Performance Optimization of Photovoltaic Thermal System Under UAE Climate Condition: Experimental and Simulation Analysis

تحسين أداء النظام الحراري الكهروضوئي تحت الظروف المناخية لدولة الإمارات العربية المتحدة:
اختبار تطبيقي و محاكاة

by

SHAIKHAH ALI ALSHAAER

A thesis submitted in fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN ARCHITECTURE AND SUSTAINABLE BUILT ENVIRONMENT
at

The British University in Dubai

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Thesis Supervisor
Professor Bassam AbuHijleh

Approved for award:

Prof. Alaa Ameer
Head of MSc in Engineering Management Programme
The British University in Dubai (BUiD)

Prof. Jon G. McGowan
University of Massachusetts

Date: 30/01/2022

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ABSTRACT

One of the worldwide challenges is reducing energy consumption to reduce greenhouse gas (GHG) emissions that are associated with energy production and use. Delay in taking proper action will lead to the catastrophic effect of global warming (Ghoneim, 2016). In general, until today, the majority of energy is produced from fossil fuel sources (Riffat, 2011). There are various reasons for still depending on fossil fuel resources to produce energy. Fossil fuel energy has a lower production cost than renewable energy (Sharma, 2016). In addition, fossil fuel is very efficient in producing energy. On the other hand, generating power from solar energy is considered to be a promising solution. However, the Photovoltaic system has low efficiency resulting from the low conversion factor of Photovoltaic cells (Shaneb & other 2017). Accordingly, various researchers focused on enhancing the PV performance through avoiding shading and, using the sun tracking system. Photovoltaic thermal is considered to be one of the methods used to enhance the electrical performance of PV systems. The main working principle of PVT is passing fluid at the back of the PV panel that removes the excess heat from the PV panel surface and enhances electrical efficiency. The fluid used in PVT is either water, air, or refrigerant (Shaneb et al, 2017).

The aim of performing the test was to evaluate and assess both electrical and thermal performance of the PVT system, under UAE climate conditions, in the first phase of the study. Then, enhance the performance of PVT, by optimizing some of the design parameters. To achieve the project aims, the research started with a review of previous studies related to PVT. The literature review focused on data required to be collected during the experimental phase, the capability of TRNSYS software, and optimization parameters.

Therefore, the research methodology has been carried out in two parts: experimental and simulation. In the first part, the performance of PVT, in comparison with PV panel, was tested experimentally. The collected data from the experiment were utilized to develop a simulation

model to represent PVT by using TRNSYS software. The simulation model was used to optimize the PVT performance by changing some of the design parameters. The design parameters were: number of collector tubes, tubes diameter, and PVT panel area, and water flow rates.

Experimental results showed that the enhancement in electrical efficiency of PVT in winter was 0.7%, which is equal to 5% more in comparison with PV. The results in summer were 1.2%, which is equal to 8.9% more in comparison with PV panel. The overall PVT efficiency in winter was 53.8%, and in summer the overall PVT efficiency was 57.1%.

A simulation model was developed for the PVT system, based on data collected from the experiment. The model has been validated, comparing the experimental results with simulation results, with a tolerance of 5% error. In the simulation part, some design parameters were optimized by testing a range of values: number of collector tubes, tubes diameter, PVT panel area, and water flow rates. The aim of changing the design parameters was to optimize the performance of PVT during winter and summer.

The results showed that the optimum number of collector tubes was 12 tubes; the optimum tube diameter was 0.04 m; and the water flow rate was 2.5 GPM in both winter and summer. In addition, results showed that changing the PVT area was not feasible. There was no enhancement in the overall efficiency.

Based on the identified optimum values of design parameters, the optimized model was created. The results from the optimized model showed further enhancement in comparison with the reference model. The percentage of electrical efficiency enhancement of PVT was 7.2% in winter and 7.5% in summer, compared to the reference model.

In addition, the research compared the electrical performance of the PV panel with the PVT optimized model. The electrical efficiency of the PVT optimized model provided higher electrical efficiency than the PV panel by 6% during winter and 10% during summer.

ملخص المشروع

أصبح تقليل استهلاك الطاقة مؤخرًا مصدر قلق عالمي. تزداد انبعاثات غازات الاحتباس الحراري مع زيادة إنتاج الطاقة واستهلاكها. في حالة عدم اتخاذ أي إجراء مناسب ضد الاستهلاك الهائل للطاقة ، فإن الاحتباس الحراري سيكون كارثيًا (غنيم ، 2016). لا تزال الطاقة المنتجة من مصادر الوقود الأحفوري تتمتع بأعلى حصة من بين المصادر الأخرى (رفعت ، 2011). الأسباب هي أن النوع التقليدي من الطاقة يعتبر أرخص مقارنة بالمصادر المتجددة وأكثر ملاءمة للاستخدام (شارما ، 2016). ولكن نظرًا لأنه يضر بالبيئة ويسبب تغير المناخ ، فإن التركيز على الطاقة المتجددة يزداد. تعتبر الطاقة الشمسية من مصادر الطاقة المتجددة الواعدة نظرًا لتوفرها ومجموعة واسعة من التطبيقات (شارما ، 2016). لكن المشكلة الرئيسية في النظام الكهروضوئي هي الكفاءة المنخفضة الناتجة عن انخفاض كفاءة التحويل للخلايا الكهروضوئية (Shaneb & other 2017). تستخدم العديد من التقنيات لتحسين الأداء الكهروضوئي من خلال زيادة الإشعاع الشمسي وتجنب التظليل واستخدام نظام التتبع الشمسي. يقترح نظام PVT تقنية أخرى تستخلص الحرارة عن طريق تمرير سائل عامل (ماء ، هواء ، مبرد ، ماء / هواء) على الجزء الخلفي من الوحدة الكهروضوئية (Shaneb & other 2017). وبالتالي ، يتم تقليل الحرارة الزائدة الناتجة عن الجزء الخلفي من الوحدة الكهروضوئية من أجل الحفاظ على كفاءة الكهروضوئية.

كان الهدف من الاختبار هو تقييم أداء PVT تحت دولة الإمارات العربية المتحدة أو في منطقة المناخ الحار ثم تحسين الأداء من خلال تحسين المعلمات. لذلك تم إجراء الدراسة من خلال ثلاث مراحل رئيسية هي المرحلة التجريبية ومرحلة المحاكاة ومرحلة التحسين. في المرحلة التجريبية ، تم اختبار أداء PVT مقارنةً باللوحة الكهروضوئية تجريبياً. تم استخدام البيانات المجمعة من المرحلة التجريبية لتطوير نموذج المحاكاة باستخدام برنامج TRNSYS. نموذج المحاكاة المستخدم لتحسين نظام PVT من خلال تغيير المعلمات.

من أجل تحقيق أهداف المشروع ، بدأ البحث بمراجعة الأبحاث السابقة المتعلقة بـ PVT. ركزت مراجعة الأدبيات على البيانات المطلوب جمعها خلال المرحلة التجريبية ، وإمكانيات برنامج TRNSYS ومعايير التحسين.

تم تطوير نموذج محاكاة لنظام PVT بناءً على البيانات التي تم جمعها من المرحلة التجريبية. تم التحقق من صحة النموذج والتأكد من توافقه مع البيانات التجريبية. في مرحلة المحاكاة ، تم اختبار بعض معلمات التصميم مثل (عدد أنابيب التجميع ، قطر الأنابيب ، ومنطقة لوحة PVT ومعدلات تدفق المياه). كان الهدف من تغيير معايير التصميم هو تحسين أداء PVT خلال الشتاء والصيف.

أظهرت النتائج أن العدد الأمثل لأنابيب التجميع كان 12 أنبوبًا ، وقطر الأنبوب الأمثل كان 0.04 مترًا ومعدل تدفق الماء 2.5 جرامًا في الدقيقة في كل من الذبول والصيف. بالإضافة إلى ذلك ، لم يكن تغيير منطقة لوحة PVT ممكنًا لأن التغيير الكلي في الكفاءة كان طفيفًا. بناءً على المعلمات المُحسَّنة المحددة ، تم إنشاء النموذج الأمثل. أظهرت النتائج من النموذج الأمثل مزيدًا من التحسين مقارنة بالنموذج المرجعي. نسبة التحسين وجدت 7.2٪ في الشتاء و 7.5٪ في الصيف.

بالإضافة إلى ذلك ، مقارنة الأداء الكهربائي للوحة الكهروضوئية مع نموذج PVT الأمثل. قدمت الكفاءة الكهربائية لنموذج PVT المحسن أداءً أعلى من الألواح الكهروضوئية بنسبة 6٪ خلال الشتاء و 10٪ خلال الصيف.

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Abbreviations	Meaning
DC	Direct Current
GCC	Gulf Cooperation Council
IEC	International Electro technical Commission
Irradiance	Power received by area (W/m2)
Radiant Energy	Define as the amount of energy transferred by the radiation and measured by J.
WEO	World Energy Outlook
PV	Photovoltaic
PVT	Photovoltaic thermal
STC	standard testing conditions
DHW	Domestic hot water

Symbols:

θ	*solar zenith angle*
α	*solar altitude*
h	is the hour angle, in the local solar time
δ	the current declination of the Sun
φ	The local latitude.
F_R	collector heat removal factor
$(\tau\alpha)_e$	Effective transmittance-absorptance product.
U_L	Overall heat loss coefficient.
Ac	Area of collector
$T_{f,i}$	Useful heat gain(difference between Temperature out and Temperature in)
T_a	Ambient Temperature
Voc	open circuit voltage
Isc	the short circuit current
FF	Filled factor
η	Efficiency
η_o	Efficiency for (t_m-t_a=0) conversion factor
a_1	heat loss coefficient, independent of temperature (W/m^2K)
a_2	heat loss coefficient, independent of temperature (W/m^2K^2)
G	Global irradiance in W/m^2
T_m	mean fluid temperature in the collector in °C (T_m= T_{in} – T_{out})/2
T_{out}	collector outlet temperature in °C
T_{in}	collector inlet temperature in °C
T_a	ambient Temperature in °C
Tm*	reduce temperature difference in m^2K/m

CHAPTER I

Introduction

1.1 Background

Globally there are increasing concerns related to the catastrophic effect of increasing CO_2 emission. During the United Nations Climate Change Conference, COP 21, in 2015, over 190 countries signed an agreement to keep global warming below 2^{o}C by 2050 (Guarracino, 2017). The agreement goal cannot be achieved unless all the countries locally limit CO_2 emission. Accordingly, many countries around the world initiated green agendas to mitigate the effects of increasing CO_2 concentration. The agenda included initiatives that focus on energy conservation and the use of renewable energy sources.

The UAE is committed to the COP 21 agreement, through establishing Energy Strategy 2050 (National Climate Change Plan of the United Arab Emirates 2050, 2017). The UAE energy strategy aims to produce energy from mixed renewable sources (solar and nuclear) sources. Therefore, the UAE increased the renewable energy share by implementing a series of initiatives on different scales (Kazim, 2015). One of the best renewable energy solutions is solar energy, as it is available in the UAE and GCC areas all around the year.

Despite the fact that earth receives a huge amount of solar energy on daily basis (Bagher & others 2015), utilization of solar energy is marginal. Mainly sun light can be utilized in two ways; either generating electricity by using photovoltaic, or heat by using a solar collector. In the case of a water collector, working fluid is used to transfer the absorbed heat from solar radiation to be utilized in different applications. The type of application determines the type of solar collector that needs to be used. As an example for domestic use water heater, a flat plate solar collector is the best option for the application. However, for higher temperature applications concentrated solar collector can be used. Solar collectors and photovoltaic both have a variety of types available in the market, with different specifications and efficiencies. Boubekri (2009) stated that, at the peak time the highest efficiency of PV panels can reach only up to 20%. The rest of the absorbed solar energy is wasted as heat. The wasted heat affects the PV panel's electrical performance negatively (Sciubba and Toro, 2011). The electrical efficiency of the PV panel loses about 0.25% to 0.5% if the surface temperature of the panel increases by 1 degree Kelvin above the reference temperature.

Therefore, the idea of attaching PV panels with solar collector panels was initiated. The panel is called PVT hybrid which can produce both electrical and thermal energy simultaneously (Allan, 2015). Coupling PV panel with solar collectors, removes the excess heat from the back of the panel, which results in higher produced voltage.

Based on previous research, PVT has proven to be a promising solution for various reasons: the overall efficiency is higher than sole PV, enhanced electrical performance, and the cost of integration of both panels is considered to be moderated (Sciubba and Toro, 2011). Figure 1.1 PVT Hybrid basic components.

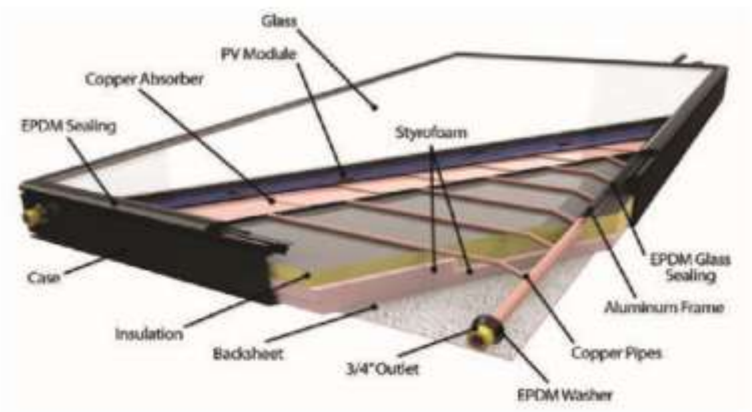


Figure1.1: PVT Hybrid basic components
(www.solarpowerworldonline.com)

1.2 Research Problem

Since the UAE has the vision to achieve 50% clean energy by 2050, adopting a system such as PVT, would be feasible. However, PVT performance is affected by changing geographical location and climate conditions. Geographical location affects the solar intensity and climate condition affecting the surface temperature of the PVT panel. The UAE has hot climate conditions. Therefore, PVT performance is required to be tested under UAE climate conditions to assess the performance of PVT prior to start the adaptation process. From the literature review several knowledge gaps have been identified:

- There are inadequate studies performed in the UAE to study the performance of the PVT system. Therefore, the current study will focus on testing PVT under UAE climate conditions.
- Performance evaluation and optimization for PVT will be conducted in the same study.

1.3 Study Motivation

There are several reasons to highlight the importance of this study. The UAE has an energy vision that aims to achieve 50% clean energy by 2050. The vision focus on reducing CO_2 emissions and mitigating climate change (National Climate Change Plan of the United Arab Emirates 2050, 2017).

Therefore, to achieve the stated vision, the UAE has many initiatives in different ranges to transfer incrementally from using the conventional type of fuel to renewable energy. Dubai (one of the seven UAE emirates) started an initiative called “Shams Dubai”. Shams Dubai aims to encourage householders to install PV panels on the house roof to provide electricity and connect to the local Electricity and Water Authority’s grid. In addition, Dubai Municipality has Green building regulations and specifications which require Dubai residents to use solar water heating systems for domestic systems (Green Building Regulations & Specifications, 2015) in all types of buildings. Hence, using PVT to produce both electricity and hot water from the same unit will be a suitable solution to stratify Dubai regulations.

In addition to the above reason, energy is responsible for about 80% of CO_2 emissions and almost 70% of GHG emissions. Hence, finding alternative renewable sources to reduce GHG emissions is a must (Sciubba and Toro, 2011). Solar energy is considered one of the best renewable energy sources due to it is availability (Nalis, 2012). Adaptation of new solar technology can increase the renewable energy share and help reduce GHG emissions (Nalis, 2012). PVT is considered a promising solution (Sciubba and Toro, 2011).

1.4 Scope of the Study

The scope of the research will cover the following main activities:

1- Field experimental test for two panels the PVT panel and conventional PV panel in Dubai. The collect data from experiment are (power output from both panel, inlet and outlet water temperature from PVT panel and solar intensity). The experiment will be conducted twice during summer and winter.

2- Develop simulation model on TRNSYS by using the collected data from the field experiment.

3- Enhancing the overall performance (electrical and thermal) of PVT through changing design parameters and assessing the impact of each parameter on overall PVT performance.

The re-test for the optimized parameters will not be covered in this study due to time limitations. However, the retest can be covered in another study.

1.5 Research Aims and Objectives

This search is intended mainly to achieve two main aims. The first aim is to assess PVT system performance under UAE conditions. The second aim is to develop a simulation model to optimize the PVT performance. The aims will be achieved through the following objectives:

1. Test and evaluate electrical efficiency of PVT systems in comparison to standard PV systems during winter and summer.
2. Develop a simulation model by using TRNSYS software.
3. Compare field experiment results with simulation results.
4. Optimize the performance of PVT using the simulation model by changing some of the parameters such as (number of tubes, diameters of tubes, PVT panel area, and water flow rate).

1.6 Outline of the Thesis

The thesis is divided into six chapters, as follows:

Chapter I: will cover the introduction with background, research problem, study motivation, scope of the study, and research aims and objectives.

Chapter II: will include general information on solar radiation, solar systems (photovoltaic and solar collector), data weather, the impact of temperature on PV electrical performance, and UAE climate conditions.

Chapter III: will focus on the history of PVT, different studies/ research conducted to study the PVT performance and feasibility and data required to be collected during the experiment. In addition, the reason for selecting TRNSYS software as a simulation model.

Chapter IV: methodology which includes field experiment testing setup, data collection procedure and simulation model.

Chapter V: all the results from both experimental and simulation phases will be presented with the interpretation and discussion of the results and linking with previous studies.

Chapter VI: conclusion and final recommendations with further study recommendations.

CHAPTER II

Solar Energy and Technologies

2.1Introduction

This chapter will cover multiple topics related to energy consumption, solar energy, and different solar technologies. These topics are essential to understand the energy demand as the first step, then, solar energy intensity and availability in the GCC area. The last part will discuss general information related to different types of photovoltaic, photovoltaic performance with temperature increasing, and market cost. In addition to that, information on solar collector material construction, types, and performance. All information given in this chapter is essential to understand the basic design, limitations, and external/ internal factors which affect solar technology's performance.

2.2Energy Consumption

Energy consumption is increasing rapidly in developing countries, due to several reasons such as population increase and advances in technology (Aldossary, 2017). Accordingly, The Green House Gases (GHG) emissions level dramatically increased to dangerous levels which required immediate action worldwide (Delisle, 2008). Increasing atmospheric concentrations of GHG lead to climate change (Radi, 2010). Climate change includes extreme conditions of weather such as increasing heat, flooding, and draught (Delisle, 2008). The World Energy Outlook (WEO) reported that by 2040, the energy demand will increase about 37% (Aldossary, 2017). Hence, relying on non-renewable energy sources will lead to increases in GHG and eventually to catastrophic results. The electricity demand increased dramatically due to an increase in population, transportation, industry, and building operation (Radi, 2010).

The GCC Countries' (Gulf Cooperation Council) economy depends mainly on the fossil fuel industry. The population in GCC represents about 0.6% of the total world population and they were responsible for 2.7% of CO_2 emissions in 2010. Saudi Arabia has the highest carbon footprint (446 Million tons of CO_2/ year) among the rest of GCC countries (Munawwar and Ghedira, 2013). The abundance of oil leads to dominating the oil industry (Masud et al., 2018). With oil depletion, GCC countries started to explore using other sources of renewable energy. One of the most promising renewable sources is solar energy. The main reason is the availability of sunlight year round (Akash & others, 2016). The International Renewable Energy Agency (IRENA) reported that by implementing renewable energy GCC countries can gain huge benefits. Apart from the environmental benefit, there are various advantages of implementing renewable energy such as reducing exporting oil which may save the oil reserves and create new jobs (Abubakar & others, 2018).

The average annual solar radiation in GCC per m^2 is equivalent to 1.1 oil barrels. The highest solar radiation level during summertime in June with (8200 kWh/m^2) in Kuwait and lowest in Oman with (6400 kWh/m^2). The lowest solar radiation is in the wintertime during January in the UAE, with (4200 kWh/m^2) and during December with (3200 kWh/m^2) in Bahrain. Hence, many renewable systems in different scales have been adapted and implemented by GCC. There are enormous socio-economic benefits of adopting a renewable energy system in GCC such as saving oil, creating new jobs. The Gulf Research Centre report shows that the UAE is in lead in the renewable energy index with several solar projects (Abubakar et al., 2018).

In the UAE, almost 98% of electricity is generated by using natural gas as fuel. Accordingly, the UAE has set a plan to mix other renewable energy sources, along with natural gas for producing electricity. The UAE paid significant efforts to facing the dramatic increase in energy demand. Abu Dhabi plans to use 25% of nuclear and 7% of renewable energy by 2020 (Torcat and Almansoori, 2015). The 7% renewable energy will be a mix between (wind and solar) energy plants with a capacity of 1500 MW in 2020 with a 7% share. The plan is to gradually increase the (wind and solar) share from 7% in 2020, up to 75% by 2050 (Abubakar et al., 2018). Major solar energy projects in UAE are based in Abu Dhabi and Dubai and Dubai. Abu Dhabi commissioned a 100 MW Shams 1 plant in 2013, which is considered the largest solar energy project in the region. In addition, the Abu Dhabi Solar Rooftop program with a capacity of 2.3 MW which completed in 2012, the Marawah island PV plant with a capacity of 492kW in 2011, Um Al-zomul off grid power plant with a capacity of 100kW in 2009.

Dubai's clean energy strategy included five pillars: infrastructure, legislation, funding, building skills, and developing an environmental plan based on energy combination. In MBR (Mohammed bin Rashid Al-Maktoum) Solar Phase I Which has been commissioned in 2013 with a total capacity of 13 MW. MBR phase II with a total capacity of 200MW was commissioned in 2017. MBR solar Phase III with a total capacity of total 800 MW using solar panels commissioned on full operation in 2020. The next plan, which is already in the execution stage, is the fourth phase with a capacity of 950 MW. In this phase, both PV and CSP will be used to produce power the expected and commissioned date is 2021.

The CEIC data reports show the increasing consumption of electricity in UAE between 2003 and 2017 as shown in Figure 2.1.

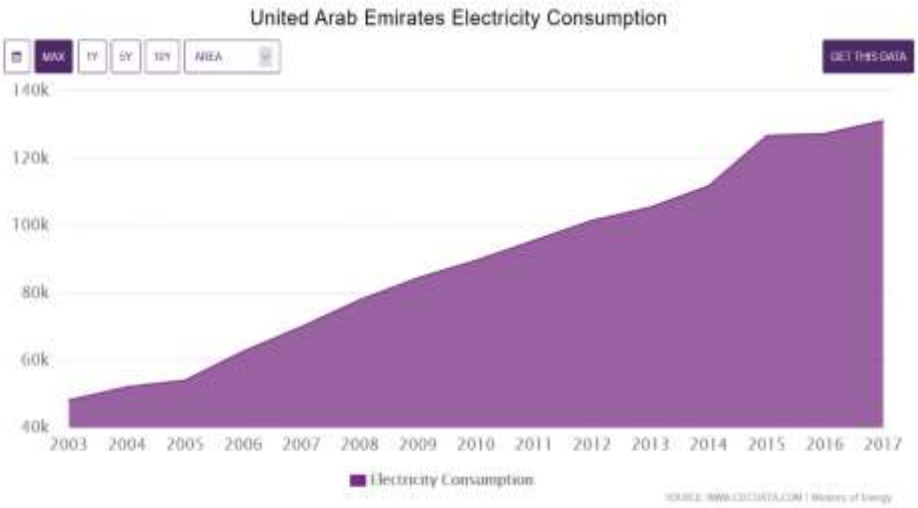


Figure 2.1: Electricity Consumption in UAE between 2003 and 2017
https://www.ceicdata.com/en/united-arab-emirates/electricity-consumption/electricity-consumption visited on 14/12/2018

2.3Solar Energy

Solar energy, or solar radiation, is defined as the energy emitted by the sun (Wald, 2018). The sun generates it is energy through processes called nuclear fusion. In nuclear fusion processes hydrogen (H2) is converted into helium (He). The sun's volume is composed of about 75% of Hydrogen and 23% of Helium, and 2% other elements (Günther, 2014). The most important reaction is the proton-proton chain. The result from a defect in mass from the reaction releases energy about 26.7 MeV/ reaction. The mass energy can be found by equation (1.1). Hence, the solar radiation power emits from the sun about 3.85*1026 W (Günther, 2014).

$$E = mrc^2 \text{.................}(1.1)$$

The solar radiation received by the earth varies during the day, and between seasons, due to the earth's orbit. The closer to the sun, the higher the received radiation (Wald, 2018). Although the sun sends a huge amount of solar radiation, the atmosphere depletes a huge amount of it. The aerosols and molecules absorb and scatter about 20% to 30% of the radiation which has been sent to earth (Wald, 2018). Sun can provide the earth with the required energy every 20 minutes (Patil and Deshmukh, 2015). As mentioned before, time of the day, season, and cloud affect the amount of solar radiation received to earth. In addition, there is a critical factor which is the location of which represented by the latitude and the elevation (Ettah, Nwabueze and G. N., 2011).

In general, solar radiation influences all the aspects of life on earth. As an example, solar radiation affects agriculture, ocean, ecology, ocean, architect building, and material (Wald, 2018)

Mainly solar radiation is electromagnetic radiation consists of:

i. Infrared (52 – 55% λ > 700 nm)

ii. Visible (42-43% 400 < λ < 700 nm)

iii. Ultraviolet (3-5% 100 < λ < 400 nm) - see Figure 2.2

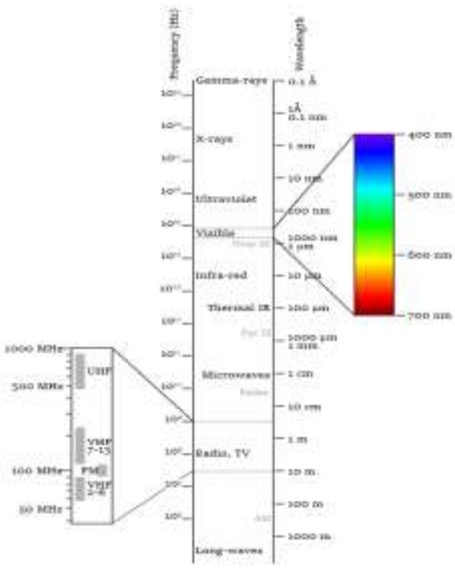


Figure 2.2: Electromagnetic Spectrum

https://www.e-education.psu.edu/eme812/node/643 , visited on

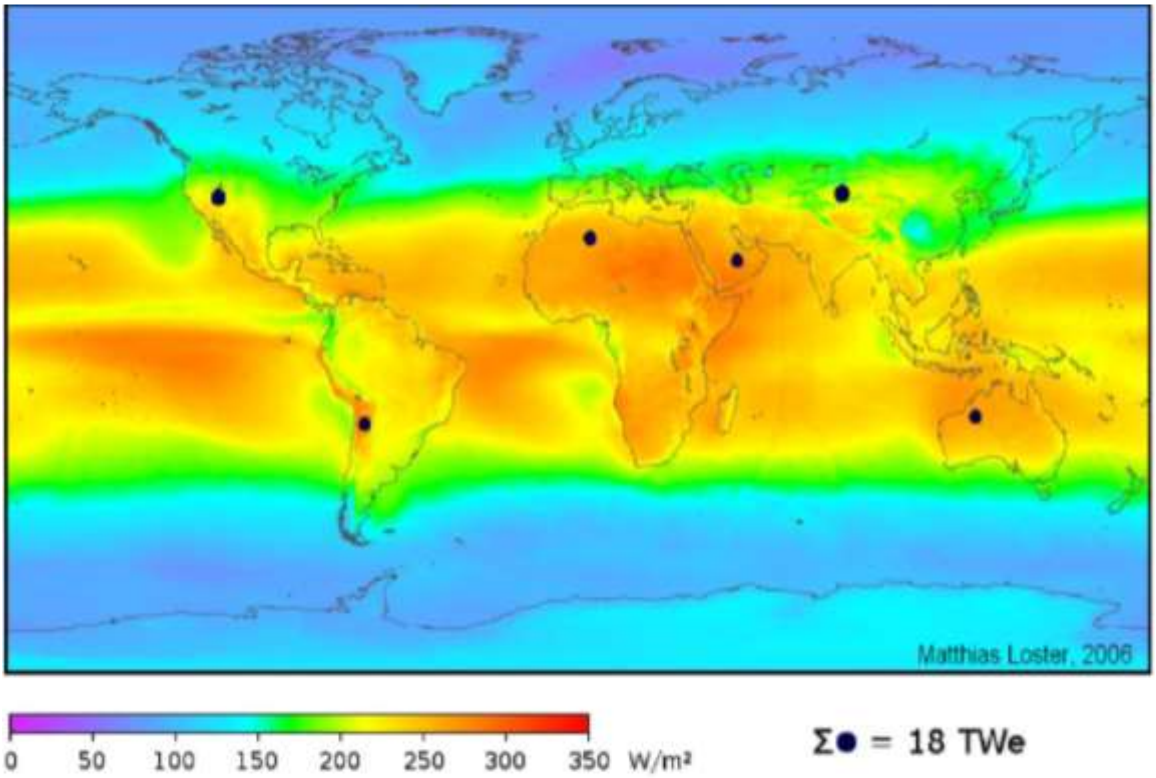


Figure 2.3: Distribution of the average solar irradiance all over earth surface annually (Kabir et al, 2018)

Several factors are affecting the density of solar influx received from the sun. The factors are latitude, daytime variation, climate, and geographic variation (Kabir et al, 2018). Solar energy can be converted into three basic forms to utilize the sunlight as follows (Delisle, 2008):

i. Passive solar heating: defined as the process of utilizing the sunlight without the requirement of the mechanical or electrical system. It is a simple form of harvesting the sunlight through windows or any thermosyphon system.

ii. Active solar heating: the active solar system has a mechanical system such as a pump to circulate the fluid or simply a fan. The best example of active solar heating is the solar collector.

iii. Photovoltaic cells: is a device that converts fall sunlight into electrical energy.

Solar flux has a direct positive impact on the PV panel output current. Therefore, higher solar radiation leads to enhance PV panel output current, accordingly enhancing the output electrical power and the electrical efficiency (Ettah, Nwabueze and G. N., 2011).

2.4 Solar Angles

The sun is continuously moving in an orbit. Hence, the sun location and the density of the solar radiation changing during the day and all around the year. Accordingly, understanding the sun angles dramatically helps in optimizing the solar radiation falls on the PV panels. Mainly the solar angles are (Solar declination, Solar Zenith Angle, Solar Elevation angle and Solar Azimuth). In the following the definition of each angle will be given (Wald, 2018):

i. **Solar Declination**: Angle formed between the equator and a line drawn from the center of the Earth to the center of the sun.

$$\delta = -23.45^{o} \times \cos\left(\frac{360}{365} \times (d + 10)\right) \ldots\ldots\ldots\ldots(2.1)$$

d is the day of the year with Jan as $d = 1$

δ is the current declination of the Sun

ii. **Solar Zenith angle:** Angle formed between the Sun rays and the local vertical.

$$\cos\theta = \sin\alpha = \sin\varphi \sin\delta + \cos\varphi \cos(h) \ldots\ldots\ldots\ldots(2.2)$$

θ is the solar zenith angle

α is the ' or solar altitude angle, $\alpha = 90° - \theta$

h is the hour angle, in the local solar time

φ is the local latitude.

iii. **Solar Elevation Angle:** is the angle form between the sun height and the horizontal. The angle is 0 at the sunrise and 90 degrees when the sun is directly overhead**.**

$$\alpha = 90 + \varphi - \delta \text{..........................(2.3)}$$

iv. **Solar Azimuth:** The angle formed between the sun rays and the horizontal plan.

$$\sin(z) = \frac{\cos\delta \sin(h)}{\cos\alpha} \text{..........................(2.4)}$$

2.5 Solar Energy Technologies

The history of using solar energy started ages ago. The first man who discovered the photovoltaic effect on selenium was Becquerel in 1830. The first use of solar energy was for space between the late 1950s and 1960s as there is no other source of power available and the cost was not the issue (Kalogirou, 2001). Currently, new technologies are used to harvest solar energy with different ranges in size, design, and quality. Solar technologies have already been tested and proven all over the world as feasible sources of renewable energy. In theory, solar energy has adequate capacity to fulfill the world energy demands if harvesting technologies are readily available (Kabir et al, 2018). Fossil fuels are still the dominant source of energy. Many countries have already taken necessary steps in transferring gradually to other renewable sources of energy (Copiello &Grillenzoni, 2017).

Solar technologies can be divided into two main categories photovoltaic and solar collector (Aldossary, 2017). Solar photovoltaic converts the sunlight into electricity, and solar collectors convert solar energy into heat (Kaya, 2013). All of the mentioned solar systems are available with a various range of designs. However, the operation principle is the same (Aldossary, 2017). In the case of solar collectors, the operation principle starts with passing a fluid (water, air, or refrigerant) through the absorber. The fluid absorbs the heat so the outlet fluid will be at a higher temperature than the inlet fluid (Kaya, 2013). In many solar collector systems, the resulting thermal energy is stored to be used later on, such as in the case of the water heater. But, in other cases, such the produced heat is directly used as the case of hot air used for the heating purpose (Aldossary, 2017).

On the other hand, the other technology is the photovoltaic system which has a component with the chemical property that directly converts the solar radiation into electricity. There are too many applications with small and large scales for photovoltaic systems (Kaya, 2013).

2.5.1 Photovoltaic System Technology

The photovoltaic system converts light into electricity (Bagher & others, 2015). PV material ejects electrons once it is exposed to the light source (Mulvaney, 2015). The reason is that PV material is semiconductor material with two layers, p and n (metal and insulator). Layer p with a positive charge, and layer n with a negative charge and free electrons. In case lights fall on semiconductor material the electrons will move and create current. Figure (2.4) explains the Solar cell basic component source. The most common and well-known semiconductor material is silicon.

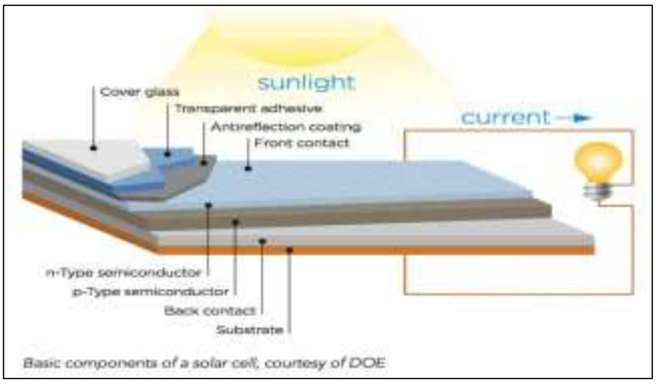


Figure 2.4: Solar cell basic component source

(Tan & Seng, 2011).

The first PV cell was made in 1941. The PV cell was made from silicon with an efficiency of 1% (Glunz & others, 2012). Since introducing the first PV cell and over past decades there were many improvements in the design and material in order to enhance the efficiency of PV panels. There are many advantages for PV panels: provide clean energy, high durability, high reliability, and has adjustable scales/ capacity. Due to the mentioned advantages and the target set by most of the countries worldwide to increase renewable energy share, the PV market growing fast to keep up with the requirement of clean energy (Gul, et al 2016). In general PV efficiency is affected by several factors. These factors are classified as internal and external factors. The manufacturing process and type of material are considered to be internal factors. External factors related to weather conditions: ambient temperature, solar intensity, wind speed, and humidity (Matias et al, 2017).

Some countries are considered to be leading in the implementation of Photovoltaic systems as per statistical report 2014 which shows that China, Japan, USA, Germany, and UK are at the top (Gul, et al, 2016). As has been mentioned, PV system has low efficiency ranging from 5%to 20%. Many studies and Techniques have been implemented in order to enhance PV efficiency (Gul, et al, 2016):

I. Using reflectors in order to focus the solar radiation on the panel.

II. Photovoltaic concentrated type.

III. Photovoltaic system with solar radiation tracking.

IV. Avoiding Shading.

V. Performing regular cleaning.

PV system classified as mono-crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide based on the material used to produce the panels (Chu, 2011).

The mathematical model of the PV function when exposed to light as following:

$$I = I_{pv} - I_D \text{.....................................}(2.5)$$

Where,

I is the output current.

I_{PV} is the photo generated current.

I_D is the Shockley diode equation.

In addition, The I-V characteristic curve represent with the following equation (Vega, 2019):

$$I = I_{sc} - I_{o,cell}\left[\exp(\frac{qv}{\alpha kT}) - 1\right] \text{.........................}(2.6)$$

Where,

T Temperature in $°K$

$I_{o,cell}$ is the inverse saturation current of the diode.

α the ideality or quality factor, measured how close the diode to the ideal diode.

q Electron charge

v Frequency

k the Boltzmann constant,

I_{SC} is the short-circuited and define as "maximum current value that flow in to the PV cell

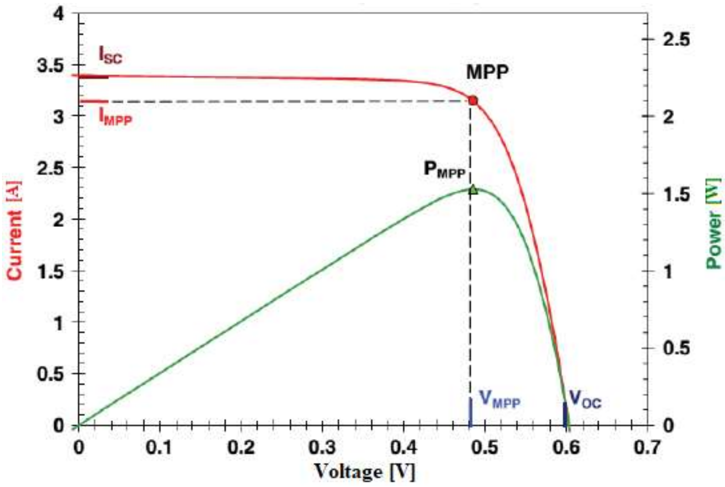


Figure 2.5: The I-V curve and power output
(Dahlen, 2019)

Figure 2.5 indicated that when I= I_{SC} the p side and n side shorted with each other and V= 0. On the other hand, to obtain the maximum value of V the terminals kept open I= 0 and V= VOC. The power is varying based on the light intensity and the produced voltage and current. P = V*I.

Thermal voltage represents in equation (2.7) which is define the relationship between the current flow and the electrostatic potential across the p-n junction. Thermal voltage depends on absolute temperature (Vega, 2019)

$$V_T = \frac{(k.T)}{q} \quad \text{....................................(2.7)}$$

2.5.2 Photovoltaic Technologies

The expected PV modules life span is 25 years with approximate power degradation of 85% (Vega, 2019). The average efficiency of PV modules is 15% (Čotar, 2012). In general, PV panels consist of several solar cells. The solar cells are connected in series and parallel. The purpose of connection in series to produce higher voltage and in parallel to produce a higher current (Vega, 2019).

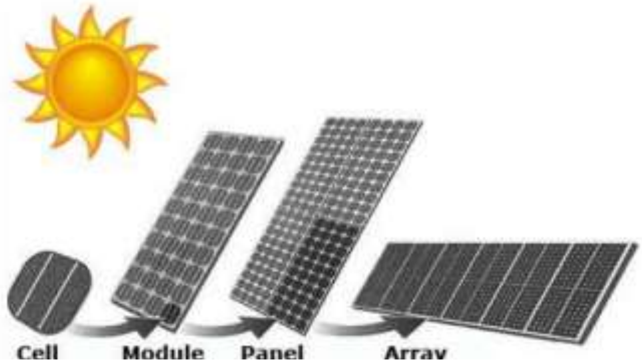


Figure 2.6: Solar PV system (Vega, 2019).

Figure 2.6. Shows solar PV system which has different shapes, types, and applications. Generally, PV systems are classified into on-grid and off-grid or either connected with the local power grid or not.

The other classification of the PV system is done based on the type (Crystalline Silicon, Thin Film, and Compound semiconductor e.g. GaAs-based). There are many sub-classifications for each of the mentioned types. The most common type is the Crystalline Silicon type that is divided into (Poly-crystalline and Mono-crystalline) (Tan & Seng, 2011).

The other types of PV technology that have the highest market share are wafer-based solar cells and the thin-film panel. The main challenge of PV technology emerging widely in the market, was the high cost of the system in comparison to low efficiency. Therefore, many R&D centers around the world are trying to achieve significant cost reduction by improving PV efficiency (Mohanty, et al, 2016). Organic PV cell shows promising solution and caught the attention.

The basic material used to produce the PV cell/modules is Silicon. The physical properties of silicon as single-crystal, multi-crystal, and amorphous are as follows:

i. Silicon Single – Crystal type has the highest efficiency as crystal has free grain boundaries. The free grain boundaries are considered as defects in the crystal structure which lead to a decrease in thermal and electrical conductivity.
ii. Silicon Multi – Crystal has grain boundaries, unlike the single crystal.
iii. Amorphous Silicon is non-crystalize material. The atoms are arranged randomly. The random arrangement of the atoms leads to creating a loose bond of some Atoms that disrupts the flow. Despite that, the amorphous Silicon is considered to be the least efficient among the rest of the types. However, it is considered as low cost (Mohanty, et al, 2016).

PV generates DC (direct current). Hence, Connecting the PV system to the local grid required some modifications and interconnection arrangements in the system. In order to match the electricity produced by the PV system with public utility (Grid), inverters are required to be used. The main function of the inverter is to convert the DC electricity produced by the PV system to AC electricity to either connect to the grid or to be used for any other electrical equipment (Vega, 2019).

2.5.2.1 Crystalline Silicon Photovoltaic Solar

PV type, made of crystalline material, has the highest share in the market with a, 85-90 percentage (Chu, 2011). There are two types of crystalline silicon: Monocrystalline and Polycrystalline (Mohanty, et al, 2016). The main difference between Monocrystalline and Polycrystalline is that monotype is made of one crystal of silicon and poly-crystalline is made of multiple crystals of silicon. The type of silicon used to produce mono-crystalline PV panels is very pure silicon which is usually used to make semiconductor chips. The first step of melting the raw material (Silicon) then form very thin layers as wafers with a thickness of 150-200 microns to form the PV cell (Tan & Seng, 2011). After that, all the produced celled electrically connected to form modules (Chu, 2011). PV made of Crystalline Silicon has the highest efficiency among the other types of PV. In addition, the durability of the PV reaches up to 25 years with a factor of degrades (Čotar, 2012). Monocrystalline efficiency ranged from 13% - 15%.

In the case of Poly-crystalline, or multiple silicon crystals manufactured in a different way than mono-crystalline. First, the molted silicon is bored in mold and then form as wafers. The efficiency of Poly-crystalline ranged from 11% to 14% (Čotar, 2012). The cost of polycrystalline is less than Monocrystalline type (Chu, 2011).

2.5.2.2 Thin- Film Technology

Thin-film PV type is produced by piling thin layers with a micrometer of photosensitive materials on a flat surface such as glass, plastic, or stainless steel (Chu, 2011). In general, the efficiency of thin-film less than the silicon type varies between 3% to 13% (Tan and Seng, 2011). The production cost of Thin-film is considered to be less than other types of PV types. There are three main classifications of the Thin-film PV (a-Si, CdTe, and CIGS (copper indium gallium di-selenide)) (Sharma & others 2015). Other raw materials used to produce Thin-film such (cadmium telluride (CdTe) and copper-indium-gallium-diselenide (CIGS)).

The advantages of using Thin–film type are as follows (Chu, 2011):

i. The production process consumed less material and can be automated easily.
ii. Thin-film type can be integrated into building easily.
iii. The performance of Thin-film is better in high ambient temperature.

In Table 2.1 common PV technologies is indicated with the average module efficiency for each type.

Table 2.1: Different PV technologies with average efficiency

(Tan & Seng, 2011)

PV available technologies	Efficiency Range
Monocrystalline Silicon	12.5 - 15%
Polycrystalline Silicon	11-14%
Thin-film Copper Indium Gallium Selenide (CIGS)	10-13%
Thin-film Cadmium Telluride (CdTe)	9-12%
Thin-film Amorphous Silicon (a-Si)	5-7%

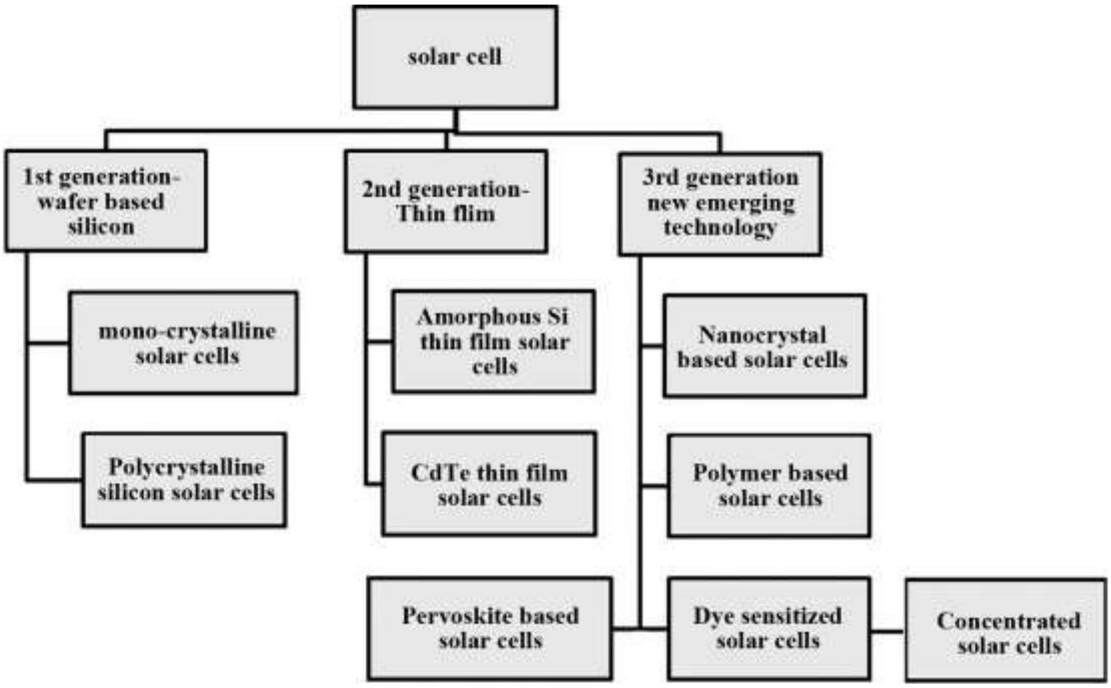


Figure 2.7: Different types of PV cells source (Sharma, et al 2015)

2.5.3 Photovoltaic Cell Efficiency

The efficiency of PV is represented as per the below equation. Efficiency defines as the ratio of the output electrical power to the input power received from a light source or sun (Ray, 2010). In an ideal case, sunlight power is equal to ($1000 W/m^2$). Multiple parameters affect the amount of solar radiation received from the sun (geographical location, climate condition, and different seasons). The PV Efficiency can be found by using equation 2.8 (Aldossary, 2017):

$$\eta = \frac{P_{\max}}{P_{in}} = \frac{I_{\max} \times V_{\max}}{I_t \times A_c} \quad \text{..........................(2.8)}$$

Where I_{max} and V_{max} represent maximum the voltage and current. The other parameters I_t and A_c are the solar intensity and the PV panel area respectively (Fesharaki, et al 2011). As per previous discussion efficiency of PV cells varies based on several reasons (internally and externally). Internal reasons such as type of material and manufacturer process. External parameters such as weather conditions and installation geometry. Weather condition includes ambient temperature, wind speed, and solar radiation (Dubey, Sarvaiya and Seshadri, 2012).

2.5.4 Photovoltaic Efficiency and Temperature Effect

There is an inverse relationship between an increase in temperature and PV efficiency. The efficiency of PV decreases with increasing PV surface temperature above the reference temperature of the cell. The reason is that output voltage drops with increasing temperature of the PV surface as shown in Figure 2.8. Accordingly, cooling down PV surface resulted in increasing the output power and enhancing the performance. PV cell can convert a certain percentage of light to electrical energy, the rest of the light is wasted as heat. The efficiency of mono-crystalline (c-Si) PV module and polycrystalline (pc-Si) PV module, decreases by 0.45%

with increasing of 1 K in temperature. For amorphous silicon a-Si, the decrease in efficiency is about 0.25% with each 1 K raised in temperature (Kalogirou & Tripanagnostopoulos, 2006)

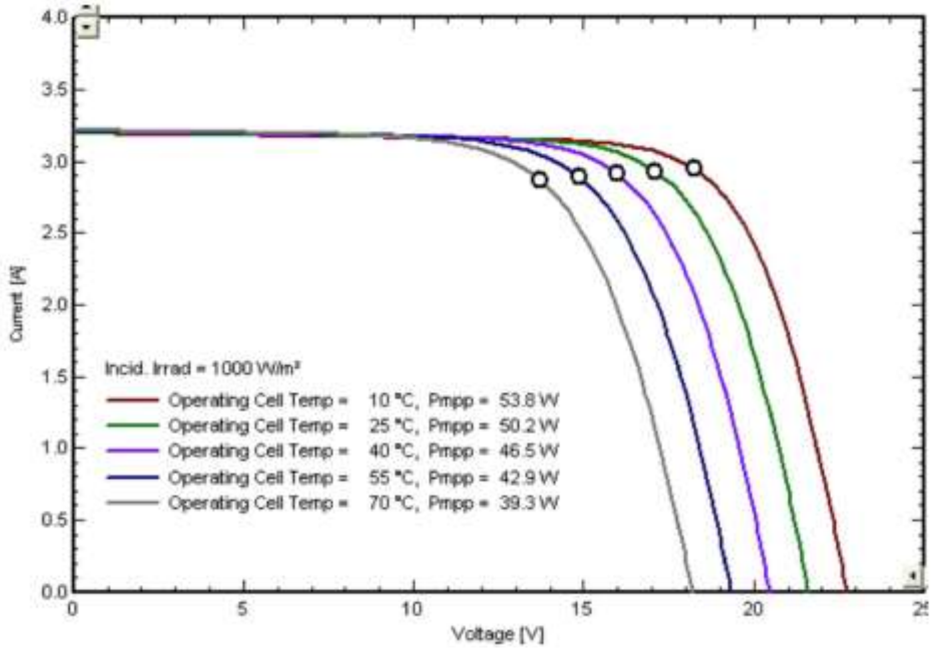


Figure 2.8: Output Voltage of the PV module with different temperatures source (Fesharaki, et al 2011)

2.5.5 PV Installation Capacity and Cost

Over the past years, the cost of the PV system has been reduced radically as the market of the system grew (Dahlen, 2018). Based on IRENA, 2019 report over 580 GW of solar PV system has been installed by end of 2019 worldwide. During 2019, the approximate total capacity of the PV system, installed and commissioned was 98GW. In addition, between December 2009 and December 2019 the cost of crystalline silicon type sold in Europe declined on average up to 90%. The cost of the modules varies based on the type. The highest module cost of high-efficiency crystalline the around USD 0.38/Watt and the lower module cost is around USD 0.21/ Watt. The main factors affecting the module cost are the manufacturer scale and experience. Moreover, there are some of the newly introduced factors such as optimized manufacturing process and the cell architecture types which enhance the efficiency gain as shown in Figure 2.9 and Figure 2.10.

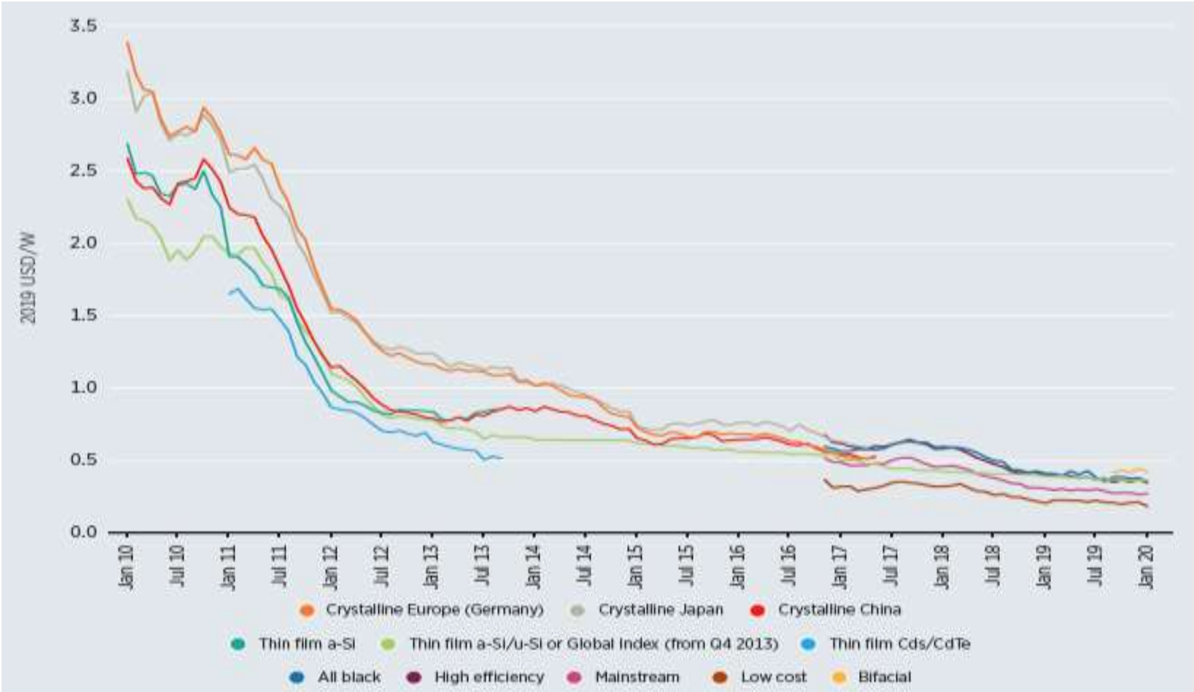


Figure 2.9: Average monthly solar PV module prices by technology and manufacturing country sold in Europe, 2010 to 2020

(IRENA, 2019)

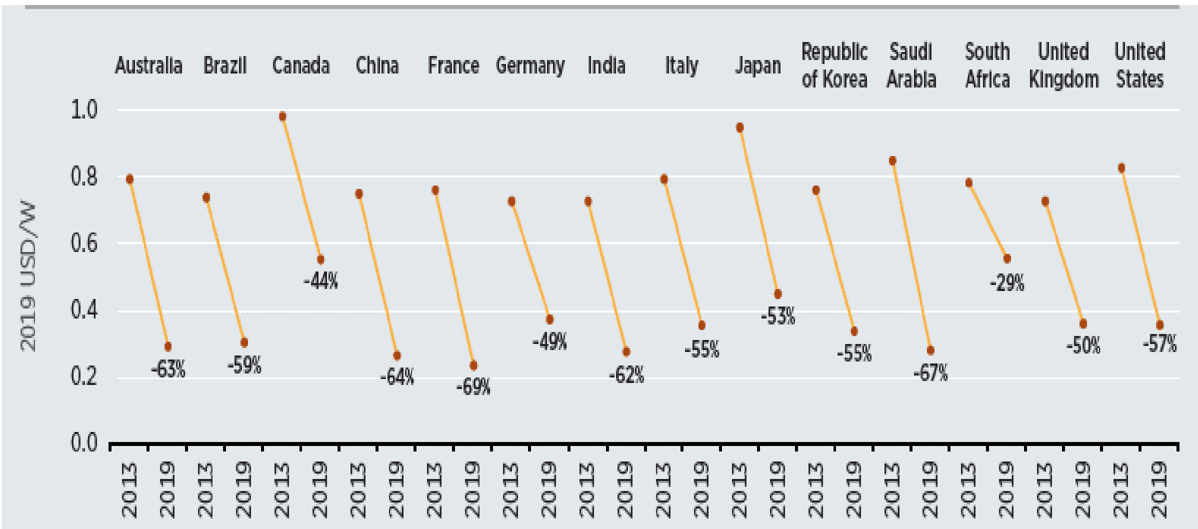


Figure 2.10: Average yearly module prices by market in 2013 and 2019

(IRENA, 2019)

2.5.6 Solar Collector Overview

The working mechanism of the solar collector starts with collecting solar radiation and transferring it into heat. The heat transfers to the working fluid (water or air), can be utilized in domestic or industrial applications. There are three main types of solar collectors: flat plate, evacuated tube, and concentrated type (Bhowmik and Amin, 2017). In the flat plate type, the absorbing area is almost the same as the surface area. However, in the concentrated type, the absorbing area is small, and large are of mirror and lenses reflecting the sunlight and direct it to the absorber (Patil and Deshmukh, 2015). The most popular type in Europe is flat plat due to it is low cost, easy installation, simple structure, and safe operation (Shemelin and Matuska, 2017). In addition, flat plate solar collect can collect direct and diffuse radiation (Bhowmik and Amin, 2017). The main components of both types are common (Casing, frame, insulator, tubes or pipes, and absorber) (Irfan and others, 2015). The main part of the solar collector is the absorber which is usually made of metallic material (Patil and Deshmukh, 2015). The metallic material of the absorber is a high thermally conductive material such as aluminum or copper. In addition to the conductive material, the absorber is usually coated with selective to enhance the solar radiation absorber and reduce the energy emission (Saleh, 2012). Solar collectors have various applications, such as domestic water heating, heating swimming pool water, and heating the space (Irfan et al., 2015). The performance of the solar collector is affected by the surrounding ambient temperature and the heat transfer (Shemelin and Matuska, 2017). In this research, the focus will be on the flat solar collector type. The basic working concept of the solar collector is as follows the sequence (Aghaei, 2014):

i. The absorber collects the sunlight and transfers it to the working fluid. Several technologies have been developed for the absorber to enhance the absorbing heat.
ii. The second stage is transferring the heat through the working fluid to the user or the storage. The working fluid can be water, refrigerant, oil, or air.

2.5.6.1 Flat Plate Solar Collector

A flat plate solar collector is the most commonly used collector. Usually used in applications such as domestic water heaters and providing heating to space (Jesko, 2008). It has many classifications and types. The classification has been done based on the working fluid, design, and material used Figure 2.11. Shows classification of flat plate solar collectors.

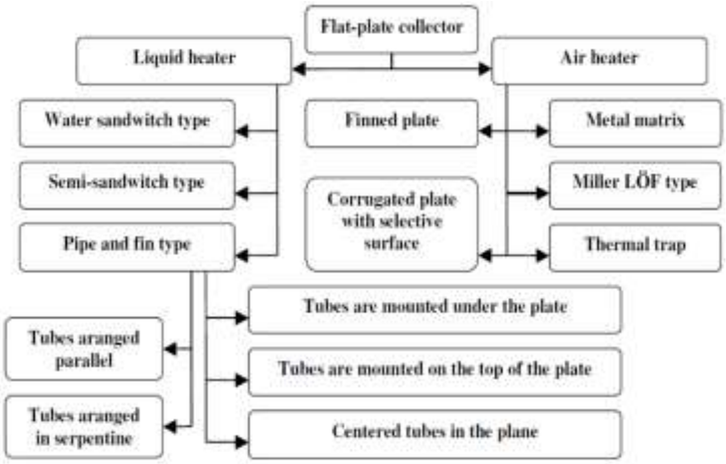


Figure 2.11: Classification of Flat Plate solar collector
(Jesko, 2008)

As mentioned, the main parts of the solar collector are common to all types. In the case of the flat plate type the main parts are (glazing, Absorber sheet, Manifold or header, Insulation, and the frame) (Aghaei, 2014) as shown in Figure 2.12.

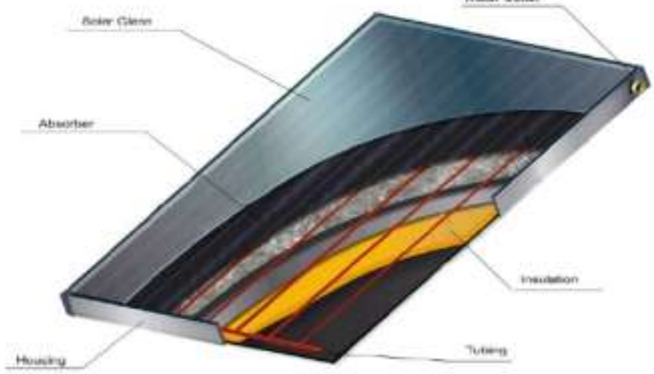


Figure 2.12: Main parts of the solar collector (T. Aghaei, 2014)

The glazing is not available in all types. There is some flat plate solar collector without glaze/ uncovered at the top of the panel. Solar panels with glazing are considered to be more thermally efficient than the non-glazing type. There are two types of glazing cover, single glazed or double glazed. The main function of glaze is to trap the penetrated sunlight and enhance the heat transfer. The glaze traps the long-wavelength and transmits the shorter wave. The transmittance of normal window glass is about 0.87 to 0.90. Glazing made of plastic material has better transmittance to short waves. Unfortunately, cannot stand ultraviolet radiation for a long time. Accordingly, it is not common to use plastic as cover material for solar collectors (Sadaq, 2015). In the below table Transmittance of different glazing materials is shown:

Table 2.2: Transmittance of different material (Sadaq, 2015)

Transmittance value of different material	(τ)
Crystal glass	0.91
Window glass	0.85
Acrylate, Plexiglass	0.84
Polycarbonate	0.84
Polyester	0.84
Polyamide	0.80

The other main part is the absorber. The absorber is mainly painted black to maximize heat absorption. It is mainly a metallic sheet with different configurations straight, wavy, and fluted (Aghaei, 2014). As mentioned above, absorber plays a key role in enhancing the performance of the solar collector as it is responsible for absorbing the solar radiation. In designing the absorber and selecting the suitable construction material. Some factors need to be taken into consideration: Durability, Thermal conductivity, easy handling, material cost, and availability.

Hence, the design and the thermal properties of the absorber special attention (Sadaq, 2015). Absorber design parameters are:

i. Type of material usually used to construct the absorber (copper, aluminum, stainless steel, stable polymers, and mild steel). Copper is preferred due to it is high thermal conductivity. However, copper is considered to be costly in comparison with Aluminum with only a slight enhance in collector performance (about 3%). (Majid et al, 2015).
ii. Thickness of the absorber.
iii. Design of the absorber (straight sheet, wavy or fluted).
iv. Thermal conductivity of the absorber either due to used material or due to using black paint or selective coating.

Piping and tubing of the solar collectors carry the fluid through the solar collector. There are mainly two common configurations (parallel and serpentine). The pipe parallel configuration consists of several risers connected from top and bottom with the main manifold. The risers are responsible for transferring the fluid through the collector and increasing the area of contact between the fluid and the absorber. The manifold is usually placed on the top and the bottom of the collector to drain the fluid. The pressure is high at the bottom of the collector and lowers at the top. The flow rate at the middle part of the collector is the lowest where the heat transfer is the most. The serpentine tube type is one long tube that bends several times. Therefore, their uniformity in flow rate. Accordingly, the heat transferred all along the collect is uniform. In addition, the serpentine configuration is easier to construct and does not require any welding work (Sadaq, 2015). The design parameters of the tubes which directly affect collector performance are:

i. Tubes design and arrangement (parallel, spiral).
ii. Tubes thickness.

iii. Number of tubes with the collector.
iv. Tubes Material.
v. Gaps or spacing between tubes.

In the flat plate solar collector, the most important aspect to enhance the thermal performance is to enhance the performance of the absorber. Hence, the more solar radiation absorbed by the absorber will result in higher the temperature outlet from the absorber. Accordingly, the efficiency of the collector increase. In the domestic water application, the solar collector system can increase the water temperature up to 50 ^{o}C (Sadaq et al., 2015). The thermal properties and design of the absorber play the main role in the efficiency enhancement.

The inside part of the collector is insulated with layers of insulation such as Rockwool or free polyurethane foam (PUF) material to minimize heat loss (Aghaei, 2014). Insulation material shall confirm the requirement of durability, fireproof, waterproof, and weather tolerant (Tripathi et al, 2018).

The last part of the solar collector is the frame which keeps all the other parts together and protects the solar collector from dust, moisture, and water penetration (Aghaei, 2014).

In general, to design a suitable solar water heater using flat plate solar collectors. Some design criteria need to be taken into consideration and other assumptions (Patil and Deshmukh, 2015). The assumptions are as follows:

i. Estimating the daily water consumption to decide the size of the water tanks and the number of solar collectors required.
ii. Water inlet temperature as it is affecting the efficiency of the system.
iii. Inclination of the solar panels which affect the intensity of solar radiation falls on the solar panel.

Other design considerations which affect the design of the solar water system are:

i. Weather conditions including ambient temperature, wind speed, and humidity.

ii. Solar intensity depends on the geographical location.

Other than the mentioned assumption and other design considerations which affect the design and estimating the capacity of the system. There are other criteria required to be highlighted. The below-mentioned criteria are related to the operational characteristics of the solar panel (Patil and Deshmukh, 2015):

i. Collector efficiency: defines as the ratio between the useful amounts of thermal energy gained for a certain time to the total solar intensity fell on the collector surface for the same time.

ii. Collector Thermal Capacity: Thermal capacity or heat capacity is the amount of heat stored per solar collector area to produce a unit change in fluid temperature.

iii. Pressure Drop: Define as the difference of pressure between inlet and outlet due to friction. Deciding the pressure drop for each collector is very important to design the capacity of the circulation pump.

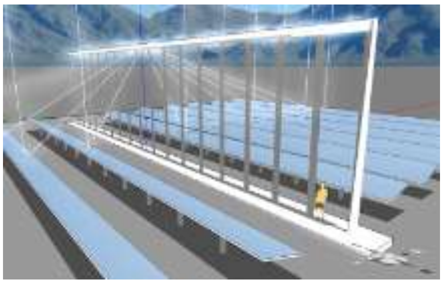
iv. Stagnant Conditions: the time that the fluid does not gain any useful energy from the solar collector and there is no circulation. Usually happened during summertime when the hot water tank reached the required temperature of about 95^{o}C. The pump stop working, as a result, the absorber gets very high due to continuous exposure to solar radiation without water circulation. In stagnation conditions, the temperature of the absorber reaches 180 -220^{o}C, in case of using a selective coating (Hausner and Fink, 2002)

v. Optical Properties of the cover: three main values express the optical properties of the solar collector cover: reflectance, transmission, and absorptance. The glass cover used on the top of the solar collector is not perfectly transparent. Part of the solar radiation reflected from the top of the solar collector the rest of the solar radiation is either transmitted through solar collector material or absorbed (Patil and Deshmukh, 2015).

2.5.6.2 Concentrated Solar Collector

Patil and Deshmukh, 2015 clarified that the different between the flat plate solar collector and concentrated type is the size of the absorber and the availability of mirrors or lenses. In the case of the concentrated solar collector the mirror or the reflectors used to focus and concentrate the sunlight on the absorber. The benefit of the concentration is to compensate the losses in solar radiation in it is way to the earth. Hence, the higher concentration lead to higher thermal power generation (Mishra and Tripathy, 2012). In addition, concentrated solar collector achieved higher power output than the flat plat with less consumed area (Kedare and Desai 2017).

There are various systems of concentrated solar collectors: parabolic trough, Linear Fresnel reflector, solar chimney/solar tower, and Dish Stirling system, as shown in Figure 2.13. The solar concentrated system is able to produce very high temperatures. The parabolic trough solar collector produces temperatures reaching up to 400^{o} C. Dish Stirling system temperature reaches about 650^{o}C and above 1000^{o}C for solar power tower. Concentrated solar collector can be classified in to tracking and non-tracking systems. The tracking system further classified in to one axis or two axis tracking (Jesko, 2008).



Linear Fresnel reflector

https://concord.org/blog/modeling-linear-fresnel-reflectors-in-energy3d/

Parabolic trough

http://www.eusolaris.eu/Technology/ParabolicTrough.aspx

solar chimney/ solar tower

https://eurekalert.org/multimedia/pub/175485.php

Dish stirling system

https://www.volker-quaschning.de/fotos/psa/Dish1_1024x768.jpg

Figure 2.13: The four different types of concentrated solar collector

(www.e-education.psu.edu/eme812/node/3 visited on 11/02/2019)

2.5.6.2.1 Parabolic Trough

Solar collector parabolic trough produces super-heated steam with high pressure. The technology is mainly used in power plants in order to produce the required steam to drive the turbines. PTC system consists of a curved mirror placed on two sides of the receiver which is a tube that carries water in most cases. The main function of the curved mirror is to reflect and focus the incident solar radiation on the centered pipe. The water passes through a series of PTC fixed in one line until the steam is reaching to the required temperature and pressure. Then, it will be sent to a steam turbine (Padilla, 2011).

2.5.6.2.2 Solar Chimney or Tower

Solar chimney mainly consists of three main elements: solar air collector, chimney/tower, and wind turbines. The working principle of the solar chimney is very simple, the solar collectors all around the tower heat up the air during the daytime. The hot air is lighter than the cold air accordingly the hot air flows through the tower to reach up. The wind turbine placed in the tower starts to rotate and draw more hot air. Rotation movement generated electricity (Schlaich, et al, 2009).

2.5.6.2.3 Linear Fresnel Reflector

Linear Fresnel Reflector (LFR) technology has the same concept as the parabolic trough. The only difference is that in LFR the mirror is a straight mirror instead of a curved type. The mirrors are arranged on two sides of the receiver in a way that reflects and focuses incident solar radiation directly to the receiver. The LFR application is the same as PTC used to produce steam to drive turbines. LFR is producing less temperature than the PTC. Hence, the efficiency is less than PTC which is considered to be a disadvantage. There are several other advantages of LFR, such as using a straight mirror is simpler and less costly than the parabolic type (Padilla, 2011).

2.5.6.2.4 Dish Stirling System

Dish Stirling system is a sun tracking system consisting of parabolic dish concentrate solar radiation into receiver or power conversion unit (PCU). The receiver then transfers the heat to the generator (Mancini, et al 2003).

2.5.6.3 Evacuated Tube Solar Collector

Evacuated tube is another type of flat plate collector which consists of parallel rows of glass tubes connected with a common header. Vacuum the tubes above the absorber to help reduce the heat loss by convection. Accordingly, the thermal performance of the collector enhances (Tripathi et al, 2018). The vacuum glass tubes consist of two layers: an outer shell and inner shell. The outer tube is used for protection function, and the inner tube is coated with absorptive material (Olek1, Olczak, and Kryzia, 2016) as shown in Figure 2.14.

The efficiency of the flat plate collector is considered to be lower than the efficiency of the evacuated tube. The reason is that the evacuated tube has less gross area than the flat plat type. Mainly evacuate tubes solar collector used in hot climate condition as the efficiency of the system affected by the cold weather (Kalogirou, 2004). In the case of the evacuated tube solar collector, the ratio of gross area to absorber area can be changed based on the distance maintained between tubes. Therefore, increasing the space between tubes has a negative impact on the overall efficiency of the solar collector. Other factors are affecting the overall performance of the solar collector such as: title angle, collector dimensions, and weather condition (Hayek, Assaf, and Lteif, 2011).

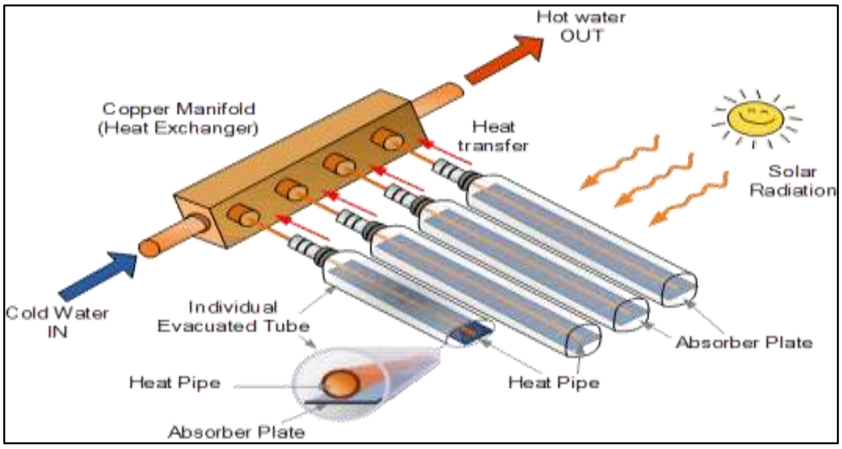


Figure 2.14: Evacuated solar collector main components

http://www.alternative-energy-tutorials.com/solar-hot-water/evacuated-tube-collector.html visited on 11/02/2019

2.6 Chapter Summary

Multiple topics have been included in chapter II related to the internal and external factors that affect the performance of the solar systems. External factors were solar intensity, the Inclination of the solar panels, and weather conditions. Internal factors were absorber material, the number of tubes, tubes thickness, and tubes material. Based on the information provided the design parameters required to be tested in this research have been decided.

CHAPTER III

Photovoltaic Thermal System (PVT)

3.1 Introduction

In the current chapter, a general overview of PVT will be introduced. In addition, a brief about PVT basic function, main types, and classifications. This chapter will include information that will be useful to perform the field experiment and develop a simulation model. Hence, previous studies and researches related to PVT performance and performance enhancement will be explored. The last part will cover different simulation tools available in TRNSYS and the advantages and disadvantages of each tool.

3.2 PVT Basic Concept

As previously mentioned, the PVT is a system that produces electricity and thermal energy simultaneously. Dual-energy production from the same unit increases the overall effectiveness of PVT in comparison to sole PV (Büker, 2015). The idea behind PVT functionality is that photovoltaic panels convert solar radiation into electricity with an efficiency ranging from 9% to 20%. Hence, more than 80% of solar radiation is either reflected or converted to thermal energy. The converted thermal energy increases the PV panel temperature which, causes a further reduction in efficiency (Dalvand, Mohtasebi, and Rafiee, 2012). PVT generates thermal energy bypassing fluid behind the PV panel which will absorb the excess thermal energy. Removing the heat will cool down the PV panel surface and improve electrical efficiency. The absorbed heat by the fluid can be reused in different applications. Hence, the PVT system offers an enhancement in the overall efficiency with the same solar radiation input. It is well known that the PV efficiency decreases with increasing operational temperature

(Ualboonrueng et al., 2012). In addition, PVT as a unit produces more energy per unit area more than two separate units of PV and solar collector (Büker, 2015).

3.3 PVT History

Over the past years, much research has been conducted on PVT system performance and feasibility. The research started in the mid-1970s (Zondag, 2008). The main objective was to enhance the PV efficiency by removing the heat. The idea of using PV panels as a façade in 1990 trigger the idea of utilizing the produced heat from the panels to heat rooms. Most of the PVT system research started in US and Japan in the early-stage later spread all over the world (Zondag, 2008). Initial researches produced many theoretical models which have been validated experimentally. All of these models are the basis for the current researches (T.T. Chow, 2010).

Major contributions to work in PVT were recorded by Wolf, Florschuetz, Kern & Russel, and Hendrie in different research and studies (T.T. Chow, 2010). The past research mainly focused on improving the overall performance of the PVT system. Over the past 40 years, the studies conducted experimentally and by using simulation. Zondag (2005), gave a comprehensive overview of all the past research related to the PVT system. He mentioned that the first water-type PVT system was conducted by Martine Wolf to investigate the feasibility of the system. The results showed that the system is technically feasible. After Martine's findings, many of the ideas have been evolved and expanded. In 1976 Martin Wolf re-tested the PVT system. He coupled the PVT system with heat storage to enhance the output. Following Wolf's research, another research by Ken Russel published in 1978 discussed using coolant as additives to working fluid of PVT. In 1982 the first theoretical model has been developed by Hendrie (Zondag, 2005). Later studies focused on optimizing the overall performance of PVT. Hence, many different designs have been developed to enhance the efficiency of the PVT system.

Different PVT system designs have been studied through experimental, theoretical, simulation, and numerical ways. The developed designs and simulation models focused on improving the operational factors to optimize the system and enhance efficiency (Koech, et al 2012).

Ghoneim & Mohammedein (2016) explained that there are differences in characteristics between a conventional PV system and a combined PVT system. They justified the statement by mentioning that the electrical output of the PVT is affected by some parameters such as the type of fluid passing behind the PV panel and the flow rate of the fluid. Hence, the output thermal energy of the PVT is changing heat transfer between the absorber and the working fluid. So, in the following section, the different available technologies of the PVT will be presented.

3.4 PVT Available Technologies

There are various types, configurations, and technologies of PVT systems (Dean. el at, 2015). The classification of the types mainly depends on the design of the system, target application, the flow pattern of the fluid, and working fluids. In addition to the mentioned classification, there are subcategories for each main type, as shown in Figure 3.1. The classification depends on working fluid divided into three categories water, air, or refrigerant (Huanga & Huanga, 2013). (Li Jin, et al, 2013) initiated a classification for PVT system which divided the PVT types into five different types Liquid PVT Collector, Air PVT Collector, Ventilated PVT with heat recovery, Liquid and air PVT collector, and PVT concentrator. The most popular classification depends on the collector design which divided the PVT system into two main categories flat plate type and concentrated collector type. Recently, Hischier, et al, (2017) added the level of insulation to the main categories of classification.

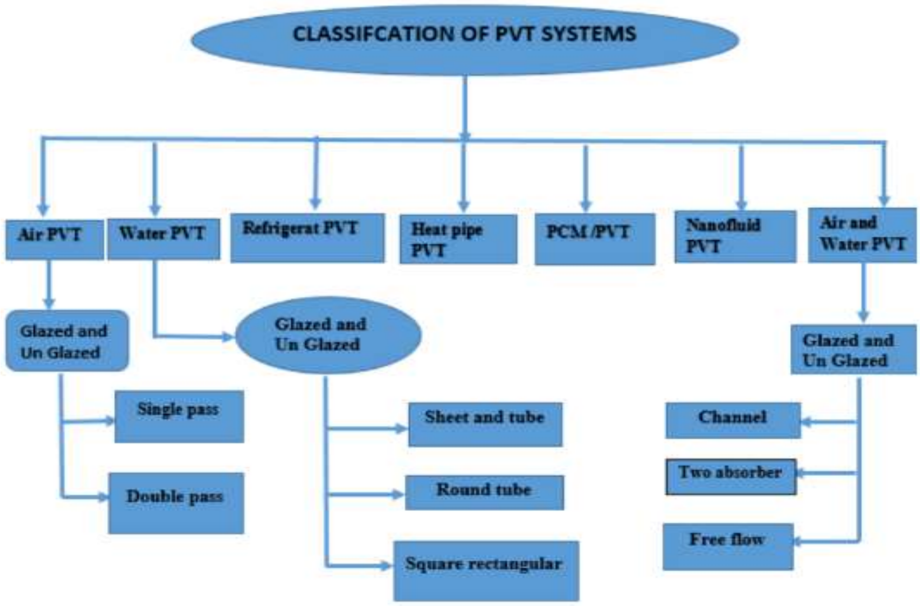


Figure 3.1: Classification of PVT system source (Abdullah, et al, 2019)

As mentioned, the other classification is based on the type of working fluid. There are two main working fluids used to extract the heat: either water or air. Hence, PVT flat plat can be divided into subcategories of flat plate air PVT collector and the flat plate water PVT collector. In the case of a water PVT collector, working fluid (water) absorbs the excess generated heat from the back of the PV panel. The resulting hot water can be reused for various applications such as hot domestic water and heating swimming pools, which are considered to be low-temperature applications. The other popular PVT is the air collector type which is considered to be an economical type due to low operation cost (Sharma, et al., 2012). PVT- air used to reheat the air inside the building in cold climate areas. In this study, the focus will be on flat plat PVT–water collector type. The flat plate type is cheaper than the concentrated type. Moreover, it is available in the market and can be installed easily. However, the efficiency of PVT flat plate is considered to be less than the concentrated type (Ramos, Cardoso, and Alcaso, 2017). Figure 3.2 shows the typical design for flat plate PVT.

The other main classification based on the panel design is the PVT concentrated type. As it is well known concentrated type used to enhance the thermal performance of the module.

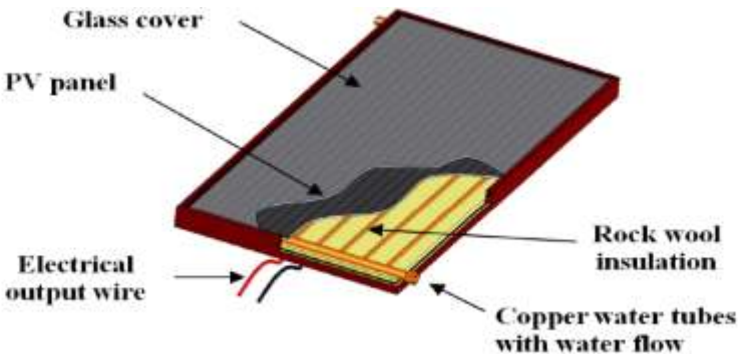


Figure 3.2: Typical flat plate PV thermal with glaze and straight absorber (Nualboonrueng, et al, 2012)

In the concentrated type, the reflector is used to focus the solar radiation on the PV surface of the receiver (Touafek et al, 2014). (CHAPS) stands for combined heat and power solar that is considered to be one of the PV concentrated types. CHAPS has a concentration ratio of 37 times. In general, the PVT concentrated type is more expensive than the PVT flat plate type (Vimal, 2017).

There is another classification based on panel design, which is a classification based on the availability of glaze cover. PVT is classified as glazed and unglazed (Kim, et al, 2012). There are some differences in performance between the two types. The performance of PVT glazed type is better than unglazed type thermally. On the other hand, the unglazed cover has lower thermal performance but higher electrical efficiency (Zondag, 2008). Zondag, et al 2001, conducted an experimental study to compare conventional PV with two types of PVT (glazed and unglazed). The annual results showed that glazed PVT had less electrical performance than the other two panels (PV and unglazed PVT). The explanation for the result was due to the use PVT panel with a cover made of glass with a transparency of 92%. Hence, there was a reflection loss which gave a lower electrical performance. The fourth classification of PVT type is based on the working fluid used to extract the excess heat. In general, three main types of fluid used in PVT are water, air, water/air, or refrigerant. Mainly, water and air are the common fluid and the selection of fluid is based on the application. However, water is used dominantly as the working fluid. The main reason is that the water is less costly than the refrigerant and more efficient in extracting the heat from the system than the air (Rosli et al. 2014). Water has higher specific heat than air and is more suitable to accommodate variation in solar radiation during the day (Rosli, et al. 2014). In addition, in hot climate areas, the requirement of hot water is more than the requirement of hot air (Vimal, 2017). Therefore, producing hot water from PVT is considered more suitable for the UAE case. Tripanagnostopoulos et al. (2002) studied experimentally two types of PVT, one with water as working fluid and the second with air as working fluid. They found that water as a working fluid is more efficient in extracting heat than air.

PVT has unlimited configurations, as it is mainly a combination of PV panels with a solar collector. There are various types of PV panels (Mono-crystalline, Polycrystalline Solar panels, Amorphous Silicon Solar cells, Biohybrid Solar cells, Cadmium Telluride Solar cells, and concentrated PV cells). In addition, solar collectors as well have many configurations and different designs with different classifications. The classification can be done according to type of flow rate, absorber pattern, and glaze/unglazed. Hence, too many combinations of two PV modules and solar collectors can be developed. The available pattern of the solar collector absorbers is sheet-and-tube structure, flat-plate tube, rectangular tunnel with or without fins/grooves, channel, free flow, double pass, single pass, and round tube. Each mentioned pattern for the absorber is suitable for the type of working fluid. In this study, the focus will be given to the PVT flat plate type with water as a working fluid.

Three types of collector patterns are considered to be suitable for water as working fluid: sheet and tube absorber, round tubes absorber, and rectangular tubes absorber (ÖNER, et al, 2016).

According to Miglioli (2017) and based on the conducted study, he concluded that the round tube shape of the collector has better performance than the rectangular shape even if the material was made from aluminum, not copper. The reason he gave that round shape is better in heat transfer than the rectangular shape. Moreover, it is easy to restructure the round tube with many innovative shapes.

3.5 PVT System Advantages

Several benefits are resulting from using the PVT system. Conventional PV convert 5-20% of the solar radiation into electricity, the rest of the solar radiation is converted to heat. PVT extracts the heat from the back of the PV panel and re-uses it for low heat applications. The examples applications are pre-heat the air for heating system, hot water for domestic use, drying application for agriculture (Delisle & Kummert, 2012). Therefore, by removing the extra generated heat, PV operation temperature will be low, thus the electrical performance will be enhanced (Kalogirou, 2001). Dual application of the PVT (generating electricity and hot water/ air) from the same unit save area especially, other than using two panels (PV and solar collector) separately (Koech, et al. 2012). Hence, PVT considers as a good solution for the congested area on the roof (Ibrahim et al. 2009).

3.6 PVT System Dis- advantages

The PVT system has some disadvantages related to higher costs. PVT is higher in capital cost and installation cost. For the operational cost, it is considered to be better than conventional PV as it can save a higher amount of energy (Hernández et al. 2013).

To overcome the high initial cost, low-cost material can be used to construct a PVT system. In addition, the PVT system is not popular in the market as it is considered to be a new system (Ibrahim et al. 2008).

In addition to the above-mentioned disadvantages, PVT thermal performance is considered to be less than the conventional solar collector type. This is due to enhancement in electricity performance which reduces the thermal proportion resulting from solar radiation. The absorptivity of PV as a cover for PVT is less than the conventional type of covers used for solar collectors (Pressiani, 2016).

3.7 Previous PVT Experimental Studies Overview

There are numerous efforts have been deployed to investigate, study and optimize PVT system performance worldwide. In the following, some of the examples will be presented which directly related to the current research.

Hosseini, Hosseini, and Khorasanizadeh (2011) performed an outdoor experiment to compare the performance of conventional PV panels with another PV panel with the same specification cooled by pumping water on the top of the panel in the form of a thin layer. The experiment took place in Tehran. The weather data (solar radiation and the ambient temperature) were recorded at the site. Thermocouples were attached to the back of the panels to record the temperature. In addition, the temperature of the outlet water from the panel has been recorded. The experiment was conducted in September. For 10 days the data were collected every 10 minutes. The results showed that the combined PV panel with a cooling system had better electrical efficiency for two main reasons. The first reason was pumping a film of water at the top of the PV panel reduced the reflected solar radiation. The second advantage was decreasing PV temperature up to 18^{o}C in comparison with the other panel. Figure 3.3 showed the results and the improvement in electrical efficiency between the conventional panel and the panel with the cooling system.

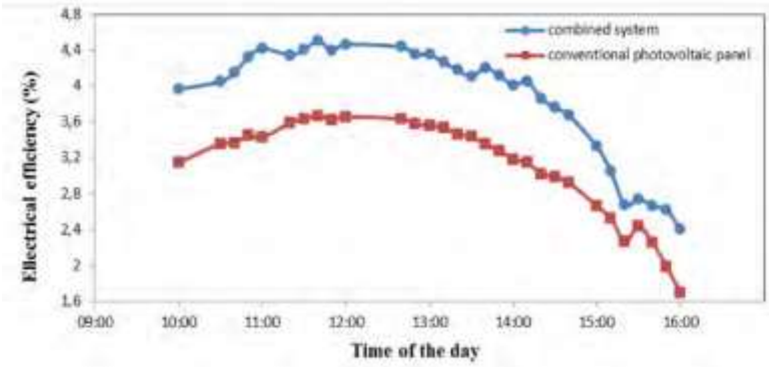


Figure 3.3: comparison between the electrical efficiency of conventional PV and PV attached with cooling system.
(Hosseini, Hosseini and Khorasanizadeh, 2011)

Huang, Sung, and Yen (2012) performed outdoor test using unglazed PVT in India. The PVT specification was polycrystalline silicon PV, 240 W power output, sheet and tube type collector made of copper. There was an adhesive on the backside of the PV panel. The system was a closed-loop system with a water tank, piping, thermocouples, Pyranometer, and data logger. The data collected at the site were inlet water temperature, outlet water temperature, ambient temperature, solar radiation. The data has been recorded every 5 minutes. Experimental results showed that the water inlet temperature increased from 17.4°C to 35.72°C, PVT electrical efficiency was 14.46% and thermal efficiency was 43.94%. Figure 3.4 shows the relation between the overall PVT efficiency and the change in inlet temperature, ambient temperature, and radiation.

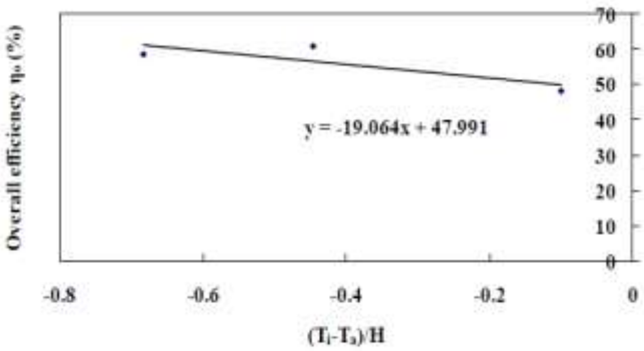


Figure 3.4: Change of PVT overall efficiency with change in outdoor condition and inlet water temperature
(Huang, Sung & Yen, 2012)

Dubey and Tay (2012) compared the performance of two types of PVT panels. The study took place in Singapore on 29/07/2010. The first type of PVT A was mono-crystalline Si solar cells attached with the thermal collector of tube-and-sheet type. The second PVT B type is a polycrystalline solar panel attached with a thermal collector parallel-plate type. The experiment was performed with two water flow rates (0.03 kg/s and 0.06 kg/s). The thermal performance of the PVT panels has been validated theoretically. The results showed that the performance of both PVT types was close to each other. Type A panel electrical efficiency was 11.8%, and thermal efficiency was 40.7%. Type B electrical efficiency was 11.5%, and thermal efficiency was 39.4%. The outlet temperature of the PVT A at mass flow rate 0.03 kg/s and 0.06 kg/s were 55.3°C and 52.1°C respectively. For type B at mass flow rate 0.03 kg/s and 0.06 kg/s were 56.0°C and 53.4°C respectively. In addition to the change in mass flow rate, the reason behind the variation in outlet temperature was the intensity of solar radiation. In the validation part between the experimental and theoretical results. Figure 3.5 shows the compatibility between the experimental data and theoretical calculation.

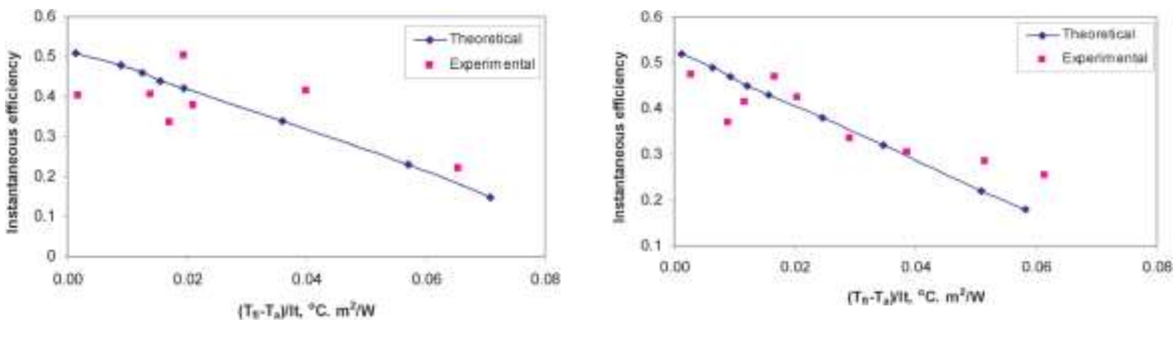


Figure 3.5: Variation of PVT overall efficiency with change in outdoor condition and inlet water temperature at mass flow rate of 0.03 kg/s for A type and B type respectively (Dubey and Tay, 2012)

Jaiganesh and Duraiswamy (2013) ran an experiment on the glass to glass PV panel combined with the flat plate solar collector in comparison with glass to tedlar PV. Tedlar is a thermoplastic material that has characteristics of low permeability of water, weather resistance, and high strength. The results from the mentioned experiment were as follows:

i. The electrical efficiency of the GTG – PVT was higher than the Glass to tedlar PV with 0.7%.
ii. The electrical output of both panels increased with increasing the solar radiation and PV surface temperature as well.
iii. GTG-PVT panel produced thermal efficiency of 44.37%. The overall efficiency was 56.02%.
iv. The electrical efficiency is decreasing by increasing the PV surface temperature. The PV surface temperature needs to be kept close to STC (standard test condition) temperature to achieve better electrical efficiency results.

Calise and Vicidomini (2016) evaluated the technical and economic potential of implementing PVT in comparison with the conventional PV system in their study. The experimental setup consisted of four number of PVT Polycrystalline silicon panels and four unglazed type PVT Polycrystalline silicon panels. The total generated power was 2 kW (250 W/ Panel) with a total PV area of 13 m2. In addition to the experimental test, a numerical analysis has been conducted as well. The experimental components and layout Figure 3.6 were as follows:

i. Four number of PV panels (250 W per panel).
ii. Four number of PVT panels with the specification of (250 W / panel, Thermal production about 400 kW/m2, flow rate 100L/h and Area of 1.44 / panel)
iii. Wilo Pump (capacity 3.2 m3/h, Head 7.0 m)

iv. Heat storage tank with a capacity of 200 L and maximum operating temperature of 95°C.

v. Expansion vessel.

vi. Flow meter for measuring flow meters.

vii. Thermocouples for measuring temperature.

viii. Data logger.

ix. Inverter.

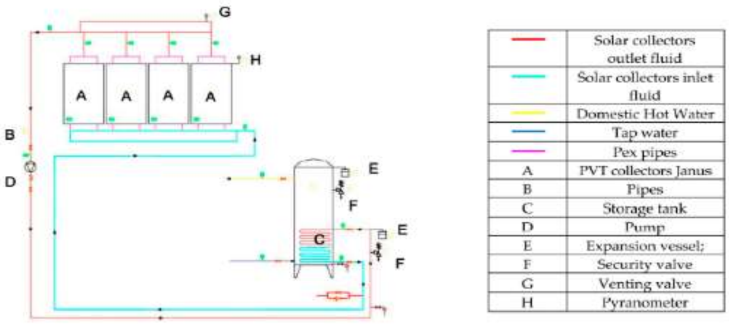


Figure 3.6: Experiment layout
(Calise and Vicidomini, 2016)

Results from the experiment showed that the electrical performance of PV was better than PVT as the conventional PV system generated 1778 kWh/year, and the PVT system generated 1156 kWh/ year. The electrical efficiency of the conventional PV system was 18%, and the electrical efficiency of PVT was 11.6%. The difference in electrical efficiency was due to the higher average temperature of PVT than PV, which resulted in decreasing the electrical efficiency of PVT. The authors stated that PVT was forced to operate at higher temperatures to satisfy the required hot water during winter. The overall efficiency of the PVT was about 26% which compensates for the shortage in electrical efficiency. In addition to the operational results, the research included economic feasibility study of the PVT and PV. A mathematical model has been developed with some assumptions to assess the financial part of the study. The following equations presented the mathematical models developed to evaluate the yearly saving of PV

(ΔCPV) and PVT (ΔCPVT) systems. Both models were developed based on initial cost, operational cost, maintenance cost. The initial cost and the operation cost have been estimated based on the reference system (RS). RS assumed that daily requirement of the electricity and Hot water provided from gas boiled and the national grid. The maintenance cost is assumed to be 2% of the total initial or capital cost. Accordingly, the yearly cost saving of both PV and PVT systems was represented by the following equations:

$$\Delta C_{PV} = E_{PV,el} \times C_{el} - M_{PV} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

$$\Delta C_{PVT} = E_{PVT,el} \times C_{el} + \frac{E_{DHW,th} \times c_{NC}}{\eta_{GB} \times LCV} - M_{PV} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Where:

$E_{PVT,el}$ and $E_{PV,el}$ (kWh/year) - the energy produced by both PVT and PV.

$E_{DHW,th}$ (kWh/year) – Energy consumed for boiler to produced hot water.

η_{GB} – Thermal efficiency of the gas boiler.

The initial costs for the PVT system and PV system were 5575 € and 2380 € respectively. The revenue from generated electrical power of PV systems was 296 €/ year. The revenue from generated electrical and thermal energy from PVT was 650 €/ year. In case the government provided a 50% contribution to cover the capital cost of both systems. The payback period for each system was 4 years, which is considered to be a positive result for both systems.

Other than the study conducted to compare the performance of PV with PVT system, there were studies focused on experimentally testing working fluid with some additives. Mohammad and Passandideh-Fard (2016) conducted an experiment test and developed a numerical model to study the impact of adding some coolant (nano-fluid) to the water in PVT to enhance the performance. The nano-fluids of particles that have been chosen to be tested in comparison with water as a base were (Aluminum-oxide (Al_2O_3)), Titanium-oxide (TiO_2), and Zinc-oxide (ZnO)). The main idea of the research was to add additives to the water which enhance heat transfer between the absorber and the fluid. Accordingly, the overall efficiency of the PVT will improve without changing the structure of the system. The experimental setup consists of one PVT panel with 40W electrical output and sheet and tubes collector type. Other parts were thermocouples, data logger, water tank, Pyranometer, and flow meter. The test started at 9:00 am and ended at 3:00 pm during selective days in August and September in Iran. From the experiment the outcomes showed that TiO_2/water and ZnO/water nano-fluids gave higher electrical efficiency than Al_2O_3/water nano-fluid and deionized water.

The electrical efficiency has been calculated from the PVT surface temperature values collected from the test. Hence, water with TiO_2 and ZnO better enhance/ decrease the temperature of the PVT surface. For the developed numerical model certain assumptions have been made to simulate PVT performance. The assumptions were as follows:

i. Neglecting the Ohmic losses of PV as the Ohmic losses are very low in comparison with electrical production.
ii. Fluid temperature inside the PVT various only in one direction (axial direction) as the collector copper tubes are very small in diameter. Hence, the flow can be considered lumped in the flow direction.
iii. The flow of fluid is uniform.
iv. Sky is the black body

The resulted in electrical efficiency model as follows:

$$\eta_{elec} = \frac{\dot{E_{elec}}}{\dot{E}_{in}} = \frac{V_{oc} * I_{sc} * FF}{\dot{G}_{effective}} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.3)$$

Where:

η_{elec} Electrical Efficiency

V_{oc} - open circuit voltage

I_{sc} – the short circuit current

FF - Filled factor

$\dot{G}_{effective}$ Input energy from the sun

The above mentioned model has been used to test different nano-fluid partial mass fractions ranging from 0.05 to 10 wt%. Testing results exposed that the increase of nano-fluid mass fraction from 0.05 to 10 wt% decreased the PVT surface temperature by 2%. The reduction in temperature is not considered to be high. Hence, there was no significant improvement in electrical efficiency. On the other hand, there was a high increase in the thermal performance of the PVT when the nano-fluid flow rate increased from 0.05 to 10 wt% almost four times.

Ibrahim et al, 2010 conducted an outdoor experimental test to investigate the performance of a special spiral tube design absorber within the PVT unit. The spiral absorber was made of stainless steel material with a rectangular shape (dimensions 12.7×12.7 mm). The size of the absorber tubes were (0.815 × 0.628 x 0.03 m). The spiral absorber was placed between the PV panel at the top and insulation from the bottom. The PV panel dimensions were (1×0.65×0.3 m). PV panel was standard polycrystalline with single glaze type with 80 W power output. Different flow rates have been tested (0.034, 0.039, and 0.041 kg/ s). The experiment was conducted on 30 December 2009. The peak of solar radiation at 14:00 hr was 1321 W/m2. The results are shown in Figure 3.7. As the water flow rate increased the efficiency reached steady-state values. Therefore, it can be concluded that increasing the fluid flow rate resulted in decreasing the PV surface temperature due to an increase in heat transfer rate. Accordingly, both electrical and thermal efficiency is enhanced. As well known, PVT efficiency is the summation of electrical and thermal efficiencies.

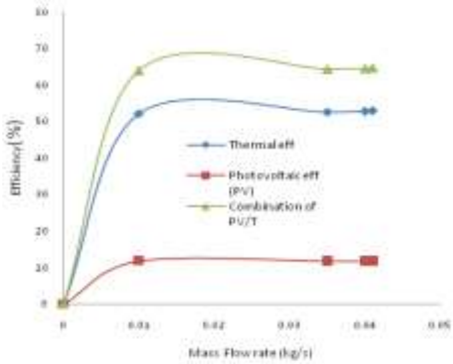


Figure 3.7: PVT efficiency, PV electrical efficiency and thermal efficiency verse time (Ibrahim et al, 2010)

Rahou et al., (2014) studied the effect of changing the water flow rate on the efficiency of the PVT. The results were matching with the (Ibrahim et al, 2010) study. The results are shown in Figure 3.8. Effect of change flow rate on PVT efficiency.

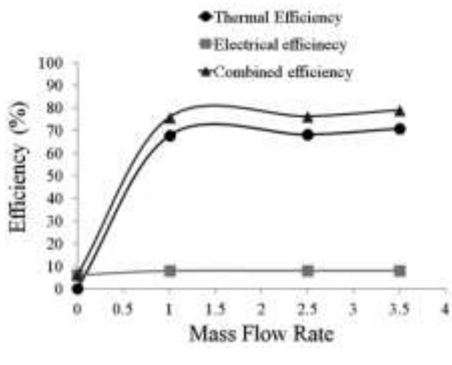


Figure 3.8: Effect of change flow rate on PVT efficiency (Rahou et al., 2014)

Mati ling the PV surface temperature and related enhancement in electrical efficiency. The test rig consisted of luminaires used to simulate solar radiation, water tank, PV panel with 140 W, Temperature sensor to measure ambient and PV surface temperature, flow meter. A maximum power point tracker device (MPPT) is used to extract the generated power from the PV panel. The water was sprayed on the top of the panel and flowed down using gravity. A gutter has been placed on the lower level of the PV panel to collect the water. The test has been conducted with changing water flow rates (1 L/min, 2 L/min, 3 L/min, and 4 L/min). Figure 3.9 shows that the higher power generation was with a flow rate of 2 L/min. Moreover, decreasing the surface temperature enhanced PV output voltage and accordingly output power.

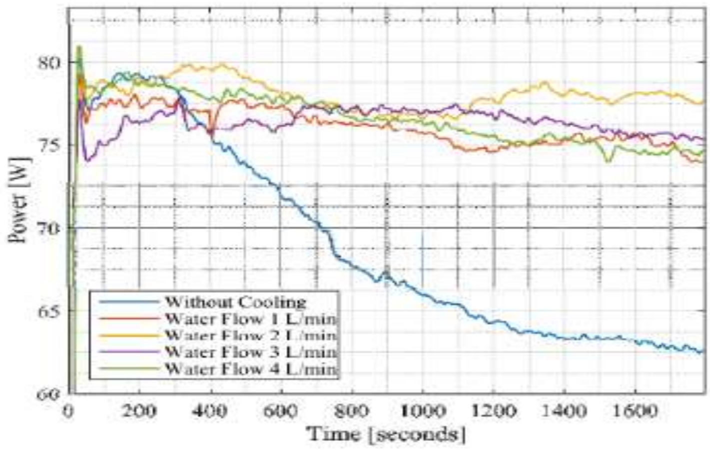


Figure 3.9: Resulted PV power output with different water flow rate verses time (Matias et al, 2017)

From ave been tested in the first phase of the project were excessive. The variation in power output from PV was limited despite the change in flow rate. Therefore, a new approach has been followed to test the power output from the PV panel. The same condition of the previous test has been kept unchanged. The water flow rate was kept constant at 1 L/min and, the solenoid was opened and closed alternatively in different time intervals to achieve different flow rates. Table 3.1 shows the resulted (output power and electrical efficiency) from different flow rates. The highest value of output power was with 60% with (0.6 L/min) flow.

Table 3.1: Resulted PV power output and efficiency with different flow rates (Matias et al, 2017)

EFFICIENCY GAIN OF THE PV PANEL WITH THE COOLING SYSTEM.

Water Flow (%)	Energy (Wh)	Efficiency Gain (%)
Without	63.09	-
100	71.12	12.72
87.5	75.65	19.90
80	76.67	21.52
66	76.68	21.54
60	78.74	24.80
50	77.77	23.27
40	76.85	21.81
33	76.23	20.82
20	75.20	19.19
12.5	75.05	18.96

Vimal, (2017) in his experimental work, compared the performance of two systems configurations (series and parallel). The first system was two flat plate solar collectors connected in parallel. One of the collectors was attached to the PV panel. The second system was the series connection of two flat plates and one of the collectors was attached with a PV panel to form PVT. PV panel was glass to glass type with dimensions of 0.65 x 0.61 m, with an efficiency of 12%, and output power 40W. The flat plate solar collectors specifications were, tube and plate type, Area 2 m2 tubes made of copper, plate thickness 0.002m, and thickness of insulation 0.1m. The results showed that the thermal performance of parallel configuration was better than a series connection. The disadvantage of the parallel connection was higher PVT surface temperature which decreased the electrical efficiency. Series test connection produced better electrical efficiency than parallel connection.

Abdullah et al. (2019) presented a full review of the main parameters that are affecting the performance of PVT based on other researches. They classified the parameters into three groups: design parameters, climate parameters, and operation parameters. One of the parameter was the climate conditions. The sub-parameters in the climate conditions were solar radiation, ambient temperature, dust, relative humidity, and wind speed. The first tested sub-parameter was the solar intensity. The solar radiation intensity was increased from 100 to 1000 W/m^2.

This resulted in increasing the output PV current and output PV power gradually as shown in Figure 3.10. The PV temperature was maintained constant at the reference cell temperature of 25ºC.

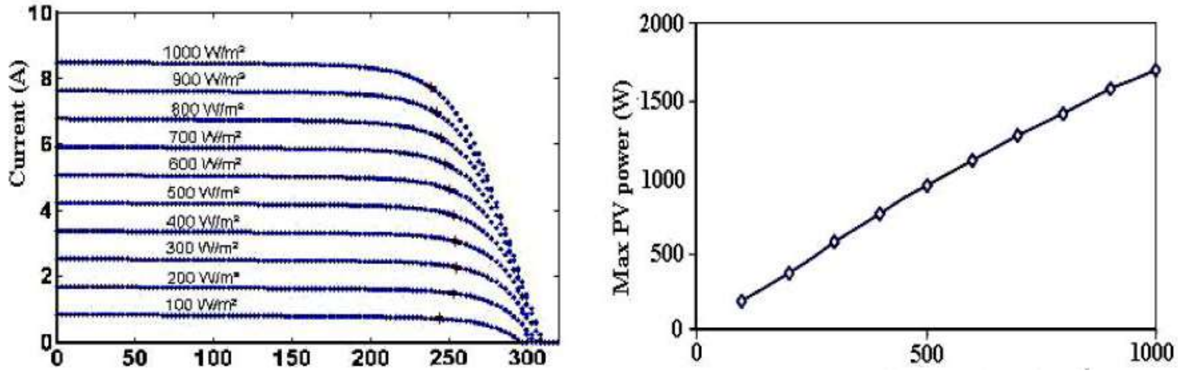


Figure 3.10: Effect of increasing solar radiation on both generated power and current with maintaining PV temperature constant at 25C
(Abdullah et al, 2019)

In ad ng the solar radiation intensity from 100 to1000 W/m^2 as shown in Figure 3.11

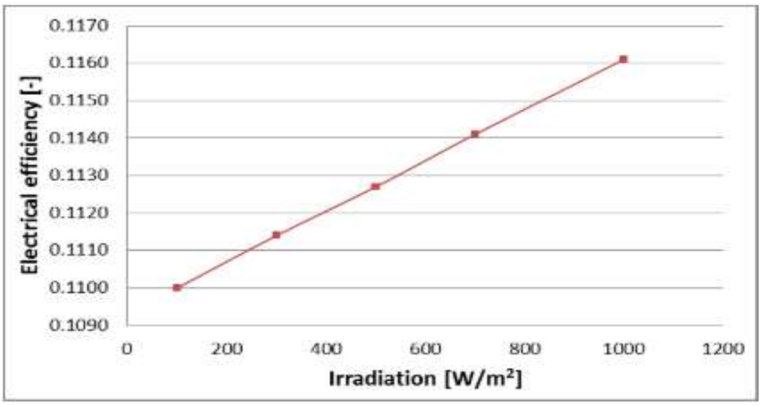


Figure 3.11: Effect of increasing solar radiation on Electrical efficiency
(Abdullah et al, 2019)

Njok et al. (2019) studied the effect of relative humidity on PV efficiency. The results disclosed that the efficiency conversion factor increased with decreasing the relative humidity. In addition, another study conducted by Omubo-Pepple et al, 2009. The results are presented in Figure 3.12. The effect of increasing relative humidity on PV electrical efficiency.

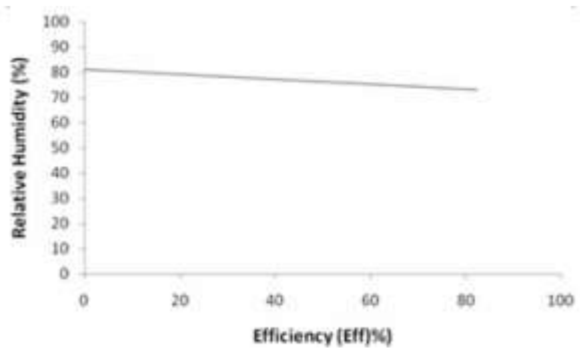


Figure 3.12: Effect of increasing Relative humidity on Electrical efficiency (Abdullah et al, 2019)

The effect of wind speed experimentally studied by Adeli et al, 2012. The results showed that increasing wind speed from 0-10 m/s decreased the thermal efficiency of the PVT from 51% to 29% and increased the electrical efficiency from 8% to 9.5%.

In another study Koech et al. (2012) considered the effect of ambient temperature on the performance of PVT. The outcomes of the study showed that increasing ambient temperature affect negatively on both electrical and thermal efficiencies of PVT as shown in Figure 3.13.

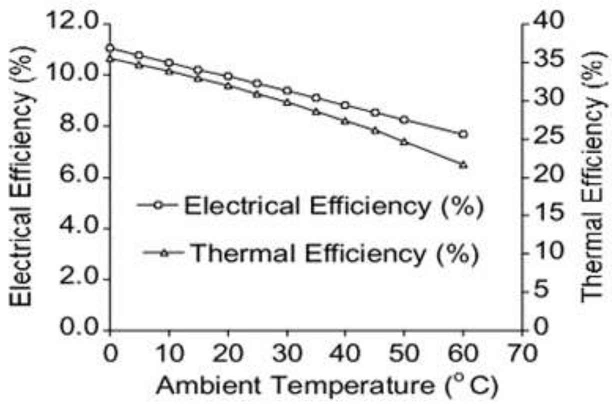


Figure 3.13: Effect of ambient temperature on both electrical and thermal efficiency (Abdullah et al, 2019)

Several studies have been conducted to investigate the effect of dust accumulation on PV performance and transmission. Ndiaye et al. (2013) studied the impact of dust on the performance of PV. They found that accumulating dust on the panel decreases the output generated power as shown in Figure 3.14. The impact of dust varies with the type of the PV panel.

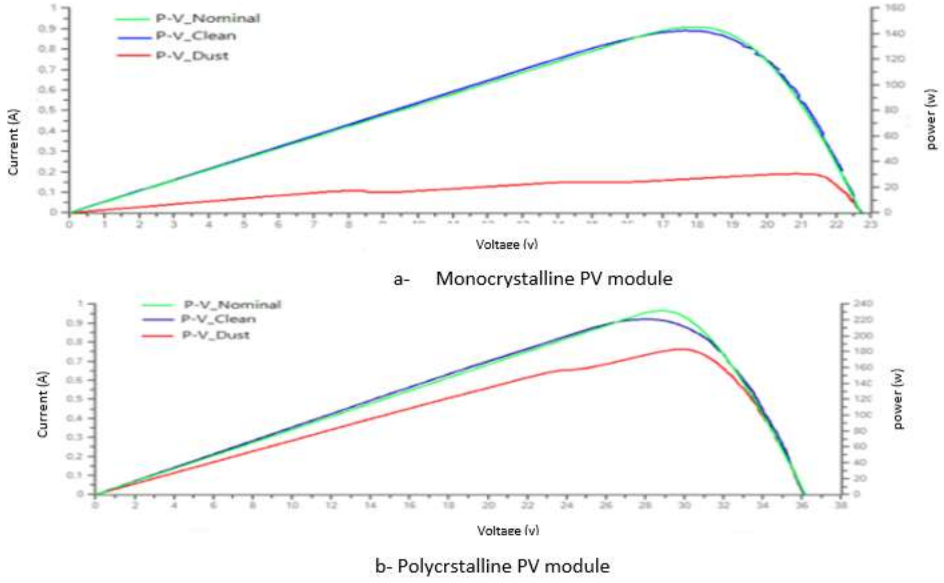


Figure 3.14: Effect of dust on the performance of different types of PV panels (Abdullah et al, 2019)

Des the panel. Therefore, many studies have been conducted to explore the impact of changing design parameters (Abdullah et al. 2019):

i. Duct/ channel collector dimensions (length or width),
ii. Number of collectors tubes
iii. Using the tracking system
iv. Using the reflectors.
v. Panel Tilt Angle.
vi. PV module type.
vii. Number of glazing and glazing thickness
viii. Using Anti-reflection coating.
ix. Riser configuration and location.
x. Tedlar thermal properties.

xi. Thermal insulation properties.

xii. Absorber material and thickness.

xiii. Availability of fins and Effect of muti-inlet.

Tonui and Tripanagnostopoulos (2007) in their study investigated the effect of changing the duct/channel collector length on PVT performance. The study concluded that with increasing the duct channel length the thermal efficiency increased. However, the electrical efficiency decreased as the temperature of the PV module increased with a constant flow rate as shown in Figure 3.15.

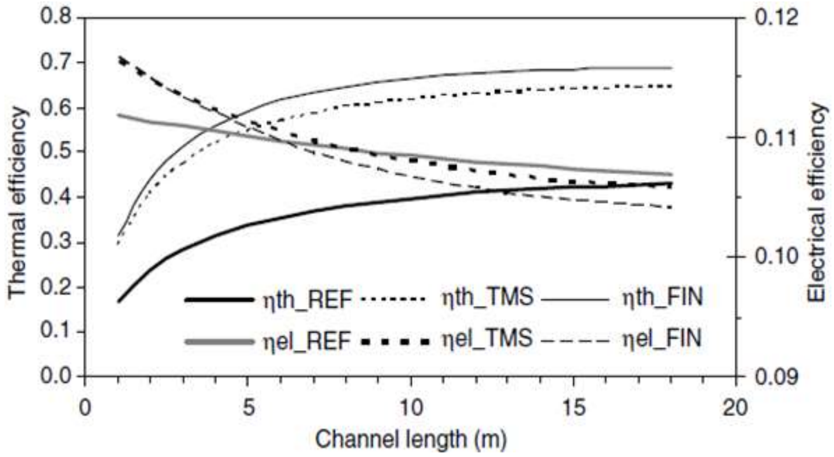


Figure 3.15: Effect of changing duct/ channel length on PVT performance (Abdullah et al, 2019)

Adeli et al. (2012) studied the effect of changing the duct/ channel depth on the performance of PVT. The channel depth increased from 0.001 to 0.2 m. Accordingly, thermal efficiency enhanced and increased from 0% to 48%. However, there was a minor increase in the electrical efficiency as shown in Figure 3.16.

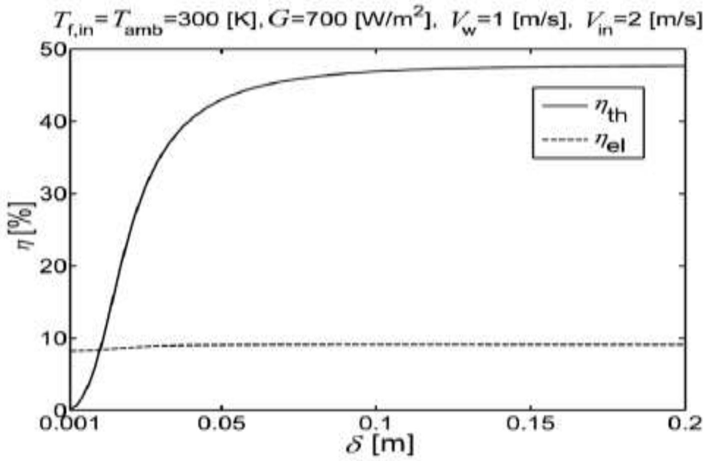


Figure 3.16: Effect of changing duct/ channel depth on PVT performance
(Abdullah et al, 2019)

Tiwari (2011) Conducted a theoretical study to assess the effect of the increasing number of collectors from (2 to 8) on the PVT performance with a constant flow rate of 0.04 kg/s. The results showed that the electrical efficiency enhanced with increasing collectors number. On the other hand, the electrical efficiency decreased as shown in Figure 3.17

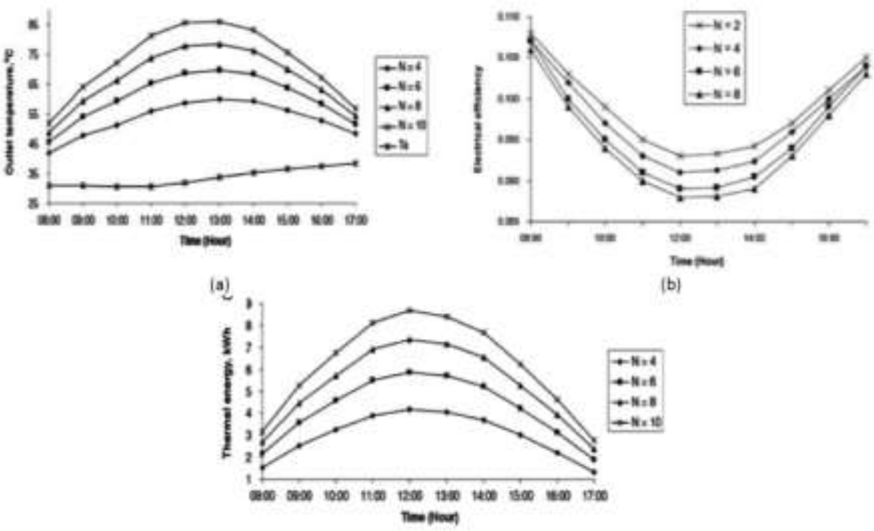


Figure 3.17: Effect of increased number of collectors on electrical and thermal performance
(Abdullah et al, 2019)

Kacira et al. (2004) studied the impact of using a sun tracking system on PV performance. The results showed that the total solar radiation gained increased by 29.3 % and resulted in increasing the PV power generated by 34.6 % as shown in Figure 3.18.

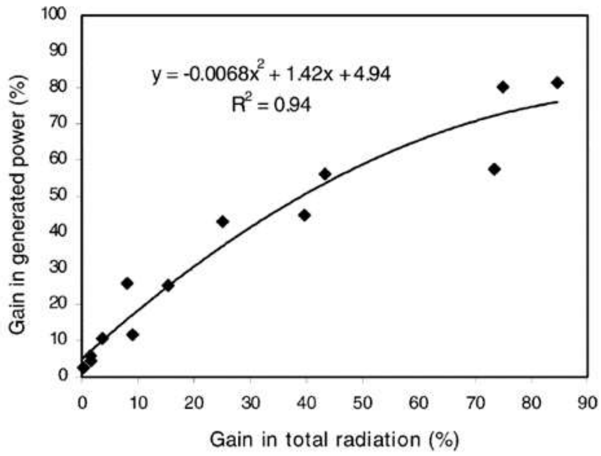


Figure 3.18: Effect of using solar tracking system on the PV power generation (Abdullah et al, 2019)

Tripanagnosto Poulos et al. (2002) in their study, integrated the booster diffuse reflector system into the PVT system. The booster diffuse reflector provided an additional 35% of solar radiation on the PV surface. As a result, the power output increased by 30%. Thermal efficiency increased from 55% to 75% by using water as a working fluid.

Kaya (2013) analyzed the performance of PVT under UAE climate conditions. Analysis was done experimentally and theoretically. By using the Polysun simulation software the tilt angle has been changed with 19 different angles starting from 0 to 90 degrees. The electrical and thermal output have been found as per Figure 3.19. The optimum tilt angle that resulted in the highest electrical power generation was 25 degrees.

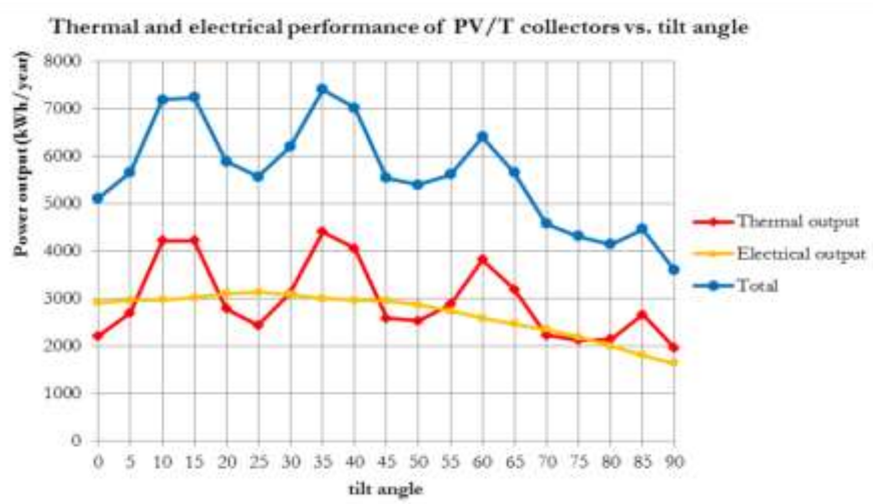


Figure 3.19: Effect of changing tilt angle on both electrical and thermal output power of PVT (Kaya, 2013)

Daghigh et al. (2012) tested different types of PV (amorphous and crystalline silicon) as part of the PVT system. The two types of PV tested with solar radiation between 700–900 W/m2, under Malaysia climate, ambient temperature between 22–32 C and flow rate 0.02 kg /s. The results revealed that the performance of crystalline silicon PV type is better than amorphous PV type in terms of electrical efficiency. The electrical efficiency, thermal efficiency, and overall PVT efficiency with crystalline silicon PV type were 11.6%, 51%, and 63% respectively. In the case of amorphous PV types, the results were 4.9%, 72%, 77% respectively as shown in Figure 3.20.

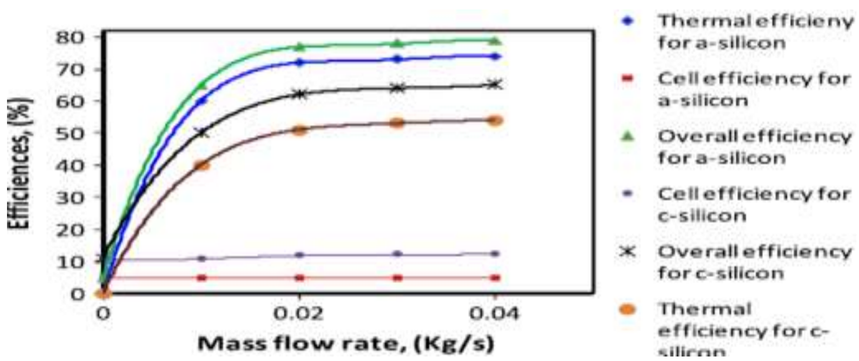


Figure 3.20: Effect of changing flow rate on two types of PVT (Daghigh et al., 2012)

Bakari et al. (2014) analyzed the number of glaze effects and glaze thickness on the flat plate solar collector performance. The study included testing 4 types of the collector with different thicknesses of glaze type low iron glass. The range of test thicknesses was 3 mm, 4 mm, 5 mm, and 6 mm. Many factors are affecting the performance of solar collectors and related to the glaze properties such as transmittance, absorptance, and reflectance of the glass. The optimum thickness which gave the highest efficiency was 4mm as shown in the below Figure 3.21.

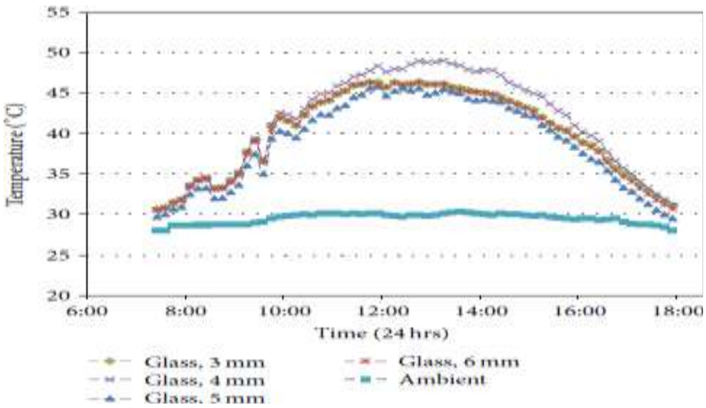


Figure 3.21: Output thermal energy from solar collector for different glass thickness (Bakari et al. 2011)

In addition to the previous study Zondag et al. (2003) stated that using of glaze and the number of glazed depends on the application of PVT. Therefore, the application with the low-temperature requirement and high requirement of electrical energy unglazed PVT type is a suitable option. In Table 3.2 different PVT options with glaze and unglazed are presented.

Table 3.2: Thermal and electrical efficiencies for PVT unglazed and glazed types (Abdullah et al, 2019)

Panel type	Thermal efficiency	Electrical efficiency
PV laminate	-	0.097
Sheet and tube PVT-collector 0 cover	0.52	0.097
Sheet and tube PVT-collector 1 cover	0.58	0.089
Sheet and tube PVT-collector 2 cover	0.58	0.081

Khaki et al. (2017) studied the energy improvement of two types of glazed and un-glazed (BIPV/T). The outcome showed that the performance of glazed was higher than the unglazed BIPV/T system as shown in Figure 3.22.

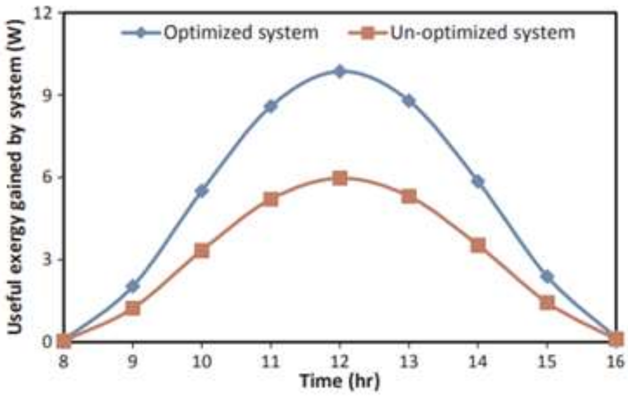


Figure 3.22: Useful exergy gain for un-glazed and glazed BIPV/T system (Khaki et al, 2017)

Yahia et al. (2019) studied the effect of change of two parameters tubes diameters and collector length on the PVT efficiency. The tube diameters were made of coppers and the diameters have been changed as per the range of (8, 8.64, 13.84, 16.92, and 19.94 mm) the efficiency change did not exceed 2% as shown in Figure 3.23.

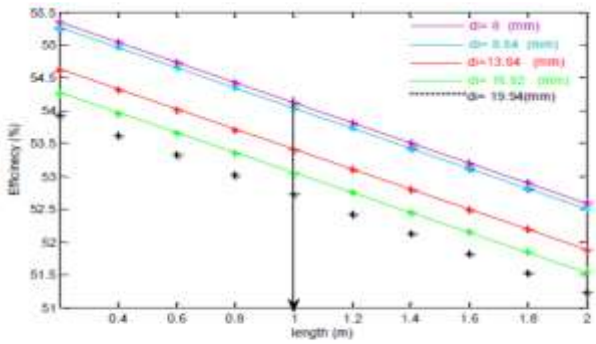


Figure 3.23: effect of change in tubes diameter and length on PVT efficiency (Yahia et al. 2019)

Ekramian et al. (2014) conducted a simulation study for different types of risers (f) triangular, (g) square, (h) hexagonal, and (c) circular shapes). The flow rate was kept constant during the study (0.02 kg/s). Simulation results showed that shape C (Circular shape) produced the highest efficiency among the other shapes as shown in Figure 3.24.

Figure 3.24: PVT efficiency verses riser shape (Ekramian et al. 2014)

Sachit et al. (2019) conducted a simulation study to compare two types of absorbers. The types were serpin-direct and serpentine flow design as shown in Figure 3.25 and Figure 3.26. The results are shown in Figures 2.27 and 2.28 serpentine absorber design had better performance in terms of thermal and electrical efficiencies.

Figure 3.25 serpin-direct absorber, (Sachit et al, 2019)

Figure 3.26 serpentine Flow Design (Sachit et al, 2019)

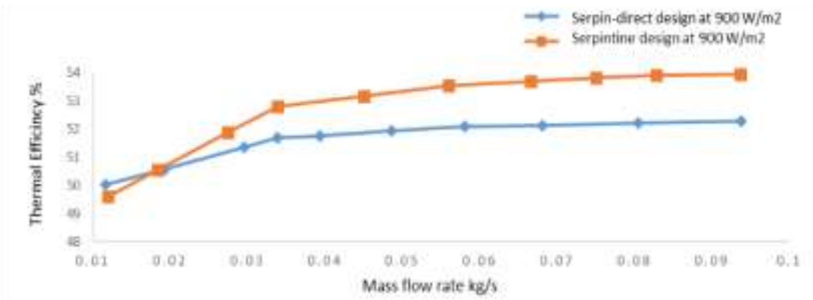


Figure 3.27: Thermal efficiency of two types of absorbers (Sachit et al, 2019)

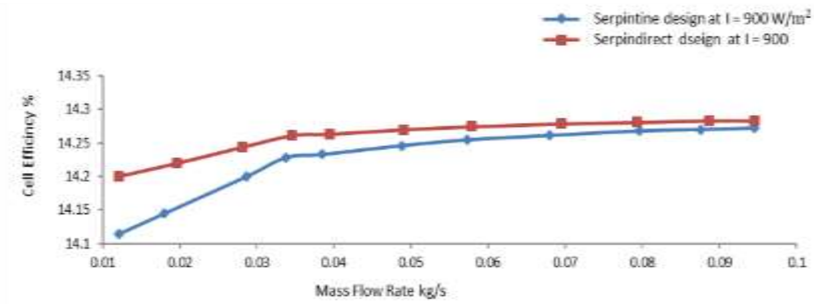


Figure 3.28: Electrical efficiency of two types of absorbers (Sachit et al, 2019)

Ekramian et al. (2014) studied the effect of changing the absorptivity of the solar collector absorber on the thermal efficiency. The main characteristics of the absorber are shown in Table 3.3. The results of the study showed that the thermal efficiency increased linearly with increasing the solar collector absorptivity as shown in Figure 3.29.

Table: 3.3 Absorber main characteristics

Absorber material	Thickness [mm]	Density [kg/m^3]	Thermal conductivity [W/mk]	Heat capacity [j/kgK]
Copper	~0.3	8,920	380	350
Aluminium	~1	2,700	160	900
Steel	~2	7,860	50	450
Polymer	~2-3	900-1,500	0.2-0.8	1200-1800

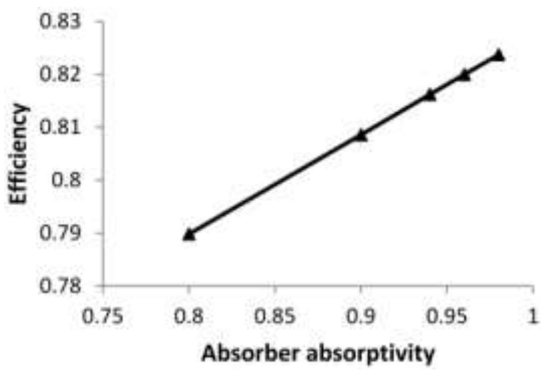


Figure 3.29: Thermal efficiency verses absorptivity (Ekramian et al. 2014)

Hongbing et al. (2015) studied the effect of inlet water temperature on the electrical and thermal performance of the PVT. The results showed that increasing inlet fluid temperature decreases both electrical and thermal efficiency as shown in Figure 3.30.

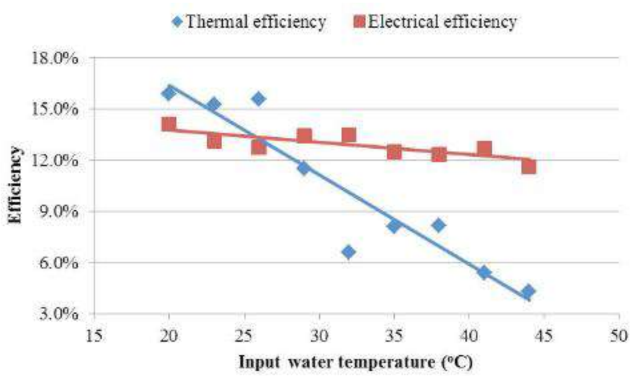


Figure 3.30: Effect of increasing inlet temperature on the electrical and thermal efficiency of the PVT (Hongbing et al. 2015)

Rosli et al. (2015) studied the effect of heat removal factor FR on PVT. The PVT was with serpentine tube collector type. The study was focused on the thickness of the absorber and the tubes. Absorber with a thickness of 0.015 m gave the highest thermal removal factor equal to 0.88 as shown in Figure 3.31.

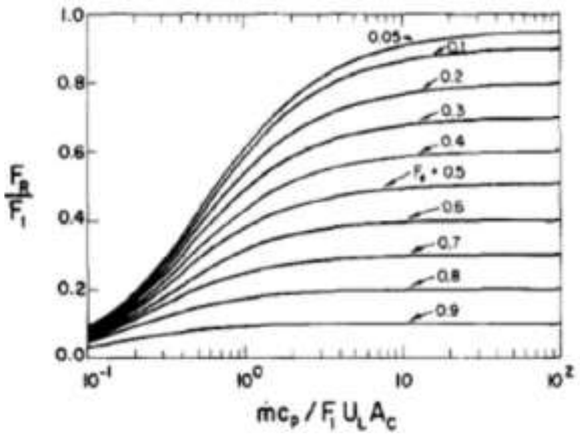


Figure 3.31: Heat removal factor for collector with serpentine tube collector type in PVT (Rosli et al. 2015)

Somasundaram and Tay (2019) performed a study to investigate the performance and cost-effectiveness of PVT. The PVT system was installed in a student hostel in Singapore. The average solar radiation intensity in Singapore is 435 W/m^2 per year. There were three storage tanks connected to the PVT system. Tank A the coldest one and connected with the freshwater supply. Tank C was filled with the highest water temperature and connected to the showers. The system has been equipped with all the necessary sensors, data logger, pyranometer, and flow meters to record the required data.

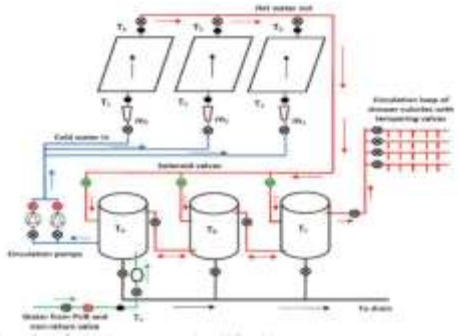


Figure 3.32: Schematic diagram of the testing set-up
(Somasundaram and Tay, 2019)

There were three different types of PVT installed on the hostel roof for comparison purposes. The used types and the characteristics of each one are summarized in Table 3.4.

Table3.4: Characteristics of three types of PVT used in the experiment
(Somasundaram and Tay, 2019)

Cluster No.	No. of modules	Type	Thermal area (m^2)	Series × Parallel (thermal)	PV cell	PV area (m^2)	Series × Parallel (electrical)	STC efficiency (%)	Electrical power (kWp)
1	20	Unglazed	26.40	2 × 10	Mono	26.4	10 × 2	14.5	3.8
2	21	Glazed PVT	29.60	3 × 7	Mono	28.2	10 × 2	12.3	3.5
3	20	Glazed PVT	22.70	1 × 20	Multi	20.0	20 × 1	12.3	2.5

The total cost of the system was calculated from the capital cost and installation. The capital cost including, material cost was 46,000 SGD, and the installation cost was about14,000 SGD. The financial feasibility of the system has been found by including the following parameters:

i. 1% of the capital cost is considered to be Annual Operation and maintenance cost.
ii. 5% of the capital cost was considered to be Decommissioning cost.
iii. 5% of the capital cost was considered to be salvage cost.
iv. Lifetime of system 25 years
v. Discount rate assumed to be 5%
vi. Inflation rate 2.4% per year
vii. Degradation rate 0.75% per year
viii. Cost of electricity (Tariff) 0.2634 SGD /kWh

Table 3.5 shows annual cost savings resulting from using the PVT system. The same has been used to calculate the financial feasibility of the system.

Table 3.5: Shows annual cost saving resulted from using PVT system

Item	Output	Benefits
Electrical energy	10,235 kWh	$2696
Solar thermal energy	16,511 kWh	$4578

The results from the experiments showed typical electrical and thermal efficiencies as shown in Figure 3.33 and Figure 3.34.

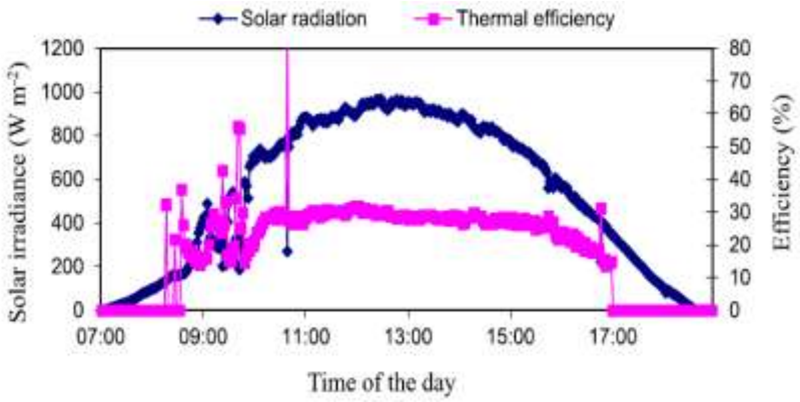


Figure 3.33: Typical resulted thermal efficiency from PVT system under Singapore climate condition (Somasundaram and Tay, 2019)

Thermal efficiency defines as the ratio between the output thermal energy to the total solar radiation that falls into the PVT panel. Figure 3.34 shows that thermal energy during morning time was better than in afternoon time. The reason was due to high solar radiation intensity at noontime. The second reason is the water inlet in the afternoon time has a higher temperature.

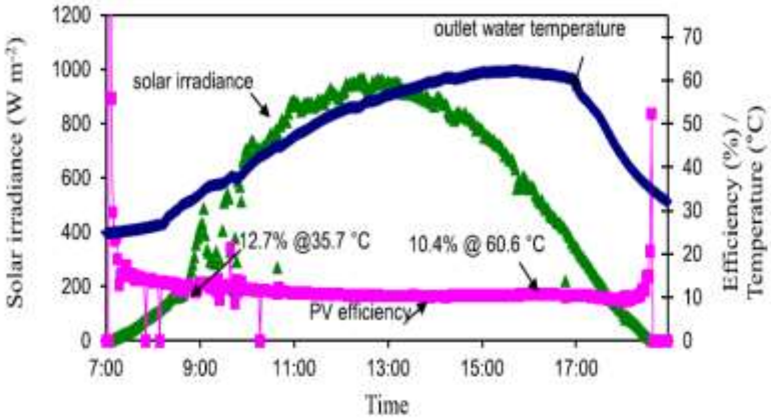


Figure 3.34: Typical resulted Electrical efficiency from PVT system under Singapore climate condition (Somasundaram and Tay, 2019)

The same performance of electrical efficiency was observed, the electrical efficiency started at morning time with high value then degraded. The reasons were due to high solar intensity during noontime and due to high water temperature inlet.

In general, the authors concluded that the PVT performance is highly affected by the usage and the load profile. The payback period of the system was 12.5 years. Hence, financially feasible solution.

Keizer et al. (2016) studied three different systems of unglazed PVT with the following descriptions:

i. System A: Two number of c-Si PV types attached with solar collector with the specification of (uninsulated absorber, total gross area of 3.3 m^2) and mass flow rate 74 l/m^2h.

ii. System B: CIGS panel attached with the insulated absorber. The number of PVT panels was four with a total gross area of 4.4 m^2 and a flow rate of 24 l/m^2h.

iii. System C: building-integrated c-Si PV with the insulated absorber. Two PVT panels, gross area of 3.5 m^2, flow rate 18 l/m^2h.

PVT panels were connected in series for each system. Water flow rates were different and decided based on the manufacturer's recommendation. The inlet water temperature for all the systems was the same. The output electrical system from all the PVT was connected to the optimizer and AC/DC inverter. The thermal and electrical power were measured at the maximum point. The metrological data have been collected onsite. The results of thermal and electrical outputs showed in Table 3.6. and Figure 3.35 that showed the thermal efficiency curve.

Table 3.6: Experimental results of System A, B, and C (Keizer et al. 2016)

Collector	η_{0}	b_u (s/m)	b_1 (W/m^{2}K)	b_2 (J/m^{3}K)	η_{el} (DC)
A	36 %	0.05	10	1.6	14.2 %
B	25 %	0.05	4.3	0.3	12.2 %
C	53 %	0.02	7.0	1.1	12.9 %

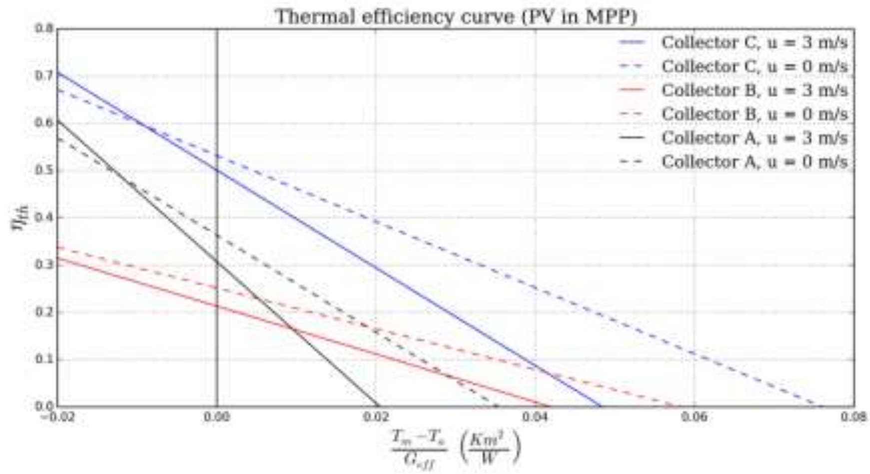


Figure 3.35: Thermal efficiency curve for each system with different wind speed (Keizer et al. 2016)

The variation of the electrical efficiency between the three systems was due to different peak power per square meter for each system. In addition, thermal efficiency for the insulated system had the highest thermal efficiency due to less heat loss from the system. In addition, better thermal contact between the absorber and the PV panel led to higher thermal efficiency.

Alobaid et al. (2018) developed a mathematical model to anticipate PVT performance. The model has been developed by using results from experiments conducted in Saudi Arabia. The study aimed to investigate the impact of two parameters (outlet temperature and PV surface temperature) on both thermal efficiency and electrical efficiency. The outcomes of the study showed that thermal efficiency is affected by instant solar radiation, ambient temperature, inlet water temperature, and outlet water temperature.

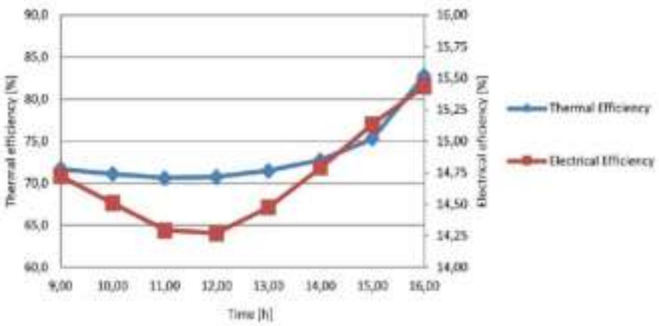


Figure 3.36: Electrical and the Thermal efficiency of PVT during day (Alobaid et al. 2018)

Figure 3.36 shows the change in both thermal and electrical efficiency during day time. The electrical efficiency was high during the morning time. Then, decreased on the noontime due to increased PV surface temperature. Hence, electrical efficiency is affected by (instance solar radiation, PV surface temperature, and ambient temperature). In addition, thermal efficiency as well started with a high value, then decreased at noontime due to high solar radiation, increase in inlet water temperature. In the afternoon both thermal and electrical efficiency enhanced again.

3.8 TRNSYS Model

Many studies have been conducted in order to investigate PVT performance or enhance the performance by using simulation software. The most commonly used software are TRNSYS, Matlab, and Computational Fluid Dynamic (CFD). In this study, Transient Simulation Program (TRNSYS) 18 simulation software will be used to perform the optimization of the PVT system. In TRNSYS each component is called TYPE with a unique number. Some of the components are available in the default TRNSYS library and some are required to be TESS component library. TESS is a library developed for special components (controller components, Electrical components, Heat pump, HVAC equipment etc). PVT (TYPE 560) component is one of the TESS library components.

3.8.1 Reasons for selecting TRNSYS

TRNSYS modeling software is a very powerful tool used to mimic the behavior of PVT. TRNSYS has a huge library of components that are validated and ready to use. All the available TRNSYS components and tools were developed based on a mathematical model from known algebraic equations (Kalogirou, 2001). The library is very rich and has almost all required components to construct a complete system with all components such as pump, valves, fans, HVAC units, PV, PVT, solar collectors, controllers, weather files, etc (Delisle, 2008). Bosanac, et al. (2003) stated that TRNSYS is friendly to use and anyone can use it without prior experience. In addition, sensitivity analysis can be performed easily by changing the required design parameters to assess the impact on the efficiency of PVT. The heat transfer model needs to be accurate, to accurately predict the PVT-generated energy (Stannard, 2013). Many previous studies have followed the assumption of steady-state heat transfer to develop the simulation model. Steady-state heat transfer, means that the temperature of a system at any point does not change with respect to time. The validation of the models has been done by comparing the simulation results with the experimental results. The acceptable range of difference between the experiment and simulation results was less than or equal to 5%.

There are many components or TYPE S which represent PVT in TRNSYS. These components have been developed and improved within every new version of TRNSYS. In TRNSYS 16, PVT was represented by Type 50. As has been mentioned before each model is built based on a well-known mathematical equation. TYPE 50, used Florschuetz model to represent PVT water type (Bilbao and Sproul, 2012). The Florschuetz model is an advanced model of Hottel-Whillier developed for flat plate collectors.

Zondag (2005) in his research mentioned that most of the early analytical models were developed based on the Hottel-Whillier model. In addition, the 1D model based on Hottel-Whillier and Klein equations was the best suited for the annual yields results (Smith &Weiss, 1997)

$$Q_u = F_R A_C \lfloor (\tau\alpha)_e I - U_L (T_{fi} - T_a) \rfloor \text{..} (3.4)$$

Where:

F_R - collector heat removal factor

$(\tau\alpha)_e$ - effective transmittance-absorptance product.

U_L - overall heat loss coefficient.

A_c - Area of collector

$T_{f,i}$ Useful heat gain(difference between Temperature out and Temperature in)

T_a – Ambient Temperature

Hottel-Whillier equation identified three main factors that affect the thermal performance of the solar collector (Smith and Weiss, 1997).

i. Collector heat removal factor which defines as the ratio between the actual heat transfers to the maximum value of heat transfer to the collector. Accordingly, there are two main factors affecting heat removal. Heat transfer resistance between the absorber and fluid effect and the mass flow rate of the fluid. (Smith & Weiss, 1997)

ii. Overall heat loss coefficient. The factors which are affecting the heat loss coefficient are the number of glazes, the number of spacing between glaze/ covers, and wind speed.

iii. Effective transmittance-absorptance product influenced by a number of covers, covert transmittance, and absorber plate absorptance.

Bilbao and Sproul (2012) in their review mentioned that the Klein equation is suitable to be used for the steady-state heat transfer assumption. In this research and for the sake of simplicity, Steady-state heat transfer will be adopted. By using the heat balance concept, the heat transfer equation will be developed. In addition, heat loss will be taken into consideration to identify the exact value of heat which has been transferred from the top layer PV to the solar collector absorber.

Kalogirou (2001) in his study used TRNSYS as a simulation software with typical metrological year data for Cyprus. The study aimed to compare the electrical performance of conventional Type of PV with PVT system and find the life cycle saving of PVT system. The second objective was to find the optimum water flow rate of the PVT system. Electrical and hot water demand has been calculated for a typical house of four persons accordingly the daily demand found to be 25,700 kJ and 120 liters at 50°C (30 l/person). TYP 49 was used to represent the PVT system. The results showed that the optimum water flow rate was 25 kg/h. The optimum flow rate was found after assessing the range of flow rates values and studying the electrical efficiency of the PVT system. PVT system electrical efficiency kept increasing with increasing the water flow rate until reaching a certain value then dropped. The reason is that with a high flow rate there is not sufficient time for heat transfer. So, the optimum flow rate gives both the highest electrical output and the highest PVT efficiency.

3.8.1.1 TRNSYS Type 50

In TRNSYS there are many models which represent the PVT system. The models have been developed and enhanced with each new version of TRNSYS. The Types which are represented PVT in TRNSYS are Type 50, Type 49, Type 250, Type 850, Type 853, Type 560, and Type 563. The default Type which represents PVT in TRNSYS is Type 50. For Type 50 there are eight operation modes of Type 50 as follows (Collins, 2009): Type 50a, Type 50b, Type 50c, Type50d, Type 50e, Type 50f, TYPE 50g and Type 50h.

Type 50 is not reliable due to several reasons first it contains errors (Collins, 2009). Second, the Type 50 model was built with the assumption that the PV is directly attached and laminated to the collector absorber which makes both PV and collector absorber have the same temperature. There is a difference of temperature between the top PV panel and collector absorber in the PVT system about 12 K. This difference of temperature resulted in 10% overproduction in electrical power which is considered to be an error value. The third source of error was related to the collector efficiency factor which is considered to be constant in TYPE 50. Despite that, it is a function of several variables of irradiation, wind speed, and internal temperature of the collector layers. The mentioned assumption of the constant collector efficiency factor is applicable for the glazed collector. In the case of an unglazed collector, the same assumption will lead to a greater error value. In addition, Type 50 does not consider the thermal resistance of the bonds between absorber and tubes ($C_p = \infty$).

The algorithm used in Type 50 may also be a source of error. The Florscheutz model requires multiple iterations to converge on a solution. Type 50 is hardcoded to perform only three iterations only, which may not be enough to reach an acceptable convergence (Bilbao and

Sproul, 2012). The majority of the PVT performance investigations have been done based on the Type 50 model. As mentioned previously, Type 50 has it is limitations such as (matching the PV temperature with the absorber temperature and the limited modeling capabilities of heat transfer with the surroundings. On the other hand, Type 560 offers a multi-layered model which solves the major errors of Type 50. Unfortunately, it is not used by nearly as many researchers as Type 50, and there is little documentation to validate its performance with experimental data. The main reason is that Type 560 and Type 563 are not available in the default library of TRNSYS. Both types are available in the TESS library which needs to be bought separately. In the upcoming section Type, 560 will be explained in detail. TRNSYS – Type 250:

Type 250 is a simplified model of Type 50d. Hence same errors and issues are sustained. The only resolved issue of Type 250 in comparison with Type 50 d was the (floating point error). Type 250 has been used in limited number of researches (Pressiani, 2016).

3.8.1.2 TRNSYS – Type 850

The mathematical model represents Type 850 based on Akhtar and Mullick equation with a single iteration. In comparison with Type 50, Type 850 produces less error with less than 5% for UL and under 2% for q_{th}. (Pressiani, 2016).

3.8.1.3 TRNSYS -Type 560

Type 560 represents the unglazed PVT model using heat transfer equations derived by Duffie-Beckman (1991). The energy balances equation was developed based on layers of (PV layer, absorber fins, and absorber tubes). It uses an iterative approach to solve the analytical equations until convergence is reached and is also based on a fin-tube absorber design. Iterative approach is mathematical procedure that uses the initial values to generate sequence of improving solution (Yun, 2011). A special feature of Type 560 is that it considers the PV and absorber layers separately, allowing the user to define the thermal resistance between them. It also considers convection coefficients as inputs. In Type 560, wind speed is an input and the convection coefficient on the front of the collector is calculated using the linear relationship defined by McAdams (1954). This allows users to calculate convection externally using Type 1232 or a custom equation. Convective and radiative heat transfer is also considered on the backside of the module in Type 560, which is of particular interest in a PVT without insulation. The main assumptions used to develop the Type 560 model are (Pressiani, 2016):

i. 2D steady-state
ii. The thermal gradient on the z-axis is not considered.
iii. Temperature gradients between tubes and in the flow direction can be handled separately.
iv. Temperature around tubes can be neglected.
v. PV works at maximum power condition (MPP).

The mathematical model has three layers of PVT: PV layer, fluid layer, and the absorber layer. The optical properties are a function of the incident angle of the solar radiation. The conductive heat transferred with surrounded ambient is taken into consideration.

The following equation 3.5 represent the energy balance of the first layer PV:

$$s_{abs} - q_{el} - h_{cov,top}\left(T_{pv,x} - T_{amb}\right) - h_{rad}\left(T_{pv,x} - T_{sky}\right) - \frac{T_{pv,x} - T_{abs,x}}{R_T} = 0 \ldots (3.5)$$

Where:

$h_{cov,top}$ - Convective heat transfer coefficient

h_{rad} - Radiative heat transfer coefficient

R_T - Resistance of the adhesive layer between the PV module and the absorber

$$h_{rad} = \varepsilon_{PV}\sigma\left(T_{PV,x} + T_{sky}\right)\left(T_{PV,x}^2 + T_{sky}^2\right) \ldots\ldots\ldots\ldots (3.6)$$

ε_{PV} Represents emissivity coefficient of the PV module

S is the effective amount of radiation

$$S = S_{abs} - q_{el} = (\tau\alpha)_n IAMG_T(1 - \eta_{PV}) \dots \dots \dots \dots (3.7)$$

$(\tau\alpha)_n$ – The transmittance absorptance product

IAM- is the incidence angle modifier

$$(\tau\alpha)_n = 1 - \rho \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (3.8)$$

ρ- Reflectance

η_{PV} – PV efficiency

$$\eta_{PV} = \eta_{PV,ref} X_{cell\ temp} X_{Radiation} \dots \dots \dots \dots \dots \dots (3.9)$$

$X_{cell\ temp}$-Temperature correction coefficient

Eff_T – Temperature coefficient of the PV panel

$$X_{cell,Temp} = 1 + Eff_T\left(T_{PV} - T_{PV,ref}\right) \dots \dots \dots (3.10)$$

$X_{Radiation}$ – Radiation correction coefficient

$$X_{Radiation} = 1 + Eff_G\left(G_T - G_{T,ref}\right) \dots \dots \dots (3.11)$$

Eff_G – Dependence of the electrical efficiency from the total incident radiation. The radition correction coefficient cannot be calculated nor found in the material catalogue. Accordingly, TRNSYS suggest new formula to find the radiation correction coefficient. The variation is very small and can be neglected (Pressiani, 2016).

The temperature of PV module can be calculated by using following formula:

$$T_{PV} = \frac{(D\ T_{PV,b} + (W - D)T_{PV,fin}}{W} \dots \dots \dots \dots \dots \dots (3.12)$$

The user cannot change or insert the collector tube thickness as the outer tube and the inner diameter set to be equal. The effect of tube thickness is negligible ad do not affect the results. Hence, the assumption is acceptable. The temperature of the PV module over the tube can be found by using equation 3.13:

$$T_{Pv,b} = R_T \acute{F}(S + h_{rad}T_{sky} + h_{conv,Top}T_{amb} + \frac{T_{abs,b}}{R_T}) \dots \dots (3.13)$$

$\acute{F}$ – The collector efficiency factor which can be found by equation 3.14

$$\acute{F} = \frac{1}{h_{rad}R_T + h_{Conv,Top}R_T + 1} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (3.14)$$

In Type 560 the coefficient is calculated every step unlike the case for Type 50 and Type 250 which considered to be constant.

The temperature over the absorber fines can be calculated by the following equation 3.15.

$$T_{PV,fin} = R_T \acute{F}\left(S + h_{rad}T_{sky} + h_{conv,Top}T_{amb} + \frac{T_{abs,fin}}{R_T}\right) \dots \dots (3.15)$$

The following equation is the energy balance equation over the absorber layer. The Temperature of the absorber can be found by using equation 3.16.

$$T_{abs} = \frac{DT_{abs,b} + (W - D)T_{abs,fin}}{W} \dots \dots \dots \dots \dots \dots \dots \dots (3.16)$$

The temperature of the absorber over the tube form the energy balance equation can be found by using 3.17.

$$T_{abs,b} = T_f + \frac{1}{h_{fl}\pi D + R_b} * \frac{\dot{m}C_p(T_{fo} - T_{fi})}{N_{tubes}L_1} \dots \dots (3.17)$$

The Temperature over the fines can be found by following equation 3.18:

$$T_{abs,fin} = \zeta + \frac{\left(T_{abs,b} - \zeta\right) \tan h(m\frac{W-D}{2})}{(m\frac{W-D}{2})} \ldots\ldots\ldots\ldots\ldots.(3.18)$$

Where the R_b is back resistance:

$$R_b = R_{ins} + \frac{1}{h_{conv,back}} \ldots\ldots\ldots\ldots\ldots.(3.19)$$

Where:

$h_{conv,back}$ – Represent the convective heat transfer coefficient at the back of the panel to the ambient.

R_{ins} – Represent the resistance of heat transfer by the insulation material at the back of the panel.

The outlet fluid temperature can be found by using equation 3.20.

$$T_{fo} = \left(T_{fi} + \frac{\varepsilon}{k}\right) \exp\left(\frac{N_{tubes}k}{\dot{m}C_p\theta} L_1\right) - \frac{\varepsilon}{k} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(3.20)$$

Where:

ε – Emissivity

θ – Incident Angle.

k - Conductivity

The heat loss coefficient can be found by using equation 3.21.

$$U_L = \frac{S}{T_{abs} - T_{amb}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(3.21)$$

The collector heat removal factor represented by equation 3.22.

$$F_R = \frac{Q_{th}}{A_c(S - U_L(T_{fi} - T_{amb}))} \dots\dots\dots\dots (3.22)$$

The energy output can be found by using equation 3.23 and equation 3.24.

$$Q_{el} = (\tau\alpha)_n IAM\ G_T \eta_{PV} A_c \dots\dots\dots\dots\dots\dots\dots (3.23)$$

$$Q_{th} = \dot{m}\ cp\ (T_{fo} - T_{fi}) \dots\dots\dots\dots\dots\dots\dots\dots (3.24)$$

In case the flow rate was zero, no fluid pass through the PVT the outlet temperature can be found:

$$T_{fo} = T_{mf} = T_{abs} = \frac{R_T\ T_{back} + R_B T_{PV}}{R_T + R_B} \dots\dots\dots\dots\dots\dots\dots\dots (3.25)$$

3.8.1.4 TRNSYS - Type 563

Type 563 Type 560 are similar to each other. However, Type 563 is for PVT glazed panel type. The same mathematical model and equation for Type 560 is applicable for Type 563. This version is used for multi-zone building simulation in TRNSYS (Pressiani, 2016). Hence, the change in the previous model are as follows:

i. T_{back} which represents the temperature at the back of the collector is no longer available. It is replaced by the inner temperature of the building at the roof level.
ii. The back side convective coefficient ($h_{conv,back}$) is replaced by the conductive coefficient at roof level (U_{roof}).

The above review indicates that the best TRNSYS model that can be used to suit the research requirement is Type 560 as the PVT used is unglazed type. In addition, the model has good potential to provide realistic outcomes with fewer percentage errors. Accordingly, will be used in the current research.

3.9 Chapter Summary

Chapter 3, included two parts of the literature review. The first part related to PVT's different available technologies and some of the previous field experiment studies. The aim was to explore the previous studies and understand the information related to the (testing setup, data that need to be collected during the test, interpretation for the findings, and main parameters that affect PVT performance) before starting the experiment. In this study, an experiment and simulation model will be conducted. The second part was related to the simulation software, TRNSYS capabilities, the reasons for selecting TRNSYS, and component Type 560 to represent PVT. All the given information in this chapter will be utilized in the methodology of this research.

CHAPTER IV

Research Methodology

4.1Introduction

The methodology followed in order to achieve project objectives is divided into two parts. The first part was a field experiment of a PVT system in comparison with PV. The second part is developing a simulation model based on the data collected from part one (experimental test). The test procedure for the field test was developed based on (BS EN12975-2:2006 and IEC 61215-1-1). Up-to-date, there is no defined standard to evaluate the PVT performance. Hence, the best way to evaluate the performance of the PVT is to assess both the electrical and thermal performance of the system separately. The adapted method for evaluating the thermal performance of the PVT was the steady-state. The steady-state suggests that all the solar collector characterization remains constant with time during the test. All the parameters such as solar radiation incident on the collector, the ambient temperature, the inlet temperature of the heat transfer fluid, and the mass flow rate should be within certain limits defined by EN 12975-2:2006 as shown in Table 4.4 (Osórioa and Carvalho, 2012). According to the EN 12975 (2012) standard, both steady-state and Quasi dynamic methods are acceptable and can give robust and reliable results. Each of the mentioned methods has it is advantages and drawbacks. EN12975-2:2006 standard will be used to develop the thermal test procedure. IEC 61215-1-1 will be used to evaluate the electrical output of the system. In the experiment, two PV and PVT will be used with identical electrical specifications and areas. The data will be collected and used to develop the TRNSYS model. In this section, the experimental setup will be explained in detail. The experiments setup has been designed and installed based on the recommendation of BS EN12975-2:2006 and IEC 61215-1-1. In addition, the simulation model and its components will be presented and explained. Data will be collected in two seasons summer and winter. The comparison between collected data will be conducted based on the electrical performance, thermal performance, and overall performance. In the simulation part, the developed model will be optimized by changing design parameters of PVT such as number of water tubes, water tubes diameters, PVT panel Area, and water flow. The objective of changing design parameters is to further enhance and optimize PVT performance. Finally, all the optimized parameters will be combined in one model, and the results will be compared with the original model.

4.2 UAE Weather and Geographical Data

The external parameters that affect the solar system performance are climate conditions and geographical location. In this section, UAE climate conditions information and geographical data will be given as it is the location of the experiment. The same information will be used as input for the simulation model. The geographical location of UAE is between longitudes 22° and 26.5° North and latitudes 51° and 56.5° East (Assi, Al-Shamisi, and Hejase, 2012). The total area of UAE is about 83600 km^2 and has mainly three ecological areas (Coastal, mountains, and desert) (Radi, 2010). UAE climate can be characterized by two seasons winter and summer. Winter begin in November and ended in March. The temperature during winter time seldom drops below 6 ^oC. Summertime is very dry in desert areas and high humidity reaches up to 90% in coastal areas. The temperature level reaches up to 48^oC (Radi, 2010).

The UAE has solar energy abundance in comparison to European Countries and Japan. The total number of sunny days in UAE is 330 around the year with 9.6 average sunny hours per day. The average annual sunshine is about 3568 hr and an approximate average annual solar radiation of 2285 kWh/m^2 (Hejase & Assi, 2013). The highest average direct radiation in May and October with 613 W/m^2 and 546 W/m^2 respectively. On the other hand, the highest diffuse radiation is in July with an average value of 273 W/m^2 (Radi, 2010). The average wind speed in UAE is about 4 m/s with a North West direction.

4.3 Test Rig Description and Instrumentations

The test rig consisted of a PV panel and PVT panel fixed on the same frame with the same tilt angle and with the same fixation height. Both (PV and PVT) panels are identical in size with a 1.2 m^2 gross area and the same electrical specification. The only difference is that one of them is attached to the solar collector to form PVT. The main aim of the field test is to collect sufficient realistic data to develop a simulation model and validate it. Therefore, the test rig was connected to the data logger and storage batteries. Both panels were connected to batteries to store the generated power and separate energy meters. The batteries were connected to a light fixture as a load. The light fixtures were used to drain the batteries during the nighttime or after 90% charging. Each one of the panels is connected to an energy meter to record the generated power instantly (voltage, current, and output power). The inlet and outlet water temperature of the PVT panel were measured by using thermocouples. Thermocouples were connected to the data logger. In addition, a pump and flow meter were installed at the inlet line of the PVT panel. Two water storage tanks were attached to the PVT. One was to feed the PVT with water and the other one was used to collect the outlet water as the system was isolated. The experimental setup is mainly open-loop test type as there is no feedback water return to the feeding water tank. Hence, the water does not recirculate into the PVT again, and there is no thermal storage in the setup. The reason for selecting the open-loop method is due to the delay in transferring the heat from the absorber to fluid which is called thermal mass. It required minutes to transfer the absorbed heat from the absorber to the working fluid or vice versa. Therefore, the open-loop system testing method has been adopted in the current research to maximize the thermal gain and reduce the effect of thermal mass. In addition, in the case of an open-loop testing method system, the variation in inlet temperature of the water can be controlled which results in less percentage error.

The selected pump was a low flow rate ranging from 0.5 GPM to 8 GPM with a pressure of 6 psi. The pump is sized based on manufacture recommendation (0.5 GPM with 6 psi). Flow meter used to control the flow rate after the pump and adjust the water flow rate as per PVT manufacturer recommendation of the ideal flow rate of 0.5 GPM. The capacity of both the feeding tank and the collecting tank is done based on the design flow rate and the expected 12 working hours per day. The weather station has been installed directly next to the testing setup to collect the weather data such as (diffused solar radiation, ambient temperature, wind speed, wind direction). The solar radiation intensity has been measured by using a pyranometer. The pyranometer was mounted with the same inclined angle and in the half-length of the testing setup. The data collected every two minutes started from 07:00 AM time and ended at 18:00. Data for the full two days were collected one day during the winter season on 07/02/2020 and the second day during the summertime on 24/08/2020. The aim of the testing during the different seasons with the same setup was to compare the performance of PVT in both weather conditions and find the enhancement in the electrical and thermal performance. These two days were selected as one of the coldest days during winter and one of the warmest days during summer. Both days represent the least and highest weather temperatures all over the year in the UAE.

4.3.1 Testing Setup Mounting

As per the IEC 61215-1-1 recommendation, the solar PVT was mounted in a way that the lower edge is not less than 0.5 m above the local ground-mounted. Hence, the frame elevated from the ground level. The height of the PVT frame edge was about 60 cm from ground level.

4.3.2 Tilt Angle

The solar panels in the test rig were fixed with a tilt angle of 15 degrees. The installation at the site level was done by using Protractor. The suitable direction for PV panels in UAE is south. The optimum tilt angle is changing monthly and yearly. The yearly optimum tilt angle for UAE is 22 degrees (Jafarkazemi and Saadabadi, 2012). However, due to the site conditions and avoiding shading from adjusted structures, the tilt angle was decided to be 15 degrees.

4.3.3 Instrumentation

The instruments used in the experiment are introduced in detail with all specifications in the following section. The instruments are mainly used to collect required data such as solar radiation intensity, water temperature, ambient temperature, wind speed, wind direction, and water flow rate.

4.3.3.1 Pyranometer:

The instrument used to measure solar radiation was a Pyranometer. As per IEC 61215-1-1, the Pyranometer should be a class I, class II, or better as per ISO 9060. The Pyranometer is mainly used to measure the global short-wave radiation from both the sky and the sun. There were certain steps and precautions were taken before using or collecting the output data from the Pyranometer. Before using the Pyranometer the outer dome should be cleaned from dust or soiling daily basis. The Pyranometer was allowed to equilibrate for at least 30 min before data collecting. The Pyranometer used in this experiment is LP PYRA, 03-second class, following ISO 9060 made in Italy as shown in Figure 4.1. The working principle of the Pyranometer is based on a thermopile. The thermopile is coated with black paint matt type, which allows the pyranometer not to be selective at a different wavelength. The output of the Pyranometer was connected to the data logger to record solar radiation intensity for the whole day. The technical specification of the used Pyranometer as shown in Table 4.1:

Table 4.1: Technical specification of the Pyranometer used in the experiment.

Technical Specification	LP PYRA 03
Typical sensitivity	10 µV(W/m^2)
Impedance	33 Ω - 45 Ω
Measuring range	0 - 2000 (W/m^2)
Viewing field	2π sr
Spectral field	305 nm - 2800 nm (W/m^2) 50%
Operating Temperature C	-40ºC to 80ºC
Response time 95%	< 30 s
Weight	0.45 Kg
ISO 9060 Specification	
Zero Off-set	
Response to thermal radiation (200W/m^2)	25 W/m^2
Response to temperature change 5K/h	2 <|± 6|W/m^2
Non stability over 1 year	<|± 2.5 | %
Non linearity	<|± 2| %
Cosine response	2 <|±22|W/m^2
Spectral selectivity	<|±7| %
Response with regard to temperature	% < 8
Tilt response	<|± 4| %

4.3.3.2 Pyranometers Outdoor Mounting

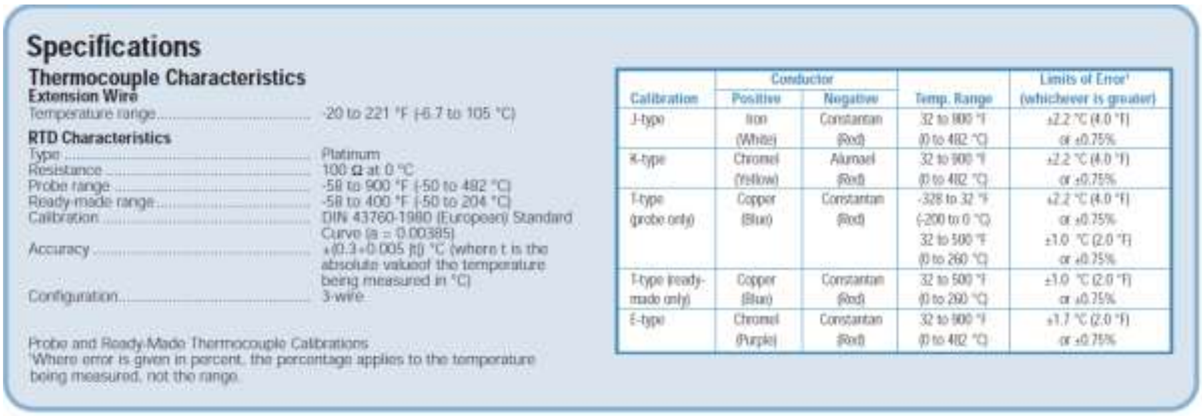
As per IEC 61215-1-1, the Pyranometer shall be mounted in the same plane as the solar panels. The acceptable tolerance is ±1 degree with the plane of the PVT aperture. It should not cast a shadow onto the aperture at any time during the test period. Moreover, Pyranometer should be mounted to receive the same level of direct, diffuse, and reflected solar radiation as the solar collector. In the current outdoor test, the Pyranometer was fixed at the mid-height of the PVT panel and with the same title angle. Hence, the Pyranometer installation was as per the mounting recommendation of the IEC standard. The shadow issue on both the test rig and Pyranometer during the test period was eliminated as the installation height level of the Pyranometer was in parallel with the test rig as shown in Figure 4.2 which shows the installation at the site.

Figure 4.1: Pyranometer LP PYRA 03

Figure 4.2: Pyranometer installation at the site

4.3.4 Temperature Measurement Tool (Thermocouples)

Three temperatures values need to be recorded for PVT testing (water temperature at the inlet of PVT, the water temperature at the outlet, and ambient temperature). The temperature sensor (Thermocouple) accuracy should be (±0.02 K) as per IEC 61215-1-1 recommendations. The thermocouple shall be mounted at no more than 200mm from the PVT inlet and exit. All the pipes should be insulated to prevent heat loss. In the test rig, all the pipes were insulated and the thermocouples were placed inside the pipes. The recorded temperatures were inlet temperature and outlet temperature of PVT. The type of thermocouple used is K type with a temperature range from 0 to 482ºC and limits error of ±2.2ºC and with suitable accuracy as mentioned. The ambient temperature was recorded from the weather station which, was placed next to the test rig. Specification of the thermocouples shown in Figure 4.3.



Specifications

Thermocouple Characteristics

Extension Wire

Temperature range .... -20 to 221 °F (-6.7 to 105 °C)

RTD Characteristics

Type .... Platinum

Resistance .... 100 Ω at 0 °C

Probe range .... -58 to 900 °F (-50 to 482 °C)

Ready-made range .... -58 to 400 °F (-50 to 204 °C)

Calibration .... DIN 43760-1980 (European) Standard Curve (a = 0.00385)

Accuracy .... ±(0.3+0.005 |t|) °C (where t is the absolute valueof the temperature being measured in °C)

Configuration 3-wire

Probe and Ready-Made Thermocouple Calibrations

'Where error is given in percent, the percentage applies to the temperature being measured, not the range.

Calibration	Conductor		Temp. Range	Limits of Error' (whichever is greater)
	Positive	Negative		
J-type	Iron (White)	Constantan (Red)	32 to 900 °F (0 to 482 °C)	±2.2 °C (4.0 °F) or ±0.75%
K-type	Chromel (Yellow)	Alumel (Red)	32 to 900 °F (0 to 482 °C)	±2.2 °C (4.0 °F) or ±0.75%
T-type (probe only)	Copper (Blue)	Constantan (Red)	-328 to 32 °F (-200 to 0 °C) 32 to 500 °F (0 to 260 °C)	±2.2 °C (4.0 °F) or ±0.75% ±1.0 °C (2.0 °F) or ±0.75%
T-type (ready-made only)	Copper (Blue)	Constantan (Red)	32 to 500 °F (0 to 260 °C)	±1.0 °C (2.0 °F) or ±0.75%
E-type	Chromel (Purple)	Constantan (Red)	32 to 900 °F (0 to 482 °C)	±1.7 °C (2.0 °F) or ±0.75%

Figure 4.3: Thermocouple Specification K type

4.3.5 Surrounding Air Temperature (t_a) Measuring

The measurements such as air temperature (t_a) will be recorded by using an onsite weather station. In addition to the ambient temperature the wind speed, wind direction, and diffuse solar radiation have been recorded. The weather station type used was ambient weather WS-2902 from professional weather Station brand with Internet monitoring, compatible with Alexa as shown in Figure 4.4.

Figure 4.4: Ambient Weather Station WS-2902

4.3.6 Water Flow Rate Measurement

The water flow rate was measured by using a flow meter installed in the inlet line of PVT. In this experiment, the fluid used is water with a density of 997 kg/m^3. The flow rate used during the test is 0.5 GPM as per the recommendation PVT manufacturer with pressure less than 6 psi.

4.3.7 Air/ Wind Speed Measurement

The Performance of the PVT is sensitive and affected by wind speed. Hence, wind speed is a parameter which required to be measured during the test in order to get good quality results. The wind speed and direction were recorded from the weather station and they will be used as input for the simulation model.

4.3.8 Data Recorders / Data Logger

The data logger used in the setup is USB-6210 from the National instrument. The main specification of the data logger was 16 AI (16-Bit, 250 kS/s), 4 DI, 4 DO USB Multifunction I/O Device as shown in Table 4.2 and Figure 4.5.

Table 4.2: Technical specification of Data logger.

Analog Input

Number of channels	8 differential or 16 single ended
ADC resolution	16 bits
DNL	No missing codes guaranteed
INL	Refer to the *AI Absolute Accuracy* section
Sample rate	
Single channel maximum	250 kS/s
Multichannel maximum (aggregate)	250 kS/s
Minimum	0 S/s
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Input coupling	DC

Figure 4.5: Data logger fixed in the testing setup

4.4 Test Rig Schematic Diagram

The experimental test layout shown in Figure 4.6 explains the electrical and thermal connection of the testing setup. PV panel and PVT panel each one connected to Energy meter then connected to DC charger. The Charger was connected to the DC batteries and light fixtures (lamps). The light fixtures were used as a load to drain the batteries. PVT connected with two water tanks with a water pump supply pump. All the pipes were insulated. A data logger has been used to record the temperature (inlet water temperature, outlet water temperature, electrical power from PV, and electrical power from PVT). All the experimental rig parts are included in Table 3.4. and Figures 4.6 and 4.7.

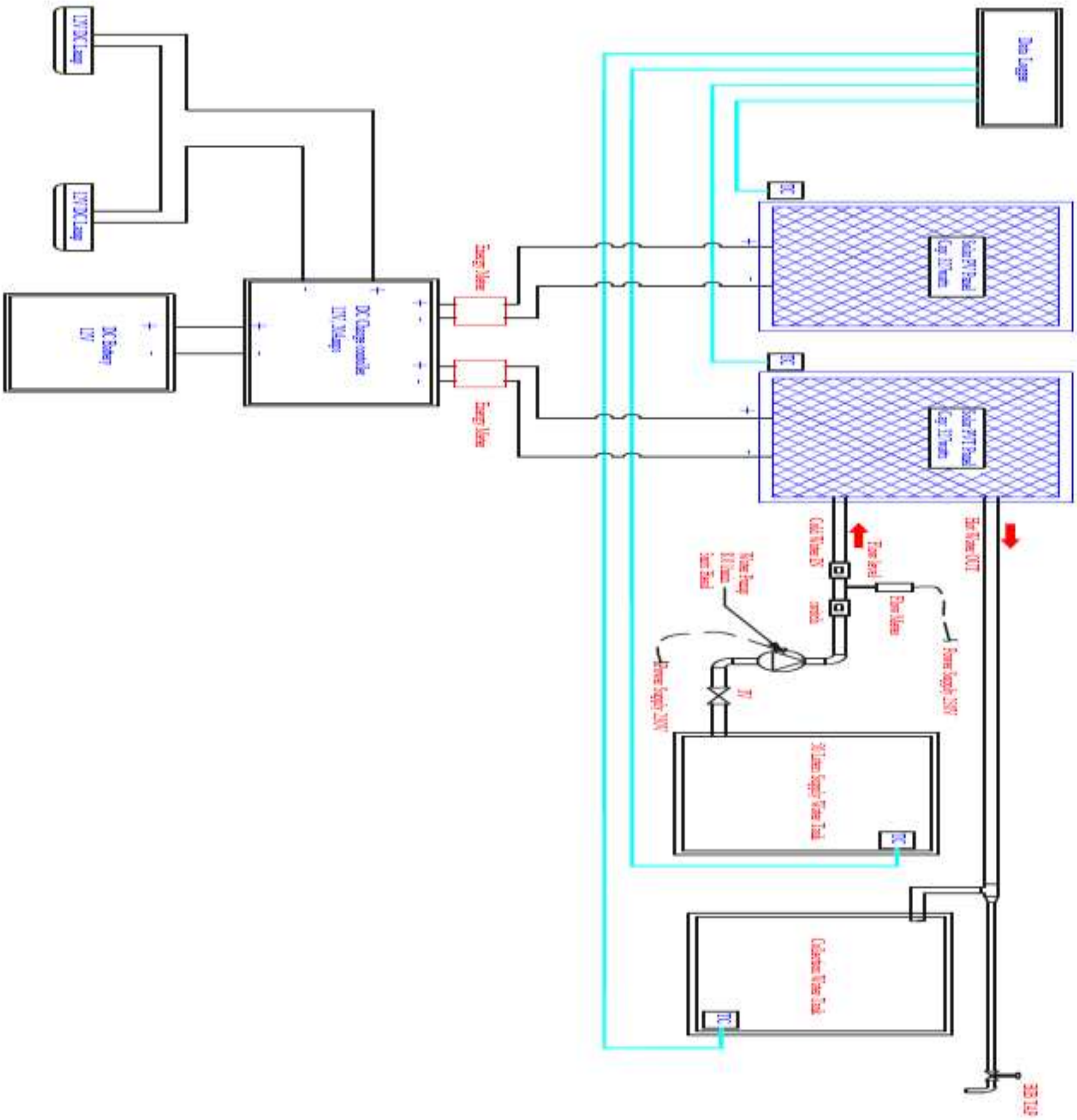


Figure 4.6: Experimental Test- setup Schematic Diagram

Figure 4.7: Site installation of test Rig at site

Table 4.3: Experimental setup parts and specification

Part	Quantity	Model /Specification
PVT	1	SDM100-300 Collector and PV, insulated type
PV	1	Sun Power E-Series Residential Solar Panels | E20-327 W
Pump	1	Normal pump with flow rate range from 1 LPM to 8 LPM
Data logger	1	USB-6210/ 16 AI (16-Bit, 250 kS/s), 4 DI, 4 DO USB Multifunction I/O Device
Thermocouple	4	Type K
DC batteries	2	12 V DC batteries
DC charger	1	DC charger controller with 12V and 20 Amps
Water tank	2	Non-insulated water tanks with capacity of 1000 G
Weather station	1	Ambient Weather WS-2902
Pyranometer	1	LP PYRA 03

4.5 Outdoor Performance Test Procedure

4.5.1 Test Precondition

Test procedure started with precondition steps as follows:

i. The first step was a visual inspection for PVT and PV panels for any damage to be rectified/ replaced before conducting the test.

ii. PVT and PV panel’s covers were thoroughly cleaned before starting the test and collecting the data. The cleaning is required to avoid any power losses due to accumulated dust or formed moisture on the panel surfaces.

iii. The trapped air vented from pipes by circulating water with a high flow rate for 10 min before starting the test.

iv. PVT and PV were exposed to solar radiation for 5 hrs. at a level more than 700 W/m2 before one day of test day.

v. Electrical performance/power output of both PV and PVT was checked one day before the test day.

vi. All the instruments (pump, thermocouples, weather station, data logger, and energy meters) were checked as well and calibrated.

vii. A trial test has been conducted one day before the real test to ensure the healthiness of the system.

4.5.2 Measurements and Data Recording

The following data were measured/recorded:

i. PVT and PV Gross area AG was measured before fixing the panels on the frame and during the visual inspection.
ii. Hemispherical Solar irradiance at the PVT and PV aperture which considered to be direct solar irradiance.
iii. Diffuse solar irradiance at site collected from the data weather station.
iv. Ambient temperature was reordered by using the onsite weather station.
v. Temperature of the water at the PVT inlet was measured by thermocouple and recorded by a Data logger.
vi. Temperature of the water at the PVT outlet was measured by thermocouple and recorded by a Data logger.
vii. Flow rate of the water was constant at 0.5 GPM
viii. Electrical performance (Voltage, Current, Power) for each panel was measured by using an energy meter and recorded in the data logger.

4.5.3 Test Period (Steady-State)

As mentioned steady-state approach was adopted in this research. Accordingly, the steady-state condition required at least 15 min running time called pre-condition period before recording any data as per the recommendation of BS EN12975-2:2006. Steady-state condition reach when there is no change in parameters with time.

PVT is considered to operate in steady-state conditions if none of the experimental parameters deviate or change from their mean values after the pre-condition period (15 min) by more than the given limits mentioned in Table 4.4. The value of each mentioned parameter was recorded over a consecutive period of 30 s. The averages / mean values have been found and compared to the measurements during the pre-condition period to ensure that the steady-state condition already exists.

Table 4.4: Steady state-permitted deviation of measurements for parameters during a measurement period.

Parameter	Permitted deviations from the mean value
solar irradiance (Global)	± 50 W/m^2
Air temperature (indoor)	± 1 K
ambient temperature (outdoor)	± 1.5 K
Water mass flow rate	± 1%
water temperature at PVT inlet / outlet	± 0.1 K

Accordingly, the test was started 25 minutes prior to start recording any of the data to be on the safe side.

4.6 Computation of Collected Output Data

The actual useful power extracted from the solar collector is calculated from the following equation. The same equation was used to calculate the useful power generated from the PVT panel as per EN 12975-2:2006 (Kovacs, 2012):

$$\dot{Q} = \dot{m} c_f \Delta T \qquad (4.1)$$

Where:

$\dot{Q}$ - useful power

c_f – Mean fluid temperature

$\dot{m}$ - Mass flow rate

ΔT - Difference between outlet temperature and inlet temperature

Solar Energy captured/absorbed by collector:

The actual useful power extracted as per EN 12975-2:2006 (Kovacs, 2012) can be found by using equation 4.2: Solar Energy captured/absorbed by collector:

$$\dot{Q} = A_a G \eta \text{..(4.2)}$$

Where:

$\dot{Q}$ - The actual useful power

A_a - absorber area of the collector.

G - Solar intensity

Reduce temperature difference:

When the mean temperature of the heat transfer fluid t_m is used:

$$t_m = t_{in} + \frac{\Delta T}{2} \text{..(4.3)}$$

The reduce temperature difference is calculated as:

$$T_m^* = \frac{t_m - t_a}{G} \text{..(4.4)}$$

Modeling of instantaneous efficiency:

$$\eta = \eta_o - a_1 T_m^* - a_2 G (T_m^*)^2 \text{..(4.5)}$$

Collector output:

$$Q = A.G(\eta_o - a_1 \frac{T_m - t_a}{G} - a_2 \frac{T_m - T_a}{G}) \text{......................................(4.6)}$$

Where:

η - Efficiency

η_o - Efficiency for (t_m-t_a=0) conversion factor

a_1 - heat loss coefficient, independent of temperature (W/m^2K)

a_2 - heat loss coefficient, independent of temperature (W/m^2K^2)

G - Global irradiance in W/m^2

T_m- mean fluid temperature in the collector in °C (T_m= T_{in} – T_{out})/2

T_{out} - collector outlet temperature in °C

T_{in} - collector inlet temperature in °C

T_a - ambient Temperature in °C

T_m^* - reduce temperature difference in m^2K/m

Output electrical power calculated by following equation.

$$P = V \times I \text{..............................(4.7)}$$

Where:

P - Electrical Power

I – current

V – Voltage.

Electrical and Thermal Efficiency

$$\eta_{Thermal} = \frac{\dot{m}(T_{out} - T_{in})}{A_a G} \text{..............................(4.8)}$$

$$\eta_{Electrical} = \frac{P_{max}}{P_{in}} = \frac{I_{max} \times V_{max}}{G \times A_a} \text{.........................(4.9)}$$

$$\eta_{PVT} = \eta_{Thermal} + \eta_{Electrical} \text{.........................(4.10)}$$

Where

$\dot{m}$ – Water flow rate

C_p – Specific heat

Efficiency of PV cell can be found by using equation 4.11 (Pressiani, 2016).

$$\eta_{cell} = \eta_{cellref}\left[1 - \gamma(T_{cell} - T_{cell,ref})\right] \qquad (4.11)$$

Where

γ - Temperature coefficient which is in this case -0.35% 1/°C

$\eta_{cell\ ref}$ - Reference efficiency is 15% in this case

$T_{cell,ref}$ – is the reference temperature which is about 25 °C in this case as per the catalogue of the PV

4.7 PVT and PV Panels Technical Specification

The following specifications for both panels (PVT and PV) were extracted from the datasheet. In the following Table 4.5 all the specifications related to PVT and PV panels.

Table 4.5: Technical data of PV and PVT panels

Electrical specification	PV Conventional panel	PVT panel
P_{max}(W)	327 W	327 W
V_{max}(V)	54.7	54.7
I_{max}(A)	5.98	5.98
V_{oc}(V)	64.9	64.9
I_{sc}(A)	6.46	6.46
Solar cells 60 multi-crystalline	60	60
Predicted electrical efficiency (%)	12% - 15%	12% - 15%
Certifications	IEC 62716	IEC 62716
Thermal specification	PV only panel	PVT panel
Water flow rate (GPM)	NA	0.5
Collector area(m^2) (Gross Area)	NA	1.2
Predicted Thermal efficiency (%)	NA	60 - 70%
Heating medium	NA	water
Length(m)	NA	1.321
Width(m)	NA	0.914

Thickness(m)	NA	0.06
Weight(kg) with/without water	NA	11.04/
Operating temperature (°C)	NA	-400 C to +900 C
Number of tubes	NA	8

4.8 Test Limitations

Maximum Operation Temperature of PVT panel: 80^{o}C

Maximum Operation Pressure of PVT panel: 6 psi

4.9 TRNSYS Model

The second part of the methodology was the simulation phase. In the simulation part, the collected data from the experiment were used to develop a simulation model in TRNSYS 18. TRNSYS is a simulation tool that has powerful capabilities to mimic or simulate the behavior of both electrical and thermal performance of the PVT. In the current research, two simulation models were developed. One model for conventional PV and the Second for PVT as shown in Figures 4.8 and 4.9. In this case, Type 560 was used to represent the PVT. Type 560 is the component that represents the unglazed type of PVT in TRNSYS. The reason for choosing the type PVT mentioned earlier in this research in the literature review. Additionally, a plotter of Type 65d is used to plot the results in comparison to input data. Type 25^{o}C was used to print out the results file after running the simulation. The full model is shown in Figure 4.8.

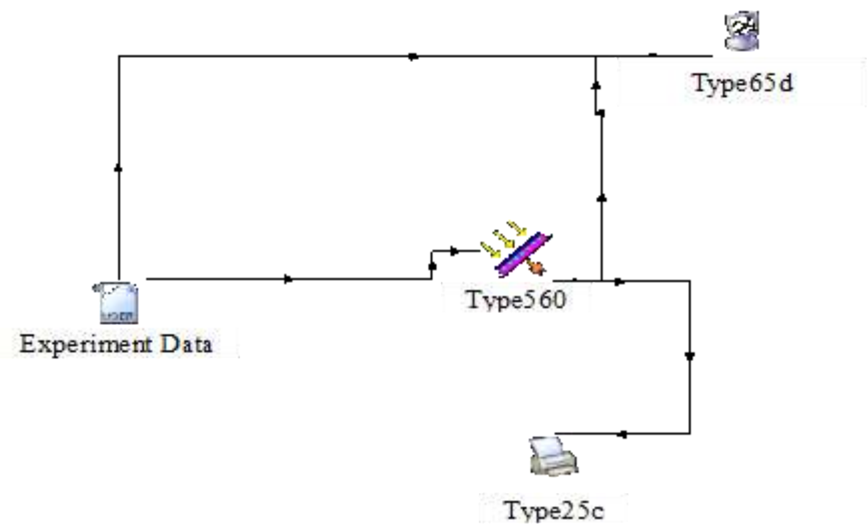


Figure 4.8: PVT system TRNSYS Model

4.10 Simulation Input Parameters

Table 4.8 expressed the input parameters used for the TRNSYS model. All the input values of solar radiation, wind speed, thermal power, and electrical power measured units were changed to match with TRNSYS units as below.

Table 4.6: Parameters used to develop TRNSYS Simulation model.

Parameters	Values	Unit
Collector Length	1.3	m
Collector Width	0.914	m
Absorber Plate Thickness	0.0025	m
Thermal Conductivity of the Absorber	1385.9	kJ/hr.m.K
Number of Tubes	8	-
Tube Diameter	0.01	m
Bond Width	0.01	m
Bond Thickness	0.001	m
Bond Thermal Conductivity	1386	kJ/hr.m.K
Resistance of Substrate Material	0.01	$h.m^2.K/kJ$
Resistance of Back Material	3	$h.m^2.K/kJ$
Fluid Specific Heat	4.19	kJ/kg.K
Reflectance	0.15	Fraction
Emissivity	0.85	Fraction
PV Cell Reference Temperature	25	C
PV Cell Reference Radiation	3600	$kJ/hr.m^2$
PV Efficiency at Reference Condition	0.15	Fraction

Efficiency Modifier - Temperature	-0.0035	1/C
Efficiency Modifier - Radiation	0.000025	$h.m^2/kJ$
Inlet Temperature	20	C
Inlet Flow rate	113.6	kg/hr
Ground Reflectance	0.2	Fraction
Collector Slope	15	degrees
Top Loss Convection Coefficient	20	$kJ/hr.m^2.K$

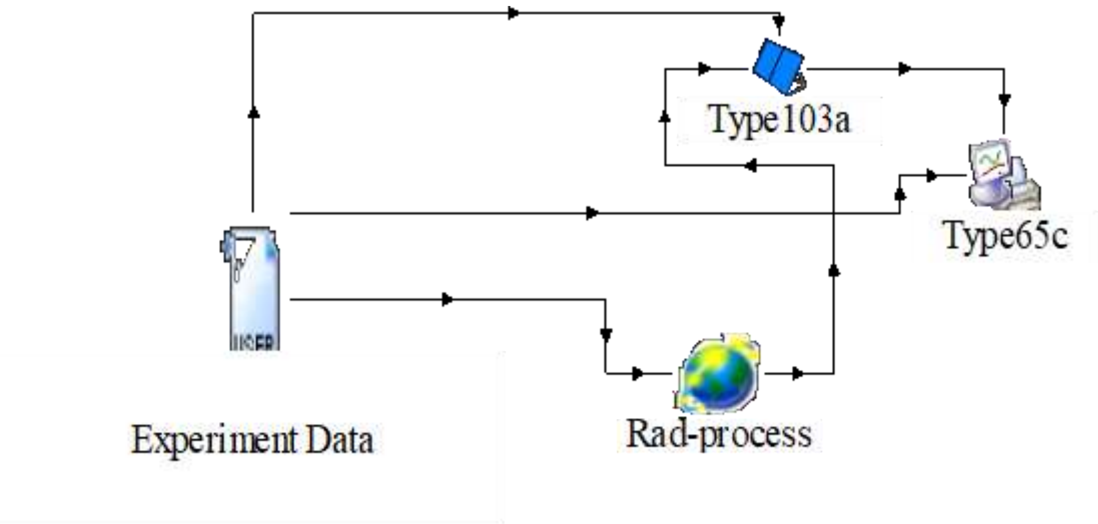


Figure 4.9: PV system TRNSYS Model

CHAPTER V

Research Results and Discussion

5.1 Introduction

This chapter includes research results from the experiment, simulation, and interpretation of the results. In addition, a comparison between the experimental results and simulation results is conducted. Then, the results for the optimized parameters are given with interpretation for each case. Finally, a comparison between the experimental results with the optimized model is conducted.

5.2 Filed Experiment Results

The first objective of this research is to test and evaluate the electrical efficiency of PVT in comparison to standard PV during winter and summer. Table 5.1 and Table 5.2 show the results from the field experiment during summer and winter. In addition, the instance electrical power, electrical efficiency, thermal power, thermal efficiency, and total efficiency were found by using equations (4.1, 4.7, 4.8, 4.9, and 4.10).

Table 5.1: Summary of experimental input data and output results for winter.

	Parameters	Value	Unit
Input data	water flow rate	0.5	GPM
	Date of test	7-Feb-20	
	start time	6:00	AM
	End time	6:00	PM
	Test Duration	12.00	hr
	Sun rise	6:58	AM
	Sun Set	6:05	PM
	flow rate	0.031467	kg/s
	Cp	4179	J/kg·K
	Area	1.2	m2

Output data (Results)	Maximum Electrical power PVT	119.196	W
	Electrical Efficiency PVT	14%	
	Maximum Thermal power PVT	494.2577	W
	Maximum Thermal Efficiency PVT	53.8%	
	Average Thermal Efficiency PVT	42.5%	
	Maximum Electrical power PV	115.5	W
	Average Electrical power PV	62.9	W
	Electrical Efficiency PV	13.3%	

Table 5.2: Summary of experimental input data and output results for summer.

	Parameters	Value	Unit
Input data	water flow rate	0.5	GPM
	Date of test	24-August-20	
	start time	6:00	AM
	End time	6:55	PM
	Test Duration	12.00	hr
	Sun rise	6:00	AM
	Sun Set	6:05	PM
	Cp	4179	J/kg·K
	Area	1.2	m2
Output data (Results)	Maximum Electrical power PVT	127.59	W
	Electrical Efficiency PVT	13.40%	
	Maximum Thermal power PVT	584.163	W
	Maximum Thermal Efficiency PVT	83.0%	
	Average Thermal Efficiency PVT	57.1%	
	Maximum Electrical power PV	120.375	W
	Average Electrical power PV	64.122	W
	Electrical Efficiency PV	12.2%	

5.3 Comparing the PVT Experimental results with Simulation results

The simulation model results were compared with the data collected from the field experiment to investigate the accuracy of the simulation model. In the literature review, it has been mentioned the accurate simulation model must produce results within 5% error in comparison with the experimental results. Accordingly, the same principle has been applied to the simulation results and the results show that maximum error was within the given limits of 5% as shown in Table 5.3 for both winter and summer results. The compatibility between the experiments results and simulation results is shown in Figures 5.1 and 5.2. The comparison has been conducted between experimental and simulation results of (T_{out}, output thermal power, and output electrical power).

Table 5.3: shows the maximum error value between experimental results and simulation results for both (winter and summer)

Parameter	Error
Winter Results	
T_{out}	0.52%
Thermal power	4.49%
Electrical power	4.83%
Summer Results	
Tout	0.155%
Thermal power	5.00%
Electrical power	4.66%

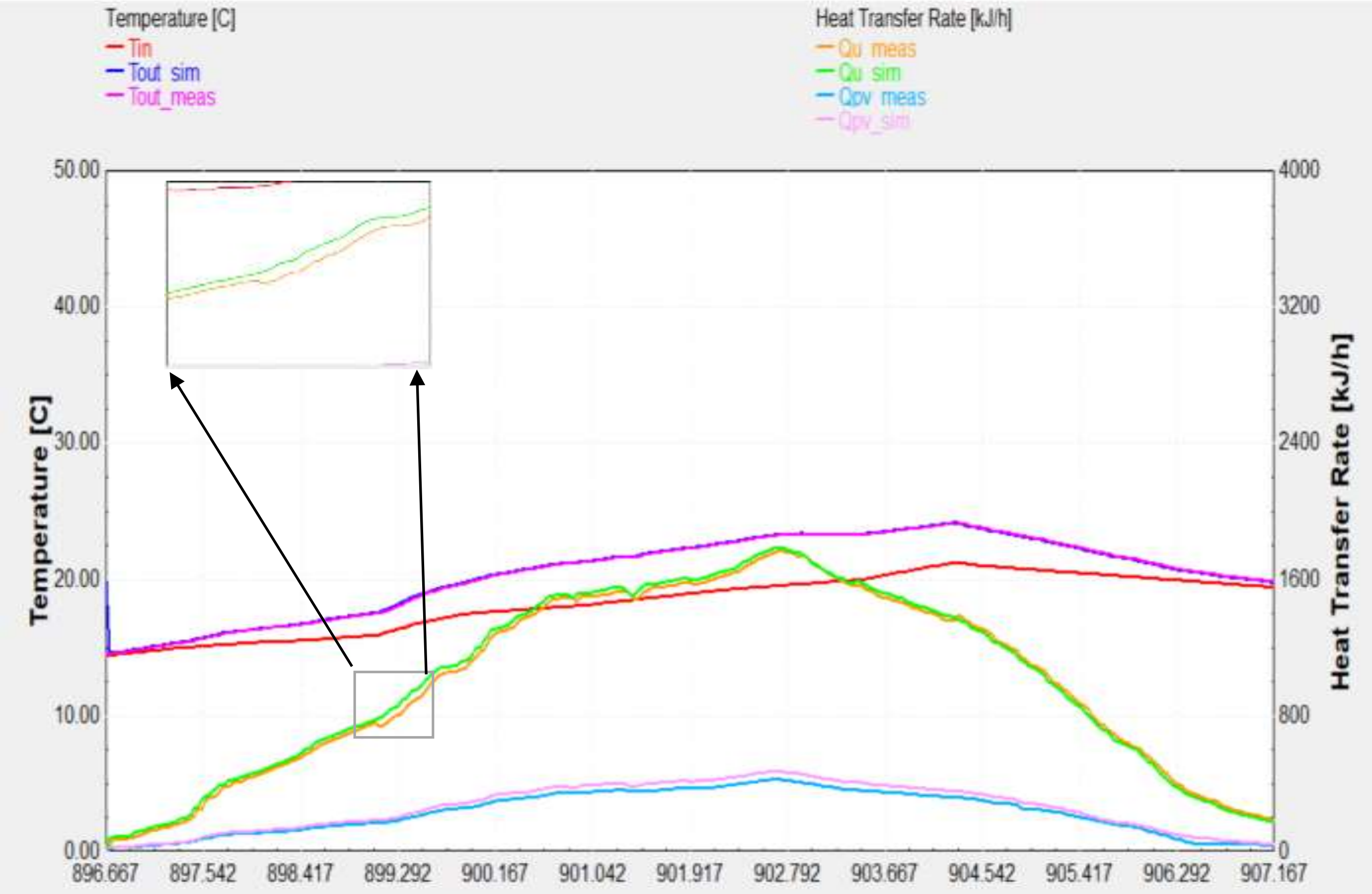


Figure 5.1: TRNSYS model results during winter in comparison with input data (Experimental results)

Where

- T_{in} -Water Temperature inlet
- T_{out_Sim} -Water Temperature outlet simulation
- T_{out_meas} -Water Temperature outlet simulation
- Q_{u_meas} – Thermal power from experiment
- Q_{u_Sim} – Thermal power from Simulation
- $Q_{PV-meas}$ – Electrical power from experiment
- Q_{PV-sim} – Electrical power from simulation

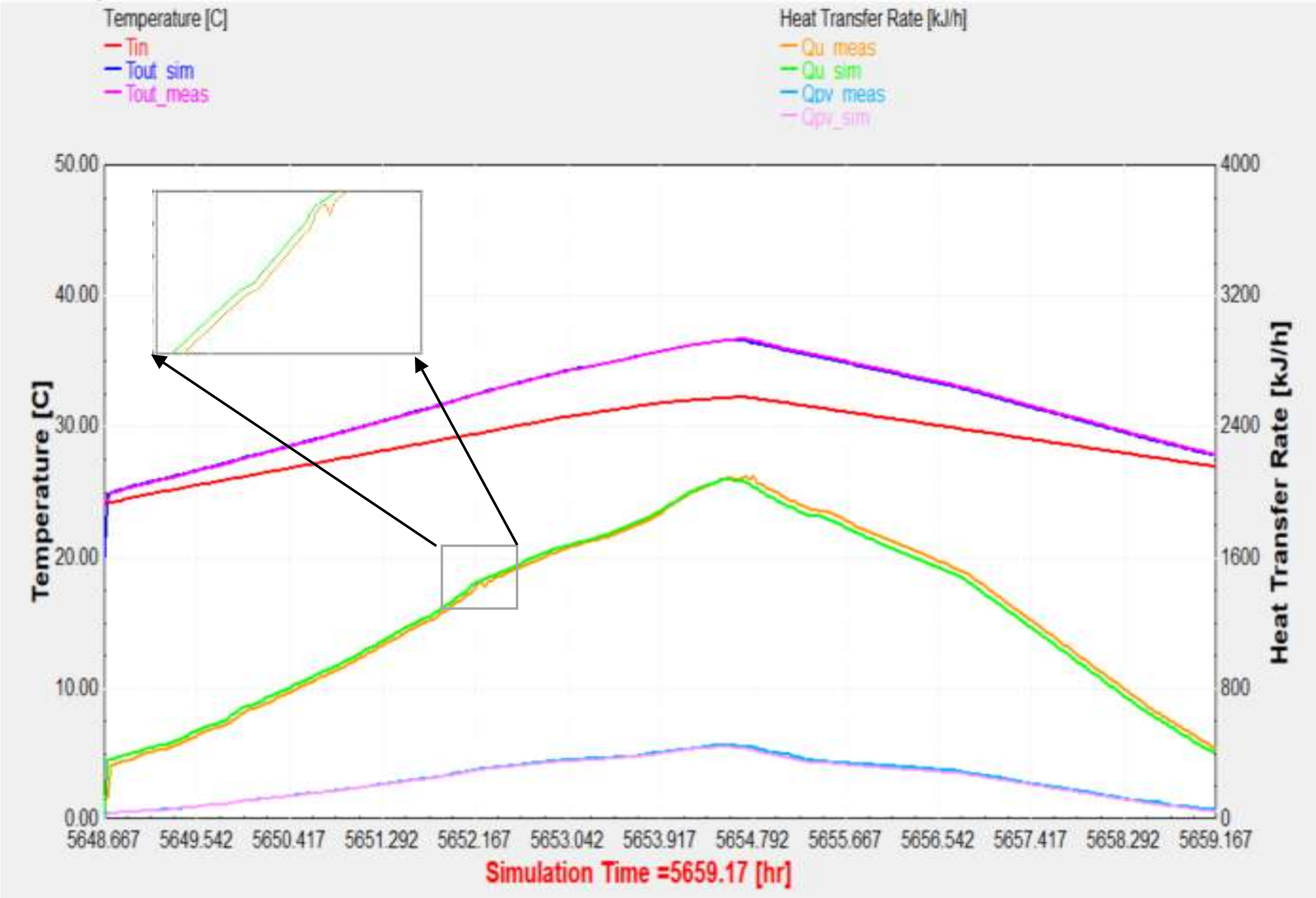


Figure 5.2: TRNSYS model results during summer in comparison with input data (Experimental results)

In addition to the given comparison between experimental results and the simulation results, another compatibility test was conducted. Comparison of Simulation results of thermal efficiency according to the reduced temperature difference with experimental results during winter and summer were conducted. Reduce in temperature difference represented with equation (4.4). The compatibility between the experiment results and the simulation results is in Figures 5.3 and 5.4.

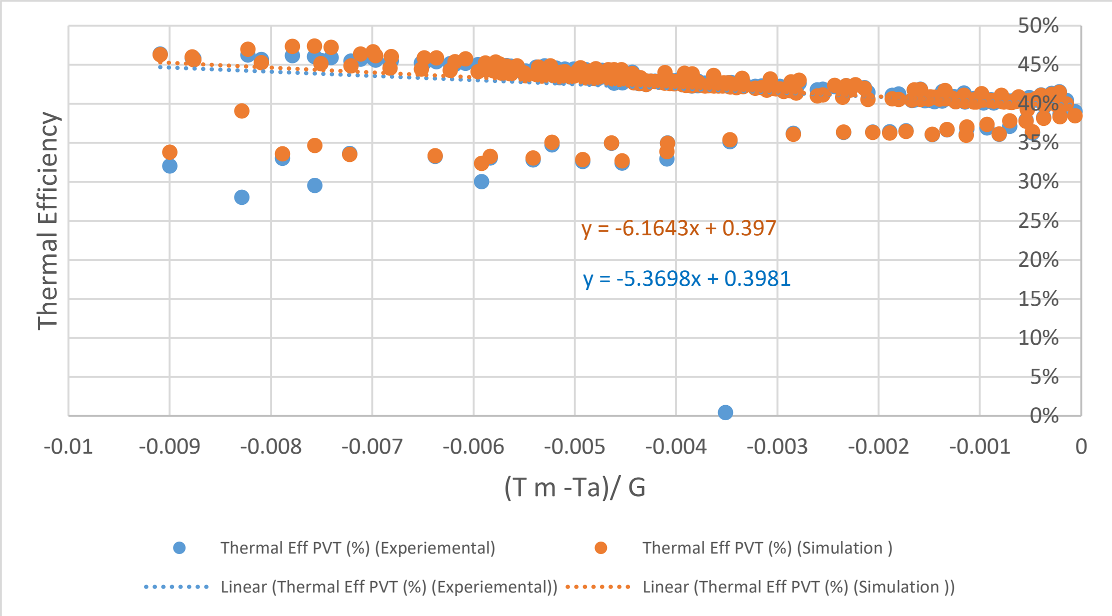


Figure 5.3: Comparison of Simulation results of thermal efficiency according to the reduced temperature with experimental results during winter

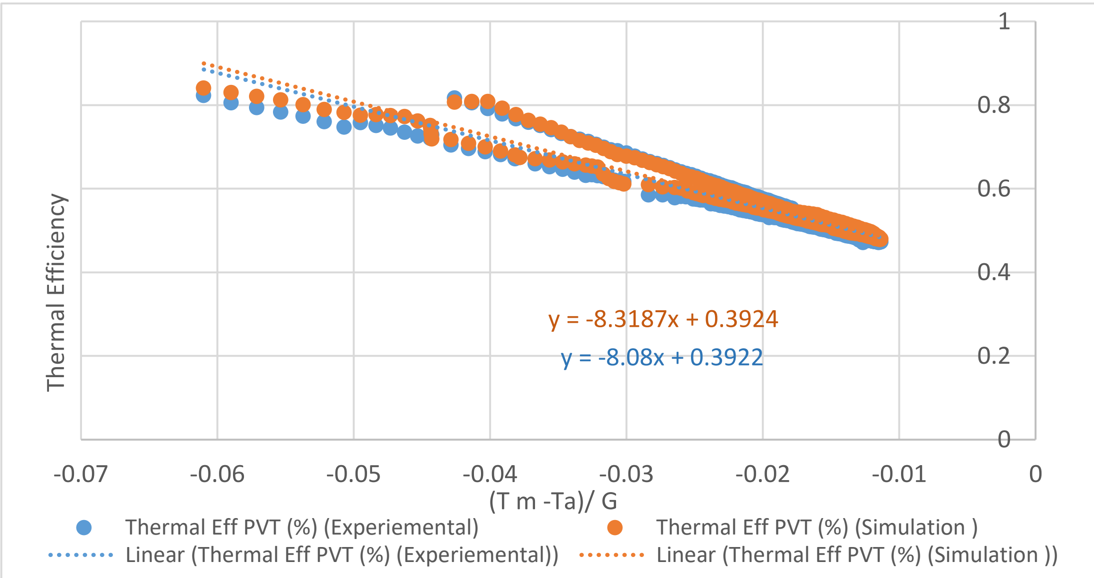


Figure 5.4: Comparison of Simulation results of thermal efficiency according to the reduced temperature with experimental results during summer

Considerable research has had almost the same output when the thermal efficiency is plotted verse the reduced temperature with experimental results as per the (Dubey and Tay, 2012) study and (Huang, Sung & Yen, 2012) mentioned in the literature review.

In addition, Peng Xu et al. (2015) in their study which aimed to compare the electrical performance of PVT with PV showed that the enhancement in efficiency of PVT in comparison with PV reached up to 5%.

Alzaabi et al. (2014) performed a study to experimentally test PVT performance (electrical and thermal efficiencies) under UAE weather conditions. They concluded that PVT electrical performance enhanced by 15 to 20% when compared to PV.

Accordingly, the found results seem consistent with previous studies results.

5.4 PV Simulation Results:

PV simulation model was developed to mimic the electrical performance of PV during winter and summer. The accuracy of the PV simulation model was confirmed by comparing the experimental results with simulation results. The acceptable error percentage between experimental results and simulation results was 5%. The results are shown in Table 5.4 and Figures 5.5 and 5.6.

Table 5.4: Comparison between experimental results and simulation results of PV panel in both winter and summer

Season	Criteria	Simulation Results	Experimental Results	Error
Winter	Average Power (kJ/hr)	225.767	226.772	0.44%
	Average Power (W)	62.713	62.992	
Summer	Average Power (kJ/hr)	229.845	230.839	0.43%
	Average Power (W)	63.846	64.122	

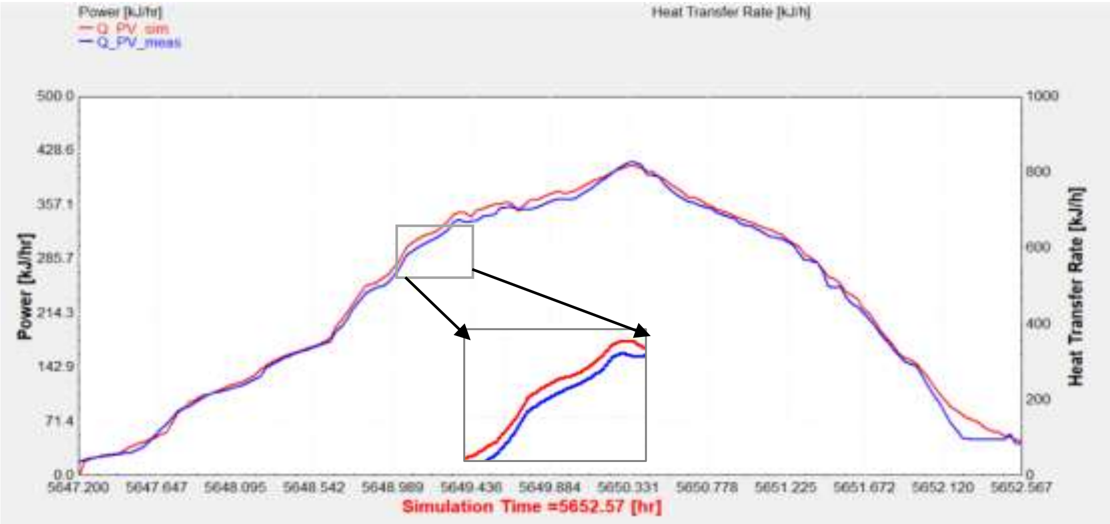


Figure 5.5: PV Comparison between Simulation and experimental power output of PV during winter

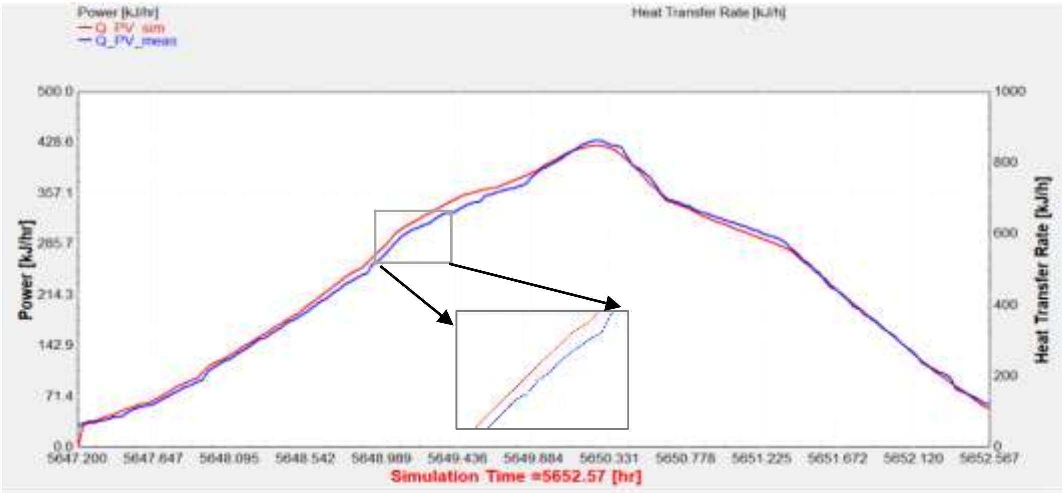


Figure 5.6: PV Comparison between Simulation and experimental power output of PV during summer

Q_{PV_Sim} - Electrical power from simulation

Q_{PV_meas} - Electrical power from simulation

5.5 PVT Optimization Results

The Second Simulation model was developed to represent PVT in order to achieve study objectives. Optimize the performance of PVT using the simulation model by changing some of the parameters. The optimization was done by changing each of the mentioned design parameters and assessing the impact of change on the (Electrical efficiency, Thermal Efficiency, and overall Efficiency). The selected design parameters to be checked were:

i. Number of water tubes
ii. Diameters of water tubes
iii. Water flow rate
iv. PVT panel Area.

The selection of the parameters was done based on the literature review results. Based on the literature review outcomes:

i. Increasing the number of tubes and tube diameters increases the heat transfer rate due to increasing the area of heat exchange/ heat transfer.
ii. Increasing the flow rate enhances the heat transfer coefficient.

Therefore, increasing design parameters is expected to enhance both the thermal and electrical efficiencies of PVT.

Accordingly, the simulation was run for each of the design parameters with a range value. The following is a summary of the results for each parameter and its impact on the overall efficiency. In addition, the same analysis has been done for both summer and winter. The criterion that has been adopted to decide the optimum value of the design parameter was based on the rate change of electrical efficiency. Each of the design parameters has been changed until the rate change in the electrical efficiency reaches zero. Hence, increasing the design parameter will not result in further enhancement in electrical efficiency.

In the below simulation results optimum value will be highlighted in yellow. In some cases, the optimum value for the same design category is different between summer and winter for the same parameter. Accordingly, the selection was done for the first parameter that resulted in a change in electrical efficiency equal to zero.

5.5.1 PVT Water Tubes Number Changes

In the tested PVT panel, the number of tubes was 8 tubes. By using the developed simulation model the number of tubes was changed from 2 to 20 tubes. Increasing the number of tubes led to increasing the area of contact between the working fluid and the absorber. Accordingly, the heat transfer rate was enhanced. Enhancing heat transfer rate resulted in reducing the PV cell temperature and improving both thermal and electrical efficiency. Tables 5.5 and 5.6 show the summary results of changing collector number of tubes in both winter and summer. Figures from 5.7 to 5.10 represent the simulation results of changing the number of the tubes on overall PVT efficiency, PVT electrical efficiency, PVT thermal efficiency, and the PV cell temperature during winter. Figure 5.11 represents the impact of changing PVT number tubes on both cell temperature and Electrical efficiency during winter. The original number of tubes is highlighted in Green for reference. In addition, Figures 5.12 – 5.15 represent the simulation results of changing tubes number on overall PVT efficiency, PVT electrical efficiency, PVT thermal efficiency, and the PV cell temperature during summer. Figure 5.16 represents the impact of changing PVT number tubes on both cell temperature and Electrical efficiency during summer. The results show that by increasing the number of tubes the surface temperature (PVT cell temperature) decreased and resulted in enhancing the electrical efficiency.

Table 5.5: effect of changing PVT collector number of tubes during winter on overall efficiency.

Number of tubes	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Chang in Electrical Efficiency/ Change number tubes	Chang in Thermal Efficiency/ Change number tubes	Chang in overall Thermal/ Change number tubes

2.00	13.77%	31.82%	33.59	46.48	45.59%			
4.00	13.95%	38.69%	31.20	42.28	52.64%	0.0009	0.0344	0.03522
6.00	14.01%	40.99%	30.39	40.86	55.00%	0.0003	0.0115	0.01182
8.00	14.04%	42.11%	30.00	40.17	56.14%	0.0001	0.0056	0.00572
10.00	14.05%	42.76%	29.77	39.76	56.81%	0.0001	0.0033	0.00334
12.00	14.06%	43.18%	29.62	39.50	57.25%	0.0001	0.0021	0.00218
14.00	14.07%	43.48%	29.52	39.31	57.55%	0.0000	0.0015	0.00153
16.00	14.08%	43.70%	29.44	39.18	57.78%	0.0000	0.0011	0.00113
18.00	14.08%	43.87%	29.38	39.0709	57.95%	0.0000	0.0009	0.00087
20.00	14.09%	44.01%	29.33	38.99	58.09%	0.0000	0.0007	0.00069

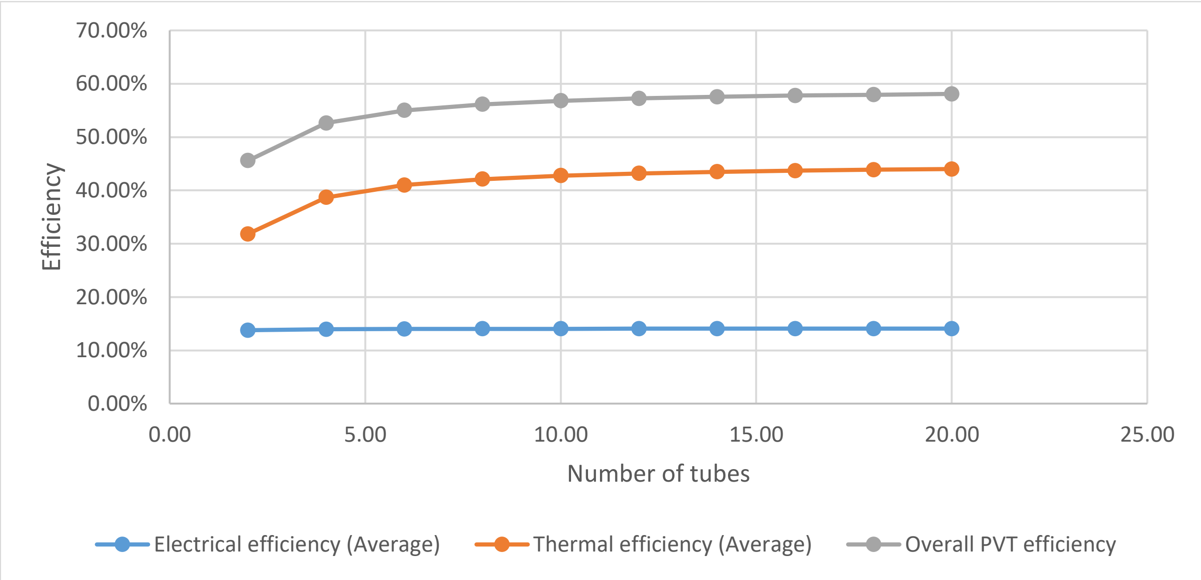


Figure 5.7: Effect of changing number of water tubes on overall PVT Efficiency in winter

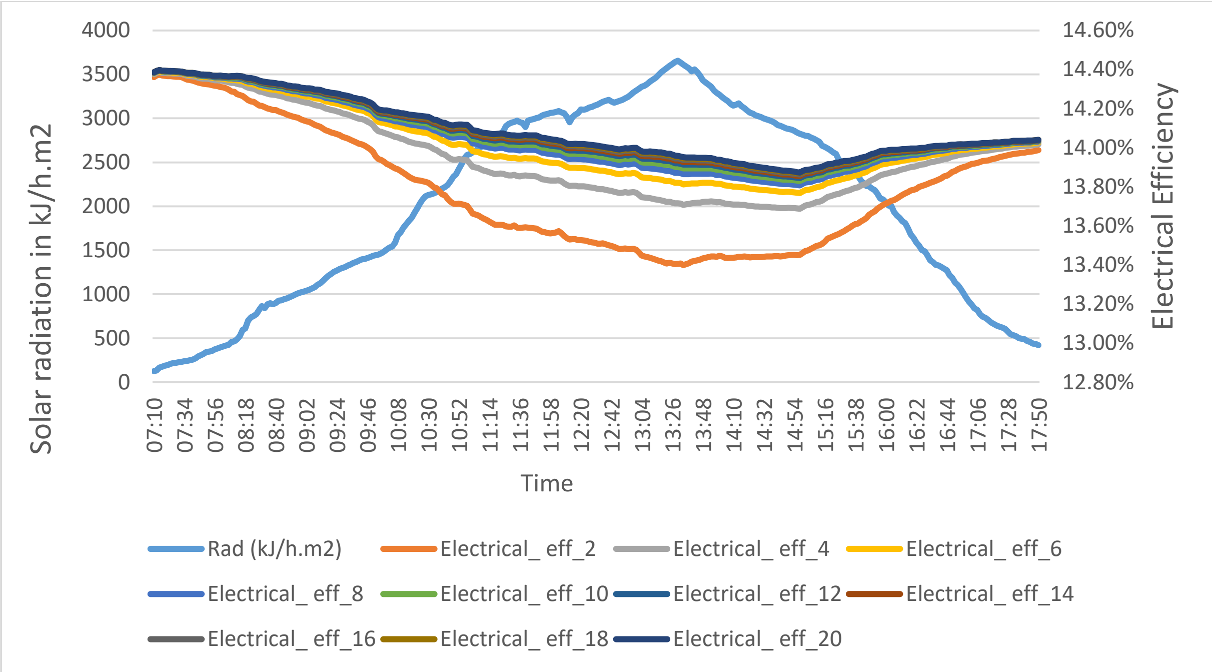


Figure 5.8: Effect of Change in number of water Tubes on PVT Electrical Efficiency during winter

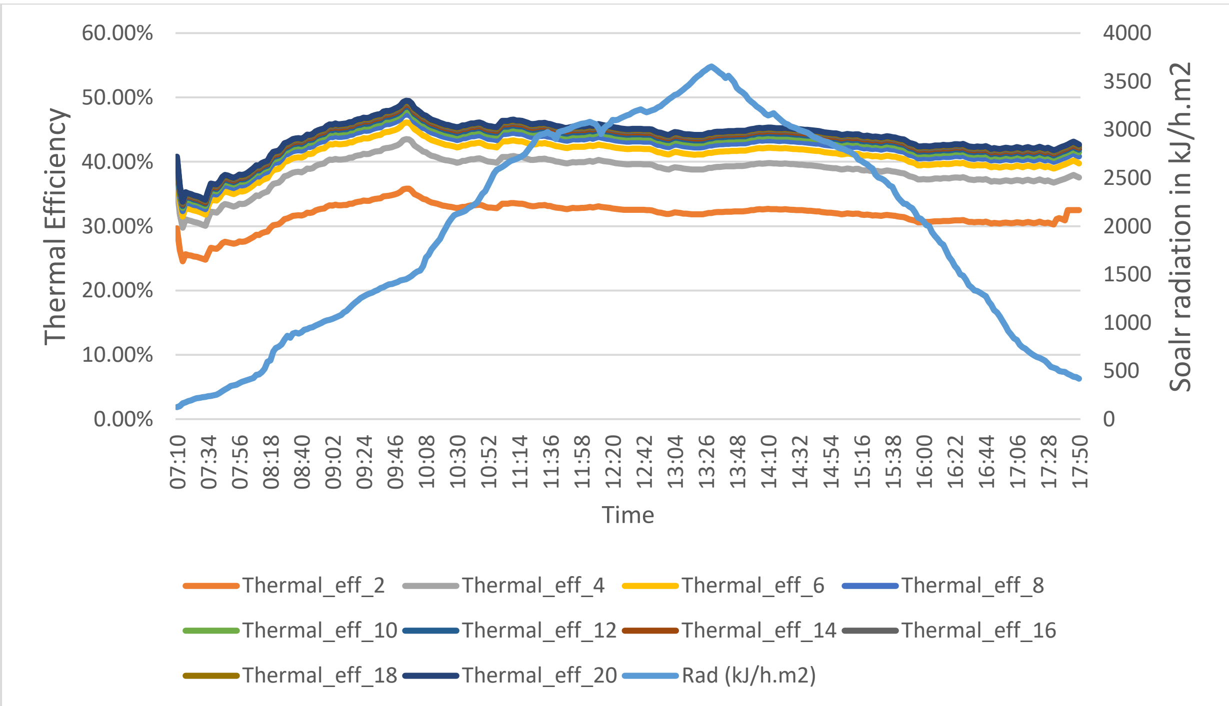


Figure 5.9: Effect of Change in number of water Tubes on PVT Thermal Efficiency during winter

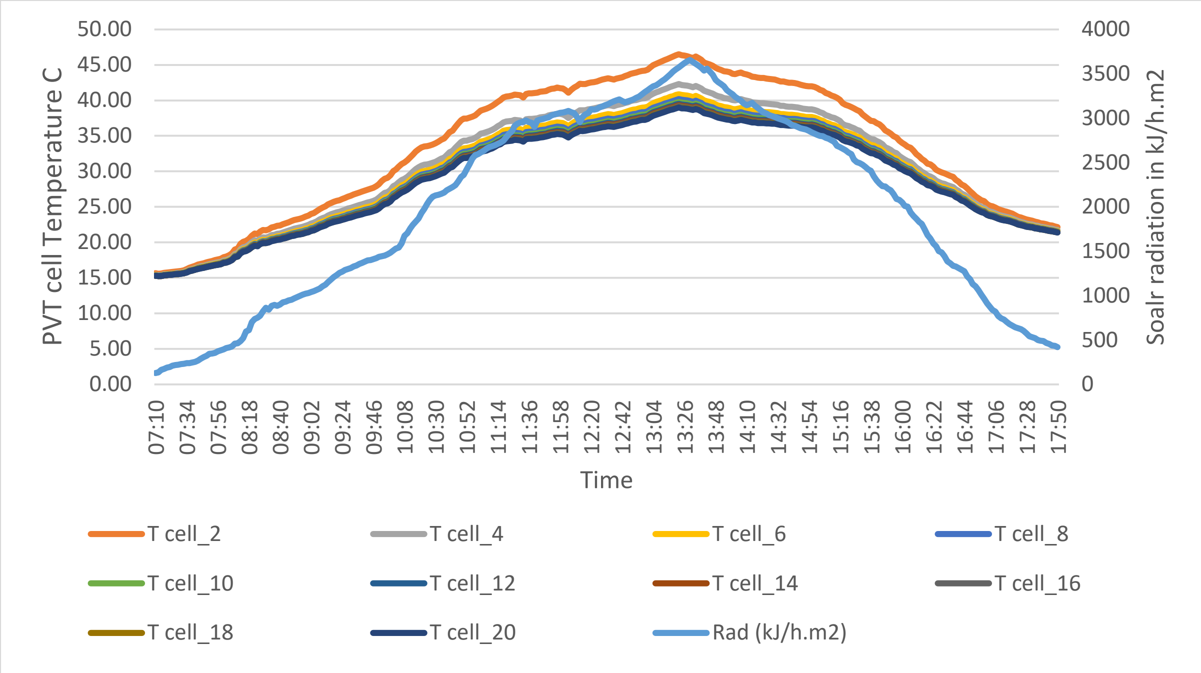


Figure 5.10: Effect of Change in number of water tubes on PVT Cell Temperature during winter

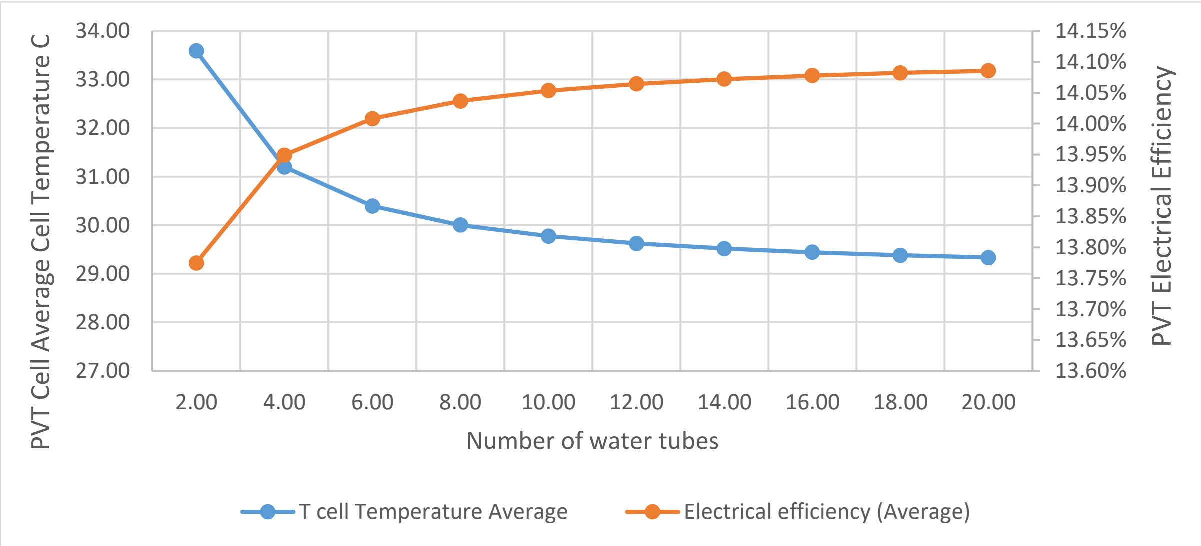


Figure 5.11: Effect of change PVT tubes number on both Cell temperature and Electrical efficiency during winter

Table 5.6: effect of changing PVT collector number of water tubes during summer on overall efficiency.

Number of tubes	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Chang in Electrical Efficiency/ Change number tubes	Chang in Thermal Efficiency/ Change number tubes	Chang in overall Efficiency/ Change number tubes
2.00	13.24%	43.35%	47.73	62.82	56.59%			
4.00	13.40%	52.55%	44.76	58.02	65.94%	0.0008	0.04599	0.04675
6.00	13.45%	0.56	43.76	56.39	69.06%	0.0003	0.01535	0.01560
8.00	13.47%	57.10%	43.27	55.00	70.57%	0.0001	0.00741	0.00753
10.00	13.49%	57.96%	42.99	55.14	71.45%	0.0001	0.00432	0.00439
12.00	13.49%	58.53%	42.80	54.84	72.02%	0.0000	0.00282	0.00287
14.00	13.50%	58.92%	42.67	54.62	72.42%	0.0000	0.00198	0.00201
16.00	13.51%	59.21%	42.58	54.47	72.72%	0.0000	0.00147	0.00149
18.00	13.51%	59.44%	42.50	54.34	72.95%	0.0000	0.00113	0.00115
20.00	13.51%	59.62%	42.44	54.25	73.13%	0.0000	0.00089	0.00091

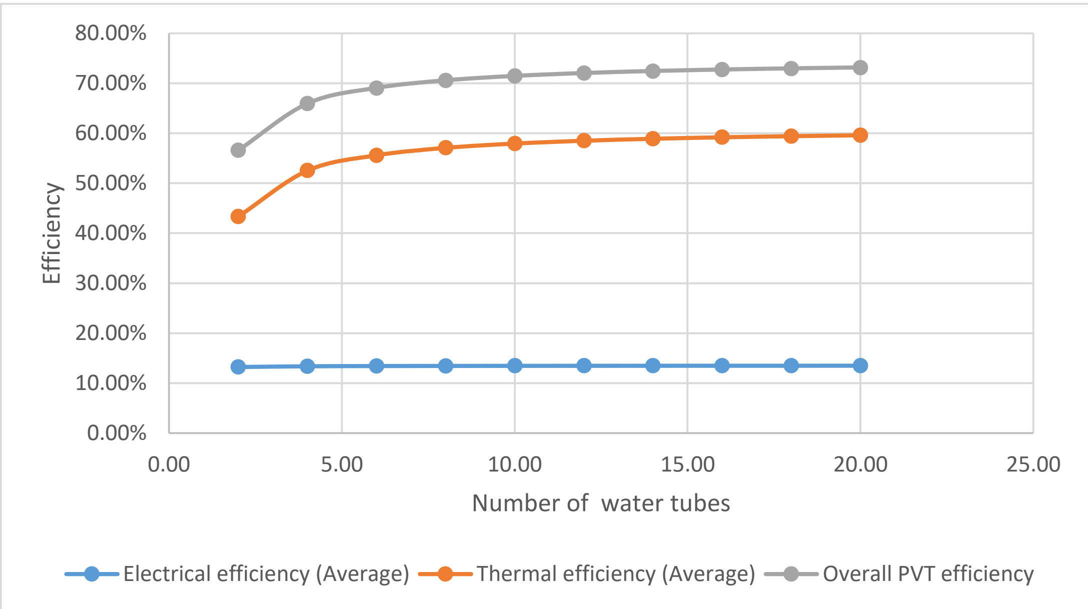


Figure 5.12: Effect of change in number of water tubes on overall PVT Efficiency during summer

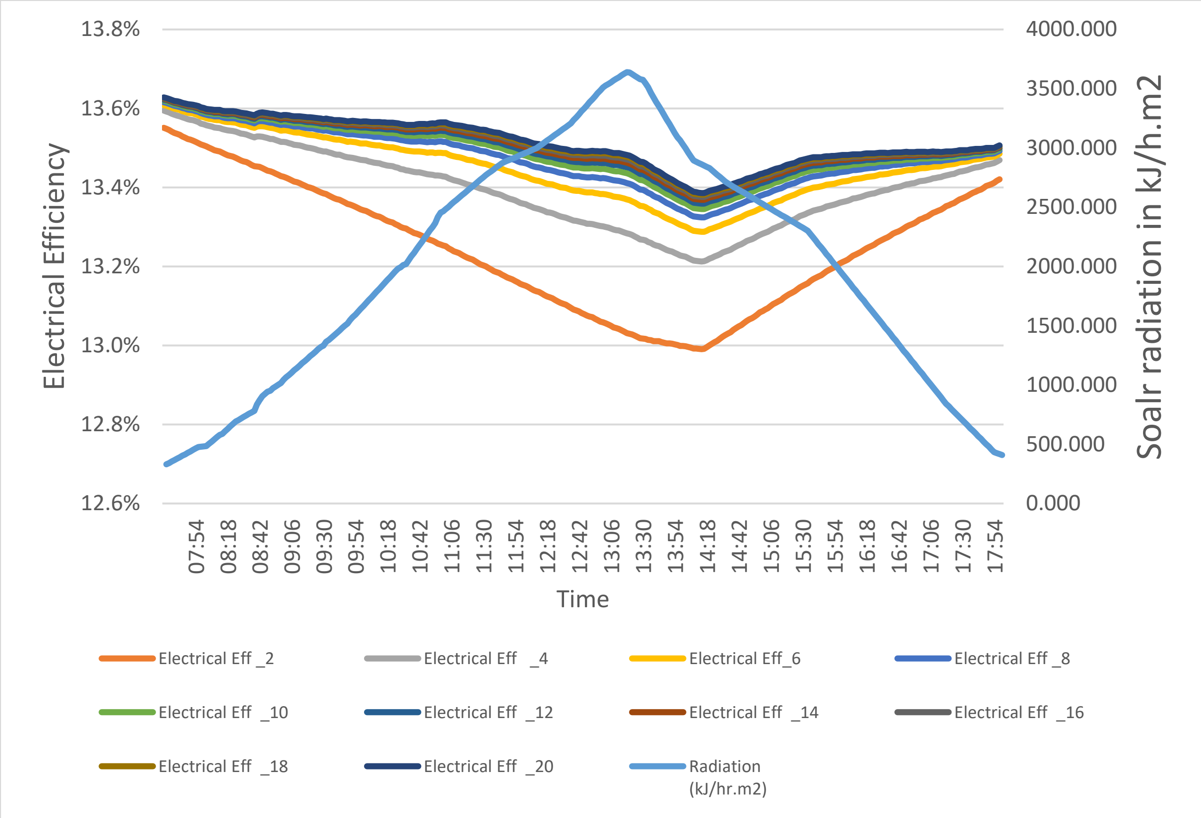


Figure 5.13: Effect of Change in number of water tubes on PVT Electrical Efficiency during summer

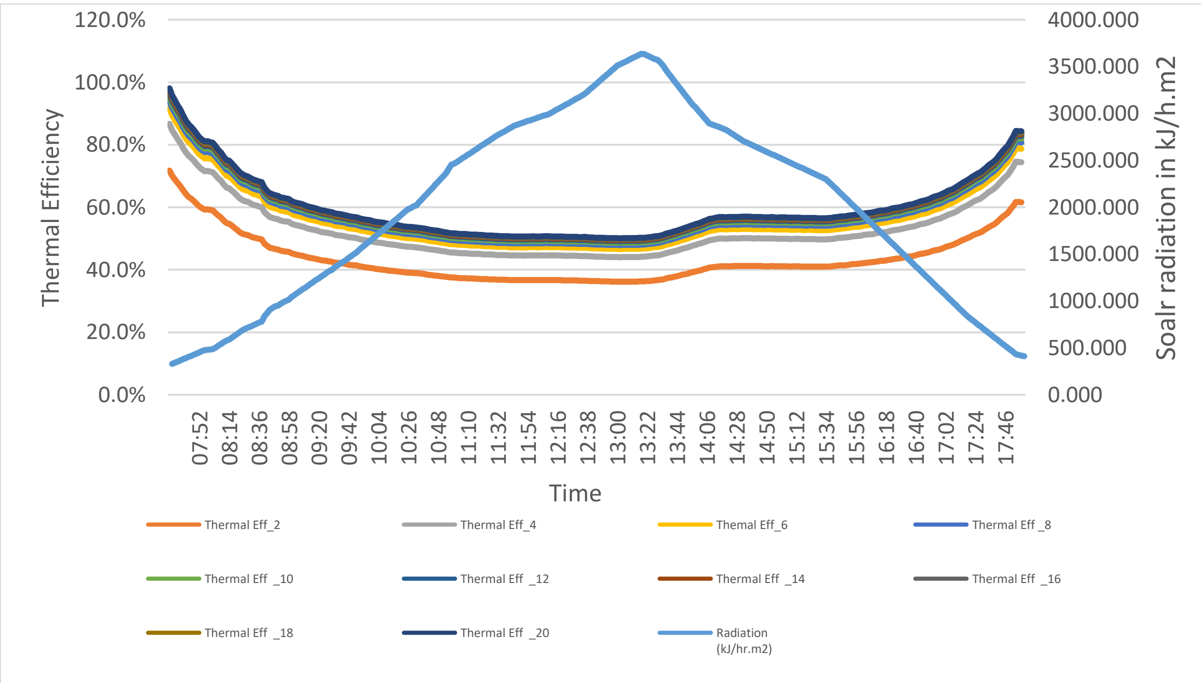


Figure 5.14: Effect of Change in number of water tubes on PVT Thermal Efficiency during summer

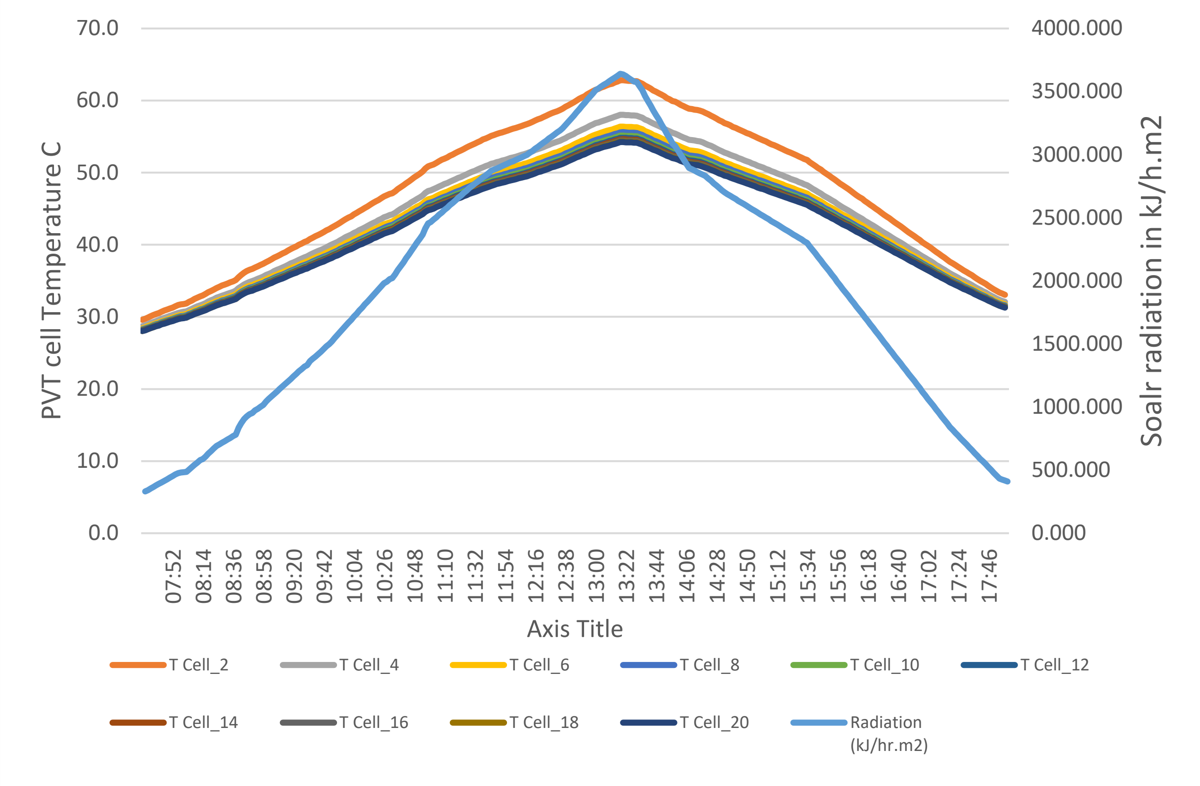


Figure 5.15: Effect of Change in number of water tubes on PVT cell Temperature during summer

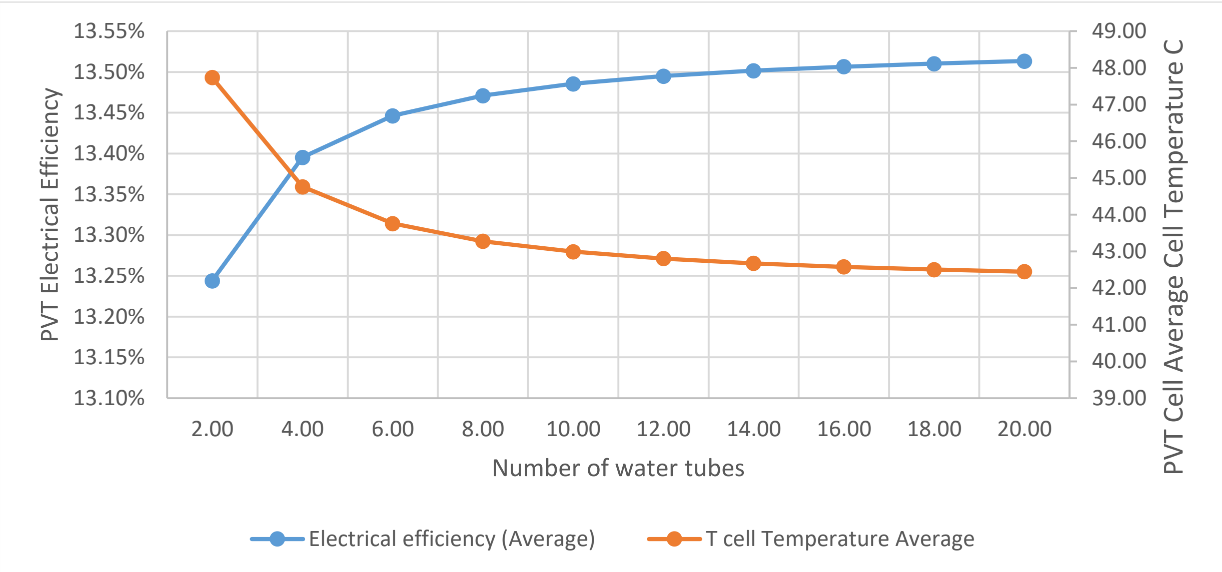


Figure 5.16: Effect of change PVT water tubes number on both cell temperature and electrical efficiency during summer

5.5.2 PVT Water Tubes Diameters Changes

In the tested PVT panel, the tube's diameter was 0.01 m highlighted in green. In simulation analysis tubes' diameter has been changed with freezing other design parameters to study the effect of diameters changes. The selected range is from (0.005 m to 0.055 m). In the following Table 5. 7 and Table 5.8 results summary for both winter and summer. Increasing the tube's diameters enhanced the heat transfer rate. It is expected that by increasing the tube diameter the heat transfer rate increases as the area of contact increases. Accordingly, the PV surface temperature decrease and enhance both (thermal and electrical efficiency). The results are shown in Figures 5.17 and 5.18.

Table 5.7: effect of PVT collector tubes diameters during winter on overall efficiency.

Tube Diameters (m)	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Chang in Electrical Efficiency/ Change tubes diameter	Chang in Thermal Efficiency/ Change tubes diameter	Chang in overall Efficiency/ Change tubes diameter
0.005	13.97%	39.68%	30.85	41.67	53.65%			
0.01	14.04%	42.11%	30.00	40.17	56.14%	0.125	4.8606	4.9851
0.015	14.06%	43.01%	29.68	39.61	57.07%	0.047	1.8130	1.8596
0.02	14.07%	43.50%	29.51	39.30	57.57%	0.025	0.9747	0.9997
0.025	14.08%	43.81%	29.40	39.11	57.89%	0.016	0.6218	0.6378
0.03	14.09%	44.03%	29.33	38.97	58.12%	0.011	0.4377	0.4489
0.035	14.09%	44.19%	29.27	38.87	58.28%	0.008	0.3278	0.3363
0.04	14.09%	44.32%	29.22	38.79	58.42%	0.007	0.2560	0.2626
0.045	14.10%	44.42%	29.19	38.72	58.52%	0.005	0.2056	0.2109
0.05	14.10%	44.51%	29.16	38.67	58.61%	0.000	0.1685	0.1728
0.055	14.10%	44.57%	29.13	38.63	58.68%	0.000	0.1399	0.1436

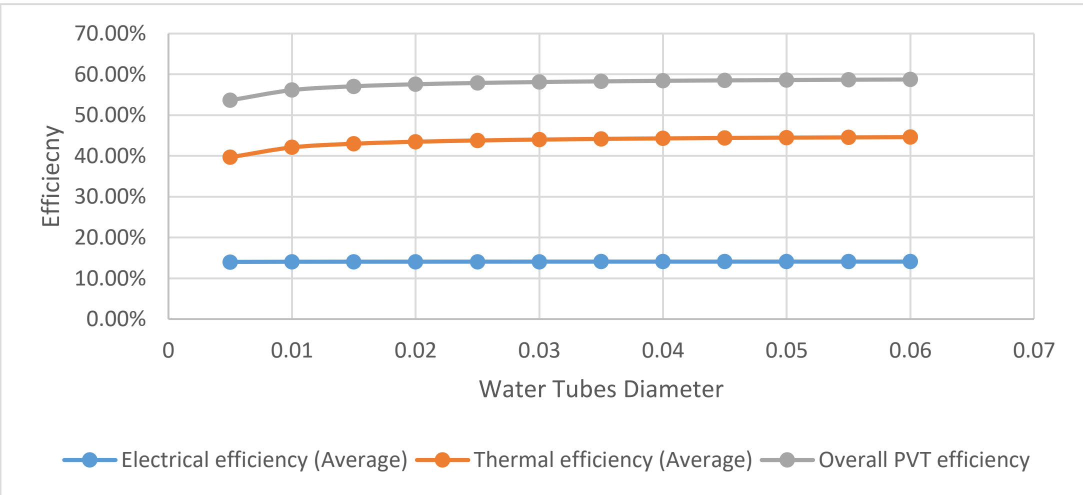


Figure 5.17: Effect of change in tubes diameter on overall PVT Efficiency during winter

Table 5.8: Effect of change collector tubes diameters during summer on PVT overall efficiency.

Tube Diameters (m)	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Chang in Electrical Efficiency/ Change tubes diameter	Chang in Thermal Efficiency/ Change tubes diameter	Chang in overall Efficiency/ Change tubes diameter
0.005	13.42%	53.87%	44.33	57.32	67.28%			
0.01	13.47%	57.10%	43.27	55.60	70.57%	0.1077	6.463793	6.571471
0.015	13.49%	58.30%	42.88	54.96	71.79%	0.0402	2.406342	2.446564
0.02	13.50%	58.95%	42.67	54.61	72.45%	0.0216	1.292558	1.314194
0.025	13.51%	59.36%	42.53	54.39	72.87%	0.0138	0.824203	0.83801
0.03	13.51%	59.65%	42.44	54.23	73.16%	0.0097	0.579971	0.589691
0.035	13.52%	59.87%	42.36	54.12	73.38%	0.0073	0.434334	0.441617
0.04	13.52%	60.04%	42.31	54.02	73.56%	0.000	0.339045	0.344732
0.045	13.52%	60.17%	42.26	53.95	73.69%	0.000	0.272304	0.276872
0.05	13.52%	60.28%	42.23	53.89	73.81%	0.000	0.223082	0.226825
0.055	13.52%	60.38%	42.20	53.84	73.90%	0.000	0.18531	0.18842

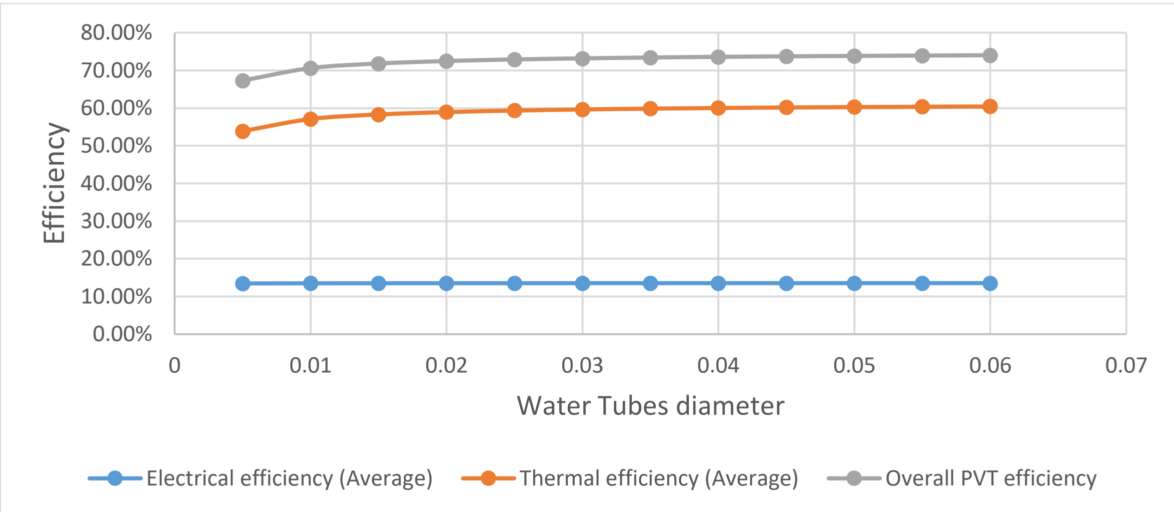


Figure 5.18: Effect of change in water tubes diameter on overall PVT Efficiency during summer

5.5.3 Water Flow Rate Changes

The fluid flow rate affects directly the performance of PVT. Accordingly, through using the simulation model the flow rate of the water was changed from (0.125 GPM to 5 GPM). Increasing the flow rate enhanced the thermal coefficient which reduced the PV surface temperature. Accordingly, both thermal and electrical efficiencies of the PVT were enhanced.

Table 5.9 and 5.10 summary of the analysis for both winter and summer. Figure 5.19 and 5.20 represents the results of changing water flow rate as explained graphically for both winter and summer as indicated below.

Table 5.9: Effect of change in water flow rate on overall efficiency of PVT during winter.

flow rate GPM	flow rate Kg/hr	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Chang in Electrical Efficiency/ Change in flow rate	Chang in Thermal Efficiency/ Change in flow rate	Chang in overall Efficiency/ Change in flow rate
0.125	28.4	13.94%	35.82%	31.28	42.40	49.76%			
0.25	56.8	14.02%	39.05%	30.23	40.56	53.07%	0.0061	0.258	0.264
0.5	113.6	14.06%	40.81%	29.66	39.56	54.87%	0.0017	0.070	0.072
1	227.2	14.08%	41.73%	29.37	39.03	55.81%	0.0004	0.018	0.019
1.5	340.8	14.09%	42.04%	29.26	38.85	56.13%	0.0001	0.006	0.006
2	454.4	14.09%	42.20%	29.21	38.76	56.29%	0.0001	0.003	0.003
2.5	568	14.10%	42.29%	29.18	38.70	56.39%	0.0000	0.002	0.002
3	681.6	14.10%	42.35%	29.16	38.67	56.45%	0.0000	0.001	0.001
3.5	795.2	14.10%	42.40%	29.15	38.64	56.50%	0.0000	0.001	0.001
4	908.8	14.10%	42.43%	29.14	38.62	56.53%	0.0000	0.001	0.001
4.5	1022.4	14.10%	42.46%	29.13	38.61	56.56%	0.0000	0.001	0.001
5	1136	14.10%	42.48%	29.12	38.59	56.58%	0.0000	0.000	0.000

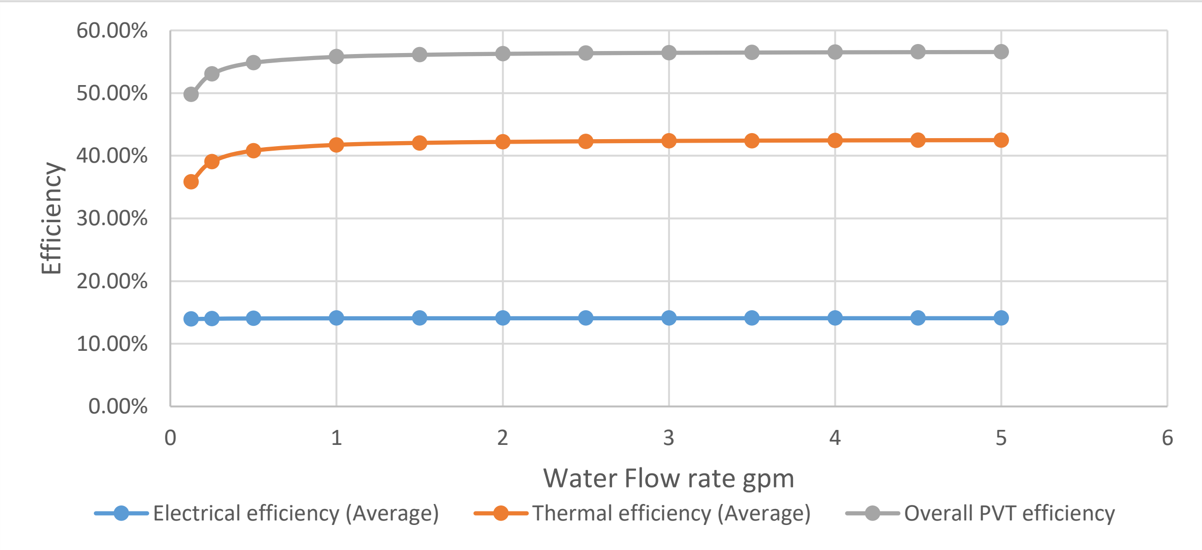


Figure 5.19: Effect of changing flow Rate on overall PVT Efficiency during winter

Table 5.10: Effect of change in water flow rate on overall efficiency of PVT during summer

flow rate GPM	flow rate Kg/hr	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Chang in Electrical Efficiency/ Change in flow rate	Chang in Thermal Efficiency/ Change in flow rate	Chang in overall Efficiency/ Change in flow rate
0.125	28.4	13.36%	50.53%	45.42	59.09	63.89%			
0.25	56.8	13.43%	54.79%	44.03	56.83	68.22%	0.0057	0.341	0.346
0.5	113.6	13.47%	57.10%	43.27	55.60	70.57%	0.0015	0.092	0.094
1	227.2	13.49%	58.30%	42.88	54.96	71.79%	0.0004	0.024	0.024
1.5	340.8	13.50%	58.71%	42.75	54.74	72.20%	0.0001	0.008	0.008
2	454.4	13.50%	58.91%	42.68	54.63	72.41%	0.0001	0.004	0.004
2.5	568	13.50%	59.03%	42.64	54.56	72.54%	0.0000	0.002	0.002
3	681.6	13.50%	59.12%	42.61	54.52	72.62%	0.0001	0.002	0.002
3.5	795.2	13.51%	59.18%	42.59	54.49	72.68%	0.0000	0.001	0.001
4	908.8	13.51%	59.22%	42.58	54.46	72.73%	0.0000	0.001	0.001
4.5	1022.4	13.51%	59.26%	42.56	54.44	72.76%	0.0000	0.001	0.001
5	1136	13.51%	0.592827	42.56	54.43	72.79%	0.0000	0.001	0.001

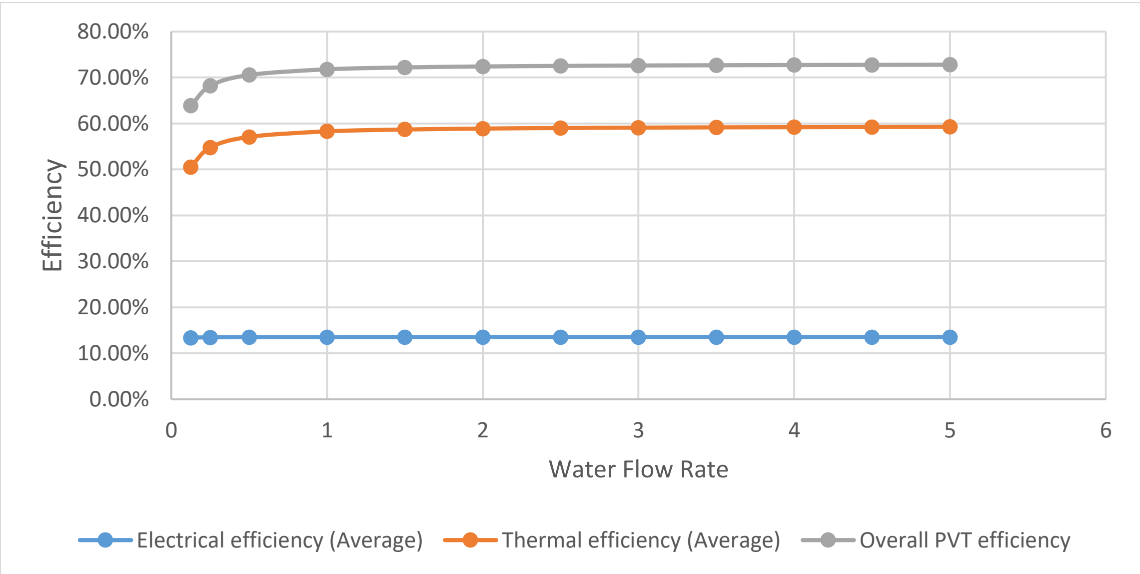


Figure 5.20: Effect of changing flow Rate on overall PVT Efficiency during summer

5.5.4 PVT Panel Area Changes

PVT panel area was changed by using a simulation model to assess the impact of the changing panel area on the overall efficiency. The results showed that the PVT efficiency decreased with increasing the area of the panel as shown in Tables 5.10 and 5.11. The reason is that efficiency has inverse relation with area as shown in equation 4.8 and equation 4.9. Both electrical efficiency and thermal efficiency slightly changed with changing the area of the panel. Hence, the effect on efficiencies were minor on the tested range of area as shown in Figures 5.21 and 5.22.

Table 5.11: Effect of change PVT panel area on overall efficiency of PVT during winter

PVT Panel Area m^2	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency
0.914	14.10%	42.4%	29.14	38.63	56.53%
1.2	14.10%	42.35%	29.16	38.67	56.45%
1.5	14.10%	42.27%	29.19	38.72	56.37%

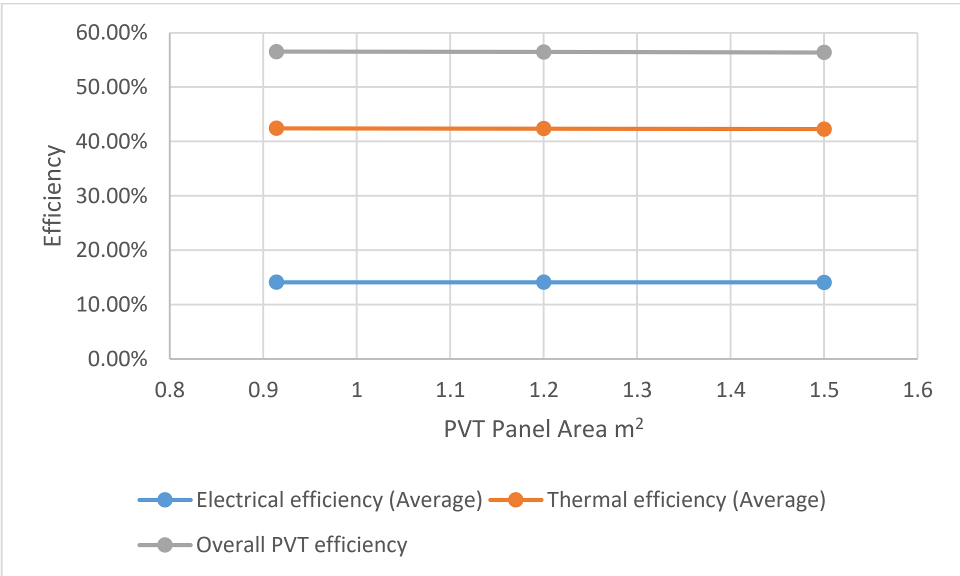


Figure 5.21: Effect of change panel Area overall PVT Efficiency during winter

Table 5.12: Effect of change PVT panel area on overall efficiency of PVT during summer

PVT Panel Area m^2	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency
0.914	13.48%	57.65%	43.09	55.31	71.13%
1.2	13.47%	57.10%	43.27	55.60	70.57%
1.5	13.46%	57.10%	43.45	55.89	70.56%

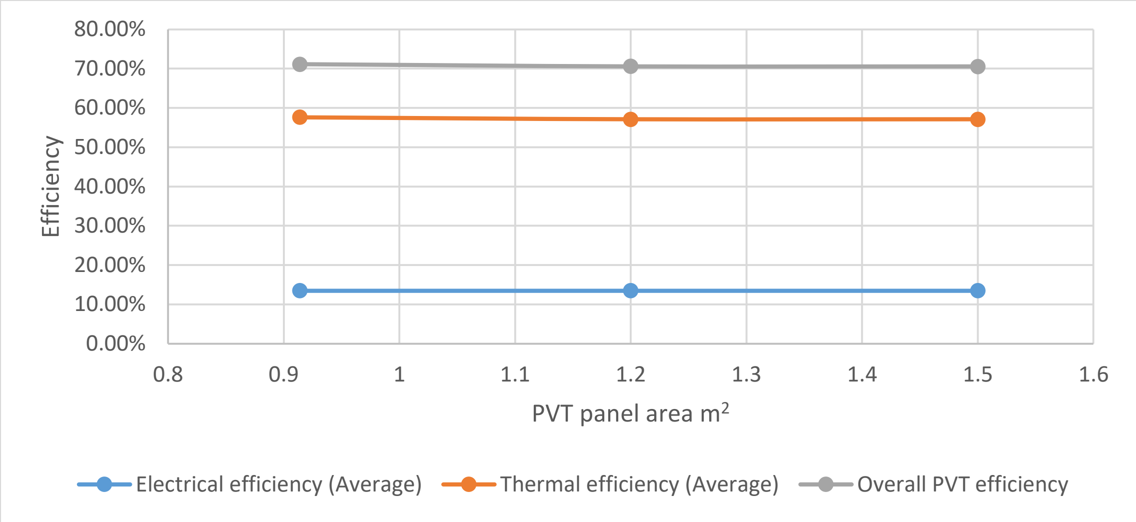


Figure 5.22: Effect of change Panel on overall PVT Efficiency during summer

5.5.5 Complied Optimized Model

After identifying individual optimized parameter in the previous steps. Simulation for the optimized model has been tested compiling all the optimized values in one model. The optimized design parameters shown in below Table 5.12.

Table 5.12: List of optimize design parameters

Parameters	Optimum value	Unit
Number of water tubes	12	Number
Diameters of water tubes	0.040	m
Water flow rate	2.5	gpm

Table: 5.13: Comparison between the reference model and Optimized model during winter

Model	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Percentage of Enhancement in overall efficiency of PVT
Reference model	14.04%	42.11%	30.00	40.17	56.14%	7.2%
Optimized Model	14.15%	46.38%	28.50	37.50	60.53%	

Table: 5.14: Comparison between the reference model and Optimized model during summer.

Model	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average C	T cell Temperature Maximum C	Overall PVT efficiency	Percentage of Enhancement in overall efficiency of PVT
Reference model	13.47%	57.10%	43.27	55	70.57%	7.5%
Optimized Model	13.57%	62.73%	41.41	52.55	76.29%	

Table 5.15: Compassion between PV panel Experimental results and Optimized model

	Optimized Model	PV	Enhancement in Electrical Efficiency
Electrical Efficiency in Winter	14.15%	13. 3%	6%
electrical Efficiency in Summer	13.57%	12.2%.	10%

5.6 Results Discussion

5.6.1 Experimental Results

Experimental results during winter gave a maximum electrical power generated from PVT of 119.2 W with a maximum electrical efficiency of 14% during the day. In comparison with the conventional PV panel, the maximum generated power was 115.5 W with a maximum electrical efficiency of 13.3%. Therefore, the enhancement of electrical efficiency in PVT was due to the cooling effect of water on the PVT cells (surface temperature). The cooling effect of water enhanced the output voltage from the PVT panel. Photovoltaic power output is affected mainly by two factors:

i. Weather conditions.

ii. PV cell temperature.

The enhancement in the efficiency was equal to 0.7% between the PVT and the PV that is equal to 5%.

In addition to the electrical power, PVT generated thermal power of 494.25 W with a maximum thermal efficiency of 53.8% and average thermal efficiency of 42.5% during the test day; the test day was 7th Feb 2020. The maximum ambient temperature was around 24^oC degrees during noontime and the highest global solar radiation was 1005 W/m^2. All the mentioned results are shown in Table 5.1.

During summer the test was conducted on 24th August 2020; the highest ambient temperature reached around 46^oC degrees and the highest global solar radiation was 1014 W/ m^2.

The maximum electrical power generated from the PVT was 127.59 W and the maximum electrical efficiency was 13.40%. The maximum power generated from the PV panel was 120.375 W and the highest electrical efficiency was 12.2%. Accordingly, the enhancement in the electrical efficiency of PVT in comparison to PV and due to the effect of water cooling during summer was 1.2% that is equal to 8.9%. As per equation (4.11), the PV's electrical efficiency has an inverse relationship with increase PV cell temperature.

The generated thermal power was 584.163 W with a maximum thermal efficiency of 83% and Average thermal efficiency of 57.1 %. Thermal efficiency, in general, depends on several factors as inlet water temperature, ambient temperature, and global solar radiation. All of the above results are summarized in Table 5.2.

From the results, PVT thermal performance was higher during summer more than in winter due to two reasons:

i. High ambient temperature.
ii. Higher solar radiation.

On the other hand, the electrical efficiency of PVT during summer was less than the electrical efficiency during winter due to an increase in PVT cell temperature which resulted in decreasing the electrical efficiency.

However, the enhancement of the PVT electrical efficiency during summer was 1.2% more than in winter at 0.7%.

5.6.2 Simulation Results:

Simulation results are shown in the following section. The optimization results for the design parameters (number of water tubes, water tubes diameter, water flow rate, and PVT area) are given in detail. The aim of changing the design parameters was to find the optimum value for each design parameter. Then, find the optimum performance of PVT by combining all the optimized parameters in one model.

5.6.3 Changing number of PVT collector tubes

Simulation results showed that increasing the number of tubes resulted in enhancing both the electrical and thermal efficiency of the PVT. This was due to an increase in the area of contact between the collector tubes and the working fluid. Accordingly, heat transfer enhanced and the PVT overall performance improved. Table 5.5 shows the effect of changing the collector number of tubes during winter on the overall efficiency of PVT. The optimum number of tubes was 12 tubes as per the setup criterion. In addition, increasing the number of tubes from 2 to 12 decreased the PV cell surface temperature from 33.59^{o}C to 29.62^{o}C in average temperature and from 46.48^{o}C to 39.50^{o}C in T cell maximum temperature. The thermal efficiency was enhanced from 31.82% for 2 tubes to 43.18% for 12 tubes. The overall efficiency increased from 45.59% to 57.25%.

For summer results, Table 5.6 shows the effect of changing the number of water tubes in summer on PVT overall efficiency. The optimum number of tubes was 12. The electrical efficiency was enhanced from 13.24 % for 2 tubes to 13.49% due to water cooling effect the PVT cell temperature from 47.73^{o}C to 42.80^{o}C on average and 62.82^{o}C to 54.84^{o}C in maximum PV cell Temperature. The thermal efficiency was enhanced from 43.35% for 2 tubes to 58.53% for 12 tubes. Accordingly, the overall efficiency was enhanced by almost 15.18 % for an increasing number of tubes.

In addition, Figure 5.8 shows that the lowest electrical efficiency values during noontime as the global solar intensity was high. As mentioned before, factors that affect electrical efficiency are PV cell temperature (PV surface Temperature) and weather conditions. Equation (4.9) indicates that electrical efficiency has an inverse relationship with solar radiation. Accordingly, the electrical efficiency is expected to be lower during noon time when the solar radiation intensity is high, and the PV temperature cell is high.

Figure 5.9 represents the effect of changing the number of collector tubes on PVT Thermal Efficiency during winter. The thermal efficiency during morning time increased as the inlet water temperature was cold. Hence, the water is highly absorbing the heat. Thermal efficiency is defined as the ratio of thermal energy absorbed by water and increased fluid temperature to the total solar energy falling on the collector surface. The thermal energy degraded in the middle of the day where the solar radiation was high and the inlet water temperature increased. Hence, water's ability or capacity to absorb more heat decreased.

Thermal efficiency in summer was higher than thermal efficiency in winter. However, as shown in 5.14, thermal efficiency at the early morning hours was very high then decreased almost 15% to 20% noontime. The reason is that the inlet temperature of water increased at noontime. An increase in inlet water temperature especially if it is reaching the ambient temperature values, decreases the thermal efficiency as it affects the ability of water to gain more energy. Thermal efficiency has an inverse relation with $(T_m - T_a)/G$ as shown in Figure 5.3 and Figure 5.4.

The study conducted by Adeli et al. (2012) supported the results in this research. In Adeli's study, the channel length has increased which has the same effect of increasing the water tube numbers as the length of the tubes was increased. Water has to flow in a long bath before exiting the PVT panel. Adeli et al. (2012) result showed that both thermal and electrical efficiency kept increasing until reaching stable values as shown in Figure 3.16

In addition, the study conducted by Alobaid et al. (2018) the results showed that thermal and electrical efficiencies were high during the morning time and afternoon time. However, at the noontime when the instance solar radiation, ambient temperature, Intel water temperature, and PVT surface temperature were high, the thermal and electrical efficiencies were low as shown in Figure 3.36.

5.6.4 PVT Collector Tubes Diameter Changes

The second parameter was changing tubes diameter. By increasing the diameter of the tubes, the area of contact with working fluid increases. As a result, the heat transferred between the collector and the working fluid is enhanced.

The optimum tube diameter in both winter and summer was found to be 0.04 m. In winter, electrical efficiency was 14.09%, Thermal efficiency was 44.32%, and the overall PVT efficiency was 58.42%.

The PV cell temperature (PV surface temperature) decreased from 30.85^{o}C at diameters of 0.005 m to 29.22^{o}C in an Average temperature and from 41.67^{o}C to 38.79^{o}C in the maximum PV cell temperature as shown in Table 5.7

During summer, the thermal performance was better. However, the electrical performance was less during winter due to an increase in PV cell temperature. Electrical efficiency was 13.52%, thermal efficiency 60.04% and, overall PV thermal efficiency was 73.56%. The enhanced average temperature at the diameter of 0.005 m was from 44.33ºC to 42.31ºC as shown in Table 5.8

5.6.5 Water Flow Rate Changes

The water flow rate was changed to a range of values: 0.125, 0.25, 0.5, 1, 1.5, 2, 2.5,….. and 5. All the mentioned flow rates were in gallon per minute. According to the simulation model results, the optimum flow rate for winter and summer was 2.5 GPM. The efficiency kept increasing with increasing the water flow rate as shown in Table 5.9.

During winter, electrical efficiency was 13.94%, thermal efficiency was 35.82%, and overall efficiency was 49.76% as shown in Table 5.9 at a water flow rate of 0.125 GPM. The efficiency was enhanced at the optimum flow rate of 2.5 GPM as electrical efficiency reached 14.10%, Thermal efficiency reached 42.29%, and overall efficiency 56.39%.

In summer analysis, with a water flow rate of 0.125 GPM, electrical efficiency was 13.36%, thermal efficiency 50.53%, and overall efficiency 63.89%. In optimum water flow rate 2.5 GPM, electrical efficiency was 13.50%, thermal efficiency was 59.03%, and the overall PVT efficiency was 72.54%. The average PV cell temperature decreased from 45.42ºC at 0.125 GPM to 42.64 C at 2.5 GPM as shown in Table 5.10.

Many researchers have studied the effect of changing the mass flow rate. In general, the outcomes of previous studies related to efficiencies enhancement are matching with the current study results. Rahou et al. (2014) conducted a study of changing the mass flow rate and, the results showed that increasing the mass flow rate resulted in increasing both electrical and thermal efficiency. Thermal efficiency was enhanced dramatically against electrical efficiency which, was enhanced slightly as shown in Figure 3.8.

5.6.6 PVT Panel Area Changes

PVT panel gross area was changed with a range of 0.914, 1.2, and 1.5 m2. The impact of changing PVT area on electrical efficiency, Thermal efficiency, and overall efficiency for both winter and summer is shown in Table 5.11 and Table 5.12. The results showed that the electrical and thermal efficiency both slightly decreased when the PVT area increased. In winter, the PVT panel area increase from 0.914m2 to 1.5 m2. The electrical efficiency kept constant at 14.10%. The main reason was that the PV surface temperature changed slightly from 29.14^{o}C to 29.19^{o}C on average. However, thermal efficiency decreased slightly from 42.4% to 42.27%. In summer, electrical efficiency slightly decreased from 13.48% to 13.46% with increasing the PVT area. This is due to an increase in PV surface temperature from 43.05^{o}C to 43.45^{o}C on average. Thermal efficiency as well decreased slightly from 57.65% to 57.10%. Accordingly, the overall efficiency slightly decreased from 71.13% to 70.56%. By increasing the panel area, the instance solar energy falling on the PVT panel increase that led to decrease in efficiencies. In addition, electrical and thermal efficiency have an inverse relation with the area.

5.6.7 Optimized Model

In the optimized model where all the optimum parameters were compiled the results are shown in Tables 5.13 and 5.14. Winter results showed that the optimized model has a 7.2% increase in overall efficiency than the reference model, the electrical efficiency increased from 14.04% to 14.14%, and thermal efficiency enhanced from 56.14% to 60.53%.

Summer results showed that the optimized model has a 7.5% increase in overall efficiency than the reference model. The electrical efficiency increased from 13.47% to 13.57%, and the thermal efficiency increased from 57.10% to 62.73%.

In addition, the enhancement in the electrical efficiency between conventional PV panels and the optimized model in the winter was 6% and in summer was 10% as shown in Table 5.15.

CHAPTER VI

Research Conclusion and Recommendations

6.1 Research Conclusion

In the current research, the study has been carried out through two main parts (experimental part and simulation part) in order to achieve the study objectives. The first objective was to test and evaluate the electrical efficiency of PVT in comparison to standard PV during winter and summer. Hence, in the experimental part PVT panel and PV panel have been tested under the same weather conditions to study the performance. The experiment was conducted twice during winter and summer. In winter, the enhancement in the PVT electrical efficiency was 5% (as the increase was 0.7%) compared with the PV panel. In summer, the enhancement in electrical efficiency was 8.9% (as the increase was 1.2 %) compared to the PV panel of the identical electrical specification. On the other hand, thermal performance in both winter and summer was acceptable as in winter was 53.8% and in summer 57.1%. Since there was a tangible improvement in the electrical efficiency, PVT consider being a feasible system being used under UAE climate conditions.

In the second part of the research, the experimental data was utilized to develop a simulation model to achieve the second objective of the research. The software which was used to develop the model was TRNSYS. The TRNSYS component used to represent PVT was Type 560.

In order to validate the developed simulation model, the experiment results were compared with simulation results with an acceptable error percentage of 5%. In chapter 5, the results of the comparison were presented in Table 5.3 and Table 5.4. The simulation models provide results with percentage errors that did not exceed 5%. Therefore, it can be concluded the developed simulation models were valid and provided realistic results. Accordingly, the third objective of the research was accomplished.

The last objective was to optimize PVT performance by changing selected parameters such as (number of tubes, diameters of tubes, PVT panel area, and water flow rate). The optimization was performed by using the PVT simulation model in winter and summer.

The results showed that an increasing number of tubes enhanced both the electrical and thermal efficiency of the PVT. The optimum number of tubes was found to be 12 number with overall PVT efficiency of 57.25% during winter and 72.02% during summer.

The second parameter was the diameter of the tubes. The optimum size of collector tubes was 0.04 m. The optimum size of tubes resulted in 58.42% of overall PVT efficiency during winter and 73.56% during summer.

The third selected parameter was the PVT panel area, the results showed that increasing the gross area decreases both thermal and electrical efficiency. The overall efficiency in winter decreased from 56.53% to 56.37% with increasing the PVT areas from 0.941 m2 to 1.5 m2. In summer, the overall efficiency decreased from 71.13% to 70.56%. Therefore, increasing the panel is not a feasible option.

For the change in flow rate, the optimum flow rate was 2.5 GPM. The overall PVT efficiency during winter was 56.39% and during summer was 72.54%.

Lastly, all the optimized parameters were combined and used in one model. In the optimized model, the overall efficiency in winter was 60.53%, and in summer, the overall efficiency was 76.29%.

In comparing PV electrical efficiency resulting from the experiment with the electrical efficiency of the optimized model, the results that the electrical efficiency of the PVT optimized model was better than PV by 6% more during winter and 10% more during summer.

In addition, it can be concluded that PVT performance was higher during summer than winter. The most influenced parameter among the studied ones was water flow rate. From mentioned results, it can be concluded that PVT is considered a feasible system in countries with the same weather conditions as the UAE.

6.2 Recommendations for Further Studies

Based on the knowledge gained from the study. I would like to recommend the following further studies.

i. Experimentally test the optimized model to verify simulation results. There was a limitation of time in the current research. Hence, the re-test was not conducted.
ii. Other design parameters can be tested (using different types of absorber material and changing absorber thickness).
iii. Link the change in design parameters with the cost of each parameter. Without proper cost estimation of the change in design parameters.
iv. Study using the generated electrical power from PVT to power a heater to further heat the water in the collecting tank. That might provide enough energy to raise the water temperature to a high temperature equivalent to water temperature resulting from a concentrated solar collector.

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Appendix A:

Data logger

SPECIFICATIONS

USB-6210

16 AI (16-Bit, 250 kS/s), 4 DI, 4 DO USB Multifunction I/O Device

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

The following characteristic specifications describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- *Typical* specifications describe the performance met by a majority of models.
- *Nominal* specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are *Typical* unless otherwise noted.

Conditions

Specifications are valid at 25 °C unless otherwise noted.

Analog Input

Number of channels	8 differential or 16 single ended
ADC resolution	16 bits
DNL	No missing codes guaranteed
INL	Refer to the *AI Absolute Accuracy* section
Sample rate	
Single channel maximum	250 kS/s
Multichannel maximum (aggregate)	250 kS/s
Minimum	0 S/s
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Input coupling	DC

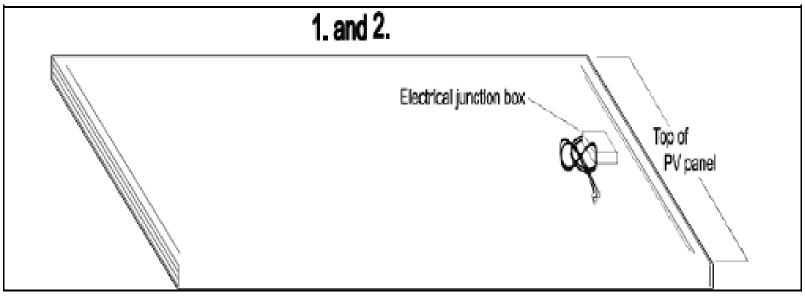
NATIONAL INSTRUMENTS

SDM100

Hybrid Solar Collector

HarvestHP™
Assembly Guide

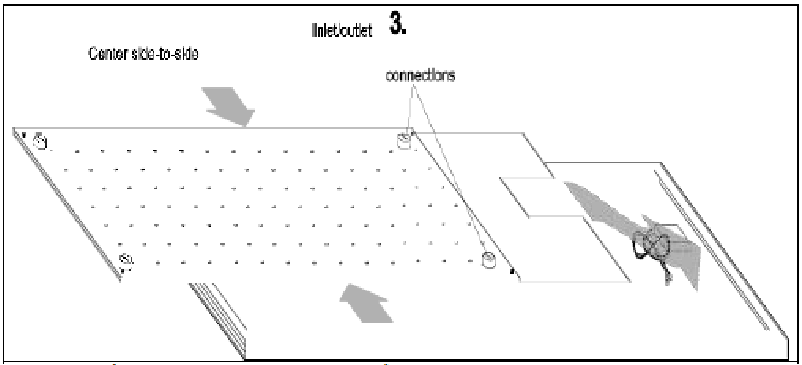
Revision #	Description	Date	Author	Approved
001	Release to Publication	11/21/16	GI	MGI



The back side of the PV panel, before placing the SDM100 collector on the panel. "Top" is on the right in this drawing.

2. Clean the back of the PV panel, and be sure it is free of dust and grit. If necessary, you may have to vacuum or wipe it. Also, note that the surface of the SDM100 collector has some thermal pads attached to protect the back of the PV panel.

3. Place the SDM100 collector flat on the back side of the PV panel, within the PV panel frame, taking care to ensure that the cutout end surrounds the junction box and the inlet/outlet connections are face up. Center the collector on the back of the PV panel in left-right direction.



Alignment of the SunDrum collector with the PV panel frame.

Note: *SDM100 collectors use the top bracket to make the ground connection.*

SUNDRUM
SOLAR

SDM100-300 Technical Data Sheet

General Specifications:

	Metric (mm)	English (inches)
Housing Length	1321	52
Housing Width	914	36
Housing Fin Cut out	101.6x203	4x8
Housing Thickness	6	0.240
Insulation Dimensions	914x572 2X	36x22.5 2X
Compatible PV panels	SunPower; Schott; Schuco; Suntech; Trina; Perlight Solar; Solar World; Suniva; Canadian Solar; Mage; Solon; Silevo; LG; Hanwha	
Operating Temp	-40 - 90 C	-40 - 194 F
Connections	1/2 NPT 4X	

Class C Fire Rating

SunPower			Schott			Schuco			
Bracket Length	1040	40.93	Bracket Length	987	38.85	Bracket Length	987	38.85	
Bracket Depth	35	1.36	Bracket Depth	38	1.50	Bracket Depth	35	1.37	
Bracket Weight 4x	3.50	lb		3.50	lb		3.50	lb	
	Metric		English			Metric		English	
Gross Area:	1.30	m^2	14.00	ft^2	Net Aperture area	1.09	m^2	11.8	ft^2
Dry Weight:	11.04	kg	23	lb	Min Fluid Capacity	2.90	Litres	0.8	gal
Max pressure	41.34	KPa	6	psi	Max Fluid Capacity	4.15	Litres	1.1	gal

Data subject to change without notice. Performance data without guarantee.
Kinetic Resistance:

SunDrum® Solar Confidential

SunDrum Solar, LLC 469 River Road Hudson, MA 01749 508-740-6256 www.sundrumsolar.com

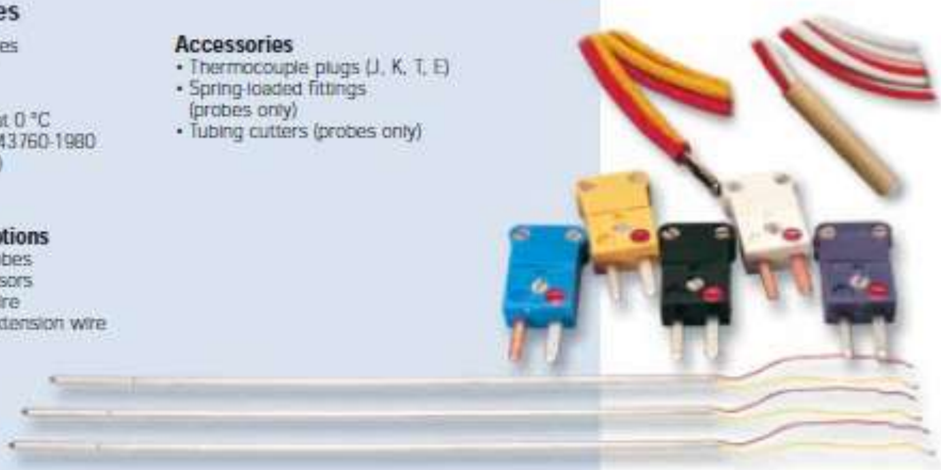
Thermocouple and RTD Sensors

Thermocouples
- J, K, T, and E types

RTDs
- Platinum 100 Ω at 0 °C
- Conform to DIN 43760-1980 (alpha = 0.00385)
- 3-wire

Configuration Options
- Field-cuttable probes
- Ready-made sensors
- Thermocouple wire
- Thermocouple extension wire

Accessories
- Thermocouple plugs (J, K, T, E)
- Spring-loaded fittings (probes only)
- Tubing cutters (probes only)



Overview
NI offers thermocouples and RTDs for your measurement and automation systems. These sensors are available in versatile configurations – field-cuttable probes and ready-made sensors. NI also offers spools of thermocouple wire and extension wire.

Thermocouples
Thermocouples are the most popular temperature measurement transducers available. Because of their low cost and wide temperature acceptance range, you can use thermocouples for a wide variety of applications in all industries. All NI thermocouples and extension wires are available in J, K, T, and E types and follow ANSI color coding specifications.

Field-Cuttable Thermocouples
NI field-cuttable thermocouples suit a wide variety of temperature applications. With field-cuttable thermocouples, you can cut the metal sheathed probe to the desired length – from 8.9 to 61 cm (3.5 to 24 in.)

Ready-Made Thermocouples
For cost-sensitive applications, NI offers ready-made thermocouples – individual packets of thermocouple wire with the measuring junction provided at one end. Ready-made thermocouples are ideal for starter or educational applications.

Thermocouple and Extension Wire
For large-scale or custom temperature measurement applications, NI offers spools of thermocouple and extension wire. You are responsible for making the thermocouple junction.

Thermocouple Miniconnector Plugs
For applications requiring fast, easy connection and disconnection of thermocouples, we suggest thermocouple miniconnectors. These plugs work with any standard thermocouple miniconnector jack, including those available with the TC-2095, SCXI-1112, SC-2311, SC-2345, and CA-1000 Series connector panelettes. Thermocouple miniconnector plugs come in quantities of 10, and are available for J, K, T, and E types.

INFO CODES
For more information, or to order products online visit ni.com/info and enter:
tempsensors
BUY ONLINE!

RTDs
RTDs are popular for high-accuracy temperature measurement applications. NI offers 3-wire, 100 Ω platinum RTDs that conform to the DIN 43760-1980 (European) standard curve (a = 0.00385). These RTDs are available as field-cuttable metal sheathed probes and ready-made element configurations.

Field-Cuttable RTDs
NI field-cuttable RTDs are ideal for a wide variety of temperature applications. With field-cuttable RTDs, you can cut the metal sheathed probe to the desired length – from 8.9 to 61 cm (3.5 to 24 in.).

Ready-Made RTDs
Ready-made RTDs offer solutions for cost-sensitive temperature measurement applications. Each RTD element is sealed in an Alumina tube, with three Teflon-coated leads, and can measure up to 204 °C (400 °F).

Appendix B:

Winter Results:

Winter Experimental Results:

Input parameters	water flow rate	0.5	gpm
	Date of test	7-Feb-20	
	start time	6:00	AM
	End time	6:00	PM
	Test Duration	12.00	hr
	Sun rise	6:58	AM
	Sunset	6:05	PM
	flow rate	113.6	kg/hr
	Cp	4179	J/kg·K
	A	1.2	m2
	flow rate	0.03147	kg/s

Time	Solar Intensity from Pyranometer (W/m2)	Weather station output				PVT							PV	
		Ambient Temperature	Wind speed mph	Wind direction	Solar intensisty(W/m2)	Temp in C	Temp out C	Power PVT (W)	Elec Eff PVT(%)	Thermal Power (W)	Thermal Eff PVT (%)	Overall Eff PVT (%)	Power PV (W)	Elec Eff PV(%)
7:10	35	14.6	1.1	S	27	14.31	14.4	5.93	14.1%	11.8	28.2%	42.3%	5.51	13.12%
7:12	37	14.6	2.2	S	30	14.32	14.42	6.16	13.9%	13.2	29.6%	43.5%	5.89	13.26%
7:14	45.6	14.6	1.1	S	32.9	14.33	14.44	6.44	11.8%	14.5	26.4%	38.2%	6.10	11.15%
7:18	48.9	14.8	1.1	S	38.3	14.36	14.46	6.61	11.3%	13.2	22.4%	33.7%	6.27	10.69%
7:20	52	14.8	1.1	S	40.5	14.39	14.48	6.79	10.9%	11.8	19.0%	29.8%	6.61	10.60%

7:22	54	14.8	1.1	S	41.9	14.41	14.5	6.96	10.7%	11.8	18.3%	29.0%	6.81	10.51%
7:24	58	14.8	1.1	S	42.9	14.43	14.52	7.14	10.3%	11.8	17.0%	27.3%	6.96	10.00%
7:26	60	14.8	0	0	44.8	14.45	14.54	7.32	10.2%	11.8	16.4%	26.6%	7.08	9.83%
7:28	61	14.8	0	0	45	14.47	14.56	7.52	10.3%	11.8	16.2%	26.4%	7.19	9.83%
7:30	63	14.8	0	0	46.1	14.49	14.58	7.65	10.1%	11.8	15.7%	25.8%	7.31	9.67%
7:32	64	14.8	0	0	46.6	14.51	14.68	7.78	10.1%	22.4	29.1%	39.2%	7.42	9.67%
7:34	66	14.8	0	0	47	14.53	14.69	7.90	10.0%	21.0	26.6%	36.5%	7.72	9.75%
7:36	67	14.9	0	0	47.2	14.55	14.73	8.03	10.0%	23.7	29.4%	39.4%	7.84	9.75%
7:38	69	14.9	0	0	47.3	14.58	14.74	8.16	9.9%	20.9	25.3%	35.1%	7.96	9.61%
7:40	71	14.9	0	0	47.7	14.61	14.78	8.29	9.7%	22.2	26.1%	35.8%	8.08	9.48%
7:42	75	14.9	1.1	SW	55.3	14.64	14.82	8.42	9.4%	23.7	26.3%	35.7%	8.20	9.11%
7:44	81	14.9	1.1	SW	59.6	14.67	14.86	8.55	8.8%	25.4	26.1%	34.9%	8.32	8.56%
7:46	85.3	14.9	1.1	SW	60.2	14.7	14.92	8.68	8.5%	28.9	28.2%	36.7%	8.43	8.24%
7:48	90	14.9	1.1	SW	62.4	14.73	14.93	9.05	8.4%	26.3	24.4%	32.7%	8.79	8.14%
7:50	95.3	14.9	1.1	SW	64.1	14.76	15.10	9.55	8.3%	44.7	39.1%	47.4%	9.27	8.10%
7:52	97	14.9	1.1	SW	66	14.79	15.06	10.05	8.6%	35.1	30.2%	38.8%	9.74	8.37%
7:54	99	14.9	1.1	SW	68.3	14.82	15.10	10.54	8.9%	36.6	30.8%	39.7%	10.22	8.60%
7:56	104	14.9	0	0	71.2	14.85	15.14	11.04	8.8%	37.7	30.2%	39.1%	10.69	8.57%
7:58	107	15.1	1.1	S	73.4	14.88	15.18	12.16	9.5%	39.7	31.0%	40.4%	11.76	9.16%
8:00	110	15.1	1.1	SW	76	14.91	15.22	13.27	10.1%	40.8	30.9%	41.0%	12.83	9.72%
8:02	113.2	15.1	1.1	SW	79.2	14.95	15.26	14.39	10.6%	40.6	29.9%	40.5%	13.98	10.29%
8:04	115.4	15.1	1.1	SW	83.4	14.97	15.31	15.51	11.2%	44.8	32.4%	43.6%	15.06	10.87%
8:06	118.4	15.1	1.1	SW	85.1	14.99	15.34	16.63	11.7%	46.1	32.5%	44.2%	16.13	11.35%
8:08	127.5	15.1	1.1	S	87.2	15.01	15.37	17.76	11.6%	47.3	30.9%	42.5%	17.21	11.25%
8:10	129	15.1	1.1	S	89.8	15.03	15.40	18.88	12.2%	48.7	31.4%	43.6%	18.28	11.81%
8:12	135.3	15.1	1.1	S	93.2	15.05	15.45	20.01	12.3%	52.3	32.2%	44.5%	19.36	11.92%
8:14	144.9	15.1	1.1	S	95.1	15.07	15.49	21.14	12.2%	55.5	31.9%	44.1%	20.43	11.75%
8:16	165.2	15.1	1.1	S	96.3	15.09	15.53	22.27	11.2%	57.9	29.2%	40.4%	21.51	10.85%
8:18	169.4	15.2	1.1	SE	97.5	15.11	15.64	23.40	11.5%	69.9	34.4%	45.9%	22.70	11.17%
8:20	195	15.2	2.2	SE	103	15.13	15.68	24.53	10.5%	71.7	30.6%	41.1%	23.78	10.16%

8:22	205	15.2	2.2	SE	116	15.15	15.79	25.67	10.4%	83.8	34.1%	44.5%	24.86	10.11%
8:24	209	15.2	2.2	S	125	15.17	15.84	25.94	10.3%	88.7	35.4%	45.7%	25.10	10.01%
8:26	215	15.3	1.1	S	132	15.19	15.84	26.21	10.2%	85.5	33.1%	43.3%	25.34	9.82%
8:28	229	15.3	2.2	S	139	15.21	15.94	26.48	9.6%	95.4	34.7%	44.4%	25.58	9.31%
8:30	240	15.3	3.4	S	146	15.23	16.01	27.12	9.4%	102.6	35.6%	45.0%	26.60	9.23%
8:32	234	15.3	2.2	SE	143	15.25	16.07	27.76	9.9%	107.8	38.4%	48.3%	27.21	9.69%
8:34	246	15.6	2.2	SE	151	15.27	16.08	28.41	9.6%	106.0	35.9%	45.5%	27.82	9.42%
8:36	249	15.7	1.1	SE	154	15.29	16.14	29.06	9.7%	111.8	37.4%	47.1%	28.43	9.51%
8:38	246	15.7	2.2	SE	157	15.31	16.19	29.70	10.1%	116.1	39.3%	49.4%	29.04	9.84%
8:40	250	15.9	3.4	SE	160	15.33	16.20	30.35	10.1%	114.4	38.1%	48.3%	29.65	9.88%
8:42	257	15.9	2.2	SE	163	15.35	16.24	31.00	10.1%	117.0	37.9%	48.0%	30.26	9.81%
8:44	259	16	2.2	SE	166	15.37	16.29	31.28	10.1%	121.0	38.9%	49.0%	30.50	9.81%
8:46	263	16	1.1	SE	168	15.39	16.32	31.55	10.0%	122.9	39.0%	49.0%	30.74	9.74%
8:48	265	16	2.2	SE	171	15.41	16.33	31.83	10.0%	121.0	38.0%	48.1%	30.99	9.74%
8:50	269	16.2	3.4	SE	175	15.43	16.39	32.10	9.9%	125.8	39.0%	48.9%	31.23	9.68%
8:52	273	16.2	2.2	SE	177	15.4	16.43	32.38	9.9%	129.8	39.6%	49.5%	31.48	9.61%
8:54	277	16.3	2.2	S	182	15.45	16.46	32.66	9.8%	132.5	39.9%	49.7%	31.72	9.54%
8:56	281	16.4	1.1	S	189	15.5	16.48	33.18	9.8%	134.8	40.0%	49.8%	32.21	9.55%
8:58	284	16.5	2.2	S	197	15.47	16.52	33.71	9.9%	137.5	40.3%	50.2%	32.70	9.59%
9:00	286	16.6	3.4	S	200	15.5	16.54	33.99	9.9%	139.8	40.7%	50.6%	32.94	9.60%
9:02	289	16.6	2.2	S	206	15.49	16.57	34.27	9.9%	141.6	40.8%	50.7%	33.18	9.57%
9:04	292	16.7	2.2	S	209	15.5	16.59	34.55	9.9%	143.4	40.9%	50.8%	33.43	9.54%
9:06	296	16.9	1.1	SW	213	15.51	16.61	34.83	9.8%	145.2	40.9%	50.7%	33.67	9.48%
9:08	300	16.9	2.2	SW	218	15.5	16.65	35.49	9.9%	148.4	41.2%	51.1%	34.28	9.52%
9:10	307	17	3.4	SW	223	15.53	16.68	36.40	9.9%	151.2	41.0%	50.9%	35.14	9.54%
9:12	312	17	2.2	SW	229	15.5	16.72	36.94	9.9%	154.8	41.3%	51.2%	35.62	9.51%
9:14	320	17.1	2.2	SW	232	15.55	16.75	37.47	9.8%	157.5	41.0%	50.8%	36.11	9.40%
9:16	328	17.2	1.1	SW	236	15.6	16.79	38.01	9.7%	160.3	40.7%	50.4%	36.60	9.30%
9:18	336	17.2	2.2	SW	241	15.59	16.84	38.55	9.6%	164.7	40.9%	50.4%	37.09	9.20%
9:20	342	17.3	3.4	SW	245	15.6	16.89	41.24	10.0%	168.3	41.0%	51.1%	39.65	9.66%

9:22	349	17.5	2.2	SW	247	15.63	16.94	41.51	9.9%	171.8	41.0%	50.9%	40.87	9.76%
9:24	353	17.5	1.1	S	251	15.7	16.99	41.86	9.9%	176.3	41.6%	51.5%	41.11	9.71%
9:26	358	17.7	2.2	S	254	15.67	17.03	42.10	9.8%	178.9	41.6%	51.4%	41.70	9.71%
9:28	361	17.7	1.1	S	259	15.7	17.07	42.35	9.8%	181.5	41.9%	51.7%	41.94	9.68%
9:30	364	17.8	2.2	S	264	15.71	17.11	43.59	10.0%	184.2	42.2%	52.2%	43.17	9.88%
9:32	369	17.9	3.4	S	268	15.7	17.14	43.72	9.9%	185.4	41.9%	51.7%	43.30	9.78%
9:34	372	17.9	2.2	S	271	15.75	17.19	44.22	9.9%	189.0	42.3%	52.2%	43.79	9.81%
9:36	377	18.1	2.2	S	279	15.8	17.22	44.71	9.9%	190.7	42.1%	52.0%	44.28	9.79%
9:38	380	18.1	1.1	S	282	15.79	17.26	45.08	9.9%	193.7	42.5%	52.4%	44.65	9.79%
9:40	384	18.3	2.2	S	289	15.8	17.30	45.60	9.9%	195.9	42.5%	52.4%	45.02	9.77%
9:42	388	18.3	3.4	S	295	15.83	17.34	45.98	9.9%	198.6	42.6%	52.5%	45.39	9.75%
9:44	389	18.5	2.2	SW	299	15.9	17.38	46.35	9.9%	201.2	43.1%	53.0%	45.76	9.80%
9:46	392	18.6	1.1	SW	306	15.87	17.41	46.73	9.9%	202.5	43.0%	53.0%	46.13	9.81%
9:48	395	18.7	2.2	S	310	15.9	17.43	47.10	9.9%	202.5	42.7%	52.7%	46.49	9.81%
9:50	399	18.7	3.4	SE	316	15.91	17.48	47.47	9.9%	206.5	43.1%	53.0%	46.86	9.79%
9:52	401	18.9	2.2	SE	321	15.93	17.53	47.85	9.9%	210.4	43.7%	53.7%	47.23	9.82%
9:54	403	19	2.2	SE	330	16.0	17.56	48.22	10.0%	211.2	43.7%	53.6%	47.60	9.84%
9:56	407	19.2	2.2	S	336	16.03	17.59	48.59	9.9%	205.5	42.1%	52.0%	47.97	9.82%
9:58	412	19.5	2.2	S	341	16.1	17.68	48.97	9.9%	206.5	41.8%	51.7%	48.34	9.78%
10:00	419	20	2.2	S	350	16.19	17.80	49.50	9.8%	212.1	42.2%	52.0%	48.71	9.69%
10:02	425	20	1.1	S	366	16.3	17.93	49.88	9.8%	218.5	42.8%	52.6%	49.08	9.62%
10:04	428	20.1	2.2	SE	389	16.35	18.05	50.25	9.8%	223.6	43.5%	53.3%	49.45	9.63%
10:06	441	20	3.4	SE	409	16.4	18.12	52.45	9.9%	222.2	42.0%	51.9%	51.27	9.69%
10:08	465	20	2.2	SE	386.5	16.51	18.25	54.31	9.7%	228.8	41.0%	50.7%	53.09	9.51%
10:10	473	20	2.2	SE	395	16.6	18.40	55.75	9.8%	238.0	41.9%	51.8%	54.41	9.59%
10:12	488	20	1.1	SE	422	16.67	18.50	56.75	9.7%	240.6	41.1%	50.8%	55.39	9.46%
10:14	499	20	2.2	SE	458	16.8	18.63	58.38	9.7%	247.6	41.3%	51.1%	56.97	9.51%
10:16	509	20	3.4	SE	479	16.8	18.74	59.64	9.8%	251.8	41.2%	51.0%	58.07	9.51%
10:18	519	20	2.2	S	486	16.91	18.85	61.02	9.8%	255.1	41.0%	50.8%	59.41	9.54%
10:20	536	20	3.4	SE	494	16.96	18.96	63.40	9.9%	263.2	40.9%	50.8%	61.73	9.60%

10:22	549	20.1	2.2	SE	503	17.01	19.07	64.68	9.8%	270.4	41.0%	50.9%	63.07	9.57%
10:24	565	20.1	1.1	S	511	17.06	19.16	66.05	9.7%	276.2	40.7%	50.5%	64.42	9.50%
10:26	577	20.1	2.2	S	519	17.11	19.26	67.43	9.7%	282.7	40.8%	50.6%	65.76	9.50%
10:28	587	20.1	4.5	SE	524	17.16	19.35	68.75	9.8%	288.5	41.0%	50.7%	67.10	9.53%
10:30	591	20.1	4.5	SE	520	17.21	19.43	70.18	9.9%	292.5	41.2%	51.1%	67.95	9.58%
10:32	593	20.1	2.2	SE	519	17.26	19.49	70.56	9.9%	293.8	41.3%	51.2%	68.32	9.60%
10:34	596	20.1	2.2	SE	517	17.31	19.53	70.94	9.9%	291.9	40.8%	50.7%	69.02	9.65%
10:36	600	20.1	2.2	S	509	17.36	19.60	71.32	9.9%	294.6	40.9%	50.8%	69.39	9.64%
10:38	607	20.1	2.2	SE	555	17.41	19.66	71.69	9.8%	295.9	40.6%	50.5%	69.76	9.58%
10:40	612	20.4	2.2	S	569	17.46	19.73	72.07	9.8%	299.0	40.7%	50.5%	69.78	9.50%
10:42	617	20.5	2.2	SE	578	17.51	19.81	72.45	9.8%	302.2	40.8%	50.6%	70.15	9.47%
10:44	623	20.5	2.2	SE	587	17.53	19.89	73.58	9.8%	310.0	41.5%	51.3%	71.25	9.53%
10:46	635	20.9	1.1	S	607	17.55	19.93	74.84	9.8%	313.0	41.1%	50.9%	72.94	9.57%
10:48	649	20.9	2.2	S	628	17.57	20.01	75.97	9.8%	320.2	41.1%	50.9%	74.05	9.51%
10:50	656	21	1.1	S	634	17.59	20.09	77.11	9.8%	328.4	41.7%	51.5%	75.15	9.55%
10:52	673	21.3	0	0	661	17.61	20.13	79.25	9.8%	331.4	41.0%	50.8%	77.00	9.53%
10:54	689	21.3	1.1	SW	643	17.63	20.20	81.15	9.8%	338.0	40.9%	50.7%	78.84	9.54%
10:56	707	21.3	2.2	SW	679	17.65	20.31	83.05	9.8%	349.8	41.2%	51.0%	80.69	9.51%
10:58	718	21.1	2.2	S	688	17.67	20.39	84.75	9.8%	357.8	41.5%	51.4%	82.53	9.58%
11:00	721	21.1	2.2	SW	715	17.69	20.40	85.00	9.8%	356.4	41.2%	51.0%	82.78	9.57%
11:02	726	21.1	1.1	SW	734	17.71	20.40	85.25	9.8%	353.7	40.6%	50.4%	83.03	9.53%
11:04	731	21.1	1.1	S	760	17.73	20.50	86.04	9.8%	363.8	41.5%	51.3%	83.94	9.57%
11:06	738	21.1	2.2	S	756	17.75	20.53	86.93	9.8%	365.8	41.3%	51.1%	84.80	9.58%
11:08	743	21.9	2.2	S	753	17.77	20.57	87.43	9.8%	368.8	41.4%	51.2%	85.30	9.57%
11:10	746	22	3.4	SE	751	17.79	20.64	88.01	9.8%	374.9	41.9%	51.7%	85.79	9.58%
11:12	749	22	1.1	SE	719	17.81	20.70	88.52	9.8%	380.0	42.3%	52.1%	86.29	9.60%
11:14	753	22.1	1.1	SE	707	17.83	20.74	89.03	9.9%	382.2	42.3%	52.2%	86.78	9.60%
11:16	757	22.3	2.2	SE	690	17.85	20.77	89.68	9.9%	384.3	42.3%	52.2%	87.28	9.61%
11:18	763	22.3	1.1	S	715	17.87	20.82	90.18	9.8%	387.5	42.3%	52.2%	87.77	9.59%
11:20	774	22.3	1.1	S	725	17.89	20.86	90.95	9.8%	390.6	42.0%	51.8%	88.52	9.53%

11:22	785	22.4	2.2	SW	731	17.91	20.92	92.07	9.8%	395.7	42.0%	51.8%	89.40	9.49%
11:24	793	22.4	1.1	S	733	17.93	20.97	93.09	9.8%	399.8	42.0%	51.8%	90.40	9.50%
11:26	809	22.4	1.1	SE	737	17.95	21.02	94.24	9.7%	403.7	41.6%	51.3%	91.51	9.43%
11:28	816	22.2	2.2	E	740	17.97	21.10	95.90	9.8%	411.6	42.0%	51.8%	93.12	9.51%
11:30	820	22.2	2.2	SE	746	17.99	21.14	96.41	9.8%	413.8	42.1%	51.8%	93.62	9.51%
11:32	822	22.2	2.2	SE	749	18.01	21.16	96.92	9.8%	414.3	42.0%	51.8%	94.12	9.54%
11:34	826	22.4	2.2	SE	752	18.03	21.19	97.44	9.8%	415.0	41.9%	51.7%	92.78	9.36%
11:36	821	22.4	2.2	SE	744	18.05	21.22	98.10	10.0%	416.9	42.3%	52.3%	93.27	9.47%
11:38	819	22.4	2.2	SE	730	18.07	21.24	98.23	10.0%	416.2	42.3%	52.3%	93.39	9.50%
11:40	806	22.4	2.2	SE	735	18.09	21.25	98.36	10.2%	415.1	42.9%	53.1%	93.51	9.67%
11:42	826	22.4	1.1	SE	731	18.11	21.20	98.48	9.9%	406.3	41.0%	50.9%	93.63	9.45%
11:44	829	22.4	2.2	S	726	18.13	21.31	98.61	9.9%	417.8	42.0%	51.9%	93.75	9.42%
11:46	831	22.2	1.1	S	723	18.15	21.33	97.27	9.8%	418.2	41.9%	51.7%	94.18	9.44%
11:48	834	22.2	2.2	S	717	18.18	21.35	98.53	9.8%	417.3	41.7%	51.5%	95.40	9.53%
11:50	836	22.2	2.2	S	713	18.21	21.38	98.78	9.8%	417.3	41.6%	51.4%	95.65	9.53%
11:52	842	22.1	3.4	S	710	18.24	21.42	98.91	9.8%	417.9	41.4%	51.2%	95.77	9.48%
11:54	845	22.1	2.2	S	718	18.27	21.46	99.04	9.8%	419.8	41.4%	51.2%	95.89	9.46%
11:56	847	22.1	1.1	S	722	18.3	21.50	99.16	9.8%	420.3	41.4%	51.1%	96.01	9.45%
11:58	850	22.4	2.2	S	732	18.33	21.53	100.86	9.9%	420.9	41.3%	51.2%	98.34	9.64%
12:00	851	22.4	2.2	SE	735	18.36	21.58	100.99	9.9%	423.4	41.5%	51.4%	98.47	9.64%
12:02	853	22.4	2.2	SE	738	18.39	21.62	101.12	9.9%	424.7	41.5%	51.4%	98.59	9.63%
12:04	856	22.5	3.4	S	740	18.42	21.65	101.25	9.9%	424.7	41.4%	51.2%	98.72	9.61%
12:06	852	22.5	2.2	S	752	18.45	21.69	101.38	9.9%	426.1	41.7%	51.6%	98.84	9.67%
12:08	849	22.5	1.1	S	758	18.48	21.71	101.12	9.9%	424.7	41.7%	51.6%	98.59	9.68%

12:10	837	22.6	0	0	761	18.51	21.73	100.86	10.0%	423.4	42.2%	52.2%	98.34	9.79%
12:12	821	22.6	1.1	SE	764	18.54	21.72	100.61	10.2%	418.2	42.4%	52.7%	98.09	9.96%
12:14	837	22.6	2.2	S	767	18.57	21.70	100.35	10.0%	411.8	41.0%	51.0%	97.84	9.74%
12:16	845	23	4.5	SW	761	18.6	21.78	100.33	9.9%	418.2	41.2%	51.1%	97.75	9.64%
12:18	849	23	3.4	S	763	18.63	21.85	100.07	9.8%	423.4	41.6%	51.4%	97.50	9.57%
12:20	861	23	2.2	S	765	18.66	21.91	100.49	9.7%	427.4	41.4%	51.1%	97.75	9.46%
12:22	860	22.9	3.4	SW	767	18.69	21.98	100.74	9.8%	432.6	41.9%	51.7%	98.24	9.52%
12:24	862	22.9	1.1	S	769	18.72	22.00	101.00	9.8%	431.3	41.7%	51.5%	98.49	9.52%
12:26	867	22.9	1.1	S	771	18.75	22.03	101.26	9.7%	431.4	41.5%	51.2%	98.74	9.49%
12:28	870	22.8	2.2	SE	772	18.78	22.08	101.77	9.7%	433.3	41.5%	51.3%	99.24	9.51%
12:30	874	22.8	1.1	SE	773	18.81	22.11	102.45	9.8%	433.8	41.4%	51.1%	99.74	9.51%
12:32	877	22.8	2.2	SE	771	18.84	22.14	102.96	9.8%	434.0	41.2%	51.0%	100.24	9.52%
12:34	882	22.8	2.2	SE	774	18.87	22.18	103.47	9.8%	435.9	41.2%	51.0%	100.74	9.52%
12:36	886	22.8	1.1	S	773	18.9	22.23	103.99	9.8%	437.8	41.2%	51.0%	101.24	9.52%
12:38	889	22.8	1.1	S	775	18.93	22.27	104.50	9.8%	439.3	41.2%	51.0%	101.74	9.54%
12:40	892	22.9	2.2	S	777	18.96	22.30	104.38	9.8%	439.2	41.0%	50.8%	101.70	9.50%

12:42	887	22.9	1.1	S	771	18.99	22.34	104.25	9.8%	440.5	41.2%	50.9%	101.57	9.54%
12:44	883	22.9	2.2	SE	774	19.02	22.36	104.12	9.8%	439.2	41.3%	51.1%	101.45	9.57%
12:46	886	23	4.5	S	770	19.05	22.38	103.99	9.8%	437.7	41.3%	51.1%	101.32	9.53%
12:48	889	23	3.4	S	772	19.08	22.42	104.12	9.8%	439.2	41.3%	51.1%	101.45	9.51%
12:50	892	23	2.2	S	769	19.11	22.46	104.25	9.7%	440.5	41.3%	51.0%	101.57	9.49%
12:52	897	23.1	4.5	S	767	19.14	22.50	105.10	9.8%	441.8	41.3%	51.0%	102.00	9.48%
12:54	901	23.1	6.1	SE	771	19.17	22.54	105.87	9.8%	443.2	41.2%	51.0%	102.75	9.50%
12:56	908	23.1	6.1	S	773	19.2	22.59	106.65	9.8%	446.2	41.3%	51.1%	103.50	9.50%
12:58	915	22.8	8.1	S	777	19.23	22.63	107.42	9.8%	447.1	41.0%	50.8%	104.25	9.49%
13:00	921	22.8	3.4	S	769	19.26	22.67	108.19	9.8%	448.4	40.8%	50.6%	105.00	9.50%
13:02	927	22.8	4.5	S	761	19.29	22.73	108.96	9.8%	452.4	41.5%	51.3%	105.75	9.51%
13:04	933	22.6	4.5	SE	756	19.31	22.77	109.74	9.8%	454.9	41.2%	51.0%	106.50	9.51%
13:06	936	22.6	2.2	S	751	19.33	22.80	110.51	9.8%	456.3	41.0%	50.9%	107.25	9.55%
13:08	942	22.6	1.1	S	744	19.35	22.82	111.28	9.8%	456.4	40.8%	50.6%	108.00	9.55%
13:10	949	23.1	2.2	S	739	19.37	22.84	112.06	9.8%	456.3	40.6%	50.5%	108.75	9.55%
13:12	955	23.1	2.2	S	736	19.39	22.92	112.92	9.9%	464.2	41.3%	51.2%	109.50	9.55%

13:14	962	23.1	2.2	S	733	19.41	22.96	113.69	9.8%	466.8	41.3%	51.1%	110.25	9.55%
13:16	970	23	1.1	SW	731	19.43	23.02	114.55	9.8%	472.1	41.5%	51.3%	111.00	9.54%
13:18	979	23	1.1	SE	729	19.45	23.06	115.33	9.8%	475.1	41.5%	51.3%	111.75	9.51%
13:20	986	23	1.1	S	727	19.47	23.11	116.10	9.8%	478.4	41.4%	51.3%	112.50	9.51%
13:22	992	23	0	0	724	19.49	23.15	116.87	9.8%	481.4	41.4%	51.2%	113.25	9.51%
13:24	999	23	1.1	SE	721	19.51	23.19	117.65	9.8%	483.8	41.2%	51.0%	114.00	9.51%
13:26	1005	23	1.1	S	718	19.53	23.23	118.42	9.8%	486.7	40.4%	50.2%	114.75	9.51%
13:28	1011	23.1	1.1	S	715	19.55	23.27	118.81	9.8%	489.2	40.3%	50.1%	115.13	9.49%
13:30	1015	23.1	1.1	SE	713	19.57	23.32	119.20	9.8%	493.1	40.5%	50.3%	115.50	9.48%
13:32	1009	23.1	1.1	S	710	19.59	23.33	118.68	9.8%	491.8	40.6%	50.4%	115.00	9.50%
13:34	1003	23.4	2.2	SE	708	19.61	23.34	118.16	9.8%	490.5	40.8%	50.6%	114.50	9.51%
13:36	997	23.4	3.4	SE	722	19.63	23.36	117.65	9.8%	490.5	41.0%	50.8%	114.00	9.53%
13:38	991	23.4	6.2	SE	739	19.65	23.37	116.10	9.8%	488.6	41.1%	50.9%	112.50	9.46%
13:40	982	23.6	8.1	S	746	19.67	23.36	114.55	9.7%	485.8	41.2%	50.9%	110.82	9.40%
13:42	988	23.6	4.2	S	755	19.69	23.35	114.29	9.6%	481.3	40.6%	50.2%	110.57	9.33%
13:44	979	23.6	3.4	S	741	19.71	23.40	114.04	9.7%	485.2	41.3%	51.0%	110.32	9.39%

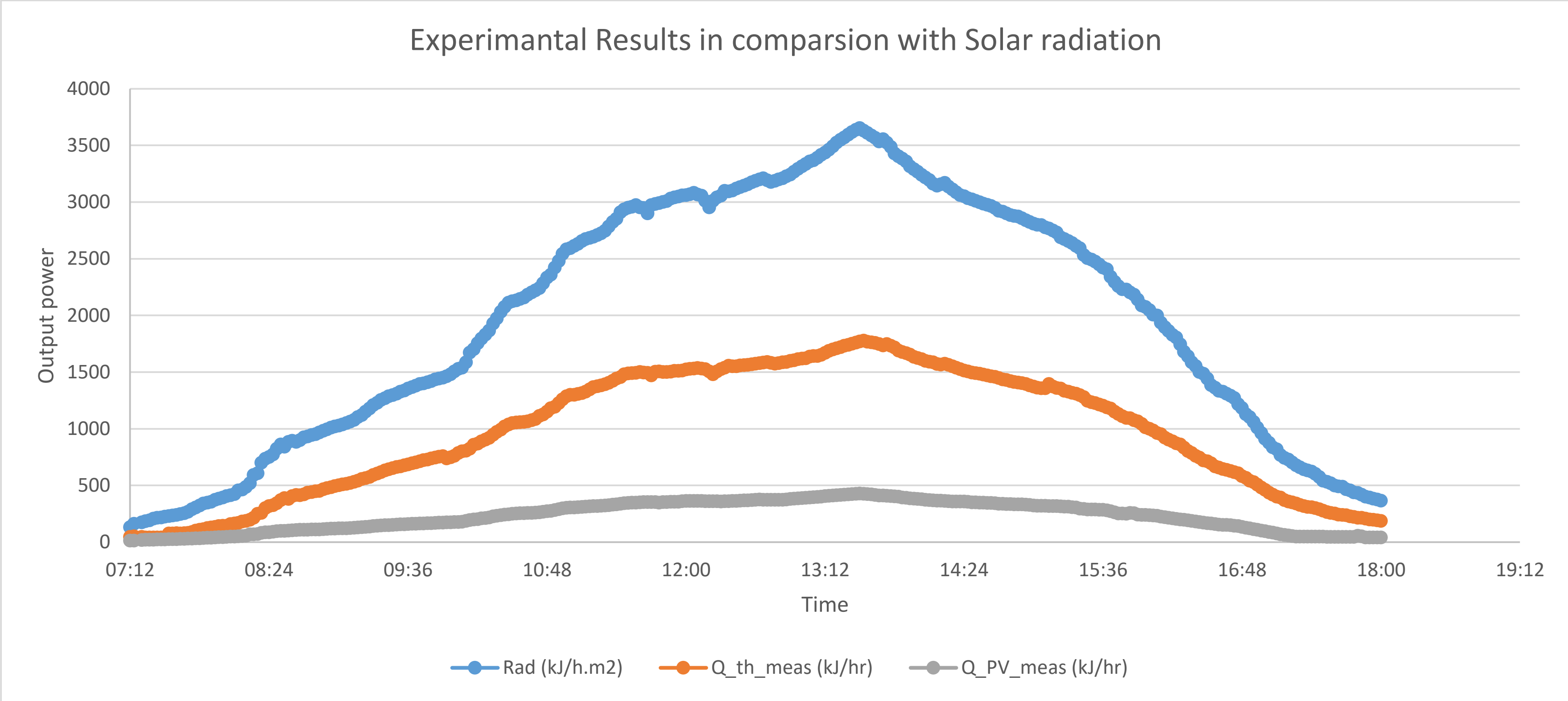
13:46	969	23.6	6.2	S	738	19.73	23.38	112.90	9.7%	480.0	41.3%	51.0%	110.07	9.47%
13:48	953	23.6	4.2	S	736	19.75	23.37	112.64	9.8%	476.0	41.6%	51.5%	109.82	9.60%
13:50	946	23.6	2.2	S	731	19.77	23.34	111.87	9.9%	469.8	41.4%	51.2%	109.08	9.61%
13:52	940	23.6	2.2	S	729	19.79	23.33	109.82	9.7%	465.5	41.3%	51.0%	107.08	9.49%
13:54	933	23.6	1.1	S	724	19.81	23.34	108.80	9.7%	464.2	41.5%	51.2%	106.08	9.47%
13:56	921	23.6	1.1	S	721	19.83	23.32	107.78	9.8%	458.9	41.5%	51.3%	105.08	9.51%
13:58	914	23.6	1.1	SE	717	19.85	23.30	106.75	9.7%	453.7	41.4%	51.1%	104.08	9.49%
14:00	908	23.6	0	0	715	19.87	23.31	106.11	9.7%	452.4	41.5%	51.3%	103.46	9.50%
14:02	900	23.6	1.1	SE	713	19.89	23.30	105.47	9.8%	448.4	41.5%	51.3%	102.84	9.52%
14:04	894	23.8	2.2	S	710	19.91	23.29	104.01	9.7%	444.6	41.4%	51.1%	102.21	9.53%
14:06	888	23.8	1.1	S	708	19.93	23.30	103.38	9.7%	442.8	41.6%	51.3%	101.59	9.53%
14:08	879	23.8	1.1	S	707	19.95	23.30	102.74	9.7%	440.9	41.8%	51.5%	100.96	9.57%
14:10	874	24	2.2	S	706	19.97	23.29	102.36	9.8%	436.6	41.6%	51.4%	100.59	9.59%
14:12	877	24	1.1	S	711	19.99	23.28	101.98	9.7%	432.6	41.1%	50.8%	100.21	9.52%
14:14	881	24	3.4	S	717	20.01	23.34	101.60	9.6%	437.9	41.4%	51.0%	99.84	9.44%
14:16	872	24.1	4.5	SW	719	20.06	23.37	100.42	9.6%	435.0	41.6%	51.2%	99.47	9.51%

14:18	865	24.1	1.1	S	724	20.11	23.39	100.04	9.6%	431.0	41.5%	51.2%	99.09	9.55%
14:20	858	24.1	1.1	SE	728	20.16	23.41	99.67	9.7%	427.8	41.6%	51.2%	98.72	9.59%
14:22	851	24.1	2.2	S	732	20.21	23.44	100.08	9.8%	424.2	41.5%	51.3%	98.34	9.63%
14:24	848	24.1	1.1	S	735	20.26	23.45	99.70	9.8%	419.5	41.2%	51.0%	97.97	9.63%
14:26	843	24.1	0	0	737	20.31	23.50	99.31	9.8%	419.5	41.5%	51.3%	96.97	9.59%
14:28	840	24.2	2.2	S	740	20.36	23.52	98.15	9.7%	415.9	41.3%	51.0%	96.60	9.58%
14:30	837	24.2	3.4	SE	742	20.41	23.56	97.78	9.7%	414.2	41.2%	51.0%	96.22	9.58%
14:32	833	24.2	1.1	S	746	20.46	23.62	97.40	9.7%	415.5	41.6%	51.3%	95.85	9.59%
14:34	830	24.2	1.1	S	747	20.51	23.63	97.02	9.7%	410.3	41.2%	50.9%	95.48	9.59%
14:36	827	24.2	2.2	SE	749	20.56	23.67	96.64	9.7%	409.0	41.2%	50.9%	95.11	9.58%
14:38	824	24.2	1.1	S	751	20.61	23.71	96.26	9.7%	407.1	41.2%	50.9%	94.74	9.58%
14:40	819	24.2	1.1	S	753	20.66	23.74	95.89	9.8%	405.2	41.2%	51.0%	94.36	9.60%
14:42	812	24.2	1.1	SE	749	20.71	23.77	94.25	9.7%	402.5	41.3%	51.0%	92.75	9.52%
14:44	810	24.2	2.2	S	750	20.76	23.79	94.00	9.7%	398.8	41.0%	50.7%	92.50	9.52%
14:46	806	24.2	1.1	S	751	20.81	23.83	93.74	9.7%	397.4	41.1%	50.8%	92.26	9.54%
14:48	802	24.2	2.2	SE	747	20.86	23.86	93.49	9.7%	395.1	41.1%	50.8%	92.01	9.56%
14:50	800	24.2	4.5	S	741	20.91	23.90	93.24	9.7%	392.8	40.9%	50.6%	91.76	9.56%
14:52	798	24.2	3.4	S	733	20.96	23.94	92.99	9.7%	391.3	40.9%	50.6%	91.51	9.56%
14:54	794	24.2	2.2	S	728	21.01	23.98	92.74	9.7%	389.9	40.9%	50.7%	91.26	9.58%
14:56	789	24.1	4.5	S	723	21.06	24.01	91.98	9.7%	387.6	40.9%	50.7%	90.52	9.56%
14:58	785	24.1	6.1	SE	718	21.11	24.04	91.22	9.7%	385.3	40.9%	50.6%	89.78	9.53%
15:00	781	24.1	6.1	S	712	21.16	24.06	90.47	9.7%	381.4	40.7%	50.3%	89.03	9.50%
15:02	778	24.1	8.1	S	709	21.21	24.09	89.71	9.6%	378.7	40.6%	50.2%	88.29	9.46%
15:04	777	24.1	3.4	S	701	21.26	24.12	89.46	9.6%	376.1	40.3%	49.9%	88.04	9.44%
15:06	772	24.1	4.5	S	697	21.3	24.17	89.21	9.6%	377.4	40.7%	50.4%	87.79	9.48%
15:08	769	23.8	4.5	SE	693	21.24	24.19	88.96	9.6%	387.9	42.0%	51.7%	87.54	9.49%
15:10	764	23.8	2.2	S	689	21.21	24.11	88.70	9.7%	381.4	41.6%	51.3%	87.30	9.52%
15:12	759	23.8	1.1	S	685	21.18	24.06	88.45	9.7%	378.5	41.6%	51.3%	87.05	9.56%

15:14	747	23.8	2.2	S	681	21.15	24.01	87.71	9.8%	376.6	42.0%	51.8%	86.80	9.68%
15:16	743	23.6	1.1	SE	677	21.12	23.94	87.46	9.8%	371.5	41.7%	51.5%	86.20	9.67%
15:18	738	23.6	1.1	S	673	21.09	23.90	87.21	9.8%	369.0	41.7%	51.5%	85.96	9.71%
15:20	733	23.6	4.5	S	669	21.06	23.84	86.21	9.8%	365.6	41.6%	51.4%	84.97	9.66%
15:22	726	23.5	3.4	S	665	21.03	23.79	85.20	9.8%	362.9	41.7%	51.4%	83.98	9.64%
15:24	721	23.2	4.5	S	661	21	23.74	82.70	9.6%	360.3	41.6%	51.2%	81.51	9.42%
15:26	704	23.2	4.5	SE	645	20.98	23.68	81.45	9.6%	355.1	42.0%	51.7%	80.28	9.50%
15:28	696	23.2	2.2	S	621	20.96	23.59	80.19	9.6%	346.5	41.5%	51.1%	79.04	9.46%
15:30	693	23	1.1	S	609	20.94	23.55	80.57	9.7%	343.1	41.3%	50.9%	79.41	9.55%
15:32	688	23	2.2	S	619	20.92	23.51	80.19	9.7%	340.9	41.3%	51.0%	79.04	9.57%
15:34	681	23	1.1	S	612	20.9	23.47	79.82	9.8%	337.9	41.3%	51.1%	78.67	9.63%
15:36	673	22.8	1.1	S	598	20.88	23.43	79.44	9.8%	334.9	41.5%	51.3%	78.30	9.70%
15:38	669	22.8	2.2	SE	591	20.86	23.37	77.94	9.7%	330.1	44.0%	53.8%	76.82	9.57%
15:40	651	22.8	1.1	S	584	20.84	23.33	76.43	9.8%	327.4	41.9%	51.7%	75.34	9.64%
15:42	638	22.8	2.2	S	571	20.82	23.25	73.55	9.6%	319.5	41.7%	51.3%	72.49	9.47%
15:44	628	22.6	4.5	S	567	20.8	23.19	70.67	9.4%	314.3	41.7%	51.1%	69.65	9.24%
15:46	620	22.6	3.4	S	565	20.78	23.13	70.42	9.5%	309.0	41.5%	51.0%	69.41	9.33%
15:48	619	22.5	2.2	SE	556.5	20.76	23.08	70.17	9.4%	304.6	41.0%	50.4%	69.16	9.31%
15:50	612	22.3	6.9	W	550.4	20.74	23.05	71.65	9.8%	303.8	41.4%	51.1%	70.03	9.54%
15:52	607	22.3	6.9	W	544.3	20.72	23.00	71.39	9.8%	299.3	41.1%	50.9%	69.78	9.58%
15:54	595	22.1	3.9	SW	538.2	20.7	22.96	68.00	9.5%	297.2	41.6%	51.1%	66.52	9.32%
15:56	580	21.9	2.2	SW	532.1	20.68	22.89	67.36	9.7%	290.0	41.7%	51.3%	65.84	9.46%
15:58	577	21.7	4.5	SW	526	20.66	22.80	66.72	9.6%	281.4	40.6%	50.3%	65.00	9.39%
16:00	569	21.7	4.5	NW	519.9	20.64	22.76	66.07	9.7%	278.2	40.7%	50.4%	63.35	9.28%
16:02	558	21.4	1.1	SW	513.8	20.62	22.70	65.48	9.8%	273.5	40.8%	50.6%	62.73	9.37%
16:04	556	21.3	3.4	SW	507.7	20.6	22.63	64.74	9.7%	266.9	40.0%	49.7%	62.12	9.31%
16:06	538	21.3	4.5	SW	501.6	20.58	22.59	62.59	9.7%	264.3	40.9%	50.6%	61.13	9.47%
16:08	527	21.3	4.5	SW	495.5	20.56	22.50	61.31	9.7%	255.1	40.3%	50.0%	59.88	9.47%
16:10	518	21.2	3.4	NW	489.4	20.54	22.45	60.03	9.7%	251.2	40.4%	50.1%	58.63	9.43%
16:12	508	21.2	4.5	SW	483.3	20.52	22.39	58.75	9.6%	245.9	40.3%	50.0%	57.38	9.41%

16:14	502	21.2	5.8	SW	477.2	20.5	22.34	57.47	9.5%	242.3	40.2%	49.8%	56.13	9.32%
16:16	485	21.2	3.4	SW	167.5	20.48	22.30	55.75	9.6%	239.8	41.2%	50.8%	54.88	9.43%
16:18	467	21.1	6.9	W	161	20.46	22.23	54.87	9.8%	232.3	41.4%	51.2%	53.63	9.57%
16:20	456	21.1	5.8	W	157	20.44	22.14	53.55	9.8%	223.8	40.9%	50.7%	51.96	9.49%
16:22	441	21.1	8.1	NW	151.8	20.42	22.08	52.27	9.9%	218.5	41.3%	51.2%	50.72	9.58%
16:24	432	21	6.9	NW	143.5	20.4	22.01	50.95	9.8%	211.7	40.8%	50.7%	49.48	9.54%
16:26	417	21	2.2	SW	137.9	20.38	21.96	49.68	9.9%	207.5	41.5%	51.4%	48.55	9.70%
16:28	413	21	5.8	NW	132.7	20.36	21.88	48.36	9.8%	199.9	40.3%	50.1%	46.62	9.41%
16:30	401	21	5.8	W	127.5	20.34	21.85	47.08	9.8%	198.6	41.3%	51.0%	46.05	9.57%
16:32	385	20.9	5.8	SW	116.6	20.32	21.79	45.81	9.9%	193.5	41.9%	51.8%	44.52	9.64%
16:34	379	20.9	4.5	SW	114.6	20.3	21.71	44.50	9.8%	185.9	40.9%	50.7%	8.03	1.76%
16:36	371	20.9	6.9	SW	112.3	20.28	21.67	43.10	9.7%	182.8	41.1%	50.7%	41.91	9.41%
16:38	369	20.7	5.8	SW	111	20.26	21.62	42.75	9.7%	179.4	40.5%	50.2%	41.54	9.38%
16:40	364	20.7	2.2	SW	111	20.24	21.59	42.33	9.7%	177.7	40.7%	50.4%	41.17	9.42%
16:42	359	20.6	2.2	SW	105	20.22	21.55	41.95	9.7%	174.6	40.5%	50.3%	40.80	9.47%
16:44	354	20.6	6.9	SW	91.9	20.2	21.51	40.75	9.6%	172.0	40.5%	50.1%	40.42	9.52%
16:46	338	20.6	3.4	SW	90.5	20.18	21.47	39.72	9.8%	169.4	41.8%	51.6%	38.69	9.54%
16:48	329	20.5	4.5	W	87.6	20.16	21.39	37.55	9.5%	162.3	41.1%	50.6%	36.95	9.36%
16:50	314	20.5	5.8	W	84.5	20.14	21.34	35.78	9.5%	157.8	41.9%	51.4%	34.93	9.27%
16:52	307	20.5	3.4	SW	82.3	20.12	21.27	34.02	9.2%	150.7	40.9%	50.1%	33.21	9.01%
16:54	295	20.3	2.2	SW	79.2	20.1	21.22	32.26	9.1%	147.3	41.6%	50.7%	31.49	8.89%
16:56	281	20.3	4.5	W	74.6	20.08	21.16	30.71	9.1%	141.4	41.9%	51.0%	29.77	8.83%
16:58	268	20.3	6.9	NW	71.6	20.06	21.08	28.93	9.0%	134.1	41.7%	50.7%	28.04	8.72%
17:00	254	20.2	4.5	W	68.5	20.04	21.02	27.14	8.9%	128.5	42.1%	51.0%	26.51	8.70%
17:02	244	20.2	5.8	NW	66.3	20.02	20.95	25.36	8.7%	121.7	41.6%	50.2%	24.76	8.46%
17:04	233	20.2	5.8	W	64.7	20	20.88	23.58	8.4%	115.7	41.4%	49.8%	23.03	8.24%
17:06	228	20.2	4.5	W	62.4	19.98	20.83	21.33	7.8%	112.0	40.9%	48.7%	20.98	7.67%
17:08	214	20.1	2.2	S	60.6	19.96	20.80	19.84	7.7%	109.9	42.8%	50.5%	19.36	7.54%
17:10	207	20.1	4.5	S	58.6	19.94	20.72	18.28	7.4%	103.2	41.5%	48.9%	17.91	7.21%
17:12	203	20.1	6.1	S	56.7	19.92	20.67	16.80	6.9%	98.6	40.5%	47.4%	16.46	6.76%

17:14	196	20.1	6.1	S	54.7	19.9	20.65	15.31	6.5%	98.0	41.7%	48.2%	15.00	6.38%
17:16	189	20	8.1	SE	52.8	19.88	20.60	13.83	6.1%	95.0	41.9%	48.0%	13.55	5.98%
17:18	184	20	3.4	S	50.8	19.86	20.56	13.83	6.3%	91.5	41.4%	47.7%	13.55	6.14%
17:20	179	20	4.5	S	48.9	19.84	20.52	13.83	6.4%	88.9	41.4%	47.8%	13.55	6.31%
17:22	176	20	4.5	S	46.9	19.82	20.48	13.83	6.5%	86.8	41.1%	47.7%	13.33	6.31%
17:24	173	19.9	2.2	S	45.0	19.8	20.45	13.78	6.6%	85.5	41.2%	47.8%	13.33	6.42%
17:26	168	19.9	1.1	SE	43.0	19.78	20.42	13.78	6.8%	84.0	41.6%	48.5%	13.33	6.61%
17:28	160	19.9	2.2	S	41.1	19.76	20.38	13.78	7.2%	81.4	42.4%	49.5%	13.33	6.94%
17:30	151	19.9	4.5	S	39.1	19.74	20.33	13.78	7.6%	77.9	43.0%	50.6%	13.33	7.36%
17:32	148	19.8	3.4	S	37.2	19.72	20.28	13.55	7.6%	73.9	41.6%	49.3%	13.33	7.50%
17:34	145	19.8	2.2	S	35.2	19.7	20.24	13.55	7.8%	71.0	40.8%	48.6%	13.33	7.66%
17:36	139	19.8	4.5	S	33.3	19.68	20.22	13.55	8.1%	70.6	42.3%	50.4%	13.33	7.99%
17:38	137	19.7	6.1	SE	31.3	19.66	20.18	13.55	8.2%	68.0	41.4%	49.6%	13.33	8.11%
17:40	136	19.7	6.1	S	29.4	19.64	20.15	13.55	8.3%	66.8	40.9%	49.2%	13.33	8.17%
17:42	130	19.7	8.1	S	27.4	19.62	20.12	13.55	8.7%	66.0	42.3%	51.0%	13.33	8.54%
17:44	127	19.7	3.4	S	25.5	19.6	20.08	13.55	8.9%	63.5	41.6%	50.5%	13.33	8.75%
17:46	122	19.7	4.5	S	23.5	19.58	20.05	13.55	9.3%	62.3	42.5%	51.8%	13.33	9.10%
17:48	121	19.7	4.5	S	21.6	19.56	20.02	15.73	10.8%	60.2	41.5%	52.3%	15.47	10.65%
17:50	117	19.7	3.4	S	19.6	19.54	20.00	14.52	10.3%	59.9	42.7%	53.0%	14.28	10.17%
17:52	112	19.7	2.2	S	17.7	19.52	19.96	12.10	9.0%	58.3	43.4%	52.4%	11.89	8.85%
17:54	110	19.7	4.5	SE	15.7	19.5	19.93	12.10	9.2%	56.2	42.6%	51.7%	11.89	9.01%
17:56	107	19.6	6.1	S	13.8	19.48	19.90	12.10	9.4%	55.5	43.2%	52.6%	11.89	9.26%
17:58	105	19.6	2.2	S	11.8	19.46	19.87	12.10	9.6%	53.8	42.7%	52.3%	11.89	9.44%
18:00	102	19.6	2.2	S	9.9	19.44	19.84	12.10	9.9%	52.6	43.0%	52.9%	11.89	9.71%
								119.20	14.1%	493.13	44.0%	53.8%	115.50	13.26%
									10.0%		40%	49.4%		10.0%



Experimantal Results in comparsion with Solar radiation
Output power
4000
3500
3000
2500
2000
1500
1000
500
0
07:12
08:24
09:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
Time
Rad (kJ/h.m2)
Q_th_meas (kJ/hr)
Q_PV_meas (kJ/hr)

Winter Data validating (comparing experimental data with simulation) percentage of maximum error less than 5%:

Rad (Kj/h.m2)	Tamb	Tin	Tout	Tout_Sim	Deviation	Q_th_meas (kJ/hr)	Q_th_Sim (kJ/hr)	Deviation	Q_PV_meas (kJ/hr)	Q_PV_ Sim (kJ/hr)	Deviation
230.4	14	14.31	14.67	14.68	-0.04%	78.0	80.00	-2.5%	27.443	28.00	-2%
237.6	14	14.32	14.70	14.69	0.05%	79.0	81.00	-2.6%	27.443	28.30	-3%
241.2	14	14.33	14.72	14.73	-0.05%	81.6	81.40	0.2%	28.314	28.00	1%
248.4	14	14.36	14.74	14.74	0.04%	77.8	82.00	-5.4%	30.492	29.70	3%
255.6	14	14.39	14.78	14.78	0.00%	80.0	83.00	-3.7%	30.928	31.40	-2%
270	14.2	14.41	14.81	14.82	-0.04%	82.3	85.00	-3.3%	31.363	31.70	-1%
291.6	14.2	14.43	14.86	14.86	0.00%	91.5	92.00	-0.6%	31.799	32.00	-1%
307.08	14.2	14.45	14.92	14.92	0.00%	104.0	99.90	4.0%	33.818	33.00	2%
324	14.2	14.47	14.96	14.93	0.22%	110.1	108.00	1.9%	35.575	34.40	3%
343.08	14.3	14.49	15.01	15.10	-0.62%	116.8	116.10	0.6%	37.332	35.80	4%
349.2	14.4	14.51	15.06	15.06	0.00%	126.4	124.20	1.7%	39.089	37.20	5%
356.4	14.4	14.53	15.10	15.10	0.00%	131.8	132.30	-0.4%	40.846	39.50	3%
374.4	14.4	14.55	15.14	15.14	0.00%	135.8	140.40	-3.4%	42.602	41.80	2%
385.2	14.4	14.58	15.18	15.18	0.00%	143.1	145.50	-1.7%	44.359	44.10	1%
396	14.4	14.61	15.30	15.22	0.52%	147.0	148.60	-1.1%	46.116	46.40	-1%
407.52	14.5	14.64	15.26	15.26	0.00%	146.1	151.70	-3.8%	47.873	48.70	-2%
415.44	14.5	14.67	15.31	15.31	0.00%	161.3	159.80	0.9%	49.63	50.30	-1%
426.24	14.5	14.7	15.34	15.34	0.00%	166.1	167.90	-1.1%	51.386	51.80	-1%
459	14.5	14.73	15.35	15.37	-0.13%	170.3	176.00	-3.3%	53.361	53.30	0%
464.4	14.6	14.76	15.42	15.40	0.13%	184.7	184.10	0.3%	56.007	56.30	-1%
487.08	14.6	14.79	15.46	15.45	0.08%	188.3	192.20	-2.1%	56.889	56.73	0%
521.64	14.7	14.82	15.49	15.49	0.00%	199.9	200.30	-0.2%	69.678	68.09	2%
594.72	14.7	14.85	15.55	15.53	0.12%	217.0	227.66	-4.9%	70.119	70.30	0%
609.84	14.7	14.88	15.64	15.64	0.00%	251.8	262.70	-4.3%	72.324	73.00	-1%

702	14.8	14.91	15.68	15.68	0.00%	258.1	268.98	-4.2%	82.467	83.51	-1%
738	14.8	14.95	15.77	15.79	-0.11%	301.7	312.83	-3.7%	87.318	86.50	1%
752.4	14.9	14.97	15.84	15.84	0.00%	319.4	330.61	-3.5%	88.2	89.49	-1%
774	15.2	14.99	15.88	15.84	0.26%	327.1	338.38	-3.5%	92.61	92.48	0%
824.4	15.2	15.01	15.93	15.94	-0.04%	343.6	354.96	-3.3%	97.733	95.47	2%
864	15.3	15.03	16.01	16.01	0.03%	371.5	383.05	-3.1%	99.954	98.47	1%
842.4	15.3	15.05	16.08	16.07	0.03%	390.8	402.47	-3.0%	101.29	101.46	0%
885.6	15.6	15.07	16.08	16.08	0.01%	382.0	393.56	-3.0%	103.06	104.45	-1%
896.4	15.7	15.09	16.15	16.14	0.05%	406.6	418.30	-2.9%	106.62	107.44	-1%
885.6	15.7	15.11	16.19	16.19	0.00%	418.1	429.87	-2.8%	108.75	110.43	-2%
900	15.9	15.13	16.20	16.20	0.03%	414.2	425.96	-2.8%	110.53	113.42	-3%
925.2	15.9	15.15	16.25	16.24	0.03%	423.7	435.55	-2.8%	111.42	114.70	-3%
932.4	16	15.17	16.30	16.29	0.03%	438.2	450.12	-2.7%	111.42	115.98	-4%
946.8	16	15.19	16.32	16.32	0.00%	442.6	454.54	-2.7%	112.31	117.25	-4%
954	16	15.21	16.36	16.33	0.19%	450.3	462.29	-2.7%	113.2	118.53	-5%
968.4	16.2	15.23	16.39	16.39	0.00%	452.9	464.88	-2.6%	114.19	119.80	-5%
982.8	16.2	15.25	16.43	16.43	0.00%	467.2	474.46	-1.6%	115.97	121.08	-4%
997.2	16.3	15.27	16.45	16.46	-0.05%	477.0	484.41	-1.5%	117.75	122.36	-4%
1011.6	16.4	15.29	16.48	16.48	0.00%	485.1	492.52	-1.5%	119.54	123.63	-3%
1022.4	16.5	15.31	16.52	16.52	0.00%	495.0	502.47	-1.5%	121.32	124.91	-3%
1029.6	16.6	15.33	16.54	16.54	0.00%	503.2	510.75	-1.5%	122.21	126.19	-3%
1040.4	16.6	15.35	16.55	16.57	-0.10%	509.8	517.37	-1.5%	123.11	127.46	-4%
1051.2	16.7	15.37	16.60	16.59	0.06%	516.2	523.82	-1.5%	124	128.74	-4%
1065.6	16.9	15.39	16.61	16.61	0.00%	522.7	530.27	-1.5%	126.23	130.01	-3%
1080	16.9	15.41	16.64	16.65	-0.05%	534.4	542.04	-1.4%	128.46	131.29	-2%
1105.2	17	15.43	16.68	16.68	0.00%	544.3	551.98	-1.4%	130.69	132.57	-1%
1123.2	17	15.4	16.72	16.72	0.00%	557.3	565.08	-1.4%	132.92	133.84	-1%
1152	17.1	15.45	16.74	16.75	-0.05%	567.0	574.85	-1.4%	135.15	135.12	0%
1180.8	17.2	15.5	16.78	16.79	-0.05%	576.9	589.59	-2.2%	137.38	136.40	1%
1209.6	17.2	15.47	16.84	16.84	0.00%	593.0	605.80	-2.1%	142.73	139.30	2%

1231.2	17.3	15.5	16.89	16.89	0.02%	607.3	620.17	-2.1%	144.96	143.90	1%
1256.4	17.5	15.49	16.94	16.94	0.00%	618.3	631.22	-2.1%	149.42	148.50	1%
1270.8	17.5	15.5	16.99	16.99	0.00%	634.6	647.59	-2.0%	150.68	151.10	0%
1288.8	17.7	15.51	17.03	17.03	0.00%	644.1	657.15	-2.0%	151.57	153.70	-1%
1299.6	17.7	15.5	17.07	17.07	0.02%	655.3	668.36	-2.0%	152.47	156.30	-3%
1310.4	17.8	15.53	17.11	17.11	0.00%	663.1	676.26	-2.0%	156.94	158.90	-1%
1328.4	17.9	15.5	17.14	17.14	0.02%	669.2	682.33	-2.0%	157.39	161.50	-3%
1339.2	17.9	15.55	17.19	17.19	0.00%	680.3	693.54	-1.9%	159.17	164.10	-3%
1357.2	18.1	15.6	17.22	17.22	0.00%	686.3	699.61	-1.9%	160.96	166.70	-4%
1368	18.1	15.59	17.26	17.26	0.00%	697.5	710.82	-1.9%	162.3	168.30	-4%
1382.4	18.3	15.6	17.30	17.30	0.00%	705.4	718.72	-1.9%	164.17	169.90	-3%
1396.8	18.3	15.63	17.34	17.34	0.00%	714.9	728.27	-1.9%	165.52	171.50	-4%
1400.4	18.5	15.7	17.38	17.38	0.00%	724.4	737.82	-1.9%	166.86	173.10	-4%
1411.2	18.6	15.67	17.41	17.41	0.00%	728.9	742.41	-1.9%	168.21	174.70	-4%
1422	18.7	15.7	17.45	17.43	0.12%	738.6	752.15	-1.8%	169.56	175.30	-3%
1436.4	18.7	15.71	17.49	17.48	0.04%	746.5	760.05	-1.8%	170.9	175.90	-3%
1443.6	18.9	15.7	17.52	17.53	-0.04%	754.1	767.76	-1.8%	172.25	176.50	-2%
1450.8	19	15.75	17.52	17.56	-0.21%	760.3	774.00	-1.8%	173.59	177.10	-2%
1465.2	19.2	15.8	17.58	17.59	-0.07%	766.6	782.09	-2.0%	174.94	177.70	-2%
1483.2	19.5	15.79	17.69	17.68	0.07%	772.8	791.25	-2.4%	176.28	178.30	-1%
1508.4	20	15.8	17.81	17.80	0.04%	779.0	805.75	-3.4%	178.2	178.90	0%
1530	20	15.83	17.92	17.93	-0.07%	785.2	829.08	-5.6%	179.55	179.50	0%
1540.8	20.1	15.9	18.05	18.05	-0.02%	806.6	845.23	-4.8%	180.9	180.10	0%
1587.6	20	15.87	18.13	18.12	0.08%	814.0	849.05	-4.3%	188.83	186.23	1%
1674	20	15.9	18.25	18.25	0.01%	830.0	867.54	-4.5%	195.52	192.36	2%
1702.8	20	15.91	18.41	18.40	0.03%	859.6	902.32	-5.0%	200.7	198.49	1%
1756.8	20	15.93	18.51	18.50	0.04%	869.7	912.53	-4.9%	204.3	204.62	0%
1796.4	20	16.0	18.63	18.63	0.00%	891.3	934.28	-4.8%	210.15	210.75	0%
1832.4	20	16.03	18.74	18.74	-0.02%	906.4	949.42	-4.7%	214.71	216.88	-1%
1868.4	20	16.1	18.85	18.85	0.02%	919.8	962.90	-4.7%	219.68	223.01	-2%

1929.6	20	16.19	18.96	18.96	-0.01%	947.4	976.38	-3.1%	228.25	229.14	0%
1976.4	20.1	16.3	19.06	19.07	-0.03%	973.4	1002.48	-3.0%	232.84	235.27	-1%
2034	20.1	16.35	19.16	19.16	0.01%	994.6	1023.83	-2.9%	237.79	241.40	-2%
2077.2	20.1	16.4	19.27	19.26	0.03%	1020.7	1050.10	-2.9%	242.74	243.53	0%
2113.2	20.1	16.51	19.35	19.35	0.00%	1038.5	1067.94	-2.8%	247.5	245.66	1%
2127.6	20.1	16.6	19.43	19.43	0.00%	1053.0	1082.49	-2.8%	252.66	247.79	2%
2134.8	20.1	16.67	19.49	19.49	0.00%	1057.6	1087.19	-2.8%	254.02	249.92	2%
2145.6	20.1	16.8	19.54	19.53	0.05%	1059.0	1088.60	-2.8%	255.38	252.05	1%
2160	20.1	16.8	19.60	19.60	0.02%	1062.1	1091.66	-2.8%	256.74	254.18	1%
2185.2	20.1	16.91	19.66	19.66	0.02%	1066.7	1096.35	-2.8%	258.1	256.31	1%
2203.2	20.4	16.96	19.72	19.73	-0.07%	1076.3	1105.96	-2.8%	259.46	258.44	0%
2221.2	20.5	17.01	19.80	19.81	-0.04%	1088.1	1117.80	-2.7%	260.82	260.57	0%
2242.8	20.5	17.06	19.87	19.89	-0.09%	1115.9	1131.48	-1.4%	264.9	262.70	1%
2286	20.9	17.11	19.92	19.93	-0.05%	1126.8	1142.41	-1.4%	269.41	264.83	2%
2336.4	20.9	17.16	20.01	20.01	0.00%	1152.9	1168.68	-1.4%	273.5	269.96	1%
2361.6	21	17.21	20.09	20.09	0.00%	1182.3	1198.21	-1.3%	277.59	275.09	1%
2422.8	21.3	17.26	20.13	20.13	0.02%	1194.7	1210.76	-1.3%	285.31	280.22	2%
2480.4	21.3	17.31	20.23	20.20	0.13%	1229.0	1245.18	-1.3%	292.14	285.35	2%
2545.2	21.3	17.36	20.31	20.31	0.00%	1259.7	1276.11	-1.3%	298.98	290.48	3%
2584.8	21.1	17.41	20.39	20.39	0.00%	1288.2	1304.78	-1.3%	305.09	295.61	3%
2595.6	21.1	17.46	20.44	20.40	0.19%	1301.7	1318.31	-1.3%	306	300.74	2%
2613.6	21.1	17.51	20.46	20.40	0.30%	1302.2	1318.78	-1.3%	306.91	305.87	0%
2631.6	21.1	17.53	20.50	20.50	0.00%	1309.5	1326.19	-1.3%	309.74	311.00	0%
2656.8	21.1	17.55	20.53	20.53	0.00%	1316.9	1333.60	-1.3%	312.94	316.13	-1%
2674.8	21.9	17.57	20.57	20.57	0.00%	1327.5	1344.28	-1.3%	314.76	321.26	-2%
2685.6	22	17.59	20.64	20.64	0.00%	1349.5	1366.39	-1.3%	316.84	323.39	-2%
2696.4	22	17.61	20.70	20.70	0.02%	1370.1	1387.10	-1.2%	318.67	325.52	-2%
2710.8	22.1	17.63	20.74	20.74	0.00%	1376.1	1393.08	-1.2%	320.5	327.65	-2%
2725.2	22.3	17.65	20.77	20.77	-0.01%	1383.6	1400.70	-1.2%	322.83	329.78	-2%
2746.8	22.3	17.67	20.82	20.82	0.00%	1394.9	1411.99	-1.2%	324.67	331.91	-2%

2786.4	22.3	17.69	20.86	20.86	0.02%	1407.5	1424.70	-1.2%	327.41	334.04	-2%
2826	22.4	17.71	20.92	20.92	0.00%	1424.6	1441.87	-1.2%	331.46	336.17	-1%
2854.8	22.4	17.73	20.98	20.97	0.04%	1443.5	1460.87	-1.2%	335.14	338.30	-1%
2912.4	22.4	17.75	21.03	21.02	0.04%	1457.5	1474.99	-1.2%	339.27	340.43	0%
2937.6	22.2	17.77	21.10	21.10	0.01%	1482.7	1500.27	-1.2%	345.25	342.56	1%
2952	22.2	17.79	21.14	21.14	0.00%	1489.6	1507.22	-1.2%	347.09	344.69	1%
2959.2	22.2	17.81	21.16	21.16	0.00%	1491.6	1509.29	-1.2%	348.93	346.82	1%
2973.6	22.4	17.83	21.18	21.19	-0.03%	1494.1	1511.79	-1.2%	350.77	348.95	1%
2955.6	22.4	17.85	21.23	21.22	0.03%	1503.5	1521.22	-1.2%	353.16	351.08	1%
2948.4	22.4	17.87	21.24	21.24	0.00%	1498.3	1516.02	-1.2%	353.62	353.21	0%
2901.6	22.4	17.89	21.24	21.25	-0.03%	1494.4	1512.02	-1.2%	354.08	354.34	0%
2973.6	22.4	17.91	21.22	21.20	0.10%	1472.6	1490.12	-1.2%	354.54	355.47	0%
2984.4	22.4	17.93	21.31	21.31	0.00%	1504.2	1521.89	-1.2%	355	356.60	0%
2991.6	22.2	17.95	21.34	21.33	0.05%	1508.3	1526.01	-1.2%	350.18	357.73	-2%
3002.4	22.2	17.97	21.34	21.35	-0.06%	1502.4	1524.83	-1.5%	354.72	358.86	-1%
3009.6	22.2	17.99	21.38	21.38	0.00%	1502.4	1524.89	-1.5%	355.62	359.99	-1%
3031.2	22.1	18.01	21.41	21.42	-0.04%	1504.5	1527.01	-1.5%	356.08	361.12	-1%
3042	22.1	18.03	21.45	21.46	-0.06%	1511.3	1533.79	-1.5%	356.53	362.25	-2%
3049.2	22.1	18.05	21.49	21.50	-0.03%	1513.2	1535.70	-1.5%	356.98	363.38	-2%
3060	22.4	18.07	21.53	21.53	0.00%	1515.3	1537.81	-1.5%	363.11	364.51	0%
3063.6	22.4	18.09	21.58	21.58	0.00%	1524.5	1547.07	-1.5%	363.57	365.64	-1%
3070.8	22.4	18.11	21.62	21.62	0.01%	1530.5	1553.09	-1.5%	364.03	366.77	-1%
3081.6	22.5	18.13	21.66	21.65	0.03%	1532.6	1555.20	-1.5%	364.49	367.90	-1%
3067.2	22.5	18.15	21.70	21.69	0.04%	1538.1	1560.78	-1.5%	364.95	369.03	-1%
3056.4	22.5	18.18	21.72	21.71	0.03%	1532.4	1555.00	-1.5%	364.03	370.16	-2%
3013.2	22.6	18.21	21.73	21.73	0.02%	1526.4	1548.99	-1.5%	363.11	371.29	-2%
2955.6	22.6	18.24	21.72	21.72	0.02%	1507.7	1530.21	-1.5%	362.19	372.42	-3%
3013.2	22.6	18.27	21.70	21.70	0.00%	1482.6	1504.92	-1.5%	361.27	373.55	-3%
3042	23	18.3	21.78	21.78	0.02%	1507.3	1529.79	-1.5%	361.19	374.68	-4%
3056.4	23	18.33	21.85	21.85	0.02%	1526.4	1549.02	-1.5%	360.27	375.81	-4%

3099.6	23	18.36	21.91	21.91	0.01%	1539.1	1561.75	-1.5%	361.75	376.94	-4%
3096	22.9	18.39	21.97	21.98	-0.04%	1557.3	1580.10	-1.5%	362.68	378.07	-4%
3103.2	22.9	18.42	22.09	22.00	0.41%	1552.8	1575.50	-1.5%	363.6	379.20	-4%
3121.2	22.9	18.45	22.03	22.03	0.00%	1553.0	1575.77	-1.5%	364.53	380.33	-4%
3132	22.8	18.48	22.08	22.08	0.00%	1560.0	1582.75	-1.5%	366.38	381.46	-4%
3146.4	22.8	18.51	22.10	22.11	-0.04%	1561.9	1584.64	-1.5%	368.8	382.59	-4%
3157.2	22.8	18.54	22.14	22.14	0.00%	1565.4	1588.16	-1.5%	370.66	383.72	-4%
3175.2	22.8	18.57	22.18	22.18	0.00%	1569.1	1591.89	-1.5%	372.51	384.85	-3%
3189.6	22.8	18.6	22.22	22.23	-0.04%	1576.0	1598.87	-1.5%	374.36	385.98	-3%
3200.4	22.8	18.63	22.27	22.27	0.00%	1581.3	1604.22	-1.4%	376.22	387.11	-3%
3211.2	22.9	18.66	22.31	22.30	0.04%	1585.0	1607.95	-1.4%	375.75	388.24	-3%
3193.2	22.9	18.69	22.35	22.34	0.04%	1590.6	1613.52	-1.4%	375.29	389.37	-4%
3178.8	22.9	18.72	22.36	22.36	0.02%	1583.2	1606.12	-1.4%	374.83	390.50	-4%
3189.6	23	18.75	22.37	22.38	-0.04%	1575.6	1598.50	-1.5%	374.36	391.63	-5%
3200.4	23	18.78	22.42	22.42	0.00%	1581.2	1604.07	-1.4%	374.83	392.76	-5%
3211.2	23	18.81	22.46	22.46	0.01%	1586.7	1609.64	-1.4%	375.29	393.89	-5%
3229.2	23.1	18.84	22.49	22.50	-0.04%	1590.4	1613.37	-1.4%	378.36	395.02	-4%
3243.6	23.1	18.87	22.52	22.54	-0.09%	1599.2	1622.18	-1.4%	381.14	396.15	-4%
3268.8	23.1	18.9	22.59	22.59	0.00%	1606.3	1629.37	-1.4%	383.93	397.28	-3%
3294	22.8	18.93	22.64	22.63	0.06%	1616.5	1639.58	-1.4%	386.71	398.41	-3%
3315.6	22.8	18.96	22.68	22.67	0.06%	1621.1	1644.26	-1.4%	389.49	399.54	-3%
3337.2	22.8	18.99	22.72	22.73	-0.04%	1624.2	1647.32	-1.4%	392.27	400.67	-2%
3358.8	22.6	19.02	22.76	22.77	-0.04%	1637.5	1655.90	-1.1%	395.06	401.80	-2%
3369.6	22.6	19.05	22.79	22.80	-0.04%	1642.7	1661.18	-1.1%	397.84	402.93	-1%
3391.2	22.6	19.08	22.82	22.82	0.00%	1643.1	1661.60	-1.1%	400.62	404.06	-1%
3416.4	23.1	19.11	22.86	22.84	0.09%	1652.0	1670.56	-1.1%	403.4	405.19	0%
3438	23.1	19.14	22.92	22.92	0.01%	1671.7	1690.31	-1.1%	406.5	406.32	0%
3463.2	23.1	19.17	22.98	22.96	0.08%	1689.7	1708.45	-1.1%	409.28	407.45	0%
3492	23	19.2	23.02	23.02	0.01%	1700.2	1719.01	-1.1%	412.39	408.58	1%
3524.4	23	19.23	23.07	23.06	0.03%	1710.5	1729.34	-1.1%	415.17	409.71	1%

3549.6	23	19.26	23.11	23.11	0.01%	1722.4	1741.29	-1.1%	417.96	410.84	2%
3571.2	23	19.29	23.16	23.15	0.04%	1732.9	1751.84	-1.1%	420.75	411.97	2%
3596.4	23	19.31	23.17	23.19	-0.08%	1741.8	1760.77	-1.1%	423.53	413.10	2%
3618	23	19.33	23.22	23.23	-0.05%	1752.3	1771.32	-1.1%	426.32	414.23	3%
3639.6	23.1	19.35	23.26	23.27	-0.04%	1761.1	1780.25	-1.1%	427.71	415.36	3%
3654	23.1	19.37	23.31	23.32	-0.03%	1771.8	1791.01	-1.1%	429.11	416.49	3%
3632.4	23.1	19.39	23.35	23.33	0.08%	1779.3	1798.54	-1.1%	427.25	417.62	2%
3610.8	23.4	19.41	23.35	23.34	0.03%	1768.9	1788.10	-1.1%	425.39	418.75	2%
3589.2	23.4	19.43	23.36	23.36	-0.02%	1764.0	1783.17	-1.1%	423.53	419.88	1%
3567.6	23.4	19.45	23.35	23.37	-0.07%	1759.1	1778.24	-1.1%	417.96	421.01	-1%
3535.2	23.6	19.47	23.36	23.36	-0.02%	1748.8	1767.80	-1.1%	412.39	422.14	-2%
3556.8	23.6	19.49	23.36	23.35	0.04%	1737.2	1756.18	-1.1%	411.46	415.33	-1%
3524.4	23.6	19.51	23.41	23.40	0.03%	1749.7	1768.79	-1.1%	410.53	408.52	0%
3488.4	23.6	19.53	23.39	23.38	0.06%	1734.5	1753.50	-1.1%	406.43	401.71	1%
3430.8	23.6	19.55	23.38	23.37	0.04%	1717.7	1736.59	-1.1%	405.5	399.90	1%
3405.6	23.6	19.57	23.34	23.34	-0.01%	1691.2	1709.98	-1.1%	402.74	398.09	1%
3384	23.6	19.59	23.34	23.33	0.03%	1679.2	1697.90	-1.1%	395.37	396.28	0%
3358.8	23.6	19.61	23.34	23.34	-0.02%	1668.8	1687.44	-1.1%	391.68	394.47	-1%
3315.6	23.6	19.63	23.33	23.32	0.04%	1656.8	1675.36	-1.1%	387.99	392.66	-1%
3290.4	23.6	19.65	23.31	23.30	0.04%	1636.8	1655.19	-1.1%	384.31	390.85	-2%
3268.8	23.6	19.67	23.30	23.31	-0.03%	1624.7	1643.10	-1.1%	382	385.04	-1%
3240	23.6	19.69	23.31	23.30	0.04%	1614.3	1632.63	-1.1%	379.7	379.23	0%
3218.4	23.8	19.71	23.29	23.29	0.00%	1600.7	1618.92	-1.1%	374.45	373.42	0%
3196.8	23.8	19.73	23.29	23.30	-0.03%	1593.9	1612.13	-1.1%	372.16	369.61	1%
3164.4	23.8	19.75	23.30	23.30	0.00%	1587.2	1605.35	-1.1%	369.87	365.80	1%
3146.4	24	19.77	23.29	23.29	0.00%	1571.9	1590.01	-1.2%	368.5	363.99	1%
3157.2	24	19.79	23.30	23.28	0.08%	1566.8	1584.84	-1.2%	367.13	362.18	1%
3171.6	24	19.81	23.34	23.34	-0.02%	1574.5	1592.63	-1.1%	365.76	360.37	1%
3139.2	24.1	19.83	23.36	23.37	-0.03%	1566.0	1598.35	-2.1%	361.52	358.56	1%
3114	24.1	19.85	23.38	23.39	-0.03%	1551.5	1583.72	-2.1%	360.16	356.75	1%

3088.8	24.1	19.87	23.41	23.41	-0.01%	1540.1	1572.33	-2.1%	358.8	354.94	1%
3063.6	24.1	19.89	23.43	23.44	-0.02%	1527.0	1559.09	-2.1%	360.27	353.13	2%
3052.8	24.1	19.91	23.46	23.45	0.03%	1513.8	1545.85	-2.1%	358.9	351.32	2%
3034.8	24.1	19.93	23.49	23.50	-0.03%	1507.1	1539.09	-2.1%	357.53	349.51	2%
3024	24.2	19.95	23.52	23.52	0.00%	1497.1	1529.09	-2.1%	353.35	347.70	2%
3013.2	24.2	19.97	23.56	23.56	0.01%	1492.2	1524.18	-2.1%	351.99	345.89	2%
2998.8	24.2	19.99	23.60	23.62	-0.08%	1487.4	1519.27	-2.1%	350.63	344.08	2%
2988	24.2	20.01	23.63	23.63	0.02%	1479.0	1510.88	-2.2%	349.27	342.27	2%
2977.2	24.2	20.06	23.67	23.67	0.00%	1472.3	1504.12	-2.2%	347.91	340.46	2%
2966.4	24.2	20.11	23.71	23.71	0.00%	1465.6	1497.36	-2.2%	346.55	338.65	2%
2948.4	24.2	20.16	23.74	23.74	0.00%	1458.9	1490.60	-2.2%	345.19	336.84	2%
2923.2	24.2	20.21	23.77	23.77	0.00%	1448.9	1480.60	-2.2%	339.29	335.03	1%
2916	24.2	20.26	23.79	23.79	0.00%	1435.7	1467.34	-2.2%	338.39	333.22	2%
2901.6	24.2	20.31	23.83	23.83	0.00%	1430.6	1462.20	-2.2%	337.48	331.41	2%
2887.2	24.2	20.36	23.86	23.86	0.00%	1422.3	1453.82	-2.2%	336.57	329.60	2%
2880	24.2	20.41	23.90	23.90	0.00%	1413.9	1445.43	-2.2%	335.66	327.79	2%
2872.8	24.2	20.46	23.94	23.94	0.00%	1408.8	1440.29	-2.2%	334.76	325.98	3%
2858.4	24.2	20.51	23.98	23.98	0.00%	1403.7	1435.15	-2.2%	333.85	324.17	3%
2840.4	24.1	20.56	24.01	24.01	0.01%	1395.4	1426.76	-2.3%	331.13	322.36	3%
2826	24.1	20.61	24.03	24.04	-0.03%	1383.6	1414.90	-2.3%	328.41	320.55	2%
2811.6	24.1	20.66	24.06	24.06	0.00%	1373.4	1404.67	-2.3%	325.68	318.74	2%
2800.8	24.1	20.71	24.09	24.09	0.01%	1365.0	1396.28	-2.3%	322.96	316.93	2%
2797.2	24.1	20.76	24.13	24.12	0.04%	1358.3	1389.51	-2.3%	322.06	315.12	2%
2779.2	24.1	20.81	24.17	24.17	0.01%	1359.5	1386.00	-1.9%	321.15	313.31	2%
2768.4	23.8	20.86	24.19	24.19	0.01%	1397.3	1376.36	1.5%	320.24	311.50	3%
2750.4	23.8	20.91	24.11	24.11	0.02%	1375.0	1368.21	0.5%	319.33	309.69	3%
2732.4	23.8	20.96	24.06	24.06	0.00%	1362.5	1355.68	0.5%	318.43	307.88	3%
2689.2	23.8	21.01	24.01	24.01	0.00%	1355.6	1348.69	0.5%	315.76	306.07	3%
2674.8	23.6	21.06	23.95	23.94	0.02%	1337.3	1330.30	0.5%	314.85	304.26	3%
2656.8	23.6	21.11	23.90	23.90	0.02%	1328.3	1321.24	0.5%	313.95	302.45	4%

2638.8	23.6	21.16	23.84	23.84	0.01%	1317.6	1310.55	0.5%	310.34	300.64	3%
2613.6	23.5	21.21	23.80	23.79	0.04%	1310.7	1303.54	0.5%	306.73	298.83	3%
2595.6	23.2	21.26	23.74	23.74	0.01%	1298.6	1291.43	0.6%	297.71	297.02	0%
2534.4	23.2	21.3	23.68	23.68	0.01%	1279.6	1277.04	0.2%	293.2	295.21	-1%
2505.6	23.2	21.24	23.59	23.59	-0.02%	1247.3	1244.57	0.2%	288.69	293.40	-2%
2494.8	23	21.21	23.54	23.55	-0.04%	1235.1	1232.28	0.2%	290.04	291.59	-1%
2476.8	23	21.18	23.51	23.51	-0.01%	1227.3	1224.46	0.2%	288.69	289.78	0%
2451.6	23	21.15	23.46	23.47	-0.04%	1216.3	1213.37	0.2%	287.34	287.97	0%
2422.8	22.8	21.12	23.43	23.43	0.00%	1205.7	1202.71	0.2%	285.98	286.16	0%
2408.4	22.8	21.09	23.37	23.37	0.01%	1189.8	1186.72	0.3%	280.57	281.35	0%
2343.6	22.8	21.06	23.33	23.33	0.01%	1180.3	1177.26	0.3%	275.16	276.54	-1%
2296.8	22.8	21.03	23.25	23.25	0.01%	1151.9	1148.63	0.3%	264.78	271.73	-3%
2260.8	22.6	21	23.19	23.19	0.00%	1131.5	1128.14	0.3%	254.41	266.92	-5%
2232	22.6	20.98	23.13	23.13	0.00%	1112.3	1108.86	0.3%	253.51	262.11	-3%
2228.4	22.5	20.96	23.08	23.08	0.02%	1096.4	1092.85	0.3%	252.6	257.30	-2%
2203.2	22.3	20.94	23.06	23.05	0.04%	1093.7	1090.12	0.3%	257.93	252.49	2%
2185.2	22.3	20.92	22.99	23.00	-0.03%	1077.5	1073.90	0.3%	257.01	247.68	4%
2142	22.1	20.9	22.95	22.96	-0.03%	1066.5	1062.78	0.3%	244.8	242.87	1%
2088	21.9	20.88	22.89	22.89	0.02%	1044.0	1040.21	0.4%	242.49	240.06	1%
2077.2	21.7	20.86	22.80	22.80	0.00%	1013.0	1009.03	0.4%	240.18	237.25	1%
2048.4	21.7	20.84	22.76	22.76	0.02%	1001.6	997.50	0.4%	237.87	234.44	1%
2008.8	21.4	20.82	22.70	22.70	0.01%	985.6	981.46	0.4%	235.74	231.63	2%
2001.6	21.3	20.8	22.63	22.63	0.02%	962.9	958.66	0.4%	233.07	228.82	2%
1936.8	21.3	20.78	22.59	22.59	0.01%	953.1	948.77	0.5%	225.33	226.01	0%
1897.2	21.3	20.76	22.51	22.50	0.04%	922.6	918.16	0.5%	220.72	223.20	-1%
1864.8	21.2	20.74	22.45	22.45	0.01%	905.4	900.85	0.5%	216.12	220.39	-2%
1828.8	21.2	20.72	22.40	22.39	0.04%	889.7	884.99	0.5%	211.51	217.58	-3%
1807.2	21.2	20.7	22.34	22.34	-0.01%	872.2	867.47	0.5%	206.9	210.77	-2%
1746	21.2	20.68	22.30	22.30	-0.02%	863.2	858.36	0.6%	200.71	203.96	-2%
1681.2	21.1	20.66	22.22	22.23	-0.03%	836.1	831.17	0.6%	197.53	197.15	0%

1641.6	21.1	20.64	22.14	22.14	-0.01%	805.6	800.48	0.6%	192.77	191.34	1%
1587.6	21.1	20.62	22.08	22.08	-0.01%	786.5	781.28	0.7%	188.17	185.53	1%
1555.2	21	20.6	22.01	22.01	0.00%	762.7	757.33	0.7%	183.43	182.72	0%
1501.2	21	20.58	21.96	21.96	0.00%	746.9	741.42	0.7%	178.83	179.91	-1%
1486.8	21	20.56	21.88	21.88	0.02%	721.2	715.60	0.8%	174.1	177.10	-2%
1443.6	21	20.54	21.85	21.85	0.01%	715.4	709.76	0.8%	169.5	171.29	-1%
1386	20.9	20.52	21.79	21.79	-0.01%	696.4	690.72	0.8%	164.91	165.48	0%
1364.4	20.9	20.5	21.71	21.71	-0.02%	669.1	663.23	0.9%	160.19	159.67	0%
1335.6	20.9	20.48	21.67	21.67	0.00%	658.2	652.23	0.9%	155.14	155.86	0%
1328.4	20.7	20.46	21.62	21.62	-0.02%	645.8	639.77	0.9%	153.89	152.05	1%
1310.4	20.7	20.44	21.59	21.59	0.00%	639.6	633.52	0.9%	152.39	148.24	3%
1292.4	20.6	20.42	21.55	21.55	0.00%	628.4	622.33	1.0%	151.01	144.43	4%
1274.4	20.6	20.4	21.51	21.51	0.00%	619.1	612.97	1.0%	146.7	140.62	4%
1216.8	20.6	20.38	21.47	21.47	0.00%	609.8	603.61	1.0%	142.98	136.81	4%
1184.4	20.5	20.36	21.39	21.39	-0.02%	584.2	577.91	1.1%	135.17	133.00	2%
1130.4	20.5	20.34	21.34	21.34	0.00%	568.4	561.93	1.1%	128.82	129.19	0%
1105.2	20.5	20.32	21.27	21.27	0.00%	542.6	536.02	1.2%	122.47	125.38	-2%
1062	20.3	20.3	21.22	21.22	0.02%	531.8	525.18	1.2%	116.12	121.57	-5%
1011.6	20.3	20.28	21.15	21.16	-0.03%	509.1	502.36	1.3%	110.56	111.76	-1%
964.8	20.3	20.26	21.08	21.08	0.00%	483.1	476.23	1.4%	104.16	105.00	-1%
914.4	20.2	20.24	21.02	21.02	0.02%	462.4	455.42	1.5%	97.687	98.24	-1%
878.4	20.2	20.22	20.95	20.95	0.00%	438.2	431.11	1.6%	91.296	91.48	0%
838.8	20.2	20.2	20.89	20.88	0.04%	420.6	413.42	1.7%	84.905	84.72	0%
820.8	20.2	20.18	20.83	20.83	0.00%	403.2	395.90	1.8%	76.781	77.96	-2%
770.4	20.1	20.16	20.79	20.80	-0.03%	395.7	388.34	1.9%	71.424	71.20	0%
745.2	20.1	20.14	20.72	20.72	0.00%	371.5	363.99	2.0%	65.801	64.44	2%
730.8	20.1	20.12	20.68	20.67	0.04%	358.8	351.26	2.1%	60.466	61.78	-2%
705.6	20.1	20.1	20.65	20.65	0.00%	352.9	345.35	2.2%	55.13	56.25	-2%
680.4	20	20.08	20.60	20.60	-0.01%	342.1	334.46	2.2%	49.795	51.72	-4%
662.4	20	20.06	20.56	20.56	0.00%	329.4	321.72	2.3%	49.795	50.43	-1%

644.4	20	20.04	20.52	20.52	0.00%	320.1	312.30	2.4%	48.787	49.14	-1%
633.6	20	20.02	20.48	20.48	0.00%	312.5	304.72	2.5%	47.779	47.85	0%
622.8	19.9	20	20.45	20.45	0.01%	308.3	300.47	2.5%	46.771	46.56	0%
604.8	19.9	19.98	20.41	20.42	-0.04%	302.3	294.38	2.6%	45.763	45.27	1%
576	19.9	19.96	20.38	20.38	0.00%	292.9	284.96	2.7%	44.755	43.98	2%
543.6	19.9	19.94	20.33	20.33	0.00%	280.4	272.38	2.9%	43.747	42.69	2%
532.8	19.8	19.92	20.28	20.28	0.00%	266.2	258.13	3.0%	42.739	41.40	3%
522	19.8	19.9	20.25	20.24	0.05%	260.1	252.03	3.1%	41.731	40.11	4%
500.4	19.8	19.88	20.22	20.22	0.00%	254.1	245.93	3.2%	40.723	39.88	2%
493.2	19.7	19.86	20.18	20.18	0.00%	244.9	236.68	3.3%	39.715	39.65	0%
489.6	19.7	19.84	20.15	20.15	0.00%	240.4	232.24	3.4%	38.707	39.42	-2%
468	19.7	19.82	20.12	20.12	0.00%	237.7	229.47	3.5%	37.699	39.19	-4%
457.2	19.7	19.8	20.08	20.08	0.00%	228.5	220.21	3.6%	36.691	37.96	-3%
439.2	19.7	19.78	20.05	20.05	0.00%	224.2	215.95	3.7%	35.683	36.73	-3%
435.6	19.7	19.76	20.02	20.02	0.00%	216.7	208.35	3.8%	34.675	35.50	-2%
421.2	19.7	19.74	20.00	20.00	0.00%	215.8	207.43	3.9%	33.667	34.27	-2%
403.2	19.7	19.72	19.97	19.96	0.03%	209.9	201.50	4.0%	32.659	33.04	-1%
396	19.7	19.7	19.93	19.93	0.00%	202.3	193.90	4.2%	31.651	31.81	-1%
385.2	19.6	19.68	19.90	19.90	0.00%	199.7	191.30	4.2%	30.643	30.58	0%
378	19.6	19.66	19.87	19.87	0.00%	193.7	185.19	4.4%	29.635	29.35	1%
367.2	19.6	19.64	19.84	19.84	0.00%	189.2	180.75	4.5%	28.627	28.12	2%
				Max	0.52%		Max	4.49%		Max	4.83%

Winter Simulation Results:

Change in number of water tubes:

Number of Tubes 2				Number of Tubes 4			Number of Tubes 6			Number of Tubes 8		
Tout_sim	Electrical_eff_2	Thermal_eff_2	T cell_2	Electrical_eff_4	Thermal_eff_4	T cell_4	Electrical_eff_6	Thermal_eff_6	T cell_6	Electrical_eff_8	Thermal_eff_8	T cell_8
14.53	14.36%	29.64%	15.66	14.38%	35.93%	15.45	14.38%	38.03%	15.38	14.38%	39.05%	15.35
14.54	14.37%	26.27%	15.57	14.38%	31.84%	15.38	14.39%	33.70%	15.32	14.39%	34.61%	15.29
14.56	14.37%	24.55%	15.60	14.39%	29.75%	15.41	14.39%	31.49%	15.34	14.39%	32.34%	15.31
14.59	14.37%	25.63%	15.71	14.38%	31.07%	15.51	14.39%	32.89%	15.44	14.39%	33.77%	15.41
14.61	14.37%	25.48%	15.75	14.38%	30.89%	15.54	14.39%	32.70%	15.47	14.39%	33.57%	15.44
14.63	14.37%	25.41%	15.81	14.38%	30.80%	15.59	14.39%	32.61%	15.52	14.39%	33.48%	15.48
14.66	14.37%	25.27%	15.84	14.38%	30.63%	15.62	14.39%	32.42%	15.55	14.39%	33.29%	15.52
14.68	14.36%	25.21%	15.90	14.38%	30.56%	15.68	14.38%	32.35%	15.60	14.39%	33.21%	15.56
14.70	14.36%	25.08%	15.93	14.38%	30.40%	15.71	14.38%	32.18%	15.63	14.39%	33.04%	15.60
14.73	14.36%	24.93%	15.99	14.38%	30.21%	15.76	14.38%	31.98%	15.69	14.39%	32.84%	15.65
14.77	14.36%	24.78%	16.06	14.38%	30.04%	15.82	14.38%	31.80%	15.74	14.38%	32.65%	15.71
14.81	14.35%	25.69%	16.23	14.37%	31.15%	15.97	14.38%	32.97%	15.88	14.38%	33.86%	15.84
14.86	14.35%	26.60%	16.45	14.37%	32.25%	16.16	14.37%	34.14%	16.06	14.38%	35.05%	16.02
14.90	14.35%	26.54%	16.57	14.37%	32.17%	16.27	14.37%	34.06%	16.16	14.38%	34.97%	16.12
14.94	14.34%	26.49%	16.70	14.37%	32.12%	16.38	14.37%	34.00%	16.27	14.38%	34.91%	16.22
14.99	14.34%	26.83%	16.87	14.36%	32.53%	16.53	14.37%	34.44%	16.42	14.37%	35.36%	16.36
15.03	14.33%	27.37%	16.98	14.36%	33.19%	16.63	14.37%	35.13%	16.51	14.37%	36.08%	16.45
15.07	14.33%	27.56%	17.08	14.35%	33.42%	16.71	14.36%	35.38%	16.59	14.37%	36.33%	16.53
15.11	14.33%	27.49%	17.21	14.35%	33.32%	16.83	14.36%	35.28%	16.70	14.37%	36.22%	16.64
15.14	14.33%	27.37%	17.30	14.35%	33.18%	16.91	14.36%	35.12%	16.78	14.37%	36.07%	16.72
15.18	14.32%	27.25%	17.39	14.35%	33.04%	16.99	14.36%	34.98%	16.86	14.36%	35.92%	16.79
15.23	14.32%	27.39%	17.52	14.35%	33.21%	17.10	14.36%	35.15%	16.96	14.36%	36.10%	16.90
15.26	14.32%	27.61%	17.61	14.35%	33.48%	17.18	14.36%	35.44%	17.04	14.36%	36.39%	16.97

15.28	14.31%	27.56%	17.69	14.34%	33.41%	17.26	14.35%	35.37%	17.11	14.36%	36.32%	17.04
15.33	14.31%	27.63%	17.93	14.34%	33.50%	17.46	14.35%	35.47%	17.30	14.36%	36.42%	17.22
15.35	14.31%	27.81%	18.00	14.34%	33.72%	17.52	14.35%	35.70%	17.36	14.36%	36.66%	17.29
15.39	14.30%	28.06%	18.20	14.34%	34.03%	17.69	14.35%	36.03%	17.52	14.36%	36.99%	17.44
15.44	14.30%	28.33%	18.47	14.34%	34.36%	17.93	14.35%	36.37%	17.74	14.35%	37.35%	17.65
15.52	14.29%	28.66%	19.02	14.33%	34.75%	18.39	14.35%	36.80%	18.17	14.35%	37.78%	18.07
15.55	14.29%	28.61%	19.13	14.33%	34.70%	18.48	14.35%	36.73%	18.27	14.35%	37.72%	18.16
15.64	14.27%	28.89%	19.81	14.33%	35.04%	19.06	14.34%	37.10%	18.80	14.35%	38.10%	18.68
15.69	14.27%	29.04%	20.09	14.32%	35.22%	19.30	14.34%	37.29%	19.03	14.35%	38.30%	18.90
15.72	14.26%	29.15%	20.23	14.32%	35.36%	19.42	14.34%	37.44%	19.15	14.35%	38.45%	19.01
15.76	14.25%	29.74%	20.50	14.31%	36.07%	19.65	14.33%	38.20%	19.36	14.34%	39.22%	19.22
15.83	14.24%	30.13%	20.94	14.31%	36.56%	20.02	14.33%	38.71%	19.72	14.34%	39.75%	19.57
15.88	14.24%	30.21%	21.25	14.30%	36.65%	20.29	14.33%	38.80%	19.96	14.34%	39.84%	19.81
15.89	14.24%	30.30%	21.14	14.30%	36.76%	20.20	14.32%	38.92%	19.88	14.33%	39.97%	19.73
15.95	14.22%	30.64%	21.53	14.29%	37.17%	20.53	14.32%	39.36%	20.19	14.33%	40.42%	20.03
15.99	14.21%	31.12%	21.73	14.29%	37.75%	20.70	14.31%	39.97%	20.35	14.32%	41.05%	20.18
16.00	14.21%	31.21%	21.69	14.28%	37.87%	20.67	14.31%	40.10%	20.33	14.32%	41.18%	20.16
16.04	14.21%	31.41%	21.85	14.28%	38.11%	20.81	14.31%	40.35%	20.46	14.32%	41.43%	20.29
16.08	14.20%	31.58%	22.09	14.28%	38.31%	21.01	14.30%	40.57%	20.65	14.31%	41.66%	20.48
16.11	14.20%	31.64%	22.18	14.27%	38.39%	21.09	14.30%	40.65%	20.72	14.31%	41.74%	20.55
16.14	14.19%	31.69%	22.32	14.27%	38.45%	21.21	14.30%	40.71%	20.84	14.31%	41.81%	20.66
16.16	14.19%	31.62%	22.37	14.27%	38.37%	21.26	14.30%	40.63%	20.89	14.31%	41.72%	20.71
16.20	14.19%	31.80%	22.54	14.27%	38.58%	21.40	14.29%	40.86%	21.02	14.30%	41.96%	20.84
16.19	14.18%	32.09%	22.68	14.26%	38.94%	21.52	14.29%	41.24%	21.13	14.30%	42.35%	20.94
16.25	14.18%	32.06%	22.83	14.26%	38.90%	21.65	14.29%	41.19%	21.25	14.30%	42.30%	21.06
16.31	14.17%	32.14%	23.01	14.25%	39.01%	21.81	14.28%	41.31%	21.41	14.30%	42.42%	21.21
16.30	14.16%	32.43%	23.13	14.25%	39.36%	21.90	14.28%	41.68%	21.49	14.29%	42.80%	21.29
16.34	14.16%	32.58%	23.25	14.25%	39.53%	22.01	14.28%	41.86%	21.59	14.29%	42.99%	21.39
16.34	14.16%	32.69%	23.34	14.24%	39.67%	22.09	14.27%	42.01%	21.67	14.29%	43.14%	21.46
16.36	14.15%	32.75%	23.45	14.24%	39.75%	22.18	14.27%	42.09%	21.75	14.29%	43.23%	21.55

16.39	14.15%	33.03%	23.64	14.24%	40.09%	22.34	14.27%	42.45%	21.90	14.28%	43.60%	21.69
16.40	14.14%	33.24%	23.79	14.23%	40.34%	22.47	14.26%	42.72%	22.02	14.28%	43.87%	21.81
16.45	14.13%	33.20%	24.00	14.23%	40.30%	22.65	14.26%	42.68%	22.20	14.28%	43.83%	21.98
16.43	14.13%	33.32%	24.14	14.23%	40.44%	22.76	14.26%	42.83%	22.30	14.28%	43.99%	22.08
16.51	14.12%	33.23%	24.39	14.22%	40.34%	22.98	14.26%	42.72%	22.51	14.27%	43.87%	22.28
16.58	14.12%	33.25%	24.67	14.22%	40.36%	23.22	14.25%	42.74%	22.74	14.27%	43.89%	22.50
16.60	14.11%	33.29%	24.89	14.22%	40.41%	23.41	14.25%	42.79%	22.91	14.27%	43.95%	22.67
16.62	14.11%	33.30%	25.07	14.21%	40.43%	23.56	14.25%	42.82%	23.05	14.27%	43.97%	22.81
16.68	14.10%	33.46%	25.34	14.21%	40.63%	23.79	14.24%	43.02%	23.27	14.26%	44.19%	23.02
16.76	14.09%	33.48%	25.53	14.20%	40.64%	23.96	14.24%	43.04%	23.44	14.26%	44.20%	23.18
16.75	14.08%	33.67%	25.70	14.20%	40.88%	24.10	14.23%	43.29%	23.56	14.25%	44.46%	23.30
16.80	14.08%	33.77%	25.84	14.19%	41.00%	24.22	14.23%	43.42%	23.68	14.25%	44.59%	23.42
16.82	14.07%	33.81%	25.95	14.19%	41.05%	24.32	14.23%	43.47%	23.77	14.25%	44.65%	23.50
16.83	14.07%	33.96%	26.12	14.19%	41.23%	24.46	14.23%	43.67%	23.90	14.24%	44.84%	23.63
16.88	14.06%	33.92%	26.25	14.18%	41.19%	24.57	14.22%	43.62%	24.01	14.24%	44.80%	23.74
16.95	14.06%	33.95%	26.45	14.18%	41.23%	24.75	14.22%	43.66%	24.18	14.24%	44.84%	23.91
16.96	14.05%	34.12%	26.57	14.17%	41.42%	24.86	14.21%	43.87%	24.28	14.23%	45.06%	24.00
16.98	14.05%	34.23%	26.73	14.17%	41.56%	24.99	14.21%	44.02%	24.41	14.23%	45.21%	24.12
17.03	14.04%	34.30%	26.90	14.16%	41.65%	25.14	14.21%	44.12%	24.55	14.23%	45.31%	24.26
17.10	14.03%	34.34%	27.01	14.16%	41.70%	25.24	14.20%	44.17%	24.65	14.22%	45.36%	24.36
17.09	14.03%	34.62%	27.16	14.15%	42.04%	25.36	14.20%	44.53%	24.76	14.22%	45.73%	24.47
17.13	14.02%	34.70%	27.30	14.15%	42.14%	25.49	14.19%	44.63%	24.88	14.21%	45.84%	24.58
17.15	14.02%	34.72%	27.43	14.15%	42.16%	25.60	14.19%	44.66%	24.98	14.21%	45.86%	24.69
17.18	14.01%	34.83%	27.55	14.14%	42.29%	25.70	14.19%	44.80%	25.08	14.21%	46.01%	24.78
17.27	14.00%	34.93%	27.71	14.13%	42.42%	25.85	14.18%	44.94%	25.22	14.20%	46.15%	24.92
17.31	13.99%	35.08%	27.91	14.13%	42.61%	26.02	14.17%	45.13%	25.38	14.19%	46.35%	25.08
17.41	13.98%	35.31%	28.20	14.12%	42.88%	26.28	14.16%	45.42%	25.63	14.18%	46.65%	25.32
17.53	13.96%	35.71%	28.64	14.10%	43.38%	26.66	14.14%	45.95%	26.00	14.17%	47.19%	25.67
17.67	13.94%	35.84%	28.98	14.08%	43.55%	26.96	14.13%	46.13%	26.29	14.16%	47.38%	25.96
17.73	13.94%	35.80%	29.10	14.08%	43.49%	27.08	14.13%	46.07%	26.39	14.15%	47.32%	26.06

17.81	13.93%	35.54%	29.44	14.08%	43.18%	27.37	14.13%	45.74%	26.68	14.15%	46.98%	26.34
17.97	13.92%	34.99%	30.05	14.07%	42.52%	27.90	14.12%	45.04%	27.18	14.15%	46.26%	26.83
18.08	13.91%	34.77%	30.29	14.07%	42.25%	28.12	14.12%	44.76%	27.39	14.14%	45.97%	27.03
18.18	13.90%	34.51%	30.68	14.06%	41.93%	28.46	14.11%	44.42%	27.72	14.14%	45.63%	27.35
18.33	13.89%	34.22%	31.01	14.05%	41.58%	28.76	14.11%	44.05%	28.00	14.14%	45.25%	27.63
18.36	13.89%	34.13%	31.26	14.05%	41.47%	28.97	14.11%	43.94%	28.20	14.13%	45.13%	27.82
18.49	13.88%	33.89%	31.55	14.05%	41.19%	29.23	14.10%	43.64%	28.45	14.13%	44.82%	28.07
18.58	13.87%	33.69%	31.99	14.04%	40.94%	29.61	14.10%	43.38%	28.81	14.13%	44.55%	28.42
18.67	13.86%	33.59%	32.36	14.04%	40.82%	29.93	14.10%	43.25%	29.11	14.12%	44.42%	28.71
18.76	13.85%	33.47%	32.80	14.03%	40.68%	30.31	14.09%	43.10%	29.47	14.12%	44.27%	29.06
18.84	13.84%	33.32%	33.11	14.03%	40.51%	30.58	14.09%	42.92%	29.73	14.12%	44.08%	29.32
18.91	13.84%	33.20%	33.38	14.02%	40.36%	30.82	14.08%	42.76%	29.95	14.12%	43.92%	29.53
18.97	13.83%	33.12%	33.50	14.02%	40.26%	30.93	14.08%	42.65%	30.06	14.11%	43.81%	29.64
19.02	13.83%	33.04%	33.57	14.02%	40.17%	30.99	14.08%	42.56%	30.12	14.11%	43.72%	29.70
19.08	13.83%	32.97%	33.66	14.02%	40.08%	31.08	14.08%	42.46%	30.21	14.11%	43.62%	29.79
19.13	13.82%	32.89%	33.78	14.01%	39.98%	31.19	14.08%	42.36%	30.31	14.11%	43.51%	29.89
19.20	13.82%	32.79%	33.98	14.01%	39.86%	31.36	14.07%	42.24%	30.48	14.10%	43.38%	30.05
19.27	13.81%	32.87%	34.20	14.00%	39.96%	31.56	14.07%	42.34%	30.67	14.10%	43.49%	30.24
19.34	13.80%	33.00%	34.46	13.99%	40.13%	31.78	14.06%	42.52%	30.88	14.09%	43.67%	30.44
19.38	13.79%	33.00%	34.64	13.99%	40.13%	31.94	14.05%	42.52%	31.03	14.09%	43.67%	30.59
19.44	13.78%	33.12%	35.06	13.98%	40.28%	32.30	14.05%	42.68%	31.36	14.08%	43.84%	30.91
19.51	13.76%	33.23%	35.52	13.97%	40.41%	32.69	14.04%	42.82%	31.74	14.07%	43.98%	31.27
19.55	13.76%	33.22%	35.73	13.96%	40.40%	32.87	14.03%	42.81%	31.90	14.07%	43.97%	31.44
19.62	13.74%	33.30%	36.27	13.95%	40.50%	33.33	14.02%	42.92%	32.33	14.06%	44.09%	31.85
19.69	13.72%	33.34%	36.75	13.94%	40.55%	33.74	14.02%	42.97%	32.72	14.05%	44.14%	32.23
19.76	13.71%	33.21%	37.20	13.94%	40.40%	34.12	14.01%	42.81%	33.08	14.05%	43.98%	32.58
19.80	13.71%	33.04%	37.42	13.94%	40.19%	34.31	14.02%	42.59%	33.26	14.05%	43.75%	32.75
19.82	13.71%	32.91%	37.44	13.94%	40.04%	34.33	14.02%	42.42%	33.28	14.05%	43.58%	32.77
19.85	13.71%	32.87%	37.57	13.94%	39.98%	34.45	14.02%	42.37%	33.39	14.05%	43.52%	32.88
19.89	13.71%	32.82%	37.70	13.94%	39.93%	34.56	14.01%	42.31%	33.50	14.05%	43.47%	32.98

19.92	13.70%	32.77%	37.88	13.93%	39.87%	34.72	14.01%	42.25%	33.64	14.05%	43.40%	33.13
19.98	13.68%	33.09%	38.24	13.92%	40.26%	35.02	14.00%	42.66%	33.93	14.04%	43.83%	33.40
20.03	13.66%	33.47%	38.57	13.90%	40.72%	35.31	13.98%	43.15%	34.20	14.02%	44.33%	33.67
20.06	13.66%	33.47%	38.68	13.90%	40.73%	35.40	13.98%	43.16%	34.29	14.02%	44.34%	33.75
20.10	13.65%	33.48%	38.82	13.90%	40.74%	35.52	13.98%	43.17%	34.40	14.02%	44.35%	33.86
20.13	13.64%	33.57%	39.01	13.89%	40.85%	35.68	13.97%	43.29%	34.56	14.01%	44.47%	34.01
20.17	13.64%	33.61%	39.22	13.88%	40.90%	35.86	13.97%	43.34%	34.73	14.01%	44.52%	34.18
20.22	13.63%	33.53%	39.49	13.88%	40.80%	36.10	13.96%	43.24%	34.95	14.00%	44.42%	34.40
20.27	13.62%	33.49%	39.80	13.87%	40.76%	36.36	13.96%	43.20%	35.20	14.00%	44.38%	34.63
20.32	13.61%	33.47%	40.03	13.87%	40.74%	36.56	13.96%	43.17%	35.39	14.00%	44.35%	34.82
20.38	13.61%	33.37%	40.43	13.87%	40.62%	36.90	13.95%	43.05%	35.71	14.00%	44.22%	35.13
20.41	13.60%	33.24%	40.55	13.87%	40.45%	37.00	13.95%	42.87%	35.81	14.00%	44.04%	35.22
20.43	13.61%	33.12%	40.60	13.87%	40.31%	37.05	13.96%	42.72%	35.85	14.00%	43.89%	35.27
20.45	13.60%	33.09%	40.65	13.87%	40.27%	37.10	13.96%	42.68%	35.90	14.00%	43.85%	35.32
20.49	13.60%	33.14%	40.82	13.86%	40.33%	37.24	13.95%	42.74%	36.03	13.99%	43.91%	35.44
20.50	13.60%	33.23%	40.76	13.86%	40.44%	37.20	13.95%	42.86%	35.99	13.99%	44.03%	35.41
20.51	13.60%	33.22%	40.72	13.86%	40.43%	37.17	13.95%	42.85%	35.96	13.99%	44.02%	35.38
20.50	13.60%	33.27%	40.41	13.86%	40.49%	36.91	13.95%	42.91%	35.72	13.99%	44.08%	35.15
20.57	13.59%	33.15%	40.91	13.85%	40.35%	37.33	13.94%	42.76%	36.12	13.99%	43.93%	35.53
20.60	13.59%	33.12%	40.99	13.85%	40.31%	37.40	13.94%	42.72%	36.19	13.99%	43.89%	35.60
20.62	13.59%	33.01%	40.99	13.86%	40.18%	37.41	13.95%	42.59%	36.19	13.99%	43.75%	35.61
20.65	13.59%	32.89%	41.02	13.86%	40.03%	37.43	13.95%	42.43%	36.22	13.99%	43.59%	35.63
20.68	13.59%	32.86%	41.08	13.86%	39.99%	37.49	13.95%	42.39%	36.28	13.99%	43.55%	35.69
20.72	13.59%	32.77%	41.21	13.85%	39.88%	37.61	13.94%	42.27%	36.39	13.99%	43.43%	35.80
20.75	13.59%	32.69%	41.27	13.85%	39.79%	37.66	13.94%	42.17%	36.44	13.99%	43.32%	35.85
20.79	13.59%	32.65%	41.33	13.85%	39.75%	37.72	13.94%	42.13%	36.49	13.99%	43.28%	35.90
20.83	13.58%	32.74%	41.50	13.85%	39.85%	37.86	13.94%	42.24%	36.64	13.98%	43.39%	36.04
20.87	13.57%	32.83%	41.62	13.84%	39.96%	37.97	13.93%	42.35%	36.74	13.97%	43.51%	36.14
20.90	13.57%	32.79%	41.68	13.84%	39.92%	38.03	13.93%	42.31%	36.79	13.97%	43.47%	36.19
20.94	13.56%	32.79%	41.79	13.83%	39.92%	38.13	13.93%	42.31%	36.89	13.97%	43.47%	36.29

20.96	13.56%	32.83%	41.74	13.83%	39.96%	38.09	13.92%	42.36%	36.85	13.97%	43.51%	36.25
20.98	13.56%	32.82%	41.68	13.83%	39.95%	38.04	13.92%	42.34%	36.81	13.97%	43.50%	36.21
20.98	13.57%	32.88%	41.42	13.83%	40.03%	37.83	13.92%	42.43%	36.62	13.97%	43.59%	36.03
20.97	13.57%	32.97%	41.08	13.83%	40.13%	37.54	13.92%	42.54%	36.35	13.96%	43.70%	35.77
21.04	13.56%	32.87%	41.48	13.83%	40.02%	37.89	13.92%	42.41%	36.67	13.96%	43.57%	36.08
21.10	13.55%	32.97%	41.80	13.82%	40.14%	38.16	13.91%	42.55%	36.93	13.95%	43.71%	36.34
21.15	13.54%	33.09%	42.02	13.81%	40.28%	38.35	13.90%	42.70%	37.12	13.94%	43.87%	36.51
21.21	13.53%	33.01%	42.32	13.80%	40.19%	38.62	13.90%	42.60%	37.36	13.94%	43.76%	36.75
21.24	13.53%	32.95%	42.28	13.80%	40.12%	38.59	13.90%	42.52%	37.34	13.94%	43.69%	36.73
21.27	13.53%	32.88%	42.32	13.80%	40.03%	38.62	13.90%	42.43%	37.37	13.94%	43.59%	36.76
21.31	13.53%	32.83%	42.45	13.80%	39.97%	38.74	13.90%	42.37%	37.48	13.94%	43.53%	36.87
21.34	13.53%	32.76%	42.51	13.80%	39.88%	38.79	13.90%	42.27%	37.53	13.94%	43.43%	36.92
21.38	13.53%	32.68%	42.59	13.80%	39.78%	38.86	13.90%	42.17%	37.60	13.94%	43.32%	36.99
21.41	13.52%	32.64%	42.67	13.80%	39.74%	38.94	13.89%	42.12%	37.68	13.94%	43.28%	37.07
21.45	13.52%	32.60%	42.81	13.80%	39.69%	39.06	13.89%	42.07%	37.79	13.94%	43.22%	37.18
21.49	13.52%	32.56%	42.92	13.80%	39.64%	39.16	13.89%	42.02%	37.88	13.94%	43.17%	37.27
21.53	13.51%	32.52%	43.00	13.79%	39.60%	39.23	13.89%	41.97%	37.96	13.93%	43.12%	37.34
21.57	13.51%	32.52%	43.11	13.79%	39.60%	39.33	13.88%	41.98%	38.05	13.93%	43.13%	37.43
21.59	13.51%	32.56%	43.03	13.79%	39.64%	39.27	13.88%	42.02%	38.00	13.93%	43.17%	37.38
21.60	13.51%	32.55%	42.95	13.79%	39.63%	39.20	13.88%	42.01%	37.94	13.93%	43.16%	37.32
21.64	13.51%	32.55%	43.06	13.78%	39.64%	39.31	13.88%	42.01%	38.03	13.92%	43.17%	37.42
21.68	13.50%	32.55%	43.18	13.78%	39.64%	39.41	13.88%	42.02%	38.13	13.92%	43.17%	37.51
21.72	13.50%	32.52%	43.26	13.78%	39.60%	39.48	13.87%	41.97%	38.20	13.92%	43.12%	37.58
21.76	13.49%	32.51%	43.42	13.77%	39.59%	39.62	13.87%	41.97%	38.34	13.92%	43.12%	37.71
21.80	13.49%	32.51%	43.56	13.77%	39.59%	39.75	13.87%	41.97%	38.45	13.91%	43.12%	37.83
21.85	13.48%	32.46%	43.74	13.77%	39.53%	39.90	13.86%	41.91%	38.60	13.91%	43.05%	37.97
21.89	13.48%	32.30%	43.84	13.77%	39.34%	39.99	13.87%	41.70%	38.69	13.91%	42.84%	38.06
21.92	13.48%	32.15%	43.91	13.77%	39.15%	40.06	13.87%	41.50%	38.75	13.92%	42.64%	38.12
21.96	13.48%	32.11%	44.07	13.77%	39.10%	40.20	13.87%	41.45%	38.88	13.91%	42.58%	38.25
21.99	13.48%	32.00%	44.17	13.77%	38.97%	40.28	13.87%	41.31%	38.97	13.92%	42.44%	38.33

22.01	13.48%	31.90%	44.19	13.77%	38.85%	40.31	13.87%	41.19%	38.99	13.92%	42.32%	38.35
22.05	13.48%	31.87%	44.35	13.77%	38.81%	40.44	13.87%	41.14%	39.12	13.92%	42.27%	38.47
22.10	13.46%	32.01%	44.66	13.76%	38.99%	40.71	13.86%	41.33%	39.37	13.91%	42.46%	38.72
22.15	13.45%	32.15%	44.96	13.75%	39.16%	40.96	13.85%	41.52%	39.61	13.90%	42.66%	38.95
22.19	13.44%	32.12%	45.14	13.74%	39.12%	41.12	13.85%	41.47%	39.76	13.90%	42.61%	39.10
22.22	13.44%	32.04%	45.31	13.74%	39.03%	41.27	13.85%	41.38%	39.90	13.89%	42.51%	39.23
22.26	13.44%	31.96%	45.51	13.74%	38.94%	41.44	13.84%	41.28%	40.06	13.89%	42.41%	39.39
22.30	13.43%	31.93%	45.68	13.74%	38.90%	41.59	13.84%	41.23%	40.20	13.89%	42.37%	39.53
22.33	13.43%	31.90%	45.84	13.74%	38.86%	41.72	13.84%	41.19%	40.33	13.89%	42.32%	39.65
22.37	13.42%	31.86%	46.01	13.73%	38.82%	41.88	13.84%	41.15%	40.48	13.89%	42.28%	39.79
22.40	13.42%	31.83%	46.17	13.73%	38.78%	42.01	13.84%	41.11%	40.60	13.89%	42.24%	39.92
22.44	13.41%	31.83%	46.35	13.73%	38.78%	42.17	13.83%	41.12%	40.75	13.88%	42.24%	40.06
22.47	13.41%	31.84%	46.48	13.72%	38.79%	42.28	13.83%	41.13%	40.86	13.88%	42.26%	40.17
22.48	13.41%	31.84%	46.34	13.72%	38.80%	42.17	13.83%	41.13%	40.76	13.88%	42.26%	40.07
22.49	13.41%	31.95%	46.29	13.72%	38.92%	42.13	13.82%	41.26%	40.72	13.88%	42.40%	40.03
22.50	13.40%	32.05%	46.24	13.71%	39.05%	42.09	13.82%	41.40%	40.68	13.87%	42.54%	40.00
22.51	13.41%	32.06%	46.10	13.72%	39.06%	41.98	13.82%	41.41%	40.58	13.87%	42.54%	39.90
22.51	13.41%	32.14%	45.95	13.71%	39.16%	41.85	13.82%	41.51%	40.46	13.87%	42.65%	39.79
22.55	13.40%	32.17%	46.16	13.71%	39.20%	42.03	13.81%	41.56%	40.63	13.86%	42.70%	39.95
22.54	13.40%	32.19%	45.95	13.71%	39.22%	41.86	13.81%	41.58%	40.47	13.86%	42.72%	39.80
22.53	13.41%	32.21%	45.72	13.71%	39.24%	41.66	13.81%	41.60%	40.29	13.86%	42.74%	39.62
22.51	13.42%	32.25%	45.34	13.72%	39.28%	41.35	13.82%	41.65%	39.99	13.87%	42.79%	39.33
22.51	13.42%	32.26%	45.18	13.72%	39.29%	41.21	13.82%	41.66%	39.87	13.87%	42.80%	39.22
22.52	13.42%	32.26%	45.04	13.72%	39.30%	41.10	13.82%	41.66%	39.76	13.87%	42.81%	39.12
22.52	13.43%	32.27%	44.88	13.72%	39.31%	40.97	13.82%	41.67%	39.64	13.87%	42.82%	39.00
22.50	13.43%	32.30%	44.60	13.72%	39.34%	40.73	13.82%	41.71%	39.42	13.87%	42.85%	38.78
22.50	13.44%	32.31%	44.44	13.72%	39.35%	40.60	13.82%	41.72%	39.30	13.87%	42.86%	38.67
22.51	13.44%	32.31%	44.30	13.72%	39.36%	40.49	13.82%	41.72%	39.19	13.87%	42.87%	38.57
22.50	13.44%	32.33%	44.12	13.73%	39.37%	40.33	13.82%	41.74%	39.05	13.87%	42.89%	38.43
22.51	13.44%	32.41%	44.04	13.72%	39.47%	40.27	13.82%	41.85%	38.99	13.86%	42.99%	38.37

22.52	13.44%	32.49%	43.96	13.72%	39.57%	40.20	13.81%	41.95%	38.93	13.86%	43.10%	38.31
22.52	13.45%	32.51%	43.75	13.72%	39.60%	40.03	13.82%	41.98%	38.77	13.86%	43.13%	38.16
22.53	13.44%	32.59%	43.69	13.72%	39.70%	39.98	13.81%	42.08%	38.73	13.86%	43.24%	38.12
22.56	13.44%	32.64%	43.83	13.71%	39.76%	40.10	13.81%	42.15%	38.84	13.85%	43.30%	38.23
22.59	13.43%	32.61%	43.93	13.71%	39.72%	40.20	13.81%	42.10%	38.93	13.85%	43.26%	38.32
22.62	13.44%	32.64%	43.76	13.71%	39.76%	40.06	13.80%	42.15%	38.81	13.85%	43.31%	38.20
22.65	13.44%	32.67%	43.64	13.71%	39.79%	39.97	13.80%	42.18%	38.72	13.85%	43.34%	38.12
22.68	13.44%	32.66%	43.49	13.71%	39.78%	39.85	13.80%	42.17%	38.61	13.84%	43.32%	38.01
22.71	13.44%	32.65%	43.35	13.71%	39.76%	39.73	13.80%	42.15%	38.51	13.84%	43.31%	37.91
22.75	13.44%	32.62%	43.29	13.71%	39.73%	39.69	13.80%	42.11%	38.48	13.84%	43.27%	37.88
22.78	13.44%	32.60%	43.19	13.71%	39.70%	39.62	13.80%	42.09%	38.41	13.84%	43.24%	37.82
22.82	13.44%	32.61%	43.17	13.70%	39.71%	39.61	13.79%	42.10%	38.40	13.84%	43.26%	37.81
22.86	13.44%	32.62%	43.15	13.70%	39.73%	39.59	13.79%	42.12%	38.39	13.83%	43.27%	37.81
22.90	13.44%	32.59%	43.07	13.70%	39.70%	39.54	13.79%	42.08%	38.34	13.83%	43.24%	37.76
22.94	13.44%	32.56%	43.02	13.70%	39.66%	39.50	13.79%	42.04%	38.31	13.83%	43.20%	37.73
22.98	13.44%	32.53%	42.97	13.70%	39.62%	39.47	13.79%	42.01%	38.28	13.83%	43.16%	37.70
23.02	13.44%	32.50%	42.91	13.70%	39.59%	39.43	13.78%	41.97%	38.25	13.83%	43.12%	37.68
23.05	13.44%	32.48%	42.81	13.70%	39.56%	39.35	13.78%	41.94%	38.18	13.83%	43.09%	37.61
23.08	13.44%	32.47%	42.67	13.70%	39.54%	39.23	13.78%	41.92%	38.07	13.82%	43.07%	37.51
23.12	13.44%	32.43%	42.64	13.70%	39.50%	39.22	13.78%	41.87%	38.06	13.82%	43.02%	37.50
23.16	13.44%	32.40%	42.56	13.69%	39.47%	39.16	13.78%	41.84%	38.01	13.82%	42.99%	37.45
23.19	13.44%	32.38%	42.49	13.69%	39.43%	39.11	13.78%	41.80%	37.96	13.82%	42.95%	37.41
23.24	13.44%	32.34%	42.46	13.69%	39.39%	39.09	13.78%	41.76%	37.95	13.82%	42.90%	37.40
23.28	13.44%	32.31%	42.43	13.69%	39.34%	39.07	13.77%	41.71%	37.94	13.82%	42.85%	37.39
23.31	13.44%	32.28%	42.35	13.69%	39.31%	39.02	13.77%	41.67%	37.89	13.81%	42.82%	37.34
23.34	13.45%	32.21%	42.23	13.69%	39.23%	38.92	13.77%	41.58%	37.80	13.81%	42.72%	37.25
23.38	13.45%	32.14%	42.12	13.69%	39.14%	38.84	13.77%	41.49%	37.73	13.81%	42.63%	37.19
23.41	13.45%	32.11%	42.05	13.69%	39.10%	38.78	13.77%	41.45%	37.68	13.81%	42.59%	37.14
23.45	13.45%	32.07%	41.99	13.69%	39.06%	38.74	13.77%	41.41%	37.65	13.81%	42.54%	37.11
23.50	13.45%	32.03%	41.99	13.69%	39.01%	38.75	13.77%	41.35%	37.65	13.81%	42.49%	37.12

23.52	13.45%	32.01%	41.89	13.69%	38.99%	38.67	13.77%	41.33%	37.58	13.81%	42.47%	37.05
23.45	13.46%	31.95%	41.70	13.70%	38.91%	38.50	13.78%	41.24%	37.42	13.81%	42.38%	36.90
23.40	13.47%	31.86%	41.48	13.70%	38.80%	38.31	13.78%	41.13%	37.24	13.82%	42.26%	36.72
23.36	13.47%	31.91%	41.35	13.71%	38.85%	38.20	13.78%	41.19%	37.13	13.82%	42.32%	36.61
23.30	13.48%	31.98%	41.05	13.71%	38.94%	37.93	13.79%	41.28%	36.88	13.83%	42.41%	36.37
23.25	13.49%	31.93%	40.88	13.72%	38.88%	37.79	13.79%	41.21%	36.74	13.83%	42.34%	36.23
23.20	13.50%	31.89%	40.69	13.72%	38.83%	37.62	13.80%	41.16%	36.58	13.83%	42.28%	36.08
23.16	13.50%	31.93%	40.56	13.72%	38.88%	37.50	13.80%	41.22%	36.47	13.84%	42.34%	35.97
23.11	13.51%	31.94%	40.35	13.73%	38.89%	37.32	13.80%	41.22%	36.30	13.84%	42.35%	35.80
23.06	13.52%	31.80%	40.10	13.74%	38.72%	37.11	13.81%	41.04%	36.10	13.85%	42.17%	35.61
22.99	13.54%	31.74%	39.59	13.75%	38.64%	36.68	13.82%	40.96%	35.69	13.85%	42.08%	35.21
22.95	13.54%	31.79%	39.39	13.75%	38.70%	36.50	13.82%	41.02%	35.52	13.86%	42.14%	35.05
22.92	13.55%	31.73%	39.25	13.76%	38.62%	36.38	13.83%	40.93%	35.41	13.86%	42.05%	34.94
22.88	13.55%	31.67%	39.07	13.76%	38.54%	36.22	13.83%	40.85%	35.26	13.87%	41.97%	34.79
22.84	13.56%	31.71%	38.89	13.76%	38.60%	36.07	13.83%	40.91%	35.11	13.87%	42.03%	34.65
22.79	13.57%	31.66%	38.63	13.77%	38.53%	35.84	13.84%	40.84%	34.90	13.87%	41.96%	34.45
22.76	13.57%	31.59%	38.46	13.77%	38.45%	35.70	13.84%	40.76%	34.77	13.88%	41.87%	34.32
22.69	13.58%	31.68%	38.02	13.78%	38.55%	35.32	13.85%	40.86%	34.41	13.88%	41.98%	33.97
22.64	13.59%	31.75%	37.69	13.78%	38.64%	35.04	13.85%	40.95%	34.15	13.88%	42.07%	33.71
22.59	13.60%	31.70%	37.38	13.79%	38.58%	34.78	13.85%	40.89%	33.90	13.88%	42.01%	33.47
22.54	13.61%	31.65%	37.12	13.79%	38.51%	34.56	13.86%	40.81%	33.69	13.89%	41.93%	33.27
22.52	13.61%	31.62%	37.06	13.80%	38.48%	34.50	13.86%	40.78%	33.64	13.89%	41.89%	33.22
22.47	13.62%	31.50%	36.80	13.80%	38.33%	34.27	13.87%	40.62%	33.42	13.90%	41.73%	33.01
22.43	13.63%	31.43%	36.61	13.81%	38.24%	34.11	13.87%	40.53%	33.27	13.90%	41.64%	32.86
22.38	13.64%	31.38%	36.25	13.82%	38.18%	33.81	13.88%	40.47%	32.98	13.91%	41.57%	32.58
22.31	13.66%	31.23%	35.76	13.83%	37.99%	33.39	13.89%	40.26%	32.59	13.91%	41.36%	32.20
22.27	13.67%	31.03%	35.57	13.84%	37.74%	33.22	13.89%	40.00%	32.43	13.92%	41.09%	32.05
22.22	13.67%	30.95%	35.31	13.84%	37.65%	33.00	13.90%	39.90%	32.22	13.92%	40.99%	31.84
22.17	13.69%	30.83%	34.95	13.85%	37.50%	32.69	13.90%	39.74%	31.93	13.93%	40.82%	31.56
22.13	13.70%	30.62%	34.78	13.86%	37.24%	32.55	13.91%	39.46%	31.79	13.94%	40.54%	31.43

22.06	13.71%	30.62%	34.30	13.86%	37.24%	32.14	13.92%	39.46%	31.41	13.94%	40.54%	31.06
22.01	13.71%	30.67%	34.02	13.87%	37.30%	31.90	13.92%	39.53%	31.19	13.94%	40.60%	30.84
21.97	13.72%	30.65%	33.76	13.87%	37.28%	31.68	13.92%	39.50%	30.98	13.94%	40.58%	30.64
21.92	13.73%	30.64%	33.48	13.87%	37.26%	31.44	13.92%	39.48%	30.75	13.95%	40.56%	30.42
21.88	13.73%	30.68%	33.33	13.88%	37.31%	31.31	13.92%	39.53%	30.62	13.95%	40.61%	30.29
21.82	13.74%	30.75%	32.90	13.88%	37.39%	30.94	13.93%	39.62%	30.28	13.95%	40.70%	29.96
21.75	13.75%	30.75%	32.42	13.89%	37.39%	30.54	13.93%	39.62%	29.90	13.95%	40.70%	29.59
21.70	13.76%	30.74%	32.12	13.89%	37.38%	30.27	13.93%	39.60%	29.65	13.96%	40.68%	29.35
21.64	13.77%	30.81%	31.74	13.89%	37.46%	29.95	13.94%	39.70%	29.35	13.96%	40.78%	29.06
21.60	13.77%	30.79%	31.48	13.90%	37.44%	29.73	13.94%	39.67%	29.14	13.96%	40.75%	28.86
21.53	13.78%	30.79%	31.07	13.90%	37.43%	29.39	13.94%	39.66%	28.82	13.96%	40.74%	28.54
21.50	13.78%	30.84%	30.97	13.90%	37.49%	29.29	13.94%	39.72%	28.73	13.96%	40.80%	28.45
21.45	13.79%	30.91%	30.66	13.91%	37.57%	29.03	13.94%	39.81%	28.48	13.96%	40.89%	28.22
21.39	13.80%	30.91%	30.23	13.91%	37.57%	28.67	13.95%	39.81%	28.14	13.97%	40.89%	27.88
21.35	13.80%	30.88%	30.05	13.91%	37.53%	28.51	13.95%	39.77%	27.99	13.97%	40.85%	27.74
21.31	13.81%	30.94%	29.84	13.92%	37.61%	28.33	13.95%	39.85%	27.82	13.97%	40.93%	27.57
21.28	13.81%	30.81%	29.73	13.92%	37.44%	28.23	13.96%	39.67%	27.73	13.97%	40.75%	27.48
21.24	13.82%	30.67%	29.54	13.92%	37.28%	28.07	13.96%	39.50%	27.57	13.98%	40.57%	27.33
21.21	13.83%	30.63%	29.38	13.93%	37.23%	27.93	13.96%	39.44%	27.44	13.98%	40.52%	27.21
21.17	13.83%	30.59%	29.22	13.93%	37.18%	27.79	13.96%	39.39%	27.31	13.98%	40.46%	27.08
21.11	13.84%	30.68%	28.82	13.93%	37.28%	27.45	13.97%	39.50%	26.99	13.98%	40.57%	26.77
21.07	13.84%	30.64%	28.56	13.94%	37.24%	27.23	13.97%	39.45%	26.78	13.98%	40.52%	26.56
21.00	13.85%	30.63%	28.15	13.94%	37.21%	26.88	13.97%	39.43%	26.45	13.99%	40.50%	26.25
20.97	13.86%	30.69%	27.97	13.94%	37.29%	26.73	13.97%	39.51%	26.31	13.99%	40.58%	26.10
20.91	13.87%	30.55%	27.61	13.95%	37.12%	26.42	13.98%	39.32%	26.02	13.99%	40.39%	25.82
20.85	13.88%	30.40%	27.19	13.95%	36.93%	26.07	13.98%	39.13%	25.69	13.99%	40.19%	25.50
20.79	13.88%	30.48%	26.86	13.96%	37.03%	25.79	13.98%	39.23%	25.42	13.99%	40.30%	25.25
20.73	13.89%	30.45%	26.48	13.96%	36.99%	25.46	13.98%	39.18%	25.12	14.00%	40.24%	24.95
20.69	13.90%	30.39%	26.20	13.96%	36.92%	25.22	13.99%	39.11%	24.89	14.00%	40.17%	24.73
20.64	13.90%	30.48%	25.91	13.97%	37.03%	24.98	13.99%	39.22%	24.66	14.00%	40.29%	24.51

20.61	13.90%	30.56%	25.78	13.97%	37.12%	24.86	13.99%	39.32%	24.55	14.00%	40.39%	24.40
20.55	13.91%	30.51%	25.40	13.97%	37.06%	24.54	13.99%	39.26%	24.25	14.00%	40.32%	24.10
20.51	13.92%	30.44%	25.19	13.97%	36.97%	24.35	13.99%	39.17%	24.07	14.00%	40.23%	23.94
20.48	13.92%	30.52%	25.08	13.98%	37.07%	24.26	13.99%	39.27%	23.99	14.00%	40.33%	23.85
20.44	13.92%	30.62%	24.90	13.98%	37.19%	24.10	14.00%	39.39%	23.84	14.00%	40.46%	23.71
20.40	13.93%	30.54%	24.69	13.98%	37.09%	23.92	14.00%	39.29%	23.67	14.01%	40.35%	23.54
20.36	13.93%	30.45%	24.53	13.98%	36.98%	23.78	14.00%	39.17%	23.54	14.01%	40.23%	23.42
20.33	13.93%	30.54%	24.39	13.98%	37.10%	23.67	14.00%	39.29%	23.43	14.01%	40.36%	23.31
20.30	13.94%	30.64%	24.31	13.99%	37.20%	23.60	14.00%	39.41%	23.36	14.01%	40.48%	23.24
20.27	13.94%	30.53%	24.20	13.99%	37.08%	23.50	14.00%	39.28%	23.26	14.01%	40.34%	23.15
20.24	13.94%	30.43%	24.04	13.99%	36.96%	23.36	14.01%	39.15%	23.13	14.01%	40.21%	23.02
20.20	13.95%	30.55%	23.83	13.99%	37.10%	23.18	14.01%	39.29%	22.97	14.01%	40.36%	22.86
20.16	13.95%	30.68%	23.60	13.99%	37.26%	22.98	14.01%	39.46%	22.78	14.01%	40.53%	22.68
20.13	13.95%	30.56%	23.49	14.00%	37.11%	22.89	14.01%	39.31%	22.69	14.02%	40.37%	22.59
20.10	13.96%	30.44%	23.37	14.00%	36.96%	22.79	14.01%	39.14%	22.59	14.02%	40.20%	22.50
20.06	13.96%	30.56%	23.22	14.00%	37.11%	22.65	14.01%	39.30%	22.47	14.02%	40.37%	22.37
20.03	13.96%	30.42%	23.13	14.00%	36.94%	22.58	14.02%	39.12%	22.39	14.02%	40.18%	22.30
20.01	13.97%	30.28%	23.07	14.00%	36.76%	22.52	14.02%	38.94%	22.34	14.02%	39.99%	22.25
19.98	13.97%	31.10%	22.91	14.01%	36.91%	22.39	14.02%	39.10%	22.21	14.02%	40.15%	22.13
19.95	13.97%	31.25%	22.83	14.01%	37.06%	22.31	14.02%	39.25%	22.14	14.02%	40.31%	22.06
19.92	13.97%	31.09%	22.69	14.01%	37.23%	22.20	14.02%	39.43%	22.03	14.03%	40.50%	21.95
19.89	13.97%	30.92%	22.66	14.01%	37.37%	22.17	14.02%	39.58%	22.00	14.03%	40.65%	21.92
19.87	13.98%	32.50%	22.55	14.01%	37.55%	22.07	14.02%	39.77%	21.91	14.03%	40.85%	21.83
19.83	13.98%	32.50%	22.42	14.01%	37.76%	21.96	14.02%	39.99%	21.80	14.03%	41.07%	21.73
19.81	13.98%	32.50%	22.36	14.01%	37.93%	21.91	14.02%	40.18%	21.75	14.03%	41.26%	21.68
19.78	13.98%	32.50%	22.25	14.01%	37.75%	21.81	14.02%	39.98%	21.66	14.03%	41.06%	21.59
19.75	13.99%	32.50%	22.16	14.02%	37.54%	21.73	14.03%	39.76%	21.59	14.03%	40.84%	21.52
Average	13.77%	31.85%	33.59	13.95%	38.69%	31.20	14.01%	40.99%	30.39	14.04%	42.11%	30.00
Max	14.37%	35.84%	46.48	14.38%	43.55%	42.28	14.39%	46.13%	40.86	14.39%	47.38%	40.17
Number of Tubes 10			Number of Tubes 12			Number of Tubes 14			Number of Tubes 16			

Electrical_ eff_10	Thermal_eff_10	T cell_10	Electrical_ eff_12	Thermal_eff_12	T cell_12	Electrical_ eff_14	Thermal_ eff_14	T cell_14	Electrical_ eff_16	Thermal_eff_16	T cell_16
14.38%	39.65%	15.33	0.14	0.40	15.31	0.14	0.40	15.31	0.14	0.41	15.30
14.39%	35.13%	15.27	0.14	0.35	15.26	0.14	0.36	15.25	0.14	0.36	15.25
14.39%	32.83%	15.29	0.14	0.33	15.28	0.14	0.33	15.27	0.14	0.34	15.27
14.39%	34.28%	15.39	0.14	0.35	15.37	0.14	0.35	15.36	0.14	0.35	15.36
14.39%	34.08%	15.42	0.14	0.34	15.40	0.14	0.35	15.39	0.14	0.35	15.39
14.39%	33.99%	15.46	0.14	0.34	15.45	0.14	0.35	15.44	0.14	0.35	15.44
14.39%	33.80%	15.49	0.14	0.34	15.48	0.14	0.34	15.47	0.14	0.35	15.47
14.39%	33.72%	15.54	0.14	0.34	15.53	0.14	0.34	15.52	0.14	0.34	15.51
14.39%	33.54%	15.57	0.14	0.34	15.56	0.14	0.34	15.55	0.14	0.34	15.54
14.39%	33.34%	15.63	0.14	0.34	15.61	0.14	0.34	15.60	0.14	0.34	15.60
14.39%	33.15%	15.68	0.14	0.33	15.67	0.14	0.34	15.66	0.14	0.34	15.65
14.38%	34.37%	15.82	0.14	0.35	15.80	0.14	0.35	15.79	0.14	0.35	15.78
14.38%	35.59%	15.99	0.14	0.36	15.97	0.14	0.36	15.96	0.14	0.36	15.95
14.38%	35.50%	16.09	0.14	0.36	16.07	0.14	0.36	16.05	0.14	0.36	16.05
14.38%	35.44%	16.19	0.14	0.36	16.17	0.14	0.36	16.16	0.14	0.36	16.15
14.38%	35.90%	16.33	0.14	0.36	16.31	0.14	0.36	16.29	0.14	0.37	16.28
14.37%	36.63%	16.42	0.14	0.37	16.40	0.14	0.37	16.38	0.14	0.37	16.37
14.37%	36.88%	16.50	0.14	0.37	16.47	0.14	0.37	16.46	0.14	0.38	16.45
14.37%	36.78%	16.61	0.14	0.37	16.58	0.14	0.37	16.57	0.14	0.38	16.55
14.37%	36.62%	16.68	0.14	0.37	16.66	0.14	0.37	16.64	0.14	0.37	16.63
14.37%	36.46%	16.75	0.14	0.37	16.73	0.14	0.37	16.71	0.14	0.37	16.70
14.36%	36.65%	16.86	0.14	0.37	16.83	0.14	0.37	16.81	0.14	0.37	16.80
14.36%	36.95%	16.93	0.14	0.37	16.90	0.14	0.38	16.89	0.14	0.38	16.87
14.36%	36.88%	17.00	0.14	0.37	16.97	0.14	0.37	16.95	0.14	0.38	16.94
14.36%	36.97%	17.18	0.14	0.37	17.15	0.14	0.38	17.13	0.14	0.38	17.11
14.36%	37.22%	17.24	0.14	0.38	17.21	0.14	0.38	17.19	0.14	0.38	17.17
14.36%	37.56%	17.39	0.14	0.38	17.36	0.14	0.38	17.34	0.14	0.38	17.32

14.36%	37.92%	17.60	0.14	0.38	17.57	0.14	0.39	17.54	0.14	0.39	17.53
14.36%	38.36%	18.01	0.14	0.39	17.97	0.14	0.39	17.95	0.14	0.39	17.93
14.36%	38.30%	18.10	0.14	0.39	18.06	0.14	0.39	18.03	0.14	0.39	18.01
14.36%	38.68%	18.61	0.14	0.39	18.56	0.14	0.39	18.53	0.14	0.40	18.51
14.36%	38.88%	18.83	0.14	0.39	18.78	0.14	0.40	18.75	0.14	0.40	18.72
14.35%	39.03%	18.94	0.14	0.39	18.89	0.14	0.40	18.85	0.14	0.40	18.82
14.35%	39.82%	19.14	0.14	0.40	19.09	0.14	0.40	19.05	0.14	0.41	19.03
14.34%	40.35%	19.48	0.14	0.41	19.42	0.14	0.41	19.38	0.14	0.41	19.35
14.34%	40.45%	19.72	0.14	0.41	19.66	0.14	0.41	19.61	0.14	0.41	19.58
14.34%	40.58%	19.64	0.14	0.41	19.58	0.14	0.41	19.54	0.14	0.41	19.51
14.34%	41.03%	19.93	0.14	0.41	19.87	0.14	0.42	19.83	0.14	0.42	19.80
14.33%	41.68%	20.09	0.14	0.42	20.02	0.14	0.42	19.98	0.14	0.43	19.94
14.33%	41.81%	20.06	0.14	0.42	20.00	0.14	0.43	19.95	0.14	0.43	19.92
14.32%	42.07%	20.19	0.14	0.42	20.13	0.14	0.43	20.08	0.14	0.43	20.05
14.32%	42.30%	20.37	0.14	0.43	20.31	0.14	0.43	20.26	0.14	0.43	20.23
14.32%	42.38%	20.44	0.14	0.43	20.38	0.14	0.43	20.33	0.14	0.43	20.29
14.32%	42.45%	20.55	0.14	0.43	20.48	0.14	0.43	20.43	0.14	0.43	20.40
14.32%	42.36%	20.60	0.14	0.43	20.53	0.14	0.43	20.48	0.14	0.43	20.45
14.31%	42.60%	20.73	0.14	0.43	20.66	0.14	0.43	20.61	0.14	0.44	20.57
14.31%	42.99%	20.83	0.14	0.43	20.75	0.14	0.44	20.70	0.14	0.44	20.67
14.31%	42.95%	20.95	0.14	0.43	20.88	0.14	0.44	20.83	0.14	0.44	20.79
14.30%	43.07%	21.10	0.14	0.43	21.02	0.14	0.44	20.97	0.14	0.44	20.93
14.30%	43.45%	21.18	0.14	0.44	21.10	0.14	0.44	21.05	0.14	0.44	21.01
14.30%	43.65%	21.27	0.14	0.44	21.20	0.14	0.44	21.14	0.14	0.45	21.10
14.30%	43.80%	21.34	0.14	0.44	21.27	0.14	0.45	21.21	0.14	0.45	21.17
14.30%	43.89%	21.43	0.14	0.44	21.35	0.14	0.45	21.29	0.14	0.45	21.25
14.29%	44.26%	21.57	0.14	0.45	21.49	0.14	0.45	21.43	0.14	0.45	21.39
14.29%	44.54%	21.68	0.14	0.45	21.60	0.14	0.45	21.54	0.14	0.46	21.50
14.29%	44.50%	21.85	0.14	0.45	21.76	0.14	0.45	21.71	0.14	0.45	21.66
14.29%	44.66%	21.95	0.14	0.45	21.86	0.14	0.45	21.80	0.14	0.46	21.75

14.28%	44.54%	22.14	0.14	0.45	22.06	0.14	0.45	21.99	0.14	0.46	21.95
14.28%	44.57%	22.36	0.14	0.45	22.27	0.14	0.45	22.21	0.14	0.46	22.16
14.28%	44.62%	22.53	0.14	0.45	22.43	0.14	0.45	22.37	0.14	0.46	22.32
14.28%	44.64%	22.66	0.14	0.45	22.57	0.14	0.45	22.50	0.14	0.46	22.46
14.27%	44.86%	22.87	0.14	0.45	22.78	0.14	0.46	22.71	0.14	0.46	22.66
14.27%	44.88%	23.03	0.14	0.45	22.93	0.14	0.46	22.87	0.14	0.46	22.82
14.26%	45.14%	23.15	0.14	0.46	23.05	0.14	0.46	22.98	0.14	0.46	22.93
14.26%	45.28%	23.26	0.14	0.46	23.16	0.14	0.46	23.09	0.14	0.46	23.04
14.26%	45.33%	23.35	0.14	0.46	23.25	0.14	0.46	23.17	0.14	0.46	23.12
14.26%	45.53%	23.48	0.14	0.46	23.37	0.14	0.46	23.30	0.14	0.47	23.25
14.25%	45.49%	23.58	0.14	0.46	23.48	0.14	0.46	23.40	0.14	0.46	23.35
14.25%	45.53%	23.74	0.14	0.46	23.64	0.14	0.46	23.57	0.14	0.47	23.51
14.25%	45.75%	23.84	0.14	0.46	23.73	0.14	0.47	23.65	0.14	0.47	23.60
14.24%	45.90%	23.96	0.14	0.46	23.85	0.14	0.47	23.77	0.14	0.47	23.72
14.24%	46.01%	24.09	0.14	0.46	23.98	0.14	0.47	23.91	0.14	0.47	23.85
14.23%	46.06%	24.19	0.14	0.47	24.08	0.14	0.47	24.01	0.14	0.47	23.95
14.23%	46.43%	24.29	0.14	0.47	24.18	0.14	0.47	24.10	0.14	0.47	24.05
14.23%	46.54%	24.41	0.14	0.47	24.30	0.14	0.47	24.22	0.14	0.48	24.16
14.22%	46.57%	24.51	0.14	0.47	24.40	0.14	0.47	24.32	0.14	0.48	24.26
14.22%	46.72%	24.60	0.14	0.47	24.49	0.14	0.48	24.41	0.14	0.48	24.35
14.21%	46.86%	24.74	0.14	0.47	24.63	0.14	0.48	24.55	0.14	0.48	24.49
14.21%	47.06%	24.90	0.14	0.48	24.78	0.14	0.48	24.70	0.14	0.48	24.64
14.20%	47.37%	25.14	0.14	0.48	25.02	0.14	0.48	24.93	0.14	0.48	24.87
14.18%	47.92%	25.49	0.14	0.48	25.36	0.14	0.49	25.28	0.14	0.49	25.21
14.17%	48.11%	25.77	0.14	0.49	25.64	0.14	0.49	25.55	0.14	0.49	25.49
14.17%	48.05%	25.87	0.14	0.49	25.75	0.14	0.49	25.66	0.14	0.49	25.59
14.16%	47.70%	26.14	0.14	0.48	26.01	0.14	0.49	25.92	0.14	0.49	25.85
14.16%	46.97%	26.63	0.14	0.47	26.49	0.14	0.48	26.40	0.14	0.48	26.33
14.16%	46.68%	26.82	0.14	0.47	26.69	0.14	0.47	26.59	0.14	0.48	26.52
14.16%	46.33%	27.14	0.14	0.47	27.00	0.14	0.47	26.91	0.14	0.47	26.83

14.15%	45.95%	27.42	0.14	0.46	27.28	0.14	0.47	27.18	0.14	0.47	27.11
14.15%	45.82%	27.60	0.14	0.46	27.46	0.14	0.47	27.36	0.14	0.47	27.29
14.15%	45.51%	27.85	0.14	0.46	27.71	0.14	0.46	27.60	0.14	0.47	27.53
14.14%	45.24%	28.19	0.14	0.46	28.04	0.14	0.46	27.94	0.14	0.46	27.86
14.14%	45.11%	28.48	0.14	0.46	28.33	0.14	0.46	28.22	0.14	0.46	28.15
14.14%	44.95%	28.83	0.14	0.45	28.67	0.14	0.46	28.56	0.14	0.46	28.48
14.13%	44.76%	29.08	0.14	0.45	28.92	0.14	0.46	28.81	0.14	0.46	28.72
14.13%	44.60%	29.29	0.14	0.45	29.13	0.14	0.45	29.02	0.14	0.46	28.93
14.13%	44.49%	29.39	0.14	0.45	29.23	0.14	0.45	29.12	0.14	0.45	29.03
14.13%	44.39%	29.46	0.14	0.45	29.30	0.14	0.45	29.18	0.14	0.45	29.10
14.13%	44.29%	29.54	0.14	0.45	29.38	0.14	0.45	29.27	0.14	0.45	29.18
14.12%	44.18%	29.64	0.14	0.45	29.48	0.14	0.45	29.37	0.14	0.45	29.28
14.12%	44.05%	29.80	0.14	0.44	29.64	0.14	0.45	29.52	0.14	0.45	29.44
14.12%	44.17%	29.98	0.14	0.45	29.82	0.14	0.45	29.70	0.14	0.45	29.62
14.11%	44.35%	30.19	0.14	0.45	30.02	0.14	0.45	29.90	0.14	0.45	29.82
14.10%	44.35%	30.33	0.14	0.45	30.16	0.14	0.45	30.04	0.14	0.45	29.96
14.10%	44.52%	30.65	0.14	0.45	30.48	0.14	0.45	30.35	0.14	0.46	30.26
14.09%	44.66%	31.00	0.14	0.45	30.82	0.14	0.45	30.70	0.14	0.46	30.61
14.09%	44.65%	31.16	0.14	0.45	30.98	0.14	0.45	30.86	0.14	0.46	30.77
14.08%	44.77%	31.57	0.14	0.45	31.39	0.14	0.46	31.26	0.14	0.46	31.16
14.07%	44.82%	31.94	0.14	0.45	31.75	0.14	0.46	31.62	0.14	0.46	31.52
14.07%	44.66%	32.28	0.14	0.45	32.09	0.14	0.45	31.95	0.14	0.46	31.85
14.07%	44.43%	32.45	0.14	0.45	32.26	0.14	0.45	32.12	0.14	0.45	32.02
14.08%	44.26%	32.48	0.14	0.45	32.28	0.14	0.45	32.14	0.14	0.45	32.04
14.08%	44.20%	32.58	0.14	0.45	32.38	0.14	0.45	32.25	0.14	0.45	32.14
14.07%	44.14%	32.68	0.14	0.45	32.49	0.14	0.45	32.35	0.14	0.45	32.24
14.07%	44.07%	32.82	0.14	0.45	32.62	0.14	0.45	32.48	0.14	0.45	32.38
14.06%	44.51%	33.09	0.14	0.45	32.89	0.14	0.45	32.75	0.14	0.45	32.65
14.05%	45.01%	33.35	0.14	0.45	33.15	0.14	0.46	33.00	0.14	0.46	32.90
14.04%	45.03%	33.44	0.14	0.45	33.23	0.14	0.46	33.09	0.14	0.46	32.98

14.04%	45.04%	33.55	0.14	0.45	33.34	0.14	0.46	33.19	0.14	0.46	33.09
14.03%	45.16%	33.69	0.14	0.46	33.49	0.14	0.46	33.34	0.14	0.46	33.23
14.03%	45.21%	33.86	0.14	0.46	33.65	0.14	0.46	33.50	0.14	0.46	33.39
14.03%	45.11%	34.07	0.14	0.46	33.86	0.14	0.46	33.71	0.14	0.46	33.60
14.03%	45.06%	34.30	0.14	0.46	34.09	0.14	0.46	33.94	0.14	0.46	33.83
14.02%	45.04%	34.48	0.14	0.45	34.27	0.14	0.46	34.11	0.14	0.46	34.00
14.02%	44.91%	34.79	0.14	0.45	34.57	0.14	0.46	34.41	0.14	0.46	34.30
14.02%	44.73%	34.88	0.14	0.45	34.66	0.14	0.45	34.51	0.14	0.46	34.39
14.02%	44.57%	34.93	0.14	0.45	34.70	0.14	0.45	34.55	0.14	0.46	34.43
14.02%	44.53%	34.97	0.14	0.45	34.75	0.14	0.45	34.60	0.14	0.46	34.48
14.02%	44.59%	35.10	0.14	0.45	34.88	0.14	0.45	34.72	0.14	0.46	34.60
14.02%	44.72%	35.06	0.14	0.45	34.84	0.14	0.45	34.68	0.14	0.46	34.57
14.02%	44.71%	35.04	0.14	0.45	34.82	0.14	0.45	34.66	0.14	0.46	34.54
14.02%	44.77%	34.81	0.14	0.45	34.59	0.14	0.46	34.44	0.14	0.46	34.32
14.01%	44.62%	35.19	0.14	0.45	34.97	0.14	0.45	34.81	0.14	0.46	34.69
14.01%	44.57%	35.26	0.14	0.45	35.03	0.14	0.45	34.87	0.14	0.46	34.76
14.01%	44.43%	35.26	0.14	0.45	35.04	0.14	0.45	34.88	0.14	0.45	34.76
14.02%	44.27%	35.29	0.14	0.45	35.07	0.14	0.45	34.91	0.14	0.45	34.79
14.01%	44.22%	35.34	0.14	0.45	35.12	0.14	0.45	34.96	0.14	0.45	34.84
14.01%	44.10%	35.45	0.14	0.45	35.22	0.14	0.45	35.07	0.14	0.45	34.95
14.01%	44.00%	35.50	0.14	0.44	35.27	0.14	0.45	35.12	0.14	0.45	35.00
14.01%	43.95%	35.55	0.14	0.44	35.33	0.14	0.45	35.17	0.14	0.45	35.05
14.01%	44.06%	35.69	0.14	0.45	35.46	0.14	0.45	35.30	0.14	0.45	35.18
14.00%	44.19%	35.79	0.14	0.45	35.56	0.14	0.45	35.40	0.14	0.45	35.28
14.00%	44.14%	35.84	0.14	0.45	35.61	0.14	0.45	35.45	0.14	0.45	35.33
14.00%	44.15%	35.94	0.14	0.45	35.71	0.14	0.45	35.54	0.14	0.45	35.42
13.99%	44.19%	35.90	0.14	0.45	35.67	0.14	0.45	35.51	0.14	0.45	35.39
13.99%	44.17%	35.86	0.14	0.45	35.64	0.14	0.45	35.47	0.14	0.45	35.36
13.99%	44.26%	35.68	0.14	0.45	35.46	0.14	0.45	35.30	0.14	0.45	35.18
13.99%	44.38%	35.43	0.14	0.45	35.21	0.14	0.45	35.05	0.14	0.45	34.94

13.99%	44.25%	35.74	0.14	0.45	35.51	0.14	0.45	35.35	0.14	0.45	35.24
13.98%	44.39%	35.99	0.14	0.45	35.76	0.14	0.45	35.60	0.14	0.45	35.48
13.97%	44.55%	36.16	0.14	0.45	35.93	0.14	0.45	35.77	0.14	0.46	35.65
13.97%	44.44%	36.40	0.14	0.45	36.17	0.14	0.45	36.00	0.14	0.45	35.88
13.97%	44.36%	36.38	0.14	0.45	36.14	0.14	0.45	35.98	0.14	0.45	35.86
13.97%	44.27%	36.41	0.14	0.45	36.18	0.14	0.45	36.01	0.14	0.45	35.89
13.97%	44.21%	36.52	0.14	0.45	36.28	0.14	0.45	36.12	0.14	0.45	36.00
13.97%	44.11%	36.57	0.14	0.45	36.33	0.14	0.45	36.17	0.14	0.45	36.05
13.97%	44.00%	36.64	0.14	0.44	36.40	0.14	0.45	36.24	0.14	0.45	36.12
13.97%	43.95%	36.71	0.14	0.44	36.47	0.14	0.45	36.31	0.14	0.45	36.19
13.96%	43.89%	36.82	0.14	0.44	36.58	0.14	0.45	36.41	0.14	0.45	36.29
13.96%	43.84%	36.91	0.14	0.44	36.67	0.14	0.45	36.50	0.14	0.45	36.38
13.96%	43.79%	36.98	0.14	0.44	36.74	0.14	0.45	36.57	0.14	0.45	36.45
13.96%	43.80%	37.07	0.14	0.44	36.83	0.14	0.45	36.67	0.14	0.45	36.54
13.96%	43.84%	37.02	0.14	0.44	36.78	0.14	0.45	36.62	0.14	0.45	36.49
13.95%	43.83%	36.96	0.14	0.44	36.73	0.14	0.45	36.56	0.14	0.45	36.44
13.95%	43.84%	37.05	0.14	0.44	36.82	0.14	0.45	36.65	0.14	0.45	36.53
13.95%	43.84%	37.15	0.14	0.44	36.91	0.14	0.45	36.74	0.14	0.45	36.62
13.95%	43.80%	37.22	0.14	0.44	36.98	0.14	0.45	36.82	0.14	0.45	36.69
13.94%	43.79%	37.35	0.14	0.44	37.11	0.14	0.45	36.94	0.14	0.45	36.82
13.94%	43.79%	37.46	0.14	0.44	37.22	0.14	0.45	37.05	0.14	0.45	36.93
13.94%	43.73%	37.61	0.14	0.44	37.36	0.14	0.44	37.19	0.14	0.45	37.07
13.94%	43.51%	37.69	0.14	0.44	37.44	0.14	0.44	37.27	0.14	0.44	37.15
13.94%	43.30%	37.75	0.14	0.44	37.51	0.14	0.44	37.34	0.14	0.44	37.21
13.94%	43.25%	37.88	0.14	0.44	37.63	0.14	0.44	37.46	0.14	0.44	37.33
13.94%	43.10%	37.95	0.14	0.44	37.71	0.14	0.44	37.54	0.14	0.44	37.41
13.95%	42.97%	37.98	0.14	0.43	37.73	0.14	0.44	37.56	0.14	0.44	37.43
13.94%	42.93%	38.10	0.14	0.43	37.85	0.14	0.44	37.68	0.14	0.44	37.55
13.94%	43.13%	38.34	0.14	0.44	38.09	0.14	0.44	37.92	0.14	0.44	37.79
13.93%	43.32%	38.57	0.14	0.44	38.32	0.14	0.44	38.14	0.14	0.44	38.01

13.92%	43.27%	38.71	0.14	0.44	38.46	0.14	0.44	38.28	0.14	0.44	38.15
13.92%	43.17%	38.84	0.14	0.44	38.59	0.14	0.44	38.41	0.14	0.44	38.28
13.92%	43.07%	39.00	0.14	0.44	38.74	0.14	0.44	38.56	0.14	0.44	38.43
13.92%	43.03%	39.14	0.14	0.43	38.88	0.14	0.44	38.70	0.14	0.44	38.56
13.92%	42.98%	39.26	0.14	0.43	39.00	0.14	0.44	38.82	0.14	0.44	38.68
13.92%	42.94%	39.40	0.14	0.43	39.14	0.14	0.44	38.95	0.14	0.44	38.82
13.92%	42.90%	39.52	0.14	0.43	39.26	0.14	0.44	39.07	0.14	0.44	38.94
13.91%	42.90%	39.66	0.14	0.43	39.40	0.14	0.44	39.21	0.14	0.44	39.07
13.91%	42.92%	39.76	0.14	0.43	39.50	0.14	0.44	39.31	0.14	0.44	39.18
13.91%	42.92%	39.67	0.14	0.43	39.40	0.14	0.44	39.22	0.14	0.44	39.08
13.91%	43.06%	39.63	0.14	0.43	39.37	0.14	0.44	39.19	0.14	0.44	39.05
13.90%	43.20%	39.60	0.14	0.44	39.34	0.14	0.44	39.15	0.14	0.44	39.02
13.90%	43.21%	39.50	0.14	0.44	39.24	0.14	0.44	39.06	0.14	0.44	38.92
13.90%	43.32%	39.39	0.14	0.44	39.13	0.14	0.44	38.95	0.14	0.44	38.82
13.89%	43.37%	39.55	0.14	0.44	39.29	0.14	0.44	39.11	0.14	0.44	38.98
13.89%	43.38%	39.40	0.14	0.44	39.14	0.14	0.44	38.96	0.14	0.44	38.83
13.89%	43.41%	39.23	0.14	0.44	38.98	0.14	0.44	38.80	0.14	0.44	38.66
13.89%	43.46%	38.95	0.14	0.44	38.70	0.14	0.44	38.52	0.14	0.44	38.39
13.89%	43.47%	38.83	0.14	0.44	38.58	0.14	0.44	38.41	0.14	0.44	38.28
13.89%	43.47%	38.74	0.14	0.44	38.49	0.14	0.44	38.31	0.14	0.44	38.18
13.89%	43.49%	38.62	0.14	0.44	38.37	0.14	0.44	38.20	0.14	0.44	38.07
13.89%	43.52%	38.41	0.14	0.44	38.17	0.14	0.44	38.00	0.14	0.44	37.87
13.89%	43.53%	38.30	0.14	0.44	38.06	0.14	0.44	37.89	0.14	0.45	37.76
13.89%	43.54%	38.20	0.14	0.44	37.96	0.14	0.44	37.79	0.14	0.45	37.66
13.89%	43.55%	38.06	0.14	0.44	37.83	0.14	0.44	37.66	0.14	0.45	37.53
13.89%	43.66%	38.01	0.14	0.44	37.77	0.14	0.44	37.61	0.14	0.45	37.48
13.89%	43.78%	37.95	0.14	0.44	37.72	0.14	0.45	37.55	0.14	0.45	37.43
13.89%	43.80%	37.80	0.14	0.44	37.57	0.14	0.45	37.40	0.14	0.45	37.28
13.88%	43.91%	37.76	0.14	0.44	37.53	0.14	0.45	37.37	0.14	0.45	37.24
13.88%	43.98%	37.87	0.14	0.44	37.64	0.14	0.45	37.47	0.14	0.45	37.35

13.88%	43.93%	37.96	0.14	0.44	37.72	0.14	0.45	37.56	0.14	0.45	37.43
13.88%	43.98%	37.84	0.14	0.44	37.61	0.14	0.45	37.45	0.14	0.45	37.32
13.87%	44.02%	37.76	0.14	0.44	37.53	0.14	0.45	37.37	0.14	0.45	37.25
13.87%	44.00%	37.66	0.14	0.44	37.43	0.14	0.45	37.27	0.14	0.45	37.15
13.87%	43.98%	37.56	0.14	0.44	37.34	0.14	0.45	37.18	0.14	0.45	37.06
13.87%	43.94%	37.54	0.14	0.44	37.31	0.14	0.45	37.15	0.14	0.45	37.04
13.87%	43.92%	37.48	0.14	0.44	37.25	0.14	0.45	37.09	0.14	0.45	36.98
13.86%	43.93%	37.47	0.14	0.44	37.25	0.14	0.45	37.09	0.14	0.45	36.97
13.86%	43.95%	37.47	0.14	0.44	37.24	0.14	0.45	37.09	0.14	0.45	36.97
13.86%	43.91%	37.42	0.14	0.44	37.20	0.14	0.45	37.04	0.14	0.45	36.93
13.86%	43.87%	37.39	0.14	0.44	37.17	0.14	0.45	37.02	0.14	0.45	36.90
13.85%	43.83%	37.37	0.14	0.44	37.15	0.14	0.45	36.99	0.14	0.45	36.88
13.85%	43.79%	37.34	0.14	0.44	37.12	0.14	0.45	36.97	0.14	0.45	36.85
13.85%	43.76%	37.28	0.14	0.44	37.06	0.14	0.45	36.91	0.14	0.45	36.80
13.85%	43.74%	37.18	0.14	0.44	36.96	0.14	0.44	36.81	0.14	0.45	36.70
13.85%	43.69%	37.17	0.14	0.44	36.96	0.14	0.44	36.81	0.14	0.45	36.69
13.84%	43.66%	37.13	0.14	0.44	36.91	0.14	0.44	36.76	0.14	0.45	36.65
13.84%	43.62%	37.08	0.14	0.44	36.87	0.14	0.44	36.72	0.14	0.45	36.61
13.84%	43.57%	37.07	0.14	0.44	36.86	0.14	0.44	36.71	0.14	0.45	36.60
13.84%	43.52%	37.07	0.14	0.44	36.85	0.14	0.44	36.71	0.14	0.44	36.60
13.84%	43.48%	37.02	0.14	0.44	36.81	0.14	0.44	36.66	0.14	0.44	36.55
13.84%	43.39%	36.94	0.14	0.44	36.73	0.14	0.44	36.58	0.14	0.44	36.47
13.84%	43.29%	36.87	0.14	0.44	36.66	0.14	0.44	36.52	0.14	0.44	36.41
13.83%	43.25%	36.83	0.14	0.44	36.62	0.14	0.44	36.48	0.14	0.44	36.37
13.83%	43.21%	36.80	0.14	0.44	36.60	0.14	0.44	36.45	0.14	0.44	36.35
13.83%	43.15%	36.81	0.14	0.44	36.61	0.14	0.44	36.46	0.14	0.44	36.36
13.83%	43.13%	36.74	0.14	0.44	36.54	0.14	0.44	36.40	0.14	0.44	36.29
13.84%	43.04%	36.59	0.14	0.43	36.39	0.14	0.44	36.25	0.14	0.44	36.14
13.84%	42.92%	36.42	0.14	0.43	36.22	0.14	0.44	36.08	0.14	0.44	35.97
13.85%	42.98%	36.31	0.14	0.43	36.11	0.14	0.44	35.97	0.14	0.44	35.87

13.85%	43.07%	36.07	0.14	0.44	35.88	0.14	0.44	35.74	0.14	0.44	35.64
13.85%	43.00%	35.94	0.14	0.43	35.74	0.14	0.44	35.61	0.14	0.44	35.51
13.86%	42.94%	35.79	0.14	0.43	35.59	0.14	0.44	35.46	0.14	0.44	35.36
13.86%	43.00%	35.68	0.14	0.43	35.49	0.14	0.44	35.35	0.14	0.44	35.25
13.86%	43.01%	35.51	0.14	0.43	35.32	0.14	0.44	35.19	0.14	0.44	35.09
13.87%	42.82%	35.32	0.14	0.43	35.13	0.14	0.44	35.00	0.14	0.44	34.90
13.88%	42.73%	34.93	0.14	0.43	34.75	0.14	0.43	34.62	0.14	0.44	34.53
13.88%	42.80%	34.77	0.14	0.43	34.59	0.14	0.44	34.47	0.14	0.44	34.37
13.88%	42.71%	34.66	0.14	0.43	34.49	0.14	0.43	34.36	0.14	0.44	34.27
13.88%	42.62%	34.52	0.14	0.43	34.34	0.14	0.43	34.22	0.14	0.44	34.12
13.89%	42.68%	34.38	0.14	0.43	34.20	0.14	0.43	34.08	0.14	0.44	33.99
13.89%	42.61%	34.18	0.14	0.43	34.00	0.14	0.43	33.88	0.14	0.44	33.79
13.89%	42.52%	34.05	0.14	0.43	33.88	0.14	0.43	33.76	0.14	0.43	33.67
13.90%	42.63%	33.71	0.14	0.43	33.54	0.14	0.43	33.42	0.14	0.44	33.34
13.90%	42.73%	33.46	0.14	0.43	33.30	0.14	0.43	33.18	0.14	0.44	33.09
13.90%	42.66%	33.22	0.14	0.43	33.06	0.14	0.43	32.95	0.14	0.44	32.86
13.91%	42.58%	33.02	0.14	0.43	32.86	0.14	0.43	32.75	0.14	0.44	32.67
13.91%	42.54%	32.97	0.14	0.43	32.81	0.14	0.43	32.70	0.14	0.43	32.62
13.91%	42.38%	32.77	0.14	0.43	32.61	0.14	0.43	32.50	0.14	0.43	32.42
13.92%	42.28%	32.62	0.14	0.43	32.47	0.14	0.43	32.36	0.14	0.43	32.28
13.92%	42.22%	32.35	0.14	0.43	32.20	0.14	0.43	32.09	0.14	0.43	32.01
13.93%	42.00%	31.98	0.14	0.42	31.83	0.14	0.43	31.72	0.14	0.43	31.65
13.94%	41.73%	31.82	0.14	0.42	31.68	0.14	0.42	31.58	0.14	0.43	31.50
13.94%	41.63%	31.62	0.14	0.42	31.48	0.14	0.42	31.38	0.14	0.43	31.30
13.95%	41.46%	31.35	0.14	0.42	31.21	0.14	0.42	31.11	0.14	0.42	31.03
13.95%	41.17%	31.21	0.14	0.42	31.07	0.14	0.42	30.98	0.14	0.42	30.90
13.96%	41.17%	30.85	0.14	0.42	30.72	0.14	0.42	30.62	0.14	0.42	30.55
13.96%	41.23%	30.64	0.14	0.42	30.50	0.14	0.42	30.41	0.14	0.42	30.34
13.96%	41.21%	30.44	0.14	0.42	30.31	0.14	0.42	30.22	0.14	0.42	30.15
13.96%	41.18%	30.22	0.14	0.42	30.09	0.14	0.42	30.00	0.14	0.42	29.94

13.96%	41.24%	30.10	0.14	0.42	29.97	0.14	0.42	29.88	0.14	0.42	29.82
13.96%	41.33%	29.78	0.14	0.42	29.65	0.14	0.42	29.57	0.14	0.42	29.50
13.97%	41.33%	29.41	0.14	0.42	29.29	0.14	0.42	29.21	0.14	0.42	29.15
13.97%	41.31%	29.18	0.14	0.42	29.06	0.14	0.42	28.98	0.14	0.42	28.92
13.97%	41.41%	28.89	0.14	0.42	28.78	0.14	0.42	28.70	0.14	0.42	28.64
13.97%	41.38%	28.69	0.14	0.42	28.58	0.14	0.42	28.50	0.14	0.42	28.45
13.97%	41.37%	28.38	0.14	0.42	28.27	0.14	0.42	28.20	0.14	0.42	28.15
13.97%	41.43%	28.29	0.14	0.42	28.19	0.14	0.42	28.12	0.14	0.42	28.06
13.97%	41.52%	28.06	0.14	0.42	27.96	0.14	0.42	27.89	0.14	0.42	27.84
13.98%	41.53%	27.73	0.14	0.42	27.64	0.14	0.42	27.57	0.14	0.42	27.52
13.98%	41.48%	27.59	0.14	0.42	27.49	0.14	0.42	27.43	0.14	0.42	27.38
13.98%	41.57%	27.43	0.14	0.42	27.34	0.14	0.42	27.27	0.14	0.42	27.22
13.98%	41.38%	27.34	0.14	0.42	27.25	0.14	0.42	27.18	0.14	0.42	27.13
13.99%	41.20%	27.19	0.14	0.42	27.10	0.14	0.42	27.04	0.14	0.42	26.99
13.99%	41.14%	27.07	0.14	0.42	26.98	0.14	0.42	26.91	0.14	0.42	26.87
13.99%	41.08%	26.94	0.14	0.41	26.85	0.14	0.42	26.79	0.14	0.42	26.75
13.99%	41.19%	26.64	0.14	0.42	26.55	0.14	0.42	26.49	0.14	0.42	26.45
13.99%	41.15%	26.44	0.14	0.42	26.35	0.14	0.42	26.30	0.14	0.42	26.25
13.99%	41.12%	26.13	0.14	0.42	26.05	0.14	0.42	25.99	0.14	0.42	25.95
14.00%	41.21%	25.99	0.14	0.42	25.91	0.14	0.42	25.85	0.14	0.42	25.81
14.00%	41.01%	25.71	0.14	0.41	25.64	0.14	0.42	25.58	0.14	0.42	25.55
14.00%	40.81%	25.40	0.14	0.41	25.33	0.14	0.41	25.28	0.14	0.42	25.24
14.00%	40.92%	25.14	0.14	0.41	25.08	0.14	0.42	25.03	0.14	0.42	25.00
14.00%	40.86%	24.85	0.14	0.41	24.79	0.14	0.42	24.74	0.14	0.42	24.71
14.00%	40.79%	24.63	0.14	0.41	24.57	0.14	0.41	24.53	0.14	0.42	24.50
14.01%	40.91%	24.42	0.14	0.41	24.36	0.14	0.42	24.32	0.14	0.42	24.29
14.01%	41.01%	24.31	0.14	0.41	24.26	0.14	0.42	24.22	0.14	0.42	24.19
14.01%	40.95%	24.02	0.14	0.41	23.97	0.14	0.42	23.93	0.14	0.42	23.90
14.01%	40.85%	23.86	0.14	0.41	23.81	0.14	0.42	23.77	0.14	0.42	23.74
14.01%	40.95%	23.77	0.14	0.41	23.72	0.14	0.42	23.69	0.14	0.42	23.66

14.01%	41.08%	23.63	0.14	0.41	23.58	0.14	0.42	23.55	0.14	0.42	23.52
14.01%	40.98%	23.47	0.14	0.41	23.42	0.14	0.42	23.39	0.14	0.42	23.36
14.01%	40.85%	23.34	0.14	0.41	23.30	0.14	0.42	23.27	0.14	0.42	23.24
14.01%	40.98%	23.24	0.14	0.41	23.20	0.14	0.42	23.16	0.14	0.42	23.14
14.01%	41.10%	23.17	0.14	0.42	23.13	0.14	0.42	23.10	0.14	0.42	23.07
14.02%	40.96%	23.08	0.14	0.41	23.04	0.14	0.42	23.01	0.14	0.42	22.99
14.02%	40.82%	22.96	0.14	0.41	22.92	0.14	0.42	22.89	0.14	0.42	22.87
14.02%	40.98%	22.80	0.14	0.41	22.76	0.14	0.42	22.73	0.14	0.42	22.71
14.02%	41.15%	22.62	0.14	0.42	22.58	0.14	0.42	22.56	0.14	0.42	22.54
14.02%	40.99%	22.53	0.14	0.41	22.49	0.14	0.42	22.47	0.14	0.42	22.45
14.02%	40.82%	22.44	0.14	0.41	22.41	0.14	0.42	22.38	0.14	0.42	22.36
14.02%	40.99%	22.32	0.14	0.41	22.29	0.14	0.42	22.26	0.14	0.42	22.24
14.03%	40.80%	22.25	0.14	0.41	22.22	0.14	0.41	22.19	0.14	0.42	22.17
14.03%	40.61%	22.20	0.14	0.41	22.17	0.14	0.41	22.14	0.14	0.41	22.12
14.03%	40.77%	22.08	0.14	0.41	22.04	0.14	0.41	22.02	0.14	0.42	22.00
14.03%	40.93%	22.01	0.14	0.41	21.98	0.14	0.42	21.95	0.14	0.42	21.94
14.03%	41.12%	21.90	0.14	0.42	21.87	0.14	0.42	21.85	0.14	0.42	21.84
14.03%	41.28%	21.87	0.14	0.42	21.84	0.14	0.42	21.82	0.14	0.42	21.81
14.03%	41.48%	21.79	0.14	0.42	21.76	0.14	0.42	21.74	0.14	0.42	21.72
14.03%	41.70%	21.68	0.14	0.42	21.66	0.14	0.42	21.64	0.14	0.43	21.62
14.03%	41.90%	21.64	0.14	0.42	21.61	0.14	0.43	21.59	0.14	0.43	21.57
14.03%	41.69%	21.55	0.14	0.42	21.52	0.14	0.42	21.50	0.14	0.43	21.49
14.03%	41.46%	21.48	0.14	0.42	21.45	0.14	0.42	21.43	0.14	0.42	21.42
14.05%	42.76%	29.77	14.06%	43.18%	29.62	14.07%	43.48%	29.52	14.08%	43.70%	29.44
14.39%	48.11%	39.76	14.39%	48.58%	39.50	14.39%	48.92%	39.31	14.39%	49.16%	39.18

Number of Tubes 18			Number of Tubes 20		
Electrical_ eff_18	Thermal_eff_18	T cell_18	Electrical_ eff_20	Thermal_eff_20	T cell_20
0.14	0.41	15.29	0.14	0.41	15.29
0.14	0.36	15.24	0.14	0.36	15.24
0.14	0.34	15.26	0.14	0.34	15.26
0.14	0.35	15.35	0.14	0.35	15.35
0.14	0.35	15.38	0.14	0.35	15.38
0.14	0.35	15.43	0.14	0.35	15.43
0.14	0.35	15.46	0.14	0.35	15.46
0.14	0.35	15.51	0.14	0.35	15.50
0.14	0.34	15.54	0.14	0.35	15.53
0.14	0.34	15.59	0.14	0.34	15.59
0.14	0.34	15.65	0.14	0.34	15.64
0.14	0.35	15.78	0.14	0.35	15.77
0.14	0.37	15.94	0.14	0.37	15.94
0.14	0.36	16.04	0.14	0.37	16.03
0.14	0.36	16.14	0.14	0.36	16.13
0.14	0.37	16.27	0.14	0.37	16.27
0.14	0.38	16.36	0.14	0.38	16.36
0.14	0.38	16.44	0.14	0.38	16.43
0.14	0.38	16.54	0.14	0.38	16.54
0.14	0.38	16.62	0.14	0.38	16.61
0.14	0.37	16.69	0.14	0.38	16.68
0.14	0.38	16.79	0.14	0.38	16.78
0.14	0.38	16.86	0.14	0.38	16.85
0.14	0.38	16.93	0.14	0.38	16.92
0.14	0.38	17.10	0.14	0.38	17.09
0.14	0.38	17.16	0.14	0.38	17.15
0.14	0.39	17.31	0.14	0.39	17.30

0.14	0.39	17.51	0.14	0.39	17.50
0.14	0.39	17.91	0.14	0.39	17.90
0.14	0.39	18.00	0.14	0.39	17.98
0.14	0.40	18.49	0.14	0.40	18.47
0.14	0.40	18.70	0.14	0.40	18.69
0.14	0.40	18.80	0.14	0.40	18.79
0.14	0.41	19.01	0.14	0.41	18.99
0.14	0.41	19.33	0.14	0.42	19.31
0.14	0.41	19.56	0.14	0.42	19.54
0.14	0.42	19.48	0.14	0.42	19.46
0.14	0.42	19.77	0.14	0.42	19.75
0.14	0.43	19.92	0.14	0.43	19.90
0.14	0.43	19.90	0.14	0.43	19.88
0.14	0.43	20.02	0.14	0.43	20.00
0.14	0.43	20.20	0.14	0.44	20.18
0.14	0.43	20.27	0.14	0.44	20.25
0.14	0.44	20.37	0.14	0.44	20.35
0.14	0.43	20.42	0.14	0.44	20.40
0.14	0.44	20.54	0.14	0.44	20.52
0.14	0.44	20.64	0.14	0.44	20.61
0.14	0.44	20.76	0.14	0.44	20.74
0.14	0.44	20.90	0.14	0.44	20.88
0.14	0.45	20.98	0.14	0.45	20.95
0.14	0.45	21.07	0.14	0.45	21.05
0.14	0.45	21.14	0.14	0.45	21.12
0.14	0.45	21.22	0.14	0.45	21.19
0.14	0.45	21.36	0.14	0.46	21.33
0.14	0.46	21.47	0.14	0.46	21.44
0.14	0.46	21.63	0.14	0.46	21.60
0.14	0.46	21.72	0.14	0.46	21.69

0.14	0.46	21.91	0.14	0.46	21.89
0.14	0.46	22.13	0.14	0.46	22.10
0.14	0.46	22.28	0.14	0.46	22.26
0.14	0.46	22.42	0.14	0.46	22.39
0.14	0.46	22.62	0.14	0.46	22.59
0.14	0.46	22.78	0.14	0.46	22.75
0.14	0.46	22.89	0.14	0.46	22.86
0.14	0.46	23.00	0.14	0.47	22.97
0.14	0.47	23.08	0.14	0.47	23.05
0.14	0.47	23.20	0.14	0.47	23.17
0.14	0.47	23.31	0.14	0.47	23.28
0.14	0.47	23.47	0.14	0.47	23.43
0.14	0.47	23.56	0.14	0.47	23.52
0.14	0.47	23.67	0.14	0.47	23.64
0.14	0.47	23.80	0.14	0.47	23.77
0.14	0.47	23.90	0.14	0.47	23.87
0.14	0.48	24.00	0.14	0.48	23.97
0.14	0.48	24.11	0.14	0.48	24.08
0.14	0.48	24.21	0.14	0.48	24.18
0.14	0.48	24.30	0.14	0.48	24.26
0.14	0.48	24.44	0.14	0.48	24.40
0.14	0.48	24.59	0.14	0.48	24.55
0.14	0.49	24.82	0.14	0.49	24.78
0.14	0.49	25.16	0.14	0.49	25.12
0.14	0.49	25.44	0.14	0.50	25.40
0.14	0.49	25.54	0.14	0.49	25.50
0.14	0.49	25.80	0.14	0.49	25.76
0.14	0.48	26.27	0.14	0.48	26.23
0.14	0.48	26.47	0.14	0.48	26.43
0.14	0.48	26.78	0.14	0.48	26.73

0.14	0.47	27.05	0.14	0.47	27.01
0.14	0.47	27.23	0.14	0.47	27.18
0.14	0.47	27.47	0.14	0.47	27.43
0.14	0.46	27.80	0.14	0.47	27.76
0.14	0.46	28.08	0.14	0.46	28.04
0.14	0.46	28.42	0.14	0.46	28.37
0.14	0.46	28.66	0.14	0.46	28.61
0.14	0.46	28.87	0.14	0.46	28.82
0.14	0.46	28.97	0.14	0.46	28.92
0.14	0.46	29.03	0.14	0.46	28.98
0.14	0.45	29.12	0.14	0.46	29.07
0.14	0.45	29.22	0.14	0.45	29.17
0.14	0.45	29.37	0.14	0.45	29.32
0.14	0.45	29.55	0.14	0.45	29.50
0.14	0.46	29.75	0.14	0.46	29.70
0.14	0.46	29.89	0.14	0.46	29.84
0.14	0.46	30.20	0.14	0.46	30.14
0.14	0.46	30.54	0.14	0.46	30.48
0.14	0.46	30.69	0.14	0.46	30.64
0.14	0.46	31.09	0.14	0.46	31.03
0.14	0.46	31.45	0.14	0.46	31.39
0.14	0.46	31.78	0.14	0.46	31.71
0.14	0.46	31.94	0.14	0.46	31.88
0.14	0.45	31.97	0.14	0.46	31.90
0.14	0.45	32.07	0.14	0.45	32.00
0.14	0.45	32.17	0.14	0.45	32.10
0.14	0.45	32.30	0.14	0.45	32.24
0.14	0.46	32.57	0.14	0.46	32.50
0.14	0.46	32.82	0.14	0.46	32.75
0.14	0.46	32.90	0.14	0.46	32.84

0.14	0.46	33.00	0.14	0.46	32.94
0.14	0.46	33.15	0.14	0.46	33.08
0.14	0.46	33.31	0.14	0.47	33.24
0.14	0.46	33.51	0.14	0.46	33.44
0.14	0.46	33.74	0.14	0.46	33.67
0.14	0.46	33.91	0.14	0.46	33.84
0.14	0.46	34.21	0.14	0.46	34.14
0.14	0.46	34.30	0.14	0.46	34.23
0.14	0.46	34.34	0.14	0.46	34.27
0.14	0.46	34.39	0.14	0.46	34.32
0.14	0.46	34.51	0.14	0.46	34.44
0.14	0.46	34.48	0.14	0.46	34.41
0.14	0.46	34.45	0.14	0.46	34.38
0.14	0.46	34.24	0.14	0.46	34.17
0.14	0.46	34.60	0.14	0.46	34.53
0.14	0.46	34.67	0.14	0.46	34.59
0.14	0.46	34.67	0.14	0.46	34.60
0.14	0.45	34.70	0.14	0.46	34.63
0.14	0.45	34.75	0.14	0.46	34.68
0.14	0.45	34.86	0.14	0.45	34.79
0.14	0.45	34.91	0.14	0.45	34.84
0.14	0.45	34.96	0.14	0.45	34.89
0.14	0.45	35.09	0.14	0.45	35.02
0.14	0.45	35.19	0.14	0.45	35.12
0.14	0.45	35.24	0.14	0.45	35.17
0.14	0.45	35.33	0.14	0.45	35.26
0.14	0.45	35.30	0.14	0.45	35.23
0.14	0.45	35.26	0.14	0.45	35.19
0.14	0.45	35.09	0.14	0.46	35.02
0.14	0.46	34.85	0.14	0.46	34.78

0.14	0.45	35.15	0.14	0.46	35.07
0.14	0.46	35.39	0.14	0.46	35.31
0.14	0.46	35.56	0.14	0.46	35.48
0.14	0.46	35.79	0.14	0.46	35.71
0.14	0.46	35.77	0.14	0.46	35.69
0.14	0.45	35.80	0.14	0.46	35.72
0.14	0.45	35.90	0.14	0.46	35.83
0.14	0.45	35.95	0.14	0.45	35.88
0.14	0.45	36.02	0.14	0.45	35.95
0.14	0.45	36.09	0.14	0.45	36.02
0.14	0.45	36.20	0.14	0.45	36.12
0.14	0.45	36.29	0.14	0.45	36.21
0.14	0.45	36.36	0.14	0.45	36.28
0.14	0.45	36.45	0.14	0.45	36.37
0.14	0.45	36.40	0.14	0.45	36.32
0.14	0.45	36.34	0.14	0.45	36.27
0.14	0.45	36.44	0.14	0.45	36.36
0.14	0.45	36.53	0.14	0.45	36.45
0.14	0.45	36.60	0.14	0.45	36.52
0.14	0.45	36.72	0.14	0.45	36.65
0.14	0.45	36.83	0.14	0.45	36.76
0.14	0.45	36.97	0.14	0.45	36.90
0.14	0.45	37.05	0.14	0.45	36.97
0.14	0.44	37.11	0.14	0.45	37.04
0.14	0.44	37.24	0.14	0.45	37.16
0.14	0.44	37.31	0.14	0.44	37.23
0.14	0.44	37.34	0.14	0.44	37.26
0.14	0.44	37.45	0.14	0.44	37.38
0.14	0.44	37.69	0.14	0.44	37.61
0.14	0.44	37.91	0.14	0.45	37.83

0.14	0.44	38.05	0.14	0.45	37.97
0.14	0.44	38.18	0.14	0.44	38.10
0.14	0.44	38.33	0.14	0.44	38.25
0.14	0.44	38.46	0.14	0.44	38.38
0.14	0.44	38.58	0.14	0.44	38.50
0.14	0.44	38.71	0.14	0.44	38.63
0.14	0.44	38.83	0.14	0.44	38.75
0.14	0.44	38.97	0.14	0.44	38.88
0.14	0.44	39.07	0.14	0.44	38.99
0.14	0.44	38.98	0.14	0.44	38.89
0.14	0.44	38.94	0.14	0.44	38.86
0.14	0.44	38.91	0.14	0.44	38.83
0.14	0.44	38.82	0.14	0.44	38.74
0.14	0.44	38.71	0.14	0.45	38.63
0.14	0.45	38.87	0.14	0.45	38.79
0.14	0.45	38.72	0.14	0.45	38.64
0.14	0.45	38.56	0.14	0.45	38.48
0.14	0.45	38.29	0.14	0.45	38.21
0.14	0.45	38.18	0.14	0.45	38.10
0.14	0.45	38.09	0.14	0.45	38.01
0.14	0.45	37.97	0.14	0.45	37.90
0.14	0.45	37.77	0.14	0.45	37.70
0.14	0.45	37.66	0.14	0.45	37.59
0.14	0.45	37.57	0.14	0.45	37.49
0.14	0.45	37.44	0.14	0.45	37.36
0.14	0.45	37.39	0.14	0.45	37.31
0.14	0.45	37.33	0.14	0.45	37.26
0.14	0.45	37.19	0.14	0.45	37.11
0.14	0.45	37.15	0.14	0.45	37.08
0.14	0.45	37.26	0.14	0.45	37.18

0.14	0.45	37.34	0.14	0.45	37.26
0.14	0.45	37.23	0.14	0.45	37.16
0.14	0.45	37.16	0.14	0.45	37.08
0.14	0.45	37.06	0.14	0.45	36.99
0.14	0.45	36.97	0.14	0.45	36.90
0.14	0.45	36.94	0.14	0.45	36.87
0.14	0.45	36.89	0.14	0.45	36.81
0.14	0.45	36.88	0.14	0.45	36.81
0.14	0.45	36.88	0.14	0.45	36.81
0.14	0.45	36.84	0.14	0.45	36.77
0.14	0.45	36.81	0.14	0.45	36.74
0.14	0.45	36.79	0.14	0.45	36.72
0.14	0.45	36.77	0.14	0.45	36.70
0.14	0.45	36.71	0.14	0.45	36.64
0.14	0.45	36.61	0.14	0.45	36.54
0.14	0.45	36.61	0.14	0.45	36.54
0.14	0.45	36.57	0.14	0.45	36.50
0.14	0.45	36.52	0.14	0.45	36.46
0.14	0.45	36.52	0.14	0.45	36.45
0.14	0.45	36.51	0.14	0.45	36.45
0.14	0.45	36.47	0.14	0.45	36.40
0.14	0.45	36.39	0.14	0.45	36.33
0.14	0.44	36.33	0.14	0.45	36.26
0.14	0.44	36.29	0.14	0.45	36.22
0.14	0.44	36.26	0.14	0.44	36.20
0.14	0.44	36.28	0.14	0.44	36.21
0.14	0.44	36.21	0.14	0.44	36.15
0.14	0.44	36.06	0.14	0.44	36.00
0.14	0.44	35.89	0.14	0.44	35.83
0.14	0.44	35.79	0.14	0.44	35.72

0.14	0.44	35.56	0.14	0.44	35.50
0.14	0.44	35.43	0.14	0.44	35.37
0.14	0.44	35.28	0.14	0.44	35.22
0.14	0.44	35.18	0.14	0.44	35.11
0.14	0.44	35.01	0.14	0.44	34.95
0.14	0.44	34.83	0.14	0.44	34.77
0.14	0.44	34.45	0.14	0.44	34.39
0.14	0.44	34.30	0.14	0.44	34.24
0.14	0.44	34.19	0.14	0.44	34.14
0.14	0.44	34.05	0.14	0.44	33.99
0.14	0.44	33.92	0.14	0.44	33.86
0.14	0.44	33.72	0.14	0.44	33.67
0.14	0.44	33.60	0.14	0.44	33.54
0.14	0.44	33.27	0.14	0.44	33.21
0.14	0.44	33.03	0.14	0.44	32.97
0.14	0.44	32.80	0.14	0.44	32.74
0.14	0.44	32.60	0.14	0.44	32.55
0.14	0.44	32.55	0.14	0.44	32.50
0.14	0.43	32.35	0.14	0.44	32.30
0.14	0.43	32.21	0.14	0.44	32.16
0.14	0.43	31.95	0.14	0.43	31.90
0.14	0.43	31.59	0.14	0.43	31.54
0.14	0.43	31.44	0.14	0.43	31.39
0.14	0.43	31.25	0.14	0.43	31.20
0.14	0.43	30.98	0.14	0.43	30.93
0.14	0.42	30.85	0.14	0.42	30.80
0.14	0.42	30.50	0.14	0.42	30.45
0.14	0.42	30.29	0.14	0.42	30.25
0.14	0.42	30.10	0.14	0.42	30.06
0.14	0.42	29.89	0.14	0.42	29.85

0.14	0.42	29.77	0.14	0.42	29.73
0.14	0.42	29.45	0.14	0.43	29.42
0.14	0.42	29.10	0.14	0.43	29.06
0.14	0.42	28.87	0.14	0.43	28.84
0.14	0.42	28.60	0.14	0.43	28.56
0.14	0.42	28.40	0.14	0.43	28.37
0.14	0.42	28.10	0.14	0.43	28.07
0.14	0.43	28.02	0.14	0.43	27.99
0.14	0.43	27.79	0.14	0.43	27.76
0.14	0.43	27.48	0.14	0.43	27.45
0.14	0.43	27.34	0.14	0.43	27.31
0.14	0.43	27.18	0.14	0.43	27.15
0.14	0.42	27.10	0.14	0.43	27.07
0.14	0.42	26.95	0.14	0.42	26.92
0.14	0.42	26.83	0.14	0.42	26.80
0.14	0.42	26.71	0.14	0.42	26.68
0.14	0.42	26.41	0.14	0.42	26.39
0.14	0.42	26.22	0.14	0.42	26.19
0.14	0.42	25.92	0.14	0.42	25.89
0.14	0.42	25.78	0.14	0.42	25.76
0.14	0.42	25.52	0.14	0.42	25.49
0.14	0.42	25.21	0.14	0.42	25.19
0.14	0.42	24.97	0.14	0.42	24.95
0.14	0.42	24.69	0.14	0.42	24.67
0.14	0.42	24.47	0.14	0.42	24.46
0.14	0.42	24.27	0.14	0.42	24.25
0.14	0.42	24.16	0.14	0.42	24.15
0.14	0.42	23.88	0.14	0.42	23.86
0.14	0.42	23.72	0.14	0.42	23.71
0.14	0.42	23.64	0.14	0.42	23.62

0.14	0.42	23.50	0.14	0.42	23.49
0.14	0.42	23.35	0.14	0.42	23.33
0.14	0.42	23.22	0.14	0.42	23.21
0.14	0.42	23.12	0.14	0.42	23.11
0.14	0.42	23.06	0.14	0.42	23.04
0.14	0.42	22.97	0.14	0.42	22.96
0.14	0.42	22.85	0.14	0.42	22.84
0.14	0.42	22.69	0.14	0.42	22.68
0.14	0.42	22.52	0.14	0.42	22.51
0.14	0.42	22.43	0.14	0.42	22.42
0.14	0.42	22.35	0.14	0.42	22.34
0.14	0.42	22.23	0.14	0.42	22.22
0.14	0.42	22.16	0.14	0.42	22.15
0.14	0.42	22.11	0.14	0.42	22.10
0.14	0.42	21.99	0.14	0.42	21.98
0.14	0.42	21.93	0.14	0.42	21.92
0.14	0.42	21.82	0.14	0.42	21.81
0.14	0.42	21.79	0.14	0.42	21.78
0.14	0.43	21.71	0.14	0.43	21.70
0.14	0.43	21.61	0.14	0.43	21.60
0.14	0.43	21.56	0.14	0.43	21.55
0.14	0.43	21.47	0.14	0.43	21.47
0.14	0.43	21.41	0.14	0.43	21.40
14.08%	43.87%	29.38	14.09%	44.01%	29.33
14.39%	49.35%	39.07	14.39%	49.50%	38.99

Change in water tubes diameters:

Tubes diameter 0.005 m			Tubes diameter 0.01 m			Tubes diameter 0.015 m			Tubes diameter 0.02 m		
Electrical_ eff_0.005	Thermal_eff_0.005	T cell_0.005	Electrical_ eff_0.01	Thermal_eff_0.01	T cell_0.01	Electrical_ eff_0.015	Thermal_eff_0.015	T cell_0.015	Electrical_ eff_0.02	Thermal_eff_0.02	T cell_0.02
14.38%	36.83%	15.42	14.38%	39.05%	15.35	14.38%	39.88%	15.32	14.39%	40.33%	15.31
14.38%	32.64%	15.36	14.39%	34.61%	15.29	14.39%	35.34%	15.26	14.39%	35.73%	15.25
14.39%	30.50%	15.38	14.39%	32.34%	15.31	14.39%	33.02%	15.29	14.40%	33.39%	15.27
14.38%	31.85%	15.48	14.39%	33.77%	15.41	14.39%	34.48%	15.38	14.39%	34.87%	15.36
14.38%	31.66%	15.51	14.39%	33.57%	15.44	14.39%	34.28%	15.41	14.39%	34.66%	15.39
14.38%	31.58%	15.56	14.39%	33.48%	15.48	14.39%	34.19%	15.46	14.39%	34.57%	15.44
14.38%	31.40%	15.59	14.39%	33.29%	15.52	14.39%	34.00%	15.49	14.39%	34.38%	15.47
14.38%	31.33%	15.64	14.39%	33.21%	15.56	14.39%	33.92%	15.54	14.39%	34.30%	15.52
14.38%	31.16%	15.67	14.39%	33.04%	15.60	14.39%	33.74%	15.57	14.39%	34.12%	15.55
14.38%	30.97%	15.73	14.39%	32.84%	15.65	14.39%	33.54%	15.62	14.39%	33.91%	15.60
14.38%	30.80%	15.79	14.38%	32.65%	15.71	14.39%	33.34%	15.67	14.39%	33.72%	15.66
14.37%	31.93%	15.93	14.38%	33.86%	15.84	14.38%	34.57%	15.81	14.38%	34.96%	15.79
14.37%	33.06%	16.12	14.38%	35.05%	16.02	14.38%	35.80%	15.98	14.38%	36.20%	15.96
14.37%	32.98%	16.22	14.38%	34.97%	16.12	14.38%	35.71%	16.08	14.38%	36.11%	16.05
14.37%	32.93%	16.33	14.38%	34.91%	16.22	14.38%	35.65%	16.18	14.38%	36.05%	16.16
14.37%	33.35%	16.48	14.37%	35.36%	16.36	14.38%	36.11%	16.32	14.38%	36.51%	16.29
14.36%	34.02%	16.58	14.37%	36.08%	16.45	14.37%	36.84%	16.41	14.37%	37.25%	16.38
14.36%	34.26%	16.66	14.37%	36.33%	16.53	14.37%	37.10%	16.48	14.37%	37.51%	16.46
14.36%	34.16%	16.78	14.37%	36.22%	16.64	14.37%	36.99%	16.59	14.37%	37.41%	16.57
14.36%	34.01%	16.85	14.37%	36.07%	16.72	14.37%	36.83%	16.67	14.37%	37.24%	16.64
14.36%	33.87%	16.93	14.36%	35.92%	16.79	14.37%	36.68%	16.74	14.37%	37.09%	16.71
14.35%	34.04%	17.04	14.36%	36.10%	16.90	14.37%	36.86%	16.84	14.37%	37.27%	16.81

14.35%	34.32%	17.12	14.36%	36.39%	16.97	14.36%	37.17%	16.91	14.37%	37.58%	16.88
14.35%	34.26%	17.19	14.36%	36.32%	17.04	14.36%	37.09%	16.98	14.37%	37.51%	16.95
14.35%	34.34%	17.39	14.36%	36.42%	17.22	14.36%	37.19%	17.16	14.37%	37.60%	17.13
14.35%	34.57%	17.45	14.36%	36.66%	17.29	14.36%	37.44%	17.22	14.36%	37.86%	17.19
14.34%	34.89%	17.62	14.36%	36.99%	17.44	14.36%	37.78%	17.37	14.36%	38.20%	17.33
14.34%	35.22%	17.85	14.35%	37.35%	17.65	14.36%	38.14%	17.58	14.36%	38.57%	17.54
14.34%	35.63%	18.30	14.35%	37.78%	18.07	14.36%	38.59%	17.99	14.36%	39.02%	17.94
14.34%	35.57%	18.39	14.35%	37.72%	18.16	14.36%	38.52%	18.08	14.36%	38.95%	18.03
14.33%	35.93%	18.95	14.35%	38.10%	18.68	14.36%	38.91%	18.58	14.36%	39.34%	18.53
14.33%	36.11%	19.19	14.35%	38.30%	18.90	14.36%	39.11%	18.80	14.36%	39.55%	18.74
14.33%	36.25%	19.30	14.35%	38.45%	19.01	14.36%	39.26%	18.91	14.36%	39.70%	18.85
14.32%	36.99%	19.53	14.34%	39.22%	19.22	14.35%	40.06%	19.11	14.35%	40.51%	19.05
14.32%	37.48%	19.89	14.34%	39.75%	19.57	14.35%	40.59%	19.44	14.35%	41.05%	19.38
14.31%	37.57%	20.15	14.34%	39.84%	19.81	14.35%	40.69%	19.68	14.35%	41.15%	19.61
14.31%	37.69%	20.06	14.33%	39.97%	19.73	14.34%	40.82%	19.60	14.35%	41.27%	19.53
14.30%	38.11%	20.38	14.33%	40.42%	20.03	14.34%	41.28%	19.90	14.34%	41.74%	19.83
14.30%	38.71%	20.55	14.32%	41.05%	20.18	14.33%	41.92%	20.05	14.34%	42.39%	19.97
14.30%	38.83%	20.52	14.32%	41.18%	20.16	14.33%	42.05%	20.02	14.34%	42.52%	19.95
14.29%	39.07%	20.66	14.32%	41.43%	20.29	14.33%	42.32%	20.15	14.33%	42.79%	20.08
14.29%	39.28%	20.86	14.31%	41.66%	20.48	14.32%	42.54%	20.33	14.33%	43.02%	20.26
14.28%	39.36%	20.93	14.31%	41.74%	20.55	14.32%	42.63%	20.40	14.33%	43.11%	20.33
14.28%	39.42%	21.05	14.31%	41.81%	20.66	14.32%	42.70%	20.51	14.32%	43.18%	20.43
14.28%	39.34%	21.10	14.31%	41.72%	20.71	14.32%	42.61%	20.56	14.32%	43.09%	20.48
14.28%	39.56%	21.24	14.30%	41.96%	20.84	14.32%	42.85%	20.69	14.32%	43.33%	20.60
14.27%	39.93%	21.35	14.30%	42.35%	20.94	14.31%	43.25%	20.78	14.32%	43.73%	20.70
14.27%	39.88%	21.48	14.30%	42.30%	21.06	14.31%	43.20%	20.91	14.32%	43.69%	20.82
14.27%	39.99%	21.64	14.30%	42.42%	21.21	14.31%	43.32%	21.05	14.31%	43.81%	20.97
14.26%	40.35%	21.73	14.29%	42.80%	21.29	14.30%	43.71%	21.13	14.31%	44.20%	21.04
14.26%	40.53%	21.83	14.29%	42.99%	21.39	14.30%	43.91%	21.23	14.31%	44.40%	21.14
14.26%	40.68%	21.91	14.29%	43.14%	21.46	14.30%	44.06%	21.30	14.31%	44.55%	21.21
14.26%	40.75%	22.00	14.29%	43.23%	21.55	14.30%	44.15%	21.38	14.30%	44.64%	21.29
14.25%	41.10%	22.15	14.28%	43.60%	21.69	14.29%	44.53%	21.52	14.30%	45.03%	21.43

14.25%	41.36%	22.28	14.28%	43.87%	21.81	14.29%	44.81%	21.63	14.30%	45.31%	21.54
14.24%	41.32%	22.46	14.28%	43.83%	21.98	14.29%	44.76%	21.80	14.30%	45.26%	21.70
14.24%	41.47%	22.57	14.28%	43.99%	22.08	14.29%	44.92%	21.89	14.30%	45.43%	21.80
14.24%	41.36%	22.78	14.27%	43.87%	22.28	14.29%	44.80%	22.09	14.29%	45.31%	21.99
14.23%	41.38%	23.01	14.27%	43.89%	22.50	14.28%	44.83%	22.31	14.29%	45.33%	22.21
14.23%	41.43%	23.19	14.27%	43.95%	22.67	14.28%	44.88%	22.47	14.29%	45.39%	22.37
14.23%	41.45%	23.34	14.27%	43.97%	22.81	14.28%	44.91%	22.61	14.29%	45.41%	22.50
14.22%	41.66%	23.57	14.26%	44.19%	23.02	14.28%	45.13%	22.82	14.28%	45.64%	22.71
14.22%	41.67%	23.74	14.26%	44.20%	23.18	14.27%	45.15%	22.97	14.28%	45.66%	22.86
14.21%	41.92%	23.87	14.25%	44.46%	23.30	14.27%	45.41%	23.09	14.28%	45.92%	22.98
14.21%	42.04%	23.99	14.25%	44.59%	23.42	14.26%	45.55%	23.20	14.27%	46.06%	23.09
14.21%	42.09%	24.08	14.25%	44.65%	23.50	14.26%	45.60%	23.29	14.27%	46.11%	23.17
14.20%	42.28%	24.22	14.24%	44.84%	23.63	14.26%	45.80%	23.41	14.27%	46.32%	23.30
14.20%	42.23%	24.33	14.24%	44.80%	23.74	14.26%	45.75%	23.52	14.27%	46.27%	23.40
14.19%	42.27%	24.51	14.24%	44.84%	23.91	14.25%	45.80%	23.68	14.26%	46.32%	23.56
14.19%	42.48%	24.61	14.23%	45.06%	24.00	14.25%	46.02%	23.77	14.26%	46.54%	23.65
14.19%	42.62%	24.74	14.23%	45.21%	24.12	14.25%	46.18%	23.89	14.26%	46.70%	23.77
14.18%	42.71%	24.89	14.23%	45.31%	24.26	14.24%	46.28%	24.03	14.25%	46.80%	23.90
14.18%	42.76%	24.99	14.22%	45.36%	24.36	14.24%	46.33%	24.13	14.25%	46.85%	24.00
14.17%	43.11%	25.10	14.22%	45.73%	24.47	14.23%	46.71%	24.23	14.24%	47.23%	24.10
14.17%	43.21%	25.23	14.21%	45.84%	24.58	14.23%	46.82%	24.34	14.24%	47.35%	24.21
14.16%	43.23%	25.34	14.21%	45.86%	24.69	14.23%	46.84%	24.44	14.24%	47.37%	24.31
14.16%	43.37%	25.43	14.21%	46.01%	24.78	14.22%	46.99%	24.53	14.23%	47.52%	24.40
14.15%	43.50%	25.58	14.20%	46.15%	24.92	14.22%	47.14%	24.67	14.23%	47.67%	24.54
14.15%	43.69%	25.75	14.19%	46.35%	25.08	14.21%	47.34%	24.83	14.22%	47.87%	24.69
14.14%	43.98%	26.00	14.18%	46.65%	25.32	14.20%	47.65%	25.06	14.21%	48.19%	24.93
14.12%	44.48%	26.38	14.17%	47.19%	25.67	14.19%	48.20%	25.41	14.20%	48.75%	25.27
14.10%	44.65%	26.67	14.16%	47.38%	25.96	14.17%	48.39%	25.69	14.18%	48.94%	25.55
14.10%	44.60%	26.78	14.15%	47.32%	26.06	14.17%	48.33%	25.80	14.18%	48.88%	25.65
14.10%	44.28%	27.07	14.15%	46.98%	26.34	14.17%	47.98%	26.06	14.18%	48.52%	25.92
14.09%	43.60%	27.59	14.15%	46.26%	26.83	14.17%	47.25%	26.55	14.18%	47.79%	26.39
14.09%	43.32%	27.80	14.14%	45.97%	27.03	14.16%	46.95%	26.74	14.18%	47.48%	26.59

14.08%	43.00%	28.14	14.14%	45.63%	27.35	14.16%	46.61%	27.06	14.17%	47.13%	26.90
14.08%	42.64%	28.43	14.14%	45.25%	27.63	14.16%	46.22%	27.33	14.17%	46.74%	27.17
14.08%	42.53%	28.64	14.13%	45.13%	27.82	14.16%	46.10%	27.52	14.17%	46.62%	27.35
14.07%	42.24%	28.90	14.13%	44.82%	28.07	14.15%	45.78%	27.76	14.16%	46.30%	27.60
14.07%	41.99%	29.27	14.13%	44.55%	28.42	14.15%	45.51%	28.10	14.16%	46.02%	27.93
14.06%	41.87%	29.58	14.12%	44.42%	28.71	14.15%	45.38%	28.39	14.16%	45.89%	28.22
14.06%	41.72%	29.95	14.12%	44.27%	29.06	14.14%	45.22%	28.73	14.16%	45.73%	28.55
14.05%	41.54%	30.22	14.12%	44.08%	29.32	14.14%	45.03%	28.98	14.15%	45.54%	28.80
14.05%	41.39%	30.45	14.12%	43.92%	29.53	14.14%	44.86%	29.19	14.15%	45.37%	29.01
14.05%	41.29%	30.55	14.11%	43.81%	29.64	14.14%	44.75%	29.29	14.15%	45.26%	29.11
14.04%	41.20%	30.62	14.11%	43.72%	29.70	14.14%	44.66%	29.36	14.15%	45.16%	29.17
14.04%	41.10%	30.71	14.11%	43.62%	29.79	14.13%	44.55%	29.44	14.15%	45.06%	29.26
14.04%	41.00%	30.81	14.11%	43.51%	29.89	14.13%	44.45%	29.54	14.14%	44.95%	29.36
14.04%	40.88%	30.98	14.10%	43.38%	30.05	14.13%	44.32%	29.70	14.14%	44.82%	29.51
14.03%	40.99%	31.18	14.10%	43.49%	30.24	14.12%	44.43%	29.88	14.14%	44.93%	29.69
14.02%	41.16%	31.40	14.09%	43.67%	30.44	14.11%	44.61%	30.09	14.13%	45.12%	29.90
14.02%	41.15%	31.55	14.09%	43.67%	30.59	14.11%	44.61%	30.23	14.13%	45.12%	30.04
14.01%	41.31%	31.90	14.08%	43.84%	30.91	14.11%	44.78%	30.54	14.12%	45.29%	30.35
14.00%	41.45%	32.28	14.07%	43.98%	31.27	14.10%	44.93%	30.90	14.11%	45.44%	30.69
13.99%	41.43%	32.46	14.07%	43.97%	31.44	14.10%	44.92%	31.06	14.11%	45.43%	30.85
13.98%	41.54%	32.90	14.06%	44.09%	31.85	14.09%	45.04%	31.46	14.10%	45.55%	31.25
13.97%	41.59%	33.30	14.05%	44.14%	32.23	14.08%	45.09%	31.83	14.10%	45.60%	31.61
13.97%	41.44%	33.67	14.05%	43.98%	32.58	14.08%	44.93%	32.17	14.10%	45.44%	31.94
13.97%	41.22%	33.86	14.05%	43.75%	32.75	14.08%	44.69%	32.34	14.10%	45.20%	32.11
13.97%	41.06%	33.88	14.05%	43.58%	32.77	14.09%	44.52%	32.36	14.10%	45.02%	32.14
13.97%	41.01%	33.99	14.05%	43.52%	32.88	14.08%	44.46%	32.46	14.10%	44.97%	32.24
13.97%	40.95%	34.10	14.05%	43.47%	32.98	14.08%	44.40%	32.56	14.10%	44.91%	32.34
13.97%	40.89%	34.26	14.05%	43.40%	33.13	14.08%	44.33%	32.70	14.10%	44.84%	32.48
13.95%	41.29%	34.55	14.04%	43.83%	33.40	14.07%	44.77%	32.97	14.09%	45.28%	32.74
13.94%	41.76%	34.83	14.02%	44.33%	33.67	14.05%	45.28%	33.23	14.07%	45.80%	32.99
13.93%	41.78%	34.93	14.02%	44.34%	33.75	14.05%	45.30%	33.32	14.07%	45.81%	33.08
13.93%	41.78%	35.04	14.02%	44.35%	33.86	14.05%	45.31%	33.42	14.07%	45.82%	33.18

13.92%	41.90%	35.20	14.01%	44.47%	34.01	14.04%	45.43%	33.57	14.06%	45.95%	33.33
13.92%	41.95%	35.38	14.01%	44.52%	34.18	14.04%	45.49%	33.73	14.06%	46.00%	33.49
13.92%	41.85%	35.61	14.00%	44.42%	34.40	14.04%	45.38%	33.94	14.06%	45.90%	33.70
13.91%	41.81%	35.86	14.00%	44.38%	34.63	14.03%	45.33%	34.18	14.05%	45.85%	33.93
13.91%	41.78%	36.06	14.00%	44.35%	34.82	14.03%	45.31%	34.35	14.05%	45.83%	34.10
13.90%	41.66%	36.39	14.00%	44.22%	35.13	14.03%	45.18%	34.65	14.05%	45.69%	34.40
13.90%	41.49%	36.49	14.00%	44.04%	35.22	14.03%	44.99%	34.75	14.05%	45.51%	34.50
13.91%	41.34%	36.53	14.00%	43.89%	35.27	14.03%	44.83%	34.79	14.05%	45.34%	34.54
13.90%	41.31%	36.59	14.00%	43.85%	35.32	14.03%	44.80%	34.84	14.05%	45.31%	34.59
13.90%	41.37%	36.72	13.99%	43.91%	35.44	14.03%	44.86%	34.97	14.05%	45.37%	34.71
13.90%	41.48%	36.68	13.99%	44.03%	35.41	14.03%	44.98%	34.93	14.04%	45.49%	34.67
13.90%	41.47%	36.65	13.99%	44.02%	35.38	14.02%	44.97%	34.91	14.04%	45.48%	34.65
13.90%	41.53%	36.40	13.99%	44.08%	35.15	14.02%	45.04%	34.68	14.04%	45.55%	34.43
13.89%	41.39%	36.81	13.99%	43.93%	35.53	14.02%	44.88%	35.06	14.04%	45.39%	34.80
13.89%	41.35%	36.88	13.99%	43.89%	35.60	14.02%	44.84%	35.12	14.04%	45.35%	34.86
13.89%	41.21%	36.89	13.99%	43.75%	35.61	14.02%	44.70%	35.13	14.04%	45.20%	34.87
13.90%	41.06%	36.91	13.99%	43.59%	35.63	14.03%	44.53%	35.16	14.04%	45.04%	34.90
13.89%	41.02%	36.97	13.99%	43.55%	35.69	14.02%	44.49%	35.21	14.04%	44.99%	34.95
13.89%	40.91%	37.08	13.99%	43.43%	35.80	14.02%	44.36%	35.31	14.04%	44.87%	35.06
13.89%	40.81%	37.14	13.99%	43.32%	35.85	14.02%	44.26%	35.36	14.04%	44.76%	35.11
13.89%	40.77%	37.19	13.99%	43.28%	35.90	14.02%	44.22%	35.42	14.04%	44.72%	35.16
13.88%	40.87%	37.34	13.98%	43.39%	36.04	14.02%	44.33%	35.55	14.04%	44.83%	35.29
13.88%	40.99%	37.44	13.97%	43.51%	36.14	14.01%	44.45%	35.65	14.03%	44.96%	35.39
13.88%	40.95%	37.50	13.97%	43.47%	36.19	14.01%	44.41%	35.71	14.03%	44.91%	35.44
13.87%	40.95%	37.60	13.97%	43.47%	36.29	14.01%	44.41%	35.80	14.03%	44.92%	35.53
13.87%	40.99%	37.56	13.97%	43.51%	36.25	14.00%	44.46%	35.76	14.02%	44.96%	35.50
13.87%	40.98%	37.51	13.97%	43.50%	36.21	14.00%	44.44%	35.73	14.02%	44.95%	35.46
13.87%	41.06%	37.31	13.97%	43.59%	36.03	14.00%	44.53%	35.55	14.02%	45.04%	35.29
13.87%	41.17%	37.03	13.96%	43.70%	35.77	14.00%	44.65%	35.30	14.02%	45.15%	35.04
13.87%	41.05%	37.37	13.96%	43.57%	36.08	14.00%	44.52%	35.60	14.02%	45.02%	35.34
13.86%	41.17%	37.63	13.95%	43.71%	36.34	13.99%	44.66%	35.85	14.01%	45.16%	35.59
13.85%	41.32%	37.82	13.94%	43.87%	36.51	13.98%	44.82%	36.02	14.00%	45.33%	35.76

13.84%	41.22%	38.08	13.94%	43.76%	36.75	13.98%	44.71%	36.26	14.00%	45.22%	35.99
13.84%	41.15%	38.05	13.94%	43.69%	36.73	13.98%	44.63%	36.24	14.00%	45.14%	35.97
13.84%	41.06%	38.08	13.94%	43.59%	36.76	13.98%	44.53%	36.27	14.00%	45.04%	36.00
13.84%	41.00%	38.20	13.94%	43.53%	36.87	13.98%	44.47%	36.38	14.00%	44.98%	36.11
13.84%	40.91%	38.25	13.94%	43.43%	36.92	13.98%	44.37%	36.43	14.00%	44.88%	36.16
13.84%	40.81%	38.32	13.94%	43.32%	36.99	13.98%	44.26%	36.49	14.00%	44.77%	36.23
13.84%	40.76%	38.40	13.94%	43.28%	37.07	13.98%	44.21%	36.57	14.00%	44.72%	36.30
13.84%	40.71%	38.52	13.94%	43.22%	37.18	13.97%	44.16%	36.67	13.99%	44.66%	36.40
13.84%	40.66%	38.61	13.94%	43.17%	37.27	13.97%	44.10%	36.76	13.99%	44.61%	36.49
13.83%	40.62%	38.69	13.93%	43.12%	37.34	13.97%	44.06%	36.84	13.99%	44.56%	36.56
13.83%	40.62%	38.79	13.93%	43.13%	37.43	13.97%	44.06%	36.93	13.99%	44.56%	36.66
13.83%	40.66%	38.72	13.93%	43.17%	37.38	13.97%	44.11%	36.88	13.99%	44.61%	36.60
13.83%	40.65%	38.66	13.93%	43.16%	37.32	13.96%	44.10%	36.82	13.98%	44.60%	36.55
13.82%	40.66%	38.76	13.92%	43.17%	37.42	13.96%	44.10%	36.91	13.98%	44.60%	36.64
13.82%	40.66%	38.86	13.92%	43.17%	37.51	13.96%	44.11%	37.01	13.98%	44.61%	36.73
13.82%	40.62%	38.93	13.92%	43.12%	37.58	13.96%	44.06%	37.08	13.98%	44.56%	36.80
13.82%	40.61%	39.07	13.92%	43.12%	37.71	13.95%	44.05%	37.21	13.97%	44.56%	36.93
13.81%	40.61%	39.19	13.91%	43.12%	37.83	13.95%	44.05%	37.32	13.97%	44.56%	37.04
13.81%	40.55%	39.35	13.91%	43.05%	37.97	13.95%	43.99%	37.46	13.97%	44.49%	37.18
13.81%	40.35%	39.43	13.91%	42.84%	38.06	13.95%	43.77%	37.54	13.97%	44.27%	37.26
13.81%	40.16%	39.50	13.92%	42.64%	38.12	13.95%	43.56%	37.60	13.98%	44.06%	37.33
13.81%	40.11%	39.63	13.91%	42.58%	38.25	13.95%	43.51%	37.73	13.97%	44.00%	37.45
13.81%	39.98%	39.72	13.92%	42.44%	38.33	13.95%	43.36%	37.81	13.98%	43.86%	37.53
13.81%	39.86%	39.74	13.92%	42.32%	38.35	13.96%	43.23%	37.83	13.98%	43.73%	37.55
13.81%	39.81%	39.87	13.92%	42.27%	38.47	13.96%	43.19%	37.95	13.98%	43.68%	37.67
13.80%	39.99%	40.14	13.91%	42.46%	38.72	13.95%	43.39%	38.19	13.97%	43.88%	37.91
13.79%	40.18%	40.38	13.90%	42.66%	38.95	13.94%	43.58%	38.42	13.96%	44.08%	38.13
13.79%	40.13%	40.53	13.90%	42.61%	39.10	13.94%	43.53%	38.56	13.96%	44.03%	38.27
13.79%	40.04%	40.68	13.89%	42.51%	39.23	13.94%	43.43%	38.69	13.96%	43.93%	38.40
13.79%	39.94%	40.85	13.89%	42.41%	39.39	13.94%	43.33%	38.84	13.96%	43.83%	38.55
13.78%	39.90%	41.00	13.89%	42.37%	39.53	13.93%	43.28%	38.98	13.96%	43.78%	38.69
13.78%	39.86%	41.13	13.89%	42.32%	39.65	13.93%	43.24%	39.10	13.95%	43.74%	38.81

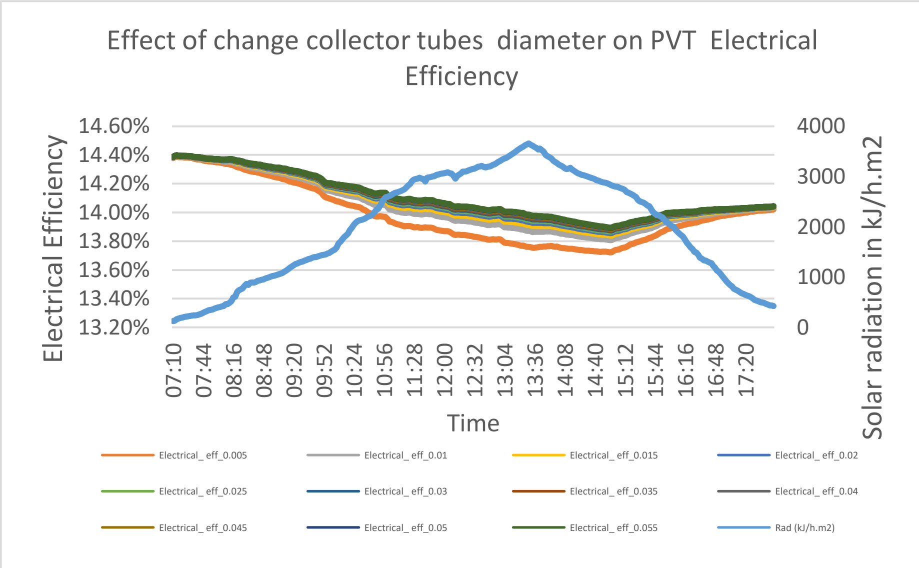
13.78%	39.82%	41.28	13.89%	42.28%	39.79	13.93%	43.20%	39.24	13.95%	43.69%	38.94
13.78%	39.78%	41.41	13.89%	42.24%	39.92	13.93%	43.16%	39.36	13.95%	43.65%	39.06
13.77%	39.78%	41.56	13.88%	42.24%	40.06	13.93%	43.16%	39.50	13.95%	43.65%	39.20
13.77%	39.80%	41.67	13.88%	42.26%	40.17	13.92%	43.17%	39.61	13.95%	43.67%	39.30
13.77%	39.80%	41.56	13.88%	42.26%	40.07	13.92%	43.18%	39.51	13.95%	43.67%	39.21
13.76%	39.93%	41.52	13.88%	42.40%	40.03	13.92%	43.32%	39.48	13.94%	43.81%	39.17
13.76%	40.06%	41.49	13.87%	42.54%	40.00	13.91%	43.46%	39.44	13.94%	43.96%	39.14
13.76%	40.06%	41.38	13.87%	42.54%	39.90	13.91%	43.47%	39.34	13.94%	43.96%	39.05
13.76%	40.17%	41.25	13.87%	42.65%	39.79	13.91%	43.58%	39.24	13.93%	44.08%	38.94
13.75%	40.21%	41.43	13.86%	42.70%	39.95	13.91%	43.63%	39.40	13.93%	44.13%	39.10
13.75%	40.23%	41.26	13.86%	42.72%	39.80	13.91%	43.65%	39.25	13.93%	44.14%	38.95
13.76%	40.25%	41.07	13.86%	42.74%	39.62	13.91%	43.67%	39.08	13.93%	44.17%	38.78
13.76%	40.30%	40.76	13.87%	42.79%	39.33	13.91%	43.72%	38.80	13.93%	44.22%	38.51
13.76%	40.31%	40.64	13.87%	42.80%	39.22	13.91%	43.73%	38.68	13.93%	44.23%	38.40
13.76%	40.31%	40.53	13.87%	42.81%	39.12	13.91%	43.74%	38.59	13.93%	44.24%	38.30
13.76%	40.33%	40.40	13.87%	42.82%	39.00	13.91%	43.75%	38.47	13.93%	44.25%	38.19
13.76%	40.36%	40.17	13.87%	42.85%	38.78	13.91%	43.78%	38.27	13.93%	44.28%	37.99
13.76%	40.37%	40.04	13.87%	42.86%	38.67	13.91%	43.79%	38.15	13.93%	44.29%	37.87
13.77%	40.38%	39.93	13.87%	42.87%	38.57	13.90%	43.80%	38.05	13.93%	44.30%	37.78
13.77%	40.39%	39.78	13.87%	42.89%	38.43	13.90%	43.82%	37.92	13.92%	44.32%	37.65
13.76%	40.49%	39.72	13.86%	42.99%	38.37	13.90%	43.93%	37.87	13.92%	44.43%	37.59
13.76%	40.60%	39.66	13.86%	43.10%	38.31	13.90%	44.04%	37.81	13.92%	44.54%	37.54
13.76%	40.62%	39.49	13.86%	43.13%	38.16	13.90%	44.06%	37.66	13.92%	44.57%	37.39
13.76%	40.72%	39.45	13.86%	43.24%	38.12	13.89%	44.17%	37.62	13.91%	44.68%	37.36
13.75%	40.78%	39.56	13.85%	43.30%	38.23	13.89%	44.24%	37.73	13.91%	44.75%	37.46
13.75%	40.74%	39.65	13.85%	43.26%	38.32	13.89%	44.20%	37.81	13.91%	44.70%	37.55
13.75%	40.79%	39.52	13.85%	43.31%	38.20	13.89%	44.25%	37.70	13.91%	44.75%	37.43
13.75%	40.82%	39.43	13.85%	43.34%	38.12	13.88%	44.28%	37.62	13.90%	44.79%	37.36
13.75%	40.80%	39.32	13.84%	43.32%	38.01	13.88%	44.27%	37.53	13.90%	44.77%	37.26
13.75%	40.79%	39.21	13.84%	43.31%	37.91	13.88%	44.25%	37.43	13.90%	44.75%	37.17
13.75%	40.75%	39.17	13.84%	43.27%	37.88	13.88%	44.21%	37.40	13.90%	44.71%	37.14
13.75%	40.73%	39.10	13.84%	43.24%	37.82	13.88%	44.18%	37.34	13.89%	44.68%	37.08

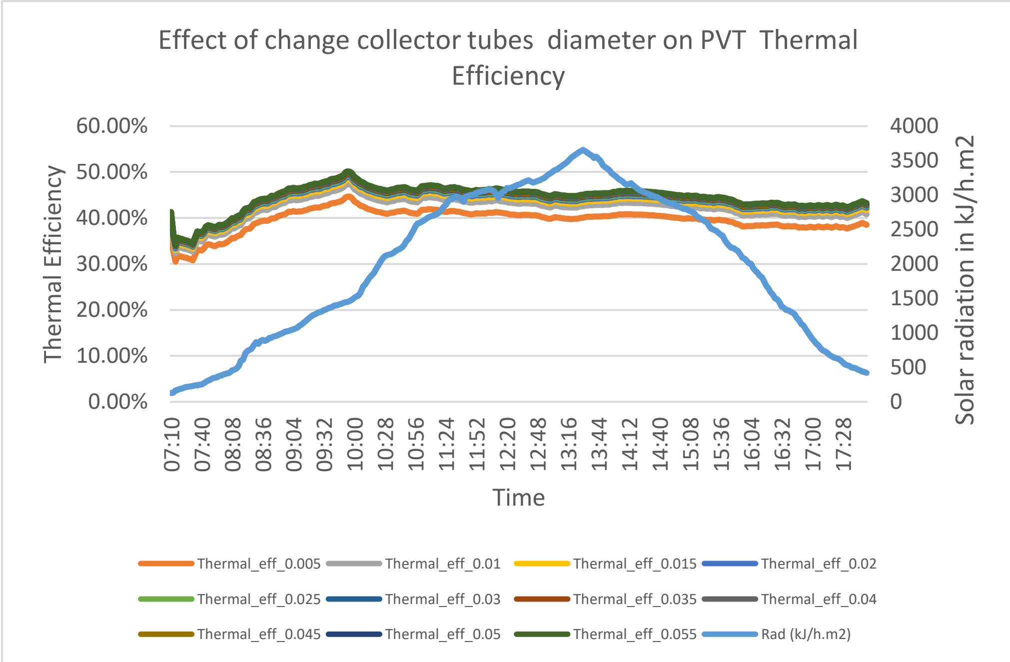
13.74%	40.74%	39.09	13.84%	43.26%	37.81	13.87%	44.20%	37.34	13.89%	44.70%	37.08
13.74%	40.75%	39.08	13.83%	43.27%	37.81	13.87%	44.21%	37.33	13.89%	44.72%	37.08
13.74%	40.72%	39.02	13.83%	43.24%	37.76	13.87%	44.18%	37.29	13.89%	44.68%	37.03
13.74%	40.68%	38.99	13.83%	43.20%	37.73	13.86%	44.14%	37.26	13.88%	44.64%	37.01
13.74%	40.65%	38.96	13.83%	43.16%	37.70	13.86%	44.09%	37.24	13.88%	44.60%	36.98
13.73%	40.61%	38.92	13.83%	43.12%	37.68	13.86%	44.05%	37.21	13.88%	44.56%	36.96
13.73%	40.58%	38.85	13.83%	43.09%	37.61	13.86%	44.02%	37.15	13.88%	44.53%	36.90
13.73%	40.56%	38.74	13.82%	43.07%	37.51	13.86%	44.00%	37.05	13.88%	44.51%	36.80
13.73%	40.52%	38.72	13.82%	43.02%	37.50	13.86%	43.96%	37.04	13.87%	44.46%	36.80
13.73%	40.48%	38.67	13.82%	42.99%	37.45	13.85%	43.92%	37.00	13.87%	44.42%	36.75
13.73%	40.45%	38.62	13.82%	42.95%	37.41	13.85%	43.88%	36.95	13.87%	44.38%	36.71
13.73%	40.40%	38.60	13.82%	42.90%	37.40	13.85%	43.83%	36.95	13.87%	44.33%	36.70
13.73%	40.36%	38.59	13.82%	42.85%	37.39	13.85%	43.78%	36.94	13.87%	44.28%	36.70
13.73%	40.32%	38.53	13.81%	42.82%	37.34	13.85%	43.74%	36.89	13.86%	44.24%	36.65
13.73%	40.24%	38.44	13.81%	42.72%	37.25	13.85%	43.65%	36.81	13.86%	44.15%	36.57
13.73%	40.15%	38.36	13.81%	42.63%	37.19	13.85%	43.55%	36.75	13.86%	44.05%	36.51
13.73%	40.11%	38.31	13.81%	42.59%	37.14	13.84%	43.51%	36.70	13.86%	44.01%	36.47
13.72%	40.07%	38.27	13.81%	42.54%	37.11	13.84%	43.47%	36.68	13.86%	43.96%	36.44
13.72%	40.02%	38.28	13.81%	42.49%	37.12	13.84%	43.41%	36.69	13.86%	43.91%	36.45
13.72%	39.99%	38.20	13.81%	42.47%	37.05	13.84%	43.39%	36.62	13.86%	43.88%	36.39
13.73%	39.91%	38.04	13.81%	42.38%	36.90	13.85%	43.29%	36.47	13.86%	43.79%	36.24
13.74%	39.80%	37.85	13.82%	42.26%	36.72	13.85%	43.17%	36.30	13.87%	43.67%	36.07
13.74%	39.86%	37.74	13.82%	42.32%	36.61	13.85%	43.23%	36.19	13.87%	43.73%	35.96
13.74%	39.94%	37.48	13.83%	42.41%	36.37	13.86%	43.33%	35.95	13.87%	43.82%	35.73
13.75%	39.88%	37.34	13.83%	42.34%	36.23	13.86%	43.26%	35.82	13.88%	43.76%	35.60
13.75%	39.83%	37.18	13.83%	42.28%	36.08	13.86%	43.20%	35.67	13.88%	43.69%	35.45
13.76%	39.88%	37.06	13.84%	42.34%	35.97	13.87%	43.26%	35.56	13.88%	43.76%	35.34
13.76%	39.89%	36.88	13.84%	42.35%	35.80	13.87%	43.27%	35.40	13.89%	43.77%	35.18
13.77%	39.72%	36.67	13.85%	42.17%	35.61	13.88%	43.08%	35.21	13.89%	43.57%	34.99
13.78%	39.64%	36.25	13.85%	42.08%	35.21	13.88%	42.99%	34.82	13.90%	43.48%	34.61
13.78%	39.70%	36.08	13.86%	42.14%	35.05	13.88%	43.06%	34.67	13.90%	43.55%	34.46
13.79%	39.61%	35.96	13.86%	42.05%	34.94	13.89%	42.96%	34.56	13.90%	43.45%	34.35

13.79%	39.54%	35.81	13.87%	41.97%	34.79	13.89%	42.88%	34.41	13.91%	43.37%	34.21
13.79%	39.59%	35.66	13.87%	42.03%	34.65	13.89%	42.94%	34.27	13.91%	43.43%	34.07
13.80%	39.53%	35.44	13.87%	41.96%	34.45	13.90%	42.87%	34.07	13.91%	43.36%	33.87
13.80%	39.44%	35.30	13.88%	41.87%	34.32	13.90%	42.78%	33.95	13.92%	43.26%	33.75
13.81%	39.55%	34.93	13.88%	41.98%	33.97	13.90%	42.89%	33.61	13.92%	43.38%	33.42
13.81%	39.63%	34.66	13.88%	42.07%	33.71	13.90%	42.98%	33.36	13.92%	43.47%	33.17
13.82%	39.57%	34.40	13.88%	42.01%	33.47	13.91%	42.92%	33.13	13.92%	43.40%	32.94
13.82%	39.50%	34.18	13.89%	41.93%	33.27	13.91%	42.84%	32.93	13.93%	43.32%	32.74
13.82%	39.46%	34.13	13.89%	41.89%	33.22	13.92%	42.80%	32.88	13.93%	43.28%	32.69
13.83%	39.32%	33.91	13.90%	41.73%	33.01	13.92%	42.64%	32.67	13.93%	43.12%	32.49
13.84%	39.23%	33.75	13.90%	41.64%	32.86	13.92%	42.54%	32.53	13.94%	43.02%	32.35
13.84%	39.16%	33.45	13.91%	41.57%	32.58	13.93%	42.47%	32.26	13.94%	42.95%	32.08
13.85%	38.96%	33.05	13.91%	41.36%	32.20	13.94%	42.25%	31.89	13.95%	42.73%	31.72
13.86%	38.71%	32.89	13.92%	41.09%	32.05	13.94%	41.98%	31.74	13.96%	42.45%	31.57
13.87%	38.62%	32.67	13.92%	40.99%	31.84	13.95%	41.88%	31.54	13.96%	42.35%	31.37
13.87%	38.46%	32.37	13.93%	40.82%	31.56	13.95%	41.70%	31.26	13.96%	42.18%	31.10
13.88%	38.19%	32.22	13.94%	40.54%	31.43	13.96%	41.41%	31.13	13.97%	41.88%	30.97
13.89%	38.19%	31.83	13.94%	40.54%	31.06	13.96%	41.41%	30.77	13.97%	41.88%	30.61
13.89%	38.26%	31.59	13.94%	40.60%	30.84	13.96%	41.48%	30.56	13.97%	41.95%	30.40
13.89%	38.23%	31.38	13.94%	40.58%	30.64	13.96%	41.45%	30.36	13.98%	41.92%	30.21
13.90%	38.21%	31.14	13.95%	40.56%	30.42	13.97%	41.43%	30.14	13.98%	41.90%	30.00
13.90%	38.26%	31.01	13.95%	40.61%	30.29	13.97%	41.48%	30.02	13.98%	41.96%	29.88
13.90%	38.35%	30.66	13.95%	40.70%	29.96	13.97%	41.58%	29.70	13.98%	42.05%	29.56
13.90%	38.35%	30.26	13.95%	40.70%	29.59	13.97%	41.58%	29.34	13.98%	42.05%	29.21
13.91%	38.33%	30.01	13.96%	40.68%	29.35	13.97%	41.56%	29.11	13.98%	42.03%	28.97
13.91%	38.42%	29.69	13.96%	40.78%	29.06	13.97%	41.65%	28.82	13.98%	42.13%	28.69
13.91%	38.40%	29.48	13.96%	40.75%	28.86	13.98%	41.62%	28.62	13.98%	42.10%	28.50
13.92%	38.39%	29.14	13.96%	40.74%	28.54	13.98%	41.62%	28.32	13.99%	42.09%	28.20
13.92%	38.44%	29.05	13.96%	40.80%	28.45	13.98%	41.68%	28.23	13.99%	42.15%	28.11
13.92%	38.53%	28.80	13.96%	40.89%	28.22	13.98%	41.77%	28.00	13.99%	42.25%	27.88
13.93%	38.53%	28.44	13.97%	40.89%	27.88	13.98%	41.77%	27.67	13.99%	42.25%	27.56
13.93%	38.49%	28.28	13.97%	40.85%	27.74	13.98%	41.73%	27.53	13.99%	42.20%	27.42

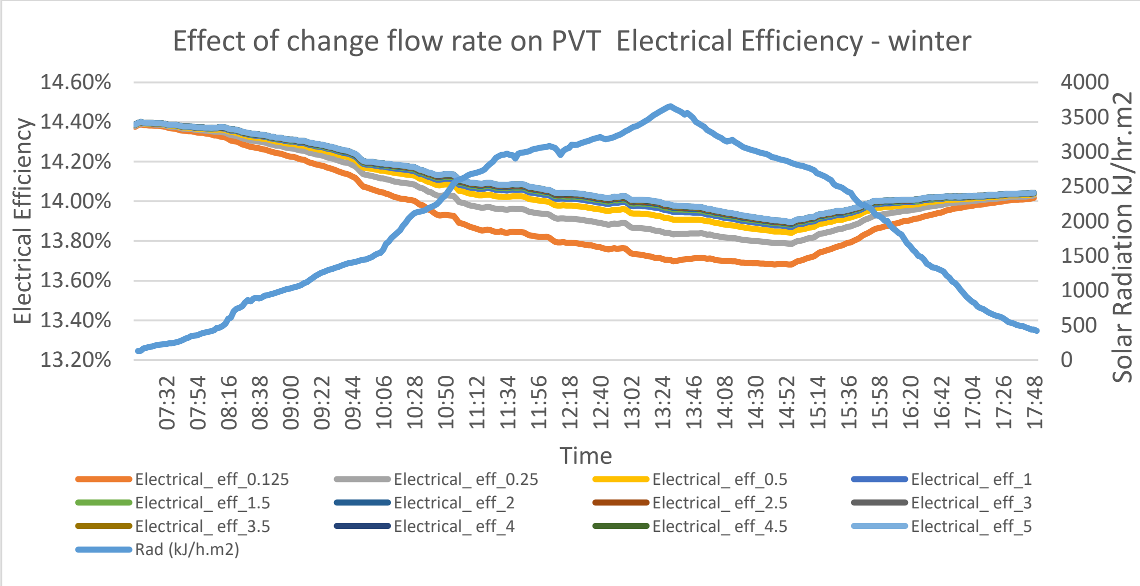
13.93%	38.57%	28.11	13.97%	40.93%	27.57	13.98%	41.81%	27.37	13.99%	42.29%	27.27
13.93%	38.40%	28.01	13.97%	40.75%	27.48	13.99%	41.62%	27.28	13.99%	42.10%	27.18
13.94%	38.23%	27.86	13.98%	40.57%	27.33	13.99%	41.44%	27.14	14.00%	41.91%	27.03
13.94%	38.18%	27.72	13.98%	40.52%	27.21	13.99%	41.39%	27.01	14.00%	41.86%	26.91
13.95%	38.13%	27.59	13.98%	40.46%	27.08	13.99%	41.33%	26.89	14.00%	41.80%	26.79
13.95%	38.23%	27.25	13.98%	40.57%	26.77	13.99%	41.44%	26.58	14.00%	41.91%	26.49
13.95%	38.19%	27.04	13.98%	40.52%	26.56	14.00%	41.39%	26.39	14.00%	41.86%	26.29
13.95%	38.16%	26.70	13.99%	40.50%	26.25	14.00%	41.37%	26.08	14.00%	41.83%	25.99
13.96%	38.25%	26.55	13.99%	40.58%	26.10	14.00%	41.45%	25.94	14.00%	41.92%	25.85
13.96%	38.07%	26.25	13.99%	40.39%	25.82	14.00%	41.26%	25.67	14.01%	41.73%	25.58
13.97%	37.88%	25.90	13.99%	40.19%	25.50	14.00%	41.05%	25.35	14.01%	41.52%	25.27
13.97%	37.98%	25.63	13.99%	40.30%	25.25	14.00%	41.16%	25.10	14.01%	41.63%	25.03
13.97%	37.93%	25.31	14.00%	40.24%	24.95	14.01%	41.11%	24.81	14.01%	41.57%	24.74
13.97%	37.86%	25.08	14.00%	40.17%	24.73	14.01%	41.03%	24.60	14.01%	41.50%	24.53
13.98%	37.97%	24.84	14.00%	40.29%	24.51	14.01%	41.15%	24.38	14.01%	41.62%	24.32
13.98%	38.06%	24.73	14.00%	40.39%	24.40	14.01%	41.25%	24.28	14.01%	41.72%	24.21
13.98%	38.01%	24.41	14.00%	40.32%	24.10	14.01%	41.19%	23.99	14.01%	41.66%	23.93
13.98%	37.91%	24.23	14.00%	40.23%	23.94	14.01%	41.09%	23.83	14.02%	41.55%	23.77
13.98%	38.01%	24.14	14.00%	40.33%	23.85	14.01%	41.20%	23.74	14.02%	41.66%	23.69
13.98%	38.13%	23.99	14.00%	40.46%	23.71	14.01%	41.33%	23.60	14.02%	41.79%	23.55
13.99%	38.04%	23.81	14.01%	40.35%	23.54	14.01%	41.22%	23.44	14.02%	41.68%	23.39
13.99%	37.92%	23.68	14.01%	40.23%	23.42	14.02%	41.10%	23.32	14.02%	41.56%	23.26
13.99%	38.04%	23.57	14.01%	40.36%	23.31	14.02%	41.22%	23.21	14.02%	41.69%	23.16
13.99%	38.15%	23.49	14.01%	40.48%	23.24	14.02%	41.34%	23.15	14.02%	41.81%	23.10
13.99%	38.02%	23.40	14.01%	40.34%	23.15	14.02%	41.20%	23.06	14.02%	41.67%	23.01
14.00%	37.90%	23.26	14.01%	40.21%	23.02	14.02%	41.07%	22.93	14.02%	41.53%	22.89
14.00%	38.04%	23.09	14.01%	40.36%	22.86	14.02%	41.22%	22.77	14.02%	41.69%	22.73
14.00%	38.20%	22.90	14.01%	40.53%	22.68	14.02%	41.40%	22.60	14.02%	41.87%	22.55
14.00%	38.05%	22.80	14.02%	40.37%	22.59	14.02%	41.24%	22.51	14.03%	41.70%	22.47
14.00%	37.90%	22.71	14.02%	40.20%	22.50	14.02%	41.07%	22.42	14.03%	41.53%	22.38
14.01%	38.05%	22.57	14.02%	40.37%	22.37	14.02%	41.23%	22.30	14.03%	41.70%	22.26
14.01%	37.88%	22.50	14.02%	40.18%	22.30	14.03%	41.04%	22.23	14.03%	41.51%	22.19

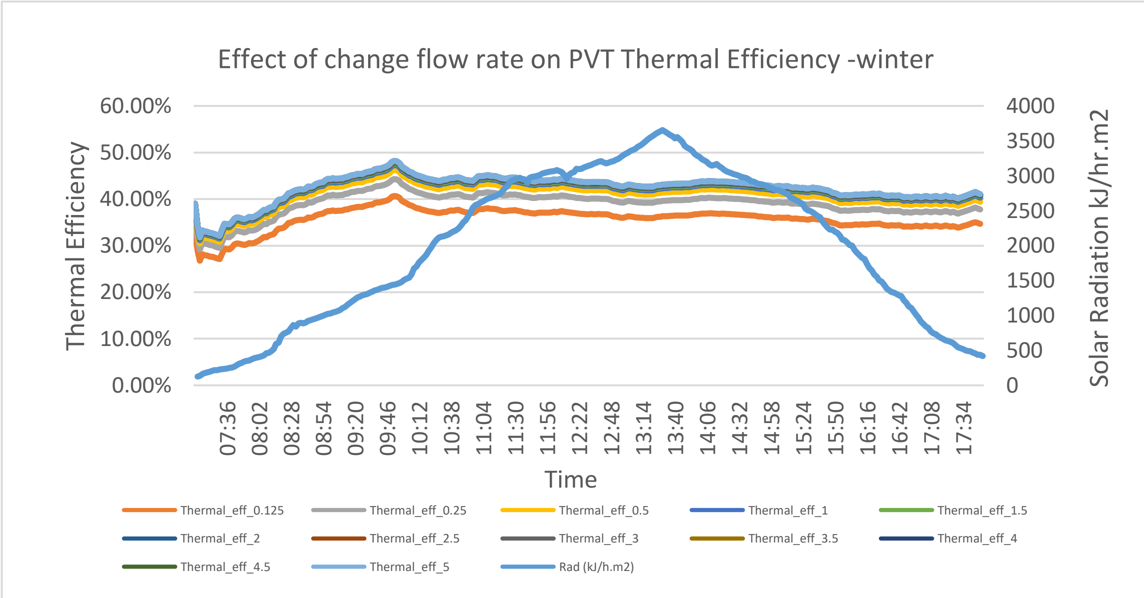
14.01%	37.70%	22.44	14.02%	39.99%	22.25	14.03%	40.85%	22.18	14.03%	41.31%	22.14
14.01%	37.85%	22.31	14.02%	40.15%	22.13	14.03%	41.01%	22.06	14.03%	41.48%	22.02
14.01%	38.00%	22.24	14.02%	40.31%	22.06	14.03%	41.18%	21.99	14.03%	41.64%	21.95
14.01%	38.17%	22.13	14.03%	40.50%	21.95	14.03%	41.36%	21.89	14.03%	41.83%	21.85
14.01%	38.32%	22.10	14.03%	40.65%	21.92	14.03%	41.52%	21.86	14.03%	41.99%	21.82
14.01%	38.51%	22.00	14.03%	40.85%	21.83	14.03%	41.72%	21.77	14.03%	42.19%	21.74
14.02%	38.72%	21.89	14.03%	41.07%	21.73	14.03%	41.95%	21.67	14.03%	42.42%	21.63
14.02%	38.90%	21.84	14.03%	41.26%	21.68	14.03%	42.15%	21.62	14.03%	42.62%	21.59
14.02%	38.71%	21.74	14.03%	41.06%	21.59	14.03%	41.94%	21.53	14.04%	42.41%	21.50
14.02%	38.49%	21.67	14.03%	40.84%	21.52	14.04%	41.71%	21.46	14.04%	42.18%	21.43
13.97%	39.68%	30.85	14.04%	42.11%	30.00	14.06%	43.01%	29.68	14.07%	43.50%	29.51
14.38%	44.65%	41.67	14.39%	47.38%	40.17	14.39%	48.39%	39.61	14.39%	48.94%	39.30




Effect of change collector tubes diameter on PVT Thermal Efficiency
Thermal Efficiency
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
4000
3500
3000
2500
2000
1500
1000
500
0
Solar radiation in kJ/h.m2
07:10
07:40
08:08
08:36
09:04
09:32
10:00
10:28
10:56
11:24
11:52
12:20
12:48
13:16
13:44
14:12
14:40
15:08
15:36
16:04
16:32
17:00
17:28
Time
Thermal_eff_0.005
Thermal_eff_0.01
Thermal_eff_0.015
Thermal_eff_0.02
Thermal_eff_0.025
Thermal_eff_0.03
Thermal_eff_0.035
Thermal_eff_0.04
Thermal_eff_0.045
Thermal_eff_0.05
Thermal_eff_0.055
Rad (kJ/h.m2)

Change in water flow rate results:





Change PVT Area:

1- Changing PVT area:

Area 0.914 m2						Area 1.2 m2						Area 1.5 m2					
Tout_sim	Q_PV	Electrical_ eff_0.941	Q_ th	Thermal_eff_0.941	T cell_0.941	Tout_sim	Q_PV	Electrical_ eff_1.2	Q_ th	Thermal_eff_1.2	T cell_1.2	Tout_sim	Q_PV	Electrical_ eff_1.5	Q_ th	Thermal_eff_1.5	T cell_1.5
14.41	20.06	14.39%	66.71	38.99%	15.26	14.42	26.08	14.39%	86.57	38.92%	15.27	14.43	32.90	14.39%	109.00	38.84%	15.27
14.43	20.84	14.40%	60.67	34.14%	15.20	14.44	27.09	14.39%	78.73	34.08%	15.21	14.44	34.18	14.39%	99.13	34.02%	15.21
14.45	22.39	14.40%	60.45	31.67%	15.22	14.46	29.11	14.40%	78.45	31.62%	15.22	14.46	36.72	14.40%	98.77	31.56%	15.22
14.47	23.16	14.40%	65.62	33.24%	15.31	14.48	30.10	14.40%	85.16	33.18%	15.31	14.49	37.98	14.40%	107.22	33.12%	15.31
14.49	23.54	14.40%	66.28	33.02%	15.34	14.50	30.61	14.40%	86.01	32.96%	15.34	14.51	38.61	14.40%	108.30	32.90%	15.34
14.51	24.31	14.40%	68.24	32.92%	15.39	14.52	31.61	14.40%	88.57	32.87%	15.39	14.53	39.87	14.40%	111.51	32.80%	15.39
14.53	24.70	14.39%	68.90	32.72%	15.41	14.54	32.11	14.39%	89.42	32.66%	15.42	14.55	40.51	14.39%	112.59	32.60%	15.42
14.55	25.47	14.39%	70.87	32.64%	15.46	14.56	33.11	14.39%	91.98	32.58%	15.46	14.57	41.77	14.39%	115.81	32.52%	15.47
14.58	25.86	14.39%	71.53	32.45%	15.49	14.58	33.61	14.39%	92.83	32.39%	15.49	14.59	42.40	14.39%	116.89	32.33%	15.49
14.61	26.63	14.39%	73.18	32.23%	15.54	14.61	34.61	14.39%	94.97	32.18%	15.54	14.62	43.66	14.39%	119.57	32.11%	15.55
14.64	27.40	14.39%	74.82	32.03%	15.59	14.64	35.61	14.39%	97.10	31.97%	15.60	14.65	44.93	14.39%	122.26	31.91%	15.60
14.67	28.93	14.39%	82.28	33.34%	15.72	14.68	37.61	14.39%	106.78	33.28%	15.73	14.69	47.45	14.39%	134.45	33.22%	15.73
14.70	31.24	14.39%	92.35	34.65%	15.89	14.71	40.61	14.39%	119.85	34.59%	15.89	14.72	51.23	14.39%	150.91	34.52%	15.89
14.73	32.90	14.39%	97.00	34.56%	15.98	14.74	42.77	14.39%	125.88	34.50%	15.98	14.76	53.95	14.39%	158.50	34.43%	15.99
14.77	34.71	14.39%	102.17	34.50%	16.08	14.78	45.12	14.39%	132.59	34.44%	16.08	14.79	56.92	14.39%	166.95	34.38%	16.09
14.80	36.75	14.38%	109.72	34.99%	16.21	14.81	47.78	14.38%	142.40	34.93%	16.21	14.82	60.27	14.38%	179.29	34.86%	16.22
14.83	37.40	14.38%	114.17	35.77%	16.30	14.84	48.62	14.38%	148.17	35.71%	16.30	14.86	61.33	14.38%	186.57	35.64%	16.31
14.86	38.16	14.38%	117.42	36.05%	16.37	14.87	49.61	14.38%	152.38	35.98%	16.38	14.89	62.58	14.38%	191.86	35.91%	16.38

14.89	40.09	14.38%	122.98	35.94%	16.48	14.91	52.11	14.38%	159.60	35.88%	16.48	14.92	65.74	14.38%	200.95	35.81%	16.49
14.92	41.24	14.38%	125.92	35.77%	16.55	14.94	53.62	14.38%	163.42	35.70%	16.55	14.95	67.64	14.38%	205.76	35.64%	16.56
14.96	42.40	14.38%	128.87	35.60%	16.62	14.97	55.12	14.38%	167.24	35.54%	16.62	14.98	69.53	14.38%	210.57	35.47%	16.63
15.00	43.62	14.37%	133.35	35.80%	16.72	15.01	56.71	14.37%	173.06	35.74%	16.72	15.03	71.54	14.37%	217.90	35.67%	16.73
15.02	44.47	14.37%	137.18	36.13%	16.79	15.03	57.81	14.37%	178.03	36.06%	16.79	15.05	72.92	14.37%	224.15	36.00%	16.80
15.04	45.62	14.37%	140.44	36.05%	16.85	15.05	59.31	14.37%	182.27	35.99%	16.86	15.07	74.82	14.37%	229.49	35.92%	16.86
15.06	49.13	14.37%	151.67	36.15%	17.02	15.08	63.87	14.37%	196.84	36.09%	17.03	15.10	80.57	14.37%	247.84	36.02%	17.03
15.08	49.70	14.37%	154.58	36.42%	17.08	15.10	64.61	14.37%	200.62	36.36%	17.09	15.12	81.51	14.37%	252.60	36.29%	17.09
15.11	52.13	14.37%	163.76	36.78%	17.23	15.12	67.76	14.37%	212.52	36.72%	17.23	15.14	85.48	14.37%	267.59	36.65%	17.24
15.13	55.82	14.37%	177.24	37.17%	17.43	15.15	72.57	14.37%	230.01	37.11%	17.43	15.17	91.55	14.37%	289.61	37.04%	17.44
15.16	63.65	14.37%	204.66	37.65%	17.81	15.18	82.74	14.37%	265.61	37.59%	17.82	15.21	104.38	14.37%	334.42	37.51%	17.83
15.18	65.27	14.37%	209.49	37.58%	17.90	15.21	84.85	14.37%	271.87	37.52%	17.90	15.23	107.04	14.37%	342.31	37.45%	17.91
15.22	75.15	14.37%	243.80	38.00%	18.38	15.24	97.69	14.37%	316.40	37.93%	18.38	15.27	123.23	14.37%	398.38	37.86%	18.39
15.24	79.00	14.37%	257.78	38.22%	18.58	15.27	102.69	14.37%	334.54	38.15%	18.59	15.30	129.55	14.37%	421.22	38.08%	18.60
15.26	80.53	14.37%	263.94	38.38%	18.69	15.29	104.68	14.37%	342.54	38.32%	18.69	15.32	132.06	14.37%	431.29	38.24%	18.70
15.29	82.81	14.37%	277.51	39.23%	18.89	15.32	107.65	14.37%	360.15	39.16%	18.90	15.35	135.79	14.37%	453.47	39.09%	18.91
15.32	88.18	14.36%	299.90	39.80%	19.21	15.35	114.63	14.36%	389.20	39.73%	19.22	15.38	144.61	14.36%	490.04	39.66%	19.23
15.34	92.42	14.36%	315.16	39.91%	19.43	15.37	120.14	14.36%	409.01	39.84%	19.44	15.41	151.55	14.36%	514.99	39.76%	19.45
15.36	90.09	14.36%	308.31	40.04%	19.36	15.39	117.11	14.36%	400.12	39.97%	19.37	15.43	147.73	14.36%	503.79	39.90%	19.38
15.38	94.68	14.36%	328.08	40.53%	19.65	15.42	123.08	14.36%	425.78	40.46%	19.66	15.46	155.27	14.35%	536.10	40.38%	19.67
15.41	95.80	14.35%	337.75	41.22%	19.79	15.44	124.53	14.35%	438.33	41.15%	19.80	15.48	157.09	14.35%	551.89	41.07%	19.82
15.43	94.62	14.35%	334.80	41.36%	19.78	15.46	123.01	14.35%	434.50	41.29%	19.79	15.50	155.17	14.35%	547.08	41.21%	19.80

15.45	96.14	14.34%	342.57	41.64%	19.90	15.49	124.98	14.34%	444.57	41.57%	19.91	15.53	157.66	14.34%	559.76	41.49%	19.92
15.47	98.82	14.34%	354.23	41.89%	20.08	15.51	128.45	14.34%	459.71	41.82%	20.09	15.55	162.04	14.34%	578.82	41.74%	20.10
15.50	99.57	14.34%	357.78	41.98%	20.14	15.53	129.44	14.34%	464.32	41.91%	20.15	15.57	163.28	14.34%	584.63	41.83%	20.17
15.52	101.10	14.34%	363.94	42.06%	20.25	15.56	131.42	14.34%	472.31	41.98%	20.26	15.60	165.78	14.34%	594.69	41.90%	20.27
15.54	101.86	14.34%	365.89	41.96%	20.29	15.58	132.41	14.34%	474.84	41.89%	20.30	15.62	167.04	14.34%	597.87	41.81%	20.32
15.56	103.38	14.33%	373.65	42.21%	20.42	15.60	134.38	14.33%	484.92	42.14%	20.43	15.64	169.52	14.33%	610.55	42.06%	20.44
15.53	104.91	14.33%	383.04	42.64%	20.51	15.57	136.37	14.33%	497.10	42.57%	20.52	15.62	172.03	14.33%	625.89	42.49%	20.54
15.59	106.42	14.33%	388.22	42.59%	20.63	15.63	138.34	14.33%	503.82	42.52%	20.64	15.67	174.51	14.33%	634.35	42.44%	20.66
15.64	107.93	14.33%	395.00	42.72%	20.77	15.68	140.30	14.33%	512.62	42.65%	20.78	15.73	176.98	14.32%	645.44	42.57%	20.80
15.61	109.07	14.32%	403.09	43.14%	20.85	15.65	141.78	14.32%	523.12	43.06%	20.86	15.70	178.85	14.32%	658.65	42.98%	20.88
15.64	109.81	14.32%	407.92	43.35%	20.94	15.69	142.74	14.32%	529.39	43.27%	20.96	15.73	180.06	14.32%	666.55	43.19%	20.97
15.63	110.95	14.32%	413.75	43.51%	21.01	15.68	144.23	14.32%	536.96	43.44%	21.02	15.73	181.94	14.32%	676.08	43.35%	21.04
15.65	112.09	14.32%	418.93	43.60%	21.09	15.69	145.71	14.32%	543.68	43.53%	21.10	15.74	183.81	14.32%	684.54	43.44%	21.12
15.66	113.59	14.31%	428.62	44.01%	21.23	15.70	147.66	14.31%	556.26	43.93%	21.24	15.76	186.27	14.31%	700.38	43.85%	21.26
15.65	115.11	14.31%	437.36	44.31%	21.34	15.70	149.64	14.31%	567.59	44.23%	21.35	15.75	188.76	14.31%	714.65	44.14%	21.37
15.69	117.79	14.31%	447.08	44.26%	21.50	15.73	153.11	14.31%	580.21	44.18%	21.51	15.79	193.14	14.31%	730.54	44.10%	21.53
15.66	119.71	14.31%	456.16	44.43%	21.59	15.71	155.61	14.31%	591.99	44.36%	21.60	15.76	196.29	14.31%	745.37	44.27%	21.62
15.71	122.76	14.31%	466.52	44.31%	21.78	15.76	159.57	14.31%	605.44	44.23%	21.79	15.82	201.29	14.31%	762.31	44.15%	21.81
15.77	125.79	14.30%	478.50	44.34%	21.99	15.82	163.52	14.30%	620.98	44.26%	22.00	15.87	206.27	14.30%	781.87	44.17%	22.02
15.76	128.86	14.30%	490.81	44.39%	22.14	15.81	167.51	14.30%	636.96	44.32%	22.16	15.87	211.30	14.30%	801.99	44.23%	22.18
15.78	131.15	14.30%	499.88	44.42%	22.28	15.83	170.49	14.30%	648.73	44.34%	22.29	15.89	215.06	14.30%	816.81	44.26%	22.31
15.81	133.79	14.30%	512.81	44.66%	22.48	15.86	173.92	14.30%	665.51	44.58%	22.49	15.92	219.38	14.30%	837.93	44.49%	22.51

15.88	135.28	14.29%	518.94	44.68%	22.63	15.94	175.85	14.29%	673.46	44.60%	22.65	16.00	221.82	14.29%	847.94	44.51%	22.66
15.86	137.18	14.29%	529.61	44.96%	22.74	15.91	178.32	14.29%	687.32	44.88%	22.76	15.97	224.94	14.29%	865.39	44.80%	22.78
15.89	138.29	14.29%	535.75	45.10%	22.86	15.94	179.77	14.29%	695.28	45.03%	22.87	16.01	226.76	14.29%	875.41	44.94%	22.89
15.90	139.43	14.29%	540.92	45.16%	22.94	15.96	181.24	14.29%	701.99	45.09%	22.95	16.02	228.62	14.28%	883.87	45.00%	22.97
15.89	141.32	14.29%	550.95	45.38%	23.06	15.95	183.71	14.28%	715.00	45.30%	23.08	16.02	231.73	14.28%	900.25	45.21%	23.09
15.94	142.44	14.28%	554.82	45.33%	23.16	16.00	185.16	14.28%	720.03	45.25%	23.18	16.07	233.56	14.28%	906.58	45.16%	23.20
16.00	144.31	14.28%	562.89	45.38%	23.32	16.06	187.59	14.28%	730.50	45.30%	23.34	16.12	236.63	14.28%	919.77	45.21%	23.36
15.99	145.44	14.28%	570.33	45.61%	23.41	16.05	189.05	14.27%	740.15	45.53%	23.43	16.12	238.47	14.27%	931.91	45.45%	23.45
16.00	146.94	14.27%	578.41	45.78%	23.53	16.06	191.00	14.27%	750.64	45.70%	23.54	16.13	240.93	14.27%	945.12	45.61%	23.56
16.04	148.43	14.27%	585.83	45.89%	23.66	16.10	192.94	14.27%	760.28	45.81%	23.67	16.17	243.38	14.27%	957.25	45.72%	23.69
16.11	148.75	14.26%	588.07	45.94%	23.76	16.17	193.36	14.26%	763.18	45.87%	23.77	16.24	243.91	14.26%	960.91	45.78%	23.79
16.08	149.87	14.26%	597.77	46.34%	23.86	16.14	194.81	14.26%	775.77	46.27%	23.87	16.21	245.74	14.26%	976.76	46.18%	23.89
16.11	150.97	14.26%	603.90	46.46%	23.97	16.17	196.25	14.26%	783.73	46.38%	23.99	16.25	247.55	14.25%	986.78	46.29%	24.01
16.12	152.49	14.25%	610.37	46.49%	24.07	16.19	198.22	14.25%	792.12	46.41%	24.08	16.26	250.03	14.25%	997.35	46.32%	24.10
16.15	153.21	14.25%	615.53	46.65%	24.15	16.21	199.16	14.25%	798.82	46.57%	24.17	16.28	251.22	14.25%	1005.78	46.48%	24.19
16.22	153.90	14.24%	620.68	46.81%	24.29	16.28	200.05	14.24%	805.50	46.73%	24.31	16.36	252.35	14.24%	1014.19	46.64%	24.33
16.25	155.37	14.24%	629.72	47.02%	24.44	16.32	201.96	14.24%	817.24	46.94%	24.46	16.39	254.76	14.24%	1028.97	46.85%	24.48
16.32	157.17	14.23%	641.99	47.36%	24.68	16.39	204.30	14.23%	833.15	47.28%	24.70	16.47	257.70	14.23%	1049.00	47.18%	24.72
16.42	159.67	14.21%	661.03	47.95%	25.02	16.49	207.55	14.21%	857.87	47.86%	25.04	16.57	261.80	14.21%	1080.12	47.77%	25.07
16.54	161.83	14.20%	673.29	48.15%	25.30	16.61	210.35	14.20%	873.77	48.06%	25.32	16.69	265.34	14.20%	1100.15	47.97%	25.34
16.59	162.93	14.20%	677.15	48.08%	25.40	16.66	211.79	14.20%	878.79	48.00%	25.42	16.74	267.15	14.20%	1106.46	47.91%	25.44
16.64	167.87	14.20%	692.34	47.71%	25.65	16.71	218.21	14.20%	898.49	47.63%	25.67	16.80	275.25	14.20%	1131.27	47.54%	25.70

16.76	177.01	14.20%	718.16	46.94%	26.11	16.84	230.09	14.20%	932.00	46.86%	26.13	16.92	290.23	14.20%	1173.46	46.77%	26.16
16.85	180.02	14.20%	725.55	46.62%	26.30	16.93	234.00	14.19%	941.60	46.54%	26.32	17.02	295.16	14.19%	1185.55	46.45%	26.35
16.93	185.71	14.19%	742.65	46.25%	26.60	17.01	241.40	14.19%	963.78	46.17%	26.62	17.09	304.49	14.19%	1213.47	46.08%	26.65
17.06	189.84	14.19%	752.60	45.84%	26.86	17.14	246.76	14.19%	976.70	45.76%	26.88	17.23	311.26	14.19%	1229.74	45.67%	26.91
17.07	193.66	14.19%	765.52	45.71%	27.03	17.15	251.73	14.19%	993.46	45.63%	27.06	17.24	317.52	14.19%	1250.84	45.54%	27.08
17.18	197.41	14.19%	774.83	45.37%	27.27	17.26	256.61	14.19%	1005.54	45.29%	27.29	17.35	323.68	14.18%	1266.06	45.21%	27.32
17.24	203.87	14.19%	795.13	45.08%	27.59	17.32	265.00	14.19%	1031.89	45.01%	27.61	17.41	334.27	14.18%	1299.23	44.92%	27.64
17.29	208.78	14.18%	811.88	44.94%	27.87	17.38	271.39	14.18%	1053.63	44.87%	27.89	17.47	342.32	14.18%	1326.60	44.78%	27.92
17.35	214.83	14.18%	832.50	44.78%	28.19	17.44	279.25	14.18%	1080.38	44.70%	28.22	17.54	352.23	14.18%	1360.28	44.62%	28.24
17.41	219.38	14.18%	846.33	44.58%	28.43	17.49	285.16	14.18%	1098.33	44.50%	28.45	17.59	359.69	14.18%	1382.88	44.41%	28.48
17.46	223.16	14.18%	857.58	44.40%	28.63	17.55	290.08	14.18%	1112.93	44.32%	28.65	17.65	365.89	14.18%	1401.27	44.24%	28.68
17.51	224.66	14.18%	861.10	44.28%	28.72	17.60	292.02	14.18%	1117.50	44.20%	28.75	17.70	368.34	14.17%	1407.01	44.12%	28.78
17.56	225.39	14.18%	862.04	44.18%	28.79	17.65	292.97	14.18%	1118.72	44.10%	28.81	17.75	369.53	14.17%	1408.55	44.02%	28.84
17.61	226.50	14.18%	864.27	44.07%	28.87	17.70	294.41	14.17%	1121.61	43.99%	28.89	17.80	371.36	14.17%	1412.19	43.91%	28.92
17.66	227.99	14.17%	867.78	43.96%	28.96	17.75	296.35	14.17%	1126.17	43.88%	28.99	17.86	373.80	14.17%	1417.93	43.79%	29.02
17.72	230.63	14.17%	875.16	43.82%	29.11	17.81	299.78	14.17%	1135.75	43.74%	29.14	17.91	378.12	14.17%	1429.99	43.66%	29.17
17.77	232.42	14.17%	884.81	43.94%	29.29	17.86	302.11	14.16%	1148.26	43.86%	29.32	17.97	381.06	14.16%	1445.75	43.78%	29.35
17.82	234.19	14.16%	896.07	44.14%	29.49	17.92	304.41	14.16%	1162.88	44.06%	29.52	18.02	383.96	14.15%	1464.14	43.98%	29.55
17.85	236.43	14.16%	904.75	44.14%	29.63	17.94	307.32	14.15%	1174.15	44.06%	29.66	18.05	387.64	14.15%	1478.33	43.97%	29.69
17.87	240.88	14.15%	926.00	44.32%	29.93	17.97	313.10	14.15%	1201.73	44.24%	29.96	18.08	394.93	14.15%	1513.06	44.16%	29.99
17.90	246.09	14.14%	949.82	44.48%	30.27	18.00	319.86	14.14%	1232.64	44.40%	30.30	18.11	403.46	14.14%	1551.98	44.31%	30.33
17.93	248.71	14.14%	959.79	44.47%	30.43	18.03	323.27	14.14%	1245.57	44.39%	30.46	18.14	407.75	14.14%	1568.26	44.30%	30.49

17.96	255.04	14.14%	987.46	44.59%	30.82	18.06	331.50	14.13%	1281.48	44.51%	30.85	18.17	418.13	14.13%	1613.48	44.43%	30.88
17.98	261.02	14.13%	1012.23	44.65%	31.17	18.09	339.27	14.13%	1313.62	44.57%	31.20	18.21	427.93	14.13%	1653.94	44.48%	31.23
18.01	267.84	14.13%	1034.70	44.48%	31.49	18.12	348.14	14.13%	1342.79	44.40%	31.52	18.24	439.11	14.13%	1690.66	44.31%	31.56
18.04	272.06	14.13%	1044.94	44.23%	31.65	18.14	353.62	14.13%	1356.08	44.15%	31.68	18.27	446.03	14.13%	1707.39	44.07%	31.71
18.06	273.25	14.14%	1044.91	44.04%	31.67	18.16	355.16	14.13%	1356.03	43.97%	31.70	18.29	447.97	14.13%	1707.34	43.88%	31.73
18.08	275.13	14.14%	1050.67	43.98%	31.76	18.19	357.61	14.13%	1363.51	43.91%	31.79	18.31	451.06	14.13%	1716.76	43.82%	31.83
18.10	277.01	14.13%	1056.44	43.92%	31.86	18.21	360.06	14.13%	1370.99	43.85%	31.89	18.33	454.15	14.13%	1726.17	43.76%	31.93
18.12	279.66	14.13%	1064.77	43.85%	31.99	18.23	363.49	14.13%	1381.80	43.77%	32.02	18.36	458.48	14.13%	1739.79	43.69%	32.06
18.15	281.29	14.12%	1083.46	44.32%	32.26	18.26	365.61	14.12%	1406.06	44.24%	32.29	18.39	461.15	14.12%	1770.33	44.15%	32.33
18.18	282.12	14.11%	1101.21	44.86%	32.52	18.29	366.70	14.10%	1429.10	44.79%	32.55	18.42	462.51	14.10%	1799.34	44.70%	32.59
18.20	283.21	14.10%	1106.03	44.88%	32.60	18.31	368.11	14.10%	1435.35	44.80%	32.64	18.44	464.30	14.10%	1807.20	44.71%	32.67
18.22	284.68	14.10%	1112.12	44.89%	32.71	18.34	370.02	14.10%	1443.26	44.81%	32.74	18.47	466.70	14.10%	1817.16	44.72%	32.78
18.24	286.08	14.10%	1121.45	45.02%	32.85	18.36	371.84	14.09%	1455.37	44.95%	32.88	18.49	469.00	14.09%	1832.40	44.86%	32.92
18.27	288.27	14.09%	1131.73	45.08%	33.01	18.38	374.68	14.09%	1468.71	45.00%	33.04	18.52	472.59	14.09%	1849.20	44.91%	33.08
18.29	292.42	14.09%	1145.19	44.97%	33.21	18.41	380.07	14.09%	1486.17	44.89%	33.24	18.55	479.38	14.09%	1871.18	44.80%	33.28
18.32	296.53	14.09%	1160.26	44.92%	33.43	18.44	385.42	14.09%	1505.72	44.84%	33.47	18.57	486.12	14.08%	1895.80	44.75%	33.50
18.34	299.50	14.09%	1171.47	44.90%	33.60	18.46	389.28	14.08%	1520.28	44.82%	33.64	18.60	491.00	14.08%	1914.13	44.73%	33.68
18.37	305.54	14.09%	1191.32	44.75%	33.89	18.49	397.13	14.08%	1546.04	44.68%	33.92	18.63	500.89	14.08%	1946.56	44.59%	33.96
18.39	308.24	14.09%	1196.40	44.56%	33.97	18.51	400.63	14.09%	1552.63	44.48%	34.01	18.65	505.31	14.08%	1954.85	44.39%	34.05
18.41	309.80	14.09%	1197.63	44.39%	34.01	18.53	402.67	14.09%	1554.22	44.31%	34.05	18.68	507.88	14.09%	1956.87	44.22%	34.09
18.43	310.54	14.09%	1199.53	44.35%	34.06	18.56	403.63	14.09%	1556.69	44.27%	34.09	18.70	509.09	14.09%	1959.98	44.19%	34.13
18.45	311.97	14.09%	1207.24	44.42%	34.18	18.58	405.48	14.08%	1566.69	44.34%	34.22	18.72	511.42	14.08%	1972.56	44.25%	34.26

18.47	309.99	14.08%	1203.41	44.55%	34.15	18.60	402.91	14.08%	1561.73	44.47%	34.18	18.74	508.17	14.08%	1966.31	44.38%	34.22
18.49	309.21	14.08%	1200.19	44.54%	34.13	18.62	401.90	14.08%	1557.55	44.46%	34.16	18.76	506.91	14.08%	1961.05	44.37%	34.20
18.50	304.28	14.08%	1182.88	44.60%	33.91	18.63	395.49	14.08%	1535.08	44.52%	33.95	18.77	498.82	14.08%	1932.76	44.44%	33.99
18.53	311.82	14.08%	1207.84	44.44%	34.27	18.66	405.29	14.08%	1567.48	44.36%	34.30	18.80	511.18	14.08%	1973.55	44.28%	34.34
18.55	312.94	14.08%	1211.03	44.40%	34.33	18.68	406.74	14.08%	1571.61	44.32%	34.37	18.82	513.01	14.07%	1978.76	44.23%	34.41
18.57	313.75	14.08%	1209.70	44.24%	34.33	18.70	407.79	14.08%	1569.88	44.16%	34.37	18.84	514.34	14.08%	1976.58	44.08%	34.41
18.60	314.92	14.08%	1209.32	44.07%	34.36	18.73	409.32	14.08%	1569.39	43.99%	34.39	18.87	516.27	14.08%	1975.96	43.91%	34.43
18.63	315.65	14.08%	1210.89	44.02%	34.41	18.76	410.27	14.08%	1571.43	43.94%	34.45	18.90	517.46	14.08%	1978.53	43.86%	34.49
18.67	317.93	14.08%	1215.97	43.89%	34.51	18.79	413.23	14.08%	1578.02	43.81%	34.54	18.94	521.19	14.08%	1986.83	43.73%	34.58
18.70	319.07	14.08%	1217.21	43.78%	34.55	18.82	414.71	14.08%	1579.63	43.70%	34.59	18.97	523.06	14.08%	1988.85	43.62%	34.63
18.73	319.80	14.08%	1218.78	43.73%	34.61	18.85	415.66	14.08%	1581.67	43.66%	34.64	19.00	524.25	14.08%	1991.42	43.57%	34.68
18.76	320.79	14.08%	1226.49	43.85%	34.74	18.89	416.95	14.07%	1591.67	43.78%	34.77	19.03	525.89	14.07%	2004.01	43.69%	34.82
18.79	321.03	14.07%	1231.64	43.98%	34.84	18.92	417.26	14.07%	1598.35	43.91%	34.87	19.06	526.28	14.07%	2012.42	43.82%	34.92
18.82	321.76	14.07%	1233.21	43.94%	34.89	18.95	418.21	14.07%	1600.39	43.86%	34.93	19.10	527.47	14.06%	2014.99	43.78%	34.97
18.85	322.83	14.07%	1237.68	43.94%	34.98	18.98	419.59	14.06%	1606.20	43.87%	35.02	19.13	529.22	14.06%	2022.30	43.78%	35.06
18.88	321.25	14.06%	1233.19	43.99%	34.95	19.01	417.55	14.06%	1600.37	43.91%	34.99	19.16	526.64	14.06%	2014.97	43.83%	35.03
18.91	320.09	14.06%	1228.36	43.97%	34.91	19.04	416.04	14.06%	1594.10	43.90%	34.95	19.18	524.73	14.06%	2007.08	43.81%	34.99
18.93	315.50	14.06%	1213.63	44.07%	34.75	19.06	410.07	14.06%	1574.98	43.99%	34.78	19.20	517.21	14.05%	1983.00	43.90%	34.82
18.96	309.40	14.06%	1193.77	44.19%	34.51	19.08	402.14	14.05%	1549.21	44.11%	34.55	19.22	507.21	14.05%	1950.55	44.03%	34.59
18.99	315.41	14.06%	1213.27	44.05%	34.80	19.12	409.95	14.05%	1574.52	43.98%	34.84	19.26	517.06	14.05%	1982.42	43.89%	34.88
19.03	318.25	14.05%	1229.01	44.20%	35.04	19.16	413.65	14.05%	1594.94	44.13%	35.08	19.30	521.72	14.04%	2008.13	44.04%	35.12
19.06	319.58	14.04%	1239.62	44.37%	35.22	19.19	415.38	14.04%	1608.71	44.30%	35.25	19.34	523.90	14.03%	2025.47	44.21%	35.29

19.10	324.07	14.04%	1253.99	44.26%	35.44	19.23	421.21	14.04%	1627.36	44.19%	35.47	19.38	531.26	14.03%	2048.95	44.10%	35.52
19.13	323.71	14.04%	1250.10	44.18%	35.42	19.26	420.74	14.04%	1622.32	44.10%	35.45	19.41	530.66	14.03%	2042.59	44.01%	35.49
19.16	324.47	14.04%	1250.06	44.07%	35.45	19.29	421.73	14.04%	1622.25	44.00%	35.48	19.44	531.91	14.03%	2042.52	43.91%	35.52
19.19	326.32	14.04%	1255.47	44.01%	35.55	19.32	424.14	14.04%	1629.27	43.93%	35.58	19.47	534.94	14.03%	2051.35	43.85%	35.63
19.22	327.46	14.04%	1256.70	43.90%	35.59	19.35	425.61	14.04%	1630.87	43.82%	35.63	19.50	536.81	14.03%	2053.37	43.74%	35.67
19.25	328.97	14.04%	1259.21	43.79%	35.66	19.38	427.58	14.04%	1634.13	43.71%	35.70	19.53	539.29	14.03%	2057.47	43.62%	35.74
19.28	330.08	14.04%	1262.06	43.74%	35.73	19.41	429.01	14.04%	1637.83	43.66%	35.76	19.56	541.10	14.03%	2062.12	43.57%	35.81
19.31	331.93	14.04%	1267.47	43.67%	35.83	19.45	431.42	14.03%	1644.85	43.60%	35.87	19.60	544.13	14.03%	2070.96	43.51%	35.91
19.35	333.40	14.04%	1271.59	43.62%	35.91	19.48	433.34	14.03%	1650.20	43.54%	35.95	19.63	546.55	14.03%	2077.70	43.46%	35.99
19.38	334.50	14.03%	1274.44	43.57%	35.98	19.51	434.77	14.03%	1653.90	43.49%	36.02	19.66	548.35	14.03%	2082.36	43.41%	36.06
19.41	335.56	14.03%	1278.91	43.57%	36.07	19.54	436.15	14.03%	1659.70	43.50%	36.11	19.69	550.09	14.03%	2089.66	43.41%	36.15
19.44	333.62	14.03%	1273.15	43.62%	36.03	19.57	433.61	14.03%	1652.22	43.55%	36.06	19.72	546.90	14.02%	2080.24	43.46%	36.11
19.46	332.08	14.03%	1267.04	43.61%	35.97	19.60	431.62	14.02%	1644.29	43.53%	36.01	19.74	544.38	14.02%	2070.26	43.45%	36.05
19.50	333.14	14.02%	1271.51	43.62%	36.06	19.63	433.00	14.02%	1650.09	43.54%	36.10	19.78	546.12	14.02%	2077.56	43.45%	36.14
19.53	334.20	14.02%	1275.98	43.62%	36.15	19.66	434.37	14.02%	1655.89	43.54%	36.19	19.81	547.86	14.02%	2084.86	43.46%	36.23
19.56	335.30	14.02%	1278.82	43.57%	36.22	19.69	435.80	14.02%	1659.58	43.50%	36.26	19.84	549.66	14.01%	2089.51	43.41%	36.30
19.59	337.11	14.02%	1285.85	43.57%	36.35	19.72	438.15	14.02%	1668.70	43.49%	36.38	19.88	552.62	14.01%	2100.99	43.40%	36.43
19.62	338.54	14.02%	1291.59	43.57%	36.45	19.76	440.02	14.01%	1676.15	43.49%	36.49	19.91	554.97	14.01%	2110.38	43.41%	36.53
19.66	341.14	14.01%	1299.55	43.50%	36.59	19.79	443.40	14.01%	1686.48	43.42%	36.63	19.94	559.23	14.01%	2123.38	43.34%	36.67
19.69	343.86	14.02%	1302.65	43.27%	36.66	19.82	446.93	14.01%	1690.51	43.19%	36.70	19.98	563.69	14.01%	2128.45	43.11%	36.74
19.72	346.20	14.02%	1304.48	43.05%	36.72	19.85	449.97	14.02%	1692.88	42.97%	36.75	20.01	567.53	14.01%	2131.43	42.89%	36.80
19.75	348.43	14.02%	1311.16	42.99%	36.83	19.89	452.86	14.02%	1701.54	42.91%	36.87	20.04	571.17	14.01%	2142.34	42.83%	36.92

19.77	350.74	14.02%	1314.93	42.83%	36.91	19.91	455.87	14.02%	1706.44	42.76%	36.94	20.06	574.96	14.02%	2148.50	42.67%	36.99
19.79	351.93	14.02%	1314.87	42.69%	36.92	19.93	457.41	14.02%	1706.36	42.62%	36.96	20.08	576.91	14.02%	2148.40	42.54%	37.01
19.81	354.16	14.02%	1321.87	42.65%	37.04	19.95	460.32	14.02%	1715.45	42.57%	37.08	20.11	580.57	14.02%	2159.85	42.49%	37.12
19.84	356.57	14.01%	1338.24	42.86%	37.28	19.98	463.44	14.01%	1736.69	42.78%	37.32	20.14	584.51	14.01%	2186.59	42.70%	37.36
19.86	358.59	14.01%	1353.33	43.07%	37.50	20.00	466.07	14.00%	1756.28	42.99%	37.54	20.16	587.82	14.00%	2211.25	42.91%	37.58
19.89	361.20	14.00%	1361.61	43.02%	37.63	20.03	469.45	14.00%	1767.02	42.94%	37.67	20.19	592.09	14.00%	2224.78	42.86%	37.72
19.91	364.22	14.01%	1369.55	42.91%	37.76	20.05	473.38	14.00%	1777.32	42.84%	37.80	20.21	597.04	14.00%	2237.74	42.75%	37.84
19.93	367.61	14.01%	1378.76	42.80%	37.90	20.08	477.79	14.00%	1789.27	42.73%	37.94	20.24	602.61	14.00%	2252.79	42.64%	37.99
19.96	370.22	14.01%	1387.03	42.75%	38.03	20.10	481.18	14.00%	1800.01	42.68%	38.07	20.26	606.87	14.00%	2266.31	42.59%	38.12
19.98	372.45	14.00%	1394.03	42.71%	38.14	20.12	484.07	14.00%	1809.09	42.63%	38.19	20.29	610.52	14.00%	2277.74	42.55%	38.23
20.00	375.05	14.00%	1402.30	42.66%	38.28	20.15	487.45	14.00%	1819.82	42.59%	38.32	20.31	614.79	14.00%	2291.26	42.50%	38.36
20.02	377.27	14.00%	1409.29	42.62%	38.39	20.17	490.35	14.00%	1828.90	42.54%	38.43	20.34	618.43	14.00%	2302.68	42.46%	38.48
20.05	379.46	14.00%	1417.91	42.62%	38.52	20.19	493.18	14.00%	1840.07	42.55%	38.57	20.36	622.01	13.99%	2316.75	42.47%	38.61
20.07	380.89	14.00%	1423.96	42.64%	38.63	20.22	495.04	13.99%	1847.93	42.56%	38.67	20.38	624.35	13.99%	2326.65	42.48%	38.72
20.09	378.62	14.00%	1415.65	42.64%	38.53	20.23	492.09	13.99%	1837.15	42.57%	38.58	20.40	620.63	13.99%	2313.07	42.48%	38.62
20.10	376.21	13.99%	1412.19	42.79%	38.51	20.25	488.97	13.99%	1832.66	42.72%	38.55	20.42	616.70	13.98%	2307.41	42.63%	38.60
20.12	373.82	13.99%	1408.73	42.94%	38.48	20.27	485.85	13.98%	1828.17	42.87%	38.52	20.44	612.76	13.98%	2301.76	42.78%	38.57
20.14	371.55	13.98%	1400.42	42.95%	38.39	20.29	482.90	13.98%	1817.38	42.87%	38.43	20.45	609.05	13.98%	2288.18	42.79%	38.48
20.16	368.07	13.98%	1391.51	43.07%	38.29	20.30	478.38	13.98%	1805.82	42.99%	38.33	20.47	603.35	13.97%	2273.62	42.91%	38.38
20.18	370.21	13.98%	1401.75	43.12%	38.45	20.33	481.16	13.97%	1819.10	43.04%	38.49	20.49	606.85	13.97%	2290.35	42.96%	38.54
20.20	366.82	13.98%	1389.60	43.14%	38.31	20.34	476.76	13.97%	1803.34	43.06%	38.35	20.51	601.30	13.97%	2270.50	42.98%	38.39
20.21	363.05	13.97%	1376.18	43.16%	38.15	20.36	471.87	13.97%	1785.92	43.09%	38.19	20.52	595.13	13.97%	2248.57	43.00%	38.23

20.22	357.04	13.97%	1355.09	43.21%	37.88	20.37	464.06	13.97%	1758.56	43.14%	37.92	20.53	585.28	13.97%	2214.12	43.05%	37.97
20.24	354.40	13.97%	1345.49	43.23%	37.78	20.38	460.62	13.97%	1746.10	43.15%	37.82	20.54	580.95	13.97%	2198.44	43.07%	37.86
20.26	352.13	13.97%	1337.17	43.23%	37.68	20.40	457.68	13.97%	1735.30	43.16%	37.72	20.56	577.24	13.97%	2184.84	43.07%	37.77
20.27	349.49	13.97%	1327.57	43.24%	37.58	20.41	454.24	13.97%	1722.84	43.17%	37.62	20.57	572.91	13.97%	2169.15	43.08%	37.66
20.29	344.98	13.97%	1311.58	43.28%	37.38	20.43	448.38	13.97%	1702.09	43.20%	37.42	20.58	565.52	13.97%	2143.03	43.12%	37.46
20.31	342.34	13.97%	1301.98	43.29%	37.27	20.44	444.95	13.97%	1689.63	43.22%	37.31	20.59	561.19	13.96%	2127.34	43.13%	37.36
20.32	340.07	13.97%	1293.65	43.30%	37.18	20.46	442.00	13.97%	1678.82	43.22%	37.22	20.61	557.47	13.96%	2113.73	43.14%	37.26
20.34	337.05	13.97%	1282.77	43.32%	37.06	20.47	438.08	13.97%	1664.70	43.24%	37.09	20.62	552.53	13.96%	2095.95	43.16%	37.14
20.36	334.71	13.96%	1277.68	43.43%	37.01	20.49	435.04	13.96%	1658.09	43.36%	37.05	20.64	548.69	13.96%	2087.63	43.27%	37.09
20.38	332.37	13.96%	1272.59	43.55%	36.96	20.51	431.99	13.96%	1651.49	43.48%	37.00	20.66	544.85	13.95%	2079.32	43.39%	37.04
20.39	328.98	13.96%	1260.42	43.58%	36.82	20.52	427.59	13.96%	1635.70	43.50%	36.86	20.67	539.30	13.95%	2059.44	43.42%	36.90
20.41	327.01	13.96%	1256.61	43.70%	36.79	20.54	425.03	13.95%	1630.76	43.62%	36.82	20.69	536.08	13.95%	2053.21	43.53%	36.87
20.43	328.04	13.95%	1263.03	43.77%	36.89	20.56	426.37	13.95%	1639.09	43.69%	36.93	20.71	537.76	13.95%	2063.70	43.61%	36.97
20.45	329.52	13.95%	1267.49	43.72%	36.97	20.59	428.29	13.95%	1644.87	43.65%	37.01	20.74	540.18	13.95%	2070.98	43.56%	37.05
20.50	326.06	13.95%	1255.95	43.77%	36.87	20.63	423.80	13.94%	1629.90	43.70%	36.91	20.78	534.52	13.94%	2052.13	43.61%	36.95
20.55	323.36	13.94%	1246.97	43.81%	36.80	20.68	420.29	13.94%	1618.24	43.74%	36.84	20.82	530.09	13.94%	2037.46	43.65%	36.88
20.59	320.70	13.94%	1236.37	43.79%	36.71	20.72	416.82	13.94%	1604.48	43.72%	36.74	20.87	525.72	13.94%	2020.13	43.63%	36.78
20.64	318.03	13.94%	1225.76	43.78%	36.61	20.77	413.36	13.94%	1590.72	43.70%	36.65	20.91	521.36	13.93%	2002.80	43.61%	36.69
20.69	316.86	13.94%	1220.27	43.73%	36.59	20.81	411.84	13.93%	1583.60	43.66%	36.63	20.96	519.44	13.93%	1993.84	43.57%	36.67
20.73	314.95	13.94%	1212.23	43.70%	36.53	20.86	409.35	13.93%	1573.15	43.63%	36.57	21.00	516.30	13.93%	1980.69	43.54%	36.61
20.78	313.74	13.93%	1208.36	43.72%	36.53	20.91	407.79	13.93%	1568.14	43.64%	36.57	21.05	514.33	13.93%	1974.37	43.56%	36.61
20.83	312.54	13.93%	1204.49	43.74%	36.53	20.96	406.22	13.93%	1563.12	43.66%	36.57	21.10	512.36	13.92%	1968.05	43.57%	36.61

20.88	311.00	13.93%	1197.72	43.70%	36.49	21.00	404.22	13.92%	1554.33	43.62%	36.53	21.15	509.83	13.92%	1956.99	43.54%	36.57
20.93	309.83	13.92%	1192.23	43.66%	36.47	21.05	402.71	13.92%	1547.21	43.58%	36.50	21.19	507.92	13.92%	1948.02	43.49%	36.54
20.98	308.67	13.92%	1186.74	43.61%	36.44	21.10	401.19	13.92%	1540.08	43.54%	36.48	21.24	506.01	13.92%	1939.05	43.45%	36.52
21.02	307.50	13.92%	1181.25	43.57%	36.42	21.15	399.68	13.92%	1532.96	43.49%	36.46	21.29	504.10	13.91%	1930.08	43.41%	36.49
21.07	305.59	13.92%	1173.20	43.54%	36.36	21.19	397.19	13.91%	1522.51	43.46%	36.40	21.33	500.97	13.91%	1916.92	43.37%	36.44
21.12	302.93	13.92%	1162.59	43.51%	36.27	21.24	393.74	13.91%	1508.74	43.44%	36.31	21.38	496.61	13.91%	1899.59	43.35%	36.34
21.17	302.14	13.91%	1158.38	43.46%	36.26	21.29	392.71	13.91%	1503.28	43.39%	36.30	21.42	495.31	13.91%	1892.71	43.30%	36.34
21.21	300.60	13.91%	1151.61	43.42%	36.22	21.33	390.71	13.91%	1494.49	43.35%	36.26	21.47	492.79	13.91%	1881.64	43.26%	36.30
21.26	299.06	13.91%	1144.84	43.38%	36.18	21.38	388.71	13.91%	1485.70	43.31%	36.22	21.51	490.27	13.90%	1870.58	43.22%	36.26
21.31	298.27	13.91%	1140.62	43.33%	36.18	21.43	387.68	13.90%	1480.23	43.26%	36.21	21.56	488.98	13.90%	1863.69	43.17%	36.25
21.36	297.48	13.90%	1136.41	43.28%	36.17	21.48	386.66	13.90%	1474.77	43.20%	36.21	21.61	487.68	13.90%	1856.81	43.12%	36.24
21.41	295.94	13.90%	1129.64	43.24%	36.13	21.52	384.66	13.90%	1465.98	43.16%	36.16	21.66	485.17	13.90%	1845.75	43.08%	36.20
21.45	294.07	13.90%	1119.96	43.14%	36.05	21.57	382.22	13.90%	1453.42	43.06%	36.08	21.70	482.09	13.90%	1829.94	42.98%	36.12
21.50	292.57	13.90%	1111.57	43.03%	35.99	21.62	380.27	13.90%	1442.52	42.96%	36.02	21.75	479.63	13.90%	1816.22	42.88%	36.06
21.55	291.03	13.90%	1104.79	42.99%	35.95	21.66	378.28	13.90%	1433.73	42.92%	35.98	21.79	477.12	13.89%	1805.15	42.83%	36.02
21.59	289.87	13.90%	1099.30	42.94%	35.93	21.71	376.77	13.89%	1426.60	42.87%	35.96	21.84	475.21	13.89%	1796.17	42.78%	36.00
21.64	289.45	13.90%	1096.37	42.88%	35.94	21.76	376.23	13.89%	1422.80	42.81%	35.97	21.89	474.53	13.89%	1791.38	42.72%	36.01
21.68	287.56	13.89%	1088.64	42.86%	35.87	21.79	373.76	13.89%	1412.77	42.78%	35.91	21.92	471.42	13.89%	1778.76	42.70%	35.94
21.62	286.59	13.90%	1081.91	42.76%	35.72	21.73	372.50	13.90%	1404.04	42.68%	35.76	21.86	469.83	13.90%	1767.77	42.60%	35.79
21.59	284.84	13.91%	1071.63	42.63%	35.56	21.70	370.24	13.90%	1390.70	42.55%	35.59	21.82	466.98	13.90%	1750.97	42.47%	35.62
21.55	283.00	13.91%	1066.22	42.69%	35.45	21.66	367.84	13.91%	1383.67	42.62%	35.48	21.79	463.96	13.90%	1742.12	42.53%	35.52
21.52	278.55	13.91%	1051.82	42.79%	35.23	21.63	362.05	13.91%	1364.99	42.72%	35.26	21.75	456.66	13.90%	1718.60	42.63%	35.30

21.49	277.14	13.91%	1044.44	42.72%	35.10	21.59	360.23	13.91%	1355.42	42.65%	35.13	21.72	454.36	13.91%	1706.55	42.56%	35.17
21.45	275.36	13.92%	1035.78	42.65%	34.96	21.56	357.91	13.92%	1344.17	42.58%	34.99	21.68	451.44	13.91%	1692.39	42.50%	35.02
21.42	273.52	13.92%	1030.36	42.72%	34.85	21.53	355.52	13.92%	1337.14	42.65%	34.88	21.65	448.42	13.91%	1683.53	42.56%	34.92
21.39	270.96	13.92%	1020.75	42.73%	34.69	21.49	352.19	13.92%	1324.67	42.66%	34.72	21.61	444.22	13.92%	1667.83	42.57%	34.76
21.35	269.24	13.93%	1008.84	42.52%	34.50	21.46	349.95	13.93%	1309.22	42.45%	34.53	21.58	441.40	13.92%	1648.38	42.37%	34.57
21.32	262.98	13.93%	982.83	42.43%	34.14	21.43	341.82	13.93%	1275.46	42.35%	34.17	21.54	431.15	13.93%	1605.88	42.27%	34.20
21.30	260.00	13.93%	973.22	42.50%	33.99	21.40	337.95	13.93%	1262.99	42.42%	34.02	21.52	426.27	13.93%	1590.18	42.34%	34.05
21.28	258.96	13.94%	966.79	42.40%	33.88	21.38	336.59	13.94%	1254.64	42.32%	33.91	21.49	424.55	13.93%	1579.67	42.24%	33.94
21.26	257.16	13.94%	957.79	42.31%	33.74	21.36	334.25	13.94%	1242.97	42.24%	33.77	21.47	421.60	13.94%	1564.97	42.15%	33.80
21.23	254.55	13.94%	949.46	42.37%	33.61	21.33	330.87	13.94%	1232.16	42.30%	33.64	21.44	417.33	13.94%	1551.36	42.22%	33.67
21.21	251.63	13.95%	936.61	42.30%	33.42	21.31	327.07	13.94%	1215.48	42.22%	33.45	21.42	412.54	13.94%	1530.36	42.14%	33.48
21.19	250.20	13.95%	928.89	42.20%	33.29	21.28	325.21	13.95%	1205.46	42.12%	33.32	21.39	410.20	13.95%	1517.75	42.04%	33.35
21.16	243.47	13.95%	906.42	42.32%	32.97	21.25	316.46	13.95%	1176.31	42.24%	33.00	21.36	399.17	13.95%	1481.04	42.16%	33.03
21.13	238.61	13.95%	890.37	42.41%	32.74	21.22	310.15	13.95%	1155.48	42.34%	32.76	21.33	391.20	13.95%	1454.82	42.26%	32.79
21.11	234.93	13.95%	874.94	42.34%	32.51	21.20	305.36	13.95%	1135.45	42.27%	32.54	21.30	385.17	13.95%	1429.60	42.19%	32.57
21.08	231.99	13.96%	862.07	42.26%	32.32	21.17	301.55	13.95%	1118.75	42.18%	32.35	21.27	380.36	13.95%	1408.58	42.10%	32.37
21.06	231.66	13.96%	859.83	42.22%	32.27	21.15	301.11	13.96%	1115.84	42.14%	32.29	21.25	379.81	13.96%	1404.91	42.06%	32.32
21.04	229.12	13.96%	846.63	42.04%	32.07	21.12	297.82	13.96%	1098.71	41.97%	32.10	21.22	375.65	13.96%	1383.34	41.89%	32.13
21.01	227.31	13.97%	837.62	41.94%	31.93	21.10	295.46	13.97%	1087.01	41.87%	31.96	21.20	372.68	13.96%	1368.62	41.78%	31.98
20.99	222.87	13.97%	819.60	41.86%	31.67	21.07	289.69	13.97%	1063.63	41.79%	31.70	21.17	365.40	13.97%	1339.18	41.71%	31.72
20.96	217.34	13.98%	794.48	41.63%	31.31	21.04	282.51	13.98%	1031.03	41.56%	31.34	21.13	356.35	13.97%	1298.14	41.48%	31.36
20.93	216.33	13.98%	784.81	41.34%	31.17	21.02	281.19	13.98%	1018.48	41.27%	31.19	21.11	354.68	13.98%	1282.33	41.18%	31.21

20.91	213.38	13.99%	771.93	41.23%	30.97	20.99	277.36	13.99%	1001.77	41.16%	31.00	21.08	349.85	13.98%	1261.30	41.08%	31.02
20.88	209.32	13.99%	753.57	41.04%	30.71	20.96	272.09	13.99%	977.95	40.97%	30.73	21.05	343.21	13.99%	1231.30	40.89%	30.75
20.86	208.68	14.00%	745.19	40.73%	30.57	20.94	271.25	14.00%	967.07	40.66%	30.60	21.03	342.15	14.00%	1217.61	40.58%	30.62
20.83	201.94	14.00%	721.04	40.73%	30.23	20.91	262.49	14.00%	935.73	40.66%	30.25	20.99	331.10	14.00%	1178.15	40.58%	30.28
20.81	197.81	14.00%	707.52	40.80%	30.03	20.88	257.12	14.00%	918.18	40.73%	30.05	20.96	324.33	14.00%	1156.05	40.65%	30.08
20.78	194.45	14.00%	694.96	40.77%	29.84	20.86	252.76	14.00%	901.88	40.70%	29.86	20.94	318.83	14.00%	1135.53	40.62%	29.89
20.76	190.72	14.00%	681.10	40.75%	29.64	20.83	247.91	14.00%	883.90	40.68%	29.66	20.91	312.71	14.00%	1112.89	40.60%	29.68
20.74	188.47	14.00%	674.02	40.81%	29.52	20.81	244.99	14.00%	874.71	40.74%	29.54	20.89	309.02	14.00%	1101.32	40.66%	29.56
20.71	182.08	14.00%	652.75	40.90%	29.22	20.78	236.68	14.00%	847.10	40.83%	29.24	20.85	298.55	14.00%	1066.56	40.75%	29.26
20.68	175.33	14.00%	628.55	40.91%	28.87	20.75	227.91	14.00%	815.71	40.83%	28.89	20.82	287.49	14.00%	1027.03	40.75%	28.91
20.65	171.22	14.01%	613.39	40.88%	28.65	20.72	222.56	14.00%	796.03	40.81%	28.67	20.79	280.74	14.00%	1002.26	40.73%	28.69
20.63	165.58	14.00%	594.68	40.98%	28.38	20.69	215.23	14.00%	771.74	40.91%	28.40	20.76	271.50	14.00%	971.68	40.83%	28.42
20.60	162.22	14.01%	582.09	40.95%	28.19	20.66	210.86	14.00%	755.41	40.88%	28.21	20.73	265.99	14.00%	951.11	40.80%	28.23
20.58	156.59	14.01%	561.74	40.94%	27.90	20.64	203.55	14.01%	729.01	40.87%	27.92	20.70	256.77	14.00%	917.87	40.79%	27.93
20.56	155.10	14.01%	557.23	41.00%	27.82	20.61	201.61	14.01%	723.15	40.93%	27.84	20.68	254.31	14.00%	910.49	40.85%	27.85
20.53	150.58	14.01%	542.37	41.11%	27.60	20.59	195.74	14.01%	703.86	41.03%	27.62	20.65	246.92	14.00%	886.21	40.95%	27.63
20.50	144.58	14.01%	520.72	41.10%	27.29	20.56	187.94	14.01%	675.76	41.03%	27.31	20.62	237.08	14.01%	850.83	40.95%	27.32
20.48	142.35	14.01%	511.99	41.06%	27.15	20.53	185.04	14.01%	664.44	40.99%	27.17	20.59	233.41	14.01%	836.58	40.91%	27.19
20.46	139.34	14.01%	502.30	41.15%	27.00	20.51	181.13	14.01%	651.86	41.08%	27.02	20.57	228.48	14.01%	820.74	41.00%	27.03
20.43	138.63	14.01%	497.13	40.94%	26.91	20.49	180.20	14.01%	645.16	40.87%	26.93	20.54	227.31	14.01%	812.30	40.79%	26.95
20.41	136.78	14.02%	488.09	40.75%	26.77	20.46	177.80	14.02%	633.42	40.68%	26.79	20.52	224.28	14.01%	797.52	40.60%	26.80
20.39	134.92	14.02%	480.66	40.69%	26.65	20.44	175.38	14.02%	623.77	40.62%	26.67	20.50	221.23	14.02%	785.38	40.54%	26.68

20.37	133.06	14.02%	473.22	40.63%	26.53	20.42	172.96	14.02%	614.13	40.56%	26.55	20.47	218.18	14.02%	773.23	40.48%	26.56
20.34	127.03	14.02%	453.16	40.75%	26.25	20.39	165.13	14.02%	588.09	40.68%	26.26	20.44	208.30	14.02%	740.45	40.60%	26.27
20.31	123.66	14.02%	440.54	40.70%	26.06	20.36	160.75	14.02%	571.72	40.62%	26.07	20.41	202.77	14.02%	719.83	40.55%	26.08
20.29	118.03	14.02%	420.14	40.66%	25.76	20.33	153.42	14.02%	545.25	40.59%	25.78	20.38	193.54	14.02%	686.51	40.52%	25.79
20.26	115.39	14.02%	411.73	40.76%	25.63	20.31	150.00	14.02%	534.32	40.69%	25.64	20.36	189.22	14.02%	672.75	40.61%	25.66
20.24	110.90	14.02%	393.59	40.55%	25.37	20.28	144.16	14.02%	510.79	40.48%	25.38	20.33	181.86	14.02%	643.12	40.40%	25.39
20.21	105.65	14.02%	372.86	40.33%	25.07	20.25	137.34	14.02%	483.89	40.26%	25.08	20.29	173.25	14.02%	609.25	40.18%	25.09
20.18	100.76	14.02%	356.65	40.44%	24.83	20.22	130.98	14.02%	462.85	40.37%	24.84	20.26	165.23	14.02%	582.76	40.30%	24.86
20.16	95.50	14.02%	337.52	40.39%	24.56	20.19	124.14	14.02%	438.02	40.32%	24.57	20.23	156.60	14.02%	551.51	40.24%	24.58
20.13	91.74	14.02%	323.58	40.30%	24.35	20.17	119.26	14.02%	419.93	40.23%	24.36	20.21	150.45	14.02%	528.72	40.16%	24.37
20.11	87.60	14.02%	309.95	40.43%	24.15	20.14	113.88	14.02%	402.24	40.36%	24.16	20.18	143.66	14.02%	506.45	40.28%	24.17
20.09	85.72	14.02%	304.11	40.54%	24.05	20.12	111.44	14.02%	394.66	40.47%	24.06	20.15	140.57	14.02%	496.91	40.39%	24.07
20.06	80.46	14.02%	284.96	40.47%	23.77	20.09	104.60	14.02%	369.81	40.40%	23.78	20.12	131.95	14.02%	465.63	40.32%	23.79
20.04	77.84	14.03%	274.91	40.36%	23.62	20.06	101.18	14.03%	356.76	40.29%	23.63	20.10	127.64	14.02%	449.19	40.21%	23.64
20.01	76.33	14.03%	270.36	40.48%	23.54	20.04	99.23	14.03%	350.86	40.41%	23.55	20.07	125.18	14.02%	441.77	40.33%	23.56
19.99	73.70	14.03%	261.92	40.61%	23.40	20.02	95.81	14.03%	339.91	40.54%	23.41	20.05	120.86	14.02%	427.97	40.46%	23.42
19.97	71.07	14.03%	251.85	40.50%	23.25	19.99	92.39	14.03%	326.85	40.43%	23.26	20.02	116.55	14.03%	411.53	40.35%	23.27
19.95	69.20	14.03%	244.39	40.37%	23.13	19.97	89.96	14.03%	317.16	40.30%	23.14	20.00	113.48	14.03%	399.33	40.22%	23.15
19.92	67.32	14.03%	238.54	40.50%	23.03	19.95	87.52	14.03%	309.57	40.43%	23.04	19.98	110.40	14.03%	389.78	40.35%	23.05
19.90	66.19	14.03%	235.29	40.63%	22.97	19.93	86.05	14.03%	305.36	40.56%	22.98	19.95	108.55	14.03%	384.47	40.48%	22.98
19.88	65.08	14.03%	230.43	40.48%	22.88	19.90	84.59	14.03%	299.04	40.41%	22.89	19.93	106.72	14.03%	376.52	40.33%	22.90
19.86	63.20	14.03%	222.96	40.33%	22.76	19.88	82.16	14.03%	289.35	40.27%	22.77	19.91	103.64	14.03%	364.32	40.19%	22.78

19.83	60.19	14.03%	213.21	40.50%	22.61	19.86	78.24	14.03%	276.70	40.43%	22.62	19.88	98.70	14.03%	348.38	40.35%	22.63
19.81	56.80	14.03%	202.15	40.69%	22.44	19.83	73.84	14.03%	262.34	40.62%	22.45	19.86	93.15	14.03%	330.31	40.54%	22.46
19.79	55.68	14.03%	197.28	40.51%	22.36	19.81	72.38	14.03%	256.03	40.44%	22.37	19.83	91.31	14.03%	322.36	40.36%	22.37
19.77	54.56	14.03%	192.42	40.33%	22.27	19.79	70.92	14.03%	249.71	40.26%	22.28	19.81	89.47	14.03%	314.41	40.18%	22.29
19.74	52.30	14.03%	185.26	40.51%	22.16	19.76	67.99	14.03%	240.42	40.44%	22.16	19.79	85.77	14.03%	302.71	40.36%	22.17
19.72	51.55	14.04%	181.69	40.31%	22.09	19.74	67.02	14.04%	235.79	40.24%	22.10	19.76	84.54	14.04%	296.88	40.16%	22.10
19.70	51.19	14.04%	179.43	40.10%	22.04	19.72	66.54	14.04%	232.86	40.03%	22.05	19.74	83.94	14.04%	293.18	39.95%	22.05
19.68	48.93	14.04%	172.27	40.27%	21.92	19.70	63.60	14.04%	223.56	40.20%	21.93	19.72	80.24	14.04%	281.49	40.13%	21.94
19.66	47.80	14.04%	169.01	40.45%	21.86	19.68	62.14	14.04%	219.34	40.38%	21.87	19.70	78.39	14.04%	276.17	40.30%	21.87
19.64	45.92	14.04%	163.16	40.64%	21.76	19.65	59.69	14.04%	211.74	40.57%	21.77	19.67	75.30	14.04%	266.59	40.49%	21.77
19.62	45.54	14.04%	162.51	40.82%	21.73	19.63	59.20	14.04%	210.89	40.75%	21.74	19.65	74.69	14.04%	265.53	40.67%	21.74
19.60	44.04	14.04%	157.95	41.03%	21.65	19.61	57.25	14.04%	204.98	40.96%	21.66	19.63	72.22	14.04%	258.09	40.88%	21.66
19.57	42.16	14.04%	152.09	41.27%	21.55	19.59	54.80	14.04%	197.37	41.20%	21.56	19.61	69.13	14.04%	248.51	41.12%	21.56
19.55	41.40	14.04%	150.13	41.48%	21.51	19.57	53.82	14.04%	194.84	41.41%	21.51	19.59	67.90	14.04%	245.32	41.33%	21.52
19.53	40.28	14.04%	145.26	41.26%	21.42	19.55	52.36	14.04%	188.52	41.19%	21.43	19.56	66.06	14.04%	237.36	41.11%	21.43
19.51	39.53	14.04%	141.69	41.01%	21.35	19.52	51.39	14.04%	183.88	40.94%	21.36	19.54	64.83	14.04%	231.53	40.86%	21.36
	Average	14.10%		42.43%	29.14		Average	14.10%		42.35%	29.16		Average	14.10%		42.27%	29.19
	Max	14.40%		48.15%	38.63		Max	14.40%		48.06%	38.67		Max	14.40%		47.97%	38.72

Appendix C:

1- Summer Data and Experimental Results:

Date of test	24-Aug-20	
start time	6:00	AM
End time	6:00	PM
Test Duration	12.00	hr
Sun rise	6:58	
SunSet	6:05	
flow rate	113.6	kg/hr
Cp	4179	J/kg·K
A	1.2	m2

Time	Solar Intensity from Pyranometer (W/m2)	Weather station output				PVT							PV	
		Ambient Temperature	Wind speed mph	Wind direction	Solar intensisty(W/m2)	Temp in C	Temp out C	Power PVT (W)	Elec Eff PVT(%)	Thermal gain	Thermal Eff PVT (%)	Overall Eff PVT (%)	Power PV (W)	Elec Eff PV(%)
7:10	70	29.2	1.1	S	91.0	23.6	23.7	9.3	11.04%	9.0	0.1	0.2	8.5	10.13%
7:12	72.5	29.3	1.1	S	93.5	23.7	23.7	9.5	10.94%	9.2	0.1	0.2	8.7	10.04%
7:14	75	29.4	1.1	S	96.0	23.7	23.8	9.8	10.84%	10.6	0.1	0.2	9.0	9.96%
7:18	77.5	29.5	1.1	S	98.5	23.8	23.9	10.0	10.76%	11.7	0.1	0.2	9.4	10.14%
7:20	80	29.5	1.1	S	101.0	23.8	23.9	10.3	10.72%	12.3	0.1	0.2	9.7	10.06%
7:22	82.5	29.6	1.1	S	103.5	23.9	24.0	10.5	10.64%	13.8	0.1	0.2	9.9	10.02%
7:24	84.4	29.7	1.1	S	105.4	24.0	24.1	10.8	10.64%	15.7	0.2	0.3	10.2	10.03%
7:26	85	29.8	0.0	0.0	106.0	24.0	24.2	11.0	10.81%	26.0	0.3	0.4	10.4	10.18%
7:28	87.8	29.9	0.0	0.0	108.8	24.1	24.4	11.3	10.70%	37.7	0.4	0.5	10.6	10.08%
7:30	91.2	29.9	0.0	0.0	112.2	24.2	24.5	11.4	10.41%	37.8	0.3	0.4	10.8	9.86%
7:32	94.6	30.0	0.0	0.0	115.6	24.2	25.0	11.7	10.27%	93.5	0.8	0.9	10.9	9.61%
7:34	98	30.1	0.0	0.0	119.0	24.3	25.0	12.0	10.23%	94.8	0.8	0.9	11.3	9.57%
7:36	101.4	30.2	0.0	0.0	122.4	24.4	25.1	12.5	10.29%	96.7	0.8	0.9	11.7	9.63%
7:38	104.8	30.3	0.0	0.0	125.8	24.5	25.2	12.6	10.06%	98.6	0.8	0.9	11.8	9.41%

7:40	108.2	30.3	0.0	0.0	129.2	24.5	25.3	12.8	9.84%	100.5	0.8	0.9	12.2	9.36%
7:42	111.6	30.4	1.1	SW	132.6	24.6	25.4	13.6	10.19%	101.9	0.8	0.9	13.0	9.69%
7:44	115	30.5	1.1	SW	136.0	24.7	25.4	13.1	9.52%	103.2	0.7	0.8	12.5	9.06%
7:46	118.4	30.6	1.1	SW	139.4	24.7	25.5	14.6	10.30%	107.8	0.8	0.9	13.9	9.80%
7:48	121.8	30.7	1.1	SW	142.8	24.8	25.6	15.1	10.35%	109.9	0.8	0.9	14.4	9.85%
7:50	125.2	30.7	1.1	SW	146.2	24.8	25.7	15.6	10.40%	112.0	0.7	0.8	14.9	9.90%
7:52	128.6	30.8	1.1	SW	149.6	24.9	25.7	16.1	10.41%	113.6	0.7	0.8	15.1	9.79%
7:54	132	30.9	1.1	SW	153.0	24.9	25.8	16.4	10.38%	115.1	0.7	0.8	15.6	9.83%
7:56	135.4	31.0	0.0	0.0	156.4	25.0	25.9	16.8	10.35%	117.2	0.7	0.8	15.9	9.80%
7:58	136.2	31.1	0.0	0.0	157.2	25.0	25.9	17.2	10.52%	119.3	0.7	0.8	16.3	9.96%
8:00	137	31.1	0.0	0.0	158.0	25.1	26.0	17.4	10.61%	120.2	0.7	0.8	16.5	10.04%
8:02	137.8	31.2	0.0	0.0	158.8	25.1	26.0	17.6	10.63%	120.6	0.7	0.8	16.7	10.07%
8:04	143	31.3	0.0	0.0	164.0	25.2	26.1	17.7	10.31%	121.0	0.7	0.8	16.8	9.78%
8:06	148.2	31.4	0.0	0.0	169.2	25.2	26.2	17.9	10.09%	123.9	0.7	0.8	17.0	9.57%
8:08	153.4	31.5	1.1	S	174.4	25.3	26.2	18.8	10.20%	126.8	0.7	0.8	17.7	9.63%
8:10	158.6	31.5	1.1	S	179.6	25.3	26.3	19.5	10.26%	129.8	0.7	0.8	18.4	9.69%
8:12	163.8	31.6	1.1	S	184.8	25.4	26.4	20.3	10.32%	132.2	0.7	0.8	19.2	9.75%
8:14	166.1	31.7	1.1	S	187.1	25.4	26.4	21.0	10.56%	134.6	0.7	0.8	20.0	10.01%
8:16	172	31.8	1.1	S	193.0	25.5	26.5	21.3	10.32%	136.2	0.7	0.8	20.2	9.78%
8:18	177.9	31.9	1.1	SW	198.9	25.5	26.6	21.9	10.27%	139.4	0.7	0.8	20.8	9.74%
8:20	183.8	31.9	1.1	SW	204.8	25.6	26.6	22.6	10.23%	142.7	0.6	0.7	21.4	9.70%
8:22	189.4	32.0	1.1	SW	210.4	25.6	26.7	23.2	10.20%	145.4	0.6	0.7	22.0	9.67%
8:24	195	32.1	1.1	S	216.0	25.7	26.8	23.8	10.18%	148.0	0.6	0.7	22.6	9.65%
8:26	198.6	32.2	1.1	S	219.6	25.7	26.9	24.9	10.47%	151.1	0.6	0.7	23.7	9.93%
8:28	202.2	32.3	2.2	S	223.2	25.8	26.9	25.3	10.43%	153.3	0.6	0.7	24.0	9.90%
8:30	205.8	32.3	2.2	S	226.8	25.8	27.0	25.6	10.35%	155.5	0.6	0.7	24.3	9.82%
8:32	209.4	32.4	2.2	SE	230.4	25.9	27.1	25.9	10.32%	157.1	0.6	0.7	24.6	9.80%
8:34	213	32.5	2.2	SE	234.0	25.9	27.1	26.7	10.44%	158.8	0.6	0.7	25.3	9.91%
8:36	216.6	32.6	1.1	SE	237.6	26.0	27.2	26.9	10.37%	161.0	0.6	0.7	25.6	9.84%
8:38	220	32.7	1.1	SE	241.0	26.0	27.3	27.5	10.42%	163.2	0.6	0.7	26.1	9.87%

8:40	235	32.7	1.1	SE	256.0	26.1	27.3	28.1	9.96%	165.3	0.6	0.7	26.7	9.45%
8:42	245	32.8	1.1	SE	266.0	26.1	27.4	29.7	10.11%	172.2	0.6	0.7	28.2	9.60%
8:44	254.4	32.9	1.1	SE	275.4	26.2	27.5	31.4	10.28%	176.7	0.6	0.7	29.8	9.76%
8:46	260	33.0	1.1	SE	281.0	26.2	27.6	32.5	10.42%	181.6	0.6	0.7	30.9	9.89%
8:48	265	33.1	1.1	S	286.0	26.3	27.7	33.3	10.46%	184.7	0.6	0.7	31.5	9.90%
8:50	267.4	33.1	1.1	S	288.4	26.3	27.7	33.5	10.45%	187.5	0.6	0.7	32.2	10.04%
8:52	273	33.2	1.1	S	294.0	26.4	27.8	34.2	10.43%	188.6	0.6	0.7	32.8	10.02%
8:54	277	33.3	1.1	S	298.0	26.4	27.9	34.8	10.47%	191.2	0.6	0.7	33.4	10.06%
8:56	281.2	33.4	1.1	S	302.2	26.5	27.9	35.3	10.46%	193.6	0.6	0.7	33.9	10.05%
8:58	285	33.5	1.1	S	306.0	26.5	28.0	35.8	10.47%	196.0	0.6	0.7	34.4	10.06%
9:00	293	33.5	1.1	S	314.0	26.6	28.1	36.3	10.33%	198.3	0.6	0.7	34.9	9.92%
9:02	298.5	33.6	1.1	S	319.5	26.6	28.1	37.1	10.35%	202.0	0.6	0.7	35.6	9.95%
9:04	304	33.7	2.2	S	325.0	26.7	28.2	37.8	10.37%	204.5	0.6	0.7	36.4	9.97%
9:06	309.5	33.8	1.1	S	330.5	26.7	28.3	38.6	10.40%	207.5	0.6	0.7	37.1	9.99%
9:08	315	33.9	1.1	S	336.0	26.8	28.4	39.4	10.42%	210.6	0.6	0.7	37.8	10.01%
9:10	320.5	33.9	1.1	S	341.5	26.8	28.4	40.1	10.43%	213.6	0.6	0.7	38.6	10.02%
9:12	326	34.0	1.1	S	347.0	26.9	28.5	40.9	10.45%	216.2	0.6	0.7	39.3	10.04%
9:14	331.5	34.1	1.1	S	352.5	26.9	28.6	41.7	10.47%	218.7	0.5	0.7	40.0	10.06%
9:16	337	34.2	1.1	SW	358.0	27.0	28.6	42.4	10.49%	221.7	0.5	0.7	40.7	10.08%
9:18	342.5	34.3	1.1	SW	363.5	27.0	28.7	43.2	10.51%	224.8	0.5	0.7	41.5	10.09%
9:20	348	34.3	1.1	SW	369.0	27.1	28.8	43.9	10.52%	227.8	0.5	0.7	42.2	10.11%
9:22	353.3	34.4	1.1	SW	374.3	27.1	28.9	44.5	10.48%	230.3	0.5	0.6	42.7	10.07%
9:24	359	34.5	1.1	S	380.0	27.2	28.9	44.8	10.41%	232.7	0.5	0.6	43.1	10.00%
9:26	364.5	34.6	1.1	S	385.5	27.2	29.0	45.7	10.45%	235.9	0.5	0.6	44.3	10.12%
9:28	370	34.7	1.1	S	391.0	27.3	29.1	46.3	10.42%	238.9	0.5	0.6	44.6	10.06%
9:30	373	34.7	1.1	S	394.0	27.3	29.2	46.7	10.43%	242.0	0.5	0.6	45.0	10.06%
9:32	381.6	34.8	1.1	S	402.6	27.4	29.2	47.3	10.33%	243.3	0.5	0.6	45.6	9.97%
9:34	386.5	34.9	1.1	S	407.5	27.4	29.3	48.2	10.39%	247.3	0.5	0.6	46.5	10.02%
9:36	392	35.0	1.1	S	413.0	27.5	29.4	49.1	10.44%	250.0	0.5	0.6	47.4	10.07%
9:38	397.1	35.1	1.1	S	418.1	27.5	29.4	50.0	10.49%	253.1	0.5	0.6	48.2	10.12%

9:40	402.2	35.1	1.1	S	423.2	27.6	29.5	51.1	10.58%	255.9	0.5	0.6	49.1	10.17%
9:42	408.5	35.2	1.1	S	429.5	27.6	29.6	51.5	10.50%	258.3	0.5	0.6	49.4	10.09%
9:44	414	35.3	2.2	SW	435.0	27.7	29.6	51.8	10.43%	261.1	0.5	0.6	49.8	10.03%
9:46	419.5	35.4	1.1	SW	440.5	27.7	29.7	52.2	10.37%	264.2	0.5	0.6	50.2	9.97%
9:48	425	35.5	2.2	S	446.0	27.8	29.8	53.2	10.44%	267.2	0.5	0.6	51.2	10.03%
9:50	432.6	35.5	2.2	SE	453.6	27.8	29.9	53.9	10.38%	270.2	0.5	0.6	51.8	9.98%
9:52	439.3	35.6	2.2	SE	460.3	27.9	29.9	54.5	10.34%	273.7	0.5	0.6	52.4	9.94%
9:54	446	35.7	2.2	SE	467.0	27.9	30.0	55.4	10.36%	276.7	0.5	0.6	53.3	9.95%
9:56	452.7	35.8	2.2	S	473.7	28.0	30.1	56.3	10.37%	280.3	0.5	0.6	54.1	9.96%
9:58	459.4	35.9	2.2	S	480.4	28.0	30.2	57.4	10.42%	283.9	0.5	0.6	55.0	9.97%
10:00	466.1	35.9	2.2	S	487.1	28.1	30.2	58.3	10.43%	287.5	0.5	0.6	55.8	9.98%
10:02	472.8	36.0	1.1	S	493.8	28.1	30.3	59.2	10.44%	290.5	0.5	0.6	56.7	9.99%
10:04	479.5	36.1	2.2	SE	500.5	28.2	30.4	60.1	10.45%	293.6	0.5	0.6	57.6	10.00%
10:06	486.2	36.2	2.2	SE	507.2	28.2	30.5	61.0	10.46%	297.1	0.5	0.6	57.6	9.87%
10:08	492.9	36.3	2.2	SE	513.9	28.3	30.5	61.9	10.47%	300.7	0.5	0.6	58.4	9.88%
10:10	499.6	36.3	2.2	SE	520.6	28.3	30.6	62.8	10.48%	304.3	0.5	0.6	59.7	9.95%
10:12	506.3	36.4	1.1	SE	527.3	28.4	30.7	63.7	10.49%	307.3	0.5	0.6	60.5	9.96%
10:14	513	36.5	1.1	SE	534.0	28.4	30.8	64.6	10.50%	310.4	0.5	0.6	61.4	9.97%
10:16	519.7	36.6	1.1	SE	540.7	28.5	30.8	65.0	10.43%	313.9	0.5	0.6	61.7	9.90%
10:18	526.4	36.7	1.1	S	547.4	28.5	30.9	65.4	10.35%	317.5	0.5	0.6	62.1	9.83%
10:20	533.1	36.7	1.1	S	554.1	28.6	31.0	66.9	10.47%	321.1	0.5	0.6	63.6	9.94%
10:22	539.8	36.8	1.1	S	560.8	28.6	31.1	68.0	10.49%	324.1	0.5	0.6	64.5	9.96%
10:24	546.5	36.9	1.1	S	567.5	28.7	31.1	68.4	10.42%	327.1	0.5	0.6	64.9	9.90%
10:26	553.2	37.0	1.1	S	574.2	28.7	31.2	69.0	10.39%	330.7	0.5	0.6	65.5	9.87%
10:28	556.8	37.1	1.1	SE	577.8	28.8	31.3	69.6	10.42%	334.3	0.5	0.6	66.1	9.90%
10:30	562	37.1	1.1	SE	583.0	28.8	31.4	70.6	10.46%	336.4	0.5	0.6	66.7	9.90%
10:32	564.3	37.2	1.1	SE	585.3	28.9	31.4	71.2	10.52%	338.8	0.5	0.6	67.3	9.95%
10:34	573	37.3	1.1	SE	594.0	28.9	31.5	71.5	10.39%	339.8	0.5	0.6	67.9	9.88%
10:36	581.7	37.4	1.1	S	602.7	29.0	31.6	71.7	10.28%	344.3	0.5	0.6	68.2	9.77%
10:38	590.4	37.5	1.1	SE	611.4	29.0	31.7	73.7	10.40%	348.8	0.5	0.6	70.0	9.88%

10:40	599.1	37.5	1.1	S	620.1	29.1	31.7	75.6	10.51%	353.2	0.5	0.6	71.5	9.94%
10:42	607.8	37.6	1.1	SE	628.8	29.1	31.8	76.2	10.45%	357.1	0.5	0.6	72.1	9.89%
10:44	616.5	37.7	1.1	SE	637.5	29.2	31.9	76.9	10.39%	361.1	0.5	0.6	72.7	9.83%
10:46	625.2	37.8	1.1	S	646.2	29.2	32.0	79.0	10.53%	365.5	0.5	0.6	75.0	10.00%
10:48	633.9	37.9	2.2	S	654.9	29.3	32.1	79.3	10.42%	370.0	0.5	0.6	75.3	9.90%
10:50	642.6	37.9	1.1	S	663.6	29.3	32.2	80.2	10.40%	374.4	0.5	0.6	76.1	9.87%
10:52	651.3	38.0	0.0	0.0	672.3	29.4	32.2	81.5	10.42%	378.4	0.5	0.6	77.4	9.90%
10:54	660	38.1	1.1	SW	681.0	29.4	32.3	82.8	10.45%	382.3	0.5	0.6	78.6	9.92%
10:56	674	38.2	2.2	SW	695.0	29.5	32.4	84.0	10.39%	386.7	0.5	0.6	79.8	9.87%
10:58	685	38.3	2.2	SW	706.0	29.5	32.5	85.3	10.38%	396.2	0.5	0.6	81.1	9.86%
11:00	688	38.3	2.2	SW	709.0	29.5	32.6	86.6	10.49%	401.9	0.5	0.6	82.3	9.97%
11:02	693.3	38.4	1.1	SW	714.3	29.5	32.6	87.0	10.46%	403.5	0.5	0.6	82.8	9.95%
11:04	698.6	38.5	1.1	S	719.6	29.7	32.7	87.9	10.49%	395.5	0.5	0.6	83.8	10.00%
11:06	703.9	38.6	2.2	S	724.9	29.7	32.8	88.5	10.47%	405.7	0.5	0.6	84.3	9.98%
11:08	709.2	38.7	2.2	S	730.2	29.8	32.9	89.5	10.52%	408.6	0.5	0.6	85.3	10.02%
11:10	714.5	38.7	3.4	SE	735.5	29.8	32.9	90.0	10.49%	411.5	0.5	0.6	85.7	9.99%
11:12	719.8	38.8	1.1	SE	740.8	29.9	33.0	90.4	10.46%	413.9	0.5	0.6	86.0	9.96%
11:14	725.1	38.9	1.1	SE	746.1	29.9	33.1	91.1	10.47%	416.3	0.5	0.6	86.8	9.97%
11:16	730.4	39.0	2.2	SE	751.4	30.0	33.1	91.7	10.47%	419.2	0.5	0.6	87.0	9.93%
11:18	735.7	39.1	1.1	S	756.7	30.0	33.2	92.0	10.42%	422.1	0.5	0.6	87.3	9.89%
11:20	741	39.1	1.1	S	762.0	30.1	33.3	92.3	10.38%	425.0	0.5	0.6	87.5	9.84%
11:22	746.3	39.2	2.2	SW	767.3	30.1	33.4	93.3	10.42%	427.4	0.5	0.6	88.5	9.88%
11:24	751.6	39.3	1.1	SW	772.6	30.2	33.4	94.4	10.46%	429.8	0.5	0.6	89.5	9.92%
11:26	756.9	39.4	1.1	SW	777.9	30.2	33.5	95.0	10.46%	432.7	0.5	0.6	90.1	9.92%
11:28	762.2	39.5	2.2	SW	783.2	30.3	33.6	95.7	10.46%	435.6	0.5	0.6	90.7	9.92%
11:30	767.5	39.5	2.2	SW	788.5	30.3	33.6	96.3	10.46%	438.5	0.5	0.6	91.4	9.92%
11:32	772.2	39.6	2.2	SW	793.2	30.4	33.7	97.0	10.46%	440.8	0.5	0.6	92.0	9.93%
11:34	776.9	39.7	2.2	SW	797.9	30.4	33.8	97.6	10.47%	442.9	0.5	0.6	91.0	9.76%
11:36	781.6	39.8	2.2	SW	802.6	30.5	33.8	98.3	10.48%	445.6	0.5	0.6	91.6	9.76%
11:38	786.3	39.9	2.2	SW	807.3	30.5	33.9	98.9	10.48%	448.2	0.5	0.6	92.2	9.77%

11:40	791	39.9	2.2	SE	812.0	30.6	34.0	99.6	10.50%	450.9	0.5	0.6	92.8	9.77%
11:42	795.7	40.0	1.1	SE	816.7	30.6	34.1	100.3	10.50%	453.0	0.5	0.6	93.4	9.78%
11:44	800.4	40.1	2.2	S	821.4	30.7	34.1	101.0	10.51%	455.1	0.5	0.6	94.0	9.79%
11:46	803.1	40.2	1.1	S	826.1	30.7	34.2	101.6	10.54%	457.7	0.5	0.6	94.9	9.85%
11:48	805.8	40.3	2.2	S	830.8	30.8	34.3	101.9	10.53%	459.4	0.5	0.6	95.2	9.84%
11:50	808.5	40.3	2.2	S	835.5	30.8	34.3	102.3	10.54%	462.5	0.5	0.6	95.5	9.85%
11:52	811.2	40.4	3.4	S	840.2	30.8	34.4	102.7	10.55%	463.8	0.5	0.6	95.9	9.85%
11:54	813.9	40.5	2.2	S	844.9	30.9	34.4	103.0	10.55%	465.1	0.5	0.6	96.3	9.86%
11:56	816.6	40.6	1.1	S	849.6	30.9	34.5	103.2	10.53%	467.0	0.5	0.6	96.4	9.84%
11:58	819.3	40.7	2.2	S	854.3	31.0	34.5	103.3	10.51%	468.8	0.5	0.6	98.7	10.04%
12:00	822	40.7	2.2	SE	859.0	31.0	34.6	103.8	10.52%	470.6	0.5	0.6	98.8	10.02%
12:02	824.7	40.8	2.2	SE	863.7	31.0	34.6	103.9	10.50%	472.0	0.5	0.6	99.0	10.00%
12:04	827.4	40.9	3.4	S	868.4	31.1	34.7	104.0	10.48%	473.3	0.5	0.6	99.1	9.98%
12:06	830.1	41.0	2.2	S	873.1	31.1	34.7	104.5	10.49%	475.1	0.5	0.6	99.6	10.00%
12:08	832.8	41.1	1.1	S	877.8	31.2	34.8	104.9	10.50%	477.0	0.5	0.6	100.0	10.00%
12:10	835.5	41.1	0.0	0.0	882.5	31.2	34.8	105.2	10.49%	478.8	0.5	0.6	100.2	10.00%
12:12	840	41.2	1.1	SE	887.2	31.2	34.9	105.5	10.46%	480.1	0.5	0.6	100.5	9.97%
12:14	844.5	41.3	2.2	S	891.9	31.3	34.9	105.7	10.43%	482.2	0.5	0.6	100.7	9.94%
12:16	849	41.4	4.5	SW	896.6	31.3	35.0	106.2	10.43%	484.9	0.5	0.6	101.1	9.93%
12:18	853.5	41.5	3.4	SW	901.3	31.4	35.1	106.5	10.40%	487.5	0.5	0.6	101.4	9.90%
12:20	858	41.5	2.2	SW	906.0	31.4	35.1	106.7	10.37%	490.2	0.5	0.6	101.6	9.87%
12:22	862.5	41.6	3.4	SW	910.7	31.4	35.2	107.1	10.35%	492.3	0.5	0.6	102.1	9.87%
12:24	867	41.7	1.1	S	915.4	31.5	35.2	107.4	10.32%	494.4	0.5	0.6	102.4	9.84%
12:26	871.5	41.8	1.1	S	920.1	31.5	35.3	107.6	10.29%	497.0	0.5	0.6	102.6	9.81%
12:28	876	41.9	2.2	S	924.8	31.6	35.4	108.0	10.27%	499.7	0.5	0.6	102.9	9.79%
12:30	880.5	41.9	1.1	S	929.5	31.6	35.4	109.4	10.35%	502.3	0.5	0.6	104.2	9.87%
12:32	885	42.0	2.2	S	934.2	31.6	35.5	110.9	10.44%	504.5	0.5	0.6	105.6	9.95%
12:34	889.5	42.1	2.2	SE	938.9	31.7	35.5	112.3	10.52%	506.6	0.5	0.6	107.0	10.02%
12:36	894	42.2	1.1	SE	943.6	31.7	35.6	113.1	10.54%	509.2	0.5	0.6	107.8	10.04%
12:38	901	42.3	1.1	SE	948.3	31.8	35.7	113.9	10.53%	511.9	0.5	0.6	108.5	10.04%

12:40	908	42.3	2.2	S	953.0	31.8	35.7	114.4	10.50%	515.6	0.5	0.6	109.1	10.01%
12:42	915	42.4	1.1	S	957.7	31.8	35.8	114.9	10.47%	518.8	0.5	0.6	109.6	9.98%
12:44	922	42.5	2.2	SE	962.4	31.9	35.8	115.5	10.44%	522.1	0.5	0.6	110.1	9.95%
12:46	929	42.6	2.2	SE	967.1	31.9	35.9	116.0	10.40%	528.4	0.5	0.6	110.6	9.92%
12:48	936	42.7	2.2	SE	971.8	31.9	36.0	116.8	10.40%	532.4	0.5	0.6	111.4	9.91%
12:50	943	42.7	2.2	SE	976.5	31.9	36.0	117.6	10.39%	536.4	0.5	0.6	112.1	9.91%
12:52	950	42.8	2.2	SE	981.2	32.0	36.1	118.4	10.38%	539.8	0.5	0.6	112.5	9.87%
12:54	957	42.9	1.1	SE	985.9	32.0	36.1	119.1	10.37%	543.3	0.5	0.6	113.3	9.86%
12:56	964	43.0	1.1	S	990.6	32.0	36.2	119.9	10.37%	547.2	0.5	0.6	114.0	9.85%
12:58	971	43.1	1.1	S	995.3	32.0	36.2	120.7	10.36%	551.2	0.5	0.6	114.8	9.85%
13:00	978	43.1	1.1	S	1000.0	32.0	36.3	121.5	10.35%	555.2	0.5	0.6	115.5	9.84%
13:02	982	43.2	1.1	S	1004.7	32.1	36.3	122.3	10.38%	558.6	0.5	0.6	116.3	9.87%
13:04	986	43.3	1.1	SE	1009.4	32.1	36.3	122.9	10.39%	560.7	0.5	0.6	117.0	9.89%
13:06	990	43.4	1.1	S	1014.1	32.1	36.4	123.7	10.41%	563.3	0.5	0.6	117.8	9.91%
13:08	994	43.5	1.1	S	1018.8	32.1	36.4	124.5	10.44%	566.0	0.5	0.6	118.5	9.93%
13:10	998	43.5	2.2	S	1023.5	32.1	36.5	125.5	10.48%	568.6	0.5	0.6	118.9	9.93%
13:12	1002	43.6	2.2	S	1028.2	32.2	36.5	125.9	10.47%	570.7	0.5	0.6	119.3	9.92%
13:14	1006	43.7	2.2	S	1032.9	32.2	36.5	126.3	10.46%	572.8	0.5	0.6	119.6	9.91%
13:16	1010	43.8	1.1	SW	1037.6	32.2	36.6	127.1	10.48%	575.4	0.5	0.6	119.9	9.89%
13:18	1014	43.9	1.1	SE	1042.3	32.2	36.6	127.3	10.46%	578.1	0.5	0.6	120.1	9.87%
13:20	1013	43.9	1.1	S	1047.0	32.2	36.7	127.0	10.45%	580.7	0.5	0.6	120.3	9.89%
13:22	1009	44.0	0.0	0.0	1051.7	32.3	36.7	127.6	10.54%	580.6	0.5	0.6	120.4	9.94%
13:24	1005	44.1	1.1	SE	1043.0	32.3	36.7	126.7	10.50%	579.1	0.5	0.6	119.5	9.91%
13:26	1001	44.2	1.1	S	1034.3	32.3	36.7	125.9	10.48%	578.2	0.5	0.6	118.8	9.89%
13:28	997	44.3	1.1	S	1025.6	32.3	36.7	125.6	10.50%	577.3	0.5	0.6	118.5	9.90%
13:30	995.9	44.3	1.1	SE	1016.9	32.3	36.7	125.3	10.49%	581.7	0.5	0.6	118.3	9.89%
13:32	987.2	44.4	1.1	S	1008.2	32.3	36.7	125.1	10.56%	581.9	0.5	0.6	118.0	9.96%
13:34	978.5	44.5	1.1	SE	999.5	32.3	36.7	124.8	10.63%	578.8	0.5	0.6	117.8	10.03%
13:36	965.1	44.6	1.1	SE	986.1	32.2	36.6	124.6	10.75%	584.2	0.5	0.6	117.5	10.15%
13:38	954.7	44.7	1.1	SE	975.7	32.2	36.5	122.7	10.71%	569.7	0.5	0.6	115.8	10.10%

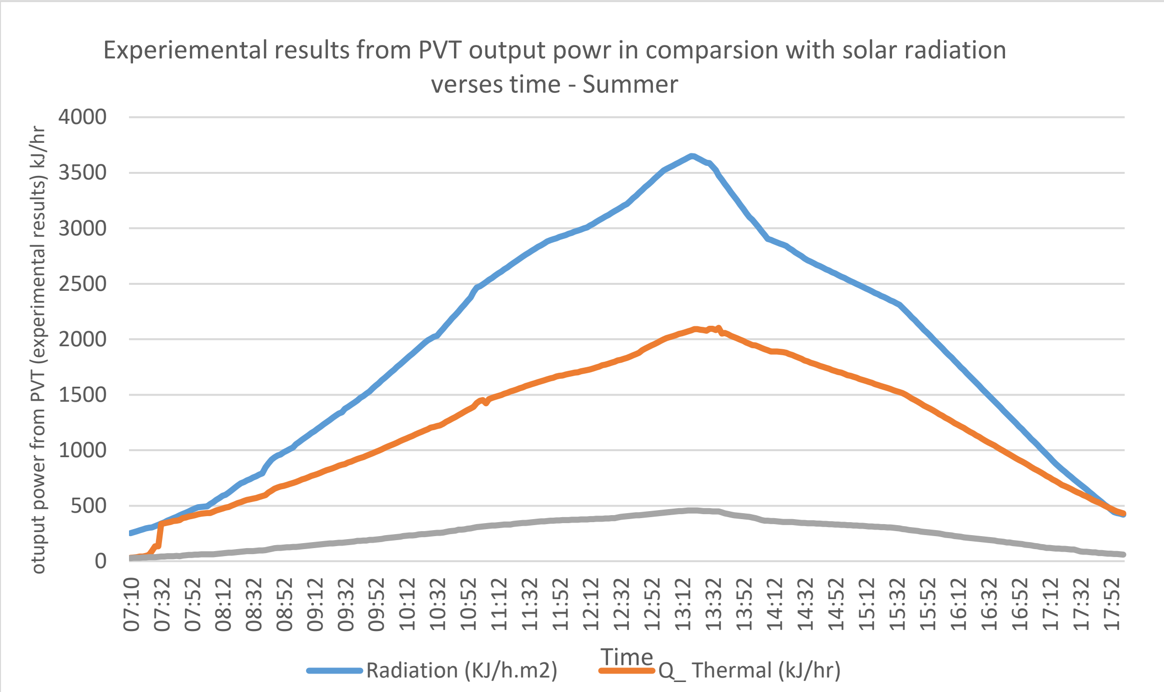
13:40	944.3	44.7	1.1	S	965.3	32.1	36.5	120.4	10.62%	571.4	0.5	0.6	113.8	10.04%
13:42	933.9	44.8	1.1	S	954.9	32.1	36.4	118.5	10.58%	567.8	0.5	0.6	112.1	10.00%
13:44	923.5	44.9	1.1	S	944.5	32.1	36.3	116.7	10.53%	564.1	0.5	0.6	110.3	9.96%
13:46	913.1	45.0	1.1	S	934.1	32.0	36.3	115.4	10.53%	561.0	0.5	0.6	109.9	10.03%
13:48	902.7	45.1	1.1	S	923.7	32.0	36.2	114.8	10.59%	557.9	0.5	0.6	109.3	10.09%
13:50	892.3	45.1	1.1	S	913.3	31.9	36.2	113.8	10.63%	554.8	0.5	0.6	108.5	10.13%
13:52	881.9	45.2	1.1	S	902.9	31.9	36.1	112.9	10.67%	551.2	0.5	0.6	107.6	10.17%
13:54	871.5	45.3	1.1	S	892.5	31.9	36.0	112.0	10.71%	547.5	0.5	0.6	106.7	10.20%
13:56	861.1	45.4	1.1	S	882.1	31.8	36.0	111.1	10.75%	544.4	0.5	0.6	105.8	10.24%
13:58	854.5	45.5	1.1	SE	875.5	31.8	35.9	109.4	10.67%	541.3	0.5	0.6	104.2	10.16%
14:00	845	45.5	0.0	0.0	866.0	31.7	35.8	107.7	10.62%	539.9	0.5	0.6	102.6	10.12%
14:02	835.5	45.6	1.1	SE	856.5	31.7	35.8	106.0	10.57%	536.7	0.5	0.6	101.0	10.07%
14:04	826	45.7	2.2	S	847.0	31.7	35.7	103.5	10.44%	533.4	0.5	0.6	99.3	10.02%
14:06	816.5	45.8	1.1	S	837.5	31.6	35.7	101.8	10.39%	530.7	0.5	0.6	97.7	9.97%
14:08	807	45.9	1.1	S	828.0	31.6	35.6	101.4	10.47%	528.0	0.5	0.6	97.3	10.05%
14:10	804	45.9	2.2	S	825.0	31.5	35.5	101.0	10.47%	525.3	0.5	0.6	97.0	10.05%
14:12	801	46.0	1.1	S	822.0	31.5	35.5	100.6	10.47%	524.9	0.5	0.7	96.6	10.05%
14:14	798	46.0	2.2	S	819.0	31.5	35.4	100.2	10.47%	524.6	0.5	0.7	96.2	10.05%
14:16	795	46.0	2.2	SW	816.0	31.4	35.4	99.1	10.38%	524.2	0.5	0.7	95.8	10.05%
14:18	792	45.8	1.1	S	813.0	31.4	35.4	98.7	10.38%	523.3	0.6	0.7	95.5	10.05%
14:20	789	45.7	1.1	SE	810.0	31.3	35.3	98.3	10.38%	521.3	0.6	0.7	95.1	10.04%
14:22	783.8	45.6	2.2	S	804.8	31.3	35.2	98.7	10.49%	518.8	0.6	0.7	94.7	10.07%
14:24	778.6	45.5	1.1	S	799.6	31.3	35.2	98.3	10.52%	515.8	0.6	0.7	94.3	10.10%
14:26	773.4	45.4	0.0	0.0	794.4	31.2	35.1	97.9	10.55%	512.8	0.6	0.7	93.4	10.06%
14:28	768.2	45.2	2.2	S	789.2	31.2	35.1	96.8	10.50%	509.9	0.6	0.7	93.0	10.09%
14:30	763	45.1	3.4	SE	784.0	31.1	35.0	96.4	10.52%	506.3	0.6	0.7	92.6	10.12%
14:32	757.8	45.0	1.1	S	778.8	31.1	34.9	96.0	10.55%	502.8	0.6	0.7	92.3	10.15%
14:34	753.1	44.9	1.1	S	774.1	31.1	34.9	95.6	10.58%	499.8	0.6	0.7	91.9	10.17%
14:36	749.4	44.8	2.2	SE	770.4	31.0	34.8	95.2	10.59%	497.1	0.6	0.7	91.5	10.18%
14:38	745.7	44.6	1.1	S	766.7	31.0	34.7	94.8	10.60%	494.8	0.6	0.7	91.1	10.19%

14:40	742	44.5	1.1	S	763.0	30.9	34.7	94.4	10.61%	491.9	0.6	0.7	90.8	10.19%
14:42	738.3	44.4	1.1	SE	759.3	30.9	34.6	94.0	10.61%	489.1	0.6	0.7	90.4	10.20%
14:44	734.6	44.3	2.2	S	755.6	30.9	34.6	93.7	10.62%	486.7	0.6	0.7	90.0	10.21%
14:46	730.9	44.1	1.1	S	751.9	30.8	34.5	93.3	10.63%	484.4	0.6	0.7	89.7	10.22%
14:48	727.2	44.0	2.2	SE	748.2	30.8	34.4	92.9	10.64%	481.6	0.6	0.7	89.3	10.23%
14:50	723.5	43.9	2.2	S	744.5	30.7	34.4	92.5	10.65%	478.7	0.6	0.7	88.9	10.24%
14:52	719.8	43.8	2.2	S	740.8	30.7	34.3	92.1	10.66%	476.4	0.6	0.7	88.5	10.25%
14:54	716.1	43.7	2.2	S	737.1	30.7	34.3	91.7	10.67%	474.1	0.6	0.7	88.2	10.26%
14:56	712.4	43.5	2.2	S	733.4	30.6	34.2	91.3	10.68%	471.8	0.6	0.7	87.8	10.27%
14:58	708.7	43.4	2.2	SE	729.7	30.6	34.1	90.9	10.69%	468.9	0.6	0.7	87.4	10.28%
15:00	705	43.3	1.1	S	726.0	30.5	34.1	90.6	10.70%	466.1	0.6	0.7	87.0	10.29%
15:02	701.3	43.2	1.1	S	722.3	30.5	34.0	90.2	10.71%	463.8	0.6	0.7	86.7	10.30%
15:04	697.6	43.1	3.4	S	718.6	30.5	34.0	89.8	10.73%	461.5	0.6	0.7	86.3	10.31%
15:06	693.9	42.9	4.5	S	714.9	30.4	33.9	89.4	10.74%	459.2	0.6	0.7	85.9	10.32%
15:08	690.2	42.8	4.5	SE	711.2	30.4	33.8	89.0	10.75%	456.3	0.6	0.7	85.6	10.33%
15:10	686.5	42.7	2.2	S	707.5	30.3	33.8	88.6	10.76%	453.4	0.6	0.7	85.2	10.34%
15:12	682.8	42.6	2.2	S	703.8	30.3	33.7	88.2	10.77%	451.1	0.6	0.7	84.8	10.35%
15:14	679.1	42.5	2.2	S	700.1	30.3	33.7	87.4	10.72%	448.8	0.6	0.7	84.4	10.36%
15:16	675.4	42.3	2.2	SE	696.4	30.2	33.6	87.0	10.73%	446.5	0.6	0.7	83.7	10.33%
15:18	671.7	42.2	1.1	S	692.7	30.2	33.6	86.6	10.74%	443.6	0.6	0.7	83.4	10.34%
15:20	668	42.1	1.1	S	689.0	30.1	33.5	86.2	10.76%	440.8	0.5	0.7	83.0	10.35%
15:22	664.3	42.0	1.1	S	685.3	30.1	33.4	85.8	10.77%	438.5	0.6	0.7	82.6	10.36%
15:24	660.6	41.9	1.1	S	681.6	30.1	33.4	85.4	10.78%	436.2	0.6	0.7	82.3	10.38%
15:26	656.9	41.7	1.1	SE	677.9	30.0	33.3	85.1	10.79%	433.9	0.6	0.7	81.9	10.39%
15:28	653.2	41.6	1.1	S	674.2	30.0	33.3	84.7	10.80%	431.0	0.5	0.7	81.5	10.40%
15:30	649.5	41.5	1.1	S	670.5	29.9	33.2	84.0	10.78%	428.1	0.5	0.7	80.9	10.38%
15:32	645.8	41.4	1.1	S	666.8	29.9	33.1	83.4	10.76%	425.8	0.5	0.7	80.3	10.36%
15:34	642.1	41.3	1.1	S	663.1	29.9	33.1	82.8	10.74%	423.5	0.5	0.7	79.7	10.34%
15:36	634.3	41.1	1.1	S	655.3	29.8	33.0	80.8	10.62%	421.2	0.6	0.7	77.8	10.22%
15:38	626.5	41.0	2.2	SE	647.5	29.8	32.9	79.8	10.61%	416.5	0.6	0.7	76.8	10.22%

15:40	618.7	40.9	1.1	S	639.7	29.7	32.9	78.8	10.61%	411.8	0.6	0.7	75.8	10.21%
15:42	610.9	40.8	2.2	S	631.9	29.7	32.8	77.7	10.61%	407.6	0.6	0.7	74.8	10.21%
15:44	603.1	40.7	2.2	S	624.1	29.7	32.7	76.7	10.60%	403.5	0.6	0.7	73.9	10.20%
15:46	595.3	40.5	2.2	S	616.3	29.6	32.7	75.7	10.60%	399.3	0.6	0.7	72.9	10.20%
15:48	587.5	40.4	2.2	SE	608.5	29.6	32.6	74.7	10.59%	394.6	0.6	0.7	71.9	10.20%
15:50	579.7	40.3	2.2	W	600.7	29.5	32.5	74.0	10.63%	389.9	0.6	0.7	70.7	10.16%
15:52	571.9	40.2	2.2	W	592.9	29.5	32.4	73.2	10.66%	385.7	0.6	0.7	69.9	10.19%
15:54	564.1	40.1	2.2	SW	585.1	29.5	32.4	72.3	10.69%	381.6	0.6	0.7	69.2	10.22%
15:56	556.3	39.9	2.2	SW	577.3	29.4	32.3	71.6	10.72%	377.4	0.6	0.7	68.3	10.24%
15:58	548.5	39.8	3.4	SW	569.5	29.4	32.2	70.8	10.75%	372.7	0.6	0.7	67.4	10.24%
16:00	540.7	39.7	3.4	NW	561.7	29.3	32.1	69.3	10.68%	368.0	0.6	0.7	64.9	10.01%
16:02	532.9	39.6	1.1	SW	553.9	29.3	32.1	67.9	10.62%	363.8	0.6	0.7	63.6	9.94%
16:04	525.1	39.5	1.1	SW	546.1	29.3	32.0	66.8	10.60%	359.6	0.6	0.7	62.6	9.94%
16:06	517.3	39.3	1.1	SW	538.3	29.2	31.9	65.6	10.57%	355.4	0.6	0.7	62.6	10.09%
16:08	509.5	39.2	2.2	SW	530.5	29.2	31.8	64.6	10.56%	350.7	0.6	0.7	61.6	10.08%
16:10	501.7	39.1	2.2	NW	522.7	29.1	31.8	63.5	10.55%	346.0	0.6	0.7	60.6	10.07%
16:12	493.9	39.0	2.2	SW	514.9	29.1	31.7	62.5	10.54%	341.8	0.6	0.7	59.6	10.06%
16:14	486.1	38.9	2.2	SW	507.1	29.1	31.6	61.4	10.53%	337.6	0.6	0.7	58.6	10.05%
16:16	478.3	38.7	2.2	SW	499.3	29.0	31.6	59.9	10.44%	333.5	0.6	0.7	57.6	10.04%
16:18	470.5	38.6	2.2	W	491.5	29.0	31.5	59.3	10.50%	328.7	0.6	0.7	56.6	10.03%
16:20	462.7	38.5	2.2	W	483.7	28.9	31.4	58.5	10.53%	324.0	0.6	0.7	55.4	9.98%
16:22	454.9	38.4	1.1	NW	475.9	28.9	31.3	57.7	10.57%	319.8	0.6	0.7	54.7	10.02%
16:24	447.1	38.3	1.1	NW	468.1	28.9	31.3	56.9	10.60%	315.6	0.6	0.7	53.9	10.05%
16:26	439.3	38.1	1.1	SW	460.3	28.8	31.2	56.1	10.64%	311.5	0.6	0.7	53.5	10.16%
16:28	431.5	38.0	1.1	NW	452.5	28.8	31.1	55.2	10.67%	306.7	0.6	0.7	52.0	10.05%
16:30	423.7	37.9	1.1	W	444.7	28.7	31.0	54.5	10.71%	302.0	0.6	0.7	52.0	10.24%
16:32	415.9	37.8	1.1	SW	436.9	28.7	31.0	53.7	10.76%	297.8	0.6	0.7	51.0	10.21%
16:34	408.1	37.7	1.1	SW	429.1	28.7	30.9	52.9	10.79%	293.6	0.6	0.7	9.3	1.90%
16:36	400.3	37.5	1.1	SW	421.3	28.6	30.8	51.7	10.76%	289.4	0.6	0.7	49.1	10.22%
16:38	392.5	37.4	1.1	SW	413.5	28.6	30.7	50.5	10.73%	284.7	0.6	0.7	48.0	10.19%

16:40	384.7	37.3	1.1	SW	405.7	28.5	30.7	49.3	10.69%	280.0	0.6	0.7	46.9	10.15%
16:42	376.9	37.2	2.2	SW	397.9	28.5	30.6	48.5	10.73%	275.8	0.6	0.7	46.1	10.20%
16:44	369.1	37.1	2.2	SW	390.1	28.5	30.5	46.8	10.58%	271.6	0.6	0.7	45.4	10.25%
16:46	361.3	36.9	2.2	SW	382.3	28.4	30.5	46.9	10.82%	267.4	0.6	0.7	44.6	10.30%
16:48	353.5	36.8	2.2	W	374.5	28.4	30.4	45.7	10.77%	262.6	0.6	0.7	43.9	10.35%
16:50	345.7	36.7	2.2	W	366.7	28.3	30.3	44.9	10.82%	257.9	0.6	0.7	42.8	10.32%
16:52	337.9	36.6	2.2	SW	358.9	28.3	30.2	43.9	10.82%	253.7	0.6	0.7	41.8	10.31%
16:54	330.1	36.5	2.2	SW	351.1	28.3	30.2	42.8	10.81%	249.5	0.6	0.7	40.8	10.31%
16:56	322.3	36.3	4.5	W	343.3	28.2	30.1	41.8	10.81%	245.3	0.6	0.7	39.9	10.30%
16:58	314.5	36.2	4.5	NW	335.5	28.2	30.0	40.8	10.80%	240.5	0.6	0.7	38.9	10.30%
17:00	306.7	36.1	4.5	W	327.7	28.1	29.9	39.7	10.80%	235.8	0.6	0.7	38.2	10.37%
17:02	298.9	36.0	1.1	NW	319.9	28.1	29.9	38.7	10.79%	231.6	0.6	0.8	37.1	10.35%
17:04	291.1	35.9	1.1	W	312.1	28.1	29.8	37.7	10.78%	227.4	0.7	0.8	36.1	10.35%
17:06	283.3	35.7	1.1	W	304.3	28.0	29.7	36.1	10.61%	223.2	0.7	0.8	34.6	10.19%
17:08	275.5	35.6	1.1	S	296.5	28.0	29.6	35.1	10.60%	218.4	0.7	0.8	33.4	10.10%
17:10	267.7	35.5	1.1	S	288.7	27.9	29.6	33.9	10.55%	213.7	0.7	0.8	32.4	10.09%
17:12	259.9	35.4	1.1	S	280.9	27.9	29.5	33.4	10.71%	209.5	0.7	0.8	31.9	10.24%
17:14	252.1	35.3	1.1	S	273.1	27.9	29.4	32.9	10.87%	205.2	0.7	0.8	31.5	10.40%
17:16	244.3	35.1	1.1	SE	265.3	27.8	29.3	32.4	11.05%	201.0	0.7	0.8	31.0	10.57%
17:18	236.5	35.0	1.1	S	257.5	27.8	29.3	31.9	11.23%	196.3	0.7	0.8	30.2	10.66%
17:20	230.2	34.9	1.1	S	251.2	27.7	29.2	31.4	11.36%	191.5	0.7	0.8	29.8	10.77%
17:22	223.9	34.8	1.1	S	244.9	27.7	29.1	30.9	11.49%	188.0	0.7	0.8	29.3	10.90%
17:24	217.6	34.7	2.2	S	238.6	27.7	29.1	30.4	11.63%	184.4	0.7	0.8	28.8	11.03%
17:26	211.3	34.5	1.1	SE	232.3	27.6	29.0	29.9	11.77%	180.9	0.7	0.8	28.3	11.17%
17:28	205	34.4	2.2	S	226.0	27.6	28.9	29.3	11.93%	176.8	0.7	0.8	27.5	11.18%
17:30	198.7	34.3	2.2	S	219.7	27.5	28.9	27.1	11.35%	172.8	0.7	0.8	25.4	10.64%
17:32	192.4	34.2	2.2	S	213.4	27.5	28.8	24.8	10.74%	169.2	0.7	0.8	23.2	10.06%
17:34	186.1	34.1	2.2	S	207.1	27.5	28.7	24.2	10.83%	165.7	0.7	0.9	22.8	10.19%
17:36	179.8	33.9	2.2	S	200.8	27.4	28.7	23.7	10.98%	162.2	0.8	0.9	22.1	10.24%
17:38	173.5	33.8	2.2	SE	194.5	27.4	28.6	23.2	11.14%	158.1	0.8	0.9	21.6	10.38%

17:40	167.2	33.7	2.2	S	188.2	27.3	28.5	22.7	11.30%	154.0	0.8	0.9	21.2	10.54%
17:42	160.9	33.6	2.2	S	181.9	27.3	28.4	22.2	11.49%	150.5	0.8	0.9	20.7	10.71%
17:44	154.6	33.5	2.2	S	175.6	27.3	28.4	21.2	11.40%	146.9	0.8	0.9	20.2	10.89%
17:46	148.3	33.3	2.2	S	169.3	27.2	28.3	20.7	11.61%	143.4	0.8	0.9	19.7	11.09%
17:48	142	33.2	2.2	S	163.0	27.2	28.2	20.2	11.84%	139.3	0.8	0.9	18.9	11.07%
17:50	135.7	33.1	2.2	S	156.7	27.1	28.2	19.5	11.99%	135.2	0.8	1.0	17.9	11.00%
17:52	129.4	33.0	2.2	S	150.4	27.1	28.0	19.0	12.26%	118.4	0.8	0.9	17.5	11.25%
17:54	123.1	32.9	4.5	SE	144.1	27.1	27.9	18.9	12.80%	110.5	0.7	0.9	17.1	11.54%
17:56	121	32.7	2.2	S	137.8	27.0	27.8	18.9	13.02%	102.6	0.7	0.8	17.1	11.74%
17:58	118.9	32.6	2.2	S	131.5	27.0	27.7	18.9	13.25%	94.7	0.7	0.8	17.1	11.95%
18:00	116.8	32.5	2.2	S	125.2	26.9	27.6	18.8	13.40%	86.8	0.6	0.8	17.1	12.16%
								127.6	13.40%	584.2	0.8	1.0	120.4	12.16%
									10.60%					10.05%


Experiemental results from PVT output powr in comparsion with solar radiation verses time - Summer
otuput power from PVT (experimental results) kJ/hr
4000
3500
3000
2500
2000
1500
1000
500
0
07:10
07:32
07:52
08:12
08:32
08:52
09:12
09:32
09:52
10:12
10:32
10:52
11:12
11:32
11:52
12:12
12:32
12:52
13:12
13:32
13:52
14:12
14:32
14:52
15:12
15:32
15:52
16:12
16:32
16:52
17:12
17:32
17:52
Time
Radiation (KJ/h.m2)
Q_ Thermal (kJ/hr)

2- Validating the simulation model by comparing the experimental Data with simulation data (with maximum percentage error less than 5%)

Radiation(kJ/hr. m2)	Tout_sim	Tout_ Measured	Deviation	PV Elec_ Sim	PV _electrical measured	Deviation	Q th_ Sim	Q thermal measured	Deviation
252.00	24.94	24.95	0.04%	40.96	41.96	2.4%	366.68	368.00	0.4%
261.00	25.02	25.03	0.04%	42.48	43.30	1.9%	371.57	372.00	0.1%
270.00	25.10	25.12	0.04%	44.00	45.09	2.4%	378.35	376.00	-0.6%
279.00	25.19	25.20	0.04%	45.52	45.53	0.0%	385.12	380.00	-1.3%
288.00	25.27	25.28	0.04%	47.03	45.98	-2.3%	391.90	384.00	-2.1%
297.00	25.35	25.36	0.04%	48.55	49.10	1.1%	396.78	388.00	-2.3%
303.84	25.43	25.45	0.04%	50.07	49.80	-0.5%	401.66	392.00	-2.5%
306.00	25.52	25.53	0.04%	51.59	52.68	2.1%	408.44	396.00	-3.1%
316.08	25.58	25.60	0.05%	53.11	54.46	2.5%	415.96	400.00	-4.0%
328.32	25.65	25.66	0.05%	54.62	56.25	2.9%	423.48	404.00	-4.8%
340.56	25.71	25.72	0.05%	56.14	57.83	2.9%	429.11	408.00	-5.2%
352.80	25.77	25.79	0.05%	57.67	59.19	2.6%	434.74	414.45	-4.9%
365.04	25.84	25.85	0.05%	59.18	60.54	2.2%	442.26	422.03	-4.8%
377.28	25.90	25.92	0.05%	60.70	61.90	1.9%	449.78	429.60	-4.7%
389.52	25.96	25.97	0.05%	61.04	62.80	2.8%	453.01	432.86	-4.7%
401.76	26.01	26.03	0.05%	61.39	63.25	2.9%	454.34	434.20	-4.6%
414.00	26.07	26.08	0.05%	61.74	63.70	3.1%	455.67	435.54	-4.6%
426.24	26.14	26.15	0.05%	64.06	64.61	0.8%	466.16	446.10	-4.5%
438.48	26.21	26.22	0.05%	66.39	67.59	1.8%	476.65	456.66	-4.4%
450.72	26.28	26.30	0.05%	68.71	70.31	2.3%	487.13	467.22	-4.3%
462.96	26.35	26.37	0.05%	71.04	73.03	2.7%	495.71	475.85	-4.2%
475.20	26.42	26.43	0.05%	73.37	75.75	3.1%	504.29	484.49	-4.1%
487.44	26.48	26.50	0.05%	74.38	76.66	3.0%	509.99	490.23	-4.0%
490.32	26.56	26.57	0.05%	77.02	78.93	2.4%	521.62	501.94	-3.9%

493.20	26.63	26.65	0.06%	79.66	81.19	1.9%	533.25	513.65	-3.8%
496.08	26.70	26.72	0.06%	82.30	83.46	1.4%	542.97	523.43	-3.7%
514.80	26.77	26.79	0.06%	84.80	85.73	1.1%	552.20	532.72	-3.7%
533.52	26.84	26.86	0.06%	87.30	89.81	2.8%	563.32	543.92	-3.6%
552.24	26.91	26.93	0.06%	88.90	91.08	2.4%	571.15	551.81	-3.5%
570.96	26.98	26.99	0.06%	90.50	91.99	1.6%	578.98	559.70	-3.4%
589.68	27.04	27.05	0.06%	92.11	93.36	1.3%	584.91	565.67	-3.4%
597.96	27.10	27.12	0.06%	93.71	96.09	2.5%	590.84	571.63	-3.4%
619.20	27.17	27.18	0.06%	95.31	97.00	1.7%	598.67	579.52	-3.3%
640.44	27.23	27.25	0.06%	96.91	99.06	2.2%	606.50	587.40	-3.3%
661.68	27.30	27.32	0.06%	98.41	101.10	2.7%	613.99	594.95	-3.2%
681.84	27.40	27.42	0.06%	105.15	107.02	1.7%	638.64	619.76	-3.0%
702.00	27.49	27.50	0.06%	109.64	112.94	2.9%	655.06	636.29	-3.0%
714.96	27.57	27.59	0.07%	113.85	117.04	2.7%	672.40	653.74	-2.9%
727.92	27.65	27.66	0.07%	116.34	119.79	2.9%	683.49	664.91	-2.8%
740.88	27.72	27.74	0.07%	118.57	120.70	1.8%	693.60	675.09	-2.7%
753.84	27.78	27.79	0.07%	119.63	122.99	2.7%	697.54	679.06	-2.7%
766.80	27.84	27.86	0.07%	122.13	125.27	2.5%	706.72	688.30	-2.7%
779.76	27.91	27.93	0.07%	123.90	127.10	2.5%	715.19	696.83	-2.6%
792.00	27.98	28.00	0.07%	125.77	128.93	2.5%	723.98	705.68	-2.6%
846.00	28.05	28.07	0.07%	127.45	130.76	2.5%	732.11	713.88	-2.6%
882.00	28.13	28.15	0.07%	131.03	133.50	1.9%	745.22	727.07	-2.5%
915.84	28.19	28.21	0.07%	133.49	136.25	2.0%	754.23	736.14	-2.5%
936.00	28.27	28.29	0.07%	135.93	138.99	2.2%	765.14	747.13	-2.4%
954.00	28.34	28.36	0.07%	138.38	141.73	2.4%	776.04	758.11	-2.4%
962.64	28.41	28.43	0.07%	140.83	144.48	2.5%	786.95	769.09	-2.3%
982.80	28.48	28.50	0.08%	143.28	147.22	2.7%	795.95	778.15	-2.3%
997.20	28.55	28.57	0.08%	145.74	149.96	2.8%	804.94	787.21	-2.3%
1012.32	28.62	28.65	0.08%	148.18	152.70	3.0%	815.84	798.19	-2.2%

1026.00	28.70	28.72	0.08%	150.62	155.45	3.1%	826.74	809.16	-2.2%
1054.80	28.77	28.79	0.08%	153.07	158.19	3.2%	837.63	820.13	-2.1%
1074.60	28.84	28.86	0.08%	155.52	160.02	2.8%	846.62	829.18	-2.1%
1094.40	28.91	28.93	0.08%	157.89	161.39	2.2%	855.27	837.89	-2.1%
1114.20	28.98	29.00	0.08%	160.42	164.59	2.5%	866.48	849.18	-2.0%
1134.00	29.05	29.08	0.08%	162.86	166.62	2.3%	877.37	860.15	-2.0%
1153.80	29.13	29.15	0.08%	165.30	167.99	1.6%	888.25	871.10	-2.0%
1173.60	29.19	29.21	0.08%	166.62	170.29	2.2%	893.14	876.03	-2.0%
1193.40	29.27	29.29	0.08%	170.47	173.50	1.7%	907.17	890.15	-1.9%
1213.20	29.34	29.36	0.08%	172.64	176.72	2.3%	917.06	900.12	-1.9%
1233.00	29.41	29.43	0.08%	175.08	179.93	2.7%	927.93	911.07	-1.9%
1252.80	29.48	29.51	0.09%	177.34	183.86	3.5%	938.15	921.36	-1.8%
1271.88	29.55	29.57	0.09%	179.61	185.24	3.0%	946.46	929.73	-1.8%
1292.40	29.62	29.65	0.09%	182.42	186.62	2.3%	956.72	940.05	-1.8%
1312.20	29.69	29.72	0.09%	184.86	188.01	1.7%	967.58	950.99	-1.7%
1332.00	29.77	29.79	0.09%	187.29	191.69	2.3%	978.44	961.93	-1.7%
1342.80	29.84	29.87	0.09%	189.73	194.00	2.2%	989.29	972.87	-1.7%
1373.76	29.91	29.94	0.09%	193.12	196.30	1.6%	1001.65	985.31	-1.7%
1391.40	29.99	30.01	0.09%	196.11	199.53	1.7%	1012.55	996.28	-1.6%
1411.20	30.06	30.09	0.09%	199.09	202.75	1.8%	1025.35	1009.17	-1.6%
1429.56	30.14	30.17	0.09%	202.06	206.78	2.3%	1038.14	1022.06	-1.6%
1447.92	30.22	30.25	0.09%	205.04	210.02	2.4%	1050.93	1034.94	-1.5%
1470.60	30.29	30.32	0.09%	208.03	213.26	2.5%	1061.81	1045.90	-1.5%
1490.40	30.36	30.39	0.09%	211.02	216.50	2.5%	1072.69	1056.85	-1.5%
1510.20	30.44	30.47	0.10%	213.99	219.74	2.6%	1085.47	1069.72	-1.5%
1530.00	30.52	30.55	0.10%	216.96	222.97	2.7%	1098.24	1082.59	-1.4%
1557.36	30.59	30.62	0.10%	219.94	226.21	2.8%	1111.02	1095.46	-1.4%
1581.48	30.67	30.70	0.10%	222.92	229.45	2.8%	1121.88	1106.39	-1.4%
1605.60	30.74	30.77	0.10%	225.91	232.69	2.9%	1132.73	1117.33	-1.4%

1629.72	30.82	30.85	0.10%	228.88	234.08	2.2%	1145.50	1130.18	-1.4%
1653.84	30.89	30.92	0.10%	231.85	235.46	1.5%	1158.26	1143.03	-1.3%
1677.96	30.97	31.00	0.10%	234.82	241.01	2.6%	1171.01	1155.88	-1.3%
1702.08	31.04	31.07	0.10%	237.81	244.72	2.8%	1181.85	1166.80	-1.3%
1726.20	31.12	31.15	0.10%	240.79	246.10	2.2%	1192.69	1177.71	-1.3%
1750.32	31.19	31.22	0.10%	243.76	248.42	1.9%	1205.44	1190.55	-1.3%
1774.44	31.27	31.30	0.10%	246.73	250.73	1.6%	1218.18	1203.39	-1.2%
1798.56	31.34	31.37	0.10%	248.29	254.03	2.3%	1225.90	1211.17	-1.2%
1822.68	31.40	31.44	0.11%	250.59	256.35	2.2%	1234.30	1219.63	-1.2%
1846.80	31.46	31.49	0.11%	251.59	257.28	2.2%	1238.01	1223.37	-1.2%
1870.92	31.54	31.58	0.11%	255.46	258.21	1.1%	1253.97	1239.45	-1.2%
1895.04	31.63	31.66	0.11%	259.33	265.17	2.2%	1269.93	1255.52	-1.1%
1919.16	31.71	31.75	0.11%	263.19	272.14	3.3%	1285.88	1271.59	-1.1%
1943.28	31.79	31.83	0.11%	267.08	274.46	2.7%	1299.92	1285.73	-1.1%
1967.40	31.87	31.91	0.11%	270.97	276.78	2.1%	1313.95	1299.86	-1.1%
1991.52	31.95	31.99	0.11%	274.83	284.38	3.4%	1329.89	1315.91	-1.1%
2004.48	32.04	32.07	0.11%	278.70	285.31	2.3%	1345.82	1331.96	-1.0%
2023.20	32.12	32.16	0.11%	282.56	288.58	2.1%	1361.74	1348.00	-1.0%
2031.48	32.20	32.24	0.11%	286.45	293.24	2.3%	1375.75	1362.10	-1.0%
2062.80	32.28	32.32	0.12%	290.34	297.90	2.5%	1389.75	1376.20	-1.0%
2094.12	32.36	32.40	0.12%	294.20	302.56	2.8%	1405.66	1392.23	-1.0%
2125.44	32.46	32.50	0.12%	300.46	307.23	2.2%	1430.09	1426.31	-0.3%
2156.76	32.54	32.58	0.12%	305.38	311.89	2.1%	1450.46	1446.82	-0.3%
2188.08	32.58	32.62	0.12%	306.70	313.27	2.1%	1456.04	1452.44	-0.2%
2219.40	32.63	32.67	0.12%	309.05	316.59	2.4%	1465.31	1423.92	-2.9%
2250.72	32.76	32.80	0.12%	311.33	318.46	2.2%	1473.41	1460.48	-0.9%
2282.04	32.83	32.87	0.12%	313.65	322.20	2.7%	1483.82	1470.97	-0.9%
2313.36	32.90	32.94	0.12%	315.97	323.86	2.4%	1494.23	1481.46	-0.9%
2344.68	32.97	33.01	0.12%	318.31	325.26	2.1%	1502.72	1490.02	-0.9%

2376.00	33.03	33.08	0.12%	320.65	328.07	2.3%	1511.22	1498.57	-0.8%
2426.40	33.11	33.15	0.12%	322.97	330.27	2.2%	1521.62	1509.05	-0.8%
2466.00	33.18	33.22	0.12%	325.28	331.21	1.8%	1532.02	1519.54	-0.8%
2476.80	33.25	33.29	0.12%	327.59	332.15	1.4%	1542.42	1530.02	-0.8%
2495.88	33.32	33.36	0.12%	329.93	335.91	1.8%	1550.90	1538.56	-0.8%
2514.96	33.39	33.43	0.13%	332.27	339.67	2.2%	1559.38	1547.10	-0.8%
2534.04	33.46	33.50	0.13%	334.58	342.01	2.2%	1569.77	1557.57	-0.8%
2553.12	33.53	33.57	0.13%	336.89	344.36	2.2%	1580.16	1568.05	-0.8%
2572.20	33.60	33.64	0.13%	339.20	346.71	2.2%	1590.55	1578.51	-0.8%
2591.28	33.67	33.71	0.13%	341.54	349.06	2.2%	1599.02	1587.05	-0.8%
2610.36	33.74	33.78	0.13%	343.60	351.41	2.2%	1606.52	1594.61	-0.7%
2629.44	33.80	33.85	0.13%	345.64	353.76	2.3%	1615.94	1604.10	-0.7%
2648.52	33.87	33.92	0.13%	347.67	356.11	2.4%	1625.36	1613.60	-0.7%
2667.60	33.94	33.99	0.13%	349.71	358.73	2.5%	1634.77	1623.09	-0.7%
2686.68	34.01	34.05	0.13%	351.77	361.08	2.6%	1642.27	1630.64	-0.7%
2705.76	34.08	34.12	0.13%	353.83	363.43	2.6%	1649.77	1638.19	-0.7%
2724.84	34.15	34.19	0.13%	355.86	365.78	2.7%	1659.18	1647.68	-0.7%
2743.92	34.21	34.25	0.13%	356.99	366.72	2.7%	1665.39	1653.94	-0.7%
2763.00	34.27	34.32	0.13%	358.11	368.14	2.7%	1671.59	1664.94	-0.4%
2779.92	34.32	34.37	0.13%	359.27	369.55	2.8%	1676.27	1669.66	-0.4%
2796.84	34.37	34.42	0.13%	360.44	370.96	2.8%	1680.95	1674.37	-0.4%
2813.76	34.43	34.47	0.13%	361.57	371.43	2.7%	1687.55	1681.03	-0.4%
2830.68	34.48	34.52	0.13%	362.70	371.90	2.5%	1694.14	1687.68	-0.4%
2847.60	34.53	34.58	0.13%	363.83	373.51	2.6%	1700.74	1694.33	-0.4%
2864.52	34.58	34.63	0.13%	364.99	373.98	2.4%	1705.42	1699.04	-0.4%
2881.44	34.63	34.68	0.13%	366.15	374.45	2.2%	1710.09	1703.76	-0.4%
2891.16	34.69	34.73	0.13%	367.28	376.34	2.4%	1716.68	1710.41	-0.4%
2900.88	34.74	34.79	0.13%	368.40	377.75	2.5%	1723.28	1717.06	-0.4%
2910.60	34.79	34.84	0.13%	369.53	378.69	2.4%	1729.87	1723.71	-0.4%

2920.32	34.84	34.89	0.13%	370.69	379.64	2.4%	1734.54	1728.42	-0.4%
2930.04	34.90	34.95	0.13%	372.66	380.58	2.1%	1742.09	1736.03	-0.3%
2939.76	34.96	35.01	0.14%	374.60	382.40	2.0%	1751.56	1745.57	-0.3%
2949.48	35.02	35.07	0.14%	376.54	383.34	1.8%	1761.02	1755.11	-0.3%
2959.20	35.08	35.13	0.14%	378.48	384.29	1.5%	1770.48	1764.65	-0.3%
2968.92	35.14	35.18	0.14%	380.45	385.53	1.3%	1778.02	1772.25	-0.3%
2978.64	35.19	35.24	0.14%	382.41	386.47	1.1%	1785.56	1779.84	-0.3%
2988.36	35.25	35.30	0.14%	384.35	387.42	0.8%	1795.02	1789.38	-0.3%
2998.08	35.31	35.36	0.14%	386.29	388.66	0.6%	1804.47	1798.91	-0.3%
3007.80	35.37	35.42	0.14%	388.22	393.87	1.4%	1813.93	1808.45	-0.3%
3024.00	35.43	35.48	0.14%	390.19	399.08	2.2%	1821.46	1816.04	-0.3%
3040.20	35.48	35.53	0.14%	392.15	404.28	3.0%	1828.99	1823.62	-0.3%
3056.40	35.54	35.59	0.14%	394.09	407.12	3.2%	1838.44	1833.15	-0.3%
3072.60	35.60	35.65	0.14%	396.02	409.96	3.4%	1847.89	1842.68	-0.3%
3088.80	35.67	35.72	0.14%	399.08	411.86	3.1%	1861.31	1856.21	-0.3%
3105.00	35.73	35.79	0.14%	402.17	413.75	2.8%	1872.82	1867.80	-0.3%
3121.20	35.80	35.85	0.14%	405.26	415.65	2.5%	1884.31	1879.39	-0.3%
3137.40	35.87	35.92	0.14%	408.32	417.54	2.2%	1897.73	1902.38	0.2%
3153.60	35.92	35.97	0.14%	411.40	420.38	2.1%	1911.93	1916.69	0.2%
3169.80	35.97	36.02	0.15%	414.47	423.22	2.1%	1926.12	1931.00	0.3%
3186.00	36.01	36.07	0.15%	417.58	426.06	2.0%	1938.38	1943.36	0.3%
3202.20	36.06	36.11	0.15%	420.69	428.90	1.9%	1950.65	1955.71	0.3%
3218.40	36.11	36.16	0.15%	423.76	431.74	1.8%	1964.83	1970.01	0.3%
3243.60	36.16	36.21	0.15%	426.83	434.58	1.8%	1979.01	1984.31	0.3%
3268.80	36.21	36.26	0.15%	429.90	437.42	1.7%	1993.19	1998.60	0.3%
3294.00	36.25	36.31	0.15%	433.01	440.26	1.6%	2005.44	2010.94	0.3%
3319.20	36.29	36.34	0.15%	434.76	442.43	1.7%	2012.92	2018.49	0.3%
3344.40	36.33	36.38	0.15%	436.47	445.26	2.0%	2022.33	2027.98	0.3%
3369.60	36.37	36.42	0.15%	438.19	448.10	2.2%	2031.74	2037.47	0.3%

3394.80	36.41	36.46	0.15%	439.90	451.92	2.7%	2041.15	2046.96	0.3%
3420.00	36.44	36.50	0.15%	441.65	453.34	2.6%	2048.64	2054.50	0.3%
3445.20	36.48	36.54	0.15%	443.40	454.77	2.5%	2056.12	2062.05	0.3%
3470.40	36.52	36.58	0.15%	445.11	457.44	2.7%	2065.52	2071.53	0.3%
3495.60	36.56	36.62	0.15%	446.82	458.40	2.5%	2074.93	2081.02	0.3%
3520.80	36.60	36.66	0.16%	448.53	457.14	1.9%	2084.33	2090.51	0.3%
3535.20	36.62	36.67	0.16%	448.02	459.35	2.5%	2083.89	2090.07	0.3%
3549.60	36.63	36.68	0.15%	446.16	456.01	2.2%	2078.70	2084.84	0.3%
3564.00	36.64	36.70	0.15%	444.26	453.15	2.0%	2075.43	2081.56	0.3%
3578.40	36.65	36.71	0.15%	442.36	452.20	2.2%	2072.16	2078.28	0.3%
3592.80	36.67	36.72	0.15%	440.47	451.24	2.4%	2068.89	2093.94	1.2%
3607.20	36.65	36.71	0.15%	439.95	450.29	2.3%	2069.86	2094.93	1.2%
3621.60	36.61	36.66	0.15%	436.02	449.33	3.0%	2058.79	2083.78	1.2%
3636.00	36.57	36.62	0.15%	432.04	448.38	3.6%	2049.64	2102.99	2.5%
3650.40	36.46	36.51	0.15%	426.01	441.70	3.6%	2035.38	2050.78	0.8%
3646.80	36.43	36.49	0.15%	421.26	433.38	2.8%	2022.75	2057.00	1.7%
3632.40	36.36	36.42	0.15%	416.58	426.73	2.4%	2009.74	2043.91	1.7%
3618.00	36.29	36.35	0.15%	411.91	420.08	1.9%	1996.73	2030.81	1.7%
3603.60	36.23	36.29	0.15%	407.20	415.48	2.0%	1985.65	2019.67	1.7%
3589.20	36.17	36.22	0.15%	402.49	413.12	2.6%	1974.56	2008.52	1.7%
3585.24	36.11	36.16	0.15%	397.79	409.82	2.9%	1963.47	1997.36	1.7%
3553.92	36.04	36.09	0.15%	393.12	406.52	3.3%	1950.44	1984.25	1.7%
3522.60	35.97	36.02	0.15%	388.45	403.22	3.7%	1937.40	1971.13	1.7%
3474.36	35.91	35.96	0.15%	383.75	399.92	4.0%	1926.30	1959.96	1.7%
3436.92	35.84	35.90	0.15%	379.06	393.79	3.7%	1915.19	1948.79	1.7%
3399.48	35.79	35.85	0.15%	376.07	387.66	3.0%	1910.13	1943.71	1.7%
3362.04	35.73	35.78	0.15%	371.81	381.52	2.5%	1898.50	1932.01	1.7%
3324.60	35.66	35.72	0.15%	367.56	372.53	1.3%	1886.88	1920.31	1.7%
3287.16	35.60	35.66	0.15%	363.27	366.44	0.9%	1877.19	1910.57	1.7%

3249.72	35.54	35.60	0.15%	358.99	365.04	1.7%	1867.50	1900.82	1.8%
3212.28	35.48	35.53	0.15%	354.71	363.64	2.5%	1857.80	1891.08	1.8%
3174.84	35.44	35.49	0.15%	353.37	362.23	2.4%	1856.53	1889.80	1.8%
3137.40	35.40	35.45	0.15%	352.03	360.83	2.4%	1855.25	1888.53	1.8%
3099.96	35.36	35.41	0.15%	350.69	356.66	1.7%	1853.98	1887.25	1.8%
3076.20	35.31	35.36	0.15%	349.38	355.27	1.7%	1850.75	1884.01	1.8%
3042.00	35.25	35.30	0.15%	348.12	353.87	1.6%	1843.63	1876.83	1.8%
3007.80	35.19	35.25	0.14%	346.90	355.21	2.3%	1834.57	1867.68	1.8%
2973.60	35.13	35.18	0.14%	344.66	353.81	2.6%	1823.94	1856.96	1.8%
2939.40	35.07	35.12	0.14%	342.42	352.40	2.8%	1813.30	1846.24	1.8%
2905.20	35.01	35.06	0.14%	340.18	348.30	2.3%	1802.67	1835.52	1.8%
2894.40	34.94	34.99	0.14%	337.97	346.91	2.6%	1790.09	1822.83	1.8%
2883.60	34.87	34.92	0.14%	335.75	345.51	2.8%	1777.50	1810.14	1.8%
2872.80	34.81	34.86	0.14%	333.51	344.12	3.1%	1766.86	1799.41	1.8%
2862.00	34.75	34.80	0.14%	331.49	342.73	3.3%	1757.02	1789.48	1.8%
2851.20	34.69	34.74	0.14%	329.92	341.33	3.3%	1748.78	1781.17	1.8%
2840.40	34.63	34.68	0.14%	328.37	339.94	3.4%	1738.59	1770.89	1.8%
2821.68	34.57	34.62	0.14%	326.82	338.55	3.5%	1728.40	1760.61	1.8%
2802.96	34.51	34.56	0.14%	325.25	337.15	3.5%	1720.16	1752.30	1.8%
2784.24	34.46	34.50	0.14%	323.67	335.76	3.6%	1711.91	1743.98	1.8%
2765.52	34.40	34.44	0.14%	322.12	334.37	3.7%	1701.72	1733.70	1.8%
2746.80	34.33	34.38	0.14%	320.57	332.97	3.7%	1691.53	1723.42	1.9%
2728.08	34.28	34.32	0.14%	318.99	331.58	3.8%	1683.28	1715.11	1.9%
2711.16	34.22	34.27	0.13%	317.41	330.19	3.9%	1675.04	1706.79	1.9%
2697.84	34.16	34.21	0.13%	315.83	328.80	3.9%	1666.79	1698.47	1.9%
2684.52	34.10	34.15	0.13%	314.28	327.40	4.0%	1656.60	1688.19	1.9%
2671.20	34.04	34.08	0.13%	312.72	326.01	4.1%	1646.41	1677.91	1.9%
2657.88	33.98	34.03	0.13%	311.14	324.62	4.2%	1638.16	1669.59	1.9%
2644.56	33.92	33.97	0.13%	309.56	323.22	4.2%	1629.90	1661.27	1.9%

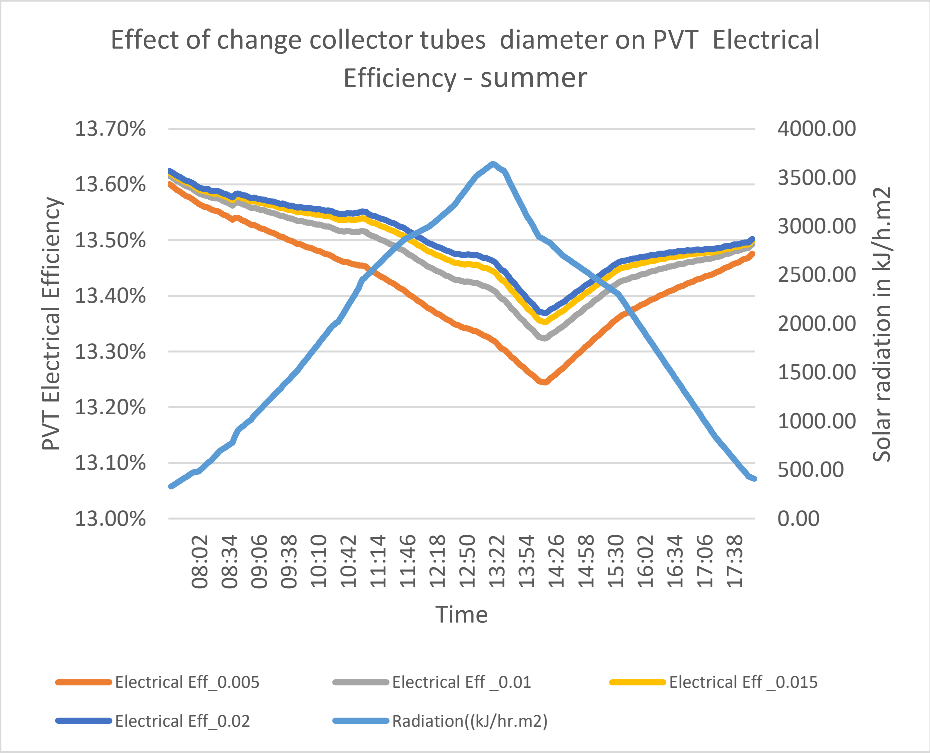
2631.24	33.87	33.91	0.13%	307.98	321.83	4.3%	1621.65	1652.95	1.9%
2617.92	33.81	33.85	0.13%	306.42	320.44	4.4%	1611.46	1642.67	1.9%
2604.60	33.74	33.79	0.13%	304.86	319.04	4.4%	1601.27	1632.39	1.9%
2591.28	33.69	33.73	0.13%	303.28	317.65	4.5%	1593.02	1624.07	1.9%
2577.96	33.63	33.67	0.13%	301.69	314.54	4.1%	1584.76	1615.74	1.9%
2564.64	33.57	33.62	0.13%	300.10	313.15	4.2%	1576.50	1607.42	1.9%
2551.32	33.51	33.55	0.13%	298.54	311.77	4.2%	1566.31	1597.14	1.9%
2538.00	33.45	33.49	0.13%	296.98	310.38	4.3%	1556.12	1586.86	1.9%
2524.68	33.39	33.43	0.13%	295.39	309.00	4.4%	1547.86	1578.53	1.9%
2511.36	33.33	33.38	0.13%	293.80	307.61	4.5%	1539.61	1570.20	1.9%
2498.04	33.28	33.32	0.13%	292.21	306.23	4.6%	1531.35	1561.88	2.0%
2484.72	33.22	33.26	0.13%	290.64	304.84	4.7%	1521.15	1551.60	2.0%
2471.40	33.15	33.20	0.12%	289.08	302.53	4.4%	1510.96	1541.32	2.0%
2458.08	33.10	33.14	0.12%	287.48	300.22	4.2%	1502.70	1532.99	2.0%
2444.76	33.04	33.08	0.12%	285.89	297.91	4.0%	1494.44	1524.66	2.0%
2431.44	32.98	33.02	0.12%	284.30	290.98	2.3%	1486.18	1516.33	2.0%
2418.12	32.91	32.95	0.12%	280.88	287.29	2.2%	1469.39	1499.40	2.0%
2404.80	32.83	32.87	0.12%	277.47	283.59	2.2%	1452.59	1482.48	2.0%
2391.48	32.76	32.80	0.12%	274.03	279.90	2.1%	1437.72	1467.49	2.0%
2378.16	32.69	32.73	0.12%	270.59	276.20	2.0%	1422.85	1452.50	2.0%
2364.84	32.62	32.66	0.12%	267.15	272.51	2.0%	1407.97	1437.51	2.1%
2351.52	32.54	32.58	0.12%	263.73	268.81	1.9%	1391.16	1420.57	2.1%
2338.20	32.47	32.50	0.12%	260.30	266.32	2.3%	1374.34	1403.62	2.1%
2324.88	32.40	32.43	0.11%	256.86	263.48	2.5%	1359.45	1388.62	2.1%
2311.56	32.32	32.36	0.11%	253.42	260.45	2.7%	1344.56	1373.61	2.1%
2283.48	32.25	32.29	0.11%	249.97	257.61	3.0%	1329.66	1358.60	2.1%
2255.40	32.18	32.21	0.11%	246.55	254.77	3.2%	1312.83	1341.64	2.1%
2227.32	32.10	32.14	0.11%	243.12	249.58	2.6%	1295.99	1324.67	2.2%
2199.24	32.03	32.07	0.11%	239.68	244.56	2.0%	1281.08	1309.65	2.2%

2171.16	31.96	31.99	0.11%	236.23	240.41	1.7%	1266.16	1294.62	2.2%
2143.08	31.89	31.92	0.11%	232.78	236.27	1.5%	1251.24	1279.59	2.2%
2115.00	31.81	31.85	0.11%	229.35	232.50	1.4%	1234.39	1262.61	2.2%
2086.92	31.74	31.77	0.10%	225.92	228.73	1.2%	1217.54	1245.62	2.3%
2058.84	31.67	31.70	0.10%	222.47	224.95	1.1%	1202.60	1230.58	2.3%
2030.76	31.60	31.63	0.10%	219.02	221.18	1.0%	1187.66	1215.53	2.3%
2002.68	31.52	31.56	0.10%	215.57	215.75	0.1%	1172.72	1200.47	2.3%
1974.60	31.45	31.48	0.10%	212.13	213.47	0.6%	1155.85	1183.47	2.3%
1946.52	31.37	31.40	0.10%	208.70	210.48	0.8%	1138.98	1166.47	2.4%
1918.44	31.30	31.33	0.10%	205.25	207.66	1.2%	1124.02	1151.41	2.4%
1890.36	31.23	31.26	0.10%	201.79	204.68	1.4%	1109.06	1136.34	2.4%
1862.28	31.16	31.19	0.10%	198.34	201.85	1.7%	1094.10	1121.26	2.4%
1834.20	31.08	31.11	0.09%	194.90	198.88	2.0%	1077.21	1104.24	2.4%
1806.12	31.01	31.04	0.09%	191.46	196.06	2.3%	1060.31	1087.22	2.5%
1778.04	30.94	30.96	0.09%	188.01	193.24	2.7%	1045.34	1072.13	2.5%
1749.96	30.86	30.89	0.09%	184.55	190.27	3.0%	1030.35	1057.04	2.5%
1721.88	30.79	30.82	0.09%	181.09	186.04	2.7%	1015.37	1041.95	2.6%
1693.80	30.72	30.74	0.09%	177.65	181.95	2.4%	998.46	1024.91	2.6%
1665.72	30.64	30.67	0.09%	174.21	177.58	1.9%	981.54	1007.87	2.6%
1637.64	30.57	30.60	0.09%	170.75	174.77	2.3%	966.55	992.76	2.6%
1609.56	30.50	30.53	0.09%	167.29	168.65	0.8%	951.54	977.65	2.7%
1581.48	30.43	30.45	0.08%	163.83	168.87	3.0%	936.53	962.53	2.7%
1553.40	30.35	30.38	0.08%	160.39	164.40	2.4%	919.60	945.47	2.7%
1525.32	30.28	30.30	0.08%	156.94	161.61	2.9%	902.67	928.41	2.8%
1497.24	30.20	30.23	0.08%	153.48	157.90	2.8%	887.65	913.28	2.8%
1469.16	30.13	30.16	0.08%	150.02	154.18	2.7%	872.62	898.15	2.8%
1441.08	30.06	30.09	0.08%	146.56	150.47	2.6%	857.59	883.01	2.9%
1413.00	29.99	30.01	0.08%	143.11	146.75	2.5%	840.64	865.94	2.9%
1384.92	29.91	29.93	0.08%	139.66	143.04	2.4%	823.69	848.86	3.0%

1356.84	29.84	29.86	0.07%	136.20	139.32	2.2%	808.65	833.71	3.0%
1328.76	29.77	29.79	0.07%	132.74	135.60	2.1%	793.60	818.55	3.0%
1300.68	29.70	29.72	0.07%	129.27	129.84	0.4%	778.55	803.39	3.1%
1272.60	29.62	29.64	0.07%	125.82	126.19	0.3%	761.58	786.30	3.1%
1244.52	29.54	29.56	0.07%	122.37	122.05	-0.3%	744.61	769.20	3.2%
1216.44	29.47	29.49	0.07%	118.91	120.23	1.1%	729.54	754.02	3.2%
1188.36	29.40	29.42	0.07%	115.44	118.40	2.5%	714.47	738.85	3.3%
1160.28	29.33	29.35	0.07%	111.98	116.58	3.9%	699.40	723.67	3.4%
1132.20	29.25	29.27	0.06%	108.52	110.20	1.5%	682.41	706.55	3.4%
1104.12	29.18	29.20	0.06%	105.07	107.30	2.1%	665.41	689.43	3.5%
1076.04	29.11	29.13	0.06%	102.27	104.40	2.0%	652.79	676.72	3.5%
1047.96	29.04	29.06	0.06%	99.48	101.50	2.0%	640.15	664.00	3.6%
1019.88	28.98	29.00	0.06%	96.68	98.60	1.9%	627.52	651.27	3.6%
991.80	28.91	28.92	0.06%	93.90	95.70	1.9%	612.97	636.62	3.7%
963.72	28.84	28.85	0.06%	91.11	92.80	1.8%	598.43	621.96	3.8%
935.64	28.77	28.79	0.06%	88.31	89.90	1.8%	585.78	609.23	3.8%
907.56	28.70	28.72	0.06%	85.52	87.00	1.7%	573.14	596.50	3.9%
879.48	28.64	28.65	0.05%	82.72	84.10	1.6%	560.49	583.76	4.0%
851.40	28.57	28.58	0.05%	79.93	81.20	1.6%	545.93	569.09	4.1%
828.72	28.50	28.51	0.05%	77.14	78.30	1.5%	531.37	554.42	4.2%
806.04	28.43	28.44	0.05%	74.34	75.40	1.4%	518.72	541.68	4.2%
783.36	28.36	28.38	0.05%	71.54	72.50	1.3%	506.06	528.93	4.3%
760.68	28.30	28.31	0.05%	68.74	69.60	1.2%	493.40	516.18	4.4%
738.00	28.23	28.24	0.05%	65.95	66.70	1.1%	478.83	501.50	4.5%
715.32	28.16	28.17	0.05%	63.16	63.80	1.0%	464.25	486.82	4.6%
692.64	28.09	28.10	0.05%	60.36	60.90	0.9%	451.58	474.07	4.7%
669.96	28.02	28.03	0.04%	57.56	58.00	0.8%	438.91	461.30	4.9%
647.28	27.96	27.97	0.04%	54.76	55.10	0.6%	426.24	448.54	5.0%
624.60	27.90	27.91	0.04%	53.84	52.20	-3.1%	418.58	440.82	5.0%

601.92	27.02	27.01	-0.04%	50.50	49.30	-2.4%	415.00	433.10	4.2%
		Max	0.155%			4.7%			5.0%

3- Simulation Results for changing water tubes diameter:



4- Simulation Results for changing the water flow rate:

Flow rate 0.125 gpm						Flow rate 0.25 gpm					
Tout_sim	Q_PV	Electrical Eff_0.125	Q_th	Thermal Eff_0.125	T Cell_0.125	Tout_sim	Q_PV	Electrical Eff _0.25	Q_th	Thermal Eff_0.25	T Cell_0.25
26.91	40.86	13.58%	325.47	83.43%	28.91	25.65	40.92	13.60%	352.20	90.28%	28.49
27.01	42.38	13.58%	329.80	81.50%	29.04	25.74	42.44	13.60%	356.89	88.20%	28.62
27.13	43.89	13.58%	335.81	80.11%	29.20	25.84	43.96	13.60%	363.40	86.69%	28.77
27.25	45.41	13.58%	341.81	78.81%	29.35	25.93	45.48	13.60%	369.91	85.28%	28.92
27.37	46.92	13.57%	347.82	77.59%	29.51	26.03	46.99	13.60%	376.41	83.97%	29.07
27.48	48.43	13.57%	352.14	76.08%	29.64	26.12	48.51	13.59%	381.10	82.34%	29.20
27.59	49.95	13.57%	356.46	74.67%	29.78	26.21	50.03	13.59%	385.78	80.81%	29.33
27.71	51.46	13.57%	362.46	73.68%	29.94	26.31	51.54	13.59%	392.28	79.75%	29.48
27.81	52.97	13.56%	369.13	72.88%	30.08	26.39	53.06	13.59%	399.51	78.88%	29.61
27.92	54.48	13.56%	375.80	72.13%	30.23	26.47	54.57	13.58%	406.73	78.07%	29.75
28.01	56.00	13.56%	380.78	71.10%	30.35	26.54	56.09	13.58%	412.13	76.96%	29.87
28.10	57.51	13.56%	385.76	70.13%	30.48	26.61	57.61	13.58%	417.53	75.90%	29.99
28.21	59.02	13.56%	392.43	69.50%	30.62	26.69	59.12	13.58%	424.75	75.23%	30.13
28.31	60.53	13.55%	399.09	68.91%	30.77	26.78	60.64	13.58%	431.97	74.58%	30.26
28.39	60.87	13.55%	401.95	68.99%	30.86	26.84	60.98	13.57%	435.07	74.68%	30.35
28.45	61.22	13.55%	403.12	68.79%	30.93	26.89	61.33	13.57%	436.35	74.46%	30.42
28.51	61.57	13.55%	404.30	68.59%	31.00	26.95	61.68	13.57%	437.62	74.24%	30.48
28.64	63.88	13.54%	413.59	67.61%	31.18	27.04	64.00	13.57%	447.69	73.19%	30.66
28.76	66.19	13.54%	422.88	66.71%	31.37	27.13	66.32	13.57%	457.76	72.21%	30.83
28.89	68.50	13.54%	432.16	65.86%	31.55	27.23	68.64	13.57%	467.82	71.30%	31.01
29.01	70.82	13.54%	439.77	64.82%	31.71	27.31	70.96	13.57%	476.06	70.17%	31.16
29.12	73.14	13.54%	447.37	63.85%	31.87	27.39	73.29	13.56%	484.29	69.12%	31.31
29.21	74.15	13.53%	452.41	63.68%	32.00	27.47	74.30	13.56%	489.76	68.93%	31.43
29.35	76.77	13.53%	462.71	62.89%	32.20	27.56	76.93	13.56%	500.92	68.08%	31.61
29.48	79.39	13.53%	473.00	62.16%	32.40	27.66	79.56	13.56%	512.08	67.29%	31.80

29.61	82.02	13.53%	481.61	61.26%	32.57	27.75	82.20	13.56%	521.41	66.32%	31.97
29.73	84.51	13.53%	489.78	60.46%	32.74	27.84	84.70	13.56%	530.27	65.45%	32.13
29.86	87.00	13.53%	499.63	59.90%	32.94	27.93	87.20	13.56%	540.95	64.85%	32.31
29.97	88.59	13.52%	506.56	59.63%	33.09	28.01	88.79	13.56%	548.46	64.56%	32.45
30.08	90.18	13.52%	513.49	59.37%	33.24	28.10	90.39	13.55%	555.97	64.28%	32.59
30.17	91.77	13.52%	518.74	58.93%	33.37	28.17	91.99	13.55%	561.66	63.80%	32.71
30.26	93.37	13.52%	523.99	58.50%	33.49	28.24	93.59	13.55%	567.35	63.34%	32.83
30.37	94.95	13.52%	530.91	58.27%	33.64	28.33	95.18	13.55%	574.86	63.09%	32.97
30.48	96.54	13.51%	537.84	58.05%	33.80	28.41	96.78	13.55%	582.37	62.86%	33.12
30.59	98.04	13.51%	544.47	57.86%	33.94	28.49	98.28	13.54%	589.56	62.65%	33.25
30.82	104.73	13.51%	566.29	56.34%	34.31	28.64	105.00	13.55%	613.22	61.00%	33.60
30.99	109.19	13.51%	580.83	55.42%	34.57	28.75	109.48	13.55%	628.98	60.02%	33.84
31.17	113.37	13.51%	596.17	54.78%	34.85	28.87	113.68	13.55%	645.61	59.33%	34.10
31.30	115.85	13.51%	605.98	54.49%	35.04	28.97	116.17	13.55%	656.26	59.01%	34.28
31.43	118.05	13.51%	614.92	54.25%	35.22	29.06	118.39	13.54%	665.95	58.75%	34.45
31.51	119.11	13.50%	618.41	54.07%	35.32	29.12	119.45	13.54%	669.73	58.55%	34.54
31.63	121.59	13.50%	626.53	53.65%	35.49	29.21	121.94	13.54%	678.55	58.11%	34.70
31.74	123.35	13.50%	634.01	53.51%	35.65	29.30	123.71	13.54%	686.67	57.95%	34.85
31.85	125.20	13.50%	641.79	53.36%	35.81	29.38	125.57	13.54%	695.10	57.79%	35.00
31.96	126.86	13.50%	648.98	53.23%	35.97	29.46	127.24	13.54%	702.90	57.66%	35.15
32.11	130.42	13.50%	660.57	52.71%	36.19	29.57	130.82	13.54%	715.47	57.09%	35.36
32.23	132.86	13.49%	668.54	52.36%	36.35	29.65	133.27	13.54%	724.12	56.71%	35.51
32.36	135.28	13.49%	678.18	52.15%	36.54	29.75	135.71	13.53%	734.58	56.49%	35.69
32.49	137.71	13.49%	687.83	51.95%	36.74	29.84	138.14	13.53%	745.05	56.28%	35.87
32.62	140.13	13.49%	697.47	51.76%	36.93	29.93	140.58	13.53%	755.51	56.07%	36.05
32.74	142.57	13.49%	705.42	51.46%	37.09	30.02	143.03	13.53%	764.14	55.74%	36.21
32.85	145.00	13.49%	713.37	51.16%	37.26	30.11	145.48	13.53%	772.77	55.42%	36.36
32.99	147.42	13.48%	723.00	50.99%	37.45	30.20	147.91	13.53%	783.22	55.23%	36.54
33.12	149.84	13.48%	732.63	50.82%	37.64	30.29	150.35	13.53%	793.67	55.06%	36.72

33.25	152.26	13.48%	742.26	50.66%	37.83	30.39	152.78	13.52%	804.12	54.89%	36.90
33.36	154.70	13.48%	750.20	50.40%	38.00	30.47	155.23	13.52%	812.74	54.60%	37.05
33.48	157.04	13.48%	757.85	50.15%	38.16	30.56	157.59	13.52%	821.04	54.33%	37.21
33.61	159.55	13.47%	767.76	50.00%	38.35	30.66	160.11	13.52%	831.79	54.17%	37.39
33.74	161.96	13.47%	777.37	49.86%	38.54	30.75	162.54	13.52%	842.23	54.02%	37.57
33.87	164.38	13.47%	786.98	49.72%	38.73	30.84	164.97	13.52%	852.66	53.87%	37.75
33.96	165.69	13.47%	791.30	49.60%	38.85	30.91	166.29	13.52%	857.36	53.74%	37.85
34.11	169.50	13.47%	803.70	49.24%	39.08	31.02	170.13	13.52%	870.81	53.35%	38.07
34.24	171.65	13.46%	812.43	49.14%	39.26	31.11	172.29	13.52%	880.30	53.25%	38.24
34.37	174.06	13.46%	822.04	49.02%	39.45	31.20	174.72	13.51%	890.72	53.12%	38.41
34.49	176.29	13.46%	831.06	48.93%	39.63	31.29	176.97	13.51%	900.52	53.02%	38.59
34.61	178.54	13.46%	838.39	48.73%	39.78	31.38	179.23	13.51%	908.48	52.81%	38.73
34.73	181.32	13.46%	847.45	48.50%	39.97	31.47	182.03	13.51%	918.32	52.55%	38.90
34.86	183.73	13.46%	857.04	48.40%	40.16	31.56	184.46	13.51%	928.74	52.44%	39.08
34.99	186.14	13.45%	866.63	48.30%	40.35	31.66	186.88	13.51%	939.15	52.34%	39.26
35.12	188.54	13.45%	876.21	48.20%	40.54	31.75	189.31	13.50%	949.56	52.23%	39.44
35.27	191.90	13.45%	887.13	47.94%	40.75	31.85	192.69	13.50%	961.41	51.96%	39.64
35.40	194.86	13.45%	896.75	47.72%	40.94	31.94	195.67	13.50%	971.86	51.72%	39.81
35.54	197.80	13.45%	908.05	47.60%	41.15	32.05	198.64	13.50%	984.13	51.59%	40.02
35.69	200.74	13.44%	919.34	47.48%	41.37	32.15	201.60	13.50%	996.39	51.46%	40.22
35.83	203.68	13.44%	930.63	47.36%	41.58	32.25	204.56	13.50%	1008.66	51.33%	40.42
35.96	206.63	13.44%	940.23	47.16%	41.77	32.34	207.54	13.50%	1019.09	51.11%	40.60
36.09	209.59	13.44%	949.83	46.97%	41.96	32.44	210.52	13.50%	1029.51	50.91%	40.77
36.24	212.52	13.44%	961.11	46.86%	42.18	32.54	213.47	13.50%	1041.77	50.79%	40.98
36.38	215.46	13.44%	972.38	46.76%	42.39	32.64	216.43	13.50%	1054.01	50.68%	41.18
36.53	218.39	13.43%	983.65	46.65%	42.61	32.74	219.39	13.49%	1066.26	50.57%	41.38
36.66	221.34	13.43%	993.23	46.48%	42.80	32.83	222.37	13.49%	1076.67	50.38%	41.56
36.79	224.29	13.43%	1002.81	46.30%	42.99	32.93	225.34	13.49%	1087.08	50.20%	41.73
36.93	227.22	13.43%	1014.07	46.21%	43.20	33.03	228.30	13.49%	1099.31	50.10%	41.93

37.08	230.15	13.43%	1025.32	46.12%	43.42	33.13	231.25	13.49%	1111.54	50.00%	42.13
37.22	233.08	13.42%	1036.57	46.04%	43.63	33.23	234.21	13.49%	1123.77	49.91%	42.34
37.35	236.02	13.42%	1046.14	45.88%	43.82	33.33	237.18	13.49%	1134.16	49.74%	42.51
37.48	238.97	13.42%	1055.69	45.72%	44.01	33.42	240.15	13.49%	1144.55	49.57%	42.69
37.63	241.89	13.42%	1066.93	45.64%	44.22	33.52	243.10	13.49%	1156.76	49.48%	42.89
37.77	244.82	13.42%	1078.17	45.56%	44.44	33.62	246.05	13.49%	1168.98	49.40%	43.09
37.88	246.35	13.41%	1084.97	45.55%	44.59	33.70	247.61	13.48%	1176.37	49.39%	43.23
37.99	248.63	13.41%	1092.37	45.44%	44.74	33.79	249.90	13.48%	1184.42	49.27%	43.38
38.07	249.61	13.41%	1095.63	45.39%	44.84	33.85	250.89	13.48%	1187.97	49.22%	43.48
38.24	253.42	13.41%	1109.71	45.28%	45.10	33.97	254.74	13.48%	1203.27	49.09%	43.71
38.40	257.23	13.41%	1123.78	45.16%	45.35	34.08	258.59	13.48%	1218.57	48.97%	43.95
38.57	261.04	13.40%	1137.84	45.05%	45.61	34.19	262.43	13.48%	1233.86	48.86%	44.19
38.73	264.87	13.40%	1150.21	44.88%	45.84	34.30	266.30	13.48%	1247.31	48.67%	44.41
38.88	268.70	13.40%	1162.58	44.72%	46.07	34.41	270.17	13.48%	1260.76	48.49%	44.62
39.05	272.50	13.40%	1176.63	44.62%	46.33	34.52	274.01	13.48%	1276.03	48.39%	44.86
39.22	276.30	13.40%	1190.67	44.52%	46.58	34.64	277.86	13.47%	1291.29	48.29%	45.10
39.38	280.11	13.40%	1204.70	44.43%	46.84	34.75	281.70	13.47%	1306.55	48.19%	45.34
39.54	283.93	13.40%	1217.04	44.28%	47.07	34.86	285.56	13.47%	1319.97	48.02%	45.55
39.69	287.76	13.40%	1229.38	44.13%	47.30	34.96	289.43	13.47%	1333.39	47.86%	45.77
39.86	291.56	13.39%	1243.39	44.04%	47.55	35.08	293.27	13.47%	1348.63	47.77%	46.01
40.09	297.71	13.39%	1264.92	43.87%	47.92	35.23	299.49	13.47%	1372.05	47.59%	46.34
40.27	302.54	13.39%	1282.87	43.78%	48.21	35.34	304.38	13.47%	1391.56	47.49%	46.61
40.34	303.84	13.39%	1287.78	43.76%	48.31	35.39	305.69	13.47%	1396.91	47.47%	46.71
40.44	306.15	13.39%	1295.95	43.70%	48.46	35.46	308.03	13.47%	1405.79	47.40%	46.85
40.61	308.39	13.38%	1303.05	43.61%	48.67	35.60	310.30	13.47%	1413.54	47.30%	47.06
40.74	310.67	13.38%	1312.21	43.58%	48.86	35.69	312.60	13.46%	1423.51	47.28%	47.23
40.86	312.94	13.38%	1321.37	43.56%	49.04	35.78	314.90	13.46%	1433.48	47.25%	47.40
40.98	315.24	13.38%	1328.84	43.48%	49.20	35.87	317.23	13.46%	1441.62	47.17%	47.55
41.09	317.54	13.38%	1336.31	43.40%	49.36	35.95	319.56	13.46%	1449.75	47.09%	47.70

41.22	319.81	13.37%	1345.46	43.38%	49.54	36.04	321.85	13.46%	1459.71	47.06%	47.87
41.34	322.08	13.37%	1354.61	43.36%	49.73	36.14	324.15	13.46%	1469.67	47.04%	48.05
41.47	324.35	13.37%	1363.75	43.34%	49.91	36.23	326.45	13.45%	1479.63	47.02%	48.22
41.58	326.64	13.36%	1371.21	43.26%	50.07	36.31	328.77	13.45%	1487.75	46.94%	48.37
41.70	328.94	13.36%	1378.67	43.19%	50.23	36.40	331.10	13.45%	1495.87	46.86%	48.52
41.82	331.20	13.36%	1387.80	43.17%	50.41	36.49	333.39	13.45%	1505.82	46.84%	48.69
41.95	333.47	13.36%	1396.94	43.15%	50.60	36.58	335.69	13.45%	1515.77	46.82%	48.86
42.08	335.73	13.35%	1406.07	43.13%	50.78	36.67	337.98	13.44%	1525.71	46.80%	49.04
42.19	338.02	13.35%	1413.51	43.06%	50.94	36.75	340.30	13.44%	1533.82	46.72%	49.19
42.29	340.05	13.35%	1420.11	42.99%	51.08	36.84	342.35	13.44%	1541.01	46.65%	49.33
42.41	342.04	13.35%	1428.38	42.98%	51.25	36.92	344.37	13.44%	1550.02	46.64%	49.49
42.53	344.03	13.35%	1436.66	42.97%	51.43	37.01	346.39	13.44%	1559.04	46.63%	49.65
42.65	346.02	13.34%	1444.93	42.96%	51.60	37.10	348.41	13.43%	1568.05	46.62%	49.81
42.76	348.04	13.34%	1451.52	42.90%	51.74	37.18	350.45	13.43%	1575.23	46.56%	49.95
42.86	350.06	13.34%	1458.10	42.84%	51.89	37.26	352.50	13.43%	1582.41	46.49%	50.09
42.98	352.05	13.34%	1466.37	42.83%	52.06	37.35	354.52	13.43%	1591.41	46.48%	50.25
43.08	353.15	13.33%	1471.82	42.84%	52.19	37.42	355.63	13.43%	1597.35	46.50%	50.37
43.17	354.25	13.33%	1477.26	42.86%	52.32	37.50	356.75	13.42%	1603.29	46.52%	50.49
43.25	355.38	13.33%	1481.37	42.83%	52.42	37.56	357.90	13.42%	1607.77	46.49%	50.59
43.32	356.52	13.32%	1485.47	42.81%	52.52	37.61	359.05	13.42%	1612.25	46.46%	50.68
43.41	357.62	13.32%	1491.26	42.83%	52.64	37.68	360.18	13.42%	1618.56	46.49%	50.80
43.50	358.72	13.32%	1497.05	42.86%	52.77	37.75	361.30	13.41%	1624.87	46.52%	50.92
43.59	359.83	13.32%	1502.83	42.88%	52.89	37.81	362.42	13.41%	1631.18	46.54%	51.04
43.66	360.96	13.31%	1506.94	42.86%	52.99	37.87	363.57	13.41%	1635.66	46.52%	51.13
43.74	362.09	13.31%	1511.04	42.83%	53.09	37.93	364.72	13.41%	1640.13	46.49%	51.23
43.83	363.19	13.31%	1516.82	42.86%	53.22	38.00	365.84	13.41%	1646.44	46.52%	51.34
43.92	364.29	13.31%	1522.61	42.88%	53.34	38.06	366.95	13.40%	1652.75	46.55%	51.46
44.00	365.39	13.30%	1528.39	42.90%	53.47	38.13	368.07	13.40%	1659.05	46.57%	51.58
44.08	366.52	13.30%	1532.49	42.88%	53.57	38.19	369.22	13.40%	1663.53	46.55%	51.67

44.17	368.45	13.30%	1539.12	42.84%	53.70	38.26	371.18	13.40%	1670.75	46.50%	51.80
44.28	370.35	13.30%	1547.43	42.84%	53.86	38.34	373.10	13.39%	1679.81	46.50%	51.95
44.39	372.24	13.29%	1555.74	42.84%	54.03	38.42	375.02	13.39%	1688.87	46.50%	52.11
44.50	374.13	13.29%	1564.04	42.84%	54.19	38.49	376.94	13.39%	1697.92	46.51%	52.26
44.60	376.06	13.29%	1570.66	42.80%	54.32	38.56	378.90	13.39%	1705.14	46.46%	52.39
44.69	377.98	13.29%	1577.28	42.75%	54.46	38.63	380.85	13.39%	1712.35	46.41%	52.52
44.80	379.87	13.28%	1585.58	42.75%	54.62	38.71	382.77	13.39%	1721.40	46.42%	52.67
44.91	381.76	13.28%	1593.88	42.76%	54.78	38.79	384.69	13.38%	1730.45	46.42%	52.82
45.02	383.65	13.28%	1602.18	42.76%	54.94	38.87	386.61	13.38%	1739.50	46.42%	52.97
45.12	385.57	13.28%	1608.79	42.71%	55.08	38.94	388.56	13.38%	1746.71	46.38%	53.10
45.22	387.49	13.27%	1615.40	42.67%	55.22	39.01	390.51	13.38%	1753.91	46.33%	53.23
45.32	389.37	13.27%	1623.69	42.67%	55.38	39.09	392.42	13.38%	1762.96	46.33%	53.38
45.43	391.26	13.27%	1631.99	42.68%	55.54	39.17	394.34	13.37%	1772.00	46.34%	53.53
45.57	394.24	13.27%	1643.78	42.65%	55.75	39.26	397.37	13.37%	1784.85	46.31%	53.73
45.70	397.27	13.26%	1653.88	42.58%	55.94	39.35	400.44	13.37%	1795.86	46.24%	53.90
45.82	400.29	13.26%	1663.97	42.51%	56.13	39.43	403.51	13.37%	1806.87	46.16%	54.08
45.96	403.27	13.26%	1675.75	42.49%	56.34	39.53	406.54	13.37%	1819.71	46.14%	54.28
46.09	406.27	13.26%	1688.22	42.48%	56.54	39.60	409.59	13.37%	1833.29	46.13%	54.46
46.21	409.26	13.26%	1700.69	42.48%	56.74	39.68	412.63	13.37%	1846.88	46.13%	54.65
46.32	412.30	13.26%	1711.47	42.43%	56.92	39.75	415.71	13.37%	1858.62	46.08%	54.82
46.43	415.33	13.25%	1722.24	42.38%	57.10	39.82	418.79	13.37%	1870.36	46.03%	54.98
46.56	418.32	13.25%	1734.70	42.38%	57.30	39.90	421.84	13.36%	1883.94	46.02%	55.17
46.68	421.31	13.25%	1747.15	42.37%	57.50	39.97	424.88	13.36%	1897.51	46.02%	55.36
46.81	424.30	13.25%	1759.60	42.36%	57.70	40.05	427.92	13.36%	1911.08	46.01%	55.54
46.92	427.33	13.25%	1770.35	42.32%	57.88	40.12	431.00	13.36%	1922.81	45.96%	55.71
46.99	429.03	13.25%	1776.93	42.30%	58.00	40.17	432.74	13.36%	1929.97	45.95%	55.82
47.08	430.70	13.24%	1785.18	42.33%	58.14	40.23	434.43	13.36%	1938.97	45.97%	55.95
47.17	432.36	13.24%	1793.44	42.35%	58.28	40.29	436.13	13.36%	1947.98	46.00%	56.08
47.26	434.02	13.24%	1801.69	42.37%	58.42	40.34	437.83	13.35%	1956.98	46.03%	56.21

47.34	435.73	13.24%	1808.25	42.36%	58.53	40.39	439.56	13.35%	1964.14	46.01%	56.32
47.41	437.43	13.24%	1814.82	42.34%	58.65	40.44	441.29	13.35%	1971.30	45.99%	56.42
47.50	439.09	13.23%	1823.07	42.37%	58.79	40.50	442.98	13.35%	1980.30	46.02%	56.55
47.59	440.75	13.23%	1831.32	42.39%	58.93	40.56	444.68	13.35%	1989.30	46.05%	56.69
47.68	442.40	13.23%	1839.57	42.41%	59.07	40.62	446.37	13.35%	1998.30	46.07%	56.82
47.70	441.90	13.23%	1839.16	42.44%	59.09	40.63	445.86	13.34%	1997.87	46.11%	56.83
47.68	440.08	13.22%	1834.59	42.51%	59.04	40.63	444.02	13.34%	1992.89	46.17%	56.79
47.67	438.22	13.22%	1831.70	42.61%	59.02	40.64	442.13	13.34%	1989.75	46.29%	56.77
47.67	436.36	13.22%	1828.81	42.71%	58.99	40.65	440.24	13.33%	1986.62	46.40%	56.75
47.66	434.50	13.21%	1825.92	42.81%	58.97	40.65	438.36	13.33%	1983.49	46.51%	56.73
47.65	433.99	13.21%	1826.77	42.88%	58.96	40.64	437.85	13.33%	1984.42	46.58%	56.72
47.55	430.14	13.21%	1817.04	43.03%	58.80	40.57	433.94	13.33%	1973.81	46.74%	56.57
47.46	426.24	13.21%	1809.00	43.22%	58.66	40.52	430.00	13.32%	1965.05	46.95%	56.44
47.28	420.34	13.20%	1796.50	43.52%	58.40	40.38	424.01	13.32%	1951.41	47.27%	56.20
47.18	415.69	13.20%	1785.38	43.72%	58.24	40.33	419.29	13.32%	1939.31	47.49%	56.05
47.05	411.11	13.20%	1773.96	43.92%	58.03	40.24	414.65	13.31%	1926.86	47.70%	55.85
46.91	406.53	13.20%	1762.53	44.12%	57.82	40.14	410.01	13.31%	1914.41	47.92%	55.66
46.79	401.92	13.19%	1752.79	44.37%	57.64	40.06	405.33	13.31%	1903.80	48.19%	55.49
46.67	397.30	13.19%	1743.05	44.63%	57.46	39.97	400.66	13.30%	1893.18	48.47%	55.32
46.55	392.69	13.19%	1733.31	44.89%	57.27	39.89	395.99	13.30%	1882.57	48.75%	55.14
46.41	388.12	13.19%	1721.86	45.11%	57.07	39.80	391.35	13.30%	1870.09	49.00%	54.95
46.27	383.54	13.19%	1710.41	45.34%	56.86	39.71	386.72	13.29%	1857.61	49.24%	54.76
46.15	378.94	13.18%	1700.65	45.62%	56.67	39.62	382.05	13.29%	1846.98	49.55%	54.59
46.03	374.33	13.18%	1690.89	45.91%	56.49	39.54	377.39	13.29%	1836.34	49.85%	54.41
45.95	371.39	13.18%	1686.44	46.14%	56.39	39.48	374.42	13.28%	1831.50	50.11%	54.31
45.83	367.22	13.18%	1676.23	46.38%	56.20	39.39	370.19	13.28%	1820.37	50.36%	54.14
45.70	363.04	13.17%	1666.01	46.62%	56.01	39.30	365.96	13.28%	1809.24	50.62%	53.96
45.59	358.84	13.17%	1657.50	46.91%	55.84	39.22	361.71	13.28%	1799.97	50.94%	53.80
45.48	354.63	13.17%	1648.98	47.21%	55.68	39.14	357.45	13.27%	1790.69	51.27%	53.65

45.37	350.43	13.17%	1640.46	47.52%	55.51	39.07	353.20	13.27%	1781.41	51.61%	53.49
45.32	349.11	13.16%	1639.35	47.67%	55.46	39.02	351.86	13.27%	1780.19	51.76%	53.44
45.27	347.78	13.16%	1638.24	47.81%	55.40	38.97	350.53	13.27%	1778.97	51.92%	53.38
45.22	346.46	13.16%	1637.12	47.96%	55.34	38.93	349.20	13.27%	1777.75	52.08%	53.33
45.15	345.18	13.16%	1634.30	48.06%	55.26	38.88	347.89	13.27%	1774.67	52.19%	53.25
45.06	343.96	13.17%	1628.06	48.06%	55.13	38.81	346.65	13.27%	1767.86	52.18%	53.13
44.95	342.77	13.17%	1620.11	48.00%	54.97	38.73	345.44	13.27%	1759.19	52.12%	52.98
44.84	340.58	13.17%	1610.78	48.04%	54.80	38.65	343.22	13.28%	1749.02	52.17%	52.81
44.72	338.39	13.18%	1601.45	48.08%	54.62	38.57	341.00	13.28%	1738.84	52.21%	52.65
44.60	336.20	13.18%	1592.11	48.13%	54.44	38.48	338.78	13.28%	1728.66	52.25%	52.48
44.47	334.05	13.18%	1581.06	48.12%	54.24	38.39	336.58	13.28%	1716.62	52.24%	52.30
44.33	331.89	13.19%	1570.02	48.10%	54.04	38.30	334.39	13.29%	1704.58	52.23%	52.11
44.22	329.69	13.19%	1560.67	48.15%	53.87	38.22	332.16	13.29%	1694.39	52.27%	51.94
44.10	327.72	13.19%	1552.03	48.18%	53.70	38.14	330.16	13.29%	1684.97	52.31%	51.79
44.00	326.18	13.20%	1544.80	48.19%	53.55	38.07	328.60	13.29%	1677.08	52.32%	51.65
43.89	324.68	13.20%	1535.85	48.15%	53.38	37.99	327.07	13.30%	1667.33	52.27%	51.49
43.77	323.17	13.20%	1526.91	48.11%	53.21	37.90	325.53	13.30%	1657.58	52.23%	51.33
43.67	321.63	13.21%	1519.67	48.12%	53.07	37.83	323.97	13.30%	1649.69	52.24%	51.19
43.57	320.09	13.21%	1512.43	48.13%	52.92	37.76	322.41	13.31%	1641.80	52.25%	51.05
43.45	318.58	13.22%	1503.48	48.09%	52.75	37.68	320.87	13.31%	1632.05	52.20%	50.89
43.34	317.07	13.22%	1494.54	48.05%	52.58	37.60	319.34	13.31%	1622.29	52.15%	50.74
43.24	315.53	13.22%	1487.29	48.06%	52.43	37.52	317.77	13.32%	1614.40	52.17%	50.60
43.14	313.98	13.23%	1480.05	48.07%	52.29	37.45	316.20	13.32%	1606.50	52.18%	50.46
43.04	312.44	13.23%	1472.80	48.08%	52.14	37.38	314.64	13.32%	1598.61	52.19%	50.32
42.92	310.92	13.23%	1463.85	48.04%	51.97	37.30	313.10	13.32%	1588.85	52.14%	50.16
42.81	309.40	13.24%	1454.90	47.99%	51.80	37.22	311.55	13.33%	1579.10	52.09%	50.00
42.71	307.86	13.24%	1447.66	48.00%	51.66	37.14	309.98	13.33%	1571.20	52.10%	49.87
42.60	306.31	13.24%	1440.41	48.02%	51.51	37.07	308.41	13.33%	1563.30	52.11%	49.73
42.50	304.76	13.25%	1433.16	48.03%	51.36	37.00	306.84	13.34%	1555.40	52.12%	49.59

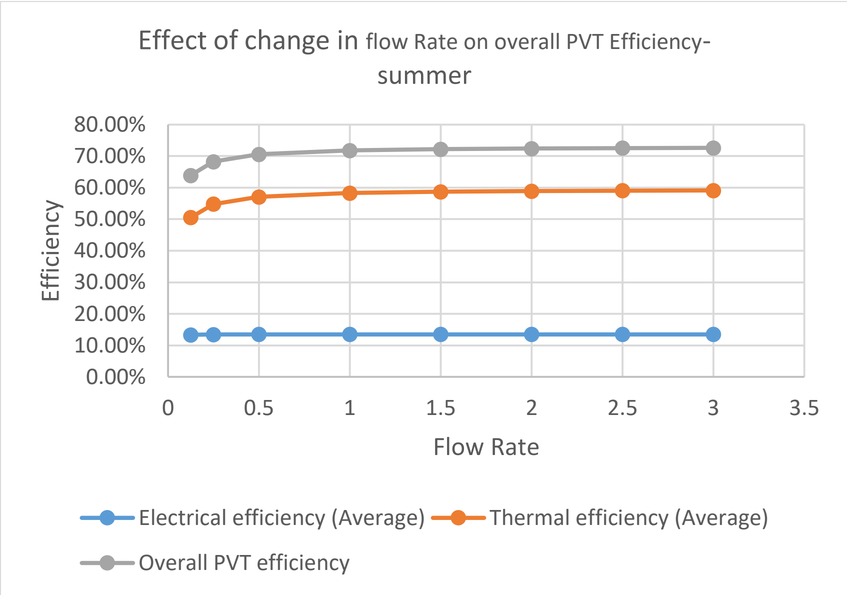
42.39	303.24	13.25%	1424.20	47.98%	51.19	36.91	305.30	13.34%	1545.65	52.07%	49.43
42.27	301.72	13.25%	1415.25	47.94%	51.02	36.83	303.75	13.34%	1535.89	52.02%	49.27
42.17	300.17	13.26%	1407.99	47.95%	50.88	36.76	302.18	13.35%	1527.99	52.03%	49.14
42.07	298.61	13.26%	1400.74	47.96%	50.73	36.69	300.60	13.35%	1520.08	52.05%	49.00
41.97	297.06	13.26%	1393.48	47.97%	50.59	36.61	299.03	13.35%	1512.18	52.06%	48.86
41.86	295.53	13.27%	1384.53	47.92%	50.41	36.53	297.48	13.35%	1502.42	52.00%	48.70
41.74	294.01	13.27%	1375.57	47.88%	50.24	36.45	295.93	13.36%	1492.67	51.95%	48.54
41.64	292.45	13.27%	1368.31	47.89%	50.10	36.38	294.35	13.36%	1484.76	51.96%	48.40
41.54	290.89	13.28%	1361.05	47.90%	49.95	36.31	292.78	13.36%	1476.85	51.97%	48.27
41.44	289.34	13.28%	1353.79	47.91%	49.81	36.23	291.20	13.36%	1468.94	51.98%	48.13
41.32	287.81	13.28%	1344.83	47.86%	49.64	36.15	289.64	13.37%	1459.18	51.93%	47.97
41.21	286.27	13.29%	1335.87	47.81%	49.46	36.07	288.09	13.37%	1449.43	51.87%	47.81
41.11	284.71	13.29%	1328.60	47.82%	49.32	36.00	286.51	13.37%	1441.51	51.89%	47.67
41.00	283.15	13.29%	1321.34	47.83%	49.17	35.92	284.93	13.38%	1433.60	51.90%	47.53
40.90	281.59	13.30%	1314.07	47.84%	49.03	35.85	283.34	13.38%	1425.69	51.91%	47.40
40.74	278.24	13.30%	1299.29	47.89%	48.77	35.74	279.95	13.38%	1409.61	51.95%	47.16
40.57	274.89	13.30%	1284.50	47.93%	48.51	35.64	276.56	13.38%	1393.52	52.00%	46.92
40.42	271.51	13.30%	1271.41	48.04%	48.28	35.54	273.14	13.38%	1379.27	52.12%	46.71
40.27	268.12	13.31%	1258.31	48.15%	48.05	35.44	269.72	13.39%	1365.02	52.24%	46.49
40.12	264.74	13.31%	1245.20	48.27%	47.82	35.34	266.30	13.39%	1350.76	52.36%	46.27
39.96	261.38	13.31%	1230.39	48.32%	47.56	35.23	262.90	13.39%	1334.66	52.41%	46.04
39.80	258.02	13.32%	1215.58	48.37%	47.31	35.12	259.50	13.39%	1318.55	52.47%	45.80
39.65	254.63	13.32%	1202.46	48.49%	47.08	35.02	256.08	13.39%	1304.28	52.60%	45.58
39.49	251.24	13.32%	1189.34	48.62%	46.85	34.92	252.65	13.39%	1290.01	52.73%	45.37
39.34	247.85	13.32%	1176.21	48.75%	46.61	34.82	249.23	13.40%	1275.73	52.87%	45.15
39.18	244.48	13.32%	1161.38	48.81%	46.36	34.71	245.82	13.40%	1259.60	52.93%	44.91
39.02	241.11	13.33%	1146.54	48.87%	46.10	34.60	242.41	13.40%	1243.47	53.00%	44.67
38.86	237.72	13.33%	1133.40	49.00%	45.87	34.50	238.99	13.40%	1229.18	53.15%	44.46
38.71	234.32	13.33%	1120.25	49.14%	45.64	34.40	235.56	13.40%	1214.88	53.30%	44.24

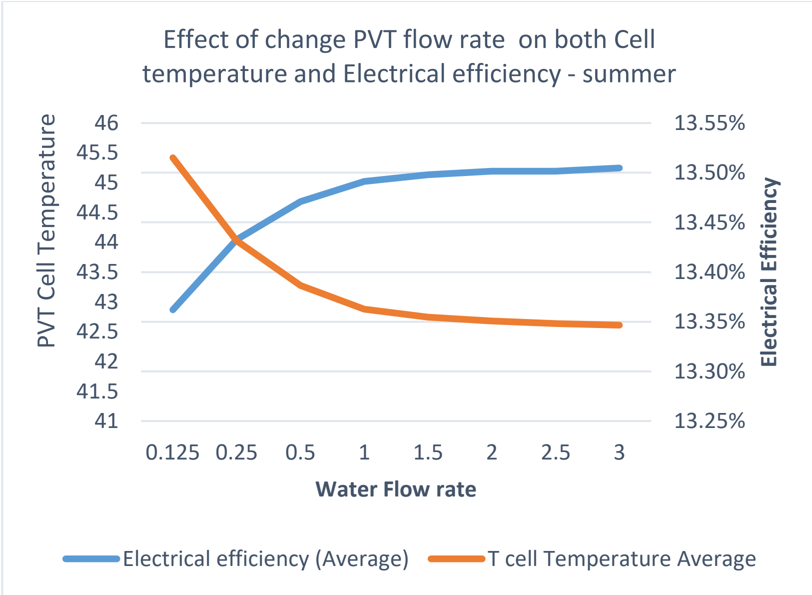
38.56	230.93	13.33%	1107.09	49.29%	45.40	34.30	232.13	13.40%	1200.58	53.45%	44.03
38.40	227.55	13.34%	1092.24	49.36%	45.15	34.20	228.72	13.40%	1184.43	53.53%	43.79
38.23	224.17	13.34%	1077.38	49.43%	44.89	34.09	225.30	13.41%	1168.28	53.61%	43.55
38.08	220.77	13.34%	1064.21	49.59%	44.66	33.99	221.87	13.41%	1153.97	53.77%	43.33
37.93	217.37	13.34%	1051.03	49.75%	44.43	33.89	218.44	13.41%	1139.65	53.94%	43.12
37.78	213.96	13.35%	1037.85	49.91%	44.19	33.79	215.00	13.41%	1125.32	54.12%	42.90
37.62	210.58	13.35%	1022.97	50.00%	43.94	33.68	211.59	13.41%	1109.15	54.21%	42.66
37.45	207.19	13.35%	1008.09	50.09%	43.68	33.57	208.17	13.41%	1092.98	54.31%	42.42
37.30	203.78	13.35%	994.89	50.27%	43.45	33.47	204.73	13.42%	1078.64	54.50%	42.20
37.15	200.38	13.35%	981.69	50.45%	43.21	33.37	201.29	13.42%	1064.30	54.70%	41.99
37.00	196.97	13.36%	968.49	50.64%	42.98	33.27	197.86	13.42%	1049.95	54.90%	41.77
36.83	193.57	13.36%	953.58	50.75%	42.72	33.16	194.43	13.42%	1033.76	55.01%	41.53
36.67	190.18	13.36%	938.67	50.86%	42.47	33.06	191.01	13.42%	1017.57	55.13%	41.29
36.52	186.76	13.36%	925.45	51.06%	42.23	32.96	187.57	13.42%	1003.21	55.35%	41.08
36.37	183.35	13.37%	912.23	51.28%	42.00	32.85	184.13	13.42%	988.84	55.58%	40.86
36.21	179.93	13.37%	899.00	51.50%	41.77	32.75	180.69	13.42%	974.47	55.82%	40.64
36.05	176.53	13.37%	884.07	51.63%	41.51	32.65	177.26	13.43%	958.26	55.96%	40.40
35.88	173.13	13.37%	869.14	51.77%	41.25	32.54	173.83	13.43%	942.04	56.11%	40.16
35.73	169.71	13.38%	855.89	52.01%	41.02	32.44	170.38	13.43%	927.66	56.37%	39.95
35.58	166.29	13.38%	842.64	52.27%	40.78	32.34	166.94	13.43%	913.27	56.65%	39.73
35.43	162.87	13.38%	829.39	52.53%	40.55	32.24	163.49	13.43%	898.88	56.93%	39.51
35.26	159.46	13.38%	814.43	52.70%	40.29	32.13	160.06	13.43%	882.64	57.11%	39.27
35.10	156.05	13.38%	799.47	52.87%	40.03	32.02	156.63	13.43%	866.40	57.30%	39.03
34.95	152.62	13.39%	786.20	53.17%	39.80	31.92	153.18	13.43%	852.00	57.62%	38.81
34.80	149.20	13.39%	772.93	53.48%	39.57	31.82	149.73	13.43%	837.59	57.95%	38.60
34.64	145.77	13.39%	759.65	53.80%	39.33	31.72	146.28	13.44%	823.17	58.30%	38.38
34.48	142.36	13.39%	744.67	54.01%	39.07	31.61	142.84	13.44%	806.92	58.53%	38.14
34.31	138.94	13.39%	729.69	54.24%	38.81	31.50	139.41	13.44%	790.65	58.77%	37.90
34.16	135.51	13.40%	716.39	54.61%	38.58	31.40	135.96	13.44%	776.23	59.17%	37.68

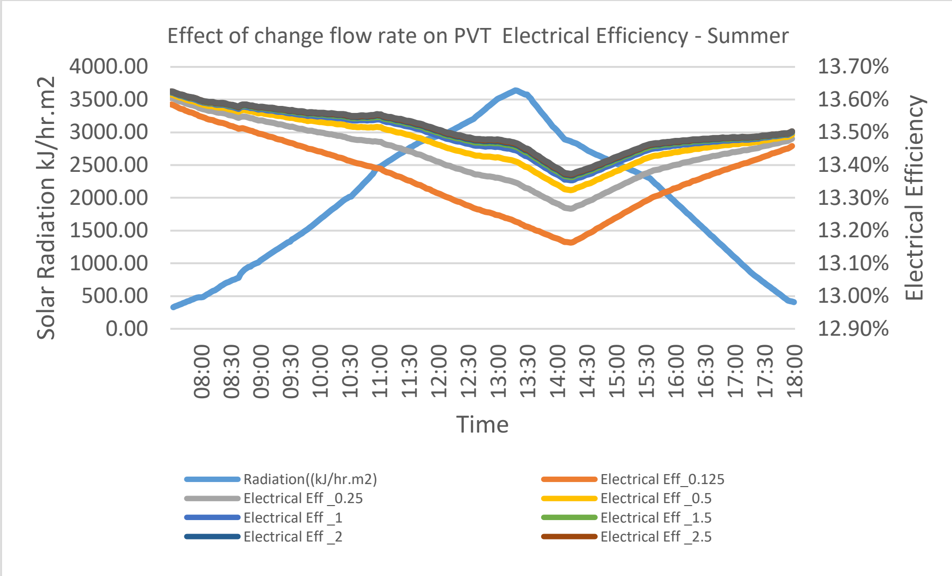
34.01	132.08	13.40%	703.09	54.99%	38.35	31.30	132.50	13.44%	761.79	59.58%	37.46
33.86	128.64	13.40%	689.78	55.40%	38.11	31.20	129.05	13.44%	747.35	60.02%	37.25
33.69	125.22	13.40%	674.78	55.68%	37.85	31.09	125.61	13.44%	731.07	60.33%	37.01
33.52	121.80	13.40%	659.77	55.99%	37.59	30.98	122.17	13.44%	714.79	60.65%	36.77
33.37	118.36	13.41%	646.45	56.45%	37.36	30.88	118.71	13.45%	700.34	61.16%	36.55
33.22	114.93	13.41%	633.12	56.95%	37.13	30.78	115.26	13.45%	685.88	61.70%	36.33
33.07	111.49	13.41%	619.79	57.48%	36.89	30.68	111.81	13.45%	671.42	62.26%	36.11
32.90	108.06	13.41%	604.76	57.87%	36.63	30.57	108.36	13.45%	655.12	62.69%	35.87
32.74	104.63	13.41%	589.73	58.30%	36.37	30.46	104.91	13.45%	638.82	63.15%	35.63
32.60	101.86	13.42%	578.56	58.76%	36.17	30.37	102.13	13.45%	626.70	63.64%	35.44
32.47	99.08	13.42%	567.39	59.24%	35.97	30.28	99.34	13.45%	614.58	64.17%	35.25
32.33	96.31	13.42%	556.21	59.76%	35.76	30.19	96.55	13.45%	602.46	64.73%	35.06
32.19	93.54	13.42%	543.34	60.11%	35.53	30.09	93.77	13.45%	588.50	65.11%	34.85
32.04	90.77	13.42%	530.47	60.49%	35.31	29.99	90.99	13.46%	574.54	65.52%	34.64
31.90	87.99	13.43%	519.28	61.10%	35.10	29.90	88.20	13.46%	562.41	66.17%	34.45
31.77	85.21	13.43%	508.09	61.74%	34.90	29.81	85.41	13.46%	550.28	66.86%	34.26
31.64	82.43	13.43%	496.90	62.42%	34.70	29.72	82.62	13.46%	538.14	67.60%	34.07
31.49	79.66	13.43%	484.01	62.93%	34.47	29.62	79.83	13.46%	524.17	68.15%	33.86
31.34	76.88	13.44%	471.12	63.48%	34.24	29.52	77.05	13.46%	510.20	68.75%	33.65
31.21	74.10	13.44%	459.92	64.31%	34.04	29.43	74.26	13.46%	498.06	69.64%	33.46
31.07	71.32	13.44%	448.71	65.20%	33.83	29.34	71.46	13.47%	485.91	70.60%	33.27
30.94	68.53	13.44%	437.50	66.16%	33.63	29.25	68.67	13.47%	473.75	71.64%	33.08
30.79	65.75	13.44%	424.60	66.93%	33.40	29.15	65.88	13.47%	459.77	72.48%	32.87
30.64	62.97	13.45%	411.70	67.78%	33.17	29.05	63.09	13.47%	445.78	73.39%	32.65
30.51	60.19	13.45%	400.47	68.99%	32.97	28.96	60.30	13.47%	433.62	74.70%	32.46
30.37	57.40	13.45%	389.25	70.32%	32.77	28.87	57.50	13.47%	421.46	76.14%	32.28
30.24	54.61	13.45%	378.02	71.79%	32.56	28.78	54.71	13.47%	409.29	77.73%	32.09
30.14	53.70	13.45%	371.24	71.73%	32.42	28.71	53.79	13.48%	401.94	77.66%	31.96
30.04	52.78	13.46%	364.46	71.66%	32.29	28.64	52.87	13.48%	394.59	77.58%	31.82

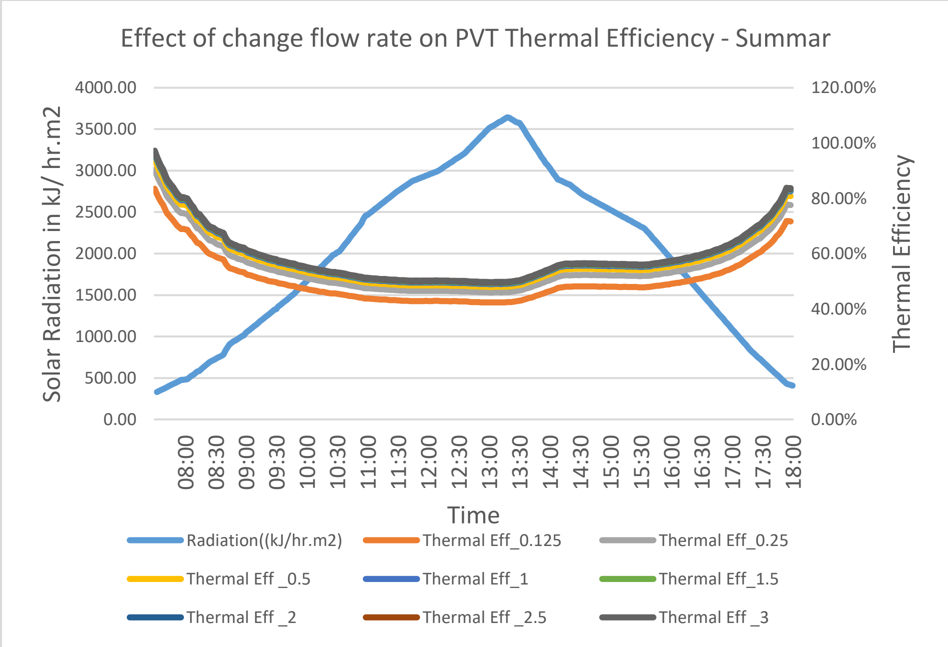
Average	13.36%		50.53%	45.42
Max	13.58%		83.43%	59.09

Average	13.43%		54.79%	44.03
Max	13.60%		90.28%	56.83





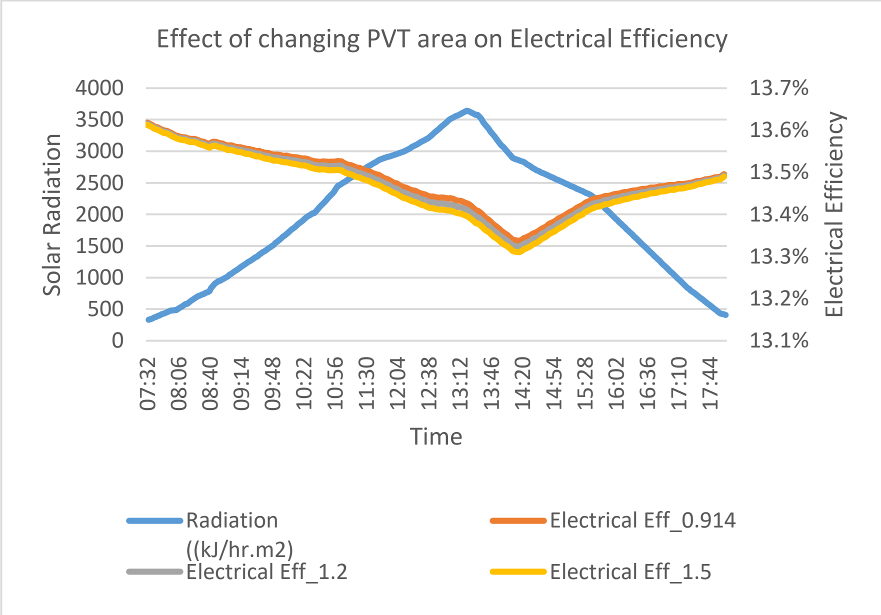

Effect of change flow rate on PVT Electrical Efficiency - Summer
Solar Radiation kJ/hr.m2
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Electrical Efficiency
13.70%
13.60%
13.50%
13.40%
13.30%
13.20%
13.10%
13.00%
12.90%
08:00
08:30
09:00
09:30
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
Time
Radiation((kJ/hr.m2)
Electrical Eff_0.125
Electrical Eff _0.25
Electrical Eff _0.5
Electrical Eff _1
Electrical Eff _1.5
Electrical Eff _2
Electrical Eff _2.5

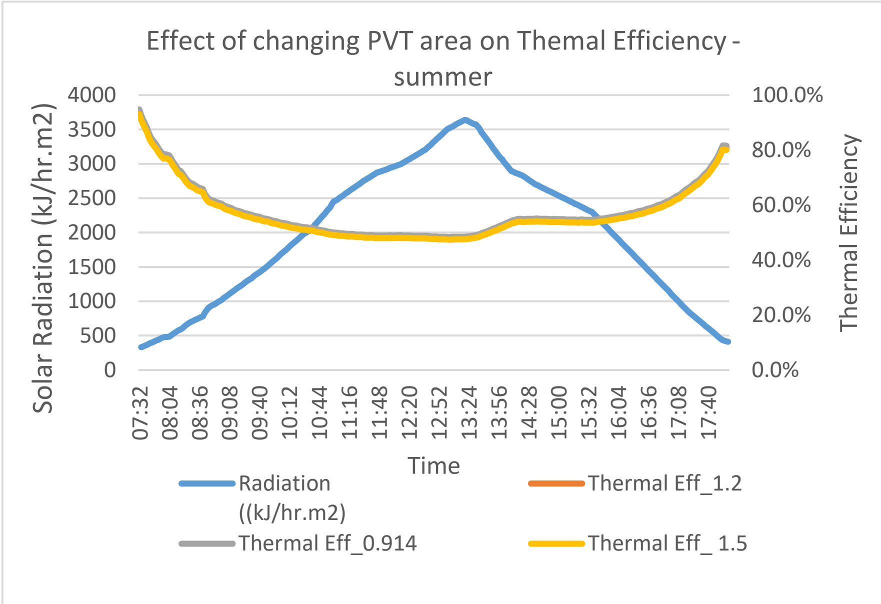


Effect of change flow rate on PVT Thermal Efficiency - Summar
Solar Radiation in kJ/ hr.m2
Thermal Efficiency
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
08:00
08:30
09:00
09:30
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
Time
Radiation((kJ/hr.m2)
Thermal Eff_0.125
Thermal Eff_0.25
Thermal Eff _0.5
Thermal Eff_1
Thermal Eff_1.5
Thermal Eff _2
Thermal Eff _2.5
Thermal Eff _3

5- Simulation Results for changing PVT area:

Area m^2	Electrical efficiency (Average)	Thermal efficiency (Average)	T cell Temperature Average	T cell Temperature Maximum	Overall PVT efficiency
0.914	13.48%	57.65%	43.1	55.30	71.13%
1.2	13.47%	57.10%	43.3	55.60	70.57%
1.5	13.46%	56.55%	43.5	55.89	70.02%




Effect of changing PVT area on Themal Efficiency - summer
Solar Radiation (kJ/hr.m2)
4000
3500
3000
2500
2000
1500
1000
500
0
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Thermal Efficiency
07:32
08:04
08:36
09:08
09:40
10:12
10:44
11:16
11:48
12:20
12:52
13:24
13:56
14:28
15:00
15:32
16:04
16:36
17:08
17:40
Time
Radiation ((kJ/hr.m2)
Thermal Eff_1.2
Thermal Eff_0.914
Thermal Eff_ 1.5