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Roof Top PV Energy System in Pharos University: An Aggregated Approach to Economical Environmental Returns

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Abstract

This work describes the analysis carried out for the sizing and simulation of grid-tie photovoltaic system in Pharos University. The design calculations and sizing results are performed with the aid of PV syst and other sizing software tool. The simulation is primarily performed in order to understand the behavior of grid tied photovoltaic installations at a specific location, while avoiding the over sizing or under sizing of the systems, Theoretical calculations are performed conventionally in order to make comparisons of calculated data with simulation results. We highlight the good potential of the studied area, with total energy yield 1654 kWh per year at optimal orientation, which would generate 1175 kWh/year for a 1 kW PV system, such information on potential and performance is a valuable reference for any possible sizing of photovoltaic projects at similar latitudes.

Keywords: PVsyst, sizing software, Photovoltaic, Pharos University, Aggregated Approach for Environment Economic Return

Introduction:

Renewable energy is the energy derived from natural resources that are renewable, that is, that are not being implemented. It is fundamentally different from fossil fuels such as oil, coal, and natural gas, or nuclear fuels that are used in nuclear reactors. Renewable energy does not usually generate carbon dioxide (CO_2) residues or harmful gases, or increase global warming, as occurs when fossil fuels or harmful atomic wastes from nuclear reactors are burned. Renewable energy is produced from wind, hot water and the sun. It can also be produced from the movement of waves and tides or from geothermal energy, as well as from agricultural crops and trees that produce oils. However, the latter have residues that increase global warming.

Currently, most of the production of renewable energy is produced in hydroelectric power stations by means of great dams wherever suitable places are found for their construction on rivers and waterfalls. (1)

Wind and solar methods are widely used in developed and some developing countries; But the means of producing electricity using renewable energy sources has become commonplace recently, and there are many countries that have drawn up plans to increase their production of renewable energy to cover their energy needs by 20% of their consumption in 2020, including Egypt. Recently, what is known as the trade of renewable energy is increasing, which is a type of business that interferes with the transformation of renewable energies into sources of income and its promotion Approximately 65 countries. (2)

It plans to invest in renewable energies, and worked on developing the necessary policies to develop and encourage investment in clean renewable energies by 2022, and to double this percentage by 2035, with the primary participation of the private sector. (4)

The importance of solar energy is the light and heat emanating from the sun that man has used for his benefit since ancient times using a group of constantly evolving technology methods such as calculations and measurements programs under study. Techniques for using solar energy include the use of thermal energy from the sun, whether for direct heating or as part of a mechanical conversion process for movement or electrical energy or to generate electricity through photovoltaic phenomena using photovoltaic panels in addition to architectural designs that rely on the exploitation of solar energy, techniques that can contribute significantly to solving some of the world's most pressing problems today. (3)

The role of Pharos University comes in entering the new and renewable energy system by working on planning the installation of photovoltaic cells on top of the university buildings in order to support the main network and work to reduce the university's expenses by connecting to the Alexandria Electricity Distribution Network to export the surplus of the university's needs or reduce the value of bills Due to the university by conducting a comprehensive study of the value of the amounts paid in electricity consumption, measuring the economic returns of the transformation of the photovoltaic system, and comparing seven programs that are used to choose the best program in calculating spaces and cell installation costs. (5)

As well as reducing noise and air pollutants (nitrogen oxides, sulfur, hydrocarbon and carbon monoxide) at the university by dispensing with electricity generators that operate on diesel machines, which emit harmful emissions to the environment if they are used at the time of power outages at the university. (6)

Also, the value of electricity bills consumes a large part of the university’s budget, which can be directed for the purposes of scientific research in the event that the purchase of electricity from the public electricity network is dispensed with, by installing a photovoltaic cell unit to generate and produce electricity from solar energy in order to comply with the state policy, the comprehensive development plan 2030 and its addition Obtained from energy on the public grid and relying on new and renewable energy using the latest technological methods to obtain electricity through photovoltaic cells (PV).

Objectives of the study

- An economic feasibility study is being conducted to measure the financial return of the university from the use of photovoltaic technology using micro soft excel program.
- Using specialized programs in photovoltaic energy calculations to determine the size and capacity of the units to be installed (Sizing) and compare between different programs and determine the most appropriate ones for application in the case of the study, which are seven global programs.
- Identifying electrical power consumption and its cost by compiling data for voltage and financial cost from previous bills for the years 2015 to 2019.
- Ensuring that the cost of the university's use of electricity does not rise when there is a change in the price of the electricity tariff .Ensure that there is no power outage due to the installation of batteries to keep the electric current and use them in periods when the sun's brightness is less.

Study area data [(2)]

SITE INFO

Site name: **Pharos University in Alexandria (PUA), Canal El Mahmoudia St, Alexandria, Al Iskandariyah 21, Egypt**
Latitude: 31.206167°
Longitude: 29.961083°
Altitude: N/A

SOLAR RESOURCE AND AIR TEMPERATURE

Long-term yearly and daily averages

Global horizontal irradiation [kWh/sq m]:	2038 per year (5.584 per day)
Direct normal irradiation [kWh/sq m]:	1989 per year (5.449 per day)
Diffuse horizontal irradiation [kWh/sq m]:	730 per year (2.000 per day)
Global tilted irradiation [kWh/sq m]:	2226 per year (6.099 per day), for surface tilted at 26° facing 180°
Air temperature [°C]:	20.6

PHOTOVOLTAIC POWER OUTPUT

Photovoltaic system of size 1 kWp with modules facing 180° tilted at 20°, long-term yearly and daily averages

Photovoltaic electricity [kWh]:	**1654 per year (4.53 per day)**
Global tilted irradiation [kWh/sq m]:	2214 per year (6.065 per day)

https://globalsolaratlas.info/detail?m=site&c=31.206739,29.960522,11&s=31.206739, 29.960522 **(23/7/2019@ 10:44p.m)**

A field study of the geographical location and available surface areas to determine the volume and energy that can be produced by photovoltaic cells, and to determine the environmental benefit and the material and economic return of the university.

Material & methods

Through this work some of software's used such as PVSYST V6.85 and RET screen. Calculation of the sizing, cost, and the load. On the other hand, Atlas map for solar energy for Egypt used.

The most important programs used in calculating costs and sizes of photovoltaic cells

https://www.linkedin.com/pulse/7-most-popular-solar-pv-design-simulation-software-eslam-allam/

PVSYST V6.85		31/08/21	Page 1/1

Definition of a geographical site

Geographical Site **Pharos univeristy** Country **Egypt**

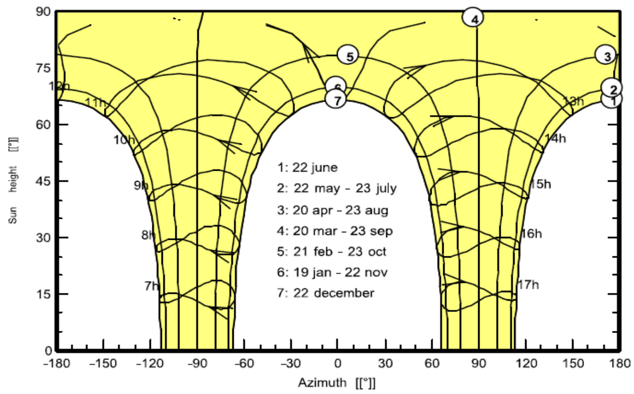
File New.SIT of 01/05/21 14h20

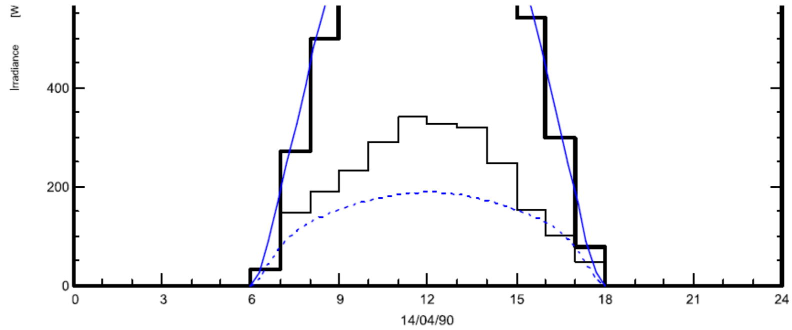
Situation Latitude 0.00° N Longitude 0.00° E
Time defined as Legal Time Time zone UT Altitude 0 m

Monthly Meteo Values Source pharos univeristy_MN72.SIT -- Meteonorm 7.2, Sat=100%

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	
Hor. global	226	221	230	227	220	226	227	225	232	235	232	223	227	W/m²
Hor. diffuse	119	127	125	108	108	102	99	111	106	115	113	110	112	W/m²
Extraterrestrial	420	434	438	425	403	388	392	412	430	433	422	413	417	W/m²
Clearness Index	0.538	0.509	0.524	0.535	0.546	0.583	0.580	0.546	0.540	0.542	0.549	0.539	0.544	
Amb. temper.	27.6	28.0	28.2	27.4	27.4	25.6	24.9	25.3	25.8	26.5	26.3	27.2	26.7	°C
Wind velocity	2.4	2.6	2.6	2.6	3.0	3.5	3.6	3.7	3.7	3.2	2.8	2.6	3.0	m/s

Solar paths at Pharos univeristy, (Lat. 0.0000° N, long. 0.0000° E, alt. 0 m) - Legal Time





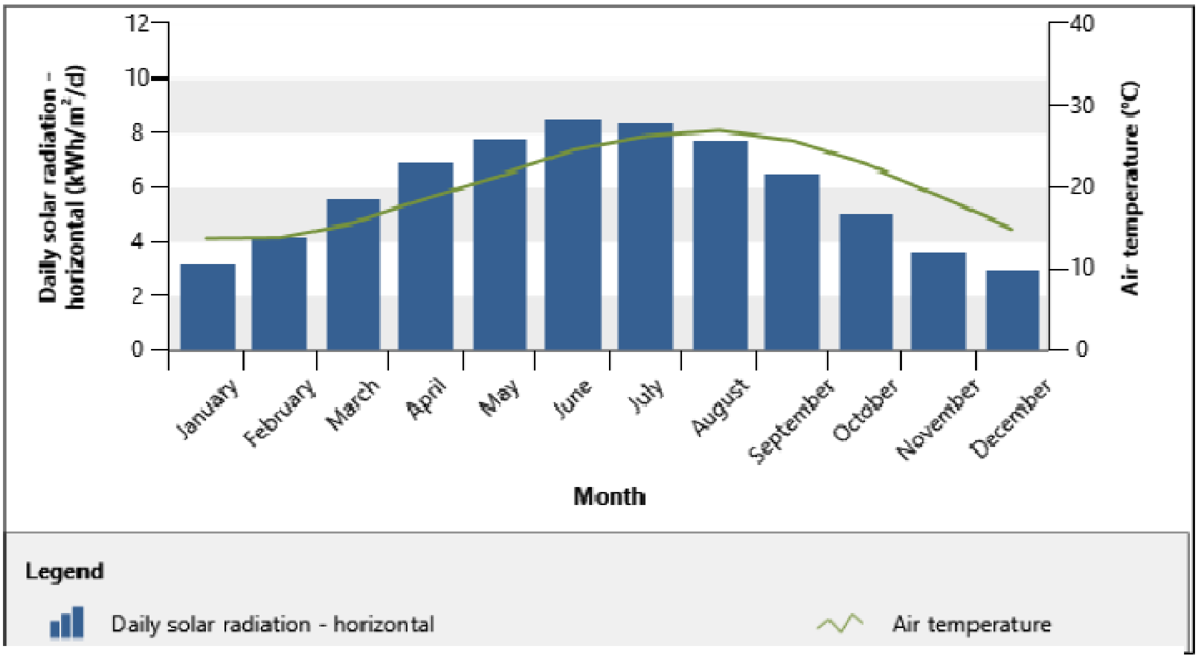
RET Feasibility report

Location | Climate data

Location

	Unit	Climate data location	Facility location
Name		Egypt - Alexandria/Nouzha	Egypt
Latitude	˚N	31.2	31.2
Longitude	˚E	30.0	30.0
Climate zone		2B - Hot - Dry	2B - Hot - Dry
Elevation	m	7	7

Climate data



	Heating design temperature		7.9						
	Cooling design temperature		31.2						
	Earth temperature amplitude		13.0						
Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	13.8	71.4%	37.78	3.21	101.6	3.9	16.1	130	118
February	13.9	69.1%	27.23	4.14	101.5	4.3	16.2	115	109
March	15.7	67.6%	13.09	5.56	101.3	4.4	17.9	71	177
April	18.7	65.8%	8.57	6.92	101.1	4.4	21.0	0	261
May	21.5	67.4%	3.96	7.79	101.1	4.3	24.3	0	357
June	24.6	69.1%	1.48	8.50	100.9	4.5	27.5	0	438
July	26.4	70.7%	0.03	8.35	100.6	4.7	29.5	0	508
August	27.1	70.7%	0.29	7.72	100.7	4.4	29.9	0	530
September	25.8	67.9%	2.65	6.56	101.0	4.0	28.5	0	474
October	22.9	67.4%	8.44	5.04	101.3	3.7	25.2	0	400
November	19.0	69.5%	16.01	3.64	101.5	3.5	21.3	0	270
December	15.0	71.9%	28.67	2.97	101.6	3.6	17.6	93	155
Annual	20.4	69.1%	148.21	5.87	101.2	4.1	23.0	409	3,797

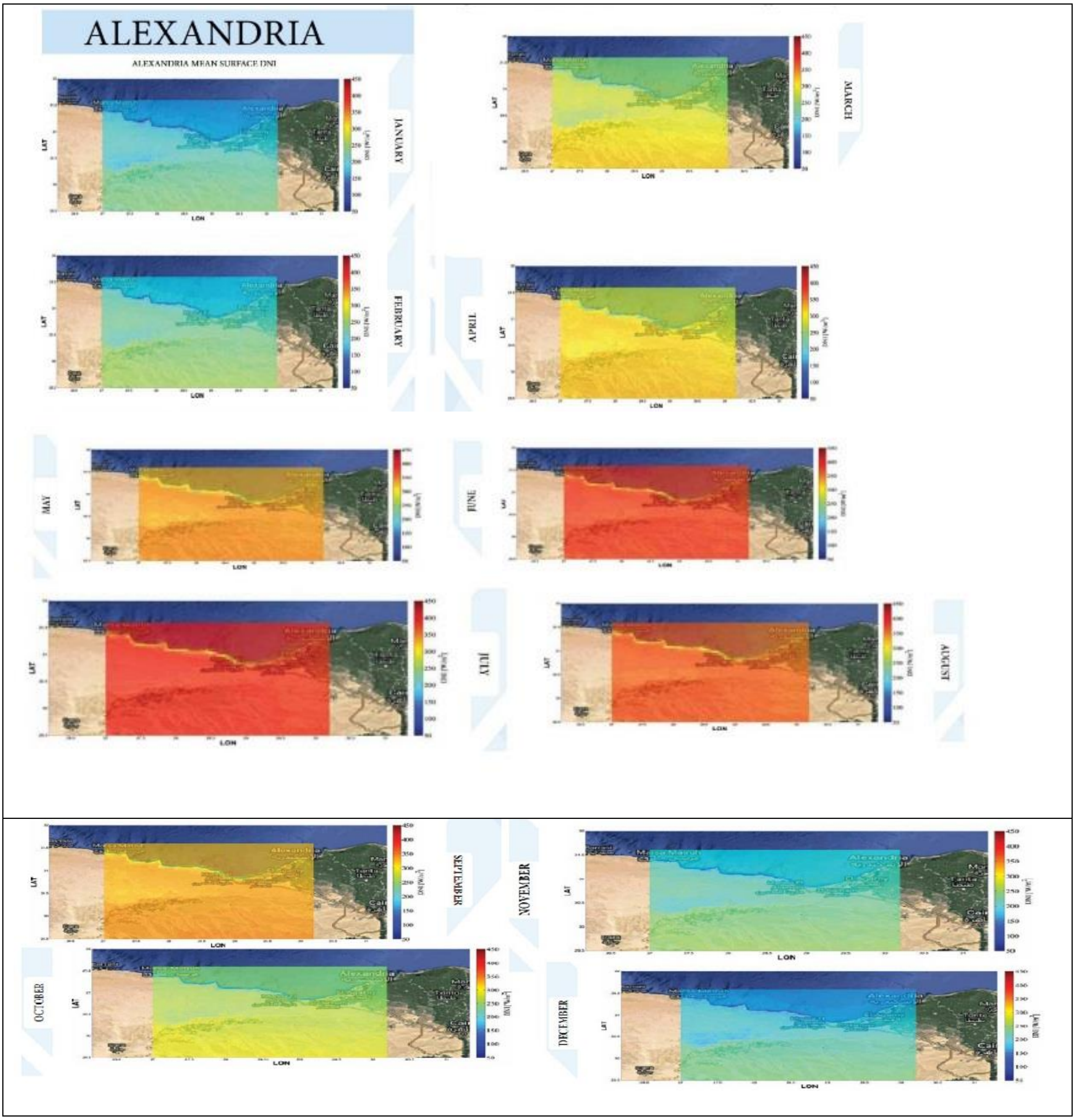
Places suitable for photovoltaic cells

Table 1
From PV Sys Program Table 1 the minimum Produced Power as following
W*L*N*PV
Where W is The Building Width by Meter
L is the Building longitude by meter
N is the Number of Building
Pv is the produced power watt per square meter 220 (table1)

Places suitable for making photoelectric cells

Roof Squar Area	**Name of Building**	**Min Produced Power**
Width 15m x length 30m	1- Flat building of the College of Engineering Two Roofs	**198 KW**
Width 15m x length 30m	2- Theoretical building flat Two Roofs	**198 KW**
Width 13m x length 30m	3- The flat of the College of Pharmacy	**85.8 KW**
Width 16m x length 21m	4- Flat College of Dentistry	**73.9 KW**
Width 10m x length 45m	5- Flat Art and Design Building (workshops) Two Roofs	**198 KW**
Width 16m x length 30m	6-Flat of the educational building 1Two Roofs	**211.2 KW**
Width 16m x length 31m	7- The flat of the educational building2 Three Roofs	**327.3 KW**
Width 11m x length 26.5m	8- The flat of the administrative building	**64.1KW**
6165.5 M^2	**1366.3 KW Total Produced Power**	

The SOLAR ATLAS of Egypt Map used as a reference and quid for the solar intensity in Alexandria



Results and discussion

Calculation of sizing and cost of consumption

Calculating the cost of consumption by using the bill of electricity/month for 2019 as shown in tables (1) and Table (2).

Table (1): Calculating the total consumption and the cell's production KWH/Month

Administrative Building		University Building		Total consumption	PV Cells Production KWH/Month
KWH	**cost**	**KWH**	**cost**	**KWH**	
24992	25023.75	423691.8	530991.95	448683.8	501625.08
23936	23964.1	360906	467285.05	384842	490527.18
23408	23435.8	218649.9	259706.1	242057.9	510503.4
21824	21850.95	141143.1	231669.9	162967.1	503844.66
24992	25020.65	290485.65	383188.55	315477.65	488307.6
25696	25725.05	360159.45	821233.65	385855.45	501625.08
34320	34353.75	453639.9	513450.25	487959.9	503844.66
44400	44436.35	528913.75	631780.75	573313.75	499405.5
51000	51039.5	566608.45	669976.95	617608.45	514942.56
51800	51839.9	592618	696332.5	644418	521601.3
50400	50439.2	825467.7	932280.15	875867.7	514942.56
27600	27628.25	372126.2	592607.25	399726.2	494966.34
404368	404757.3	5134409.9	6730503.1	5538777.9	6046135.92

Table (2) show the data collected for different years for Bill cost and the Cell production

Year	Bills / L.E.	PV KWH/Month
2015	1254893	6046136
2016	1587319	6046136
2017	3327799	6046136
2018	4741230	6046136
2019	5538778	6046136

Table (3): Calculation from the software PVSYST from

Ser	Month	PV w/m2	Total Area m2	Power (KW) pv syst	PV Cells Production KWH/Month
1	Jan	226	6165.5	1393.403	**501625.08**
2	Feb	221	6165.5	1362.5755	**490527.18**
3	Mar	230	6165.5	1418.065	**510503.4**
4	Apr	227	6165.5	1399.5685	**503844.66**
5	May	220	6165.5	1356.41	**488307.6**
6	Jun	226	6165.5	1393.403	**501625.08**
7	Jul	227	6165.5	1399.5685	**503844.66**
8	Aug	225	6165.5	1387.2375	**499405.5**
9	Sep	232	6165.5	1430.396	**514942.56**
10	Oct	235	6165.5	1448.8925	**521601.3**
11	Nov	232	6165.5	1430.396	**514942.56**
12	Dec	223	6165.5	1374.9065	**494966.34**
Annual Produced Power				**16794.822**	**6046135.92**

Conclusion

1. Calculation the cost and electrical load existing (2015 – 2019) reefer to graph NO.2THE Annual cost is reduced by the shown value.
2. Calculation of the cost and electrical for PV load by using two software's PV SYST V.6.85 and RET SCREEN estimated.
3. Determine the suitable area for PV cells = (6165.5 m2) which will give 1366.3kw reefer to table NO.1 the total area is 6165.5 square meter roofs area available by using sizing program can have produced 1366.3 kw/year.

References

1- Agrawal, Bassant, Tiwari, G.N., 2010. Optimizing the energy and energy of building integrated photovoltaic thermal (BIPVT) systems under cold climatic conditions. Appl. Energy 87, 417–426.

2-Ammari, H.D., 2003. A mathematical model of thermal performance of a solar air heater with slats. Renewable Energy 28, 1597–1615.

3- Athienitis, Andreas K., Bambara, James, O'Neill, Brendan, Faille, Jonathan, 2011. A prototype photovoltaic/thermal system integrated with transpired collector. Sol. Energy 85, 139–153.

4- Candanedo, Luis M., Athienitis, Andreas, Park, Kwang-Wook, 2011.Convective heat transfer coefficients in a building-integrated photovoltaic/thermal system. J. Sol. Energy Eng. ASME 133.

5- Chen, Yuxiang, Athienitis, A.K., Galal, Khaled, 2010. Modeling, design and thermal performance of a BIPV/T system thermally coupled with a ventilated concrete slab in a low energy solar house: Part 1, BIPV/T system and house energy concept. Sol. Energy 84, 1892–1907.

6- Chow, T.T., Hand, J.W., Strachan, P.A., 2003. Building-integrated Photovoltaic and thermal applications in a subtropical hotel building. Appl. Therm. Eng. 23, 2035–2049.

7- Battisti R., Corrado A., Evaluation of technical improvements of photovoltaic systems through life cycle assessment methodology. Energy, 2005;30:952-967.

8- Chow T.T., Ji J., Environmental Life-Cycle Analysis of Hybrid Solar Photovoltaic/Thermal Systems for Use in Hong Kong, Hindawi Publishing Corporation, International Journal of Photo energy, Volume 2012, Article ID 101968, 9 pages,
doi:10.1155/2012/101968

9- T.T. Chow, A.L.S. Chan, K.F. Fong, Z. Lin, W. He, J. Ji, Annual performance of building-integrated photovoltaic/water-heating system for warm climate application, Appl. Energy 86 (2009) 689–696.

10- J.-H. Yoon, J. Song, S.-J. Lee, Practical application of building integrated photovoltaic (BIPV) system using transparent amorphous silicon thin-film PV module, Sol. Energy 85 (2011) 723–733.

11- J.-H. Kim, S.-H. Park, J.-G. Kang, J.-T. Kim, Experimental performance of heating system with building integrated PVT (BIPVT) collector, Energy Procedia 48 (2014) 1374–1384.

12- H. A. Zondag, "Flat-plat PV-thermal collector and system: A review," Renewable and Sustainable Energy Reviews, vol. 12, pp. 891-959, 2008.

13- T. T. Chow, "A review on photovoltaic/thermal hybrid solar technology," Applied Energy, vol. 87, pp. 365-379, 2010.

14- M. A. Hasan and K. Sumathy, "Photovoltaic thermal module concepts and their performance analysis: A review," Renewable and Sustainable Energy Reviews, vol. 14, pp. 1845-1859, 2010.

15- Agrawal, S. and G.N. Tiwari (2012). Exergoeconomic analysis of glazed hybrid photovoltaic thermal module air collector. Solar Energy, 86: 2826-2838.