

REVIEW ARTICLE

REVIEW OF SOLAR ABSORBER PLATE TYPES AND CONFIGURATIONS WALLS USED IN SOLAR CHIMNEY

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ABSTRACT

One of the best and cheapest techniques used by renewable solar energy sources to lower energy consumption in buildings is the use of natural ventilation in solar chimneys. Multi experimental and numerical studied have been conducted by using permitted fresh energy, such as wind energy, solar energy, in the distribution of clean energy. The solar chimney operating modes utilized in building envelopes are loosely categorized into three types: Trombe (vertical) wall solar chimney, roof solar chimney and Combining both (Trombe and Roof) solar chimney. This study gives a simple review of the literature on various types and configurations of absorber plate that used in the solar chimney in the building envelopes with inner air layers. The existing applications and technologies of solar chimney in walls, windows, and roofs are summarized and outlined. The results of all of these experimental and numerical researches are relevant to the regulation of energy in the case of absenteeism of available source of energy in order to reward energy loss by releasing or storing it. Finally, the current review study contains three various types of solar chimney reviews, including computational research, experimental testing, and numerical investigations.

KEYWORDS

Natural Ventilation, Solar Chimney, Renewable Energy, Energy Consumption

1. INTRODUCTION

Regarding to the previous studies, researchers are experimenting with and demonstrating the effect of these engineering elements on the thermal efficiency of the solar chimney. The most common measurement used by researchers is the density of solar radiation; as solar radiation rises, so do wind speed and chimney temperatures. When there is little solar radiation, the interior temperatures are thermally comfortable. Tropical areas have constant daily total solar radiation (Shi et al., 2018). The solar chimney angle is another factor that affects the ventilation rate and effectiveness of the solar chimney. The solar chimney, which is frequently used in residences, has an angle that can be anywhere between entirely inclined and fully vertical. The ideal angle of inclination for the solar chimney can be reached when solar radiation is perpendicular to the solar chimney and is thus subject to the highest volume of solar radiation.

Measuring the angle of inclination in various solar chimney models reveals that the tilt slope has a significant influence on the air flow rate in various temperature zones. The other parameter is a difference in the chimney's window opening and escape opening (Rahman and Chu, 2021). The rate, in contrast, has a monthly result that changes throughout a year. In contrast, the monthly solar energy sowing adjustment achieved to increase the tilt angle spontaneously increases the effective height of the solar chimney, resulting in a rate of enrichment of ventilated air volume. The ratio of the above elements results in an ideal tilt angle of 60° since these two parameters (the effective height of the chimney and the absorption of solar energy) are effective ventilation rate variables (Rahman and Chu, 2021). The main objective of the present review article is to perform a simple and short competition of the previous types and configurations of the solar chimney absorber plate kinds that presented numerically and experimentally in the previous works.

1.1 Types of Solar Chimney

Primarily three kinds of solar chimneys that usually mounted on walls, roofs, and windows, according to numerous research as shown in Figure 1 (Rahman and Chu, 2021):

1. Trombe (vertical) wall solar chimney.
2. Roof solar chimney.
3. Combining both (Trombe and Roof) solar chimney.

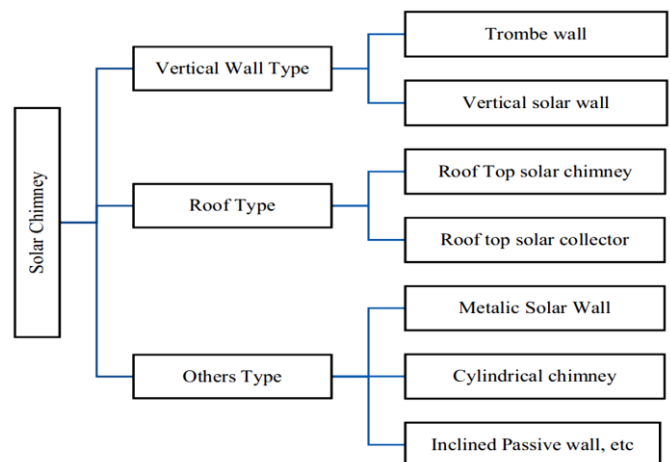


Figure 1: Organization of the solar chimney (Rahman and Chu, 2021).

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A diagram of a Trombe wall of model of (Type 1) utilized for heating in winter can be found in Table 1. A large wall painted a dark hue in order to absorb the energy by thermal reaction from solar radiation is known as a trombe wall. Glass serves as both the interior storage wall and the exterior glazing. The chimney's cavity is warmed by using solar heat flux that enters through exterior glass. Following that, air in the cavity rises and enters the room through the top aperture. Trombe wall used for cooling in the summer (Table 1). In this situation, heated air from the interior can travel via the chimney to the outdoor air.

1.2 Vertical Solar Wall

Solar chimney with vertical wall-type is located on a vertical structure walls. Vertical wall solar chimney type divided into Trombe wall or vertical wall. Trombe wall type has outside windows on one side and an air gap on the other solar radiation typically as shown in Figure 1 (Rahman and Chu, 2021; Harris and Helwig, 2007). The effectiveness of a metallic solar wall's natural ventilation. The glass cover, air gap, black metallic plate, and insulator made of microfiber and plywood make up the metallic solar wall. Figure 2 is a schematic illustration of a passive solar home with a metallic sun wall providing natural ventilation. The results showed that the metallic solar wall provided the maximum air mass flow rate, averaging 0.01-0.02 kg/s (Gan, 1998). The straightforward solar chimney, also known as a trombe wall, can be used for both ventilation and room heating. By adjusting the placements of the dampers, Gan employed the trombe wall for both ventilation and heating, making it suitable for usage in both the winter and summer (Gan, 1998). He built a south-facing trombe wall out of concrete and masonry, blackened the exterior, coated it with glazed glass, and created three apertures it is indicated in Figure 2, where there were previously double slums in the brickwork.

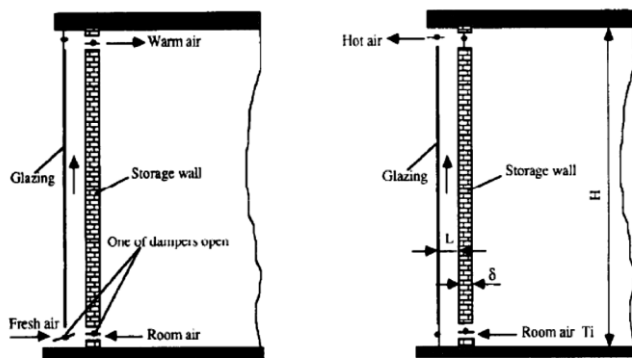


Figure 2: Trombe wall diagram for (a) heating and (b) cooling (Gan, 1998).

1.2.1 Advantage and Disadvantage of Vertical Solar Wall

1.2.1.1 Advantage of Vertical Solar Wall

The design and construction of a passive solar home are intended to utilise solar energy to keep the house naturally warm throughout the winter. Additionally, the layout should keep the home naturally cool in the summer. The main advantages if this type were listed below (Awbi, 2008):

- **Energy Efficient:** Thermal chimneys described as an energy-saving design element in a structure. The chimney works well as a heat-reduction tool in the sweltering summertime. It is a clever approach to use the cost-free solar energy for residential purposes.
- **Cost-Effective:** Solar chimneys assist in lowering household utility costs. Costs associated with ventilation can reach the hundreds, particularly in the summer when temperatures skyrocket. An affordable replacement for traditional air conditioners is a solar chimney. By employing inexpensive materials, the chimney may be built.
- **Reliable:** Thermal chimneys are not frequently subject to failure. They don't need power or other combustible fuels, thus there are no supply issues. Additionally, voltage fluctuations and power interruptions are not an issue for you. The chimney essentially functions independently after it is placed.
- **Low Maintenance:** Solar towers are a green element when it comes to house energy use. Since they don't require any conventional fuels, maintaining them is simpler. Due to their reliance on solar energy, solar towers produce significantly less smoke, soot, dirt, or grime. Additionally, they require little upkeep.

- **Environmentally Friendly:** Household amenities that encourage green living are appreciated in these times of growing environmental concerns. Thermal chimneys are a good green substitute since they don't require conventional energy for home heating or cooling. Reduced reliance on energy, gas, and oil is essential for allowing sustainable resource management. With a solar chimney, your environmental pollutants will be decreased.

1.2.1.2 Disadvantage of Vertical Solar Wall

The air flow does not permeate the ventilated space very much, which is single-sided ventilation's principal problem. Wintertime single-sided ventilation is produced by thermal buoyancy, while summertime ventilation is mostly produced by wind turbulence. The primary drawback of the vertical solar wall technology is (Liddament, 1996; Emmerich et al., 2001)

- Its very significant heat loss under cloudy conditions.
- Extremely intricate initial service plans for the administration.
- The unpredictability of ventilation exchanges and the inverse thermosiphon phenomenon, which can lead to significant heat losses.
- Heat losing to the outer environment however, in most regions, double glass (glass or any of the polymers) is required to reduce heat loss.
- At the wall's surface, high absorbency converts light into heat, while low emittance stops the heat from reflecting back toward the glass.
- Desiccant cooling is a favored conventional technique in areas of high humidity, when the presence of moisture in the air actually hinders the body's ability to cool itself through evaporation.
- This system's disadvantage is that it prevents heat from evaporating into the night sky.
- The usage of natural ventilation systems may have significant disadvantages due to outside air pollution and noise.
- Hybrid ventilation may thus be a better option than single-sided ventilation techniques in metropolitan environments.
- Occasionally, the stochastic nature of the wind and buoyancy driving forces makes it exceedingly difficult and complex to manage natural ventilation, resulting in either under-ventilation and inadequate thermal comfort or over-ventilation and an increase in energy consumption.
- In cases of harsh weather, natural ventilation's efficacy is frequently in doubt. Natural ventilation solutions should be combined with conventional air conditioning systems for proper dehumidification since air humidity is a significant element that impairs natural ventilation efficacy. Furthermore, in excessively hot areas, natural ventilation frequently fails to meet thermal comfort standards for the whole day.
- Building intricacy itself may have a constraining effect. Natural ventilation's effectiveness may suffer when used in intricate and divided interior areas. Natural ventilation should not be used in loud or air-polluted locations since it is not practical to filter the entering outdoor air. Natural ventilation is typically used in low-rise housing, small to medium-sized workplaces, schools, warehouses, and other types of buildings.

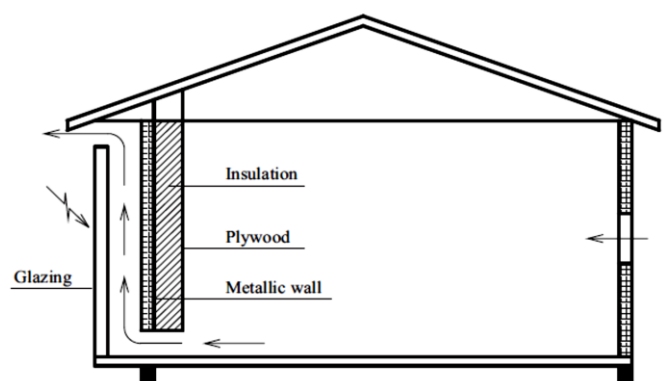


Figure 3: Passive solar with using normal aeration (Neeper, 2000).

By promoting air circulation to provide thermal comfort, due to the low cost of the materials utilized, it was claimed that the proposed method was economical. A group researchers found that such passive solar energy utilization was also energy-efficient (Hirunlabh et al., 1999). Figure 3. The properties of numerous parameters of PCM on thermal storage performance of a wall board were theoretically studied (Neeper, 2000).

If the air layer is of the closed-ended form, an insulating layer is produced as the air moves from the bottom to the top of the layer under the buoyancy effect or with the help of mechanical fans and removes the heat accumulated in the air layer from solar heat gain (Balocco, 2002). Also, some researchers suggested adding a heat storage system in the form of a solar chimney above the double-skin layers to increase ventilation (Figure 4) (Ding et al., 2005). The analysis validates the viability of the suggested approach for use in evolving intelligent façade designs.

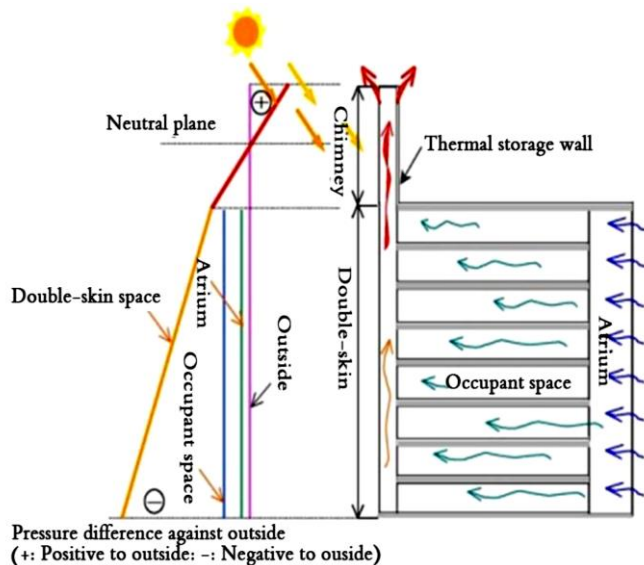


Figure 4: Thermal storage by using solar chimney (Ding et al., 2005).

A group researchers tested on a tiny solar chimney and he showed that the rate of ventilation is increasing as the distance between the glass and the absorber increases (Mathur et al., 2006). The experimental set-up has examined nine different combinations of absorber height and air gap and as the ratio between the height of the absorber. He used a 27 m³ room with solar radiation of 700 W/m² on a vertical surface and a stack height-air gap ratio of 2.83 for a 1 m high chimney was found to have the highest rate of ventilation caused by solar energy at 5.6 ACH for hour as shown in Figure 5.

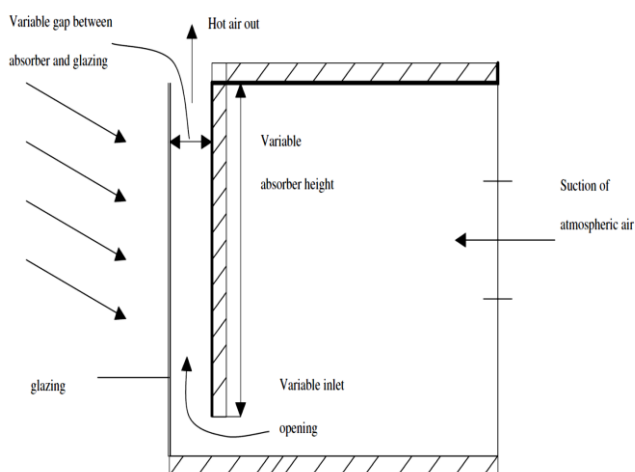


Figure 5: Isometric view and side view of experimental set-up (Mathur et al., 2006).

A thermo-syphoning air channel known as a "solar chimney" uses thermal buoyancy as its primary driving force for air movement (Gan, 2006). Several factors, such as the location, climate, direction, size of the ventilation gap, and internal heat gains, might affect the construction of a solar chimney. The solar collector, clear cover, and apertures, however, must be present in all designs (inlet and outflow) (refer to Figure 6).

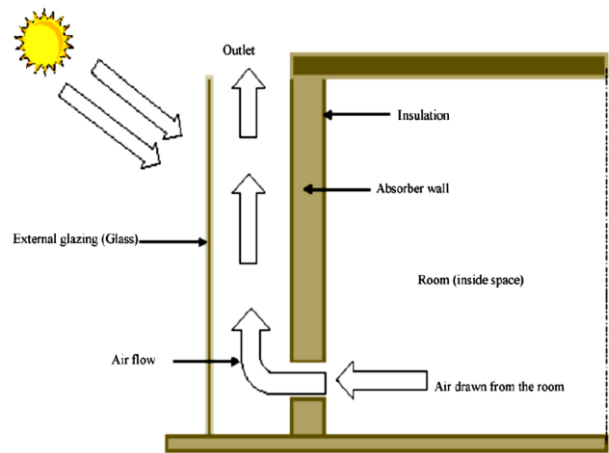


Figure 6: Schematic of solar chimney with vertical absorber geometry (Gan, 2006).

The absorber surface represented the main component in vertical wall solar chimney with the glazing, air gap, and absorber surface insulation. The influences of wind and radiation were taken into consideration when designing this solar wall. Using some of the elements seen in the workings of a vertical solar wall are explained. Here, solar radiation and air buoyancy cause the temperature of the air to rise. The air being dragged outdoors by the ambient breeze also contributes (Harris and Helwig, 2007).

Mechanical, natural, or a mix of the two forces may drive the Double skin façade DSF channel's air ventilation mechanism. The channel can experience natural air ventilation due to wind pressure and the thermal buoyancy effect caused by the temperature differential between the interior and outside façades (Gratia and Herde, 2007). While mechanical and natural forces combine to provide mixed ventilation, mechanical ventilation creates airflows in the cavity using power tools. According to the different air flow paths, a Double skin façade DSF's ventilation working modes may be categorized into four categories. Henemann characterized a building integrated photovoltaic (BIPV) system as solar cells that can be incorporated into the building envelope as part of the building structure and therefore can replace standard construction materials, as opposed to being added afterward (Henemann, 2008). It is possible to combine the photovoltaic surfaces used in BIPV (Figure 8) with ordinary roofing, glazing, or cladding materials.

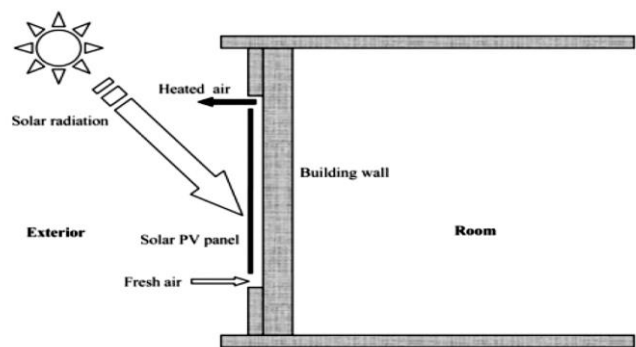


Figure 8: Building combined with photovoltaic scheme (Henemann, 2008).

When the air vents and air dampers are properly adjusted, the GTC solar wall system can operate in four different modes during the winter. depicts a PV façade with passive ventilation based on Double skin façade, conducted an experimental and numerical study on a Bangkok-based, three-story solar chimney (Friling et al., 2009; Punyasompun et al., 2009). The split and combined solar chimneys were placed into the south-facing external walls of two small scale models of three-story structures. Regarding the Double skin façade (see Figure 9) of ability to produce sustainable energy, the investigated (Chan et al., 2009). Using a 34-degree angle to the horizontal, semitransparent PV modules are mounted outside the roof. A solar chimney creates airflow for a structure that is naturally pushed by converting solar thermal energy into the kinetic energy of the cavity air. When a solar chimney is attached to an outside wall of a building, three distinct modes can be created by altering the air vents (Chen et al., 2010).

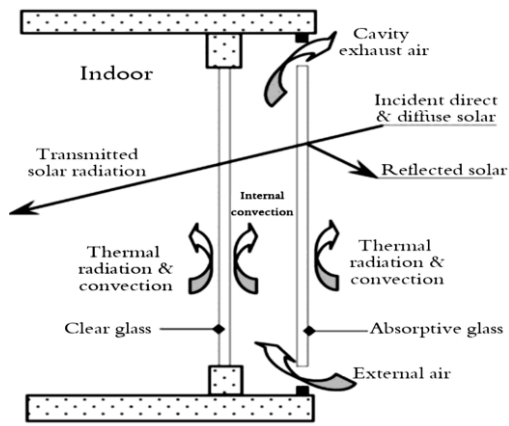


Figure 9: The heat transfer and air movement in Double skin façade (Chan et al., 2009).

A group researchers demonstrated an active ventilated PV façade that maximizes the advantages of both solar thermal and BIPV systems

(Patania et al., 2010). Some researchers carried out a numerical simulation to examine the effects of various parameters on the thermal storage performance of wallboard, such as the thermal energy storage and time shift, including the nominal average melting temperature, melting temperature range, convective heat transfer coefficients, and wall board thickness (Koo et al., 2011). similar operational tenets as wall-based solar chimneys for ventilation purposes govern roof-based solar chimneys. The construction industry was the first to use computational fluid dynamics (CFD) in the 1970s (Khanal and Lei, 2011).

Also, quicker processing times and more affordable technology led to an increase in the adoption of CFD software in the 1990s. The majority of the modeling of solar chimneys using CFD has been done in steady state as shown by Figure 10 since it is only found 14 articles that modeled solar chimneys in transient state, which are relatively new. Particularly Amori and Mohammed 2012 examined the impact of a phase change material (PCM) on the erratic thermal behavior of a solar chimney (see Figure 10) (Amori and Mohammed, 2012). The results showed that a solar chimney added to a PCM extended the ventilation period after sunset. Furthermore, a studied the energy-storage action of the phase-change material that led to the solar chimney having an output power of 1.3 W at night when the solar chimney was reproduced with a layer of energy-storage material such as (paraffin) (see Figure 11) (Yan et al., 2012).

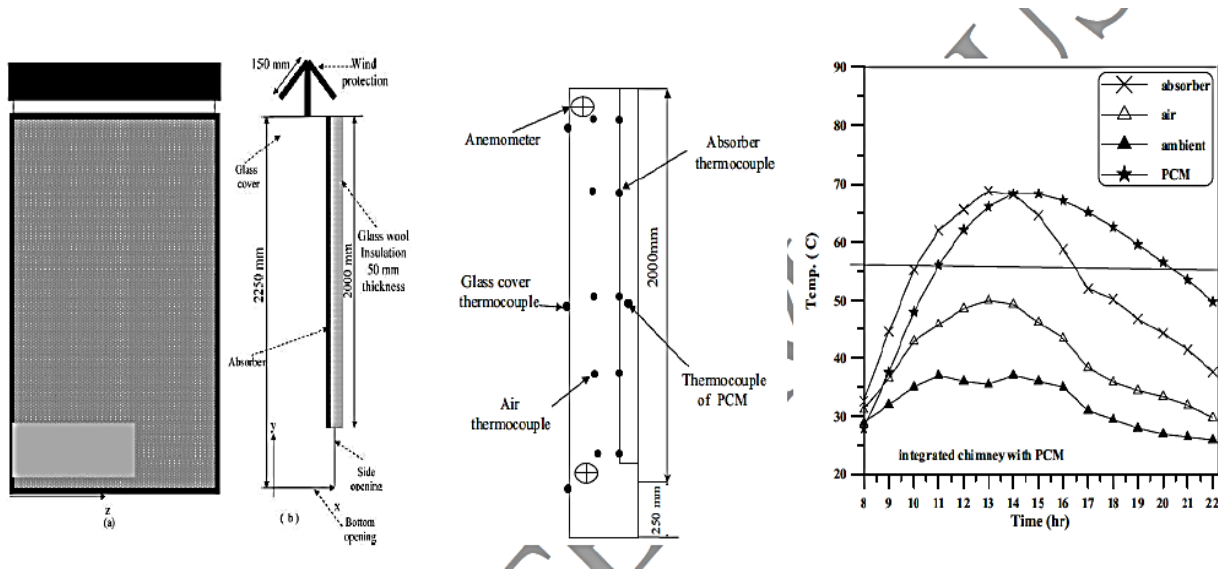


Figure 10: Experimental rig instrumented solar chimney (Amori and Mohammed, 2012).

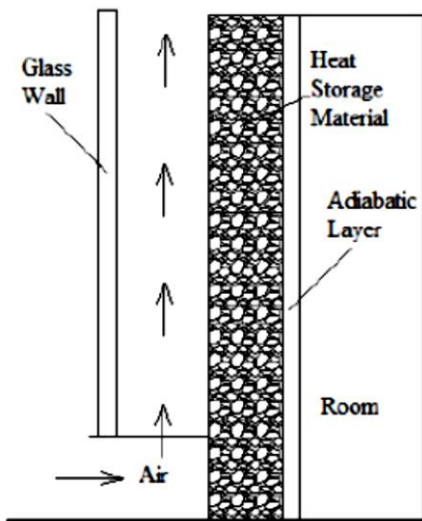


Figure 11: The chart of solar chimney with vertical heat collector (Yan et al., 2012)

The idea of the Trombe vertical wall since Felix Trombe and Jacque Michel popularized it in France (Saadatian et al., 2012). The main components of the Trombe wall are a huge wall, a cover for the outer glass, and an air channel that runs between the huge wall and the cover to dampen the vents on the glazing and change them from fixed to moveable kinds. Another name for it is the Trombe-Michel wall, which is regarded as an

improved version of the Trombe wall. The composite Trombe-Michel wall shares a structure with the traditional Trombe wall, with the exception that an insulating wall is attached to the back of the substantial wall. An outside glass cover, an enclosed air cavity, a huge wall, a ventilated air channel, and an insulating wall are some of the layers that make up a typical Trombe-Michel wall (see table 1) and (Figure 12) (Quesada et al., 2012).

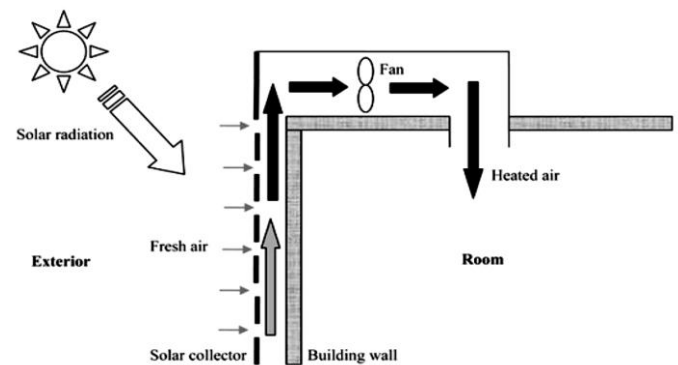


Figure 12: Building combined with a solar thermal (Quesada et al., 2012).

Building integrated photovoltaic thermal systems (BIPV/T) combine the capabilities of building integrated solar thermal systems with photovoltaic systems. This configuration allows for the most efficient electrical conversion and air/water heating from a solar energy-collecting surface. (Figure 13) (Quesada et al., 2012).

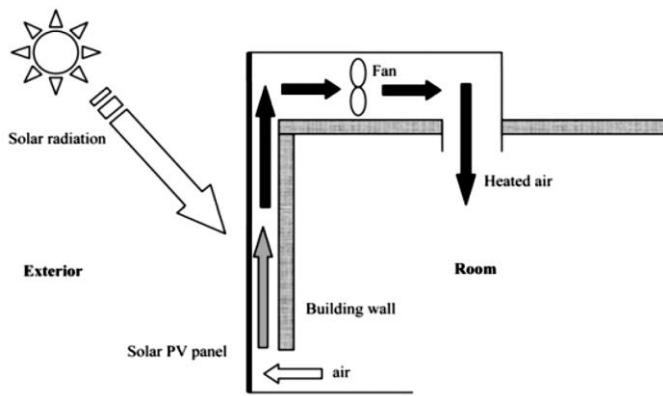


Figure 13: Photovoltaic Integrated Building (Quesada et al., 2012).

BIPV/T Thermal System Solar collector and storage tasks are combined into one unit by a thermal storage wall. Radiation and natural convection move heat since the wall to the adjacent to the air as well as the air is between the glazing surface and the wall. One of its primary purposes is to lessen indoor air temperature fluctuations as shown in Figure 14 (Quesada et al., 2012).

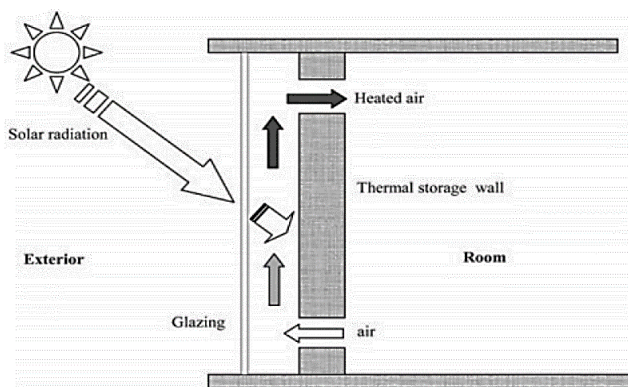


Figure 14: Thermal Storage Wall Integrated Building (Quesada et al., 2012).

A solar chimney is a building that is built on a wall facing the sun and mostly consists of one heat-absorbing glazed surface. An updraft of air occurs in the chimney as a result of solar energy heating the chimney and the air inside of it. The building can be ventilated using the natural aspiration produced at the foot of the chimney as shown in Figure 15 (Quesada et al., 2012).

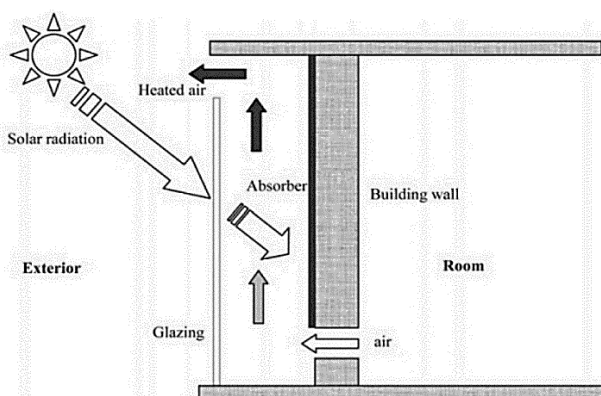


Figure 15: Schematic Diagram of Solar Chimney (Quesada et al., 2012).

A group researchers examined the enactment of the solar chimney with 9.76m^2 absorber area and 4.57m height, based on data of experimental work recorded in the Kota city, India (Lal et al., 2013). Solar data were noted using the national of the art weather station. The temperatures and air velocity in the chimney are recorded in data logger. A mathematical model was utilised for the estimation of the ACH in the residential building. They showed that the linearly variation of ambient temperature with the solar radiation. Air change rate of $5.7\text{-}7.7$ can be achieved from this solar chimney, in peak summer season.

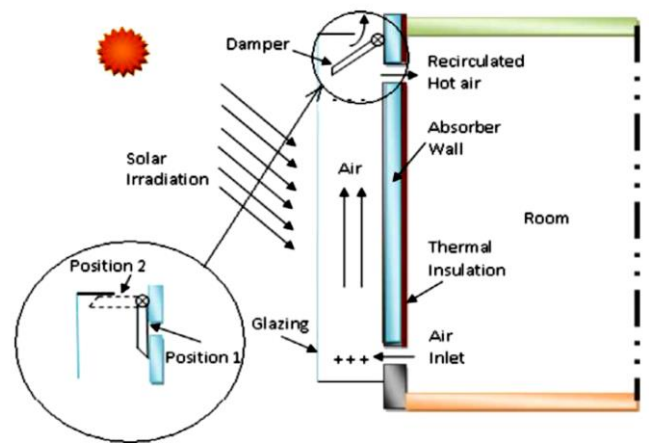


Figure 16: Building free ventilation with solar chimney (Lal et al., 2013).

Perforated solar walls without glazing in order to use solar energy for ventilation and warm air heating, unglazed transpired collectors UTC was first presented in the early 1990s. In order to warm the outside air, the unglazed transpired collectors UTC, a wall-mounted heating system, uses a perforated metal sheet as a sun absorber (Bellia et al., 2014). The Unglazed Solar Wall is another name for this unglazed transpired collectors. Table 1 provides an illustration of the UTC's schematic diagram. The GTC is introduced to resolve the problem already indicated (Gao et al., 2014). In comparison to the UTC, a glass cover is added, and the cover has appropriate air vents. Table 1 provides an illustration of the GTC arrangement. Typically linked to a building's exterior wall, the vertical solar chimney has a vertical air duct with a rectangular cross section (Suárez-López et al., 2015). The inside side of the channel is built of opaque and solar radiation-absorbing wall materials, while the outside side is covered in glass on the outside (table 1).

Crepper plants are attached directly to the exterior wall to create a direct green façade; the plants then climb up the wall of the building on their own, as illustrated in Table 1 (Raji, et al., 2015; Buker, et al., 2015). Numerous numerical and experimental investigations demonstrate the PCM with its various characteristics have a significant impact on the LHS (Zhou and Pang, 2015). The results of an experimental investigation into the thermal behavior of a collector-storage wall system utilizing PCM show that the indoor temperature was determined to be above $22\text{ }^\circ\text{C}$ and air flow rate maintained at virtually stable value during the entire discharging period Figure 17. A group researcher indicated for airflow applications, a numerical analysis of the buoyancy caused by turbulent air flow in a solar chimney with an inclined passive wall (IPWSC) connected to a room (ventilated space) over a range of control settings (Khanal and Lei, 2015).

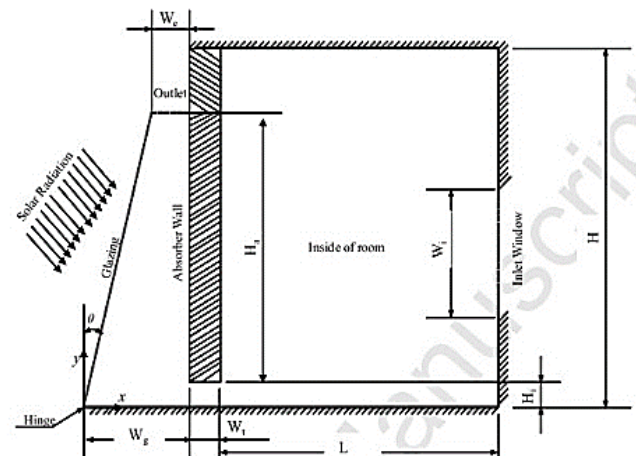


Figure 17: Computer domain schematics of boundary conditions (Khanal and Lei, 2015).

In particular, the air output velocity is set for a vertical solar output chimney connected to a chamber that is 1 m by 1 m by 1 m , and the air changes are per Hour (ACH) (Bhardwaj 2017). They number five operating and design specifications (air distance, glazing material, season, etc.) The Taguchi system calls window-to-wall ratio and window orientation at mixed phases. Additionally, he discovered that facing east and toward the window is the best window orientation.

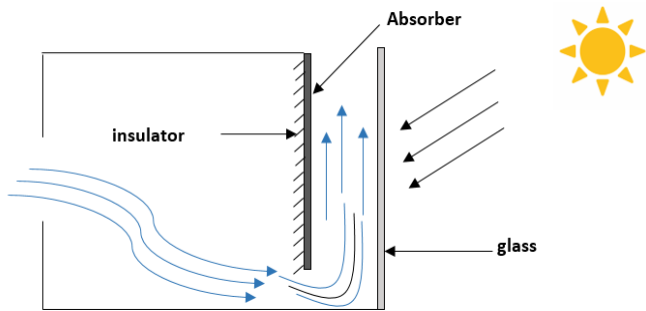


Figure 18: Design model of solar chimney (Bhardwaj, 2017)

A studied mathematically and analytically a solar chimney or Trombe wall as seen in Figure 19 (Shakeel et al., 2017). The literature-available analytical results overstate the air flow rate by 46–97%. Even though the trials use insulated walls, there may still be chimney wall loss, which is typically not taken into account in the analytical models that are currently available.

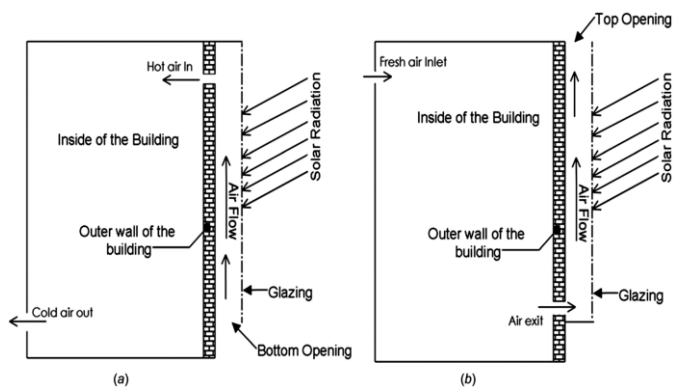


Figure 19: Schematic diagram of solar chimney (a) winter (b) summer (Shakeel et al., 2017).

A studied how the thermal comfort of inhabitants was affected by the thermal performance of a SC with a passive cooling wind tower Figure 20 (Abdallah, 2018). A 30 m² test room's roof was combined with the cooling device. Monitoring the inside environment during a two-month period in the summer indicated that the wind tower's output air temperature was 27.3 C and that the computed PMV ranged from -0.5 to +0.5. They demonstrated that the system's functionality can offer customers a daytime thermal comfort level that is appropriate for the temperature in New Assiut, Egypt.

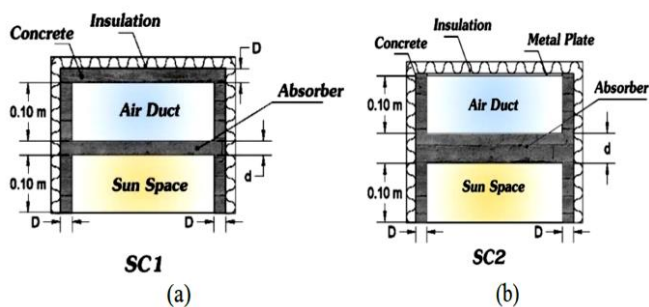


Figure 20: Horizontal cross section of (a) SC1 (b) SC2 (Abdallah, 2018)

Rajput concerned about the practicality of solar chimneys, how ventilation rates affect heat gain in dwellings, and how to improve night ventilation (Rajput, 2019). Table 21. Passive ventilation is emerging as a viable substitute for mechanical ventilation systems due to its potential benefits, including decreased carbon dioxide emissions, energy needs, and running costs.

By promoting air circulation to provide thermal comfort, due to the low cost of the materials utilized, it was claimed that the proposed method was economical. A group researchers found that such passive solar energy utilization was also energy-efficient (Hirunlabh et al., 1999). Figure 3. The properties of numerous parameters of PCM on thermal storage performance of a wall board were theoretically studied (Neeper, 2000).

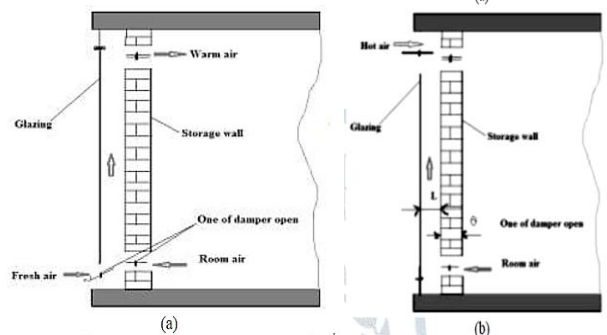


Figure 21: Trombe walls kinds (a) winter and (b) summer (Rajput, 2019).

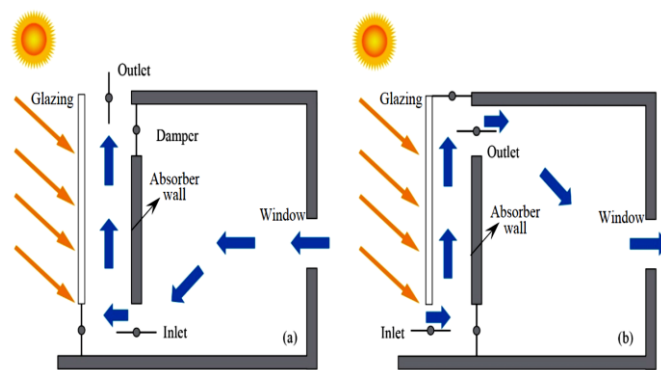


Figure 22: Typical wall solar chimney under: (a) cooling mode; and (b) heating mode (Dahri et al., 2020)

A used a two-dimensional numerical study on a prototype solar chimney system along with an absorbent capacity wall on a building's south face, as illustrated in Figure 23 (Buonomo, et al., 2019). The chimney consists of a converging channel with a single vertical absorbing wall and a glass plate that is inclined 2° away from the vertical. The chimney is 5.0 meters high, while the channel height is 4.0 meters. The channel gap measures 0.20 meters at the outflow and 0.34 meters at the intake. There is a thermal energy storage system that is four stories high. They ran a computer simulation to evaluate the thermal and fluid dynamic capabilities of a solar chimney paired with a latent thermal energy storage system.

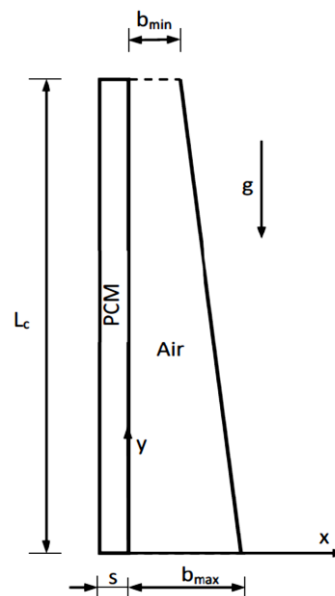


Figure 23: Solar Chimney sketch (Buonomo et al., 2019)

A looked at how the chimney model might affect the temperature and ventilation of a space (Hashim et al., 2020). By stretching the chimney while keeping the same absorber surface area, several research has altered the ideal room chimney model. Further consideration was given to the effects of expanding the room's window area. The inclined and vertical extended chimneys have increased ventilation rates by 7.5 percent and 13 percent, respectively, as compared to a typical chimney type.

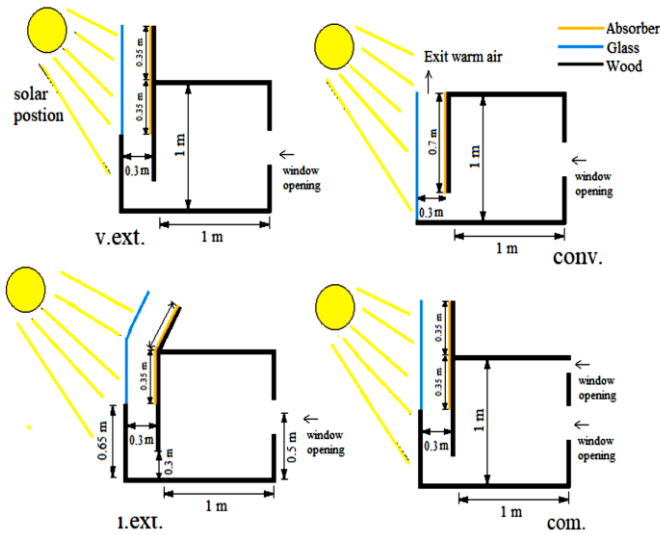


Figure 24: Room with different chimney solar types (Hashim et al., 2020).

Nguyen and Wells studied the effects of walls next to the air channel on the operation of a vertical solar chimney, which absorbs solar energy and generates airflow for natural ventilation and cooling of buildings (Nguyen and Wells, 2020). Image 25. A computational fluid dynamics model was developed to forecast the induced flow rate and thermal efficiency of a vertical solar chimney with four types of nearby walls: the vertical wall to which the solar chimney was attached, a horizontal plate above the air channel's outlet, a horizontal plate, and a horizontal wall below the air channel's inlet.

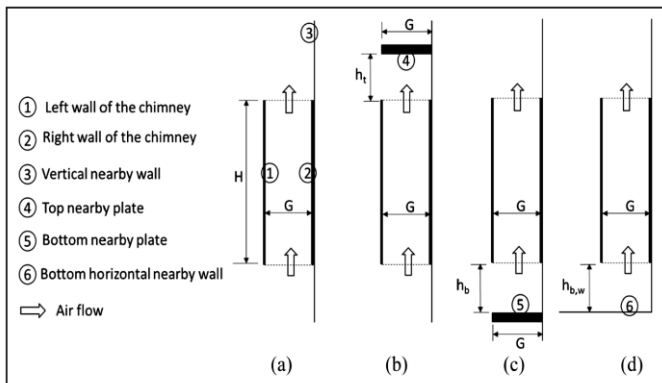


Figure 25: Side view of neighboring vertical solar chimney walls (Nguyen and Wells, 2020)

Shbailat and Nima examined a statement stating that aluminum foam can be added to improve solar chimneys (Shbailat and Nima, 2021). The location of the solar chimney with test room system was Baghdad, Iraq, where it was placed at latitude 33.3 N and longitude 44.4 E. The solar chimney was facing south. They created, produced, and tested their product to investigate how certain factors affect the solar chimney's performance under steady-state settings as shown in Figure 26.

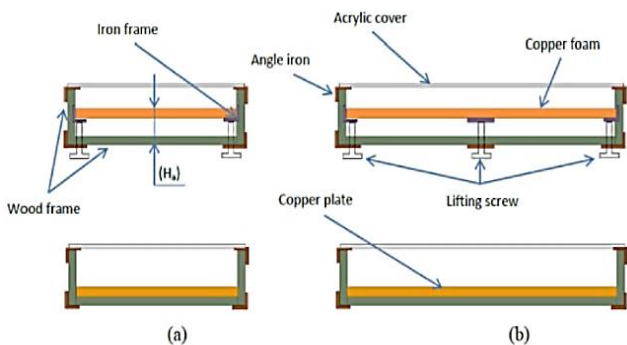


Figure 26: Location of copper foam and copper plate in-channel (Shbailat and Nima, 2021).

A group researchers attempted by using experiments on the solar chimney, to expand the absorbing surface's surface area while keeping the restrictions the same (Jihad, et al., 2021a). A model of a wooden box measuring 1 m³ and a room measuring 27 m³ were explored both theoretically and practically in Figure 27. The theoretical side of flat, V-grooved, Sinusoidal, Simi-circle outward, and Simi-circle inward absorber plates was researched with the same dimensions as the practical side (smooth plate absorber, trapezoidal plate absorber and V-grooved plate absorber). The best type is (V-grooved corrugated absorber plate) with a 10° angle of inclination and 9.6 ACH greater than flat absorber plate, according to experimental and numerical data based on air change per hour (ACH).

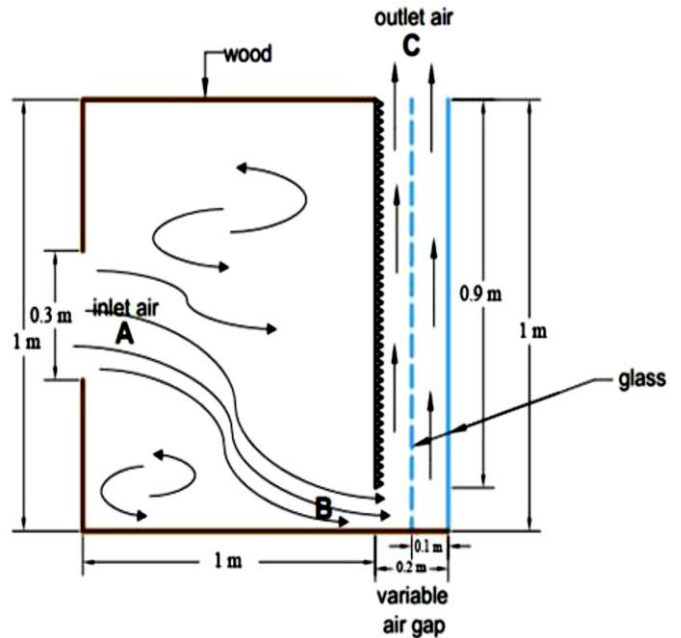


Figure 27: Schematic diagram for experimental apparatus (Jihad et al., 2021a)

A group researchers used the three absorber surface models that were used: (smooth plate absorber, trapezoidal plate absorber and V-grooved plate absorber) by using same model of as in Figure 28 (Jihad, et al., 2021b; Jihad, et al., 2021a). By studying the impact of the air gap width (0.1, 0.2) m on the test model also involves using all absorber plates at various inward-inclination angles (0°, 5°, 10°, and 15°). All variables were measured with various solar radiation levels throughout the day (150, 250, 350, 450, 550, and 700 W/m²). They demonstrated the triangular nature of the air change per hour (ACH) calculation.

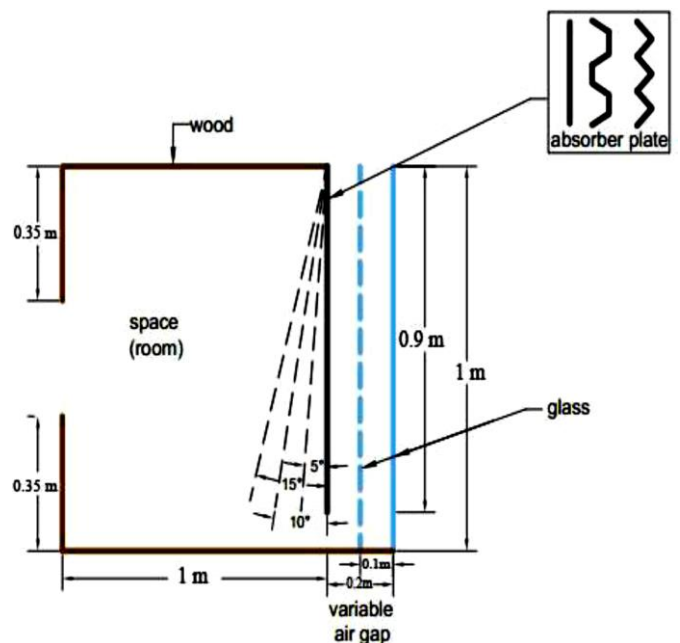


Figure 28: Schematic diagram for experimental apparatus (Jihad et al., 2021b)

Table 1: Summary of the vertical absorber plate configurations and types.

Description	Configuration	References
fresh-air cooling Solar chimney		Shi, (2018) [1]
fresh-air heating through cavity Solar chimney		Shi, (2018) [1]
fresh-air heating through room Solar chimney		Shi, (2018) [1]
sealed heating Solar chimney		Shi, (2018) [1]
Trombe wall for heating winter		Rahman and Chu, 2021 [2]
Trombe wall of cooling summer		Rahman and Chu, 2021 [2]
solar Chimney glazed wall		Rahman and Chu, 2021 [2]
passive ventilated PV façade Solar chimney		Friling, et al., 2009 [16]

Table 1: Summary of the vertical absorber plate configurations and types.

<p>classical Trombe wall Solar chimney</p>		<p>Saadatian, et al., 2012 [25]</p>
<p>unglazed transpired collector Solar chimney</p>		<p>Bellia, et al., 2014 [28]</p>
<p>glazed transpired collector Solar chimney</p>		<p>Gao, et al., 2014 [29]</p>
<p>wall-based solar chimney</p>		<p>Suárez-López, et al., 2015 [30]</p>
<p>Flat corner</p>		<p>Dhahri, et al., 2020 [39]</p>
<p>Rounded corner</p>		<p>Dhahri, et al., 2020 [39]</p>
<p>Triangle corner</p>		<p>Dhahri, et al., 2020 [39]</p>
<p>Trapeze corner</p>		<p>Dhahri, et al., 2020 [39]</p>

2. ROOF TYPE SOLAR CHIMNEY

The type of solar roof chimney is situated laterally on the building roof slope or flat and receives the most flux of solar energy when the sun is high in sky. Roof solar chimneys and roof solar collectors are additional

subgroups of solar chimney of roof type. The roof solar chimneys and a vertical solar wall are similar in many ways. The only distinctions between them are their locations and inclination angles. The roof chimney is either sloped or on a roof. A solar chimney of roof type has less visual obstructions and lower construction costs than a vertical solar wall (see Table 2) as shown in Figure. 29 (Jianliu and Weihua, 2013).

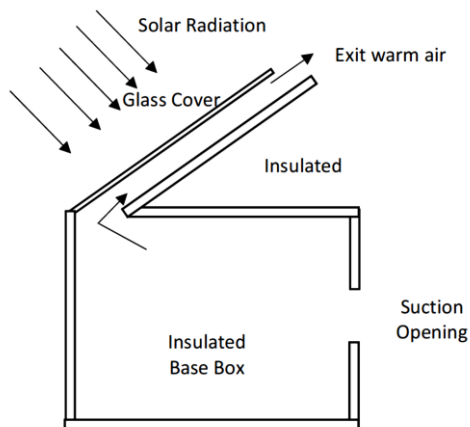


Figure 29: Solar chimney of roof type (Jianliu and Weihua, 2013)

2.1 Advantage and Disadvantage of Roof Type Solar Chimney

2.1.1 Advantage of Roof Type Solar Chimney

The main advantage of the Type Solar Chimney are presented as follow: (Lin et al., 2021; Ahmed et al., 2019)

- Simple solar chimneys are available.
- By using solar chimneys, direct gain systems can avoid many of its drawbacks, including heat loss and glare. Additionally, they are simple to install to existing homes.
- Solar chimneys might be utilized for both summer and winter cooling and heating.
- Shade is not required for solar chimneys.

2.1.2 Disadvantage of Roof Type Solar Chimney

Researchers and scientists are working to increase the efficiency of solar chimney systems by integrating them with other conventional or renewable energy systems, or hybrid solar chimneys, because one potential drawback of solar chimney systems is the low efficiency of more traditional solar chimneys. Everyone does not enjoy the constant sunshine are presented as follow (Lin et al., 2021; Ahmed et al., 2019):

- Excessive glass may result in excessive glare.
- Lacks a storage system.
- Needed meticulous design.
- They are not nearly as efficient or cost-effective in cold areas as they are in dry, sunny, southern ones.
- It is unreliable and requires a way to store solar energy so that it may be used when necessary.
- A system that is too big could cause the house to get hotter than usual.
- Construction is necessary to guarantee appropriate effectiveness and durability.
- Requires humidity management, and they are unable to function in environments with high wet-bulb temperatures.
- Extra expenditures associated with a strengthened building construction.

A group researchers concluded that the air flow rate per unit area of the roof solar collector decreased when increased roof solar collector length (Raman et al., 2001). Therefore, compared to two units of the roof solar collector, whose total length is the same as the longer unit, one longer unit would result in a lower air flow rate. In order to improve air ventilation via the roof solar collector systems, the length of the roof solar collector should be shorter, in the range of 100 to 200 cm as shown in Figure 30.

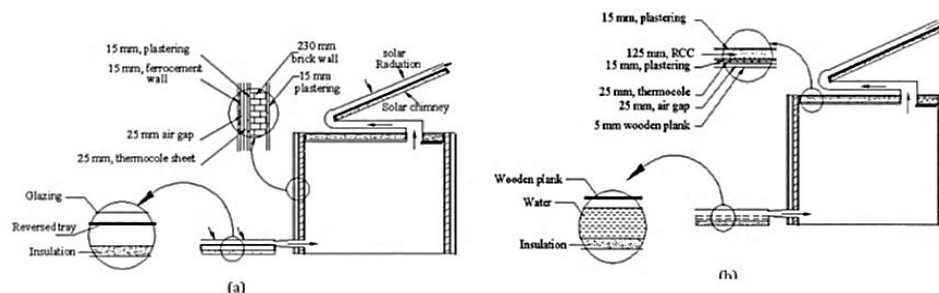


Figure 30: (a) winter passive system (b) summer passive system (Raman et al., 2001).

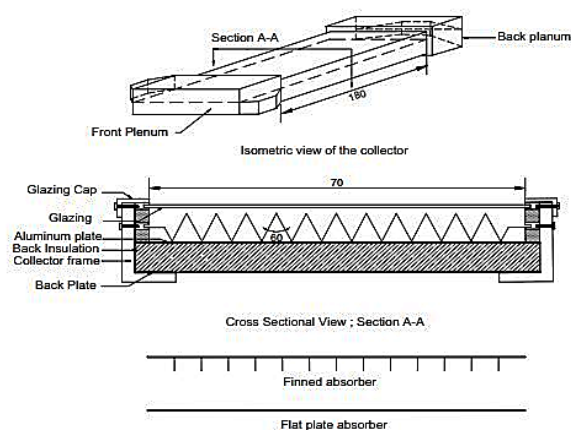


Figure 32: Frame with collectors and three absorber types (Karim and Hawlader, 2004).

Karim and Hawlader explored three different types of solar air reservoirs—plate, finned—were experimentally (Karim and Hawlader, 2004). And to get the ideal configuration for a Sun dryer, v-corrugated. A number of investigations were conducted in Singapore using ASHRAE standard climatic conditions. A variety of natural occurrences and situations are used to gauge how well the three collectors are performing.

Image 32. The best flat plate and V-corrugated collector. The three air collectors are very effective because of the high air flow volume. Effectiveness increases flow rate, exceeding 0.056 kg/m²s of saturation. The recommended flow volume for agricultural solar drying goods is about 0,035 kg/m²s. Given that the V-corrugated collector operates more efficiently in both single-pass and double-pass modes.

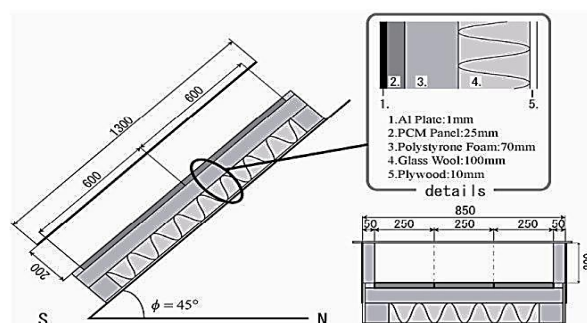


Figure 33: Solar chimney combined PCM (Kaneko et al., 2005).

A group researchers employed theoretical and experimental research on solar-chimney ventilation as shown in Figure 33 (Kaneko et al., 2005). experimental conditions output of heat, size of the gap, and chimney inclination. The measured results are consistent with the outcomes of the experiment, and a new measuring model to forecast the air flow rate has

been proposed. For solar chimney ventilation, there are daytime air testing, but there are also nighttime ventilation tests. frequently desired, if required. An algorithm for predicting air flow volume and introduce the PCM temperature, air, and aluminum (Al) plate. Differences in the chimney's PCM, Al-plate, and air were used to make the observation. If PCM melts completely during the day.

A group researchers recommended the use of single pass and double pass roof solar collectors, two different types of roof solar collectors (Zhai et al., 2005). To evaluate the effects of two roof solar collectors for both room heating and natural ventilation, a single traditional Chinese-style residence was built, on which the two collectors would be installed independently. Figure 34 shows how the roof solar chimney (RSC) idea was tested numerically and experimentally for tropical climatic conditions in India (Mathur et al., 2006).

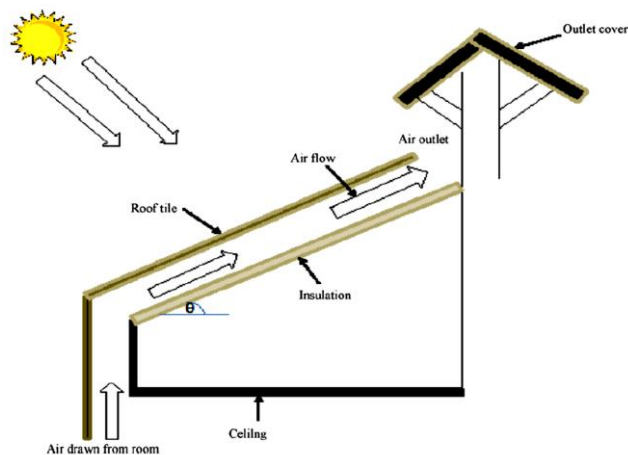


Figure 34: Schematic of inclined roof solar chimney (Mathur et al., 2006).

Buildings in the actual world with roofs and walls can both have solar chimneys. In order to improve the efficiency of natural ventilation and the thermal comfort of indoor spaces, solar chimneys are always employed in integrated designs. Solar chimneys can be used in conjunction with natural cooling systems to increase the cooling effect within buildings. Schematics for solar chimneys are shown in Figure 35 (Harris and Helwig, 2007).

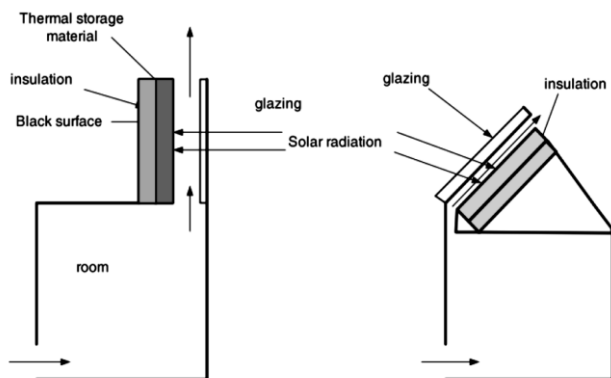


Figure 35: Solar Chimney Configurations (Harris and Helwig, 2007).

Maerefat and Haghighi presented a research on the application of solar chimneys (SC) and earth to air heat exchangers (EAHE), as depicted in Figure (36) (Maerefat and Haghighi, 2010). Since then, theoretical research has been done to better understand the cooling mechanism. The required SC and EAHE quantities for the summer months are counted, and some characteristics of such a device are presented. It is discovered that an interconnected system of a few solar chimneys with one or two at most (EAHE) cooling pipes may sustain temperatures between 28.15 and 31.94 C, which is higher than the recommended range.

The building industry consumes the most energy, at over 40%, with the majority of that going toward cooling, heating, and ventilation. The use of a solar chimney is both vertical and at an angle to the horizon. Table 2 (Mahdavejad et al., 2013). The ventilation rate efficiency of a solar chimney is influenced by its inclination angle. They studied four Iranian towns with various climatic conditions were chosen to assess the impact of solar chimneys on ventilation rate.

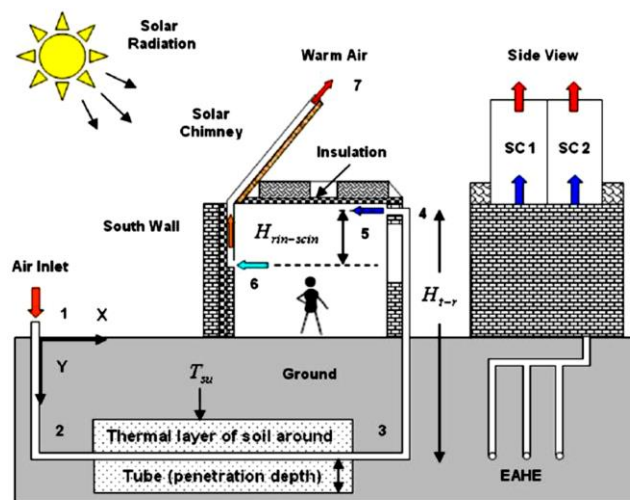


Figure 36: Solar chimney joined geothermal system (Maerefat and Haghighi, 2010).

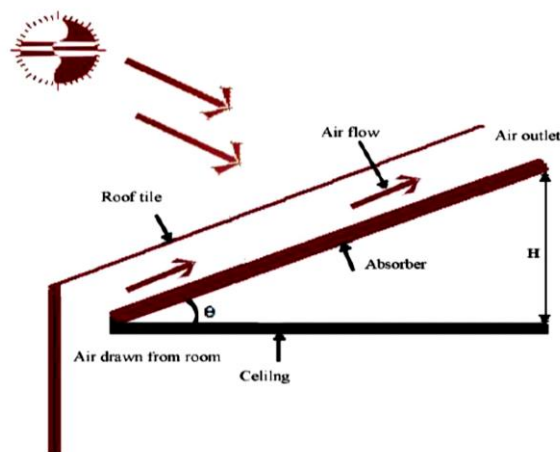


Figure 37: Schematic of room attached to solar chimney (Mahdavejad, et al., 2013)

Al-Kayiem and Heng used measurements on a modified rooftop solar chimney with two absorber surfaces are shown in Figure 38 as experimental results (Al-Kayiem and Heng, 2015). Under several operational circumstances and design modifications, the system's efficacy was evaluated. Three distinct designs were compared and assessed. The results indicated that the chimney that used ambient air as an input fared the least well. Model 3 achieved performance gains of 1.2 percent and 7.6 percent, respectively, over models 1 and 2. Model 3 is a rooftop solar chimney with an extra vertical absorber in the air outlet tube.

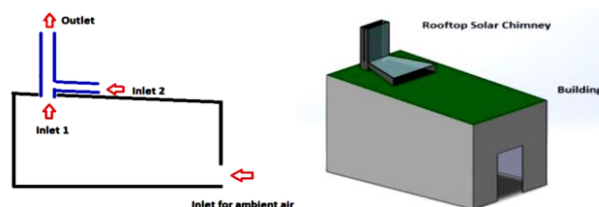


Figure 38: Outlines of the experimental setup (Al-Kayiem and Heng, 2015)

Naraghi presented a study on solar chimneys that was time-dependent. Energy balancing equations for the three discretized solar chimney components—the absorbing layer, cover glass, and air space (Naraghi, 2015). The Newton-Raphson procedure is used to solve the discretized time-varying equations for energy balance over a 24-hour period. The construction of a dependent numerical calculation is shown in Figure 39. They demonstrated that a rise in the absorption plate's heat capacity causes a higher level of airflow in the evening and at night. Whether or not there is solar brightness in the early morning, faint. Poor.

experimental test rig is used to assess the ventilation and cooling performance of a SC integrated with an EAHE system (SCEAHE) on a typical bright summer day. The SC provides the necessary driving power to drive airflow into the EAHE pipe, and the earth around it cools the air. The experimental findings show that the SC-induced buoyant driving force may propel the EAHE during the day. 252 m³/h was the highest airflow rate attained during the day. Furthermore, when the solar radiation intensity was low or absent, an airflow rate of 50 to 70 m³/h was attained.

A test room in the desert environment of Yazd, Iran, will be used to statistically evaluate the passive cooling performance of newly built and standard Trombe walls combined with solar chimney and water spraying system (WSS) Figure 43 (Rabania et al., 2019). The newly created Trombe wall increases the interior area while lowering the cost of installation. Additionally, it can receive the solar intensity from three directions as opposed to the single direction that the typical Trombe wall can. The earlier practical investigation used to validate the numerical modeling of the newly designed Trombe wall. Given that the new-design Trombe wall creates more natural air, the current numerical findings show that the average room temperature in the morning is lower in the new-design Trombe wall than it is in the conventional type.

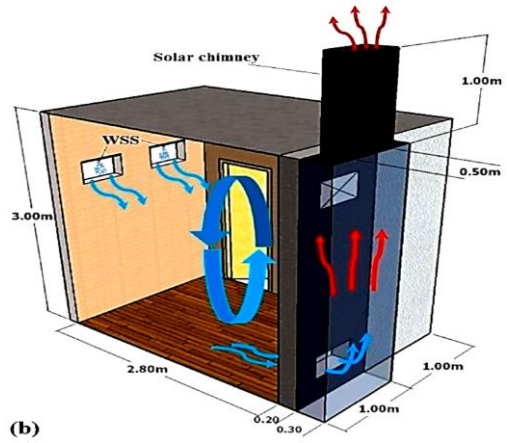


Figure 43: Diagram of circulation airflow of the cooling system performance (Rabania et al., 2019)

Table 2: Summary of roof absorber configuration and types		
Description	Configuration	References
roof inclined solar chimney		Rahman and Chu, 2021
roof vertical solar chimney		Rahman and Chu, 2021
combined roof solar chimney		Rahman and Chu, 2021
Space heating mode		Hirunlabh et al, 2001
Natural ventilation mode		Hirunlabh et al, 2001
double pass roof solar collector		Hirunlabh et al, 2001

Table 2: Summary of roof absorber configuration and types

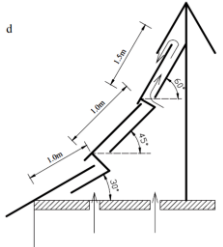
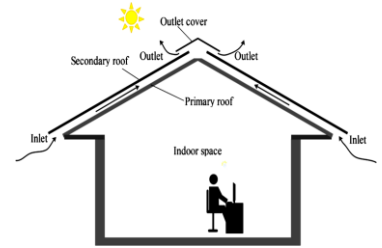
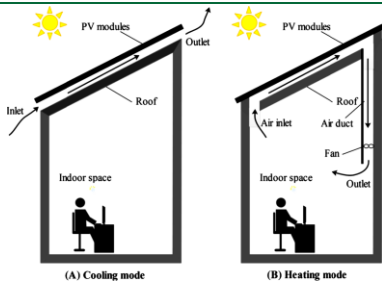
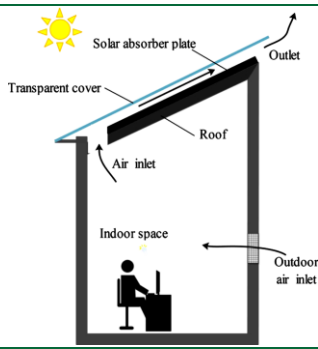
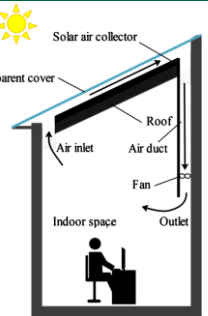
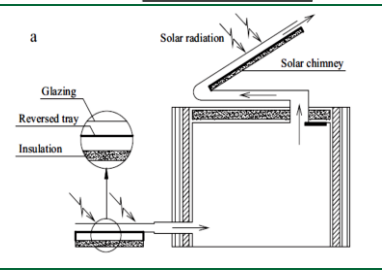
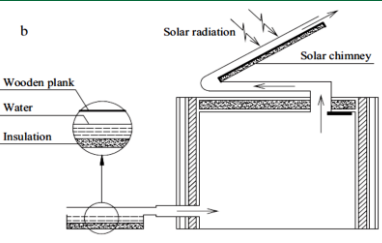
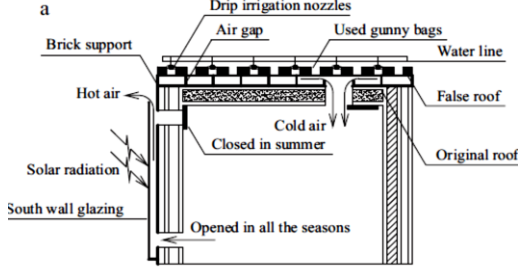
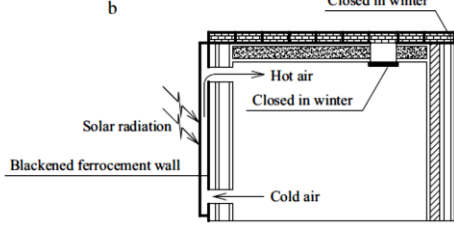
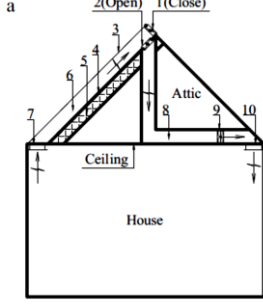
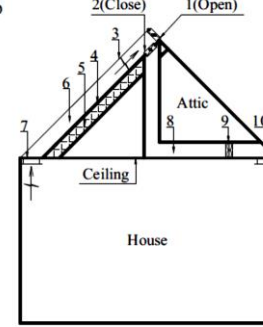
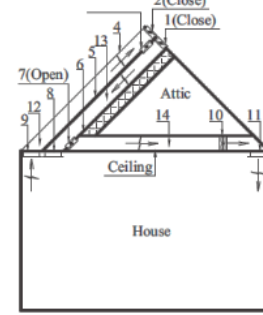
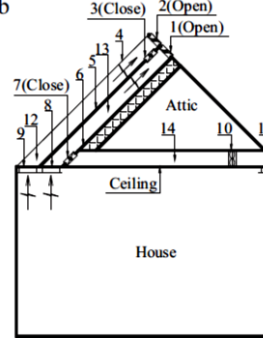
<p>double pass roof solar collector</p>		<p>Hirunlabh et al., 2001</p>
<p>double-skin roof</p>		<p>Balocco, et al., 2002</p>
<p>roof integrated PVT system.</p>		<p>Chen, et al., 2010</p>
<p>roof solar chimney.</p>		<p>Khanal, et al., 2011</p>
<p>roof-integrated solar air heater.</p>		<p>Buker, et al., 2015</p>
<p>passive winter model</p>		<p>Raman et al., 2001</p>
<p>summer model</p>		<p>Raman et al., 2001</p>

Table 2: Summary of roof absorber configuration and types

<p>passive summer model</p>		<p>Raman et al., 2001</p>
<p>winter Operation</p>		<p>Raman et al., 2001</p>
<p>single pass roof for Space heating mode</p>		<p>Zhai et al., 2005</p>
<p>single pass roof solar for Natural ventilation mode</p>		<p>Zhai et al., 2005</p>
<p>double pass roof for Space heating mode</p>		<p>Zhai et al., 2005</p>
<p>Natural ventilation mode</p>		<p>Zhai et al., 2005</p>

3. CONCLUSIONS

To increase the heat transmission property of the internal regions of the domestic buildings, the internal air natural ventilation has been widely used in the construction of exterior walls, roofs, and windows. Solar chimney systems and technologies have grown in prominence over the last century because to their capacity to decrease the heat input or loss and convert solar radiation into thermal energy for space heating or passive cooling. This study gives a review of the literature on various types and configurations of absorber plate that used in the solar chimney in the building envelopes with inner air layers. The existing applications and technologies of air layers in walls, windows, and roofs are summarized and outlined. Furthermore, the capabilities and benefits of various technologies are addressed and summarized. The air layer operating modes utilized in building envelopes are loosely categorized into three types: enclosed, naturally ventilated, and mechanically ventilated. The enclosed kind serves as an additional insulating layer; the naturally ventilated air layer is frequently used. In the following chart Figure 44, there a comparison between the amajor parameter for the two configuration of the vertical and roof solar chimney the figure shoed that the most independent parameter is the ACH for the vertical solar chimney.

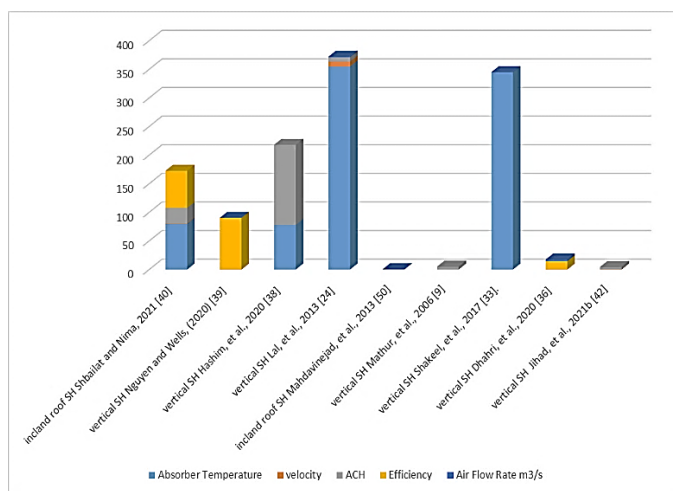


Figure 44: Comparison of the two configuration solar chimney.

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