STUDY OF THERMO-PHOTO-VOLTAIC CELL USING COMSOL

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STUDY OF THERMO-PHOTO-VOLTAIC CELL USING COMSOL

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DECLARATION OF CANDIDATE

We hereby declare that the undergraduate research work reported in this thesis has been performed by us under the supervision of Professor Dr. Md. Fokhrul Islam and this work has not been submitted elsewhere for any purpose (except for publications).

………………………………

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DEDICATION

We dedicate our thesis work to our family. A special feeling of gratitude to our loving parents. In addition, we express our deep gratitude towards our respected thesis supervisor Professor **Dr. Md. Fokhrul Islam.**

We also dedicate this thesis to our many friends who have supported us throughout the process. We will always appreciate what they have done.

ACKNOWLEDGEMENTS

ABSTRACT

Over the last 25 years, the global population using electricity has increased from 74 to 85%, since there is a vast increase in industrialization and other sectors. In the near future, there will be a scarcity of fossil fuels like coal, natural gas, and oil in the entire world. Hence there is an urge to develop some methodologies for renewable energy sources. The first and foremost renewable energy is the sun's solar energy since it is freely available as well as abundant. But the solar cell has various disadvantages which include high initial investment and less conversion efficiency. However, the methodology of integrating the thermal and photovoltaic systems was introduced broadly known as the photovoltaic thermal system. Thermal Photovoltaic (TPV) combines solar thermal and photovoltaic systems. This technique benefits from both light and heat of the solar radiation to produce electricity. Research in TPV systems is rapidly growing with more methods and techniques to increase the overall efficiency, reduce the cost, improve the modeling, and maintain the system for long periods of time and employ them for suitable applications. The paper aims to study some of the research conducted in this field in order to understand and derive key points to producing more research and providing constructive and accurate criticism for the work presented. Also, a detailed explanation of TPV systems' principles and operation is presented. Classifications of TPV in terms of absorber design, the shape of pipes, PV configuration, type of working fluid (base-fluid), and type of PV panels are all discussed in the literature survey. Finally, it is concluded that there is a clear lack in electrical, economic, and environmental evaluations, where most articles in TPV are dominated by the thermal study of the system.

LIST OF FIGURES

CHAPTER 1

Introduction

The chapter presents the main regions of this thesis which are related to the thermal photovoltaic cell (TPV). The chapter grants the motivation and describes the aims of this research. Moreover, the thesis contribution are highlighted. Additionally, this chapter includes a section that introduces important aspects of this thesis.

The current scenario is that the world requires more energy to meet the growing needs of the population since there is a vast increase in industrialization and other sectors. Though there is an increase in the population which has further induced the growth of technology and industries to meet the employment as well as the needs, there is not much increase in the energy that is being produced. Hence, the biggest issue to serve the current world community is the energy. Energy is being a requirement in all the sectors like industry, agriculture, medicine, transport, household, etc. The statistical prediction says that by the year 2035, the energy consumption by the world would increase to more than 30% [1] of what is being required and consumed now.

1.1 Project background

To address the global challenges of climate change, sustainable development and clean energy are needed to accelerate the growth of advanced energy technologies. These non-renewable sources, which means thermal photovoltaic, technological ones help control energy-related CO2 emissions. Taking this great technology to prevent global warming to 2 degrees Celsius (° C) over time and to further global development is a perfect goal.

Solar energy is very common all over the world and can help reduce dependence on energy consumption. As it does not require the risk of fuel prices or issues, it also increases the safety of the supply. Solar energy recommends energy separation and fencing in contrast to fluctuating fossil fuels, thus stabilizing the price of electricity generation in the future.

Solar photo voltaic is environmentally friendly and does not promote the emission of greenhouse gas (GHG) and other pollutants (sulfur oxides and nitrogen) throughout its operation; moreover, it does not require water or a small amount. As daily air pollution and widespread use of clean water to cool tropical energy plants has become a stressful concern in tropical and subtropical areas, the benefits of solar PV are becoming increasingly evident.

1.2 Motive for research

Electricity generation is a major source of greenhouse gases, in addition to all our driving and flight combined, and clean energy reduces harmful fumes, toxic buildup in our air and water, and the effects of coal mining and gas emissions. Using clean, renewable energy is one of the most important technologies to reduce the impact on the environment. But replacing petroleum production will take time - with strong, consistent funding from state and federal authorities to build renewable energy and demand for clean energy for consumers and businesses.

1.3 Project statement

A thermo-photo-voltaic cell (TPV) generates electricity from gasoline fires and radiation. Fuel burns inside a highly emissions substance. Photovoltaic (PV) cells are very similar to solar cells that absorb radiation and convert it into electricity.
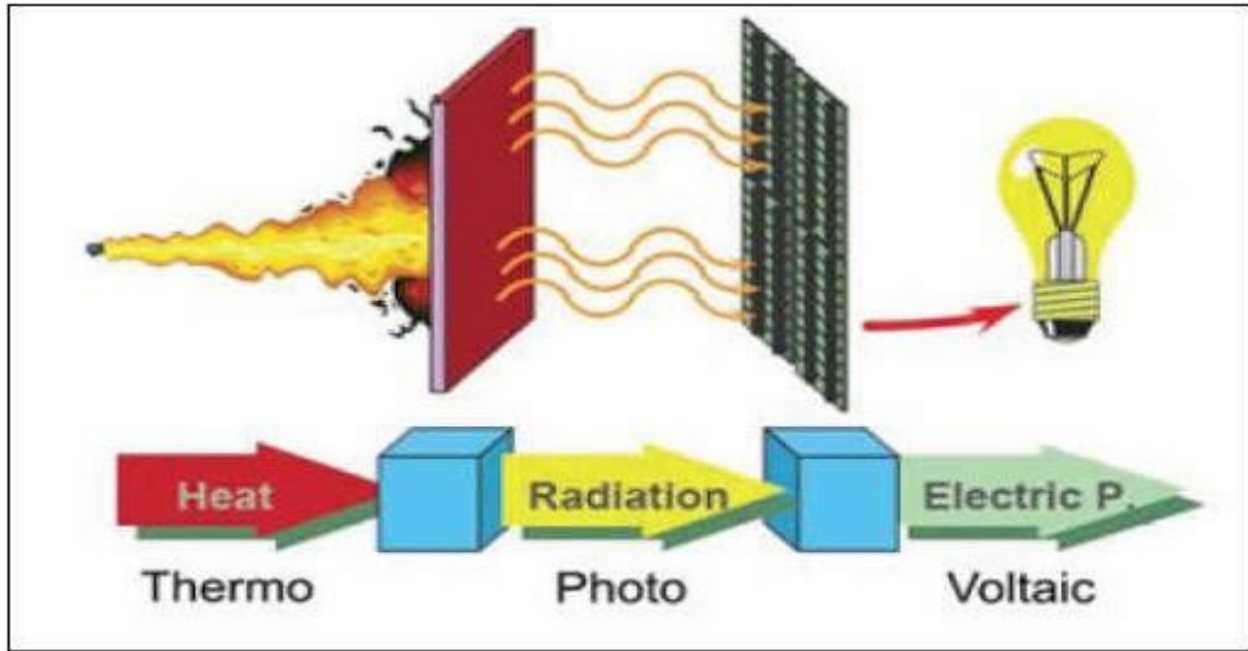
Figure 1. Schematic representation of thermophotovoltaic energy conversion (Source: Kassel University)

1.4 Project objective

The purpose of this project is to study the performance of various extraction elements in many imaging cells, including various physical properties such as thermal conductivity, specific thermal energy and volume. Next we see the changes in the following graphs: PV particles, power interruptions and interaction surface radiation

1.5 project scope

Developed countries around the world are focusing on sustainable energy sources, especially solar and wind power, to meet the growing energy demand. The industrialization of the eighteenth century greatly increased the demand for electricity worldwide. Of all the sustainable energy sources, solar PV has the highest cost, but due to its low maintenance costs and maintenance, this technology is respected worldwide. Another advantage of solar PV is the increase in efficiency and energy efficiency. The installed capacity of solar PV around the world is increasing day by day as there is high interest as suggested .
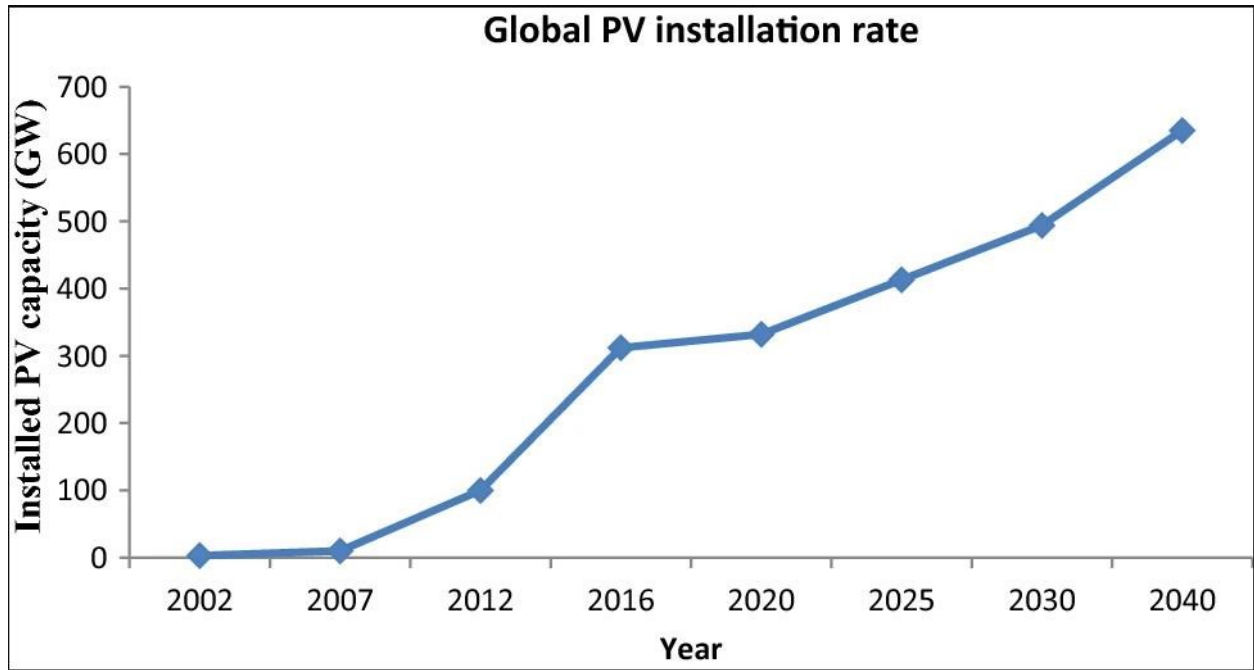
Figure 1.2 Global PV installation rate

CHAPTER 2

Literature Review

2.1 Introduction

"Thermal photovoltaic is a combination of PV and solar thermal collectors that simultaneously generate both electricity and heat. 60% to 80% compared to a thermal collector living in a panel or other area. "
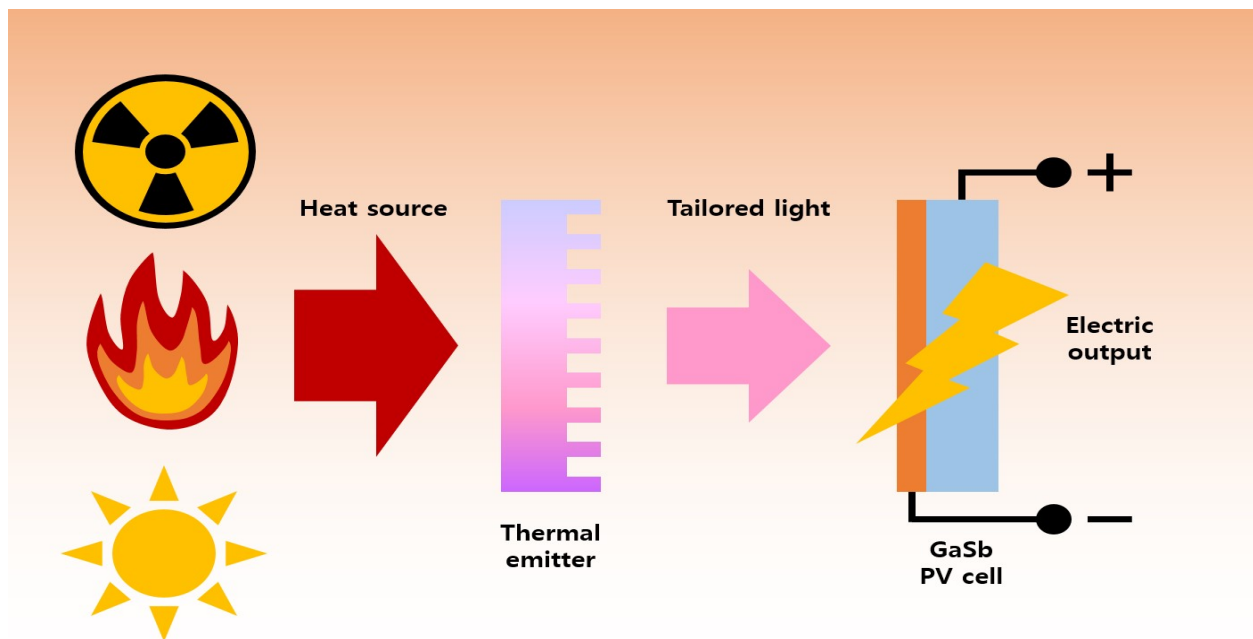

Figure 2.1 Operation of thermal solar System

Over the past decade, additional studies have been launched to promote the optimal performance of thermal photovoltaic (TPV) systems due to the growing interest in the use of solar system technology. Researchers are focusing on these days to improve the performance of photovoltaics and Solar Thermal (ST) capabilities [1-5]. For that reason, great importance has been given to the growing efficiency of photovoltaics and the efficient operation of solar thermal systems.

Lowering the photovoltaic temperature is important in keeping the circuit voltage open and consequently the total power of the cell [13]. Because PV / T structures are PV and ST structures so it is important that you provide each definition first. Photovoltaics are semiconductor devices that convert sunlight or photons into Direct current (DC). PV cells can be connected to all the variables in the same way as module series and the same can be filled in the form of their own modules to provide panels

Global demand for electricity is growing rapidly due to population and industrial development [1]. Nowadays, gasoline is used in large quantities to meet the demand for energy, following the release of pollutants that cause great damage to the atmosphere. Global warming is a serious problem that threatens the survival of people and species. The energy crisis is a barrier to financial growth in many countries. The use of renewable energy sources as an alternative to fossil fuels is a gateway to controlling this energy crisis [3] .Environmental resources are an essential requirement for the future of our planet [4]. We need urgent steps to be taken to upgrade our current power structure and make it easier to use renewable energy sources to generate electricity at low cost and with high efficiency.

➢   Solar energy is one of the richest renewable energy sources on earth, according to a source of information about 1.8×1014 kW of heat and light from the sun absorbs the earth at no cost [6]. Solar energy is full and constant energy [7].

➢   Solar energy use by eco-friendly and renewable energy sources such as Solar is much lower than other energy sources [8].

➢   Solar energy generation is a very simple and efficient source of energy especially in rural areas, industrial activities and the use of energy needs with a low level of residential (home) needs as an inexpensive energy source
[9].

2.2 Solar comparison

Semiconductor materials are used for power generation in solar panels and photovoltaic systems to convert sunlight into direct energy. Solar and photovoltaic are both developed by solar energy technology. Photovoltaics, as a result, is more efficient when the sun is shining, and should be combined with both power generation methods to make normal energy delivery.

Mirrors are used to focus on the sun through the installation of thermal technology such as emitter. Focused daylight is used without delay as a heat sink, as a solar water heater, or to power a heat cycle that contains an excellent engine. In addition, when it is considered that the sun's heat produces only heat, it is able to conserve various thermal energy. Some plants can actually save up to 7.5 hours a day instead of the sun. [3] As a result, the sun's heat can undoubtedly produce 24-hour full-time electricity.
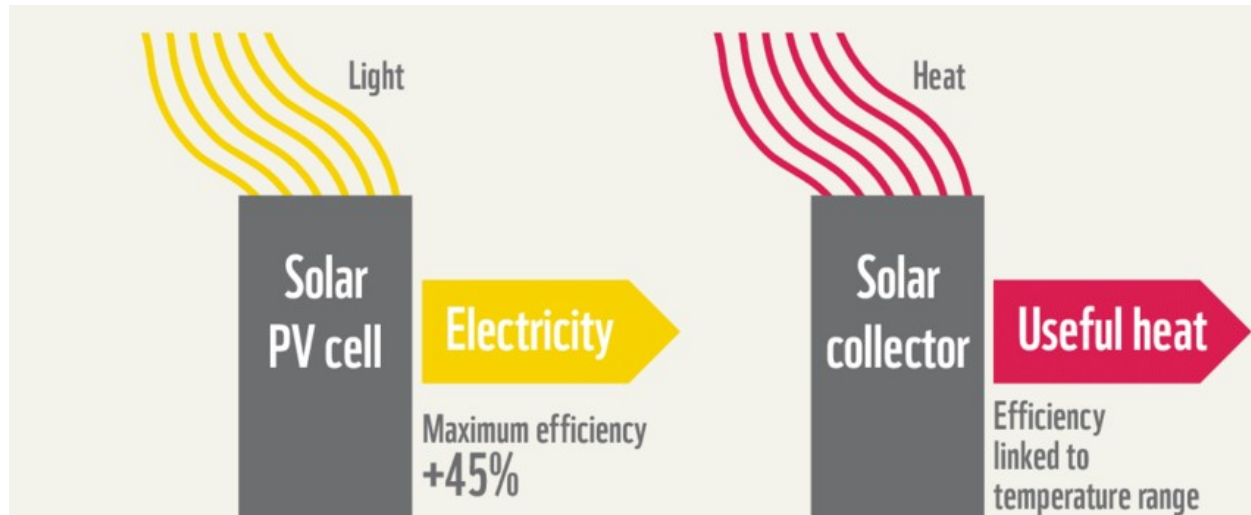
Figure 2.3 Work function of Solar PV Cell

2.3 PV system

Substantial work has been established over the past decade on independent and integrated production methods to improve the efficiency of the photovoltaic life cycle. Due to advances in PV technology, EPBT and GPBT limitations have been placed under review.

The production of PV modules involves the following processes

i) Silicone cleaning and maintenance
ii) Silicone cutting
iii) Development of PV maintenance

Silica is first melted into metallurgical-grade silicon (Mg-Si) and then processed by the Seaman process into an electronic silicon (EG-Si) or silicon solar system (SOG-Si) process. Siemens exchange [17]. Finally, silicon became available in the production of solar cells following the Sijocrals (scSi) process or other production process. The silicone rod needs to be cut into the membrane. Cell production technologies include etching, doping, screen printing and coating. Solar cells are tested, packaged and connected to other components to make PV modules.

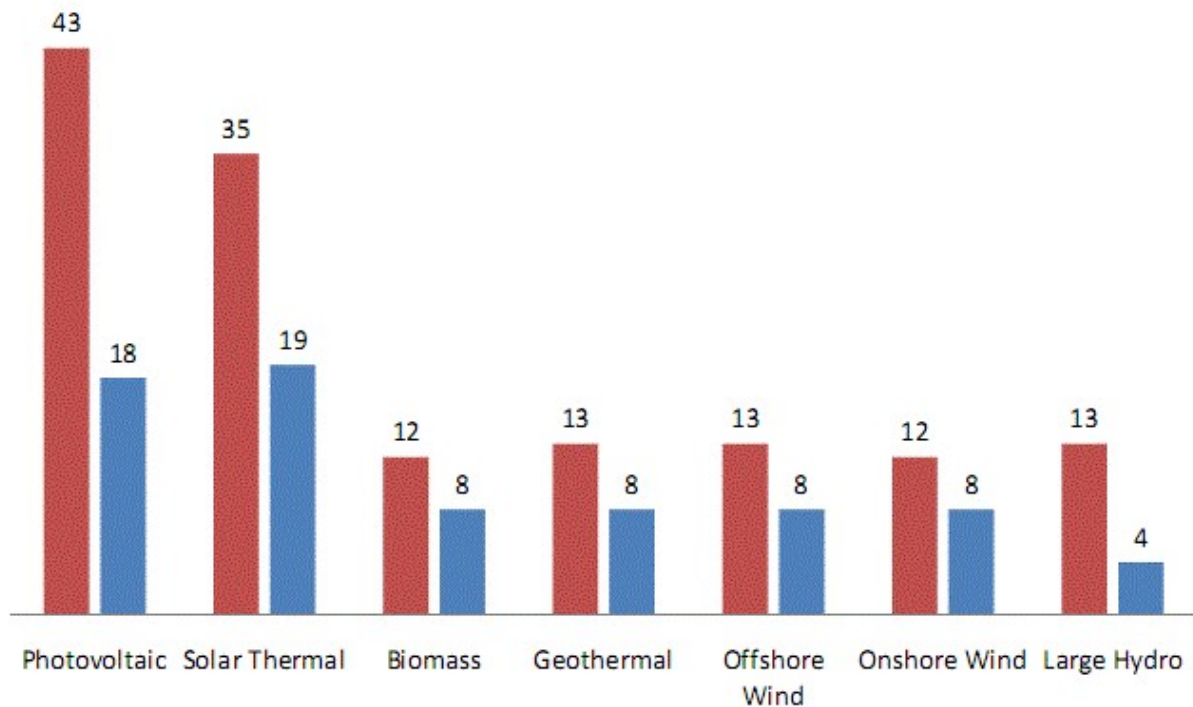**Min and Max Cost of Renewable Energy (cents/KWHr)**

Fig. 2.4: Relative cost of renewable energy. [5]

These data show that the two types of solar costs are almost identical and at least 2 times more expensive than other types of renewable energy.

2.4 Solar economy

Solar energy is one of the most expensive renewable energy sources available at 18–43 cents per kilowatt. The price of solar energy compared to other renewable energy sources is shown in Figs. From these statistics, it is clear that solar is one of the cheapest forms of alternative energy. In fact, the U.S. Project Energy Information Administration states that by 2035 solar energy will represent at least a small fraction of renewable energy.

The economics of photovoltaics are plagued with implementation problems. First, Germany has the largest solar energy market in the world. [Also] Germany, for most of northern Europe, achieved 2/3 of the intensity of the Minneapolis beam and half the parallel rays of the southwestern American cities of Los Angeles. [4] In addition, over-inversion currently accounts for most of the total value of the system. In fact, since 2007 the VAT price of a photovoltaic power plant has more than doubled over a photovoltaic panel. [10] If these installation costs are not reduced to some extent by the use of economics or other means, the cost of solar energy will be significantly reduced.

2.5 Prioritize environmental issues

Economic and technical possibilities using industrial PVT systems were analyzed (Haji et al., 2014). An analytical model has been developed to estimate economic indicators and energy parameters based on the three parameters of solar radiation, air, and water temperature. Therefore, a modern mathematical model is used to simulate PVT systems in various Romanian environments. The heat coming from the PVT system in the industrial area is economically attractive and the recovery time is less than the lifetime

2.6 Environmental Impact from Power Generation

The Photovoltaic (PV) environment is adversely affected and there is no noise or chemical pollution in use. It is one of the most effective renewable energy technologies used in urban environments, restoring existing construction materials. It is an attractive choice for use in beautiful landscapes and national parks, where arches and ropes are avoided.

2.7 Book review

The following research papers refer to or broaden the broad concepts related to PV / TK. Stabler et al. [11] In this article the researcher states that "installing a glass cover for collectors polished with transparent amorphous silicon PV modules produces 32.5% full PV / T performance and 4.7% PV efficiency". The authors of this article argue that these types of PV / T systems are more user-friendly due to the lower cost of amorphous silicon. This brings the right point to the less expensive point. However, there must be a comparison between cost and efficiency.

Hadd et al. [12] The research work compares between the three systems; PV / T, PV and ST to demonstrate the strength of PV / T systems. A monocrystalline silicon PV module was used, in which the copper tubing was mounted. The authors claim that the system achieves 42% heat work during the day. This paper highlights the importance of comparing hybrid PV / T with standard PV and ST systems. However, it should be improved in terms of electrical performance. Therefore, the thermal efficiency of PV / T can only be compared with that of ST. Power is ignored in this article.

Selifa et al. [13] Introduced the PV / T collection model using two experimental and theoretical steps. For authors of the theory classes they calculate the measure of power. Each calculation is performed on each object in the system, such as a glass cover, photographic area, and PV panel. The authors claim to have achieved 69% performance of PV / T, 14.8% from PV and 55% from ST. Careful planning and careful study of the heat will increase efficiency. This is an important aspect that needs to be developed, which understands the heat flux in the system and identifies the risks. This article recommends using useful tools to reduce costs. Here again, there is a difference between efficiency and cost, but very little

because the design of the system is very good at avoiding pitfalls. Such a program can be used for various applications.

Ammas et al. [14] Fozy Logic Control (FLC) was introduced as the PV / T rental device for the reverse osmosis (RO) abortion plant. The proposed system will include the collection of sheets and tubing. The article shows the temperature comparison between PV and hybrid PV / T. Results show that the PV / T temperature is lower than normal PV. This process may require additional costs and construction time and safety when hiring RO output plants. The authors do not explicitly mention cost or efficiency.

Mozunder J. C. Et al (2016) [16] investigated the collector type effect by proposing two types of collectors (types A and B) and doing indoor tests with a solar simulator. After the test is complete it will follow the data collection. This data is a way to integrate the vector machine model, which measures electrical and thermal emissions and thereby achieves electrical and thermal efficiency. The authors compared the figures to the actual recordings and found that B had a higher performance than A. This document provides a great way to verify results and comparisons between different types of collectors. In general, most articles with PV / T systems do not clearly show how to cope with energy efficiency or how to operate at warmer temperatures. This is due to the performance of the PV panel, which is usually determined at the production stage. However, PV systems (including other materials) can be upgraded and re-read. In addition, the cooling effect on the electrical capacity should be across the PV / T diameter. Or high maintenance of power generation remains an important process for these systems. Exhausted devices such as batteries and charging controls can cause significant financial losses over time to independent PVT systems. "

"According to Ogunzuigbe ASO et al (2016) [17] , the use of Mixed Integral Linear Programming (MILP) is extremely risky in actions such as prioritizing loads such as exposure to a different sun without reducing users' battery life. MILP is used in residential buildings and shows good promise for BIPV systems. Can also be used for BIPV / T programs.

CHAPTER 3

METHODOLOGY

3.1 How it works?

The project was implemented using Comosol Multiphysics, a cross-platform finite element analysis, solver and multifaceted simulation software. Allows for general connections based on integrated systems of physics and various scales.

Thermo-photovoltaic energy conversion (TPV) is a direct process of converting heat from photon into electricity. The primary thermophotovoltaic system consists of a thermal emitter and a photovoltaic diode cell.

We use COMSOL mutation to design and model this hot photovoltaic cell to improve cell performance by altering emissions such as silicon carbide, tungsten) and PV-cell materials (germanium, gallium antimonide) due to our hot light emission capacity. We will. At temperatures above 1300K to achieve optimal performance. By changing properties such as thermal conductivity, constant thermal energy and volume

Thermo-photo-voltaic cell (TPV) generates electricity from petrol and radiation flames. The fuel burns inside the highly degraded material. Photovoltaic (PV) cells - like solar cells - absorb radiation and convert it into electricity. TPV service efficiency ranges from 1% to 20%. In some cases, TPVs are used to generate electricity simultaneously in heat generators and their efficiency is of less importance. In some cases TPVs are used as energy sources, for example in cars. Efficiency is a big issue in those cases.

The model uses heat transfer interfaces and surface-to-surface radiation interfaces to conduct research on operating conditions (flame heat) and temperature of components of a standard TPV system. The model can also predict the effect of geometric changes.

3.2 Model definition
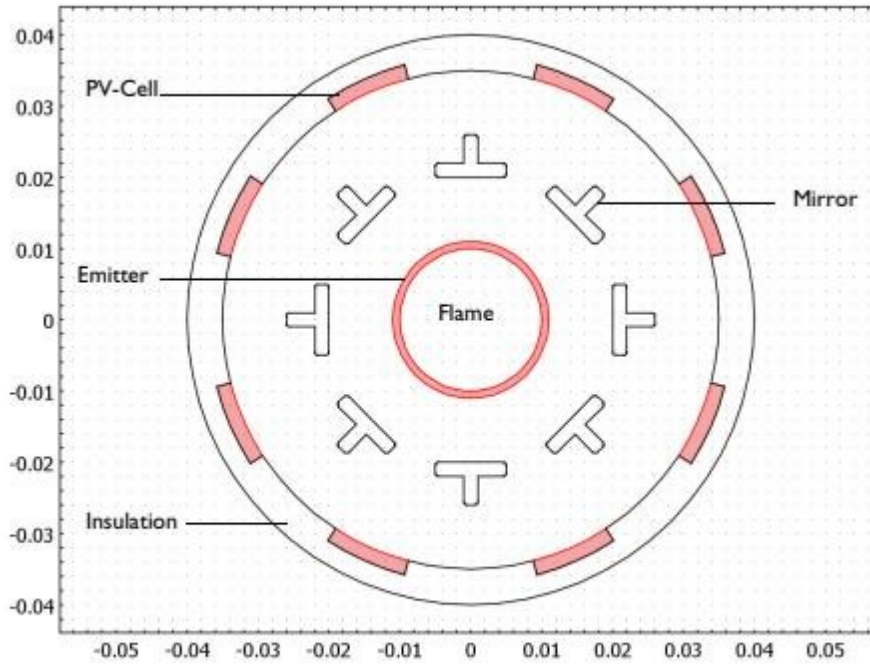
Geometry and dimensions of the modeled TPV system.

Figure 3-1 Geometry and dimensions of the modeled TPV system

The figure shows the geometry and dimensions of the system under study. To reduce the temperature, the PV cells are cooled on their back side (at the insulated interface).

Modeling instructions

From the File menu in the Comsol application, select new.

New

Inside the new window, click on the model wizard.

Model size

1 Within modeliwizardiWindow, select 2-D.

2 Selectiphysical treei, select Heat Transfer>> Radiation>> Heat Transfer with Surface_to_Surface Radiation.

3 ChooseiAdd.

4 SelectiStudy.

5 SelectiStudyiTree , select GeneraliStudies>> Stationery.

6 ChooseiDone.

3.3 Global definitions

Parameter 1

1 Inside the model builder window, select Parameters 1 under global definition.

2 inside settings window for parameters, find the parameters.

3 In Table, enter the following parameters:

Name a	Expression a	Value a	Description a
T_heatera	1000[K] a	1000 Ka	Temperature, emitter inner boundarya

Geometry 1

1 In the Model Builder window, under component 1 (comp1) click Geometry 1.
2 In the Settings window for Geometry, locate the Units section.
3 From the Length unit list, choose mm.

Circle 1 (c1)
1 In the Geometry toolbar,   .
2 In the In the Geometry toolbar, click Circle Settings window for Circle,
 locate the Size and Shape section.
3 In the Radius text field, type 40.
4 In the Sector angle text field, type 36/16.
5 In the Geometry toolbar, click Circle Click to expand the Layers section. In the table,
 enter the following settings:
6 Click Build Selected

Rectangle 1 (r1)

1 In the Geometry toolbar, click Rectangle. 2 In the Settings window for Rectangle, locate the Size and Shape section.
3 In the Width text field, type 2.
4 In the Height text field, type 5.
5 Locate the Position section. In the x text field, type 20.
6 Click Build Selected.

Rectangle 2 (r2)

1 In the Geometry toolbar, click Rectangle.
2 In the Settings window for Rectangle, locate the Size and Shape section.
3 In the Width text field, type 6.
4 Locate the Position section. In the x text field, type 20.
5 Click Build Selected

Layer1name	Thickness(mm) 1
Layer 11	5
Layer 21	24
Layer 31	1

Union 1 (uni1)
1 In the Geometry toolbar, click Booleans and Partitions and choose Union.
2 Select the objects r1 and r2 only.
3 In the Settings window for Union, locate the Union section.
4 Clear the Keep interior boundaries check box.
5 Click Build Selected.

Fillet111 (fil1)
1 In the Geometry toolbar, click Fillet.

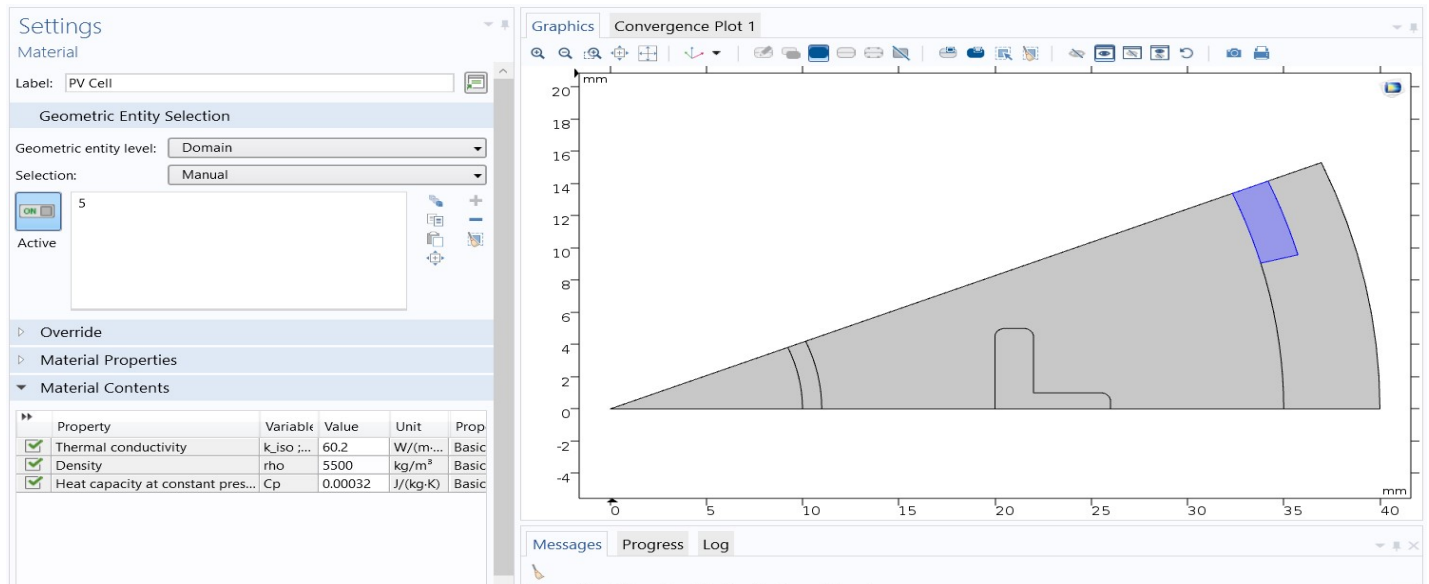## 3.4 Materials

Material 1 (mat1)

1 In the Materials toolbar, click Blank Material.
2 In the Settings window for Material, type Insulation in the Label text field.
3 Locate the Material Contents section. In the table, enter the following settings:

Property	Variable	Value	Unit	Property group
Thermal conductivity	k_iso ; kii = k_iso, kij = 0	0.05	W/(m·K)	Basic
Density	rho	700	kg/m3	Basic
Heat capacity at constant pressure	Cp	100	J/(kg·K)	Basic

Figure 3-2 Materials figure

Material 2 (mat2)

1 In the Materials toolbar, click Blank Material.

2 In the Settings window for Material, type PV Cell in the Label text field.

3 Select Domain 5 only.

This is the PV-cell domain.

4 Locate the Material Contents section. In the table, enter the following settings:

Property1	Variable1	Value1	Unit1	Property1group
Thermal conductivity1	k_iso ; kii =1 k_iso, kij = 01	931	W/(m·K)1	Basic1
Density1	rho1	20001	kg/m31	Basic1
Heat capacity at constant pressure1	Cp1	8401	J/(kg·K)1	Basic1
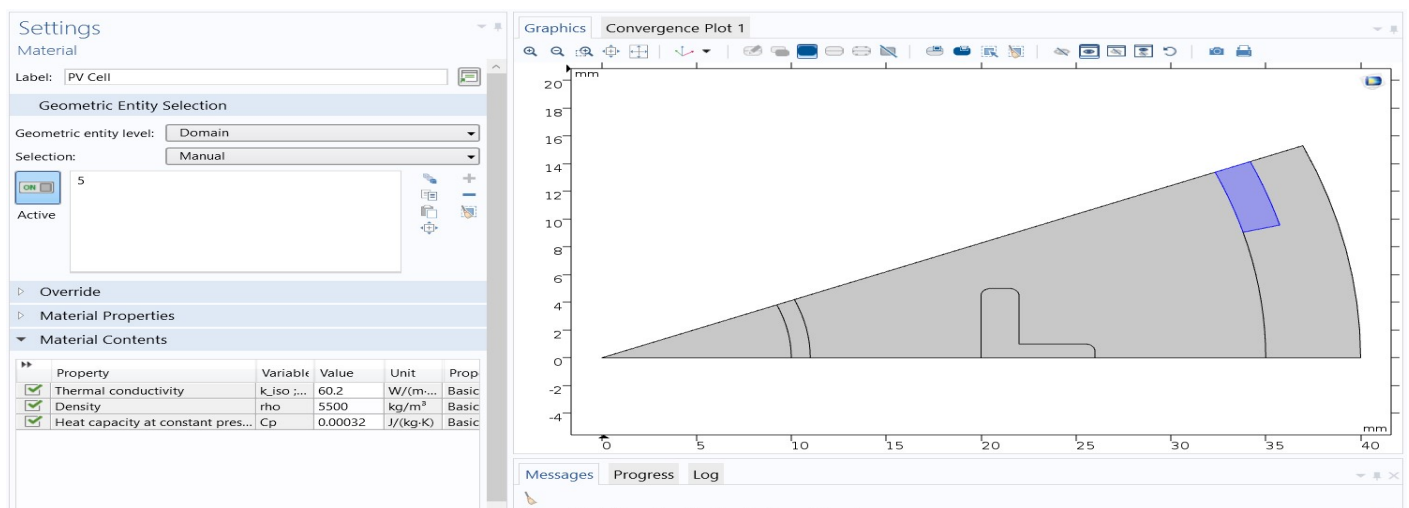
Material 3 (mat3)

1 In the Materials toolbar, click Blank Material.

2 In the Settings window for Material, type Mirror in the Label text field.

3 Select Domain 4 only.

4 Locate the Material Contents section. In the table, enter the following settings:

Property1	Variable1	Value1	Unit	Property group1
Thermal conductivity1	k_iso ; kii =1 k_iso, kij = 01	101	W/(m·K)1	Basic1
Density1	rho1	50001	kg/m31	Basic1
Heat capacity1at constant pressure1	Cp1	8401	J/(kg·K)1	Basic1

Material 4 (mat4)

Property1	Variable1	Value1	Unit1	Property group1
Thermal conductivity1	k_iso ; kii =1 k_iso, kij = 01	101	W/(m·K)1	Basic1
Density1	rho1	20001	kg/m31	Basic1
Heat capacity1at constant pressure1	Cp1	9001	J/(kg·K)1	Basic1

1 In the Materials toolbar, click Blank Material.

2 In the Settings window for Material, type Emitter in the Label text field.

3 Select Domain 2 only.

4 Locate the Material Contents section. In the table, enter the following settings:

ADD MATERIAL

1 In the Materials toolbar, click Add Material to open the Add Material window.

2 Go to the Add Material window.

3 In the tree, select Built-in>Air.

4 Click Add to Component in the window toolbar.

5 In the Materials toolbar, click Add Material to close the Add Material window.
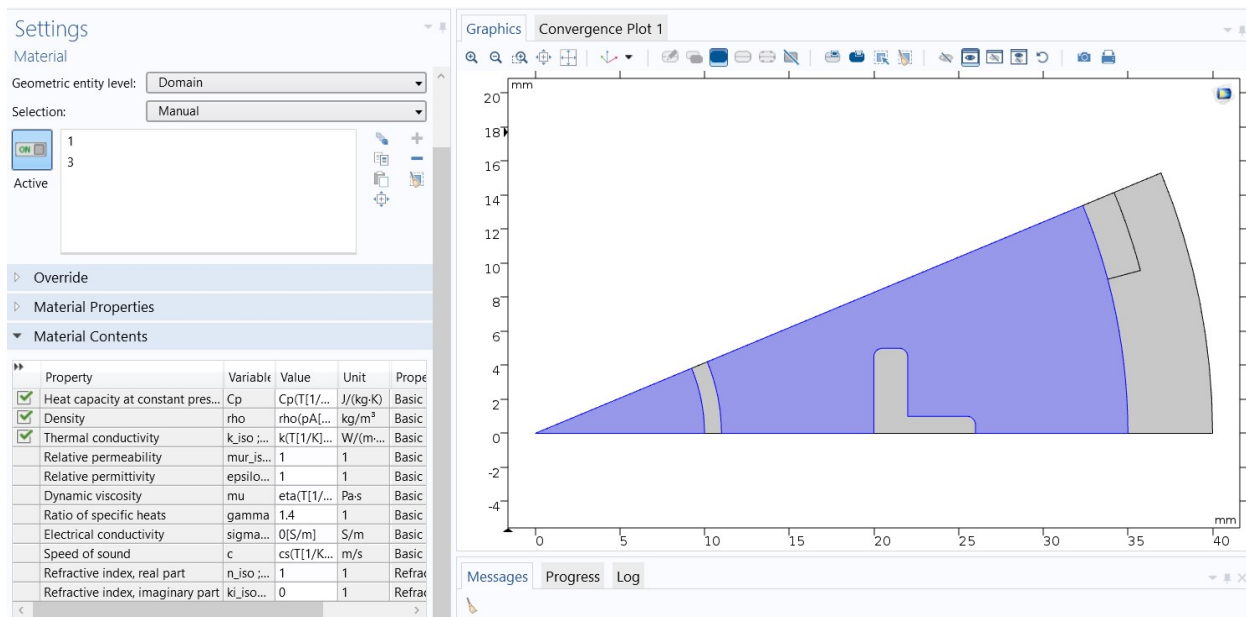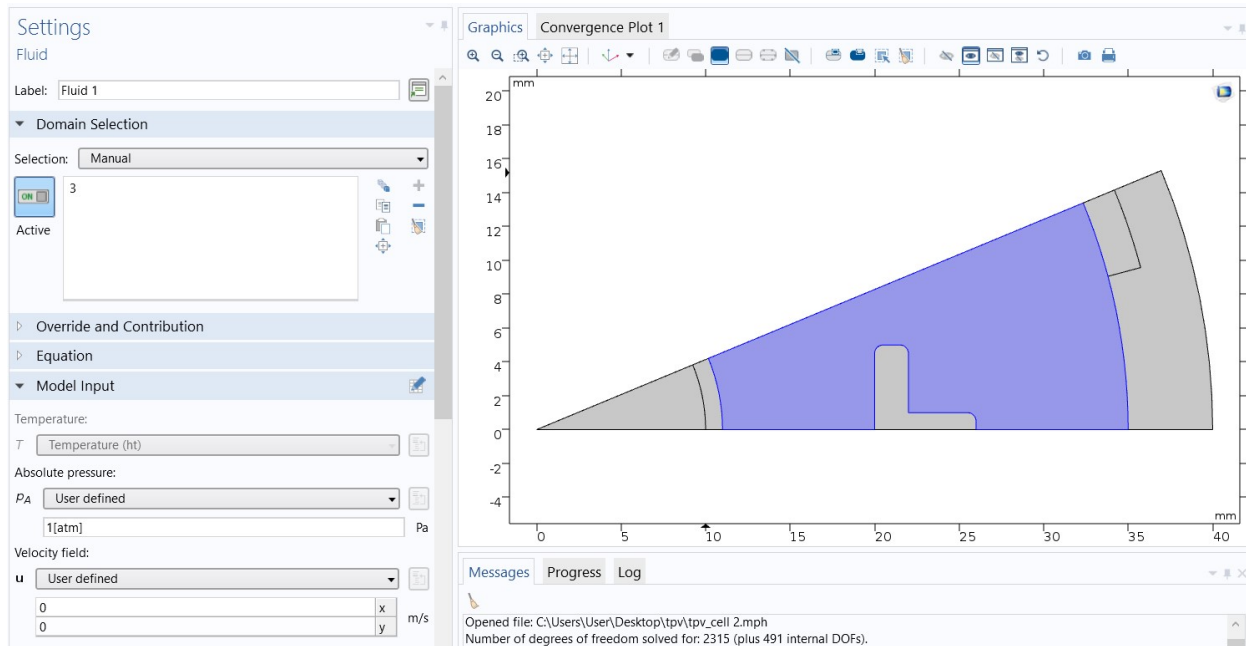

3.5 Heat transfer in solids (ht) 1

Fluid 1

1 In the Model Builder window, under Component 1 (comp1) right-click

Heat Transfer in Solids (ht) and choose Fluid.

2 Select Domain 3 only.

3 In the Settings window for Fluid, locate the Thermodynamics, Fluid section.

4 From the list, choose User defined.

Heat Flux 1

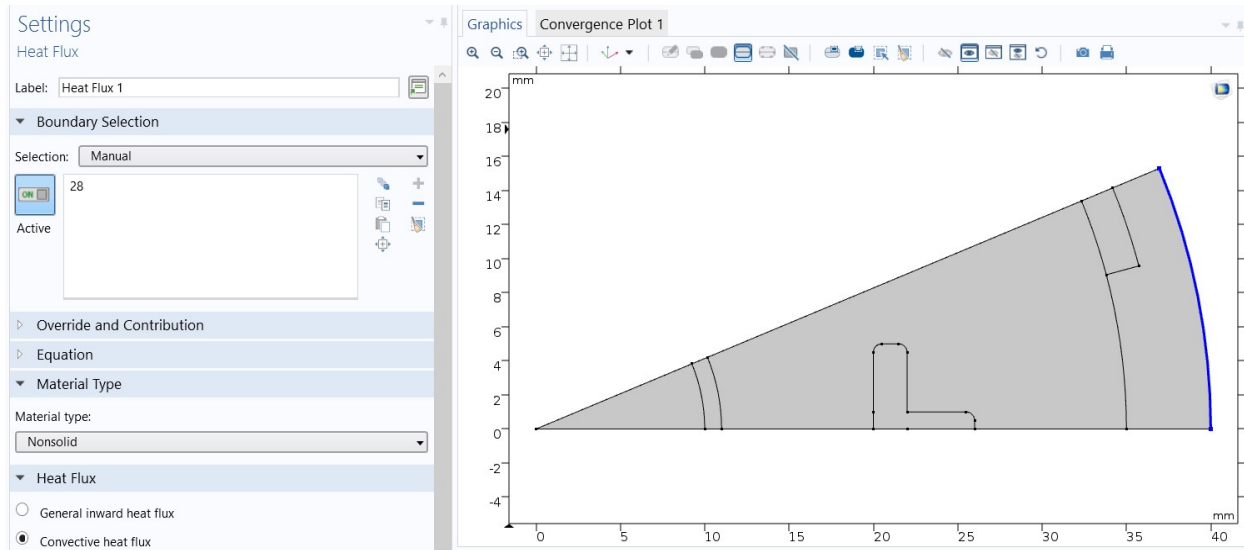**1** In the Physics toolbar, click Boundaries and choose Heat Flux.

2 Select Boundary 28 only.

This is the outer boundary of the modeling domain, where convective air cooling is applied.

3 In the Settings window for Heat Flux, locate the Heat Flux section.

4 Click the Convective heat flux button.

5 In the h text field, type 5.
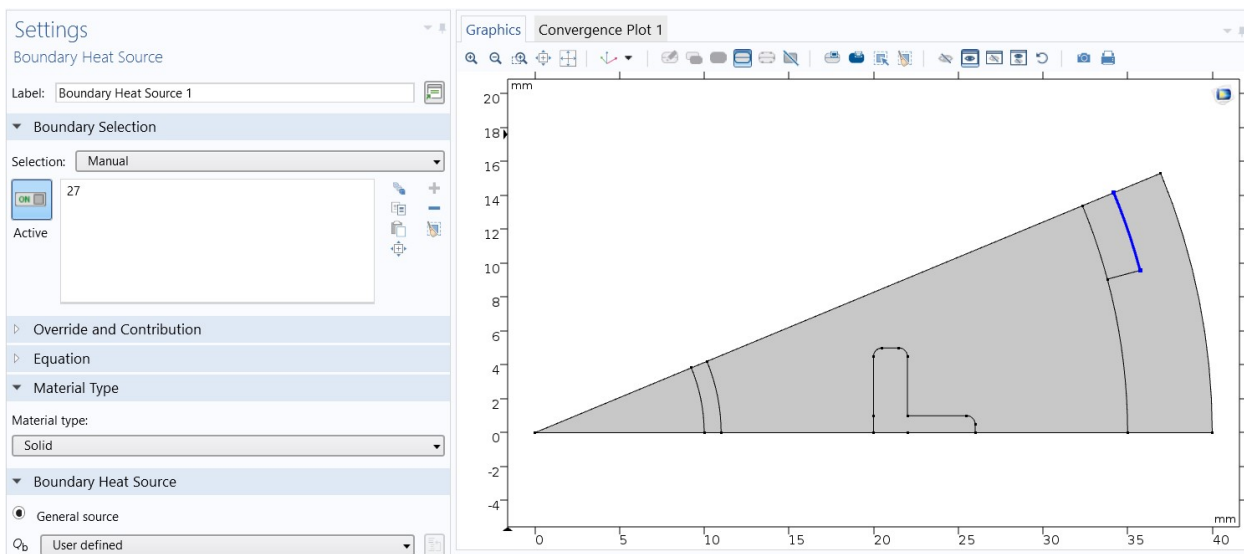
Boundary heat source 1

1 In the Physics toolbar, click Boundaries and choose Boundary Heat Source.

2 Select Boundary 27 only.

These are the outward-facing PV-cell boundaries.

3 In the Settings window for Boundary Heat Source, locate the Boundary Heat Source section.

**4** In the Qb text field, type 50[W/(m^2*K)]*(273.15[K]-T).

Boundary Heat Source 2

1 In the Physics toolbar, click Boundaries and choose Boundary Heat Source.

2 Select Boundary 25 only.

3 In the Settings window for Boundary Heat Source, locate the Boundary Heat Source section.

4 In the Qb text field, type -q_out.
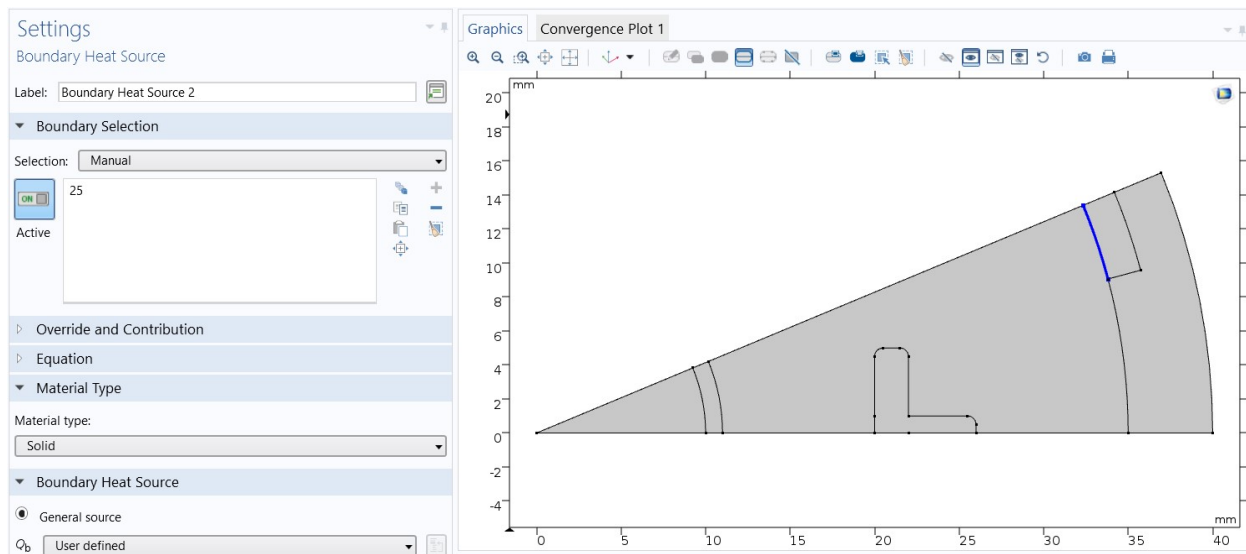
Temperature 1

1 In the Physics toolbar, click Boundaries and choose Temperature.

2 Select Boundary 20 only.

This is the inward-facing emitter boundary.

3 In the Settings window for Temperature, locate the Temperature section.

4 In the T0 text field, type T_heater.

Finally, apply a Symmetry boundary condition for the temperature.
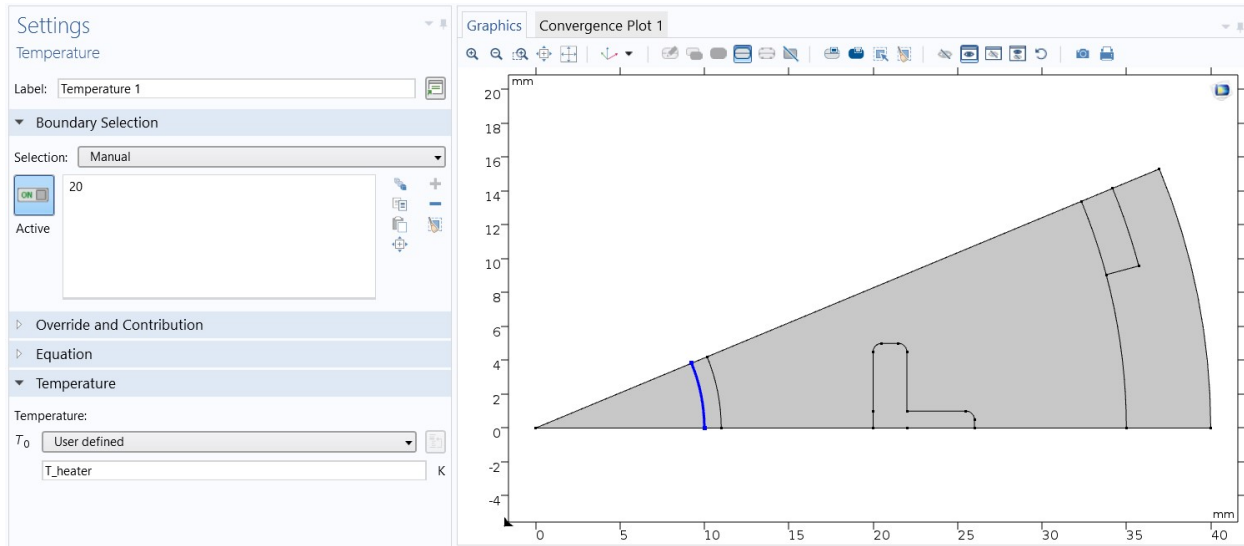
Symmetry 1

1 In the Physics toolbar, click Boundaries and choose Symmetry.

2 Select Boundaries 1–6, 8, 11, 15, 16, 18, and 19 only.
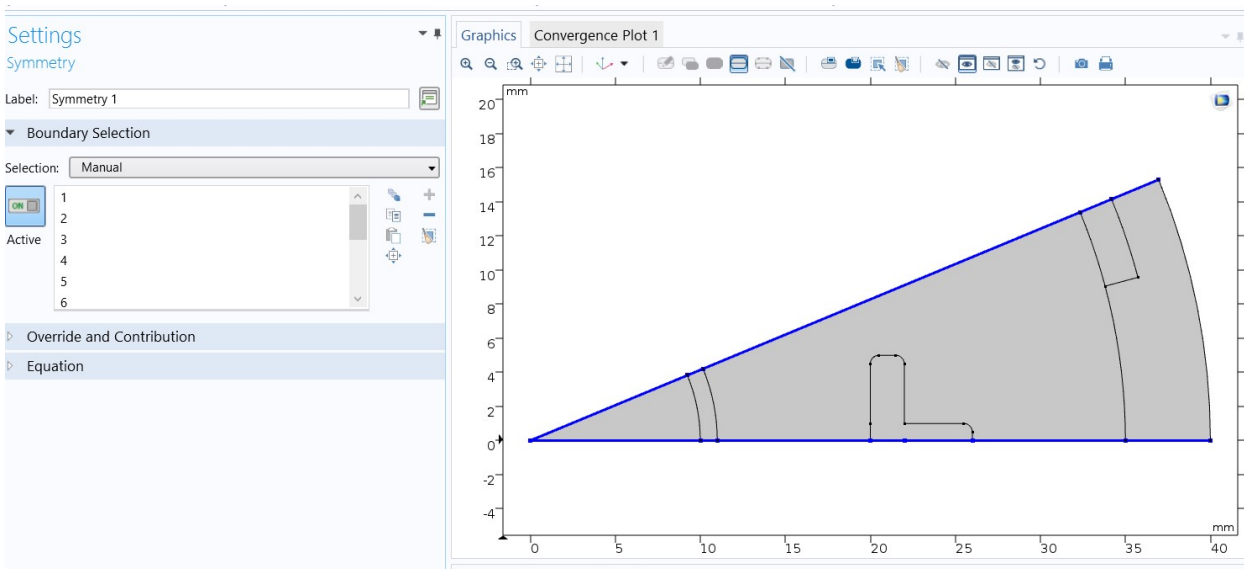
Surface-to-Ambient Radiation 1

1 In the Physics toolbar, click Boundaries and choose Surface-to-Ambient Radiation.

2 Select Boundary 28 only.

3.6 Surface-to-surface radiation (rad)

1 In the Model Builder window, under Component 1 (comp1) click Surface-to-

Surface Radiation (rad).Select Boundaries 7, 9, 10, 12–14, and 21–26 only.

Diffuse Surface 1

By default, the radiation direction is controlled by the opacity of the domain. Solid components are automatically defined as opaque, while liquid components are transparent. You can change these settings by editing the opacity subnode under Solid and Liquid Properties.

1 In the Model Builder window, under Component 1 (comp1)>Surface-to-

Surface Radiation (rad) click Diffuse Surface 1.i

2 In the Settings window for Diffuse Surface, locate the Ambient section. 1

3 Find the Ambient temperature subsection. In the Tamb text field, type T.

MATERIALS1
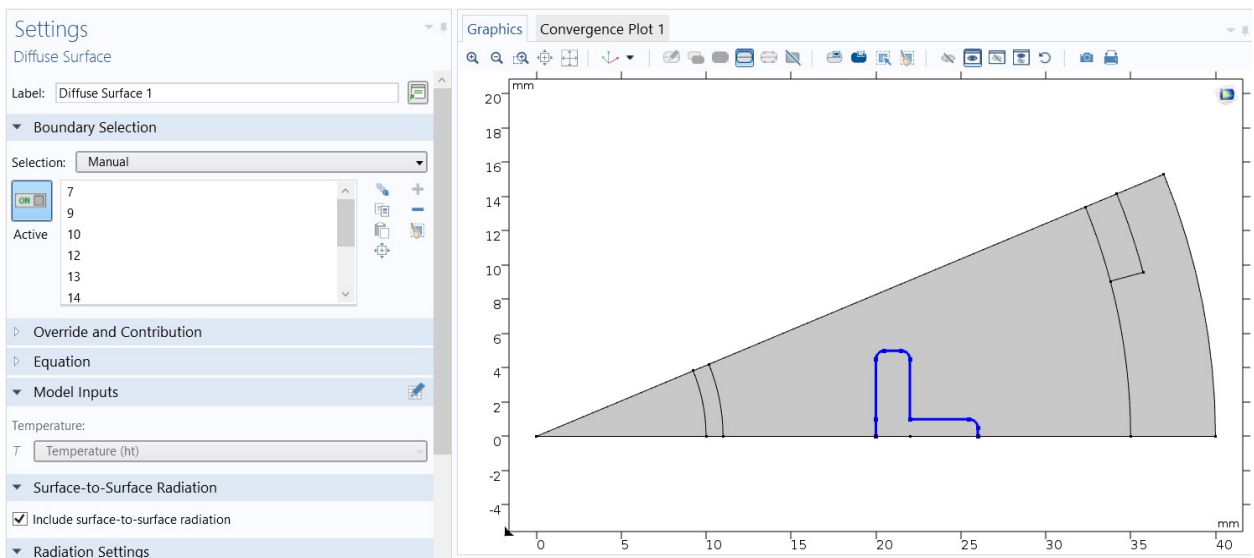
Material 6 (mat6) 1

1 In the Model Builder window, under Component 1 (comp1) right-click Materials and choose Blank Material. 1

2 In the Settings window for Material, locate the Geometric Entity Selection section. 1

3 From the Geometric entity level list, choose Boundary. 1

4 Select Boundary 21 only. 1

5 Locate the Material Contents section. In the table, enter the following settings: 1

Property1	Variable1	Value1	Unit1	Property group1
Surface1emissivity1	epsilon_rad1	0.991	I1	Basic1
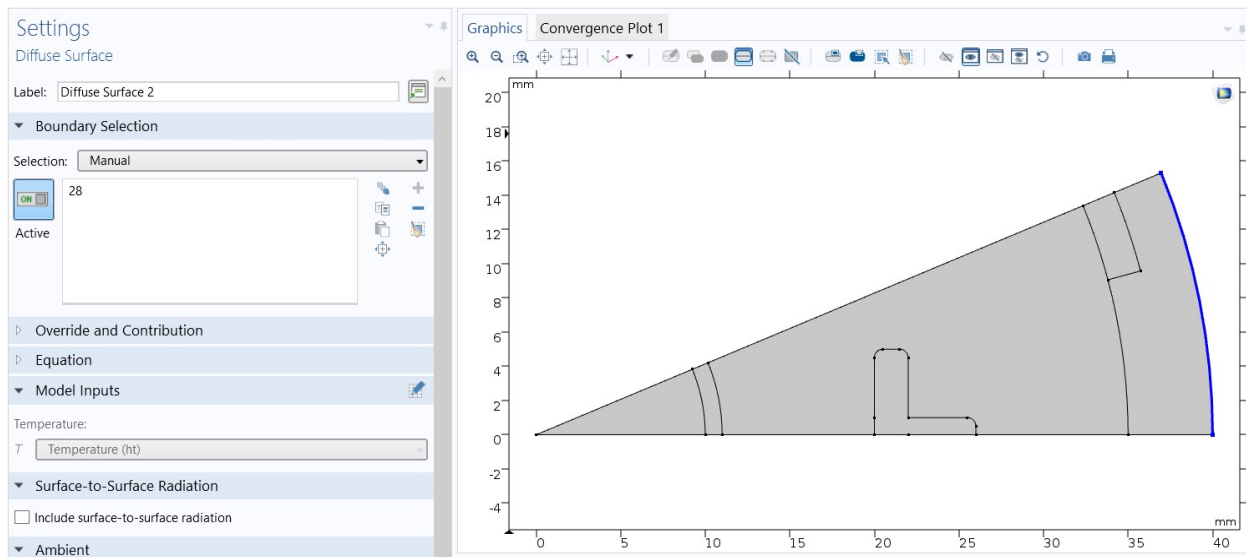
6 In the Label text field, type Emitter boundary.

Material 7 (mat7) 1

1 Right-click Materials and choose Blank Material. 1

2 Click the Select Box button in the Graphics toolbar. 1

3 Select Domain 4 only. 1

4 In the Settings window for Material, locate the Geometric Entity Selection section. 1

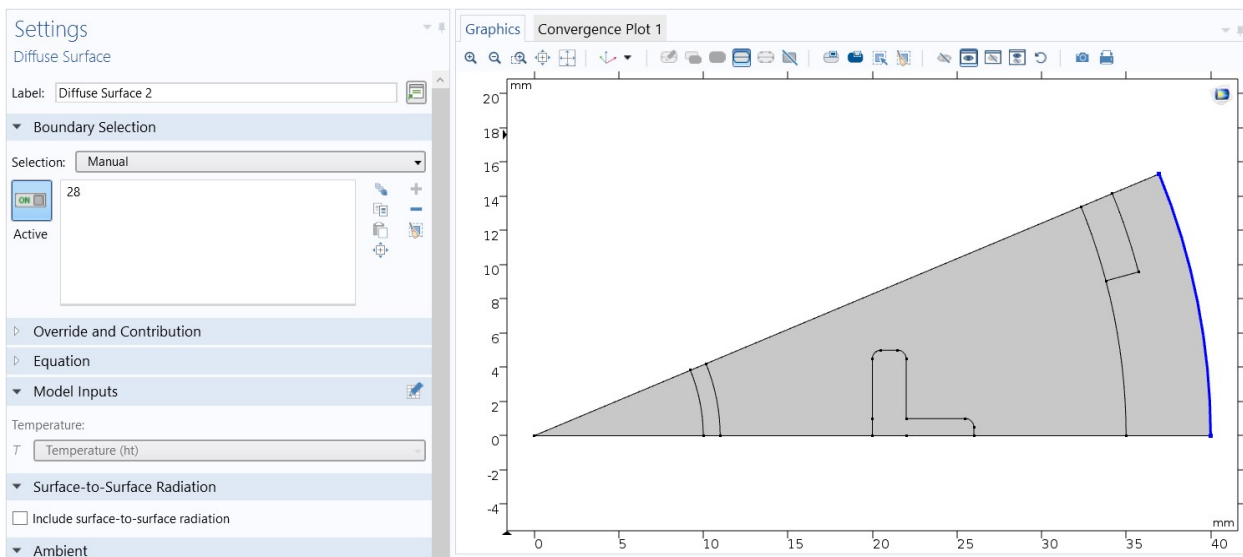**5** From the Geometric entity level list, choose Boundary. 1

6 Click the Select Box button in the Graphics toolbar. 1

7 Select Boundaries 7, 9, 10, 12–14, and 22–24 only. 1

8 Locate the Material Contents section. In the table, enter the following settings: 1

Property1	Variable1	Value1	Unit11	Property group1
Surface emissivity1	epsilon_rad1	0.011	I1	Basic1

9 In the Label text field, type Mirror boundary.

Material 8 (mat8)

1 Right-click Materials and choose Blank Material.

2 In the Settings window for Material, locate the Geometric Entity Selection section.
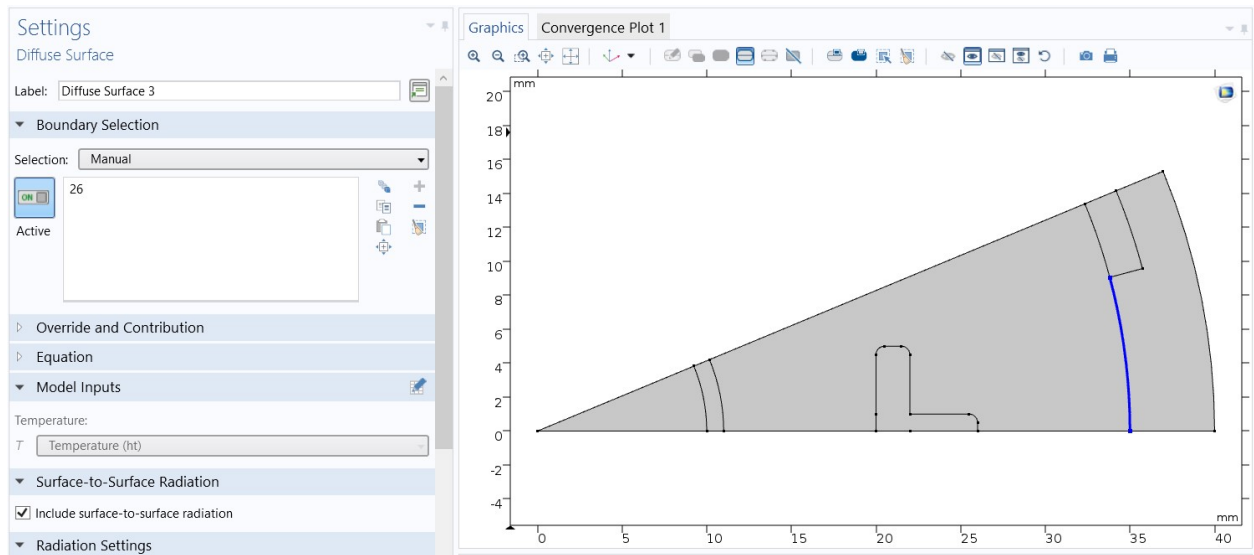
3 From the Geometric entity level list, choose Boundary.

4 Select Boundaries 26 and 28 only.

5 Locate the Material Contents section. In the table, enter the following settings: 1

Property1	Variable1	Value1	Unit1	Property group1
Surface emissivity1	epsilon_rad1	0.11	I1	Basic1

6 In the Label text field, type PV Cell boundary.

SURFACE-TO-SURFACE RADIATION (RAD)

Define the sectors of symmetry and reflection plane for the computation of view factor for surface-to-surface radiation. 1

Symmetry for Surface-to-Surface Radiation

1 In the Physics toolbar, click Global and choose Symmetry for Surface-to-Surface Radiation.

**2** In the Settings window for Symmetry for Surface-to-Surface Radiation, locate the

Symmetry for Surface-to-Surface Radiation section.

3 From the Type of symmetry list, choose Sector symmetry.

4 Locate the Sector Symmetry section. In the Number of sectors text field, type 8.

5 Locate the Additional Reflection Plane section. Select the Reflection for symmetrical sector1 check box.

6 Specify the u vector as
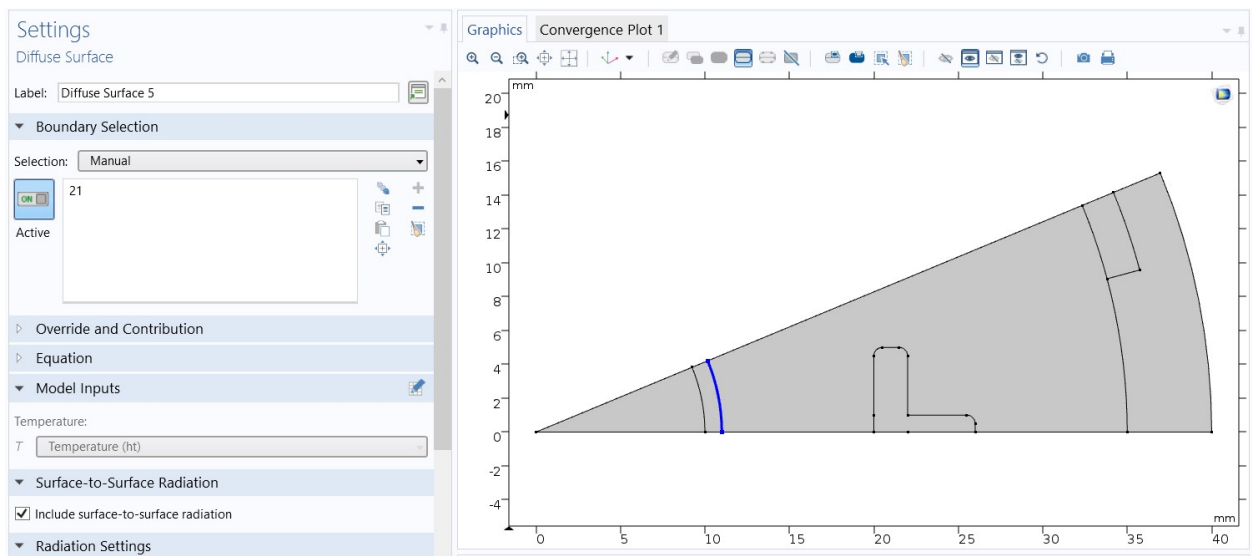
Definitions

Variables 1

1 In the Home toolbar, click Variables and choose Local Variables.

2 In the Settings window for Variables, locate the Variables section.

3 In the table, enter the following settings:

Name1	Expression1	Unit1	Description1
eta_pv1	if(T<1600[K],0.2*(1-(T/800[K]-1)^2),0) 1		Voltaic efficiency, PV cell1
q_out1	rad.Gm*eta_pv1	W/m²1	Electric output power1
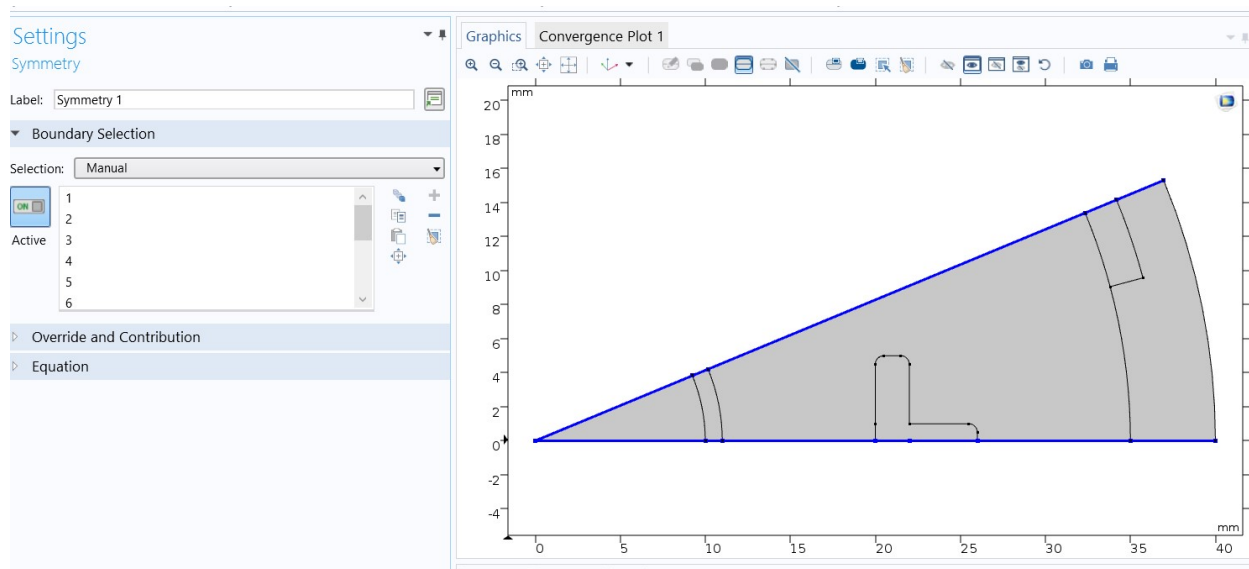
MESH 1

In the Model Builder window, under Component 1 (comp1) click Mesh.

Property Variable Value Unit Property group

Surface emissivity epsilon_rad 0.99 1 Basic

cos (pi/8) x1

sin (pi/8) y1

Name Expression Unit Description eta_pv if

(T<1600[K],0.2*(1-

(T/800[K]-1)^2), 0) 1

Voltaic efficiency, PV cell1

q_out rad.Gm*eta_pv W/m2 Electric output power1

2| THERMO-PHOTO-VOLTAIC CELL1

2 In the Settings window for Mesh, locate the Physics-Controlled Mesh section. 1

3 From the Element size list, choose Coarser. 1

Free Triangular 11

In the Mesh toolbar, click Free Triangular. 1

Size 11

Right-click Free Triangular 1 and choose Size. 1

In the Settings window for Size, locate the Geometric Entity Selection section. 1

From the Geometric entity level list, choose Boundary. 1

Select Boundaries 7, 9, 10, 12–14, and 21–26 only. 1

Locate the Element Size section. Click the Custom button.

Locate the Element Size Parameters section. Select the Maximum element size check box.
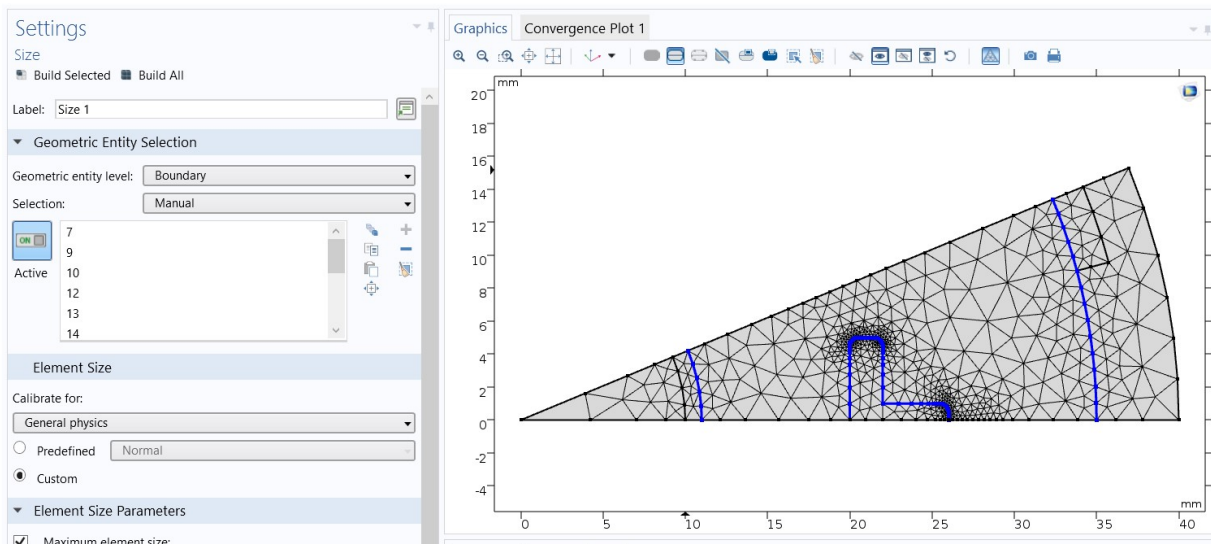
Select the Minimum element size check box.

2Select the Maximum element growth rate check box.

Select the Curvature factor check box.

In the Maximum element size text field, type 1.

Click Build All.

.

3.7 Study

Step 1: Stationary

Set up an auxiliary continuation sweep for the parameter T_heater.

1   In the Model Builder window, under Study 1 click Step 1: Stationary.

2   In the Settings window for Stationary, click to expand the Study Extensions section.

3   Select the Auxiliary sweep check box.

4   Click Add.

5   In the table, enter the following settings:

Parameter name	Parameter value list	Parameter unit
T_heater (Temperature, emitter inner boundary)		K

6   Click Range.

7   In the Range dialog box, type 1000 in the Start text field.

8   In the Step text field, type 100.

9   In the Stop text field, type 2000.

10 Click Replace.

11 In the Home toolbar, click Compute.

CHAPTER 4

RESULTS AND CONCLUSION

In this chapter we have discussed the obtained results from our designed data sets and different plots we get from the designed thermal photo voltaic system.

4.1 RESULTS

Data sets

Reconstruct the full geometry for a good visualization by defining a Sector 2D dataset.

Then use it into the default plots.

4.2 Sector 2D

1 In the Results toolbar, click More Datasets and choose Sector 2D.

2 In the Settings window for Sector 2D, locate the Symmetry section.

3 In the Number of sectors text field, type 16.

4 From the Transformation list, choose Rotation and reflection.

5 Find the Direction of reflection axis subsection. In the X text field, type cos(pi/8).

6 In the Y text field, type sin(pi/8).

7 Click Plot.

Temperature (ht) 1

1 We then moved to the Model Builder window and expanded the

Results>Temperature (ht) node, then clicked **Temperature (ht)**.

2 In the Settings window for 2D Plot Group that is clearly visible, we located the Data section there and

3 From the Dataset list, we choosed Sector 2D 1.

4 Finally in this section of the Temperature (ht) toolbar, click Plot.
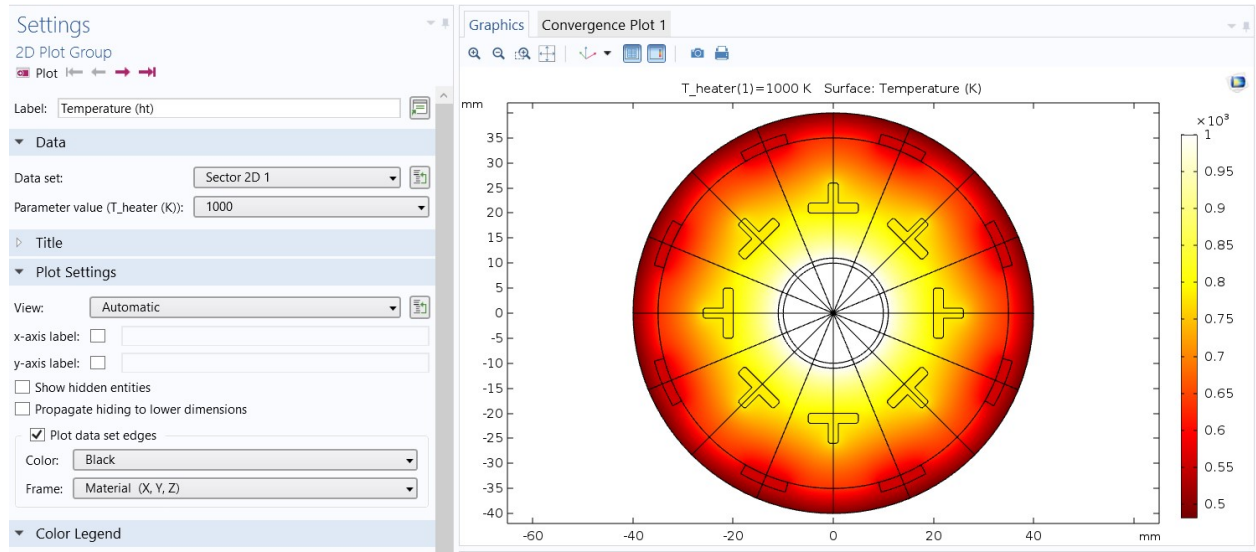
4.4 Isothermal Contours (ht)

1 In the Model Builder window, click Isothermal Contours (ht).

2 In the Settings window for 2D Plot Group, locate the Data section.

3 From the Dataset list, choose Sector 2D 1.

4 In the Isothermal Contours (ht) toolbar, click Plot.
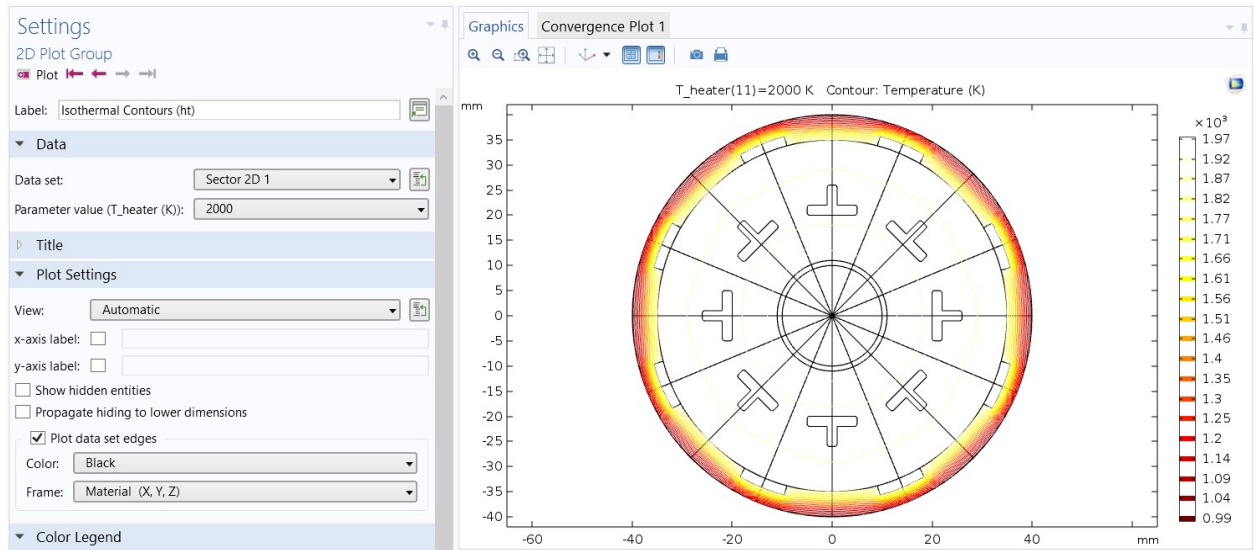
4.5 Surface Radiosity (rad)

1 In the Model Builder window, click Surface Radiosity (rad).
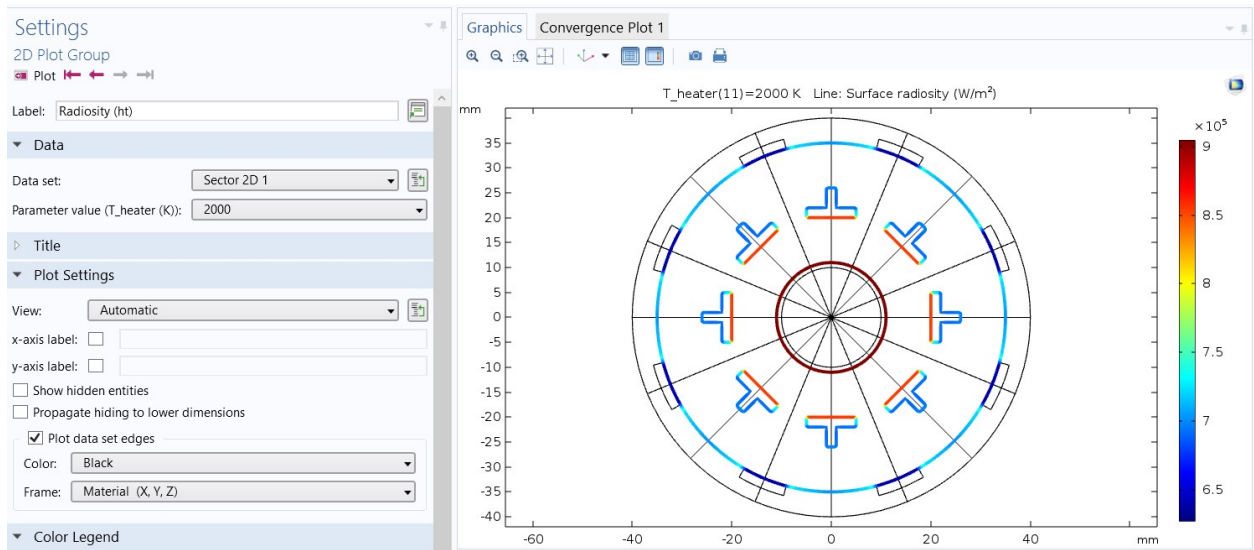
2 In the Settings window for 2D Plot Group, locate the Data section.

3 From the Dataset list, choose Sector 2D .

4 In the Surface Radiosity (rad) toolbar, click Plot.

Temperature (ht)

1 Click the Zoom Extents button in the Graphics toolbar.

The first default surface plot shows the TPV-cell temperature for the last value in the sweep over

operating temperatures.

Isothermal Contours (ht)

The second default plot shows isothermal contours.

Surface Radiosity (rad)

The third default plot shows radiosity.

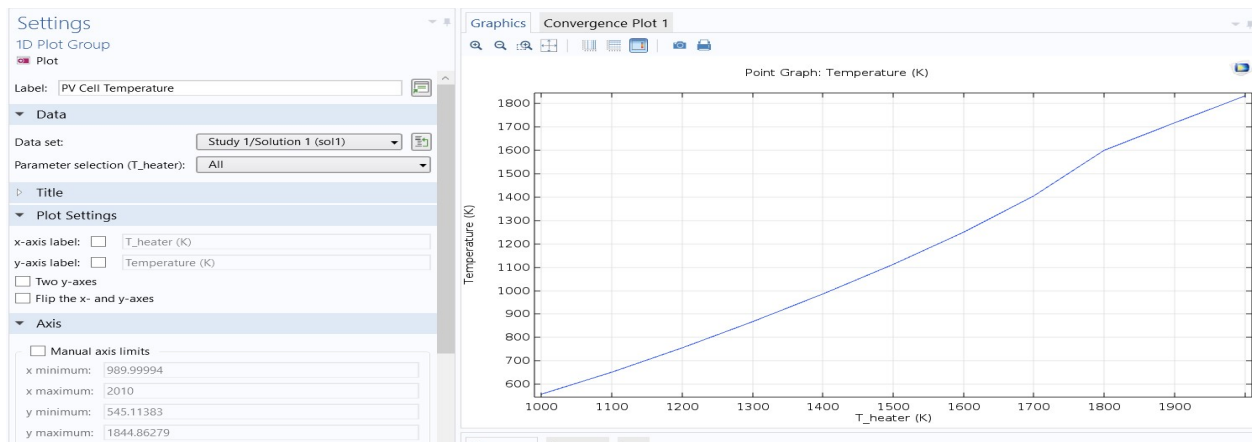Reproduce the plots in Figure 6 with the following steps:

1D Plot Group 4

1 In the Home toolbar, click Add Plot Group and choose 1D Plot Group.

2 In the Settings window for 1D Plot Group, type PV Cell Temperature in the Label text field. Point
   Graph 1

1 In the PV Cell Temperature toolbar, click Point Graph.

2 Select Point 18 only.

3 In the PV Cell Temperature toolbar, click Plot.

4.6 1D Plot Group 5

1 In the Home toolbar, click Add Plot Group and choose 1D Plot Group.

2 In the Settings window for 1D Plot Group, type Electric Output Power in the Label text field.

Point Graph 1

1 In the Electric Output Power toolbar, click Point Graph.

2 Select Point 18 only.

3 In the Settings window for Point Graph, click Replace Expression in the upperright corner of the y-axis data section. From the menu, choose Component 1>Definitions>

Variables>q_out - Electric output power - W/m².

4 In the Electric Output Power toolbar, click Plot.

As this last plot shows, the electric output power has a maximum near 1,600 K. To see the temperature distribution at this operating temperature, go back to the first plot group and change the parameter value.

Temperature (ht)

1 In the model Builder window, click Temperature (ht).

2 In the Settings window for 2D Plot Group, locate the Data section.

3 From the Parameter value (T_heater (K)) list, choose 1600.

4 In the Temperature (ht) toolbar, click Plot.

Finally, reproduce the surface irradiation plot in Figure 8 as follows:

 In the Home toolbar, click Add Plot Group and choose 1D Plot Group.

1 In the Settings window for 1D Plot Group, type Mutual Surface Irradiation in the   Label text field.

2 Locate the Data section. From the Parameter selection (T_heater) list, choose From list.

3 In the Parameter values (T_heater (K)) list, select 1600.
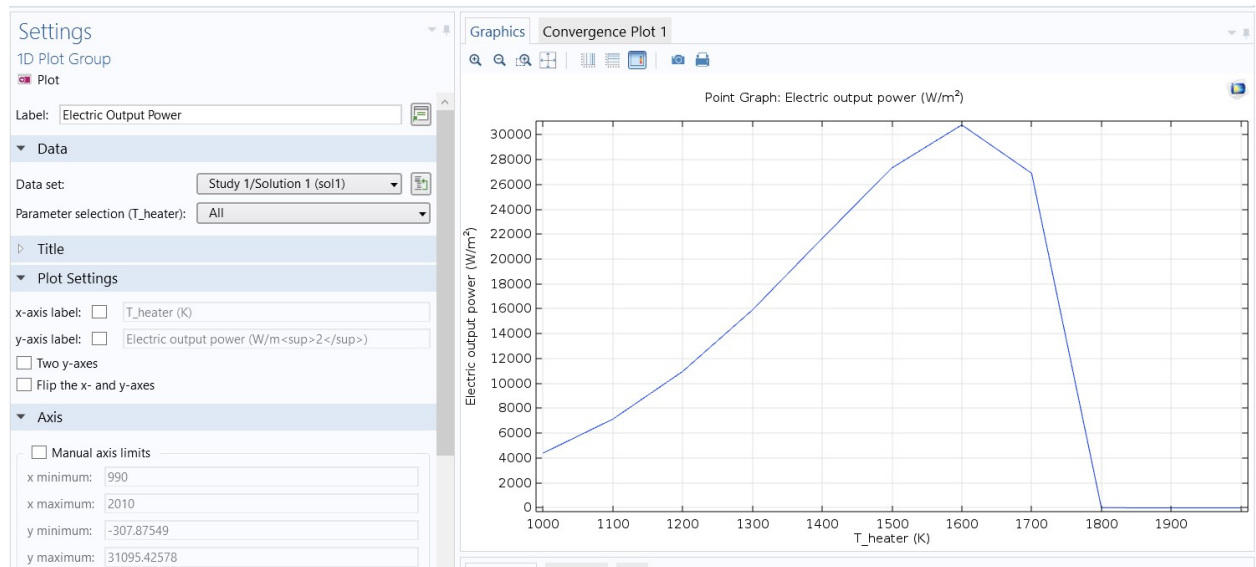
4.8 Electric power output versus Emitter temperature

1 Right-click Mutual Surface Irradiation and choose Line Graph.

2 Select Boundaries 25 and 26 only.

3 In the Settings window for Line Graph, click Replace Expression in the upperright corner

of the y-axis data section. From the menu, choose Component 1>>Surface-toSurface Radiation>>Irradiation>>rad.Gm_gp - Mutual surface irradiation - W/m².

4 Locate the x-Axis Data section. From the Parameter list, choose Expression.

5 In the Expression text field, type atan2(y,x)*180/pi.

Line Graph 2

1 Right-click Line Graph 1 and choose Duplicate.

2 In the Settings window for Line Graph, locate the x-Axis Data section.

3 In the Expression text field, type 360/8-atan2(y,x)*180/pi.

4 Click to expand the Coloring and Style section. From the Color list, choose Cycle (reset).

5 In the Mutual Surface Irradiation toolbar, click Plot.

This plot shows their radiative flux in one sector of symmetry and enlights the Shadowing effect of the

mirror (on each end of the x-axis).
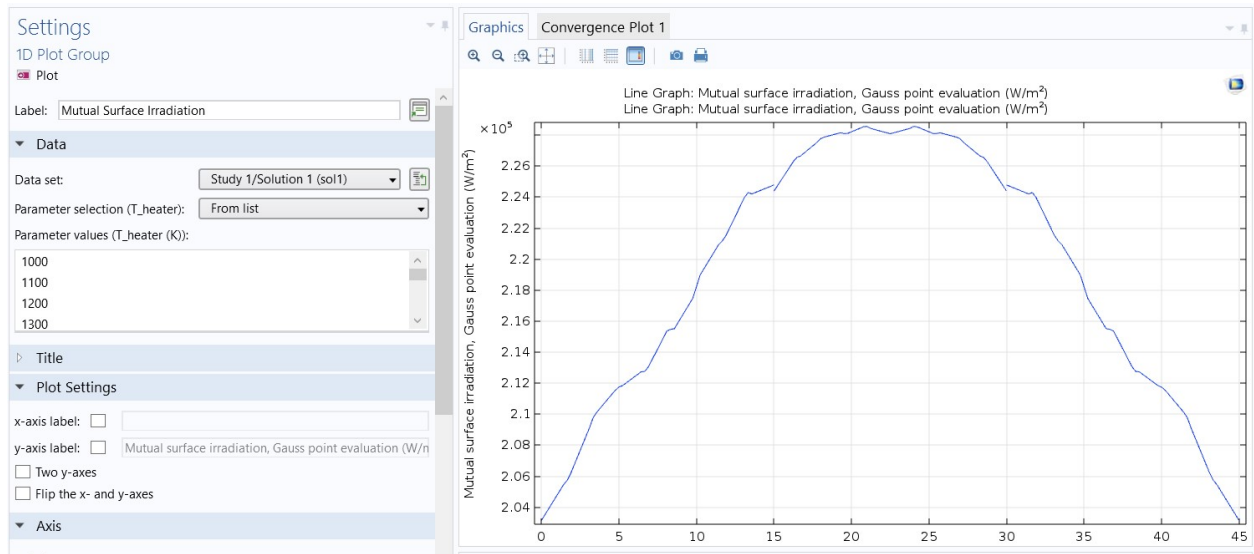
4.2 CONCLUSION

Finally, thermo_photo_voltaic (TPV) cells are auxiliary energy transfer devices that capture or dissipate heat lost in other individual power generation systems (or power plants), for example, solar cells.

Not only that, but thermophotovoltaics (TPV) for solar photovoltaics (or in addition) are commendable but the difference is that TPV operates at night and in cold weather (low temperatures). Also, TPV is very suitable for small and large-scale combined energy and heat and uses natural gases in its manufacture. Later, the TPV is not heavy and the battery can be reused or reused in the UAV. Last but not least, thermophotovoltaics are used in steel mills to convert electricity 24 hours a day for a week, and therefore, there is a huge market JAX crystal IR volume and a large number of new applications. Important for

The significant disadvantage of TPV is that it is very expensive to implement and as a result, not everyone can benefit from it.

Other processes for power generation:

Thermophotovoltaic (TPV) energy, as we have seen above, is a direct product that converts thermal energy from electricity into electricity using photons. Once again, a basic thermophotovoltaic system consists of a photovoltaic diode cell power converter and a thermal emitter.

TPV sometimes consists of components such as concentrators, filters or mirrors (reflectors). And in our design we used mirrors (reflectors) as additional components because they are less expensive and therefore, the more reflectors are used, the cheaper it becomes. This is the main reason we use eight mirrors. Therefore, electricity absorbs optical energy and is generated by a p-n junction that separates

electron/hole pairs, so this energy is converted into electrical energy in doing so. This optical energy is not generated directly by the sun (source), which is always called emission at high temperature, from which it emits light. Similarly, thermal energy is converted into electrical energy.

To improve efficiency, we can influence filters or selective emissions to create emissions in the optimized wavelength range for a specific photovoltaic (PV) converter.

Therefore, in this way, thermophotovoltaics can overcome the traditional challenge of conventional PV, which leads to efficient utilization of the entire solar spectrum.

Now some applications related to TPV:

Because TPVs are more efficient and economical than traditional non-zero power source (PV) systems. TPV also has no emissions and is very quiet. TPV produces 400 times the current density than conventional PV. For these reasons, TPV is more suitable for man-portable power due to its scalability property, which allows it to be smaller and lighter than traditional generators. Battlefield dynamics require portable power.

In addition, TPVs are suitable for spacecraft cruise power generation systems because it provides stable and reliable power without large amounts of fuel, which is very advantageous.

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