Grid-Connected Photo Voltaic System Design for Koya Software Engineering Department in Iraq

Ari A. Abdulrahman

Software Engineering, Koya University, Iraq

***Abstract*—The depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to meet up the present day demands. Solar energy being a clean, inexhaustible and environment-friendly potential resource among all renewable energy options. It uses Photovoltaic system to change the sunlight directly to electricity. Photovoltaic system is one of the attractive candidates for green power generation. The system developed in such a way that it can be connected to the Grid system to provide the demand load. From this point the term grid-connected PV system was started. In this paper the Grid-Connected PV system designed to supply 20% of the load demand for the software engineering department of Koya University in koya city in iraq. The load is calculated by taking the different appliance wattage in the department and the average hours of operation for them in the four seasons of year. Depending on the maximum load demand, the system designed to generate 20% of the peak load which is 30KW. The designed system will integrate with the utility system to form the Grid-connected PV system. The application of the designed system will be the first challenge of generating green electricity in koya city.**

***Keywords*—Grid-Connected PV system, Energy consumption, Solar irradiation**

I. INTRODUCTION

The increasing of the world energy demand, due to the modern industrial society and population growth,is motivating a lot of investments in alternative energy solutions, in order to improve energy efficiency and power quality issues [1].

At present, photovoltaic (PV) generation is assuming increased importance as a renewable energy sources application because of distinctive advantages such as simplicity of allocation, high dependability, absence of fuel cost, low maintenance and lack of noise and wear due to the absence of moving parts [1].

The solar energy can be integrated to the existing energy structure by connecting the PV system to the grid system and then the Grid-connected PV system created. Also, with the emergence of high-voltage switches, Grid-Connected PV power plants have been customary [2].

The system employees will be increased day by day in the worldwide because of decreasing the cost of the PV panels as seen in fig. 1. Also no battery usage in the Grid-Connected PV system reduces the cost of the system strongly. From 2010 to 2011 an additional 30GW of new solar PV capacity was added globally, bringing the total world capacity to 70GW. Fig. 2 shows the exponential increase, especially over the last five years, of PV capacity.

The objective of this study is lucubration of the energy consumed by the software department different electrical devices. Although, calculating the total Kilowatt-hours per day for the four seasons of year. Depending on the peak power usage by the department in the four seasons, the Grid-Connected PV system will be designed to substitute 20% of electricity. This design has the following advantages:

1- Reduce the use of the energy by 20% from the grid system so the bill of electricity also will be reduced.
2- The generated power injected to the utility system during non-use of the devices in the department in any time of the year like 7.44 KW in summer season in this design.
3- Supplying 33% and 28% of the load demand during winter and spring also autumn seasons respectively.
4- It will be the challenge of generating the green electricity in this new form in the koya city.

The paper is organized in the following manner: Section II is the literature review on the Grid-Connected PV system and its architecture is described in Section III. Grid-Connected PV system design parameter is explained in section IV. Section V is the software engineering department profile in electric point of view. Also, Grid-Connected PV system design calculations for software engineering department are described in section VI. The conclusions are explained in section VII.

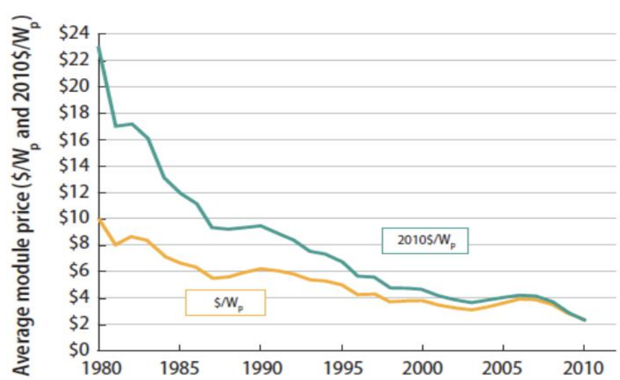

Fig. 1 Average PV module prices, all technologies (1980-2008) [3]

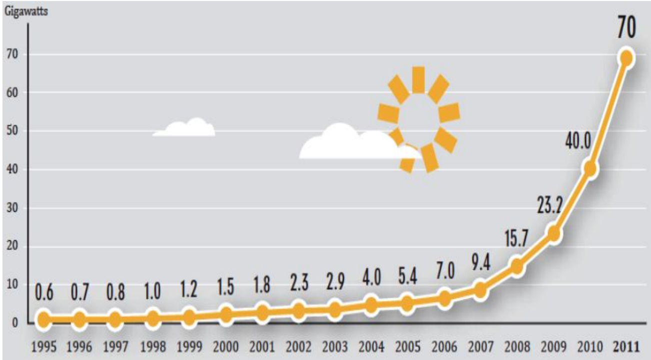

Fig. 2 Total world capacity of solar PV (1995-2011) [4]

II. Literature Review

The study on the Grid-Connected PV system as the interest field started especially after 2001and became a hot research filed in the last four years. Li et al. (2001) presented a study of a grid-connected PV system in Hong Kong, and showed that the energy payback period was estimated to be 8.9 years [5].

Souvik Ganguli et.al (2009) presented a Estimation of Grid Quality Solar Photovoltaic Power Generation Potential and its Cost Analysis in Some Districts of West Bengal. The objective of their work was to estimate the potential of grid quality solar photovoltaic power in some districts of West Bengal[6].

Y. Udea et al. (2009) performed an analysis of various system configurations and orientations of grid-connected PV systems and showed the effect of the orientation and model of PV panels on the total energy yield [5].

G. Mulder et al. (2010) presented a study of grid-connected PV systems for residential houses with energy storage, and studied the relation between storage size and energy flow to the grid in Belgium, while J. De La Hoz et al. (2010) performed an technical and economic analysis of grid-connected systems in Spain during the period 1998-2008, and intended to explain the evolution by focusing on the key growth factors and drivers embedded in the legal, economic and technical framework of the PV energy policy[5].

A.S. Elhodeiby et.al (2011) presented a performance analysis of 3.6 kW Rooftop grid connected solar photovoltaic system in Egypt. The system was monitored for one year and all the electricity generated was fed into the 220 V, 50 Hz low voltage grid to the consumer [6].

III. Grid-Connected PV System Architecture

A Grid- Connected photovoltaic system is solar system where the output of the PV array is connected to feed into the grid supply. The basic components of the system are [1, 7]:

PV Array: A number of PV panels connected to give a DC output out of the incident irradiance.

Inverter: A power converter that inverts the DC power from the panels into AC power.

Meters: They account for the energy being drawn from or fed into the grid.

Utility network: the power girds itself.

The figure below shows the main components of the Grid-Connected PV system.

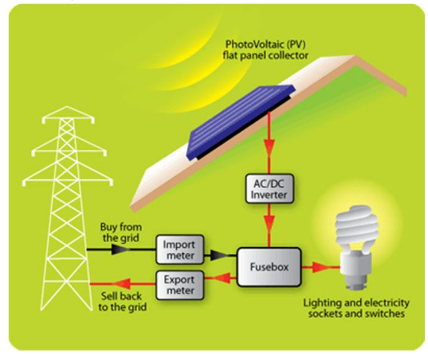

Fig. 3 Grid-connected PV system architecture.

At night or during cloudy periods, supply of electricity will be done by the grid. During the day, the power produced by the PV panels with the grid system supplies the loads.

IV. Grid-Connected PV System Design Parameter

To design any PV system tied to grid, the PV panel and inverter specifications must be known. Solar irradiation data according to that specific area is required and it can be obtained from NASA. Some other factors like specific area, Longitude and latitude of the area, tilt angle of the PV panels, orientation of them, series and parallel configuration of the PV panels must also be indicated. Also the output voltage and output current of the system must be calculate. All the mentioned parameters are calculated and presented in section VI.

V. Software Engineering Department Profile in Electricity Point of View

A. *Software Engineering Department:*

Software engineering is one of the departments of the faculty of engineering of koya university in koya city in north of iraq. The department has four halls for lecturing; six laboratories with their training boards and computers, four rooms for the lecturers and one room for the head of department. The efficient electricity for all the electrical devices in the department is supplied by the grid.

B. *Software Department Energy Consumption*

Energy consumption by the software department can be calculated by knowing the different types of electrical loads in the department. The loads mainly consist of air-conditions, lamps, computers and other loads like printer, photocopy …etc. Each of the equipment has its own power consumption. For this purpose all the equipment in the department are counted with their powers and then calculate the total power of them. Table I shows the result of calculation for load demand by the software department different electric devices.

TABLE I
TYPICAL ELECTRICAL EQUIPMENT AND THEIR WATTAGE IN SOFTWARE DEPARTMENT.

Hall-Lab-Room	Number	Light	Light	Air-condition	Computer	Training board	Other loads
		40 W	100 W	3000W	200W	220W	
Hall	4	144		12			
Laboratory	6	172	5	14	102	43	
Lecturers Room	4	32		4	4		
Head of Dept.	1	32		2			
Sum	15	380	5	32	106	43	
Total Power(W)		15200	500	96000	21200	9500	4000

The above table shows that the total load demand is 146.4 KW. It is important to calculate the actual operation of the devices. This can be done by calculating the hours of devices operation per each day. In this paper to get the equipment hours operation, the year divided into four seasons. In each season, we will take the average hours per day operation for each device then we can find the kilowatt-hours per day for each device as shown in table below:

TALE II
DAILY ENERGY CONSUMPTION OF THE SOFTWARE DEPARTMENT DEVICES

Load type	No. Of units	Rated power (W)	Autumn		Winter		Spring		Summer	
			Av.hrs used/day	KWh/ day	Av.hrs used/day	KWh/day	Av.hrs used/day	KWh/day	Av.hrs used/day	KWh/ day
Lights	380	40	0.3	4.56	0.35	5.32	0.3	4.56	0.05	0.76
Lights	5	100	0.02	0.01	0.02	0.01	0.01	0.005	-	-
Computers	106	200	0.5	10.6	0.5	10.6	0.4	8.48	0.08	1.6
Air-Condition	32	3000	0.7	67.2	0.85	81.6	0.75	72	0.2	19.2
Training board	43	220W	0.02	0.189	0.02	0.189	0.01	0.095		-
Other loads				1.5		1.5		1.3		1
Total KWh / day				84.059		99.219		86.44		22.56

From the previous table different level of power consumption in each season can be noticeable. The highest energy consumed in winter which is 99.219KWh/day whiles the lowest of it consumed in summer which is 22.56KWh/day. From table I and table II, the load parameters of the system can be calculated and presented in table below:

TABLE III
LOAD PARAMETER OF THE SYSTEM

Parameter	Value
Average load (KWh/day)	1752
Average load (KW)	73
Peak load (KW)	146.4
Load Factor	0.49

Generally Grid Connected PV system can't self-support for providing electricity because the PV system energy depends on sun but it can't appear during the night and cloudy weather. So the Grid connected PV system will be designed to provide electricity by the integration of it with the utility network.

It will be expected that 20% of electricity may provide by the renewable sources especially from solar energy in the world in 2020. So we will design the Grid-Connected PV system for software engineering department by the amount of 20 % of its peak load which is the 146.4 KW. Depend on the percentage; 30 KW must be designed for the Grid-Connected PV system for the department to supply the electricity.

VI. GRID CONNECTED PV SYSTEM DESIGN CALCULATION FOR SOFTWARE ENGINEERING DEPARTMENT

The system designed for 30KW of electricity to integrate with the Grid system. To design the system, solar Irradiation data for koya city must be known for all months in one year. These data got from NASA for koya city and showed in figure below:

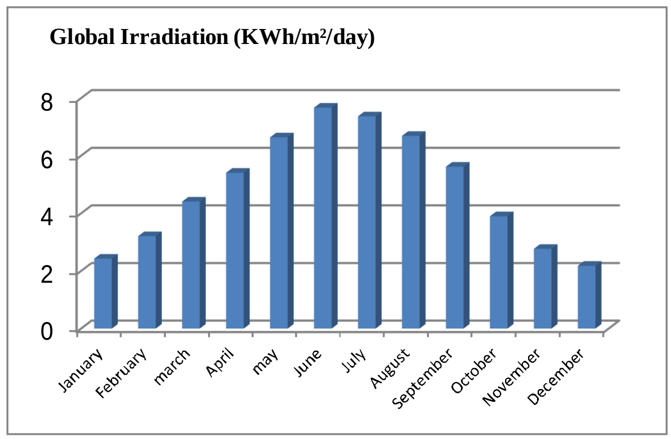

Fig.4 Solar Irradiation for koya city

It is clear from the figure that the maximum sunshine in koya city occurred during summer season while the minimum of it occurred during winter season. Koya is known to be rich in the solar resource with an annual average of 4.86 KWh/m2/day. This parameter is important in indicating the PV seizing. PV Panel specifications are demonstrated in table IV.

All parameter of the system like: number of PV panels, series and parallel configuration of them, required area, output voltage and current ratings are calculated and put the results in table V. It also contains the latitude, longitude of software department and tilt and orientation of the PV panels.
To integrate the PV with the Grid system, the inverter is required which its specifications exposed in table VI.

TABLE IV
PV PANEL SPECIFICATIONS FOR POLYCRYSTALLINE SILICON

Parameter	Value
Maximum power	300W
Open circuit voltage	45.1V
Voltage at max.power	35.2V
Short circuit current	8.94A
Current at max.Power	8.52A
Efficiency	15.3%
Dimensions	W:994mm L:1971mm
Area	1.96m^2

TABLE V
CALCULATION RESULTS OF THE SYSTEM DESIGN AND ITS INFORMATION

Parameter	Value
Latitude	36° 5'54.35"N
Longitude	44°39'27.11"E
No. of PV Panels	100
No. of PV panels in parallel	20
No. of PV panels in series	5
Total area (m2)	200m^2
Output voltage (volt)	220V
Output current (A)	160
Tilt of PV panels	33°
Orientation of PV panels	1°

TABLE VI
INVERTER SPECIFICATIONS FOR XANTREX™ GT30 INVERTER.

Parameter	Value
Max. Power output(AC)	30KW
Max. continuous AC current	80A rms
Nominal frequency	60/50 HZ
Max. PV power	35KW
Max. DC current	2 X 80A
Max. open circuit voltage	430Vdc
PV operating range	180 to 430Vdc
Power factor	0.99
Max efficiency	97.4%

VII. CONCLUSIONS

Koya is rich in the solar resources and has a great potential for PV powered projects. In this paper 20% of the energy consumed by the software engineering department which is 30KW designed and calculated for Grid-Connected PV system. The designed system can supply the full load of the department during summer season and inject the exceeded electricity which is 7.44KW to the Grid system. In winter the system can supply 33% of the load whiles in autumn and spring it supply almost 28% of the load. The installation of the designed system will be the first step in using the green electricity in koya city.

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