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# The Feasibility of Installing a Small-Scale PV System in a Carport in Kuwait

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## Abstract

*The need to obtain sustainable energy sources is one of the most important challenges in this century. Several alternatives have been sought, but attention has been focused on Wind Turbine and solar energy PV or CSP. The state of Kuwait is one of the countries that is working to Attain a Target of Achieving the 15% of its power production in 2030 from clean energy, and since Kuwait is in a hot and sunny region, it was worthwhile to have solar energy as one of the solutions. The state of Kuwait has established Al-Shagaya clean energy plant, which produces 70 MW moreover, there are Several privet ancillary power generation small scale projects have been established by consumers and small Businesses with the encouraging of Kuwait government that set Laws in 2022 to Allow the Ministry of Electricity and Water and Renewable Energy MEW to buy Power from citizens and consumers. The aim of this research is to find out how Feasible are the small-scale photovoltaic P.V. solar projects.*

**Key Words:** PV solar system, KFAS, Kuwait ancillary projects

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## 1. INTRODUCTION

The Kuwait Foundation for the Advancement of Sciences KFAS launched a project to exploit carport. This comes as a part of a plan to install photovoltaic cells in 2 cooperative societies in the First phase.

The co-operative societies are widely used by the public and, therefore one of the Objectives of this project is to use it as an excellent platform for high-profile demonstration for the public, also to promote the use of solar energy for electrical power generation and to raise public awareness on the technologies that will be applied. The second phase is to install photovoltaic cells in 150 homes to incentive the citizens and building owners to encourage their participation in the scheme though sharing the returns from the savings which considered as an initiative to accelerate the use of solar energy to produce electrical energy in Kuwait in implementation of the vision of His Highness the late Emir of Kuwait, Sheikh Sabah Al-Ahmad Al-Sabah, He has pledged to secure 15% of the GDP of electricity using renewable energy by 2030. The project is Funded initiated by The Kuwait Foundation for the Advancement of Sciences KFAS, Kuwait Institute for Scientific Research KISR will be a scientific partner which designed the PV systems and supervised the commissioning, the Ministry of Electricity and Water and Renewable Energy MEW which assure that PV plant is integrated in the local grid, The National Technology Enterprises Company NTEC will be a primary partner, And The Association of Co-operative Societies.

## II. Methodology

The research methodology is based on analyzing the outputs of installing photovoltaic cells on top of the carports of one project which located in Al-Adailiyah Co-operative Society in State of Kuwait (Fig.1)

Fig. 1. Al-Aaliyah Co-operative Society parking-lot shaded by PV solar panels.

The contribution of this project is to reduce the demand for electricity, especially during the peak period in summer seasons. We will also discuss the technical information and specifications of the photovoltaic cells that were used in the project. Before we proceed further, we will provide the annual production summary for Phase one in KFAS project by exploiting two selected co-operatives carport to install photovoltaic cells on their roof top (Table.1).

**Table.1: Annual Production (MWh) and Photovoltaic type installed in Al-Adailiyah COOP and Al-Zahra COOP in Kuwait**

| Project Type | Energy Photovoltaic type | Annual production (MWh) | instulation Area ($m^2$) |
|---|---|---|---|
| Al-Adailiya COOP | Monocrystalline | 311 | 1900 |
| Al-Zahra COOP | Thin Film | 484 | 6300 |

The annual production energy figures were computed by metering instruments as per the actual harvested power, and theoretically based on the following elements: -

A = PV solar system total area (m2)
P = Panel unit area designed power (W/m2)
E = Irradiance energy into time (W/m2-hr)
Q = Losses due to resistance (Heat, Impedance)

## 2.1 Basic analysis of Kuwait Energy consumption:

Kuwait urban Expand was huge due to the number of workers needed in industrial Areas after exporting Oil in 1940's, since then urban Areas are Expanding rabidly which led to high demand on electricity and power (Table.2). We can notice that the demand was more than double in the last 20 years, from 7750 MW in 2004 to 16180 MW in 2022.

**Table.2: Max. Consumption Load (MWh) of Electrical Energy in Kuwait During 2004-2022**

| Period | Max. Consumption (MWh) |
|---|---|
| 2004 | 7750 |
| 2005 | 8400 |
| 2006 | 8900 |
| 2007 | 9070 |
| 2008 | 9710 |
| 2009 | 9960 |
| 2010 | 10890 |
| 2011 | 11220 |
| 2012 | 11850 |
| 2013 | 12060 |
| 2014 | 12410 |
| 2015 | 12810 |
| 2016 | 13390 |
| 2017 | 13800 |
| 2018 | 13910 |
| 2019 | 14420 |
| 2020 | 14960 |
| 2021 | 15670 |
| 2022 | 16180 |

Kuwait location in the Arabian Peninsula keeps the weather conditions hot in summer season with high Temperature, as an average the temperature reaches 45 C° in summer and 6 C° in winter so, the demand on Energy in summer season will be High specially in August, but in February it's less demand.

**Table.3: Monthly Max. Consumption (MWh) of Electrical Energy in Kuwait 2022**

| Month | Max. Consumption (MWh) |
|---|---|
| January | 132893 |
| February | 127777 |
| March | 152912 |
| April | 196776 |
| May | 268840 |
| June | 304554 |
| July | 308316 |
| August | 316942 |
| September | 292749 |
| October | 242133 |
| November | 208754 |
| December | 164367 |

## 2.2 PV system details:

The used P.V. panels are Monocrystalline type, The unit panel size is 150 W, covering a total area of 1900 m2, over a fixed-tilt gantry (Figure.2) forming an angle of 37o with horizon, facing the south-west which is considered as an optimal orientation. The scheme is divided into 17 P.V. strings each of them is connected to grid-tied 3-phase inverter (SMA-AG), With a total name plate power of 268 kw, these inverters are feeding the co-op in one direction only not feeding back the grid.

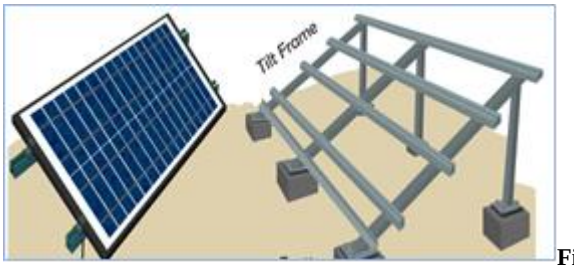


**Fig. 2. Shed gantry general elaboration.**

## 2.3 Energy Efficiency of Photovoltaic System in Kuwait.

Al-Adailiyah Co-operative Society Supermarket Carport Production from P.V. cells start from sunrise till sunset, because P.V. cells are affected by sunlight, so it's varied in the daytime, and it reaches its peak at noon (Figure.3).

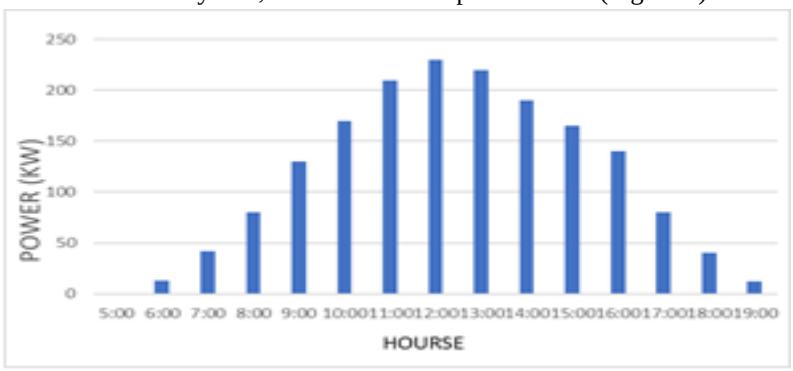


**Fig.3: Daily Production (KW) of Electrical Energy in Al-Adailiyah Co-operative Society carport P.V.**

The Production vary over the months, we find out that the maximum production was in July that was 36 MWh, and the minimum was in January, which was 14 MWh, this was clearly shown in the monthly production summary for Al-Adailiyah Co-operative Society carport found in (Table.4).

**Table.4: Monthly Production (MWh) of Electrical Energy in Al-Adailiyah Co-operative Society carport.**

| Month | Production (MWh) |
|---|---|
| January | 14 |
| February | 18 |
| March | 29 |
| April | 35 |
| May | 33 |
| June | 33 |
| July | 36 |
| August | 31 |
| September | 26 |
| October | 21 |
| November | 17 |
| December | 16 |

From the beginning of the project on 15 June 2016 the total production is 2,667 (MWh), and that's reduce 2,467 Tons of $CO_2$, it saves almost 4,448 Oil Barrels from burning in power stations, which saves almost 125,000 K.D. (Figure.4)


**Fig.4. Annual Production (MWh) of Electrical Energy in Al-Adailiyah Co-operative Society carport P.V.**

The Carbon emissions reduction by the same system since it was started up can be calculated as follows: -

$$C_t = E_t * C_f$$

$C_t$ = *Total Carbon mass (Tonnes)*
$E_t$ = *Total produced energy ($MWh_t$)*
$C_f$ = *Carbon mass per 1kWh produced from petroleum fuel (kg)*

, Whereas Cf for the generated 1 kWh of electricity by petroleum fuel is 0.924 kg/kWh.

But when applying the capacity factor (C.F. %) indicator to our system, the outcome result is not satisfactory with respect to the universal standards.

Reference to (Table.1) we shall compute the (C.F. %) considering the annual average output 309 MWh-Yr. as the following equation:

$$C.F.\% = [\, E_a / (P*24*365)] * 100$$

$E_a$ = *Annual produced energy (kWh-year)*

$P$ = *System nameplate power (kW)*

*24, 365= Number of hours per year*

*= [309 MWh*1000 /(365*24*268 kW)]*100*

*= 13.16 %*

, whereas the universal average C.F.% is 20%!

## III. Result and Discussion:

From all above figures and data we can signify that it was very encouraging to use Al-Adailiya carport as renewable energy source by installing P.V. solar cells, and from characteristic curves in (Figure-5) and (Figure.6), where the highest period of consumption is from May till September, and the highest period of production is also from May till September, So if this project will be Applied on more COOPs, that's will definitely help in reducing the consumed energy from the traditional power stations specially in High demand months of the year.

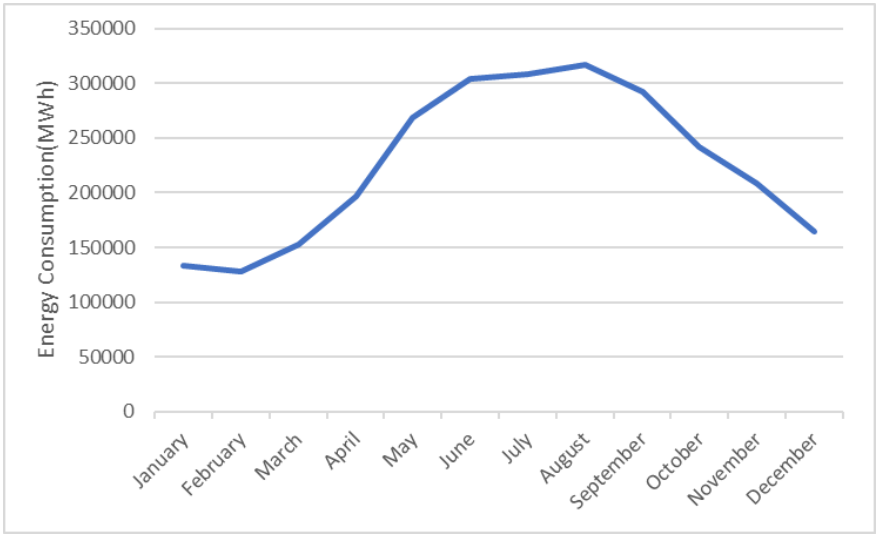


**Fig.5. Monthly Consumption (MWh) of Electrical Energy in state of Kuwait during 2022**

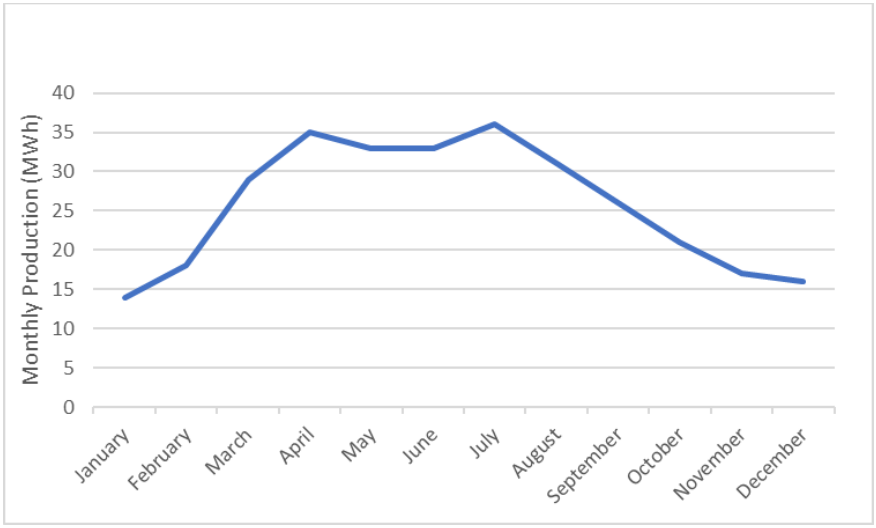


**Fig.6. Monthly Production (MWh) of Electrical Energy in Al-Adailiyah Co-operative Society carport**

But in terms of system's efficiency and economic feasibility the outcome of this project was not satisfactory enough since the capacity factor (C.F.) that we've calculated earlier was 13.16% due to low annual average output energy which was 309 MWh-year, whereas the universal average C.F. is ranging between 18% – 22%.

Meanwhile, KISR's has stated that the initial system C.F. was around 17% in the first 2 years, and probably the power output diminishing can be justified due to the lack of proper maintenance and cleaning of the cells, also it can be referred to the high impedance issues.

### IV. Conclusion

Based on the results, we can say as a conclusion that the feasibility of installing P.V. solar cells in carport in Kuwait has significantly helps to reduce the demand on the grid specially during highest demand months of the year with its small production especially if it's in large scale systems.

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