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DESIGN AND FABRICATION OF SOLAR POWERED FOOD TRUCK

SENIOR DESIGN PROJECT

Senior Design Project Report

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Abstract

This project aims to provide with the idea of converting the regular food trucks to solar powered food truck in order to become environment friendly and rather using scarce resource of fossil fuel to utilize free and abundant source of energy that is solar energy. It is eco-friendly to switch food trucks to save costs with renewables and provide food service which is earth friendly. This will be achieved by setting up a solar panel the roof of the truck. The photovoltaic cells of the panels will convert the sun's energy directly into electric energy. This can take load of kitchen partially or completely depending on the size of the solar panel and its efficiency.

Acknowledgment

First of all, we would declare that we are very thankful to Almighty Allah who has blessed us with wisdom, knowledge and courage to complete our four year engineering program and provided us with the ability to work on our senior design project report.

Secondly, we would like to pay our sincere appreciation and innumerable thanks to our Chair of Mechanical Engineering Department, Dr. Faramarz Djavan Roodi whose guidance, constructive comments, support and advice has enabled us to gain profound understanding throughout this period. We would also like to express my sincere thanks to all the faculty member of the department, who have helped us at times and in many ways and made this whole process pleasant.

In the last we would like to express our acknowledgement to our parents for their everlasting love, dreams and sacrifices they made throughout their lives to make us see this day,

List of Acronyms

P	Power output
I	Current
V	Voltage
Ah	Ampere Hour Rating
Wh	Watt Hour Rating
T	Charging time of battery
A	Current Ampere
E	Potential energy
T	Time

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Chapter 1: Introduction

1.1 Project Definition

This project aims to design and fabricate solar powered food truck via solar panels attached to the roof of the truck. This idea is proposed in support off the Saudi vision 2030 which plans along with other agendas to reduce the dependency on the oil or other fossil fuel to become more environment friendly. The food truck will be powered by 2 solar panels made of mono-crystalline cells of silicon and multi busbar, an electricity conducting thin strip of copper or aluminium between the cells of solar panel. Multi busbar is used instead of traditional 3-busbar to avoid significant losses of current and to make higher cell and system efficiency. The proposed design aims to run food truck engine on the solar power by using a battery which is charged by the solar power and then generates electric current will be used as power source to run the truck along with this the appliances used in food truck will also be powered by the solar panel like juicer, kettle, toaster, coffee maker, fridge and lights. This proposed design will give maximum results even in low sunlight and will show good resilience as a system to small reparations, which are always possible particularly in moving food truck.

1.2 Project Objectives

Solar powered food truck is now an increasing trend mainly in America so as in concept it is not new but this project aims to design and fabricate such a solar powered food truck, which tends to be more efficient and economical than the existing models in the market. To distinguish it from others our project strives to achieve following mentioned objectives:

- To produce higher power output electricity using solar panel
- To use mono-crystalline solar panel to ensure the highest quality by offering high conversion efficiency
- To optimize the weight and assembly of the solar panel to allow complete strength to the system

- To make such strong model to withstand high wind pressure and sand storms
- To use solar power to power the generator instead of fossil fuel
- To build arched roof design to have maximum sun exposure
- To design environment friendly and economical solar food truck

1.3 Project Specifications

Project specifications are given in tables below:

Table #1.1: Specifications of Project

PART	DIMENSION/WEIGHT
BRUSHLESS D.C MOTOR	60V / 3Kw /120° / 3-phase
LITHIUM ION BATTERY	201*196*128* - 8 kg
8 ANGLE BAR	40*40*5mm 6m
5 FLAT BAR	40*5mm 6m
2 SOLAR PANEL WEIGHT	8kg
OVERALL SYSTEM WEIGHT	≈200kg

Specifications of mono-crystalline solar panel

Table # 1.2: Specifications of Solar Panel

Characteristics	Specifications
MODEL NO.	BSP 98-300
MAXIMUM POWER (Pmax)	300 watts @ 1000w/m^2
MAX POWER VOLTAGE (Vpmax)	54 V
MAX POWER CURRENT (Ipmax)	5.55 A
OPERATING TEMPERATURE (°C)	-40°C ~+85°C
MAXIMUM SYSTEM VOLTAGE	1000V DC
JUNCTION BOX	IP65 Rated
WEIGHT	4.0 kg
DIMENSION	1820*920*2.5mm

Figure # 1.1: Mono-crystalline flexible thin-film Solar Panel.

1.4 Project Applications

Saudi Arabia in terms of climate falls under desert weather, which is categorized as extremely hot during daytime and relatively cool nights. The average temperature in summers in KSA is about 45°C but temperature rising up to 54°C is quite common. The length of day in KSA is also very good which makes the application of this project very useful and important as to use natural solar energy instead of fossil fuel.

Applications of this project are as follow

- This model can be applied to mobile ice cream vans as well
- Solar powered food trucks can be introduced in the universities and schools which have the capacity to have one
- Mobile food trucks operating at Azizia beach Half Moon beach and other areas of KSA can be converted to solar energy to save unnecessary fuel consumption
- This project if implemented properly all over the country it will provide opportunity to become eco-friendly and cost-effective.

Chapter 2: Literature Review

2.1 Project Background

There are over 40 known and famous food truck franchises around the kingdom along with these there are hundreds of mobile truck working only in Al Khobar, Dammam, Azizia Beach and Half Moon Beach which are contributing towards air pollution and consuming a lot fossil fuel unnecessarily. If food trucks are converted into solar powered trucks even if not completely either just for running the truck or for kitchen appliance it will reduce the gas emission up to 60 percent which will be a great achievement in regard with the Saudi vision 2030 which aims to reduce Saudi Arabia's dependency on oil, broadens the horizon of its economy and bring advancements in public sector like health, education, infrastructure, recreation and tourism.

Goals of vision 2030 are interlinked to some extent for example if food truck are transformed and shifted to solar energy it will create a demand for this solar system and to build this solar system it will require to construct more solar panel, now this rise in demand will open new jobs and new business and to supply to this demand market will provide new opportunities. This will bring more money in economy; provide new businesses to the market and in result will be an eco-friendly food truck

Food trucks trend is increasing in KSA in many cities and it is also being very famous and people are liking it depicting that earning well by selling good amount of items which in result releases a lot of pollution into the air and adds up to the global warming and also consumes a lot or petrol and diesel for truck and generator for cooking appliances.

Average Day Light / Sunshine Al Khobar Saudi Arabia

Table # 2.1: Average Daylight in Al Khobar

MONTH	DAYLIGHT HOURS	SUNSHINE HOURS
SEP	12	9.1
OCT	12	10
NOV	11	9
DEC	11	6.9

2.2 Previous Work

Solar powered food trucks are nowadays very popular in terms of that it is eco-friendly and also because in monetary terms it is very economical as it requires some investment in the beginning in the name of solar panel but in log run it is proved to be saving money. According to William Young of Sun Tree Farm Consulting, Titusville, Florida, USA some of the chefs are also opting for solar powered food trucks even for gourmet food because in long run saves a great amount of money as a truck with solar power will be enough and one will not have to pay for any utility bill or rent for restaurant. He even designed a food truck with all the kitchen appliance for gourmet food and according to him systems viability depends on the weather greatly.

A project named design and fabrication of solar car carried out by Chudamani Sharma, Abhishek Verma, Bhupendra Yadav, Om Prakash Sahu, Akash Jangde and Atul Pandey suggests that solar car as compared conventional cars have the cleanest and tranquil energy output up till now as solar car is actually a solar powered electric car. According to the study environment related many issues are solved and studies proved solar car to be the best pollution free vehicle. Study explains the need to switch to solar powered cars as it will help to save the reserves of fossil fuel which are declining drastically. Solar vehicles cons are also discussed like less speed range and initial high cost which when compared to the risk of carbon

dioxide emission caused by conventional cars affecting global warming is worth opting.

An article by Daniele Cardello articulates about Tesla starting a campaign with involvement of VS Veicoli Speciali of solar powered food truck by presenting the F-Trailer the first ecologic trailer of its type. It is based on batteries alimented by PV photo voltaic panels and furnished with the professional kitchen where all the appliances and gadgets to be used in kitchen are particularly designed to operate on solar power efficiently by consuming less energy and providing with desired results and also will have least negative impact on the environment.

The already done research and the models of solar powered food truck provides us insight to come up with a better and unique model of said project. These studies also acts as a guide to where to improve and where to improvise. These studies show that this solar technology is more effective and efficient for a county like KSA as it is blessed with a good amount of sunlight all-round the year.

2.3 Comparative Work

Solar powered food truck is an emerging technology which makes it both easy and difficult to work on easy in terms of that there will be no problem in finding the material and resource person for the project to complete and difficult also in regards with what is new or different offered in this project why to choose this project over any other solar powered food truck. So to make this project stand out the solar powered food truck is completely powered by the solar panels. Solar panels will not only support the battery to power the engine but also will provide direct current to the kitchen appliance.

Saud Arabia's real GDP's 30 % – 40 % is comprised of oil, which does not include the segment of the economy which is dependent on the oil distribution. Problems is that the reserves of fossil fuel is declining drastically and there is a dire need to switch the main power source to save the fossil fuel before it's too late, for this purpose this project suggest to convert the recreational item which food truck on solar energy.

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1: Geometrical Constraints

For solar food truck to be effective and efficient there are some constraints, which are to taken under consideration. First of all the major constraint is the weight. Truck itself is usually quite heavy and food truck are heavier which makes the it lesser fuel efficient the more the weight of the food truck more power will be required to keep it mobile. Solar panels weigh 4 kg each and in the beginning keeping weight constraint in mind we will install 2 solar panels on the roof which will increase the weight of the truck by 8 kg approx. along with another problem being faced is that either to install multiple batteries or to have an extra source like a generator on the truck which will not only increase the weight but also take up the space.

3.1.2: Sustainability

As a whole system design should be able to hold it self physically and functionally and it is not very complicated or fragile system apart from the solar panels as they require some care. The system is quite sustainable, as we have designed this particular system keeping in view the supportive climate and surroundings. There is huge market of food trucks in all of the Saudi Arabia and they are increasing day by day as many brands are taking up this opportunity to be more mobile. Once the system is properly installed there are less chance that it fails to work, for this unseen situation it is suggested to keep an alternative source of power like a spare charged battery of a generator on the truck. To make sure it functions well first of all make sure that solar panel is properly exposed to sunlight and secondly all the wiring is intact.

3.1.3: Environmental concern

Environmentally this project is very supportive as our solar food truck in terms of fossil fuel consumption can act 100% eco-friendly. It leaves no air pollution behind and neither damages any scarce fossil fuels. It will be completely operative on the solar energy. This projects promotes to use the abundant source of energy particularly in Saudi Arabia which is going wasted unused. In the shadow of this project we would to participate in the Saudi2030 goals to be completely eco-friendly.

3.1.4: Social impact

Food truck in kingdom is nothing new they have been always here especially seen on the beaches in different cities. It is a form of entertainment and fun so impact our society negatively just for entertainment cause by damaging fossil fuel which is already at verge of extinction and by releasing toxic gasses in the air like carbon monoxide. These harmful gasses are causing unrepairable damage to the ozone layer. This project will bring a positive impact on our society and will give awareness to use solar energy.

3.1.5: Economic

The financial considerations attached with this project are largest concern and constraint. As solar energy usage is not that commonly used neither commercially nor in households, which makes the access to the spare parts and solar panel bit difficult and more expensive. The initial cost of this project is very high as compared to a regular food truck but after the initial installation of setup and investment of money there will be less or no cost in terms of power source for lifetime, which is big relief. Apart from some repairs and a battery change in 10-15 years it will cost you nothing but one needs a foresightedness to understand the need. Solar panels due to less need are produce or manufactured on smaller scale so their cost is quite high same it goes with the appliance and engine of the truck. If solar energy usage is made compulsory it will bring huge change in market in terms of prices.

3.1.6: Safety

This purposed system is planned such to make it more safe for the operator and customers as well. For time being no stove or burner is being used in the truck to keep it safe. Along with this fuse are also used to minimize the damage in case of short-circuit. DC motor is used with a 3 phase so that low voltages are produced. Lithium ion battery is used which is safe to use as in terms of discharging. The exterior system is waterproof and storm proof. The system can handle heavy rains and regular sand storms**.**

3.1.7: Ethics

Solar food truck is not a new or unique idea as this is being practiced already in many countries especially in America and many ideas and designs and different

models are in market operative and for sale as well. We intend to promote the same practice here in Saudi Arabia where we have the sunlight for the longest hours and almost all round the year except for a month or two. Saudi Arabia is wealthy country economically and in terms of sun as well. Our projects will be a great success if practiced by the majority.

3.2 Engineering design standards

For any system to have a strong foundation in the engineering it must have followed and applied the engineering standards. Before going into the details of engineering standards used or followed first have look at the components of the solar food truck.

3.2.1: Components of Solar Food Truck

Table # 3.2.1: Components and Weight

COMPONENTS	WEIGHT
BRUSHLESS DC MOTOR	8kgs
STEERING WHEEL	6 kg
STEERING COLUMN	15 kg
STEERING RACK	8kg
LITHIUM ION BATTERY	20 kg
CHARGE CONTROLLER	8 kg
2 MONOCRYSTALLINE SOLAR PANEL	8 kg
HEADLIGHTS	8 kg
WHEELS 4	19 kg
UNDERPLATE	30 kg
REAR AXLE	40 kg
FRONT AXLE	40 kg
BRAKE PEDAL	6 kg
SPEEDOMETER	5kg
COFFEE MAKER	1.4 kg
KETTLE	800 g
TOASTER	650g

3.2.2: Components and Dimension

Following table shows the dimensions of the some of the components of the solar food truck:

Table # 3.2.2: Components and Dimensions

COMPONENTS	DIMENSIONS
TIRE 500-12	Diameter 55cm, width 13 cm
STEERING WHEEL	Diameter 35.3 mm
MOTOR	Length is 1.8m with wheels
THE MOUNT HOLE DISTANCE	100 mm
MONO-CRYSTALLINE SOLAR PANEL	1820 x 920 x 2.5mm

3.2.3: Component material

The following table shows the engineering standards used for the components of the solar food truck along with the materials of which there being made to assure the good quality and stable project.

Table # 3.2.3: Components and Engineering Standards

COMPONENTS	ENGINEERING STANDARDS	MATERIAL
TIRE	ASTM F118	Natural rubber NR
TIRE RIM	ASTM 569	Q235 plain carbon structural steel
ANGLE BAR	ASTM A569	Carbon steel
FLAT BAR	ASTM A569	Carbon steel
STEERING WHEEL	ASTM D7254 PP	Plastic
VIPER BLADES	ASTM PIAA 95055	Super silicon
HEADLIGHTS	ASTM D49592	Polycarbonate plastic
MOTOR	ASTM 45	Steel

3.2.4: Power requirements

As this whole project depends on the power required and power generated so to make this easy to understand following table show which appliance requires how much power to be operative.

Table # 3.2.4: Power Requirements

APPLIANCES	POWER
Lithium ion battery	12V- 100 Ah
Brushless DC Motor	60V / 3kw / 120° / 3 phase
Coffee maker	12V DC plug
Kettle	800w
Toaster	700w

3.3 Theory and Theoretical calculations:

3.3.1: Solar panel:

In order to achieve the best out of the solar panel we have decided to use Mono-crystalline solar panel. These panels have the highest efficiency rates as they made from highest grade silicon. Solar panel module 350W-72M will be producing maximum power voltage of 39.1V. As compared to other solar panel types mono-crystalline is bit expensive but it also gives a cell efficiency of 21%.

3.3.2: Power output:

Lithium ion car batteries the lithium ions move from negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. It is assumed that for one operational hour battery needs 3 hours of charging with this we can simply conclude that for 12 operational hours of battery is supposed to be charged for 36 hours. Truck engine requires 250 amps for half second and the most current a 1.5volt. The formula with the help of which this amp is calculated is given below

Amps = Watts / Voltage supply

Main aspect that has to be calculated is the power output of battery to be installed. For this purpose we have to divide the voltage by the resistance of the load to get the current, once we have both the current and voltage multiply them to get the power output as shown below.

Power output = current x voltage

$$P = IV$$

Another main aspect to be considered is the capacity of lithium ion battery that is watt hour rating now for this we have to multiply ampere hour rating and voltage. A basic battery charger will need around 2 amperes for a period of 24 hours to deliver 48 amps for a 12-volt battery rated at 48 Ah. Now from this we can easily find the capacity of the battery by multiplying ampere hour rating of 48 Ah with the voltage of 12 volts and will give the watt hour rating equals 576Wh.

Watt hour rating = Ampere hour rating x voltage

$$Ah \times V = Wh$$

Hypothetical calculation

$$Ah \times V = Wh$$

$$48Ah \times 12V = 576\ Wh$$

3.3.3: Charging and discharging:

Charging of battery:

Charging time of battery = battery Ah / charging current

$$\mathbf{T = Ah / A}$$

Hypothetical calculation

Suppose for 120 Ah battery we will firstly calculate current for 120 Ah battery as we know that charging current should be 10% of the Ah rating of the battery

Charging current for 120 Ah battery = 120 Ah x (10/100) = 12 Amperes

Keeping the losses in mind will take 12- 14 amperes instead of 12 amperes for battery charging purpose. Now suppose we took 13 Amp for charging purpose then,

Charging time for 120 Ah battery = 120 / 13 = 9.23 hrs.

Again this will the ideal case but as we know that in lithium ion batteries 40% of losses occur in case of battery charging then,

120 Ah x 40% of losses = 120 x (40 / 100) = 48

120 Ah + losses = 120 + 48 = 168 Ah

Now finally putting the values in the formula

Charging Time of Battery = Ah / charging current

12.92 = 168 / 13

Charging time of battery = 13 hrs.

So a 120Ah battery will take 13 hours to fully charge.

Discharging

When no more ions flow the battery is fully charged and ready to use but during discharging the ions flow back through the electrolyte from the negative electrode to the positive electrode. Unlike other batteries like NiCad batteries, lithium ion batteries don't have the charge memory which means that deep discharge cycles are not required. In fact it is better for the battery to use partial discharge cells. Battery experts suggest to discharge almost completely the lithium ion batteries after 30 charges.

Hypothetical calculation

Example:

Suppose

Battery Ah = 120 Ah

Battery voltage = 12 V

Applied load = 100 watts

Now putting the values in the formula

Discharging time = Battery Ah x battery volt / applied load

Discharging time = 120 Ah x 12 V / 100 W

Discharging time =12 Hrs.

Now this will be true in ideal condition and we have to keep in the view the 40 % percent loss at max

After loss correction

12 x 40 / 100 = 4.8hrs.

Now according to this discharging will take 4.8 hrs.

3.4 Manufacturing and assembling:

Our project is to completely shift a food truck from fossil fuel to soar energy. For this purpose we will mount 2 mono-crystalline solar panels on the truck parallel to the roof so that the efficiency of the solar panel is increased as it can access sunlight whole day. This solar panel will generate enough energy to power the truck, which will be running on lithium ion battery. Mono-crystalline solar panel and lithium ion battery is used to minimize the loss of any sort of power or energy. The batteries will power the coffee maker and kettle as well along with this there is a toaster as well on the truck. Both the coffee maker and kettle will use 12 volts of power for one time use.

Efforts are made to keep the truck light so that less power is required to start and run the truck. Given below are the pictures of some of the components of the truck.

Fig # 3.4: Switch set with steering, lights, wiper and ignition

Fig # 3.4(a): The mount hole

Fig # 3.4(b) Motor and axle

Fig # 3.4(c): Plates

Fig # 3.4(d): Steering wheel

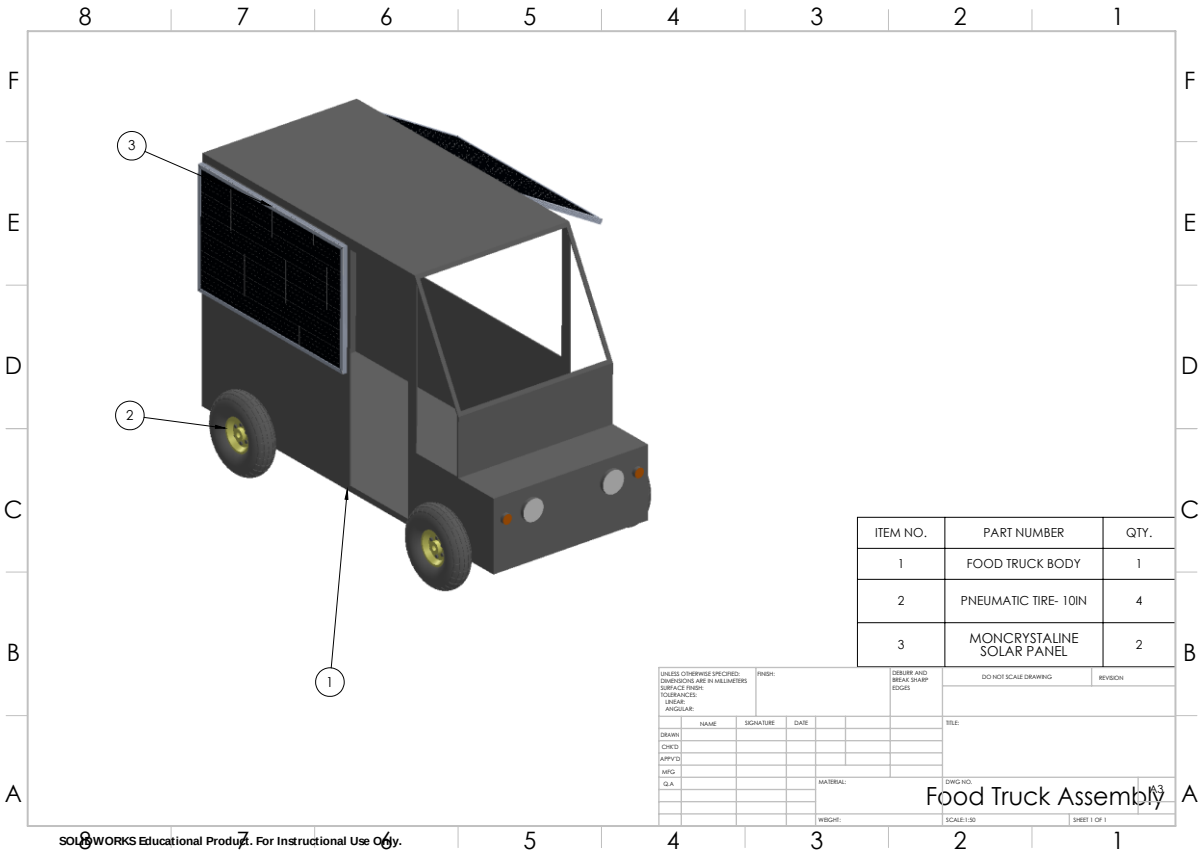

Fig # 3.4(g): CAD Model showing Solar Food truck body

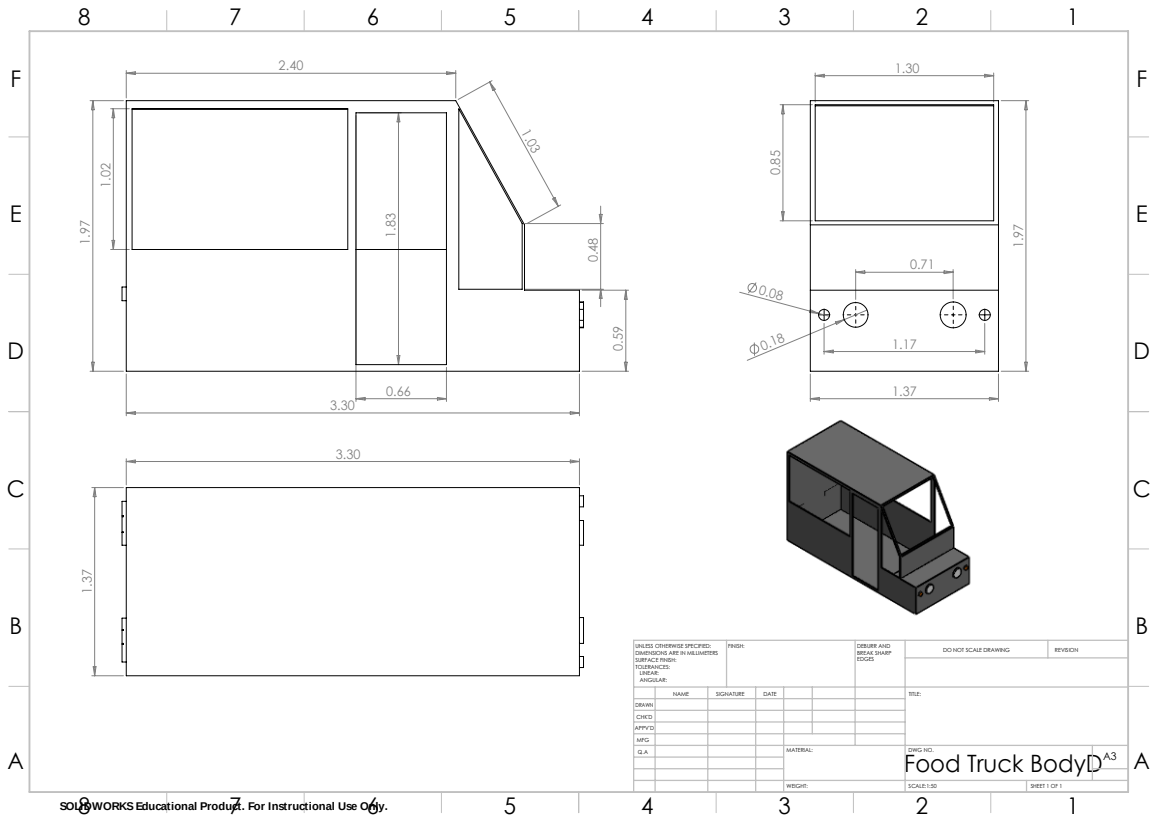

Fig # 3.4(h): CAD Model displaying Solar Food Truck assembly

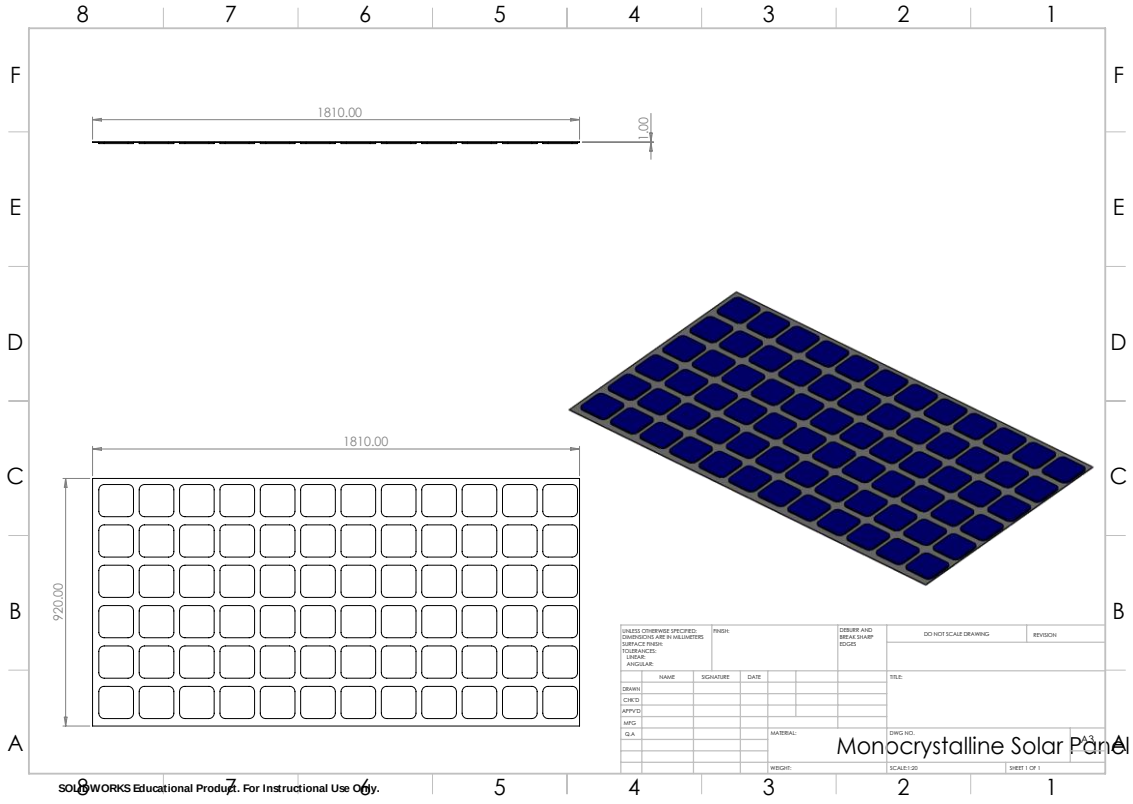

Fig # 3.4(i): CAD Model of Mono-crystalline Solar Panel

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and Data Acquisition System

4.1.1: Multimeter

In order to collect data from our solar powered food truck we had to calculate and evaluate all the important parameters required to asses our systems performance. For this setup, we collected the data using the help of our lab technician. The main purpose of this setup was to find the charging and discharging of a battery powered by solar panel. Voltage being produced by the solar panels when the sunlight was incident on the solar panels will also be recorded. First we found the voltage when the solar panel powered only the truck. Then we operated the small appliance and truck at the same by the power generated by the solar panels.

Additionally, we are also required to obtain the amount of power it produces which we did it using the $\boldsymbol{P_{OUT} = VI}$ formula. This formula gave us the power output, the power being produced. Then we calculated the efficiency of the system using both of these formulas.

Furthermore, the Multimeter used to measure the data in the table below has following specifications;

Specifications:

- Category: Digital Multimeter
- Type: Handheld
- Accuracy: 3%
- Number of Digits: 3 ¾ Digit LCD
- Voltage Range: 66 mVDC to 1000 VDC, 660 mVAC to 750 VAC.
- Resistance Range: 660 mohms to 66 mOhms.
- Capacitance Range: 6.6 nF to 66 mF
- Display Count: 6600
- Frequency: 660 Hz to 66 MHz
- Ranging: Auto, Manual
- True RMS: Yes
- Data Hold: Yes

- Package Weight: 285 g
- Package Size: 165 mm x 42.5 mm x 78 mm

Figure # 4.1: Multimeter

4.2 Results, Analysis and Discussion

Time required to charge battery completely:

First of all we decided how many batteries we needed for setup to work efficiently and after estimating all the power needed we decided to use 5 batteries now how much storage capacity 5 batteries will have we got to know from the following equation:

$$\boldsymbol{Storage\ capacity\ E = PT = 2100\ w \times 20\ h}$$

$$\boldsymbol{E = 42000\ wh}$$

We know it already that for one battery:

$$\boldsymbol{Current\ I = 35\ A}$$

$$\boldsymbol{Voltage\ V = 12\ V}$$

Now for five batteries we will take **V = 12 v x 5** because batteries are attached in series then the equation for P i.e. electric power will be like as follows;

$$\boldsymbol{Electric\ power\ P = IV = 35 \times 60 = 2100\ w}$$

As we have the electric power and storage capacity of 5 batteries and now we have to find out that how much time these batteries will take to fully charge. The charging time depends on the number of solar panels used in the setup we are currently using 2 panel and may increase the number of panels by 5 in future so we will calculate charging time for both.

For two solar panels

As power/energy producing of one panel is 300 w so

$$\boldsymbol{P_{solar\ producing} = 600\ w}$$

$$\boldsymbol{Charging\ time = \frac{E_{total}}{P_{solar\ producing}}}$$

$$= \frac{\boldsymbol{42000wh}}{\boldsymbol{600w}}$$

$$= \boldsymbol{70\ hours\ of\ sun}$$

According to above calculations we can state that if two solar panels are used then the charging time 5 batteries will be 70 hours which is almost 4-5 daylights.

For five solar panels

$$\boldsymbol{P_{solar\ producing} = 1500\ w}$$

$$\boldsymbol{Charging\ time = \frac{E_{total}}{P_{solar\ producing}}}$$

$$= \frac{\boldsymbol{42000\ wh}}{\boldsymbol{1500\ w}}$$

$$= \boldsymbol{28\ hours\ of\ sunlight}$$

The above results shows that the charging time of 5 batteries will reduce tremendously if 5 solar panels of 300 watts each will be instead of 2 as with 5 panels the charging time will be 28 hours which is almost 2 daylights.

Maximum speed truck can achieve:

To find the maximum speed solar truck can achieve we will use the following equation;

$$\boldsymbol{D = VT}$$

$$\boldsymbol{0.1\ km = 18 km/h \times 5.55 \times 10^{-3} h}$$

$$\boldsymbol{100\ m = 5 m/s \times 20}$$

$$\boldsymbol{0.06216\ mile = \ 11.2\ mph}$$

So, the maximum speed in mph = 11.2

Miles covered once fully charged:

Once battery is fully charged it is very important to find out that how many miles the solar truck will cover with a fully charged battery, to calculate this we used the following formula:

$$\boldsymbol{D = V\ \times\ T}$$

$$\boldsymbol{D = 11.2\ mph\ \times 14\ h}$$

$$\boldsymbol{D = 156.8\ miles}$$

Where T was calculated as follows:

$$\boldsymbol{Time\ of\ running\ of\ motor = \frac{E_{storage}}{P_{motor}}}$$

$$\boldsymbol{= \frac{42000\ wh}{3000\ w}}$$

$$\boldsymbol{= 14\ hours}$$

Time of running one day:

$$\boldsymbol{Time\ of\ running\ one\ day = \frac{E_{storage}}{P_{equiment\ motor}}}$$

$$\boldsymbol{= \frac{42000}{3000 + 1600}}$$

$$\boldsymbol{= 9\ hours}$$

Time of charging

The following table shows the power required by different equipment installed in the truck and energy used in hour time.

Table # 4.2: Equipment total Energy Load

- **The following table shows the power required by different equipment installed in the truck and energy used in hour time.**

	EQUIPMENT	P	T	E
1.	Coffee maker	800 w	2 h	1600 wh
2.	Blender	600 w	1 h	600 wh
3.	Boiler	800 w	2 h	1600 wh
4.	Toaster	700 w	2 h	1400 wh
5.	Motor	3000w	1/2 h	1500 wh
	Total			**6700 wh**

Now we will calculate time of charging the battery from the solar panels if the whole load of the equipment is also on the solar panel.

$$\boldsymbol{Time\ of\ charging} = \frac{\mathbf{6700}\ \boldsymbol{wh}}{\mathbf{600}\ \boldsymbol{w}}$$

$$= \mathbf{11}\ \boldsymbol{hours}(\boldsymbol{approx.})$$

After all this calculations we can to the conclusion that we will be using 5 amorphous solar panels to make the setup reliable and effective.

$$\boldsymbol{Time\ of\ charging} = \frac{\mathbf{5950}\ \boldsymbol{wh}}{\mathbf{1500}\ \boldsymbol{w}}$$

$$= \mathbf{4}\ \boldsymbol{hours}$$

Chapter 5: Project Management

5.1 Project Plan

In order to accomplish our goal effectively on time we required a good project plan. We broke down the project into smaller set of tasks and each task was allocated a deadline in which task was completed. Each group had different set of task for which they were responsible to complete on time. The following table show our plan of action:

Table # 5.1: Tasks and their Duration

S. NO.	TASKS		START	END	DURATION
1.	Chapter # 1: Introduction		09/09/19	15/09/19	7
2.	Chapter # 2: Literature Review	Project Background	16/09/19	28/09/19	14
		Previous work			
		Comparative Study			
3.	Chapter # 3: System Design	Design Constraints and Design Methodology	16/09/19	26/09/19	10
		Engineering Design Standards			
		Theory & Theoretical Calculations			
		Product Subsystems & Selection of Components			
		Manufacturing &			

		Assembly			
4.	Chapter # 4: System Testing & Analysis	Experimental Setup, Sensors and Data	14/11/19	24/11/19	**10**
		Results, Analysis & Discussions			
5.	Chapter # 5: Project Management	Contribution of team Members	20/11/19	30/11/19	10
		Project Execution Monitoring			
		Challenges and Decision Making			
		Project Bill of Materials and Budget			
6.	Chapter # 6: Project Analysis	Impact of Engineering Solution	1/12/19	5/12/19	5
		Contemporary Issues Addressed.			
7.	Chapter # 7: Conclusion & Recommendation	Conclusion	6/12/19	16/12/19	10
		Future Recommendation			
8.	Design of Prototype		25/09/19	30/10/19	5
9.	Parts Purchase		05/10/19	02/11/19	28
10.	Manufacturing		05/11/19	20/11/19	15
11.	Testing		1/01/20	10/01/20	10

Table # 5.1 (a): Assigned Members for Tasks

S. NO.	TASK	ASSIGNED MEMBERS
1.	Chapter # 1: Introduction	Everyone
2.	Chapter # 2: Literature Review	Abdul Aziz, Abdullah & Naif
3.	Chapter # 3: System Design	Everyone
4.	Chapter # 4: System Testing & Analysis	Everyone
5.	Chapter # 5: Project Management	Mohammed
6.	Chapter # 6: Project Analysis	Fahad
7.	Chapter # 7: Conclusion & Recommendation	Abdullah
8.	Design of Prototype	Everyone
9.	Parts Purchased	Mohammed & Naif
10.	Manufacturing	Fahad
11.	Testing	Everyone

5.2 Contribution of Team Members

Since projects are accomplished by team work, our team also played its role and completed all the tasks assigned to them in the given deadline. The table below show the effort and input percentage each group member put in to achieve the project goal.

Table # 5.2: Contribution of Tasks

S. NO.	TASKS		ASSIGNED MEMBER	CONTRIBUTION
1.	Chapter # 1: Introduction		Everyone	100%
2.	Chapter # 2: Literature Review	Project Background	Abdul Aziz	33%
		Previous work	Abdullah	34%
		Comparative Study	Naif	33%
3.	Chapter # 3: System Design	Design Constraints and Design Methodology	Mohammed	20%

		Engineering Design Standards	Fahad	20%
		Theory & Theoretical Calculations	Abdul Aziz	20%
		Product Subsystems & Selection of Components	Abdul Aziz	20%
		Manufacturing & Assembly	Fahad	20%
4.	Chapter # 4: System Testing & Analysis	Experimental Setup, Sensors and Data	Mohammed	100%
		Results, Analysis & Discussions		
5.	Chapter # 5: Project Management	Contribution of team Members	Fahad	100%
		Project Execution Monitoring		
		Challenges and Decision Making		
		Project Bill of Materials and Budget		
6.	Chapter # 6: Project Analysis	Impact of Engineering Solution	Abdullah	100%
		Contemporary Issues Addressed.		
7.	Chapter # 7: Conclusion & Recommendation	Conclusion	Fahad	100%
		Future Recommendation		
8.	Design of Prototype		Everyone	100%
9.	Parts Purchase		Mohammed & Naif	100%

10.	Manufacturing	Fahad	100%
11.	Testing	Everyone	100%

5.3 Project Execution Monitoring

In order to keep our project on track and meet the deadlines on time we arranged our group meetings regularly. We had some of the meeting with our supervisor along with our team members. These meeting have proved to be very fruitful as there were feedback reports presentations in developmental stages and those were all executed in timely manner as depicted in the table below:

Table # 5.3: Dates of Activities & Events

TIME/DATE	ACTIVITIES/EVENTS
ONCE IN WEEK	Assessment Class
BI-WEEKLY	Meeting with the group members
BI-WEEKLY	Meeting with the Advisor
23RD NOVEMBER , 2019	First Finished Prototype
14TH NOVEMBER, 2019	Midterm Presentation
23RD NOVEMBER, 2019	First Test of System
15TH JANUARY, 2020	Finishing Final Prototype
16TH JANUARY, 2020	Test of the System
20TH JANUARY, 2020	Final Submission of Report
30TH JANUARY, 2020	Final Presentation

5.4 Challenges and Decision Making

Working on a project from beginning till end itself is challenge and they're numerous decisions to be made at every step. We faced quite a lot problems while looking for materials and spare parts required for the project so we had to purchase them online which was not an easy task either. Getting spare parts imported from

china was hectic as it was long and tiring process to get the custom clearance of our parcel from the custom office. It took quite many days to get us the clearance. This process was not only hectic and time taking this proved to be a very expensive one as well. As we had to pay almost 2100 SAR in the name of port fee and custom clearance fee apart from the cost of the materials we ordered.

5.4.1: Equipment and Device Problems

Solar panel

The solar panel we used is the flexible solar panel and the basic problem we faced was its installation on the truck in such a manner that it becomes safe and fixed properly. Solar panel was installed in such a way that we made sure that it would sustain heavy rain and sand storms. Installing solar panel to the truck raised another concern of weight gain of the truck which may require solar power to generate power voltage to start the engine. Since our project has to be safe and functional to be successful we got the help from our advisors and expert technicians.

5.4.2: Testing and Safety Issues

We tested our system was tested by operating truck solely on the solar power generated through solar panel it took some time to charge the truck battery which powered the engine of the truck. We noticed that powering a food truck with solar power made it functional but slow as well. In terms of safety we made sure to use best quality materials and spare parts in accordance with engineering standards to avoid any shot circuit or wire heating.

5.4.3: Design Problems

After we had designing our system we did not realize about the vibrations that the system was producing upon first testing. But we soon took in consideration to seek from an expert mechanic and thankfully he was able to fix the problem by bringing slight changes to the design. Design also required to be solar panel installed on the top so that the weight is distributed all over the truck and cause an ease to motor to exert less force

5.5 Project Bill of Materials and Budget

Purchasing the project material was not an easy task as it required a lot of research. We couldn’t find material easily available in Saudi Arabia so we had to

order it online from Hong Kong China. Following table includes the cost of the material in the currency in which payment was made and converted rates are also shared. This table also contains the cost of custom clearance, warehouse and port charges in SAR

Table # 5.5: Project Bill of Materials

MATERIAL	COST (US$)	COST(SAR)
Rear Axle	**145**	**543.75**
Front Axle	**200**	**750**
Steering Rack	**20**	**75**
Steering Wheel	**20**	**75**
Steering Column	**60**	**225**
Brake Pedal	**30**	**112.5**
Under Plates	**150**	**562.5**
Speedometer	**30**	**112.5**
Headlight	**60**	**225**
Controller	**100**	**375**
Wheel	**140**	**525**
Plywood 4	**-**	**400**
8 pc Angle Bar	**-**	**400**
5 pc Flat Bar	**-**	**135**
Body Invoice	**-**	**6000**
1500w Inverter DC - AC	**-**	**378**
Kettle	**-**	**130**
Batteries 5	**-**	**800**
Renting Equipment's	**-**	**850**
Car Towing	**-**	**550**

Brake Oil 8	-	**120**
Welding	-	**800**
Customs Use	-	**519**
Dammam Port Charges	-	**1041**
Delivery Receipt	-	**200**
Warehouse Handling Charges	-	**105**
Customs Clearance	-	**1050**
Total	**955 $**	**17059.25 SR**

Chapter 6: Project Analysis

6.1 Life-long learning

We have set the goals that need to achieve during the processing of the project. It was our priority is to achieve the target goals. We intend to utilize software and hardware skills along with hands-on experience. This was achievable only by proper assistance. Keeping this strategy in mind, we had allotted one of the team members as a group leader whose additional duty was supervision of the project. His other duty was to motivate the group mates during tough time. For the desirable outcome of the project, we had also focused on our communicating and interpersonal skills. This chapter starts by highlighting few skills that we had learned during this project.

6.1.1: Software skills

In the successful completion of the project, the software that plays an important role is CAD software for designing of the prototype. One of our group members was proficient in it. We keep on learning these skills from our group mate and the online learning platforms as well. And with the passage of time and proper practicing we get expertise in these software's.

6.1.2: Hardware Skills

Our project depends in many items of hardware that should be tested and fixed before the complete manufacturing. We had learned a lot of hardware skills while doing that project. Mostly, after the connections of solar panel batteries and kitchen appliances, there comes the phase of manufacturing and assembly of the project which requires skills.

6.1.3: Time Management

Time management was the major key to a successful project. We had appointed a group leader to manage a proper timeline of the project and to keep an eye on the progress and contribution of the team members. He also motivates the team members to reach the end goals of our project. At the result of this, we work with devotion and do our best to make it possible. The whole task had been divided into different parts to make it easy for us to focus each part. This also helps in allocating a specified time in each portion. We carry out group meetings daily where we discussed the progress of the project, the hurdles that we faced and strategies to manage them. We have divided the complete task with regard to the expertise of each individual team member.

6.1.4: Project Management

Project management was the most important factor, which leads to the proper outcomes of the project. The first task, which we performed before commencing the project, was Gantt chart. Gantt chart was sort project management plan. Using the Gantt chart, we specify all the charts with their due date. We also allotted the different task to each team member. Each team member was told that he would be responsible for his task.

6.2 Impact of Engineering Solutions

6.2.1: Society

The major target of the project manager was the social impact as it deals with the impact of the project surrounding community. Majority of the people in the society were not aware of this product so we decided to market our project as much as we

can. So that people become aware of it and use it for personal benefit. This project makes use of solar panel instead of generator, solar panel environment friendly and lead to lesser harm to environment as compare to generators.

6.2.2: Economy

An economically suitable project caters to wide estimate and controlled cost. Our intention was to make a low cost project, which could be easily available to a lot of personals. The parts use in development of this solar panel food truck is not easily available in Saudi Arabia. As local sellers were not aware of these parts, we had to get these parts imported, which led to high cost. It is feasible in this sense that it does not require a fix place or land and it is portable so the pros out way the cons of the product.

6.2.3: Environmentally:

As environmental issues are increasing day by day, environmental concerns are very important. We aimed to develop a product which was environment friendly for this purpose we use solar panel which can be charged with solar light, which leads to pollution prevention, resource conservation, waste reduction and carbon emission free environment. The idea of investing in solar food panel truck is sure to become a promising idea with successful results. Moreover, this economy friendly system can reduce the demand of fossil fuel around the globe.

6.3 Contemporary Issues Addressed

With the increase in the issue of global warming, scientific technologies have been modifies which do not promote global warming. Good energy resource includes solar panel system. The efficiencies of the solar panel can be increased by depending on the angle of the axis. Solar energy is converted into electrical energy. The excessive use of fossil fuels is leading to decrease in them, these resource ones gone are difficult to achieve again. We must shift our focus from nonrenewable resource to renewable resources for future concern. This project addresses the issue of use of fossil fuels. It has been specifically design for solar panels. However we faced the issue with the cost and availability of the cost. We had to get these parts

imported as there were no easy accesses in the local market. This led to delayed completion of the project than expected.

Chapter 7: Conclusion & Future Recommendations

7.1 Conclusion

To sum up all the skills methods and expertise that we utilize in this project, we face so many ups and downs that made us learn new problem solving skills. During the interim of 3 months we came across many skills and the software that we were not aware of. We can proudly say that we were not demotivated but we encourage each other to learn about new software and hardware skills. The current project is based on solar panel food truck our main aim was to develop a low cost portable food truck. The food truck contain generator which work solar energy rather than fuel and gas. This product is environmental friendly and successful. Trial and error method help us in achieving our goals.

7.2 Future Recommendations

The goals of this project were outlined keeping in mind the timeline and resources that were attainable. This initial design can be improved. The materials and spare parts used in this project are ordered online from Hong Kong and are made in china as well. We found our material and project related spare parts very expensive. We feel the need that these materials and spare parts must be manufactured locally and sold at reasonable cost to decrease the cost of solar powered truck. As we have to bear high cost because of unavailability. The solar powered food truck should be introduced in Saudi Arabia formally and professionally as a business opportunity so that every single person should get the benefit. Furthermore accuracy can also be increased by utilizing dual axis design versus single axis design. Future projects can make use of microcontroller. This microcontroller can serve as standalone unit in the fabricated circuit.

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