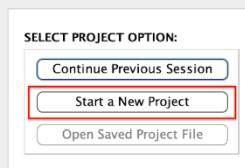
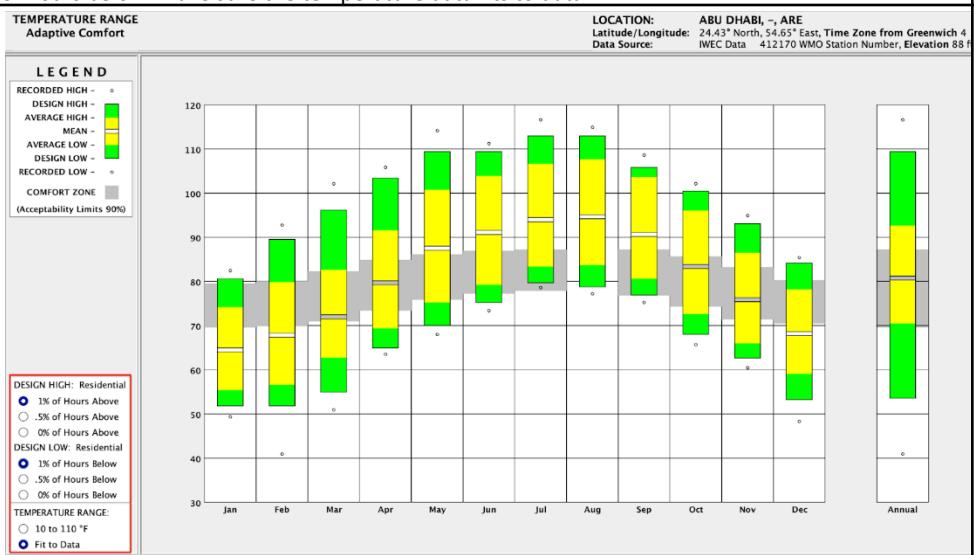


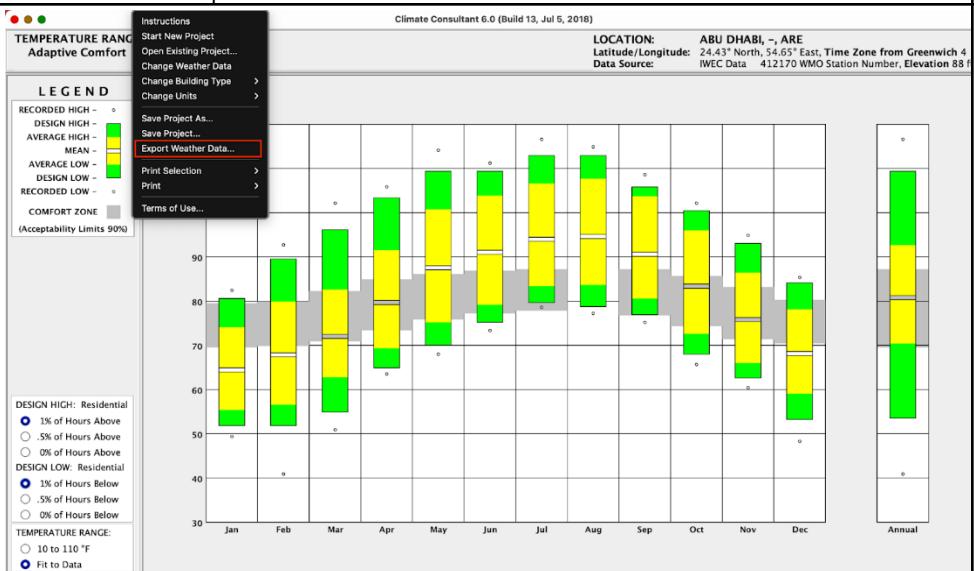
Procedure for identifying the strategies on the Psychrometric chart
December 15, 2022

1		
Choose a city		
Start a new Project in Climate Consultant		
<p>SELECT PROJECT OPTION</p> 	LOCATION: Latitude/Longitude: Data Source:	
Select the unit system and building type then select open existing epw. (Energy Plus, CBE or OneBuilding)		
<p>SELECT WEATHER DATA</p>	LOCATION: Latitude/Longitude: Data Source:	https://energyplus.net/ https://clima.cbe.berkeley.edu/ https://climate.onebuilding.org/WMO_Region_2_Asia/default.html
Under "comfort model", select "Adaptive comfort model in ASHRAE Standards"		
<p>COMFORT MODEL</p> <p>COMFORT MODELS: Human Thermal comfort can be defined primarily by dry bulb temperature and humidity, although different sources have slightly different definitions. Select the model you wish to use:</p> <ul style="list-style-type: none"> <input checked="" type="radio"/> California Energy Code Comfort Model, 2013 (DEFAULT) For the purpose of sizing residential heating and cooling systems the indoor Dry Bulb Design Conditions should be between 68°F (20°C) to 75°F (23.9°C). No Humidity limits are specified in the Code, so 80% Relative Humidity and 66°F (18.9°C) Wet Bulb is used for the upper limit and 27°F (-2.8°C) Dew Point is used for the lower limit (but these can be changed on the Criteria screen). <input type="radio"/> ASHRAE Standard 55 and Current Handbook of Fundamentals Model Thermal comfort is based on dry bulb temperature, clothing level (clo), metabolic activity (met), air velocity, humidity, and mean radiant temperature. Indoors it is assumed that mean radiant temperature is close to dry bulb temperature. The zone in which most people are comfortable is calculated using the PMV (Predicted Mean Vote) model. In residential settings people adapt clothing to match the season and feel comfortable in higher air velocities and so have wider comfort range than in buildings with centralized HVAC systems. <input type="radio"/> ASHRAE Handbook of Fundamentals Comfort Model up through 2005 For people dressed in normal winter clothes, Effective Temperatures of 68°F (20°C) to 74°F (23.3°C) (measured at 50% relative humidity), which means the temperatures decrease slightly as humidity rises. The upper humidity limit is 64°F (17.8°C) Wet Bulb and a lower Dew Point of 36°F (2.2°C). If people are dressed in light weight summer clothes then this comfort zone shifts 5°F (2.8°C) warmer. <input checked="" type="radio"/> Adaptive Comfort Model in ASHRAE Standard 55-2010 In naturally ventilated spaces where occupants can open and close windows, their thermal response will depend in part on the outdoor climate, and may have a wider comfort range than in buildings with centralized HVAC systems. This model assumes occupants adapt their clothing to thermal conditions, and are sedentary (1.0 to 1.3 met). There must be no mechanical Cooling System, but this method does not apply if a Mechanical Heating System is in operation. 	LOCATION: ABU DHABI, -, ARE Latitude/Longitude: 24.43° North, 54.65° East, Time Zone from Greenwich 4 Data Source: IWECC Data 412170 WMO Station Number, Elevation 88	

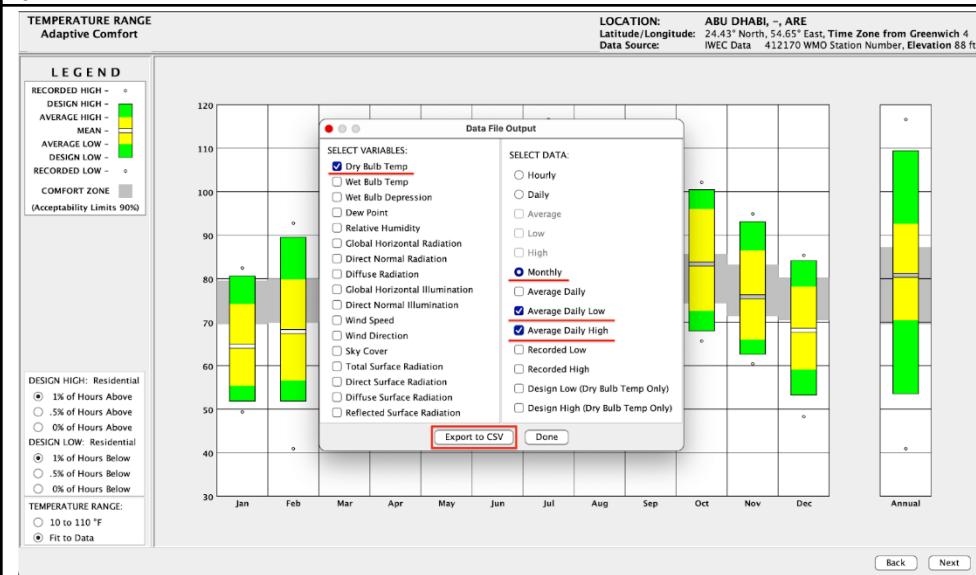
On the "Temperature Range adaptive comfort", change the design low & high to calculate the 1% of hours below. Make sure the temperature data fits to data.



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	Nov	Dec
Dry Bulb Temp	Avg Daily degrees C	23.4	26.6	28.1	33.0	38.2	39.9	41.4	42.0	39.8	35.6		
Range	Avg Daily degrees C	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 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

ASHRAE CLIMATIC DESIGN CONDITIONS 2009/2013/2017

2009 2013 2017 2021

MAP STATIONS ASHRAE PSYCHROMETRIC CALCULATOR FORUM SI IP

CLIMATIC DESIGN CONDITIONS 2017 SI

Annual Design Conditions

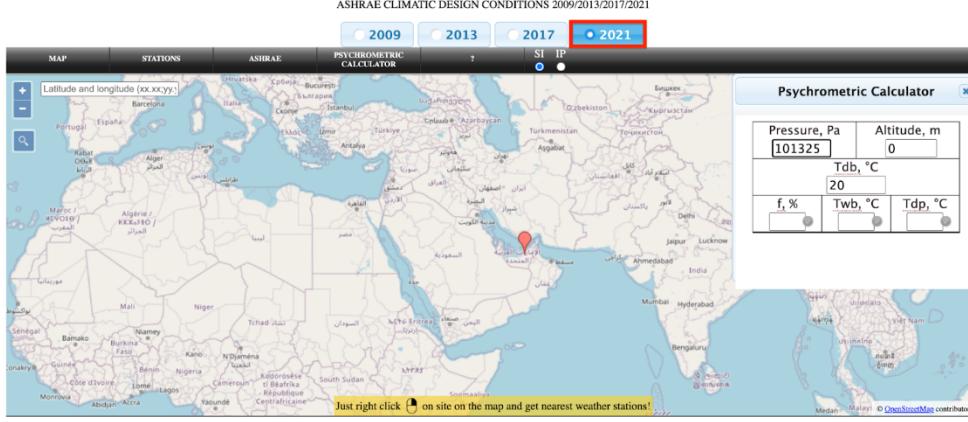
North America Latin America Australia and Oceania Europe Africa Antarctica

Monthly Design Conditions

Temperatures, Degree Days, Precipitation, Wind, Precipitation.

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

Find the desired location & select desired data location

<p>United Arab Emirates</p> <ul style="list-style-type: none"> ABU DHABI INTL AL DHAFRA ALAIN INTL BATEEN DUBAI INTL FUJAIRAH INTL RAS AL KHAIMAH INTL SHARJAH INTL 																																																																																																						
Select the desired collection year. Print the data																																																																																																						
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<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures</th> <th rowspan="2">2%</th> <th>DB</th> <th>27.9</th> <th>31.8</th> <th>35.2</th> <th>39.8</th> <th>42.8</th> <th>43.7</th> <th>45.1</th> <th>45.1</th> <th>42.1</th> <th>38.2</th> </tr> <tr> <th>MCDBR</th> <td>12.3</td> <td>13.9</td> <td>14.7</td> <td>16.1</td> <td>16.1</td> <td>15.2</td> <td>13.4</td> <td>13.8</td> <td>13.6</td> <td>13.2</td> </tr> </thead> <tbody> <tr> <th>5% DB</th> <td>MCWBR</td> <td>5.5</td> <td>5.7</td> <td>5.8</td> <td>6.4</td> <td>6.6</td> <td>6.7</td> <td>6.9</td> <td>7.0</td> <td>7.1</td> <td>6.</td> </tr> <tr> <th>5% WB</th> <td>MCDBR</td> <td>10.2</td> <td>10.6</td> <td>11.2</td> <td>13.1</td> <td>14.4</td> <td>13.0</td> <td>11.4</td> <td>11.8</td> <td>12.0</td> <td>11</td> </tr> <tr> <td>MCWBR</td> <td>5.6</td> <td>5.5</td> <td>5.4</td> <td>5.9</td> <td>6.2</td> <td>6.0</td> <td>5.9</td> <td>6.0</td> <td>7.1</td> <td>6.</td> </tr> </tbody> </table>	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	MCDBR	12.3	13.9	14.7	16.1	16.1	15.2	13.4	13.8	13.6	13.2	5% DB	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.																																											
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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

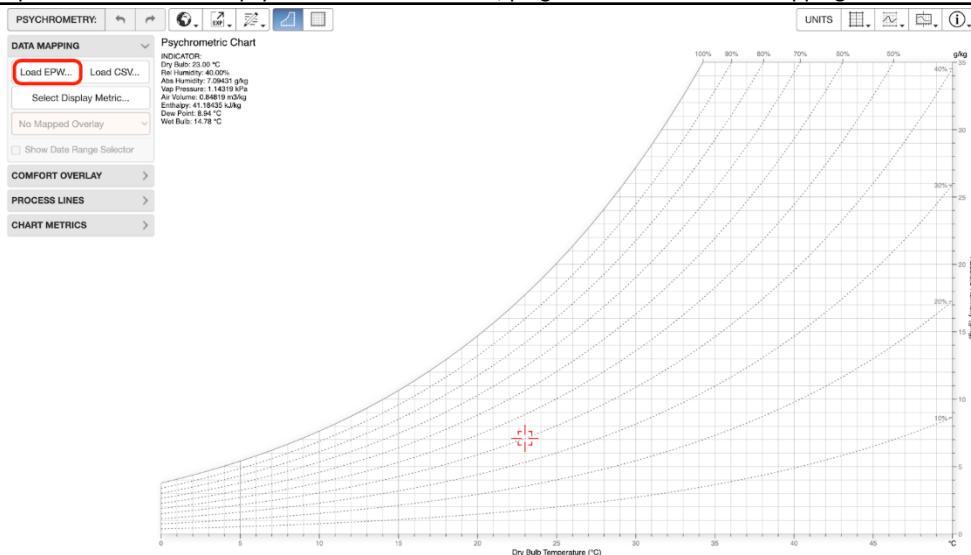
To determine if the strategies are effective, ineffective, or not needed in a specific month in a city, start with the EPW file. Energy Plus, CBE or OneBuilding

<https://energyplus.net/>

<https://clima.cbe.berkeley.edu/>

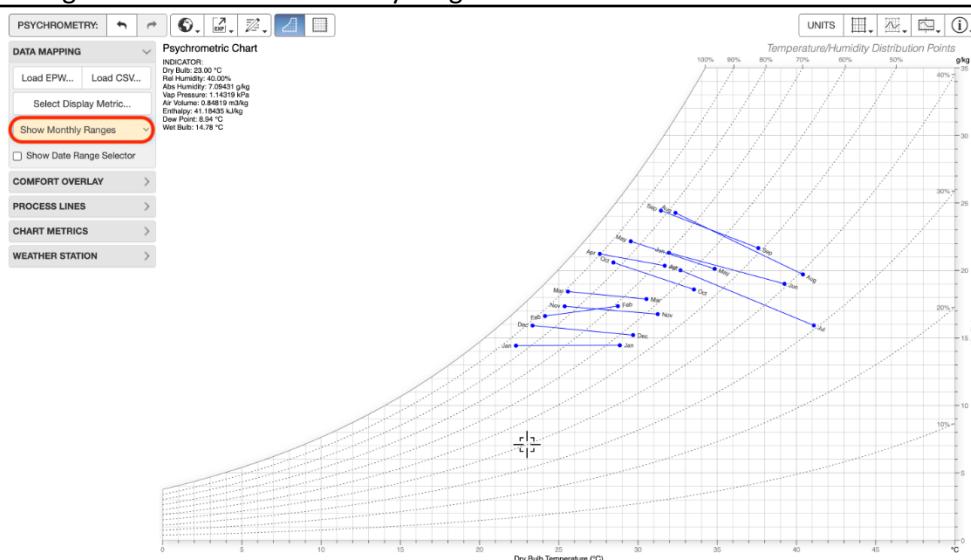
https://climate.onebuilding.org/WMO_Region_2_Asia/default.html

Open the file in Marsh's psychrometric chart maker, plug the file into the data mapping tab

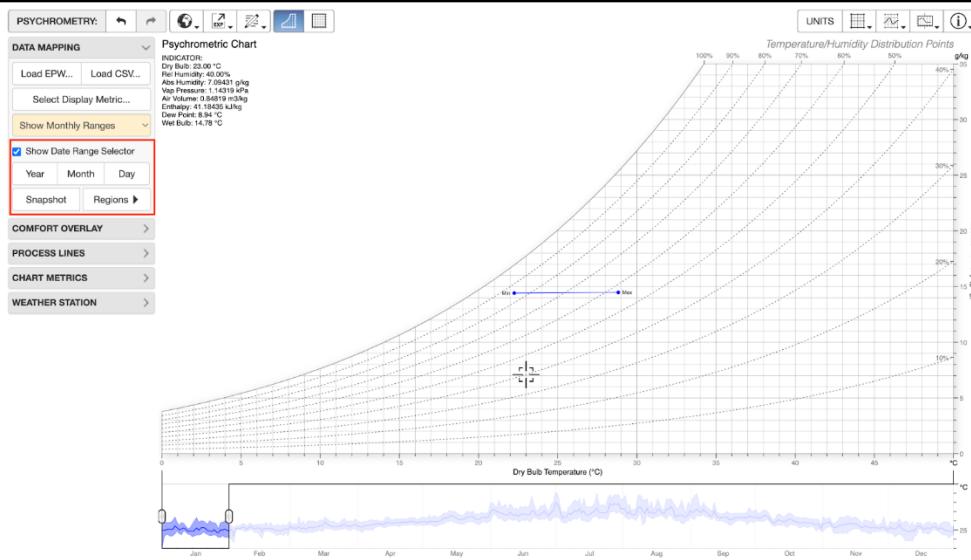


<https://draimash.bitbucket.io/psychro-chart2d.html>

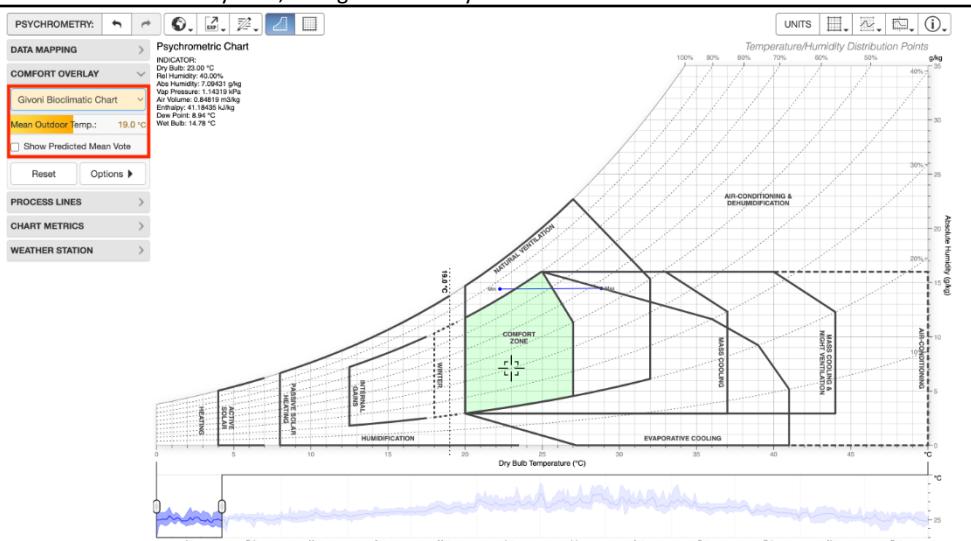
Change the data to show monthly range



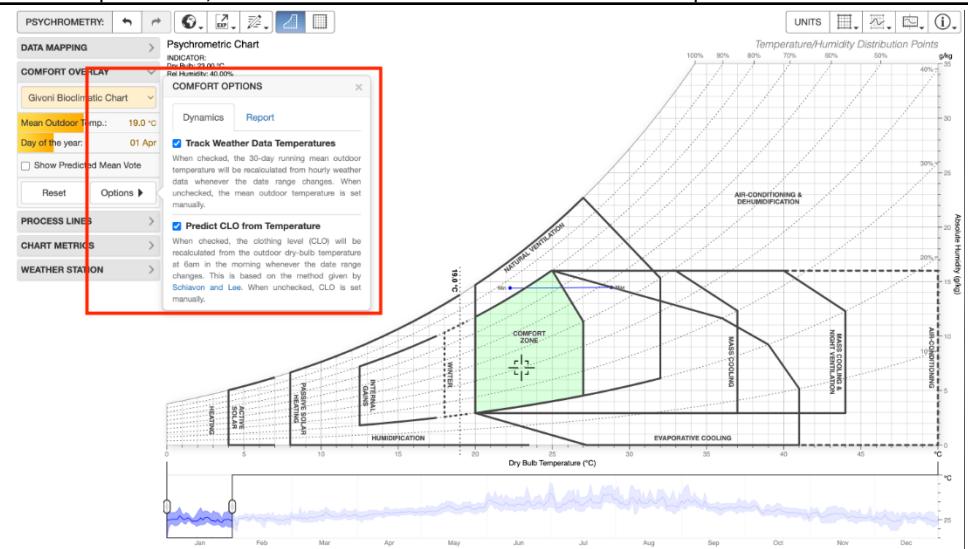
Check show data range selector and select the month in order to find the data for each individual month



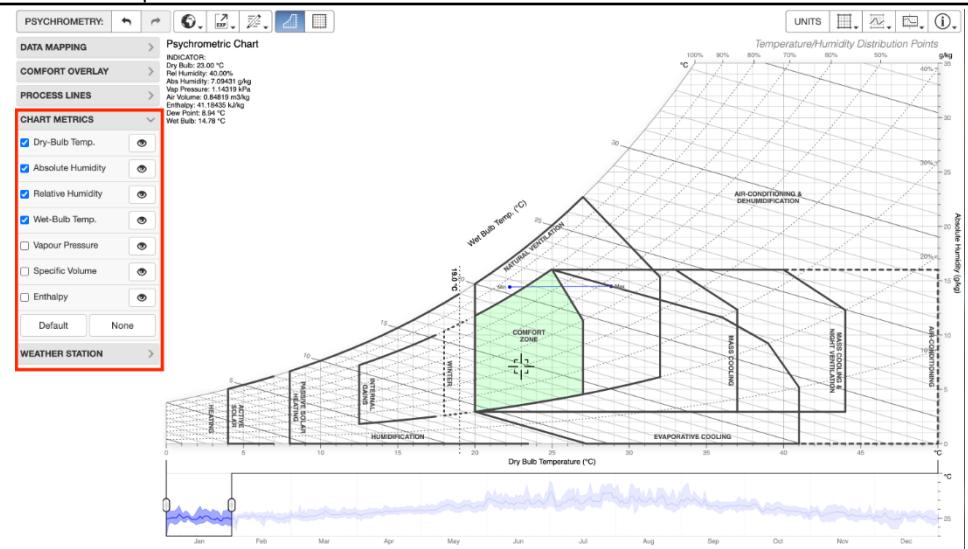
In the “Comfort overlay” tab, change the overlay to Givoni bioclimatic chart



In the “Options” tab, select track weather data & Predict Clo from temperature

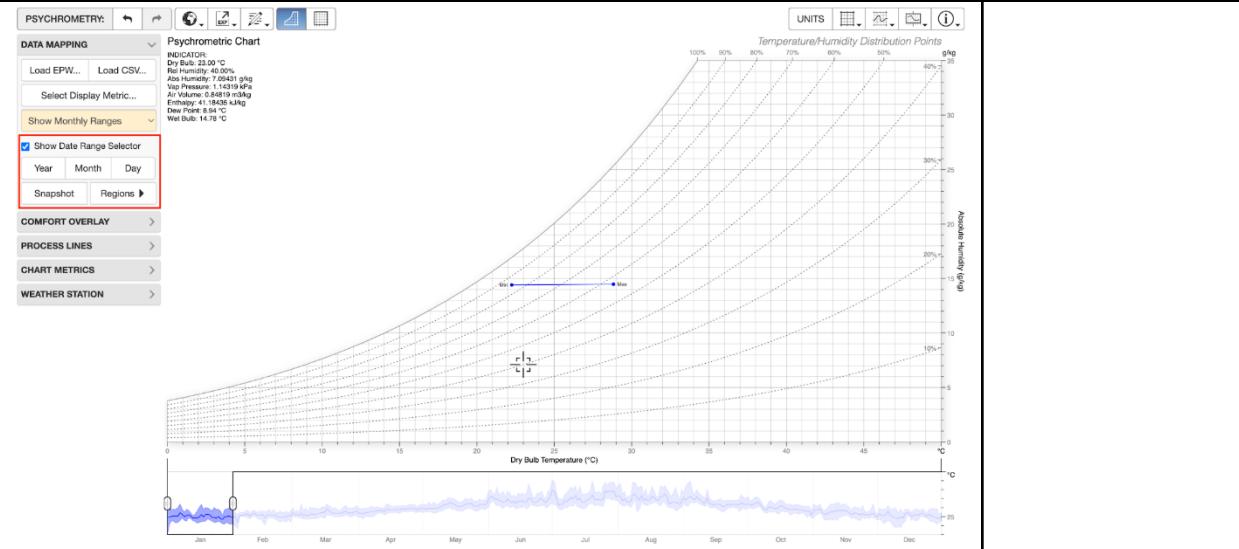


In the “Chart Metrics” tab, select dry bulb temperature, absolute humidity, relative humidity, & wet-bulb temperature.

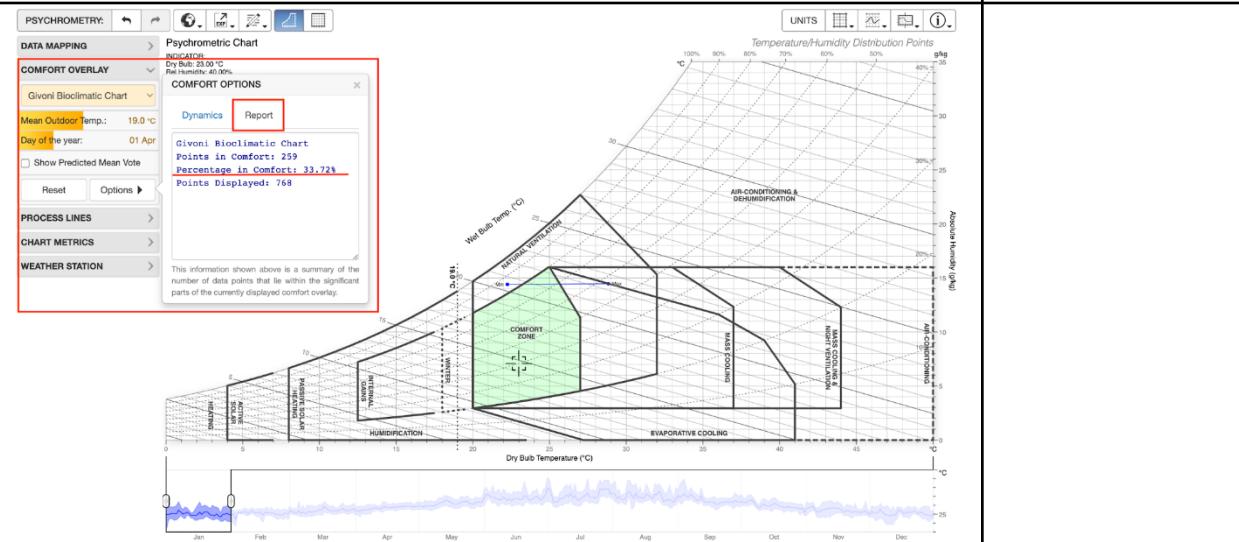


4 Finding the percentage of comfort for every month:

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

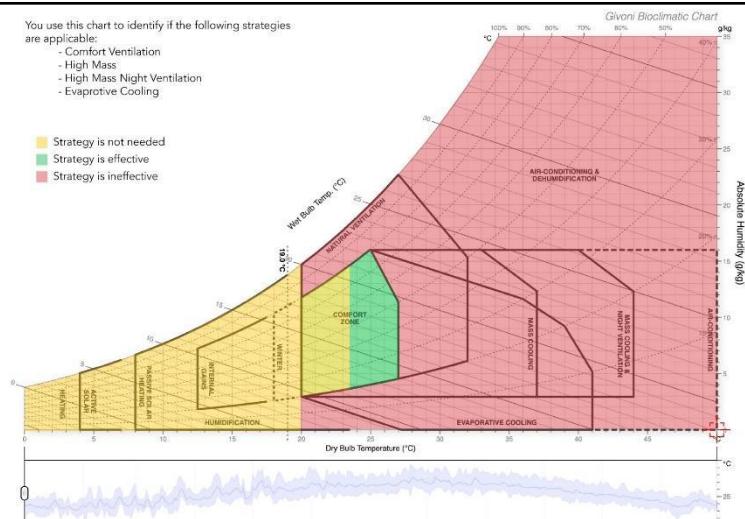
To find whether a strategy is effective or not look at the two psychrometric charts below and depending on the strategy you can determine whether the strategy is not needed, effective, or ineffective.

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.

You use this chart to identify if the following strategies are applicable:

- Comfort Ventilation
- High Mass
- High Mass Night Ventilation
- Evaprotive Cooling

■ Strategy is not needed
 ■ Strategy is effective
 ■ Strategy is ineffective

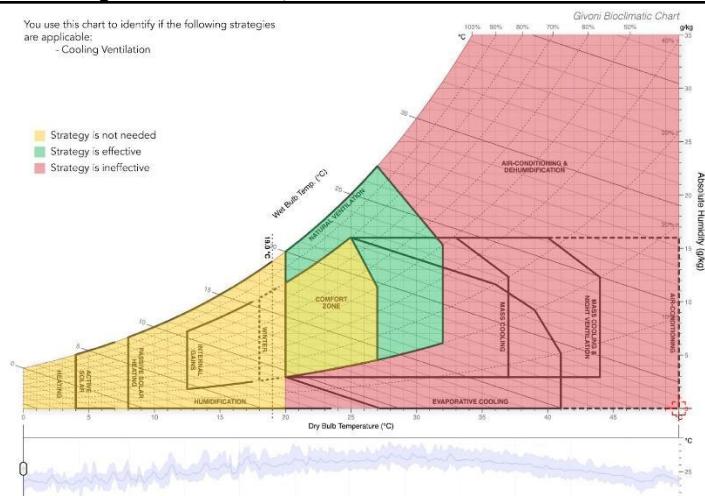


For **cooling** ventilation, if the data point falls in the yellow that deems the strategy not needed, if it is in the green it is effective, and if it is in the red it is ineffective.

You use this chart to identify if the following strategies are applicable:

- Cooling Ventilation

■ Strategy is not needed
 ■ Strategy is effective
 ■ Strategy is ineffective



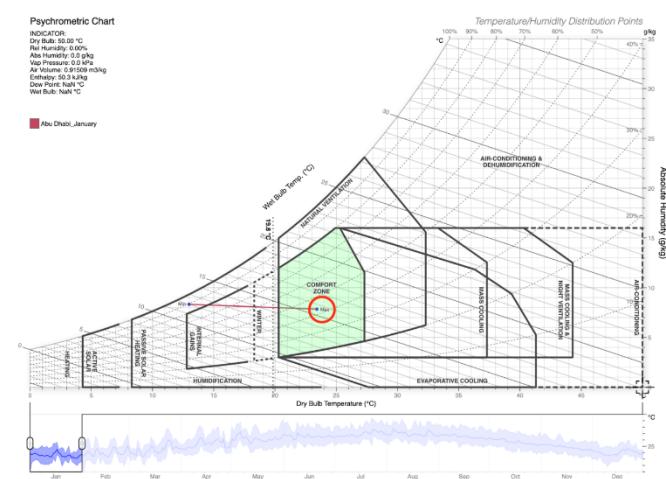
6 In order to determine if **Comfort ventilation** works:

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.

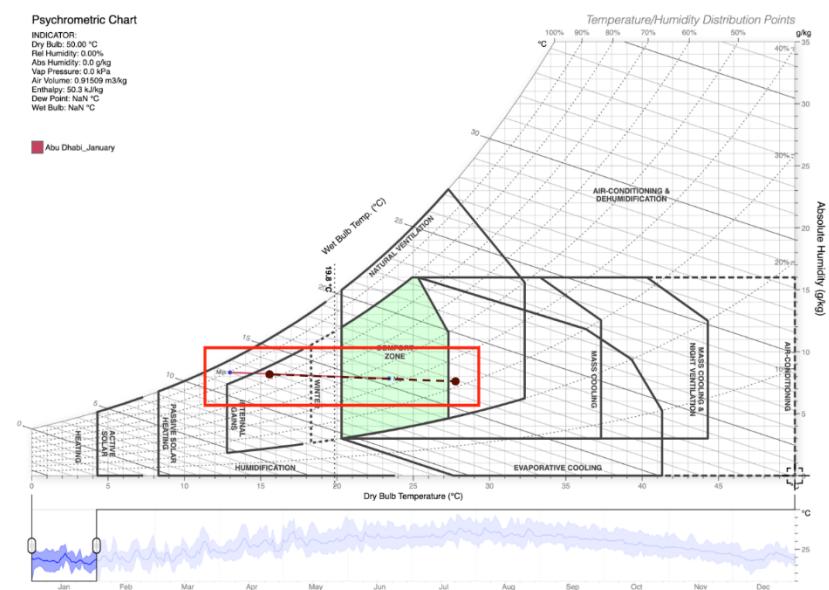
If it is within the comfort zone or below it is not needed.

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:

$$(1.5 + (\text{DesignLow} + (\text{MeanDaily}/2)))$$

HI MASS DESIGN DAY		Fully shaded, well insulated, 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: $(0.15 * \text{MeanDaily})$

HI MASS DESIGN DAY		Fully shaded, well insulated, 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	

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

HI MASS DESIGN DAY		Fully shaded, well insulated, 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	

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

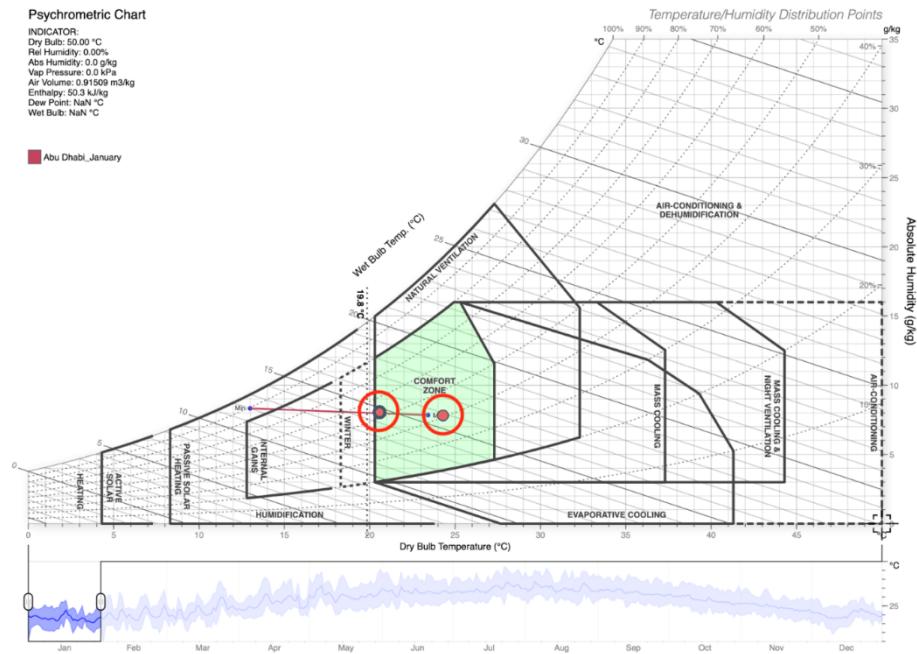
HI MASS DESIGN DAY		Fully shaded, well insulated, windows closed all day											
Tin ave		23.3	26.4	29.4	33.3	36.3	37.6	39.9	39.7	36.8	33.1	28	
Tin swing		1.8	2.1	2.2	2.4	2.4	2.3	2.0	2.1	2.0	2.0	1	
Tin max		24.2	27.4	30.5	34.5	37.5	38.7	40.9	40.7	37.8	34.1	29	
Tin min		22.3	25.3	28.2	32.0	35.0	36.5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

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	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	12.3	13.9	14.7	16.1	16.1	15.2	13.4	13.8	13.6	13.2	12.2	
Dry Bulb Temp	Avg Daily degrees C	23.4	26.6	28.1	33.0	38.2	39.9	41.4	42.0	39.8	35.6	30.1	
Range	Avg Daily degrees C	10.4	12.9	11.0	12.2	14.2	13.6	12.8	13.3	12.8	13.0	11.1	
Dry Bulb Temp	Avg Daily degrees C	13.0	13.7	17.1	20.8	24.0	26.3	28.6	28.7	27.0	22.6	18.1	

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 ($T_{minVent}$) which is used to track the low point of the High mass Night ventilation line, subtract internal minimum Temperature (T_{inMin}) from 0.5 Multiplied by internal minimum Temperature (T_{inMin}) from Monthly design day low (DDlow):
 $(T_{inMin}-0.5*(T_{inMin}-DDlow))$

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 ($T_{maxVent}$) used to track the High point of the High mass Night ventilation line, subtract the internal maximum Temperature (T_{inMax}) from 0.5 multiplied by internal Maximum Temperature (T_{inMax}) from Monthly design day low (DDHigh):
 $(T_{inMax}-0.5*(T_{inMax}-DDHigh))$

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

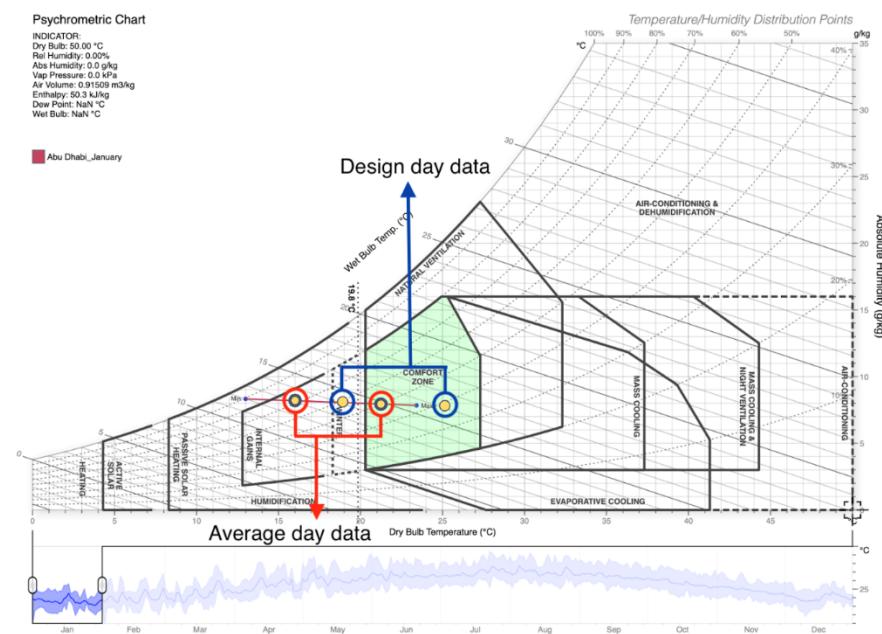
Note that the same measures are taken in order to find if High mass night ventilation works on the average day through substituting the Design day numbers done in step A (orange above) with average numbers.

			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	
Dry Bulb Temp	Avg Daily degrees C	High	23.4	26.6	28.1	33.0	38.2	39.9	41.4	42.0	39.8	35.6	30.2	
Dry Bulb Temp	Avg Daily degrees C	Low	10.4	12.9	11.0	12.2	14.2	13.6	12.8	13.3	12.8	13.0	11.3	

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



<p>9 assess if evaporation cooling is effective in a specific month</p> <p>Take the maximum temperature established by the line created by natural ventilation in order to determine if the strategy works on the <u>design day maximum</u>. 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.</p> <p>If the point is outside (or beyond) the zone the strategy is not needed.</p> <p>Take the maximum temperature established by the line created by the maximum average in order to determine if the strategy works on the <u>average day maximum</u>. 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.</p> <p>If the point is outside (or beyond) the zone the strategy is not needed.</p>	
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