International Journal of Applied Power Engineering (IJAPE)
Vol. 2, No. 2, August 2013, pp. 89~98
ISSN: 2252-8792

Feasibility Study of a Grid Connected Hybrid Wind/PV System

Hussein Al-Masri[1], FathiAmoura[2]
[1] Department of Electrical Power Engineering, Yarmouk University, Jordan
[2] Department of Electrical Engineering, Yarmouk University, Jordan

Article Info

Article history:

Received Dec 20, 2012
Revised Ap 13, 2013
Accepted Apr 28, 2013

Keyword:

Feasibility study
Grid connected
Hybrid wind
PV power system

ABSTRACT

This paper investigates the feasibility of a grid connected, large-scale hybrid wind/PV system. From data available an area called RasElnaqab in Jordan is chosen because it enjoys both high average wind speed of 6.13 m/s and high average solar radiation of 5.9KWhr/m^2/day. MATLAB and HOMER software's are used for sizing and economical analysis respectively. Results show that76124 SUNTECH PV panels and 38 GW87-1.5MW wind turbines are the optimal choice. The net present cost (NPC) is 130,115,936$, the cost of energy (COE) is 0.049$/KWhr with a renewable fraction of 74.1%.A step-by-step process to determine the optimal sizing of Hybrid Wind/PV system is presented and it can be applied anywhere.

Corresponding Author:

Hussein Al-Masri

Department of Electrical Power Engineering
Yarmouk University
Shafiq Irshidat st, Irbid 21163, Jordan
Phone: +962 2 721 1111
Email: eng.hussein99@yahoo.com

1. INTRODUCTION

Electrical energy is one of the main pillars of our daily life,it is used in agriculture, industry, health and social services. In other words, electrical energy is the backbone of our life. The population growth rate is about 1.14% per year. The world population grows and the world's energy demand increases proportionally [1].Approximately 80 % of the energy consumed on the earth comes from fossil fuels (i.e. oil, coal and natural gas), it is a fact these sources are about to run out sooner or later, although they might last more than expected, It causes the greenhouse effect, acid rains and air pollution [1].An alternative to the fossil fuel power is the renewable energy resources (solar, wind…etc), these sources are non-polluting, efficient, reduce carbon dioxide emissions, wasteless and reliable and last forever.

In the last few years there is an increased interest in renewable energy resources, this is because they are characterized by low operating costs compared with non-renewable resources and for reasons mentioned earlier. In addition to that they can be tailored to suit many applications. Comparison between renewable energy resources show that wind and photo-voltaic are the most available resources on earth and they show escalating growth all over the world. In this paper, a hybrid grid connected system (See Figure 1) composed of wind turbines and photovoltaic arrays are considered.

Hybrid grid connected system(or on-grid i.e. connected to the utility grid) allows the continuity of supply to the load even if the sun is not shining or the wind is not blowing or when the hybrid system cannot provide enough power. In addition, excess generated renewable energy is to be sold to the grid. Note that, on-grid systems eliminate the need of energy storage apparatus like batteries, in other words reduction of cost.

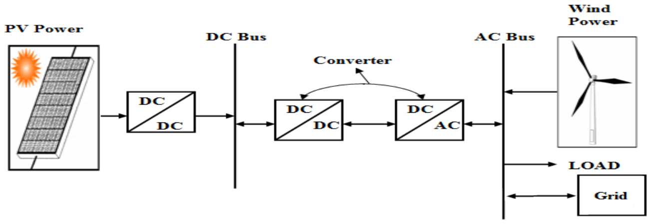


Figure 1. Hybrid Wind/PV System

2. OPTIMAL LOCATION OF HYBRID WIND/PV SYSTEM

Gaining an optimal location for hybrid system is a vital decision; its effectiveness depends greatly on the renewable energy resources available such as wind speed and its continuity and solar radiation as a function of time.

Annul average solar insolation in $kWh/m^2/day$ and annual average speed in m/s for various candidate sites in Jordan are obtained from PVGIS (Photovoltaic Geographical Information System, See Figures 2&3) available at energy center (EC) located in the Royal Scientific Society (RSS) in Jordan.

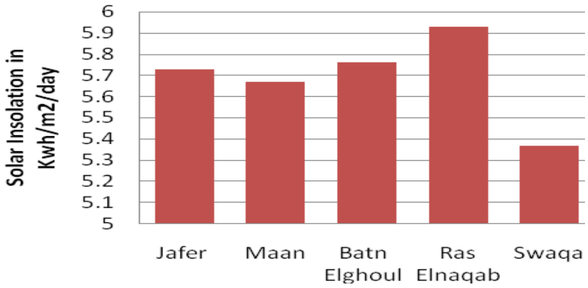


Figure 2. Annual Average Solar Insolation for Candidate Sites in Jordan

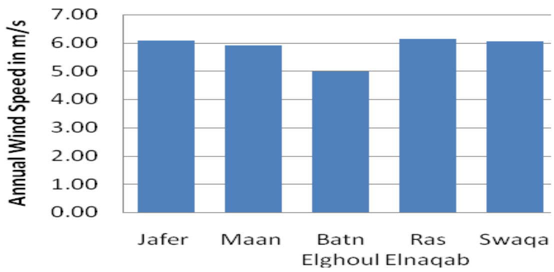


Figure 3.Annual Average Wind Speed for Candidate Sites in Jordan

Figures 2 & 3 show that RasElnaqab has the highest average annual values of bothwind speed (6.13 m/s) andsolarirradiation (5.93 $kWh/m^2/day$).Consequently, it is an appropriate and excellent choice for the proposed system.

3. TAILORING ROW DATA

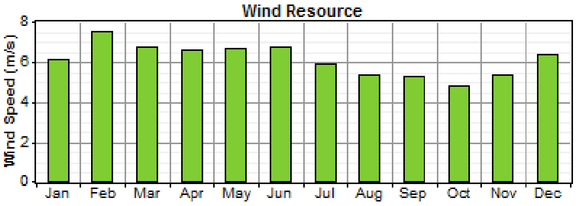
Homer software is used to tailor row data to fit the next step of calculations. As a first step instantaneous demand, i.e. load variations during the day is represented in a load profile. Load profile can be drawn at any level of aggregation for example a given month [2]. The load demand is essential to size components of the Hybrid Wind/PV system. Load profile for Ma'an (Bulk supply substation feeding RasElnaqab and the surrounding areas) is obtained from the National Control Centre (NCC) of the National Electric Power Company (NEPCO), SCADA system in Jordan for every 60 min (hourly data) for every day for the whole year of 2011. The number of entries is 8760 i.e the number of hours in a year.

The hourly average demands for 2011 are inserted to HOMER, one of the outputs is a summary of the load characteristics as shown in Table 1.

Table 1. Ma'an substation Load profile characteristics

Average (MWh/day)	**563.477**
Average (MW)	23.478
Peak (MW)	38.222
Load Factor	0.614

Another input to Homer software is the monthly average wind speed and the solar radiation for RasElnaqab as shown in Figures 4&5 Homer produces the probability distribution frequency (PDF Curve) as shown in Figure 6.



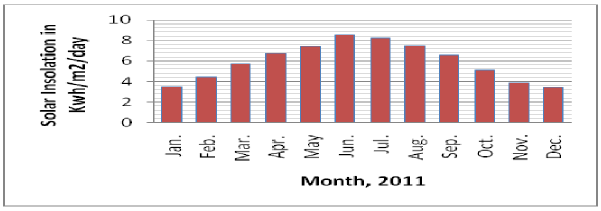


Figure 4. Monthly Average wind speeds Figure 5. Monthly Average Solar insolation for

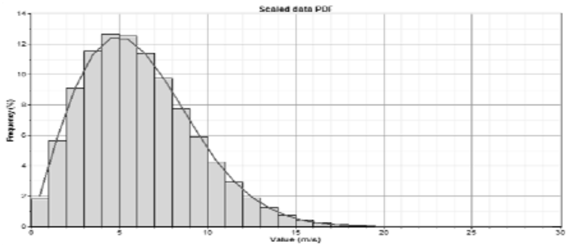


Figure 6. Probability Distribution Frequency (PDF) Curve

4. SIZING OF SYSTEM ELEMENTS

The hybrid system should be sized in order to meet the power demand fully or partially. Based on the available data of solar insolation, wind speed, wind turbineoutput rating, PV cells ratings and the power demand; the generation capacity is determined to best match the load demand [4].

There are major factors affecting the system sizing. First, *Load*(i.e. the power demand) integrated over the year period to gain the yearly energy demand.Second, *Rated power*of wind turbines and PV panels, because their number is inversely related to their sizes. Third, *sharing percent* this means that the load demand is met by PV panels and wind turbines with an appropriate percent for each. In order to gain a suitable sharing percent of both PV panels and wind turbines, factors (with assumed limits) are to be taken into consideration as follows:

1- (COE) i.e. Cost of Energy. (In Jordan COE is equal to 0.08$/KWh) [5],[6].

2- (RF) i.e. Renewable Fraction. It is the ratio of energy supplied by the hybrid system to the total energy supplied to the load.. Suitably, selection for minimum RF provides on optimal cost for the whole system [7]. Normally, it is suitable to start by assuming a 65% minimum renewable fraction.OR (GP) i.e. Grid Purchase which is the complement percent of RF. So that, it is suitable to start assuming GP = 35% maximum grid purchase.An iterative MATLAB code is prepared to accept Homer outputs as its inputs. A major result is that RF equals 74% with 22.38% sharing for PV power and 77.62% sharing for wind power.

4.1. Wind generator Sizing

Another output of Matlab is energy distribution curve (EDC) as shown in Figure 7 which shows the energy content, for various wind speeds. EDC is built using PDF curve for RasElnaqab area. Energy produced by wind turbine depends on the cubic of wind speed as equation (1) indicates multiplied by its duration. The rated speed for the wind turbine is the speedcorresponding to the peak point of the EDC. Figure 7 shows wind energy content in V^3hr(m^3/sec^3hr) versus wind speed, EDC curve shows that rated wind turbine speed is 9.5 m/s .

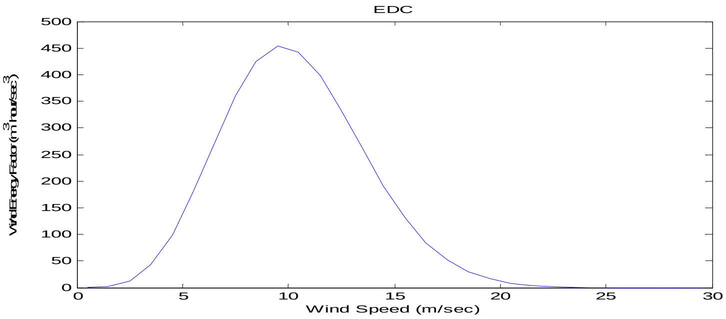


Figure7. Energy Distribution Curve (EDC)

$$\boldsymbol{P_{WT}} = \begin{cases} 0 & , \quad v < v_{cut_{in}} \\ \frac{1}{2}\rho A v^3 Cp\,\eta & , \quad v_{cut_{in}} \leq v \leq v_{rated} \\ \frac{1}{2}\rho A v_{rated}^3 Cp\,\eta & , \quad v_{rated} \leq v \leq v_{cut_{out}} \\ 0 & , \quad v > v_{cut_{out}} \end{cases} \qquad (1)$$

Where:$\boldsymbol{P_{WT}}$: *wind turbine power* , $\boldsymbol{\rho}$: *Air density (kg/m*^{3} *),* $\boldsymbol{A}$: *Swept Area (m*^{2} *) ,* $\boldsymbol{v}$: *Wind Speed (m/sec.,* $\boldsymbol{Cp}$: *Power Coefficient* , $\boldsymbol{\eta}$: *Efficiency.*

Matlab code is designed to search for wind turbine specification to satisfy previous results. Search indicates GOLDWIND87-1.5 MW satisfies the requirements. The specification and output characteristics of the wind turbine are shown in Table 2 and Figure10.

Table 2. Specifications of GW87-1.5MW

Parameter	Value
Rated output	1500 KW
Rated wind speed	9.9 m/s
Rotor diameter	87m
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Hub height	85 m

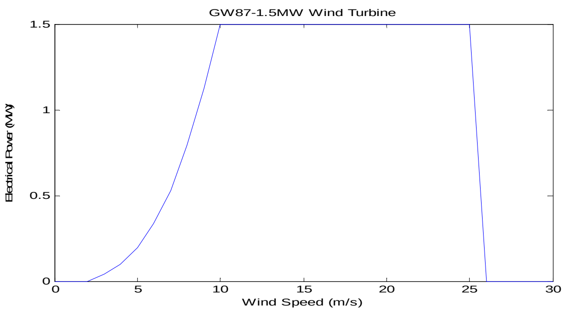


Figure 10.GOLDWIND87-1.5MW Output Characteristics

MATLAB code analyses three signals. Firstly, the load demand of Ma'an substation during the year of 2011 (See Figure 11) in $KW$is obtained from the synthesized data from HOMER for 8760 hours, this data is integrated over the whole year period to obtain the yearly energy to be supplied by hybrid system and then divided into two ratios, the wind ratio is 0.7762 of the total energy while the remaining of 0.2238 to be supplied from PV.

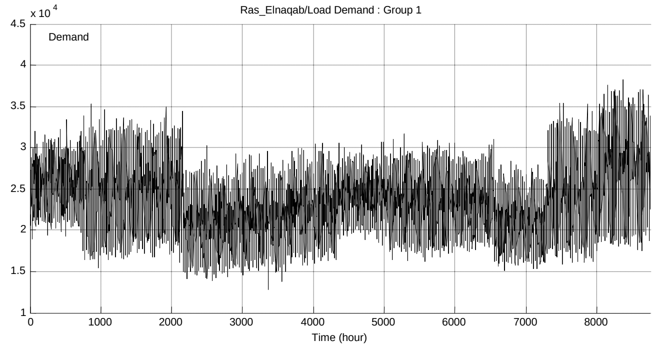


Figure 11. Load Demand (in KW) of Ma'an Substation in 2011

The second signal represents the output required of a wind turbine (See Fig.12) under the wind speeds condition of RasElnaqab throughout the year. This curve is integrated to obtain the yearly energy to be generated by one turbine. To calculate the number of wind turbines, the wind share of the load demand is divided by the energy to be generated of a single wind turbine.

$$\frac{Load\ Energy\ to\ be\ supplied\ by\ the\ hybrid\ system(kWhr) * Wind_{Sharing}}{Single\ Wind\ Turbine\ energy\ Output\ (kWhr)} \tag{2}$$

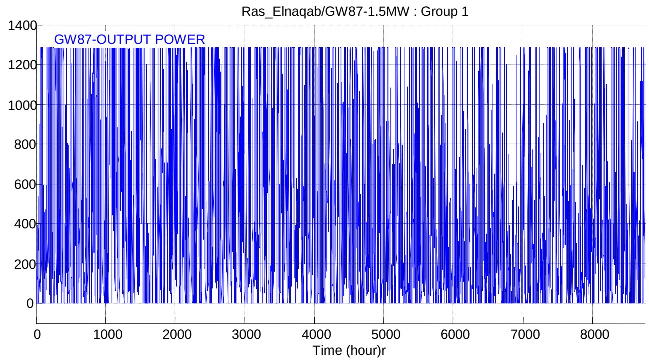


Figure 12. The Output of GW87-1.5MW wind turbine (in KW) in 2011

In order to calculate the wind farm area, the turbulence due to the rotation of the blades may affect the adjacent turbines; this effect can be reduced by providing a suitable minimum spacing of *10RD* between the rows and *3RD* betweenturbines in each row, where *RD* is the rotor diameter. As a result, the wind farm area can be calculated. The result is shown in Table 4.

Table 4. Wind Farm Sizing & Load Results

Parameter	Unit	Value
Load Energy to be supplied by the hybrid system/year	KWhr	205668986.5
Single Wind Turbine Energy/year	KWhr	4273580.5
Number of Wind Turbines	/	38
Wind farm area	m^2	4087260

4.2. PV Panel Sizing

Surveying available PV specifications, SUNTECH-280 panel is chosen because they enjoy low cost and acceptable efficiency, these specifications are shown in Table 5.

Table 5. Specifications of SUNTECH-280 solar panel

Parameter	Value
$P_{nominal}$	280 Watt
V_{oc}	44.8 V
I_{sc}	8.33 A
V_{mp}	35.2 V
I_{mp}	7.95 A
Efficiency	14.4 %
Area	1.94 m^2

Total Number of PV panels are obtained by dividing that part of the load which is covered by PV arrays in *kilowatt-hour* divided by the single PV panel energy output in *kilowatt-hour*.

$$\text{Number } of\ PV\ Panels\ = \frac{\begin{matrix}\textbf{Load Energy to be supplied by}\\ \textbf{the hybrid system}(\textbf{kWhr})*\textbf{PV}_{\textbf{Sharing}}\end{matrix}}{\textbf{Single PV Panel energy Output }(\textbf{kWhr})} \quad (3)$$

The main goal of sizing the hybrid wind/PV system is to minimize the total costs, this includes capital costs and Operations &Maintenance costs [9]. In general a typical 1 KW photovoltaic system will need around 15 m^2 [8]. In addition, PV array area is calculated such that 280 Watt will need around 1.94m^2. As a result, number of PV panels is shown in Table 6. PV single panel energy per year is calculated by integrating the product of panel area and radiation for Figure 13 times PV panel efficiency.

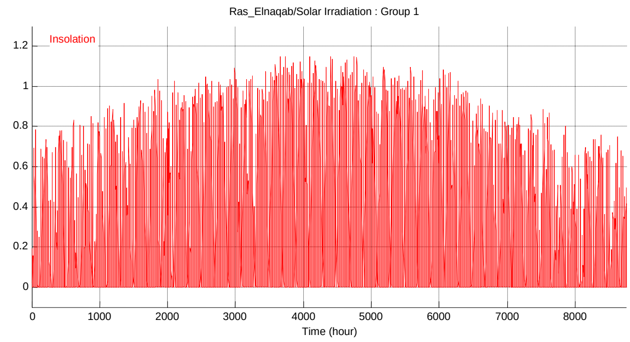


Figure 13. Solar irradiation (in KW/$\mathbf{m^2}$) of Ras Elnaqab in 2011

Table 6: PV array Sizing Results

Parameter	Unit	Value
Single PV Panel Energy/year	KWhr	604.7
Number of PV panels	/	76124
PV array area	m^2	147680.56

4.3. System Component Cost

(HOMER) is used to investigate the feasibility study of the proposed hybrid system. Table 7, 8, 9&10 show the cost of eachcomponent for thewhole hybrid system.

Table 7: PV system Component Costs

Component	*Value*
PV	
Capital cost $/kW	1770[10]
Replacement cost $/W	0
Operation and maintenance for each panel $/year	27[11]

Table 8: Wind system Component Cost

Component	*Value*
Wind Turbine	
Capital cost / turbine	1725000 [12]
Replacement cost	0
Operation & maintenance for each turbine in $/year	11700 [12]

Table 9: converter system Component Cost

Component	*Value*
Converter	
Capital cost $/kW	715 [13]
Replacement $/kW	0
Operation & maintenance $/unit/year	0 [14]

Table 10: grid Cost

Component	*Value*
Grid	
Power Price $/kWh	0.08 [6]
Sellback $/kWh	0.05 [6]

5. FEASIBILITY RESULTS

A schematic diagram for the hybrid system is shown in Figure 14.

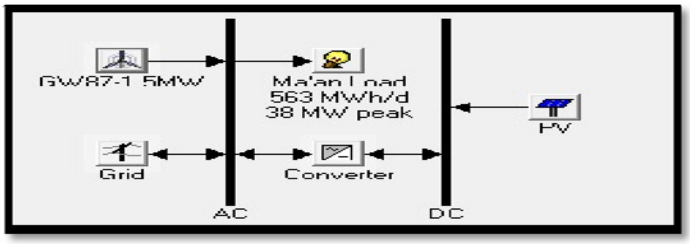


Figure 14. Schematic Diagram of Hybrid Wind/PV in HOMER

A pre-feasibility study and economical investigation is to be done before the application of any renewable energy hybrid system projects to assist owners and investors to make decisions.

5.1. Cash Flow Summary

Table 11 shows the capital, replacement and Operation and Maintenance cost (o & m) for each component and for project life of 25 years. In addition, the total cost for the whole system is shown.

Table 11. Cash Flow Summary(See Figure 17)

Component	Capital ($)	Replacement ($)	O&M ($)	Total ($)
PV	37,726,752	0	7,356,732	45,083,480
38GW87-1.5MW	65,550,000	0	5,683,484	71,233,488
Grid Sell Back	0	0	-1,440,929	-1,440,929
Converter	15,239,902	0	0	15,239,902
Net Result	118,516,656	0	11,599,288	130,115,952

The net total cost of the system which is equal 130,115,952$ is acceptable for a hybrid system. This fact is to be clearer when comparing COEof the designed systemand COE of the utility grid. From HOMER software the COE of the hybrid system is 0.049$/KWhr which is cheaper than that of the utility.

5.2. Production& Consumption of Electricity

The details about the annual production of electrical energy by the system and the total amount of energy that flows to serve the system's electrical loads are shown in Table 12. In addition, annually excess electricity and unmet load are shown in Table 13.

Table 12: Annual Production of Electricity & RF

	KWhr/yr	%	Describtion
AC primary load supplied by the hybrid system (kWhr/yr)	205,669,168	73%	The amount of energy that flows towards the AC primary load.
Grid sales (kWhr/yr)	75,679,328	27%	The total amount of electricity purchased from the grid during the year.
Total (kWhr/yr)	281,348,480	100%	The total amount of electrical load served during the year.
Renewable Fraction (%)	74		The fraction of the total electrical production that is produced by renewable sources.

Table 13: Annually Excess Electricity & Unmet Load

Quantity	kWhr/yr
Excess electricity	81,066
Unmet electrical load	0.229

HOMER calculates the results as shown in Table 14 for 8760 hours; this means that there are 8760 tables similar to Table 14. Moreover, excess electricity is calculated by subtracting the AC Primary Load

(27466.28 kW), Grid Sales (3610.625 kW) and Inverter Losses (22436.367-21314.55=1121.817 kW) from PV Power (23159.72 kW), GW87-1.5MW (9762.355 kW) and Grid Purchases (0 kW), the final result will be the Excess Electricity (723.353 kW) that is a surplus power that can be used to serve a resistive load.

Table 14. HOMER Results for March 15, 2011

Wind Speed	5.382(m/s)
AC Primary Load	27466.28 (kw)
PV Power	23159.72 (kw)
GW87-1.5MW	9762.355 (kw)
Grid Sales	3610.625 (kw)
Excess Electricity	723.353 (kw)
Unmet Load	0 (kw)
Inverter Input Power	22436.367(kw)
Inverter Output power	21314.55 (kw)

5.3. Wind Farm Output

Table 15 shows the output values of the wind farm system. Note that, the wind farm output is much higher than the PV output. This is because the sharing ratio is selected in order to minimize the cost of operation while maximizing the reliability and RF of the hybrid system.

Table 15. Wind Farm Output

Variable	Value	Units	Explanation
Total rated capacity	57,000	kW	The rated power gained from GW87 wind farm.
Mean output	18,539	kW	The average power gained from GW87 wind farm.
Capacity factor	32.5	%	Ratio of the average power gained from GW87 to the rated power gained from GW87
Total production	162,398,688	kWhr/yr	The total yearly production of electricity by GW87 wind farm in the hybrid system.
Minimum output	0	kW	Minimum output power from GW87 wind farm.
Maximum output	48,740	kW	Maximum output power from GW87 wind farm.
Wind penetration	79	%	The average power output of GW87 wind farm divided by the average primary load.
Hours of operation	7,494	hr/yr	Hourly duration of GW87 wind farm operation throughout the year.
Levelized cost	0.0343	$/kWhr	COE energy produced by the GW87 wind farm.

The total rated output is equal to the rated output of a single wind turbine multiplied by the number of wind turbines ($\text{Total rated capacity} = 1.5 * 38 = 57\text{Mw}$). The hours of operations that the turbines are not in service represent the maintenance time and the time of very low or extremely high wind speeds. The levelized COE of the wind farm system is lower than other sources which emphasizes the importance of wind energy generation.

5.4. PV Array Output

The nature of the solar energy implies a lower mean output and lower capacity factor but PV system is included because it increases the reliability of the hybrid system. Table 16 shows the output values of the photovoltaic array system.

Table 16. PV array Output

Variable	Value	Units	Description
Rated capacity	21,315	kW	The rated power gained from SUNTECH PV array.
Mean output	5,480	kW	The average power gained from SUNTECH PV array.
Mean output	131,515	kWh/d	The mean energy gained from PV array per day throughout the year.
Capacity factor	25.7	%	The average power output of the PV array (in kW) divided by its rated power.
Total production	48,002,952	kWhr/yr	The total yearly production of electricity by SUNTECH PV array in the hybrid system.
Minimum output	0	kW	Minimum output power from SUNTECH PV array.
Maximum output	25,471	kW	Maximum output power from SUNTECH PV array.
PV penetration	23.3	%	The average power output of SUNTECH PV array (5,480kW) divided by the average primary load (23,478kW).
Hours of operation	4,390	hr/yr	Hourly duration of SUNTECH PV array operation throughout the year.
Levelized cost	0.0735	$/kWhr	COE energy produced by the SUNTECH PV array.

The COE of the PV plant (0.0735 $/KWhr) is higher than the COE of the wind farm (0.0343 $/KWhr); this reflects the fact that PV energy is more expensive than wind energy. In the proposed hybrid system the cost per kw of the PV energy is (1770 $/kw) while wind energy is (1150 $/kw).

5.5. Purchasing& Selling with grid

Table 17 shows details of the expected purchases from and sales to the grid for all months of the year 2011. The first column shows the expected energy to be purchased (in kWhr) from the national grid for each month. The second column shows the expected energy to be sold to the national grid (in kWhr) for each month. The third column shows the net purchases from and to the national grid. The positive result indicates that kWhr to be purchased is higher than the kWhr to be sold. The negative result indicates that kWhr to be sold is higher than the kWhr to be purchased. The last row shows the total of the year. Moreover, the last row indicates that the hybrid system sells more than it purchases by 2,254,382kWhr.

Table 17. Purchasing& Selling with Grid

Month	Energy Purchased (kWhr)	Energy Sold (kWhr)	Net Purchases (kWhr)
Jan	7,492,586	5,536,932	1,955,654
Feb	4,375,339	8,294,791	-3,919,452
Mar	5,645,115	7,684,909	-2,039,795
Apr	4,413,875	8,869,245	-4,455,371
May	4,420,880	8,822,541	-4,401,661
Jun	4,433,031	8,481,110	-4,048,079
Jul	6,549,650	5,867,883	681,768
Aug	7,510,843	4,963,336	2,547,507
Sep	6,809,998	4,579,889	2,230,109
Oct	6,718,507	3,663,494	3,055,013
Nov	7,851,559	3,929,969	3,921,590
Dec	7,203,568	4,985,231	2,218,337
Annual	73,424,944	75,679,328	-2,254,382

6. CONCLUSIONS

Feasibility study shows that Jordan is a potential candidate for application of wind/PV hybrid systems. This is because it owns location with high wind speed and high solar radiation. Jordan also suffers from the high cost of imported fuel necessary for modern society. In this paper, RasElnaqab, which is located in South Jordan, is selected as an optimal location to apply wind/PV hybrid system. RasElnaqab shows high potential of both wind speed and solar irradiation. An interacted iterative algorithm using Matlab and HOMER softwares are used to determine the feasibility of the hybrid system over 25 years life time. The main results are: (a) RF is 74.1%. (b) optimaloptimal sharing between renewable resources is 22.38% for PV energy and 77.62% for wind energy. (c) The wind energy is to be generated from 38 units each rated 1.5MW; 9.5m/s wind speed. (d) 76124 PV panels each rated 280W for sun radiation energy generation. The net present cost of the whole hybrid system is (130,115,936$) and with a cost of energy of 0.049$/kWhr which is a feasible and competitive price compared to other techno-economical researches and to the Jordanian utilities.

7. FUTURE WORKS

In the future, similar studies can be established to investigate other possible potential locations in Jordan.The authors believe that emission levels reduction should be included to enhance feasibility of the hybrid system.Finally, other hybrid systems are available other than wind/PV systems. It is interesting to investigate other possibilities and compare results.

REFERENCES

[1] Chris Woodford. The Free Online Science & Technology Book. UK, 2012. Available:http://www.explainthatstuff.com/energy.html

[2] A.Meier. *Electric Power Systems*, IEEE Press. ISBN-13: 978-0-471-17859-0, 2006.

[3] Photovoltaic Geographical Information System (PVGIS), 2012. http://re.jrc.ec.europa.eu/pvgis/.

[4] R. Belfkira, C. Nichita, P. Reghem and G. Barakat. "Modeling and Optimal Sizing of Hybrid Renewable Energy System", *International Power Electronics and Motion Control Conference, IEEE Conf*., Pp. 1834 – 1839, 2008.

[5] National Electric Power Company (NEPCO), http://www.nepco.com.jo/. Jordan.

[6] Y. El-Tous. "A Study of a Grid-connected PV Household System in Amman and the Effect of the Incentive Tariff on the Economic Feasibility", *International Journal of Applied Science and Technology*, Vol/Issue: 2(2). Pp. 103, Al-Balqa` Applied University, Jordan, 2012.

[7] Al-Ammar, N. H. Malik, M. Usman. "Application of Using Hybrid Renewable Energy in Saudi Arabia", *ETASR - Engineering, Technology & Applied Science Research,* Vol/Issue: 1(4). Pp. 84-89, 2011.

[8] "A Guide to photovoltaic (PV) system design and installation", *California Energy Commission*. Pp. 6, 2001.

[9] S. Mathew. *Wind energy: fundamentals, resource analysis and economics*, ISBN-10 3-540-30905-5, Springer Berlin Heidelberg New York, 2006.

[10] V. Sanchez, J. M. Ramirez, and G. Arriaga. "Optimal sizing of a hybrid renewablesystem", *Industrial Technology (ICIT) IEEE International Conference, IEEE Conf.* Pp. 949-954, 2010.

[11] SUNTECH Solar Panel, 2012. http://www.altestore.com/store/Solar-Panels/Suntech-STP280-24Vd-280W-24V-Solar-Panel-USA/p7941/.

[12] Addressing Solar Photovoltaic Operations and Maintenance Challenges, 2012. http://www.smartgridnews.com/artman/uploads/1/1021496AddressingPVOaMChallenges7-2010_1_.pdf,

[13] 2010 Wind Technologies Market Report, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), 2012..http://www1.eere.energy.gov/wind/pdfs/51783.pdf.

[14] P. Sunderan1, B. Singh, N.Mohamed and N. Husain, "Techno-economic Analysis ofan Off-GridPhotovoltaic Natural Gas Power System for a University", *ThirdInternational Symposium & Exhibition in Sustainable Energy & Environment*, Malaysia, 2011. HOMER Sample files, http://www.homerenergy.com/.2012.

BIOGRAPHIES OF AUTHORS

Hussein M. Al-Masriwas born in Irbid, Jordan, in 1987. He holds M.S in electrical power engineering, Septemper 2012, and B.Sc. degree in electrical power engineering, June 2010, both from Yarmouk University, Irbid, Jordan. In the master degree, he was the first between his colleagues. Thereby, he has been awarded a PhD scholarship.He has been admitted as a PhD student at Texas A&M University-College Station on Fall 2013 with a major of Power Engineering/Renewable Energy. His research interests include Renewable Energy and power system operation.

F. K. Amoura was born in Haifa, Palestine in 1946. He received the B.Sc degree from Azhar University, Egypt in 1969, the M.Sc, degree from the University of Southern California, Los Angeles, in 1976, and the PhD degree from North Carolina State University, Raleigh, in 1986.

Currently, he is an Associate Professor at Yarmouk University, Irbid, Jordan. He is the author and coauthor of several technical papers covering distribution line carriers, distribution system reliability, economic justification of adding auto recloser and auto sectonalizers, and voltage transients in transformers.