Exploring The Ideas Of Future Cities: Can The Skyscrapers Be Considered 'Green' At All?

- Discussion on how can designers create green skyscrapers to make a liveable cities of tomorrow
- Identify what is the latest energy efficient innovations solution for skyscrapers
- Exploring the implications & challenges of implements green technologies on skyscrapers
- Outlining the achievements of current ground-breaking green skyscraper projects

Illustrating the future of green skyscrapers by example

Skyscrapers Asia Summit 2017 will be held in Singapore from

- 21 February 2017 (Pre- summit workshop),
- 22 – 23 February 2017 (Main Conference) and
- 24 February 2017 (Post-summit workshop).

Speakers are welcomed to participate **in all parts of the event** (including 2 days for main summit and 2 workshop days before and after main summit respectively). Your topic will be presented on **22 February 2017** and I will update you the time once we have finalised the agenda.

The venue of the conference is **Furama Riverfront Hotel**. http://www.furama.com/riverfront/

Also, regarding the presentation slides, we will need it 1 to 2 weeks before the conference.

http://realestate.com.kh/news/how-to-adopt-a-cooler-lifestyle-in-a-green-and-energy-efficient-building/

1. Introduction

To which extent can a green and energy efficient building diminish the hotness of a tropical country to the occupants' satisfactory level? First of all, the trick to attain thermal comfort 24/7 by outsmarting the tropical climate seems pretty simple: keeping the BIG heat out during the daytime, and harvesting the relative coolness during the nighttime. But how?

Throughout the article, prior to further investigations, the author will refer back to own individual case studies as a pilot. Reverting to more than three years of experience with outsmarting the tropical climate in two different condominium medium sized "model" bedrooms around the Peninsula, significant conclusions can be made.. The case study is a typical 3*4 m medium size bedroom in a South-East direction. Due to its Gregorian windows, the room inadvertently harvests sun from the sunrise until 3:30 to 4 PM. Under consideration were 6 days and nights with quite stable weather conditions without any rain 6 days before and during the whole experiment.

How to keep the heat out? The 3,600 occupants, tenants and landlords alike cannot perform any visible changes concerning the building envelope and the windows. So it is not possible to put proper and cheap shadings via lamella blinds outside which is the only effective tool to reduce the at times tremendous sun radiation of 55°C at the inner surface with a respective convection rate. Hence, the passive insides protection is a blackout curtain. The draw-back obviously is still the air leakage at its edges and might be the stack-effect during the daytime. However, the leading daytime hypothesis is that during the daytime by the blackout curtain the heat can be removed by about 1°C compared to the control room in a combination with the following.

During the nighttime, a prototype of a reversed radial exhaust fan blowing fresh air from the outside into the building is used. However, the fan is not easy to mount into the windows and it is not simply harvesting fresh air. It also provides a rain cover, a mosquito grill and optional haze filter for critical days. In addition, it has a dimmer function and can increase its air volume during urgent cooling necessities and when the air-flow hampering air pollution filter replacing air purifiers is set up. The leading nighttime hypothesis is that the fan can bring down the temperature by 1.5°C during the nighttime. At a later stage, a second fan completing the cross-ventilation system will harvest even coolerair as it causes a circulation flow rather than keeping the blow restricted to the windows area.

It is the onset of a future hybrid green cooling system for all summer conditions that works only by its synergies. Running a fan alone during the nighttime will not be so long effective as it will take a long time to defeat the heat that entered the room during the daytime. Conversely, even a non-airtight black out curtain alone will be a slight protection in the morning, but will stack the heat in the afternoon with the effect that it will be hotter than in an open-air control room.

Compared to the operational expenses for air conditioners, the energy saving ratio is in a range from 1 to 40 for conventional A/Cs and from 1 to 22 in the case of using inverted A/Cs. Even the latest generations of air conditions consume about 650 Watt, whereas the fan operates on the basis of 28 watt.

2. Literature Review / Research Gap:

We will discuss in brief four interrelated concepts. The passive and low-energy insulated house (2.1) is the enabler of thermal comfort (2.2). As this has far-reaching implications, we will utilize both concepts based on the redefinition in tropical conditions in terms of temperature, relative humidity and indoor CO2.

2.1 Conversely to the common traditional concept of tropical daytime open air buildings (Malik, 2010), a **Passive House** is an energy efficient thermally comfortable building standard that and in all weather conditions, regardless of the daily changing weather conditions can largely meet its own demand for heating and/ or cooling by insulation (Gesch 2015). Whereas in Europe the building serves up to 90% energy self-coverage, the figure is not yet known in tropical countries. The predominant part of the cooling demand is supplied by "passive" sources and gains the electricity which is still required by energy efficiency and the usage of renewable energies, first of all solar. This is difficult to apply in a condominium.

Inside a **Passive House**, scientifically proven correlations and synergies of a) insulation, b) air tightness and c) internal energy supply gains are being consequently adopted (Krause, 2010). Therefore, the subsequent goal is a combination of these attributes, so the dependency on a conventional CO_2-emitting cooling A/C-system can be substituted and more conducive living conditions become achievable at the same time. Whereas a passive house has clear standards, a

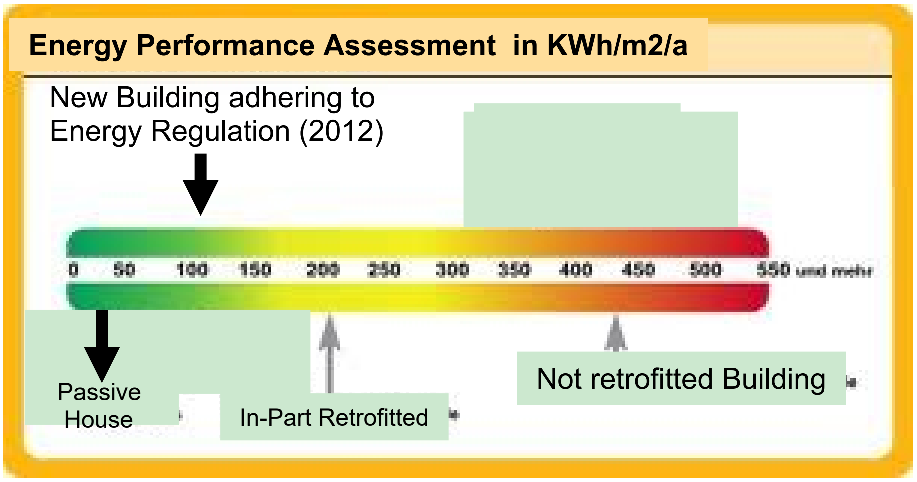


Figure 1: Energy Standards in Passive Houses and Reference Houses along the Rainbow Scale (Germany)

2.2. Thermal comfort. We define Thermal Comfort as the *state of mind that expresses satisfaction with the temperature, humidity and velocity of the surrounding environment* (according to the SO 7730 or, likewise, ASHRAE Standard 55). Together with a) environmental sustainability and b) long-term cost saving, c) creating and maintaining thermal comfort for occupants of buildings or other enclosures is the third of the three important objectives of TRIPLE GREEN building architecture and engineering (Wagner, 2014). Hereby, thermal comfort belongs to the family of basic individual needs. Presuming it is taken for granted or has significantly improved, it enables us in a concerted effort with other physical needs to climb up further the ladder of Maslow's renowned motivational pyramid of needs. Conversely, in its absence, mainstream research holds that any thermal gain or loss above or beyond the following generic borderlines may generate a sensation of discomfort. School children in low-cost buildings who are expected to do their homework in temperatures of 32 ºC and above become victimised as they will not be in a mood to perform well.

A) The typical conception of thermal comfort from the Northern hemisphere believed that the inside **temperature** for offices and homes should be 21.1° C on average with variations of +-2.5° C (Thermal Comfort, Fundamentals volume of the ASHRAE Handbook (2008). Of course, in a cold country every °C that has not to be heated can save tremendously energy and budget. For tropical countries, Busch (1990) carried out a pioneering field study for Thai offices in Bangkok and found that the neutral temperature or effective temperature for the air conditioned buildings and naturally ventilated buildings was 24.5ºC and 28.5ºC, respectively. A similar range of "neutral" conducive temperature was determined for a Malaysian School (Ibrahim Hussein, M Hazrin A Rahman (2009), based on PMV regression is 25.9ºC with a comfort range between 24.4ºC and 27.4ºC. The trendy increase of temperature in offices and public cooled down areas also follows the in-part demise of the common dress code with suits and ties translatable into the since 2011 policy by the Malaysian government requesting all state-owned buildings to set-point the temperature not lower than 24°C.
Abdul Rahman (1995) in his ground-breaking study found that the most comfortable indoor temperature in Malaysia (tropical region) for residential areas ranges even from 25.5-28°C narrowing down the general recommendation by World Health Organization (1990) ranging from 18-28°C. Similarly, UTM's researchers Sabarinah et al (2007) concluded that a 2.5°C range between 26.1°C and 28.6°C is optimum in tropical countries even for adapted people from

Northern countries. Others and our own findings clearly confirm that the optimum residential area temperature for most tropical occupants in their privacy at its highest comfortable end should not exceed 28.6º C before thermal dissatisfaction sets in. As a conclusion, "the comfort band for the Kuala Lumpur area for all building types is between 23.6° and 28.6° C with an optimum medium temperature in Malaysian households of 26.1° C" with the upper space limit (USL) set at 28.6°C. Two reasons can be sorted out. 1) the lower CO_2 respectively cost when putting the highest set-point in a tropical warm country. 2) the perception by people living in tropical regions is different from those in temperate and cold regions (Wang and Wong, 2007 or Singh et al, 2009). The perception is based on lifestyle and habits, and based on economic necessities. All of them contribute to the explanation of the following comparison:

Northern countries	*19.1*	*21.1*	*23.1*					*ASHRAE, 2008 (general)*
"new approach"				*22.5*	*24.5*	*26.5*		*Braatz et al., 2008 (offices)*
Malaysia (Kuala Lumpur)				*23.6*		*26.1*	*28.6*	*e.g.Sabarinah, 2007*

Table 1: Comparison of different thermal comfort definitions

Devising the tropically adapted concept of energy performance for thermal comfort with these higher temperature banding can cause a steep increment in terms of energy saving potentials by 4-7% of less CO_2 and energy cost with each degree centigrade the temperature is increased (Green Efforts Start at 24°C. In: The Star, 12/08/2011, 2). Unfortunately, even if the USL (upper space limit)-temperature is set to its highest end at 28.6°C, in a typical uninsulated concrete building -with the walls, windows, ceiling and roof as permanent heat traps- TTC cannot be achieved during a sunny / cloudy day even in kampong areas (Sanusi, 2010).

The determination for the greenest of the temperatures above is the one which is able to create thermal comfort along with minimum CO_2 emission at reasonable costs (below). Apart from the environmental issue, it can be concluded that whether blue, dark green or light green is the target of our building is a matter of individual well being. Therefore, European and Tropical Green may have a different weightage. If the temperature is between 26.8 and 28.6°C, the highest scores can be achieved. The weightage of European green is lower, but might receive higher scores in the Northern atmosphere. Average scores during 3 times daily with sunny/cloudy conditions, 2 days no rain[1].
28.6°C may seem to be unbelievably high. It might be easier to digest if thermal comfort considers two more dimensions:

B) During the nighttime when we harvest fresh air, in a more then 90% negative cor-relation, we inevitably harvest *higher***relative humidity (RH)** the *cooler* the temperature is.This parameter is volatile and harder to control within green cooling rather than with A/C which dehumidifies as it cools at the same time. In a tropical metropolitan city like Kuala Lumpur the officially required <60% during the nighttime is only achievable during exceptional unhealthy dry weather conditions like during the so far one-of-its-all-kind drought and haze in February 2014. Bringing in nighttime air into the building makes the humidity more humid. However, these are two more arguable insights can be considered for future research:

[1]Accuracy Option: 10 afternoons 5-8 pm with different weather conditions

1.RH is not as high as expected. In a normal overall range of 20% throughout the day, it seldom exceeds 85% even in the early morning at its highest data entry points. Keeping yourself locked up in your four walls brings the RH down by 7-10%, but falls short of healthy indoor air.
2. RH does not trigger uncomfortable sensations of sweating within a certain range of 26-28 °C onwards. Even in Northern countries the RH easily exceeds the 60% devised by the common ASHRAE standard. According to the HX-diagram and the translation into the felt temperature via iphone, up to 26 °C/ 82% RH seem to be "harmless" as it does not push thermal comfort across the tropical boundaries of 28.6 °C. As stated above, this was devised as the maximum = environmentally optimum temperatures in all weather situations where cooling has to be achieved.

Just a few data entries taken from a 60 entry points taken convenient sample in 5 tropical cities can illuminate this correlation.

Temperature	RH	Felt Temperature	Location	felt + C
25.	78.	27	Bangkok, Thaland 8 am	2
25	89.	27	Barranquilla, Colombia 8am	2
25	94.	28	Kuala Lumpur, Malaysia	2
			usual 8am, many times, 4 pm. Barranquilla, Penang	.
			Feels very comfortable still	3
25.	100	28	Penang, Malaysia	3
26.	74.	28	Bangkok, Thailand 11pm. 9am	2
26.	82.	28	KUALA LUMPUR, MALAYSIA	2
26.	83.	28	KUALA LUMPUR, MALAYSIA 7am Bangkok	,
			Barranquilla	2

Only with a RH being higher than 85%, with the same temperature of 26°C it turns out that thermal comfort moves into the ***critical zone*** and become a multiplicator, as the felt temperature i.e. sweating becomes tremendous as the following table can show us.

Temperature	RH	Felt Temperature	Location	felt + C
26.	89.	29	KUALA LUMPUR, MALAYSIA 8 am	+3
26.	94.	29	Penang, Malaysia 8 am	+ 3
26.	94.	29	KUALA LUMPUR, MALAYSIA midnight. Early morning Barranquilla	+ 3
26.	100.	30	Baranquilla	+ 4

30°Cand above, even if the RH is lower than 60%, the felt temperature is now by far beyond any thermal comfort level:

Temperature	RH	Felt Temperature	Location	felt + C
30.	35.	30	Bangkok, Thailand	0
30.	45.	31	BANGKOK, THAILAND, pp	1
30.	58.	32	Pnom Penh, Cambodia	2
31.	58	34	Penang, Malaysia 8pm	3
32.	52.	34	Bangkok, Thailand	2
32.	55.	36.	BANGKOK, THAILAND 6pm	4

Most RHs are below 82%. So it becomes no issue if we target 26.6°C as target night time temperature. The rules elaborated on green lifestyle taken into consideration, we would not look at the higher humidity as a serious issue to question thermal comfort (-> conclusion). You can run the test on your own measuring your own thermal comfort. Taken into consideration the highest morning RH of 85% I measured in Kuala Lumpur, 27.5 °C seemed to be acceptable with just the fresh air blowing with the centrifugal fan.

C. Velocity

If we consider wind speed (velocity) on our body as another driving force to create thermal comfort, the answer about the maximum temperature again is different. People at train stations are flocking to mechanical fans to get the "pretended" cooling effect. Not only natural ventilation of the wind, also and especially mechanical ventilation is deemed to be the main and only cooling agent in almost 50% of all households around the Klang Valley (Wagner, 2013). However, different from train stations and other outside applications (functions), the fan home revolves whatever it gets, whether it is used, polluted or fresh air.

Going back to Aynsley and Szokolay's model of the wind's cooling effect on the human body (1998), the research by Azhaili (2011) found empirical evidence for a tropical country like Malaysia that an air speed of 1m/second would drop the ambient temperature by 3.8°C. When lowered to 0.6 to 0.7 m/s, the cooling sensation is 1.2°C to 2.1°C. So if the Malaysian standard MS 1525 (2007) proclaims in its guidelines that the air speed can be up to 1m/s, up to 3.8°C less ambient temperature is possible. If we were to distinguish further into air volume by A/C and mechanical fans, it would be plain to see that 1.0m/s is sufficient. So far, it has not been issued yet that the permanent windy flow of A/C will be uncomfortable and hard to stand without getting flu or even asthma.

D. Indoor air quality (**IAQ**) is a term which refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Among other parameters, **indoor CO_2** is the most common one. It can be neglected in open air houses with windows open all the time or air leakages supplying the occupants with ever fresh air. The following study that was conducted by researchers from State University of New York (SUNY) Upstate Medical University, on nine scales of decision-making performance, test subjects showed significant reductions on six of the scales at CO_2 levels of 1,000 parts per million (ppm) and large reductions on seven of the scales at 2,500 ppm. The most dramatic declines in performance, in which subjects were rated as "dysfunctional," were for ***taking initiative*** and ***thinking strategically***. "Previous studies have looked at 10,000 ppm, 20,000 ppm; that's the level at which scientists thought effects started. That's why these findings are so startling."(Mendell,2012).

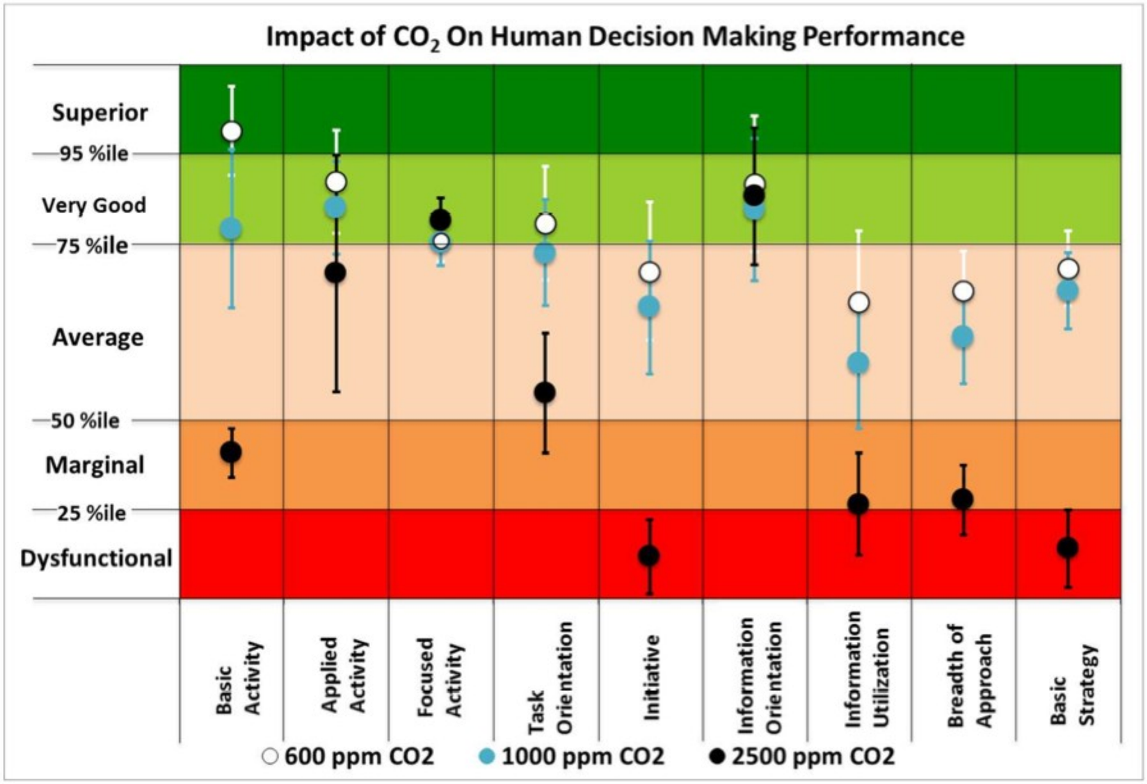


Table 1: Impact of CO_2 on Human Decision Making Performance (Fisk, 2012)

Berkeley Lab researchers found that even these moderately elevated levels of indoor carbon dioxide resulted in lower scores on six of nine scales of human decision-making performance. Airtight buildings are doomed to increase the ppm to a level of much more than 800, or they will lose out as shown above. In our own airtight building we will inevitably increase CO_2 in case the windows are closed with a n occupant inside our experimental room.

3. Research Methodology

3.1. The set up

a) experimental room: A 3*4 m typical condominium room in a highrise with SSE-orientation. Its Gregorian windows cover 50% of the sun-exposed orientation with harvesting sun from 7 a.m. (July) until 4 p.m. when the sun disappears behind the opposite position of the building. In the heart lies mechanical ventilation from outside: Basically, like in European passive houses, our ventilation reverses the air flow from exhaust to “inhaust” by breathing in air from outside the building. Compared to conventional exhaust fans on the market, we are not only changing the flow of oxygen. We are using a 50% more energy-efficient radial (centrifugal) fan at 27W performance with a dimmer yielding continuously 55% of its maximum performance in this experiment. At this time, with a cased and mounted prototype in operation, it is not possible to run more as the fan tunnel is not yet optimized and the movement creates unacceptable sound disturbing sleep. For exhaust purposes of slight cross ventilation and to avoid overpressure, the window which was not locked by the handle opened itself a jar when starting the fan motor. In case the temperature was above 28.6 ºC, a stand fan transported the fresh air through the room to the slot underneath the door which has a mosquito grill.

Figure: Centrifugal Fan

b) control room: the living area exposed to the same position is without air condition and can be varied by opening or closing the windows. This area is usually not populated. It is equipped with a ceiling fan which does not bring fresh healthy air into the building.

c) outside temperature: taken on the window sill in the same apartment. It is biased during the daytime, as it measures the sunlight temperatures that hit the window panes. Protected by a plastic bag, during nighttime and heavy rain it continues to measure.

3.2. Measurements:

In this case study, 2 different weeks of data were used for 10 minutes interval measurement of temperature and relative humidity. The first week with 7 days was tested under completely stable weather conditions without any rain. The second week was more volatile with intercepting rain on day … and …

a) Thermologger

To identify and measure the ambient temperature and the humidity inside the experimental room, the control room and outside the building, the device was placed with a suitable height at 1.4 m. It was prevented from being directly exposed to the sunlight.

b) Thermal camera

Can be used to Identify the inner surface temperature and measure hot spots from a distance. It creates pictures of heat issues that are easy to understand by the rainbow colours. In the case study, it served measuring the different temperatures of the interior walls of the ventilated experimental and the non-ventilated control room.

c) CO_2 -Logger

measures the indoor CO_2 by the traffic light method: up tp 800 ppm means “green” with acceptable CO_2 concentration inside the room, switching to yellow between 800 and 1,200 ppm means borderline air quality, and above 1,200 ppm “red” means questionable CO_2 -concentration that practically mainly disturbs our ability to focus and to take initiative.

4. Findings

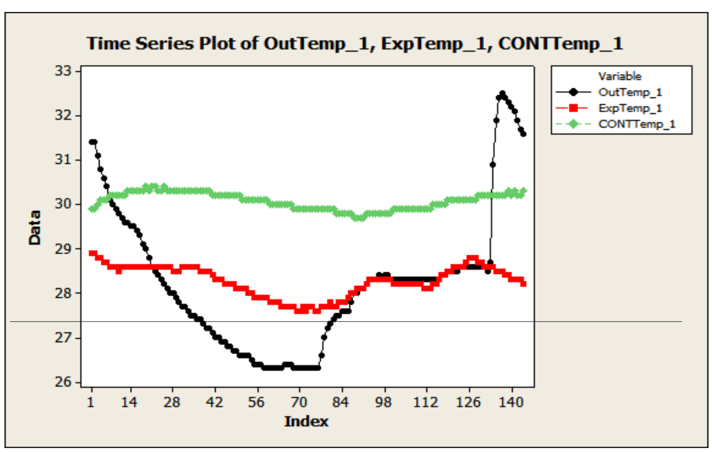
Over an observation period of altogether six days in a hot period without any rain 4 days prior, Second insight: during the 7 to 9 hours of nighttime ventilation, the walls seem to retain some of the coolness. In the morning, it is possible to run the whole room passively without any electricity.
This system is already considered smart without an electronic monitoring.

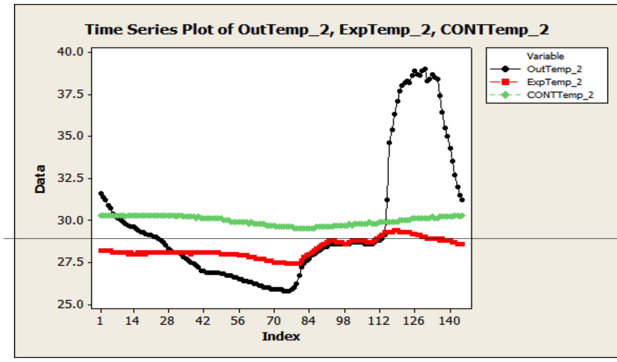
4.1. Run Chart

We compared outside and experimental room temperature with the control room (3 nights closed window, 3 nights open window (O) in the following time series plot starting every evening at 6.49 p.m.

Standard Thermal Comfort Line

of 28.6 ºC (Malaysia)





Every day with overcast weather condition follows the same trajectory. The highs of the outside temperature during the daytime and the lows of the nighttime are contrasted by balanced temperatures both in the control and experimental room. However, the temperature gap between both of 2-3 °C in case of the control room exceeds always the maximum thermal comfort line devised above, whereas the experimental room stays almost always below that critical line.

4.2. Average

Cooling Demand

Cooling demand (without RH considered))

a) around 7 am (coolest before s rise)

26 °C 27 °C 28 °C 29 °C 30 °C

Outside Experimental Control room

b) HPH (specific heat peak hour on referring days)

Day No. / Weather	Outside 7 am	Experimental Room (mechanical outside Vent.) 11 pm	7 am		Control (natural ventilation) 11 pm	7 am		
01/01/17	32.5* (no measurement during sunshine)	28.7			30.3			
02/01/17	38.9	29.3			30.3			
11/01/17	26.4	30.0	27.8		30.	29. ..		
01/01/17	38.2	29.0			30.4			
01/01/17	39.2	29.4			30.5			

01/01/17								
AVERAGE	38.9	29.1			30.4			

Summary 6 days HPH:

Experimental Control room Outside

GREEN	RED

c) AVE and standard deviation nighttime mode (7 pm – 7 am)

Along the rainbow scale from green to red we can see that the average morning temperature of the control room is by 1.4°C higher than in the experimental room.

Outside Experimental Control room

GREEN	RED

The “price” to be paid is the higher humidity which correlates with the outside RH by %. As mentioned in the literature review, this does not create problems below 28.6. It its slightly above, a shower can be taken, unless the axial fan will bring relief with its direct air flow. These ground-breaking experiments still need to be conducted.

d) AVE and standard deviation daytime mode (7 am-7pm)

Experimental Control room Outside

GREEN	RED

If occupants are inside the room, the temperature will rise by 0.4 ºC and another 0.4-0.5 ºC when the fluorescent light is on, whereas the LED-light might be almost neutral. In addition, in an almost airtight room without cross-ventilation the CO_2 will reach the questionable level within 15 minutes whereas it remains stable in a non-populated room.

4.3. Sigma Level 6 days nights, 6 days

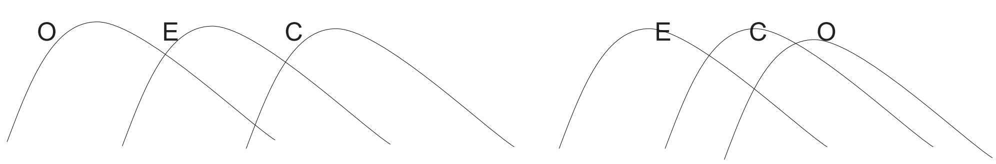


Figure: Thermal Comfort 7 am 7 pm

The calculated percentage of staying in the thermal comfort zone (chapter 2) at 7 am is… and at 7 pm is … That means that accordingly above the critical line additional cooling has to be performed to guarantee a thermal comfort 24/7. Of course, with an occupant inside, depending on the room size the cooling demand will increase (e.g. 0.4-0.5 ºC as mentioned above).

4.4. Calculation of extra-ordinary Cooling Demand of 6 nights following 6 hot days (target 28.6 C)

Day	Inverted A/C (0.65 KW/h)	Fan (if higher than 28.6, aid of conventional indoor fan) (0.027 W/h)	Conventional Fan 55 W/h	Cooling Demand
1	e.g. 2ºC * 12h	0 ºC	2 ºC	
2				
3				
4				
5				
6				

The daytime comparison will be made at a later stage of this research, with occupants inside and not inside (beyond just CO_2 alarm during daytime). In the model room, to reduce, every 15 minutes the in-fan has to blow for about 7 minutes.

4.5. Indoor CO_2

Nighttime will avoid the CO_2 accumulation automatically by the fresh air intake will be incessantly work all night long.

During the daytime, we encounter an exceeding CO emission already after 15 minutes:

We would have to switch on the CO_2 alarm and trigger minimum cross ventilation every 15 minutes. However, as most occupants are not at home and there is only little awareness towards indoor CO_2, this drawback in the overall system is not considered a big issue. Any A/C split unit and most centralized A/Cs are facing the same problem of CO_2 with an undeniable negative impact of stale air – unless there is a chance to let fresh air into the building.

5. Conclusion

Our pilot run has proven that thermal comfort in a tropical room that is mainly exposed to the sun can be achieved with low budget for capital expenditures of 2,200 RM for Black-Out curtain covering the windows plus a fresh air fan which is engineered, but not yet available on the market. The payback primarily depends on the previous usage of an air conditioner (operational costs). Without going into details, the pay-back is much shorter the more the windows can be shaded from outside.

a) Non-inverter:

At 1 KWh = RM 0.24 (for households 2015):

2.40 RM per A/C night => RM 72 per month => RM 864 p.a.

=> payback of the investment costs (RM 2,200) < 3 years. For the inverter A/C the payback for fresh and cool air would be around 4 years. Nevertheless, the in-fan is not questioning A/Cs. It is just there to protect the environment by individualising their unrestricted usage to what is necessary.

Hence, air conditioners, if present, they may not be obsolete, but their usage is restrained to a few hours for users who like to get 26.6°C especially when being "active" inside the building with activities like walking, cooking etc. For those who can live with 28.6°C, its usage is confined to a few hours during a handful of very hot days. The best protection when the temperature is above is "evaporative" cooling, simply take a cool shower before entering the room whenever you feel the uncomfortable feeling of light sweat is coming upon you. Whenever you feel hot, typically in temperatures of above 28.6 - 30ºCwhen coming from outside, take a more **extensive shower** of 2-3 minutes, and dry only what is sociably necessary. Water on the Peninsula and in Borneo is at a refreshing temperature of 24-27ºC and hence lower then the maximum thermal comfort borderline.In sleeping rooms **Do not longer use thick comforters** (research by UPM, Centre of Housing, Zaky, 2010) – except for decoration. They create a vicious circle. The colder the aircon, the more we feel in dire needs putting the set-point of the A/C very low, and the thicker the comforter, the more we sweat without a remarkably cold set point. In 28.6ºC it is enough to skip the blanket when going to sleep, and keep a thin linen standby for the cooler temperatures created throughout the night time ventilation.

Whereas the banding of -2.5 to +2.5ºC is easy to describe, there is no general upper TC-line which is still an individual sensation. Hence, we can just give a rough figure and would have to ask for individualisation depending on metabolism, body mass index and of course the food we take in quality and quantity.

Deviating from the official benchmark, 28.6ºC after taking a cool shower when going to bed and 27.8ºC even at a relative humidity of 80% might still be easily acceptable for people the author in the early morning.

6. References

Abdul Malek, A.R.; Muna Halim, A.S.;Azizi B.; MohdRodzi,I. (2009) *Towards a Low-Energy Building Design for Tropical Malaysia*; UniversitiSains Malaysia Press: Penang, Malaysia.

ABDUL RAHMAN, A.M.. (1995), Housing design in relation to environmental comfort. Build. Res. Inform., 23: 49-54.

Abdul Wahab, Izudinshah and Ismail, Lokman Hakim (2012), Natural ventilation approach in designing urban tropical house. In: The International Conference on Civil and Environmental Engineering Sustainability (IConCEES 2011), 3-5 April 2012, Johor Bahru, Malaysia.Green Buildings and Life Cycle Assessment.

Ahmad Sanusi Hassan, MahyuddinRamli (2010),*Natural Ventilation of Indoor Air Temperature: A Case Study of the Traditional Malay House in Penang.* In: American Journal of Engineering and Applied Sciences 3 (3): 521-528.

ASHRAE (2008), *Thermal Comfort*. Fundamentals volume of the ASHRAE Handbook, Atlanta, GA.

Aynsley & Szokolay (1998) in: Alberto Troccoli, Laurent Dubus, Sue Ellen Haupt, *Weather Matters for Energy*. www.arpapress.com/Volumes/Vol7/Issue4/IJRRAS_7_4_05.pdf

Braatz, Werner, Suparoek, Junsupasen (2008), *Thermal Comfort.* Unpublished Paper. Rosenheim / Germany.

Busch, J.F. (1990) '*Thermal Responses to the Thai Office Environment*', ASHRAE Transactions 96(1).

Building Energy Efficiency Technical Guideline for Passive Design, Published by the Building Sector Energy Efficiency Project (BSEEP), Malaysia. ISBN 978-967-5957-25-3.

ELLIS, F.P., *Thermal Comfort in Warm, Humid Atmosphere: Observations in a Warships in the Tropics'*, The Journal of Hygiene, 1952.

Ezanee Md. Elias, Azizi Abu Bakar, Ahmad YusniBahaudin, FadzilMohdHusi, *Green Residential Buildings: The Perspective of Potential Buyers*, Proceedings of 3rd Global Accounting, Finance and Economics Conference 5 -7 May, 2013, Rydges Melbourne, Australia, ISBN: 978-1-922069-23-8

Fisk, W. (2012) *Environmental Health Perspectives* online

IBRAHIM HUSSEIN, M, HAZRIN A. RAHMAN (2009), Field Study on Thermal Comfort in Malaysia. In: European Journal of Scientific Research ISSN 1450-216X Vol.37 No.1 (2009), pp.134-152.

Mendell, Mark & Fisk, William, Environmental Health Perspectives online. In: http://newscenter.lbl.gov/2012/10/17/elevated-indoor-carbon-dioxide-impairs-decision-making-performance/

Sabarina, S.; Nor Zaini,I.Z.; Mohammad, S.M.; MohdGhadaffi, S. (2007), *Achieving Thermal Comfort in Malaysian Building: Bioclimatic Housing*; UniversitiTeknologi: Skudai, Malaysia, 2007.

Singh, M.K., S. Mahapatra and S.K. Atreya (2009*).Thermal performance study and evaluation ofcomfort temperatures in vernacular buildings ofNorth-East India.* Build. Environ., 45: 320-329..DOI: 10.1016/j.buildenv.2009.06.009

Toftum, J. (2005). *Thermal Comfort Indices.* Handbook of Human Factors and Ergonomics *Methods, 63.CRC Press, Boca Raton Fl.*

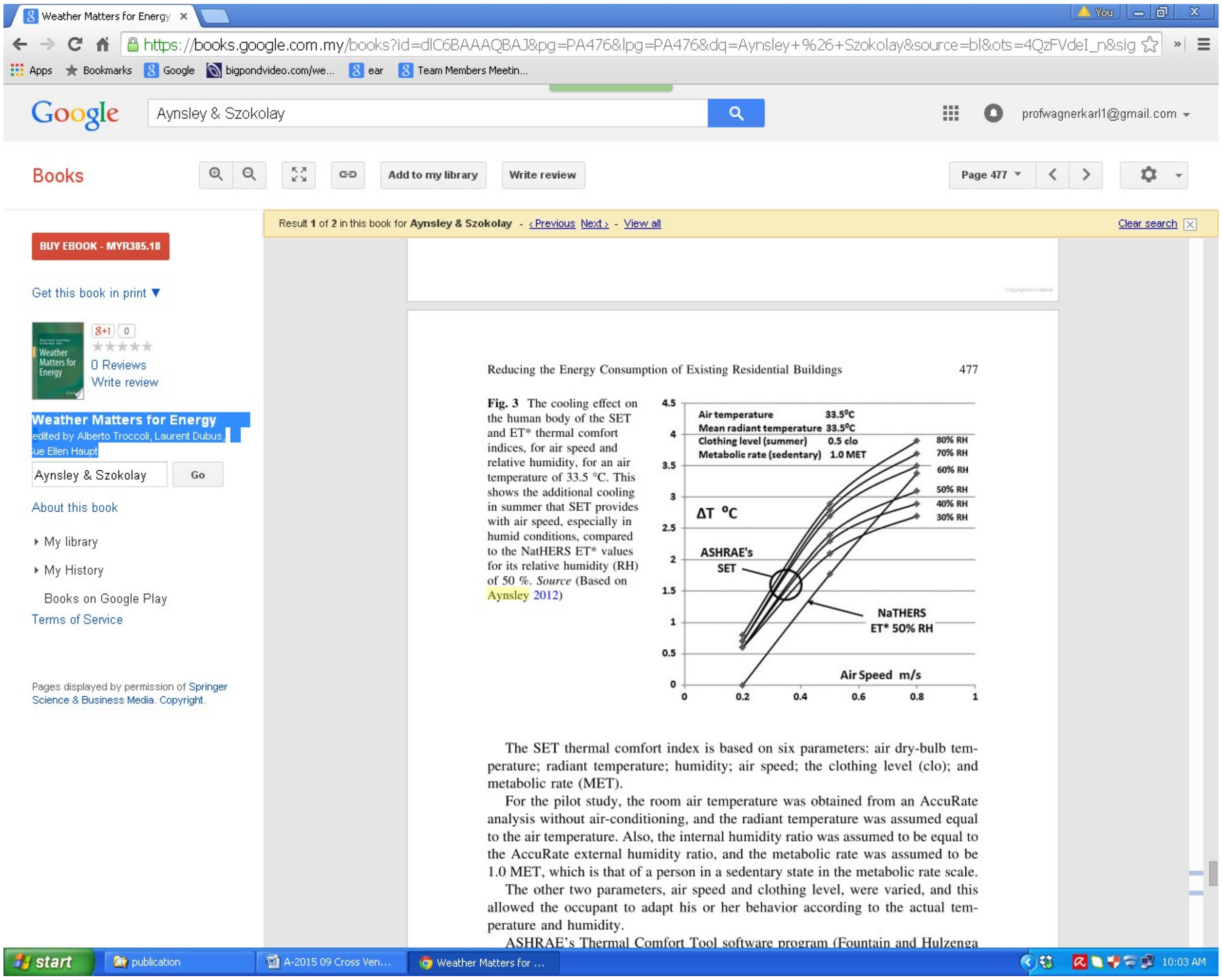
WAGNER, Karl (2013), *Tropical Thermal Comfort and Adapted Tropical Green Residential Housing.* In: Conference for Affordable Quality Housing. Putra Jaya 13/03/2013 (Proceeedings V).

Wagner, Karl (2014), uPVC Windows in a Green & Energy Efficient Building Pilot Study under the Challenging South Asian Environment“ 28/11/2014

Wagner, Karl, Gabriele Arese& Alberto De Marco, Financial Analysis of Green Mock-Up Buildings in Tropical Emerging Countries. For: ZEMCH Zero Energy Customized Housing Conference / Lecce Italy 2015.

Wang, L. and N.H. Wong (2007). *Applying naturalventilation for thermal comfort in residentialbuildings in Singapore.* Architect. Sci. Rev.,50: 224-233.

Zaky, A. (2010) UPM (own bibliography)



Reducing the Energy Consumption of Existing Residential Buildings 477

Fig. 3 The cooling effect on the human body of the SET and ET* thermal comfort indices, for air speed and relative humidity, for an air temperature of 33.5 °C. This shows the additional cooling in summer that SET provides with air speed, especially in humid conditions, compared to the NatHERS ET* values for its relative humidity (RH) of 50 %. *Source* (Based on Aynsley 2012)

The SET thermal comfort index is based on six parameters: air dry-bulb temperature; radiant temperature; humidity; air speed; the clothing level (clo); and metabolic rate (MET).

For the pilot study, the room air temperature was obtained from an AccuRate analysis without air-conditioning, and the radiant temperature was assumed equal to the air temperature. Also, the internal humidity ratio was assumed to be equal to the AccuRate external humidity ratio, and the metabolic rate was assumed to be 1.0 MET, which is that of a person in a sedentary state in the metabolic rate scale.

The other two parameters, air speed and clothing level, were varied, and this allowed the occupant to adapt his or her behavior according to the actual temperature and humidity.

ASHRAE's Thermal Comfort Tool software program (Fountain and Hulzenga

A. Pilot

Date:
Weather:
Change?

Start:
End:

I

Exp
O

1st day 25/5
Start: 9:30 pm
End: 6:30 am

Baseline 28.0 after
2 cloudy days. Little Rain 5 pm. Evening feels comfortable, heavy Rain this night
1 am
0.5 C more after 30 min tenant entered the 3*4 room

Control room closed.
Fan runs by 50%.

27,8 feels TC. Slight velocity on the skin.
after 50 min still stable 27.8 /84 is not like 31 / 50
Outside colder, need 3rd thermologger

6 am as in Taman

Official 24. 92. = 26
24.6. 87 outside
26,5 82 experimental room
28.6. 76 control room
Jz reach temp TC in early morning wt closed windows
(After warm stable conditions maybe it's 1 C warmer)
= Variation in just small border values

28.6 Ok this is when i feel i don't need anymore fan. comfort zones

Need a light blanket to sleep when the fan is still on.
High humidity of a 83 doesn't seem to matter.
Outside temperature of 25

2nd day 26/05
Start: 0:30 am
End: 6:30 am
Weather: after untypical cloudy / rainy day with almost no sun

24 83 out
26.4 exp
28.0 cont

3td day 27/05
Less rain, but gloomy afternoon

Start 10 pm
End 7:15
27.0 84 exp.
28.2 I

28/05 Daytime getting more normal, no rain but dark and cloudy afternoon

Start: 10:15 at 28.4 (compared to 29.2 in the control room). Meaning wall still have catch the previous night coolness caused by fan? even though the sun was shining the whole morning.

End:

29/5
Sunny cloudy and afternoon rainy days take turns.

30 of May afternoon heavy rain

31/5
Start 12 am
Finish 7:20 am
First of June raining afternoon take turns

Start: 12 am
End: 7am
The crossvent room keeps always 1°C lower than the control room with no cross ventilation.

Eg 29,7 cont
28.7 experiment room

In a stable weather conditions with no rain over 5 days any temp f 33. Max
8 am RETAINER effect with > 2 C less

I 27.0
Cont 29.4
O 27.9
Inside still cooler than outside. Target: keep the retainer effect as long as possible (walls as retardants)

-
Temp in 3•4 room increases 0.8 - 1 C after occupant enters and spotlights (non led)
Estd. 0.4 C due to occupant
Estd. 0.4 C due to fluorescent light
Measure separately 1h with light without occupant. Next time 1h with occupant but no light. Choose base temp of 28.

Basically 2 typical subjective measurement modes
1. Cmg in frm hotness of from shower / bath. 28 ok wtout fan 6 pm
2. After activity 28.6 /76 feels a bit hot. Switch on out fan 12 am and get what I need - with this high temp

3. Is it True That the temperature usually significantly drops by 3 C in cloudy / starry nights between 8 and 10 pm and remains stable thereafter until early morning? We have 4 tropical weather logs in reference nights (KL, 32 to 28 Georgetown 30 to 28 because cloudy, Bangkok 30 to 27 and Pnom Penh 29 to 27.

For sure some people will not yet be satisfied with that TC produced by this system. People who don't like to sleep almost naked like Tarzan and are used to thick comforters Will still feel too hot or too humid, even if we were able to reduce the temperature to the real outdoor temperature. But looking at the cooling demand, it will decrease by 60 to 70% with simple ventilation. Proper CrossVent with axial fan that has never been tried out

anywhere might bring the percentage up to 80 or 90% of saving.

CS
Let's say u wanna build a gb in sub urban area like Gombak
U wanna avoid haze and u hate mosqu . Ur budget is... And of course you like convenient temp when u and ur spouse cm home eve (type1)
How?
Let's say you live in the 23rd floor of a city condominium. You are suffering a lot from the heat when you're air condition is not on. How can you make the climate palatable for you?

Date: 25/26 6
Weather: Hot sunny cloudy, no rain
Change?

Start: 0;00
End: 7:15

I 29.6/68
Exp 27.6 / 80
O. 26 /80

Remark: all six days in a row only use cross vent in fan, no Stand fan
----
Date: 26/27
Weather: continuation hot sunny cloudy
Change? Morning more cloudy, sun comes through
--/----------------//-
Start: 23:45
End: 7:45

I 29.9 / 68.3
Exp 27.6 /80.9 feels very convenient
O 26.3/87.3

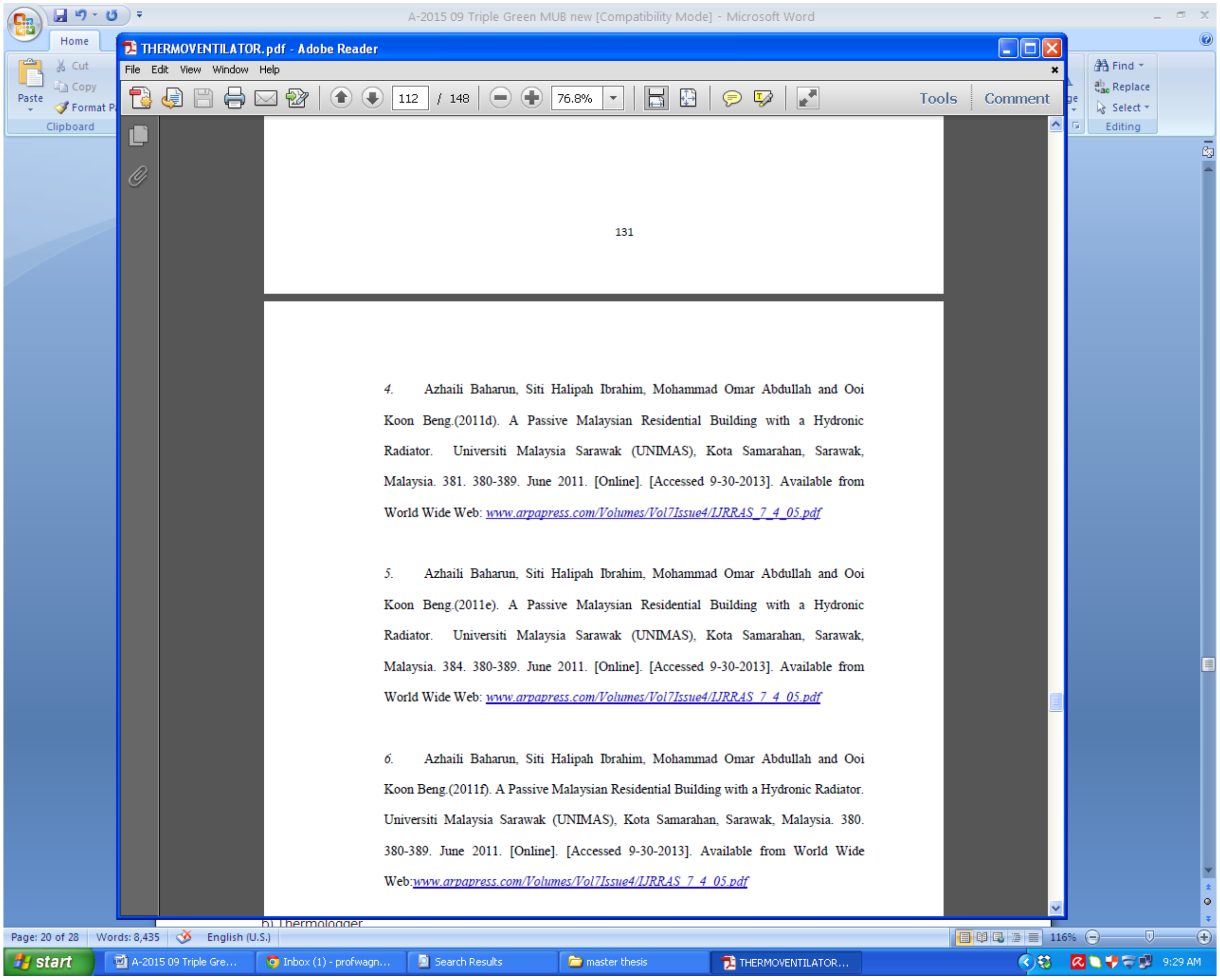
----
te:
Weather: sc
Change?

Thermologger outside on: 4:30 pm
Start: 1:00
End: 7:45

I
Exp 27.4 / 79.2
O 26.3. / 83.8

6. References

Velocity Radial				
Velocity Axial				
Shower				
Eating				
BMI				
Metabolism				
Room ambient temperature without fan				


131

4. Azhaili Baharun, Siti Halipah Ibrahim, Mohammad Omar Abdullah and Ooi Koon Beng.(2011d). A Passive Malaysian Residential Building with a Hydronic Radiator. Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia. 381. 380-389. June 2011. [Online]. [Accessed 9-30-2013]. Available from World Wide Web: www.arpapress.com/Volumes/Vol7Issue4/IJRRAS_7_4_05.pdf

5. Azhaili Baharun, Siti Halipah Ibrahim, Mohammad Omar Abdullah and Ooi Koon Beng.(2011e). A Passive Malaysian Residential Building with a Hydronic Radiator. Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia. 384. 380-389. June 2011. [Online]. [Accessed 9-30-2013]. Available from World Wide Web: www.arpapress.com/Volumes/Vol7Issue4/IJRRAS_7_4_05.pdf

6. Azhaili Baharun, Siti Halipah Ibrahim, Mohammad Omar Abdullah and Ooi Koon Beng.(2011f). A Passive Malaysian Residential Building with a Hydronic Radiator. Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia. 380. 380-389. June 2011. [Online]. [Accessed 9-30-2013]. Available from World Wide Web:www.arpapress.com/Volumes/Vol7Issue4/IJRRAS_7_4_05.pdf

25. 78. 27. Bangkok, Thailand 8 am
25. 89. 27 Barranquilla 8am
25. 94. 28 KL usual 8am, many times, 4 pm. Barranquilla, Pb, png. Feels very comfortable still.
25. 100. 28. Penang
26. 74. 28 Bangkok, Thailand 11pm. 9am
26. 82. Feels 28 KL

Most RHs are below 82. So no issue if we target 26 = night time temp

26. 83. 28 KL 7am Bangkok, Thailand , Barranquilla
:////::/::/::::::::::::::::
26. 89. 29 KL 8 am
26. 94. 29 Penang 8 am
26. 94. 29 KL midnight. Early morBarranquilla
26. 100. 30 baranquilla
with 26 ttc can almost always be achieved, not do much matter of RH
89 on 94 doesn't make a difference with 26

Meaning mid term target should be 26.
27. 74. 29. KL 11pm
27. 79. 30 baranquilla, Bangkok, Thailand
27. 80. Feels 30. Bangkok, Thailand
27. 84. 31 Barranquilla KL

27. 89. 31 KL. Baranquilla. Completely different if rh 89, but temp = 25. When temp drops just a little, high rh> 60 already comfortable
27. 94. 32. KL 0:00

5 no rain but cool evening
28. 74. 31 png
28. 79. 32 Penang
BUt NOT NIGHT TIME WHEN SLEEP and velocity Zetty

28. 84. 33. KL 6 pm
Twice. Confirmed. 5 times . Png

29. 66. 32. BANGKOK, THAILAND Same pb 8am
29. 70. 33 Bangkok, Thailand midnight . 4 times
At 29 already, level of thermal discomfort rises a lot
29. 70. 33 Bangkok, Thailand
29. 74. 33 pp
29. 79. 34 Penang 8pm, 12am, 11pm
29. 84. 35 Penang 12 am
Whereas KL 26 89. only 29 at same time! Meaning tiny difference of temp 3 degree cooler, but almost same rh causes 6 degree C higher (big difference between 29 and 35)
30. 35. 30 Bangkok, Thailand
30. 45. 31 BANGKOK, THAILAND, pp
30. 58. 32
Despite rh below Max TC level, 30=32
30 66. 34 KL 6pm
30. 70. 35. KL 8pm thrice, Penang twice
30. 74. 36 KL 5pm baran
30. 79. 37 KL 10pm,8 pm png.
31. 58 34 Penang 8pm
31. 62. 35. Bangkok, Thailand
31. 66. 36 Penang 11 am
31. 70. 37 KL 8 pm. Png
31. 75. 38 png 8pm
32. 52. 34 Bangkok, Thailand €
32. 55. 36. BANGKOK, THAILAND 6pm
32. 62. 37. Penang€
32. 66. 39 KL 1pm . Baran
32. 67. 39 Penang 6pm
32. 70. 40. Png 5pm

33. 46. 36 Bangkok, Thailand
33. 52. 37 KL 12pm
33. 55. 38 KL 1pm 2pm

33. 14. 31 negative effect Bangkok, Thailand
33. 59. 39 Bangkok, Thailand 1pm
33. 63. 40 KL 1pm
HEAT the MAIN PRIority. As we can see 63 really low rh or look at this 56:
34. 52. 39 KL 3 pm
34. 56. 40 KL 12pm, 8pm

35. 49. 41. KL 4 pm Bangkok, Thailand
35. 53. 42 KL 4 pm

37.	42.	42 Pnompenh
39.	36.	43. Pnompenh

NST, February 22, 2010

- "But my question, is how are Thai companies competitive despite higher electricity prices?"
- He added that studies showed that insulating roofs could reduce internal temperatures by an average of 3°C.

  "I've insulated the roof of my house. On Feb 16, the outside temperature was 36°C. In my house, it was 29°C."
- Gurmit said although air-conditioners worsened climate change because of their emissions, the usual knee-jerk reaction was to turn them higher as temperatures increase.

  "We should instead be retrofitting houses, insulating roofs and walls as well as closing windows and doors during the day.

  "This is what we should be doing to adapt to climate change. After all, do we want knee-jerk reactions or long-term solutions?" he asked.

  Gurmit said that at RM3,000 to RM4,000 a pop, insulating a roof was not expensive.

  Cetdem has forwarded suggestions to the government to provide incentives for people to retrofit their houses under the 10th Malaysia Plan.

Remark: all six days in a row only use cross vent in fan, no Stand fan
----
Date: 26/27
Weather: continuation hot sunny cloudy
Change? Morning more cloudy, sun comes through
--/----------------//-

Start: 23:45
End: 7:45

I 29.9 / 68.3
Exp 27.6 /80.9 feels very convenient
O 26.3/87.3

----
te: 27/28
Weather: sc
Change?

Thermologger outside on: 4:30 pm
Start: 1:00
End: 7:45

I
Exp 27.4 / 79.2
O 26.3. / 83.8

Morning occupant inside, cv for fresh air once 1 pm. Without feel sleepy, no initiative

----------/-----------/-
te: 28-29/15
Weather: mostly sunny (highs 34)
Change? Even bit hotter than previous days

Start: 11pm (at o 26.9 and I 28.6/76
End: 7:15am

I 29.6 windows open!!!!
Exp 27.8
O 25.9

Date: 29/30
Weather: morning almost 100% sunny, afternoon few thick clouds night starry

Start: 0:00
End: 7:45

I 29.6 / 68.3 with open windows
Exp 27.6 /81
O 26.3 /83

Date: 30/6-1/7
Weather: starry
Change? Not much, still continue dry weather since 21/06

Start: 23:30
End: 7:10

I
Exp
O

te: 1/7. 2/7
Weather:
Change? No

Start: 23:35 (full power as 29.2

Temperature

1588 m3 window east
1589 m3 west
1590 m4 ceiling or east window
1591 ?
1593
1594 floor
1596
1597 M3 win east
1598/
1599 m1 roof new radiation
1600 m3 Dg 11:40 pm

Applicable for sleeping rooms
With no light any tenants jz sleeping

27.7 is great ifb half rice evening

No sweat at all if switch off system
Jives with healthy nutrition or diet

Without cold shower, this system doesn't work.

Combiwt solar ge 3000 rm independent of TNB and black out. Still can get TC via ambient temp all the te

Open boc around 10pm when windows cooler than boc
Measure % we gain of outside coolness when cv. every 10 min

Simple vent does a 1/2 to 2/3 job, does cross vent perform a much better job? Can it bring down temperature up to level of outside temp? If so, How long would it take?
If not, how much more prop /absolute coolness can we gain compared with single vent?
Does the occupants behavior make a difference?
What is the truth about the humidity? Does is play any role during sleep?
Finally the blow of the fan. Does the fan create the feeling that even 30 C are bearable? = - 3.8 C =26.2.
A simple in fan can replace the indoor stand fan. It cannot create the velocity of ceiling fan, but maybe due to its coolness not necessary.
Does the axial fan make the difference? Pack away radial fans..

Outsmarting the tropical climate

The trick is pretty simple: keeping the heat out during the daytime, and harvesting the relative coolness during the nighttime.
Throughout the following pages, I will not only refer back to an individual case study. I will revert to more than three years of experience this with outsmarting the tropical climate.
My 3*4m sleeping room is in the south east direction. Due to gregorian windows, The room harvests Sun from the sunrise until 3:30 to 4 PM. As one of the many occupants, we are not supposed to do any changes in the building envelope and the windows. So it is not possible to put the proper shading via lamella blinds outside. Hence, the insides protection is a blackout curtain. The draw back obviously is still the air leakages at its edges. The hypothesis (1) is that during the daytime by the blackout curtain the heat can be removed by about 1°C compared to the control room.
During the nighttime, I preferably use a kind of a reversed exhaust fan blowing fresh air from the outside into the building. However, fan is not simply harvesting fresh air. It also has a rain cover, a mosquito grill and optional a haze filter. It has a dimmer function and can increase its air volume when the filter is set up. Compare to the operational expenses for air conditioners, The ratio is about 1 to 40 in a range of 1 to 22. Even the latest generations of air conditions consume about 650 Watt, whereas the fan operates on the basis of 28 watt.

Literature review: Thermal comfort.

4. findings

Over an observation period of altogether seven days in a hot periods without any rain, along the rainbow scale from green to red we can see that the average morning temperature of the control room is by 1.4°C higher than in the experimenter room.
Second insight: during the 7 to 9 hours of nighttime ventilation, the walls seem to retain some of the coolness.
In the morning, it is possible to run the whole room passively without any electricity.
This system is already considered smart without an electronic monitoring.

5. Conclusion

Our pilot run has proven that thermal comfort in the tropics a room that is mainly exposed to the sun can be achieved with low budget. Air conditioners May not be obsolete, but their usage is restrained to a few hours for users who like to get 26°C it. For those who can live with 28 its usage is confined to a handful of very hot days.

te:
Weather:
Change?

Start:
End:

I hü
Exp

1st day 25/5
Start: 9:30 pm
End: 6:30 am

Baseline 28.0 after
2 cloudy days. Little Rain 5 pm. Evening feels comfortable, heavy Rain this night
1 am
0.5 C more after 30 min tenant entered the 3*4 room

Control room closed.
Fan runs by 50%.

27,8 feels TC. Slight velocity on the skin.
after 50 min still stable 27.8 /84 is not like 31 / 50
Outside colder, need 3rd thermologger

6 am as in Taman

Official 24. 92. = 26
24.6. 87 outside
26,5 82 experimental room
28.6. 76 control room

Jz reach temp TC in early morning wt closed windows
(After warm stable conditions maybe it's 1 C warmer)
= Variation in just small border values

28.6 Ok this is when i feel i don't need anymore fan. comfort zones

Need a light blanket to sleep when the fan is still on.
High humidity of a 83 doesn't seem to matter.
Outside temperature of 25

2nd day 26/05
Start: 0:30 am
End: 6:30 am
Weather: after untypical cloudy / rainy day with almost no sun

24   83 out
26.4 exp
28.0 cont

3td day 27/05
Less rain, but gloomy afternoon

Start 10 pm
End 7:15
27.0 84 exp.
28.2 I

28/05 Daytime getting more normal, no rain but dark and cloudy afternoon

Start: 10:15 at 28.4 (compared to 29.2 in the control room). Meaning wall still have catch the previous night coolness caused by fan? even though the sun was shining the whole morning.
End:

29/5
Sunny cloudy and afternoon rainy days take turns.

30 of May afternoon heavy rain

31/5
Start 12 am
Finish 7:20 am
First of June raining afternoon take turns

Start: 12 am
End: 7am
The crossvent room keeps always 1°C lower than the control room with no cross ventilation.

Eg 29,7cont

28.7 experiment room

In a stable weather conditions with no rain over 5 days any temp f 33. Max
8 am RETAINER effect with > 2 C less

I 27.0
Cont 29.4
O 27.9
Inside still cooler than outside. Target: keep the retainer effect as long as possible (walls as retardants)

-
Temp in 3•4 room increases 0.8 - 1 C after occupant enters and spotlights (non led)
Estd. 0.4 C due to occupant
Estd. 0.4 C due to fluorescent light
Measure separately 1h with light without occupant. Next time 1h with occupant but no light. Choose base temp of 28.

Basically 2 typical subjective measurement modes
1.Cmg in frm hotness of from shower / bath. 28 ok wtout fan 6 pm
2. After activity 28.6 /76 feels a bit hot. Switch on out fan 12 am and get what I need - with this high temp

3. Is it True That the temperature usually significantly drops by 3 C in cloudy / starry nights between 8 and 10 pm and remains stable thereafter until early morning? We have 4 tropical weather logs in reference nights (KL, 32 to 28 Georgetown 30 to 28 because cloudy, Bangkok 30 to 27 and Pnom Penh 29 to 27.

For sure some people will not yet be satisfied with that TC produced by this system. People who don't like to sleep almost naked like Tarzan and are used to thick comforters Will still feel too hot or too humid, even if we were able to reduce the temperature to the real outdoor temperature. But looking at the cooling demand, it will decrease by 60 to 70% with simple ventilation. Proper CrossVent with axial fan that has never been tried out anywhere might bring the percentage up to 80 or 90% of saving.

CS
Let's say u wanna build a gb in sub urban area like Gombak
U wanna avoid haze and u hate mosqu . Ur budget is... And of course you like convenient temp when u and ur spouse cm home eve (type1)
How?
Let's say you live in the 23rd floor of a city condominium. You are suffering a lot from the heat when you're air condition is not on. How can you make the climate palatable for you?

Date: 25/26 6
Weather: Hot sunny cloudy, no rain
Change?

Start: 0;00
End: 7:15

I 29.6/68

Exp 27.6 / 80
O. 26 /80

Remark: all six days in a row only use cross vent in fan, no Stand fan
----
Date: 26/27
Weather: continuation hot sunny cloudy
Change? Morning more cloudy, sun comes through
--/----------------//-
Start: 23:45
End: 7:45

I 29.9 / 68.3
Exp 27.6 /80.9 feels very convenient
O 26.3/87.3

----
te: 27/28
Weather: sc
Change?

Thermologger outside on: 4:30 pm
Start: 1:00
End: 7:45

I
Exp 27.4 / 79.2
O 26.3. / 83.8

Morning occupant inside, cv for fresh air once 1 pm. Without feel sleepy, no initiative

----------/------------/-
te: 28-29/15
Weather: mostly sunny (highs 34)
Change? Even bit hotter than previous days

Start: 11pm (at o 26.9 and I 28.6/76
End: 7:15am

I 29.6 windows open!!!!
Exp 27.8
O 25.9

Date: 29/30
Weather: morning almost 100% sunny, afternoon few thick clouds night starry

Start: 0:00

End: 7:45

I 29.6 / 68.3 with open windows
Exp 27.6 /81
O 26.3 /83

Date: 30/6-1/7
Weather: starry
Change? Not much, still continue dry weather since 21/06

Start: 23:30
End: 7:10

I
Exp
O

te: 1/7. 2/7
Weather:
Change? No

Start: 23:35 (full power as 29.2/79) until 0:30 then 55%
End: 7:10

Walls. 31.4 cont
29.5 - 30 exp room

I 29.9.   69
Exp 28.3.   82
0 25.9. 86

2/7. 3/7

Start: 23:45
End: 7:15
I
Exp

0

3/7 change: mostly cloudy and little rain. Remains cloudy whole day.

3/7 - 4/7

Start 1:30 am
End around 8:30 am

4/7 rain early morning, still cloudy - 11am

4/7 -5/7
More sunny

Start 23:45
End 7:30

Today -11.45 scwithA

Why do we need a blanket ? Use (Q Bosch)

6/7
Quite hot day

7/7
Start: 1 am

Heavy rain with thunder around 5 am
End: 7:30 am

7/7 hot and stuffy. Even though overcast whole day
Start: 23:45
End; 7:30

8/7
Light rain around 6am,
Again heavy rain 1:30 - 2 pm

8/7
Start: 23:00
End: 7:10

27.3 / 79 feels very convenient when getting up, last day 28.3 felt bit high.
Could be like this every day? Cv

9/7 One day not there, no cross ventilation 1 night
What happens next day?

10/7
Temp 29.6 at 6:40 pm after occupant 30 min inside

Start: 24:00
End: 8:30 with full sun
Does it bring up temp?

11/7

12/7