CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises consequences of each simulation cases. This section brings out the comparison of each testing case in term of output data identified as velocity, temperature, and mass flow quantities. Next, it is detailed about flow pattern process in notable position in channel along step of times until steady state. This part is divided into two categories of series. First, there results about top stair chamber simulation by heat flux 200W/m², 400W/m², 600W/m², 800W/m², and 1000W/m². Another category views on whole house output data in another 5 cases: typical house with existing opening without Trombe wall (NTW); whole house designed with Trombe wall by heat flux 200W/m² (TW200W/m²) and 1000W/m² (TW1000W/m²); and two other cases which were added temperature on top ceiling surface and walls of stair block. One is named as heated chamber without Trombe wall (HC-NTW); another case is called heated chamber with Trombe wall by heat flux 1000W/m² (HC-TW1000W/m²). The part mentions about the comparison of ventilation, temperature, and mass flow in living room, kitchen, and outlet area. Later, the chapter is also specified on capacity of the system and matter during simulation period.

4.1 Simulation result on top of stair block chamber

4.1.1 Temperature simulation output

Even the boundaries condition which were input as temperature on wall surface and glass surface, the temperature was reduced by the blowing wind from the inside chamber by inlet of channel. This is evidence to indicate a trigger of different average temperature of each case from start until 200 second of time with a lower range than the temperature on wall and glass surfaces. The average temperature value originated from a line which is drown from wall to the inner surface of glass inside the channel near the outlet as shown in Figure 4.1. The temperature at the beginning was dramatically intensified because the movement of air flow from inside the chamber was still slow.

Soon, from 20 seconds the temperature was dropped and continued in a-mostly-equal range which could be confirmed that the system was on the path of steady state. Attributable to the graph, the high average of temperature inside the channel after the continual of ventilation replacement was from 310.8K for heat flux 200W/m² to 316.53K for heat flux 1000W/m².

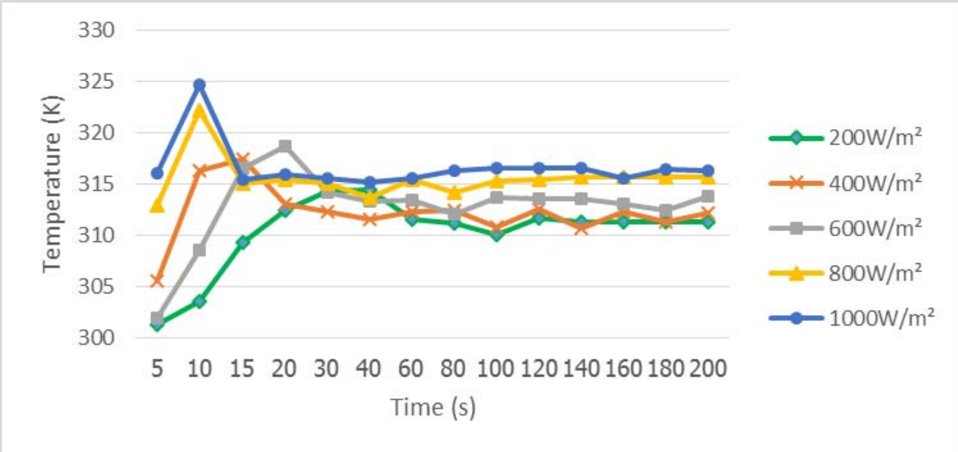


Figure 4.1 Average temperature in channel by all heat flux

1) Comparison of temperature in channel at each of time step

From Figure 4.2 - Figure 4.4, the graphics mentioned about the comparison of temperature in between wall to glass of each case of heat insertion. For heat flux 1000W/m² case, the temperature near the glass was around 323.94K which accelerated the reduction value around 33K from first set up, thus 22K lower than the temperature on wall surface compared to 334.15K beforehand. For heat flux 200W/m² case, the temperature near wall and glass leveled off from 4K near wall surface to 12K near glass surface. This could apparently imply that high heat level in channel produced higher ventilation rate, so that the dropping temperature value appeared to be bigger than the lesser heat input as be evident on 200W/m² case. At steady state, the temperature in channel signified an identical pattern every occasion of heat flux input. Heat flux 1000W/m² still provided a remaining high temperature than the lower and lowest heat flux input invariably (see Figure 4.4).

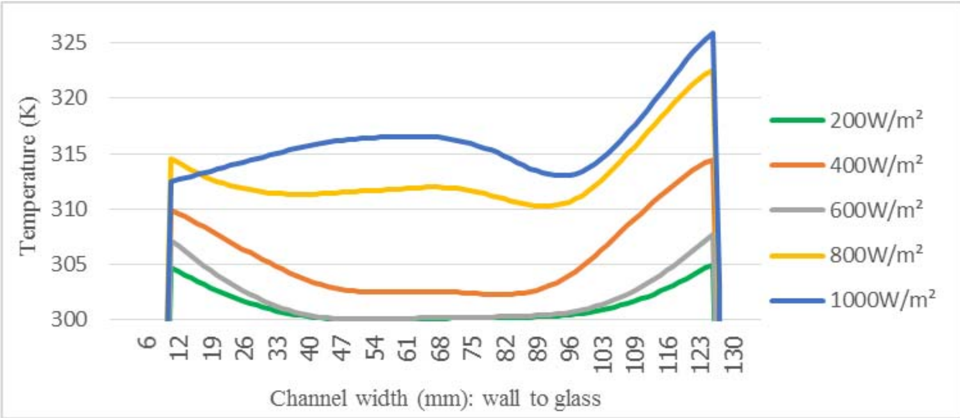


Figure 4.2 Comparison of temperature pattern in channel from wall to glass, at 5s

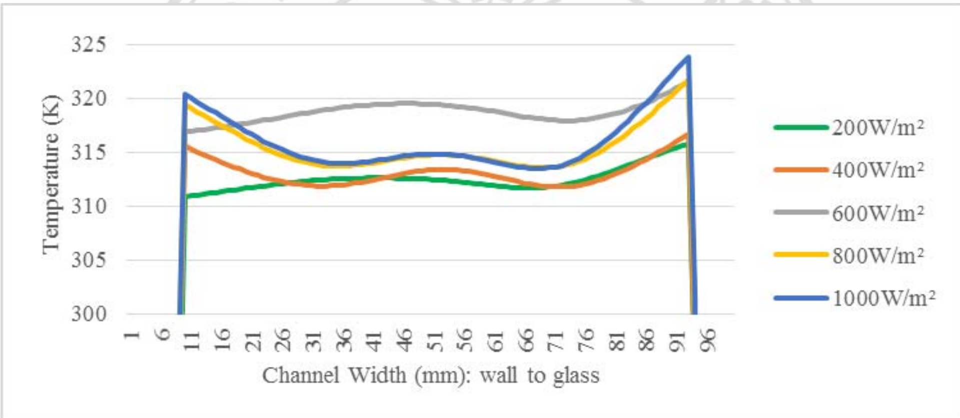


Figure 4.3 Comparison of temperature pattern in channel from wall to glass, at 20s

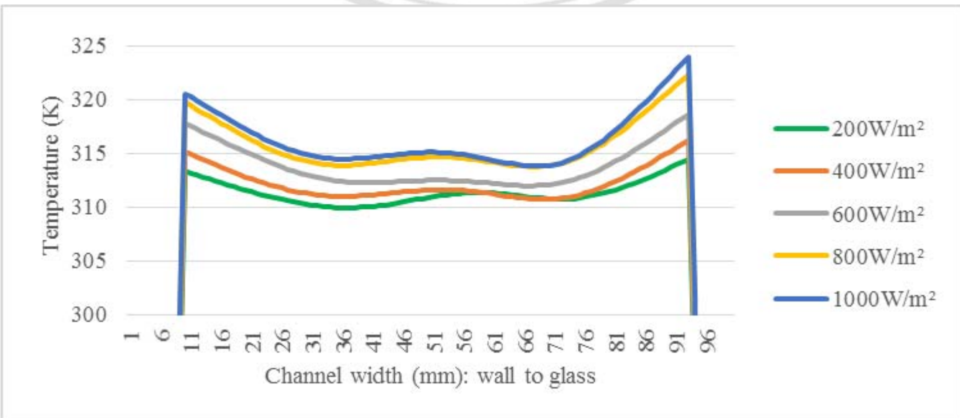


Figure 4.4 Comparison of temperature pattern in channel from wall to glass, at 200s

2) Temperature appearance in channel for each heat flux

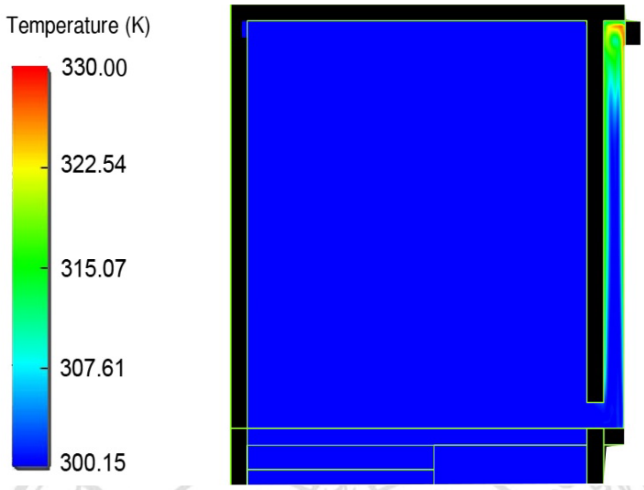
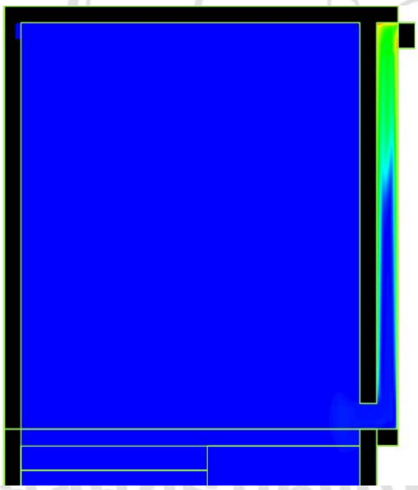


Figure 4.5 3D view temperature by heat flux 1000W/m², at time 5s



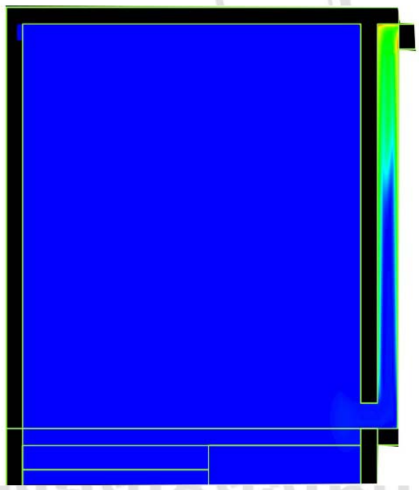


Figure 4.6 (left) 3D view temperature by heat flux 1000W/m², at time 20s

Figure 4.7 (right) 3D view temperature by heat flux 1000W/m², at time 200s

The visualization of heat in channel was presented by Figure 4.5 - Figure 4.7. The figures were brought out from simulation consequences of heat flux 1000W/m² as the sample. The observation took notification on 3 significant points of time step. First, the pre-state of simulation, which 5 seconds of time was pinned. Then, 20 seconds was put to view when there appear the stable range of average temperature in channel as already discussed in Figure 4.1. Eventually, it was interesting to see how the temperature maintain in channel while a further point of steady state, 200 seconds, was encountered. It was illustrated that by the color series, high temperature endured on the top part of channel and along the surface of wall and glass.

Figure 4.8 Figure 4.10 gave the analytical value of temperature from wall to glass in three positions of the system: near inlet, in the middle of channel, and near the outlet. The temperature near inlet was no longer high due to the cool air blowing in from stair chamber. At the same time the air rose up and store at the upper part of the channel resulting in a higher temperature near the outlet. The higher the level of chamber was, the hotter the temperature was.

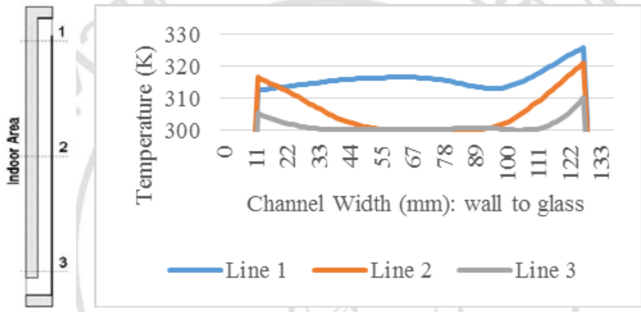
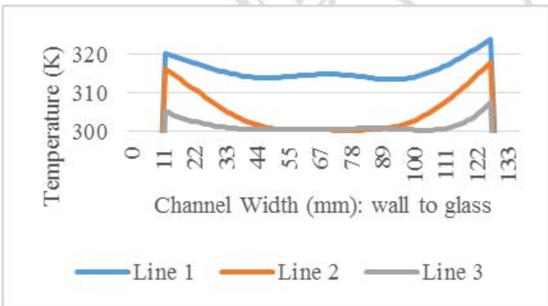


Figure 4.8 temperature pattern in channel by heat flux 1000W/m², at time 5s



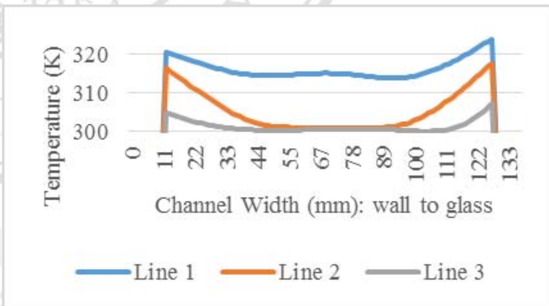


Figure 4.9 (left) temperature pattern in channel by heat flux 1000W/m², at time 20s

Figure 4.10 (right) temperature pattern in channel by heat flux 1000W/m², at time 200s

4.1.2 Velocity simulation output

Graphic of average velocity accounted for the comparison of average velocity of each heat flux from initial operation until steady state. The detail of flow in channel at start-up time until the steady state would be explained in section of flow appearance in channel. On the other hand, Figure 4.11 was associated with the average velocity of each heat flux from initial operation until 200 seconds. This graph expressed a very similar pattern of velocity from one to another heat flux input. Lower heat input gave lower wind velocity than higher heat input. It was conceivable that after the system was stably heated, the air started to flow out at outlet of channel at time 20 seconds. From 0 to 20 seconds, it seemed plausible that the air was arranging itself to adapt with heated area between wall and glass. At first 5 seconds the air rose in a very high level as the result of a great sucking speed from inlet due to low pressure in channel while heating up. Then air speed decreased a little bit back caused from the movement up and down of self-arrangement. From 40 seconds, there appears the initial of steady state, since then air flow rate won’t dramatically change its range. The result of average velocity at steady were 0.14m/s, 0.19m/s, 0.22m/s, 0.26m/s, 0.28m/s for the heat flux 200W/m^2, 400W/m^2, 600W/m^2, 800W/m^2, and 1000W/m^2 respectively.

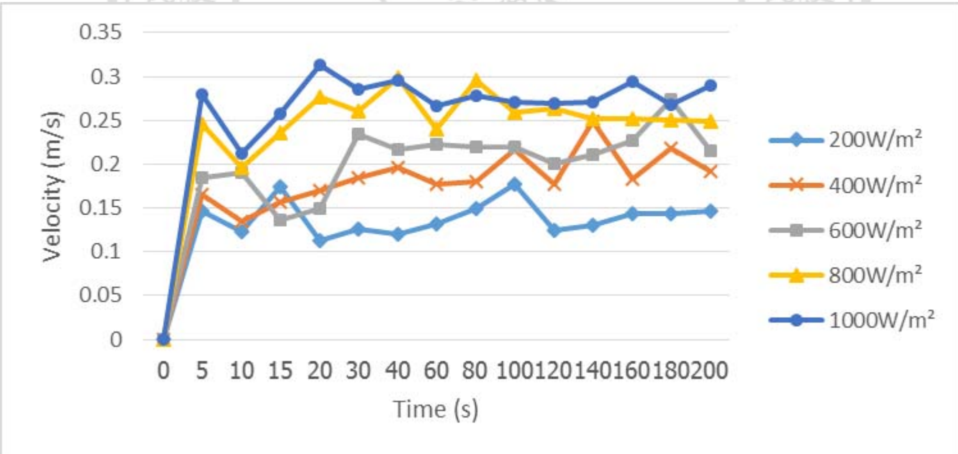


Figure 4.11 average of velocity in channel by all heat flux at step of times

1) Comparison of velocity in channel at each of time step

As declared in average graph in Figure 4.11, this section brought out three important phases of ventilation simulation result. There are states of 5s, 20s, and 200s. The sections were noted near outlet of channel. By inspection on Figure 4.12-Figure 4.14, the air speed in channel gained more near heated surface, especially the internal glass surface. At primary state, the flow did not have an organizing configuration until the air started to move out in 20 seconds time. Pending further on steady state as visible in Figure 4.14, a repeated equivalent pattern of each flow line had discovered in very similar shape by any situation of heat flux. The highest wind speed was produced by heat flux 1000W/m² in range of 0.89m/s at steady state of 200 seconds. The lowest heat flux created its maximum wind speed of 0.39m/s.

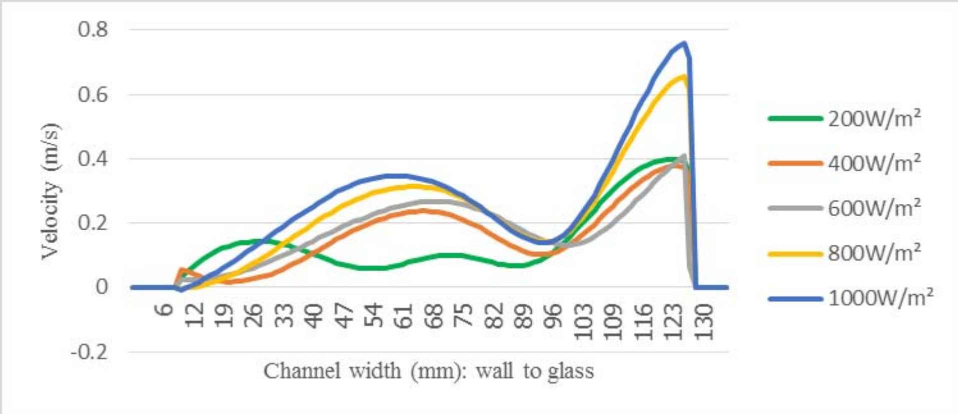


Figure 4.12 Comparison of velocity pattern in channel from wall to glass at 5s

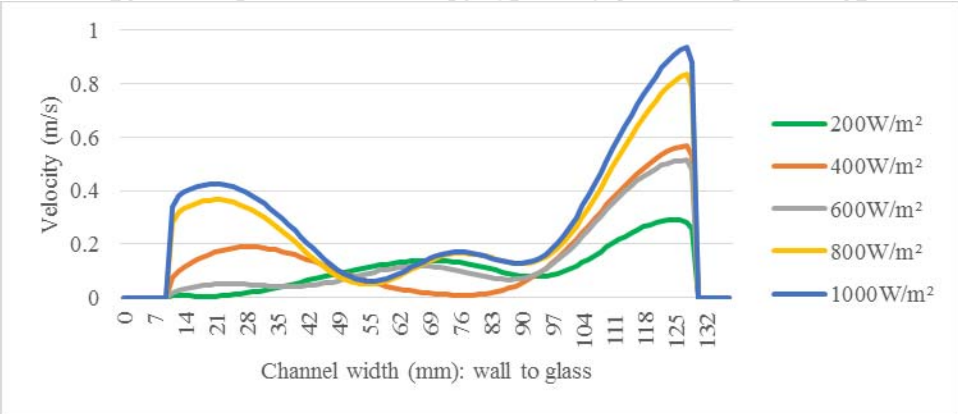


Figure 4.13 Comparison of velocity pattern in channel from wall to glass at 20s

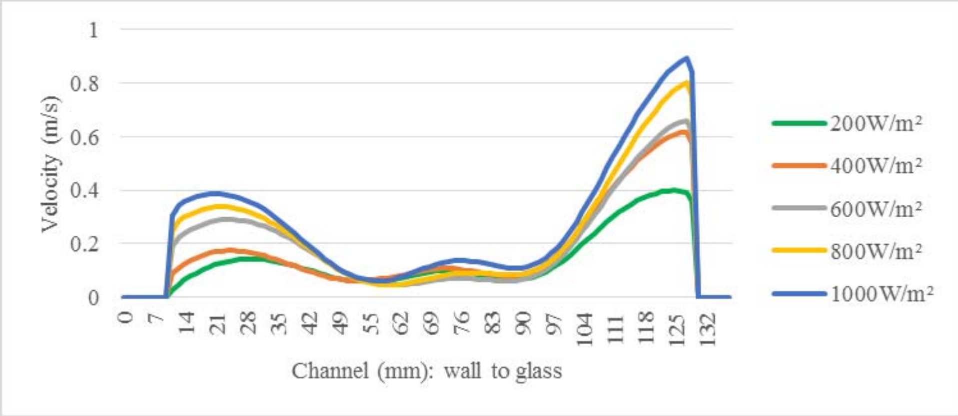


Figure 4.14 Comparison of velocity pattern in channel from wall to glass at 200s

2) Ventilation flow appearance in channel at different position

Due to the very similar flow pattern of velocity induced from one to other heat flux, a case of heat flux 1000W/m² was chosen to elaborate ventilation flow appearance in channel. From simulation, Figure 4.15 - Figure 4.17, showed how the air in channel organized itself up and down by heat dispersion in channel until it could up-process in a regular pattern. From inlet, the air were sucked from down stair part of chamber. A great amount of air was pulled into the channel and a moderate amount was blowing up and spinning circulated in the top chamber. The air moved downward and collected to the inlet of the structure while crushing the bounding surface at the back side of Trombe wall's wall. An identical appreciably rate of air proceeded smoothly at inlet as shown from 20 seconds time to later on period.

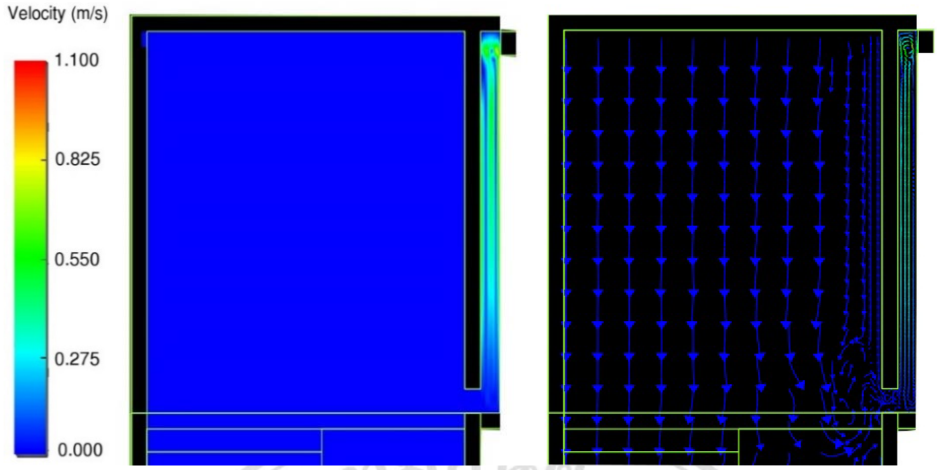


Figure 4.15 3D view and flow vector of velocity by heat flux 1000W/m², at time 5s

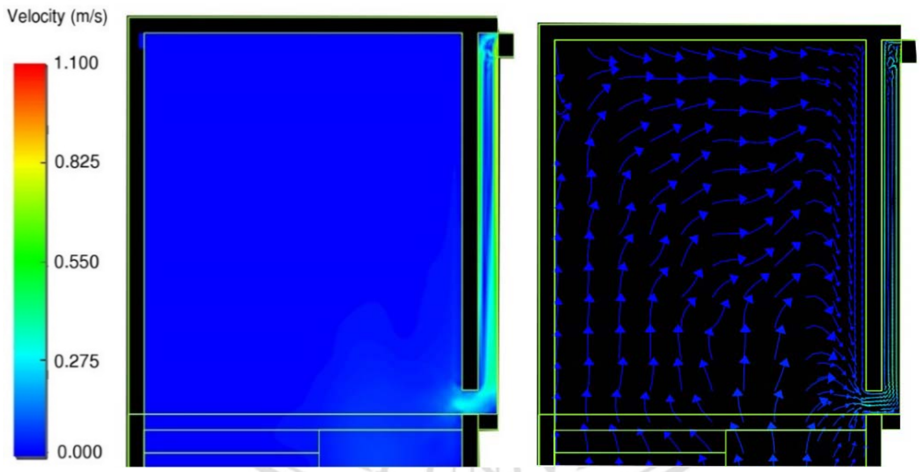


Figure 4.16 3D view and flow vector of velocity by heat flux 1000W/m², at time 20s

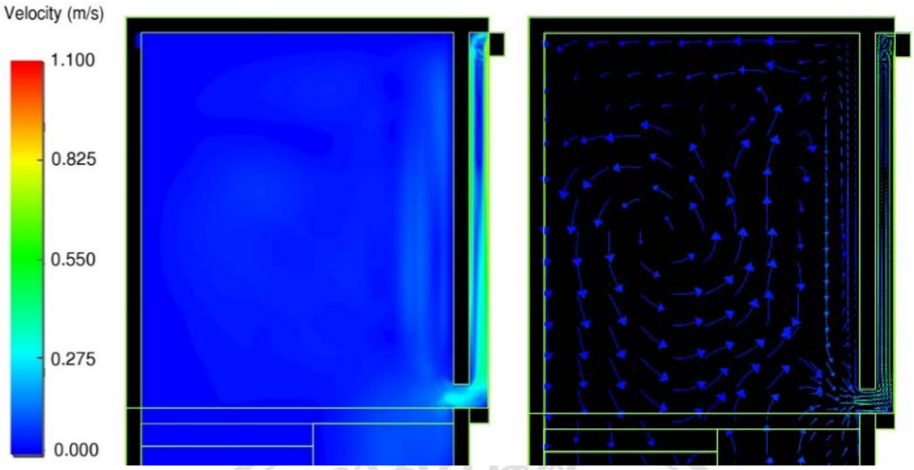


Figure 4.17 3D view and flow vector of velocity by heat flux 1000W/m², at time 200s

The analysis of air flow in channel was taken measuring on the same three order positions: near the inlet, in the middle of channel, and near the outlet, like illustration in section of temperature study in the system which demonstrated in part 4.1.1. According to Figure 4.18 - Figure 4.20, it was noticed that around the area of inlet, the air were in fairly different range either in any position from wall to glass. For line 2 and 3, the appearance of air movement could be presented in three level of speed perceived on node of near-wall surface, middle of channel, and node of near-glass surface. The air arose up to blow down the heat on wall and glass, resulted the higher air velocity near those surfaces.

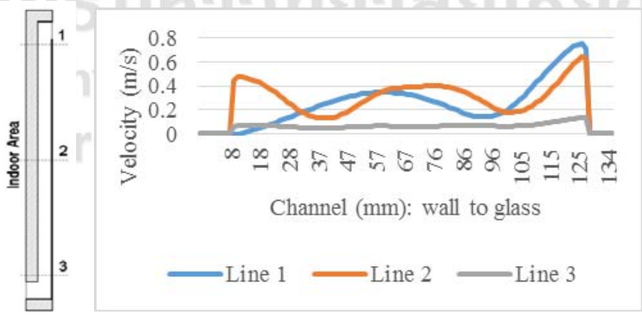
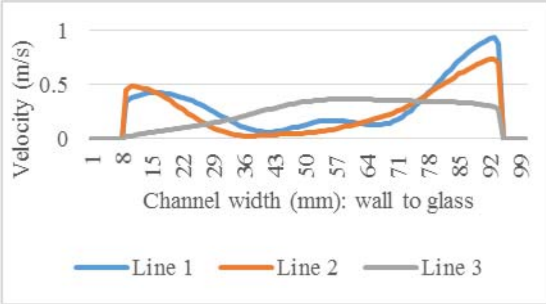


Figure 4.18 Velocity flow pattern in channel by heat flux 1000W/m², at 5s



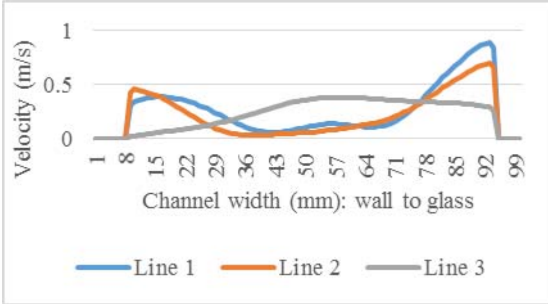


Figure 4.19 (left) Velocity flow pattern in channel by heat flux 1000W/m², at 20s

Figure 4.20 (right) Velocity flow pattern in chnnel by heat flux 1000W/m², at 200s

4.1.3 Mass flow simulation output

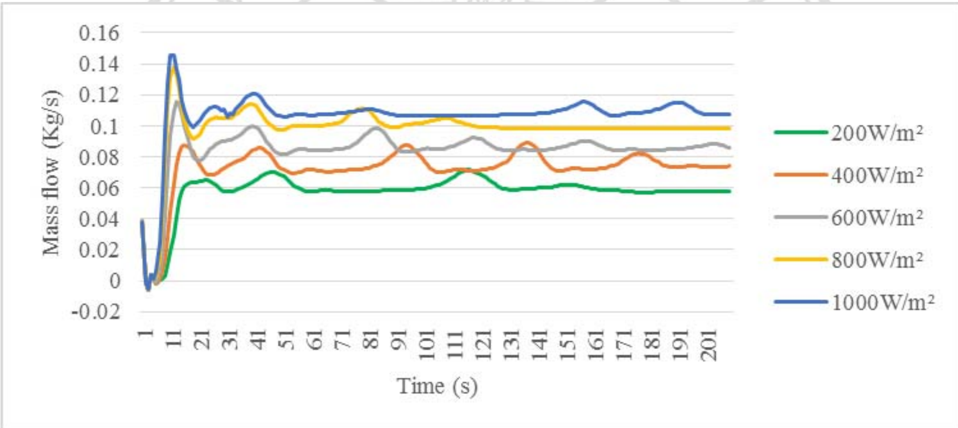


Figure 4.21 Mass flow at inlet of channel along steps to time

Figure 4.21 proclaimed the result from simulation about air mass flow rate from the beginning of operation till 200 seconds of time.

Table 4.1 displayed the average of mass flow rate at steady state of experiments for each case of heat flux. Furthermore, air mass flow rate gotten at inlet of the system was approximately 0.109Kg/s as the highest average value which heat flux 1000W/m² could create. The amount of mass flow rate slightly varied sometime along the operation period. It was predicted that the replacement of fresh air at a time cooler the channel and it took another short time to heat up again, thus the circle continually remained like that.

Table 4.1 Average mass flow at steady state of each heat flux.

Heat Flux	Average
200W/m²	0.060 Kg/s
400W/m²	0.075 Kg/s
600W/m²	0.087 Kg/s
800W/m²	0.100 Kg/s
1000W/m²	0.109 Kg/s

4.2 Simulation result for whole house experiment

This segment reported about the comparison of temperature, ventilation, and mass flow rate received from 5 simulations cases as mentioned in methodology section. There are the case without Trombe wall (NTW); whole house designed with Trombe wall by heat flux 200W/m² (TW200W/m²) and 1000W/m² (TW1000W/m²); the heated stair chamber without Trombe wall (HC-NTW); and heated stair chamber with Trombe wall design by applying heat flux 1000W/m² (HC-TW1000W/m²). First, the outcome was collected from the middle of living room area. Next, the measurement location in the middle of kitchen was taken into account. It is indifferent from the single study on stair chamber, after 60 seconds simulation for running process, the consequence made believed that the system started to work on sucking the indoor wind out to exit at 20 seconds of simulation time.

4.2.1 Temperature at specific place of house

It is essential to notify about average temperature in each room. As stated in

Table **4.2**, the temperature of ambient extended its influence by air flow from inlet to the room resulting the increasing of temperature in living room. It can therefore be inferred that the temperature in living room rose up 1-2 Kelvins more than pre-state set up value which 300.15K was encountered. Though, the evidence suggested that the temperature from a study case to another is quite a bit different only. The result also gave the agreement that in kitchen, there was mostly unchanged in temperature which could point out about the relationship with a lesser wind speed passing through this room.

Table 4.2 Average of temperature at living room, kitchen, and outlet (in K)

Case	Living r.	Kitchen	Outlet
NTW	301.33	300.52	300.15
TW200W/m^2	301.73	300.50	303.17
TW1000W/m^2	302.38	300.57	307.32
HC-NTW	302.67	300.53	302.05
HC-TW1000W/m^2	302.49	300.50	307.13

As it can be seen from Figure 4.22, the 3D views section of the house indicated temperature pattern from floor to room ceiling by opening apertures in the front. Depend on the color range, the area near ceiling of both living room and kitchen attained higher heat in rooms. From initial phase until 60 seconds simulation period, in living room, hot temperature was ongoing shifting into the room, then started to spread out heat from ceiling part downward to the lower part of the room. It was reasonable to suppose that the ambient heat was blowing within the ventilation from environment into the house. Anyway, the temperature at kitchen was still imperceptible while hot air released upward by the stair block. As identified on

Figure **4.23** and Figure 4.26, the top of stair chamber was input the heat, thus the heat strewed by convection and increase the temperature on those chambers. However, the heat could not extend its effect to more lower to down part area of stair block according to the contrast direction of ventilation which moved from ground floor up to the outlet at the top of stair chamber. Specifically on figure 4.26, the heat moved down by the wall and immediately was sucked into Trombe wall and led out by the outlet. Therefore, the lower floor of house would not be concerned about the rising of temperature affected from the heat on top chamber ceiling even if the conduction of heat transmitted from the sun without the insulation. In addition, as revealed by all vertical cutting that the temperature flow were in similar pattern and similar rate, Figure 4.27 was picked up to show how the temperature in room spread in horizontal section plan from inlet to living room and continue to kitchen.

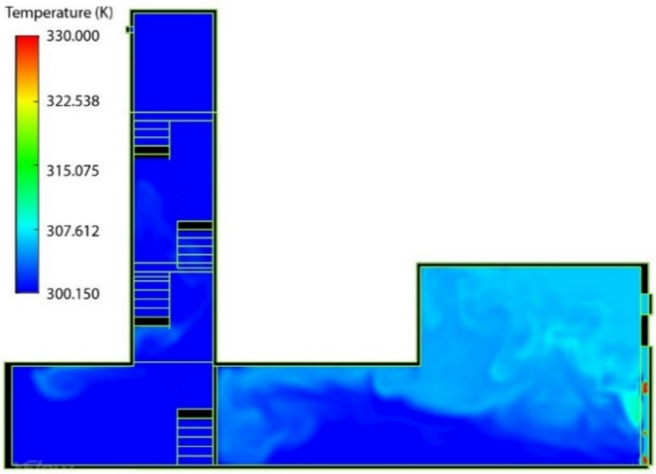


Figure 4.22 NTW case, temperature pattern at 60s

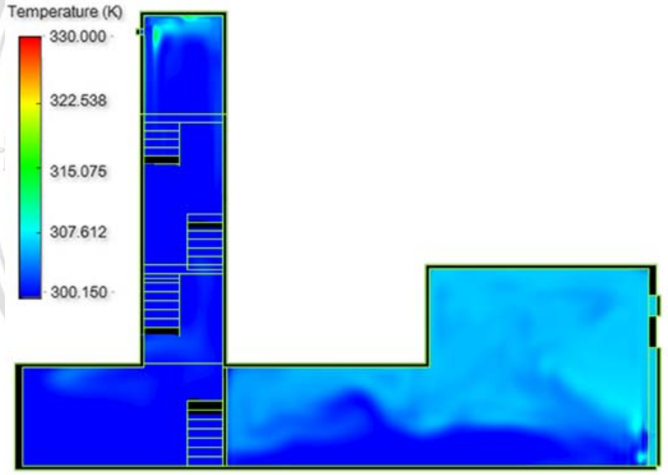


Figure 4.23 HC-NTW case, temperature pattern at 60s

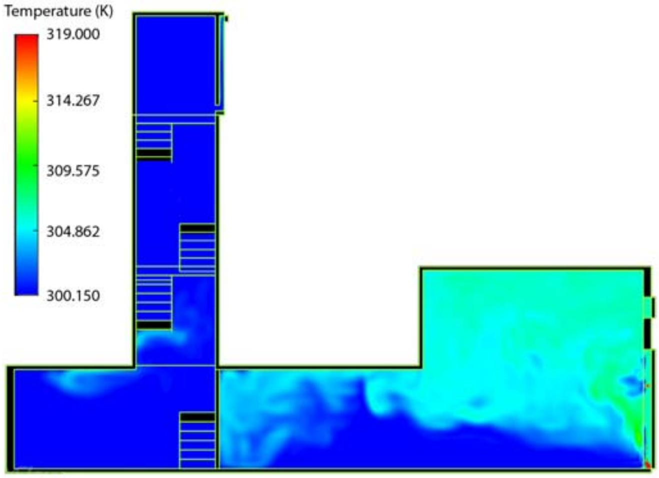


Figure 4.24 TW 200W/m² case, temperature pattern at 60s

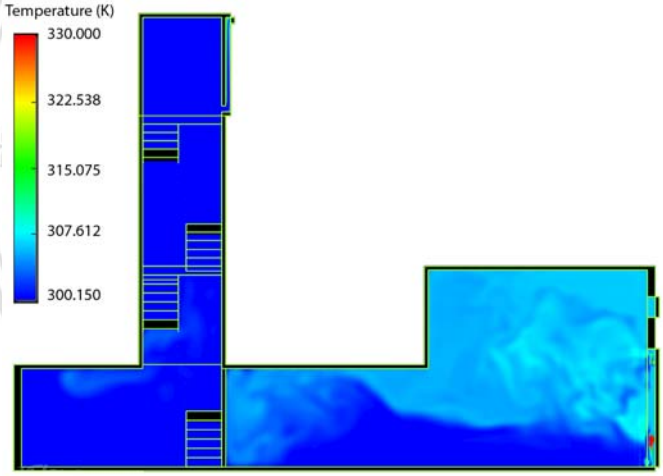


Figure 4.25 TW 1000W/m² case, temperature pattern at 60s

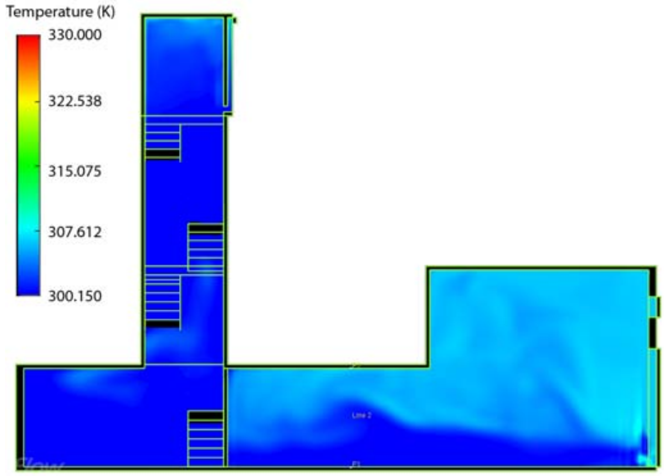


Figure 4.26 HC-TW1000W/m² case, temperature pattern at 60s

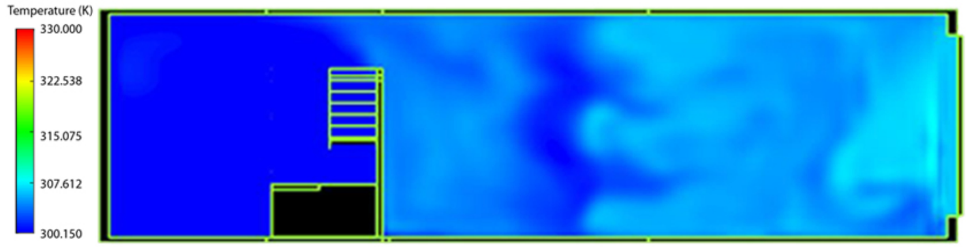
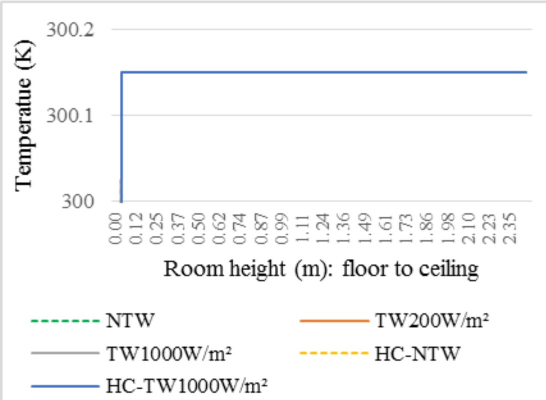


Figure 4.27 HC-TW1000W/m² case at horizontal cutting, temperature pattern at 60s

As outlined earlier, it should be noted that the subsequences of temperature in living room area was significant subject to compare with comfort standard. By a measuring line drew from floor to ceiling in the middle of the room, the temperature rate can be observed from Figure 4.28Figure 4.31. It was indicated that the ambient temperature started to expose slowly in the room. Hot temperature may store near the ceiling up to 4 or 5 degrees higher than initial room temperature set at pre-simulation. It was predicted that, in later on period, the temperature would possibly spread down to the floor more which made a whole room hotter in approximately around 303K to 304K (30-31°C). As known from literature review on standard of comfort zone which had been indicated in chapter II, this range of temperature cold not provide comfort feeling to occupants. In ASHRAE standard lower than 27.0°C could be counted as comfort. And without the enhancement of ventilation, this degree was in range of dissatisfy people in the room.



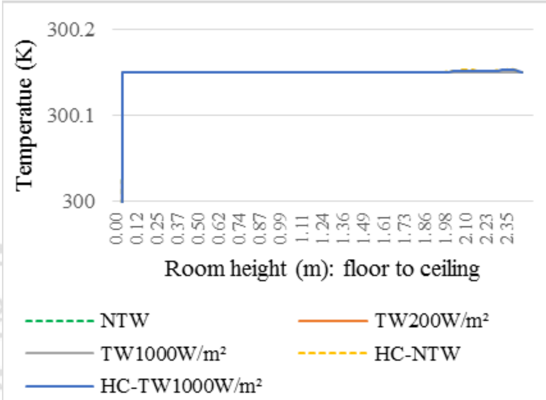
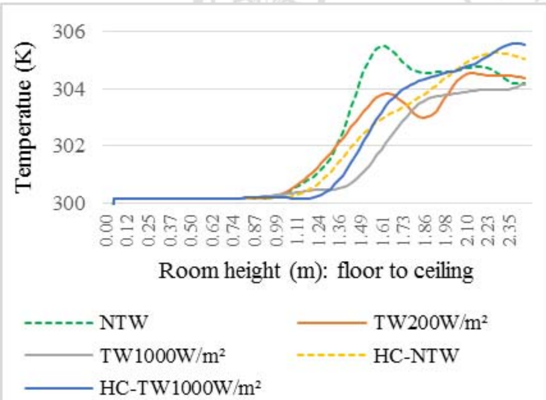


Figure 4.28 (left) Temperature pattern at living room, at time 5s

Figure 4.29 (right) Temperature pattern at living room, at time 20s



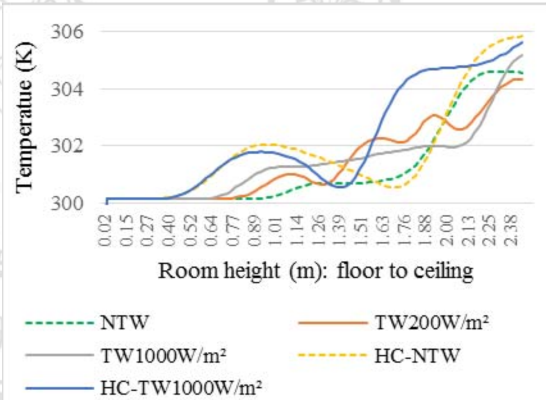


Figure 4.30 (left) Temperature pattern at living room, at time 40s

Figure 4.31 (right) Temperature pattern at living room, at time 60s

a) Temperature pattern at Kitchen area

Because kitchen location was separated by stair passage, thus a numerous of hot air lifted up by this big well resulting a slightly influence of hot temperature occurring near ceiling of the room as shown in Figure 4.32. For all experiment cases, there appeared a very little change of temperature from the first set up condition.

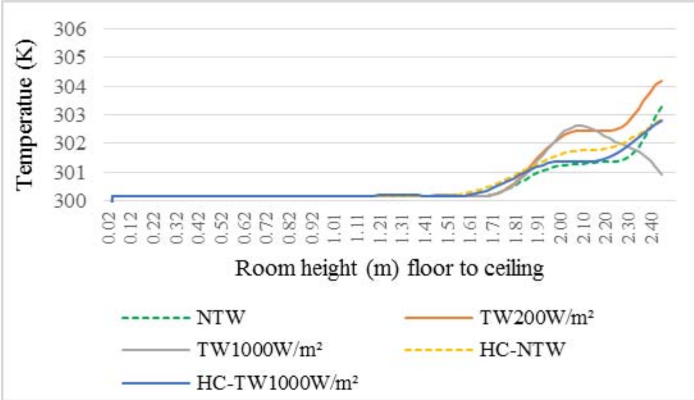


Figure 4.32 Temperature pattern at kitchen, at time 60s

4.2.2 Velocity at specific place in row house

Table 4.3 showed about average velocity at each specific location for all studied cases. The consequences informed that for the each case both in living room and kitchen gave slightly different velocity rate. At a cutting surface in the middle of living room, an average data was achieved. Studied case of TW1000W/m² could gain best average velocity, yet all the cases cannot sufficiently meet the level of comfort zone which at least 0.2m/s is needed [13].

Table 4.3 Average of air velocity in living room, kitchen and outlet (in m/s)

Case	Living r.	Kitchen	Outlet
NTW	0.123	0.128	1.544
TW200W/m²	0.142	0.100	0.938
TW1000W/m²	0.157	0.113	0.962
HC-NTW	0.144	0.102	1.659
HC-TW1000W/m²	0.146	0.101	1.093

Figure 4.37 presented 5 cases of flow visualization to better comprehend about the air pattern. The cross section were cut in the middle of the house to see both air flow at the middle of living room and outlet channel, so that the relationship of flow from living room area through the corridor were a little bit bothered by wall partition separation from room to the stair. The pictures showed that air flow circulation from inlet passing through living room and kitchen, then rose up to the outlet on the top of

stair chamber. The speed of ventilation flow was signified by range of color defined by its velocity value pallet next to it. Nonetheless, each image displayed that there were mostly no any air flow effect for kitchen.

The simulation was also specified air velocity at outlets of each case. In case of existing house without Trombe wall design, the air move up normally, crushed the top ceiling of chamber and dragged out by the outlet nearby.

Figure 4.34 illustrated that with heat adding on the top chamber (case HC-NTW), the air could move virtually faster than the non-heated chamber (case NTW). For cases of Trombe wall system was applied, as shown in figure Figure 4.35 and Figure 4.37, no matter the chamber was heating up, the air both from lower level of the house and inside the top chamber passed through the inlet of the channel for the exit. In addition, as revealed by all vertical cutting that the temperature flow were in similar pattern and similar rate, Figure 4.38Figure 4.39 were picked up to show how the velocity and vector of velocity in room spread in horizontal section plan from inlet to living room and continue to kitchen and how it moved upward.

It was also found out that the condition of HC-TW1000W/m^2 and HC-NTW created the maximum air speed up to 2m/s, while the others 3 cases of TW200W/m^2, TW1000W/m^2, and NTW could produce the maximum data of 1.45m/s, 1.63m/s, and 1.95m/s respectively. Even the different value of air velocity at ground floor was not dramatically different, it was supposed that the additional heat applied on the wall and ceiling of the top chamber was the reason for the increasing air speed to move out faster than the normal insulated-surface assumption condition. However, concerning the Table 4.3, the average air velocity of the two cases without Trombe wall system contributed higher rate than cases of Trombe wall application. It is observed that the location of those outlets could affect air flow movement.

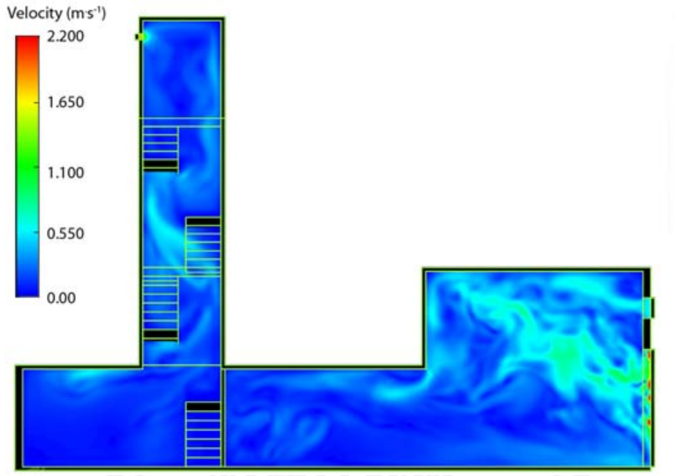


Figure 4.33 NTW case, velocity flow pattern at 60s

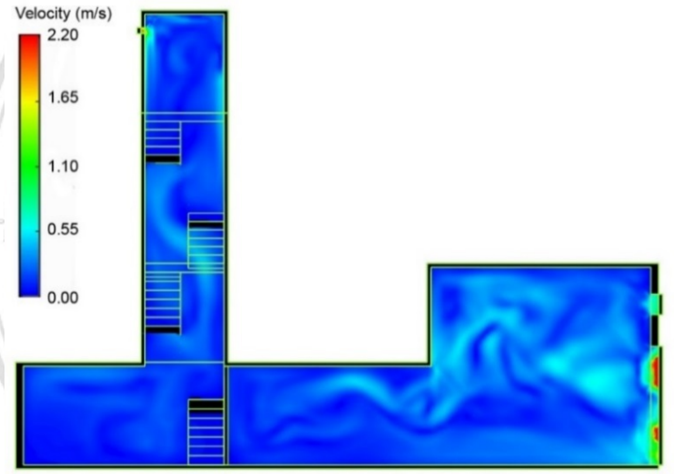


Figure 4.34 HC-NTW case, velocity flow pattern at 60s

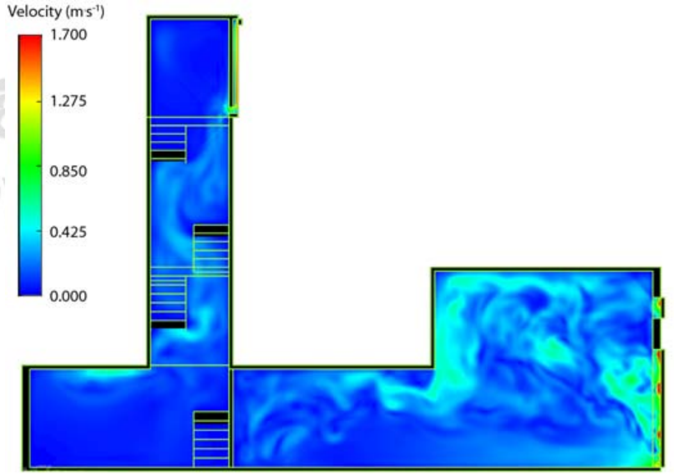


Figure 4.35 TW 200W/m² case, velocity flow pattern at 60s

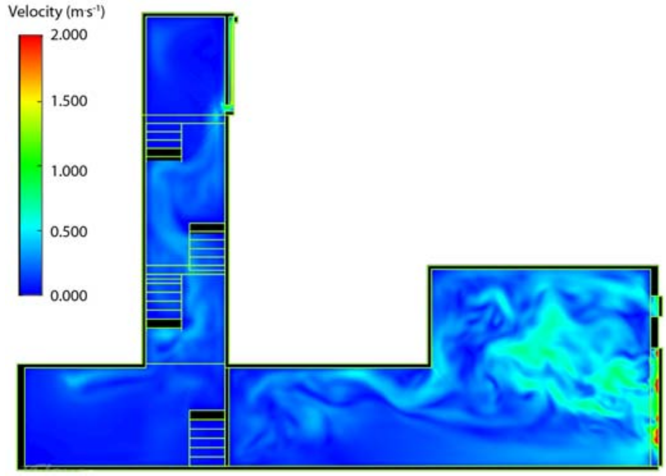


Figure 4.36 TW 1000W/m² case, velocity flow pattern at 60s

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Figure 4.37 HC-TW1000W/m² case, velocity flow pattern at 60s

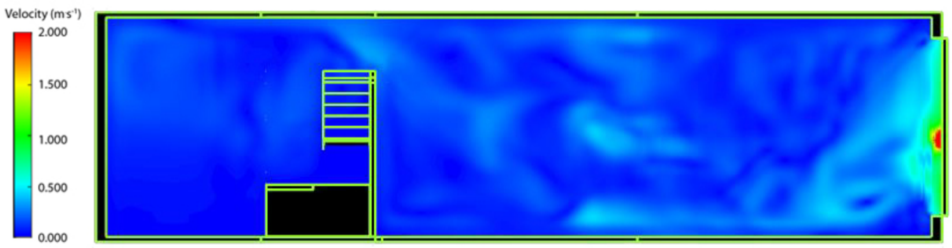


Figure 4.38 HC-TW1000W/m² case at horizontal cutting plan, velocity flow pattern at 60s

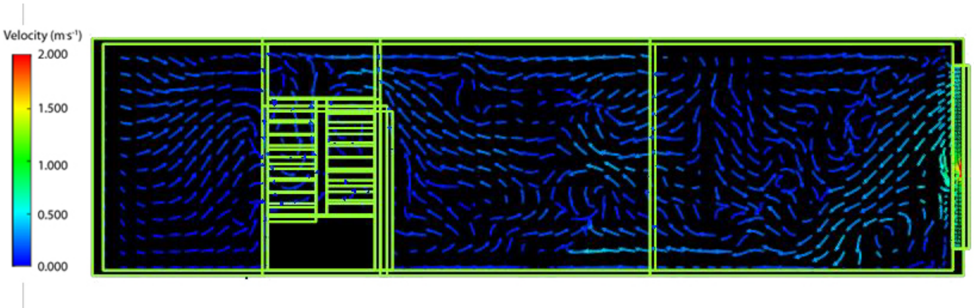
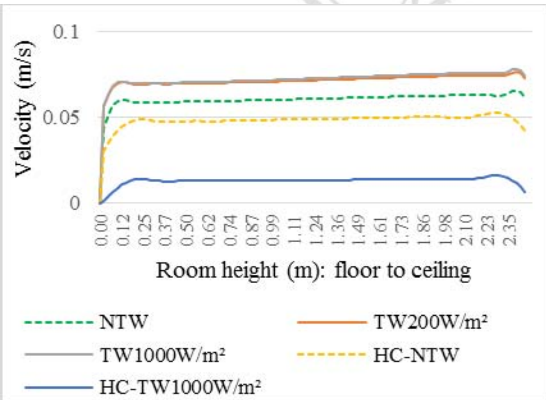


Figure 4.39 HC-TW1000W/m² case at horizontal cutting plan, velocity vector flow pattern at 60s

b) Velocity pattern at Living room area

Not different from the procedure in part 4.2.1 which analyzed about the temperature attendance, Figure 4.40 and Figure 4.43 explained the air movement into living room by order of time steps. Noticeable ventilation rate could be consider from Figure 4.42 and Figure 4.43. Air velocity circulated from ceiling where the temperature was identified higher than other level along the measuring line from floor to ceiling. According to human scale of sitting height and standing height [40], from 1.35m to 1.8m height, the model of HC-TW1000W/m² provided highest air velocity up to 0.33m/s which could satisfy occupant's comfort (see Figure 4.43).



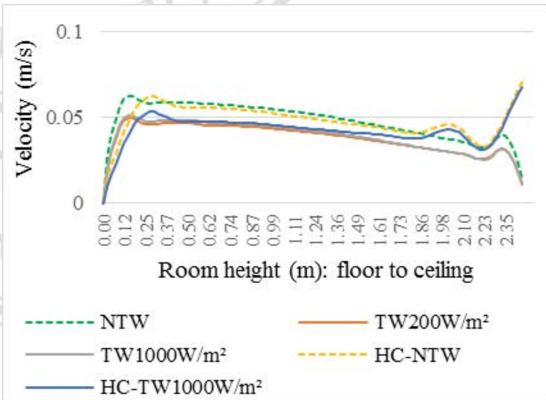
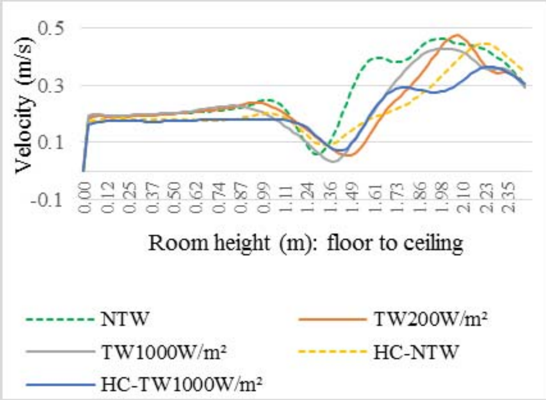


Figure 4.40 (left) Velocity pattern at living room, at time 5s

Figure 4.41 (right) Velocity pattern at living room, at time 20s



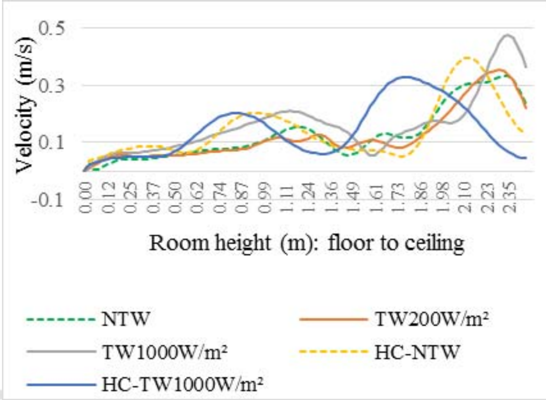
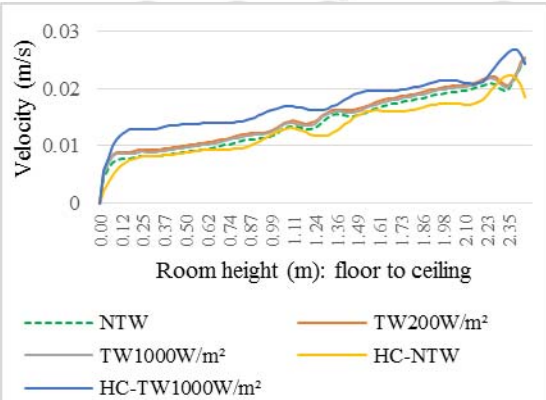


Figure 4.42 (left) Velocity pattern at living room, at time 40s

Figure 4.43 (right) Velocity pattern at living room, at time 60s

c) Velocity pattern at Kitchen area

After taking some time for air to move until kitchen (see Figure 4.44-Figure 4.46), at 60 seconds period, Figure 4.47 displayed that there are mostly no any air flow effect for kitchen. Occupation could slightly feel a very moderate air near the ceiling of room, which could just be neglected as mentioned once by the Table 4.3 about the average velocity at kitchen. This occurrence could be explained by reason of the kitchen location. Kitchen is at the end of the house without any opened window which could assume as the dead-end. Moreover, the effect of outlet at the top plus the theory of buoyancy force, the air was sucked up, and flowed to the exit.



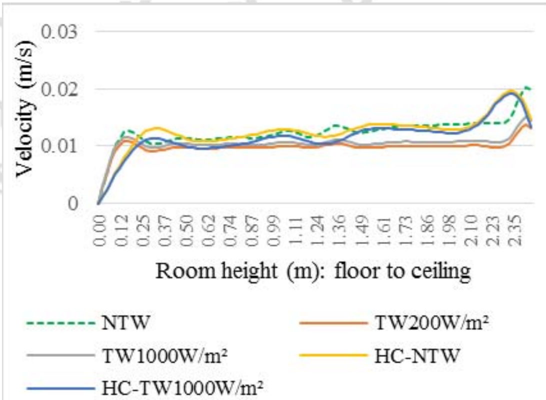
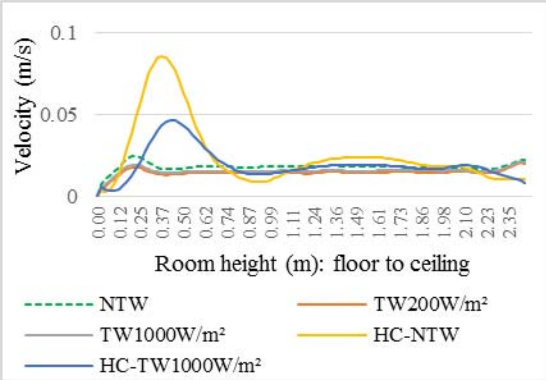


Figure 4.44 (left) Velocity pattern at kitchen, at time 5s

Figure 4.45 (right) Velocity pattern at kitchen, at time 20s



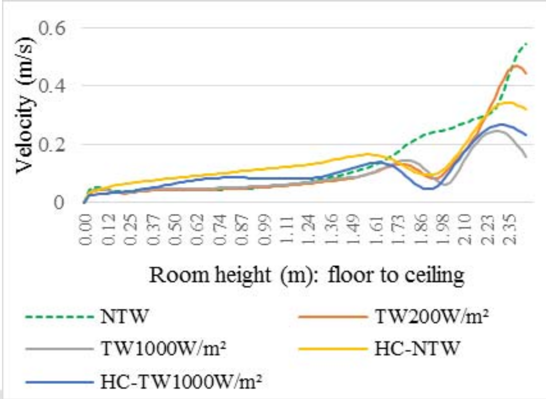


Figure 4.46 (left) Velocity pattern at kitchen, at time 40s

Figure 4.47 (right) Velocity pattern at kitchen, at time 60s

To sum up, the existing house design which outlet is located at the top of the chamber enhanced a smoother air flow more than the inlet position of trombe wall which obstructed the flow to turn into the channel. Additionally, it could be explained that the available side of Trombe wall was not adequate to induce high capacity of air speed to pull the air from ground floor to its outlet at top chamber. Base on this reason, we could see the approximately same rate for both temperature and velocity either at living room or kitchen in the comparison of all 5 cases. On the other hand, the result of velocity gotten at each location of ground floor cannot meet the demand of comfort wind speed in house, thus led the by-product as the increasing of temperature in room coming with the blowing in air from outdoor.

4.2.3 Simulation results of air mass flow rate

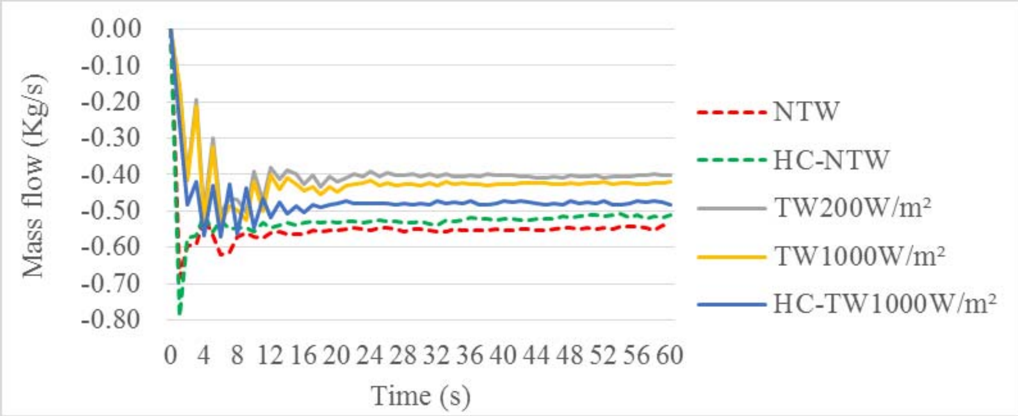


Figure 4.48 Mass flow rate gotten at outlets of each case at time steps (s)

Due to Figure 4.48, from 20 seconds time the amount of mass flow started to stay stable. Thus, NTW and HC-NTW case gave highest mass flow rate than those cases designed Trombe wall system. Mass flow rate reception for NTW was 0.55 Kg/s, and HC-NTW was 0.52Kg/s. The others 3 cases of HC-TW1000W/m². TW1000W/m²; and TW200W/m², obtained the rate of 0. 48Kg/s, 0.43Kg/s, and 0.40Kg/s respectively. It is noticed that the amount of mass flow rate for non-Trombe wall cases could be achieved more than the cases which were designed with Trombe wall. The reason could be from the resistance in the channel of Trombe wall while the size of Trombe wall was too small compare to the supplying air from inlet. Nevertheless, with the amount of air mass flow rate from any case still as little amount compared to target rooms volume. These results explained that, even the design of Trombe wall system produced a remarkable range of velocity, it cannot handle the abortion of air ground floor area, but the air moved out by pressure difference between inlet and outlet height. More or less, the top chamber outlet for each case is the only exit for the ventilation.

4.3 Discussion

4.3.1 Comparison of velocity at Trombe wall outlets for the two groups

Because there appeared different rate on air flow in channel, the comparison result at outlets of related cases should be properly discussed. For outlets area, in cases of Trombe wall were applied, the consequence gave high temperature near glass surface in range of 312.06 K for HC-TW1000W/m²; 318.6K for TW1000W/m²; and 323.94 K for top of stair block simulation with 1000W/m² (TS-1000W/m²). According to figure 4.45, it was logical that higher wind speed reduce the heat in channel. As it can be seen that TW1000W/m² and HC-TW1000W/m² obtained a remarkable high ventilation velocity in channel than the case of TS-1000W/m². Parenthetically, returning back to boundaries condition beforehand of simulation, the value of input parameters were the same from case to case of heat flux 1000W/m² except one condition while an amount of heat was extra applied on surfaces inside stair chamber, and pressure different at inlet of each case. For the case of whole house simulation (TW1000W/m2 and HC-TW1000W/m²), 5 Pa pressure unit was input. However, for top chamber group simulation, 2 Pa pressure different from outlet was insert. So, it was no doubt that, potentially altered range of pressure input at inlet mattered the speed of air flow. Presumably, there involved another reason. The size of inlet for the cases of whole house simulation was bigger compare to the inlet size which was set at a horizontal section of the middle of stair block (TS-1000W/m²). It was generally accepted that bigger inlet produced bigger amount of air. While the air was passing through smaller passage of stair block, the air compressed, thus resulted higher wind speed in trombe wall while it was the only way to exit. Figure 4.46 presented the amount and rate of air movement in the vertical stair block well of two simulation groups model by color pallets.

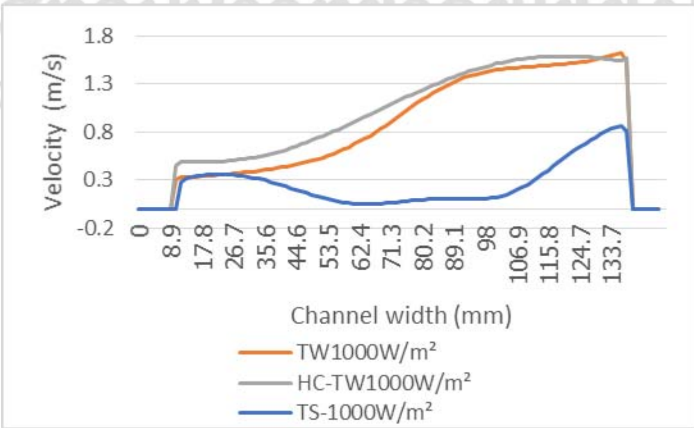


Figure 4.49 Comparison of velocity on 3 cases of heat flux 1000W/m² was applied

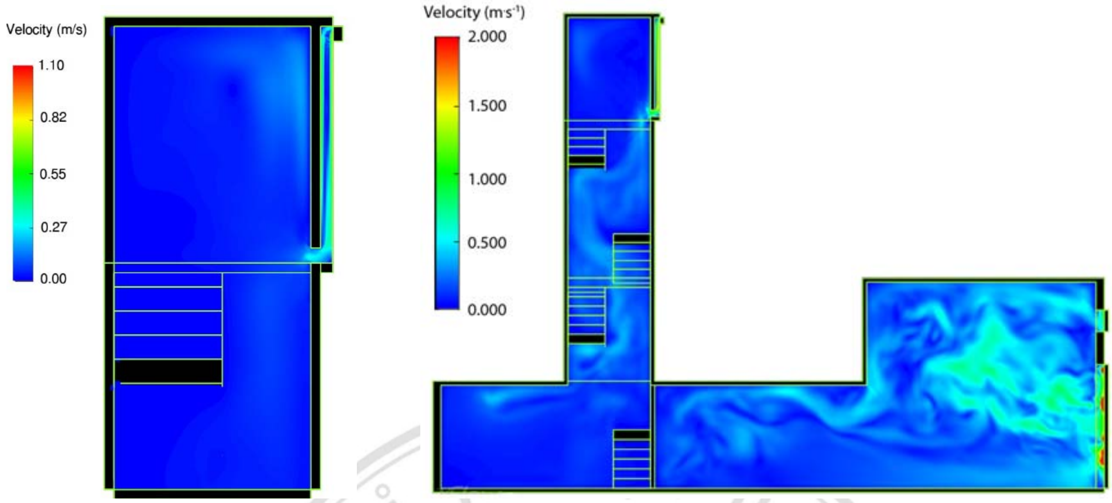


Figure 4.50 Comparison of air movement in stair channel of group Top stair chamber simulation (left), and whole house simulation (right)

4.3.2 Capacity of Trombe wall

Beside the ratio of system, it should be considered that side of the system, distance from Trombe wall to target room, the volume of target room, and ambient weather are relevant to the achieved result. In case of top stair block chamber group, it was shown that Trombe wall had ability to remove the air in stair passage into its channel and left out to exit. However, indifferent size of Trombe wall could not have adequate capacity to suck the air from an unlimited distance. This phenomenon supported the result of whatever cases on whole house simulation were handled, ventilation rate in both living room and kitchen attribute a quite similar value compared with each case. On the other hand, the size of Trombe wall compared to the target room quite in a big different. It was supposed that there are two ways to better practice Trombe wall. First, the up-size of Trombe wall should be considered. Simultaneously, target room volume should be inspected.

4.3.3 Chances for new experiments

1) Proposed design for experiment 1

As discussed that Trombe wall size which fitted to the stair block wall could produce little phenomena of ventilation which gave mostly no effect in sucking air from living room and kitchen on ground floor of row house, it is interesting to to conduct later experiments on the effect of this system to improve air movement in family room. Family room was the second common room and located on a floor below Trombe wall system which is closer to Trombe wall than any other room. If the structure of trombe wall would not be changed, the family room may get the highest effectiveness of trombe wall effect. Opening of Trombe wall inlet directly above family room ceiling is expected to provide a better flow from the room to the system outlet. Furthermore, next research question should be what the appropriate size of family room which could fit to the capability of Trombe wall, or what the size of Trombe wall should be capable to evacuate the air in the compatible volume of family room is.

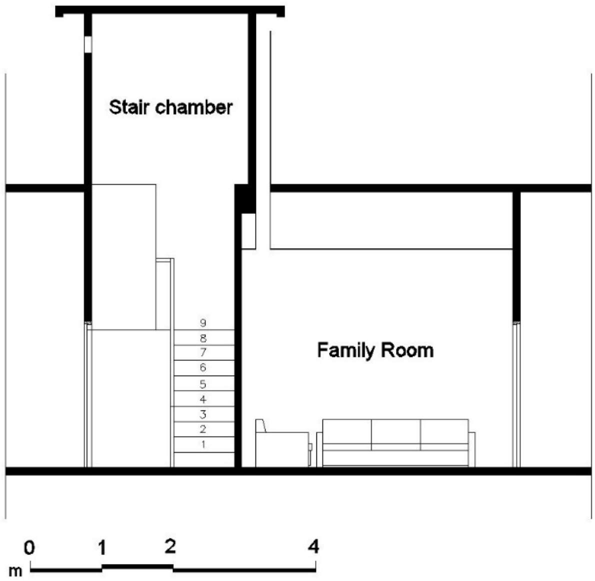


Figure 4.51 Trombe wall design for family room

2) Proposed design for experiment 2

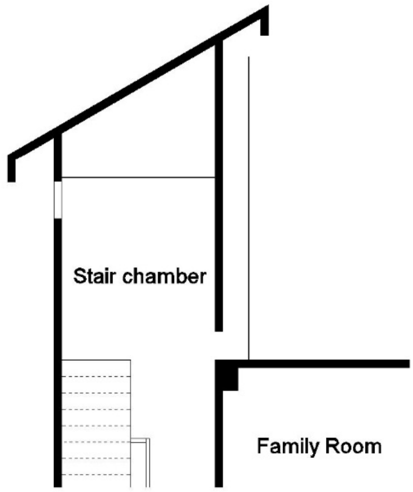


Figure 4.52 Resizing Trombe wall design and maintain the existing outlet

Bigger Trombe wall size may be expected the increasing of air mass flow rate with lesser flow resistance in channel. New experiment should consider about what the appropriate size needed of Trombe wall is, and should also notice on building regulation height allowance. Besides, the existing outlet should be remained the same and increase its size also if it is required.

3) Proposed design for experiment 3

Combination between Trombe wall and roof solar collector could be another interesting experiment which is expected to provide a larger amount of mass flow rate. While typical concrete roof of row house stores heat and exposes that heat into the chamber, creating an inlet on top of the roof could both benefit in reducing hot temperature in stair chamber and releasing air from the house out in a higher sucking speed. Moreover, the location of roof solar collector is good since hot air rises up to the ceiling it could find its way out without circulate in the chamber.

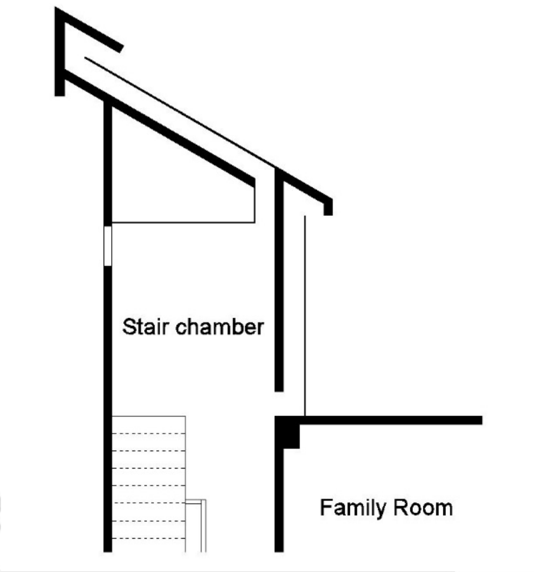


Figure 4.53 Proposed design about the combination of Trombe wall and roof solar collector

In summary, trying more experiments which encourage to design of Trombe wall as bigger as possible may provide the chance of increasing mass flow rate production. However, new development design should also consider about building regulation, cost of installation, renovation, maintenance, and using damper in precaution of reverse flow while outdoor wind speed is very high.