

# USER MANUAL EvapCal EC 2021:01

#### Developer Team:

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### 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:

- 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.

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Evaporative Cooler System Design V Evaporative Cooler Design Chart	Evaporative Cooler Design Report		С		XXXXXX			
Select Indian City B	rowse Existing EPW Weather File	Open Saved	Project (.e	vp file)	31 Unit System			
City: C		Revision No: Enter	Revision No.					
Project Name: Enter Project/Client Name		Designed By: Enter	Design Engine	er Name				
Project Reference No: Enter Reference No.		Submitted By: Enter	Design Firm N	ame				
Building Geometry: Area (sqft	: Enter Area		Height (ft):	Enter Height				
Outdoor Design Conditions: 0.4% V DBT (°C	: Enter Dry Bulb Temperature		WBT (°C):	Enter Wet Bulb Te	mperature			
Maximum Allowable Indoor Conditions: DBT (°C	: Enter Dry Bulb Temperature		RH %:	Enter Relative Hun	nidity			
Heat Load (Btu/hr): Sensible	Enter Sensible Heat Load		Total:	Enter Total Heat L	oad			
Type of Evaporative Cooling: O Direct O Indirect	2 Stage							
Saturation efficiency %: Direc	Enter Saturation Efficiency		Indirect:	Enter Saturation E	fficiency			
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 intege	r):							
Peak Water Requirement without bleed-off loss (LPH):	]							
Ambient DBT on 2D Heatmap	Ambient WBT on 2D Heatmap	Indoor DB1	on 2D Heat	nap	Indoor RH on 20	) Heatmap		
Ambient DBT on 3D Heatmap	Ambient WBT on 3D Heatmap	Indoor DB1	on 3D Heat	nap	Indoor RH on 30 Activate Wind	Heatmap		
	NEX	α			Go to Settings to a	stivate Wind	lows	
Dr. Jyoti	may Matnur with ISHRAE Technical Groups – Evaporative Co	ooling systems & Thermai Co	DITION, ISHIKAE -	2020			EU/	11

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Evaporative Cooler System Design Chart Evaporative Cooler Design Chart Evaporative Cooler Design R	eport				
Select Indian City Browse Existing EF	PW Weather File	Open Saved I	Project (.e	vp file) SI Unit System	
City:	T.	Pevision Nov Enter	Pevision No.		
Project Name: Enter Project/Client Name	🕢 City List	? ×	esign Enginee	r Name	
Project Reference No: Enter Reference No.	Select I	ndian city	Design Firm Na	me	
Building Geometry: Area (sqft): Enter Area	Ahmedabad	^	eight (ft):	Enter Height	
Outdoor Design Conditions: 0.4%  V DBT (°C): Enter Dry Bulb Ter	Allahabad		WBT (°C):	Enter Wet Bulb Temperature	
Maximum Allowable Indoor Conditions: DBT (°C): Enter Dry Bulb Ter	Aurangabad		RH %:	Enter Relative Humidity	
Heat Load (Btu/hr): Sensible: Enter Sensible He	Bangalore Barmer		Total:	Enter Total Heat Load	
Type of Evaporative Cooling: O Direct O Indirect O 2 Stage	Belgaum Bhagalpur				
Saturation efficiency %: Direct: Enter Saturation E	Bhopal		Indirect:	Enter Saturation Efficiency	
Temperature Rise through Duct-work (°C):	Bikaner			Calculate	
RESULTS :	Chitradurga Debradun				
Required Air Flow Rate (CFM):	Dibrugarh				
Supply Air Temperature (°C):	Guwahati				
Supply Air Humidity RH%:	Gwalior	OK Cancel			
Air Change Per Hour (rounded-off to the nearest integer):	L	1			
Peak Water Requirement without bleed-off loss (LPH):					
Ambient DBT on 2D Heatmap Ambient WBT on	2D Heatmap	Indoor DBT	on 2D Heatn	nap Indoor RH	on 2D Heatmap
Ambient DBT on 3D Heatmap Ambient WBT on	3D Heatmap	Indoor DBT	on 3D Heatn	nap Indoor RH Activate V	on 3D Heatmap
	NE	XT		Go to Setting	s to activate Windows
Ur. Jyotirmay Matnur With ISHRAE I	ecnnical Groups – Evaporative	cooling systems & inermal co	THORE, ISHIKAE - 2	020	EE/11

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

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Evaporative Cooler System Design     Evaporative Cooler Design Chart     C Evaporative Cooler Design Chart	prative Cooler Design Report 🔪			
Select Indian City Brow	se Existing EPW Weather File	Open Saved Project (.evp	p file) 🗌 SI Unit System	
City:       IND_AHMADABAD         Project Name:       Enter Project/Client Name         Project Reference No:       Enter Reference No.         Building Geometry:       Area (sqft):         Outdoor Design Conditions:       0.4%         Maximum Allowable Indoor Conditions:       DBT (°C):         Heat Load (Btu/hr):       Sensible:         Type of Evaporative Cooling:       D Direct         Saturation efficiency %:       Direct:         ResultTS:       ResultTS:         Required Air Flow Rate (CFM):       Supply Air Temperature (°C):         Supply Air Humidity RH%:       Context	How to use I. Fater basic project details such as Project Designer, and Dasign fatm. 2. Input building information such as Built allowed building informations, and export allowed building parameters by clicking 3. Calculate design parameters by clicking as cording to design parameters of low system in a Societ the exponentive machines and makes 6. You can select operational Schedule, input based on different standards in the second 7. Third tas haves calculated result. You can are achieved. 8. Calculations and report generation may process is complete. Plase note that Outdoor Design Conditio is selected from the city list va Select Ind Weather Data Book and change the values the dropdown menu. If weather data is read through "Browse Ex imported val "Open Saved Project" option conditions manually.	A service ster Part out Maximum ive system parameters. on pre-Calculate's button, and default units system. d power for annual service catalogue in results. d power subues and thermal comfort zone tab. m generate report after satisfactory results take time. You will be notified when the in dropdown menu is enabled only if the city an City' button. Users can refer to ISHRAE if required by selecting cutom option in isting EPW Weather File' option or project is than users need to feed outdoor air	rer Height rer Height rer Wet Bulb Temperature rer Relative Humidity rer Total Heat Load rer Saturation Efficiency Calculate	
Peak Water Requirement without bleed-off loss (LPH):				
Ambient DBT on 2D Heatmap	Ambient WBT on 2D Heatmap	Indoor DBT on 2D Heatma	ap Indoor RH or	n 2D Heatmap
Ambient DBT on 3D Heatmap	Ambient WBT on 3D Heatmap	Indoor DBT on 3D Heatma	ap Indoor RH or Activate Wil	n 3D Heatmap nd.ows
Ur. Jyotirmay	Matnur with ISHIKAE Technical Groups – Evaporative	Cooling systems & Thermai Comfort, ISHRAE - 202	N	<u> 1</u>

- 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.

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Evaporative Cooler System Design V Evaporative Cooler Design Cha	rt 🔨 Evaporative Cooler Design Report 🔪					
Select Indian City	Browse Existing EPW Weather File	Open Saved	Project (.e	vp file)	🗆 SI Unit System 🎽	e
City: IND_AHMADABAD		Revision No: R01				
Project Name: ABC Pvt. Ltd.		Designed By: Er. X	Z			
Project Reference No: 01		Submitted By: Evap	Cal Pvt. Ltd.			
Building Geometry:	sqft): 60000		Height (ft):	10		1
Outdoor Design Conditions: 0.4% 🗸 DBT	(°C): 42.0		WBT (°C):	20.82		
Maximum Allowable Indoor Co 1%	(°C): 28		RH %:	65		
Heat Load (Btu/hr): 2% Custom Set	nsible: 1500000		Total:	2500000		
Type of Evaporative Cooling: O Direct	irect O 2 Stage					
Saturation efficiency %:	irect:		Indirect:	87		
Temperature Rise through Duct-work (°C):	0.5		i		Calculate	
RESULTS :						
Required Air Flow Rate (CFM):		197755				
Supply Air Temperature (°C):		24.1				
Supply Air Humidity RH%:		36				
Air Change Per Hour (rounded-off to the nearest in	teger):	20				
Peak Water Requirement without bleed-off loss (LP	H):	2729				
Ambient DBT on 2D Heatmap	Ambient WBT on 2D Heatmap	Indoor DB	on 2D Heatr	тар	Indoor RH on 2D He	eatmap 🛛
Ambient DBT on 3D Heatmap	Ambient WBT on 3D Heatmap	Indoor DB	on 3D Heatr	map	Indoor RH on 3D He	eatmap
	NI	хт				
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- 6. The next tab is "Evaporative Cooler Design Chart".
  - I. 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 dropdown 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.

🖉 EvapCal Help	– o x
(Evaporative Cooler System Design Evaporative Cooler Design Chart Evaporative Cooler Design Chart	vaporative Cooler Design Report Location: IND_AHMADABAD, -, IND Latitude/Longitude: 23.07 / 72.63 Elevation / Time zone: 55.0 / 5.5
Annual         ×           From         To           MONTH         January         December           DAY         1         31	User defined comfort zone O ASHRAE 55 (2017)comfort zone O Indian composite bioclimate comfort zone Room air velocity near occupants (m/s): 0=0.5 ×
HOUR 1 24 Rated power of evaporative cooler(kW): 35 Energy consumption in active cooling(kW/TR): 1.1 OK	Ambient Air     X Room Supply Air     X Rosultant Indoor Air     Comfortable Indoor Conditions     Uncomfortable Indoor Conditions
Comfortable Hours n Total hours considered: n Direct Evaporative Cooling: NA Indirect Evaporative Cooling: 3174	12 pint of the second sec
Percentage Comfort Hours: 36 Evaporative Cooler Design Conditions DBT(°C) RH% Ambient Air : 42.1 20	
Room Supply Air:         26.3         49           Indoor Air:         28.0         46	0 5 10 15 20 25 30 35 40 45 50 Dry-bulb temperature, °C
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- 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.

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Help			
Evaporative Cooler System Design V Evaporative Cooler Design Chart V Evaporative Cooler Design Report			
Area	: 60000 sq.ft.		
Height	: 10 ft.		
Sensible Heat Load	: 1500000 Btu/hr		
Total Heat Load	: 2500000 Btu/hr		
Calculated Capacity	: 197755 CFM		
Air Changes (rounded-off to the nearest integer)	: 20 ACPH		
Designed Usage/Year	: 8760 HRS		
Comfortable Hours Within Design Range	: 3434 HRS		
Unomfortable Hours Outside Design Range Only Considering Upper Limits	: 5326 HRS		
% Comfortable Hours Within Design Range	: 39 %		
% Uncomfortable Hours Outside Design Range Only Considering Upper Limits	: 61 %		
Peak Water Consumption Without Bleed-off Loss	: 2729 LPH		
Evaporative Cooling Peak Power Consumption	: 35.0 kW		
Estimated Active Air Conditioning Capacity	: 208 TR		
Active Cooling Peak Power Consumption	: 228.8 kW		
Peak Power Saving With Evaporative Cooling	: 85 %		р
Sa	ve Project		
Export Da	ta as an Excel File	Activate Windows	
Gene	erate Report	Go to Settings to activate	- Windows
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#### 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.

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Help	hart \/ Evaporative Cooler Design Report \								
Select Indian City	Browse Existing EPW Weather File	Open Sa	ved	Project (.e	vp file)	🗌 SI Unit System			
City: IND_AHMADABAD		Revision No:	R01						-
Project Name: ABC Pvt. Ltd.		Designed By:	Er. XY	Z					
Project Reference No: 01		Submitted By:	Evap	Cal Pvt. Ltd.					_
Building Geometry: Area	a (sqft): 60000			Height (ft):	10				
Outdoor Design Conditions: 0.4% V DB	BT (°C): 42.0			WBT (°C):	20.82				-
Maximum Allowable Indoor Cq 1% DB	3T (°C): 28			RH %:	65				
Heat Load (Btu/hr): 2% Signature Sig	ensible: 1500000			Total:	2500000				-
Type of Evaporative Cooling: O Direct	ndirect 🔘 2 Stage								-
Saturation efficiency %:	Direct:			Indirect:	87				-
Temperature Rise through Duct-work (°C):	0.5					Calculate			
RESULTS :									
Required Air Flow Rate (CFM):		197755							
Supply Air Temperature (°C):		24.1							-
Supply Air Humidity RH%:		36							-
Air Change Per Hour (rounded-off to the nearest i	integer):	20							-
Peak Water Requirement without bleed-off loss (L	рн):	2729							
Ambient DBT on 2D Heatmap	Ambient WBT on 2D Heatmap	Indoo	or DBT	on 2D Heatr	nap	Indoor RH on	2D Heatmap		
Ambient DBT on 3D Heatmap	Ambient WBT on 3D Heatmap	Indoo	or DBT	on 3D Heatr	nap	Indoor RH on	3D Heatmap		
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	Jr. Jyotirmay Matnur with ISHIKAE Technical Groups – Evaporative C	ooling systems & the	rmai Co	mort, ISHKAE	1020			ES/	

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 1<sup>st</sup> 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.







## 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.