Analysis and Performance Results of 18 kWp Rooftop Grid-Connected PV System in SDEDC, Tanta, Egypt

Tariq M . Aid
South Delta Electricity Distribution Co., Tanta, Egypt
Tariqeed@gmail.com

Abstract
Photovoltaics (PV) or solar cells are semiconductor devices that convert sunlight into direct current (DC) electricity. Groups of PV cells are electrically configured into modules and arrays, which can be used to charge batteries, operate motors, and to power any number of electrical loads. With the appropriate power conversion equipment, PV systems can produce alternating current (AC) compatible with any conventional appliances, and can operate in parallel with, and interconnected to the utility grid .This paper presents the analysis and performance results of an 18 kW PV system installed on South Delta Electricity Distribution Company on Tanta, Egypt. The system was monitored for 4 months and all the electricity generated was fed into the 220 V, 50 Hz low voltage utility grid. monthly, daily performance results parameters of the PV system are evaluated which include : average power output per day, average power output per month , average generated kWh per day, average generated kWh per month , average system efficiency, average inverter efficiency . The results show that it must take advantage of the Egypt geographical location in the field of electric energy generation from solar energy.

Keywords : Solar energy , PV array , grid connected Photovoltaics PV system , PV's efficiency.

I. INTRODUCTION

Solar energy is the most abundant energy resource on earth. The solar energy that hits the earth's surface in one hour is about the same as the amount consumed by all human activities in a year. In solar power, two main types of technologies have been identified as being the most promising: The Concentrated Solar Power (CSP) technology and the photovoltaic (PV) technology. While the CSP focuses on the usage of the calorific power of direct sunlight radiation, the PV technology tries to transform the solar radiation into electricity directly by taking advantage of the photovoltaic effect. Our paper only discusses PV technology Today, PV provides 0.1% of total global electricity generation. However, PV is expanding very rapidly due to effective supporting policies and recent dramatic cost reductions. PV is a commercially available and reliable technology with a significant potential for long-term growth in nearly all world regions. This paper consists of seven parts, introduction, PV plant description, performance parameters, and data acquisition system, monitoring results, economical analysis, acknowledgement and conclusion.

II. PRICE HISTORY OF SILICON PV CELLS

The cost of renewable energy is primarily dependent on the capital and installation costs, with low fixed operation costs and low to nonexistent variable costs, including fuel costs Solar photovoltaic (PV) deployment has grown rapidly in the United States over the past several years. As Figure 1 shows, solar photovoltaic system costs have continued to decline. Previous modeling (2016) by the National Renewable Energy Laboratory (NREL) shows system cost reductions of about 60%–80% across sectors between the fourth quarter of 2009 (Q4 2009 and Q1 2016).

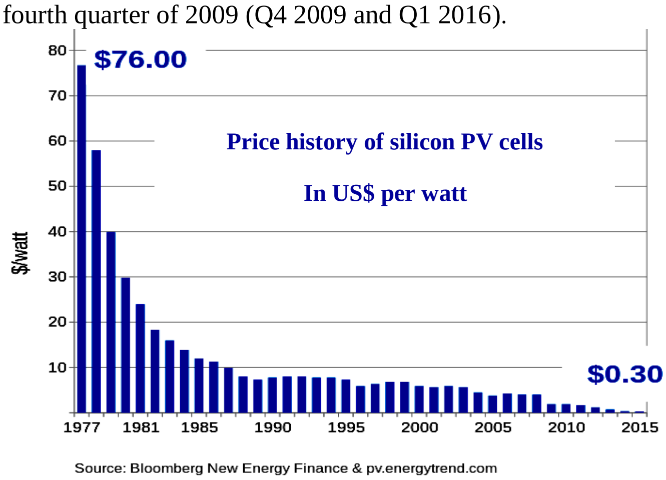

Fig. 1. Solar Energy Electricity Generation Costs as 1977 Levels (U.S. Department of Energy)

III. THE PHOTOVOLTAIC EFFECT

The photovoltaic effect is the physical phenomenon that allows the direct conversion of solar radiation into electric energy. Light can be described as being composed of particles or energy packets called photons. The amount of energy every photon has is a function of the frequency of the light of which it is part. Similarly, electrons in materials are bound to atomic structures depending on the energy they have. It is this process which creates a current in the PV cell.

IV. PHOTOVOLTAIC POWER SYSTEMS CLASSIFICATION

Photovoltaic power systems are generally classified according to their functional and operational requirements, their component configurations, and how the equipment is connected to other power sources and electrical loads. The two principal classifications are grid-connected or utility-interactive systems and stand-alone systems. Photovoltaic systems can be designed to provide DC and/or AC power service, can operate interconnected with or independent of the utility grid, and can be connected with other energy sources and energy storage systems.

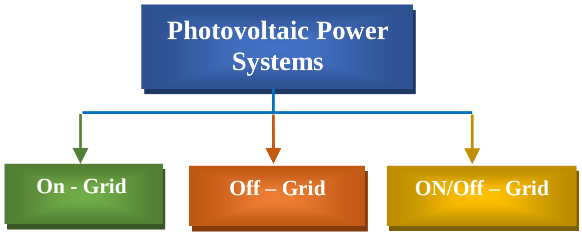

Fig. 2. Photovoltaic power systems classification

V. System Description

Grid-connected or utility-interactive PV systems are designed to operate in parallel with and interconnected with the electric utility grid. The primary component in grid-connected PV systems is the inverter, or power conditioning unit (PCU). The PCU converts the DC power produced by the PV array into AC power consistent with the voltage and power quality requirements of the utility grid, and automatically stops supplying power to the grid when the utility grid is not energized. A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the AC power produced by the PV system to either supply on-site electrical loads, or to back-feed the grid when the PV system output is greater than the on-site load demand. When the electrical loads are greater than the PV system output, the balance of power required by the loads is received from the electric utility. This safety feature is required in all grid-connected PV systems, and ensures that the PV system will not continue to operate and feed back into the utility grid when the grid is down for service or repair.

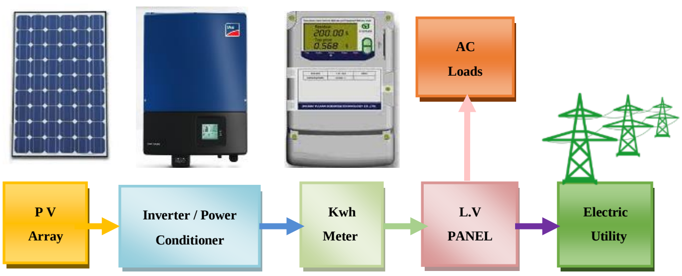

Fig. 3. Grid-connected or utility-interactive PV systems

A. ASite Selection

South Delta first solar power plant (18 Kwp PV system) was installed on the rooftop of a company car parking in Tanta, Egypt. This site on the Cairo - Alexandria main road, the aim of this choice solar PV energy culture deployment.

B. Technical Specifications for 18 kW Grid-Connected PV

TABLE I
PV PLANT SPECIFICATIONS

Plant Rating	18 k. w
Number of panels	60
Plant type	On Grid
The technology used	Polycrystalline cells
Plant efficiency	15.2 %
IP Code	IP 65

TABLE 2
PV MODULES AND ARRAY SPECIFICATIONS

International Standard	IEC	IE 61215,IEC 61730, IEC 61215
Photovoltaic Cells Efficiency	%	%18,1
Panel Dimensions	mm2	1985*955*64
Number Of Cell	cell	72
Cell Dimensions	mm2	165*165
Weight	kg	22
Operating temperature range	°c	− 5 ° ~ + 55 °
Module Power Rated	w	305Wp
Number of Module	unit	57(19*3)
Vmp	V	36.3
Imp	A	8.49
Pm	W	305
Isc	A	9.02
Voc	V	45.6

TABLE 3
INVERTER SPECIFICATIONS

Inverter Specifications	SMA - SUNNY TRIPOWER - Efficiency 98.2% - DC input voltage up to 1000v - 3 Phase, 380 V , 50 HZ
International Standard	IEC61727
Nominal AC Voltage	3Phase 380/230 V, ±10%
Nominal AC frequency	From 51 to 48.5 HZ
Long Life	5 year
Operating temperature range	−10 c˚ ~ + 55 c˚
Efficiency	98.2%
P. f	≥ 0.9

Inverter Specifications	SMA - SUNNY TRIPOWER
THD%	< 3%
Communication	Communication via Bluetooth
IP Code	IP56 (Outdoor)
No. of Inverter	1
AC nominal power at 230 V, 50 Hz	18 k w

TABLE 4
EARTHING SPECIFICATIONS

Earthing Resistance	Ohm	5

TABLE 5
KWH METER SPECIFICATIONS

Type	3 Phase – Digital Meter
Rated Current	5-100 Ampere
Rated Voltage	230/380 Volt

Fig. 4. View of the 18 kWp rooftop PV plant.


Fig. 5. View of the 18 kWp rooftop PV plant.

C. DATA ACQUISITION SYSTEM

The data acquisition system for the 18 kWp PV plant consists of a **SMA - SUNNY TRIPOWER** inverter, a SMA Sensor Box, and a SMA Web Box.

VI. MONITORING RESULTS

The system was monitored for Four months and all the electricity generated was fed into the low voltage utility grid. Monthly, daily performance results parameters of the PV system are evaluated. the average power output per day was 9.27 kW/day, the total generated kWh 12455 kWh , the average generated kWh per day was 76.46 kWh/day, the average PV array efficiency was 17.1% ,the average inverter efficiency 93.1% , the average system efficiency 51.53% .

1- DAILY SOLAR POWER PLANT OUTPUT IN KW

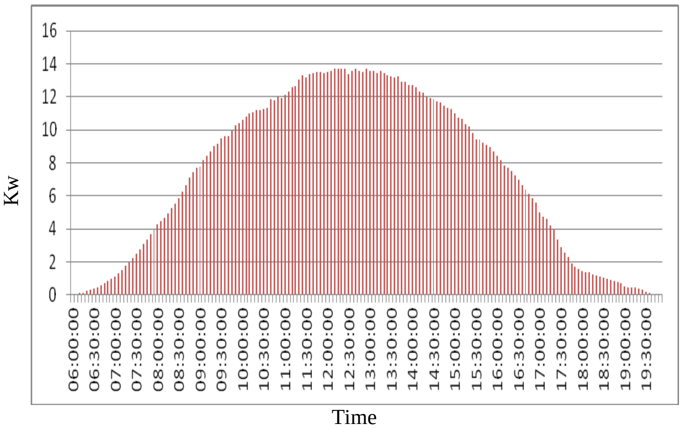

Fig. 6. Daily Solar power plant output (kW) May 17, 2017

2- Dust effect in solar plant efficiency as shown in figure

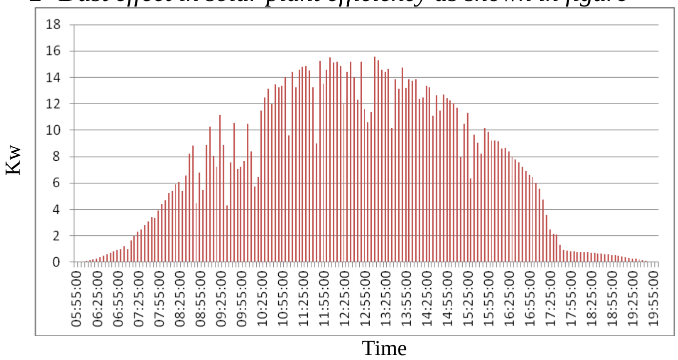

Fig. 7. Daily Solar power plant output (kW) June 1, 2017

3-DAILY SOLAR POWER PLANT OUTPUT IN KW
The effect of the washed surfaces of the solar panels

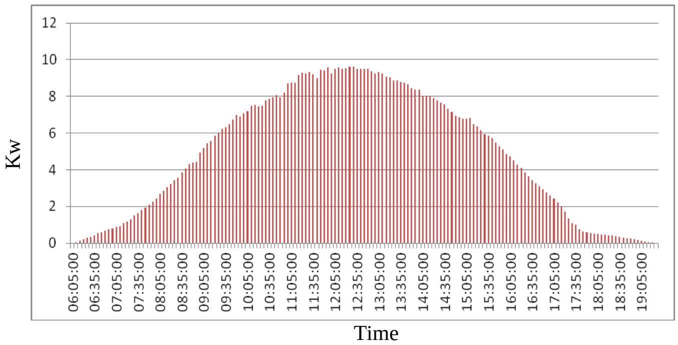

Fig. 8. Daily Solar power plant output (kW) Aug 1, 2017

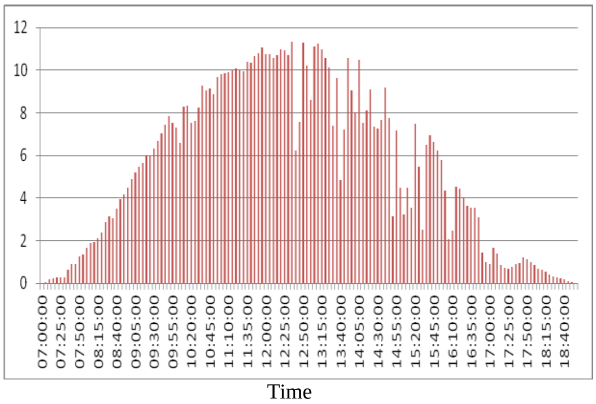

Fig. 9. Daily Solar power plant output (kW) Sep 20, 2017

4-Monthly Solar power plant output in kWh (July, 2017) The highest value was 93 kWh in July 3, while the lowest value 65 kWh in July 25 as shown in figure 10.

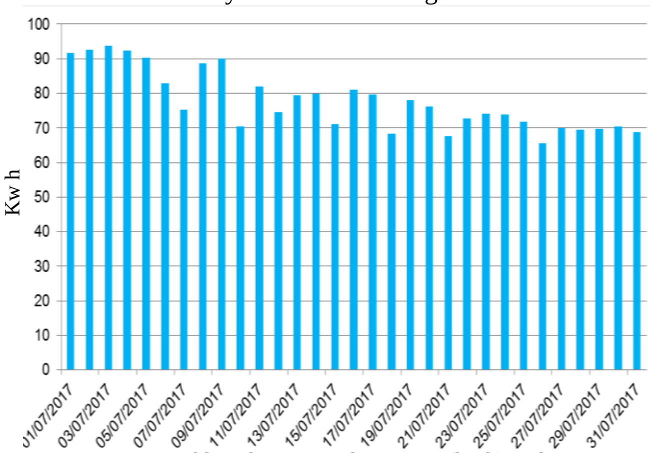

Fig. 10. Monthly Solar energy plant output (kWh) July, 2017

5-The highest value was 90 kWh in Sep 3, while the lowest value 55 kWh in Sep 3 as shown in figure 11.

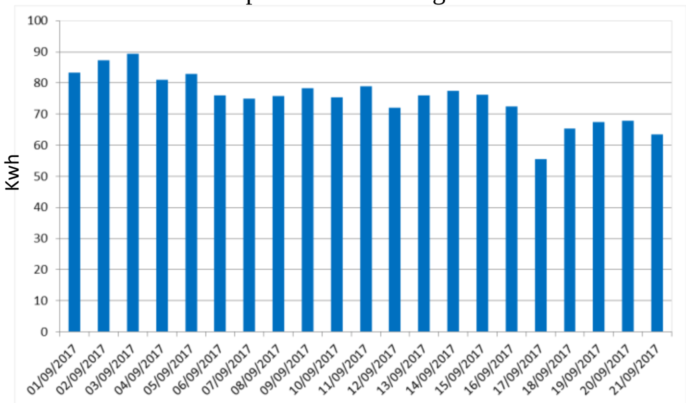

Fig. 11. Monthly Solar energy plant output (kWh) Sep, 2017

6-Performance Results

Emissions reductions Amount	Fuel Saving Amount	Yearly Energy Generation
17.73 ton /year	6.18 ton /year	28.8 MWH/year

Table (6) 18 kW solar plant Performance results

Conclusions

The 18 kWp grid connected PV system installed on the roof top of SDEDC was monitored during May 2017–Sep 2017 and its monthly and annual performance parameters were studied. The cumulative energy during 4 months reached 12455 kWh. The average generated kWh per day was 76.46 kWh/day, the average PV array efficiency was 17.1%, the average system efficiency 51.53%. For Environmental benefit side, the installed PV system has caused a reduction of about 17.7 tone of CO2 from the atmosphere per annum. This results show high potential for Egypt to use solar energy to produce clean electrical energy and reduce carbon emissions. On the other hand, the results show that dust accumulation has the great effect on decreasing Polycrystalline PV's efficiency and to meet this challenge must clean the panel's surface regularly.

Acknowledgments

This work was supported by South Delta Electricity Distribution Company, Egypt. My thanks go to all the people who have supported me to complete the research work directly or indirectly. I am extremely grateful to my parents for their love and caring. I am very much thankful to my wife and my daughters for their love, understanding and continuing support to complete this research work.

References

[1] So JH, Jung YS, Yu GJ, Choi JY, Choi JH. Monitoring and analysis of 3 kW Grid- connected PV system for performance evaluation. KIEE Int Trans Electr Mach Energy Convers Syst 2005;5B(1):52–7.

[2] Ishikawa T, Kurokawa K, Okada K, Takigawa N. Evaluation of operation characteristics in multiple interconnection of PV systems. Sol Energy Mater Sol Cells 2003;75(3–4):526–9.

[3] Thevenard D. Performance monitoring of a northern 3.2kWp grid-connected photovoltaic system. In: Proceedings of the 28th IEEE photovoltaic specialist conference 2000. p.1711–5.\

[4] Pietruszko SM, Gradzki M. Performance of a grid connected small PV system in Poland. Appl Energy 2003;74(1–2):174–7.

[5] Price history of silicon PV cells in US$ per watt (Source: Bloomberg, New Energy Finance pv.energytrend.com

[6] Official website of SMA Technology AG. http://www.sma.de/en/

[7] Pietruszko SM, Gradzki M. Performance of a grid connected small PV system in Poland. Appl Energy 2003; 74(1–2):174–7.

[8] https://www.researchgate.net/figure/Global-Irradiation-Solar-Map-for-Egypt_fig1_305657379

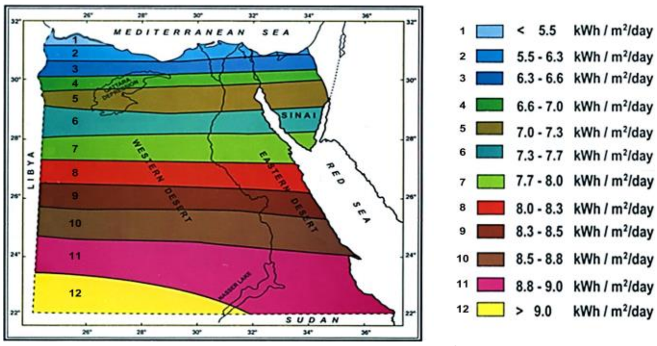

Fig. 12. Global Irradiation Solar Map for Egypt.