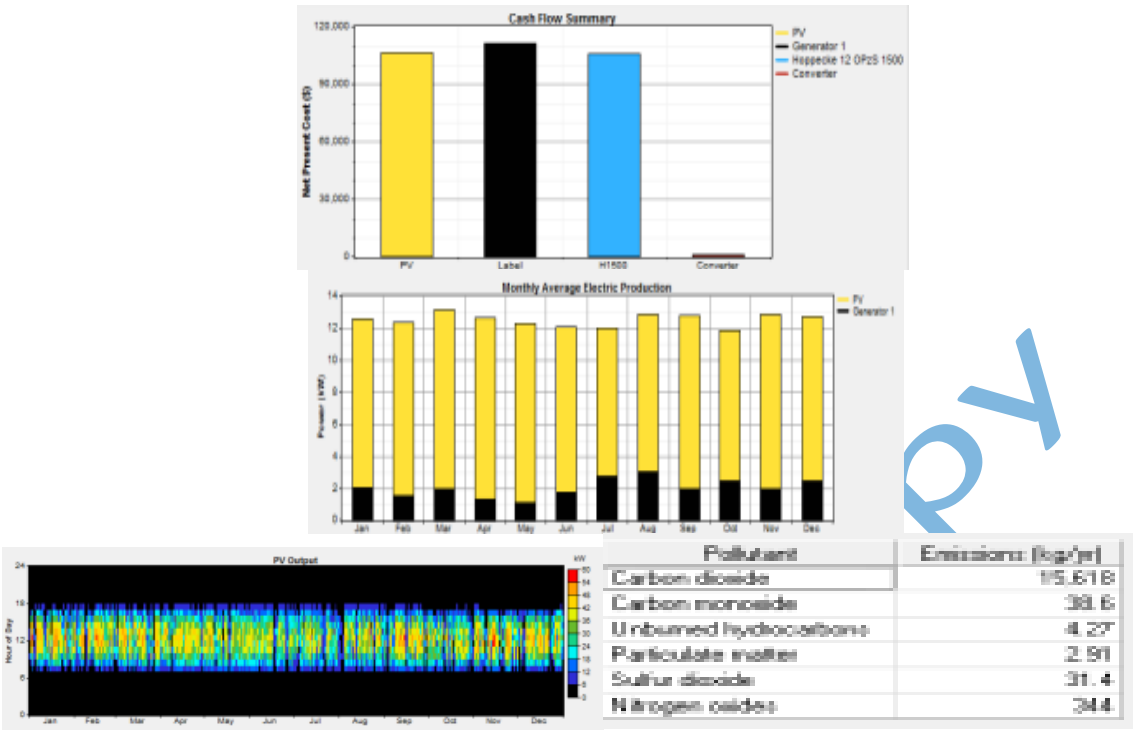
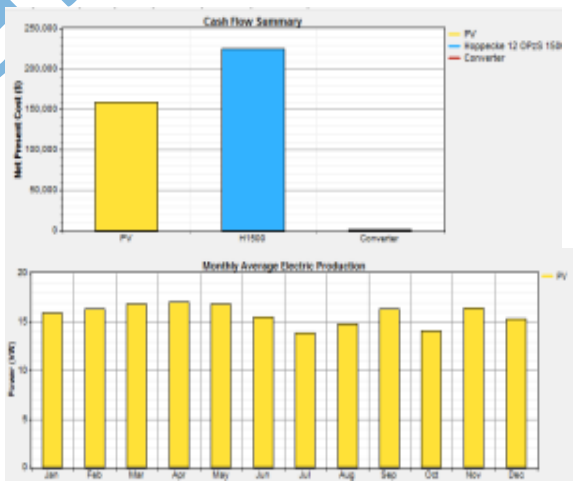


Fig. 10

Also, the results of the standalone PV system and Diesel generator obtained from the HOMER software are:
Standalone PV system as shown in Fig. 11:
The minimum cost of energy per kWh (COE) of the hybrid system is 0.344$.
Total Net Present Cost (NPC): 38,505.5$.
Operating Cost: 1,428.6$/yr.
Initial Capital cost of the system: 20,243.7$.



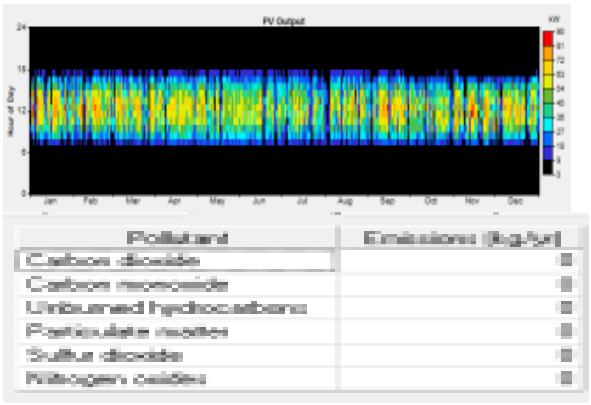


Fig. 11

Diesel generator as shown in Fig. 12:
The minimum cost of energy (COE) per kWh of the hybrid system is 0.584$.
Total Net Present Cost (NPC): 65,447.6$.
Operating Cost: 4,806.8$/yr.
Initial Capital cost of the system: 40,000$.

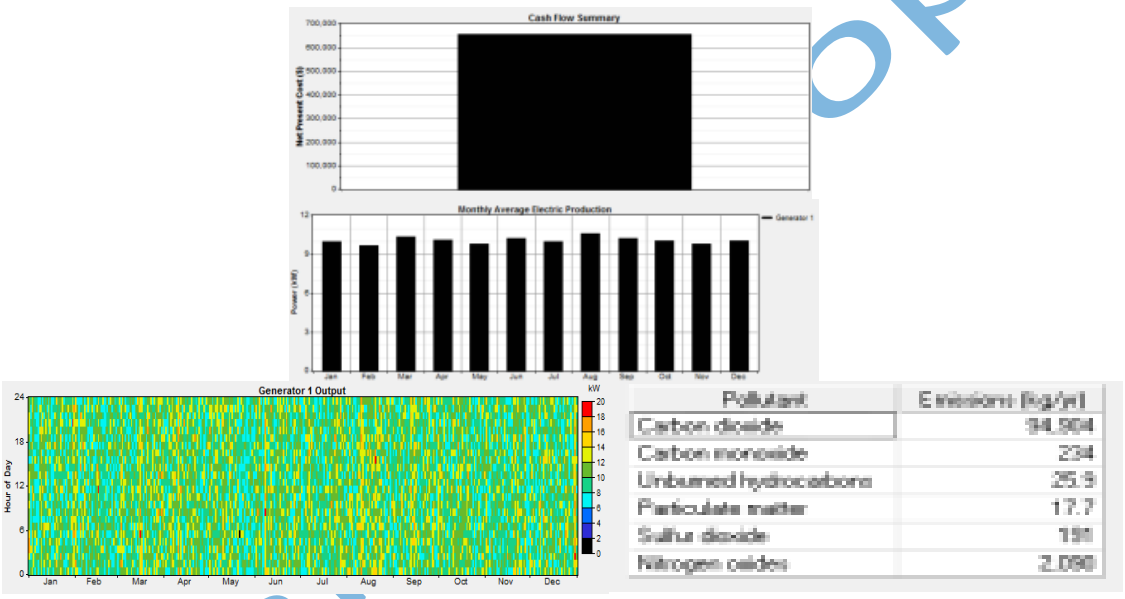


Fig. 12

VII. CONCLUSIONS

The limited availability of oil and other different types of non-renewable sources with the high costs of generating power from these non-renewable sources have led to the usage of hybrid power generations. It is considered expensive and difficult to combine various energy sources together. The expense is only for one time with a lifespan of about 20-25 years. So it can be considered an economical option.
The optimization of a hybrid system for powering telecommunication tower with 10kW in Al-Buraimi-Oman has been simulated using HOMER software. The obtained results indicate that the best total Net Percent Cost (NPC) can be achieved by using 100 batteries when the size of the used converter is 20kW, the diesel generator of 20kW and with 5.931l/h, and 50kW PV size. On the other hand, standalone system scheme for powering telecommunication tower requires 75kW PV size, 270 batteries and a converter of 20 kW. The generator system needs 20kW with 36.04l/h of diesel. Based on the simulation results obtained from HOMER software, the hybrid system is the best to power the telecommunication tower according to the cost of energy of 0.290 $/kWh.

REFERENCE

[1] Kazem, H. A., (2011) "Renewable Energy in Oman: Status and Future Prospects", Elsevier-Renewable and Sustainable Energy Review (RSER), Vol. 15, pp3465-3469.

[2] Al-Badi, A. H., Albadi, M. H., Al-Lawati, A. M. and Malik, A. S., (2011) "Economic perspective of PV electricity in Oman," Energy, Vol. 36, No. 1, pp 226–232.

[3] Abdallah, Z., Elhassan, M., Zain, M. F. M., Sopian, K. and Abass, A. A., (2012) "Design and performance of photovoltaic power system as a renewable energy source for residential in Khartoum", International Journal of the Physical Sciences, Vol. 7, No. 25, pp4036-4042.

[4] Ministry of Oil & Gas, letter dated 13 February 2008, Ref. 478

[5] Kazem, H. A., Al-Waeli, A. H. A., Al-Kabi, A. H. K. and Al-Mamari, A., (2015) "Techno-economical assessment of optimum design for photovoltaic water pumping system for rural area in Oman," Hindawi Publishing Corporation International Journal of Photoenergy, Vol. 2015, Article ID 514624, 8 pages.

[6] Kazem, H. A., Khatib, T., and Sopian, K., (2013) "Sizing of a standalone photovoltaic/battery system at minimum cost for remote housing electrification in Sohar, Oman," Energy and Buildings, Vol. 61, pp108–115.

[7] Kazem, H. A., Hasoon, F., Al-Qaisi, F., Alblushi, N., Alkumzari, H., Alfora, A., (2012) "Design of stand-alone photovoltaic for rural area in Oman," 3rd NCT Symposium, 28-29.

[8] Mohammed, M., Aziz, A., Alwaeli, A. H. A., Kazem, H. A., (XXX) "Optimal sizing of photovoltaic systems using HOMER for Sohar, Oman," International Journal of Renewable Energy Research (IJRER), Vol. 3, No. 3, pp470-475.

[9] Chaichan, M. T. & Kazem, H. A., (2011) "Thermal storage comparison for variable basement kinds of a solar chimney prototype in Baghdad-Iraq weathers," International Journal of Applied Science (IJAS), Vol. 2, No. 2, pp12-20.

[10] Ahmed, S. T. & Chaichan, M. T., (2011) "A study of free convection in a solar chimney sample," Engineering and Technology J, Vol. 29, No. 14, pp2986-2997.

[11] Chaichan, M. T. & Kazem, H. A., (2012) "Status and future prospects of renewable energy in Iraq," Renewable and Sustainable Energy Reviews, Vol. 16, No. 1, pp6007–6012.

[12] Kazem, H. A., Chaichan, M. T., Al-Shezawi, I. M., Al-Saidi, H. S., Al-Rubkhi, H. S., Al-Sinani, J. K. & Al-Waeli, A. H. A., (2012) "Effect of humidity on the PV performance in Oman," Asian Transactions on Engineering, Vol. 2, No. 4, pp29-32.

[13] Chaichan, M. T., Abaas, K. I. & Kazem, H. A., (2012) "The effect of variable designs of the central receiver to improve the solar tower efficiency," International J of Engineering and Science, Vol. 1, No. 7, pp56-61.

[14] Chaichan, M. T. & Abaas, K. I., (2012) "Productivity amelioration of solar water distillator linked with salt gradient pond," Tikrit Journal of Engineering Sciences, Vol. 19, No. 4, pp24-34.

[15] Darwish, Z. A., Kazem, H. A., Sopian, K., Alghoul, M. A. & Chaichan, M. T., (2013) "Impact of some environmental variables with dust on solar photovoltaic (PV) performance: review and research status," International J of Energy and Environment, Vol. 7, No. 4, pp152-159.

[16] Kazem, A. A., Chaichan, M. T. & Kazem, H. A., (2014) "Effect of dust on photovoltaic utilization in Iraq: review article," Renewable and Sustainable Energy Reviews, Vol. 37, pp734-749.

[17] Chaichan, M. T. & Kazem, H. A., (2015) "Using aluminum powder with PCM (paraffin wax) to enhance single slope solar water distillator productivity in Baghdad-Iraq winter weathers," International Journal of Renewable Energy Research, Vol. 1, No. 5, pp151-159.

[18] Chaichan, M. T. & Kazem, H. A., (2015) "Water solar distiller productivity enhancement using concentrating solar water heater and phase change material (PCM)," Case Studies in Thermal Engineering, Elsevier, Vol. 5, pp151-159.

[19] Kazem, H. A., Ali, S. Q., Alwaeli, A. H. A., Mani, K., Chaichan, M. T., (2013) "Life-cycle cost analysis and optimization of health clinic PV system for a rural area in Oman," World Congress on Engineering, July 3 - 5, , London, U.K.

[20] Chaichan, M. T. & Abaas, K. I., (2015) "Performance amelioration of a Trombe Wall by using phase change material (PCM)," International Advanced Research Journal in Science, Engineering and Technology, Vol. 2, No. 4, pp1-6.

[21] Chaichan, M. T., Mohammed, B. A. & Kazem, H. A., (2015) "Effect of pollution and cleaning on photovoltaic performance based on experimental study," International Journal of Scientific and Engineering Research, Vol. 6, No. 4, pp594-601.

[22] Chaichan, M. T., Kazem, H. A., Kazem, A. A., Abaas, K. I., Al-Asadi, K. A. H., (2015) "The effect of environmental conditions on concentrated solar system in desertec weathers," International Journal of Scientific and Engineering Research, Vol. 6, No. 5, pp850-856.

[23] Chaichan, M. T., Abaas, K. I., Kazem, H. A., (2015) "Design and assessment of solar concentrator distillating system using phase change materials (PCM) suitable for desertec weathers," Desalination and water treatment, pp1-11.
DOI: 10.1080/19443994.2015.1069221
[24] Kazem, H. A., Chaichan, M. T., Saif, S. A., Dawood, A. A., Salim, S. A., Rashid, A. A., Alwaeli, A. A., (2015) "Experimental investigation of dust type effect on photovoltaic systems in north region, Oman," International Journal of Scientific & Engineering Research, Vol. 6, No. 7, pp293-298.
[25] Chaichan, M. T. and Al-Asadi, K. A. H., (2015) "Environmental impact assessment of traffic in Oman," International Journal of Scientific & Engineering Research, Vol. 6, No. 7, pp493-496.
[26] Chaichan, M. T., Kamel, S. H. & Al-Ajeely, A. N. M., (2015) "Thermal conductivity enhancement by using nano-material in phase change material for latent heat thermal energy storage systems," SAUSSUREA, Vol. 5, No. 6, pp48-55.
[27] Kazem, H. A., & Chaichan, M. T., (2015) "Effect of humidity on photovoltaic performance based on experimental study," International Journal of Applied Engineering Research (IJAER), Vol. 10, No. 23, pp43572-43577.
[28] Kazem, H. A., Al-Waeli, A. H. A., Al-Mamari, A. S. A., Al-Kabi, A. H. K. & Chaichan, M. T., (2015) "A photovoltaic application in car parking lights with recycled batteries: a techno-economic study," Australian Journal of Basic and Applied Science, Vol. 9, No. 36, pp43-49.
[29] Al-Maamary, H. M. S., Kazem, H. A. & Chaichan, M. T., (2016) "Changing the energy profile of the GCC states: a review," International Journal of Applied Engineering Research (IJAER), Vol. 11, No. 3, pp1980-1988.
[30] Kazem, H. A., & Chaichan, M. T. (2016) "Experimental analysis of the performance characteristics of PEM fuel cells," International Journal of Scientific & Engineering Research, Vol. 7, No. 2, pp49-56.
[31] Kazem, H. A., Al-Waeli, A. H. A., Chaichan, M. T., Al-Mamari, A. S. & Al-Kabi, A. H., (2016) "Design, measurement and evaluation of photovoltaic pumping system for rural areas in Oman," Environ Dev Sustain, DOI 10.1007/s10668-016-9773-z.
[32] Chaichan, M. T. & Kazem, H. A., (2016) "Experimental analysis of solar intensity on photovoltaic in hot and humid weather conditions," International Journal of Scientific & Engineering Research, Vol. 7, No. 3, pp91-96.
[33] https://maps.google.com.bd/, Last day of access (February 11, 2013). [Online]
[34] NASA, available at: http://eosweb.larc.nasa.gov, accessed on 12th May, 2010.

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