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# Simulation of a Solar-Assisted Air-Conditioning System Applied to a Remote School

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**Abstract:** In this work, we present an absorption cooling system with 35 kW capacity driven by solar thermal energy, installed in the school of Puertecitos, Mexico, an off-grid community with a high level of social marginalization. The cooling system provides thermal comfort to the school's classrooms through four 8.75-kW cooling coils, while a 110-m$^2$ field of evacuated tube solar collectors delivers the thermal energy needed to activate the cooling machine. The characteristics of the equipment installed in the school were used for simulation and operative analysis of the system under the influence of typical factors of an isolated coastal community, such as the influence of climate, thermal load, and water consumption in the cooling tower, among others. The aim of this simulation study was to determine the best operating conditions prior to system start-up, to establish the requirements for external heating and cooling services, and to quantify the freshwater requirements for the proper functioning of the system. The results show that, with the simulated strategies implemented, with a maximum load operation, the system can maintain thermal comfort in the classrooms for five days of classes. This is feasible as long as weekends are dedicated to raising the water temperature in the thermal storage tank. As the total capacity of the system is distributed in the four cooling coils, it is possible to control the cooling demand in order to extend the operation periods. Utilizing 75% or less of the cooling capacity, the system can operate continuously, taking advantage of stored energy. The cooling tower requires about 750 kg of water per day, which becomes critical given the scarcity of this resource in the community.

**Keywords:** renewable energy; solar cooling; isolated community; absorption chiller; TRNSYS

## 1. Introduction

Renewable energies are an excellent option to provide electrical energy services, cooling, heating, food dehydration, and desalination, among others, in remote places where traditional fuels are not available or are difficult to acquire [1]. Decentralized low-capacity electrical systems installed in consumption centers, also known as microgrids, enable services to be brought to isolated regions where traditional electrification technologies are difficult to access [2] and, based on a combination with renewable energy sources, prevent the continued emission of large quantities of pollutants into the environment.

On the other hand, solar energy can be used for the direct production of electrical energy, as well as for heating and/or cooling of spaces or products [3]. If the air conditioning of spaces is required, it can be done using a thermal or electrical source by means of solar collectors or photovoltaic modules, respectively, as well as some source based on fossil fuels. However, thinking of sustainable development of marginalized and isolated communities, traditional fuels must make way for renewable energies, both for reducing pollutants and saving money. Because of this, the cooling and/or air-conditioning systems driven by clean energies attracted attention for their use in isolated communities, giving comfort conditions to the population and increasing their quality of life [4–6]. Absorption cooling technologies are an attractive option for the climatization of spaces because they can be driven by low-temperature thermal energy [7] without the use of large amounts of electrical energy [8], being able to use solar heating technologies as sources of activation [9]. In addition, they have great technological maturity, economic profitability, and high efficiency [10], as well as a great possibility of energy integration with other technologies to offer other services simultaneously, such as desalination [11].

A large number of studies related to solar-assisted absorption cooling technologies were carried out. Aliane et al. [12] conducted an investigation of experimental results and experiences presented in the state of the art of these types of systems, mentioning that it is necessary to have experience in the installation and to keep the design as simple as possible to ensure efficient operation. Bataineh and Taamneh [13] mentioned that low performance and high cost are the main disadvantages of sorption technologies; however, given the synchrony of solar radiation with cooling needs, these systems are still attractive when coupled with solar energy; thus, research continues to seek a solution to their technological, economic, and environmental problems. Lazzarin and Noro [14] mentioned that cooling systems coupled with photovoltaic modules consume half of the investment cost compared to cooling systems driven by thermal energy; thus, a large reduction in the cost of solar collectors must be achieved for them to be competitive.

Soto and Rivera [15] developed an absorption air-conditioning system cooled by air, which works using an ammonia–lithium nitrate mixture. Their experimental results showed that it is possible to cool the absorption system using only air; thus, there is no need for a cooling tower. They achieved a coefficient of performance (COP) in the range of 0.1 to 0.33 with cooling capacities in the order of 0.8 kW to 3.4 KW. However, the effect on electricity consumption due to the motors of the heat sink fans was not mentioned. Chen et al. [16] carried out experimental tests on an air-cooled solar-assisted absorption cooling system applied to residential buildings. They mentioned that, with this type of system, it is possible to save water, as well as reduce maintenance needs and space due to the absence of cooling tower. In addition, they commented that there are still no low-capacity commercial air-cooled absorption chillers, mainly due to the risk of crystallization of the working mix under environmental conditions. Huang et al. [17] presented the results of a 35-kW capacity solar thermal cooling system that began operation in 2018, which was evaluated during the summer cooling and winter heating periods. The average annual COP was in the range of 0.68 and 0.76, while the solar fraction for heating and cooling averaged 56.6 and 62.5%, respectively, generating electrical savings of 10,158 kWh annually. In another experimental study of thermosolar cooling, Rosiek [18] implemented operational strategies to optimize the exergetic efficiency of the system, such as the best absorption chiller–heat source coupling and equipment control. Lubis et al. [19] tested a 239-kW-capacity chiller activated in hybrid manner with solar energy and gas. By characterizing their system under a wide range of operating conditions, they simulated it under a tropical climate scenario of the Asian region, showing good operating potential. Sokhansefat et al. [20] performed a simulation and experimental validation of a five-ton solar absorption cooling system installed in Tehran, Iran. They analyzed different factors that affect the performance of the system and established the optimal sizes of the equipment to achieve a 28% increase in its performance. Li et al. [21] investigated the performance of a 23-kW solar absorption cooling system driven by a parabolic trough collector field for cooling a 102-m$^2$ meeting room. They attributed the low performance of the system to the fact that the pipes were too long and the heat loss was too high.

One of the main tools for the analysis of thermosolar absorption systems is the TRNSYS software; a large number of simulation studies used it to determine the best operating conditions, sizing, and optimizations [22–27], given the advantages of this software when analyzing the systems under conditions closer to reality. In a work related to the use of these systems in schools, Praene et al. [6] presented modeling and simulation studies, as well as preliminary experimental results, of a solar-driven 30-kW LiBr–$H_2O$ system installed at a university in France. They performed a complete analysis of the thermal loads of the classrooms using the TRNSYS software during the periods from 8:00 to 12:00 a.m. and from 1:00 to 5:00 p.m., corresponding to the class schedule. Uçkan and Yousif [28], using the TRNSYS software, analyzed the implementation of a 35-kW LiBr–$H_2O$ cooling system driven by solar thermal energy in the arid region of northern Iraq, seeking to reduce the consumption of fossil fuels and promote the use of renewables. In another similar study, Dakheel et al. [29] simulated the use of renewable energy-saving technologies in the United Arab Emirates, including solar–thermal absorption cooling systems. Reductions of 19.35% in annual cooling energy use, and 7.2% reduction in total annual energy use were achieved. Abrudan et al. [30] studied the implementation of absorption cooling equipment under different climatic conditions. They proposed new correlations between the solar hot water temperature and the cooling water temperature in order to avoid both crystallization and the reduction of the degassing zone below 6%. They concluded that, depending on the present climatic conditions, it is necessary to implement different operative strategies looking for greater efficiency of the system. Analyzing options to improve the efficiency of this type of system, Bellos and Tzivanidis [31,32] studied the incorporation of nanofluids into solar heating technologies. They found that the use of nanoparticles increased the exergetic efficiency of the collector by about 4% and the cooling output by about 0.84% on a daily basis. Mendecka et al. [33] analyzed two thermal storage options for adsorption cooling systems using solar energy. Their results showed that energy storage using phase change materials was slightly more efficient than storage using water. Another option for the activation of absorption systems is hybrid photovoltaic/thermal (PV/T) technology. Alobaid et al. [34], in their review of the state of the art of these systems, identified that up to 50% primary energy can be saved by using hybrid collectors in absorption machines compared to mechanical vapor compression equipment for cooling. The hybridization of mechanical vapor compression technologies was even proposed, working in combination with absorption technologies to improve the system efficiency [35,36].

It should be noted that very few studies mentioned the benefits of this type of solar-assisted cooling system in applications with difficult access to electricity, such as isolated communities. By using an energy resource that can be exploited in an excellent way in most of the world's territory, it makes its implementation attractive in this type of scenario where there is no electricity supply. This type of application presents factors that affect the operation of the system, different from those that would be expected in absorption systems installed in towns or cities with access to continuous fresh water and electricity services. However, as mentioned in the previous works, a detailed analysis of the engineering of these systems must be carried out so that they become both technically and economically attractive. This work presents the simulation study of an absorption air-conditioning system driven by a solar thermal collector field, installed in the school of Puertecitos, an off-grid community with a high level of social marginalization. The system was simulated using the TRNSYS software in order to determine its performance under the typical operating conditions of a school in Mexico, as well as to determine the effect of different distinctive factors of a remote community, such as the scarcity of clean water and electricity. The aim of this simulation study was to determine the best operating conditions prior to system start-up, to establish the requirements for external heating and cooling services, and to quantify the freshwater requirements for the proper functioning of the system. This study allows establishing the operation and maintenance strategies, as well as the operating limits, of the cooling system under a real scenario that was not studied in the literature.

## 2. System Description

The thermosolar absorption air-conditioning system installed in the primary school of the community of Puertecitos, Baja California, Mexico (30°21′19.7″ north (N), 114°38′26.3″ west (W)) is composed of a field of solar thermal collectors, containing evacuated tubes with a parabolic reflector in the lower part with a total aperture area of 110 $m^2$; these solar heating technologies are responsible for maintaining optimal temperature conditions using a water storage tank of 12 $m^3$ capacity, necessary for proper operation of the cooling system. Both the collector field and the thermal energy storage tank (TEST) compose the hot water circuit.

An LiBr–$H_2O$ absorption cooling system of 35 kW capacity is thermally driven by the hot circuit fluid. Due to the absorption process, heat is removed from the water that is used as a cooling medium in the chilled water circuit. For abrupt temperature changes not to affect the operation of the chiller, a 1-$m^3$ buffer tank is used in the chilled water circuit. The chilled water passes through four cooling coils with a capacity of 8.75 kW each, one in each classroom of the school, removing the thermal load when required. The heat supplied to the chiller, both by the hot and chilled water circuit, is discharged through the cooling water circuit and released into the environment with an evaporative cooling tower.

Given the problems of water availability in the region and, being a community next to the sea, the cooling water circuit has two variants: normal water mode and seawater mode. In the first mode of operation, freshwater is used as a direct cooling medium for the chiller; it is fed into the absorption machine to remove the heat and transfer it to the environment with the cooling tower. When seawater is used, the cooling of the system is carried out indirectly. The cooling water circuit is divided into two; the tower is responsible for cooling the seawater and recirculates it in an independent circuit, while, in the other circuit, freshwater is used to remove heat from the chiller and, by means of a titanium coil submerged in the seawater reservoir of the cooling tower, the removed heat is transferred. This is done in order to not introduce the incrusting and corrosive compounds that the seawater carries with it into the internal heat exchangers of the absorption machine, as well as to not depend on replenishment of freshwater due to evaporation by cooling the system. There is also a diesel auxiliary heater in the hot water circuit so that, if the temperature conditions in the TEST are not met, the system can be operated. The previous equipment installed in the Puertecitos school is shown in Figures 1 and 2.

**Figure 1.** Evacuated tube solar collector field with a bottom parabolic reflector.

The schematic diagram of the components and connections is shown in Figure 3. The solar collector field is responsible for maintaining the temperature of the TEST in the range of 75–96 °C, enough for proper chiller operation. Regardless of whether the cooling machine is operating or not (for example, on weekends, the chiller does not operate because there are no classes), the solar field pump continues to provide fluid for heating until the tank is completely at the set point temperature, in this case 96 °C, always seeking to have the system in operating conditions. When there is a need for classroom air conditioning, the chiller turns on and the TEST pump supplies hot water from the top. Since the temperature of the generator of the absorption machine is at an optimal level for operation, the pump of the chilled water circuit is turned on to bring it to the cooling coils of the classrooms, at a temperature between 7 and 10 °C, removing the heat from the spaces to be air-conditioned. This current is taken to the chiller to be cooled again. It is worth mentioning that the configuration of the chilled water circuit allows controlling the number of cooling coils used for air conditioning, allowing a saving of thermal energy when air conditioning is not required in all classrooms.

(**a**)

(**b**)

(**c**)

(**d**)

**Figure 2.** Components of the thermosolar absorption cooling system at Puertecitos school, where we can appreciate the (**a**) thermal energy storage tank, (**b**) cooling tower with freshwater and seawater storage tanks, (**c**) auxiliary heater and chiller inside the machine room, and (**d**) titanium coil inside the cooling tower.

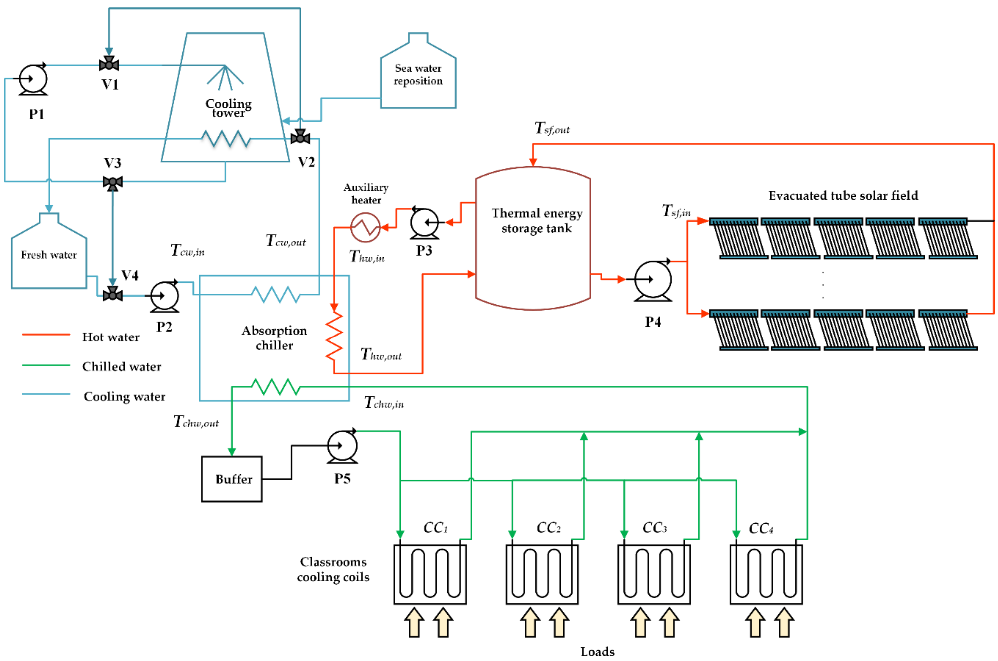


**Figure 3.** Schematic diagram of the equipment and circuits of the solar thermal cooling system.

Depending on the mode of operation in the cooling tower mentioned above, the cooling water circuit is modified with manual valves for the use of seawater and/or freshwater only. When seawater is required as cooling fluid in the tower, the seawater reposition tank fills the cooling tower tank while the P1 pump recirculates the fluid in a closed circuit between the V1 and V3 valves, cooling the seawater by evaporation. During this process, the P2 pump takes water from the freshwater tank and supplies it to the chiller to remove the heat generated. Then, it transfers it to the seawater by means of a coil heat exchanger submerged in the cooling tower reservoir (Figure 2d) and returns it to the freshwater tank, all in the closed circuit between V2 and V4. This configuration avoids the problem of freshwater evaporation in the cooling tower by using seawater, an easier resource to acquire in the community. On the other hand, when freshwater is used as a direct cooling medium, the P2 pump takes water from the cooling tower reservoir through the V3–V4 circuit, it removes the heat from the chiller, and, through the V2–V1 circuit, it cools the freshwater through evaporation in the tower. The freshwater tank is positioned in a way that when the water level in the tower tank decreases, the water is replaced by gravity and controlled by a float. In the latter configuration, the P1 pump does not work.

## 3. Methodology

The TRNSYS software was used to carry out the operational simulation of the solar thermal cooling system. This program allows analyzing the system in a semi-dynamic way, having the advantage of working with typical meteorological databases (TMY) in the region, studying the system under more realistic operating conditions. By using modules programmed with validated mathematical models of various equipment, such as pumps, motors, heat exchangers, storage tanks, solar collectors, power cycles, and refrigeration, among many others, TRNSYS becomes an ideal software for the simulation of this type of process. The validated mathematical models used in the simulator modules can be reviewed in Reference [37]. Table 1 shows the characteristics of the cooling system equipment installed in the Puertecitos school, which were used as input parameters in the developed simulator, and Table 2 presents the description of the components within TRNSYS.

**Table 1.** System characteristics.

| **Solar Collector** | |
|---|---|
| Brand/model | Suntask/SHC24 |
| Collector type | Evacuated tube with parabolic reflector |
| Number of tubes | 24 |
| Aperture area | 4.41 $m^2$ |
| Optical efficiency ($a_0$) | 0.668 |
| First order efficiency coefficient ($a_1$) | 1.496 W/$m^2$ K |
| Second order efficiency coefficient ($a_2$) | 0.005 W/$m^2$ $K^2$ |
| Fluid | Water |
| Mass flow | 0.02 kg/sec $m^2$ |
| Number in series | 5 |
| Number of loops | 5 |
| **Thermal Energy Storage Tank** | |
| Volume | 12 $m^3$ |
| Height | 2.5 m |
| Material | Fiberglass |
| Insulation thickness | 0.025 m |
| Loss coefficient | 1.4 W/$m^2$ K |
| Fluid | Water |

**Table 1.** *Cont.*

| Absorption Chiller | |
|---|---|
| Model | Lucy New Energy/RXZ-35 |
| Refrigerant | Water–lithium bromide |
| Cooling capacity | 35 kW |
| COP | 0.7 |
| Hot water nominal temperature | 90 °C |
| Hot water nominal flow rate | 8.3 $m^3$/h |
| Chilled water nominal inlet temperature | 15 °C |
| Chilled water nominal flow rate | 6 $m^3$/h |
| Cooling water nominal temperature | 30 °C |
| Cooling water nominal flow rate | 15 $m^3$/h |
| Power consumption | 0.3 kW |

**Table 2.** TRNSYS type for the components simulated.

| Component | TRNSYS Type | Description |
|---|---|---|
| Temperature control | 2 | On/off control of feed pumps of the different circuits. |
| Pumps | 3 | Pumps for mass flow feeding of circuits. |
| Time-dependent forcing function | 14 | Cooling system on/off time control. |
| Weather data processor | 15 | Climatological database. |
| Cooling tower | 51 | Evaporative cooling tower with constant volumetric flow. |
| Solar thermal collector | 71 | Evacuated tube solar thermal collector. |
| Absorption chiller | 107 | LiBr/$H_2O$ hot water-driven absorption chiller. |
| Thermal energy storage tank | 534 | Stratified thermal storage tank with variable nodes, ports, and insulation. |
| Buffer tank | 534 | Thermal storage tank with variable nodes, ports, and insulation. |
| Mass flow diverter | 647 | Mass flow diverter with variable outlets. |
| Mass flow mixer | 649 | Mass flow mixer with variable inlets. |
| Mass flow heat exchanger | 682 | Energy and mass balance heat exchanger. |
| Heat load | 686 | Heat load profile dependent on the day, weekday, month, or season. |

In order to carry out the analysis of the system with the aforementioned software, the following considerations were taken into account:

- Steady state;
- 15-min simulation intervals;
- Maximum thermal load of 8.5 kW per classroom at 12:00 p.m.;
- Pressure drops and heat losses in the equipment were not considered, only the heat transferred to the environment by the TEST losses was considered;
- On/off control by temperature difference in the solar field ($T_{sf,out} - T_{sf,in} > 0$);
- Only fresh water was used in the cooling water circuit;
- System operation with solar energy only.

The cooling system operates under an established school schedule of 8:00 a.m. to 3:00 p.m. Monday through Friday, which are typical class hours in Mexico. The vacation periods correspond to the months of July and part of August, the same days in which the highest ambient temperatures are present; thus, a constant operation is expected during May, June, mid-August, and September, where the penultimate month is the critical one due to the extreme temperatures present. Figure 4 shows the ambient temperature, relative humidity, and global radiation conditions based on a TMY file of the study region for the simulation period, corresponding to warm and sunny days in August. Being a coastal community, the relative humidity plays a very important role in the proper operation of the cooling water circuit and, therefore, the system in general.

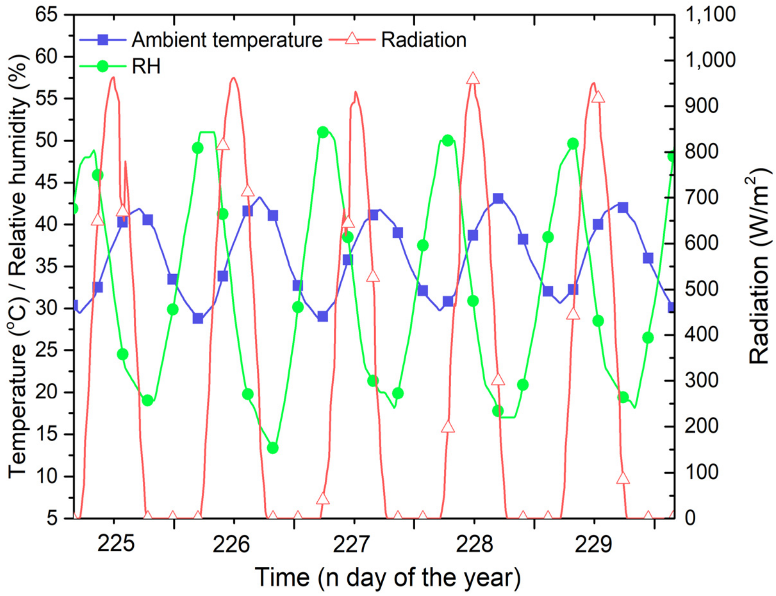


**Figure 4.** Ambient temperature, relative humidity, and global radiation in the simulation lapse for Puertecitos, México.

## 4. Results and Discussion

### 4.1. Operation at Nominal Capacity

Seeking adequate temperature conditions inside the classrooms, the chiller is turned on every day that cooling is needed from 7:00 a.m. to 3:00 p.m., i.e., one hour before the beginning of classes. This results in a constant eight-hour operation from Monday to Friday, allowing robust system programming and control without much user intervention.

Figure 5 shows the variation of the thermal load present in the classrooms during a typical operating day and the temperature of the chilled water coming from the absorption chiller. The thermal load starts at 6:00 a.m.; however, the chiller starts cooling the water at 7:00 a.m. As the hours pass, the load increases until it reaches 35 kW, with the maximum demand established at 12:00 p.m. corresponding to 8.75 kW per cooling coil. At 6:00 p.m., the thermal load is zero, but the cooling system is stopped 3 h beforehand as classes are finished and the facilities are empty, avoiding the consumption of thermal and electrical energy. The chilled water temperature remains constant at 7 °C during chiller operation due to the control of the heat supplied to the system by means of the hot water circuit. If the cooling load increases, the heat is taken out of the TEST to raise the capacity of the chiller and keep the operating conditions as stable as possible. Otherwise, if the load increases but the heat supplied to the system remains constant, it results in an increase in the temperature of the chilled water and, therefore, of the classrooms. In addition, the heat transfer rate to the chiller cooling water must be sufficient to maintain stable operating conditions, so that, as the cooling capacity increases, more heat is removed from the system by the cooling water circuit. It should be noted that the temperatures of the hot water and cooling water circuit do not remain constant, as they depend directly on the environmental conditions present during the operation of the system; however, they are always within the minimum ranges, as shown in Figure 6.

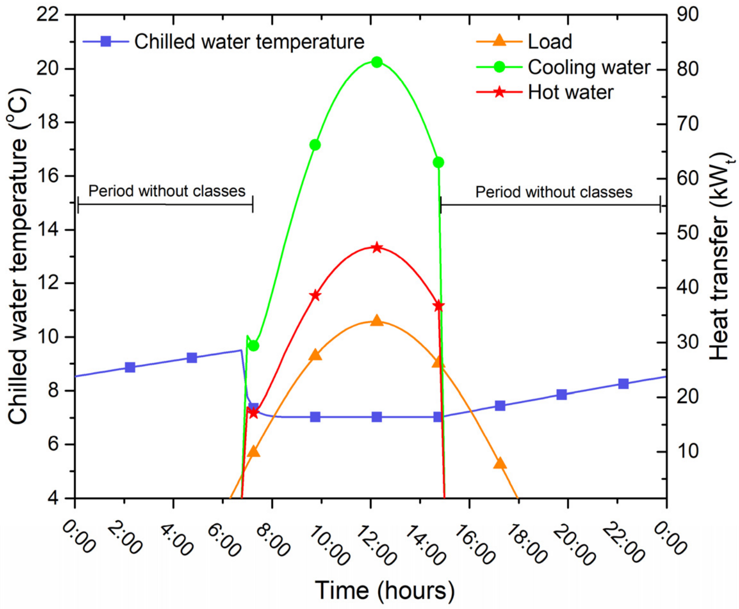


**Figure 5.** Chilled water temperature and heat transfer of the circuits.

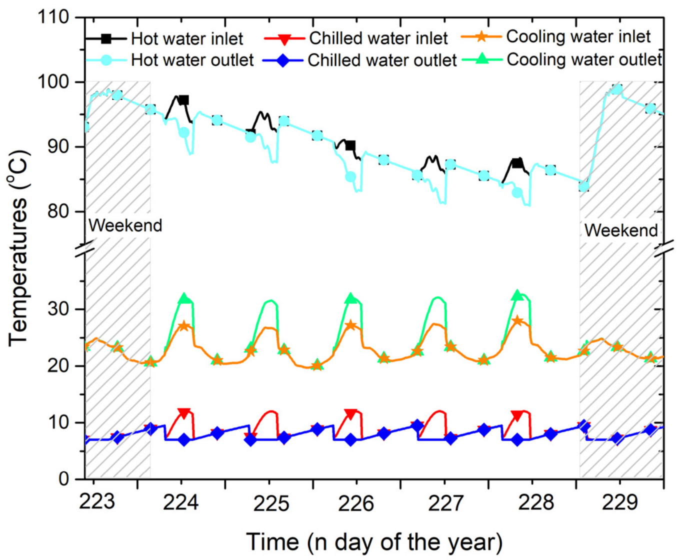


**Figure 6.** Variation in system circuit temperatures.

A typical week of operation is shown in Figure 6, where the temperature variations of the different circuits of the cooling system at its inlet and outlet can be appreciated. At the beginning of the week, the temperature of the TEST is in optimal conditions to start the system, around 97 °C for all its levels, as the field of solar collectors is dedicated to its increase in temperature on Saturday and Sunday. During the days of classes, the TEST tends to decrease its temperature significantly because the collection and storage of daily solar energy is not enough to return it to initial conditions. Since the operation of the chiller stops at 3:00 p.m., while there is still a solar resource, the TEST recovers a bit of its temperature level by keeping the solar collector pump on; however, this is not enough to counteract the loss of heat during the day. With the passing of operating days, the decrease in temperature becomes greater; thus, when the last day of classes arrives, the system operates in limited conditions of activation temperature (around 75–80 °C), while being able to satisfy the cooling demand of the classrooms. However, it is necessary for weekends to be exclusively dedicated to heating the TEST and bringing it to its initial conditions so that, at the beginning of the following week, the complete system is in optimal operating conditions and meets the cooling requirements during the five days of classes.

### 4.2. Partial Load Operation

The school where the thermosolar cooling system is installed has fluctuations in student attendance, mainly due to migration and immigration phenomena of its population, depending on weather or working conditions. For this reason, depending on the number of students in the school, it may not be necessary to air-condition the four classrooms, but only some of them.

Figure 7 shows the behavior of the mean temperature of the TEST with respect to the variation of the maximum thermal load of the classrooms, using the profile presented in Figure 5 at 25, 50, 75, and 100% of the chiller capacity. Working the system with a maximum load of 35 kW ensures operation during the five days of classes as long as weekends are used to heat the TEST, as mentioned in the previous section. However, with a maximum load of 25.5 kW, corresponding to 75% of the capacity of the cooling system, it is possible to maintain constant operation for more than five days without having to spend the entire weekend heating it. The decrease in the average temperature of the TEST is recovered in the period with the availability of the solar resources after typical operation of 7:00 a.m. to 3:00 p.m. On the other hand, when operating at 50% of the maximum capacity or less, the temperature conditions of the system are kept stable, being able to operate normally for the whole week in the aforementioned period.

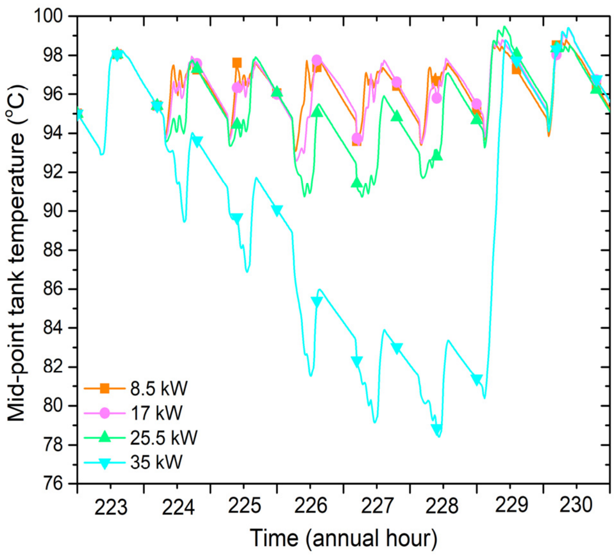


**Figure 7.** Thermal energy storage tank (TEST) temperature when varying the thermal load.

### 4.3. Evaporation of Cooling Water

The availability of water and electricity in this region is a very severe problem. There is no water distribution network and the easiest way to acquire it is in a well located 32 km away from the community; thus, it becomes a natural resource much appreciated and cared for. On the other hand, electricity is supplied by a microgrid based on renewable energy, but the school does not have the economic resources to pay for it. However, the heat entering the cooling system needs to be removed; thus, the use of a cooling tower is essential. There are two options: cooling with water or air. The first consumes a considerable amount of water with low electricity consumption, while the second does not consume water, but a large amount of electricity. Water cooling was selected by installing equipment that allows both seawater and freshwater as a working fluid. Thus, if freshwater is not available, seawater can be used given the ease of acquisition.

Figure 8 shows the weekly water consumption in the cooling tower. Depending on the thermal load of the chiller, the water evaporation rate can reach 140 kg/h. During a typical eight-hour operating day, about 750 kg of water would be needed per day, giving a total of 4000 kg (~4 $m^3$) per normal week of classes. This is critical considering the scarcity of the resource in the region and the work involved in maintaining tank levels in these conditions, as well as maintenance related to using seawater in the cooling tower due to salt concentration. With these results, it is possible to program the filling of the tanks and the cleaning of the cooling tower tank.

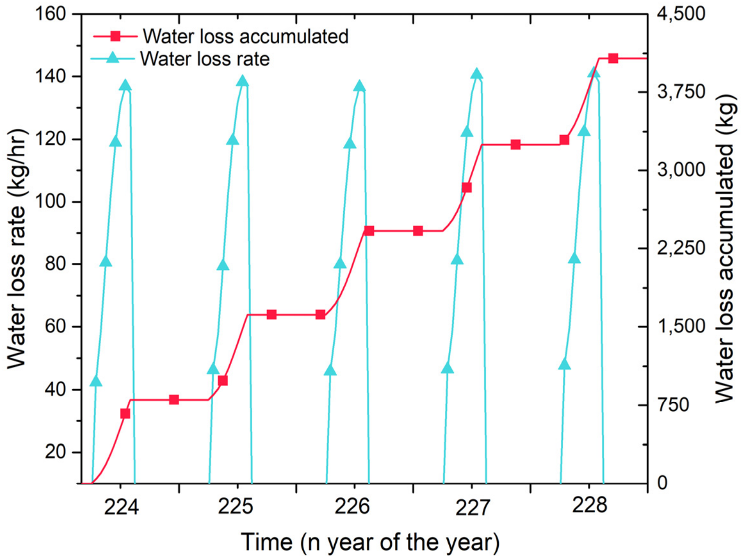


**Figure 8.** Rate of water loss due to evaporation in the cooling tower and its weekly accumulation.

## 5. Conclusions

An operational analysis of a 35-kW absorption cooling system driven by solar thermal energy was carried out and installed in a primary school in the isolated community of Puertecitos, Baja California, Mexico. The system was simulated using TRNSYS software in order to determine its performance under the typical operating conditions of a school in Mexico, as well as to determine the effect of different distinctive factors of a remote community, such as the scarcity of freshwater and electricity. The simulation results show that, under full load operation, the cooling system can satisfy the air-conditioning requirements of the four classrooms during the five days of the week, from 7:00 a.m. to 3:00 p.m. The weekends are used exclusively for the storage of thermal energy and elevation of the temperature of the TEST, using the solar collector field. The operation of the system under different thermal load profiles was also studied, and it was concluded that, under a thermal load of 75% of the chiller capacity or less, the system can operate the entire week without the need to dedicate weekends solely to thermal energy storage. With the configuration in the chilled water circuit, the individual operation of each cooling coil is possible; thus, it is possible to control the thermal load of the classrooms to extend the operation of the chiller system.

On the other hand, the consumption of freshwater in the cooling tower is a critical factor due to the scarcity of this resource in the region. At its maximum capacity, the system consumes about 4 $m^3$ of water to remove heat from the equipment per normal week of operation. Therefore, the system is designed with two independent cooling water circuits, where seawater can be used in the cooling tower as it is easier to acquire in the project community. This study allowed establishing the operation and maintenance strategies, as well as determining the best operating conditions prior to system start-up, establishing the requirements for external heating and cooling services, and quantifying the freshwater requirements for the proper functioning of the system under a real scenario not studied in the literature.

**Author Contributions:** Investigation, J.A.A.-J.; methodology, R.L.-Z., L.H.-C., and L.A.G.-U.; software, J.A.A.-J. and N.V.; formal analysis, J.A.A.-J., R.B., L.H.-C., and N.V.; writing—original draft preparation, J.A.A.-J., L.A.G.-U., and R.L.-Z.; writing—review and editing, N.V., R.B., and L.H.-C.; supervision, N.V. and L.H.-C.; funding acquisition, N.V. and L.H.-C.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

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