ARC 2412 Building Science 1

Project 1: Human Perception of Comfort level

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Abstract

The aim of this investigation was to collect primary data from a chosen inhabited space in order to analyse how its occupant would perceive thermal comfort and highlight the many factors which may affect it. Throughout our analysis, we referred to MS 1525, the regulations and standards for buildings in Malaysia.

The space we chose as our case study is an apartment unit located in an urban setting surrounded by other residential projects (high-rise as well as low-rise). Using a data logger, we were able to measure and record the temperature and relative humidity for 73 consecutive hours. Simultaneously, the occupant of the space kept a checklist of the activities conducted which may affect the thermal comfort of that space.

From our findings we found that the internal data for temperature as well as relative humidity were relatively constant compared to the external condition. The main reason for this is that heavyweight construction material of high thermal mass was used and it provided a good barrier between outside and inside. However the data still suggests that the space should somewhat of discomfort due to excess moisture.

Ultimately, based on the personal experience of the occupant, the space that was analysed is a comfortable habitable space. Perceptions of comfort level is subjective and personal to each individual and it is important to note that the quantitative data collected leads to a qualitative conclusion and we cannot quantify comfort level with accuracy.

Introduction

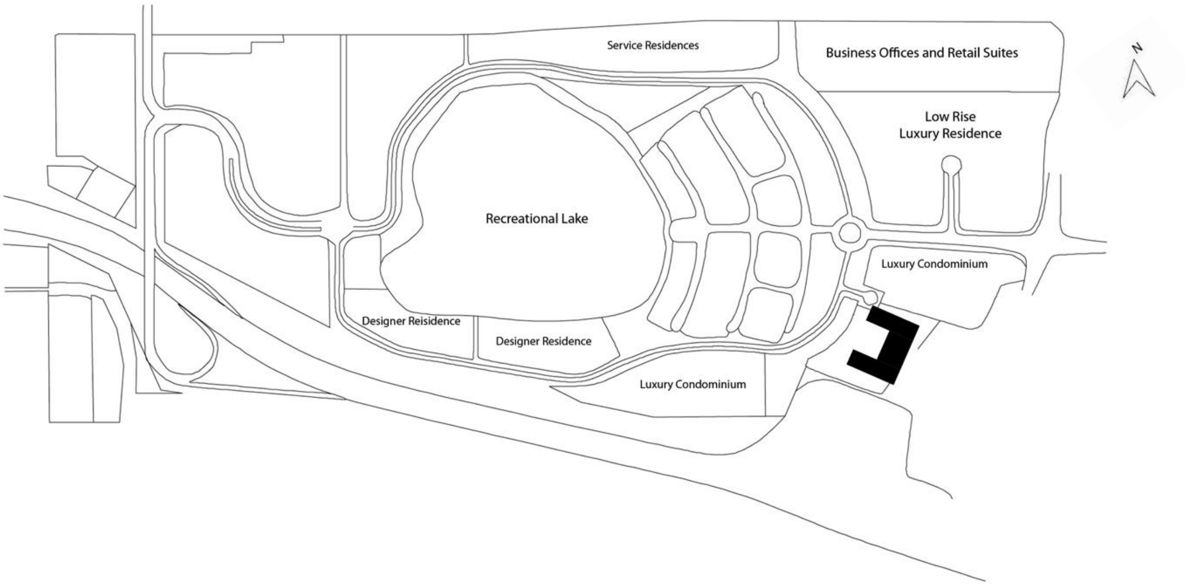
Purpose of Study

When designing and constructing a building, one must always bear in mind the effect it will have on its thermal comfort for its occupants. Thermal comfort is affected by heat conduction, convection, radiation and evaporative heat loss. This can be controlled through different means such as the inclusion of shading devices, insulation system and building materials used. In a perfect case, the aim is to achieve constant values of temperature and relative humidity in the interior spaces at all times. The objective of this task is to analyse a chosen site's thermal comfort and the factors which affect it.

Location of Site

The case study site is located at Nautica Condominum , Jalan Tasik Selatan, Sunway South Quay, Bandar Sunway, Petaling Jaya. The data was collected from 12th September, 3.01am until 15th September 2013, 4.01am. The specific unit where the investigation was carried out was on the 8th floor, with the window of the space facing south west. The surrounding area consists of other high-rise residential and semi-D houses with the lake being a large focal point.


Sunway South Quay set within the award-winning Sunway Integrated Resort City
Sunway Integrated Resort City
Sunway South Quay
Nautica


Service Residences
Business Offices and Retail Suites
Low Rise
Luxury Residence
Recreational Lake
Luxury Condominium
Designer Reisidence
Designer Residence
Luxury Condominium
N

Limitations of Study

As with other investigations, we had several limitations which may affect to a certain extent the accuracy, precision and reliability of the data presented, and our analysis that was based on it.

1. **Location of data logger** - we were unable to put the data logger in the middle of the room due to the presence of the bed. This may result in an unevenness of the temperature and humidity recorded, as the sensitivity of the data logger may not be enough to record all the activity in the space. Furthermore, the logger is placed relatively close to the bathroom.

2. **Lack of human activity** - the room is only occupied by one person, and little activity is carried out within the space. The windows and doors are closed most of the time as well. This may result in a data yield that is not very irregular.

3. **External data obtained** - the data obtained for the exterior conditions was collected from an Internet source and is data for the nearest checkpoint, which is not specific to our site. Hence, the actual external condition might differ slightly from the data used.

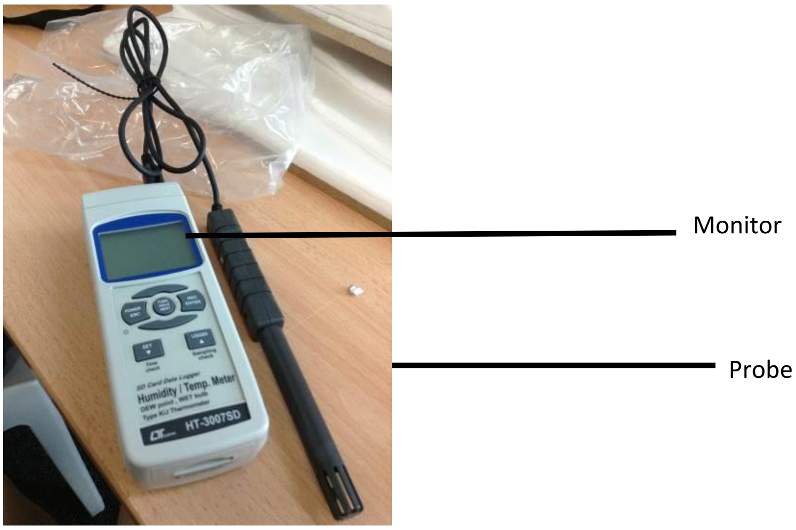
4. **Limited time of data collection** - the data was only collected over a 73 hour period. For it to be more accurate, a wider range of data would make the trends in the results more reliable.

5. **Perception of comfort is subjective** – The idea of how comfortable a space is a subjective matter and cannot be quantified into a value.

Methodology

Apparatus

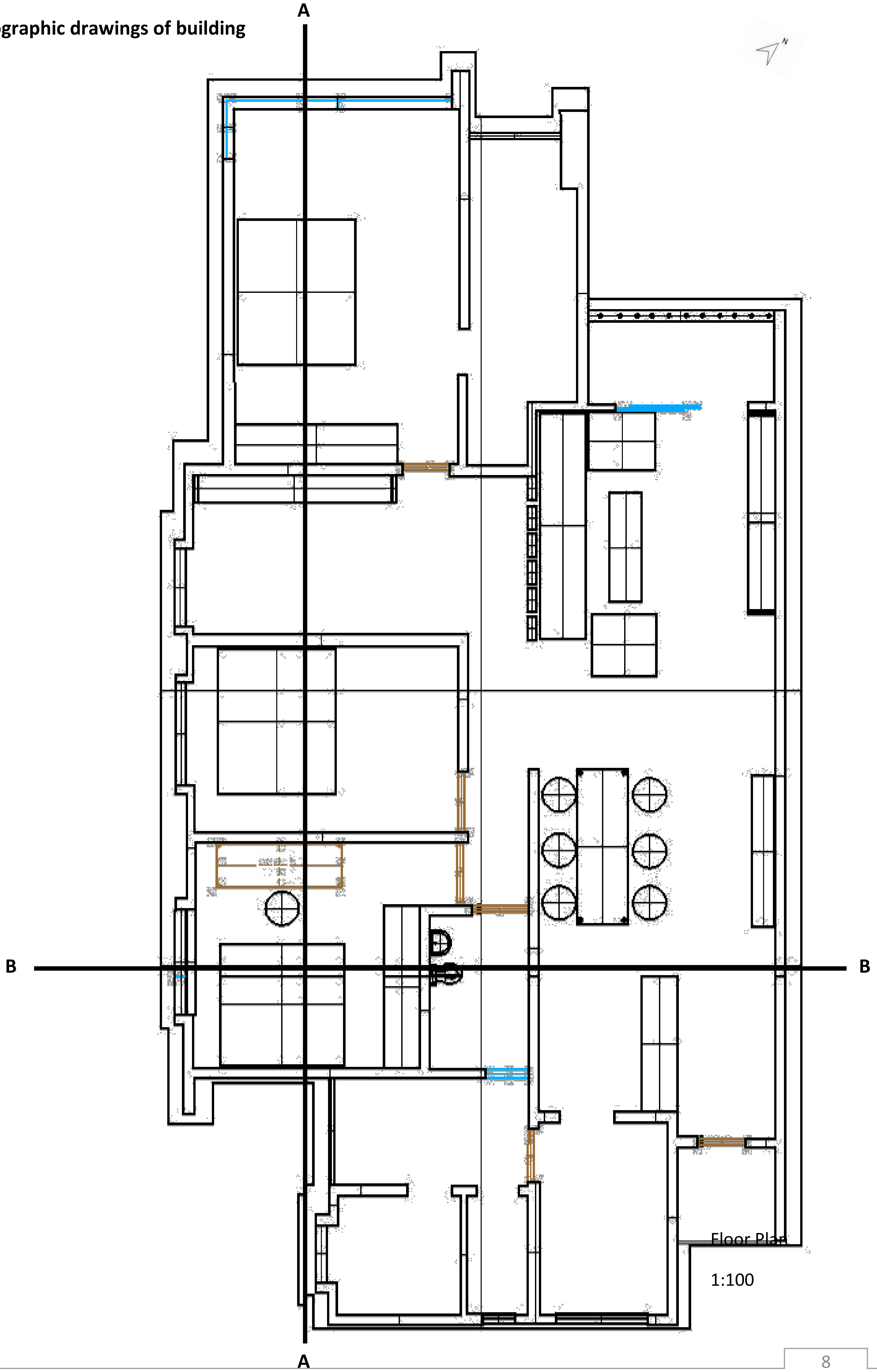
Data Logger

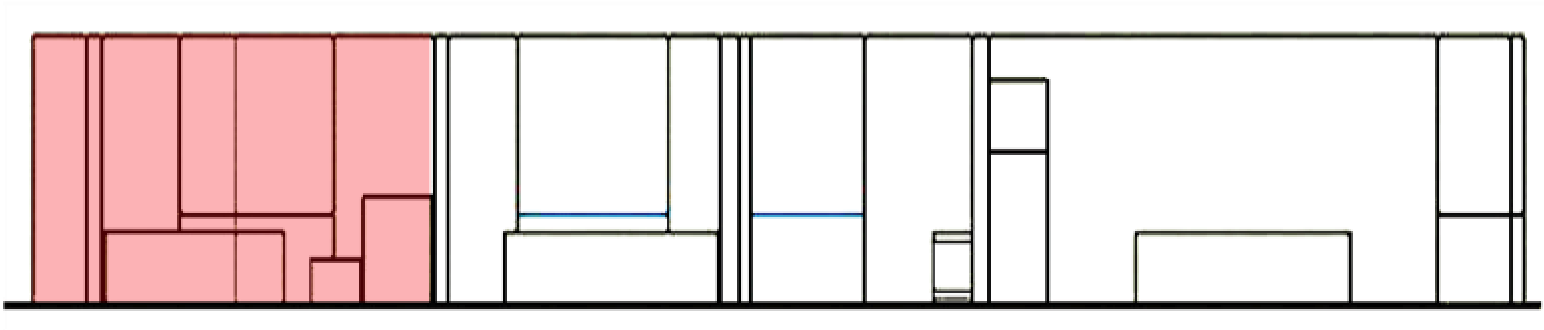


The data logger is a battery-powered device used to measure the temperature (°C) and relative humidity (%) in this project. It has a probe, which acts as the sensor. It is relatively small and is of a portable size. The monitor displays the current measurement. An advantage of using the data logger is that data can be collected though it is unattended by a human, therefore we can place it to measure and record automatically for a period of time without disturbing it.

A memory card is used to store the data. Prior formatting of the device is needed in order to set it to collect data on an hourly basis (3600s) and only collect the specific measurements needed. A manual handbook comes along the data logger, and the instructions are quite clear. After formatting the memory card inside the data logger, we started recording for 73 hours straight. The data is automatically stored in the memory card in an excel file. The data is measured to an accuracy of one decimal place.

Orthographic drawings of building





Section A - A

1:100

Section B - B

1:100

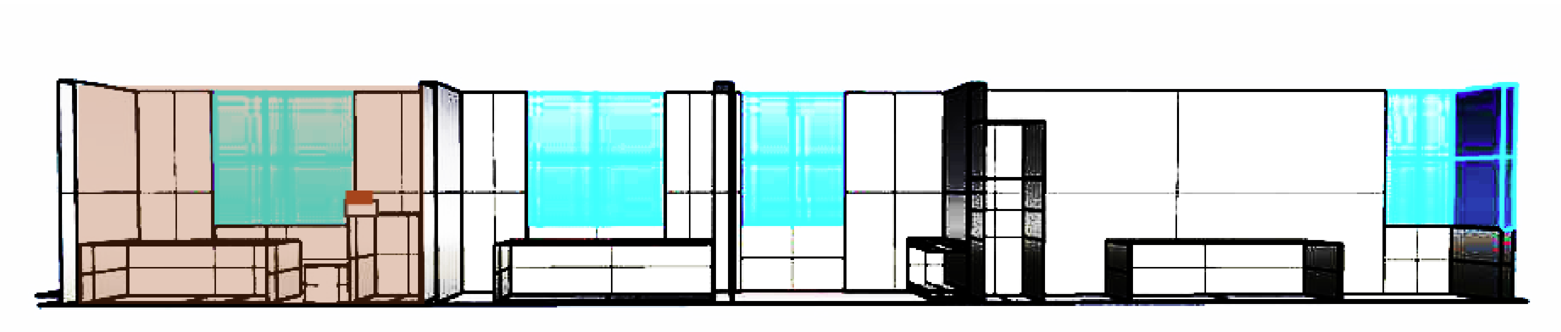
Northwest Facade

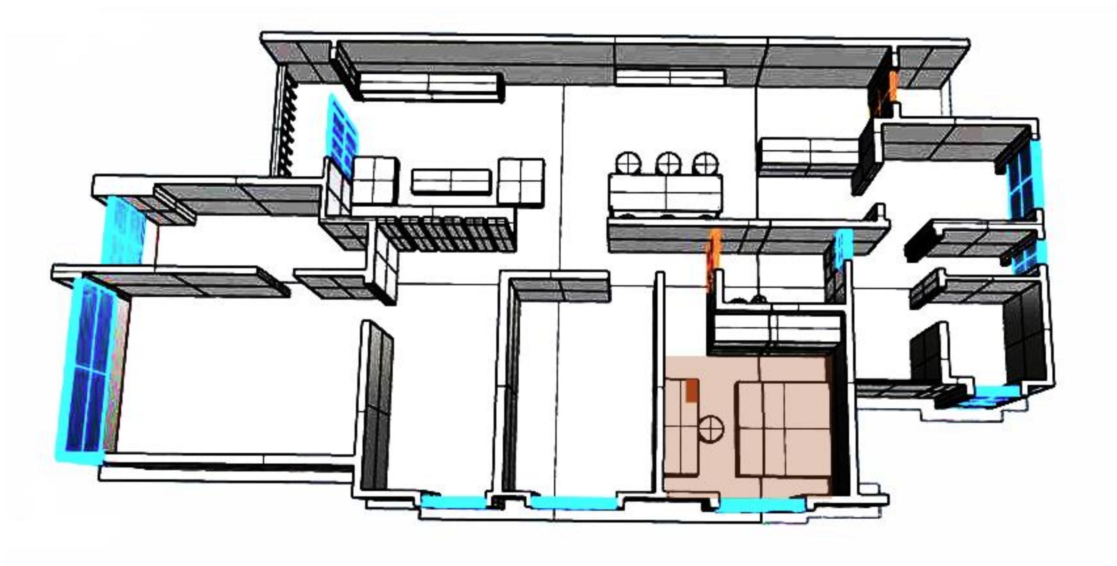
NTS

Southwest Facade

NTS

Placement of Data Logger

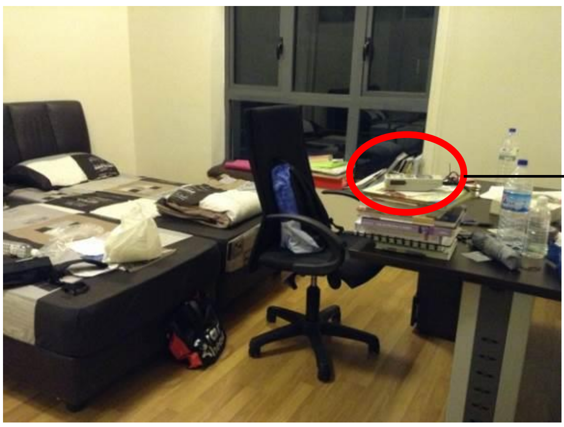




Data logger

room where data logger is placed

The data logger is placed inside a bedroom of an apartment unit on the 8th floor, and is used by 1 person. The bedroom is located next to another bedroom and very near to the bathroom.



Data logger is placed on top of the study table, and is held on top of a stack of books to get the desired height of 1 metre.

Description of room

The room is 3.7 m by 4 m. It has windows facing the south west direction. The ceiling is 3m high. The counterpoint of the room is the queen sized bed. It has a cupboard on one side, which covers the entire wall. The flooring of the room is wood. A study table is placed opposite the bed.

Recording the data & variables

The data logger is set up and placed in its location and left unattended for 73 hours. During the recording, a checklist is produced to record the activities and the appliances used at a particular time. This is used to support the analysis of the data collected.

Building Design Standard

The analysis of case study design standards will be based on the Malaysia Uniform Building By-Law 1984 and the Malaysia Standard 1525:2007 which is a code of practice on energy efficiency. UBBL is a guideline given by local authorities to ensure the user comfort to safety, energy efficiency and the comfort to surrounding environment. The building design standards differ from different climatic regions as different designs standards are set to respond to a specific climate and surrounding.

Therefore, the analysis will based on MS 1525(2007) and Malaysia Uniform Building By-Laws: 1984 to criticize design of the building which could affects the internal space thermal performance and human comfort level.

Results & Analysis

Site Context

The site context is an important factor in the thermal comfort of the building. The chosen case study is surrounded by relatively little greenery and vegetation as most has been cleared for construction of residential projects. Looking at it holistically, the site is located within a dense urban setting near to highways and high-density residential. However, the unit's balcony overlooks a 28-acre lake. A lake would affect the local climate as it changes temperature more slowly than land. So during the day, the lake will be cooler than the land. During the night, the lake will be warmer than the land. This means that during the day, the low cool air moves over the land, effectively cooling the site. The effect is reversed at night. However, it is important to note, however, that the lake may not be big enough to have a major impact on the site.

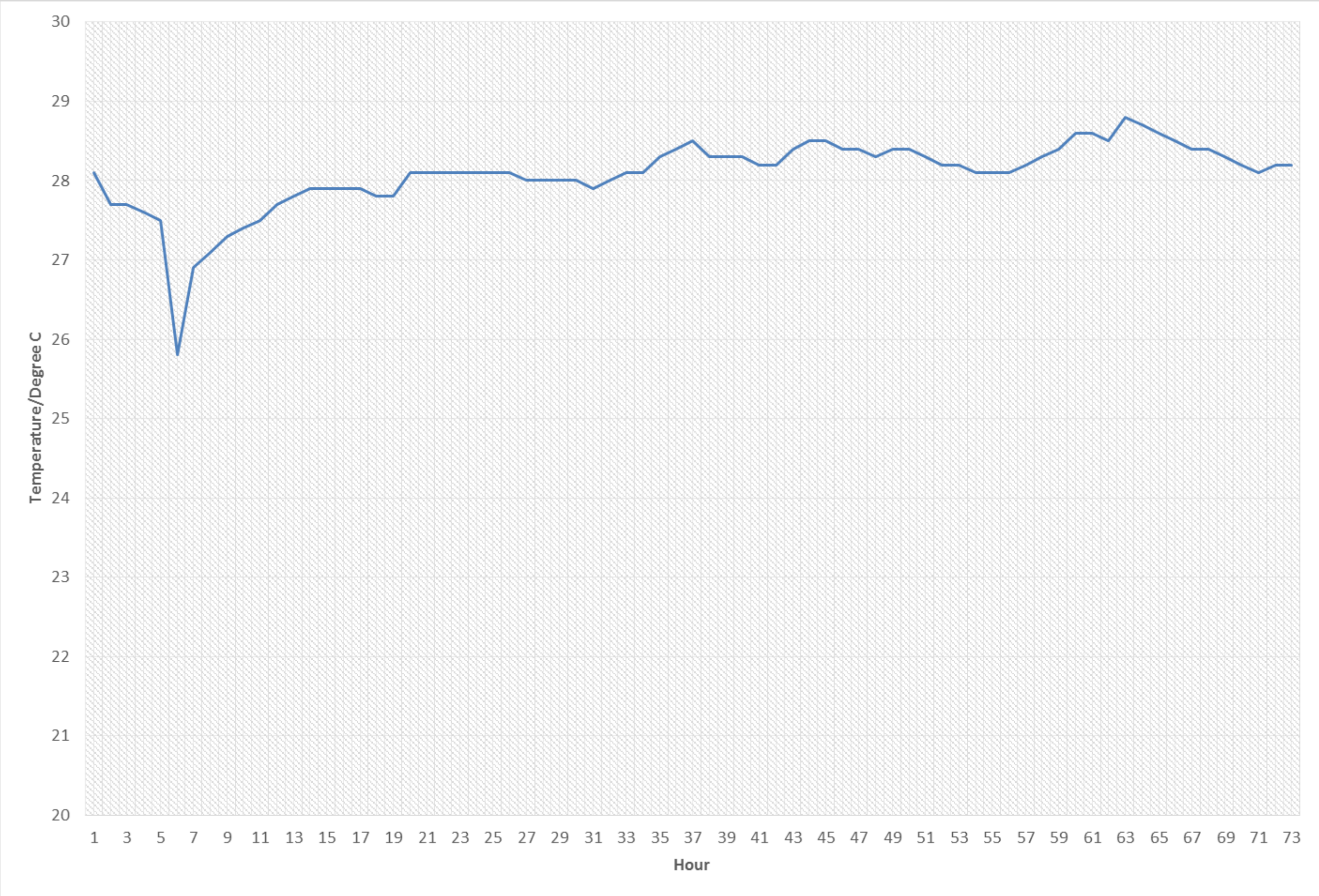
Macro Climate

The climate of the surrounding area is relatively constant throughout the 73 hours, although there were periods of heavy rain and thunderstorms. Refer to appendix for details.

	Day 1	Day 2	Day 3
Average Wind direction	↙	↖	↖
Average Wind Speed (Km)	4.6	5.3	3
Average Temperature C	26.5	27.1	27.1
Average Humidity (%RH)	86.6	85.8	82.6

Temperature

Internal

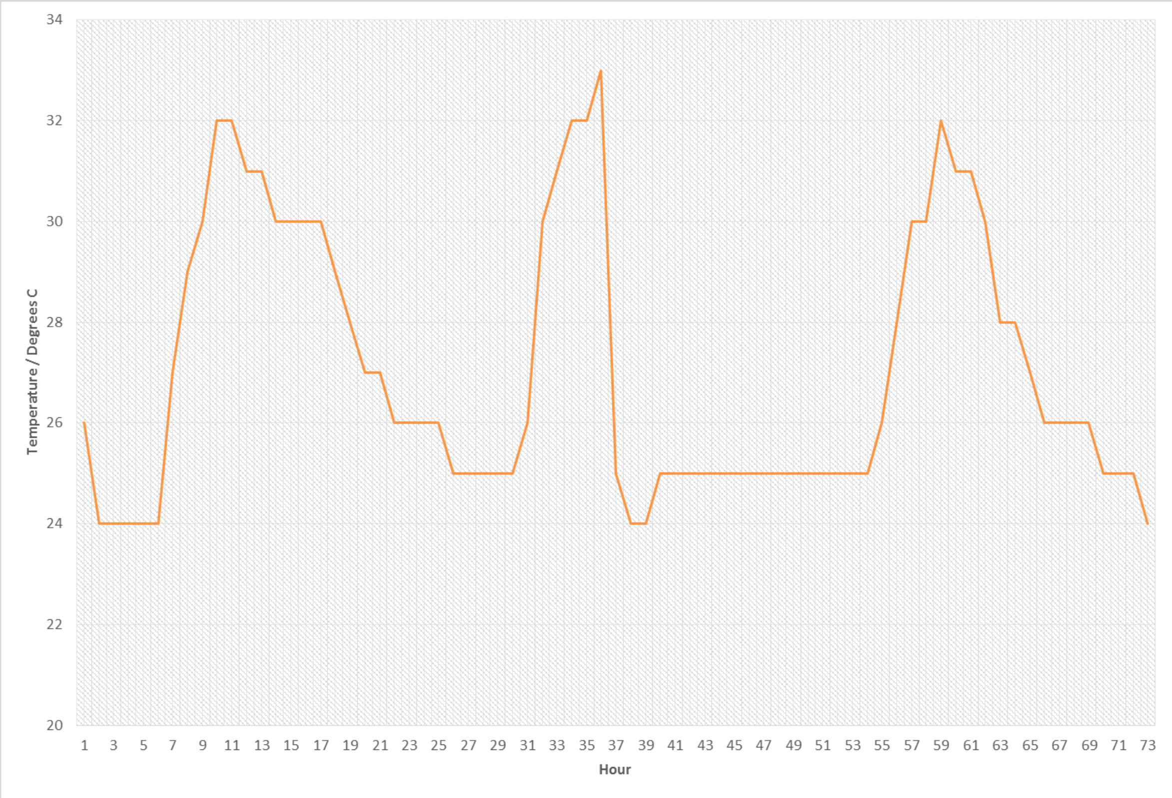


General Trend

The graph displays a generally constant trend in the indoor temperature except for one extreme dip around the 6th hour (8:00 am) where the temperature drops down to 25.8° C, which was the minimum recorded value. This is probably due to the fact that it had been raining with thunderstorm 5 hours before (with a temperature of 24° C, but once the sun rose the interior temperature once again rose to 27.1° C by 10:00 am. This suggests that the internal space does not have a good barrier against the low external temperature, and takes time to neutralize. However, this could have been an anomaly as the rest of the data collected does not support this hypothesis. Even though it rained on the 13th of September at 15:00 with an outside temperature of 25° C, the internal space temperature still remained 28.5° C.

The maximum value reached 28.8° C. The mean temperature throughout the 73 hours was 28.1° C. This shows that the indoor temperature was relatively constant throughout the recording period, with a difference of 3.0° C between the maximum and minimum temperatures. This is relatively unnoticeable for a human in terms of comfort level.

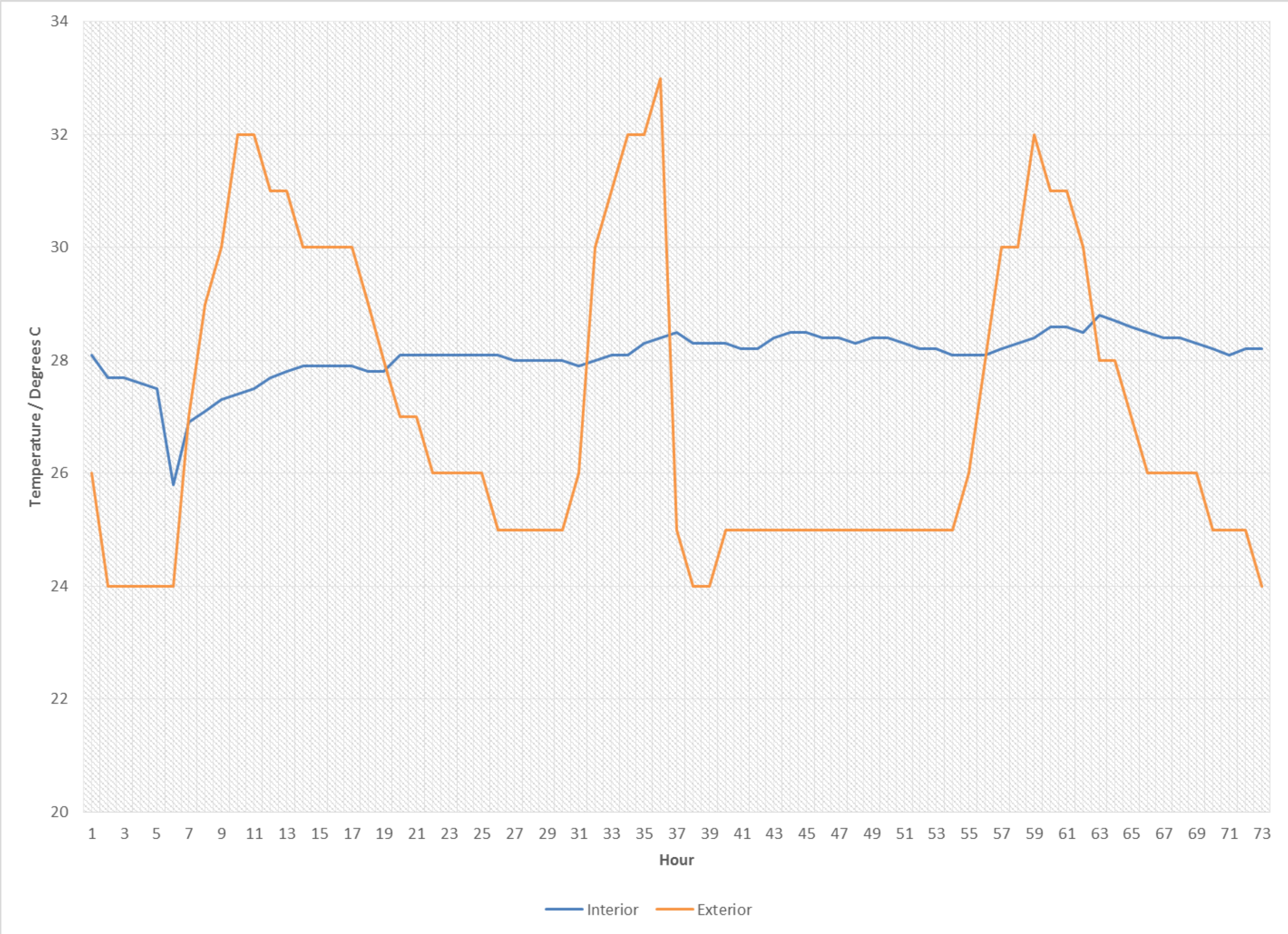
External



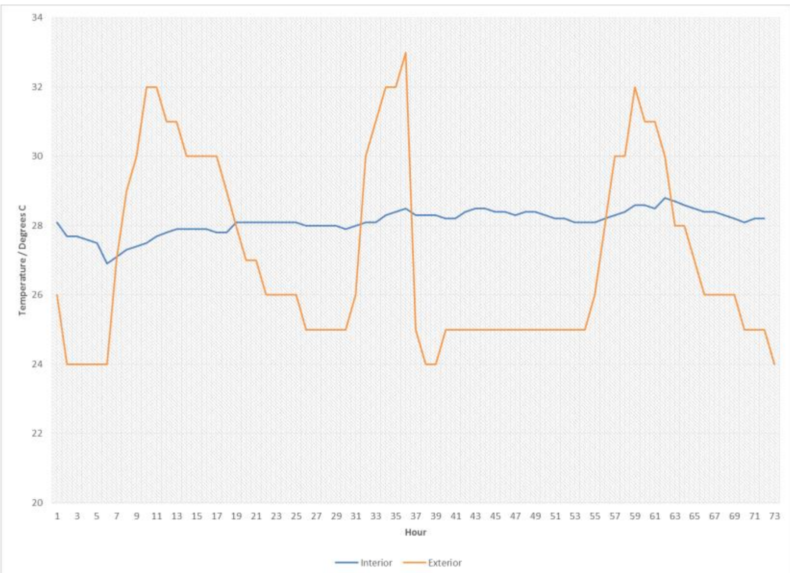
General Trend

The external temperature displayed a generally undulating trend in temperature. With a maximum temperature of 33°C, at around 14:00, 13th September. The temperature slowly rose from 26°C just 5 hours before, and it then drops to the minimum temperature which was 24°C, due to strong thunderstorms. The data gave an average value of 27°C over the 73 hours. This data shows that external temperature varies over a range of around 9°C.

Comparison



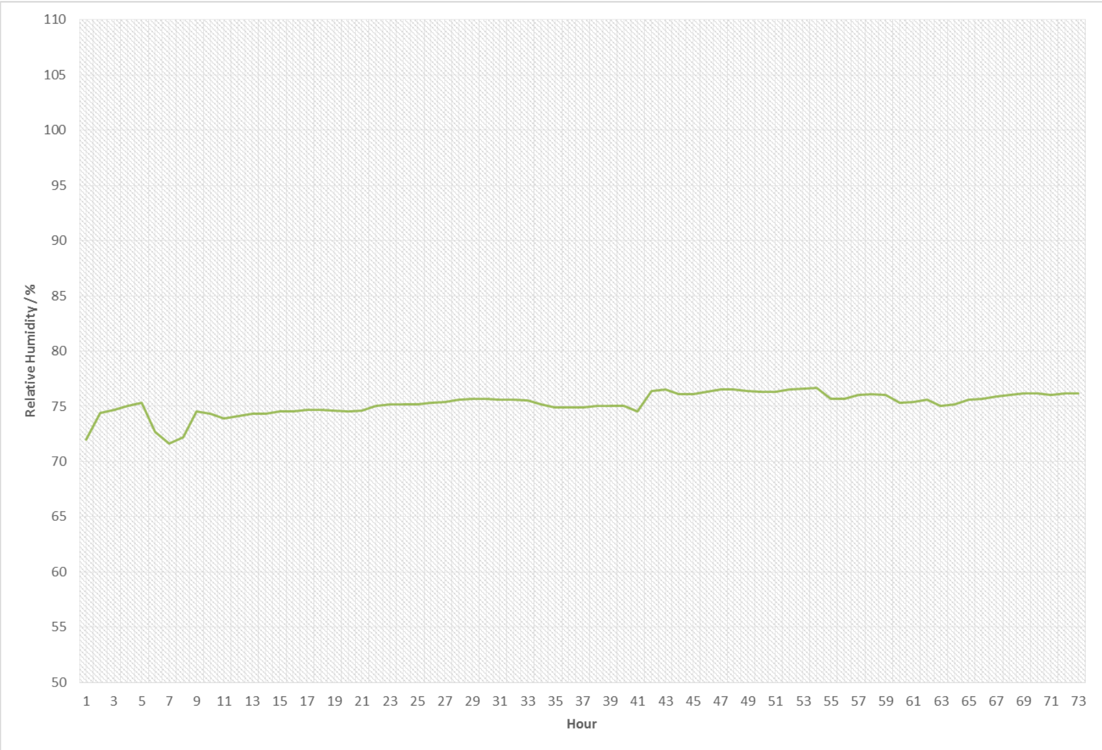
In comparing the external and internal temperature, it is noticeable that the external temperature does not affect the internal temperature to a great extent. Although the external temperature can rise and drop around 9°C over the 3 days, the internal temperature only has a range of 3°C. This also takes into account the inexplicable drop in the internal temperature at the 6th hour. If we were to treat this data point as an anomaly the graph would read as such – with a more obvious contrast between the two temperatures. This suggests that the building has sufficiently adequate insulation to protect the internal spaces from external factors.



Relative Humidity

Humidity is the amount of water vapour in the air. In forecasting, relative humidity describes the percentage of moisture in the air in comparison to how much there is when the air is saturated. The higher the reading, the greater the likelihood of precipitation, dew and fog. Relative humidity is normally highest at dawn, when the temperature is at its lowest point of the day. Even though the absolute humidity may remain the same throughout the day, the changing temperature causes the ratio to fluctuate.

Indoor



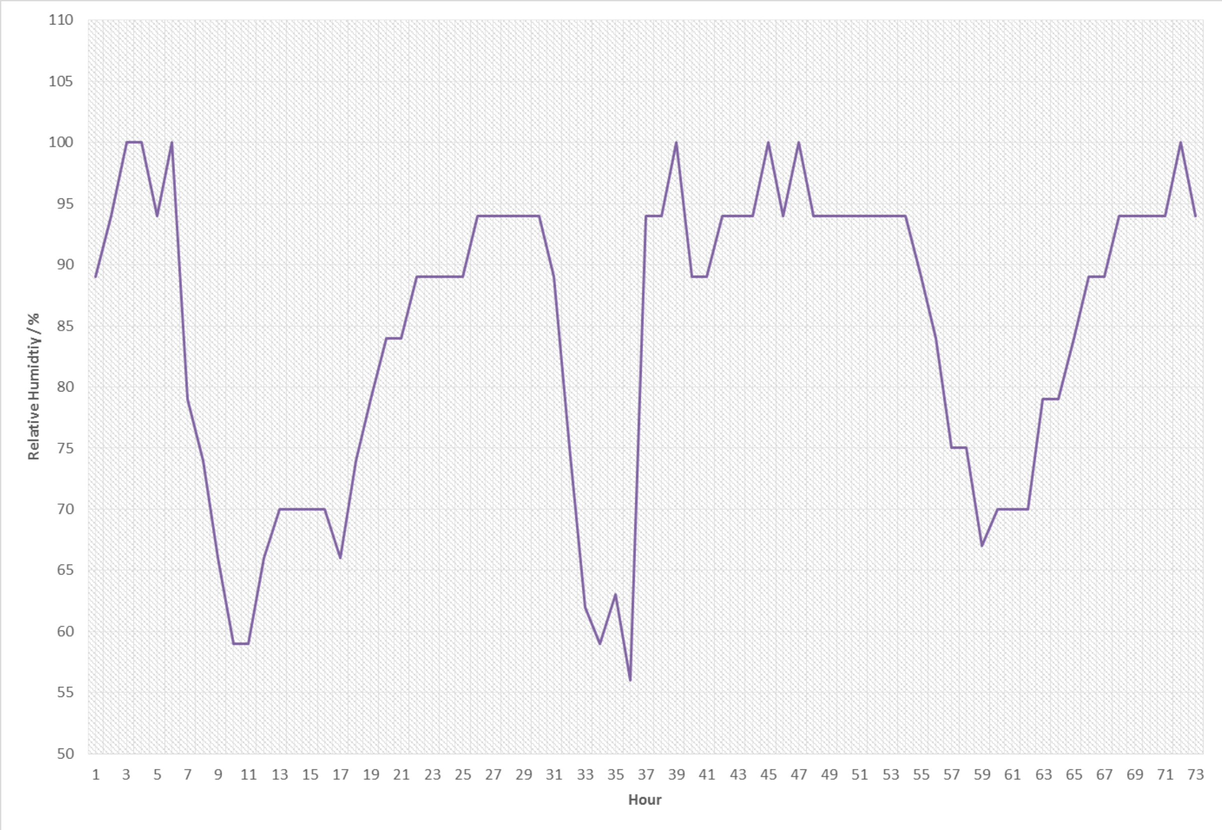
General Trend

The internal values of relative humidity depict a rather constant trend with the most out-standing data point being at 9:00am on the 12th September, reading a value of 71.6% - the minimum value recorded. This may have been caused by the heat radiated by the light, which was left on throughout the night from 3:00am until 9:00am. The light does not utilise an eco-friendly bulb and therefore may radiate a lot of heat which would decrease the humidity level. Furthermore, the phone charger which also releases a lot of radiant heat, was on from 3:00am until 6:00am.

The maximum value was 76.7%, which occurred at 08:00 on the 14th September. This may have been caused by the activity that was taking place. The occupant was taking a shower with hot water at the time, which would generate a lot of moisture. The bathroom is located right next to the studied space and as the door was open, the moisture travels from the bathroom to the bedroom. The lack of exterior wind means no ventilation, causing stagnant moisture in the space.

The average relative humidity was 75.2%.

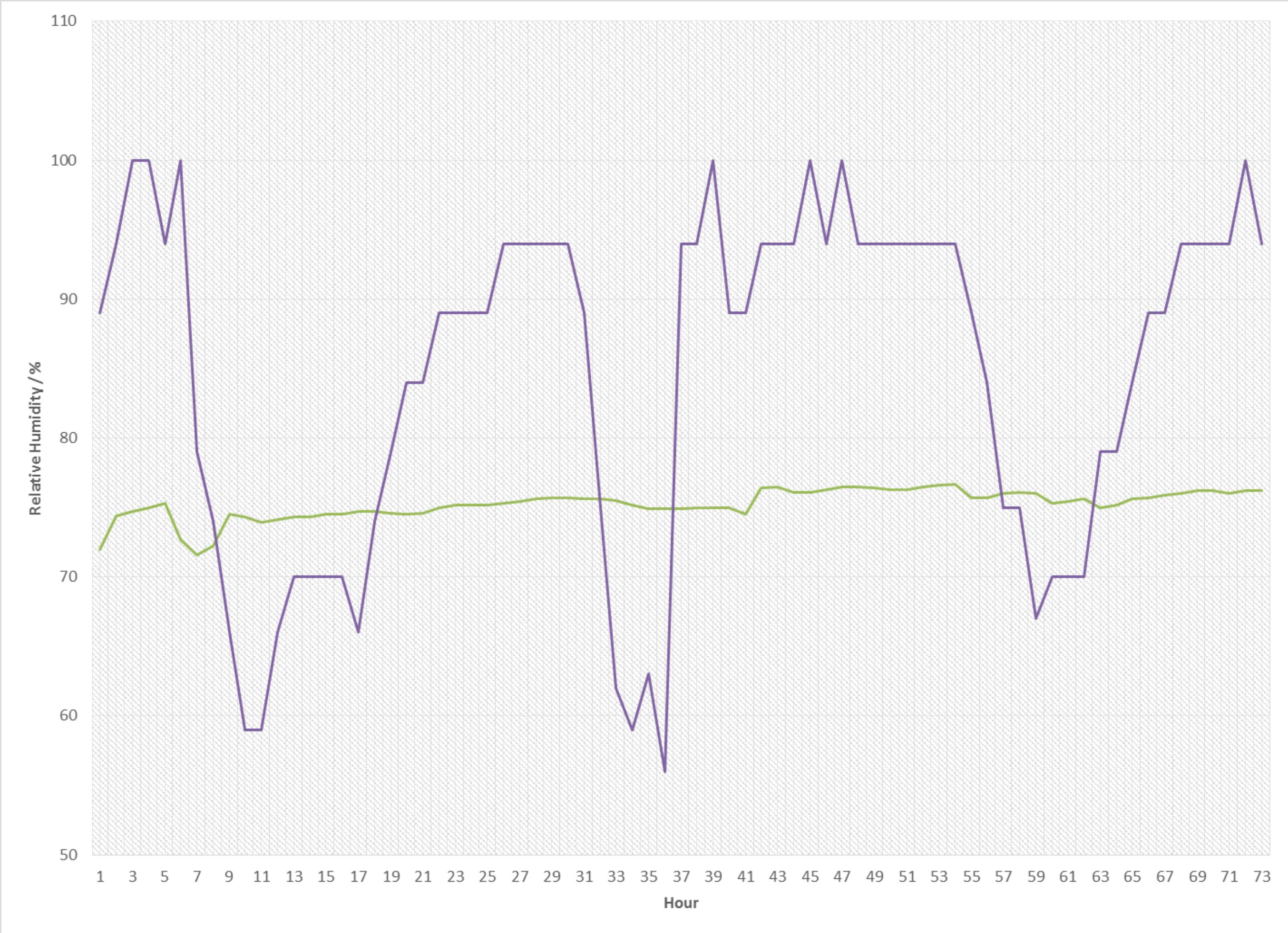
Outdoor



General Trend

External relative humidity is much more dramatic, with peaks during hours with no or little sun, and lowest values at noon. The maximum reading was 100% - as expected being an equatorial country. The minimum reading was 56%, recorded at 14:00, 36th hour. The average value was 84.5%.

Comparison

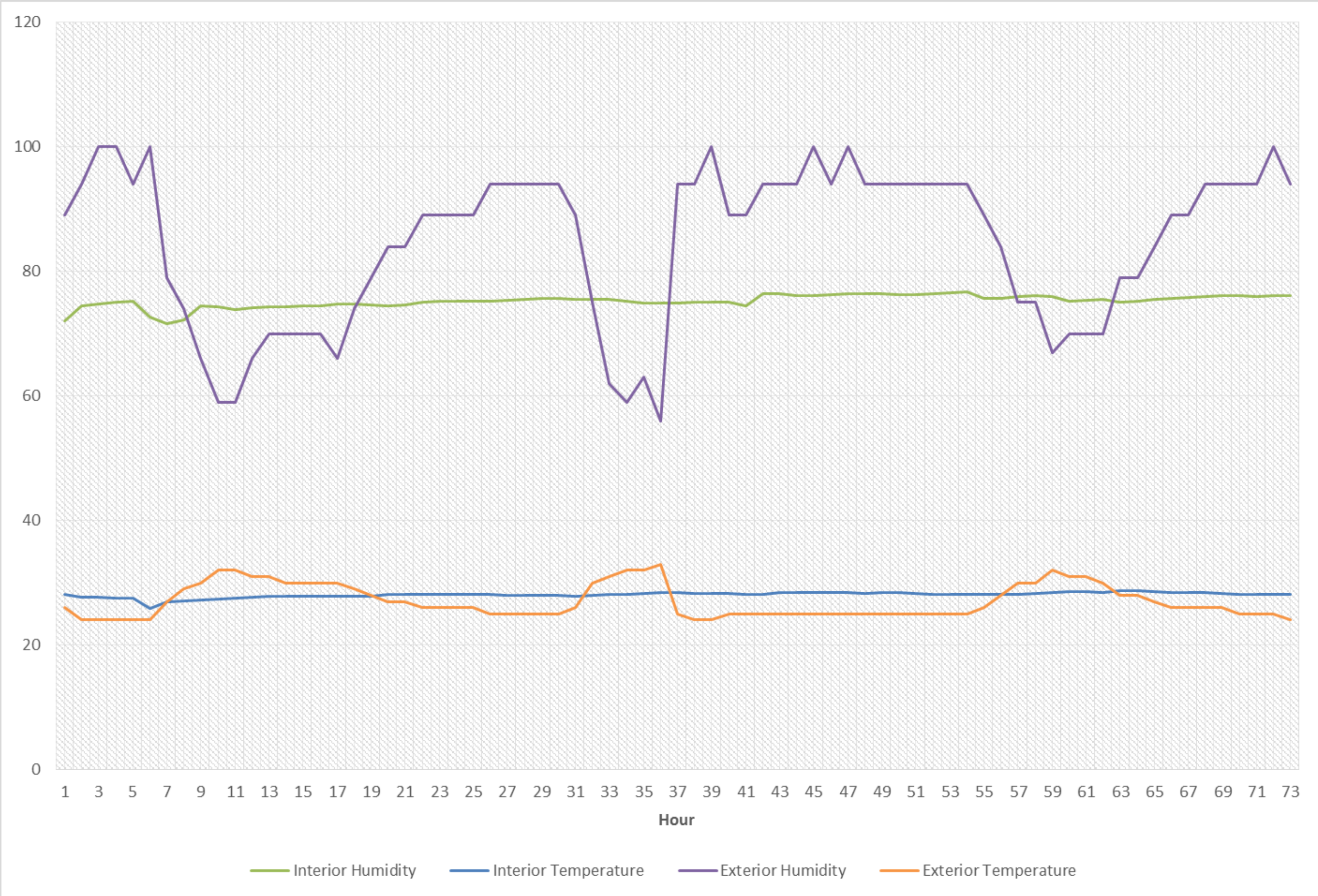


There is an obviously large difference between the internal and external values of relative humidity. This is evidence of a successful barrier between internal spaces and external weather conditions. The outliers in the internal data mimics the external data, however the difference is not significantly high.

High humidity makes people feel hotter and less comfortable than they would in a less humid climate. This is because the perspiration that occurs to cool us down cannot evaporate as readily in moist, saturated air.

As an aid to describe how hot it may seem in humid climates, meteorologists developed the humidex – short for humidity index. It is a parameter that combines temperature and humidity together to reflect the perceived temperature.

Temperature against Relative Humidity

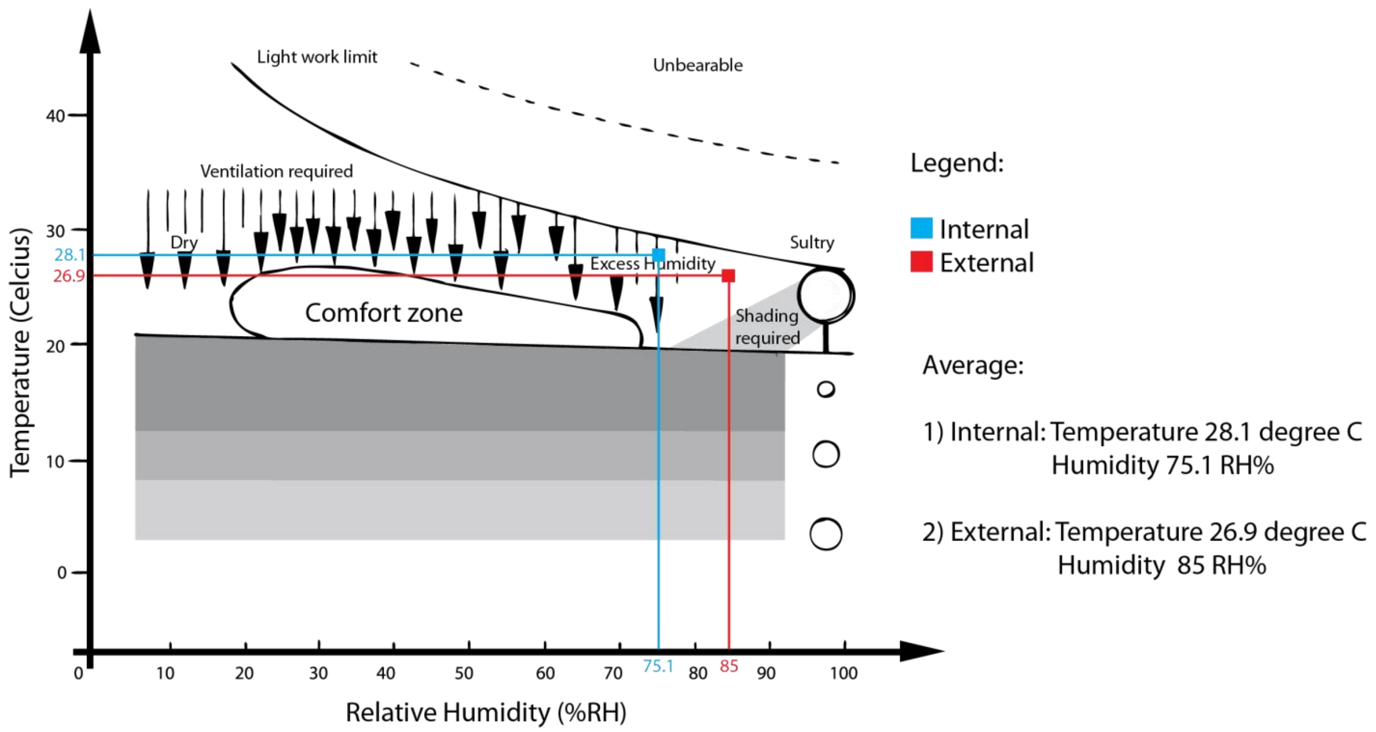


There is an inverse relationship between temperature and relative humidity; as the temperature decreases, relative humidity increases. This means that when the sun is most intense at noon, temperature is highest, and relative humidity is at its lowest. Taking the average external temperature (27°C) and relative humidity (84.5%) values gives a value of 39 on the humidex, described as 'some discomfort', bordering into 'great discomfort'. Taking the maximum value of temperature, 33°C and its corresponding relative humidity, 56 gives a higher ranking on the humidex of 43 – 'great discomfort'. This is the sensation we get at noon. At night however, taking the lowest temperature, 24°C and 100% relative humidity, gives a lower value of 35 – midrange of 'some discomfort'. However, it is important to note that the humidex is an attempt to quantify human sensations and feelings, which are subjective according to each individual. It does its job of providing a general overview but should not be treated as an accurate representation of human perception of comfort level.

Relative Humidity (%) Temperature (°C)	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%
21 °C	29	29	28	27	27	26	26	24	24	23	23	22					
22 °C	31	29	29	28	28	27	26	26	24	24	23	23					
23 °C	33	32	32	31	30	29	28	27	27	26	25	24	23				
24 °C	35	34	33	33	32	31	30	29	28	28	27	26	26	25			
25 °C	37	36	35	34	33	33	32	31	30	29	28	27	27	26			
26 °C	39	38	37	36	35	34	33	32	31	31	29	28	28	27			
27 °C	41	40	39	38	37	36	35	34	33	32	31	30	29	28	28		
28 °C	43	42	41	41	39	38	37	36	35	34	33	32	31	29	28		
29 °C	46	45	44	43	42	41	39	38	37	36	34	33	32	31	30		
30 °C	48	47	46	44	43	42	41	40	38	37	36	35	34	33	31	31	
31 °C	50	49	48	46	45	44	43	41	40	39	38	36	35	34	33	31	
32 °C	52	51	50	49	47	46	45	43	42	41	39	38	37	36	34	33	
33 °C	55	54	52	51	50	48	47	46	44	43	42	40	38	37	36	34	
34 °C	58	57	55	53	52	51	49	48	47	45	43	42	41	39	37	36	
35 °C		58	57	56	54	52	51	49	48	47	45	43	42	41	38	37	
36 °C			58	57	56	54	53	51	50	48	47	45	43	42	40	38	
37 °C					58	57	55	53	51	50	49	47	45	43	42	40	
38 °C							57	56	54	52	51	49	47	46	43	42	40

Humidex	Degree of Comfort
20 - 29	No discomfort
30 - 39	Some discomfort
40 - 45	Great discomfort; avoid exertion
46 and over	Dangerous; possible heat stroke

Bioclimatic Chart



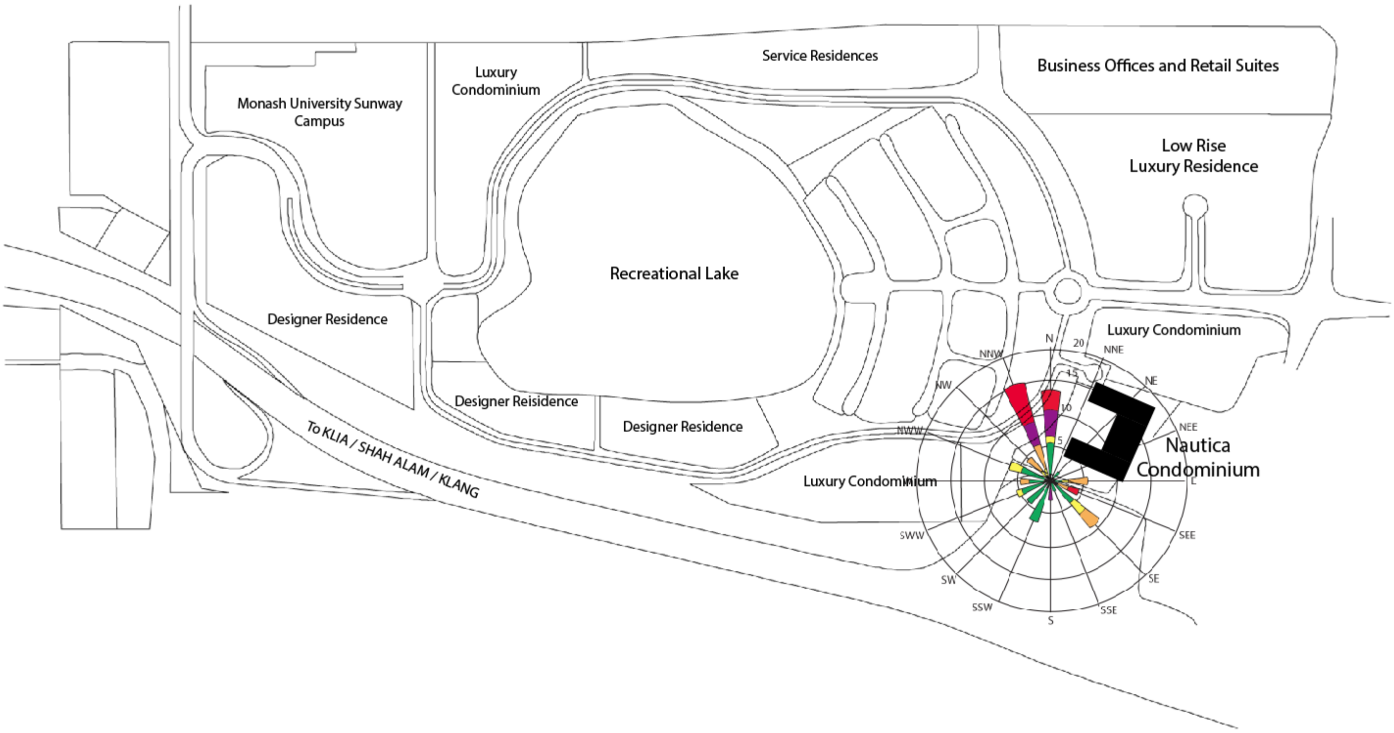
A bioclimatic chart attempts to show how one may perceive the comfort of a room based on its mean temperature and relative humidity. The chart above displays the information we collected based on our case study. Although the temperature of the space is still considered within the comfort zone, the relative humidity is slightly higher. According to the MS 1525 standard, the comfort zone lies within the temperature range of 23° - 26° Celsius and the relative humidity range of 55% - 70%. The data collected proves that the room is a safe, comfortable and habitable space for its occupants but can be further improved in terms of lowering its relative humidity. Although the excess humidity of our case study may not be extreme, it may still affect its occupants comfort level when using the space.

In order to find the best solution for the occupants, we calculated the mean of the external data and compared it with the internal room condition.

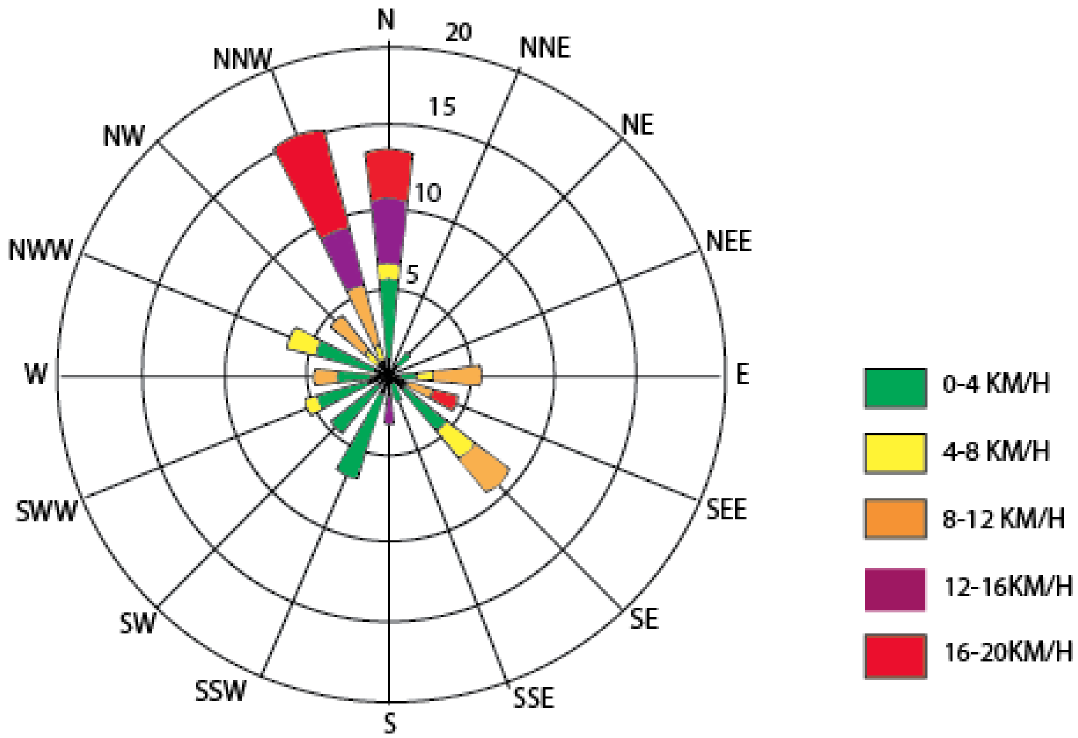
Through the comparison, the data shows that the exterior relative humidity level is higher due to the rain that happened on the days during data collection. One of the solutions to lower the humidity level would be to use a dehumidifier. This will absorb the excess moisture of the interior space without letting extra moisture in the space, which would be the rest from opening the window

Ultimately, although the data has shown that the spaces are considered relatively uncomfortable, the perception of comfort is subjective. Through asking the occupant of the space, we have learnt that the room is actually comfortable and she has not experienced any discomfort from excess moisture.

Wind Analysis



Wind-rose diagram on top of the site plan



Wind rose diagram for the three days when data was recorded.

From the wind rose diagram it can be seen that the wind tends to blow to the north direction more than the south one. The speed ranges from the lowest of 0 km/h to the highest of 19 km/h. The wind blowing to the east and west, although relatively low, is still significant. The highest frequency of the wind blow is going to the north-northwest direction.

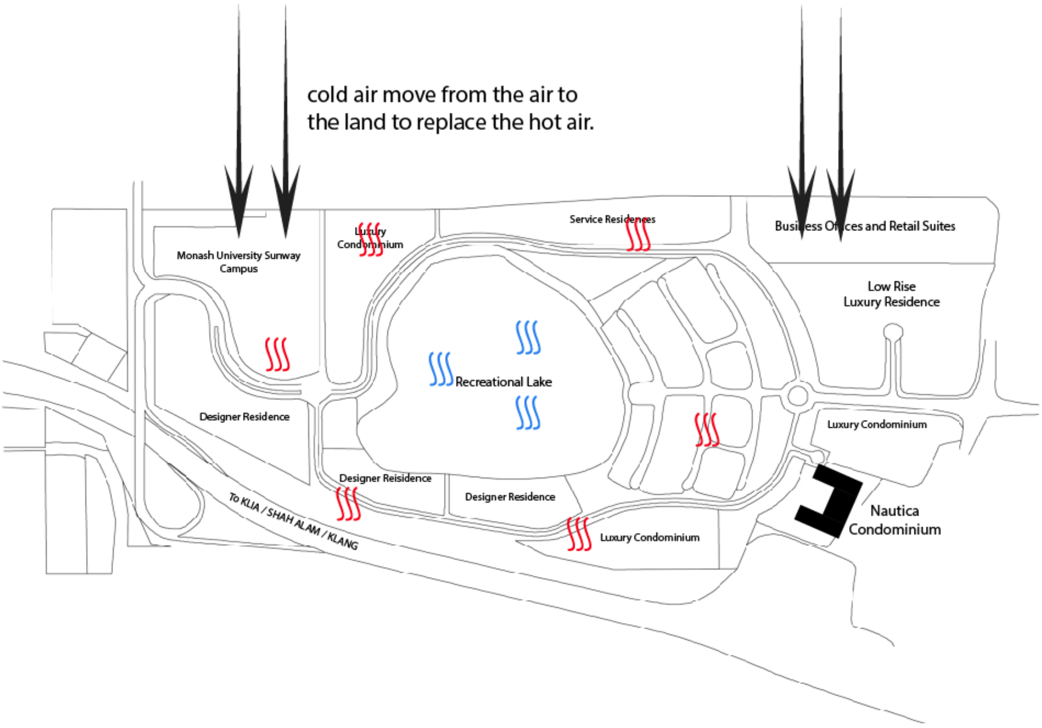
The building faces the northwest and southwest directions. The southwest facade is blocked by another condominium block. There is also no wind blowing to the northeast direction. Hence, no wind goes into the unit through the windows facing southwest. The northwest facade is not blocked at all. Hence, wind blowing to the southeast direction can enter the unit directly if the windows are opened.

Monthly wind analysis for Kuala Lumpur September 2013

The monthly wind rose diagram shows differences to that of the three days. The highest frequency of the wind blow is to the southwest direction. We can see from the diagram that there is no wind blowing to the direction of the openings of the apartment unit. Hence, the orientation of the unit is not very good.

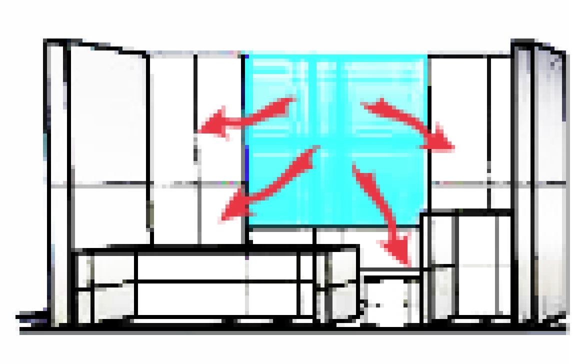
Air movement

The site is very near to a lake. According to MS 1525, water has a higher specific heat than land, and is cooler during the day and warmer at night compared to the land. At such, when the land is warmer than the water, cool air would move to the land, creating an offshore breeze. This can bring the temperature down during the day.


cold air move from the air to
the land to replace the hot air.
Monash University Sunway Campus
Luxury Condominium
Service Residences
Business Offices and Retail Suites
Low Rise Luxury Residence
Recreational Lake
Designer Residence
Luxury Condominium
Designer Reisidence
Designer Residence
Luxury Condominium
Nautica Condominium
To KLIA / SHAH ALAM / KLANG

Ventilation

Ventilation is crucial in every building to provide the user with fresh air. Without fresh air, one would feel discomfort and also sick. Moving air also helps to cool the interior of a building.

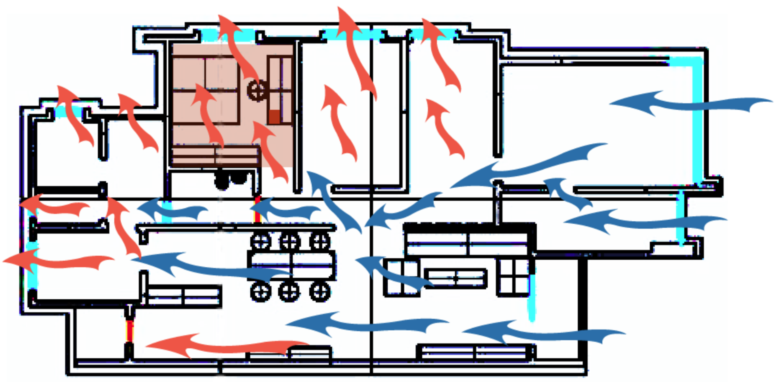


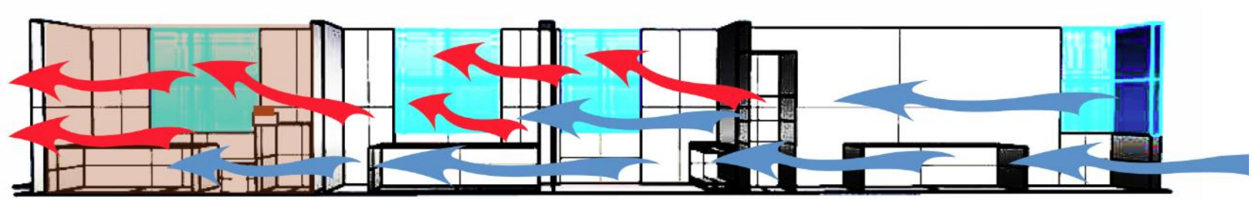
Natural Ventilation

Inside the apartment unit, wind blows in through the northwest facade, and it circulates in the inside, before released out again through windows and door. The three sides of the apartment are ventilated and one side is a solid wall with no opening.

Stack ventilation is not shown in this case as out site has only one floor. Cross ventilation is the main method of air transfer here. The presence of windows and doors facing different directions allow the wind to blow into the building from an entrance and go out through another exit.

During the data recording, only one of the windows is opened, thus cross ventilation does not occur. Only single sided ventilation is occurring, and it does not really ventilate the building well. If the windows and doors were all opened, air would move from higher to lower pressure in or out of the building, making the internal and external conditions almost the same, as shown in the following diagrams.

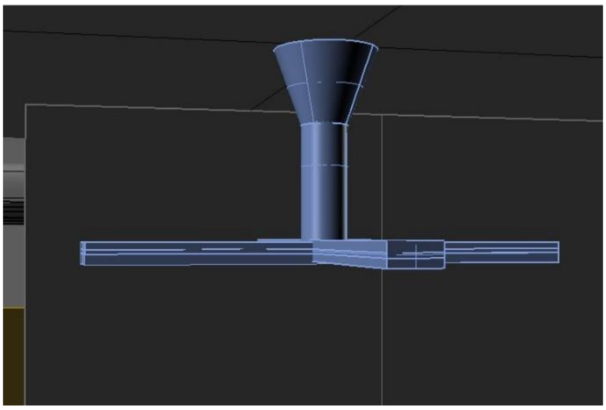


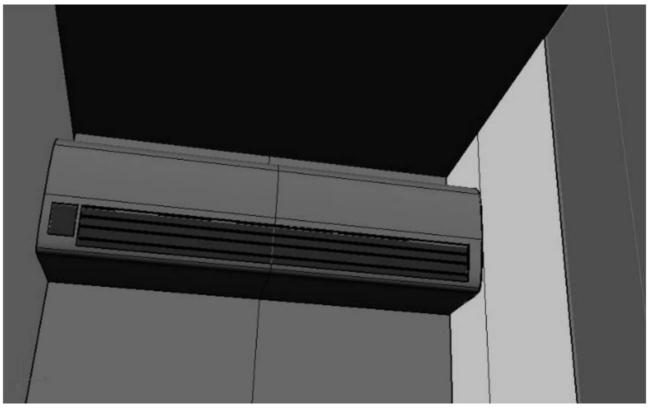


Wind circulation when all fenestrations are opened.

Simulated Ventilation

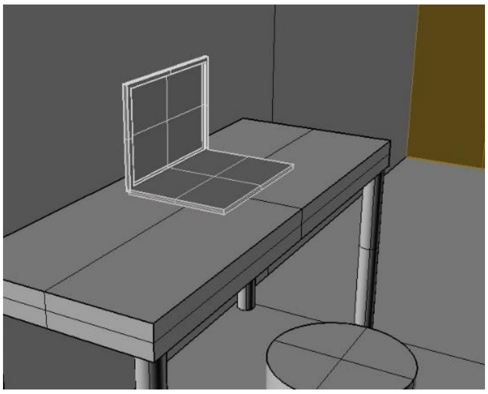
Simulated ventilation is provided by the fan and air conditioner. Whilst the latter is not used during the data recording, the fan is used every night while sleeping to help circulate the air and creates wind flow, to make the interior comfortable when the windows are closed.



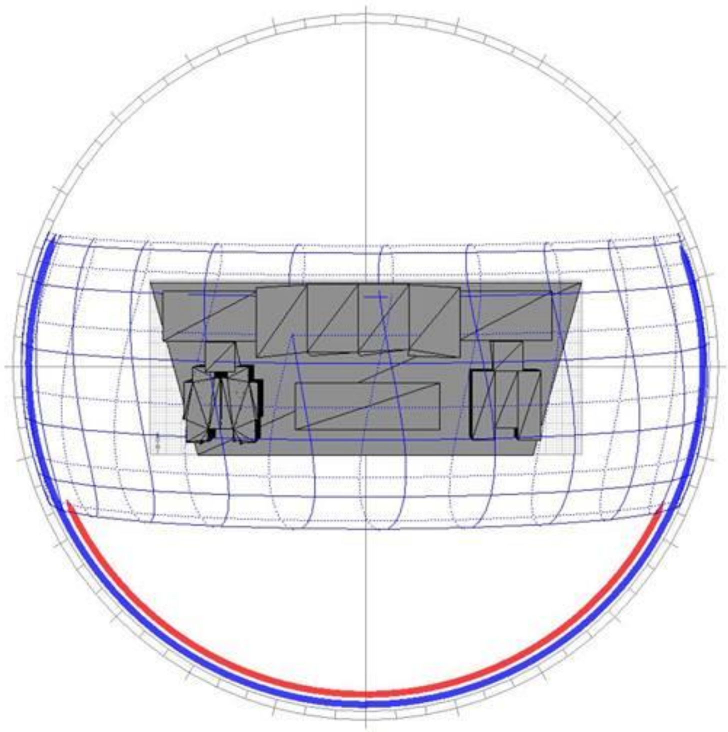


Appliances

With the lack of human activity in the space, electrical appliance is another factor that generates heat and is often used by the user. Electrical appliances such as chargers, laptop and hair drier are some of the thermal contributors. The setting of the data logger is not far away from the multiple electric sockets, this results in direct transfer of heat. Based on the activity of the user charging of mobiles and laptops are mostly used apart from lighting that was constantly used during the nighttime.

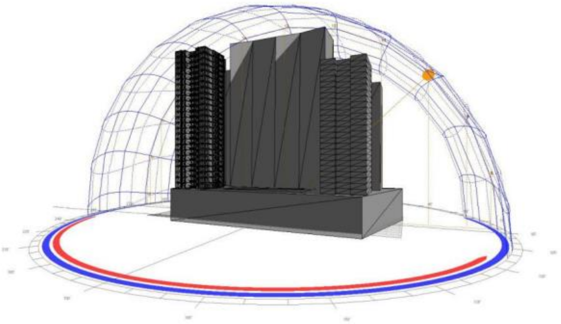


Sun Analysis



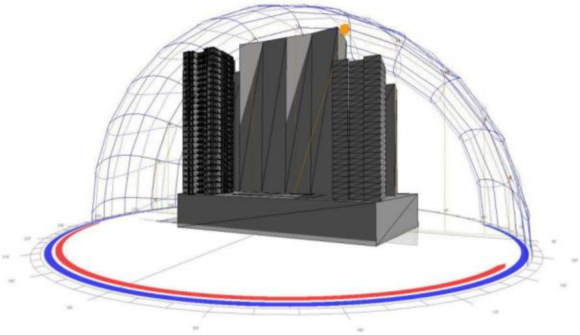
The space under investigation has fenestration facing south west. This receives the strongest radiant heat from the sun from 2:00pm until 3:30pm. The thermal comfort of the space during this time is low as the sun rays penetrate through the window. In the morning, as the sun rises from the east to the west, the sun rays are blocked by the block opposite the room, casting a shadow on the room. Therefore, less thermal heat is absorbed by the concrete walls and glass windows. Simultaneously, the warm air will passage out to external space to neutralize the internal conditions.

Sun Pathway



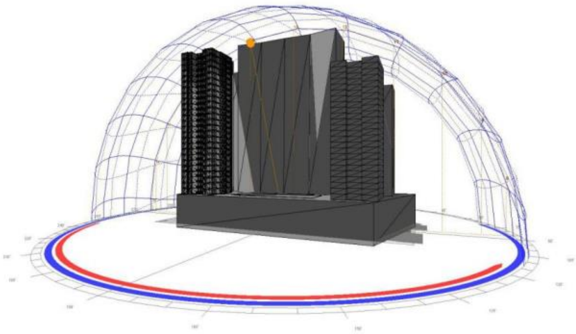
At 10:00am in the morning, the space doesn't receive any direct sunlight as it shaded by the other apartment located opposite the building where the space is located.

11 September, 10:00am



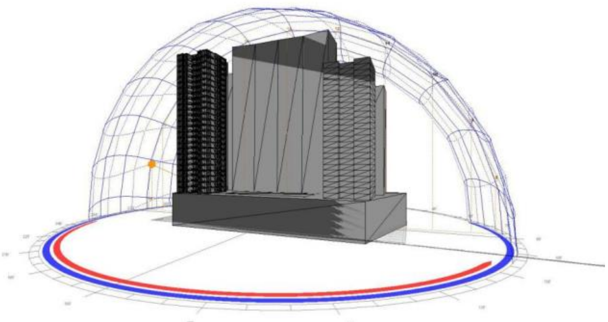
As the sun rises higher, we could see it begin to shine some part of the building, which previously shaded yet, none of them reached the room directly on this month. At this time around, the space is at advantage, as it didn't receive any direct sunlight, keeping the space cool when it's at the hottest.

11 September, 12:00pm



At 2:00pm, the sun located directly above the apartment, personal experience told that light has started to come in through the room window, though the use of awning has made the room able to block some of the light in, keeping the room in comfort temperature zone.

12 September, 2:00pm



The external temperature began to cool down as the sun is set, no more light is seen to enter the room directly. The material started to release heat absorbed from the afternoon sun resulting in slight decrease in temperature inside the room.

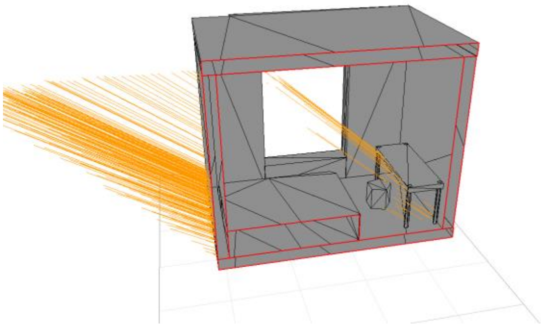
12 September, 6:00pm

Solar Radiation

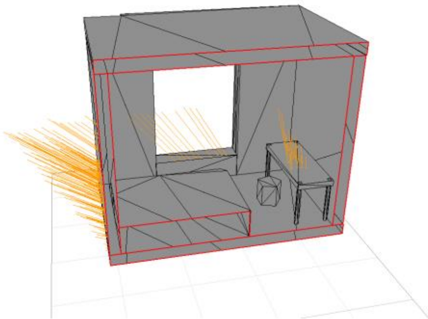
Solar radiation is the thermal energy emitted by the sun which is received from all directions in the form of electromagnetic waves. The thermal performance of a building will influence how much solar radiation will affect interior spaces. Some materials absorb and store heat more efficiently than others, thus affecting the overall thermal comfort of the space.

Since the space being investigated is located in an apartment unit, only the south west and North West direction is exposed to solar radiation, as the other facades are adjacent apartment units. The space being investigated is facing south west direction. In the morning, sunrays are blocked with the presence of other block. Only from noon until the evening will the sunrays enter through the window of the room, eventually heating it up. With the aid of exterior shading device such as the awning, and interior shading device such as the curtains, the internal space is shaded from direct sunlight.

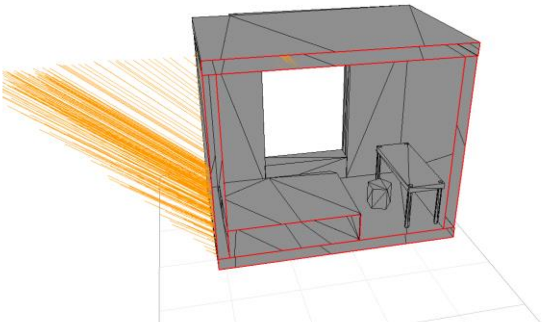
Unlike houses, the absence of roof will decrease the thermal transfer to the unit, over hung awning over the window helps to shade during the noon where the sun strikes vertically with the highest thermal radiation. Solar radiation are transmitted through walls as well. When the incident rays strikes, the wall absorbed and stored some radiation while the others are reflected back.



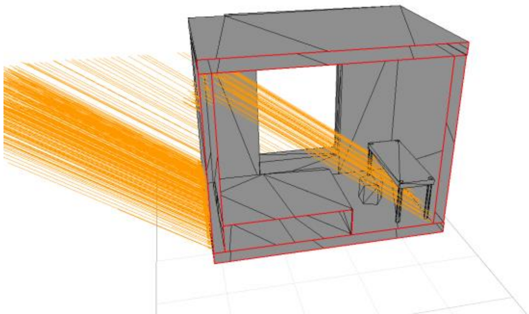
21 March 10:00am (Spring Equinox)



21 June 10:00am (Summer Solstice)

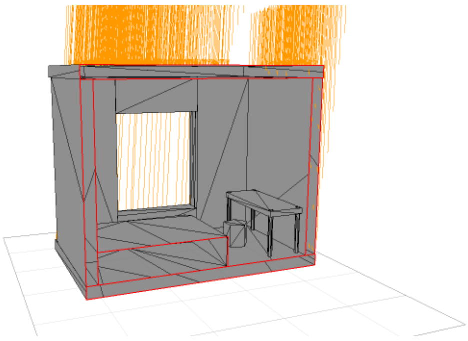


21 September 10:00am (Autumn Equinox)

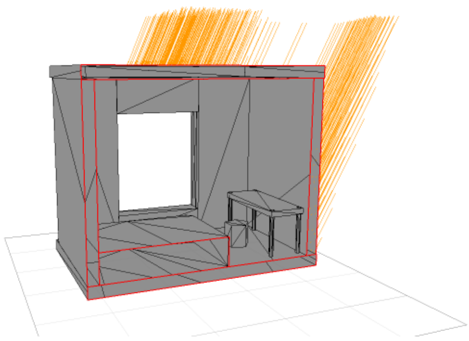


21 December 10:00am (Winter Solstice)

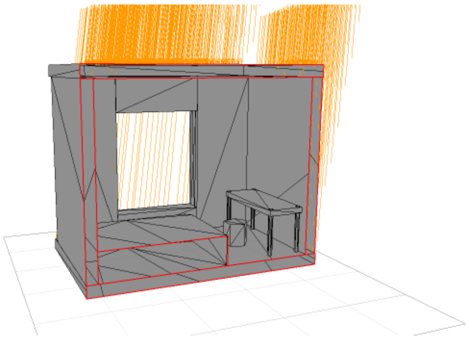
The diagrams shows the solar radiation at 10:00am at different days during the year for the space that is being analysed. In the morning, the sun rays do not penetrate through to enter the space. The revolution of the earth throughout the year means that different dates equates to a different direction of rays. Sun radiations are shown to indicate the direction of the sun. Since it’s a high rise building other rooms stop sun radiation to pass through.



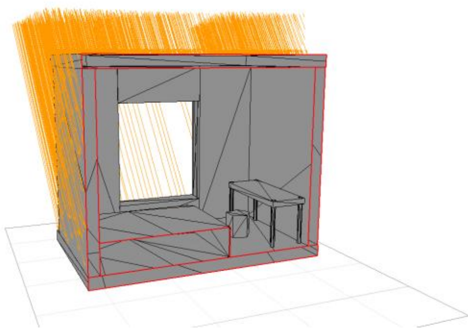
21 March 2:00pm (Spring Equinox)



21 June 2:00pm (Summer Solstice)

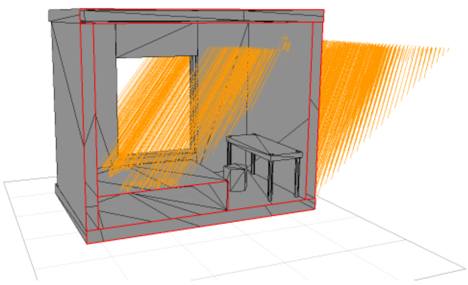


21 September 2:00pm (Autumn Equinox)

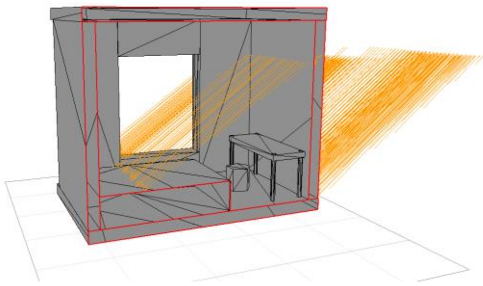


21 December 2:00pm (Winter Solstice)

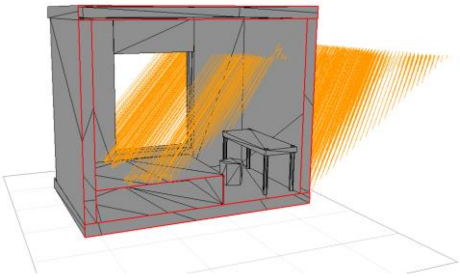
At 2:00pm, sun rays partially penetrate through Sylvia's room when the rays pass through the glass window. On the 21st June no sun rays enter the room, this happens due to the revolution of the earth that causes the sun rays to hit from a different angle.



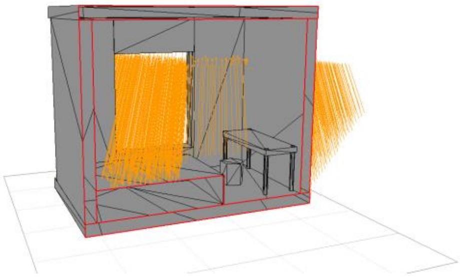
21 March 5:00pm (Spring Equinox)



21 June 5:00pm (Summer Solstice)



21 September 5:00pm (Autumn Equinox)



21 December 5:00pm (Winter Solstice)

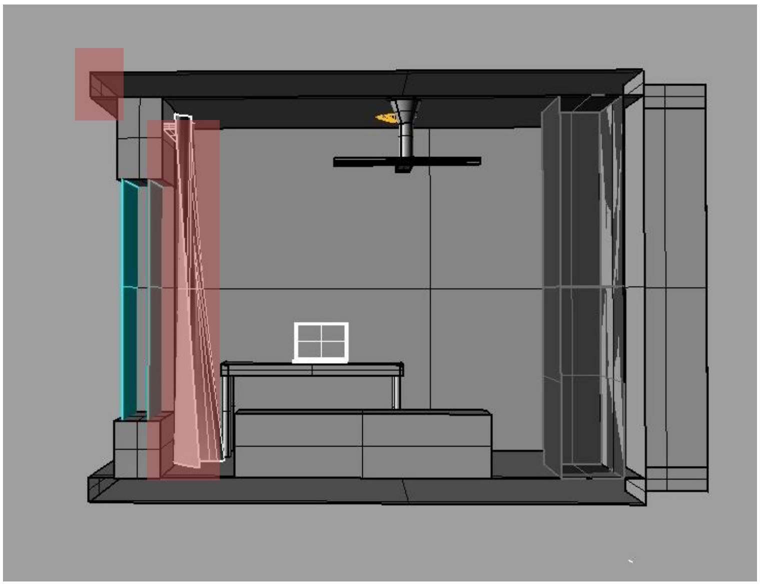
At 5:00pm is the strongest sun radiation into the space, however the evening sun does not radiate as much heat as the afternoon sun, therefore the space will not absorb that much heat. Moreover internal shading device is efficient in hindering the sun rays. This influences the internal temperature and relative humidity to be relatively constant.

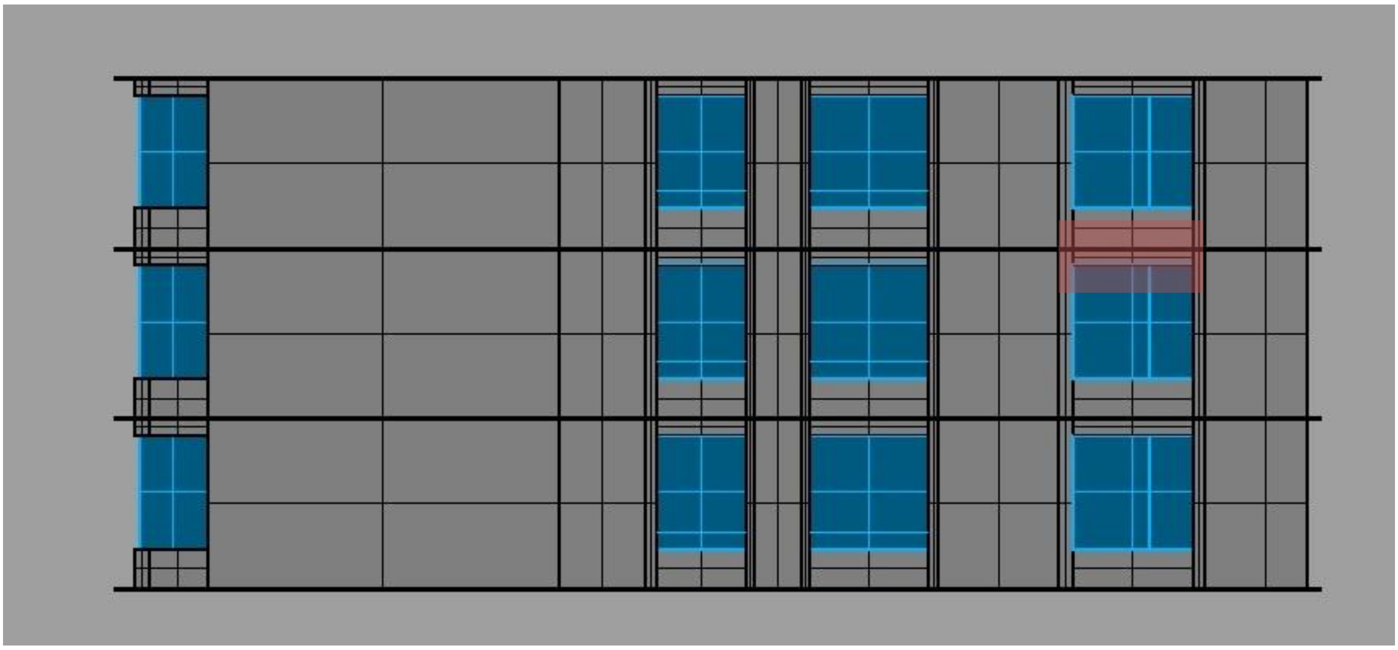
Building Design

Shading devices

Shading devices can be implemented in the exterior as well as the interior space to limit the heat gain in the internal area caused by solar radiation. Horizontal sunshades are the most common for high rise buildings. Attached above window awnings, they help prevent solar radiation from excessively heating the internal space when the sun is directly above the building.

Curtains are commonly used for internal shading, not only to prevent sunlight and solar radiation, it filters the amount of rays entering. Curtains do not stop heat from entering, though it does block it partially, trapping the heat between window and the curtain. Moreover with the double glazed windows, heat conduction is slowed down.

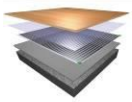




Building Materials

Human perception of thermal comfort is an expression to express how the occupant of a space may feel when using the space in relation to its temperature and relative humidity. Building material (K-value, U-value and R-value) has different effect in heat gain and thermal environment in a space. The main function of thermal insulation is to reduce heat transfer and exchange between a surface and environment which is known as low value for thermal conductivity. The lower the material thermal conductivity, the greater the ability to insulate material.

1. Sliding Mirror Closet
2. Roller Blind
3. White Finishes Painting
4. Aluminum Casement Window
5. Wood Solid Flush Door
6. Concrete Wall
7. Resilient Rubber Sheet Flooring
8. Faux Leather Bed

Material	Details	U-Value	Description
Sliding Mirror Closet	Mirror: 2.85cm	0.78	Mirror surface closet received direct sunlight from the East penetrate in will absorbs most of the light and reflected back.
White Finishes Painting	Thickness: 0.2cm	0.027	The whole room is applied white paint finishes at both exterior and interior. There is no insulation between the wall to block the heat from exterior as the paint is applied as topcoat on concrete wall.
Concrete Wall	Thickness: 25cm	1.33	Concrete has high thermal mass where it can absorb heat to keep the interior of a building cool throughout the day. The East Wall emits more heats as it experience most heat transfer from 8am until 5pm. Heat absorbs and transfer will slowly releasing during night time.
Wood Solid Flush Door	Thickness : 0.44cm	2.17	Wood Solid door has high u-value but it is shed by closet aside therefore, less exposure to sunlight, low heat pass through, low u-value.
Faux Leather Bed	Synthetic Leather Thickness: 0.20cm	0.14	Leather material and black colour tends to absorb heat and thus it gets much hotter in from direct heat. Besides, black colour absence of colours, therefore, it will absorb more heat and light penetrated.
Resilient Sheet Flooring	Dimension : 0.38cmx0.30cm(per sheet) 0.05cm, 30% PVC binder contain	1.23	 11 September, 6pm The flooring of room are covered with resilient flooring sheet which has medium thermal

			conductivity. It doesn’t absorb much of light as it has blocked by bed. Therefore, most heat absorb are from live load and electronic application.
Aluminium Casement Window	0.30m insulation	1.80	Aluminium Vinyl Casement reduce transfer heat. When windows are closed, air Infiltration through space cracks around window and other opening also ventilate interior.
Double Pane Glazing	0.28cm Fitted Low-E Coating, 1.4’’ air space	1.69	Double Pane glass insulate to avoid the heating from exterior into interior as a gas fill space of argon and krypton help to cut down the transfer heat where the glass has relatively high u-value as no layer of tint apply on the surface yet the window if facing to East, direct sunlight shine from 8am until 5pm.
White Roller Blind	Dimension: 200cm long x 190cm width x 0.2cm thick		Roller Blind is installed for shading the direct sunlight penetrates in during day-time. Roller blind is a good light control but it doesn’t affect heat thermal inside the room.

Maximum Internal Temperature Analysis

The highest reading on each day.

Date	Time	Internal Temperature(°C)	External Temperature(°C)	Internal RH	External RH	Observation	Comfort level
Day 1 (12/9)	21:01	28.4	28.0	76.5	79.0	Charger, Laptop, Light and Fan is **On**, Window **Closed**.	Frosty
Day 2 (13/9)	8:01	28.1	25.0	76.7	94.0	Charger, Laptop is **On** Door and window are **Open**.	Pleasant
Day 3 (14/9)	5:01	28.1	25.0	76.3	94.0	Door and window are **closed**. Fan is **On**.	Discomfor t

Analysis

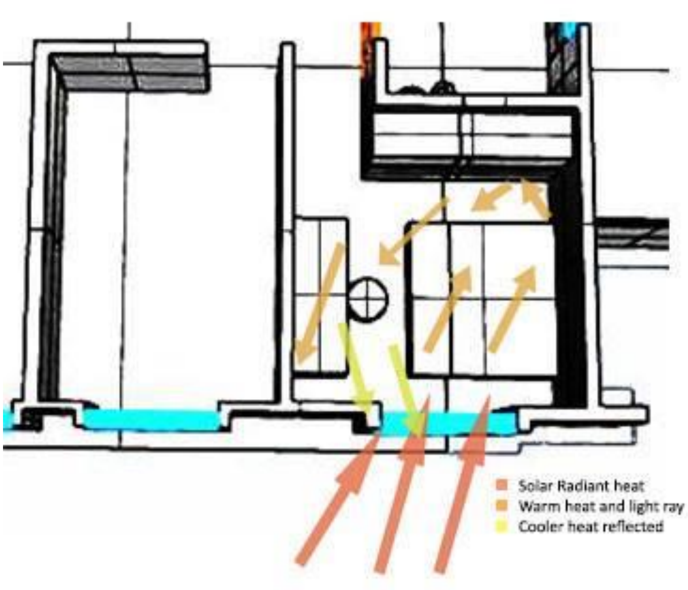
Day 1, Night:

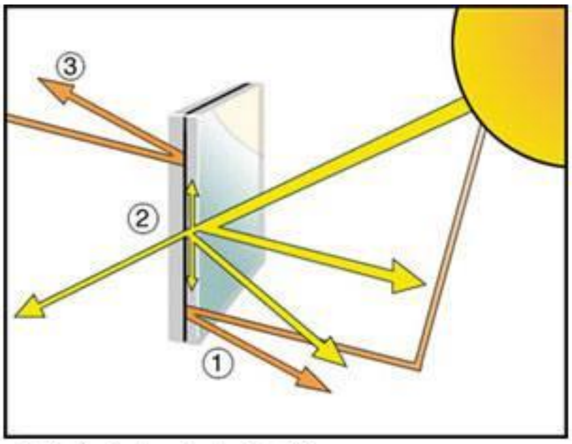
- Human produces metabolic heat from body through exhalation. As Sylvia was doing assignment in her room, therefore, more heat she has produces.
- Internal temperature at night turn the highest as electrical product such as laptop, light and charging phone were on which produces radiant heats to the environment. These causes the internal room feels frowstier and uncomfortable. Fan was switched on to increase the air movement and self-comfort when room's door and window were closed.
- In the sense of environment material, concrete wall has low passage of heat moving through therefore, interior temperature are warmer even though the exterior has high humidity level.

Day 2, Day-time:

- No-one in the room that produces metabolic heat but due to laptop was on and phone charging releases hot heats affect the reading of temperature and relative humidity.
- Big contrast of reading occurred of temperature and humidity when placement of Data Logger was near to laptop and charging phone, therefore, more heat radiant and low water vapour in the air easily being recorded.

- Light penetration to interior when the blind is not used and the external concrete wall with was facing to east received high amount of heats from morning until evening time. Heat environment occurred.
- Window and door were opened to allow cross ventilation in the room but the direct sunlight penetrated in had being reflected among mirror closet facing to window and white finishes wall around. Heat environment occurred.





1. Reflected solar heat in the space
2. Light ray is reflected from mirror closet to entire space
3. Heat passage through the closet.

Day 3, Day-time:

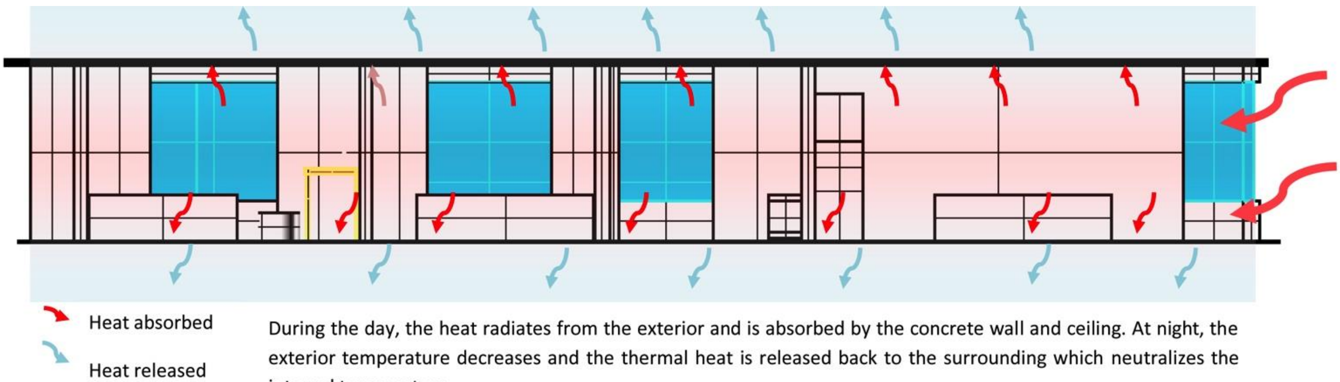
- No electrical devices were on but the reading of internal temperature and humidity were contrasted even though fan was on to ventilate the enclose space.
- Sylvia was sleeping had produces metabolic heat through exhalation and light on for 9 hours continuously had produces radiant heat in the air.
- Low humidity in interior as concrete wall with no insulation has slow passage of air transfer from exterior to interior even though the humidity were highest between these 3 day.
- When window and door were closed, small amount of exterior air able to ventilate in through air infiltration of aluminium casement window.

Thermal Mass

Thermal mass is a term to describe the ability of a material to absorb, store and release heat at a later time. This figure proves that the materials used to cover the space have effectively maintained the interior temperature at a relatively constant level, providing a good barrier from the exterior unstable conditions. The biggest factor that influenced the constant level of the interior space is the heavyweight construction material which is considered to have high thermal mass. Concrete, a high thermal mass construction material, is used as the floor and ceiling slab, as well as the wall. This means that it can reduce the heating and cooling energy requirements as compared to a construction made of low thermal mass materials such as timber flooring.

The double glazing used in the window is effective in reducing the amount of sunray which penetrates through from outside.

Adding thermal mass within the insulated building envelope helps reduce the extremes in external temperature from within the home, making the average internal temperature more constant year-round and the home more comfortable for its occupants.



During the day, the heat radiates from the exterior and is absorbed by the concrete wall and ceiling. At night, the exterior temperature decreases and the thermal heat is released back to the surrounding which neutralizes the internal temperature.

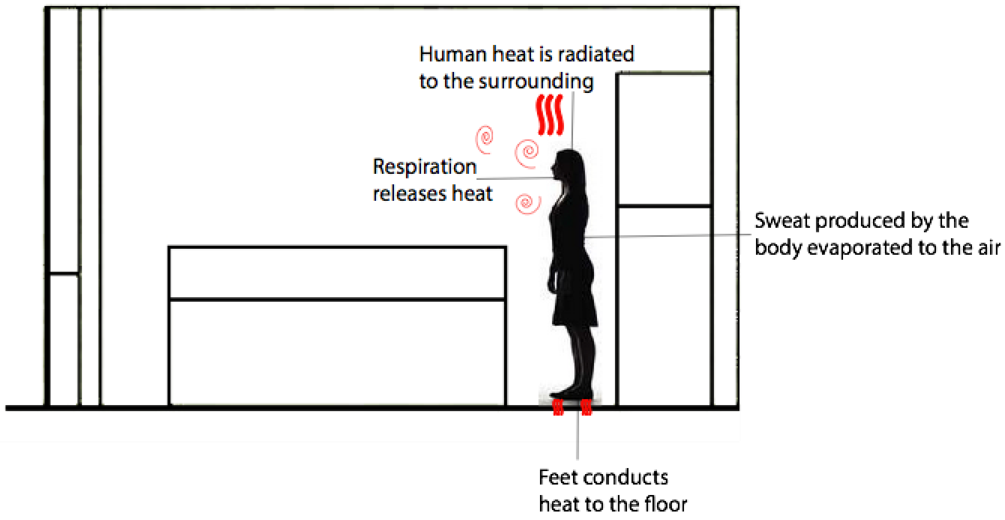
Human Factors

Clothing Insulation

The clothing the occupant wore inside the room was mainly a short sleeve T-shirt (of less than 0.1 Clo) and shorts (of less than 0.2 Clo). The room is quite stuffy and thus comfort is only experienced when using casual outfit. Wearing long sleeved shirts and long pants would result in discomfort and most of the time slight perspiration.

Physical Activities

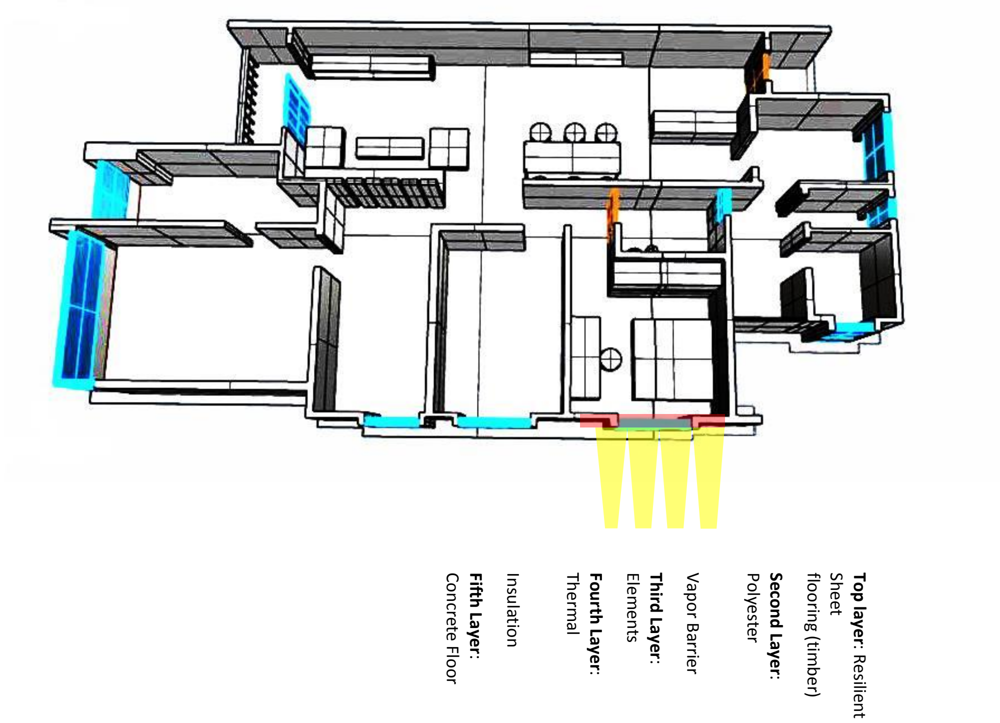
Human activities would always have an effect on the thermal comfort of a space. Heat is transferred from the body through radiation, conduction, convection and evaporation.



During the 73 hours of the recording, the occupant is mostly out, reaching home at around midnight just to shower and sleep. In the morning the windows are opened for a couple of hours, and some low non-exercise physical activity is carried out. This includes working in front of the laptop and reading. The door is opened the entire day except during the time the occupant is sleeping. The blind is rolled up most of the time, and only covers the windows during night time. The room is located very near to the bathroom, which is used twice daily for showering, and a few times for excretion. The whole unit is occupied by only one person, thus there is no much activities outside of the bedroom as well.

Possible Improvements

Shading

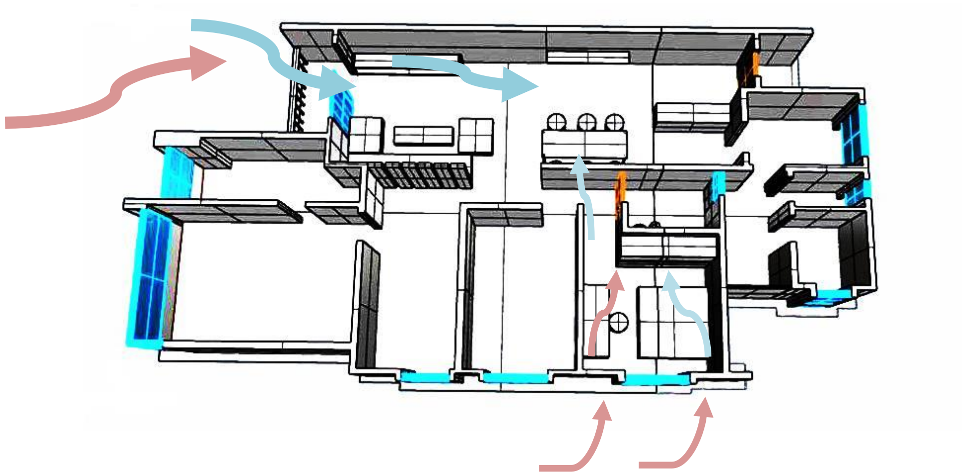


A correct choice of building material would help to minimise thermal heat gain in interior space and increase human thermal comfort to the environment.

MS 1525(2007) Facade Design: The exterior wall and cladding systems should be designed to provide an integrated solution for the provision of view, daylight control, passive and active solar energy collection.

Critic: As the room's window are facing to South-West engross high amount of solar radiant through window causes warm and uncomfortable feeling in interior during day-time. Therefore, insulation or cladding system should added of interior surface or shade east-west facing walls with large roof overhangs or maybe plant shading trees to decrease amount of heat gain.

Ventilation



The process of changing air and remove unpleasant air inside to outside in order to keep interior air circulating and avoid stagnation of interior air. A good ventilation could increase human thermal comfort level.

UBBL (1985): 39. (1) "…shall be provided ventilation by means of one or more windows having a total area…shall have openings capable of allowing free uninterrupted passage of air..."

Due to room's window facing to South-West, user is tend to pull down roller blind to decrease amount of hot heat penetrated in, therefore, cross ventilation among warm air in interior and high humidity air at exterior are mostly happened in living room. Therefore, changing the shape or size of window and added egg crate window roof design hence change the direction of wind blowing in and lower amount of solar radiant penetrated in.

Conclusion

The temperature is within comfort level, while the relative humidity is not. The air flow and thus wind movement around the water body helps to cool down the temperature. However, the water body, in our case the lake, brings the humidity up. Even though the condition inside the room is not perfectly within the comfort zone, it is still habitable as cross ventilation can occur when the windows are opened. Cross ventilation allows fresh air circulation. The room is well shaded from sun rays, and its facade is casted by sunlight only at past noon. The material of the room can absorb heat during the day to prevent heat gain of the interior and release it during the night to avoid temperature drop.

We concluded that human has different perceptions of comfort level. Even though the room is analysed to be out of the comfort zone, the inhabitant of the house says otherwise. We learnt about the different factors of the comfort zone, which would be helpful for applications in the upcoming projects.

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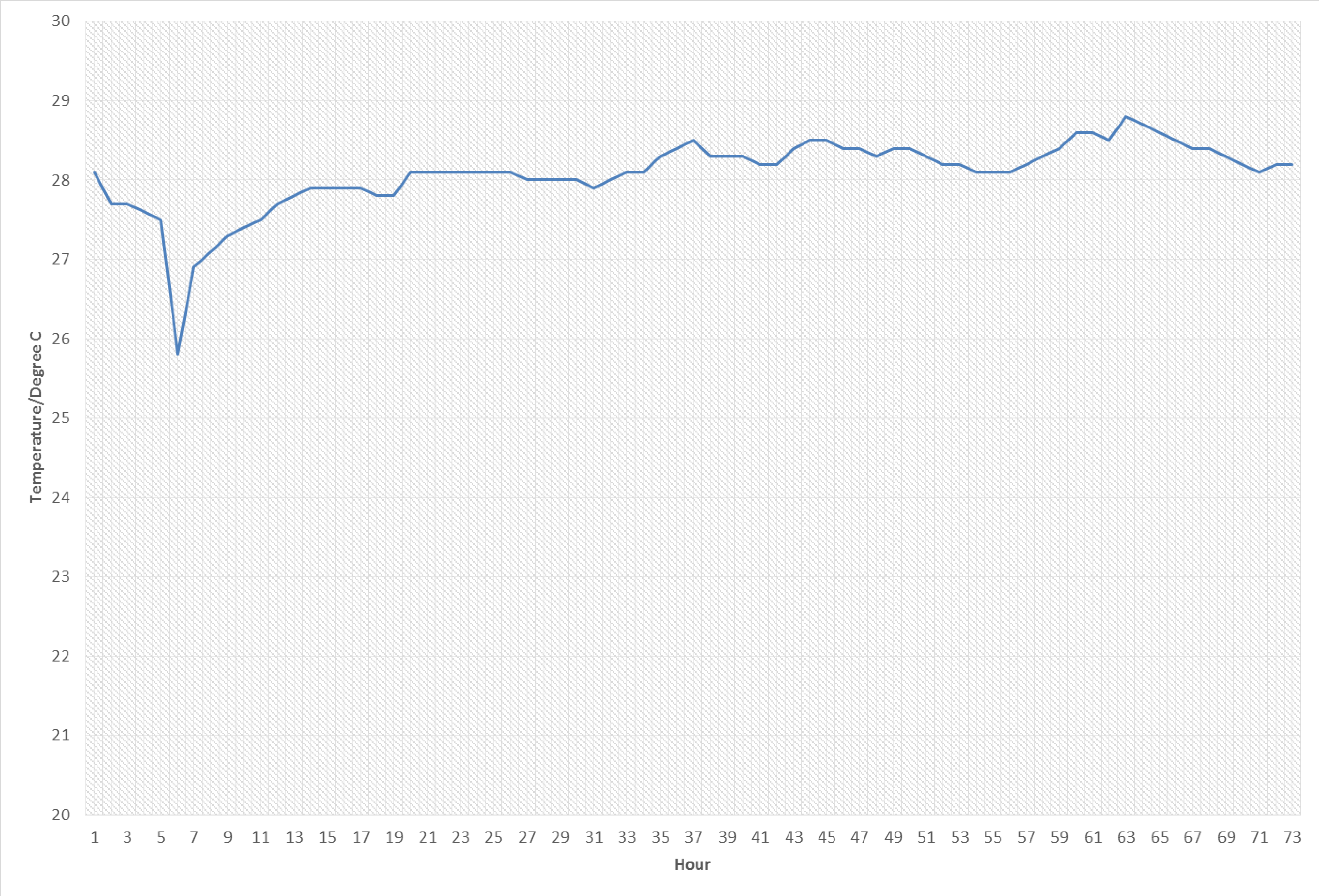
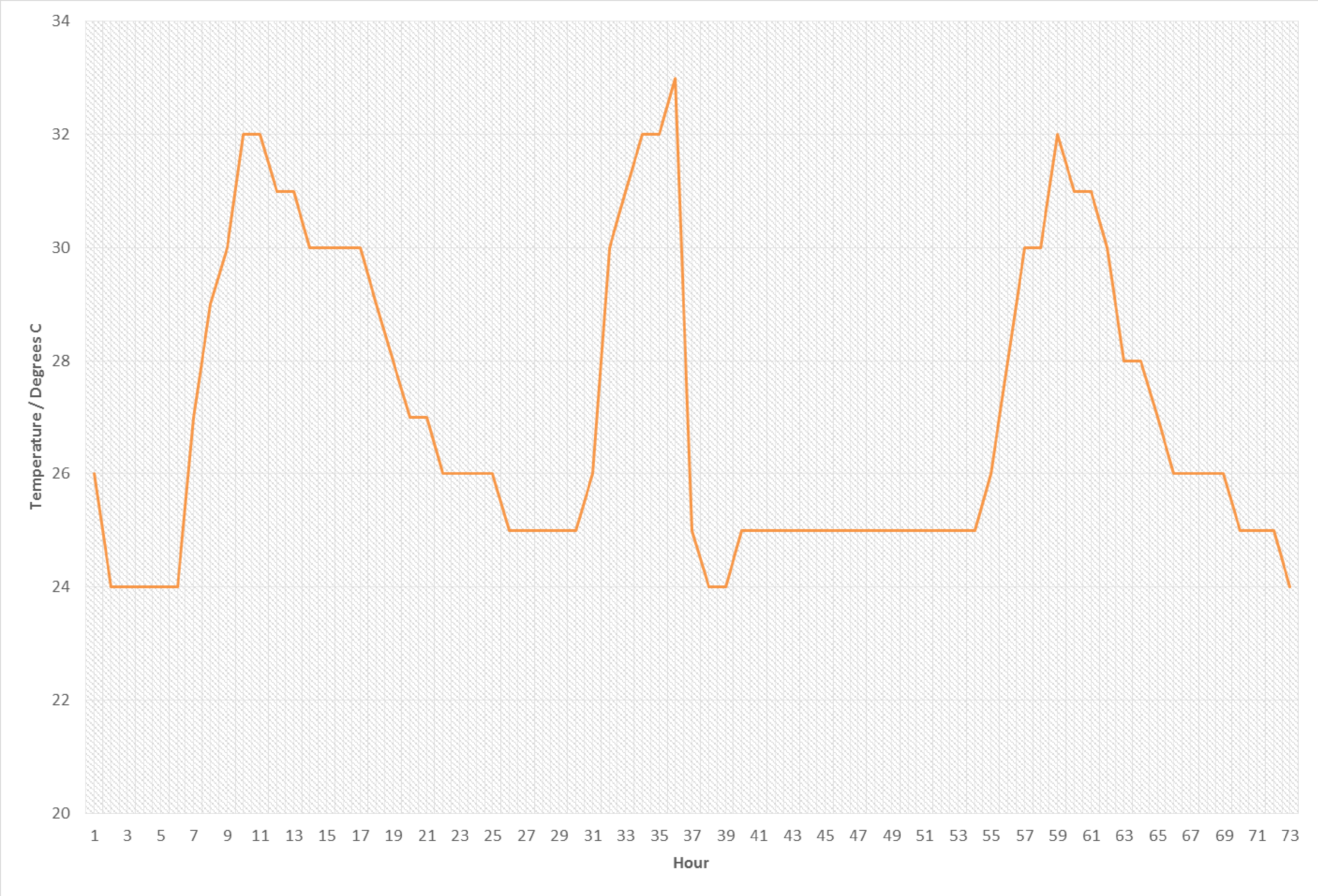
Appendix

Relative Humidity (%) Temperature (°C)	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%
21 °C	29	29	28	27	27	26	26	24	24	23	23	22					
22 °C	31	29	29	28	28	27	26	26	24	24	23	23					
23 °C	33	32	32	31	30	29	28	27	27	26	25	24	23				
24 °C	35	34	33	33	32	31	30	29	28	28	27	26	26	25			
25 °C	37	36	35	34	33	33	32	31	30	29	28	27	27	26			
26 °C	39	38	37	36	35	34	33	32	31	31	29	28	28	27			
27 °C	41	40	39	38	37	36	35	34	33	32	31	30	29	28	28		
28 °C	43	42	41	41	39	38	37	36	35	34	33	32	31	29	28		
29 °C	46	45	44	43	42	41	39	38	37	36	34	33	32	31	30		
30 °C	48	47	46	44	43	42	41	40	38	37	36	35	34	33	31	31	
31 °C	50	49	48	46	45	44	43	41	40	39	38	36	35	34	33	31	
32 °C	52	51	50	49	47	46	45	43	42	41	39	38	37	36	34	33	
33 °C	55	54	52	51	50	48	47	46	44	43	42	40	38	37	36	34	
34 °C	58	57	55	53	52	51	49	48	47	45	43	42	41	39	37	36	
35 °C		58	57	56	54	52	51	49	48	47	45	43	42	41	38	37	
36 °C			58	57	56	54	53	51	50	48	47	45	43	42	40	38	
37 °C					58	57	55	53	51	50	49	47	45	43	42	40	
38 °C							57	56	54	52	51	49	47	46	43	42	40

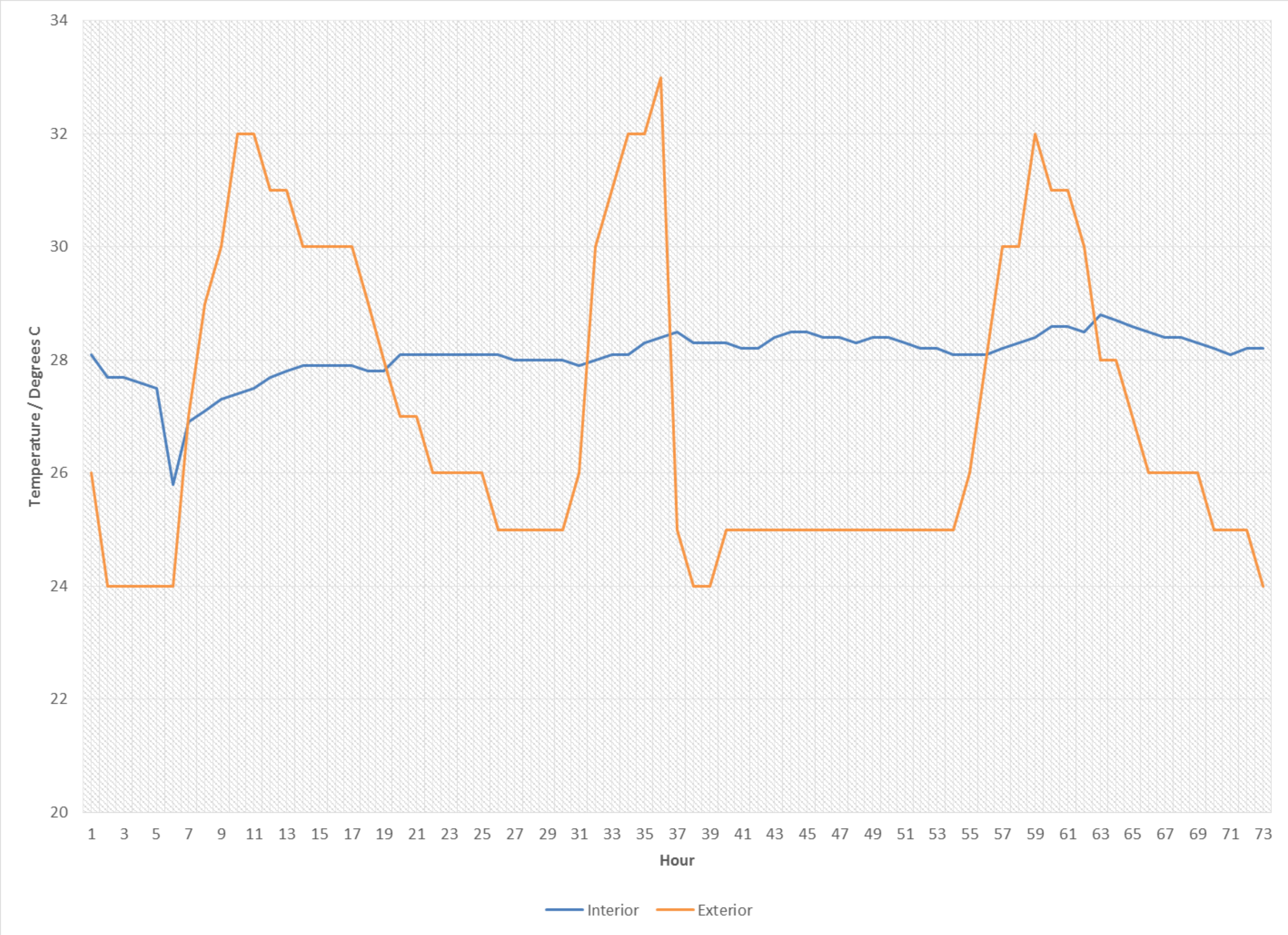
Humidex	Degree of Comfort
20 - 29	No discomfort
30 - 39	Some discomfort
40 - 45	Great discomfort; avoid exertion
46 and over	Dangerous; possible heat stroke



30
29
28
27
26
25
24
23
22
21
20
Temperature/Degree C
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour



34
32
30
28
26
24
22
20
Temperature / Degrees C
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour


34
32
30
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26
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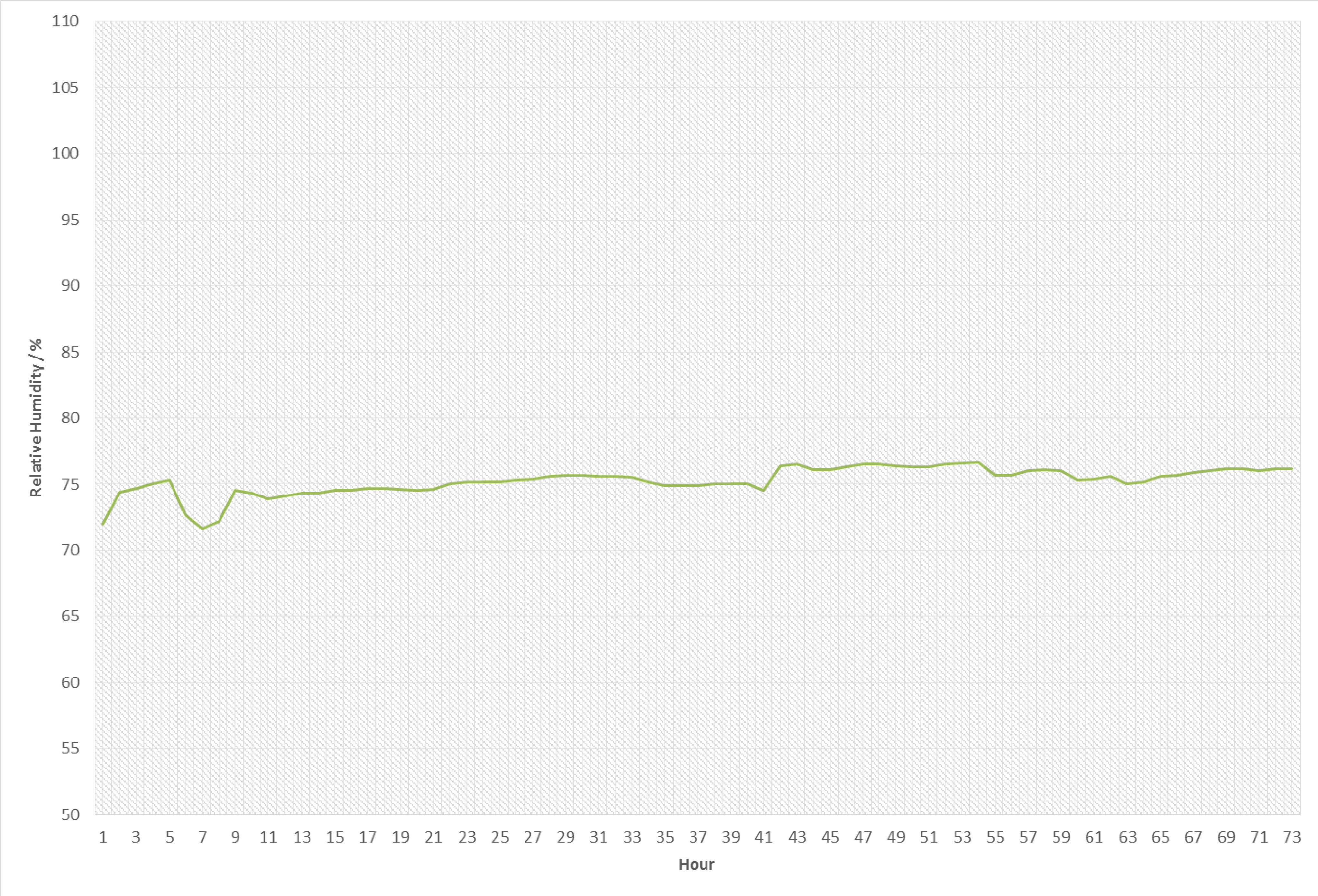
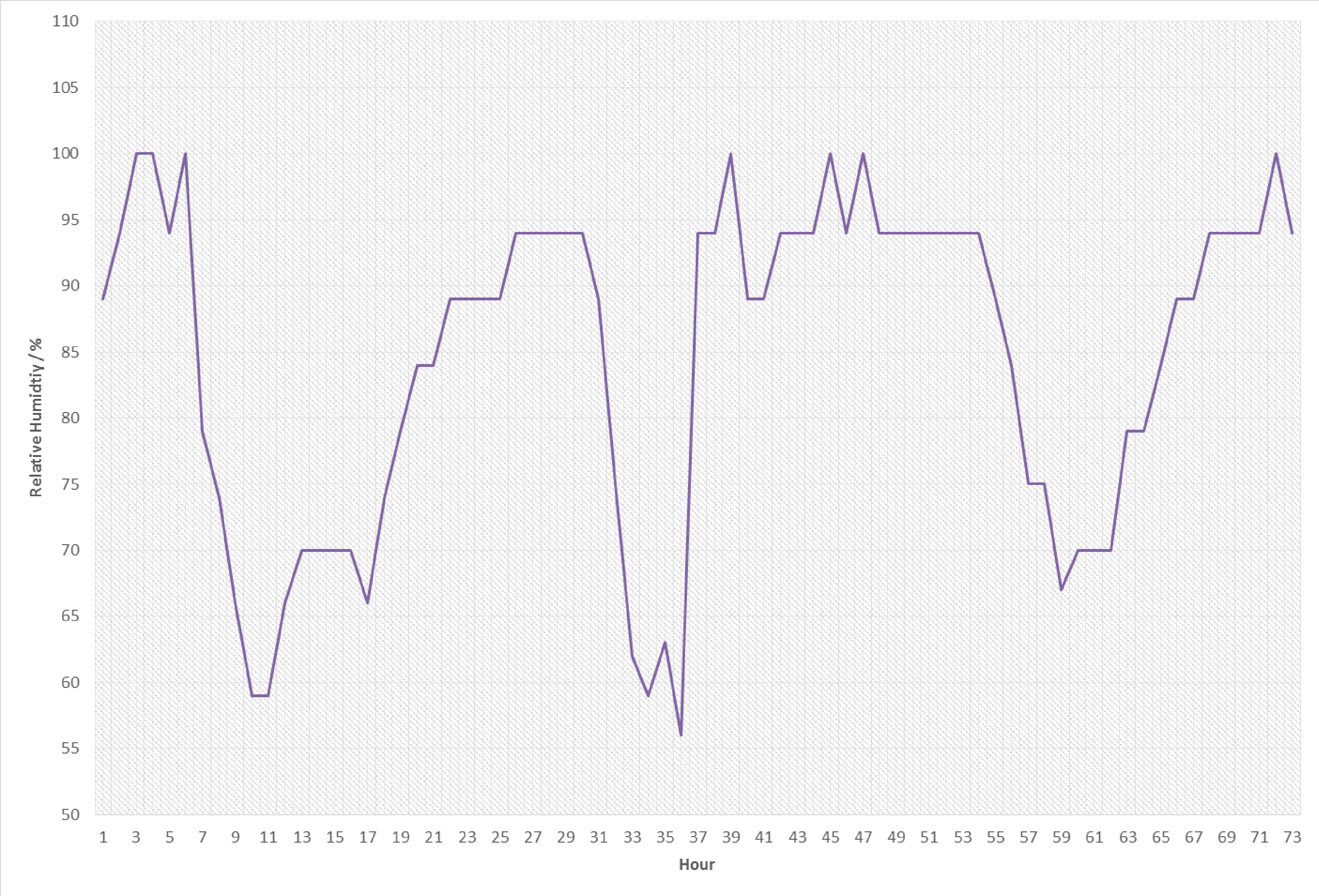
22
20
Temperature / Degrees C
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour
Interior
Exterior



Relative Humidity / %
110
105
100
95
90
85
80
75
70
65
60
55
50
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour



110
105
100
95
90
85
80
75
70
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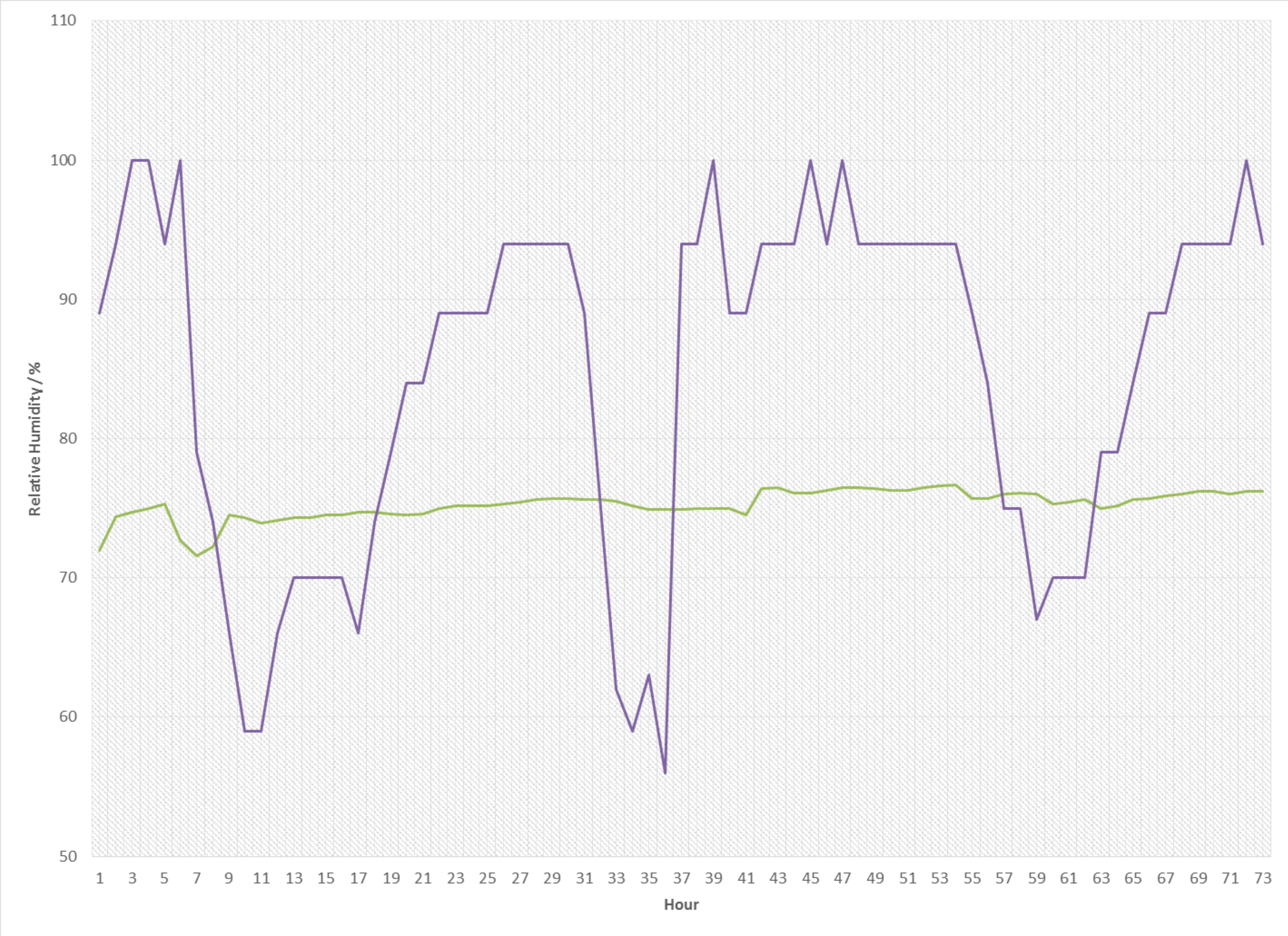
50
Relative Humidtiy / %
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour



110
100
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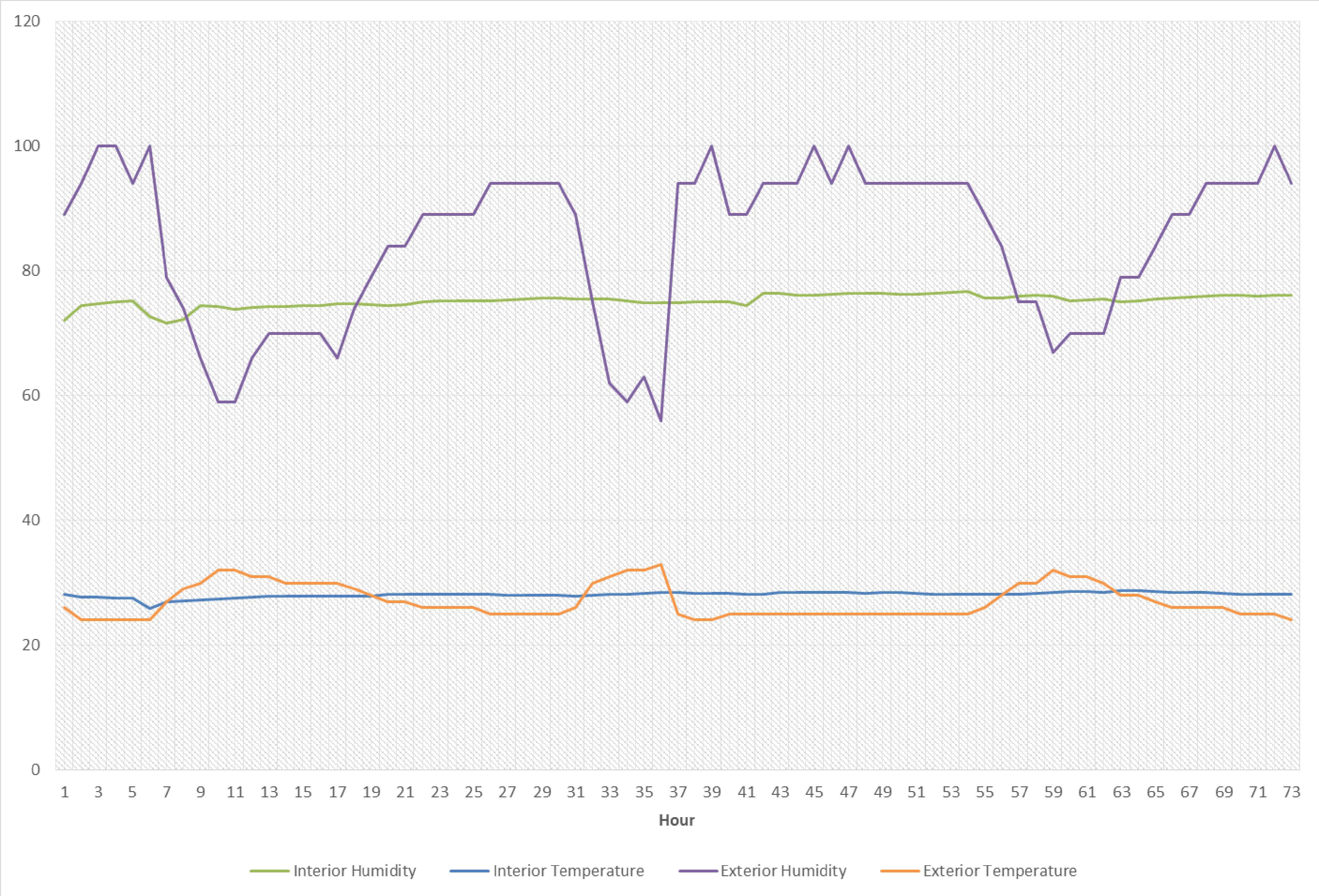
Relative Humidity / %
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour



120
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73
Hour
Interior Humidity
Interior Temperature
Exterior Humidity
Exterior Temperature

Time/appliances		Door	Window	People	Fan	Charger	Laptop	Light	Hair dryer	bathroom
Thursday	3:00 AM	▯	▯	1	▯	▯	▯	▯	▯	▯
	4:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	5:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	6:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	7:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	8:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	9:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	10:00 AM	▯	▯	0	▯	▯	▯	▯	▯	▯
	11:00 AM	▯	▯	0	▯	▯	▯	▯	▯	▯
	12:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	1:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	2:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	3:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	4:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	5:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	6:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	7:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	8:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	9:00 PM	▯	▯	0	▯	▯	▯	▯	▯	▯
	10:00 PM	▯	▯	1	▯	▯	▯	▯	▯	▯
	11:00 PM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	12:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
Friday	1:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	2:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	3:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	4:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	5:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	6:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	7:00 AM	▯	▯	sleep	▯	▯	▯	▯	▯	▯
	8:00 AM	▯	▯	0	▯	▯	▯	▯	▯	▯
	9:00 AM	▯	▯	1	▯	▯	▯	▯	▯	▯

10:00 AM	□	□	0	□	□	□	□	□	□
11:00 AM	□	□	0	□	□	□	□	□	□
12:00 PM	□	□	0	□	□	□	□	□	□
1:00 PM	□	□	0	□	□	□	□	□	□
2:00 PM	□	□	0	□	□	□	□	□	□
3:00 PM	□	□	0	□	□	□	□	□	□
4:00 PM	□	□	0	□	□	□	□	□	□
5:00 PM	□	□	0	□	□	□	□	□	□
6:00 PM	□	□	0	□	□	□	□	□	□
7:00 PM	□	□	0	□	□	□	□	□	□
8:00 PM	□	□	0	□	□	□	□	□	□
9:00 PM	□	□	1	□	□	□	□	□	□
10:00 PM	□	□	1	□	□	□	□	□	□
11:00 PM	□	□	1	□	□	□	□	□	□
12:00 AM	□	□	sleep	□	□	□	□	□	□
Saturday 1:00 AM	□	□	sleep	□	□	□	□	□	□
2:00 AM	□	□	sleep	□	□	□	□	□	□
3:00 AM	□	□	sleep	□	□	□	□	□	□
4:00 AM	□	□	sleep	□	□	□	□	□	□
5:00 AM	□	□	sleep	□	□	□	□	□	□
6:00 AM	□	□	sleep	□	□	□	□	□	□
7:00 AM	□	□	sleep	□	□	□	□	□	□
8:00 AM	□	□	0	□	□	□	□	□	□
9:00 AM	□	□	1	□	□	□	□	□	□
10:00 AM	□	□	0	□	□	□	□	□	□
11:00 AM	□	□	0	□	□	□	□	□	□
12:00 PM	□	□	0	□	□	□	□	□	□
1:00 PM	□	□	0	□	□	□	□	□	□
2:00 PM	□	□	0	□	□	□	□	□	□
3:00 PM	□	□	0	□	□	□	□	□	□
4:00 PM	□	□	0	□	□	□	□	□	□
5:00 PM	□	□	0	□	□	□	□	□	□

6:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
7:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
8:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
9:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
10:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
11:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
12:00 AM	☐	☐	0	☐	☐	☐	☐	☐	☐
11:00 PM	☐	☐	0	☐	☐	☐	☐	☐	☐
12:00 AM	☐	☐	0	☐	☐	☐	☐	☐	☐
Sunday 1:00 AM	☐	☐	1	☐	☐	☐	☐	☐	☐
2:00 AM	☐	☐	sleep	☐	☐	☐	☐	☐	☐
3:00 AM	☐	☐	sleep	☐	☐	☐	☐	☐	☐

Interior Data

Date	Time	Value	Unit	Value	Unit
9/12/2013	3:01:51	72	%RH	28.1	Degree C
9/12/2013	4:01:50	74.4	%RH	27.7	Degree C
9/12/2013	5:01:50	74.7	%RH	27.7	Degree C
9/12/2013	6:01:50	75	%RH	27.6	Degree C
9/12/2013	7:01:50	75.3	%RH	27.5	Degree C
9/12/2013	8:01:50	72.7	%RH	25.8	Degree C
9/12/2013	9:01:50	71.6	%RH	26.9	Degree C
9/12/2013	10:01:50	72.2	%RH	27.1	Degree C
9/12/2013	11:01:50	74.5	%RH	27.3	Degree C
9/12/2013	12:01:50	74.3	%RH	27.4	Degree C
9/12/2013	13:01:50	73.9	%RH	27.5	Degree C
9/12/2013	14:01:50	74.1	%RH	27.7	Degree C
9/12/2013	15:01:50	74.3	%RH	27.8	Degree C
9/12/2013	16:01:50	74.3	%RH	27.9	Degree C
9/12/2013	17:01:50	74.5	%RH	27.9	Degree C
9/12/2013	18:01:50	74.5	%RH	27.9	Degree C
9/12/2013	19:01:50	74.7	%RH	27.9	Degree C
9/12/2013	20:01:50	74.7	%RH	27.8	Degree C
9/12/2013	21:01:50	74.6	%RH	27.8	Degree C
9/12/2013	22:01:50	74.5	%RH	28.1	Degree C
9/12/2013	23:01:50	74.6	%RH	28.1	Degree C
9/13/2013	0:01:50	75	%RH	28.1	Degree C
9/13/2013	1:01:50	75.2	%RH	28.1	Degree C
9/13/2013	2:01:50	75.2	%RH	28.1	Degree C
9/13/2013	3:01:50	75.2	%RH	28.1	Degree C
9/13/2013	4:01:50	75.3	%RH	28.1	Degree C
9/13/2013	5:01:50	75.4	%RH	28	Degree C
9/13/2013	6:01:50	75.6	%RH	28	Degree C
9/13/2013	7:01:50	75.7	%RH	28	Degree C
9/13/2013	8:01:50	75.7	%RH	28	Degree C
9/13/2013	9:01:50	75.6	%RH	27.9	Degree C
9/13/2013	10:01:50	75.6	%RH	28	Degree C
9/13/2013	11:01:50	75.5	%RH	28.1	Degree C
9/13/2013	12:01:50	75.2	%RH	28.1	Degree C
9/13/2013	13:01:50	74.9	%RH	28.3	Degree C
9/13/2013	14:01:50	74.9	%RH	28.4	Degree C
9/13/2013	15:01:50	74.9	%RH	28.5	Degree C
9/13/2013	16:01:50	75	%RH	28.3	Degree C
9/13/2013	17:01:50	75	%RH	28.3	Degree C
9/13/2013	18:01:50	75	%RH	28.3	Degree C
9/13/2013	19:01:50	74.5	%RH	28.2	Degree C
9/13/2013	20:01:50	76.4	%RH	28.2	Degree C
9/13/2013	21:01:50	76.5	%RH	28.4	Degree C

9/13/2013	22:01:50	76.1	%RH	28.5	Degree C
9/13/2013	23:01:50	76.1	%RH	28.5	Degree C
9/14/2013	0:01:50	76.3	%RH	28.4	Degree C
9/14/2013	1:01:50	76.5	%RH	28.4	Degree C
9/14/2013	2:01:50	76.5	%RH	28.3	Degree C
9/14/2013	3:01:50	76.4	%RH	28.4	Degree C
9/14/2013	4:01:50	76.3	%RH	28.4	Degree C
9/14/2013	5:01:50	76.3	%RH	28.3	Degree C
9/14/2013	6:01:50	76.5	%RH	28.2	Degree C
9/14/2013	7:01:50	76.6	%RH	28.2	Degree C
9/14/2013	8:01:50	76.7	%RH	28.1	Degree C
9/14/2013	9:01:50	75.7	%RH	28.1	Degree C
9/14/2013	10:01:50	75.7	%RH	28.1	Degree C
9/14/2013	11:01:50	76	%RH	28.2	Degree C
9/14/2013	12:01:50	76.1	%RH	28.3	Degree C
9/14/2013	13:01:50	76	%RH	28.4	Degree C
9/14/2013	14:01:50	75.3	%RH	28.6	Degree C
9/14/2013	15:01:50	75.4	%RH	28.6	Degree C
9/14/2013	16:01:50	75.6	%RH	28.5	Degree C
9/14/2013	17:01:50	75	%RH	28.8	Degree C
9/14/2013	18:01:50	75.2	%RH	28.7	Degree C
9/14/2013	19:01:50	75.6	%RH	28.6	Degree C
9/14/2013	20:01:50	75.7	%RH	28.5	Degree C
9/14/2013	21:01:50	75.9	%RH	28.4	Degree C
9/14/2013	22:01:50	76	%RH	28.4	Degree C
9/14/2013	23:01:50	76.2	%RH	28.3	Degree C
9/15/2013	0:01:50	76.2	%RH	28.2	Degree C
9/15/2013	1:01:50	76	%RH	28.1	Degree C
9/15/2013	2:01:50	76.2	%RH	28.2	Degree C
9/15/2013	3:01:50	76.2	%RH	28.2	Degree C
9/15/2013	4:01:50	76.2	%RH	28.2	Degree C
9/15/2013	5:01:50	76.3	%RH	28.1	Degree C
9/15/2013	6:01:50	76.2	%RH	28.1	Degree C

Exterior Data

12 Sep	00:00	Passing clouds. Warm.	27 °C	4 km/h	→	89%	1010 millibars	9 km
12 Sep	01:00	Passing clouds. Warm.	27 °C	2 km/h	←	84%	1010 millibars	9 km
12 Sep	02:00	Partly cloudy. Warm.	26 °C	2 km/h	↙	94%	1009 millibars	9 km
12 Sep	03:00	Thunderstorms. Mostly cloudy. Warm.	26 °C	11 km/h	↘	89%	1009 millibars	7 km
12 Sep	04:00	Thunderstorms. Mostly cloudy. Mild.	24 °C	4 km/h	↑	94%	1009 millibars	7 km
12 Sep	05:00	Light rain. Mostly cloudy. Mild.	24 °C	4 km/h	←	100%	1009 millibars	7 km
12 Sep	06:00	Mostly cloudy. Mild.	24 °C	2 km/h	←	100%	1009 millibars	7 km
12 Sep	07:00	Partly cloudy. Mild.	24 °C	4 km/h	←	94%	1009 millibars	N/A
12 Sep	08:00	Broken clouds. Mild.	24 °C	4 km/h	←	100%	1009 millibars	N/A
12 Sep	09:00	Partly sunny. Warm.	27 °C	9 km/h	↖	79%	1010 millibars	N/A
12 Sep	10:00	Partly sunny. Warm.	29 °C	7 km/h	↖	74%	1011 millibars	N/A
12 Sep	11:00	Partly sunny. Warm.	30 °C	7 km/h	↑	66%	1010 millibars	N/A
12 Sep	12:00	Partly sunny. Hot.	32 °C	9 km/h	↖	59%	1010 millibars	N/A
12 Sep	13:00	Broken clouds. Hot.	32 °C	15 km/h	↑	59%	1009 millibars	N/A
12 Sep	14:00	Broken clouds. Warm.	31 °C	17 km/h	↑	66%	1009 millibars	N/A
12 Sep	15:00	Broken clouds. Warm.	31 °C	19 km/h	↖	70%	1008 millibars	N/A
12 Sep	16:00	Broken clouds. Warm.	30 °C	15 km/h	↖	70%	1007 millibars	N/A
12 Sep	17:00	Partly sunny. Warm.	30 °C	17 km/h	↖	70%	1007 millibars	N/A
12 Sep	18:00	Broken clouds. Warm.	30 °C	13 km/h	↑	70%	1007 millibars	N/A
12 Sep	19:00	Broken clouds. Warm.	30 °C	15 km/h	↖	66%	1008 millibars	N/A
12 Sep	20:00	Partly cloudy. Warm.	29 °C	6 km/h	↖	74%	1009 millibars	N/A

12 Sep	21:00		Passing clouds. Warm.	28 °C	2 km/h	↖	79%	1009 millibars	N/A
12 Sep	22:00		Passing clouds. Warm.	27 °C	No wind	-	84%	1010 millibars	N/A
12 Sep	23:00		Passing clouds. Warm.	27 °C	2 km/h	→	84%	1011 millibars	9 km

Weather on 13 Sep

13 Sep	00:00		Passing clouds. Warm.	26 °C	2 km/h	↙	89%	1012 millibars	8 km
13 Sep	01:00		Passing clouds. Warm.	26 °C	2 km/h	↓	89%	1011 millibars	8 km
13 Sep	02:00		Passing clouds. Warm.	26 °C	4 km/h	↓	89%	1011 millibars	8 km
13 Sep	03:00		Passing clouds. Warm.	26 °C	6 km/h	↘	89%	1010 millibars	8 km
13 Sep	04:00		Passing clouds. Warm.	25 °C	No wind	-	94%	1009 millibars	8 km
13 Sep	05:00		Passing clouds. Warm.	25 °C	2 km/h	↘	94%	1009 millibars	8 km
13 Sep	06:00		Passing clouds. Warm.	25 °C	2 km/h	↓	94%	1010 millibars	6 km
13 Sep	07:00		Passing clouds. Warm.	25 °C	2 km/h	↘	94%	1010 millibars	5 km
13 Sep	08:00		Broken clouds. Warm.	25 °C	2 km/h	↗	94%	1011 millibars	6 km
13 Sep	09:00		Broken clouds. Warm.	26 °C	No wind	-	89%	1012 millibars	8 km
13 Sep	10:00		Partly sunny. Warm.	30 °C	11 km/h	↖	75%	1012 millibars	7 km
13 Sep	11:00		Broken clouds. Warm.	31 °C	9 km/h	↖	62%	1012 millibars	8 km
13 Sep	12:00		Partly sunny. Hot.	32 °C	13 km/h	↖	59%	1011 millibars	N/A
13 Sep	13:00		Broken clouds. Hot.	32 °C	9 km/h	↖	63%	1011 millibars	N/A
13 Sep	14:00		Broken clouds. Hot.	33 °C	13 km/h	↑	56%	1009 millibars	9 km
13 Sep	15:00		Thunderstorms. More clouds than sun. Warm.	25 °C	6 km/h	→	94%	1009 millibars	4 km
13 Sep	16:00		Strong thunderstorms. More clouds than sun. Mild.	24 °C	17 km/h	→	94%	1009 millibars	1 km
13 Sep	17:00		Thunderstorms. Broken clouds. Mild.	24 °C	4 km/h	↙	100%	1008 millibars	N/A

13 Sep	18:00	Partly sunny. Warm.	25 °C	7 km/h	↙	89%	1008 millibars	N/A
13 Sep	19:00	Partly sunny. Warm.	25 °C	No wind	-	89%	1009 millibars	8 km
13 Sep	20:00	Partly cloudy. Warm.	25 °C	2 km/h	↙	94%	1009 millibars	N/A
13 Sep	21:00	Partly cloudy. Warm.	25 °C	2 km/h	↙	94%	1010 millibars	N/A
13 Sep	22:00	Passing clouds. Warm.	25 °C	No wind	-	94%	1011 millibars	N/A
13 Sep	23:00	Passing clouds. Warm.	25 °C	2 km/h	↘	100%	1011 millibars	N/A
Weather on 14 Sep								
14 Sep	00:00	Passing clouds. Warm.	25 °C	2 km/h	↓	94%	1011 millibars	9 km
14 Sep	01:00	Passing clouds. Warm.	25 °C	No wind	-	100%	1011 millibars	8 km
14 Sep	02:00	Passing clouds. Warm.	25 °C	No wind	-	94%	1010 millibars	8 km
14 Sep	03:00	Passing clouds. Warm.	25 °C	2 km/h	↓	94%	1010 millibars	8 km
14 Sep	04:00	Passing clouds. Warm.	25 °C	2 km/h	↙	94%	1009 millibars	8 km
14 Sep	05:00	Passing clouds. Warm.	25 °C	2 km/h	↓	94%	1009 millibars	8 km
14 Sep	06:00	Passing clouds. Warm.	25 °C	6 km/h	↘	94%	1010 millibars	8 km
14 Sep	07:00	Passing clouds. Warm.	25 °C	2 km/h	↓	94%	1010 millibars	8 km
14 Sep	08:00	Partly sunny. Warm.	25 °C	No wind	-	94%	1011 millibars	8 km
14 Sep	09:00	Partly sunny. Warm.	26 °C	2 km/h	↖	89%	1011 millibars	6 km
14 Sep	10:00	Partly sunny. Warm.	28 °C	6 km/h	↖	84%	1012 millibars	8 km
14 Sep	11:00	Broken clouds. Warm.	30 °C	9 km/h	↖	75%	1012 millibars	9 km
14 Sep	12:00	Broken clouds. Warm.	30 °C	13 km/h	↑	75%	1011 millibars	N/A
14 Sep	13:00	Broken clouds. Hot.	32 °C	17 km/h	↑	67%	1010 millibars	N/A
14 Sep	14:00	Broken clouds. Warm.	31 °C	17 km/h	↑	70%	1009 millibars	9 km
14 Sep	15:00	Broken clouds. Warm.	31 °C	19 km/h	↑	70%	1008 millibars	N/A
14 Sep	16:00	Broken clouds. Warm.	30 °C	9 km/h	↑	70%	1008 millibars	N/A

14 Sep	17:00		Partly sunny. Warm.	28 °C	15 km/h	↓	79%	1007 millibars	N/A
14 Sep	18:00		Broken clouds. Warm.	28 °C	9 km/h	↘	79%	1007 millibars	N/A
14 Sep	19:00		Broken clouds. Warm.	27 °C	11 km/h	↘	84%	1008 millibars	N/A
14 Sep	20:00		Partly cloudy. Warm.	26 °C	9 km/h	↘	89%	1009 millibars	N/A
14 Sep	21:00		Light rain. Partly cloudy. Warm.	26 °C	7 km/h	↑	89%	1009 millibars	9 km
14 Sep	22:00		Light rain. Mostly cloudy. Warm.	26 °C	7 km/h	←	94%	1010 millibars	7 km
14 Sep	23:00		Light rain. Mostly cloudy. Warm.	26 °C	9 km/h	←	94%	1011 millibars	5 km

Weather on 15 Sep

15 Sep	00:00		Partly cloudy. Warm.	25 °C	4 km/h	↖	94%	1011 millibars	5 km
15 Sep	01:00		Partly cloudy. Warm.	25 °C	2 km/h	↙	94%	1011 millibars	7 km
15 Sep	02:00		Partly cloudy. Warm.	25 °C	9 km/h	→	100%	1011 millibars	6 km
15 Sep	03:00		Partly cloudy. Mild.	24 °C	9 km/h	→	94%	1010 millibars	7 km
15 Sep	04:00		Partly cloudy. Mild.	24 °C	6 km/h	↘	94%	1010 millibars	7 km
15 Sep	05:00		Partly cloudy. Mild.	24 °C	2 km/h	←	94%	1009 millibars	7 km
15 Sep	06:00		Passing clouds. Mild.	24 °C	4 km/h	↗	94%	1009 millibars	7 km
15 Sep	07:00		Passing clouds. Mild.	24 °C	2 km/h	↓	94%	1009 millibars	9 km
15 Sep	08:00		Partly sunny. Mild.	24 °C	2 km/h	←	94%	1010 millibars	9 km
15 Sep	09:00		Broken clouds. Warm.	25 °C	4 km/h	↖	89%	1011 millibars	N/A
15 Sep	10:00		Partly sunny. Warm.	26 °C	6 km/h	←	89%	1011 millibars	N/A
15 Sep	11:00		Partly sunny. Warm.	27 °C	7 km/h	↖	84%	1011 millibars	N/A
15 Sep	12:00		Partly sunny. Warm.	29 °C	7 km/h	↖	74%	1011 millibars	N/A
15 Sep	13:00		Broken clouds. Warm.	30 °C	9 km/h	↖	66%	1010 millibars	N/A
15 Sep	14:00		Broken clouds. Warm.	31 °C	7 km/h	↖	62%	1009 millibars	N/A