Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2016, 3(4):62-72**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Design and Analysis of Standalone Solar Cells in the Desert of Oman

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Abstract Peak demand for electricity at Sultanate of Oman have been forecasted to increase from 2,773 MW in 2007 to about 4,634 MW in 2013, and power shortages are supposed to occur soon if current trends continue. One of the Omani government's future aims is to focus on the environment and to determine how to utilize renewable energy in the country. The administration and power organizations in Oman cooperate with global energy organizations that work in renewable assets to create power. The three most crucial components in selecting new vitality sources are that they should be: locally accessible, renewable, and ecologically agreeable. Sun oriented energy satisfies these prerequisites. The level of solar power density in Oman is among the most elevated on the planet. It is allowed to gather, renewable for as long the sun is sparkling, and it doesn't hurt nature.

This paper outlines the design and examination of an ideal framework with a reasonable burden to supply electrical power to Omani individuals in the desert region. This electric power will help them socially, instructively, and financially. This project was supported by the Research Council of Oman. Besides the different configuration parameters influence the execution of the PV framework, for example, solar radiation, temperature, orientation, and expense have been taken in thought. The advance of these parameters utilizing HOMER programming has been made amid the exploration stage to accomplish an ideal and viable configuration of sun-powered PV frameworks.

Keywords Stand-Alone photovoltaic system, solar energy, and solar system design.

Introduction

The global energy demand will continue to increase in the foreseeable future. Because of this increase in energy demand and the expected depletion of fossil fuel, non-renewable vitality assets are being utilized at an astonishing and unsustainable rate. These assets will be gone eventually not long from now. Such a circumstance compels us to search for option assets of vitality. These days the best and most legitimate option is to guide our consideration regarding solar energy. World's life interest is 939 MWh, 16,000 times short of what all the energy that goes to the Earth with sunlight based radiation. The energy accessibility has incredible significance since it offers the opportunity to take care of different issues in the meantime: water, sustenance, ecological, wellbeing, training, atmosphere security, data, correspondence, and versatility. The accessibility of an adequate and possibly endless supply of energy is one of the greatest difficulties confronting our planet today.

There are distinctive sorts of solar cells that do solar modules: crystalline silicon, polycrystalline, monocrystalline, thin film, and so forth. The original is silicon wafer-based with silicon cells, which has overwhelmed the business sector. Figure 1 demonstrates the record proficiency of various sorts of sun oriented cells as an element of time. The essential issue could be seen here is that all the distinctive kinds of the solar cells take after the same pattern; as more research is attempted the efficiencies go up which will drive down the expense of solar power concerning terminate the power of fossil fuel. The cost of solar cell has decreased significantly throughout the years [1-4].

The crystalline solar cells advantages can be described as they long lifetime extents to about 25 years, also, they are strong, productive, and it has a good durability. The crystalline solar cells are favored for solar power generation systems in light volumes. The thin film solar cells are less proficient and have a shorter lifetime compared to the other PV cells types. Despite this disadvantage, the thin film solar panels are utilized as a part of small applications is increasing. It is, for the most part, expected that in the long haul, remarkable film change with multi-layer cells will be broadly utilized and accomplished efficiencies past 25%. The significantly standpoint of the thin film that makes it preferred is that less material are used in its fabricating, which makes it less costly than other PV types.

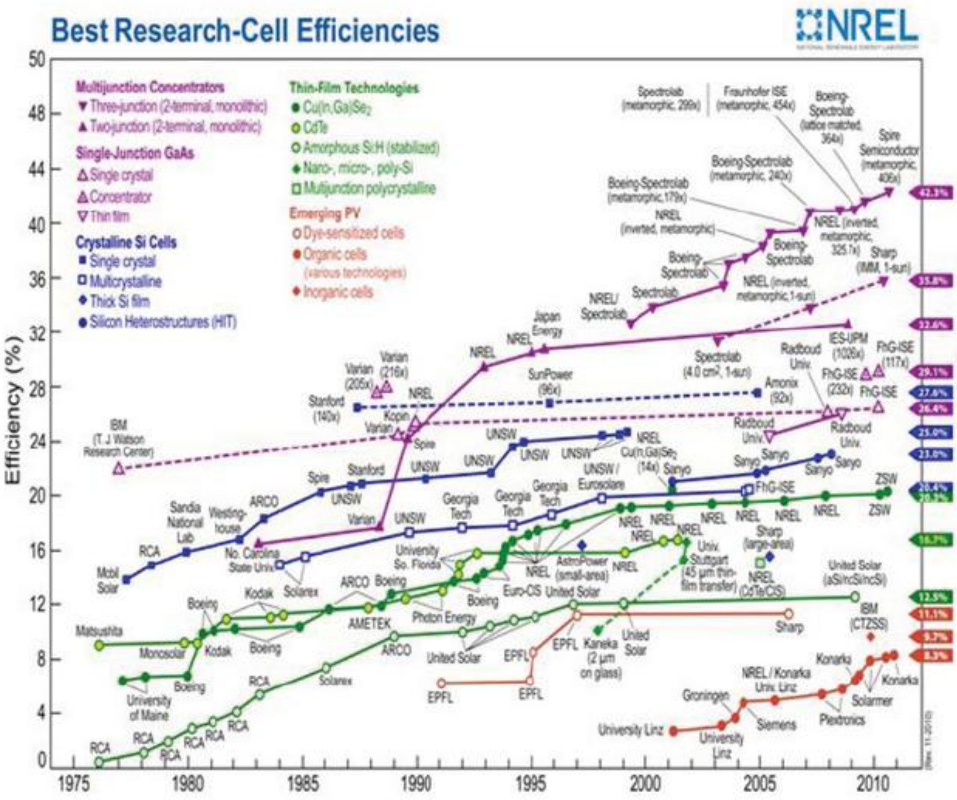

Figure 1: progress in PV efficiency [4].

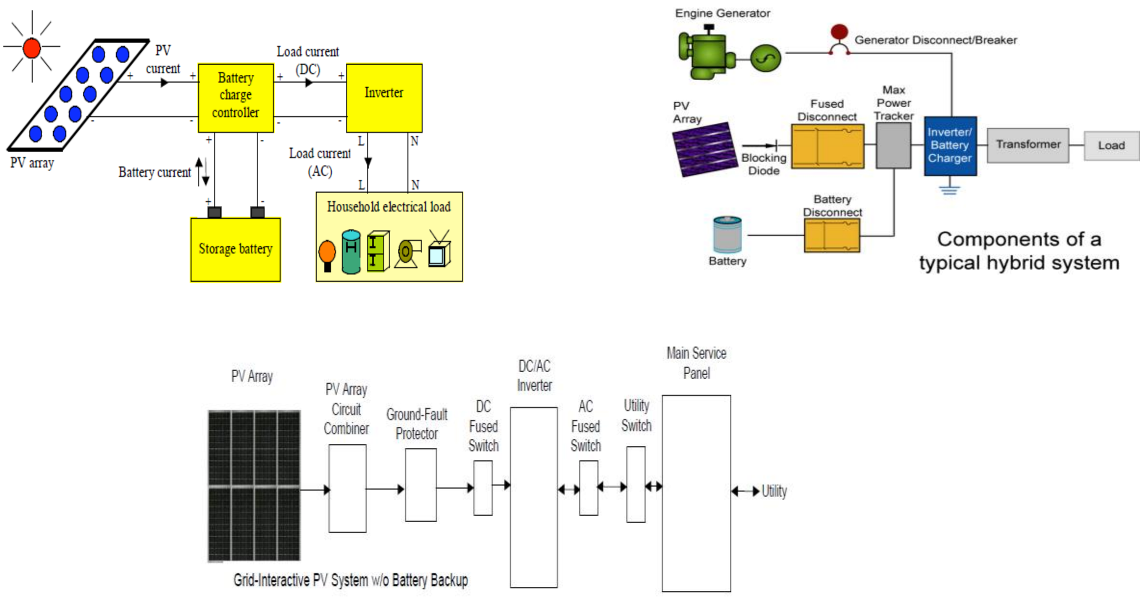

Figure 2: PV system types, stand-alone, hybrid, and grid-tie systems, respectively

PV technology has proved since years that it is a well-demonstrated for power generation. The PV systems can be established as a matrix associated (with power encouraged straightforwardly into the grid structure) or as systems utilized as a part of off-grid applications in little power frameworks in a blend with diesel power gen-sets as appeared in Fig. 2. In Oman, the two sorts of the PV systems are can work. The solar PV is particularly suitable for power off grid in the desert and rural areas. The solar radiation intensity in Oman is more than amazing, and taking an advantage of these solar energy systems, such as hybrid or half a hybrid can reduce fossil fuel use significantly.

The wise deal with educating the community to accept the technical potential for electricity generation by PV systems, both grid-connected and not connected can be done by the relevant authorities to install PV cells in possible spaces (e.g. on buildings and parking spaces, etc.). If we assume that 70 % of homes in Oman (all of which have level rooftops) hence they are appropriate for installing of PV cells. The roof zone accessible for every house, at any rate, is 20 m^2, the potential aggregate territory would give space to an introduced limit in the request of 588 MW, and a potential yearly power creation of 1050 GWh. Run of the mill limit per m^2 of the area is around 30 Wp (Watt top) relating to 30 MWp per km^2.

The proficiency of PV cells is impacted by the ambient air temperatures and the dust pollution (a possibly real issue in the Arabian Peninsula). The ecological conditions in Oman are required to lessen the effectiveness of PV cells contrasted with standard conditions, and getting excellent appraisals of this impact is a key some portion of our examination. Also, displaying is vital with a specific end goal to precisely foresee the yearly execution of a PV framework for any given topographical area, building introduction, and kind of PV cell innovation. Models can be utilized to anticipate precisely the reaction of the PV systems to the extensive variety of operational conditions they experience. PC recreation devices used to foresee the energy generation of PV frameworks is required with a specific end goal to settle on educated monetary choices. In any case, these demonstrating instruments need info parameters that describe module execution under different operational and ecological conditions. The required information parameters are ordinarily gotten inside utilizing a sun based test system, or measured outside under natural daylight. These anticipate supported by the Research Council of Oman to explore measure and look at execution parameters of various PV advancements in different circumstances (contextual analyses). What's more, examination of the estimation results with the recreation results is a key some portion of this exploration. The result will be an actual attainability study for any future extensive scale utilization of PV technology in Oman. The planned PV framework is going to supply electricity to individuals in the desert taking in thought their necessities. Additionally, the idea could be utilized later to provide the ordinary houses or eco-houses in better places in Oman. The framework uses a few PV modules associated as a part of parallel arrangement mixes to deliver enough electricity to take care of the demand. Likewise, the structure contains alongside PV arrays, inverters, battery charge controller, batteries, different wiring, mounting equipment, combiner boxes and checking gear. HOMER programming has been utilized as a part of this outline. The following phase of this exploration is to execute the framework for all intents and purposes and test it.

This article aims to study the possibilities of using photovoltaic modules in the derestrict areas of Oman. This work is a part of the continuous efforts and cooperation between the Omani Renewable Energies Organization in Sohar University and the Energy and Renewable Energy Technology Center in University of Technology, Iraq [17-65].

Solar Energy in Oman

The assessment of overall energy falling from the sun to the Earth's surface in the year up to 10,000 times the total what the world needs from energy. Oman is rich in energy as it enjoyed by high solar radiation intensity. In addition to the number of hours of sunshine exceeds more than 3,600 hours per year. The solar radiation on the desert territory every year is proportionate to countless times Oman's aggregate producing limit. PV power era gives maybe the principle approach to creating and utilizes solar energy since it is without contamination vitality that is accessible all over the place, not subject to topographical confinements and it doesn't include the utilization of any fuel. In the meantime, it can work unmanned, and requires short development periods. Furthermore, the size of design can be flexible and may be used directly and is easy to store, and it can also be incorporated in combination with the construction of buildings.

To study the feasibility of solar energy in Oman (current situation and future) it is important to discuss the following three points: solar density in Oman; benefits of using solar energy in Oman; and the future of solar energy in Oman.

Solar density in Oman

Oman is distinguishes by its large solar energy density which reach all parts of the country. Oman locatedin the Middle East, on the eastern edge of the Arabian Peninsula. The Omani latitude is 16 40 N, and its longitude is 59 40 E. The ambient temperature in general is exceptionally hot for the most parts of the country, which may rise to 54°C in summer season, from May to September. Oman atmosphere remain dry, hot, and humid in the coastal areas which is extended for about 3500 km. Humidity, dust and the absence of precipitation cause a decrease in the cells performance [5-9]. The desert regions have the highest solar intensity while the waterfront areas in the southern piece of Oman have the least solar radiation intensity [10]. The Authority for Electricity Regulation in Oman indicated that "Oman and solar energy has the potential to provide sufficient electricity to meet all of Oman's domestic power requirements and provide some electricity for export" [1].

Benefits of using solar energy in Oman

The utilization of solar energy in Oman returns in many benefits. First of all, solar energy is environmentally friendly: it is clean, sustainable and helps to protect our environment so that air pollution can be reduced. Besides, it reduces the emissions of sulfur dioxide and nitrogen oxides into the atmosphere (decreasing GHG emission). Secondly, solar energy is free thus giving economic advantages. As well, the use of solar energy will reduce Oman's dependence on nonrenewable sources. Finally, solar energy systems are relatively maintenance free and once installed, there are essentially no recurring costs [11-12].

There are three issues to getting running continue with solar electricity in Oman these are [1]:

i. The cost of power is profoundly sponsored in Oman and is sold well underneath the actual expense of generation. By and large the Batinah coast's energy is financed by 38% (clients pay as high cost as 16 baisa/kWh,the regular genuine expense is ~25 baisa/kWh). In the remote territories, the endowment is normally such higher, more than 80%, (clients pay ~14 baisa/kWh, costs ~82 baisa/kWh).

ii. The actual cost of the photovoltaic cells of the present generation are already very low, it is based on a gas price of $ 1.50 per million BTUs [roughly the same as 1000 cubic feet of gas (1 cubic feet)] with no inflation component of the expense. While this is more than what the government pays for the production of natural gas (up to $ 0.50), as the government can sells this gas at a higher price than that to liquefied natural gas terminals to export it (arrived calories in this case to about $ 4 / cubic feet). In Europe and the United States, the gas prices in the market were recently $8,0 although now the price the United States more than $13 / cubic feet (the highest ever).

iii. In hypothesis, there could be an incomplete appropriation for solar energy through carbon exchanging. However, the Omani Government has not set up the required globally perceived powers to permit transferring carbon balances under the Kyoto Protocol (as of now worth in any event $20 per ton of CO_2 spared). At that value, this could then be utilized to bring down the viable 'gas cost comparable' by more than $1.20 per MCF.

Future of solar energy in Oman

It regards begin this part asking the accompanying inquiry: why renewable and solar energy in Oman now? What's more, the answer is because of power lack, rising costs of oils and natural gas, biological dangers, adequate assets and destinations available, plenteous daylight, government motivator and expanded financing alternatives. One of the Omani government's future points is to concentrate on nature and to decide how to use renewable energies in the nation. The legislature and power organizations in Oman cooperate with worldwide force organizations that work in renewable assets to create power.

The results of these organizations study showed that Oman has the capability and property necessary for the construction of solar installations [1]. Explanation of the discoveries of the study of the viability of the investigation by the Public Authority for Electricity and Water (PAEW) led in December 2009, these experts found that a large scale, and business solar electricity unreasonable business in the country. Parameters implementation of the PV potential in Oman, for example, there has been no investigation into the implications of productivity length, scope, and the tilt angle, air mass, temperature units, and the degree of cell temperature, and pollution in their report. For those studying the feasibility study details the impact of the environment of the PV's performance is of great importance.

The Authority for Electricity Regulation in Oman put ashortlist of six vital renewable trialprojects. Two of them are the solar powered (100 kW PV) and a 500 kW wind project that are planned for quick usage and investment (in Hij City). According to the Oman Observer newspaper "The six shortlisted projects, if implemented would allow Rural Areas Electricity Company to replace 11 GWh of annual diesel generation with renewable sourced electricity. This would reduce diesel fuel consumption by 3.1 million liters per year and avoid 8,298 metric tons of CO_2 per year" [13-14]. Also, early in January 2012 solar power electricity generation stations with 400 MW announced to be implemented in Al-Duqum. Shaikh Hilal bin Khalid bin Nasser al Maawali, the neighborhood accomplice to Terra Nex and the Middle East Best Select (MEBS), who has coordinated the undertaking in Oman, remarked, "This is a great beginning for 2012 for Oman. With a significant US$2bn international investment strong indication of commitment coming to Oman so early in the year, we have yet again highlighted the potential for attractive investment in the Sultanate." [15].

Our study will complete what is recommended in the previous study [1] by investigating the effect of different performance parameters of PV systems. It will lead to a bright idea and robust information about PV feasibility for any future research on PV generation. The PV arrays performance characteristics are required to model their achievement for larger-scale implementations. Hence we intend in this proposed research to study the various PV performance parameters, in the context of Oman, and to determine ways to improve this performance. In any case, the data accessible from producers is commonly restricted to temperature coefficients; for example, short circuit current Isc, open circuit voltage Voc, and the maximum power Pmax, at rating conditions. This data, while valuable in looking at PV module execution at rating conditions, is insufficient to anticipate performance under run of the perfect working conditions particularly in the extreme conditions that apply in Omani summer periods. It has been demonstrated that the relative performance positioning at rating conditions may vary extraordinarily from the positioning because actual yearly execution.

Photovoltaic System Design:

In Oman, the PV systems will operate extremely well;because of the regular worldwide flat yearly sunlight based asset is 5.936-6.879 kWh/m^2/day [6]. Numerous elements are influencing the produced energy from PV framework incorporate the sun based declination, the kind of the used PV technology, the sun oriented rise or peak edge and hour point or azimuth, humidity, temperature, dust, air mass, the level of daylight which can be gathered in climate conditions. On the electrical side of the PV, the DC to DC converter used to decrease the variance, inverter needs to change over DC into AC, switches, channels (wires), breakers and detaches as appeared in Fig. 2.

It is standard that PV frameworks will work extremely well in Oman, where the natural worldwide even yearly sun-powered asset is 5.936-6.879 kWh/m^2/day [6]. Universal radiation on a level surface commonly used to decide the energy contribution to PV framework. These numbers are not the energy sum that can be created by a PV framework. Numerous components are influencing the produced electricity from PV framework incorporate the sun based declination, the kind of PV innovation, the sun oriented height or peak edge and hour edge or azimuth, dampness, temperature, dust, air mass, the level of daylight and when all is said in done climate conditions. On the electrical side of the PV DC to DC converter used to lessen the vacillation, inverter needs to change over DC into AC, switches, conduits (wires), breakers and disengages as appeared in Fig. 2.

A rooftop is the best area for a PV framework. Ground-mounted PV frameworks are regularly less expensive than roof mounted PV frameworks. However, a rooftop is an advantageous area since it is off the beaten path and is un-shaded. For that, the top of Faculty of Engineering building in Sohar University has been chosen to position the 3 kW PV framework.

PV Array Sizing

To start with we chose distinctive burdens to ascertain the power utilization of an ordinary house in Sohar (Oman) and picking machines to address certain issues. To decide the amount of electricity every heap expands to address that matter, this will be finished by making a rundown of necessities called a load profile. Additionally, select the suitable size of PV and expense and the right area.

It is essential to be practical about the way of life and power utilization propensities in Oman. It is found that the heap interest for a regular house in Oman is twelve times run of the ordinary house in the USA and this because of the force utilization of air-conditioning, sort of electrical gadgets and hardware utilized [3]. Table 1 demonstrates a precise appraisal of the average day by day watt-hours (Wh) utilized by the family as a part of Oman [16]. It is speaking of the ordinary day by day power that is utilized by family likewise; we attempted to characterize the measure of vitality that the PV framework must produce day by day.

Table 1: load profile for a typical house [16]

Electrical load	Qty	Volts	Run watts	Hours / day	Days/ weeks	Surge watts	Ave. WH / Day	Per cent of total
Fluorescent Lights	6	240	15	5.00	7	15	450.0	1.4%
Refrigerator	1	240	50	8.00	7	1300	400.0	1.2%
Television	1	240	100	5.00	7	570	500.0	1.6%
Satellite TV System	1	240	40	5.00	7	1600	200.0	0.6%
Computer	1	240	45	6.00	3	135	115.7	0.4%
Radio Telephone (receive)	1	240	6	24.00	7	0	144.0	0.4%
Radio Telephone (transmit)	1	240	6	1.00	7	0	6.0	0.0%
Phone Answering Machine	1	240	6	24.00	7	0	144.0	0.4%
Washing Machine	1	240	800	0.50	4	100	228.6	0.7%
Monitoring equipment	1	240	100	0.00	7	200	0.0	0.0%
Ni-Cd Battery Charger	1	240	4	15.00	2	25	17.1	0.0%
Air- conditioning	3	240	1000	10.00	7	1000	30000	93.2%
Total Daily Average Watt- hrs.							32,205.4	
Largest AC Appliance Wattage							1000	
Largest AC Appliance Surge Wattage							1600	

The load prerequisite might be both DC and AC. The generating if a DC, it could be specifically associated with the yield of the solar energy producing framework. Then again to take care of AC burden requires, it will be by utilizing DC energy that is created from the solar vitality framework and changed over to AC utilizing inverters.
As appeared from the Table I, the aggregate electricity needs for working commonplace house (Total Daily Average Watt-hrs) is around 32.2054 kWh (32205.4 Wh). It is expected that framework configuration to convey 33 kWh of electricity per day as a result of the security issues (to account the line misfortunes and change misfortunes because of the inverter).
Oman receives about 5 to 5.9 hrs of peak sun hours per day on a normal through the year. Likewise, the typical day by day number of daylight hours in Oman is around 11 hrs. So the capacity limit of the solar cell is
Power limit = 33 kWh/11 h = 3 kW
To ascertain the required number of PV modules with a specific end goal to give the electrical capacity of 3 kW. Let the PV modules most extreme force limit around 140 W (Wp= 140 crest watts). So, the claimed number of modules will be ascertained to be
Number of modules = power limit/module limit
N = 3 kW/140 W = 21.4 modules (≈ 22 modules)
The received solar radiation by the PV arrays which is the measure of created electricity will rely on the orientation and panels' surface inclination. The end goal is to discover the angle or incline of the mechanical casing that the solar modules are to be altered. The preferred angle to catch the greatest insolation is the scope of the geological area where the solar modules are to be built up. The tilt angle for establishment was set at 24° confronting South (Sohar scope is 24 28" 0' N).

Suitable types of PV

There are numerous sorts of photovoltaic modules, for example, Polycrystalline, Amorphous, Monocrystalline, Multi-crystalline and Hybrid solar cell. Polycrystalline solar boards are a standout amongst the most prevalent boards utilized for family unit control, yet a few burdens are utilizing this board, for example, polycrystalline are less useful than other sun-based modules that are produced using a single precious stone [1]. Additionally, it requires more space per square meter to deliver the same yield as a monocrystalline module [2]. Due to this outcome, it is preferred to utilize multi-crystalline or monocrystalline solar PV in the present configuration. The determination of 200 Wp monocrystalline sun oriented module the size is 1500×668×46 mm.
The expense of the PV framework is 120 OMR (≈ 300 USD)
The region of the PV module is 1.500×0.668 = 1.002 m^2.

Main sub-system equipment

The produced electricity from the photovoltaic cells could be AC or DC power or both. This power can be utilized during the evening by utilizing a capacity component, for example, battery. The utilized batteries, for this reason, have a significant stockpiling limit. PV framework will deliver DC, and an inverter is required so as to give AC. The next stride is to choose the require sub-frameworks, for example, batteries, inverter, circuit breakers and excellent links keeping in mind the end goal to get the productive force for home application.

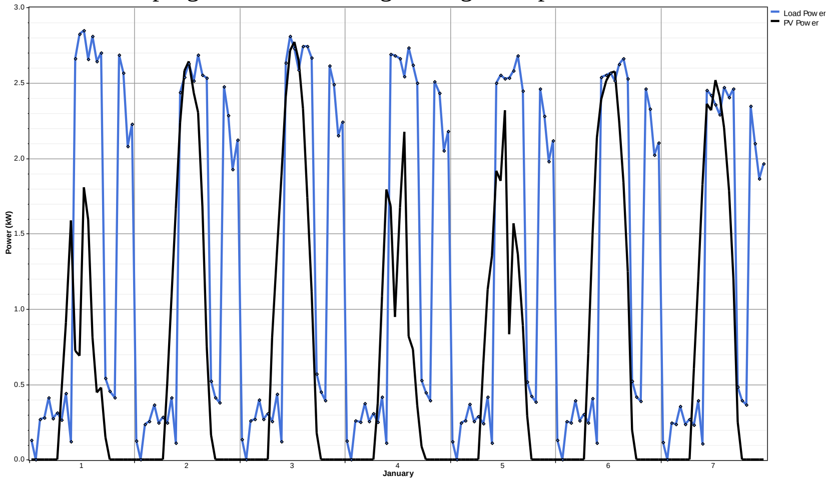

Figure 4: Comparison between PV (black) and load (blue) power with respect to time (January 2012)

Charge controller

The PV voltage changes as the solar radiation are changing with daytime; the solar cell generates more voltage at peak hours where the extremist energy could harm the batteries. So, to keep the appropriate charging voltage on the batteries, a charge controller is utilized. The charge controller duty is to modify the PV panel output voltage preventing unwanted high voltage from reaching the batteries. The reasonable sort of charge controller that is chosen is: 12V, 150A MPPT Controller

Inverter

The inverter changes over the generated DC into AC regularly needed for family apparatuses for instance radios, fridges, and TVs. Utility intuitive inverters have been worked in security highlights. A part of the produced electricity will be supplied to fulfill the required load, and the other part will be infused to the national network. The reasonable kind of inverter that is chosen to be used is: DC 12V, 1000W, 240VAC 50Hz.

Batteries, Cable, Protection and Accessories

The batteries are required with a specific end goal to store power from PV for the night utilization. The batteries utilized for PV frameworks are not the same as auto batteries. The profound cycle batteries are the most appropriate batteries for use with PV systems. The profound cycle batteries are divided into two sorts: lead acid, which requires the intermittent expansion of water, and captive electrolyte (or gelcell) batteries, which do not need maintenance. The selected type of batteries is: 12V 600Ah Lead Acid Battery (Quantity: 2)

Cables, protection, and accessories expected to be proposed by the providing company and cost have to be taken into consideration. System installation and maintenance are also required to be borne into account.

Simulation Results

PC recreation programming's utilized to anticipate the power generation of PV frameworks is required to settle on educated financial choices. This programming requires data parameters that portray module execution under different operational and ecological conditions. As a part of this study, HOMER programming was selected for configuration among much other software. HOMER energy demonstrating programming is an efficient apparatus that can be employed to outline and examine photovoltaic framework.

Once the PV modules are installed, it creates free power, so the expense of power delivered by such a system is precisely what it costs through the establishment. These systems can be financed in a manner that its spending is focused on today's private electricity costs. Figure 4 demonstrates the month to month regular electrical generation from the framework. The resulted mean yield production is 13.9 kWh/d and the aggregate creation kWh/yr.

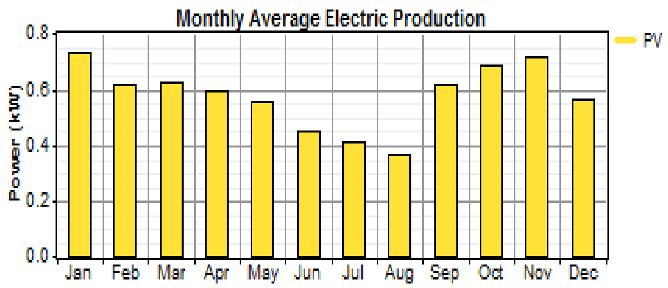

Figure 4: Monthly average electrical production.

Figure 3: shows the correlation between the load and the PV power created. The results demonstrate that the PV power is matching with the load power 92% at January (winter season) that was taken as a case. The lifetime of every subsystem is fundamental to discover the substitution cost. The lifetime of every sub-framework is illustrated in the following:

a) PV module = 25 years
b) Charge controller = 15 years
c) Battery = 5 years
d) Inverter = 10 years
e) Cables = 15 years

Interest rate in Oman, i = 5.5%
Inflation rate in Oman, f = 4.3%
Peak Sun Hours for Oman= 4.5 – 5.5 hours
Energy generated/day/module = 140 W × 11 h = 1,540 Wh
Total energy generated/day, E = 1,540 Wh × 22 = 33.88 kWh

The capital cost afforded at one year equal zero in the cash flow diagram. The costs of the annual maintenance are evaluated at the end of each year. The batteries, charger, and inverter have to be replaced every 5 years, 15 years, and 10 years respectively.

To calculate the present value of the accrued expenses at year 0, the capital cost existing account,

PW1 = 21,800 US$

The replacement expenses of batteries present value equal to [16]:

Battery cost × [(1+f)/ (1+i)] years

So that after 5, 10 and 15 years the immediate replacement assesses are: 2455.4, 2124.6 and 1882.3 US$ respectively. Besides, the cables, inverter, and charger replacement set back in the present worth are 5163.5 US$.

The present account replacement that can be considered for about 25 years is:

Maintenance cost $\times [(1+f)/(i-f)] \times [1-[(1+f)/(1+i)]^{24}] = 12{,}995.3$ *US$*

The salvage value which can be obtained by disposing the solar modules and mechanical frames at the end of 25 years:

Sal $\times [(1+f)/(1+i)]^{24} = 2300$ *US$.*

The Life Cycle Cost (LCC) = 10,000+ 2495.6+ 2224.3+ 1982.4+ 12,995.3- 2300 = 27,397.6 US$.

The Annual Life Cycle Costing (ALCC) is counted as:

ALCC $= LCC/\{[(1+f)/(i-f)] \times [1-[(1+f)/(1+i)]^{24}]\} = 526.8$ *US$.*

Then, the energy price per unit is elaborated as:

Energy price/unit = 526.8 US$/ (365 days× 33.88 kWh) = 0.043 US$.

Practical System:

From the simulation results, we have a clear idea about the system requirements. After soliciting some specialized companies, the following types of equipment have been ordered as shown in Table 2. These equipment are going to be installed and integrated with sensors system to initiate the second phase of this study.

Table 2: PV system equipment

Description	Make / Model / Rating	Quantity
Solar array	KD140, Kyocera, Europe / Asia	22 nos. (3080WP)
GI Support structure	Oman Solar Systems	Req. Qty.
Sealed lead acid batteries 623Ah	24V, 623Ah, Sonnenschein A600 Solar, GNB Industrial power A602/625, Europe	2 banks
Solar charge controller unit	MPR-9800, Digital Solar Technologies, USA	1 no.
MS enclosure for batteries	Oman Solar Systems	1 no.
Circuit breakers for DC loads	Merlin Gerin or Equivalent	1 Set.
Inverter 24V/230Vac, 1000W	Europe / Asia	1 no.
Interconnecting cable	HO7 RNF / HO7 VK	1 Set.
Grid tie inverter	SMA, Germany, 1.7KW	1 no.

Conclusion

The site of Oman considered as one of the most available areas to implement solar PV systems in the world. Implementation of PV system provides immediate benefits to the people life in the desert of Oman. Also, it could be used in small town or villages. The proposed loads and usage characteristics are efficient and energy conservative to be employed by Omanis.

The HOMER programming was utilized to simulate and model the PV frameworks performance examination of a system that intended to be installed in Sohar University for research purposes. It is presumed that the introduced frameworks are working roughly to its potential. The PV arrays assumed to deliver as much electricity they are intended to generate to meet the load necessities, and the arrays quality is the thing that the producer has indicated.

In the life cycle costing computations of the framework, it was viewed as that the lifetime of batteries is 5 years and charge controller, link and inverter are around 10 years and should be supplanted toward the end of the period. With appropriate configuration, it is conceivable to develop the lifetime of various part of the framework. This would decrease the substitution expense to a bigger degree.

Acknowledgement

The Research prompting these outcomes has gotten Research Project Grant Funding from the Research Council of the Sultanate of Oman Research Grant Agreement No. ORG SU EI 11 010. The authors like to acknowledge the support from the Research Council of Oman.

References

[1]. Authority for Electricity Regulation in Oman, "Study on Renewable Resources", Final Report, Oman, May 2008, pp. 14.

[2]. Kazem, H. A., Abdulla, R., Hason, F. &Alwaeli, A. H. (2011). Prospects of Potential Renewable and Clean Energy in Oman, International Journal of Electronics, Computer and Communications Technologies (IJECCT), 1(2): 25-29.

[3]. Kazem, H. A. (2011). Renewable Energy in Oman: Status and Future Prospects, Elsevier-Renewable and Sustainable Energy Review (RSER), 15: 3465-3469.

[4]. Kazem, H. A., Hasson, F.& Chaichan, M. T.(2013). Design and Analysis of Stand-alone Solar Photovoltaic for Desert in Oman, the 3rd Scientific International Conference, Technical College, Najaf, Iraq.

[5]. The US PV Industry Roadmap Through 2030 and beyond: www.seia.org

[6]. Kazmerski, L. L. (2010).Photovoltaic: History, Technology, Markets, Manufacturing, Applications, and Outlook", 83rd International Seminar in Brighton, Renewable Energy Policy, Security, Electricity, Sustainable Transport, Water Resources/Management and Environment, Brighton, 4-10 December 2010, UK.

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

[8]. Oman Power and Water Procurement, Annual Report 2006

[9]. Oman Power and Water procurement, Seven Years Statement, 2007- 2013.

[10]. Photon International, October 2010.

[11]. Al-Hinai, H. A.& Al-Alawi,S. M. (1995). Typical Solar Radiation Data for Oman, Department of Mechanical Engineering, Sultan Qaboos University,Applied Energy,52: 153-163.

[12]. www.mapsofworld.com

[13]. Al-Mazrouy, A. (2009). 1000 MW Hybrid Solar Power Station, Majan Electricity Company, IAES09 Conference, Sultanate of Oman, December.

[14]. Fanney, A. H., Davis, M. W., Dougherty, B. P., King, D. L., Boyson, W. E.&Kratochvil, J. A. (2006). Comparison of Photovoltaic Module Performance Measurements, Transactions of the ASME, Journal of Solar Energy Engineering, 128: 152-159.

[15]. www.photon-international.com

[16]. 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 May 2012, Nizwa, Oman.

[17]. Chaichan, M. T. and Kazem, H. A. 92015).Water Solar Distiller Productivity Enhancement using Concentrating Solar Water Heater and Phase Change Material (PCM), Case Studies in Thermal Engineering, Elsevier, 5: 151-159.

[18]. Chaichan, M. T., Kazem, H. A. &Abaas,K.I. (2012). Improving Productivity of Solar Water Distiller Linked with Salt Gradient Pond in Iraqi Weather, World Congress on Engineering 2012, London, UK, 4-6 July.

[19]. 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, 1(5): 151-159.

[20]. Chaichan, M. T. and 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), 2(2): 12-20.

[21]. Chaichan, M. T. and Abaas, K.I. (2012). Practical Investigation for Improving Concentrating Solar Power Stations Efficiency in Iraqi Weathers, Anbar J for Engineering Science, 5(1): 76-87.

[22]. 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, 2(4): 29-32, 2012.

[23]. 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, 1(7): 56-61.

[24]. Chaichan, M. T., AbaasK.I., Kazem, H. A., Al Jibori, H.S. and Abdul-Hussain, U. (2013).Novel Design of Solar Receiver in Concentrated Power System, International J. of Multidispl.Research &Advcs.in Eng. (IJMRAE), 5(1): 211-226.

[25]. 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, 7(4): 152-159.

[26]. Chaichan, M. T., Abaas, K.I.&Salih, H.M. (2014). Practical Investigation for Water Solar Thermal Storage System Enhancement using Sensible and Latent Heats in Baghdad-Iraq Weathers, Journal of Al-Rafidain University Collage for Science, Issue 33: 158-182.

[27]. 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, 37: 734-749.

[28]. Faris, S.S., Chaichan, M. T., SachitM.F.&Jaleel, J.M. (2014). Simulation and Numerical Investigation of Effect Air Gap Thickness on Trombe Wall System, International Journal of Application or Innovation in Engineering & Management (IJAIEM), 3(11): 159-168.

[29]. 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, 2(4): 1-6.
[30]. 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, 6(5): 850-856.
[31]. Chaichan, M. T., Abaas, K. I. and 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, 1-11, DOI: 10.1080/19443994.2015.1069221
[32]. Chaichan, M. T. & Al-Asadi, K.A.H. (2015). Environmental Impact Assessment of Traffic in Oman, International Journal of Scientific & Engineering Research, 6(7): 493-496.
[33]. 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, 5(6): 48-55.
[34]. Kazem, H. A. &Chaichan, M. T. (2015). Effect of Humidity on Photovoltaic Performance Based on Experimental Study, International Journal of Applied Engineering Research (IJAER), 10(23): 43572-43577.
[35]. Kazem, H. A., A.H.A. Al-Waeli, A.S.A. Al-Mamari, A.H.K. Al-Kabi and 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, 9(36): 43-49.
[36]. 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), 11(3): 1980-1988.
[37]. Kazem, H. A.&Chaichan, M. T. (2016). Experimental Analysis of the Performance Characteristics of PEM Fuel Cells, International Journal of Scientific & Engineering Research, 7(2): 49-56, 2016.
[38]. 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, 6(4): 594-601.
[39]. 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, Environment, Development&Sustainability.DOI 10.1007/s10668-016-9773-z.
[40]. Chaichan, M. T. and Kazem, H. A. (2016).Experimental Analysis of Solar Intensity on Photovoltaic in Hot and Humid Weather Conditions, International Journal of Scientific & Engineering Research, 7(3): 91-96.
[41]. Chaichan, M. T. (2016). EGR Effects on Hydrogen Engines Performance and Emissions, International Journal of Scientific & Engineering Research, 7(3): 80-90.
[42]. Chaichan, M. T., Kazem, H. A., Mahdy, A.M.J.& Al-Waeely, A.A. (2016). Optimal Sizing of a Hybrid System of Renewable Energy for Lighting Street in Salalah-Oman using Homer software, International Journal of Scientific Engineering and Applied Science (IJSEAS), 2(5): 157-164
[43]. Chaichan, M. T. (2016). Enhancing Productivity of Concentrating Solar Distillating System Accompanied with PCM at Hot Climate, Wulevina, 23(5): 1-18.
[44]. Al-Waeli, A.H.A., Al-Mamari, A.S.A., Al-KabiA.H.K., Chaichan, M. T. &Kazem, H. A. (2016). Evaluation of the Economic and Environmental Aspects of using Photovoltaic Water Pumping System, 9th International Conference on Robotic, Vision, Signal Processing & Power Applications, Malaysia.
[45]. Kazem, H. A., Chaichan, M. T., Alwaeli, A.H.&Kavish,M. (2015).Effect of Shadow on the Performance of Solar Photovoltaic, WREN/WREC World Renewable Energy Congress, Rome, Italy.
[46]. Mazin, H., Kazem, H. A., Fadhil, H.A., Alawi, S.&Chaichan, M. T. (2015). Global Linear, Nonlinear and ANN-Based Modeling of Monthly Diffuse Solar Energy, WREC XIV Proceedings, University POLITEHNICA of Bucharest, Romania, June 8 – 12.
[47]. Mazin, H., Kazem, H. A., Fadhil, H.A., Alawi, S., Mazin, Q. and Chaichan, M. T. (2014). Linear and Nonlinear Modeling for Solar Energy Prediction on the Zone, Region and Global, World Renewable Energy Council/Network (WREC XIII), London, UK, 3-8 August.
[48]. 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, Proceedings of the World Congress on Engineering, vol. II, WCE 2013, London, U.K., July 3 - 5.
[49]. Kazem, H. A., Khatib, T., Sopian, K.&Elmenreich, W.(2014). Performance and Feasibility Assessment of a 1.4kW Roof Top Grid-Connected Photovoltaic Power System under Desertec Weather Conditions, Elsevier-Energy and Building, 82: 123-129.

[50]. Kazem, H. A. &Khatib, T. (2013). Techno-Economical Assessment of Grid Connected Photovoltaic Power Systems Productivity in Oman, Elsevier-Sustainable Energy Technologies and Assessments, 3: 61–6.
[51]. Darwish, Z. A., Kazem, H. A., Sopian, K., Al-Goul, M. A.&Alawadhi, H. (2015). Effect of Dust Pollutant Type on Photovoltaic Performance, Elsevier-Renewable and Sustainable Energy Review, 53: 185-193.
[52]. Kazem, H. A. &Khatib, T. (2013). Photovoltaic Power System Prospective in Oman, Technical and Economic Study, LAP LAMBERT Academic Publishing, 1st Edition, ISBN: 978-3659372957, Germany.
[53]. Kazem, H. A., Khatib, T.,Sopian, K.,Buttinger, B., Elmenreich, W. &Albusaidi, A. S. (2013). The Effect of Dust Deposition on the Performance of Multi-Crystalline Photovoltaic Modules Based on Experimental Measurements, International Journal of Renewable Energy Research, 3(4): 850-853.
[54]. Chaichan, M. T. (2016). Evaluation of Emitted Particulate Matters Emissions in Multi-CylindersDiesel Engine Fuelled with Biodiesel, American Journal of Mechanical Engineering, 4(1): 1-6.
[55]. Chaichan, M. T. & Ahmed, S. T. (2013). Evaluation of Performance and Emissions Characteristics for Compression Ignition Engine Operated with Disposal Yellow Grease, International Journal of Engineering and Science, 2(2): 111-122.
[56]. Abaas, K. I.&Chaichan, M. T. (2009) Experimental Study of Using Solar Energy Storage Wall for Heating Iraqi Houses Purposes, Wassit Journal for Science & Medicine, 2(2): 212-221.
[57]. Chaichan, M. T. (2013). Practical Investigation of the Performance and Emission Characteristics of DI Compression Ignition Engine Using Water-Diesel Emulsion as Fuel, Al-Rafidain Engineering Journal, 21(4): 29-41.
[58]. Chaichan, M. T. &Saleh, A. M. (2013). Practical Investigation of Performance of Single Cylinder Compression Ignition Engine Fueled with Duel Fuel, The Iraqi Journal for Mechanical and Material Engineering, 13(2): 198-211.
[59]. Kazem, H. A., Al-Badi, H. A. S., Al Busaidi, A. S.&Chaichan, M. T. (2016).Optimum Design and Evaluation of Hybrid Solar/Wind/Diesel Power System for Masirah Island, Environment, Development and Sustainability. DOI: 10.1007/s10668-016-9828-1
[60]. Chaichan, M. T., Abaas, K. I. & Al-Zubidi, D. S. M. (2016). A Study of a Hybrid Solar Heat Storage Wall (Trombe wall) Utilizing Paraffin Wax and Water, Journal of Research in Mechanical Engineering, 2(11): 1-7.
[61]. Chaichan, M. T., Kazem, H. A., Abaas, K. I. & Al-Waeli, A. A. (2016). Homemade Solar Desalination System for Omani Families, International Journal of Scientific & Engineering Research, 7(5):1499-1504.
[62]. 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, 6(7): 293-298.
[63]. Chaichan, M. T., Kazem, H. A., Mahdy, A. M. J.& Al-Waeely, A. A. (2016). Optimization of Hybrid Solar PV/ Diesel System for Powering Telecommunication Tower, IJESET, 8(6): 1-10.
[64]. Chaichan, M. T., Al-Hamdani, A. H. &Kasem, A. M. (2016). Enhancing a Trombe Wall Charging and Discharging Processes by Adding Nano-Al_2O_3 to Phase Change Materials, International Journal of Scientific & Engineering Research, 7(3): 736-741.
[65]. Chaichan, M. T. (2015). The Effects of Hydrogen Addition to Diesel Fuel on the Emitted Particulate Matters, International Journal of Scientific & Engineering Research, 6(6): 1081-1087.