Investigation of solar powered sorption cooling and heating systems to supply hospital's thermal requirements in pandemic periods

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Abstract

In pandemic periods such as COVID-19, economic and sociological problems threaten human life and public order on a global scale. In these periods, the use of solar powered heating–cooling systems to meet the thermal needs of hospitals and to provide thermal comfort conditions offer important solutions for the elimination of technical, economic and environmental problems related to energy supply. In this study, the heating, cooling and hot water supply of a sample hospital building for the three largest cities of Turkey with a novel solar powered Li-Cl absorption heat pump system was investigated using the Transient System Simulation Tool (TRNSYS) simulation program. The use of a unique NH_3-H_2O resorption system as a solar powered auxiliary system was also investigated. It was determined that the total annual hot water and cooling needs of the hospital buildings in all three provinces are supplied almost completely by the solar energy powered system without compromising the hygiene and thermal comfort of the occupants. The average annual solar fraction of total heating demands are calculated as 50, 54 and 65% for İstanbul, Ankara and İzmir, respectively. In addition, depending on the use of solar energy, it has been observed that 126 tons of CO_2 emissions were saved annually, and an economic saving of 524 375 TL was achieved in total. Considering the problems with energy supply during the epidemic periods, it was concluded that meeting the energy requirements of hospitals with clean, renewable and independent energy source will provide significant benefits to the countries.

Keywords: thermal requirement; energy shortage; renewable energy; COVID-19; pandemic

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Received 25 February 2023; accepted 7 March 2023

1 INTRODUCTION

The COVID-19 pandemic threatens human health on a global scale, and many of the negativities caused by the pandemic have had significant social and economic effects on social life [1–3]. By the end of 2022, ∼17 million cases have been detected in Turkey, and >100 000 deaths have occurred; worldwide, the number of cases has been reported to be >600 million and >6.5 million people died due to the COVID-19 epidemic [4]. Pandemic conditions have also negatively affected the social life [5, 6] and health care system. It is of great importance to meet the energy needs of hospital buildings and similar medical units uninterruptedly to carry out health services without interruption in extraordinary conditions such as the global epidemic. At this point, the use of air conditioning systems working with alternative energy sources to provide the thermal comfort and hygiene requirements of both medical staff and citizens receiving health services are considered as a correct approach to eliminate possible problems. In addition, the use of such systems that can be powered with completely clean, renewable and independent energy sources and that can operate off-grid in unpredictable conditions such as natural disasters and epidemic conditions will provide significant alternative solutions.

In various research studies on this issue, the use of solar heating–cooling systems to provide the thermal requirements of buildings has been examined for different scenarios [7–11]. In these studies, it was concluded that a significant part of the

International Journal of Low-Carbon Technologies 2023, 18, 373–383
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https://doi.org/10.1093/ijlct/ctad026 Advance Access publication 20 March 2023

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thermal needs of buildings can be met by solar energy, and thus, significant advantages can be obtained in terms of technical and economic aspects. Hallstrom reported that [12] solar powered lithium chloride –water ($LiCl$-H_2O)-absorption heat pump systems have significant technical, economic and environmental advantages over conventional air conditioning systems, and these systems can be used to meet the thermal needs of buildings such as hospital buildings, hotels and shopping centers.

In this study, supplying the annual heating, cooling and domestic hot water (DHW) requirements of a hospital building with solar energy in Turkey's three biggest cities, Istanbul (41° N, 29° E), Ankara (39° N, 32° E) and Izmir (38° N, 27° E) was investigated using simulation techniques. The Transient System Simulation Tool (TRNSYS) [13] program was preferred for the simulation processes carried out within the scope of the study, and the absorption heat pump and its components are modelled with ClimateWell-Solar Cooling v1.1 software [14]. To cover the thermal requirements of the hospital building, a solar energy system consisting of a novel $LiCl$-H_2O-absorption heat pump system with interior energy storage and vacuum tube solar collectors is used. Because it is important to maximize the use of the renewable energy sources to reach the goal of this study, a unique solar powered ammonia-based resorption cooling system [15, 16] with ice storage units was preferred as an auxiliary solar cooling system to cover the cooling load of the building, when necessary.

As a result of the study, the annual heating, cooling and hot water requirements of the sample hospital buildings with the solar energy system for three different cities were calculated and the solar fractions of the energy demands for cooling, heating and DHW were determined. In addition, technical features and the thermal performance of the system were evaluated by obtaining the economic savings and the reduction in CO_2 emissions due to the use of solar energy.

2 METHODS

2.1 Hospital building

Unlike detached houses, public buildings and other commercial constructions, hospital buildings are structures that are in use every day and every hour of the year, and their thermal comfort conditions and hygiene requirements do not change with time. For this reason, the heating, cooling and DHW needs of the sample hospital building with 50 occupants in nominal working conditions, which is the subject of the study, have been calculated considering this fact. In the analyses, the indoor design temperature of the hospital building was determined as 25°C throughout the year [17], the need for DHW was taken as 100 l/day per person and the temperature was taken as 50°C [18].

The architectural design of the building was created in accordance with the Turkish Healthcare Buildings Minimum Design Standards Guide and based on a 25-bed district state hospital building [19]. The hospital building was designed as a single-storey building with a floor area of 450 m^2, and the total number of people working in the hospital and receiving service from the hospital was determined as 50. The north and south wall areas of the building are 324 m^2, and the east and west walls are 180 m^2. Taking the minimum values determined by the relevant standard into account [19], the window areas in the building also were determined as 36 m^2 in total on the north and south facades and 20 m^2 in total on the east and west facades.

The thermal properties of the building elements for three provinces located in different degree-day regions in Turkey were determined according to the TS 825 Thermal Insulation Rules in Buildings [20] standard, which is the official standard in Turkey and compatible with International Standard Organization (ISO) 9869 [21] and ISO 13790:2008 [22]. Therefore, the heat transfer coefficient was taken as 2.8 W/m^2K for the windows and 0.6, 0.5 and 0.8 W/m^2K for the exterior walls in the hospital building for Istanbul, Ankara and Izmir, respectively. Annual needs of heating and cooling of the building are calculated with the ClimateWell-Solar Cooling v1.1 software [14] built up with TRNSYS program [13]. Accordingly, annual needs of heating for Istanbul, Ankara and İzmir are calculated as 95, 110.1 and 73 kWh/m^2/year, whereas the limit values in the standard [21] are 97.9, 116.5 and 73.3 kWh/m^2, respectively. Similarly, the annual needs of cooling for Istanbul, Ankara, İzmir are calculated as 10.1, 12.2 and 27.2 kWh/m^2/year, which are acceptable according to the standard values [23].

2.2 Solar collector system

The solar collector system to derive solar energy as thermal energy to power the absorption system consists of heat pipe vacuum tube solar collectors with an absorber area of 3.02 m^2. The solar collector system with total surface area of 300 m^2 was placed on the roof of the hospital building facing south with a 30-degree inclination angle. There were also two external storage tanks in the solar collector system with a volume of 10 m^3 to store hot water obtained from the solar collectors, and the design temperature of the tanks for the heating–cooling periods was determined as 90°C.

2.3 Absorption heat pump system

The absorption heat pump system in the solar powered heating and cooling facility consists of seven LiCl absorption heat pump units in a cascade configuration, a heat rejection and a heat distribution system. Each absorption heat pump units have a nominal cooling and heating capacity of 10 and 20 kW, respectively [24]. Figure 1. represents the working principle of the absorption system.

The absorption heat pump system consists of two independent and identical chambers and a pressurization unit that connects these tanks to the external units; solar thermal energy, heat/cold distribution and the heat rejection circuits. In addition, each chamber consists of two different tanks: one filled with LiCl salt and the other with water, named as reactor, absorber, condenser and evaporator according to the working condition of the system.

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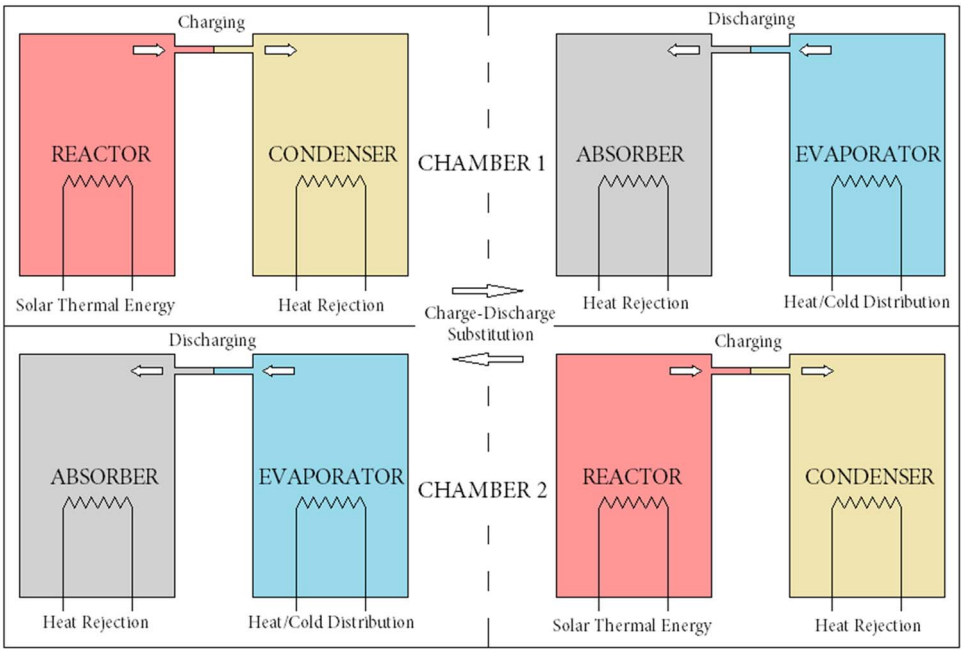


Figure 1. *Solar powered absorption system working principle.*

When the system is in the cooling mode, LiCl-H_2O solution in the reactor of chamber 1 is dried by the thermal energy obtained from the solar collector system, and the vaporized water is sent to the condenser of the other chamber 1. The waste heat generated as a result of this process is rejected with the heat rejection circuit. The process of storing solar thermal energy in chamber 1 is named as charging. Meantime in chamber 2, the water at low pressure in the evaporator evaporates from the heat drawn from the building or location to be cooled, and the cooling energy is transported to the building or location via heat/cold distribution line. Thus, the cooling energy is provided for the cooling process.

The water vapor that is generated in the evaporator by the cooling process is absorbed by LiCl-H_2O solution in the absorber of chamber 2, and the waste heat that is generated as a result of the absorption process is discharged by the heat rejection circuit. Likewise, the process of providing cooling energy in chamber 2 is named as discharging.

With the charge–discharge substitution, by changing the flow directions of the external circuits and the pressure levels; chamber 1 in the charging mode swapped to discharging mode to provide cooling energy, whereas chamber 2, in the discharging mode swapped to charging mode to store solar thermal energy in the LiCl-H_2O solution. Thus, an uninterrupted solar cooling application can be actualized by charge–discharge substitutions when solar energy is absent at nighttime or insufficient because of seasonal or atmospheric conditions.

Unlike the conventional absorption refrigeration cycle, the absorption heat pump in this study is a triple-state sorption system, works as a non-continuous characteristic, and can internally store the thermal energy obtained from solar energy in LiCl salt. Each unit has an energy storage capacity of 76 kWh for heating application and 50 kWh for cooling application. Thus, the novel absorption system not only provides an uninterrupted heating–cooling application in heating and periods when solar energy is insufficient or absent, but also eliminates the crystallization problem seen in conventional absorption systems with its energy storage feature. Yu *et al.* [25] compared the absorption cycles with LiCl-H_2O, $CaCl_2$-H_2O and LiBr-H_2O and stated that LiCl/H_2O is determined to be the best choice among the three couples, with a cold storage density of 519 kWh/m^3 and a heat storage density of 618 kWh/m^3. They also presented the P–T diagram of the three-phase LiCl-H_2O absorption system (Figure 2). Conde [26] also presented the calculation models and properties of the aqueous solution of LiCl in detail, which is used in the simulation processes of this study.

With the solar absorption system in heating mode, the system can operate as a heat pump. The waste heat in the chambers is directly transferred to the building by the heat/cold distribution circuit instead of the heat rejection line. The low-temperature thermal energy for the evaporator can be supplied from solar energy or ambient energy sources. It may be more efficient to use the solar thermal energy directly for the heating process instead of driving the absorption system's generator, by considering the design temperature for the heating application. In simulations of this study, the control strategy of using solar thermal energy for heating was determined as considering the thermal requirements of the hospital building and temperature levels of the solar thermal energy. In the solar heating and cooling system, a natural gas boiler with an efficiency of 90% was used as an auxiliary conventional heating system for supplying the heating and DHW demand of the hospital building when the solar powered system is incapable of covering the thermal requirements.

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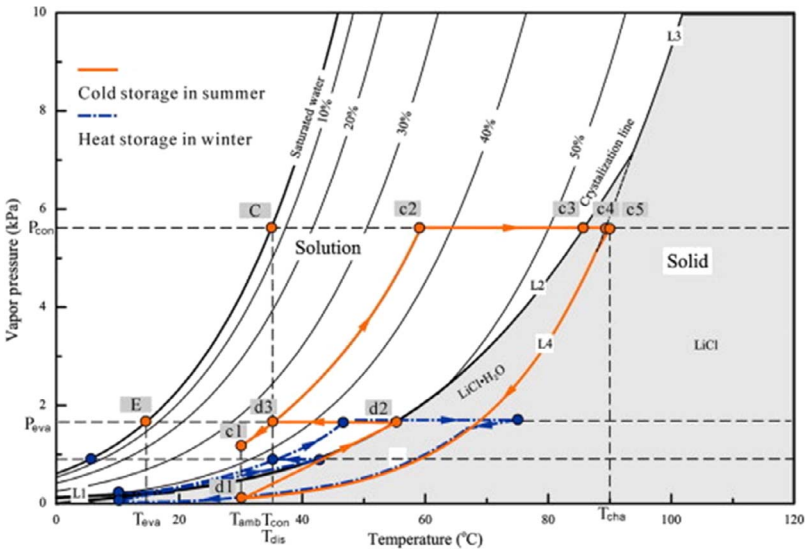


Figure 2. *P–T diagram of LiCl-H_2O system presented by Yu et al. [25]*

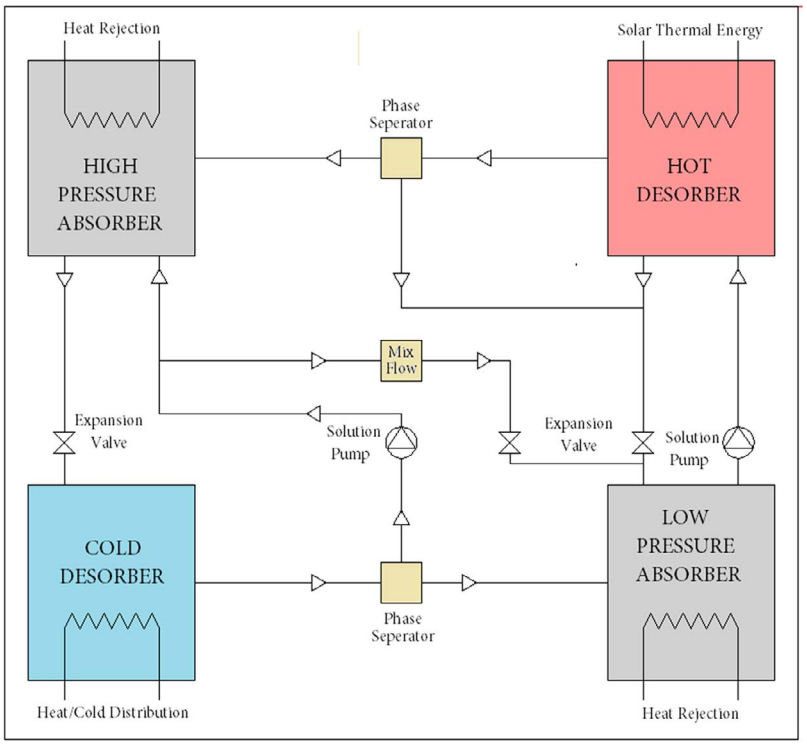


Figure 3. *Solar powered resorption chiller.*

2.4 Resorption cooling system

Solar powered resorption chillers as a unique sorption system (Figure 3.) may offer an alternative solution for this issue. Working principles and the features of the resorption chillers are comprehensively presented in previous studies [27–29]. Because the solar powered resorption systems use ammonia (NH_3) water as the refrigerant, it is possible to actualize cooling applications <0°C and store the cooling energy in ice form [30–32] to use when solar energy is absent or insufficient.

Because the pressure levels in the resorption cycle are considerably lower than the conventional ammonia-based absorption systems, solar resorption systems require lower temperature levels of solar thermal energy. In addition, thanks to its operational features, it is possible to design and actualize more feasible,

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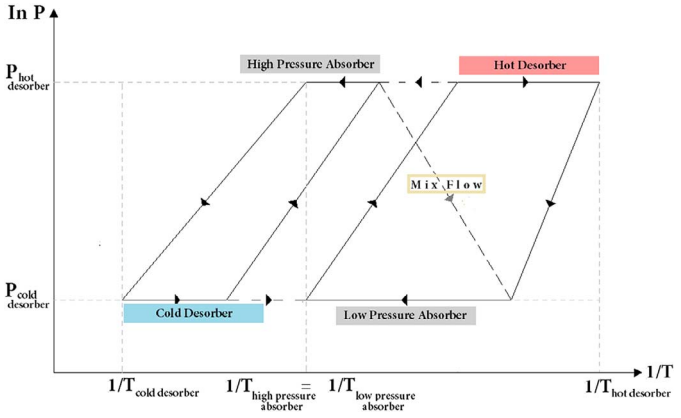


Figure 4. *InP-1/T diagram of the resorption cooling cycle.*

Table 1. *Total annual energy and solar fraction value.*

ISTANBUL	Heating	DHW	Cooling
Total annual energy demand [kWh]	207 031	84 963	22 019
Solar thermal energy [kWh]	45 921	82 763	22 019
Average annual solar fraction [%]	50%	98%	100%
ANKARA	Heating	DHW	Cooling
Total annual energy demand [kWh]	240 080	84 963	26 601
Solar thermal energy [kWh]	69 420	83 323	26 601
Average annual solar fraction [%]	54%	98%	100%
IZMIR	Heating	DHW	Cooling
Total annual energy demand [kWh]	159 196	84 963	59 299
Solar thermal energy [kWh]	54 319	84 369	55 974
Average annual solar fraction [%]	65%	100%	98%

safer and cost-effective cooling and heating applications by using solar energy [16]. Figure 4 represents the InP-1/T diagram of the resorption cooling cycle.

Thus in this study, a unique solar resorption system is chosen as an auxiliary thermal energy-driven solar cooling system, and an electrically driven vapor compression mechanical chiller with a coefficient of performance of cooling (COP_c) of 3 is chosen as a conventional auxiliary cooling system.

2.5 Simulation processes

In this study, both absorption and resorption systems are investigated using the simulation programs. Simulation processes for the solar absorption system were carried out with the TRNSYS dynamic simulation program [13] in the study. By using general programming languages—thanks to the dynamic link library-based structure of the program—it is possible to convert mathematical models created for different devices, structures or energy systems into simulation program components that can be simulated with TRNSYS. The features of the solar absorption system and external components are modelled with the ClimateWell-Solar Cooling v1.1 [14] software within the TRNSYS program. The mathematical models for the all components of the absorption system that is used in the simulation program are explained and presented in detail by Bales and Nordlander [33]. In the simulation processes, individual Meteonorm meteorological data [34] were used to determine the meteorological characteristics for the provinces of Istanbul, Ankara and Izmir. The duration of the simulation processes was determined as monthly periods, the values for each month were calculated accordingly and the annual operating characteristics of the system were determined. A daily analysis for typical days, 15th of January for heating and 15th of July for cooling periods, are also investigated. To calculate the performance of the solar resorption auxiliary system, a program that uses the mathematical models for the resorption system [28, 32] built up with Refprop [35] is preferred for the simulation processes.

In the simulation processes for the heat rejection system, a wet-type cooling tower with an axial fan with 3-kW fan power was selected to remove the waste heat generated in the absorption heat pump system [36]. The meteorological design parameters determined by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards for Istanbul, Ankara and Izmir were used to calculate the performance of the heat rejection system [23] for both absorption and resorption systems. The heat/cold distribution system for the solar absorption system is designed with air ducts with a design temperature of 12/17°C for cooling and 50/40°C for heating [36] by considering the heating–cooling performance of the system, thermal comfort and the hygiene conditions of the hospital building. The price of natural gas in Turkish Liras (TL) for the last days of 2022 was calculated as 0.91, 0.87 and 0.88 TL/kWh for İstanbul, Ankara and İzmir, respectively [37–39]. The price of electricity is 3.27 TL/kWh and is the same for all provinces. [40] The exchange rate for Turkish Lira and Euro is ∼1 TL = 19.5€ [41].

3 RESULTS AND DISCUSSION

As a result of the simulation processes carried out in monthly periods within the scope of the study, the total annual energy demand for the heating, cooling and DHW of the sample hospital buildings for the three provinces; the solar thermal energy provided by the solar energy system to cover these requirements and the average annual solar fraction of energy demand for the thermal requirements are all given in Table 1.

When the average annual solar fraction was examined, it was seen that approximately all amounts of the cooling and hot water demand for all three provinces can be covered by solar energy. For this reason, it has been concluded that the solar energy powered absorption heat pump system required very little auxiliary energy to cover the hot water and cooling demands of the hospital building. In the winter months, when thermal energy demand for heating is higher, the solar fraction for heating decreased due to the decrease in solar radiation because of seasonal conditions.

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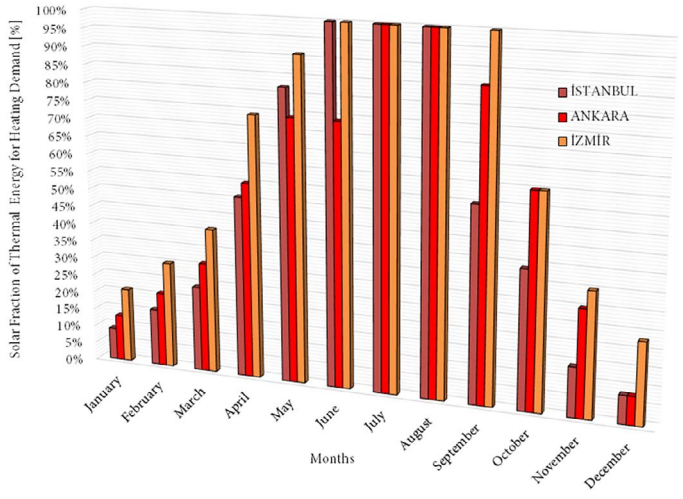


Figure 5. *Solar fraction of thermal energy for monthly heating demand.*

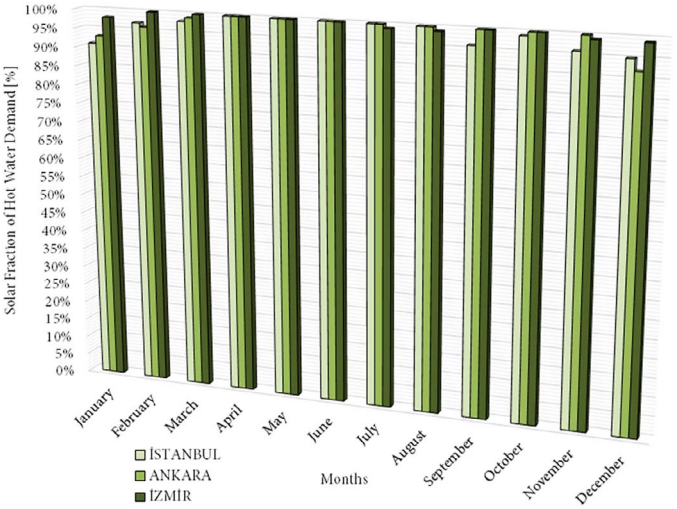


Figure 6. *Solar fraction of thermal energy for monthly hot water demand.*

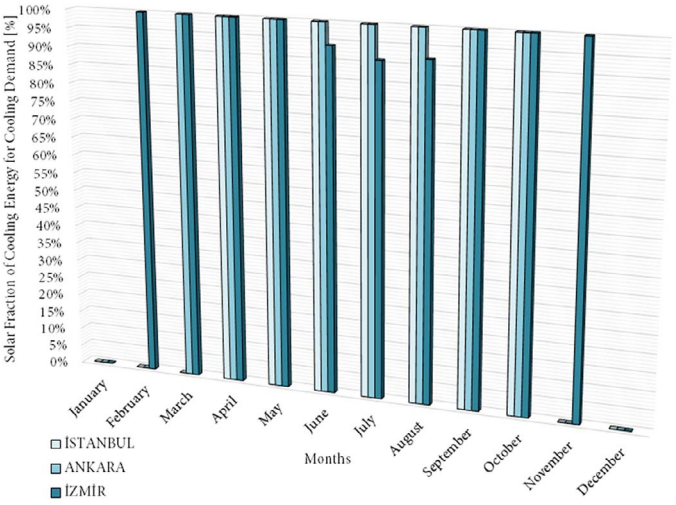


Figure 7. *Solar fraction of cooling energy for monthly cooling demand.*

However, it was concluded that the solar energy system could cover the total heating demand of the hospital buildings by half and above annually in heating season for all three provinces. Therefore, based on the increase in solar fraction of thermal energy for heating demand, it is possible to reduce natural gas consumption and the auxiliary gas boiler's capacity, which provides significant benefits for both operational and initial cost.

Figure 5 represents the solar fraction of thermal energy for the monthly heating demand of the three provinces. Even in January, when heating demand is highest, it was seen that the heating demand for Istanbul, Ankara and Izmir could be covered by solar energy at a rate of 9, 13 and 21%, respectively. In seasonal transitions, the solar fraction of thermal energy for monthly heating demand was higher. Especially during these periods and summer months, it was concluded that the solar fraction of thermal energy for heating demand increased depending on the decrease in the thermal energy for heating demand and the increase in the amount of solar radiation by seasonal changes.

The monthly variation of the solar fraction of DHW demand for the hospital building is graphically shown in Figure 6. It was seen that almost all of the annual DHW demand for all three provinces could be covered by solar energy. Moreover, the fact that the total annual solar fraction of DHW demand was $\geq$99% for all three provinces, it was deduced that using the solar energy system for covering the annual domestic hot water demand provides remarkable benefits like using solar energy in heating and cooling applications.

When the analyses were performed for investigation of the cooling period, it was calculated that the total annual cooling demand for Istanbul and Ankara could be covered with solar energy (Figure 7). In seasonal transitions, the solar fraction of thermal energy for monthly cooling demand is higher as well as heating demand. In İzmir province, the amount of energy required for cooling application is high, and the cooling period is longer than in other provinces.

However even in July, when the cooling need is at its highest, 91% of the monthly total cooling demand could be covered with solar energy, and the average solar fraction of the cooling energy for cooling demand in the summer months was 92%. According to the results of the analysis of the cooling period, it was concluded that the solar powered system showed great performance for covering the cooling demand of the hospital building.

To evaluate the cooling performance of the solar absorption system, the coefficient of performance (COP_c) of the absorption system for cooling, which is the ratio of the cooling energy provided by sorption systems and the thermal energy that is supplied to the sorption system, was calculated for monthly periods and the variation of COP is shown graphically in Figure 8. The average COPs of the absorption system for the summer months were determined as 0.37, 0.35 and 0.52 for İstanbul, Ankara and İzmir, respectively. The cooling performance of the system was higher in the summer months when more solar energy is obtained and

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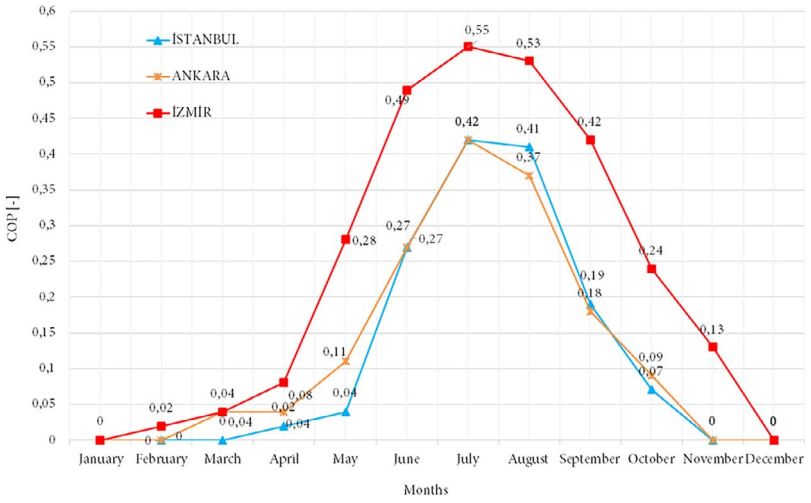


Figure 8. *Monthly variation of COP of the solar absorption system.*

Table 2. *Daily analysis of the solar absorption system in heating period for 15th of January.*

	ISTANBUL	ANKARA	I ZMIR
Energy demand for heating [kWh]	1267	1113	782
Solar thermal energy for heating [kWh]	208	214	203
Average daily solar fraction for heating [%]	16%	19%	26%
Energy demand for DHW [kWh]	243	243	244
Solar thermal energy for DHW [kWh]	182	184	184
Average daily solar fraction for DHW [%]	75%	76%	75%
Energy demand for cooling [kWh]	—	—	—

Table 3. *Daily analysis of the solar absorption system in cooling period for 15th of July.*

	ISTANBUL	ANKARA	I ZMIR
Energy demand for heating [kWh]	66	85	72
Solar thermal energy for heating [kWh]	66	85	72
Average daily solar fraction for heating [%]	100%	100%	100%
Energy demand for DHW [kWh]	226	226	226
Solar thermal energy for DHW [kWh]	202	203	204
Average daily solar fraction for DHW [%]	89%	90%	90%
Energy demand for cooling [kWh]	159	144	350
Solar thermal energy for cooling [kWh]	159	144	350
Average daily solar fraction for cooling [%]	100%	100%	100%
Daily COP value for cooling [−]	0.60	0.48	0.62

cooling periods are longer. In addition, although the cooling demand is higher in Izmir, where the solar radiation is higher, the COP of the system got higher values than other provinces.

To examine the design and transient operation of the absorption system, a daily analysis for the typical days, 15th of January for heating and 15th of July for cooling periods, is also investigated and the results are presented in Table 2 and Table 3, respectively.

Because the total amount of monthly cooling demand for summer months couldn't be covered totally in Izmir, the use of a solar resorption chiller as an auxiliary sorption was analyzed for the cooling application in Izmir. The auxiliary system demand for cooling in İzmir is 6, 9 and 8% for June, July and August, respectively. Thus, the cooling application in July for Izmir was chosen for the analyses of the resorption system to investigate the performance of a solar auxiliary system when the solar absorption system was incapable of covering cooling demand. The solar absorption system could cover the 91% of the monthly total cooling demand, which is 17 118 kWh. The deficiency of the cooling energy for the monthly period is 1514 kWh and for daily period, it is ∼50 kWh.

Figure 9 represents the monthly simulation results for Izmir in July and shows the indoor and ambient temperatures as well as the temperature variation of the solar collector system's inlet and outlet. It can be seen on Figure 9 that it is possible to provide solar thermal energy at 75°C during the daytime when solar energy is abundant for 10 hours to power the resorption cooling system's hot desorber and to cover the 50 kwh daily average cooling load of the hospital building by using the auxiliary solar resorption cooling system with a 5-kW cooling capacity.

Analyses performed for Izmir in July showed that while the design temperature for heat rejection system is 22.1°C [23] and the pressure level for the hot desorber of the resorption chiller is 5 bar; the cold desorber temperature to perform cooling application was 6.7°C, which is equal to the design temperature of 7/12°C of the cold distribution system; the cooling capacity of the system was 5.88 kW, which is sufficient to cover the lack of cooling load of the hospital building and the COP of the resorption system was 0.62. Moreover, it was deduced that, when the ambient wet bulb temperature decreases to 19°C, the cold desorber temperature decreases to −0.05 °C and enables the storage of cooling energy in ice form and the COP of the resorption system is 0.59.

When analyses were performed for Izmir in June and August, results showed that the cold desorber temperatures were 3.6 and

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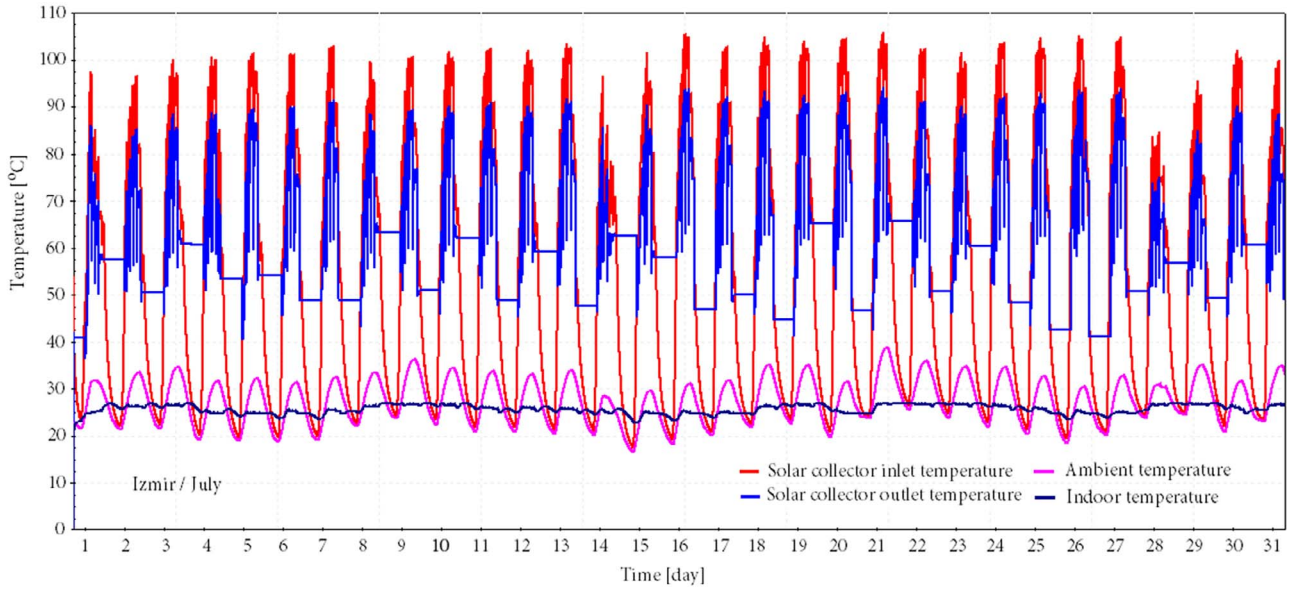


Figure 9. *Monthly temperature variation of Izmir in July.*

Table 4. *Total annual savings due to use of solar energy.*

		ISTANBUL	ANKARA	IZMIR
Annual total savings in Turkish Liras [TL]	Heating	9183	14 655	9838
	DHW	16 553	17 592	15 280
	Cooling	6974	8421	17 724
	Total	32 709	40 669	42 843
Total annual reduction in CO_2 emissions and petroleum equivalent	Reduction in CO_2 emissions [kg]	35 012	41 724	49 223
	Petroleum equivalent [l]	15 043	17 928	21 150

7.1°C, the cooling capacities of the systems were 5.78 and 5.88 kW and the COPs of the systems were 0.61 and 0.62, respectively. It was concluded that using a solar resorption chiller as an auxiliary cooling system with small cooling capacities is an efficient, feasible and advantageous alternative to using conventional electrically driven chillers or solar sorption cooling systems as an auxiliary system.

To show the economic and environmental benefits provided by the use of a solar energy system, the economic gains due to natural gas and electrical energy savings, the total amount of reduction in CO_2 emissions and its petroleum equivalent were calculated and is presented in Table 4. Accordingly, the total annual economic savings of 524 375 TL, which is approximately 26 891€, [29] and 125 959 kg CO_2 savings achieved by using solar energy in the applications performed in the three different provinces.

Figure 10 shows the variation of the monthly total economic savings due to the use of solar energy in heating, DHW and cooling applications for the three different provinces. It was seen that the amount of economic savings took on higher values in the periods when solar energy was obtained more and used more efficiently.

Considering the initial investment cost, which is one of the most important disadvantages of renewable energy-based systems and especially solar energy applications, as well as the total payback period of the system, it is obvious that the economic savings achieved due to the use of solar energy will significantly increase the technical and economic feasibility of the system.

With the use of solar energy, which is a completely clean and renewable energy source, to cover the energy demands of buildings, significant environmental gains were also achieved. Figure 11 shows the monthly variation of savings in CO_2 emissions by using solar energy. The solar fraction of the energy demand of the buildings increased so that the CO_2 emission, which occurred due to the use of conventional energy sources and plays an important role in global warming, can be reduced considerably.

4 CONCLUSION

In this study, supplying the heating, cooling and hot water requirements of a sample hospital building with 25 beds in Turkey's three biggest cities, Istanbul, Ankara and Izmir, by using a novel solar powered LiCl absorption system with interior energy storage was investigated. The analyses carried out within the scope of the study showed that, approximately, the total annual DHW and cooling demands of the hospital buildings in all three provinces could be covered uninterruptedly and efficiently without compromising the hygiene and thermal comfort of the staff and the visitors of the hospital.

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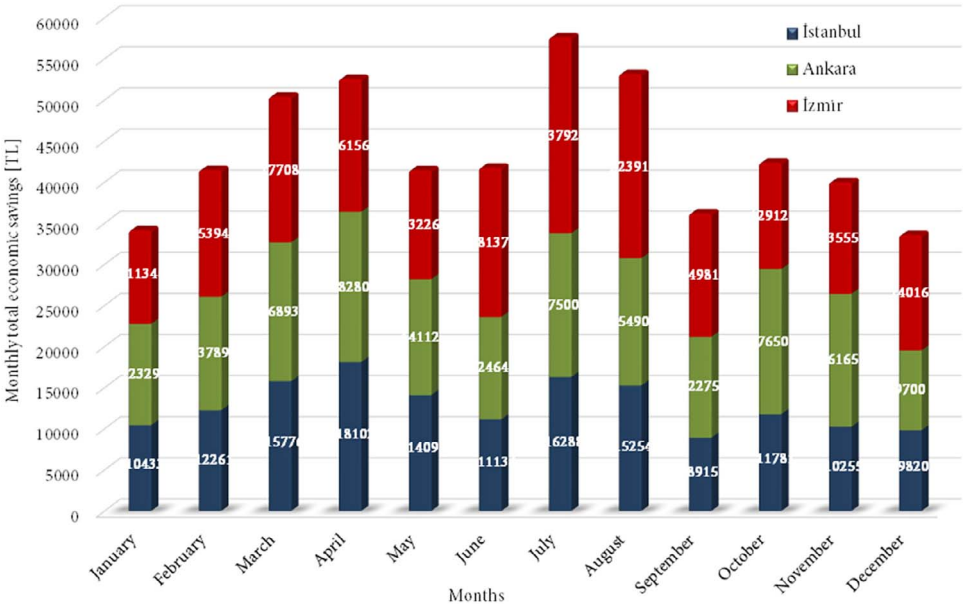


Figure 10. *Total amount of monthly economic savings due to use of solar energy.*

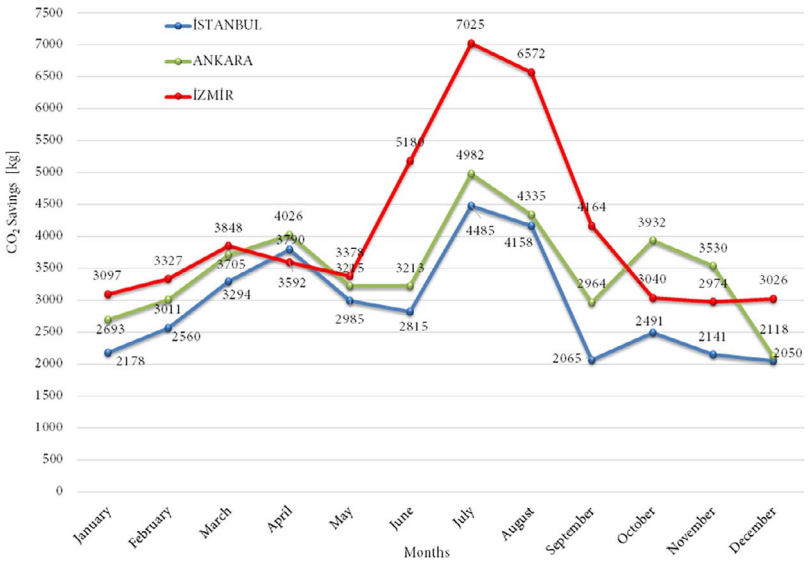


Figure 11. *Monthly variation of CO_2 savings due to use of solar energy.*

In addition, analyses showed that it is a feasible and efficient alternative to use a solar resorption chiller as an auxiliary cooling system for the solar absorption system. The average annual solar fraction of thermal energy of heating demand was calculated as 50, 54 and 65% for Istanbul, Ankara and Izmir, respectively. Therefore, it was concluded that the designed solar powered system was also feasible for covering the heating demand of the hospital by using solar energy. It was found that the total annual economic savings due to use of solar energy were notable, and this amount of savings will have a positive effect on lowering the payback period of the whole system.

It was also observed that significant savings will be achieved on CO_2 emissions due to the use of solar energy. Considering the fact that one of the biggest causes of global warming is CO_2 emission due to energy use in heating and cooling of the buildings, it is obvious that solar energy systems will provide great environmental benefits. Therefore, the effective use of solar energy, which is a completely clean, renewable and independent energy source,

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in such projects will provide significant profits and alternative solutions for the economic and ecological issues on a national and international scale.

It seems inevitable for a more sustainable future to prefer safer and more environmental friendly energy systems, especially in times such as the COVID-19 pandemic, which threaten the social order and human life, and cause many problems with unpredictable consequences on a global scale.

ACKNOWLEDGEMENTS

This work was partially funded by the Bursa Uludag University Scientific Research Project Association research grant, Project No: 2013/42, The author is thankful to the Bursa Uludag University Rectorate for the support.

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