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DESIGN AND IMPLEMENTATION A PROTOTYPE OF SOLAR CAR PARKING FOR LIGHTING LOAD

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ABSTRACT

This work described the on-grid strategy to provide energy for lighting loads. This technique included connecting a lighting lamp directly to the public utility grid shared with solar PV array in order to reduce the consumption of energy during peak hours in day. A solar car parking prototype model has been designed practically consisted of 66 W_P PV array included PV modules and smart inverter (700 W). Case study illustrated successful implementation of on-grid solar PV system across various lamp load. The results showed the on-line monitoring data on power generation in kW_h/kW_p for each lamp under different irradiance and constant temperature (25°C). Finally, it has been concluded that the maximum power generated obtained by smart inverter was (18.7W) at irradiance (760W/m^2).

KEYWORDS

Smart inverter, solar PV plant, power generation, Mosul climate data, car parking.

1. INTRODUCTION

Approximately 99 % of installed capacity worldwide is made up of on-grid solar PV systems as compared with the stand-along systems which include batteries. Battery fewer on grid solar PV system are requiring less mantenance and cost effective (Ali et al., 2023). No batteries need for on grid solar PV system and the grid receives the generated power for distribution and consumption. The main advantage of installing a solar carport is the flexibility it offers in customizing and designing solar projects (Bashar et al., 2023). The orientation and angle of the solar panels significantly influence the energy output, allowing for optimized placement. Therefore, a solar carport can be designed to enhance the positioning of solar panels, which may not be as easily achievable with a rooftop solar panel system. Additionally, the solar car parking has been incorporated into a green home system to promote smart and sustainable transformations within the community (Sreedevi et al., 2016). This integration encourages the use of renewable energy in everyday applications, thereby enhancing electric mobility. Furthermore, the energy generated by the solar panels will be influenced by sunlight availability (Pedro et al.,2016). It is designed to be directed to supply power to the building through a DC/AC converter and a DC/DC inverter, making it a crucial component of an intelligent grid power system. Taking everything into account, solar parking is an ideal option for residential and commercial uses since it provides great versatility in utilizing solar power. Access to solar energy has greatly increased thanks to the lower prices of PV panels (Farhana et al., 2019). Office buildings and industrial sites have tremendous potential for PV panels because of their flat roofs' large area. A few include warehouses, college buildings, factories, etc. Although this potential exists to replace fossil fuels with a quiet and clean energy source for powering transports, it is still largely untapped (Nawal et al., 2019). The aim focus on self-sustaining power systems and electricity generation is to optimize onsite usage while minimizing exchanges with the grid during peak load hours using PV energy for cross subsidized balancing services.

2. CONTRIBUTION

Grid connected solar PV system plays a major role in system energy landscape, communities, individuals, broader energy grid and offering numerous contributions to individuals. The key contributions like: Environmental benefit (clean energy generation), reduce carbon emission by harnessing solar energy, this system will generate electricity without Buring process of fossil fuels (Raad and Nabeel, 2024).

Economic advantages (cost saving) lower electricity bills, businesses and homeowners can significantly reduce or eliminate thein monthly bills value by generating their own power.

enhancing energy security and independence reducing the reliance on the grid where, grid connected solar PV systems allow consumers to generate a major portion of electricity and reducing the dependence on utility companies and fluctuating energy cost. Grid support and stability PV systems usually generate the higher electricity during peak demand hours that helps to alleviate stress on the grid and prevent blackouts, also these systems can reduce transmission loss and improved grid resilience (Fatima and Asmae, 2022).

3. IMPACT OF CONNECTED SOLAR PV SYSTEM TO THE GRID

When the penetration of solar PV panels is high, PV systems can subject the grid with several negative impacts like, over voltage along distribution feeders, reverse power flow, phase unbalance, voltage control difficulty, power quality problems, increased reactive power and is lauding detective difficulty (Chia-Hung et al., 2012).

4. LITERATURE REVIEW

Designed a smart grid solar carport at that constructed York University, this solar carport is an early step in reducing emissions. A creative smart grid approach is here for developing electric mobility solutions on campus and a sensible and regionally oriented response to climate change, they arrived that this project differs by incorporating a green building method to bridge the gap in PV production (Fabrizio et al., 2014).

Study of the King Abdelaziz University patent application, the application of PV panels in energy generating systems discussed in various forms or and/preparations to maximize sunshine exposure. In order to prevent light-obstructing materials like sand, dust, leaves, and other wreck from covering PV panels, they decided that this carport project would be part of the green building system rather than just producing electricity, and that the energy generated would be used to energize a green building (Ana et al., 2021).

Conducted the system's sizing, design, and feasibility study using HOMER Pro. Also modeled in Simulink were the major parts of the system-PV, inverter, battery, controller, and load. A DCDC buck-boost converter powered by the Perturbation and Observation (P&O) Algorithm served as our solar charge controller (Nasir et al., 2020).

5. METHODOLOGY

The car parking structure consists of 66 PV modules, tidied in 6 rows of 11 modules. The company Shenzhen, China of polycrystalline module model SKU:262, with 1Wp. The development of solar PV system efficiency depends on the production of predicting PV generation under various environment conditions (Abdal-Razak et al., 2025). PV module can link with each other in series or parallel or combined from numbers of modules in series for each string and connecting all strings in parallel on the desired power, the main unit of PV module is a PV cell which convert light to electricity (Safwan et al., 2024).

Small PV module and Table 1 describes the module characteristics as shown in Fig. 1.

Fig. 1. Mini PV module

Table 1. PV module characteristics

Parameter	Value
Working voltage (V)	6
Output power (W)	1
Working voltage (mA)	0-200
Product size (mm)	110*60*2.5

Six distinct strings separated the two models of several PV modules. Thus, the inverter utilized in this system should have at less two independent maximum power point tracking (MPPT) (Bashar et al., 2024). The PV layout is comprised of 11 modules with 610Wp and a 6. 71 kWp string, made up of 11 modules of 610 Wp. The total power of the two strings therefore is 40. 2 kWp. The company provided an inverter, model SG700MD, which has a power capacity of 700 Wp and includes a built-in monitoring system (Mouli et al., 2016). In Fig. 2, the inverter displayed in the upper right corner of the image. The key specifications of this inverter are summarized in Table 2. Inverter with capacity (86W) enough to coverage the load, but 700W smart inverter has been used because only this type available in the markets (Seyed et al., 2024).

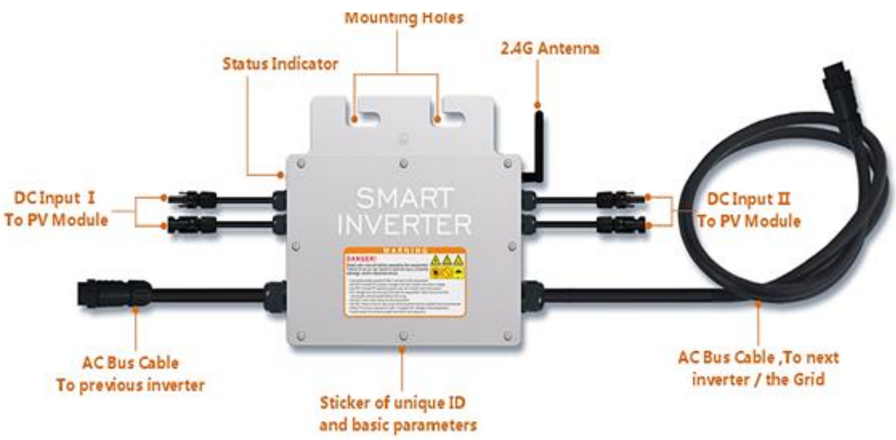


Fig. 2. Smart inverter

Table 2. Inverter type SG700MD characteristics.

Parameter	Value
Number of inputs MC4 connector	2 set
MPPT voltage range	24V-40V
Operation voltage range	18V-50V
Maximum input voltage	50V
Startup voltage	18V
Maximum input power	2*350W
Maximum input current	2*14A
Number of inputs MC4 connector	2 set

6. SMART GRID UNDER STUDY

The design of car parking project at Northern Technical University-Technical Engineering College-Mosul/Iraq. In order to supply the electrical engineering techniques department was likely due the donation of equipment by solar plant laboratory for its construction (Ali et al., 2023). The donated item, supplied by the team, was a plastic framework designed to support the PV module in a solar garage that accommodates two parking spaces. This structure features a sealing system to prevent water leakage between the modules (Ahmed et al., 2022). Additionally, it includes an intermediate clip that runs the entire vertical length of the row of elements, along with silicone applied horizontally at the contact points between each module. The structure dimensions and aspects of the module (Ali et al., 2023). And the google aerial photo is depicted in Fig. 3.

(a) **(b)**

Fig. 3. Car parking inside Technical Engineering College – Mosul
(a) Aerial photo. (b) PV strings dimensions

The block diagram that describes the connection of solar PV car parking is depicted in Fig. 4.

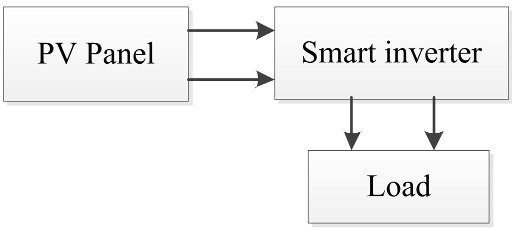


Fig. 4. Carport project to allocate the equipment

7. FLOWCHART OF SOLAR CAR PARKING

The flowchart of the project work is illustrated in Fig. 5.

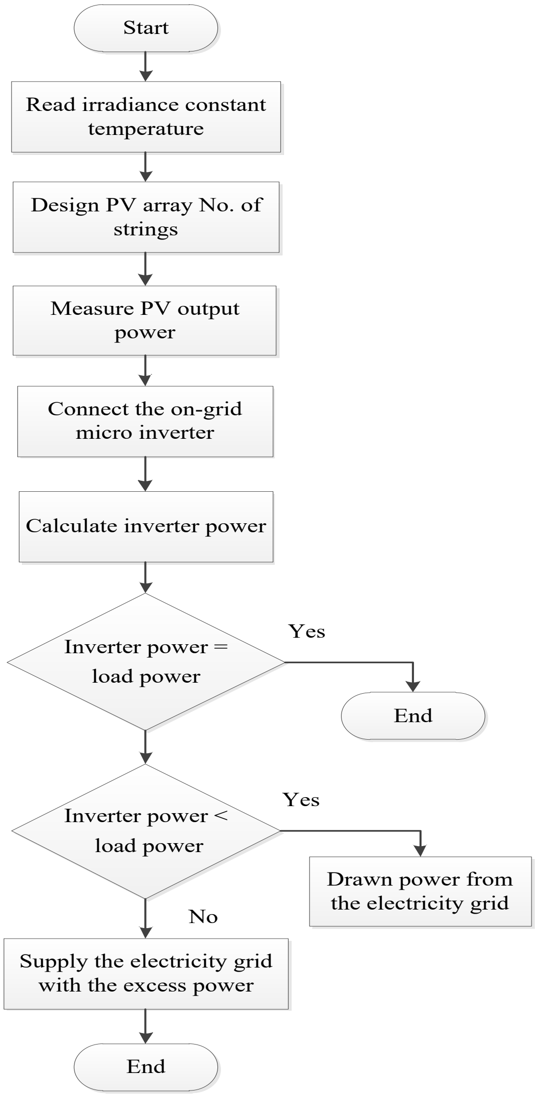


Fig. 5. Flowchart of sharing PV array electricity grid

8. SOLAR PV SYSTEM SIZING

8.1. Energy calculations

The agreeable is to add the wattage of each device that should be powered using the solar PV plant, therefore a base load calculator that are affordable on the site. Each device has a fixed consumption of the power that can be given on the name plate.

8.2. PV sizing

When the total load that energized using the solar PV array has been calculated it is necessary to find out what is the area of solar array which required to generate a much amount of power. After driving the total watt-hours on the peak sun or a total power will be obtained. After the total power calculated and driving it on the wattage of one panel a number of PVs panel has been obtained. Energy amount at day, this PV system is used to feed the college building energy per day equal:

E= 66W*6 = 396 W.h

Energy loss (E_p) = $\frac{E}{K} = \frac{264\ Wh}{0.65} = 406.15\ Wh$

Peak sun hour in month Feb. = 6.2 h

Total power = $\frac{406.15\ Wh}{6.2\ h} = \ 65.50W$

Number of PV modules = 65.50 ≅ 66 Pcs

8.3. Inverter sizing

Inverter sizing = total power * 1.3 = 85.8 W

At least the inverter power must equal 85.8 W, but in this work inverter with (700 W) has been used because only this type available in the market.

9. RESULTS AND DISCUSSION

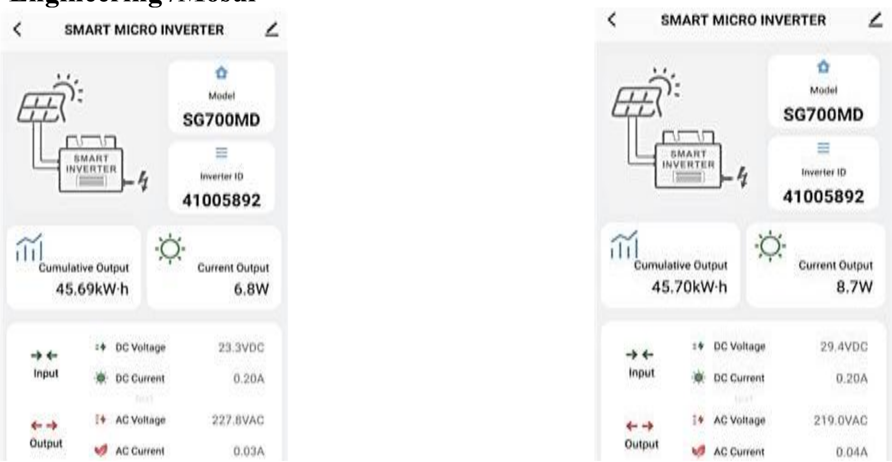
The pictures of the final prototype structure are given in Fig. 6.

9.1. Case one: At Load (9W)

In the first stage, on grid solar PV board has been shared to feed the load as shown in Fig. 7. At irradiation 420W/m^2 and 540W/ m^2 the generated power from the PV array were 6.8W and 8.7W as given in Fig. 8, therefore 2.2W and 0.3W have been drawn from the national electricity grid to share the load respectively.

Fig. 6. Real pictures inside Technical College Engineering /Mosul

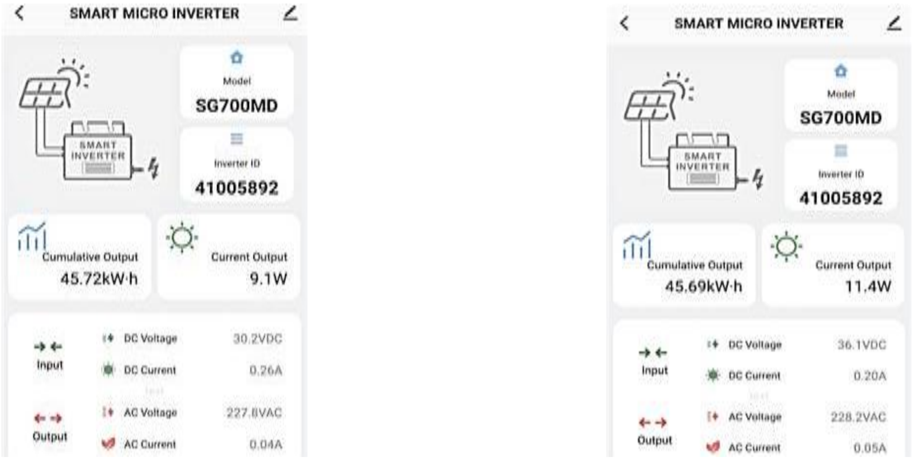
Fig. 7. Prototype model feed lamp load (9W)



(a) **(b)**

Fig. 8. Data from smart inverter (a) at Irr. 420 W/m^2 (b) at Irr. 540 W/ m^2

At irradiation 576W/m^2 and 610 W/m^2 the generated power from the PV array were 9.1W and 11.4W as given in Fig. 9, therefore excess capacity value 0.1W and 2.4W have been fed to the national electricity grid respectively.



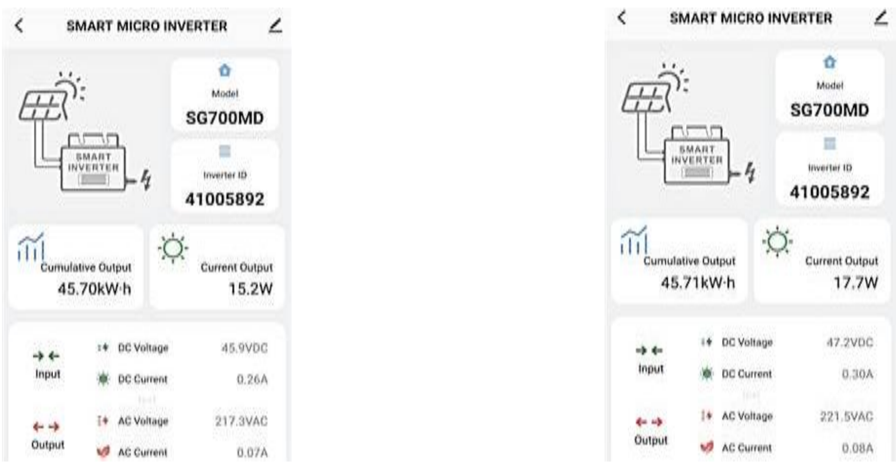
(a) **(b)**

Fig. 9. Data from smart inverter (a) at Irr. 576 W/m^2 (b) at Irr. 610 W/ m^2

9.2. Case two: At Load (18W)

In the second stage, on grid solar PV board has been shared to feed the load as shown in Fig.10. At irradiation 660W/m^2 and 695W/ m^2 the generated power from the PV array were 15.2W and 17.7W as given in Fig. 11, therefore 2.8W and 0.3 have been drawn from the national electricity grid to share the load respectively.

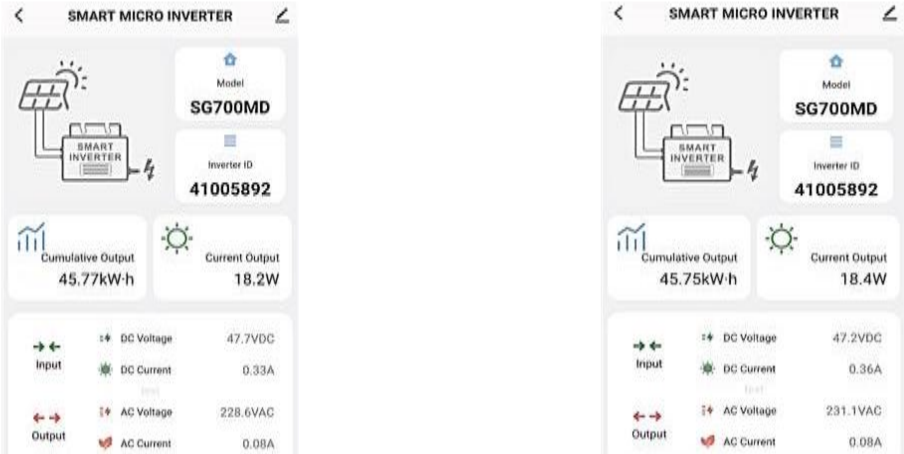
Fig. 10. Prototype model feed lamp load (18W)



(a) **(b)**

Fig. 11. Data from smart inverter (a) at Irr. 660 W/m^2 (b) at Irr. 695 W/ m^2

At irradiation 710W/m^2 and 722W/ m^2 the generated power from the PV array were 18.2W and 18.4W as given in Fig. 12, therefore 0.2W and 0.4W have been fed to the national electricity grid to share the load respectively.



(a) **(b)**

Fig. 12. Data from smart inverter (a) at Irr. 710 W/m^2 (b) at Irr. 722 W/m^2

9.3. Case three: At Load (68W)

In the third stage, on grid solar PV board has been shared to feed the load as shown in Fig. 13. At irradiation 760W/m2 the generated power from the PV array was 18.7W as given in Fig. 14, therefore 49.3W has been drawn from the national electricity grid to share the load.

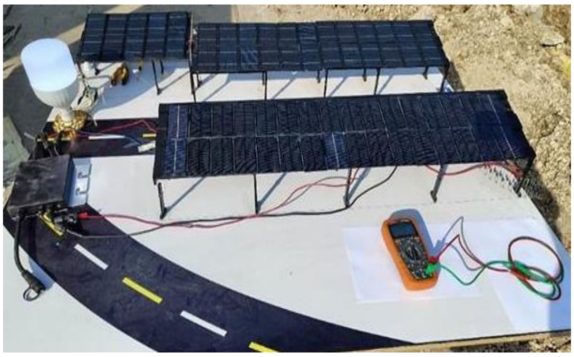


Fig. 13. Prototype model feed lamp load (68W)

Fig. 14. Data from smart inverter at irradiance 760W/m^2

The reading kWh in all previous figures of smart inverter represented the cumulative output overall days as of the first day of operating. The final practical results which obtained from the three cases are listed in Table 3.

Table 3. Results obtained from three cases

Case Number	Irradiance (W/m^2)	Power from PV (W)	Power drawn from grid (W)	Power supplied (fed) to the grid (W)
One at load 9W	420	6.8	2.2	---
	540	8.7	0.3	---
	576	9.1	---	0.1
	610	11.4	---	2.4
One at load 18W	660	15.2	2.8	---
	695	17.7	0.3	---
	710	18.2	---	0.2
	722	18.4	---	0.4
One at load 68W	760	18.7	49.3	---

10. CONCLUSION

This work has success fully showed a prototype developed of solar car parking model. With a large scale, this model may be used in university parks, public parks, malls, and apartments. It can be concluded that this project considers an energy source and a reliable source that used to provide electricity to many sites in addition to university parks and can be sold to the grid and reducing the electricity bill.

• From case one, at irradiance between approximately (0-560) W/m^2 the power has been drawn from the grid to boost the load, but at irradiance 560 until 1000 W/m^2 the power fed to the grid.

• Case two, at irradiance between approximately (660-705) W/m^2 the power has been drawn from the grid to boost the load, but at irradiance above 705 W/m^2 until 1000 W/m^2 the power fed to the grid.

• From case three, at irradiance 760 W/m^2 until 1000 W/m^2 the PV didn't excess the 20W, therefore in this case the power always must be drawn from the grid.

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