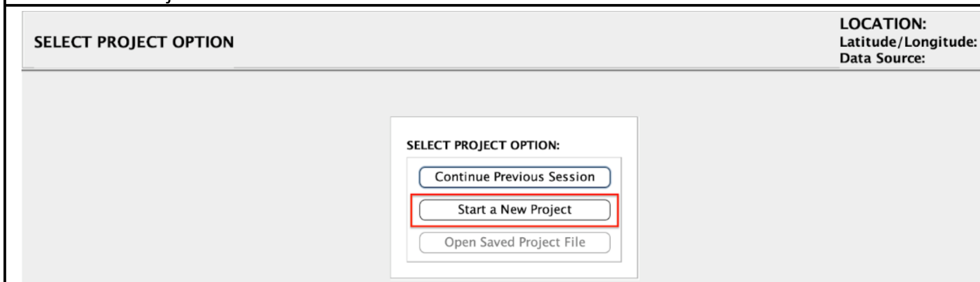
Procedure for identifying the strategies on the Psychrometric chart
December 15, 2022

<table>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>Choose a city</td><td></td><td></td></tr>
<tr><td colspan="2">Start a new Project in Climate Consultant</td><td></td></tr>
<tr><td colspan="2">
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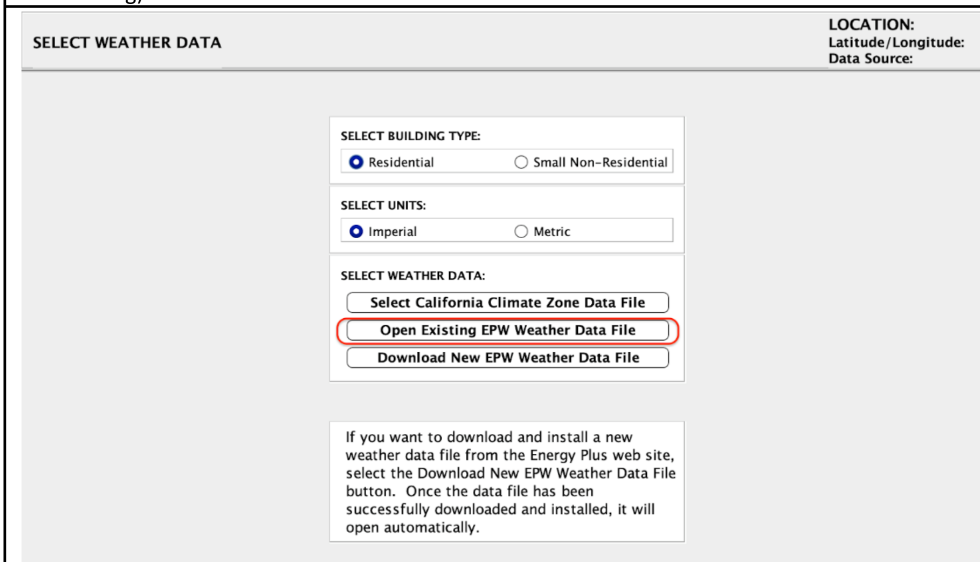
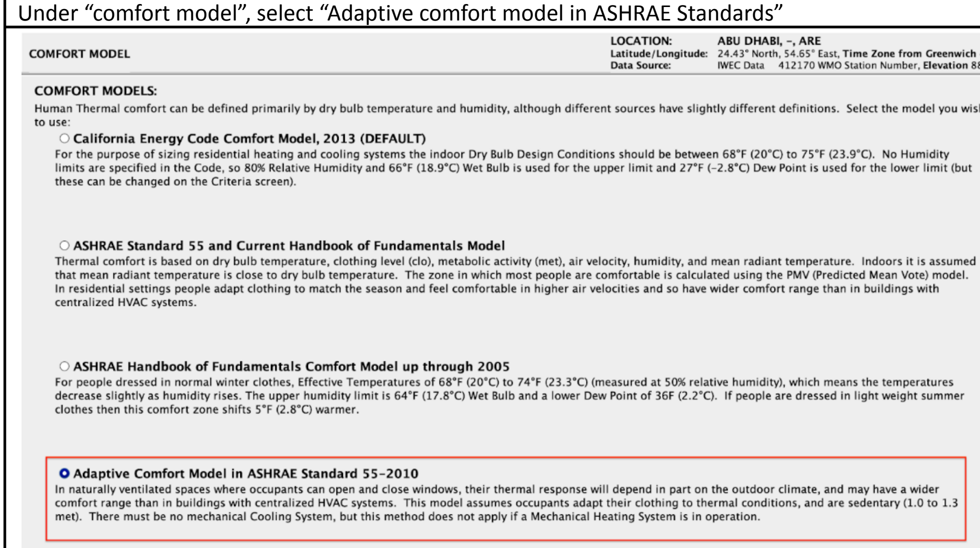
<tr><td colspan="2">Select the unit system and building type then select open existing epw. (Energy Plus, CBE or OneBuilding)</td><td></td></tr>
<tr><td colspan="2">
</td><td>https://energyplus.net/
https://clima.cbe.berkeley.edu/
https://climate.onebuilding.org/WMO_Region_2_Asia/default.html</td></tr>
<tr><td colspan="2">Under “comfort model”, select “Adaptive comfort model in ASHRAE Standards”</td><td></td></tr>
<tr><td colspan="2">
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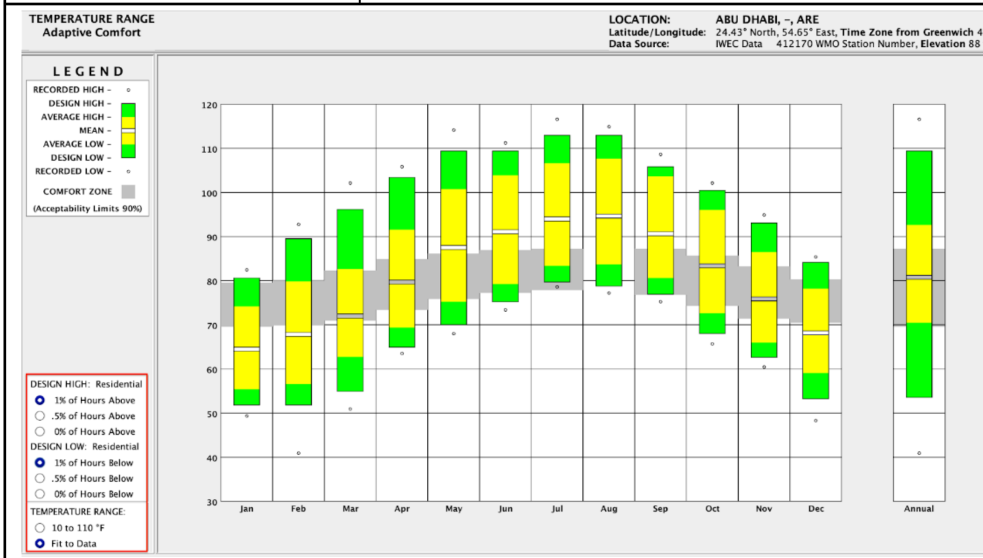
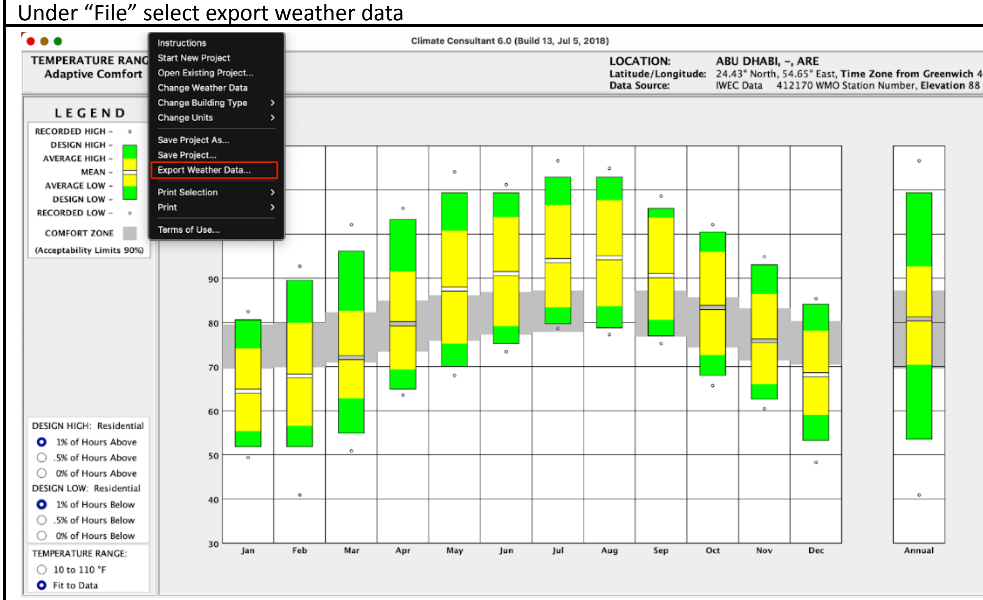
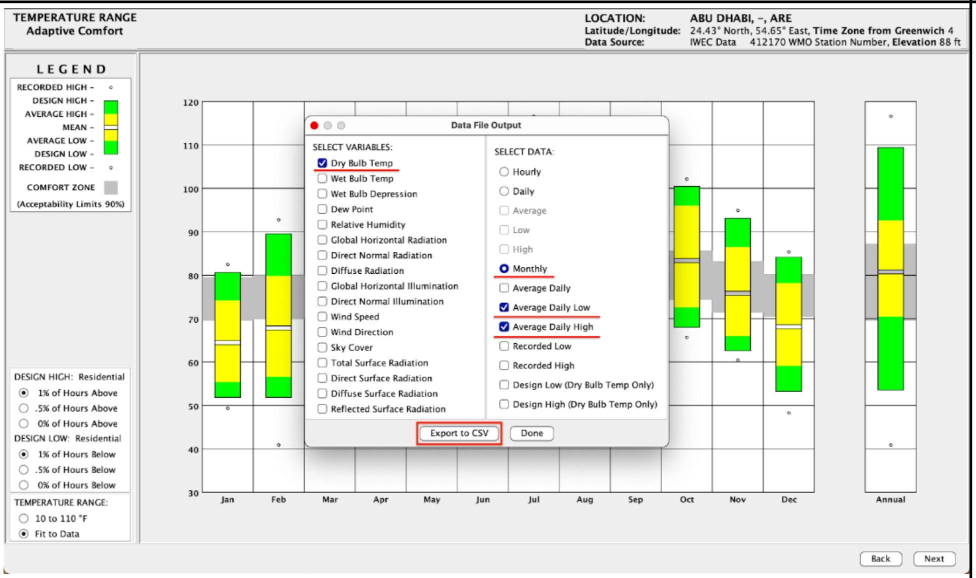
On the “Temperature Range adaptive comfort”, change the design low & high to calculate the 1% of hours below. Make sure the temperature data fits to data.



Under “File” select export weather data



Select Dry Bulb Temp. (under data: select monthly), checking average daily high, average daily low. Then export the data into a csv file in order to get exact numbers for the average high & average low.



Subtract the average high from the average low to get the average range.

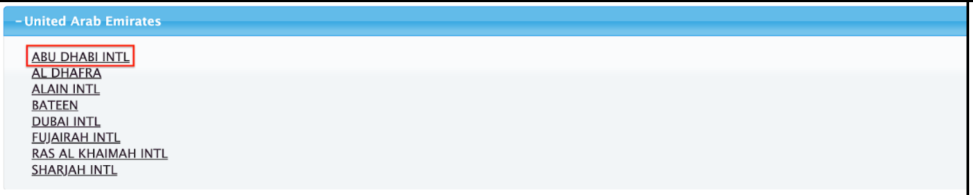
			Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	No
Dry Bulb Temp	Avg Daily High	degrees C	23.4	26.6	28.1	33.0	38.2	39.9	41.4	42.0	39.8	35.6	
Range			10.4	12.9	11.0	12.2	14.2	13.6	12.8	13.3	12.8	13.0	
Dry Bulb Temp	Avg Daily Low	degrees C	13.0	13.7	17.1	20.8	24.0	26.3	28.6	28.7	27.0	22.6	

2

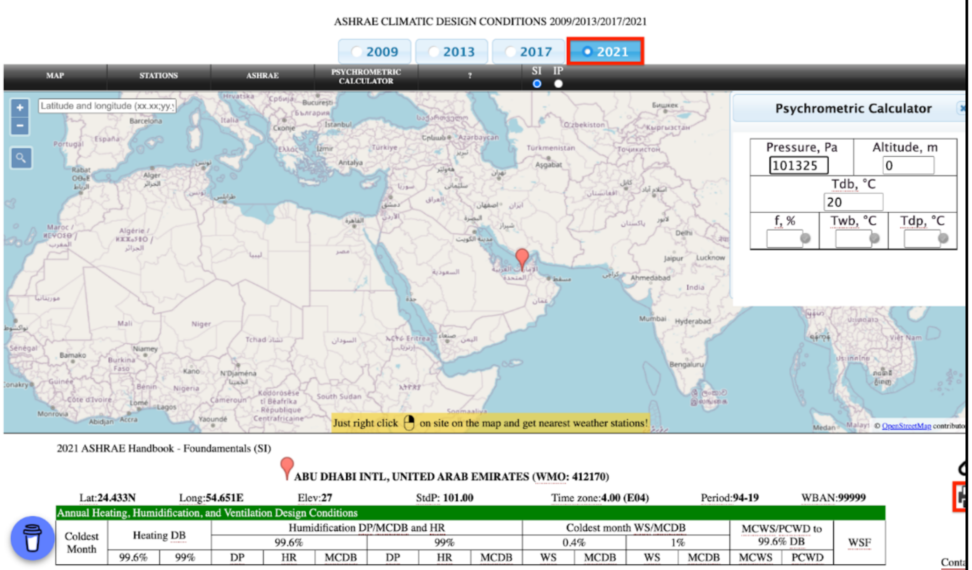
Select the desired station's continent

http://ashrae-meteo.info/v2.0/help.php#wind

Find the desired location & select desired data location



Select the desired collection year. Print the data



Download the file and open it. Copy the design day data which could be found under monthly design dry bulb and coincident wet bulb temperature, which are selected 2% of hours under dry bulb

PDF available at (http://ashrae-meteo.info/v2.0/help.php#wind)

Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB	**29.4**	**34.1**	**38.1**	**41.8**	**44.3**	**45.4**	**46.7**	**46.7**	**44.0**	**40.1**	**35.1**
		MCWB	**17.7**	**17.5**	**18.5**	**20.2**	**20.8**	**21.9**	**23.3**	**23.2**	**22.3**	**21.6**	**19.5**
	2%	DB	**27.9**	**31.8**	**35.2**	**39.8**	**42.8**	**43.7**	**45.1**	**45.1**	**42.1**	**38.2**	**33.3**
		MCWB	**17.4**	**17.6**	**18.3**	**19.6**	**20.9**	**22.5**	**23.6**	**23.3**	**23.0**	**21.6**	**20.4**
	5%	DB	**26.1**	**29.2**	**33.0**	**37.5**	**41.0**	**42.0**	**43.7**	**43.8**	**40.9**	**37.0**	**32.1**
		MCWB	**16.9**	**17.1**	**18.2**	**19.5**	**21.3**	**22.9**	**24.0**	**23.8**	**23.3**	**21.9**	**20.9**
	10%	DB	**24.1**	**27.0**	**30.8**	**35.2**	**39.1**	**40.2**	**41.8**	**42.1**	**39.2**	**35.7**	**30.8**
		MCWB	**16.9**	**17.0**	**18.2**	**19.6**	**21.7**	**23.8**	**24.9**	**24.5**	**24.3**	**22.8**	**21.2**

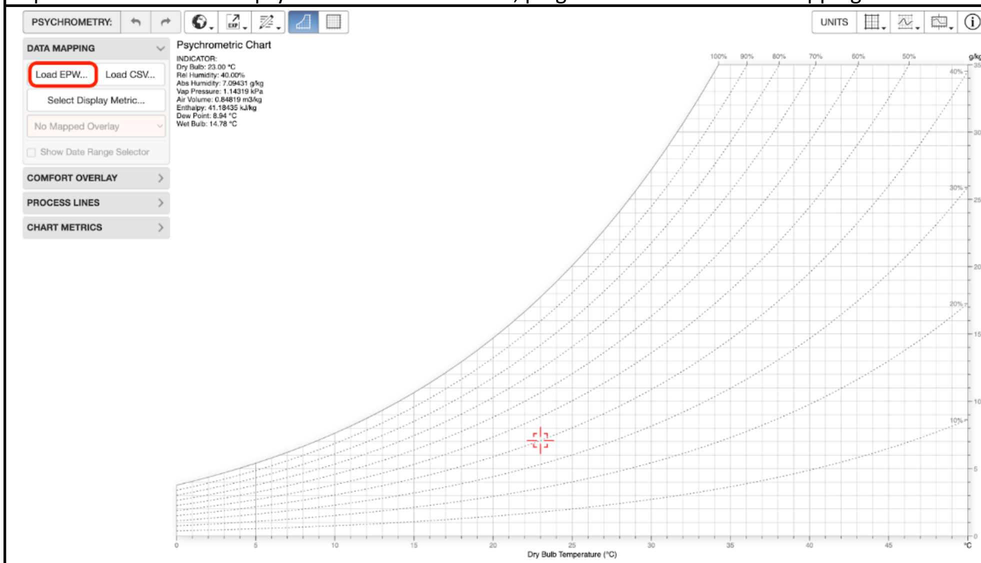
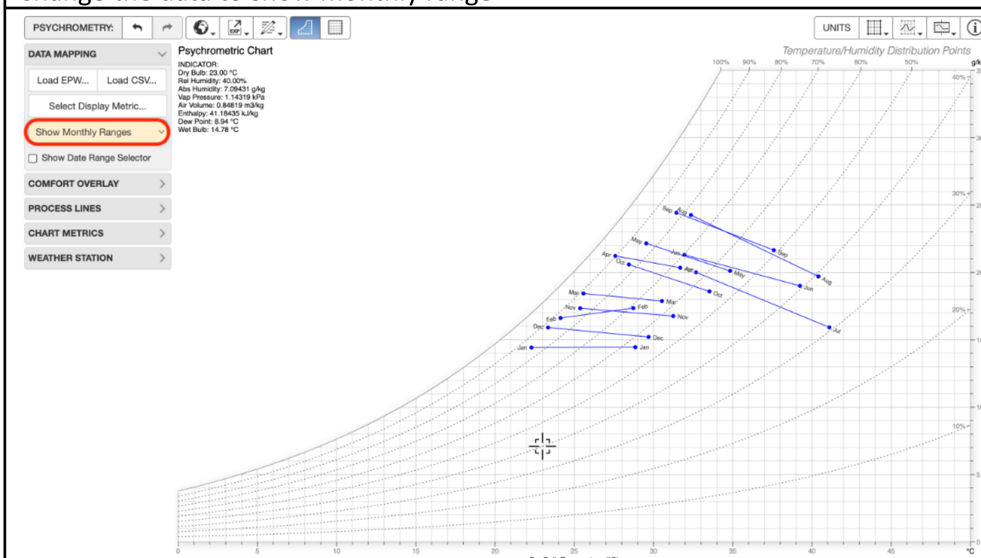
The temperature range can be found under mean daily temperature, which is selected as 5% of hours under dry bulb with Mean coincident dry bulb temperature Range (MCDBR)

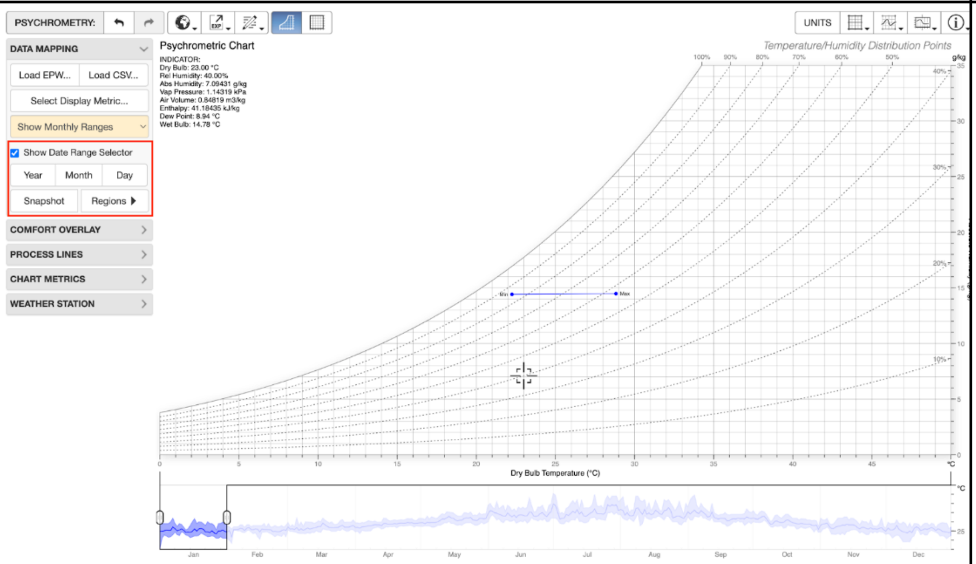
Mean Daily Temperature Range		MDBR	**9.8**	**10.4**	**11.1**	**12.8**	**13.8**	**13.1**	**11.6**	**12.1**	**12.1**	**11**
	5% DB	MCDBR	**12.3**	**13.9**	**14.7**	**16.1**	**16.1**	**15.2**	**13.4**	**13.8**	**13.6**	**13**
		MCWBR	**5.5**	**5.7**	**5.8**	**6.4**	**6.6**	**6.7**	**6.9**	**7.0**	**7.1**	**6.**
	5% WB	MCDBR	**10.2**	**10.6**	**11.2**	**13.1**	**14.4**	**13.0**	**11.4**	**11.8**	**12.0**	**11**
		MCWBR	**5.6**	**5.5**	**5.4**	**5.9**	**6.2**	**6.0**	**5.9**	**6.0**	**7.1**	**6.**

Get the monthly design day dry bulb low temperature by subtracting the high from the mean.

Monthly DD DBT = mean daily DBT – DD DB high T

			Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	2%	DB	27.9	31.8	35.2	39.8	42.8	43.7	45.1	45.1	42.1	38.2	
Mean Daily Temperature Range	5% DB	MCDBR	12.3	13.9	14.7	16.1	16.1	15.2	13.4	13.8	13.6	13.2	
			15.6	17.9	20.5	23.7	26.7	28.5	31.7	31.3	28.5	25	

These values (from ASHRAE) allow drawing the comfort ventilation line on the Givoni graph which demonstrates whether it is viable to use ventilation in a specific city in such month.	
3 Setting up the psych chart	
To determine if the strategies are effective, ineffective, or not needed in a specific month in a city, start with the EPW file. Energy Plus, CBE or OneBuilding	https://energyplus.net/ https://clima.cbe.berkeley.edu/ https://climate.onebuilding.org/WMO_Region_2_Asia/default.html
Open the file in Marsh's psychrometric chart maker, plug the file into the data mapping tab	
	https://drajmarsh.bitbucket.io/psychro-chart2d.html
Change the data to show monthly range	
	

<table>
<tr><td>Check show data range selector and select the month in order to find the data for each individual month</td><td></td></tr>
<tr><td>
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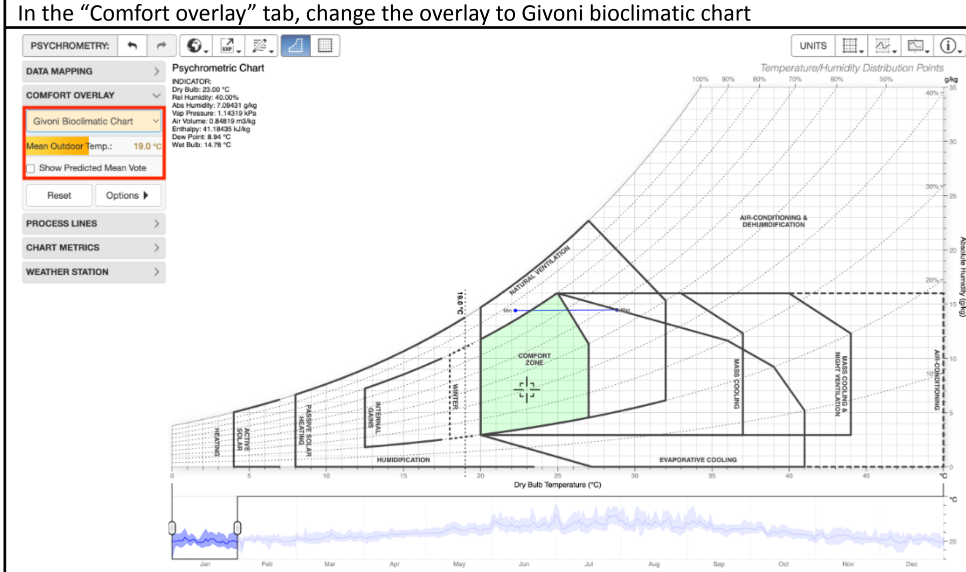
<tr><td>In the “Comfort overlay” tab, change the overlay to Givoni bioclimatic chart</td><td></td></tr>
<tr><td>
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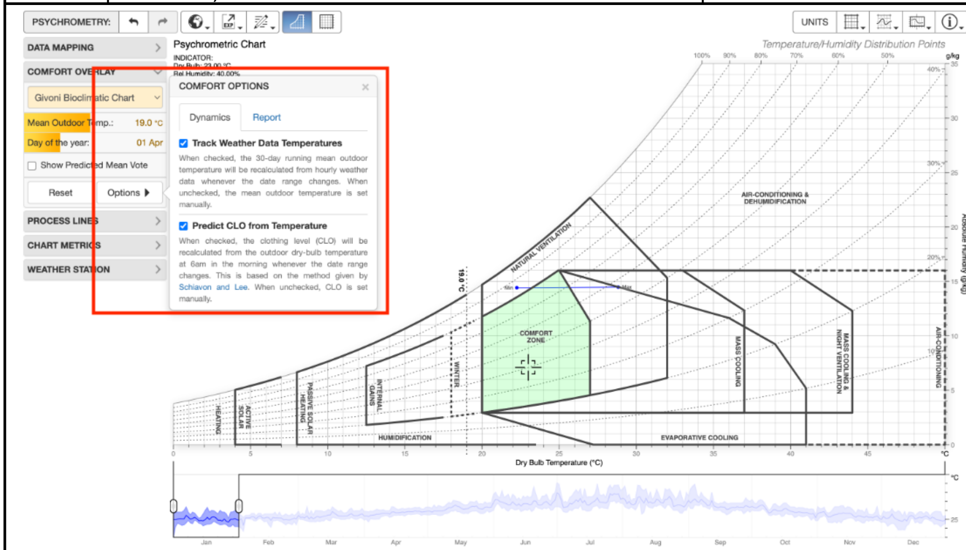
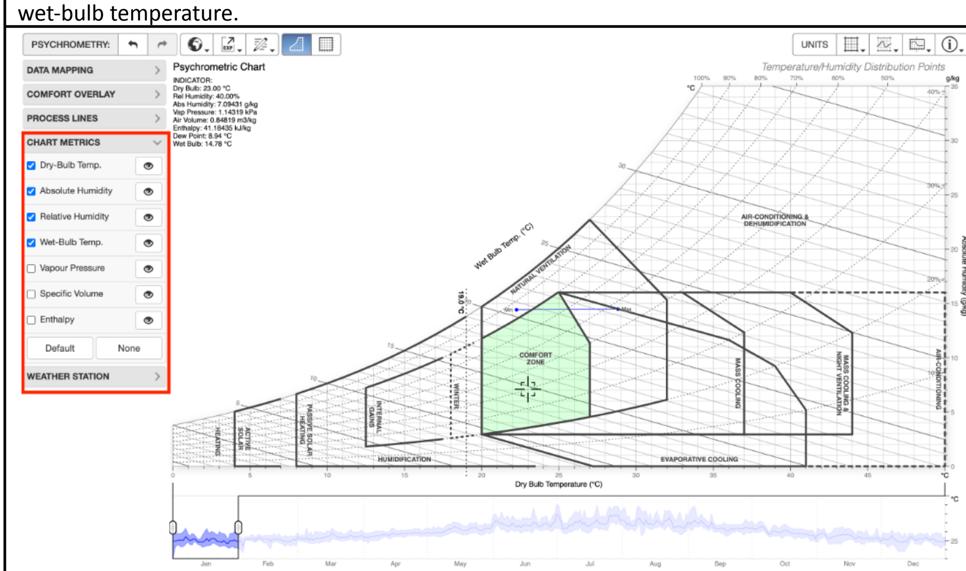
In the “Options” tab, select track weather data & Predict Clo from temperature

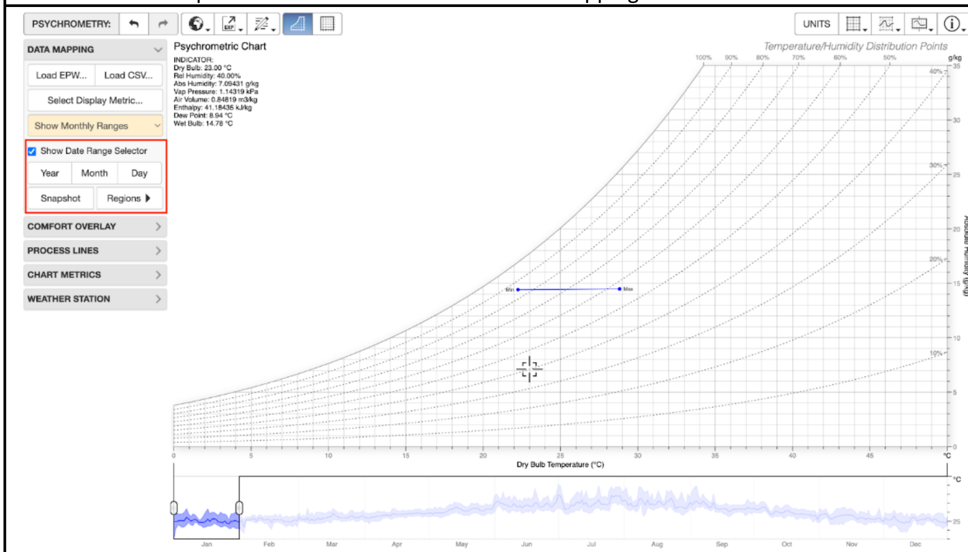


In the “Chart Metrics” tab, select dry bulb temperature, absolute humidity, relative humidity, & wet-bulb temperature.

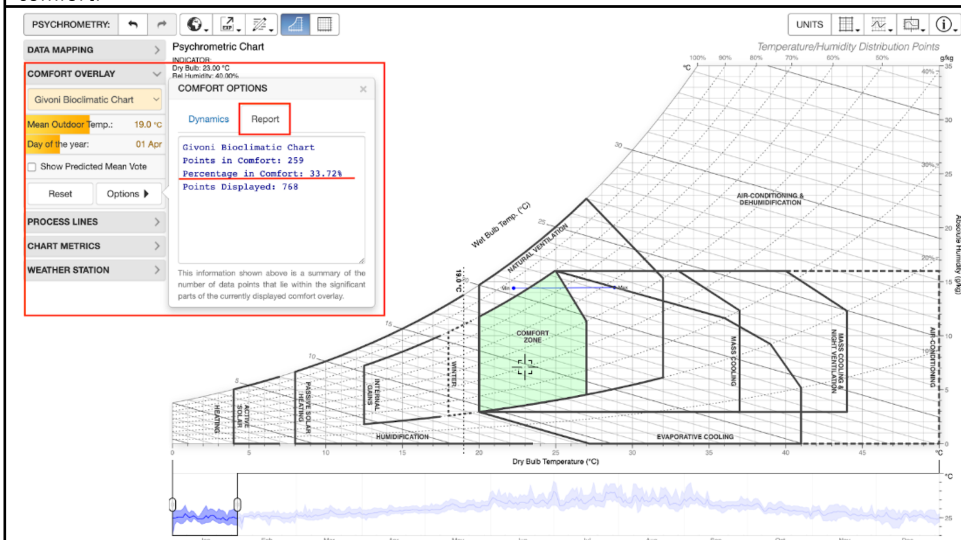


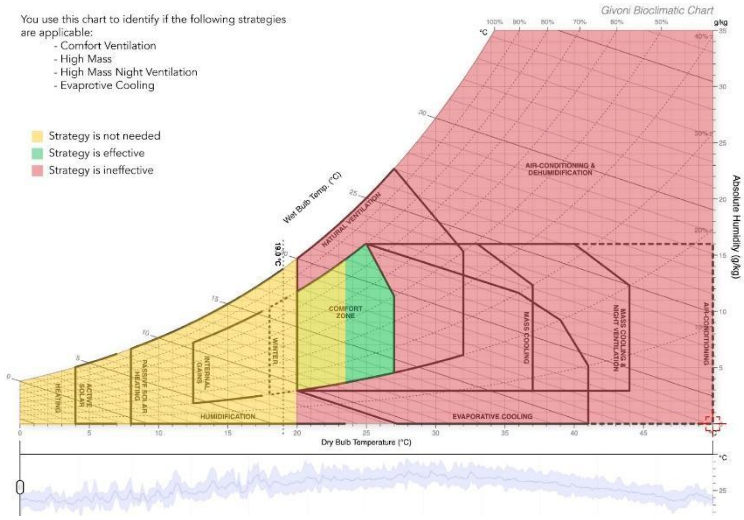
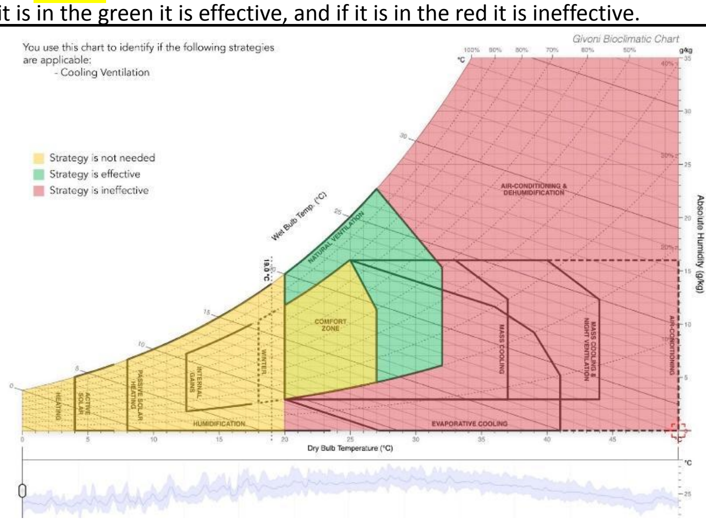
4 Finding the percentage of comfort for every month:

Make sure that a specific month is selected under data mapping.



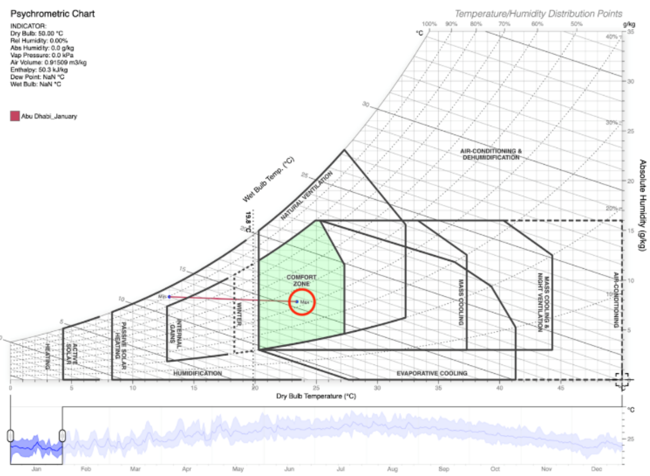
In the “Comfort overlay” tab, select options, reports and read the value under percentage in comfort.



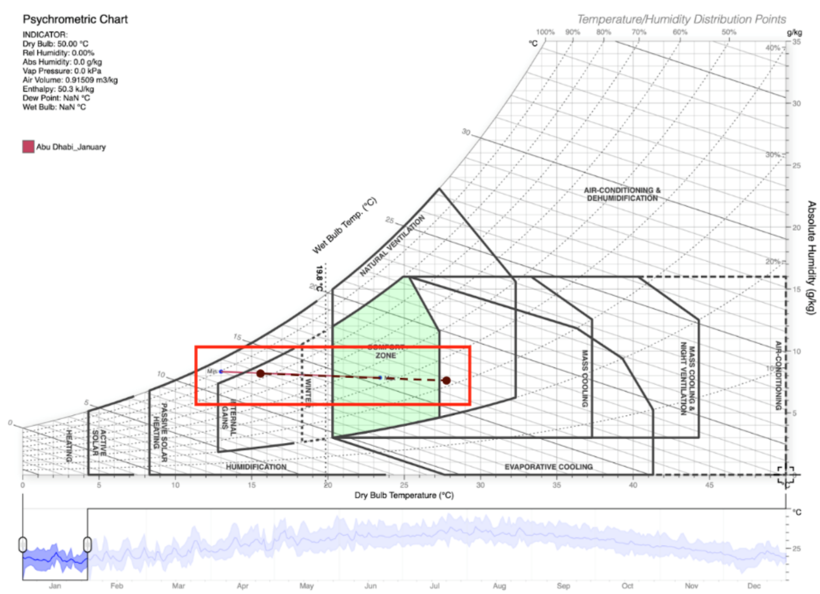
5 Efficiency of a strategy	
To find whether a strategy is effective or not look at the two psychrometric charts below and depending on the strategy you can determine whether the strategy is not needed, effective, or ineffective.	
For Comfort Ventilation, High Mass, High Mass Night Ventilation, and Evaporation Cooling, if the data point falls in the yellow that deems the strategy not needed, if it is in the green it is effective, and if it is in the red it is ineffective.	
	
For cooling ventilation, if the data point falls in the yellow that deems the strategy not needed, if it is in the green it is effective, and if it is in the red it is ineffective.	
	

6 In order to determine if Comfort ventilation works:

For the average day, locate the average daily high, which is the top point on the line on Givoni's graph.
If it is beyond the comfort zone and within the natural ventilation zone, it is effective.
If it is within the comfort zone or below it is not needed.
If it is beyond (above) the Natural ventilation zone it is ineffective.



For the design day, plot the points of the design low and design high with the same angle as the average plotted on Givoni's graph. If the new line is within the comfort zone or below the strategy is not needed.
If it is beyond the comfort ventilation box it is ineffective.



In addition, test whether cooling ventilation is effective or not through identifying whether the plotted design day point is within the comfort zone or not.
If the point is within upper half of the comfort zone then cooling ventilation is effective.
If the point is in the bottom half of the comfort zone or "below" the comfort zone the strategy is not needed.
If it is outside of the comfort zone on the right side cooling ventilation is ineffective.

7 identify the efficiency of high mass for a specific month	

Find the internal Temperature on the average day by adding 1.5°C to the sum of Monthly design day low and the mean daily temperature divided by 2:
(1.5+(DesignLow+(MeanDaily/2)))

HI MASS DESIGN DAY	Fully shaded, well insultated, windows closed all day												
Tin ave			23.3	26.4	29.4	33.3	36.3	37.6	39.9	39.7	36.8	33.1	28
Tin swing			1.8	2.1	2.2	2.4	2.4	2.3	2.0	2.1	2.0	2.0	1
Tin max			24.2	27.4	30.5	34.5	37.5	38.7	40.9	40.7	37.8	34.1	29
Tin min			22.3	25.3	28.2	32.0	35.0	36.5	38.9	38.7	35.8	32.1	27

Also find the internal Temperature swing by multiplying the mean daily temperature with 0.15:
(0.15*MeanDaily)

HI MASS DESIGN DAY	Fully shaded, well insultated, windows closed all day										
Tin ave			23.3	26.4	29.4	33.3	36.3	37.6	39.9	39.7	36.8
Tin swing			1.8	2.1	2.2	2.4	2.4	2.3	2.0	2.1	2.0
Tin max			24.2	27.4	30.5	34.5	37.5	38.7	40.9	40.7	37.8
Tin min			22.3	25.3	28.2	32.0	35.0	36.5	38.9	38.7	35.8

Find the maximum internal Temperature by adding the average internal temperature with temperature swing divided by 2:
(TinAvg+(TinSwing/2))

HI MASS DESIGN DAY	Fully shaded, well insultated, windows closed all day											
Tin ave			23.3	26.4	29.4	33.3	36.3	37.6	39.9	39.7	36.8	33.1
Tin swing			1.8	2.1	2.2	2.4	2.4	2.3	2.0	2.1	2.0	2.0
Tin max			24.2	27.4	30.5	34.5	37.5	38.7	40.9	40.7	37.8	34.1
Tin min			22.3	25.3	28.2	32.0	35.0	36.5	38.9	38.7	35.8	32.1

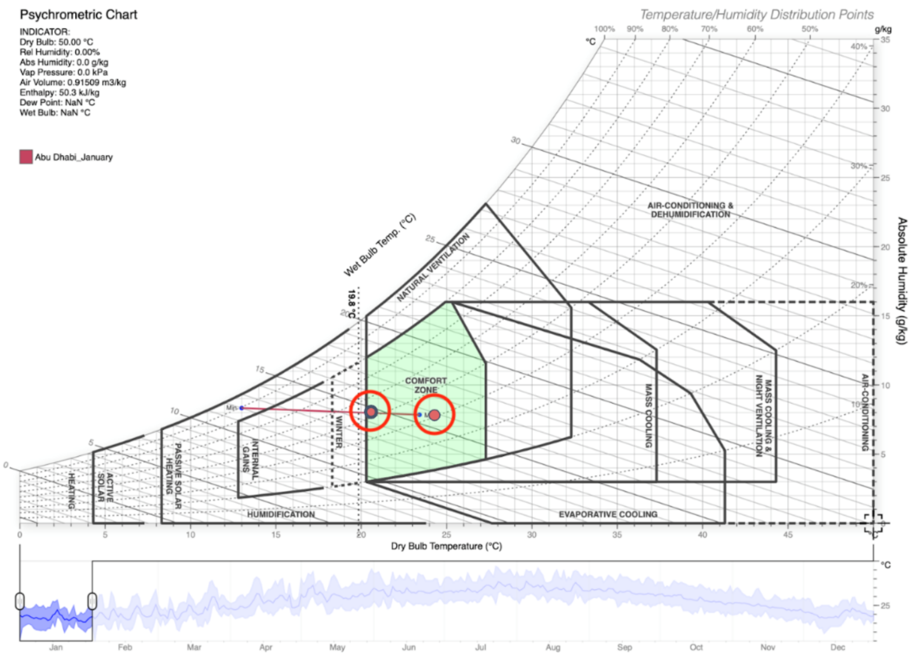
Find minimum internal Temperature by subtracting the average inside temperature with temperature swing divided by 2:
(TinAvg-(TinSwing/2))

HI MASS DESIGN DAY	Fully shaded, well insultated, windows closed all day											
Tin ave			23.3	26.4	29.4	33.3	36.3	37.6	39.9	39.7	36.8	3
Tin swing			1.8	2.1	2.2	2.4	2.4	2.3	2.0	2.1	2.0	
Tin max			24.2	27.4	30.5	34.5	37.5	38.7	40.9	40.7	37.8	3
Tin min			22.3	25.3	28.2	32.0	35.0	36.5	38.9	38.7	35.8	3

Use the internal maximum Temperature (TinMax) in order to determine if the high mass strategy works for the design day depending on its location on the Givoni graph.
Note that the same steps are taken to find if High mass works on the average day, by substituting the Design day numbers done in step A (orange above) with average numbers.

			Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	De
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	2%	DB	27.9	31.8	35.2	39.8	42.8	43.7	45.1	45.1	42.1	38.2	33.3	
Mean Daily Temperature Range	5% DB	MCDBR	12.3	13.9	14.7	16.1	16.1	15.2	13.4	13.8	13.6	13.2	12.2	
			15.6	17.9	20.5	23.7	26.7	28.5	31.7	31.3	28.5	25	21.1	

			Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov
Dry Bulb Temp	Avg Daily High	degrees C	23.4	26.6	28.1	33.0	38.2	39.9	41.4	42.0	39.8	35.6	30.
Range			10.4	12.9	11.0	12.2	14.2	13.6	12.8	13.3	12.8	13.0	11.
Dry Bulb Temp	Avg Daily Low	degrees C	13.0	13.7	17.1	20.8	24.0	26.3	28.6	28.7	27.0	22.6	18.

For a particular month, plot the point on the psychometric chart. If the point is within the upper half of the comfort zone then the strategy applies. If beyond the comfort zone then it is ineffective. If within the lower half or below the comfort zone box then the strategy is not needed.	
	

8 assess the efficiency of High mass Night ventilation

To find the minimum Temperature ventilation (TminVent) which is used to track the low point of the High mass Night ventilation line, subtract internal minimum Temperature (TinMin) from 0.5 Multiplied by internal minimum Temperature (TinMin) from Monthly design day low (DDlow): (TinMin-0.5*(TinMin-DDlow))

Givoni	Tmin ventilated	19.0	21.6	24.4	27.9
Givoni	Tmax ventilated	25.1	28.5	31.6	35.8

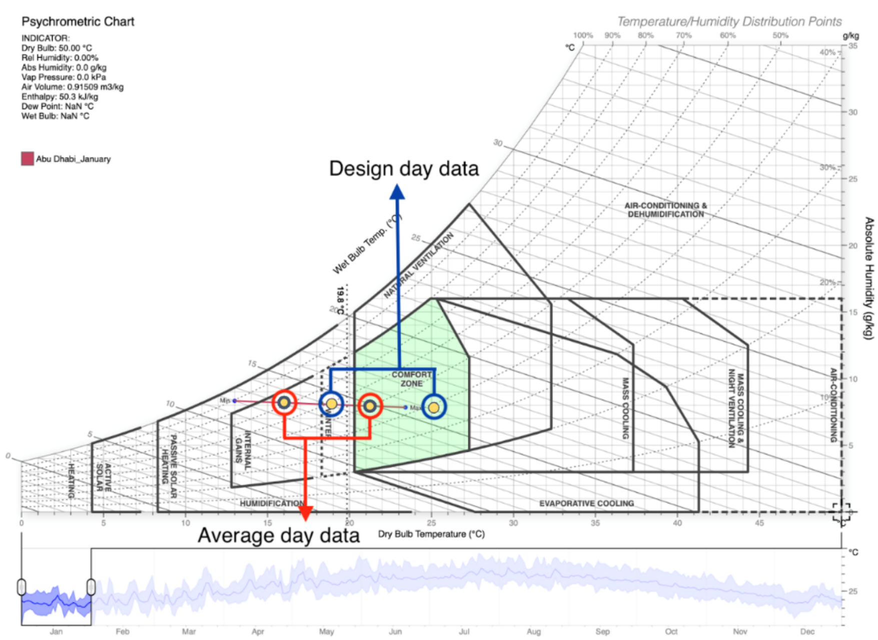
For Maximum Temperature ventilation (TmaxVent) used to track the High point of the High mass Night ventilation line, subtract the internal maximum Temperature (TinMax) from 0.5 multplied by internal Maximum Temperature (TinMax) from Monthly design day low (DDHigh): (TinMax-0.5*(TinMax-DDHigh))

Givoni	Tmin ventilated	19.0	21.6	24.4	27.9	30.9	32
Givoni	Tmax ventilated	25.1	28.5	31.6	35.8	38.8	40

Note that the same measures are taken in order to find if High mass night ventilation works on the average day through substituting the Design day numbers done in step A (orange above) with average numbers.

			Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	2%	DB	27.9	31.8	35.2	39.8	42.8	43.7	45.1	45.1	42.1	38.2	33.3	
Mean Daily Temperature Range	5% DB	MCDBR	12.3	13.9	14.7	16.1	16.1	15.2	13.4	13.8	13.6	13.2	12.2	
			15.6	17.9	20.5	23.7	26.7	28.5	31.7	31.3	28.5	25	21.1	

			Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov
Dry Bulb Temp	Avg Daily High	degrees C	23.4	26.6	28.1	33.0	38.2	39.9	41.4	42.0	39.8	35.6	30.2
Range			10.4	12.9	11.0	12.2	14.2	13.6	12.8	13.3	12.8	13.0	11.3
Dry Bulb Temp	Avg Daily Low	degrees C	13.0	13.7	17.1	20.8	24.0	26.3	28.6	28.7	27.0	22.6	18.9

<table>
<tr><td colspan="2">Plot the point on the psychometric chart of said month. As long as the high point is within the upper half of the comfort zone then the strategy applies.
If the point is beyond the comfort zone then it is ineffective.
If within the lower half or below the comfort zone then the strategy is not needed</td><td></td></tr>
<tr><td colspan="2">
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9 assess if evaporation cooling is effective in a specific month	
Take the maximum temperature established by the line created by natural ventilation in order to determine if the strategy works on the design day maximum. Note that the maximum point on the natural ventilation is the Design day High (DD high). Then (on the psychrometric chart) go down the wet bulb temperature approximately 70% of that line. If the point is within the upper half of the comfort zone then the strategy is effective otherwise it is ineffective. If the point is outside (or beyond) the zone the strategy is not needed.	
Take the maximum temperature established by the line created by the maximum average in order to determine if the strategy works on the average day maximum. Then (on the psychrometric chart) go down the wet bulb temperature approximately 70% of that line. If the point is within the upper half of the comfort zone then the strategy is effective otherwise it is ineffective. If the point is outside (or beyond) the zone the strategy is not needed.