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PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

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Senior Design Project Report

Design & Fabrication of a Solar Cooker

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

Team 11

Team Members

	Student Name	Student ID
1	Ali Syed Shah	201701390
2	Faisal Al-Abdulrahman	201700383
3	Abdulaziz Al-Ghamdi	201502576
4	Abdulrahman Al-Jabr	201202207

Project Advisors:

Advisor Name: Dr. Waqar A. Khan
Co-Advisor Name: Dr. Mohammed El-Mehdi Saleh

Abstract

The main purpose of our project is to provide an alternative to gas stoves with an eco-friendly solar cooker. A solar cooker is a device that uses the energy of sunlight to cook and heat food and drinks or to boil it. The vast variety of solar cookers presently in use are cheap, low-tech devices. Because they use no gas and cost nothing to operate, they reduce air pollution and slow deforestation and desertification. Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high. Solar cooking is commonly known as renewable and green energy applications at domestic and commercial levels. There are different types of solar cooker designs (box solar cookers, panel cookers, parabolic cookers, and tube cookers). All designs are beneficial and have the same concept which is cooking. What we used is a rectangular-shaped box solar cooker since its benefits overcome its harms.

Acknowledgments

Our team would like to express our gratitude to our advisor Dr. Waqar A. Khan for his support for our project and his guidance. Also, we express our sincere thanks to our co-advisor Dr. Mohammed El-Mehdi Saleh for sharing his expertise and encouragement. We would like to extend our gratitude and appreciation to Dr. Jamal Nayfeh, Dean of the college of engineering at PMU, and Dr. Faramarz Djavanroodi, chair of the Mechanical Engineering Department at PMU, for their continued support. Lastly, we thank our parents, friends, and colleagues for their encouragement.

List of Acronyms (Symbols) used in the report:

Symbol	Definition
$\boldsymbol{k}$	Thermal Conductivity
$\boldsymbol{A}$	Area
$\boldsymbol{\Delta x}$	Thickness
$\boldsymbol{T}$	Temperature
$\boldsymbol{R}$	Resistance
$\boldsymbol{\dot{Q}}$	Heat Transfer
$\boldsymbol{w}$	Width
$\boldsymbol{l}$	Length

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Chapter 1: Introduction

1.1 Project Definition

Historically, engineering has facilitated various tools and systems to ease and improve the quality of everyday life for humans. Engineers have to assure maintaining the quality of those systems while maintaining an efficient cost of production to those systems and tools. One of the greatest inventions made by engineers is the ovens. Ovens provide various types of services to mankind. Depending on the temperature ovens can provide, they can be used to cook food at a lower temperature. Maintaining an efficient cost while having a high quality of a system is a pillar of engineering principles. This principle has brought light to the usage of renewable and natural resources. One usage of renewable resources that deals with ovens are a solar cooker. A solar cooker, also as known as a solar oven, is a type of oven that uses the heat provided by the sun, amplifies it, and then uses that amplified heat to provide an efficient cooker that can be used to serve humans' needs. Objectives of solar cookers are various, some of the main ones are:

1. To provide an effective alternative to cooking for people without access to electricity or gas.
2. Protecting the environment from deforestation caused by harvesting wood for fuel.
3. Reduce the danger of home fires.
4. To reduce smoke inhalation, and improve the health of humans.
5. Reduce the time spent cooking, as food can be placed and left behind while doing other chores.
6. To bring light to renewable resources as a valid and efficient source of heat production.

1.2 Project Objectives

1. To design and fabricate an effective cooker the uses solar energy.
2. To utilize and use green renewable energy to cook food.
3. To harvest solar energy in order to provide an alternative to gas and electrical stoves.
4. To design a proper solar panel system to cook food.

1.3 Project Specifications

Table 1.1: The system measurements

Item	Size
Wood panel	37.5in x 17in x1in
Reflector real mirror	30in x 15in x 0.16
Heat transfer Efficient transparent glass	30in x 15 x 0.07in by 12in x 30in x 0.07in
Aluminum and fiber with rubber insulation	120in x 40in x 2in
Steal handle equipped with rubber insulation	6in x 1in x 0.5in
Heat reflector sheet	25in x12in x 0.10in
Aluminum Thermometer	6in x 4in x1in
Weight of the system	32kg

1.4 Applications

The main applications for this project are:

1. To cook and heat a large variety of food.
2. To dehydrate food.
3. To sterilize and purify water.

Chapter 2: Literature Review

2.1 Project background

Nowadays, the world is progressing industrially day after day. Throughout this progression, the air is getting polluted day after day. A solar oven provides a perfect solution for the environment and the health and wellbeing of mankind. There are multiple reasons for carrying out the project. One of them is to provide an effective alternative to cooking for people without access to electricity or gas. Another reason is protecting the environment from deforestation caused by harvesting wood for fuel. Furthermore, to reduce the danger of home fires. Moreover, reducing smoke inhalation, and improving the health of humans. It also reduces the time spent cooking, as food can be placed and left behind while doing other chores. One other reason is to bring light to renewable resources as a valid and efficient source of heat production. This project fits in every situation where reduction of air pollution is a priority and aims to further use green renewable energy as a main source of energy. Some challenges that may occur include the design of the project, getting the materials and building them in time, and the pressure caused by the covid-19 pandemic.

2.2 Previous Work

The first paper, according to Universiti Teknologi Petronas which is talking about high-efficiency solar oven for tropical countries. In this paper two attempts have been made to design two different types of solar ovens, first type is a solar oven with the parabolic collector and the second type is a solar oven without the parabolic collector. It also discussed the construction of the solar oven and the experimental procedure and the thermal analysis of the solar ovens. It concluded that the solar oven is very much helpful to conserve electricity and eco-friendly food production.

Table 2.1: Performance of solar oven with parabolic collector.

Time (min)	Amount of solar radiation collected (W/m^2 K)	Absorbed heat energy, $\frac{q_A}{A}$(J/m^2)	Heat energy loss, $\frac{q_L}{A}$ (J/m^2)	Efficiency, η (%)
0	230.4	1107643.30	23175.16	37.66
30	351.4	1689336.00	215790.64	51.16
60	380.4	1828765.24	475362.98	46.99
90	519.4	2497004.90	809050.10	58.61
120	510.3	2453256.84	876341.44	54.75
150	503.5	2420565.98	876341.44	53.62

Table 2.2: Performance of solar oven without parabolic collector.

Time (min)	Amount of solar radiation collected (W/m^2K)	Absorbed heat energy, $\frac{q_A}{A}$, (J/m^2)	Heat energy loss, $\frac{q_L}{A}$ (J/m^2)	Efficiency, η (%)
0	117.5	564878.8	23175.1	18.81
30	198.6	954765.4	190999.8	26.52
60	294.2	1414360.5	368950.6	36.30
90	254.9	1225426.5	502516.9	25.10
120	336.8	1619159.1	698922	31.95
150	325.2	1563392.3	529894	35.86

The second paper, According to Universidad Nacional Autónoma de México which is talking about a solar oven for intertropical zones: Evaluation of the cooking process. This paper showed that the solar oven can cook three basic Mexican meals, beans, nixtamal, and corn cobs. It also showed that a conservative estimation of the wood savings per oven is 850 kg per year, close to the 30% of firewood used to cook by a typical Mexican rural family.

Figure 2.1: A photograph of the constructed oven prototype.

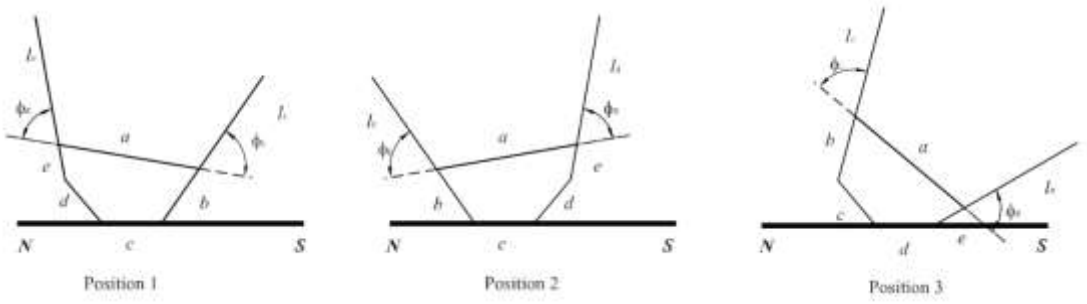


Figure 2.2: The three different positions of the oven.

Lastly, According to Universiti Malaysia Pahang is talking about the development of solar oven incorporating thermal energy storage application. This paper tested two papers of oven one with an aluminum panel and the other without, it tested the thermal analysis of two types of heat storages which is latent and sensible. It also tested the experimental setup and temperature analysis and also the glazing material for the two types of ovens.

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1 Geometrical Constraints

While designing our project, there are multiple geometrical constraints to put into consideration. The major constraint that we might face is moisture that occurs on wood. Wood approximately absorbs 20% of moisture air, for that we are still reviewing all possible options for wood to build with, the higher the moisture resistance the better for the long-term durability of the project. The second design constraint that is just as important is finding the amount of load that the chosen type of wood can withstand before creep occurs. Some things that can occur creep while building the project is installing the mirror and glass to the wood and this should be taken into consideration. The third geometrical constraint requires multiple measurements to assure a higher quality of safety for the user. Finally, as time passes, wood becomes more and more susceptible to geometrical changes. We also faced some geometrical constraints in the mirror, the mirror can be heavyweight and we faced a problem in installing it on the wood that holds it because the wood is thin and we need hard glue to hold it. Another problem is that the mirror can face expanding due to heat and it can change the geometry of the mirror.

3.1.2 Sustainability

Our project is primarily made of wood, and wood is prone to multiple problems that occur with time. One of the major sustainability issues we may face is molding that occurs on wood caused by moisture absorption. Moreover, wood is also prone to geometrical changes through time that may shorten the lifespan of the system. Aside from wood, the system has hinges attached in order to move the cover and those hinges are susceptible to corrosion with time. Finally, the upper and front parts are made of glass which is a fragile material prone to scratches and easily fractured.

3.1.3 Environmental

In today's world, a lot of countries started seeking alternatives for the regular sources of energy and began a journey into a more environmentally friendly approach. This project follows the same approach, yet one major constraint that accompanies that is the effect that

massive usage of wood can have on the environment. In a larger sample size, mass production of wood-made products may cause a serious deforestation issue. That issue is a major concern in today's day and age.

3.2.4 Social

The system we designed is suited for people who value their time and the safety of our environment. One reason that is the case is the fact that solar ovens are extremely safer in comparison or regular everyday ovens. This allows the user to place whatever they wish to cook and leave it in the solar oven while enjoying their time with other people. This key feature allows for more social interactions with serious concern.

3.2.5 Economic

The solar over is drastically more economic-friendly than the regular ovens. The main reason behind that is the fact that it is dependent on renewable green energy. That dependency allows us to ignore the cost of fuel since it is already provided by the sun. Furthermore, the materials and tools needed to create a solar oven are far more affordable and durable than regular ovens.

3.2.6 Safety

One of the most important reasons behind the safety of our system is its reliance on the sun. This reason means that there is no need to use any type of fuel, which ultimately leads to no pollution. Since pollution is an ongoing problem in today's day, our environment-friendly approach attempts to reduce causes of pollution and ultimately a better and safer environment.

3.2.7 Ethical

When it comes to ethics, our system serves it well. It provides an additional option for how people choose to live their lives. Some still prefer using conventional ovens, while others are seeking environmental-friendly alternatives. Our system provides the perfect alternative for those who wish to use green renewable energy instead of conventional one.

3.2.8 Risk Analysis

The main risk that could happen is overheating which can cause a fire. Another possible risk is glass breaking due to temperature change going to low temperature. For the overheating

risk, we added two types of heat insulators to contain heat. On top of that, we added a temperature gauge to know when the temperature is beyond what is needed for the purpose. For the glass breaking risk, in Saudi Arabia temperatures don't usually fall too low to cause the glass to break, if that ever is the case, a warning should be added to use the product in a non-cold area.

3.2 Engineering Design standards

In this section, we explained the engineering standards of each component as shown in table 3.1. the selected components are the following: screws, wood, mirror, glass, insulation, temperature gauge, hinges, handle, battery, inverter, solar panel, and range surface element. The screws and temperature gauge has been taken according to the ASME metric standard, the wood has been taken according to the ANSI metric standard, the mirror, glass, and insulation have been taken according to the ASTM metric standard. The hinges and handle are stainless steel, the battery has been taken according to the IEC metric standard. The solar panel is from the factory of Saudi Arabia solar panels, and lastly, the range surface elements are from the company General Electric.

Table 3.1: Engineering Standards

Components	Engineering Standard	Details
Screw	ASME Metric	ASME, B18.6.1 – Formed Flat Head Screw, 1.5'
Wood	ANSI Metric	SIA 265 - 18mm (Beech Wood)
Mirror	ASTM Metric	C1503 – 6mm
Glass	ASTM Metric	C1048 – 6mm (Clear Vision Tampered Glass)
Insulation	ASTM Metric	C1071-19 - 1"
Temperature Gauge	ASME Metric	ASME B40.3
Hinges	Stainless steal	18% chromium -8% nickel 74% Steel
Handle	Stainless steal	18% chromium -8% nickel 74% Steel
Battery (Optional)	IEC 62133	batteries containing alkaline or other non-acid electrolytes

Inverter (Optional)	B08Q7V3D3G	12V - 3000W
Solar Panel (Optional)	Saudi solar panel	12V – 3000W
Range Surface Element (Optional)	GE WB30M2	220v – 1500W each

3.2.1: Screw

The screw was chosen to fit the requirement of wood width and rigidity

- Diameter of the countersunk flat head 8mm
- Length 38mm
- Thickness of the head 3mm

3.2.2: Wood

The wood used in solar cooker is beech wood

- The thickness of the wood is 18mm
- The surface is smooth because the grain size is straight
- Weight is about 46lbs per cu. ft.
- Coated with water resistance material

3.2.3: Mirror

Glass piece coated with aluminum to reflect the heat

- Thickness of the mirror is 6mm with 1mm coat
- The glass is tempered to resist blasting at high temperatures
- High end finishing with no sharp edges to ensure the safety

3.2.4: Glass

Normal tempered glass coated with heat resistant material to ensure the efficiency of heat transfer through it

- Thickness of the glass is 6mm

3.2.5: Insulation

Fiberglass wool insulation used to cover the entire body of the oven to trap the heat inside the oven and keep the outer surface cold

- Thickness of the insulation is 25.4mm
- Aluminum surface

3.2.6: Temperature Gauge

The gauge was selected to measure heat in Celsius up to 400 degrees with copper sensor to ensure the accuracy

- Thickness of the gauge 26mm
- Thickness of the sensor 12mm
- Length of the sensor 38mm

3.2.7: Hinges

Hinges are used to adjust the mirror angle up to 45 degrees

- Hinges material stainless steel
- Hinges length 76mm
- Hinges thickness 6mm

3.2.8: Handle

We used aluminum handle coated with cold paint to resist the heat from increasing the temperature of the handle

- Aluminum coated with cold paint
- The length of the handle 101mm
- The width is 25mm

3.2.9: Battery

To store the charges absorbed by the solar panel and use them to charge the heater

- Voltage range 350 – 430 VDC
- Max charge and discharge current 11.9 – 14.3 Amp
- Max charge and discharge power 5kw
- Operating temperature 14 - 113ºF (-10 - 45ºC)

3.2.10: Inverter

The inverter is used to convert input of 24v - 12v to output of 110v – 220v

- Max power 5kw
- Max DC voltage 500 VDC
- Operating temperature 0°C to +40°C

3.2.11: Solar Panel

To increase efficiency of the solar cooker we used the panel as a plus option

- Max power 280W
- Open circuit voltage 39.5V
- Short circuit current 9.71A

3.2.12: Range Surface Element

General electric surface element was used to add more heat to the cooker when needed

- Max power 1500W
- Thickness 8mm
- Input voltage 220V

3.3 Theory and Theoretical Calculations

3.3.1 Thermal conductivity of each component

- $k_{wood} = 0.64\ W/mK$ [1]
- $k_{foam} = 0.03\ W/mK$ [2]
- $k_{paint} = 0.5\ W/mK$ [3]
- $k_{glass} = 0.8\ W/mK$ [4][5]

3.3.2 Cross section area of the solar cooker

To calculate the area for the solar cooker, we calculated each side alone (side, front, back, and top) and we used equation (3.1).

$$A = w \times l \qquad (3.1)$$

- $A_{side} = 4.572\ m$
- $A_{back} = 10.668\ m$
- $A_{front} = 10.668\ m$
- $A_{top} = 13.335\ m$

3.3.3 Thickness of each component

- $\Delta x_{wood} = 0.018\ m$
- $\Delta x_{foam} = 0.025\ m$
- $\Delta x_{glass} = 0.006\ m$
- $\Delta x_{paint} = 0.003\ m$

3.3.4 Temperature of outside and inside the solar cooker

- $T_{outside} = 35\ ℃$
- $T_{inside} = 150\ ℃$

3.3.5 Resistance of each component of the solar cooker

To calculate the resistance, it is the thickness divided by the thermal conductivity of each component, see equation (3.2).

$$R = \frac{\Delta x}{k} \qquad (3.2)$$

- $R_{wood} = \frac{0.018}{0.64} = 0.028\ m^2k/W$
- $R_{foam} = \frac{0.035}{0.03} = 0.83\ m^2k/W$
- $R_{paint} = \frac{0.003}{0.5} = 0.006\ m^2k/W$
- $R_{glass} = \frac{0.006}{0.8} = 0.0075\ m^2k/W$

  To calculate the R_{Total} we added all the components of the solar cooker except the glass because the glass is a component with itself, see equation (3.3).

$$R_{Total} = R_{wood} + R_{foam} + R_{paint} \qquad (3.3)$$

- $R_{Total} = 0.892\ m^2k/W$

3.3.6 Heat transfer losses for the solar cooker

To calculate the heat transfer, we multiplied the area of each side by the temperature difference and divided it by the resistance and lastly added them all together, see equation (3.4).

$$\dot{Q} = \frac{A\times(\Delta T)}{R} \qquad (3.4)$$

$$\dot{Q} = \left[\left(\frac{4.572\times(150-35)}{0.892}\times 2\right)(2\ sides(right\ and\ left)) + \left(\frac{10.886\times(150-35)}{0.892}\right)(Back\ side) + \left(\frac{410.668\times(150-35)}{0.0075}\right)(Front\ Glass) + \left(\frac{413.335\times(150-35)}{0.0075}\right)(Top\ Glass)\right] = 370600.24\ Watt/hr$$

3.3.7 Heat transfer gained for the solar cooker

According to Nasa, 1360 watt/$\boldsymbol{m^2/sec}$ of the Earth = $\mathbf{4896000}\ \boldsymbol{Watt/hr}$. So, we calculated the top area of our solar cooker so we can calculate the heat gained of our solar cooker. The area of the top view = 0.34 $\boldsymbol{m^2}$. So, the heat gained to our solar cooker ($\boldsymbol{Q} = \mathbf{4896000} \times \mathbf{0.34}$) which equals to **1664640 Watt/hr**.

According to our calculations the results came to be that the heat coming into our solar cooker is bigger than the heat lost. So, our solar cooker is working.

3.4 Product Subsystems and selection of Components

The idea behind making a solar cooker is to build a professional system that can operate any day at any time with high output efficiency while causing zero harm to the environment (Eco-friendly). The items were chosen by following the standards of safety. The frame material is beech wood which can resist heat from passing through to keep the outer wall of the frame cold and easy to handle. The walls of the frame are insulated with fiberglass wool insulations which are highly efficient in resisting heat from going out and cold from coming in. Heater elements are used to increase the efficiency of the cooker. Thermal black paint insulation is used to cover the interior walls to prevent heat loss and increase efficiency. A reflective glass mirror coated with vinyl is used to reflect the excessive sunlight into the cooker. The frame is covered with glass and the glass is heat resistant with clear visual inside the cooker. In addition, solar panel, battery, and regulator could be used for increasing efficiency and decreasing the cooking time. The quality of solar panel will be high and the cost will be low. Liquid batteries are the best batteries to use in solar panels to reduce the cost of buying dry batteries which are high in cost and too heavy. The high-quality regulator is must be used in the solar system to prevent damage to the battery from excessive charge. All material has been specified in table 3.1 for more detailed information.

Figure 3.1: Solar Cooker

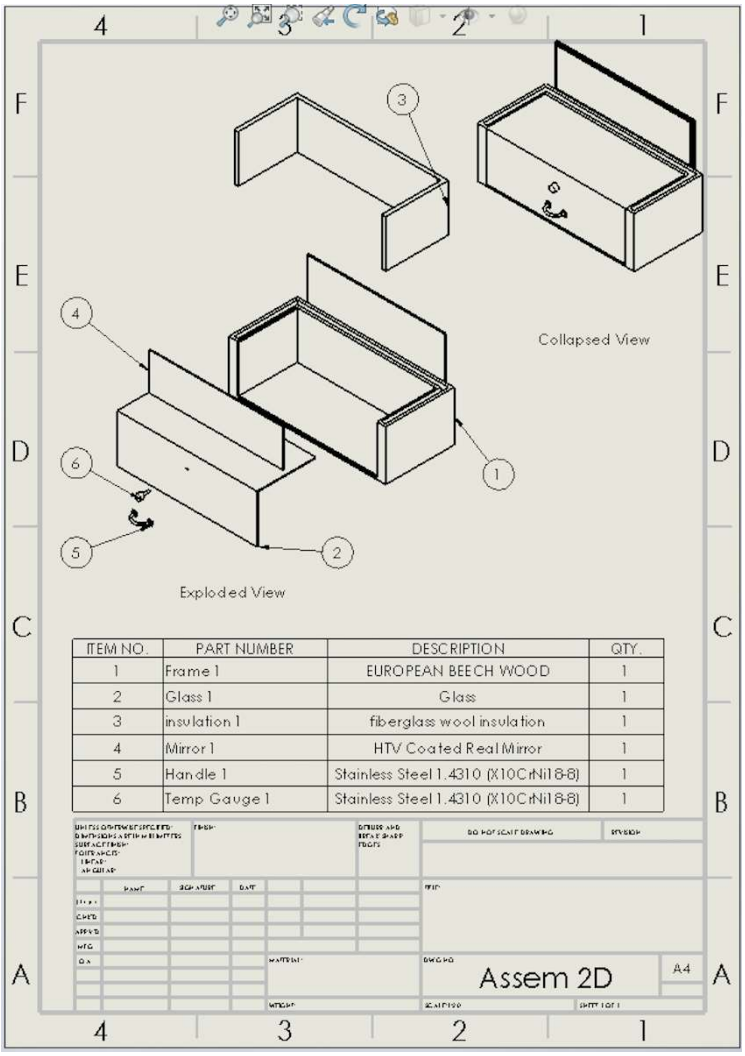
3.5 Manufacturing and Assembly (Implementation):

While designing the system, we have gone through various types of available material options and selected those that work for our purpose. Designing a solar cooker requires heat-resistant materials and durable materials for a higher lifespan of the system. For wood, we decided to use beech wood to build the structure of our system. The main reason behind this selection is because it doesn't affect the quality of the food in terms of the taste and smell. For the glass, which will act as the upper and frontal cover, we selected borosilicate glass mainly for its known low thermal expansion coefficient which will result in a more durable and safer system. On the rear top of the system, we vertically added a real mirror with a coat of heat transfer vinyl (HTV). In the rear and both sides of the system, we added two types of heat insulators to maintain heat inside the solar cooker. The first insulator is an aluminum fiberglass insulator, while the second one is a black polystyrene foam insulator. From the front vertical side, we added an aluminum temperature gauge in the middle, and below that is an aluminum handle that is coated with thick paint. In the bottom corners of the system, we added peek plastic stand adjusters.

3.6 Economic Evaluation

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs											
Equipment	2500	0	0	0	2500	0	0	0	2500	0	0
Construction	650	0	0	0	0	0	0	0	0	0	0
Total	3150	0	0	0	2500	0	0	0	2500	0	0
Operating Cost											
Energy	0	0	0	0	0	0	0	0	0	0	0
Electricitiy	0	0	0	0	0	0	0	0	0	0	0
Labour	0	0	0	0	0	0	0	0	0	0	0
Insurance	0%	0	0	0	0	0	0	0	0	0	0
Taxes	0%	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0
Revenues											
Solar panel	500	0	0	0	0	0	0	0	0	0	0
Battery	950	0	0	0	0	0	0	0	0	0	0
Charge Controller	450	0	0	0	0	0	0	0	0	0	0
Total	1900	0	0	0	0	0	0	0	0	0	0
Profits	-2425	825	825	825	-1775	825	825	825	-1775	825	825
TOTAL PROFIT	625										

CAD Drawings & Bill of Materials



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Frame 1	EUROPEAN BEECH WOOD	1
2	Glass 1	Glass	1
3	insulation 1	fiberglass wool insulation	1
4	Mirror 1	HTV Coated Real Mirror	1
5	Handle 1	Stainless Steel 1.4310 (X10CrNi18-8)	1
6	Temp Gauge 1	Stainless Steel 1.4310 (X10CrNi18-8)	1

Figure 3.2: Exploded view & Bill of materials

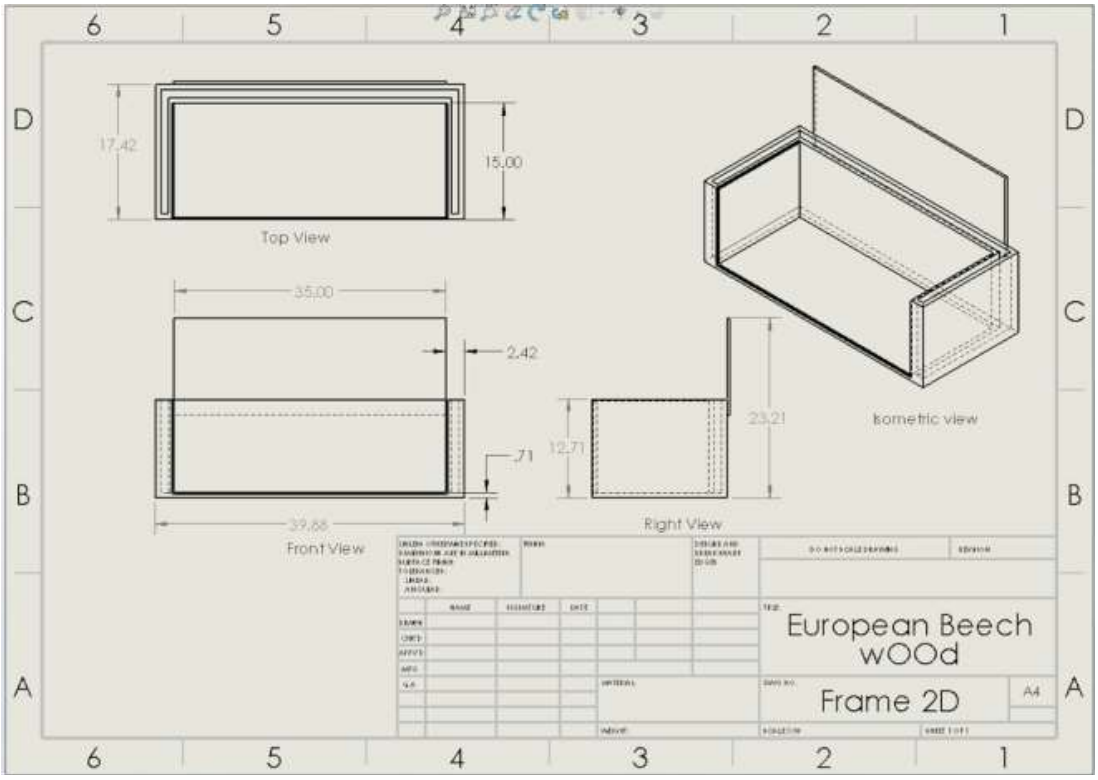


Figure 3.3: 2D Data Spreadsheet

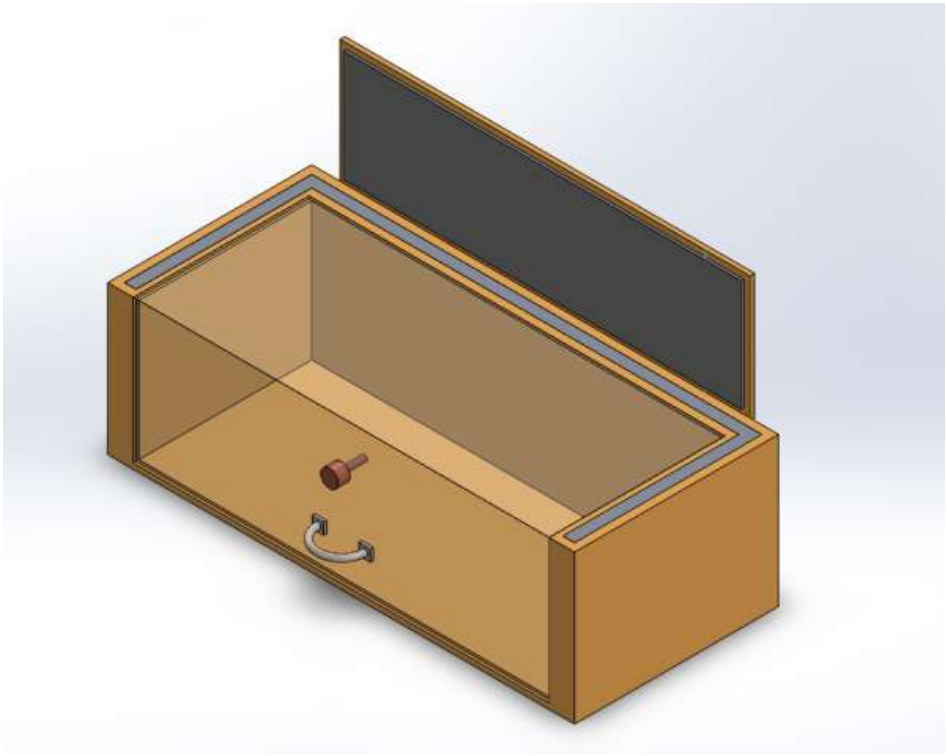


Figure 3.4: Isometric View

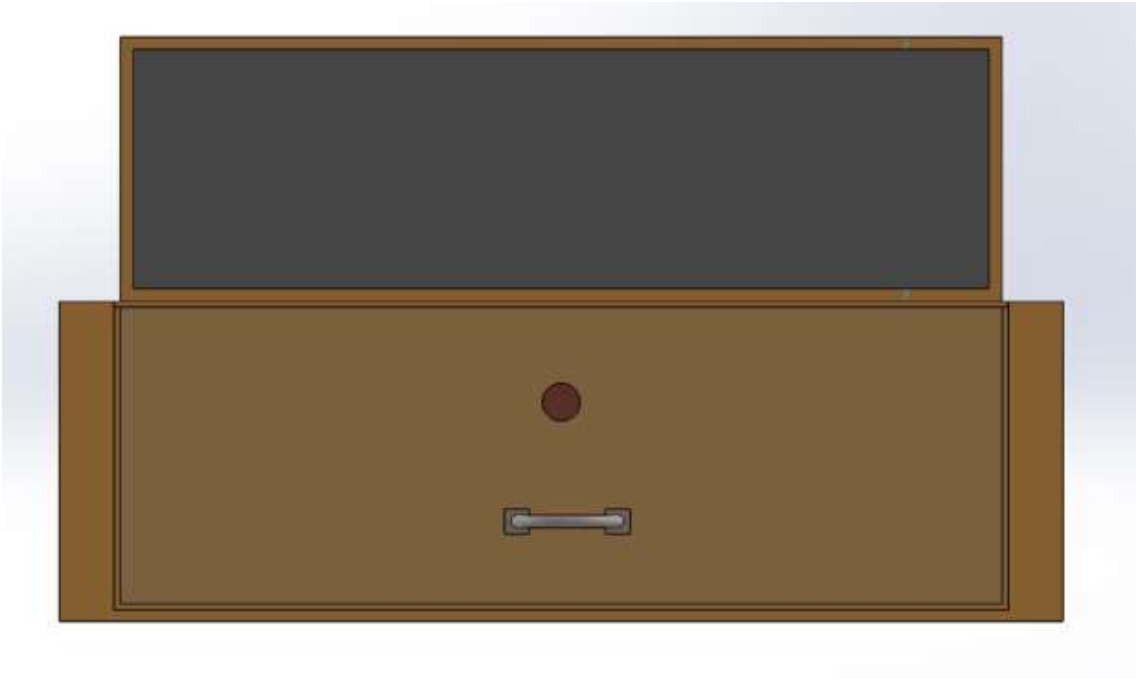


Figure 3.5: Front View

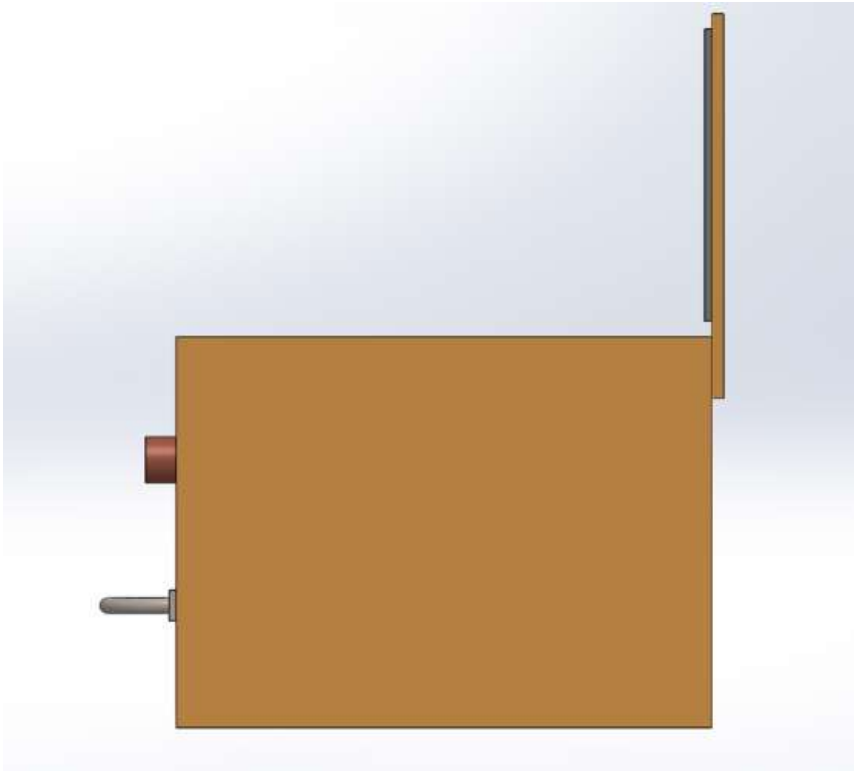


Figure 3.6: Side View

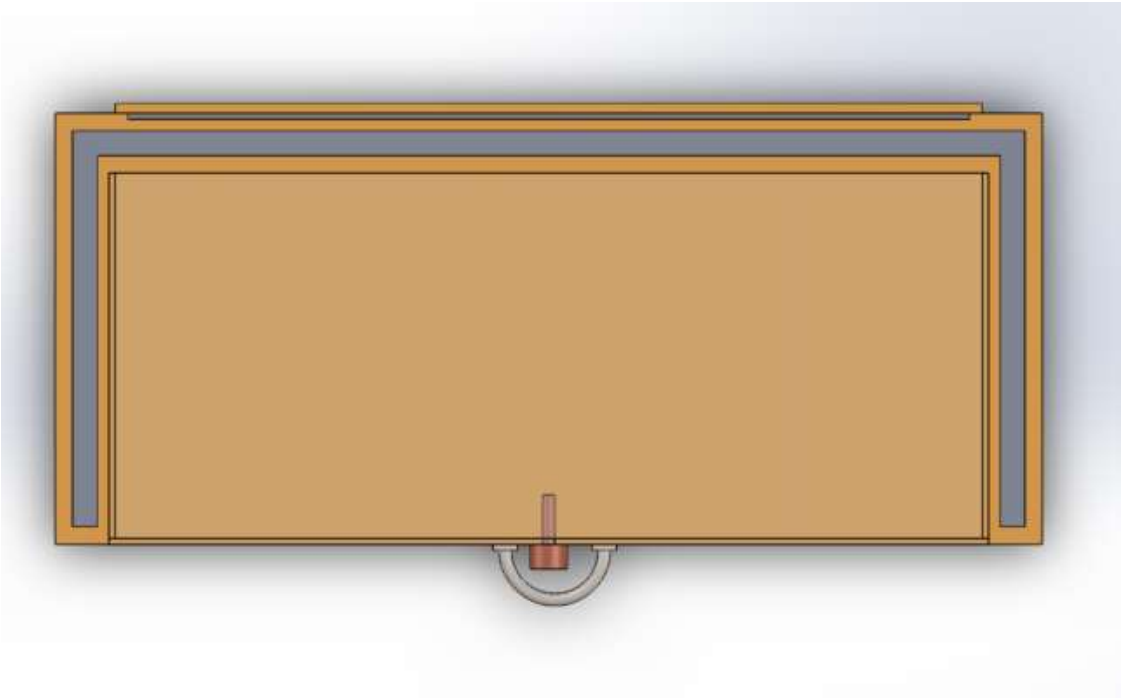


Figure 3.7: Top View

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, and data acquisition system

4.1.1: Digital laser thermometer, Analog round thermometer

In this experimental phase, we used two different types of thermometers to calculate the heat inside the cooker, also the heat absorbed by the glass. We started by heating the cooker for about an hour to reach approximately 200 degrees of Fahrenheit. We moved toward the second step of measuring the heat after adding food into the cooker. We measured the heat the moment we placed the food and it was about 180 degrees because some heat was lost after opening the glass door for placing food. The reason for using two thermometers was to decrease the percentage of error which could damage the food inside the cooker, also to calculate the difference of reading of both thermometers. And choose the best with high efficiency and accuracy.

Specifications:

Table 4.1: Data of Laser thermometer

Digital thermometer	Data
Temperature °C	-50°C ÷ 1000°C
Test Distance	2m-3m
Response time	250mS
Power supply	2×1.5V batteries type AAA LR03
Laser pointer	Red dotted
Dimensions	180×105×55mm
Weight	240g

Table 4.1.2: Data for analog thermometer

Analog Thermometer	Data
Temperature °C	0°C - 400°C
Dimensions	70mmX70mmX15mm
Weight	57g

Figure 4.1: Laser Thermometer

Figure 4.2: Analog Thermometer

4.1.2: Fry pan

In figure 4.3, we can see that a fry pan was used to test our prototype. We used a high-quality fry pan that can absorb heat quickly and cook efficiently the material inside the pan is nonstick. We used a silver chrome coated team pot which is light in weight also efficient in absorbing heat. The detailed specifications are given in the figure below.

Specifications:

Table 4.1.3: Fry pan data

Color	Black
Dimensions	430mmX330mmX67mm
Diameter	242mm
Material	Aluminum
Weight	880g

Table 4.1.4: Tea pot data

Color	Silver Chrome
Dimension	215mmX190mmX143mm
Capacity	1.42kg
Material	Aluminum
Weight	399g

Figure 4.3: Fry-Pan

Figure 4.4: Tea Pot

Table 4.1.5: The testing parameter

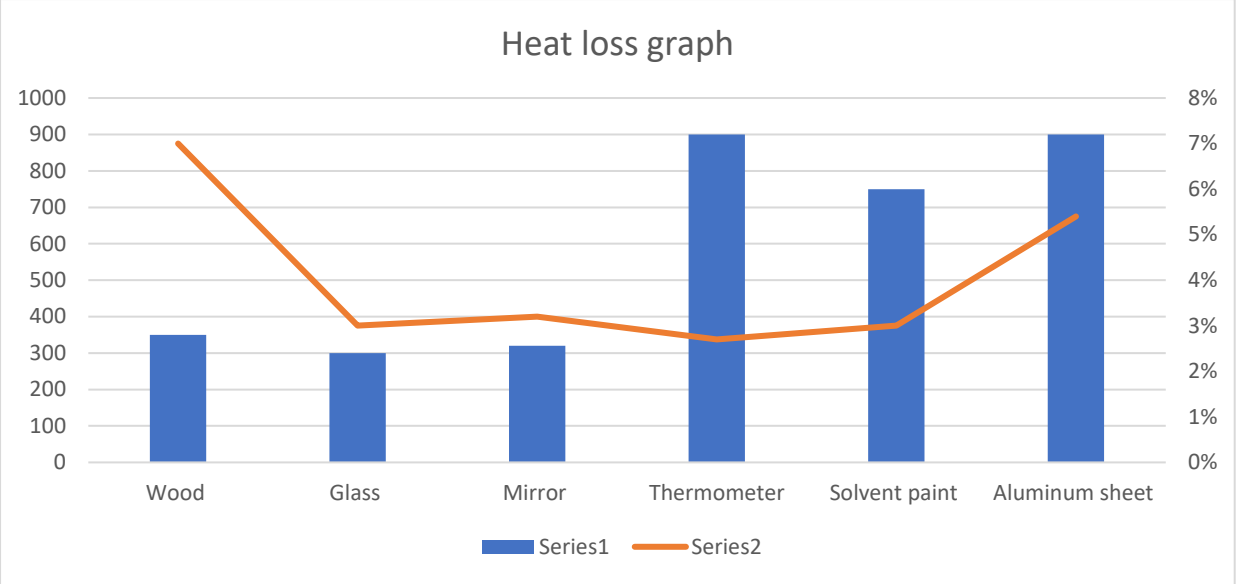
Testing parameter	Objectives
Laser digital Thermometer	To measure heat absorbed by the sun light
Analog thermometer	To measure heat absorbed by the sun light
Fry pan	To test the efficiency of cooking
Tea pot	To test the efficiency of cooking

4.2 Results, Analysis and Discussion

Table 4.2.1: Data of the result

Material	Heat capacity	Heat loss	% of loss
Wood walls	350°C	2°C	7 %
Glass	300°C	1°C	3 %
Mirror	320°C	1°C	3.2 %
Thermometer	900°C	0.3 °C	2.7 %
Solvent coating	750°C	0.4°C	3 %
Aluminum sheet	900°C	0.6 °C	5.4%

In the figure above, we have discussed the heat transformation between the materials. We also have stated the approximate heat capacity of each material, as well as the heat loss due to the specifications of the materials. The first column is filed with all the material which will be affected by heat or affect the heat. The second is stating the heat capacity, the third column stating the approximate heat loss, and the last column is to declare the approximate percentage of loss between the heat capacity and heat lost from the material.



Graph 4.2.2: Graph for the percentage of heat loss

Chapter 5: Project Management

5.1 Project Plan

In our project, we have assigned tasks to each of the group members which we will explained in the figure below with all the necessary details concerning the management including task and its duration.

Table 5.1: Tasks and their durations

Task		Start	End	Duration
Chapter 1: Introduction		17/01/2021	20/01/2021	4
Chapter 2: Literature review	Project background	21/01/2021	26/01/2021	5
	Previous work			
	Comparative study			
Chapter 3: System design	Design constraint & design methodology	27/01/2021	21/02/2021	25
	Engineering design standards			
	theory and Theoretical Calculations			
	Product Subsystems and selection of Components			
	Manufacturing and assembly			
Chapter 4: System testing and analysis	Experimental Setup, Sensors and data	23/02/2021	25/02/2021	3
	Results, Analysis and Discussion			
Chapter 5: Project management	Project Plan	26/02/2021	06/03/2021	10
	Contribution of Team members			
	Project Execution Monitoring			
	Challenges & Decision			

	Making			
	Project Bill of Material & Budget			
Chapter 6: Project analysis	Life Long Learning	07/03/2021	14/03/2021	8
	Impact of Engineering Solution			
	Contemporary Issues Addressed			
Chapter 7: conclusion & recommendation	Conclusion	16/03/2021	18/03/2021	3
	Future Recommendation			
Design of prototype	Design of box	19/03/2021	25/03/2021	7
Parts purchase	Silicon	26/03/2021	15/04/2021	20
	Wood			
	Glass			
	Mirror			
	Gauge			
	Thermometer			
	Paint			
	Insulation			
	Hinges			
	Handle			
	Screw			
	Washer			
Manufacturing	Glass cutting	16/04/2021	24/04/2021	9
	Wood making			
Testing	In hot weather	26/04/2021	28/04/2021	3
	In cold weather			

Table 5.2: Tasks and assigned members

#	Tasks	Assigned members
1	Chapter 1: Introduction	All
2	Chapter 2: Literature review	All
3	Chapter 3: System design	Ali Syed Shah
		Abdulaziz Alghamdi
		Faisal Abdulrahman
4	Chapter 4: System testing and analysis	All
5	Chapter 5: Project management	All
6	Chapter 6: Project analysis	All
7	Chapter 7: conclusion & recommendation	All
8	Design of prototype	Ali Syed Shah
		Abdulaziz Alghamdi
		Faisal Abdulrahman
9	Parts purchase	Ali Syed Shah
		Faisal Abdulrahman
10	Manufacturing	Ali Syed Shah
		Faisal Abdulrahman
11	Testing	All

5.2 Contribution of Team Members

In this part of the report, we are going to state the contribution amount of each member of our team in making the project. We are going to analysis all the contribution in detail with percentage of conurbation in the figure below.

Table 5.3: Tasks the contribution of the members

Tasks	Assigned	Percentage
Chapter 1: Introduction	All	100%
Chapter 2: Literature review	All	100%
Chapter 3: System design	Ali Syed Shah	33%
	Abdulaziz Alghamdi	33%
	Faisal Abdulrahman	33%
Chapter 4: System testing and analysis	All	100%
Chapter 5: Project management	All	100%
Chapter 6: Project analysis	All	100%
Chapter 7: conclusion & recommendation	All	100%
Design of prototype	Ali Syed Shah	33%
	Abdulaziz Alghamdi	33%
	Faisal Abdulrahman	33%
Parts purchase	Ali Syed Shah	50%
	Faisal Abdulrahman	50%
Manufacturing	Ali Syed Shah	50%
	Faisal Abdulrahman	50%
Testing	All	100%

5.3 Project Execution Monitoring

We made a table for our activities during our period of project, in which we are going to set meeting with the instructor, as well as we are going to meet the group member at least three times a week. All the details of activities are mention below in the table.

Table 5.4: Dates of the activates and events

Time & Date	Activities & Events
One time a week	Assessment class
3 times a week	Meeting with group members
Once every 2 weeks	Meeting with the advisor and co-advisor
25 March 2021	Finishing first prototype
25 March 2021	Midterm presentation
24 April 2021	First test of the system
26 April 2021	Finishing final prototype
28 April 2021	Test the system
15 May 2021	Final Submission of the report
18 May 2021	Final presentation

5.4 Challenges and Decision Making

While manufacturing the prototype we have faces so many challenges which we handled them with precise decisions to make them work as perfectly as any cooker would do. Here are some challenges that we face:

1- Size and measures for perfect cooker problem.
2- Blasting tempered glass problem.
3- Heat loss problem.

5.4.1: Size and measures for perfect cooker problem:

In our project, we used more than two materials and we have to choose wisely to minimize the cost and time. However, we faced many issues with the material but we found solutions for each of them and we will discuss them here.

- Wood structure

In the beginning, we had to make sure that the structure of the cooker should be in size, efficient, easy to carry, and easy to maintain. In the process of building the structure, we had to cut and organize every part of the structure, after cutting all parts of the structure we found out that our cutting machine dimension was out of order we had to cut all the structure again and redesign our project to make it easy to build.

5.4.2: Blasting tempered glass problem:

We used the glass to cover the top and the right side of our cooker where we can see the food cooking, we could have used wood as the cover but instead, we used glass to make it easy and efficient to stable the heat inside the cooker. The glass would break every single time we cut it and temper it because we did not have a special lifting car tool kit to transfer the glass from the factory to our manufacturing area, second problem was the glass has to be thin so the sunlight will pass through it without any blockage. So, we used 6mm thin glass and tampered with it although we organized a safe delivery from the factory to the manufacturing point.

5.4.3: Heat loss problem:

After finishing with the structure of our prototype we had to test the efficiency of our cooker. So, in our first test we realize that we had gaps between the glass and wood therefore, we had a less efficient more time taking process of cooking. We filled the gaps with solvent black paint and gave the whole wood surface three coats to minimize the heat loss. After that, we used epoxy and silicon to fill the gaps between the glass and the wood also the gaps between the glass and the analog thermometer.

5.5 Project Bill of Materials and Budget

In the table below, we have stated all the materials with costs in Saudi riyal. This table includes manufactured material and materials which was failed and rebuild for absolute results.

Table 5.5: Bill of materials

Material	Cost
Wood frame	450
Transparent glass + failed	270 + 250 + 200 + 190
Reflection mirror	60
Analog thermometer gauge	90
Wool insulation	100
Solvent paint	250
Hinges	20
Handle	15
Screws	5
Epoxy	18
Silicon	8
Wood glue	5
Total	**1913 SAR**

Chapter 6: Project Analysis

6.1 Life-long Learning

Working on has brought up light upon skill development which we acquired the knowledge of earlier throughout our studies. Under the guidance and supervision of Dr. Waqar, we have been able to experiment and further improve our prototype and use the mistakes we have made as clues to fixing and learning about the mistakes we made. While working on this project, we have always worked together as a team, which led to improvement in communication, teamwork, and time management skills. Further below, we will discuss our experience and skills acquired while working on this project.

6.1.1: Software skills

The process of writing the report while designing and manufacturing the prototype has required us to use multiple softwares that we have used in the past. Both Microsoft Word and Excel in addition to Solidworks have been used to design the prototype and improve the quality of the report. Even though these softwares have been a part of our studies throughout our undergraduate journey, we were required to dive further into more advanced settings and options to ensure we ended up with the desired prototype design with all the material properties in Solidworks. Moreover, we had to take a further step on Excel to ensure we had precise calculations and base graphs upon those.

6.1.2: Hardware Skills

We are mainly using two types of thermometers in our project. Since we have not used those thermometers objectively in the past, we had to learn their functionalities to put them to perfect use. We used both the taser thermometer and the analog thermometer. The laser thermometer, also known as an infrared thermometer, allows the user to measure the surface temperature accurately from a distance, while the analog thermometer serves as the main temperature measurement tool for our system.

6.1.3: Time Management Skills

One skill that we have acquired throughout the project journey is time management skill. One major reason that helped us organize our time and keep up with deadlines is the Gantt Chart which we have been asked to create earlier in the semester. The Gantt Chart consisted of

major tasks with deadlines corresponding with each task, and within these major tasks, we created smaller subtasks to ensure no work will be overloaded and that everything will be prepared and ready before the required deadlines. The chart was being kept updated throughout the semester in case we had issues that caused time changes.

6.1.4: Project Management

Working as a team on this project has caused the experience to be easiest and led us to learn a new skill, which is project management. We divided the project equally between us while helping each other with each part. This resulted in a more efficient time for us to write the report and design the project while at the same time adding each student's perspective to every aspect of the project. This has resulted in a drastically more efficient and polished prototype and report.

6.2 Impact of Engineering Solutions

The impact of our project covers multiple areas including environment, economy, and society mainly. Further below, we will further discuss those impacts in detail.

6.2.1 Society

Unlike conventional ovens, our system is extremely time-efficient as it can be out in the sun while cooking and requires little to no monitoring compared to conventional ovens. This causes the solar cooker to be perfect for picnics, camping, or trips in general. This leads to a more sociable experience and more time efficiency.

6.2.2 Economy

The solar oven is a great economical option for both its production cost and energy cost. For the production cost, it uses much cheaper materials compared to regular ovens which are more intricate and require a higher budget. At the same time, the conventional ovens rely on gas refilling every set it runs out which adds up recurring payments to continue using it. While in the case of solar ovens, you are reliant on solar power to generate heat which does not cost anymore and hence is a more economic option.

6.2.3 Environment

Our project is generally an environment-friendly option, especially when compared to regular ovens. Although an argument can be made regarding deforestation that may be caused and noticed while mass-producing the prototype, it is still a much more environmentally-friendly option as it prevents the usage of gas which can cause serious threats to the environment and more specifically the health of users.

6.3 Contemporary Issues Addressed

Generally, in the GCC countries and Saudi Arabia in particular we have been reliant on oil and gas-related products for the major aspects of our lives. Our project provinces an alternative to one gas-run system that is hazardous to both the environment and health. Our vision is to provide an efficient, reliable, and modern system and design that shifts the reliance on gas for cooking and instead of leaning towards renewable energy and a healthier option. Moreover, our system is much more economically friendly compared to regular ovens which serve as a financial solution for those struggling financially especially with the rise of prices and the quality of life in the Gulf region.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusions

Challenges are inevitable in every type of project involving one or many individuals, and the most important skill is utilizing those challenges as learning experiences. Our project was not any different. We have been facing multiple challenges, and though it was not easy coping with them, we were able to learn and improve from those challenges. Our objective in this project is to create a solar cooker. The whole process began with some theory crafting of the prototype design and functionality, followed by calculations that support our theories and ensure its functionality. After that, we divided the workload using the Gantt Chart which made it extremely organized and time-efficient. During the process of making the prototype, we had to go through various material options to ensure the highest quality and efficiency possible. To do that, we used Solidworks to simulate the prototype and experiment with different materials. That has risen a challenge with the availability and the price of some materials and led to us having to shift our decisions regarding some material choice. To sum up, the journey of working on this project has been enjoyable as it gave us the feeling of creating something of usefulness to humans' everyday activities.

7.2 Future recommendations

There are few ideas that we had in mind while working on this project. One idea that seemed interesting on paper was adding solar panels to store energy in batteries to our prototype. While this idea is extremely revolutionary to our design, it brings forward multiple financial and environmental issues to our idea. The creation process of batteries has proved to be extremely harmful and hazardous to our environment which is against our idea of creating an environmentally friendly solar cooker. In addition to that, adding solar panels brings forward a drastic increase to the financial side of the prototype, while requiring batteries to ensure its usefulness. Another recommendation is to try to finalize the prototype as soon as possible because one issue that a lot of students fail to understand is that finishing the prototype is still an early step to ensuring its functionality and readiness. This is a major issue that a lot of students face during their time working on projects and it can be avoided by simply putting more effort earlier on to avoid unpleasant outcomes when time becomes tighter.

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Appendix A: Progress Reports

	SDP – WEEKLY MEETING REPORT
	Department of Electrical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	**Spring**	**ACADEMIC YEAR:**	**2020/2021**
PROJECT TITLE	**Design & Fabrication of a Solar Cooker**		
SUPERVISORS	**Dr. Waqar Khan**		

Month : March

ID Number	Member Name
201700383	*Faisal Al-Abdulrahman
201502576	Abdulaziz Al-Ghamdi
201701390	Ali Sayed Shah
201202207	Abdulrahman Al-Jabr

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Design Constraints and Design Methodology	Abdulrahman	90%	BB
2	Engineering Design standards	Ali	95%	BB
3	Theory and Theoretical Calculations	Abdulaziz	85%	BB
4	Product Subsystems and selection of Components	Abdulaziz	90%	BB
5	Manufacturing and Assembly (Implementation)	Abdulrahman	80%	BB
6	Economic Evaluation	Ali	95%	BB
7	CAD Drawings & Bill of Materials	Faisal	95%	BB
8	Reviewing the report & fixing mistakes	Faisal	65%	BB

List the tasks planned for the month of March and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	**Buying the material for the prototype**	Ali & Abdulaziz

2	**Searching for most suitable workshops & prices for the prototype**	Abdulrahman & Faisal
3	**Manufacturing a prototype**	All

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks
MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives

MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Faisal	4	4	3	4
2	Abdulrahman	4	4	3	4
3	Ali	4	4	3	4
4	Abdulaziz	4	4	3	4

Comments on individual members

Name	Comments
Faisal	Good. He is approaching to achieve final goal.
Ali	Good. He is approaching to achieve final goal.
Abdulrahman	Good. He is approaching to achieve final goal.
Abdulaziz	Good. He is approaching to achieve final goal.

SDP – WEEKLY MEETING REPORT

Department of Electrical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	**Spring**	**ACADEMIC YEAR:**	**2020/2021**
PROJECT TITLE	**Design & Fabrication of a Solar Cooker**		
SUPERVISORS	**Dr. Waqar Khan**		

Month : April

ID Number	Member Name
201700383	*Faisal Al-Abdulrahman
201502576	Abdulaziz Al-Ghamdi
201701390	Ali Sayed Shah
201202207	Abdulrahman Al-Jabr

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Bought the materials for the prototype	Ali	95%	BB
2	Found the most suitable workshops & prices for the prototype	Abdulrahman	95%	BB
3	Manufactured the prototype	Faisal	90%	BB
4	Reviewing the prototype	Abdulaziz	90%	BB

List the tasks planned for the month of April and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	Showing the prototype to our advisor and applying feedback	All
2	Continuing writing the report	All
3	Finding the best place to make banners & brochures	Faisal & Ali
4	Testing the prototype	Abdulrahman & Abdulaziz

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4:
an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

Criteria	None (1)	Low (2)	Moderate (3)	High (4)
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5:
an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Criteria	None (1)	Low (2)	Moderate (3)	High (4)
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks
MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Faisal	4	4	4	4
2	Ali	4	4	4	4
3	Abdulrahman	4	4	4	4
4	Abdulaziz	4	4	4	4

Comments on individual members

Name	Comments
Faisal	Properly and efficiently makes team work plans and allocate resources and tasks
Ali	Communicates properly and effectively with team members
Abdulrahman	Properly and efficiently makes team work plans and allocate resources and tasks
Abdulaziz	Communicates properly and effectively with team members

SDP – WEEKLY MEETING REPORT

Department of Electrical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	**Spring**	**ACADEMIC YEAR:**	**2020/2021**
PROJECT TITLE	**Design & Fabrication of a Solar Cooker**		
SUPERVISORS	**Dr. Waqar Khan**		

Month : May

ID Number	Member Name
201700383	*Faisal Al-Abdulrahman
201502576	Abdulaziz Al-Ghamdi
201701390	Ali Sayed Shah
201202207	Abdulrahman Al-Jabr

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Finished Writing the report	All	90%	
2	Found the best place to make brochures and banner	Faisal & Ali	95%	
3	Reviewed the prototype	All	100%	
4	Tested the prototype	Abdulrahman & Abdulaziz	95%	

List the tasks planned for the month of March and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	Editing and submitting the final report	Faisal & Ali
2	Starting in making the brochures and banner	Abdulaziz & Abdulrahman
3	Starting in the final presentation	All
4	Peer evaluation	All

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks
MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Faisal	3	4	4	4
2	Ali	3	4	4	4

3	Abdulrahman	3	4	4	4
4	Abdulaziz	3	4	4	4

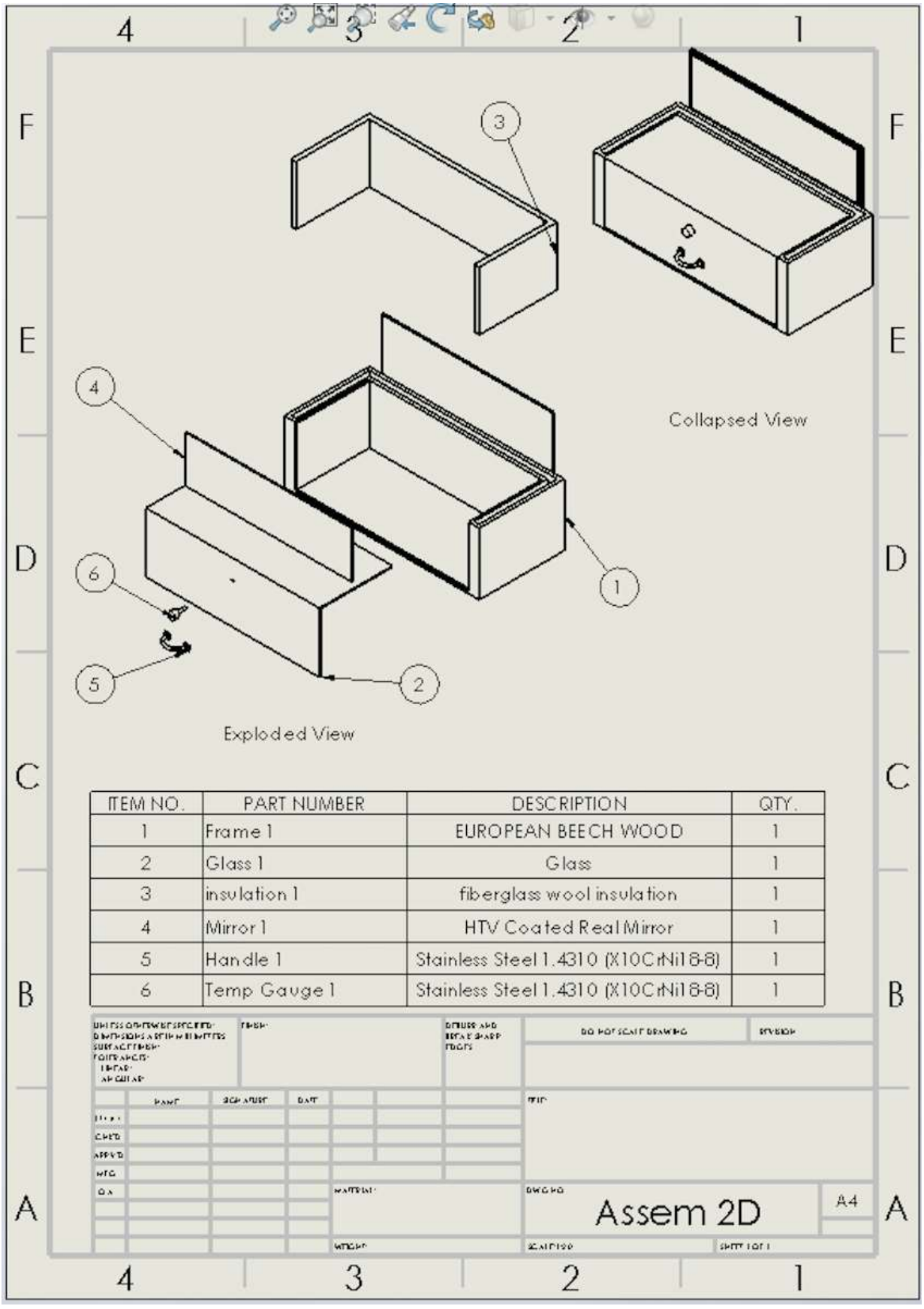
Comments on individual members

Name	Comments
Faisal	Faisal makes properly and efficiently team work plans and allocate resources and tasks.
Ali	Ali communicates properly and effectively with team members.
Abdulrahman	Abdulrahman purpose effectively in team work projects to meet objectives.
Abdulaziz	Abdulaziz demonstrated satisfactory ability to communicate effectively with team members.

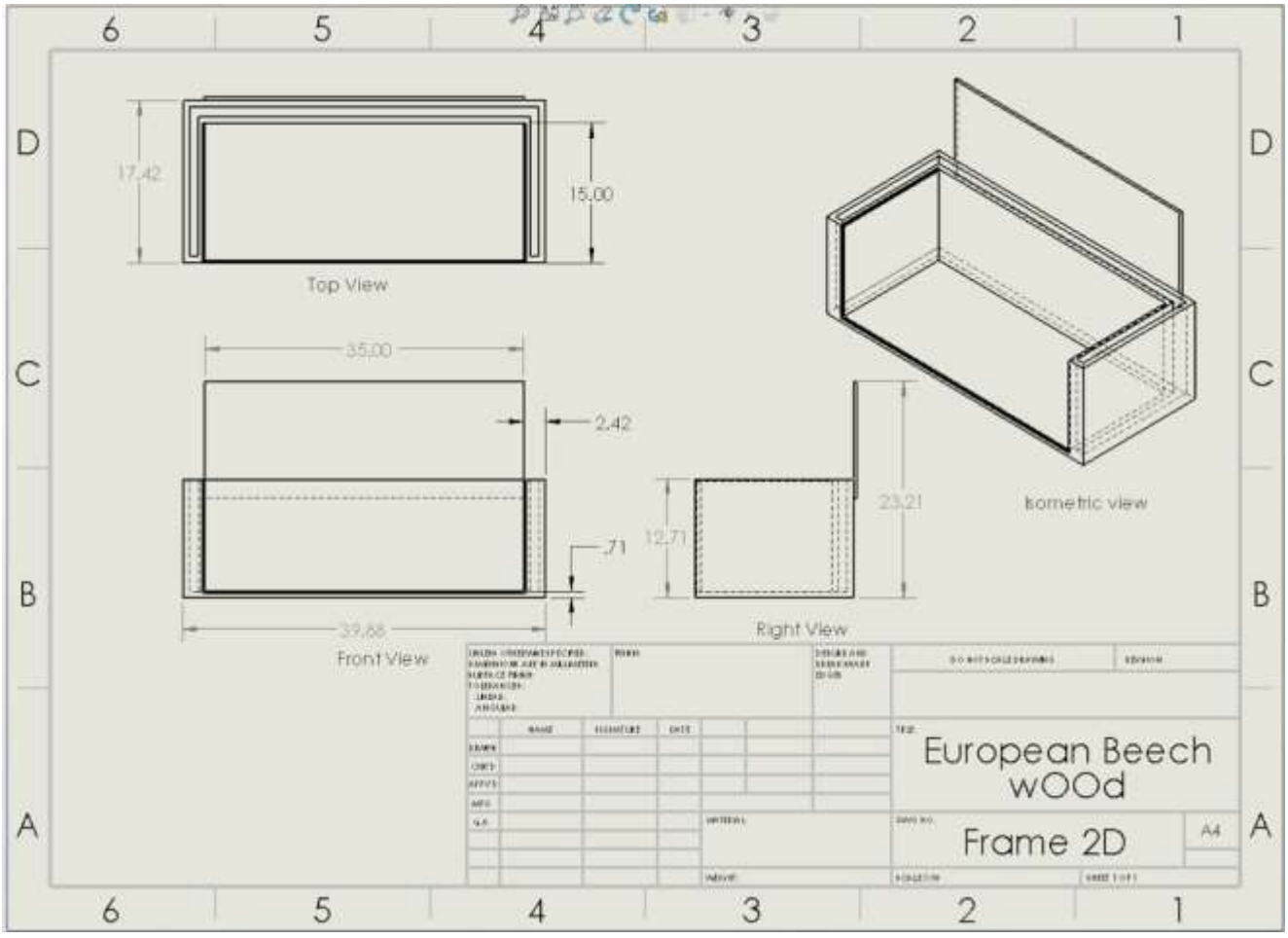
Appendix B: Engineering standards (Local and International)

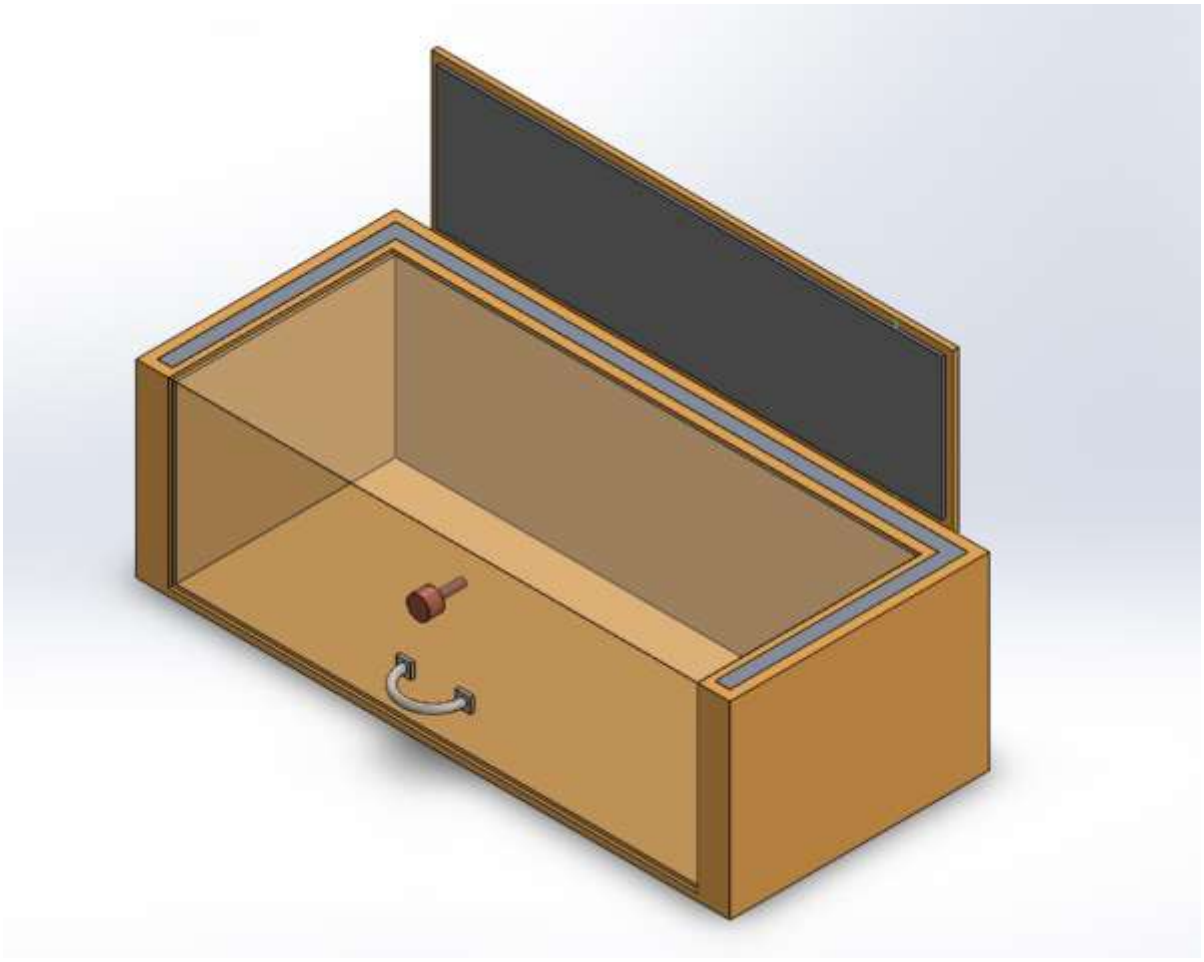
Components	Engineering Standard	Details
Screw	ASME Metric	ASME, B18.6.1 – Formed Flat Head Screw, 1.5’
Wood	ANSI Metric	SIA 265 - 18mm (Beech Wood)
Mirror	ASTM Metric	C1503 – 6mm
Glass	ASTM Metric	C1048 – 6mm (Clear Vision Tampered Glass)
Insulation	ASTM Metric	C1071-19 - 1”
Temperature Gauge	ASME Metric	ASME B40.3
Hinges	Stainless steal	18% chromium -8% nickel 74% Steel
Handle	Stainless steal	18% chromium -8% nickel 74% Steel
Battery (Optional)	IEC 62133	batteries containing alkaline or other non-acid electrolytes
Inverter (Optional)	B08Q7V3D3G	12V - 3000W
Solar Panel (Optional)	Saudi solar panel	12V – 3000W
Range Surface Element (Optional)	GE WB30M2	220v – 1500W each

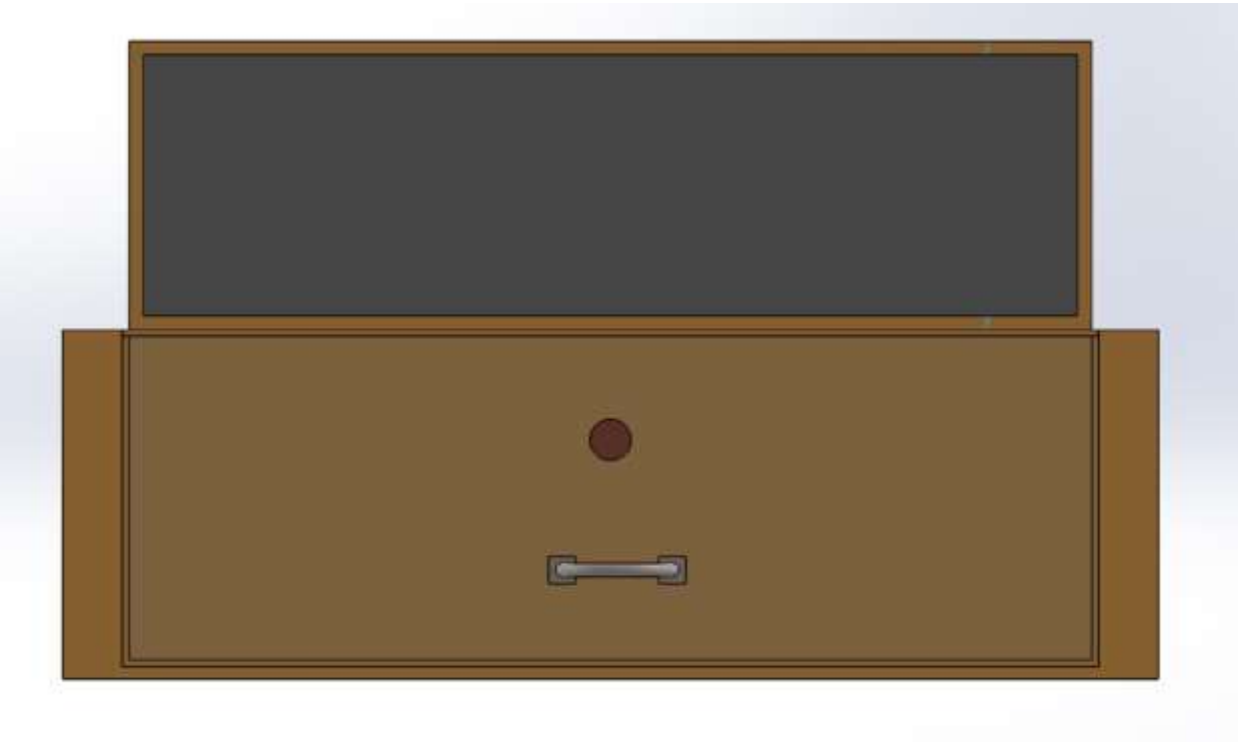
Appendix C: CAD drawings and Bill of Materials

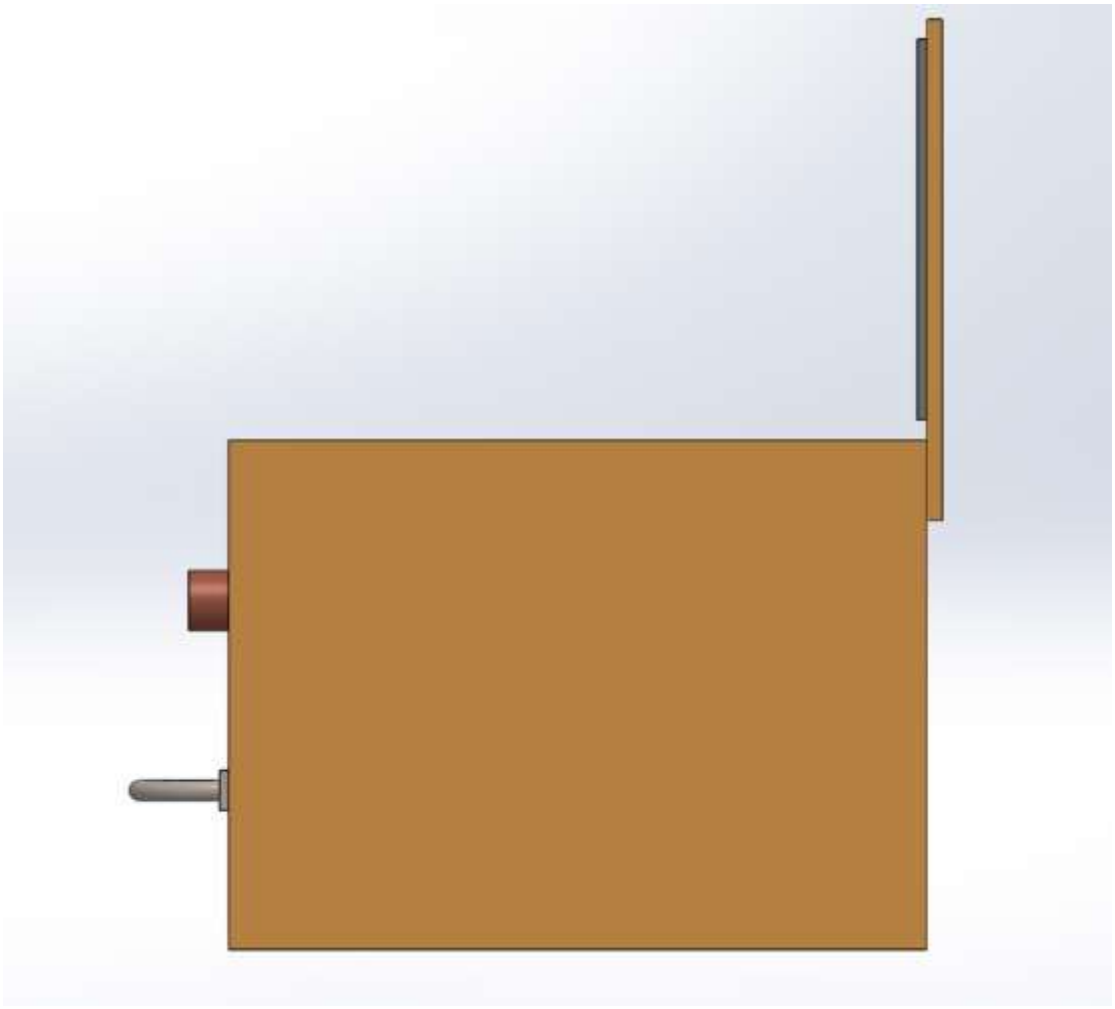


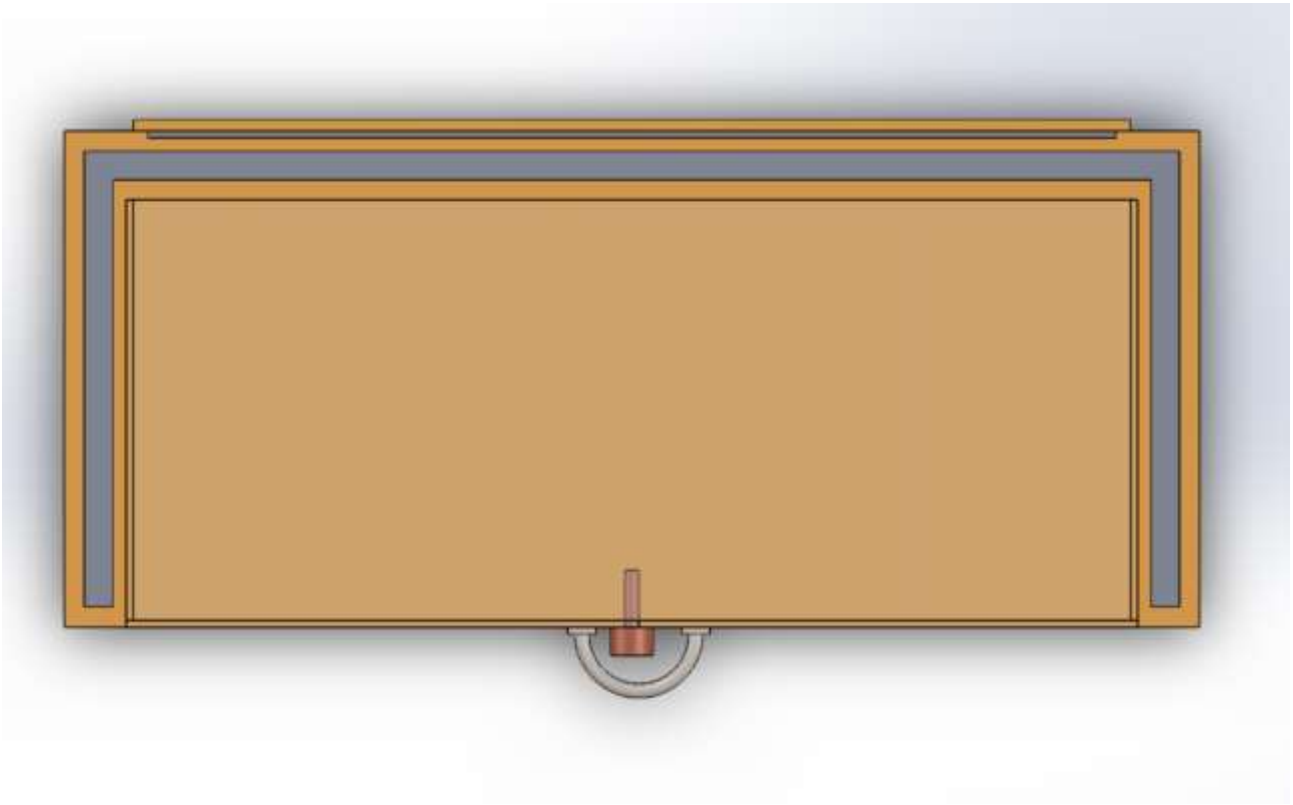
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Frame 1	EUROPEAN BEECH WOOD	1
2	Glass 1	Glass	1
3	insulation 1	fiberglass wool insulation	1
4	Mirror 1	HTV Coated Real Mirror	1
5	Handle 1	Stainless Steel 1.4310 (X10CrNi18-8)	1
6	Temp Gauge 1	Stainless Steel 1.4310 (X10CrNi18-8)	1


17.42
15.00
Top View
35.00
2.42
.71
39.68
Front View
23.21
12.71
Right View
Isometric view
European Beech wOOd
Frame 2D
A4



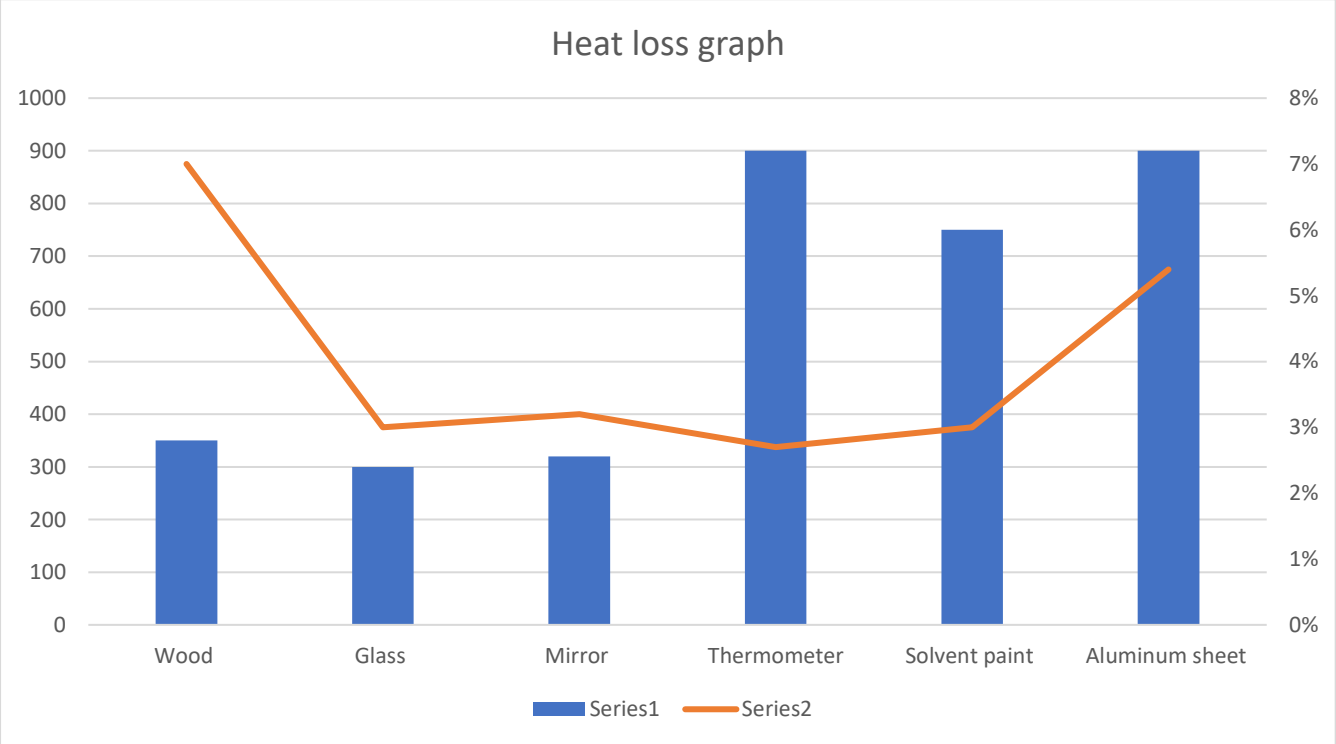






Appendix D: Datasheets

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs											
Equipment	2500	0	0	0	2500	0	0	0	2500	0	0
Construction	650	0	0	0	0	0	0	0	0	0	0
Total	3150	0	0	0	2500	0	0	0	2500	0	0
Operating Cost											
Energy	0	0	0	0	0	0	0	0	0	0	0
Electrcitiy	0	0	0	0	0	0	0	0	0	0	0
Labour	0	0	0	0	0	0	0	0	0	0	0
Insurance	0%	0	0	0	0	0	0	0	0	0	0
Taxes	0%	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0
Revenues											
Solar panel	500	0	0	0	0	0	0	0	0	0	0
Battery	950	0	0	0	0	0	0	0	0	0	0
Charge Controller	450	0	0	0	0	0	0	0	0	0	0
Total	1900	0	0	0	0	0	0	0	0	0	0
Profits	-2425	825	825	825	-1775	825	825	825	-1775	825	825
TOTAL PROFIT	625										



Appendix E: Operation Manual

To run the prototype, please follow these steps:

- Adjust the solar cooker directly to the sun
- Angle the mirrors so that they reflect the UV ray's sunlight directly to the glass (Approximately 30 degrees)
- Check the analog thermometer till it reaches 80 C or more
- Open the bottom glass to put the fry-pan or teapot inside the cooker
- After 20 – 25 minutes check if the food is cooked

The expected results from this operation are:

- Heat transfer for the solar cooker ($\dot{\boldsymbol{Q}}$)

Appendix F: Gantt Chart

Task 1	Start Date	End Date	Days to complete
Forming a group	17/01/2021	27/01/2021	11
Identifying Project			
Finding an Advisor			
Task 2			7
Researching and finding information	28/01/2021		
Finding resources			
Finishing up the Gantt Chart		04/01/2021	
Start writing a draft of the introduction including applications and literature review	05/02/2021	14/02/2021	10
Set a meeting with the advisor	15/02/2021	15/02/2021	1
Applying and finalizing feedback	15/02/2021	19/02/2021	5
Task 3			
Start a rough sketch	20/02/2021	21/02/2021	15
Researching and finding the best material	22/02/2021	24/02/2021	
Designing 3-D sketch using solid works	25/02/2021	28/02/2021	
Meeting with the advisor	01/03/2021	01/03/2021	
Applying feedback	01/03/2021	01/03/2021	
Task 4			
Applying required calculations	04/03/2021	06/03/2021	15
Getting estimated quotation for the project	07/03/2021	08/03/2021	
Starting with the midterm presentation	09/03/2021	15/03/2021	
Meeting with the advisor and applying feedback	16/03/2021	16/03/2021	
Team presentation practice	17/03/2021	19/03/2021	
Task 5			
Purchasing required materials for the prototype	20/03/2021	29/03/2021	33
Start Building the prototype	30/03/2021	06/04/2021	
Testing the prototype	07/04/2021	07/04/2021	
Meeting the advisor and showcasing	08/04/2021	08/04/2021	
Applying feedback	09/04/2021	14/04/2021	
Finalizing the prototype	15/04/2021	15/04/2021	
Complete project analysis	16/04/2021	19/04/2021	
Task 6			
Arranging all the information for the final report	20/04/2021	21/04/2021	28
Writing a final draft	22/04/2021	29/04/2021	
Meeting with the advisor and applying feedback	30/04/2021	30/04/2021	
Finalizing the report and preparing for the final presentation	01/05/2021	04/05/2021	
Team practicing for final presentation	05/05/2021	07/04/2021	
Gathering our work in a USB (videos, presentation, and final report)	08/05/2021	09/05/2021	
Doing brochures and poster	10/05/2021	14/05/2021	
Showcasing the prototype	15/05/2021	16/05/2021	
Leather bound copies	17/05/2021	18/05/2021	