Implementation of Geothermal Cooling to Prevent CPVT Overheating When Used for Building Heating, Electrical Generation and Hot Water Supply

Mehrdad Khademy [1,*]

1- Independent Researcher
*Corresponding Author: Khademy_mehrdad@outlook.com

ABSTRACT
A solar-powered photovoltaic thermal concentration (CPVT) system will be installed in a Tehran, Iran, house to provide the occupants with hot water and space heating, and this study will examine the resulting energy usage. The CPVT system employs triple-junction solar cells and linear Fresnel concentrators (LFCs). To boost electricity generation, a geothermal cooling system was proposed. The EES brings together the many LFC simulation models. Auxiliary heaters are offered in case solar energy is insufficient. The usage of thermal energy storage (TES) tanks is offered as a remedy in the event of an excess of solar thermal. Here, we test out a setup where concentrated thermal collectors are used instead of a geothermal cooling system. We also look into the use of triple-junction photovoltaic thermal technology (PVT). TRNSYSY is used to do transient simulations of such systems. The proposed system generates 4.44 MWh of electricity, which is sufficient to meet 47.1% of the building's energy needs. As 47 percent of the solar energy is transformed into thermal energy and 12 percent into electrical energy, this system achieves an efficiency of 59 percent. The existing system in fig. 1 provides 92.12 percent of the thermal energy for the building's municipal hot water demands and accounts for 32.61 percent of the required heating energy. The study's power is sold at a premium, and only 23.37 percent of the thermal energy produced by the CPVT system will be utilised.
Keywords: Renewable energy, Trigeneration, Concentrating photovoltaic thermal, Economic evaluation, Single-effect absorption chiller.

1. INTRODUCTION

Shortly after the advent of industrialization, there was a tremendous shift in how people throughout the globe used energy [1]. Plant photosynthesis energy was used or stored as coal or oil before the industrial revolution, maintaining a balance between energy generation on Earth and energy consumption. After the industrial revolution, humans altered the equilibrium by drawing on stored energy at a rate faster than it could be replenished. In spite of this, scientists began referring to fossil fuels like coal and oil as "non-renewable energy sources" not long after. However, the first renewable energy sources to deliver mechanical energy were waterwheels and windmills. The capacity of selenium cells to create electricity was nevertheless reported by William Grylls Adams as the first modern form of renewable energy generation in the world in 1876 [2]. After that, we'll turn to other renewable energy sources to meet our needs. However, these systems were shelved due to high upfront costs until data emerged in favor of Svante Arrhenius's theory that "human activity, carbon dioxide imitations will cause global warming." Manifested [3]. Solar energy, in contrast to other alternative energy sources, is widely accessible worldwide.

Solar thermal and solar electrical (PV) collectors are the two most common technologies for harnessing the sun's rays to produce usable energy. When compared to PV collectors, solar thermal energy generation is more attractive [4] due to its cheap cost equipment and high performance solar thermal collectors. Concentrating units are added to this system to make it even more cost-effective. Concentrating solar thermal collectors are less expensive and produce greater temperatures than the standard design. Comparing the PV system to the concentrating solar thermal system, Quaschning found that the concentrating solar thermal system generated energy at a 17% higher efficiency rate [5]. Combining photovoltaics (PV) with thermal collectors (PVT) is another strategy suggested to increase the efficiency of solar energy systems. Both electrical and thermal energy are present in this system as a whole [6]. In order to increase the electrical efficiency of photovoltaic cells, it is necessary to decrease their temperature by harvesting the thermal energy of the PVT system [7]. Combining the benefits of concentrating and PVT systems into a single structure, CPVT not only provides electrical and high-quality electrical energy, but also does it at a cheaper cost owing to the reduced absorber plate of the collector [8]. Higher cell temperatures and decreased electrical efficiency result from the high quality of thermal energy in a CPVT system. CPVT systems may benefit from the use of triple-junction solar cells [9], since their efficiency is less likely to fluctuate with changes in temperature.

Since the thermal energy generated by CPVT structures is of such high quality, it may be utilized to run a wide range of devices. The CPVT is based on the premise that it can generate not only thermal and electrical energy, but also hydrogen, cooling, drying, and so on. The cooling capabilities of a CPVT were investigated by Mittelman et al. Based on the results of this study, using CPVT electricity for the cooling system may be just as effective as using the conventional method, and in certain cases can even save money. [10]. Another study evaluating a CPVT-powered water desalination system was undertaken by Mittelman et al. According to the study's overview, CPVT systems are more efficient than traditional ones and consistently outperform other forms of solar systems when used to this distillation process. The team at Buonomano and colleagues model the HVAC system of a building in the region around Italy. This simulation proposes a concept for a bank of single-stage LiBr-H2O absorption chillers powered by PVT and focusing solar thermal energy. According to the results of this analysis, the suggested design generates more than enough power to fulfill the needs of the building itself [12]. Horvat et al. investigated the feasibility of using a solar-powered trigeneration system to supply homes. According to the study's findings, installing this technology in a European building might lessen that continent's reliance on imported power. Solar photovoltaic thermal mechanism modeling was investigated by Deymi-Dashtebayaz et al., and it included the use of a concentrator in addition to a heat pump. The modeling results are validated by laboratory data collected in Mashhad, Iran, where the experiments are being conducted. This study found that increasing the flow rate of the nanofluid lowered the temperature of the solar panel and the fluid output, which increased the thermal and electrical productivity while lowering the exergy efficiency of the system [14]. Calise et al. have also looked at the thermo-economic benefits of the trigeneration system. The energy needs of their system are met by a combination of solar, biomass, and geothermal sources. This building generates heat, cold, and power. In this investigation,

electricity is produced by the use of an organic Rankine cycle as well. TRNSYS software has been used for this study. Naples, in southern Italy, is where the research is being conducted. In addition to conserving energy by 139%, the authors claim that this system would also create excess energy, resulting in a payback time of 19 years [15]. Leonforte et al. have reported research on a unique heat pump framework design that is powered by a solar photovoltaic thermal collector. A domestic building's cooling, heating, and hot water needs have been met by this system. The results of this study show that the thermal and electrical efficiencies of the collector and the heat pump's performance over the year have both increased. In these circumstances, there is also less power being transferred to and from the system. The authors argue that their technique can be used to create carbon-neutral homes [16]. Chen et al. showed how to optimize a CPVT cogeneration system to meet the energy needs of an office building while also considering environmental and economic factors. The most notable findings from this research are an increase in energy performance of 41.4% and an increase in negative ecological consequences of 41.7%, respectively. 62% of the heating, 54% of the cooling, and just 30% of the electrical energy needs of the building are met by the suggested system [17].
The current research evaluates a polygeneration solar system installed on an Iranian home west of Tehran. Concentration photovoltaic thermal (CPVT) structures are studied here, with a linear Fresnel reflector (LFC) serving as a model for the concentration unit. Furthermore, the geothermal cooling system is modeled to evaluate how adding this component will change the CPVT's ability to generate heat and electricity. TRNSYS is tied to EES so that transient simulation may take place by using the EES to build the code for the specified models. The TRN-build module of TRNSYS dynamically simulates the house. The first step in answering this question is figuring out whether or not the solar system can provide enough energy to the building for it to be termed sustainable. The second goal is to contrast the proposed system with more traditional buildings. The framework that is being presented incorporates many types of solar collectors, and evaluations of the various designs are made.
Methodology

2. AN OVERVIEW OF THE PROPOSED CONCEPT

The purpose of the proposed structure is to provide heating and hot water power requirements for a residential building as well as power for the utility using solar energy. The proposed system includes solar reflectors that concentrate sunlight onto the absorber plate of collectors. The absorber plates included photovoltaic panels affixed to a thermal absorber plate. In a thermal absorber plate configuration, ten tubes are integrated beneath a plate used to convey thermal energy to a solar working fluid. The mechanism's electrical output is offered to the grid, while the solar system's thermal output is converted to heating cycles based on the building's energy requirements. The proposed heating cycle is employed to provide thermal energy for air conditioning and hot water for the building. Four auxiliary gas-fired boilers are incorporated into the outlet hot water and outlet working fluid to the air-conditioning system to provide the necessary energy when the solar system is insufficient. It is presumed that a geothermal cooling system will dissipate excess energy of the CPVT system to prevent overheating. The solar cycle's thermal energy is routed to a geothermal refrigeration system in order to maintain the CPVT pannell's operating temperature. In the event that solar energy is insufficient, an additional gas-powered heater will be activated. Fig. 1 depicts a structural diagram of this system.

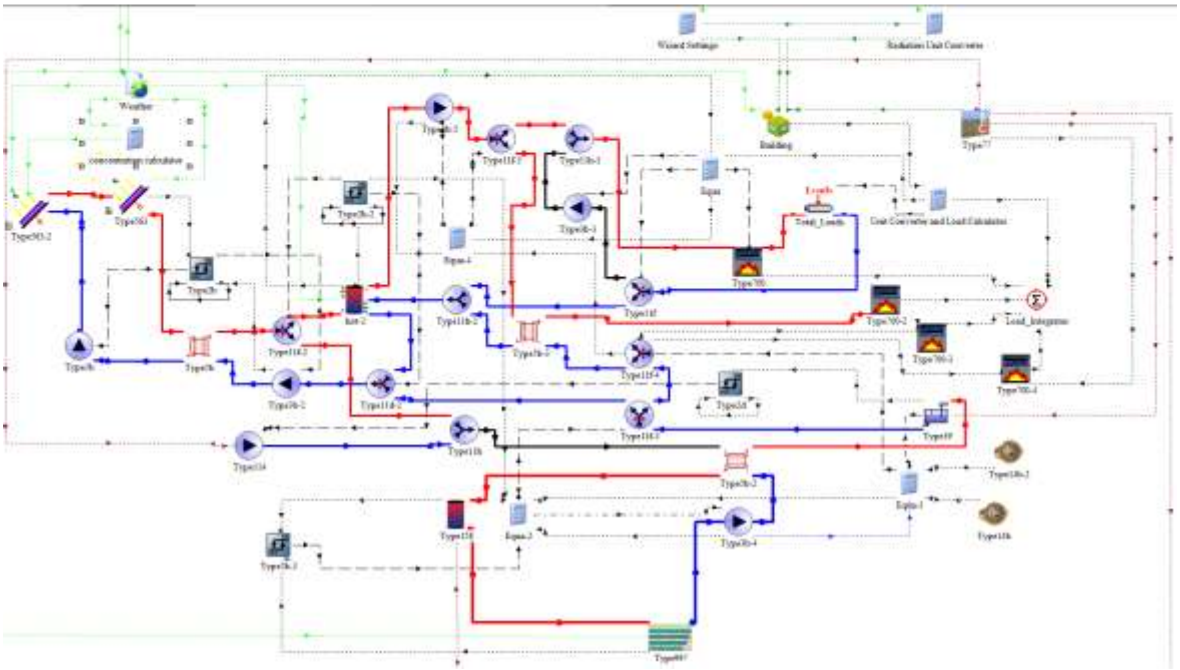

Fig. 1. System configuration diagram for the proposed system in TRNSYS 18

The system's concentrating component is the Linear Fresnel Concentrator (LFC). Table 1 presents the specifications for adopted LFC. For this mechanism, two LFC are implemented. Due to the length of the mirror, two absorber series are contemplated for the LFC. The absorbers of the LFC are comprised of a thermal absorber plate and a photovoltaic panel with multiple junction solar cells. The parameters of multijunction solar cells are presented in Table 2. The thermal absorber plate material under consideration is aluminum nitride with a heat transmission conductivity of 1116 [kJ hr m K]. Table 3 displays the characteristics of the fluid that drives the solar cycle. This system employs heat exchangers with a total heat transfer capacity of 700 W/K.

Table 1. LFC module properties [18]

Parameter	Length (m)	Width (m)	Height receiver (m)	Standard optical efficiency	Mirror width (m)	Mirror length (m)	Concentration (sun)
Value	3.6	5.0	2.72	0.95	0.25	1.3	15

Table 2. solar photovoltaic module properties [19]

Parameter	Type	Efficiency (%)	Temperature efficiency modifier (1/°C)	Radiation efficiency modifier (1/kW)	Absorption coefficient (%)	Conductivity coefficient (W/m K)
Value	triple-junction	15.8	0.002	0.0074	92	167

Table 3. The solar working fluid properties.

Parameter	Type	Operating temperature range (K)	Thermal conductivity (kj/m.K)	Density (kg/m3)	Heat capacity (W/kg-K)
Value	DURATHERM 450	248 to 505	0.5076	844	0.6111

In the proposed structure, there are two storage containers. Fig. 1's containers 1, 2, and 3 are thermal energy storage tanks with a 5 cm polyurethane foam insulation and a constant volume. The thermal resistance of this insulating layer for the storage containers is 1.92 m2K/W [20]. The number three underground water supply reservoir is a variable-volume storage facility.
Three auxiliary heaters are used to provide energy when solar energy is insufficient. These auxiliaries are gas-fired heaters with water as working fluid.
This study investigates a 110-square-meter, three-meter-tall, single-story residential structure. A family of four resides in this building with a level roof. Two family members work from 6 to 14 hours per day, five days per week. Table 4 presents the characteristics of the building's construction materials. This building is estimated to have a ventilation rate of 0.4 per hour, and the ideal winter and summer temperatures are 24 and 26 degrees Celsius, respectively.

Table 4. Parameters of the building components [23]

	External wall	Roof	Floor
Materials	1. Plaster 1.27 cm 2. Brick 10.16 cm 3. Plaster 1.27 cm	1. Asphalt 0.25 cm 2. Concrete 7.62 cm 3. Cement block 20.32cm 4. Plaster 1.27 cm	1. Plaster 1.27 cm 2. Cement block 20.32cm 3. Concrete 10.16 cm 4. Tile 2.54 cm
U-value (W/m2K)	3.8	1.9	0.34
Weight (kg/m2)	385	337	340

Energy evaluation of concentrating unit and absorption chiller
Using the following equation, one is able to determine the amount of incident energy from the sun that the linear Fresnel reflector is generated on a receiver.

$$G_{PVT} = \eta_{Opt}.I_b.IAM_{LFC}.C_{LFC} \quad (1)$$

Where GPVT, ηOpt, Ib, IAMLFC, and CLFC, are incident solar radiative, optical efficiency, beam radiation, LFC incidence angle modifier, and concentration ratio of LFC, respectively. Bellos and Tzivanidis developed the following equations to calculate the LFC incidence angle modifier [24].

$$IAM_{LFC} = K_T(\theta_T).K_L(\theta_L) \quad (2)$$

Where θT, θL, KT, and KL are transversal solar incident angle, longitude solar incident angle, transversal incident angle modifier, and longitudinal incident angle modifier,

respectively.
The proposed longitudinal incident angle modifier of LFC is:

$$K_L(\theta_L) = -\frac{F}{L}\sqrt{1+\left(\frac{W}{4F}\right)^2}.\sin(\theta_L) \;\; +\cos(\theta_L) \tag{3}$$

Where F, L, and W are focal length, LFC length, and the center and the last mirror of LFC distance, respectively.
The proposed Transversal solar incident angle modifier of LFC is:

$$K_T(\theta_T) = \begin{cases} \cos\left(\frac{\theta_T}{2}\right) - \frac{\frac{W}{4}}{F+\sqrt{F^2+\left(\frac{W}{4}\right)^2}}\sin\left(\frac{\theta_T}{2}\right) \\ \left[\cos\left(\frac{\theta_T}{2}\right) - \frac{\frac{W}{4}}{F+\sqrt{F^2+\left(\frac{W}{4}\right)^2}}\sin\left(\frac{\theta_T}{2}\right)\right].\frac{D_w}{W_0}\;.\frac{\cos(\theta_T)}{\cos\left(\frac{\theta_T+\varphi_m}{2}\right)} \end{cases} \tag{4}$$

Where Dw, and W0 are LFC reflectors distance, and LFC each mirror width.
φm position angle of the LFC mirrors is:

$$\varphi_m = 2\arctan\left(\frac{\frac{W}{4}}{F+\sqrt{F^2+\left(\frac{W}{4}\right)^2}}\right) \tag{5}$$

θT,crit critical transversal solar angle, after which shading effects starts is:

$$\theta_{T,crit} = 94.46 - 2.519.\lambda - 55.71.\lambda^2 - 0.48.\varphi_i + \frac{1.77\varphi_i}{1000} + 1.15.\lambda.\varphi_i \tag{6}$$

Where λ is the width to the distance ratio of the LFC mirror.
It is possible to express transversal and longitudinal incidence angles as a function of solar zenith and azimuth angles using the following formula:

$$\theta_T = \arctan(|\sin(\gamma_s)|.\tan(\theta_z)) \tag{7}$$
$$\theta_L = \arctan(\cos(\gamma_s).\tan(\theta_z)) \tag{8}$$

Where γs, and θz are the solar azimuth and zenith angles, respectively.

A system with a hot water storage vessel, as shown in fig. In this circumstance, one storage vessel is added to the faucet hot water system.

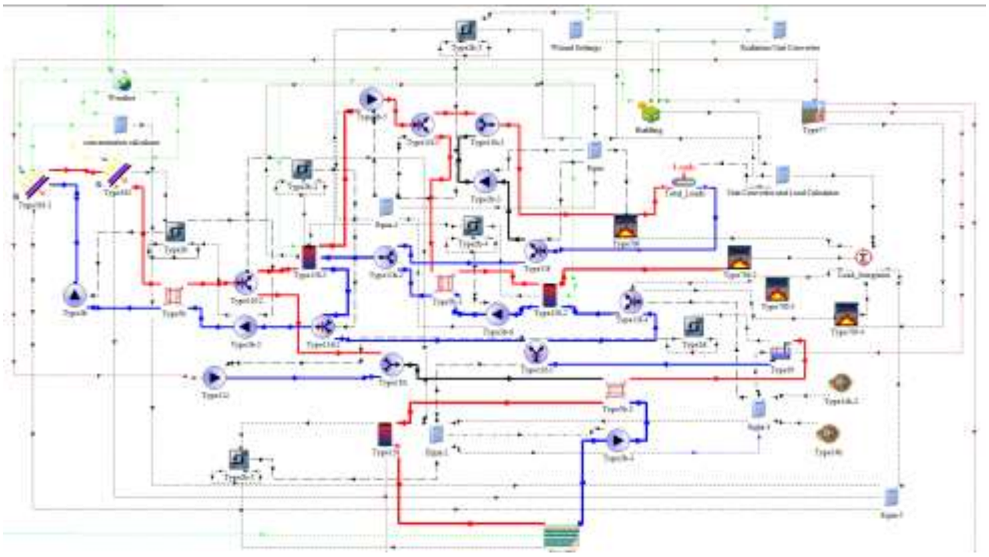

Fig. 2. System configuration diagram with a hot water storage vessel for the proposed system in TRNSYS 18

3. SIMULATION

The TRNSYS is a well recognized renewable energy softer evaluation for the transitory situation that is applied for research and commercial purposes [29]. The explanation behind the energy assessment of the building is provided by the adaptation of the SketchUp design building inside the TRNSYS.

Initial circumstances for the system are weather readings supplied by the Type15-2 modeling inquorate. Type15-2 has Tehran's climate as its input standard. Eq. 1–8 return concentrated solar radiation on the unit of area and are used in a transfer code for modeling LFC with solar beam radiation, incident angle, solar zenith, and azimuth angles. The LFC requirements provide the necessary parameters for the used equation. The PVT component of the system is represented by a Type 563 model. A PV module, synthetic oil, and a heat absorber all come together to form this part. When input temperature and radiation are given, the CPVT system's Type 563 provides electrical power and temperature outputs. The pumps in the system are modeled using an altered Type3b. There are three TES because of the short duration of solar cycles. Type158 represents the 0.5 m3 capacity of these containers. The ephemeral nature of solar energy necessitates backup systems, such as auxiliary heaters, to provide the necessary energy for the structure. This component was modeled after Type700. The lifespan of a closed loped system is longer than that of an open lope system. Because of this, heat exchangers are used to partition off certain sections of complex systems. Type5b inquiry modeling is used to simulate the proposed system's counter-flow heat exchangers. For home use, we go with a Type39 subterranean storage tank of 1 m3 capacity.

4. RESULTS AND DISCUSSIONS

validation

Validation is necessary to confirm the accuracy of models used to represent system circumstances. The model validation is divided into the building model, the LFC model, and the Concentrated solar tri-generation model since there are three primary parts of the understudied system for which reliable research findings are accessible. Table 5 shows a comparison between the current modeling results and those of Baneshi and Maruyama's study[25], demonstrating the reliability of the accepted model for building assessment. From this table of data, we may infer that the existing model for the building's energy use is correct, as most of the discrepancies result from the difference in the chosen weather data.

Table 5. The present model of building energy demand compared to Baneshi and Maruyama's research [25]

	Peak cooling load (kW)	Peak heating load (kW)	Total cooling load (kWh)	Total heating load (kWh)
Reference value [25]	2.3	3.0	3080	6120
Study value	2.4	3.1	3387.4	6362.3
Divergence	4%	3%	9%	4%

Both longitudinal and transverse incidence angle modifiers play a significant role in the LFC's model. Manufacturers of LFCs often include both longitudinal and transverse incidence angle adjusters. Figure 3 displays the LFC model and manufacturer information supplied in Famiglietti and Lecuona's [18] study. According to this graph, the level of agreement between the present model and the reference data is rather remarkable.

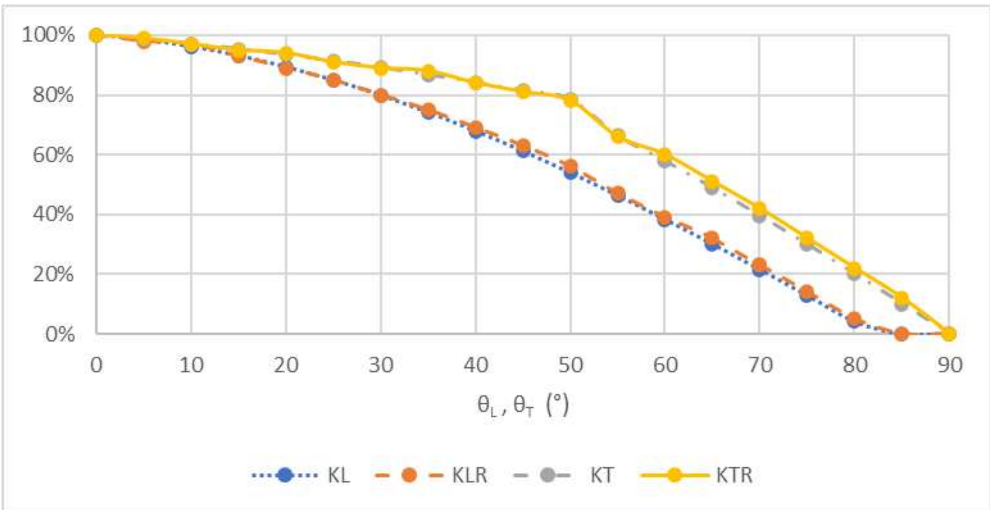

Fig. 3. The transversal and longitudinal incidence angle modifiers of this investigation were compared with the values that Famiglietti and Lecuona had obtained [18]

After the CPVT is isolated from the HVAC system and regular PV cells are used in place of the more expensive triple-junction solar cells, Moaleman et al.'s [22] planned design is realized. By adjusting the remaining system parameters to match those used by Moaleman et al., Table 6 displays a comparison between the current simulation and Moaleman et al. This table shows that the suggested model for the absorption chiller and LFC agrees well with the one used in the cited study.

Table 6. comparison of overall energy generation of the proposed model for Moaleman et al. system with their data [22]

	Electrical energy production	Thermal energy production	Cooling energy production
Reference value [22]	2290 (kWh)	6528 (kWh)	3944 (kWh)

Study value	2423.5 (kWh)	6835.6(kWh)	4018.8 (kWh)
Divergence	6%	4%	2%

The proposed system's energy performance

To prevent influence from the beginning circumstances, the heating energy needed to keep a structure comfortable all year is shown in fig. 4. The annual heating energy demand for the building is about 2.29*107 kj/hr, with the peak demand occurring in the cooling system auxiliary at 7:00 AM on January 13th, at around 1.13*104 kj/hr.

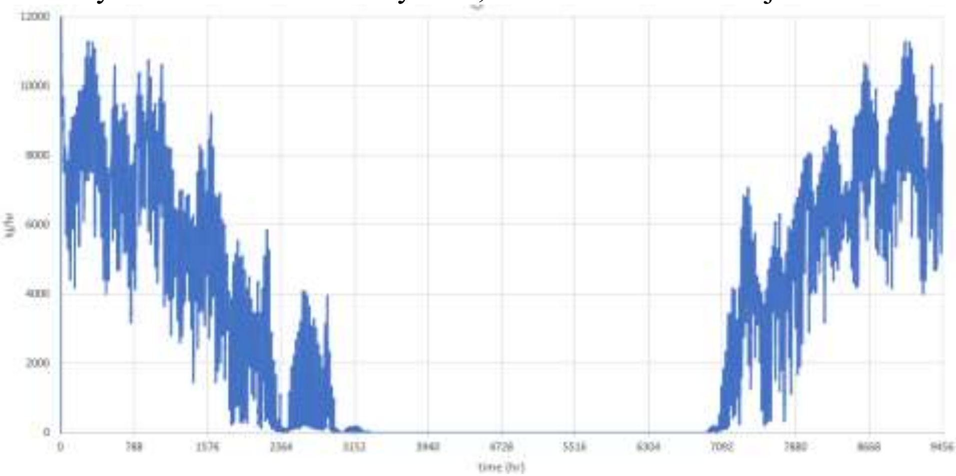

Fig. 4. Annual Heating Energy Demand for a Building

Figure 5 shows the yearly electrical output of PV panels, with one extra month added to account for variation in beginning circumstances. At 11:32 AM on March 23rd, peak demand in the cooling system auxiliary accounts for roughly 1.38*104 kj/hr of the baced system's yearly electrical energy output of about 1.6*107 kj/hr. The CPVT unit's ability to generate energy is sensitive to the absorber plate and beam radiation temperatures. The CPVT's absorber plate temperature is determined by the sun's rays, but only in a roundabout way. Electrical and thermal energy output peak in the summer, as predicted by the design of the system.

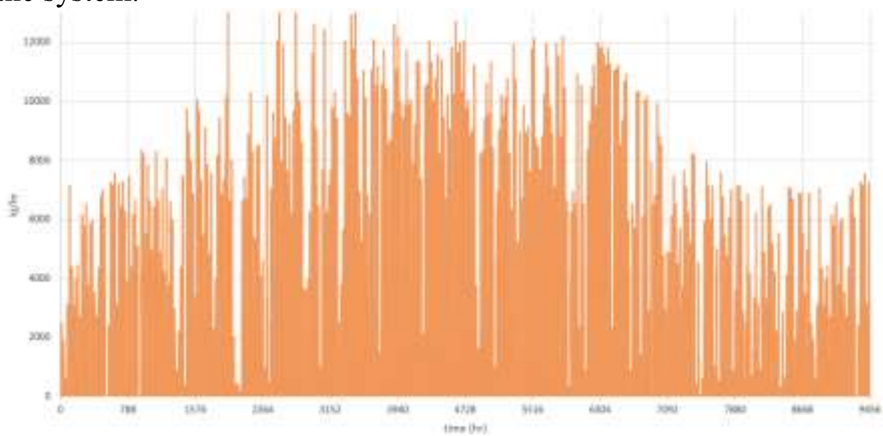

Fig. 5. The system's yearly electrical energy generation.

Thermal energy production from CPV to the fluid passing through the solar collector over the course of a year is seen in Figure 6; one additional month was added to account for differences in initial conditions. On July 12 at 10:30 a.m., the cooling system auxiliary uses around 5.41*104 kj/hr of the annual electrical energy production of about 6.11*107 kj/hr generated by the baced system.

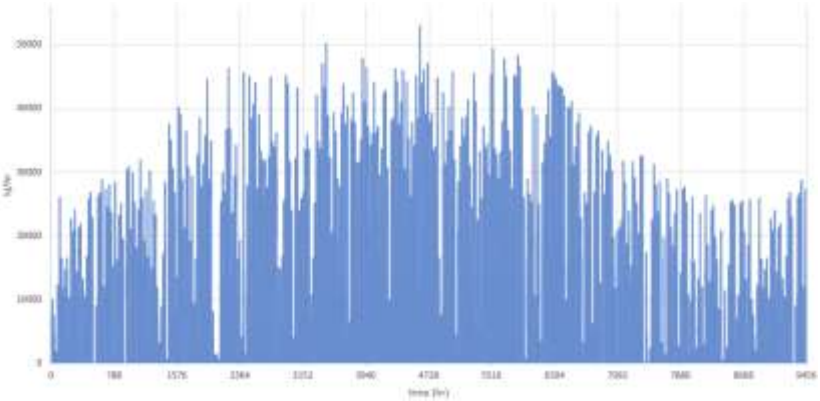

Fig. 6. The fluid in the solar collector receives the annual thermal energy output of the system.

Auxiliary heaters are used to meet energy demands because of the time lag between thermal energy generation and consumption. Since the system's thermal energy relies so heavily on the beam radiation and so relatively on the surrounding temperature, and since these parameters acted unfavorably toward the more thermal energy productions of the CPVT system in the winter when the most thermal energy was required, auxiliary heaters play crucial roles in keeping the building and the tap water at comfortable temperatures. Figure 7 depicts the supplementary heating energy supply used to maintain comfortable indoor temperatures. At 7:00 a.m. on January 13, about 1.13*104 kj/hr of the yearly electrical energy output of approximately 1.55*107 kj/hr is used by the cooling system's auxiliary.
Given that the solar thermal energy supplied to the building is insufficient to meet all the thermal energy requirements for this purpose, supplementary heaters were taken into account in this work; one for the building heating system, and another for the tap water heating, as shown in Fig. 8. At 16:30 on December 20, the cooling system's auxiliary will have used roughly 1.63*104 kj/hr of the building's annual electrical energy production of about 5.77*105 kj/hr.
Table 7 shows the system's energy evaluation. Overall, the current fig. 1 system is 59 percent efficient because it converts 47 percent of solar energy into thermal energy and 12 percent into electrical energy. The current fig. 1 system accounts for 32.61 percent of the needed energy for heating the building and delivers 92.12 percent of the thermal energy for the building's municipal hot water needs. It's important to point out that the study's electricity is sold at a premium and that only 23.37 percent of the CPVT system's thermal energy will be used.
system fig. 2 is shown in table 8. It turns 45.94% of solar energy into thermal energy and 12% into electrical energy, making it 57.94% efficient. The existing system, shown in fig. 1, provides 99.49% of the thermal energy for the building's municipal hot water demands and accounts for 20% of the required heating energy. Not only will only 19.81% of the thermal energy produced by the CPVT system be consumed, but electricity generated by the study is sold at a premium.
Case 1 PVT is produced horizontally, while Case 2 PVT is constructed at a 45 degree angle, and their respective data sets are analyzed in Table 9. situation that applies. It converts 10% of the sun's rays into usable heat and the remaining 6.37 percent into electricity, for an overall efficiency rating of 16.37%. Case 1 of the present system meets 62.27 percent of the building's thermal energy needs for municipal hot water but supplies zero percent of the necessary heating energy. Even if the study's electricity generation is sold at a premium, only 45.36 percent of the thermal energy produced by the CPVT system will be used. The second scenario is. It converts 11.49 percent of solar energy into usable electricity and 8.04

percent into usable heat, for an overall efficiency rating of 49.53 percent. Case 2 of the present system meets all of the building's municipal hot water needs (86%) but supplies zero of the necessary heating energy (0%). The CPVT system will only use 49.64% of the thermal energy it generates, and the electricity it produces will be sold for more than it's worth.

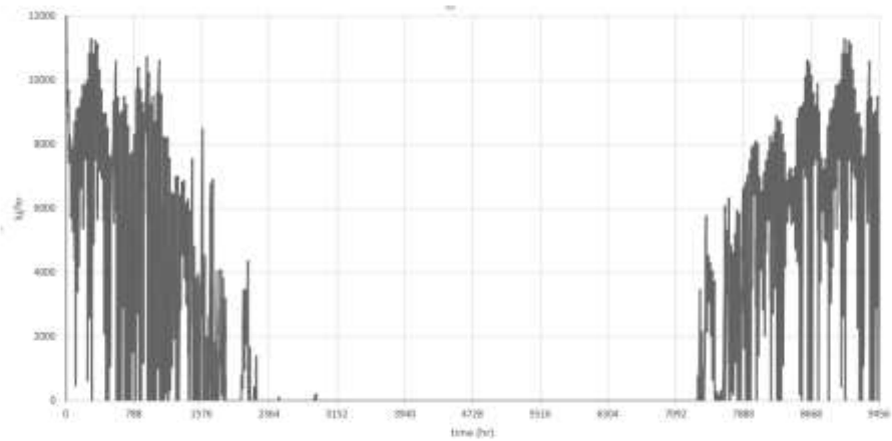

Fig. 7. Annual energy production from a building's supplementary heater.

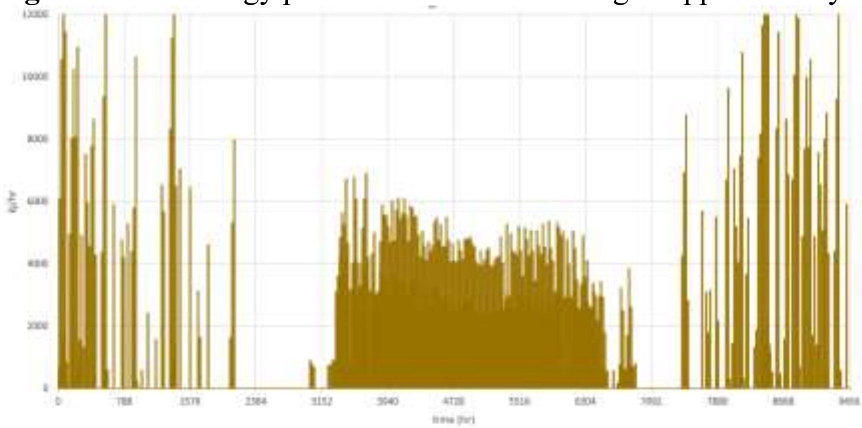

Fig. 8. Annual energy production from a tap water's supplementary heater

Table 7 . shows the system's energy evaluation fig1.

	Heating Energy Demand for a Building	Required auxiliary heater for the Building heating	Heating Energy Demand for a tap water	Required auxiliary heater for the tap water heating	electrical energy generation of CPVT	thermal energy output of CPVT	Solar energy
KW	6.37*103	4.29*103	2.05*103	1.60*102	4.44*103	1.70*104	3.62*104

Table 8 shows the system's energy evaluation fig2.

	Heating Energ	Required auxilia	Heating Energ	Required auxili	electrical energy	thermal energy	Solar energy

	y Demand for a Building	ry heater for the Building heating	y Demand for a tap water	ary heater for the tap water heating	generation of CPVT	output of CPVT	
KW	6.36*103	5.09*103	2.05*103	1.04*10	4.28*103	1.67*104	3.62*104

Table 9 shows the system's energy evaluation fig2 for CPVT and two PVT systems.

KW	Heating Energy Demand for a Building	Required auxiliary heater for the Building heating	Heating Energy Demand for a tap water	Required auxiliary heater for the tap water heating	electrical energy generation of CPVT	thermal energy output of CPVT	Solar energy
CPVT	6.36*103	5.09*103	2.05*103	1.04*10	4.28*103	1.67*104	3.62*104
Case 1	6.36*103	6.36*103	2.05*103	7.74*103	4.47*103	2.82*103	4.42*104
Case 2	6.36*103	6.36*103	2.05*103	2.87*102	5.08*103	3.56*103	4.42*104

table 10 represent a comparative assessment of the CPVT system of fig 2 and case 3 using thermal collector instead of PVT collector and case 4 eliminating geothermal heat exchanger. The overall efficiency of the existing case3 system is 55.74 percent due to the fact that it transforms just zero percent of solar energy into electrical energy. The existing case 3 system provides 98.99 percent of the thermal energy required to meet the building's municipal hot water demands, and 17.91% of the total heating energy required. Note that only 15.70% of the thermal energy produced by the CPVT system will be consumed, and that electricity generated by the study is sold at a premium. The current case4 system is only 39.41% efficient since it only converts 5.23% of solar energy into electricity. The present case 4 system delivers 19.72% of the total heating energy needed and 98.79% of the thermal energy needed to fulfill the building's municipal hot water needs. The study's power is sold at a premium, and only 26.51 percent of the thermal energy produced by the CPVT system will be used.

Table 10 shows the system's energy evaluation fig2 for CPVT and case 3 and 4.

KW	Heating Energy Demand for	Required auxiliary heater for the	Heating Energy Demand for	Required auxiliary heater for the	electrical energy generation of CPVT	thermal energy output of	Solar energy

	a Building	Building heating	a tap water	tap water heating		CPVT	
CPVT	6.36*103	5.09*103	2.05*103	1.04*10	4.28*103	1.67*104	3.62*104
Case 3	6.36*103	5.22*103	2.05*103	2.08*10	0.00	2.02*104	3.62*104
Case 4	6.36*103	5.11*103	2.05*103	2.48*10	1.90*103	1.24*104	3.62*104

Case 5: Integrating a parallel CPVT and comparing it to the fig2 setup in table 11. Since only 11.60% of solar energy is converted into electrical energy, the total efficiency of the current case5 system is just 57.21%. The current case 5 system supplies 24.96 percent of the total heating energy needed in the building, and 98.79 percent of the thermal energy needed to fulfill the municipal hot water needs of the building. Keep in mind that the research will only use 10.96% of the thermal energy created by the CPVT system, and that the electricity generated will be sold for more than it was costed to manufacture.

Table 11 shows the system's energy evaluation fig2 for CPVT and case 3.

KW	Heating Energy Demand for a Building	Required auxiliary heater for the Building heating	Heating Energy Demand for a tap water	Required auxiliary heater for the tap water heating	electrical energy generation of CPVT	thermal energy output of CPVT	Solar energy
CPVT	6.36*103	5.09*103	2.05*103	1.04*10	4.28*103	1.67*104	3.62*104
Case 5	6.36*103	4.77*103	2.05*103	1.70*10	8.40*103	3.30*104	7.24*104

5. CONCLUSION

In this research, a solar polygeneration system is analyzed. The proposed system includes a geothermal cooling system with concentrating photovoltaic thermal collectors to increase system efficiency and generate both electrical energy and thermal energy to sell back to the grid. A linear Fresnel reflector coupled with triple-junction solar cells is presented as the concentration system for collectors. There are gas-powered backup heaters in the system. The heat from the system is used directly to heat the structure. The EES is used to carefully plan and program the LFC's mathematical models. Using TRNSYS, the team recreated a building in the western part of Tehran, Iran, where people live. The model of the system is verified by comparing it to earlier research. Finally, energy efficiency and cost effectiveness of the system are studied. The most notable findings from this research are as follows:

• With triple-junction solar cells, the proposed CPVT achieves a mean thermal efficiency of 47% and a mean electrical efficiency of 16%.

• The suggested idea of CPVT has a total efficiency that is 4% greater than concentrated thermal collector and 40% higher than PVT with highly-efficient cells.
• The suggested idea of CPVT has a total energy output that is 4% greater than concentrated thermal collector and 65% higher than PVT with highly-efficient cells.
• The suggested CPVT for the system results in a 39% decrease in the building's energy consumption. However, CPVT without a geothermal cooling system reduces these needs by 39%, whilst concentrated thermal collectors reduce them by 37%, and highly effective PVT cells reduce them by 15.2%. This is true independent of the power output of any individual system.
• The system's anticipated CPVT generates 4.28*103 watt-hours of electricity. The proposed system generates 1.45*103 kWh, whereas the CPVT without the geothermal cooling system generates 1.90*103 kWh, an increase of 225%.

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