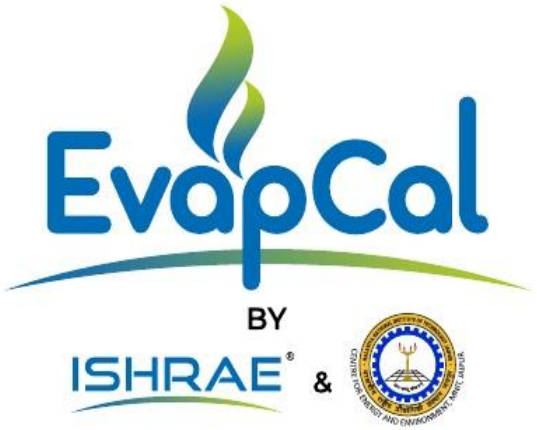


USER MANUAL

EvapCal EC 2021:01

Developer Team:

Khyati Paghdar, Centre for Energy and Environment, Malaviya National Institute of Technology, Jaipur.

Raj Gupta, Research Assistant, Indian Society of Heating, Refrigerating and Air-conditioning Engineers (ISHRAE), New Delhi.

Dr-Ing Jyotirmay Mathur, Centre for Energy and Environment, Malaviya National Institute of Technology, Jaipur.

Mr. Nishant Gupta, Managing Director, Degree Day Pvt. Ltd., Indore.

Mr. Vaibhav Gupta, Director, Humidin Casilica, Delhi.

Introduction:

EvapCal EC 2021:01 is a simulation tool with pre-installed hourly weather data files for all major cities of India. Weather data files that are available on energyplus.net can be imported into the software to run the simulations for cities which are not included in the tool.

Based on user inputs, it calculates design parameters for evaporative coolers of direct, indirect, and two-stage (indirect-direct) types with thermal comfort analysis on a psychrometric chart.

Users can simulate the design data for the application-based operational schedule in terms of months/days/hours to analyze the number of hours that can be made comfortable through the selected evaporative cooler of said saturation efficiency.

Users can carry out peak power-saving analysis with evaporative coolers over alternate active cooling technique. Peak power of evaporative cooler stands for power consumption by the cooler when it operates at full capacity. Energy consumption in active cooling takes care of total heat load of the space and operate at full capacity.

The tool is exclusively available for ISHRAE Members only.

Installation Instructions:

1. Login to ISHRAE Official Website (www.ishrae.in) using your Membership details. You will find a page to download the setup file for the EvapCal. You will be able to produce a password linked to the Membership ID which will be used every time when user open the software after installation. (To retrieve forgot password, user need to login to the website.)

2. A setup file (EvapCal_2.3_setup.exe) can be installed in a system having minimum system specifications as following:

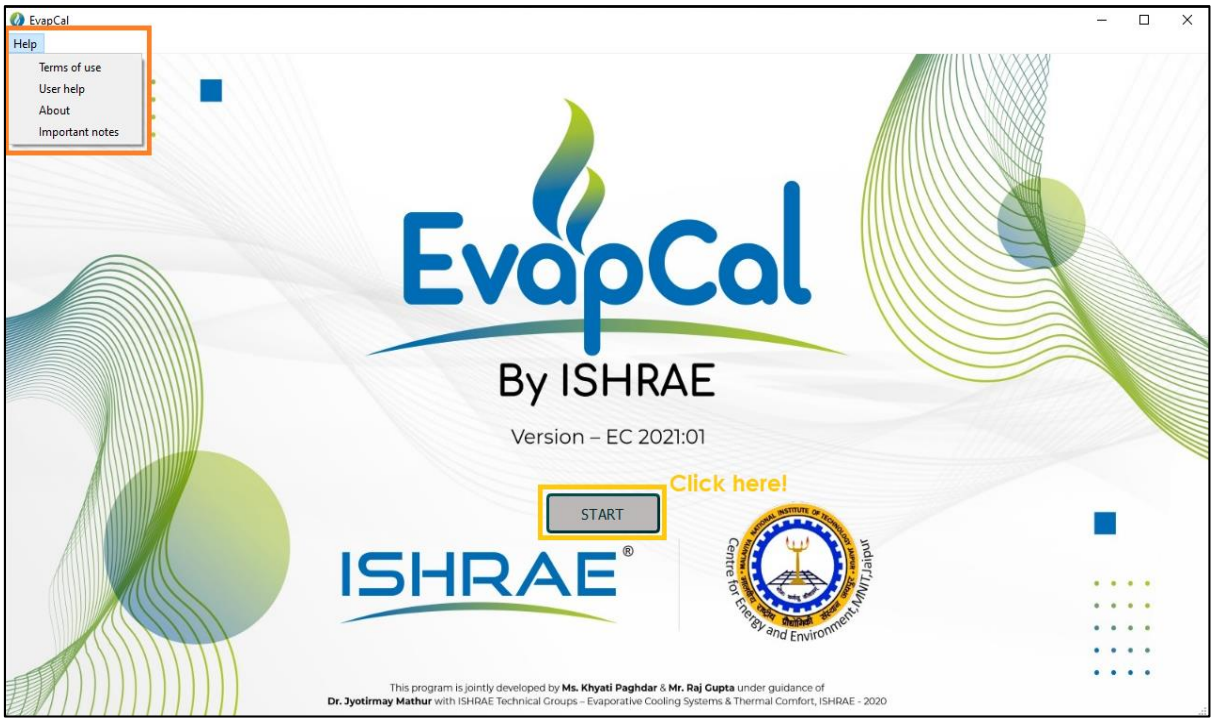
   - Windows 10, 64 – bit operating system
   - Core i3 processor

3. A desktop shortcut can be created while installing the setup file or search "EvapCal_2.3" in the window START menu to run the software.

How to Use the Tool:

1. Open the application (It takes 15 – 17 seconds to load the application after clicking open).

2. The "Help" menu on the top left corner provides information about the tool, important notes, user help, and terms of use. Click on the "START" button on the front page to proceed with the design process.



3. Users will be led to the login page.

   Login page ask for ISHRAE Membership no. as the User ID.

   User ID will be verified in the online database. Please make sure the system has good internet connection. Otherwise server connection will fail and users will not be able to login.

   Only authentic users after verification of membership no. and password will be able to proceed ahead and use the tool.

   Please note that password linked to individual membership Id will be communicated while downloading software. User need to login to the official website to retrieve forgot password.

4. A new window with three tabs will open. The first tab is Evaporative Cooler System Design.

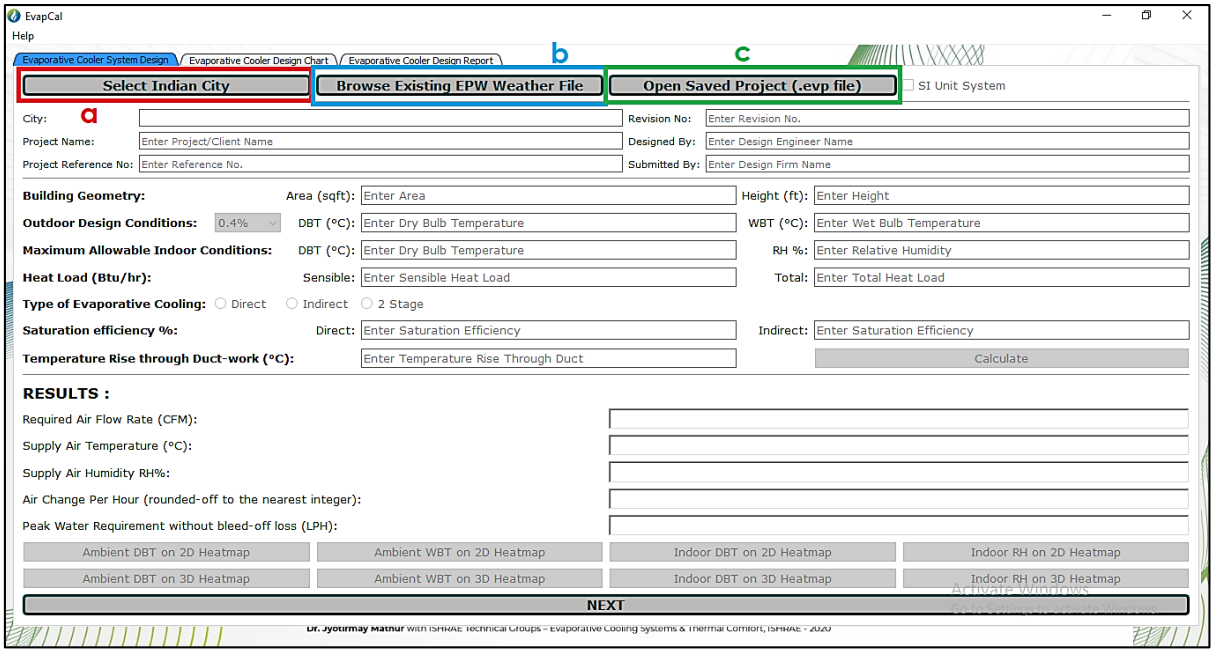
   There are two ways (a & b) to read/Import weather data files (will be notified via a message box as soon as the first tab show up.):

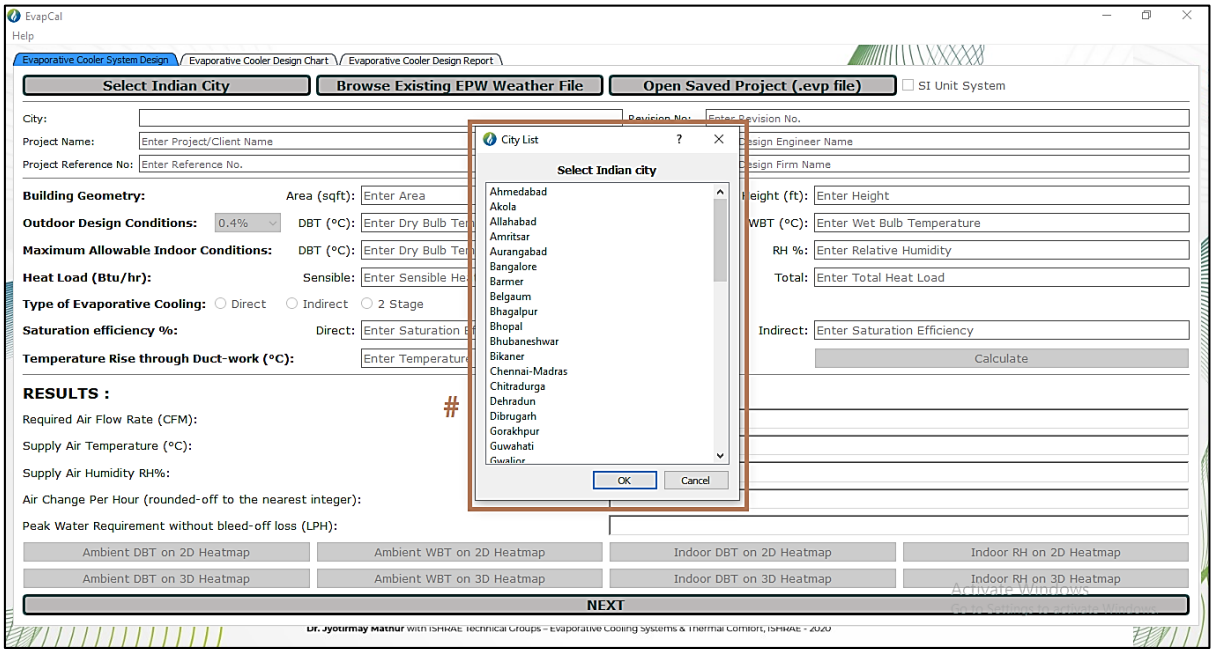
   a. "Select Indian City" button to read the in-built weather data file of the selected city. (#A city list will open upon clicking on the "Select Indian City" button)

   b. "Browse Existing EPW Weather File" to browse the ".epw" file from the system for cities that are not in the city list.

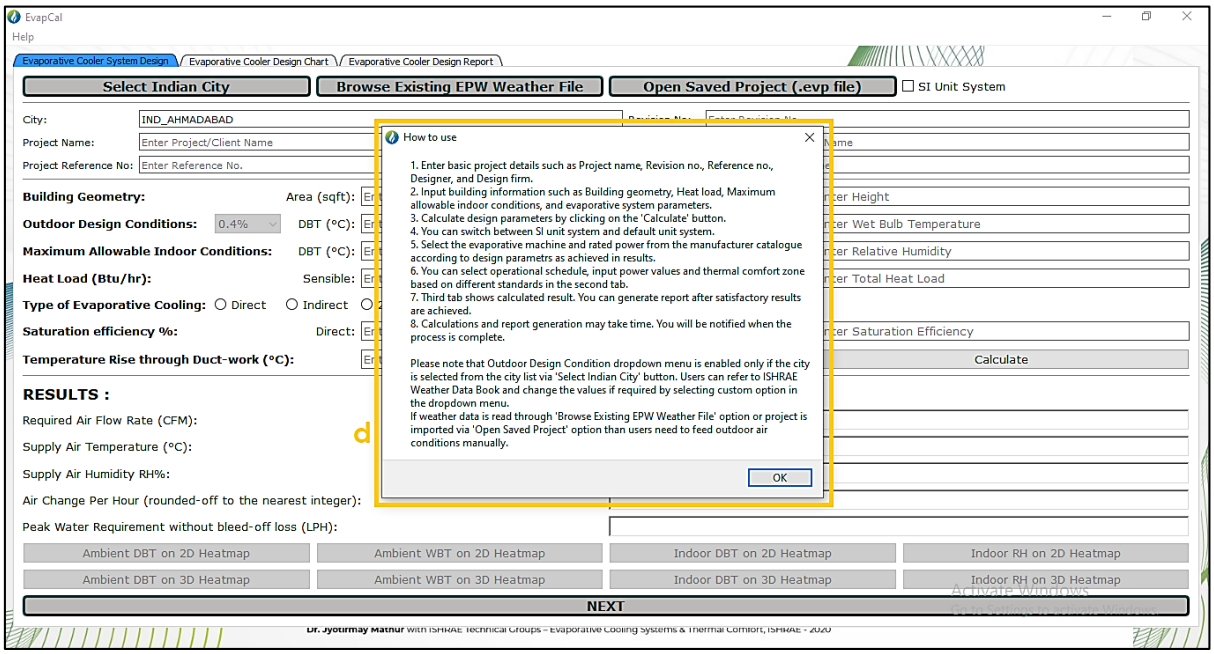
   c. "Open Saved Project" option is provided to import application-specific .evp files that can be saved in EvapCal (to be discussed later).

   It is to be noted that all input and output fields will be enabled only after weather data reading or importing the saved project as described.


EvapCal
Help
Evaporative Cooler System Design
Evaporative Cooler Design Chart
Evaporative Cooler Design Report
b
c
Select Indian City
Browse Existing EPW Weather File
Open Saved Project (.evp file)
SI Unit System
a
City:
Revision No:
Enter Revision No.
Project Name:
Enter Project/Client Name
Designed By:
Enter Design Engineer Name
Project Reference No:
Enter Reference No.
Submitted By:
Enter Design Firm Name
Building Geometry:
Area (sqft):
Enter Area
Height (ft):
Enter Height
Outdoor Design Conditions:
0.4%
DBT (°C):
Enter Dry Bulb Temperature
WBT (°C):
Enter Wet Bulb Temperature
Maximum Allowable Indoor Conditions:
DBT (°C):
Enter Dry Bulb Temperature
RH %:
Enter Relative Humidity
Heat Load (Btu/hr):
Sensible:
Enter Sensible Heat Load
Total:
Enter Total Heat Load
Type of Evaporative Cooling:
Direct
Indirect
2 Stage
Saturation efficiency %:
Direct:
Enter Saturation Efficiency
Indirect:
Enter Saturation Efficiency
Temperature Rise through Duct-work (°C):
Enter Temperature Rise Through Duct
Calculate
RESULTS :
Required Air Flow Rate (CFM):
Supply Air Temperature (°C):
Supply Air Humidity RH%:
Air Change Per Hour (rounded-off to the nearest integer):
Peak Water Requirement without bleed-off loss (LPH):
Ambient DBT on 2D Heatmap
Ambient WBT on 2D Heatmap
Indoor DBT on 2D Heatmap
Indoor RH on 2D Heatmap
Ambient DBT on 3D Heatmap
Ambient WBT on 3D Heatmap
Indoor DBT on 3D Heatmap
Indoor RH on 3D Heatmap
NEXT
Dr. Jyotirmay Mathur with ISHRAE Technical Groups – Evaporative Cooling Systems & Thermal Comfort, ISHRAE - 2020


EvapCal
Help
Evaporative Cooler System Design
Evaporative Cooler Design Chart
Evaporative Cooler Design Report
Select Indian City
Browse Existing EPW Weather File
Open Saved Project (.evp file)
SI Unit System
City List
Select Indian city
Ahmedabad
Akola
Allahabad
Amritsar
Aurangabad
Bangalore
Barmer
Belgaum
Bhagalpur
Bhopal
Bhubaneshwar
Bikaner
Chennai-Madras
Chitradurga
Dehradun
Dibrugarh
Gorakhpur
Guwahati
OK
Cancel
#
RESULTS :
Required Air Flow Rate (CFM):
Supply Air Temperature (°C):
Supply Air Humidity RH%:
Air Change Per Hour (rounded-off to the nearest integer):
Peak Water Requirement without bleed-off loss (LPH):
NEXT

d. A message box providing instructions on 'How to use' the tool will appear after weather data reading.



5. Now, provide inputs for the calculation of design parameters.

e. Input basic project details that include Project Name, Project Reference No, Revision No, Designer Name, and Design Firm Name.

f. Also, provide building data (Area, Height, Outdoor Design Condition, Maximum allowable Indoor Condition, Sensible and Total heat load,)and evaporative system details (Type and Saturation Efficiency of the evaporative cooler, Temperature gain through duct-work)

g. Users can follow the default unit system or switch to the SI unit system by checking the "SI Unit System" option.

h. If weather data is read through city selection open via "Select Indian City option", Outdoor Design Condition can be auto-fed for selected design conditions from the drop-down menu. Users can provide these values manually by selecting the "Custom" option in the drop-down menu.

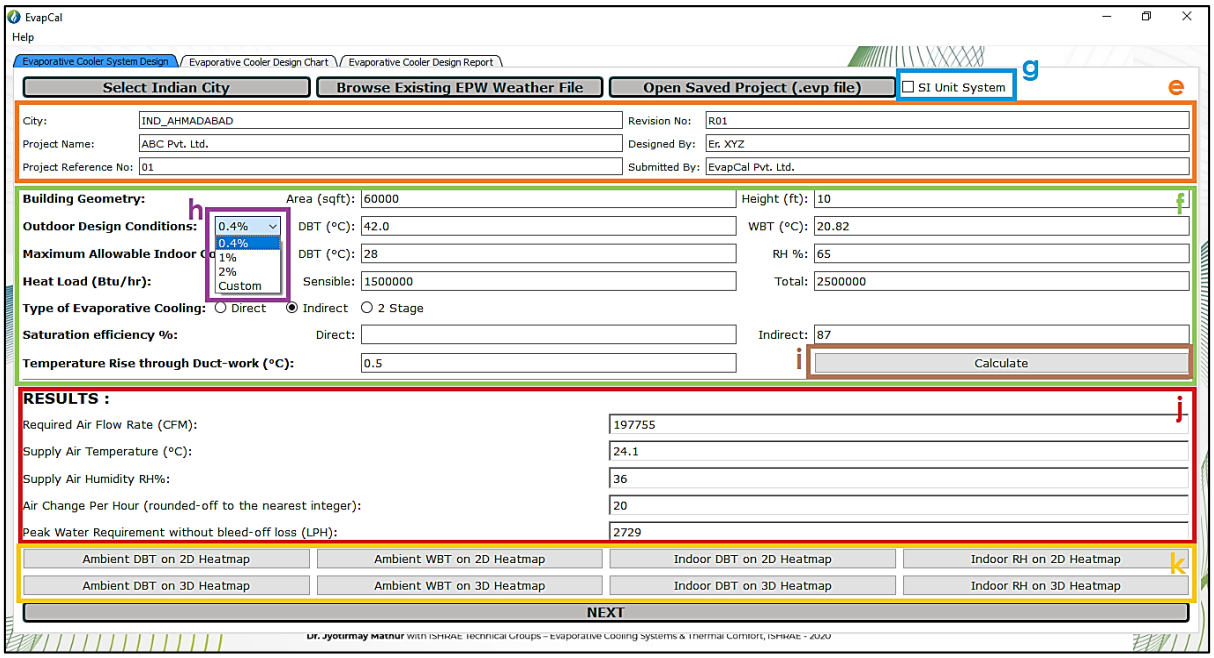
(Please note that the drop-down menu will be disabled if weather data is imported via "Browse Existing EPW Weather File" or the project is imported via the "Open Saved Project" option. Users need to input these values manually in such cases.)

i. Click on the "Calculate" button to compute evaporative cooler design parameters based on the input values. Users need to press this button when any of the input values is changed.

j. "RESULTS" section displays calculated design parameters that include Required Airflow Rate, Supply Air Condition, Air Changes Per Hour, and Peak Water Requirement without bleed-off loss. (Refer to the "How to Interpret the Results" section to expound these results.)

k. Heat maps in 2D and 3D format can be viewed through push buttons provided for ambient and indoor air conditions. Please note that users need to close the figure window to go back to the Evaporative Cooler System Design tab and proceed further.

Users can access the next tab through the "NEXT" button at the bottom or by clicking on the "Evaporative Cooling Design Chart" tab on the top.



6. The next tab is "Evaporative Cooler Design Chart".

l. The psychrometric chart shows comfort zone, number of comfort and discomfort hours, and design process. Legends on the top-left side of the psychrometric chart make it easy to read the chart.

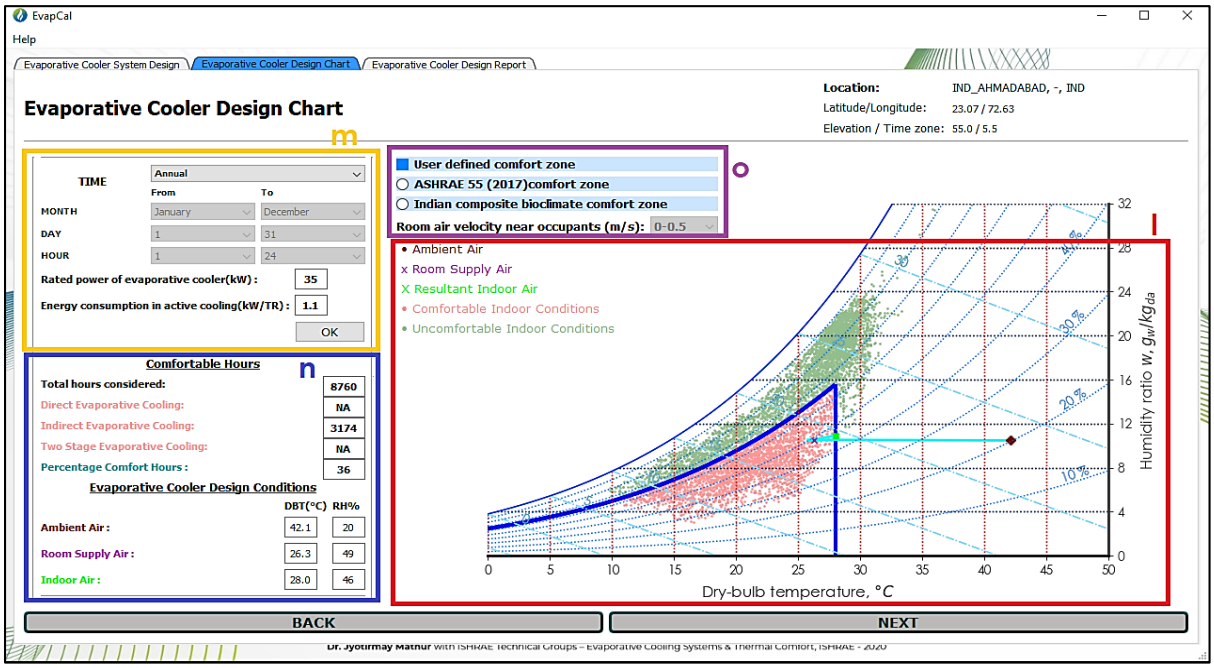
m. Depending on end-user, Season/Month/Day/Hour can be set via drop-down menus. Rated power (KW) of selected evaporative cooler based on required airflow rate is to be provided with energy consumption in

active cooling (kW/TR). Users need to press the "OK" button to reflect the changes in computation.

n. The default comfort zone is the user-defined comfort zone that can be changed through radio buttons provided to see results on other comfort zones as specified.

o. Legends are provided on the left side to display the number of hours considered, number of comfortable hours, percentage comfort hours, and design process states. Comfortable hours for selected strategy will be displayed in the case of Direct and Indirect systems whereas all 3 - direct, indirect, and two-stage comfort hours will be displayed in the case of Two-stage systems.

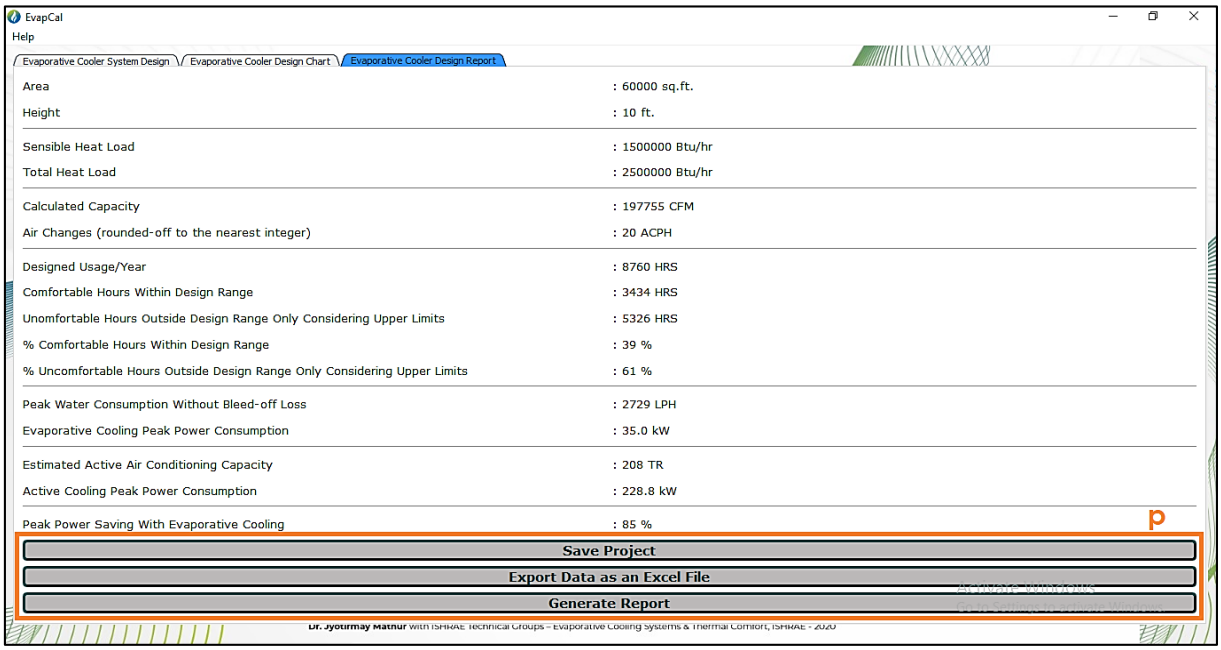
To understand these in more detail, refer to the "How to Interpret the Results" Section.

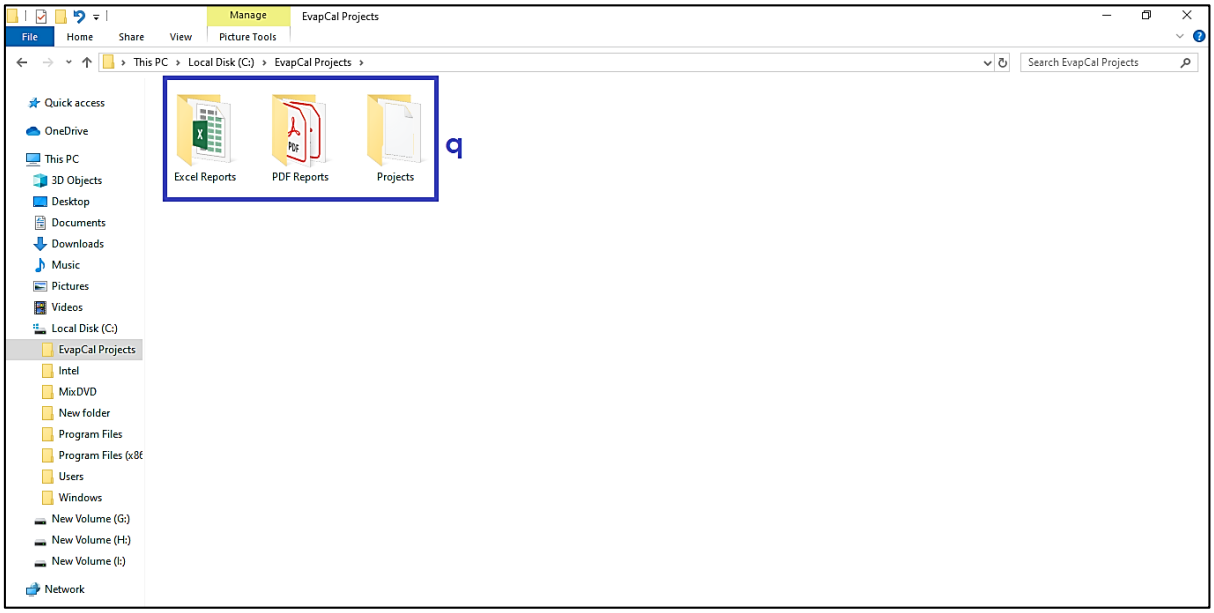


7. The third tab, "Evaporative Cooler Design Report" summarizes the design parameters and results.

p. Users can generate PDF and EXCEL reports. Also, the application-specific ".evp" file will save the project which can be imported into the tool to further revise and improve the design.

q. The tool creates a folder "EvapCal Projects" in the C drive of the system. Separate subfolders for pdf, excel, and .evp projects namely Project Reports, Excel Reports, and Projects are made to save the files respectively.





How to Interpret the Results:

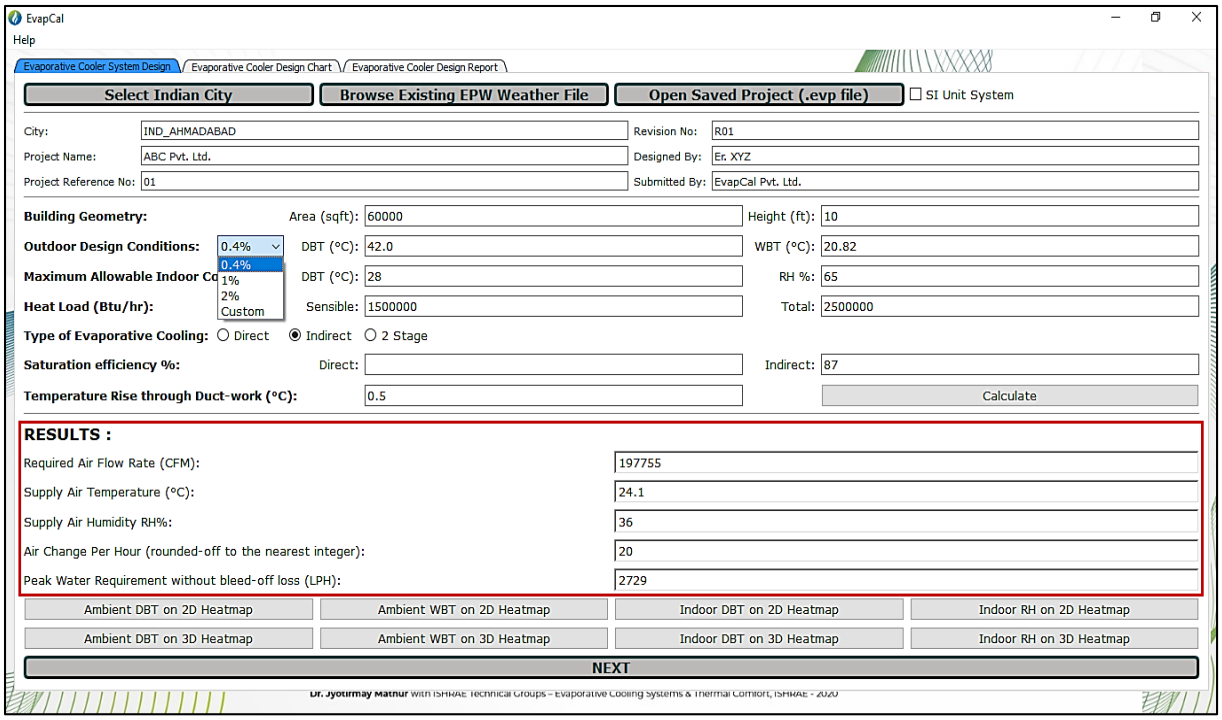
1. Calculated design parameters displayed in the "RESULTS" section can be interpreted as the following,

   Required Air Flow Rate: Air-flow rate is the volume of air supplied by the system into the conditioned space per unit of time. Here, the value is calculated with consideration to suffice the sensible heat load and maintain specified Indoor dry bulb temperature given as an input by the user for Maximum allowable Indoor Condition - DBT.

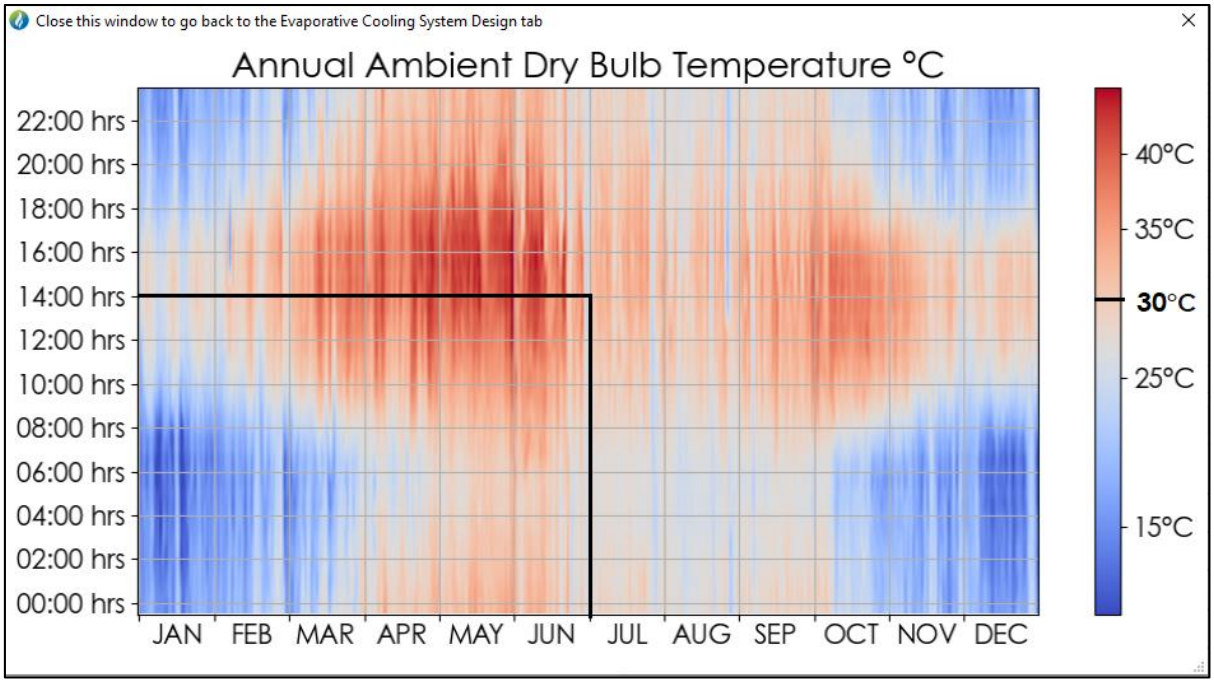
   Supply Air Temperature and Humidity: DBT and RH of air to be supplied to the conditioned space after cooling through the evaporative cooling system. It considers temperature gain through ductwork as well.

   Air Changes Per Hour: The number of times that the total volume of air in the conditioned area is changed with the supply air. The calculation is based on the air-flow rate and volume of the space to be conditioned.

   Peak Water Requirement without bleed-off loss: Water requirement for evaporation loss when the cooler is working at peak capacity. This does not include bleed-off loss, drift loss, and pump loss.



2. Heat maps display hourly simulated data (Ambient DBT, Ambient WBT, Indoor DBT, and Indoor RH) for the whole year. A sample Heatmap is displayed for annual ambient dry bulb temperature. Ambient DBT at 14:00 hrs on 1st July is nearly 30°C as projected in the picture below. Other heat maps in 2D and 3D formats can be interpreted similarly.



3. Thermal Comfort Analysis:

   A. Evaporative Cooler Design Process: The Psychrometric chat shows the design process in **cyan** color. It begins from ambient air state to supply air state and finally the resultant indoor air state.

   B. Evaporative Cooler Design Process in values: DBT and RH values at ambient, supply and indoor states are also displayed in the bottom left corner of the tab.

   C. Comfort Zone: The Comfort zone is displayed on the psychrometric chart by the **blue** color boundary.

      C1. User defined comfort zone: The user-defined comfort zone is bounded by the maximum allowable indoor DBT and RH specified by the user in the first tab. For example, Maximum allowable indoor DBT and RH defined by the user are 28°C and 65% respectively. Comfort zone considering these limits are shown in the chart.

C2. ASHRAE 55-2017 comfort zone: This comfort zone is bounded by the values specified in the Graphical Comfort Zone Method of ASHRAE 55-2017 standard. This is valid for spaces where air velocity near occupants' level is smaller than 0.2 m/s (40 fpm) and occupants' metabolic rates and clothing level of 1.0 to 1.3 met and 0.5 to 1.0 clo, respectively.

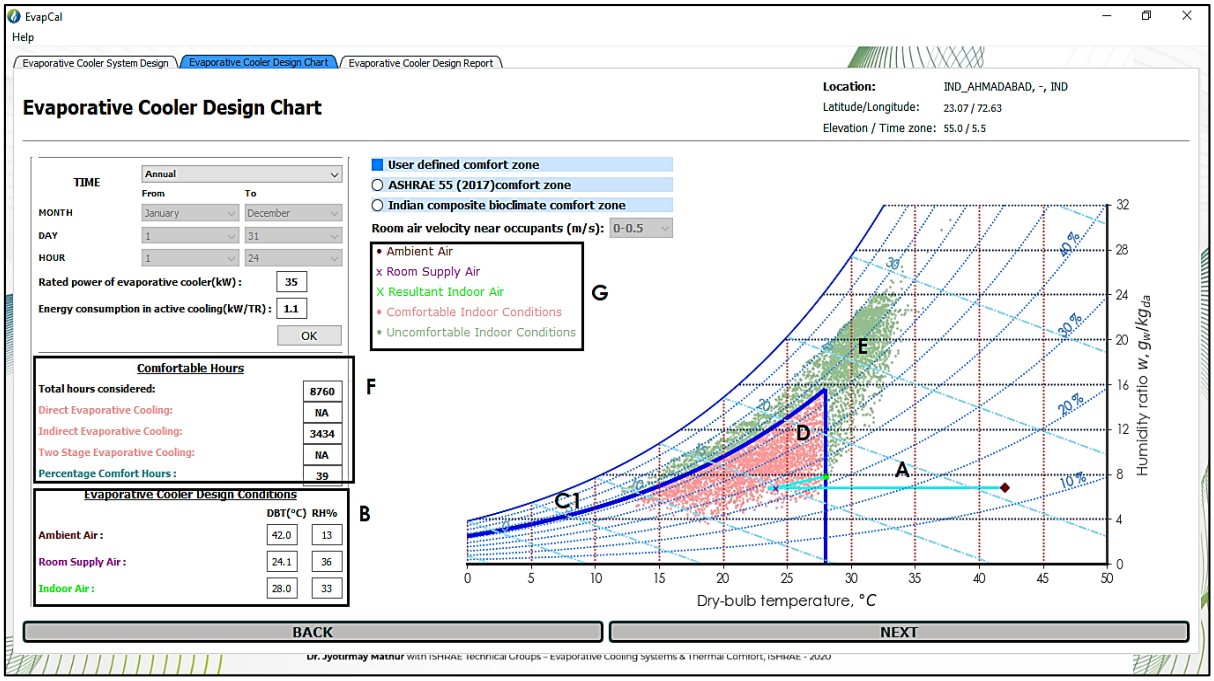
C3. Indian composite bioclimatic comfort zone: This is valid only for cities that are considered in the composite climate zone of India (Refer to Energy Conservation Building Code). The zone is defined for the three airspeed ranges, 0 to 0.5, 0.5 to 1, and 1 to 1.5 in m/s.

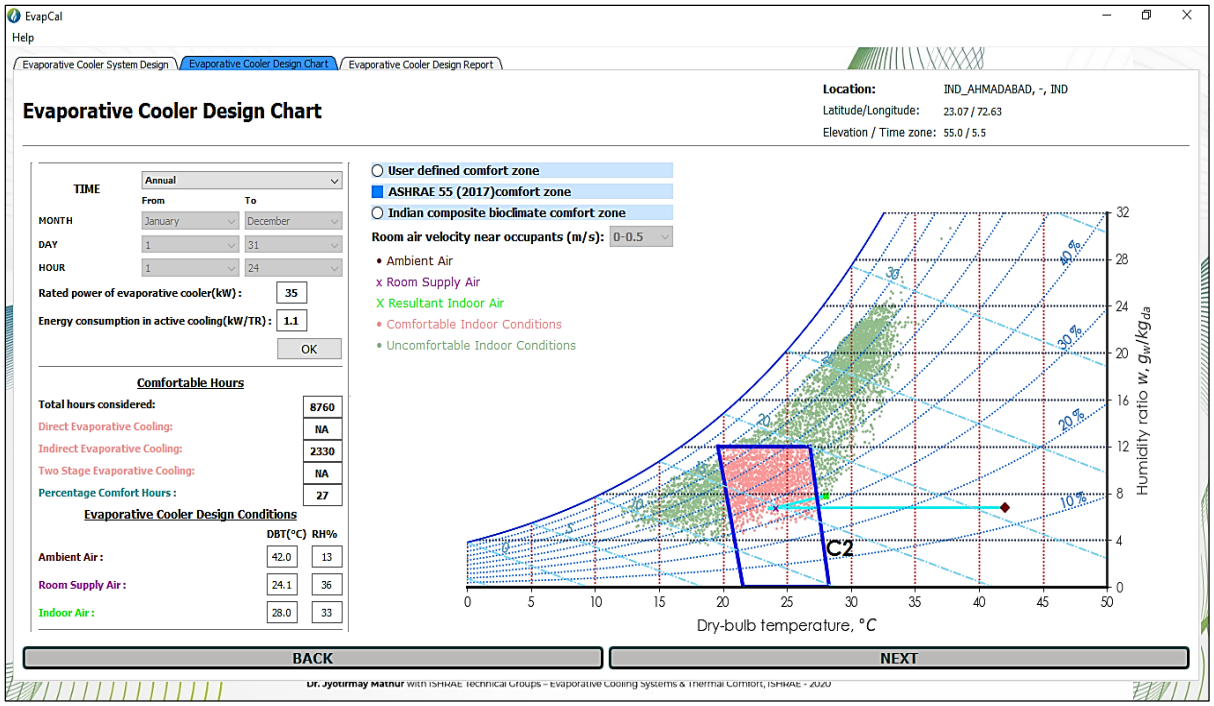
D. Comfortable Hours: Hourly weather data is simulated considering design parameter inputs to calculate resultant indoor air conditions. Resultant indoor air conditions falling inside the comfort zone are counted as the comfortable hours and are depicted on the psychrometric chart by **pink** colour dots. Number of comfort hours will vary with the type of comfort zone selected.

E. Uncomfortable Hours: Uncomfortable hours are those for which resultant indoor air condition fall outside the comfort zone and are represented by **green** colour dots.

F. The number of comfortable hours and the percentage of comfortable hours based on the total considered hours are displayed in the left legend. For the direct and indirect systems, respective comfortable hours will be displayed while in the case of two-stage system, all three – direct, indirect and two-stage comfort hours will be displayed. For example, Indirect system is selected which suffice user-defined comfort limits for 3434 hours out of 8760 hours of operation. This results in 39% of comfortable hours as can be seen in the related figure.

G. Psychrometric chart Legends: Legends on the top-left side of the psychrometric chart provides captions for evaporative design process states and comfortable/uncomfortable hours. Captions are color coded with psychrometric chart to make it easy to understand.


EvapCal
Help
Evaporative Cooler System Design
Evaporative Cooler Design Chart
Evaporative Cooler Design Report
Evaporative Cooler Design Chart
Location: IND_AHMADABAD, -, IND
Latitude/Longitude: 23.07 / 72.63
Elevation / Time zone: 55.0 / 5.5
TIME
Annual
From
To
MONTH
January
December
DAY
1
31
HOUR
1
24
Rated power of evaporative cooler(kW) :
35
Energy consumption in active cooling(kW/TR) :
1.1
OK
Comfortable Hours
Total hours considered:
8760
Direct Evaporative Cooling:
NA
Indirect Evaporative Cooling:
3434
Two Stage Evaporative Cooling:
NA
Percentage Comfort Hours :
39
Evaporative Cooler Design Conditions
DBT(°C)
RH%
Ambient Air :
42.0
13
Room Supply Air :
24.1
36
Indoor Air :
28.0
33
User defined comfort zone
ASHRAE 55 (2017)comfort zone
Indian composite bioclimate comfort zone
Room air velocity near occupants (m/s):
0-0.5
Ambient Air
Room Supply Air
Resultant Indoor Air
Comfortable Indoor Conditions
Uncomfortable Indoor Conditions
F
G
B
A
C1
D
E
Dry-bulb temperature, °C
Humidity ratio w, gw/kgda
BACK
NEXT


EvapCal
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Evaporative Cooler Design Chart
Evaporative Cooler Design Report
Evaporative Cooler Design Chart
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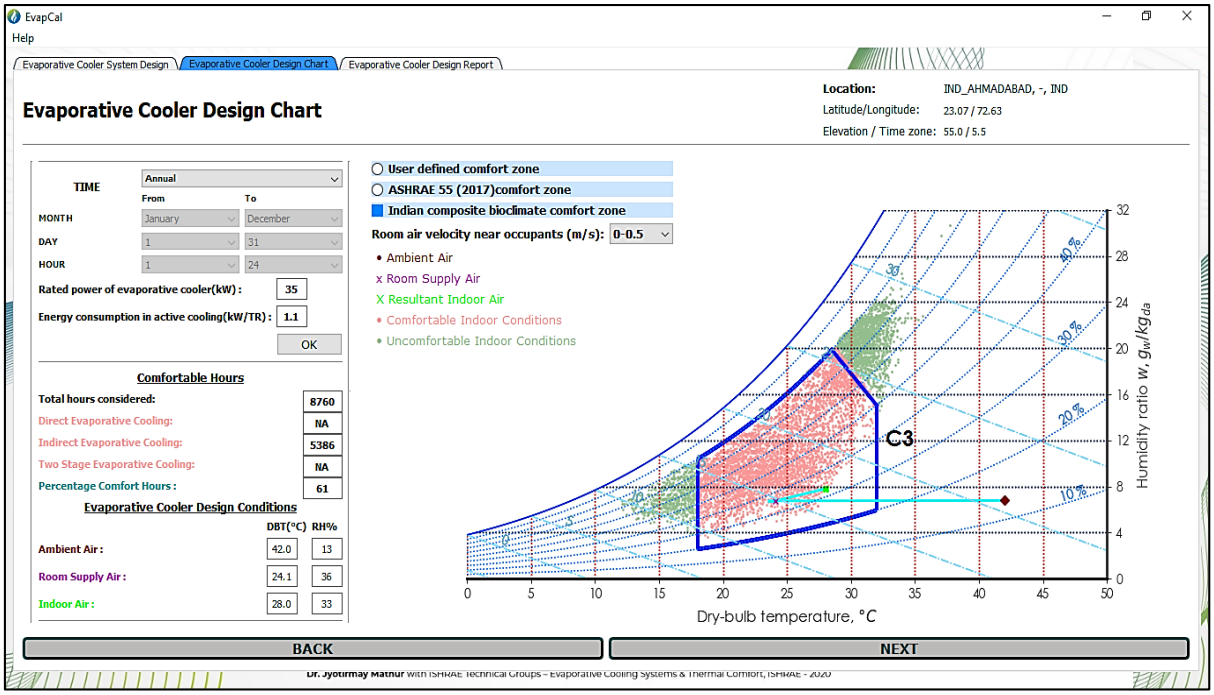
Latitude/Longitude: 23.07 / 72.63
Elevation / Time zone: 55.0 / 5.5
TIME
Annual
From
To
MONTH
January
December
DAY
1
31
HOUR
1
24
Rated power of evaporative cooler(kW) :
35
Energy consumption in active cooling(kW/TR) :
1.1
OK
Comfortable Hours
Total hours considered:
8760
Direct Evaporative Cooling:
NA
Indirect Evaporative Cooling:
2330
Two Stage Evaporative Cooling:
NA
Percentage Comfort Hours :
27
Evaporative Cooler Design Conditions
DBT(°C)
RH%
Ambient Air :
42.0
13
Room Supply Air :
24.1
36
Indoor Air :
28.0
33
User defined comfort zone
ASHRAE 55 (2017)comfort zone
Indian composite bioclimate comfort zone
Room air velocity near occupants (m/s):
0-0.5
Ambient Air
Room Supply Air
Resultant Indoor Air
Comfortable Indoor Conditions
Uncomfortable Indoor Conditions
C2
Dry-bulb temperature, °C
Humidity ratio w, gw/kgda
BACK
NEXT


EvapCal
Help
Evaporative Cooler System Design
Evaporative Cooler Design Chart
Evaporative Cooler Design Report
Evaporative Cooler Design Chart
Location: IND_AHMADABAD, -, IND
Latitude/Longitude: 23.07 / 72.63
Elevation / Time zone: 55.0 / 5.5
TIME
Annual
From
To
MONTH
January
December
DAY
1
31
HOUR
1
24
Rated power of evaporative cooler(kW) :
35
Energy consumption in active cooling(kW/TR) :
1.1
OK
Comfortable Hours
Total hours considered:
8760
Direct Evaporative Cooling:
NA
Indirect Evaporative Cooling:
5386
Two Stage Evaporative Cooling:
NA
Percentage Comfort Hours :
61
Evaporative Cooler Design Conditions
DBT(°C)
RH%
Ambient Air :
42.0
13
Room Supply Air :
24.1
36
Indoor Air :
28.0
33
User defined comfort zone
ASHRAE 55 (2017)comfort zone
Indian composite bioclimate comfort zone
Room air velocity near occupants (m/s):
0-0.5
Ambient Air
Room Supply Air
Resultant Indoor Air
Comfortable Indoor Conditions
Uncomfortable Indoor Conditions
C3
Humidity ratio w, gw/kgda
Dry-bulb temperature, °C
BACK
NEXT

DISCLAIMER

EvapCal design calculations are based on certain assumptions as described below *:

* Sensible heat load, latent heat load, and saturation efficiency remains constant throughout the operational hours to calculate achievable comfort hours.

* In the case of the indirect evaporative cooling system, heat exchange between the secondary air and primary air is assumed to be equal to the heat exchange between water and secondary air.

Outdoor design conditions at 0.4%, 1% and 2% are auto-fed in the tool. Please refer to ISHRAE Weather Data Book for further information and change the values if required.

Users must be aware of the significance of input values as calculations solely depend on these values.

The simulations and calculations done by the software are based on theoretical inputs provided by the user and are only for providing awareness. EvapCal or the developers do not take any responsibility for the performance of the system as the actual operational conditions may vary. Thus, it is recommended to confirm the applicability from OEM/Applicator as per their internal reference standards.