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RESEARCH NOTE

Performance Study of a Solar Integrated Central Heating System of a Residential Building using TRNSYS-An Hourly Simulation Model

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ABSTRACT

The performance of an existing heating system of a residential building incorporated with an array of solar thermal collectors was studied. For this purpose, transient systems simulation program model was assembled to estimate the hour-by-hour performance of the existing and the system equipped with the solar thermal collectors in terms of the provided space air conditions and energy consumption. In the modified heating system, the capability of the three standard types of solar collectors, namely, unglazed, glazed painted absorber, and evacuated tube liquid flat-plate solar collectors for providing required heating energy into the space was examined to determine the most appropriate configuration. Based on the simulation results, the system incorporated with the solar thermal collectors was capable of providing the desired indoor air conditions for four and five months of the year. However, the energy performance of the plants indicated that the existing system incorporated with the glazed painted absorber solar collectors (Plant B) has the priority in terms of the energy savings while it could provide the desired indoor air conditions for five months of the year and it is recommended to be implemented in the existing central heating system.

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NOMENCLATURE

q_u	Useful energy delivered by collector (W)
A_C	Total aperture collector area (m^2)
I_T	Irradiance, total (direct plus diffuse) solar energy incident (W/m^2)
τ	Transmittance
α	Absorptance
U_L	Overall heat loss coefficient ($W/(m^2.K)$)
t_a	Atmospheric temperature ($^\circ C$)
F_R	Collector heat removal efficiency factor
t_i	Temperature of fluid entering collector ($^\circ C$)
θ	Incident angle
$K_{\tau\alpha}$	Incident angle modifier

Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
DBT	Dry bulb temperature ($^\circ C$)
EWT	Entering water temperature ($^\circ C$)
EAT	Entering air temperature ($^\circ C$)
LWT	Leaving water temperature ($^\circ C$)
LAT	Leaving air temperature ($^\circ C$)
LF	Load factor
RH	Relative humidity (%)
TMY	Typical meteorological year
TRNSYS	Transient system simulation software

1. INTRODUCTION

Iran as a Middle East country ranks among the world's top four holders of hydrocarbon resources such as oil and natural gas. However, regarding the newly imposed energy pricing rates in order to actualize the prices of energy carriers, the exploitation and implementation of renewable energy resources and technologies have been strongly considered by the designers and engineers. Although Iran has many potential renewable energy resources, renewable energies hold an insignificant share in the total Iran's energy production basket. For instance, in 2007 renewable energies had 0.17% share in

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the total country energy production [1]. Therefore, Renewable Energy Organization of Iran has planned to impose a strategic policy for the country's renewable energies under the fourth five-year national development plan [2]. In this plan, the activities related to renewable energies are being supported. Based on the Iran's fourth national development plan, the production of 500 MW of electric power from the renewable energy resources, i.e. 1% of the country's energy, had been planned by the end of 2009 [3]. In another projection, Iran has determined to supply 10% of its electric power demand from the renewable resources by 2025 [3].

The statistics indicate that building sector almost consumes 40% of the total energy consumption and it has a considerable share in the energy basket of the country [4]. Therefore, the building sector as a key energy consumer make the policy makers, designers, and engineers to find new measures and technologies to tackle this problem by application of the renewable energy technologies such as solar thermal collectors.

Improvements in solar panel's technology have made the solar energy more popular than before as a renewable energy resource [5, 6], and many studies have already been conducted [7-14]. The economic feasibility for application of solar thermal collectors for selected cities with different climates in Iran was studied by Keyanpour-Rad et al. [7]. To this end, proper economic criteria and a life time of 25 years for capital investment were considered and life cycle savings analysis method was used for evaluations. The study indicated that the priority for use of solar energy for buildings is in accordance of their life cycle savings. Based on the study, the investment in solar hot air and water in some of studied regions, up to some collector's area, was recommended. In another study, the application of solar air collectors for buildings heating was investigated for central parts of Iran, Isfahan [10]. For this purpose, the heating loads for a residential building were calculated and the vented thermal storage wall was designed. Then, the amount of annual energy saving was estimated. The study showed that by application of the considered system more than 60% of winter energy consumption could be saved. An interconnected heat pipe solar collector was designed and fabricated to study the working condition by Azad [14]. The heat transfer was examined using an analytical method and results were compared with those obtained through theoretical analysis. The study showed that increasing collector efficiency can be achieved by increasing the number of heat pipes in the collector with only minimal increase in cost. In addition, it was found that using a selective surface instead of anodized matt black paint or the use of alternative materials would improve the collector performance.

Iran is located on the world's Sun Belt and has a considerable potential to implement the solar energy related technologies. Iran benefits 2800 sunny hours in a year, which could increase up to 3200 hours in the central parts of the country [15, 16]. The mean solar insulation is estimated as 2000 $kWh/m^2 year$ [3]; therefore, Iran has a favorable weather conditions for the establishment of solar energy technologies. Figure 1 shows Iran solar map.

Solar energy for residential buildings normally is used for power generation, hot water supply and air space heating. Power and hot water supply have been considered and many installations around the country have been performed. However, the application of solar energy for air space heating was not considered so far in the country significantly. Moreover, research studies based on the Typical Meteorological Year (TMY) weather data are limited and virtually none.

To this end, this study is conducted and the feasibility of application of solar collectors for space air heating was investigated. Normally studies in this field has been performed in dry and hot areas of the country; however, this study considers the Northwest of the country, i.e. Azerbaijan region, which receives relatively less solar radiation in comparison with other areas, (see Figure 1). For this purpose, a residential building located in Azerbaijan region was chosen as the case study and the effect of solar thermal collectors was examined on the space air conditions and energy consumption. This study enables the effect of solar thermal collectors on the heating system of the buildings to be estimated realistically as a possible justification to retrofit the solar thermal collectors in the buildings space heating system.

2. RESEARCH METHODOLOGY

The major aim of the present research is to determine the effect of array of solar thermal collectors on the existing central heating system of a residential building in terms of provided indoor air conditions and energy consumption.

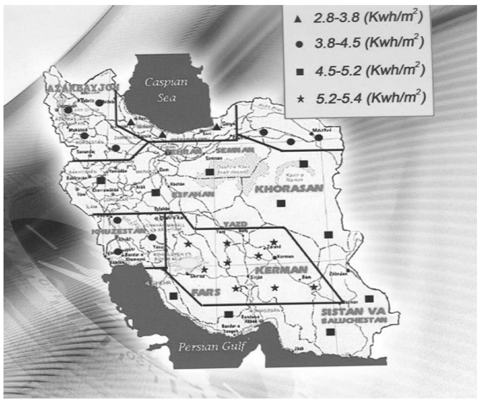


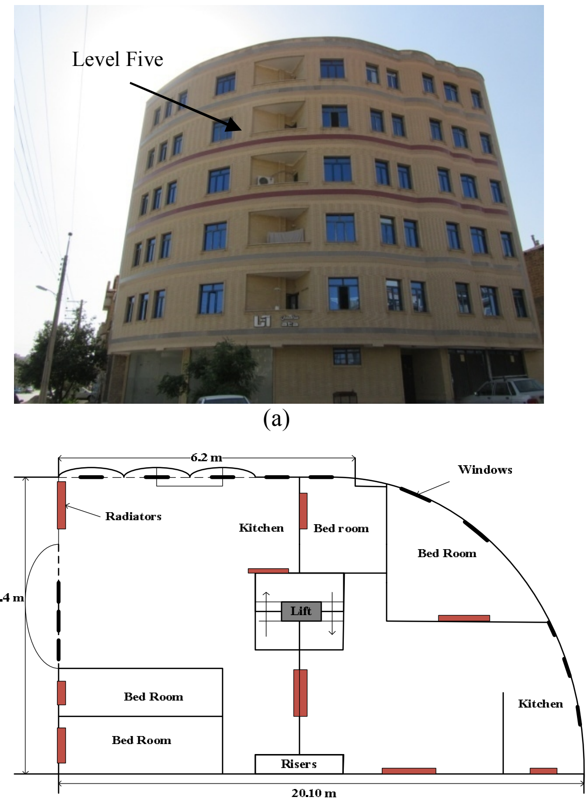
Figure 1. Solar energy map of Iran [3]

To this end, the existing operating heating system and the system added with the array of solar thermal collectors were simulated using TRNSYS software to determine the energy savings. Building architectural and internal conditions, TMY weather data of the region and mathematical performance of the solar thermal collectors were obtained and used for the simulation purposes. TRNSYS simulation software, which is a transient system simulation software for the transient simulation of the systems in buildings, was used for hour-by-hour simulation of the system performance in this research [17]. The components of the systems are assembled in the TRNSYS studio and the software recognizes the description language in which the user defines the equipment and the manner in which the components are connected. The present study is categorized into three sections. In section 3, the existing system is simulated using TRNSYS to understand the existing heating system performance in terms of provided indoor air conditions and energy consumption. Then, section 4 will describe the hourly responses of the system equipped with the array of solar thermal collectors. More details regarding the simulations are presented in sections 3 and 4. Results and discussion will be represented in section 5.

3. EXISTING SYSTEM STUDY

At first, the existing central heating system of the building was studied to estimate the impact of solar thermal collectors on the energy performance of the existing heating system. Level five of a residential building in Orumieh, Azerbaijane-garbi province, Iran was chosen as the case study and the field study was conducted (see Figure 2). Azerbaijan region, which is located in Northwest of Iran, can be considered as the one of the coldest regions of the country. Figure 3 illustrates the monthly mean temperature of the region and total solar radiation, respectively.

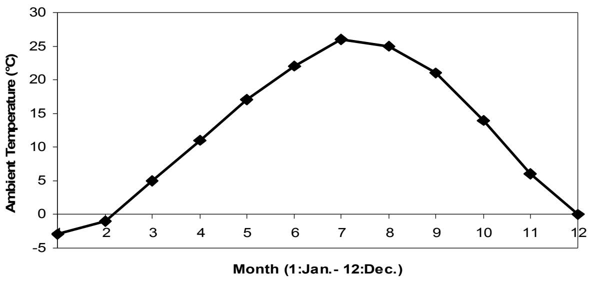
3. 1. Existing System Simulation in TRNSYS To simulate the existing heating system in TRNSYS studio, operational principles and technical specifications of the equipment as well as the internal conditions of the considered space should be obtained. The building was considered as a single thermal zone and internal and architectural conditions of the building was considered to define the building as Type 56a. The heating elements of the space were normal radiator fins and every single fin provided 157 W of heating energy based on the supplier technical data. A total number of 156 fins were operating in the space. In order to have an efficient heating system, the standard heating performance of the radiators was modified. This was achieved by replacing the radiators with a heating source as a user defined component (Type 281). This component provided an energy efficient supply of heating energy into the space while established the minimum recommended indoor air conditions. A load factor parameter, which varied from 1 to 0.05, was defined for this purpose. Figure 4 shows the simulation layout of the existing system. The TRNSYS components and functions are tabulated and described in Table 1. The system performance was studied for the months, whose temperatures were less than that required for the human thermal comfort. These months are January, February, March, April, May, October, November, and December (see Figure 3(a)). According to the ASHRAE recommendations [18], space design temperature and relative humidity (RH) are recommended to be within 21-23 $^{\circ}C$ and 20-30%, respectively. Figure 5 illustrates the monthly simulation data for the space temperature and RH for March as the representative of the simulated data. According to the simulation results, the mean space temperature and RH are 21.5$^{\circ}C$ and 22.5%, which was provided under the load factor of 0.35. The performance of the existing system in terms of the energy consumption were also estimated for the simulated months and tabulated in Table 2. Based on the simulation results, the existing heating system consumes a total amount of 5,099.53 kWh energy within the eight months of operating.



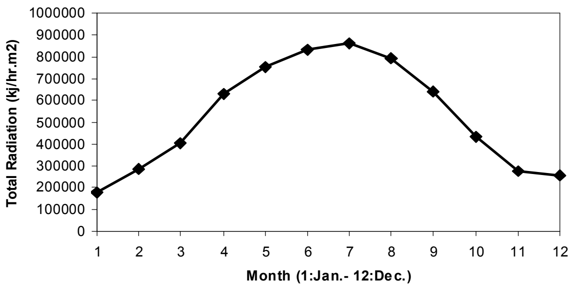
(a)

(b)

Figure 2. (a) Overview of the building and (b) plan view of the space



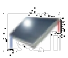
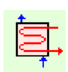
(a)



(b)

Figure 3. Monthly data for the region: (a) mean ambient temperature and (b) total radiation

TABLE 1. The processes and functions in Figures 4 and 7

Code or label	Description of the components	Function
 Type109-TMY2	Region weather data	This component reads TRNSYS TMY2 format weather file to determine the outdoor condition.
 Type56a	Building	This component takes the inlet DBT, RH and air flow and calculates the space DBT and RH.
 type281	Heater	This component takes the inlet air temperature and calculates the leaving air temperature.
 282	Solar collector	This component reads TMY2 format weather data and inlet water temperature to determine the leaving water temperature.
 TYPE280-2	Liquid-to-air heat exchanger	This component takes the inlet water and air temperature and calculates the leaving water and air temperature.
 Type14h	Time controller	This component produces a signal, controlling the time based working of the liquid-to-air heat exchanger, and user defined heater.
 TYPE11f	Flow diverter	This component takes the inlet water properties and calculates the two leaving water properties.
 TYPE11h	Flow mixer	This component takes the two inlet water properties and calculates the leaving water properties.

4. CENTERAL HEATING SYSTEM INTEGERATED WITH THE ARRAY OF SOLAR THERMAL COLLECTORS

In this section, the existing system added with the array of solar thermal collectors was studied. In order to obtain the most appropriate configuration in terms of the energy consumption and indoor air conditions, arrays consisting of three standard types of solar collectors, namely, unglazed liquid flat-plate collectors, glazed painted absorber liquid flat-plate collectors, and evacuated tube liquid flat-plate collectors were examined. The parallel flow as the most frequently used row design was considered [19]. Two rows consisting of two collectors in every row with aperture collector areas of 2, 4, 6, and 8 m^2 were examined in the system.

Before defining and adding the solar collector as a component to the simulation studio, solar collector performance needed to be derived. A solar thermal collector is a collector, which is designed to collect heat by absorbing sunlight. A flat-plate liquid collector works by transferring the heat gathered from the absorber plate to the liquid flowing through the tubes attached to the plate.

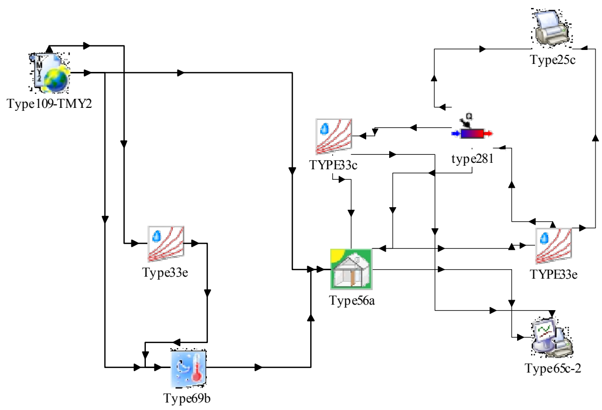


Figure 4. TRNSYS components to simulate responses of the existing heating system

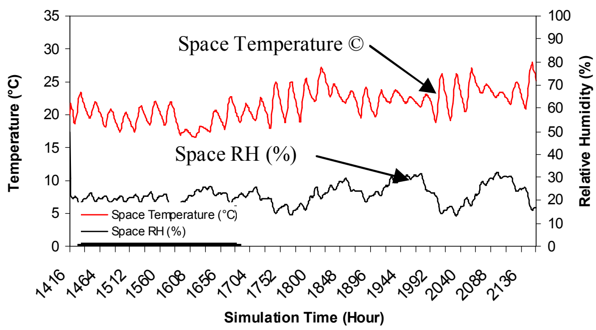


Figure 5. Monthly simulation responses of the existing system for March

TABLE 2. Mean indoor air DBT and RH- existing system

	LF	Mean space DBT (°C)	Mean space RH (%)	Energy consumption (kWh)
January	0.6	21.8	14.8	10933.22
February	0.5	21.4	17.4	8229.31
March	0.35	21.5	22.5	6377.71
April	0.15	21	30	1542.99
May	0.05	22.3	34.8	911.10
October	0.1	21.4	31.1	1822.20
November	0.35	22.4	24.1	6171.98
December	0.5	22.1	18.2	9111.02
Total				45,099.53

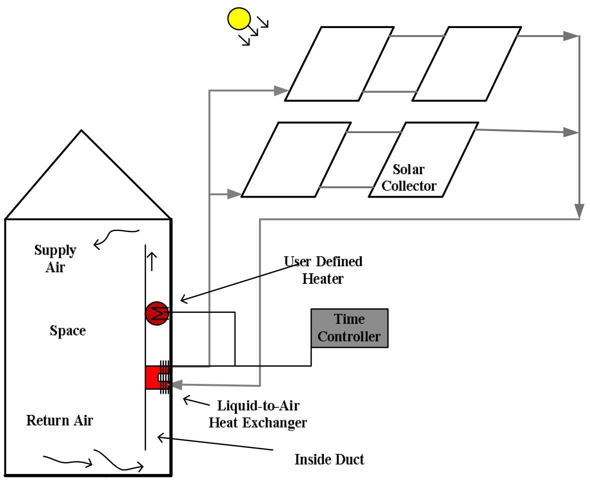


Figure 6. Schematic diagram of the system integrated with the array of solar thermal collectors

Under steady sate condition, the useful heat gained by the solar thermal collector plate is equal to the energy absorbed by the heat transfer fluid minus the direct and indirect heat loss from the collector surface to the atmosphere [19]. Every solar collector usually comes with an efficiency equation as:

$$\eta = \left[F_R \tau\alpha - F_R U_L \frac{(t_i - t_a)}{I_T} \right] \quad (1)$$

Therefore, the useful energy provided by a collector can be obtained from:

$$q_u = I_T A_c \left[F_R \tau\alpha - F_R U_L \frac{(t_i - t_a)}{I_T} \right] \quad (2)$$

The efficiency of the solar collectors normally is plotted against the heat loss parameter ($(t_i - t_a)/I_T$). In the above mentioned equations, it is assumed that the sun is normal to the collector plate, which occurs rarely. Therefore, Equation (2) is modified by incident angle modifier as in Equation (3).

$$K_{\tau\alpha} = \frac{\tau\alpha}{(\tau\alpha)_n} = 1 + b_0 \left[\frac{1}{\cos\theta} - 1 \right] \quad (3)$$

The efficiency curves indicate only the instantaneous behavior of the collectors; therefore, in order to estimate the hourly system performance, appropriate analysis tools such as TRNSYS is required. TRNSYS software provides the hour-by-hour weather and sun radiation data for the whole year and makes it possible to evaluate the hourly performance of the collectors. The performance parameters of the solar collectors were used to define the solar collector in FORTRAN source code to represent the collector component in the TRNSYS studio (Type 282) (see Table 3). Then, the existing system was integrated with the array of solar thermal collectors. In the modified system, three described liquid flat-plate collectors were examined as the plants were labeled as below:

Plant A: system integrated with an array of unglazed liquid flat-plate collectors.

Plant B: system integrated with an array of glazed painted absorber liquid flat-plate collectors.

Plant C: system integrated with an array of evacuated tube liquid flat-plate collectors.

The performance of the system with the added array of solar collectors was simulated for the eight months of the year and the results were compared to those obtained by the existing system. Figures 6 and 7 illustrate the schematic diagram of the system integrated with the array of solar collectors and its simulation layout, respectively. The processes and functions in Figure 7 have been described in Table 1.

In the modified system, the heating process was performed by placing a liquid-to-air heat exchanger inside a duct area, as illustrated in Figure 6. To define the liquid-to-air heat exchanger in the TRNSYS, the performance characteristics of the heat exchanger was required. For this purpose, a four-row liquid-to-air heat exchanger was selected by the S&P coil selection software [20] and the performance characteristic curves of the heat exchanger were determined. Then, the empirical performance equations of the heat exchanger, which were extracted from the performance characteristic curves (with the highest amount of R^2 value), were used to represent the heat exchanger mathematically in the TRNSYS studio as a component (Type 280).

Type 14h as a time controller component was defined in the simulation studio to operate the solar integrated system within the time table requirements. In this control strategy, the time controller sends an output signal as 1 and 0 to order the operation of the systems.

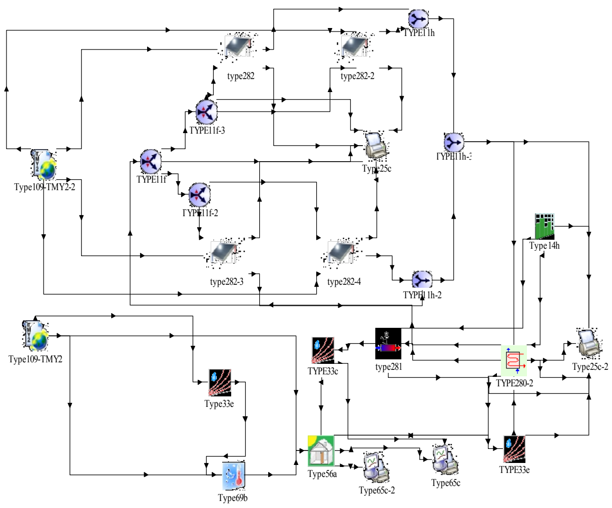


Figure 7. TRNSYS components to simulate responses of the modified heating system

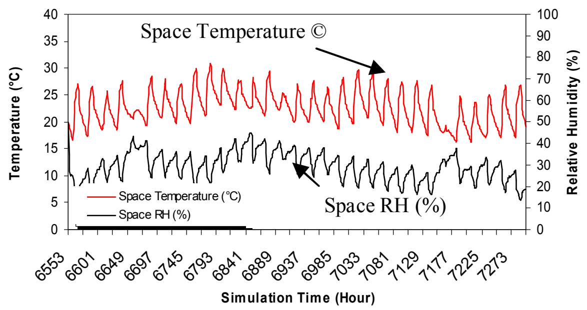


Figure 8. Simulation responses for the typical October- Plant A

TABLE 3. Average performance parameters for the standard types of liquid flat-plate collectors [19]

Collector type	$F_R\tau\alpha$ (Vertical intercept)	$-F_RU_L$ (Slope), $W/(m^2.K)$
Unglazed	0.807	-18.68
Glazed, painted absorber	0.701	-6.53
Evacuated tube	0.554	-2.52

5. RESULTS AND DISCUSSION

In Plant A, unglazed solar thermal collectors were utilized to provide the warm water to the liquid-to-air heat exchanger. Four aperture capture areas were examined and the provided indoor space conditions were tabulated in Table 4. Based on the simulation results, Plant A was not capable of providing the minimum human thermal comfort requirements for January, February, March, and December. However, it was capable of providing the desired indoor space conditions at $22^\circ C$, $23.9^\circ C$, $22.6^\circ C$, and $21.4^\circ C$ for April, May, October, and November, respectively. This was achieved with the solar collectors of 4 m^2 aperture area (see Table 4). The simulation responses for the typical month of October were illustrated in Figure 8.

For a more realistic estimation of the energy that could be saved with the added solar thermal collectors, the region TMY weather data was used for hour-by-hour simulation of the performance of the system. It was found that a total amount of 4,331.39 kWh energy could be saved with Plant A configuration.

Simulation results for Plant B showed that the indoor space conditions were not within the recommendations for January, February, and December. However, the modified system could provide the desired indoor air condition for five months of operation, as tabulated in Table 4. Based on the simulation results, Plant B could keep the space temperature at $21^\circ C$, $22.4^\circ C$, $24.3^\circ C$, 23, and $22^\circ C$ in March, April, May, October, and November, respectively. This was achieved with the solar collector of 8 m^2 aperture area. In addition, the system performance in terms of the energy consumption indicated that Plant B has the potential of saving 6,723.03 kWh energy within five months of operation.

Plant C consisted of evacuated solar collectors. The performance of the system with the incorporated evacuated solar thermal collectors indicated that the configuration was only capable of proving the desired indoor air conditions for April, May, October, and November (see Table 4).

It was estimated that Plant C would improve the system performance by about 4,331.39 kWh. For more convenience, the performances of the systems in terms of the energy consumption were tabulated in Table 5. The performance comparison revealed that Plants A and C has the capability to improve the energy performance of the system by about 4,331.39 kWh, and could meet the heating needs of the space for the four months of operation; however, Plant B has the priority in terms of the energy consumption while it could provide the desired indoor air conditions for the five months of operation. Therefore, considering all the above, Plant B is recommended to be implemented in the existing heating system of the building. The hourly responses for the liquid-to-air heat exchanger and solar thermal collectors were also simulated to monitor the performance of the components. To this end, the performances of the components in Plant B as the recommended configuration to the building were considered. Figures 9 and 10 illustrate the liquid-to-air heat exchanger and solar collector's temperature profiles within the hours of operation for a typical operating day in January, respectively. The water and air temperature profiles of the liquid-to-air heat exchanger were clearly illustrated in Figure 9.

TABLE 4. Mean space DBT and RH for the solar integrated systems

	Aperture collector area (m^2)							
	2		4		6		8	
	Mean space DBT ($^{\circ}C$)	Mean space RH (%)	Mean space DBT ($^{\circ}C$)	Mean space RH (%)	Mean space DBT ($^{\circ}C$)	Mean space RH (%)	Mean space DBT ($^{\circ}C$)	Mean space RH (%)
Plant A								
January	18.0	19.6	18.1	19.5	18.3	19.3	18.4	19.1
February	18.6	21.1	19.1	20.5	19.3	20.2	19.4	20.2
March	19.9	25.1	20.4	24.5	20.6	24.1	20.7	24.0
April	21.3	29.7	**22.0**	**28.6**	22.2	28.2	22.3	28.0
May	23.3	33.0	**23.9**	**32.0**	24.1	31.6	24.2	31.4
October	22.1	30.1	**22.6**	**29.1**	22.8	28.8	22.9	28.7
November	20.9	26.7	**21.4**	**25.9**	21.6	25.6	21.7	25.4
December	19.4	21.9	20.0	21.2	20.2	20.8	20.3	20.7
Plant B								
January	18.1	19.4	18.4	19.1	18.6	18.9	18.7	18.7
February	18.7	21.0	19.3	20.2	19.6	19.8	19.7	19.6
March	20.0	25.0	20.5	24.3	20.8	23.8	**21.0**	**23.5**
April	21.3	29.6	22.1	28.4	22.3	28.0	**22.4**	**27.8**
May	23.3	33.0	24.0	31.9	24.2	31.5	**24.3**	**31.3**
October	22.1	30.0	22.7	29.0	22.9	28.6	**23.0**	**28.5**
November	20.9	26.6	21.5	25.7	21.8	25.2	**22.0**	**24.9**
December	19.5	21.8	20.1	20.9	20.5	20.4	20.6	20.2
Plant C								
January	18.0	19.4	18.3	19.1	18.6	18.8	18.7	18.6
February	18.6	21.1	19.1	20.3	19.5	19.8	19.7	19.6
March	19.8	25.2	20.4	24.4	20.7	23.9	20.9	23.6
April	21.2	29.8	**21.9**	**28.6**	22.3	28.0	22.4	27.8
May	23.2	33.1	**23.9**	**32.6**	24.2	31.5	24.3	31.3
October	21.9	30.3	**22.6**	**29.2**	22.9	28.7	23.0	28.5
November	20.8	26.7	**21.4**	**25.8**	21.7	25.3	21.9	24.9
December	19.4	21.9	20.0	21.1	20.4	20.5	20.6	20.2

According to the Figure 10, the solar collector could increase the entering water temperature up to 20 $^{\circ}C$. However, in the modified system, the liquid-to-air heat exchanger causes the air pressure drop in the air stream (see Figure 6). Therefore, an extra fan power is required to overcome the pressure drop caused by the heat exchanger. The estimated fan power (assuming the fan efficiency to be 0.9 and motor efficiency 0.75) is 6.98 kWh and 8.77 kWh for Plants A, C and Plant B, respectively.

TABLE 5. Energy performance of the Plants

Plant	Saved energy (kWh)	Operation months	Aperture collector area (m^2)
Plant A	4,331.39	4	4
Plant B	6,723.03	5	8
Plant C	4,331.39	4	4

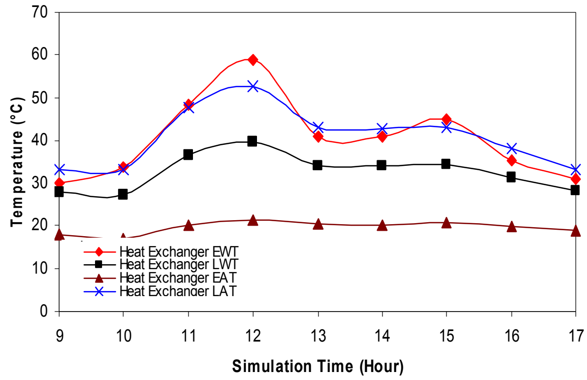


Figure 9. Simulation responses for the liquid-to-air heat exchanger within a typical operating day in January

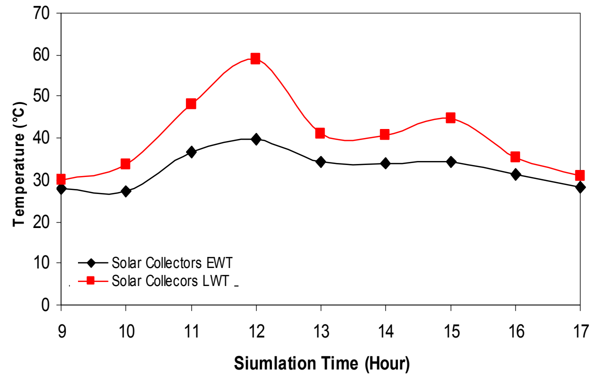


Figure 10. Simulation responses for the solar thermal collectors within a typical operating day in January

6. CONCLUSIONS

The possibility of improving the energy performance of the existing heating system of a residential building in Orumieh, Azerbaijane-garbi province, Iran with the help of an array of solar thermal collectors was investigated in the present study. In order to present a realistic estimation of the solar collectors effect on the existing system, TRNSYS software as a reliable transient thermal system simulation software was used to study the effect of solar collector hour-by-hour. To this end, the existing system and the system incorporated with the array of solar thermal collectors were simulated. To determine the most proper design, three standard types of liquid flat-plate solar collectors, namely, unglazed, glazed, and evacuated tube solar collectors were examined on the existing heating system as: Plants A, B, and C, respectively.

The provided indoor air conditions and energy savings by the Plants were estimated and compared with the existing system. The simulation results showed that the system equipped with the solar collectors was capable of providing the desired indoor air conditions for four and five months of operation. Based on the simulation results, Plants A and C were capable of establishing a desired indoor air conditions for April, May, October, and November. Moreover, it was found that 4,331.39 kWh of energy could be saved with the application of Plants A and C. However, the energy savings of the Plants indicated that Plant B has the priority in terms of the energy savings. According to the simulation results, Plant B could save a total amount of 6,723.03 kWh energy while it could provide the desired indoor air conditions for the five months of operation. Therefore, the existing heating system is recommended to be retrofitted with Plant B to improve the energy performance of the existing heating system.

7. ACKNOWLEDGMENTS

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8. REFERENCES

1. "Energy balance sheet, department of electrical and energy department of energy ministry", (2007).
2. "Renewable energy in islamic republic of iran, iran ministry of energy, presented in renewable energy conference, japan", (2006).
3. Fadai, D., Esfandabadi, Z. S. and Abbasi, A., "Analyzing the causes of non-development of renewable energy-related industries in iran", ***Renewable and Sustainable Energy Reviews***, Vol. 15, No. 6, (2011), 2690-2695.
4. "Energy balance,“energy planning office, iranian ministry of energy”", (2003).
5. Jacobson, M. Z., "Review of solutions to global warming, air pollution, and energy security", ***Energy & Environmental Science***, Vol. 2, No. 2, (2009), 148-173.
6. Keyanpour-Rad, M., Haghgou, H., Bahar, F. and Afshari, E., "Feasibility study of the application of solar heating systems in iran", ***Renewable energy***, Vol. 20, No. 3, (2000), 333-345.
7. Mohammadnejad, M., Ghazvini, M., Mahlia, T. and Andriyana, A., "A review on energy scenario and sustainable energy in iran", ***Renewable and Sustainable Energy Reviews***, Vol. 15, No. 9, (2011), 4652-4658.
8. Ghobadian, B., Najafi, G., Rahimi, H. and Yusaf, T., "Future of renewable energies in iran", ***Renewable and Sustainable Energy Reviews***, Vol. 13, No. 3, (2009), 689-695.
9. Abedi, A., "Utilization of solar air collectors for heating of isfahan buildings in iran", ***Energy Procedia***, Vol. 14, No., (2012), 1509-1514.
10. Rezaie, B., Esmailzadeh, E. and Dincer, I., "Renewable energy options for buildings: Case studies", ***Energy and Buildings***, Vol. 43, No. 1, (2011), 56-65.

11. Khalaji Assadi, M., Khalesi Doost, A., Hamidi, A. A. and Mizani, M., "Design, construction and performance testing of a new system for energy saving in rural buildings", ***Energy and Buildings***, Vol. 43, No. 12, (2011), 3303-3310.

12. Asnaghi, A. and Ladjevardi, S., "Solar chimney power plant performance in iran", ***Renewable and Sustainable Energy Reviews***, Vol. 16, No. 5, (2012), 3383-3390.

13. Azad, E., "Interconnected heat pipe solar collector", ***Int J Eng Trans***, Vol. 22, No. 3, (2009), 233-242.

14. "Renewable energy in iran, energy statistical review of iran", (2002), 223-239.

15. "Renewable energy sources, islamic republic of iran: Iranian atomic energy agency (iaea)", (2010).

16. "Solar energy laboratory. Trnsys software (a transient system simulation program), university of wisconsin-madison, wi 53706-USA, available from: Http://sel.Me.Wisc.Edu/trnsys, " (2012).

17. "ASHRAEA, “ASHREA handbook, HVAC applications (si)”", (2007).

18. "ASHRAEA, “ASHREA handbook, HVAC systems and equipments", (2008).

19. "S&P coil product limited, SPC 2000 coil selection software, http://www.Spccoils.Co.Uk, " (2012).

Performance Study of a Solar Integrated Central Heating System of a Residential Building using TRNSYS- An Hourly Simulation Model

RESEARCH NOTE

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چکیده

در این تحقیق عملکرد یک سیستم گرمایش مرکزی مجهز به کلکتورهای خورشیدی در یک ساختمان مسکونی مورد مطالعه قرار گرفته است. به این منظور عملکرد ساعت به ساعت سیستم موجود و سیستم مجهز به کلکتورهای خورشیدی از نظر شرایط هوای داخل و میزان مصرف انرژی تحت مدلهایی در نرم افزار شبیه ساز مورد ارزیابی قرار گرفته است. در سیستم جدید قابلیت سه نوع کلکتور خورشیدی استاندارد با نامهای unglazed, glazed painted و evacuated tube در فراهم کردن انرژی گرمایی مورد نیاز فضای داخل به منظور دستیابی به بهترین طرح مورد ارزیابی قرار گرفته است. بر اساس نتایج شبیه سازی سیستم مجهز به کلکتورهای خورشیدی قابلیت فراهم نمودن شرایط هوای مطلوب را در چهار و پنج ماه از سال را داشته اما عملکرد سیستمها از نظر مصرف انرژی نشان می دهد که سیستم مجهز به کلکتورهای خورشیدی از نوع glazed painted (Plant B) از اولویت بیشتری از نظر صرفه جویی در مصرف انرژی برخوردار است. بعلاوه این سیستم قابلیت فراهم نمودن هوای مطلوب داخل در پنج ماه از سال را داشته و برای سیستمهای گرمایش مرکزی توصیه می گردد.

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