International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review on An Innovative Low Cost Technique for Passive Cooling of Building

Ashish Moon[1], Sulabh Bagade[2] Nitesh Donadkar[3], Sarvesh Dethe[4], Rahul Awsare[5], Vikash Srirame[6], Naitullya Meshram[7]

[1]*Head of Civil Engineering Department, SRPCE, Nagpur, Maharashtra*
[2]*Assistant professor, Civil Engineering Department, SRPCE, Nagpur, Maharashtra*
[3,4,5,6,7] *UG Students, Department of Civil Engineering, SRPCE, Nagpur, Maharashtra*

ABSTRACT-

An earth-to-air heat exchanger (EAHE) system utilizes the low-grade thermal energy of underground soil to warm up and cool down the flowing air within an underground buried pipe. Integrating the EAHE system with building ventilation can reduce the energy demand for conditioning ventilation air. The main purposes of this paper are to estimate the year-round energy-saving potential of the EAHE-assisted building ventilation system and provide its design guidelines in a hot-summer and cold-winter climate. A steady-state heat transfer model was proposed to calculate the outlet air temperature of an EAHE and further identify its ability to preheat and precool ventilation air. Influences of depth, length, and diameter of a buried pipe on the year-round thermal performance of the EAHE system were evaluated. The results show that considering the compromise between thermal performance and construction costs of the EAHE system, a depth of 5 m and a length of 80 m are recommended. The EAHE system can provide a mean daily cooling and heating capacity of 19.6 kWh and 19.3 kWh, respectively. Moreover, the utilization of the EAHE system can reduce by 16.0% and 50.1% the energy demand for cooling and heating ventilation air throughout the whole year.

Keywords: renewable energy; earth-to-air heat exchanger **as earth tube** ; sustainable building; building ventilation; building energy efficiency

INTRODUCTION:

Nowadays, approximately 30% and 36% of the total energy use in China and the world is generated by the building sector during its whole life cycle, respectively. The building sector has been recognized as a significant portion for reducing global energy use and greenhouse gas emissions. In recent years, great efforts have been devoted toward the research and development of sustainable and high-performance buildings, in terms of improving building design guidelines, using advanced energy-efficient devices, enhancing the thermal performance of windows and walls, adopting a data-driven approach to achieve performance prediction and optimal control, taking advantages of renewable energy sources, improving indoor thermal comfort, integrating the thermal energy storage, etc. Building ventilation is essential for both residential and commercial buildings to satisfy the requirements of indoor air quality and thermal comfort. However, the minimum ventilation requirement may lead to a large amount of energy consumption for conditioning ventilation air to the required conditions. Over the past several decades, better building design and emerging technologies have been constantly developed to reduce the energy demand of building ventilation.

Currently, air-to-air heat recovery exchangers are widely used to recover the latent and sensible heat of exhaust air to precondition ventilation air, which can significantly reduce the energy demand for conditioning ventilation air. Advanced Technologies such as membrane-based or photovoltaic/thermal-collector-assisted air-to-air heat recovery exchangers are proposed to further improve the energy performance of building ventilation systems. Moreover, it is estimated that about 20% to 40% of the total energy use for air conditioning results from the dehumidification process of ventilation air. Compared with the conventional condensation dehumidification, the liquid desiccant-based air conditioning systems provide an alternative approach to remove the moisture from ventilation air with promising energy performance. Meanwhile, there exists a passive approach by integrating the ventilation system with a building envelope to reduce the energy demand of building ventilation, such as dynamic insulation (also known as the breathing wall) and the supply-air window. These technologies allow the outdoor air to flow into indoor space through the pathway within building envelopes, and the outdoor air is preheated therein by recovering the heat loss of the building envelope in the heating season. In recent years, much research has emphasized the advantages of utilizing low-grade energy sources to reduce the energy demand for conditioning ventilation air. The evaporative cooling and photovoltaic thermal (PVT) system can be used to precool and preheat ventilation air in the cooling and heating seasons, respectively. Moreover, the earth-to-air heat exchanger (EAHE) can be treated as a low-grade heat source in winter and cold source in summer for preheating and precooling ventilation air, respectively.

The EAHE system is a kind of heat exchanger that can modifies heat between soil and ventilation airflow within underground buried pipes (as shown in **Figure 1**.3). The temperature of underground soil keeps approximately constant with a low fluctuation all year round when the depth reaches to a certain degree. This makes the temperature of underground soil significantly higher or lower than the outdoor air temperature in winter or summer, respectively. In recent years, the energy-saving potential, optimal design, and heat transfer model of the EAHE system have been constantly investigated. Maoz et al. and Lee et al. pointed out that the diameter, depth, and length of buried pipes as well as airflow velocity within pipes show significant influence on the cooling and heating capacity of EAHE systems. Ascione et al. recommended a depth of 3 m and a length of 50 m for the buried pipe of the EAHE system considering the compromise between 0construction costs and energy performance. Amanowicz and Wojtkowiak provided a new design perspective of a multi-pipe EAHE system, which considers the influence of flow characteristics on the thermal performance. Minaei and Safikhani developed a new transient analytical model to quickly and accurately predict the thermal performance of the EAHE. Gomat et al. presented a simplified analytical model to estimate the impact of a vertical pipe on the thermal performance of the whole EAHE system. Moreover, the feasibility of applications of EAHE systems in different climate conditions has been fully explored. In the cooling-dominated climates, such as hot-arid or desert climate, the hot ambient air is sucked into the buried pipes and cooled down therein, and then the cool ventilation air is supplied into the indoor space.

LITERATURE REVIEW:

[1] Khalil Zaki Almustansrie, Al-musaed Amjad: Cooling tubes are a reasonably priced natural way to passively coolthe air. Cooling tubes are long pipes placed underground through which air is drawn. As the air is drawn through the pipes it either cools the air or heats the air. It is usually used to cool and dehumidify hot outside air, but can also preheat cold outside air. The drawn air temperature will move towards the ground temperature where the tubes are located. It is important to understand that soils temperatures during the summer season at certain depths are considerably lower than ambient air temperature, thus providing an important source for dissipation of a houses excess heat. Conduction or convection can achieve heat dissipation to the ground.

[2]Thomas Woodsonand, Yézouma Coulibaly: An earth-air heat exchanger (EAHX) also known as an earth tube heatexchanger, a system for cooling and heating buildings using the ground as a heat sink/source. This study examines the ground temperature gradient and the performance of an EAHX performance. Ground temperature measurements were made at certain depths. A clear phase shift was observed between the maximum outside temperature and the maximum ground temperature, the time of the day when the outside temperature is highest corresponds to the time when the underground temperature was lowest.

[3] Didier Thevenard: The purpose is providing some pre-conditioning of air, either pre-heating in the winter or pre-cooling in the summer. From the literature search it was found that the economics of earth tubes was marginal, particularly for heating. In addition, there were concern with possible problems with insects, rodents and dust accumulation in earth tubes. The purpose of the study is to evaluate an earth tube design that would respond to this concern and evaluate the economics. The report summarizes the proposed design, sizing and basic construction of an Earth To Air Heat Exchanger system that is designed to be as economical as possible with current state of technology and at current prices.

[4] C. T'JOEN, L. LIU and M. De PAEPE: The impact of different design parameters, including tube length, tubediameter, fluid flow rate, etc., have been investigated. The simple heat exchangers are made up of a single tube (or multiple in parallel) through which a fluid is circulated. By placing the tube sufficiently deep, the fluid which is circulated can be cooled down in summer and heated up in winter. This is due to temperature lag which occurs between the surface and more profound soil layers. The soil is thus used as a thermal sink and source, providing „free" heating or cooling, reducing the required heating or cooling capacity to be installed for the house. These models are used to study the influence of different design parameters (tube length, tube diameter, fluid flow rate, etc.) on the thermal- hydraulic performance.

[5] GirjaSharan: Earth-Tube Heat Exchanger (ETHE) is a device that enables transfer of heat from ambient air todeeper layers of soil and vice versa. Since the early exploration of its use in cooling commercial livestock buildings (Scottetal1965) there has been considerable increase in its application. ETHE is used to condition the air in livestock buildings (Spengler and Stombaugh 1983). It is used in North America and Europe to cool and heat greenhouses (Santa Mouris et al 1995). There have also been works aiming attaining better understanding of its working in cooling and heating mode (Baxter 1992, 1994). Mathematical models of ETHE have also been developed (Puri 1985; Goswamiand Dhaliwal 1985). There has also been some work in India. Sawhneyet al (1998) installed a ETHE based system to cool part of a guesthouse. Sharan et al (2001) installed an ETHE based cooling system for tiger dwelling at Ahmadabad Zoological Garden. Authors have visited Tata Energy Research Institute, where a system is installed to cool rooms in its training center near Delhi. The experimental system we have built is similar to Baxter's, though smaller and less elaborately instrumented. Baxter's facility at Knoxville, Tennessee (USA) is a single pass earth-tube heat exchanger 64-m long, 15-cm diameter; made of 18- gauge spirally corrugated galvanized metal. The tube is buried at 1.8-m depth, and is elaborately instrumented with temperature sensors inside the tube and in soil around it. Air is pumped by a high pressure industrial blower of about 572 W. Instrumentation permits measurement of air temperature along the tube and in soil around the tube

[6] D. Pahuda, B. Matthew A borehole heat exchanger is a ground heat exchanger devised for the extractioninjection of thermal energy from/into the ground. The thermal performance of a borehole heat exchanger can be assessed with a response test. The response test method allows the in situ determination of the thermal conductivity of the ground in the vicinity of a borehole heat exchanger, as well as the effective thermal resistance of this latter. The response test method is described before it is applied to several designs of double U-pipe borehole heat exchangers. The tests have shown the viability of the method. They reveal that the thermal resistance can be decreased by 30% when quartz sand is used instead of bentonite and when spacers are used to keep the plastic pipes in contact with the borehole wall. With a common heat extraction rate of 50 W/m of borehole length, the temperature gain in a heat pump evaporator is 2K. Finally, a mobile device has been developed to offer the possibility of accomplishing a response test.

[7] OnderOzgenera, ArifHepbasl: Ground-source heat pumps (GSHPs), also known as geothermal heat pumps (GHPs), are recognized to be outstanding heating, cooling and water heating systems and have been used since 1998 in the Turkish market. Greenhouses also have important economic potential in Turkey"s agricultural sector. In addition to solar energy gain, greenhouses should be heated during nights and cold days. In order to establish optimum growth conditions in greenhouses, renewable energy sources should be utilized as much as possible. It is expected that effective use of heat pumps with a suitable technology in the modern greenhouses will play a leading role in Turkey in the fore-seeable future. The main objective of the present study is to investigate to the performance characteristics of a Solar Assisted Ground Source Heat Pump Greenhouse Heating System (SAGSHPGHS) with a 50m vertical 1×1/4in. nominal diameter U-bend ground heat exchanger using energy analysis method. This system was designed and constructed in Solar Energy Institute of Ege University, Izmir, Turkey. The energy transports between the components and the destructions in each of the components of the SAGSHPGHS are determined for the average measured parameters obtained from the experimental results. Energetic efficiencies of the system components are determined in an attempt to assess their individual performances and the potential for improvements is also presented. The heating coefficient of performances of the ground-source heat pump unit and the overall system are obtained to be 2.64 and 2.38, respectively, while the energetic efficiency of the overall system is found to be 67.7%.

[8] D J G Butler, BRE A Gigieland S Russell: Using air as refrigerant has enormous advantages over conventional refrigerants, many of which have harmful environmental effects, are flammable or are toxic. However, the use of air for main-stream refrigeration in buildings has been held back by the low perceived energy efficiency of air cycle systems. This paper reviews the what is believed to be the world's first integrated air cycle system for heating and cooling in buildings by BRE and FRPERC, which overcomes the low energy efficiency of cooling only systems.

[9] Ralph T. Muehleisen: In the early stages of the design of building systems, the use of simple design tools can help estimate the size and/or impact of system components in evaluating the viability of various technologies. However, such design tools are not readily available to evaluate earth-air heat exchangers (EAHEs), also known as earth-tubes. Furthermore, even though many researchers have developed sophisticated equations to analyze EAHEs, they cannot be easily recast into design equations and must be used by trial-and-error. This paper describes a set of simplified analysis and design equations to support early-stage EAHE design and which are suitable for implementation in a spreadsheet. The equations we have developed allow the designer to quickly determine the length of tubing required for a desired level of heat transfer effectiveness; estimate the pressure drop across the system and required fan power; and estimate the mean monthly temperature of air exiting the tube.

[10] Keng WaiChan, Kuok Soon Chan: Soil has been proven as a promising cooling source in arid region, yet it has underperformed in hot-humid tropical countries. This paper aims to investigate the cooling performance (soil temperature) in hot and humid regions under the enhancement of different porous materials such as gravel and woodchips. Two experiments were conducted to evaluate the materials. First, the materials were tested outdoor under open condition. The performance of the surface covered by these materials was compared with other surface conditions such as the empty uncovered surface and the surface covered by a building model. The soil temperatures at the depth of 0.25 m and 1.00 m below the surface covered by wood chips are the lowest compared to other samples. Even at noon-time, the soil temperatures at these depths are 0.8°C and 0.4°C lower compared to the soil temperature at the same depths below the uncovered surface. In the second experiment, the porous materials were examined under the desired radiation intensity (1000 Wm-2) from a halogen lamp. The soil surface covered by 2 cm-thick and 5cm-thick wood chips is 3°C and 4°C lower than the soil surface covered by gravel. Meanwhile, the soil temperatures at the bottom of the container covered by 2cm-thick and 5cm-thick wood chips are 0.5°C and 0.8°C lower than the soil covered by gravel. Furthermore, soil with empty surface experienced the highest weight loss amongst the samples and the sample covered by gravel has the least weight loss though it has the highest temperature. In conclusion, wood chips performed better in enhancing the cooling effect of soil as they have lower thermal conductivity and better ability to absorb water compared to gravel. The absorbed water may evaporate when solar radiation falls on the wood chips. As evaporation happens, the heat within soil is extracted and the soil is cooled down.

THEORETICAL POINT OF VIEW:

The devises of earth cooling tubes, take place by a vary system in size and form, some system have tubes in parallel terminating in a header, and some used a ra-dial prototype collecting in a central sump some were only a single tube. It is important to design the system so as to minimize the cost and maximize the benefits. The tube length over 10 m for example is inefficient. The conclusion say that; the small diameter tubes are more effective per unit than large tubes, the long tube is unnecessary, tubes should be placed as deeply as possible, closed loop systems are more effective than open loop systems, and the tube thermal resistance is unimportant the ground thermal resistance dominates.

To slow of the fluids speed circulation, for occurs the optimal exchange of energy between the air or water and the soil (earth). The dark and humid atmosphere of the cooling tubes may be a breeding ground for door producing mould and fungi. Further more, condensation or ground water escape may accumulate in the tubes and encourage the growth of bacteria. Good construction and drainage could eliminate some of these problems. Insects may enter the tube inlet to deter potential intruders. The inlet ends of air pipes need to be screened for filtering. If we simply take 25 centimeters of window screen and put it over the end of a 25 centimeters air pipe, we will strain out most of the bugs, but we will also restrict most of the air flow. Air does not flow efficiently through a screened opening, particularly where the screen net size is small. Therefore we have to create a screen box, or a larger surface area for the screening. An area ten times as large as the area of the pipe should be provided. This allows the air to flow slowly through the screens and provides enough air for the pipe. A long roll of screening works very well. We must leave it up to the actual system design to decide what is best for the situation.

METHODOLOGY:

Tube Material:

The main considerations in selecting tube material are cost, strength, corrosion resistance, and durability. Tubes made of aluminum, plastic, and other materials have been used. The selection of material has modest influence on thermal performance. PVC or polypropylene tubes perform almost as well as metal tubes as the efficiency of cooling of PVC tubes is better than other pipes we preferred to use PVC pipes than other pipes. At actual execution on a particular site where earth tubes are to be installed we can use large diameter concrete or soil pipes.

Tube Diameter:

Optimum tube diameter varies widely with tube length, tube cost, flow velocity, and flow volumes. Diameters between 10 - 25 centimeters come into view to be most appropriate. Tube diameter is also an factor which affects the earth tubes as bigger diameter hole can drive much air but at certain limit, if pipes does not content any other external pressure air will not pass through it therefore at the time of installation we should take care of diameter, because as diameter increases we should increase the pressure also which leads to more energy consumption therefore smaller diameter of pipes always preferred. As an small scale project we are taking the diameter of piped approximately between 4 - 5 cm.

Tube Location:

Earth temperatures and, as a result, cooling tube performances vary considerably from sunny to shady location. The optimal situation is to build the house on a hill which rises 3 meters above its surrounding area. A channel can then be dug from the home, 3 meters down, and then horizontally until it reaches daylight. This horizontal section is placed on a small incline to the exterior, like a drain line. Mind must be taken that this flow line is absolutely controlled as we do not want pockets of water building up within the tube. Therefore, the flow line must be right on grade. This means the air can come into the tube, flow up the slight incline, and drop its condensation as it is travelling through the tube so the condensation drains out the tube's bottom portion. When there is humidity there will be a considerable amount of condensation in to the house. It is vital that the tube is sloped collection point. Water will run to this collection point where it must be removed. The collection point can be at either end of the tube or in the middle. It is left to the installer to decide its best location. Some tubes can all be drained to one collection point. This can be accomplished by simply installing cross-connecting the pipes with drain pipes. Drain pipes. The estimate tube diameter can be 10 centimeters. At the collection point, a sump pump can be installed which will automatically turn on and off, pumping the condensation out of the ground and sprinkling it on top. Tube measurement length wise There is no simple formula for determining the correct tube length in relation to the quantity of cooling preferred Local so it, soil moisture, tube depth, and other site-specific factors should be considered to determine the proper length. The earth tubes may buried into 3-4 m deeper to the ground to get enough efficiency of it.

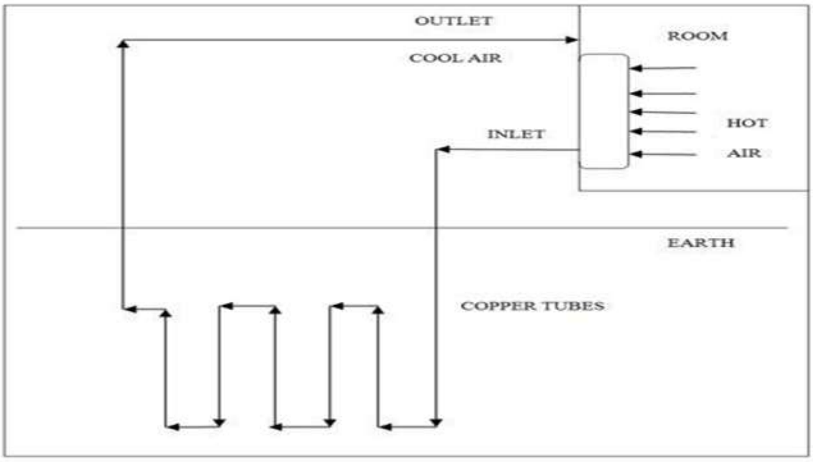

Fig 1.1: Plan of Earth Tubes

Fig 1.2: Placement of Earth Tubes

DESIGN PROCEDURE:

The experimental setup is an open loop flow system has been designed and fabricated to conduct experimental investigation on the temperature difference for inlet and Outlet section, heat transfer, coefficient of performance and fluid flow characteristics of a pipe in parallel connection. The experimental data are to be used to find the increase of cooling rate for the summer condition, and heating rate of winter condition heat transfer coefficient.

The Earth Tube Taken One horizontal pipe of 50 mm inner diameter with total length of 1m. Three pipe each length of 0.5 m are connected in Series connection, made up of PVC pipes and buried at a depth of 3 m in a flat land with dry soil. The Series connection of PVC pipes exhaust manifold for air passage. Ambient air was sucked through the pipe by means of a centrifugal fan by a 2 phase, 0.25 HP, 20 V and 200 rpm motor. The blower is used to suck the hot ambient air through the pipelines and delivered the cool air for required place in Summer the problem of cooling air in natural way is solved by using buried pipes earth tubes which are effective to cool the inside environment of a room.

DATA ANALYSIS

TIME	**INLET TEMPRETURE (°C)**	**OUTLET TEMPRETURE (°C)**	**TYPE OF MEDIA USED**
12:30 to 1:45pm	35	30	Saturated soil
2:35 to 3:30pm	35	20	
12:30 to 1:45pm	32	18	Saturated sand
2:35 to 3:30pm	32	18	
12:30 to 1:45pm	30	25	Unsaturated soil
2:35 to 3:30pm	30	20	
12:30 to 1:45pm	33	29	Water
2:35 to 3:30pm	34	22	
12:30 to 1:45pm	34	28	Unsaturated sand
2:35 to 3:30pm	33	23	

Table 1.1: Temperature variation after using earth tubes

The moist is more effective as provide more cooling effect than other soil also sand temperature goes higher due to thermal inertia of sand. Thermal inertia of soil states that at certain depth of earth surface temperature remains constant. Also saturated condition of soil helps to increase the cooling effect of earth tubes.

RESULTS CONCLUSIONS:

The EAHE system can utilize the low-grade thermal energy of underground soil to preheat and precool the flowing air within the buried pipe in the heating and cooling seasons, respectively. To reduce the energy demand of building ventilation, an EAHE-assisted building ventilation system was described and investigated in this study. An analytical model of the underground soil temperature was developed to calculate the hourly evolution of the underground soil temperature at different depths. A steady-state heat transfer model was proposed to simulate the outlet air temperature of the EAHE system and identify its ability to preheat and precool ventilation air. Sensitivity studies were carried out to evaluate the influence of different design parameters on the thermal performance of the EAHE-assisted building ventilation system. The year-round energy-saving potential and design guidelines of the EAHE-assisted building ventilation system were estimated and summarized for the hot-summer and cold-winter climate. The main results are concluded as follows.

- The temperature difference between atmosphere and underground temperature can be used for the purpose of cooling.
- The experimental data, calculations, simulation results indicate that air conditioning using ground source is a good replacement for conventional air-conditioning system
- The air conditioning effect is good and has considerable energy saving potential for Indian climatic conditions.
- Based on our model temperature reduction was observed to be 5°C. This has positive influence on improving occupant thermal comfort.

- It is also eco-friendly as it does not emit any harmful chemicals and leaves very little carbon footprint.

REFERENCES:

1. Tsinghua University Building Energy Research Center. *Annual Report on China Building Energy Efficiency*; China Architecture & Building Press: Beijing, China, 2019. [**Google Scholar**]

2. International Energy Agency (IEA). *World Energy Statistics and Balances*; OECD/IEA: Paris, France, 2018. [**Google Scholar**]

3. Ahmed, W.; Asif, M.; Alrashed, F. Application of building performance simulation to design energy-efficient homes: Case study from Saudi Arabia. *Sustainability* **2019**, *11*, 6048. [**Google Scholar**] [**CrossRef**] [**Green Version**]

4. Shahsavar, A.; Khanmohammadi, S. Feasibility of a hybrid BIPV/T and thermal wheel system for exhaust air heat recovery: Energy and exergy assessment and multi-objective optimization. *Appl. Eng.* **2019**, *146*, 104–122. [**Google Scholar**] [**CrossRef**]

5. Zhang, C.; Gang, W.J.; Wang, J.B.; Xu, X.H.; Du, Q.Z. Numerical and experimental study on the thermal performance improvement of a triple glazed window by utilizing low-grade exhaust air. *Energy* **2019**, *167*, 1132–1143. [**Google Scholar**] [**CrossRef**]

6. Wang, J.B.; Du, Q.Z.; Zhang, C.; Xu, X.H.; Gang, W.J. Mechanism and preliminary performance analysis of exhaust air insulation for building envelope wall. *Energy Build.* **2018**, *173*, 516–529. [**Google Scholar**] [**CrossRef**]

7. Fan, C.; Wang, J.; Gang, W.J.; Li, S. Assessment of deep recurrent neural network-based strategies for short-term building energy predictions. *Appl. Energy* **2019**, *236*, 700–710. [**Google Scholar**] [**CrossRef**]

8. Zhang, C.; Cui, C.L.; Zhang, Y.; Yuan, J.Q.; Luo, Y.M.; Gang, W.J. A review of renewable energy assessment methods in green building and green neighborhood rating systems. *Energy Build.* **2019**, *195*, 68–81. [**Google Scholar**] [**CrossRef**]

9. Tejero-González, A.; Esquivias, P.M. Personalized evaporative cooler to reduce energy consumption and improve thermal comfort in free-running spaces. *Sustainability* **2019**, *11*, 6451. [**Google Scholar**] [**CrossRef**] [**Green Version**]

10. Yuan, J.Q.; Cui, C.L.; Xiao, Z.W.; Zhang, C.; Gang, W.J. Performance analysis of thermal energy storage in distributed energy system under different load profiles. *Energy Convers. Manag.* **2020**, *208*, 112596. [**Google Scholar**] [**CrossRef**]