Improving Existing Methods of Generating Electrical Power Supply and Air Ventilation Inside Food Trucks

Azhar Abdullah
Politeknik Kota Bharu
azhar@pkb.edu.my

Ibrahim Abdullah
Politeknik Kota Bharu
ibrahim@pkb.edu.my

Zulkifli Mohd Yusoff
Politeknik Kota Bharu
zulkifli@pkb.edu.my

Noor Hisham Koya
Politeknik Kota Bharu
noorhisham@pkb.edu.my

Mohd Zahidi Mohd Zain
Politeknik Kota Bharu
mzahidi@pkb.edu.my

Abstract
Unlike restaurants that have fixed connections to the grid for all their electricity needs, food truck entrepreneurs need the appropriate power that can be used to handle electrical equipment. This makes mobile generators an important part of today's food trucks. However, the use of fuel-generating generators is not only noisy, these fossil fuel sources are decreasing and this causes fossil fuel prices to rise. It also causes air pollution such as acid rain, haze and rising earth temperatures. FIC KITCHEN TECHNOLOGY SDN. BHD. has opened an offer through the PPRN program to researchers from Public Institutions to submit proposals for solutions to improve existing methods for generating electricity in Food Trucks and to identify ways to improve ventilation in Food Trucks. Solar energy is one of renewable energy and will not be exhausted. The use of a silent solar power supply system without air pollution is not just to light a lamp, but it is also larger for machines in food trucks such as mini fridge, food warmer heater, coffee maker, sink water pump, blender and 1HP air-conditioning. The results of the study show the effectiveness of the use of solar systems in food trucks in terms of fuel cost savings as well as the system's power supply capabilities in handling electrical equipment. This project has opened another era of advancement in the production of food trucks using an eco-friendly supply system.
Keywords: food truck, mobile generators, solar energy

1.0 Introduction

Food trucks have now become a business trend and are evolving in the local cultures that bring a variety of local cuisine. It's easier and faster for those who love food and, most importantly, this food truck is everywhere. Not just food, the food truck is also decorated with a variety of shapes and styles, as well as stickers according to the food theme brought. However, unlike restaurants that have fixed connections to power grid lines, food trucks require a distinctive power supply to operate all their electrical needs. This makes the mobile generator of fossil fuels a major part of today's food truck. Problems that arise, the use of mobile generator fossil fuels in addition to noise, this energy source has been steadily decreasing and this has caused fossil fuel prices to soar (Kazman, 2011). It also causes air pollution such as Acid Rainfall, Haze and Increased Earth Temperature. As a proposed solution, the method of solar system application applied in the Food Truck to see its ability to operate all electrical needs for cooking use throughout the business time is a fact. Researchers see that solar energy is one of the renewable and renewable energy alternatives (Zachary, 2013). The use of solar power systems has several advantages: saving money for not using fuel, environmentally friendly as it is cleaner than air pollution and low maintenance costs.

Traditionally, the use of fossil fuel generators in generating electrical power of food truck can create noisy and pollution to the environment and highly costing in terms of fuel and maintenance. It is observed that the ventilation system in the food truck is less conducive. This study proposed a new approach to generate power system in the food truck using solar energy. Hence, the use DC air condition could improve ventilation system in the food truck.

2.0 Design of Solar Power System

The design of the solar system is composed of several combinations of equipment to complement the practical DC supply system. Among the equipment needed is a solar panel that functions as a solar energy converter to DC power supply. This solar panel needs to be equipped with a solar power controller that works to block the reverse current from the battery to the solar panel and prevent overcharging of batteries, protecting from electrical loads and displaying battery status. Next, it will be connected to several batteries that serve as the mainstay of the power supply to the equipment in the food truck. Additionally, DC to AC inverter should be used to switch on equipment that still uses 240V AC power supplies such as mini fridge, lamp, food warmer heater and blender for now. Probably, in the next few years all this AC equipment available in a more energy-efficient DC supply. One of the devices available to use DC power supply is air-conditioning, this device is still new in the market. This DC air-conditioning will be tested on the food truck to see how far it is suitable as ventilation in the food truck. This solar power system also has disadvantages when there is no sunshine at the rain or night. To accommodate these weaknesses, it is necessary to complete the connection with the 240V AC power supply socket to facilitate the charging process for batteries. Figure 1 shows the block diagram of a proposed power system using solar.

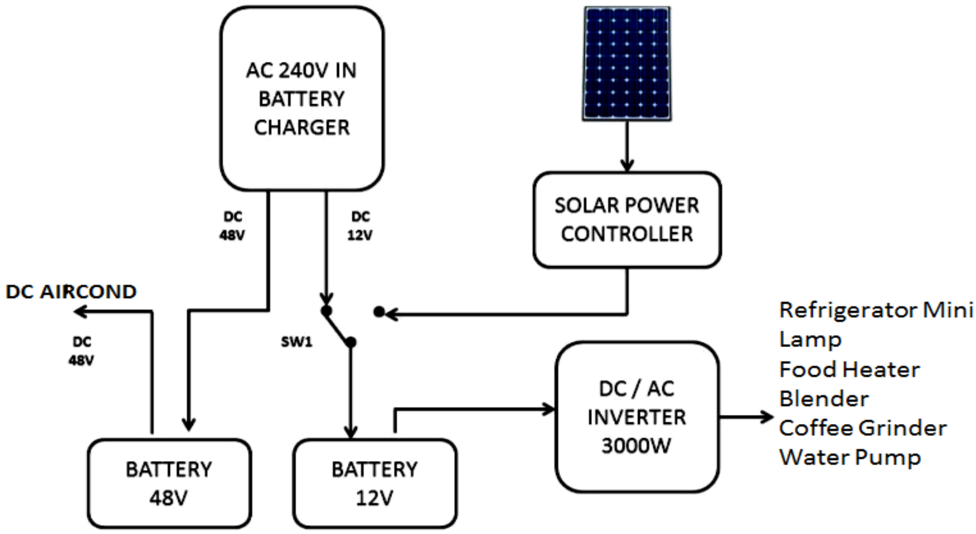

Figure 1: Block diagram of solar food truck system

2.1 Solar Panel

4 pieces of Monocrystalline Solar Panel 12V, 160W has been installed on the roof of food truck. The solar panel is connected in parallel to produce a maximum current of 52 Amp. Figure 2 illustrates the installation process of solar panels on the top of food truck.

Figure 2: Installation of solar panels

2.2 Solar Panel Controller

Solar power controller that works to block the reverse current from the battery to the solar panel and prevent overcharging of batteries, protecting from electrical loads and displaying battery status. The design of the solar power controller consists of four parts; the raking blade, the traction system, the frame and the control panel as illustrated in Figure 3. The design has been copyright approved by the Intellectual Property Corporation of Malaysia (MyIPO) with registration number *LY2018001007*.

Figure 3: Solar power controller

2.3 12V and 24V Battery

10 pieces of 12V, 60AH rechargeable battery used to generate power for 7200W to inverter supply as shown in figure 4. The 7200W is estimated to operate electric appliances such as mini fridge, food warmer heater, lamp, coffee maker, blender and sink water pump throughout the day running business. While, 2 pieces of 24V, 200AH rechargeable battery is used to operate DC air-conditioning for ventilation inside the food truck.

Figure 4: Solar power controller

2.4 DC/AC 7kW Inverter

The 7000W is estimated to operate electric appliances such as mini fridge, food warmer heater, coffee maker, sink water pump and blender throughout the day running business as shown in Figure 5.

Figure 5: Power inverter

2.5 24V DC Air-conditioning

24V DC air-conditioning is used as ventilation equipment in the food truck as illustrated in Figure 6.

Figure 6: DC Air-conditioning

2.6 Inlet socket for battery charger

Inlet socket 240VAC for Battery Charger is used for charging battery when there is no solar power source. This socket will be connected to the 240VAC electricity supply source as shown in Figure 7.

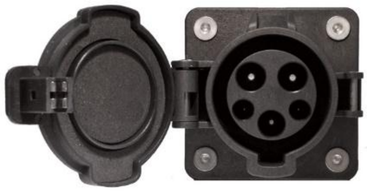

Figure 7: Inlet socket 240VAC

2.7 Distribution board

The distribution box is used as the connection point of the wiring circuit to all electrical equipment located on the truck as shown in Figure 8. It also functions as a switching system and protection against electrical equipment.

Figure 8: Inlet socket 240VAC

2.8 The Food Truck System

Figure 9 shows all the systems are installed in the food truck.

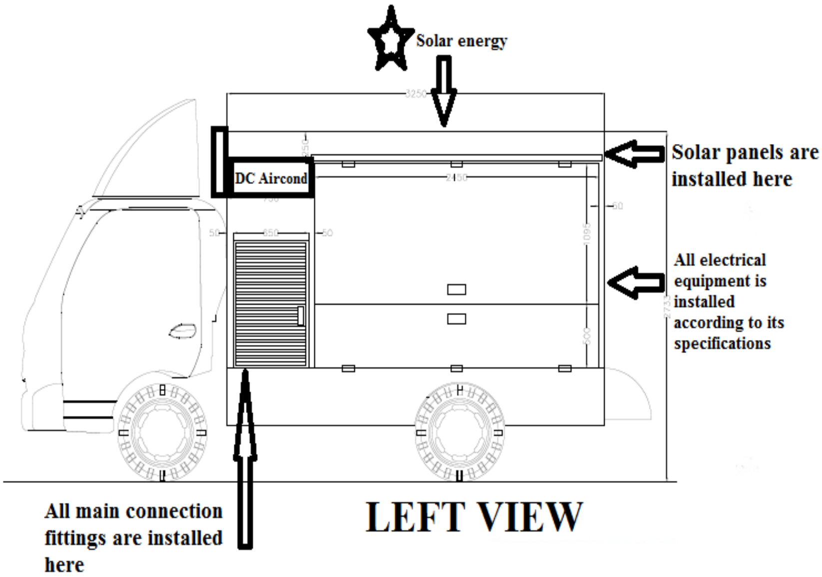

Figure 9: Side view of the food truck

2.9 The Overall Cost of The Solar System

Table 1 indicates the total cost of proposed system.

Table 1: Total cost to complete the solar system

Peripherals	Cost (RM)
Panel Solar	3800
Solar Power Controller	550
Battery	1830
Inverter	5300
Distribution Board + others	813
Total Cost	**12293**

3.0 Modelling and Analysis

Some features of a panel solar description has been highlighted for further references.

3.1 Output Current of Panel Solar

The maximum and minimum current of solar panels is directly proportional to the irradiance of sunlight and the same occurred to the voltage inputs of solar panels. This ensures the operation of the system works well (Ryan, 2012). Figure 10 described the relationship between solar panel current with voltage curve which respect to the irradiance of sunlight.

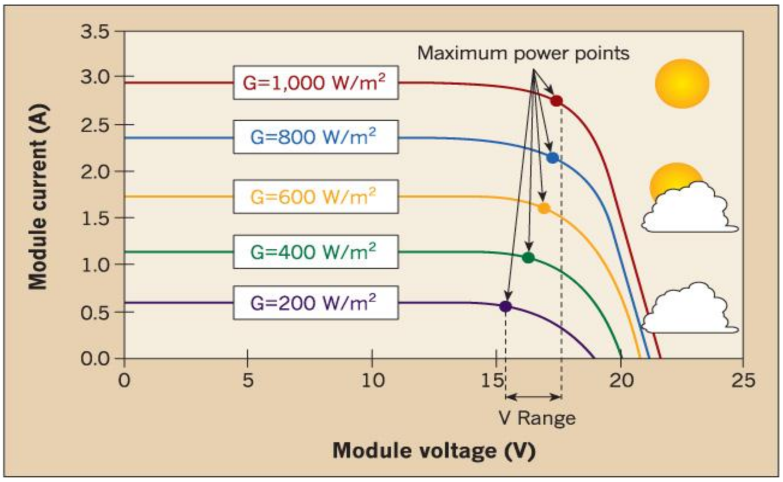

Figure 10: A solar panel current versus voltage curve varies with the irradiance of sunlight.

As shown in the graph, current dramatically changes as irradiance varies, but voltage remains relatively constant. The solar panel operating capacity versus the panel power output is shown in Figure 11.

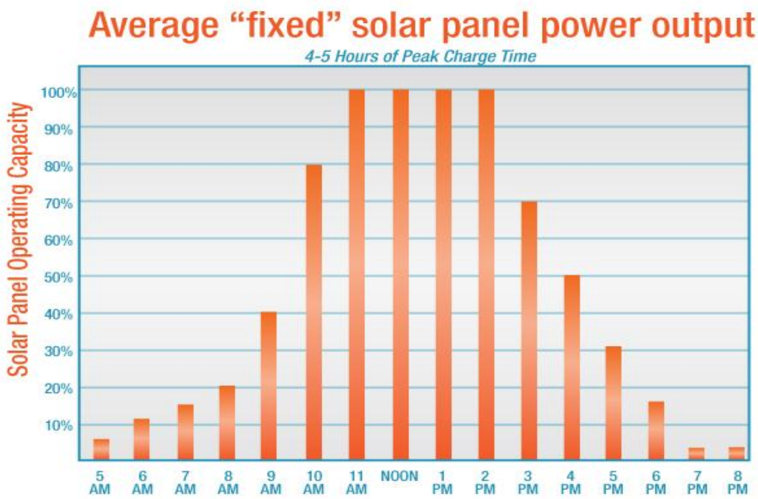

Figure 11: A solar panel take 4-5Hours of Peak Change Time (John, 2012)

The maximum current output from 1 pieces Monocrystalline Solar Panel 12V, 160W is 13A. The solar panel is connected in parallel can produce a maximum current of 52Amp. This current is used for charging a 60AH battery to 10pcs; the total battery capacity is 60AH x 10 = 600AH. With an input from 52A solar panel for 5 hours, the total capacity charged to the battery is 52A x 5H x 12V = **3120WH**.

3.2 Estimated Total of Power Required

Power consumption plays an important role in running business. Table 2 shows the tabulation of power consumption for a few devices in a food truck. Next, Table 3 shows the total amount of 1HP air conditioner based on 12 hour operation.

Table 2: Power required running the business from 10am -10pm (Retrieved from: *http://www.solarfasttrack.com/Bahasa/bab5/bab5d.htm*)

Devices	Power (Watt)	Expected time of use (Hour)	Total (WH)
Lamps	5 x 4pcs	12	240
Mini fridges	450	5	2250
Food warmer heaters	850	4	3400
Coffee maker	200	3	600
Blender	100	3	300
Sink water pump	5	3	15
		Total Power	**6805**

Table 3: Power required running the DC air-conditioning

Devices	Power (Watt)	Expected time of use (Hour)	Total (WH)
1HP air-conditioning	745.7	12	8948.4
		Total Power	**8948.4**

3.3 Remaining Power

Estimation of the remaining power of the proposed system has been mentioned in Table 4.

Table 4: Remaining power

Devices	Power (Watt)	Total (WH)
Battery 12V (inverter)	60A x 12V x 10pcs	7200
Power are used for inverter		6805
The remaining power of inverter		395
Solar power charging inverter		3120
Remaining power after business hours		3515
Battery 24V (air-conditioning)	24V x 200AH x 2pcs	9600
Power are used for air-conditioning		8948.4
	Remaining Power	**651.6**

3.4 Charging Process using Socket 240V

Domestic 240V electric supplies are used to charge the battery fully at night. To re-run the business the next day, the battery needs to be recharged to the full state of the business to run in good condition.

The amount of power required returns to charge 10pcs 12V batteries = 7200 – 3120 = 3685 Watt.

The amount of power required returns to charge 2pcs 24V battery = 9600-651.6 = 8948.4Watt.

The total amount of power required when charging = **12633.4Watt**.

Estimated time taken for charging process = 12633.4 W / 240V / 8A = 6.58 hour.

Estimated average cost of TNB bill = 12.64W x 30hari x RM0.50 = **RM189.60**.

Estimated fuel cost if using generator = RM2.00 x 15liter x 30 = **RM900.00**.

3.5 Estimated Comparison of Solar System and Generator for One Year

The cost comparison between the solar system and generator has been illustrated in Table 5.

Table 5: Costs comparison between solar system and generator

Item	Solar systems	Diesel Generator
Item price	RM12293	RM6000
TNB/Diesel Costs	RM2275.20	RM10800
Total Costs	RM15083	RM16800
	Savings	**RM1717**

4.0 Results and Discussion

The proposed system has been tested accordingly to evaluate the power consumption in the inverter for a few hours on 3 consecutive days. The time taken for fully charging also recorded for further evaluation upward power inverter.

4.1 Power Consumption in The Inverter for 3 Consecutive Days

The use of battery power is recorded when food truck is used throughout the operating business. Table 6 shows the percentage of power consumption remaining in the inverter during business hours.

Table 6: The percentage of power inverter remaining during business hours

Hour	1st day	2nd day	3rd day
10am	100%	100%	100%
11am	95%	97%	98%
12pm	92%	90%	93%
1pm	90%	84%	87%
2pm	85%	80%	81%

3pm	80%	75%	76%
4pm	72%	70%	70%
5pm	65%	66%	65%
6pm	58%	59%	58%
7pm	52%	50%	53%
8pm	49%	48%	47%
9pm	43%	44%	45%
10pm	41%	43%	40%

Figure 12 shows the power consumption in the inverter for 3 consecutive days.

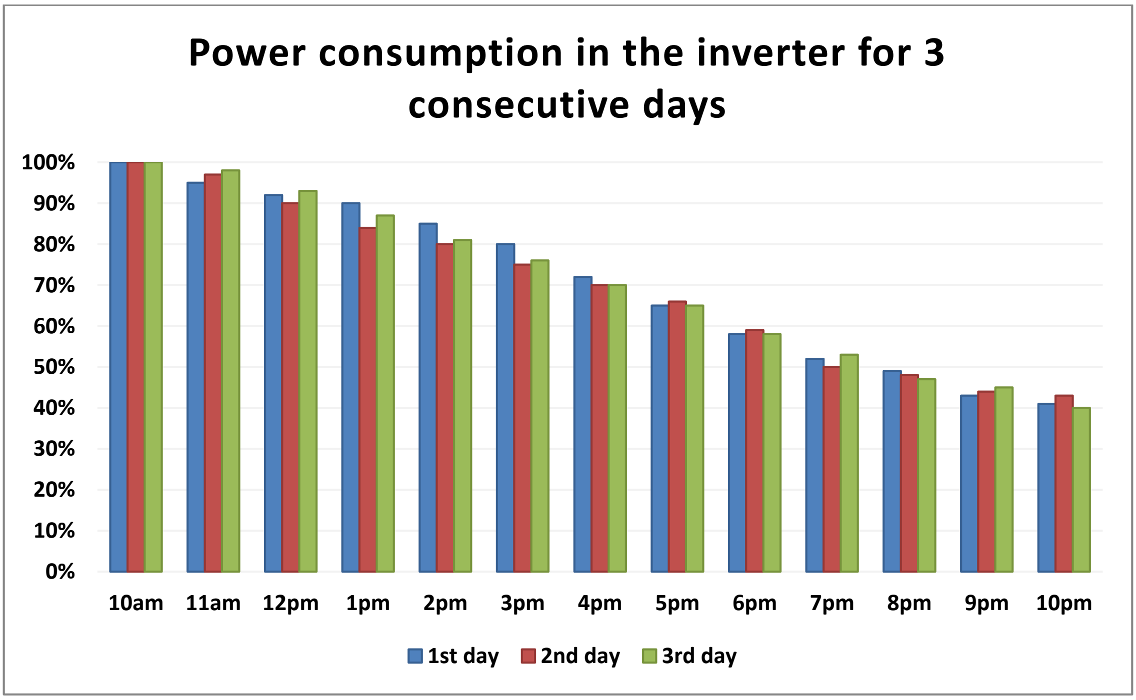

Figure 12: The graph shows a decline in power consumption

4.2 Time for Full Charge Process

The charging process starts at 12.00 pm until the morning. It is recorded using a camera that is focused on solar controller status. Table 7 indicate the delivered time for charging process in 3 consecutive days.

Table 7: Delivered time for charging process

1st day	2nd day	3rd day
7 jam 30 minutes	7 hour 25 minutes	7 hour 40 minutes

5.0 Conclusion

The proposed system has been tested to achieve the aims of improving the use of power system in the food truck. The percentage of the power consumption is remarkable when using solar system. However, energy harvesting techniques could also be used to provide the proposed system with power source to extend the battery energy and for low maintenance cost.

Acknowledgment

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