Mechartés
SIMULATION EXPERTS

HOT AIR RECIRCULATION

COOLING TOWERS AND CHILLERS

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Introduction to Cooling Tower

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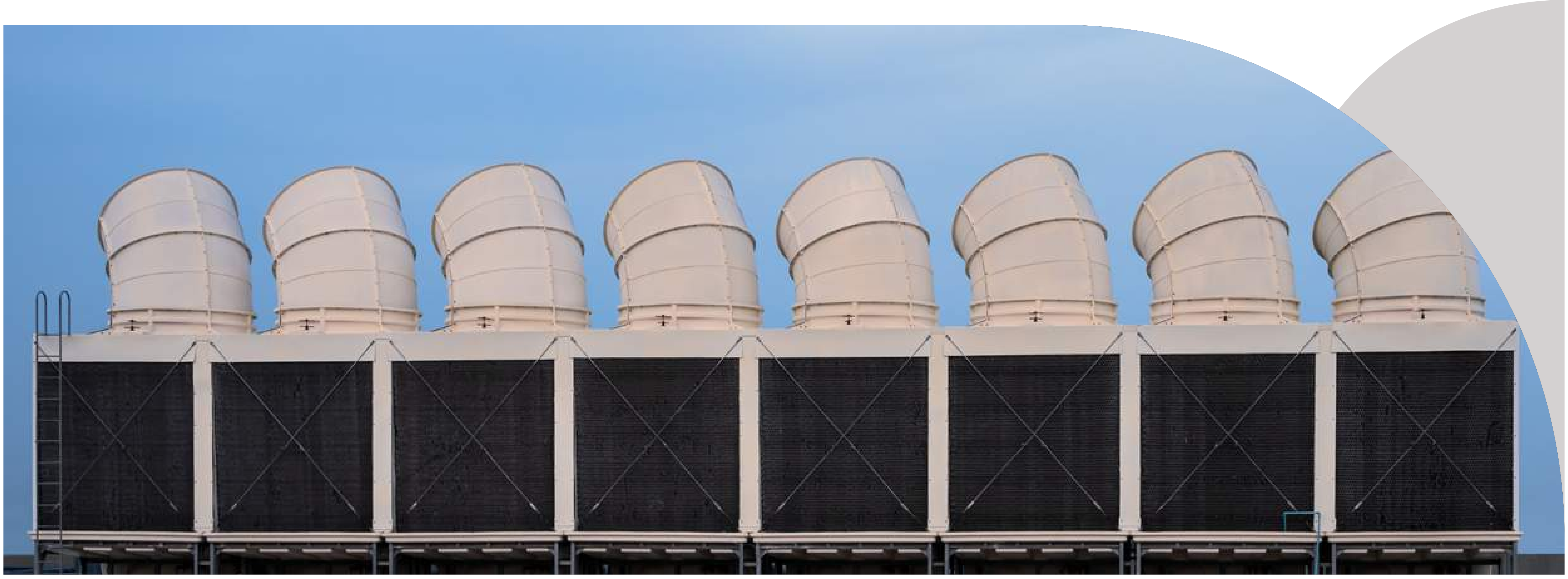
A cooling tower is a common heat rejection device. Different sectors/ industries need reliable ways to dissipate unwanted heat to keep their working environments cool and reduce the risk of equipment breakdown.

How does that process work?

Typically, hot industrially processed water flows toward the cooling tower and enters it from the top. The water then flows downward through the tower. Equipment within the tower spreads the water out over a large surface area, often by converting the water into small droplets. The increased water-to-air contact of the droplets boosts heat transfer through evaporation.

The water flows through the cooling tower until it reaches the sump at the bottom while losing most of its heat. The sump sends most of the cold water back to cool the hot equipment. When heat transfer from the equipment heats the water again, the water flows back to the cooling tower, and the process repeats itself.



Among many classifications of cooling towers, the two different types discussed here are:

- **Wet cooling towers or evaporative** cooling towers operate on the principle of evaporative cooling. The water is usually the working coolant and it is the evaporated fluid that is then exposed to the ambient air.
- **Dry cooling towers** are closed-circuit cooling towers that operate by heat transfer through a heat exchanger that separates the working coolant from ambient air, such as in a radiator, utilizing convective heat transfer. They do not rely on evaporation.

Introduction to Chillers

Introduction to Chillers

Chillers are like radiators and cool down the coolant by using air or water. Water-cooled chillers need more maintenance in comparison to air-cooled ones, but the best aspect of water-cooled ones is that they consume less power.

Within the chillers, heat is removed directly from the coolant. The heat is then transferred to the surrounding air.

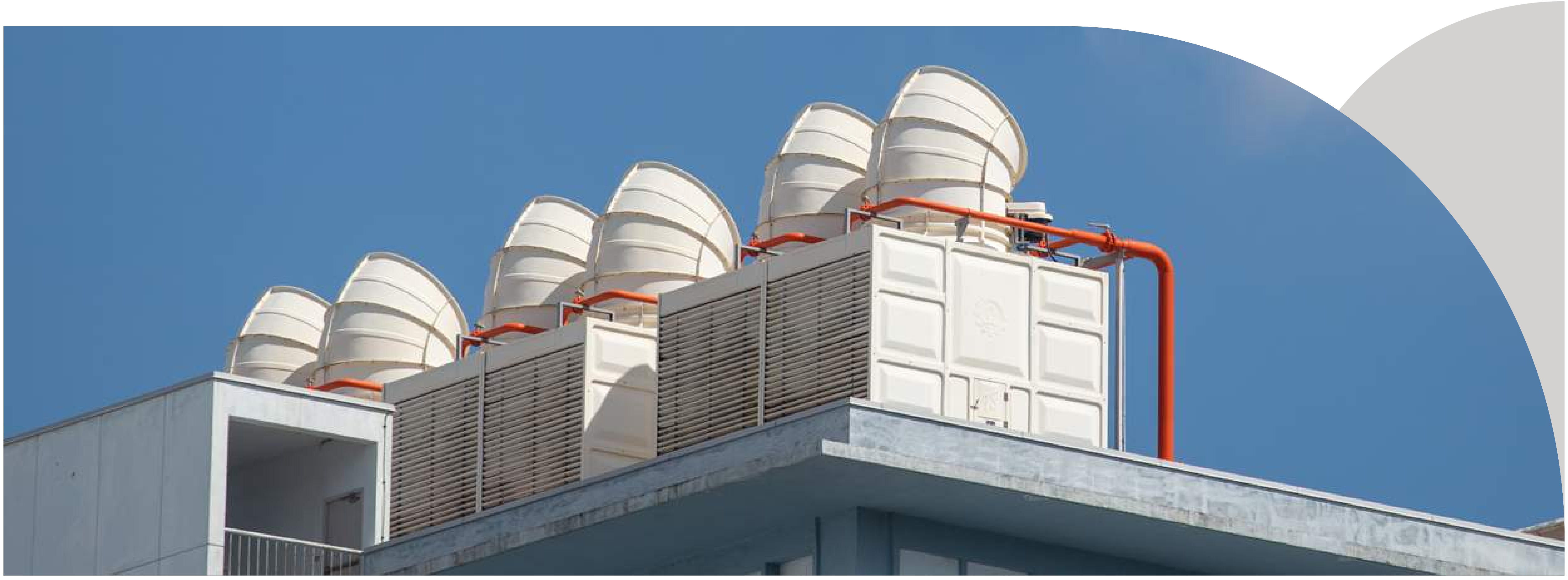
Working of a Chiller System

- Commercial buildings use Heating, Ventilation, and Air Conditioning (HVAC) systems to dehumidify and cool the building. Chillers or cooling towers are essential components of HVAC systems in different commercial establishments.
- A chiller works on the principle of vapor compression or vapor absorption. Chillers provide a continuous flow of coolant to the cold side of a process water system at the desired temperature of about 50˚F (10˚C).

We can further divide chillers into two types:

- **Water-Cooled Chillers:**

  Typically, this type of chiller is combined with a cooling tower for large-capacity applications. The combination of water-cooled chillers and cooling towers allows for maximum efficiency.



- **Air-Cooled Chillers:**

  These chillers absorb heat from the water, and then transfer this heat to outside of the system. The heat flows back into the air surrounding the unit. As soon as the air is transferred outside, the temperature lowers drastically. Factories that do not produce a lot of heat will opt for these models frequently.

Power Consumption of a Chiller vs. Cooling Tower

Power Consumption of a Chiller vs. Cooling Tower

Since chillers contain compressors and heat exchangers and considering their greater cooling capacity, they consume more power in comparison to cooling towers, where the power consumption of fans and pumps is less.

Besides, water-cooled chillers do the cooling job better than air-cooling ones and consume less power, but the costs of maintenance for water-cooled ones are higher.

Also, if the efficiency of chillers reduces, they will consume more power. Efficiency may get reduced due to many factors and of them is hot air re-entering the inlet chambers due to wind patterns or due to the location of these cooling equipment in close proximity of each other.

The Combination of Both: Cooling towers and Chillers

Depending on the scale of your industry and its requirement for cooling processes, you have a lot of options when it comes to using cooling systems. For smaller applications, one can combine a water-cooled or air-cooled chiller with a small cooling tower on the roof of the building.

For higher efficiency in a cooling process, you can apply a huge chiller accompanied by a massive cooling tower. The **budget** and the **amount of cooling your project requires** are the two important factors for deciding the appropriate system.

Another determining factor is the coolant temperature you desire to have for your equipment. If you require a temperature of 32-30˚C, cooling towers can carry out the job, but for temperatures below 30˚C, chillers, especially the water-cooled ones, are advisable.

Common Problems faced by the District Cooling Plants

Plume | Hot air re-circulation

Common Problems faced by the District Cooling Plants

1. Plume

Cooling tower plumes form when water vapor generated from the outlet of the cooling tower mixes with the colder ambient air. Under certain ambient conditions, plumes of water vapor can be seen rising out of the discharge from a cooling tower and can be mistaken as smoke from a fire. If the outdoor air is at or near saturation, and the tower adds more water to the air, saturated air with liquid water droplets can be discharged, which is seen as fog.

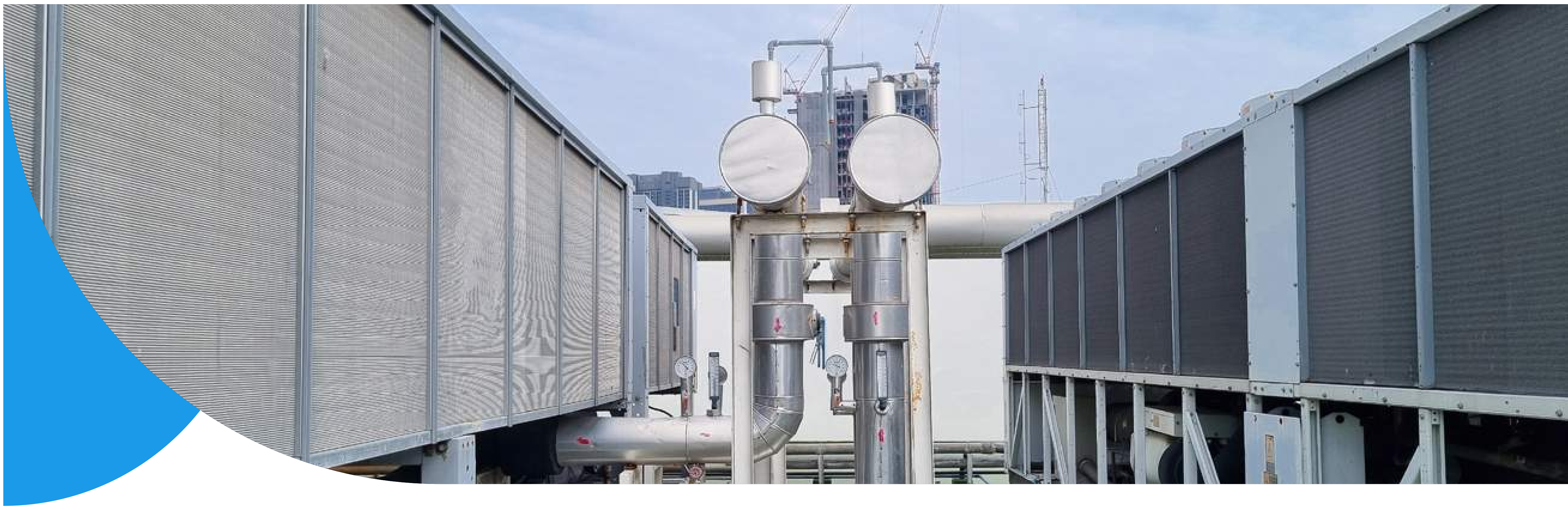
Under certain conditions, a cooling tower plume may present fogging or icing hazards to its surroundings and may cause serious visibility issues to nearby roads which may lead to traffic disruptions, and if there is any nearby airport then it can affect air traffic as well.

The cooling towers can also release aerosolized water into the atmosphere. If Legionella bacteria is present, the aerosolized water can spread the bacteria over miles.

2. Hot air re-circulation

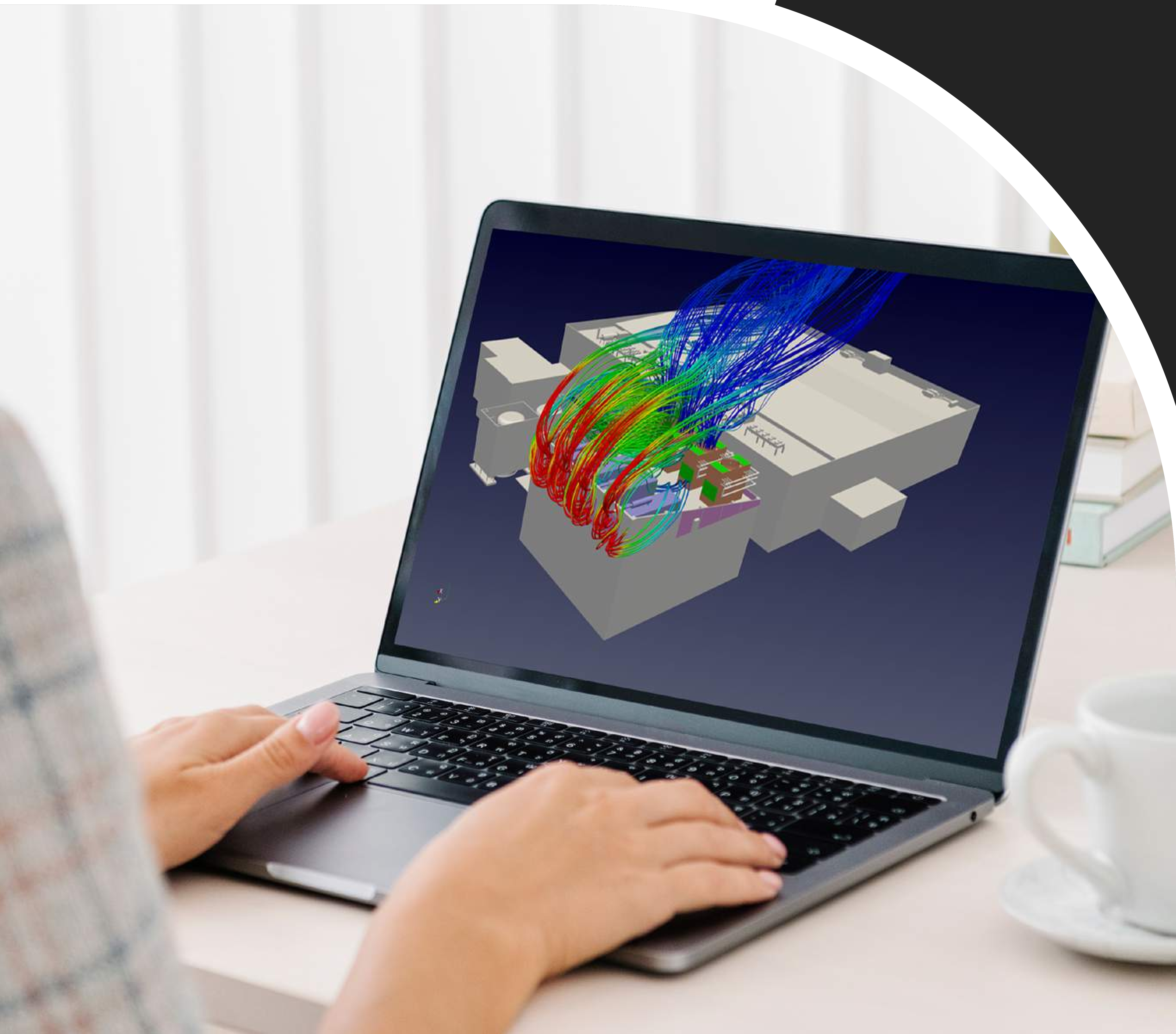
Re-circulation is a condition, particularly in forced draft towers, in which a portion of the tower's discharge re-enters the air inlets along with the fresh air. Its effect is an elevation of the average entering wet bulb temperature compared to the ambient.

This leads to a loss of efficiency of the cooling tower and in severe cases, can cause malfunction of the equipment. Re-circulation can also occur due to the presence of local heat sources upwind of the cooling tower, which can elevate the wet-bulb temperature of the air entering the tower.



Due to limited space and/or improper placement of cooling towers, chillers, and even outdoor AC units which are installed on every floor of high-rise buildings, discharge of hot air re-circulation is likely to occur in practical applications.

How CFD Analysis can Assist in the Design Stage



How CFD Analysis can Assist in the Design Stage

Design of the cooling tower/chiller and its placement is very important during the design stage to avoid the following problems,

I. Plume Travel

II. Avoiding Re-circulation

III. Spread of Legionella bacteria if cooling towers are placed near residential areas.

CFD Analysis can assist clients during the design stage by trying different simulation tests with various ambient conditions to reduce the amount of re-circulation and to check if the plume from the outlets will travel towards the residential area and spread the bacteria.

CFD analysis also help clients perform **root cause analysis** in an already installed site where there are space constraints to move or replace the units by following measures,

I. Increasing the stack height at the cooling tower/chiller outlets,

II. Placing canopy between the cooling tower/ chillers,

III. Increasing the Louver area.

Application Areas:

District Cooling Plants, Large Commercial & Public Buildings, Data Center Building, Industrial Applications, Thermal Power Plants, Processing Plants, Petroleum Refineries.

Importance of CFD Analysis

Importance of CFD Analysis

A CFD analysis of cooling towers/chillers is essential due to the following reasons:

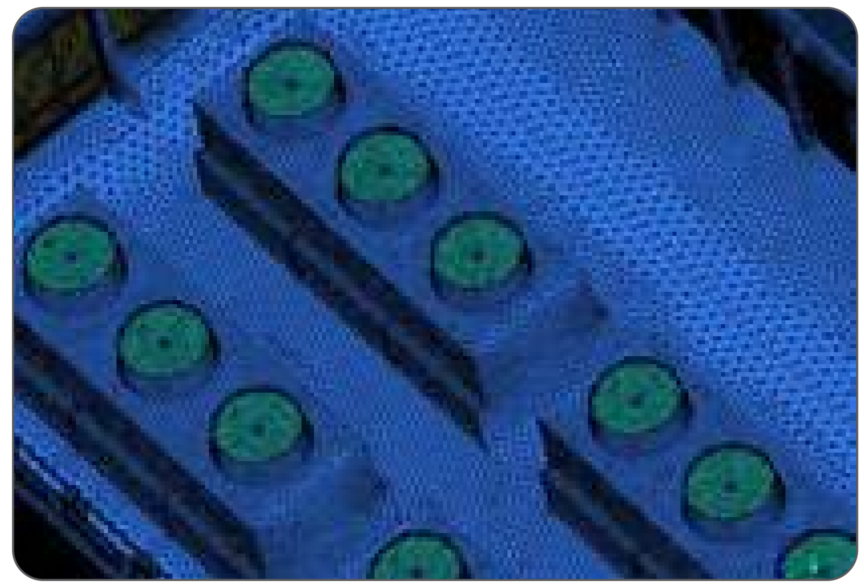
- Chiller costs consume a substantial part of any building's utility bills.
- Definite measures should be taken to obtain energy savings through maximal efficiency of the chiller system.
- The CFD analysis helps us study whether the "hot air rejected from these cooling equipment" is entering into the "inlets of the other nearby Unit" or not, and if so, what is the resultant temperature at inlets of these Units due to recirculation.
- CFD can be used for the performance analysis of cooling towers in terms of cooling efficiencies and effectiveness.
- CFD also helps assess the effect of hot humid air on the nearby/surrounding air.
- These CFD results mainly enable the equipment manufacturers to assess the unit performance based on the obtained unit inlet temperatures due to recirculation & also enables the project owners/contractors/designers to make necessary modifications to avoid the major recirculation to improve the performance of the cooling equipment.

Case Study

CFD Analysis for Cooling Tower & Chiller Yards

Objective:

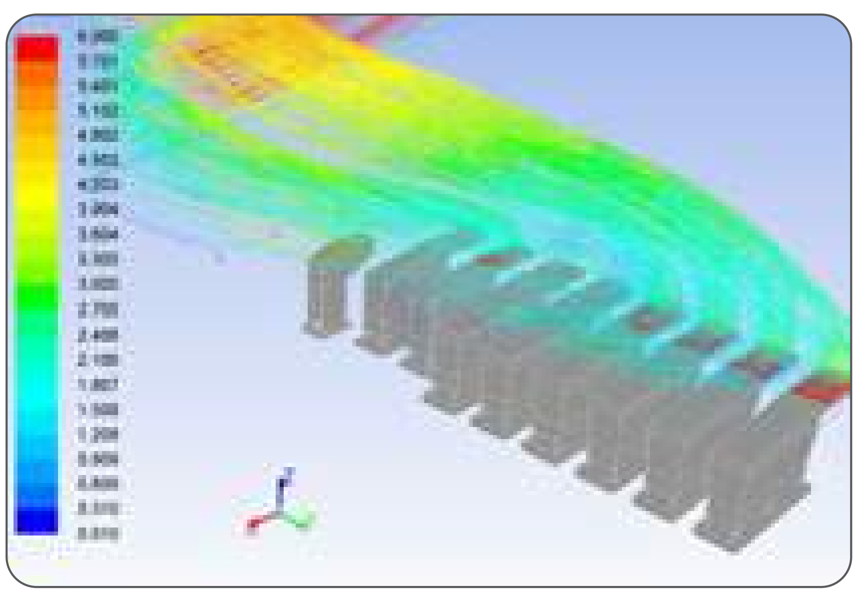
The performance of cooling towers / chillers yards / condenser units, in close vicinity of other cooling equipment can be adversely affected by the re-circulation of the cooling tower discharge into the tower intakes. Current design strategies, often account for this discharge re-ingestion issue, CFD analysis is used to evaluate worst case discharge recirculation effects in cooling towers/chillers performance & also to assess the effect of hot humid air on the nearby air. The bounding design values of tower intake wet bulb temperature increase due to recirculation, and interference are calculated considering the various conditions of cooling tower operation, ambient temperature, humidity, wind conditions & effect of presence of high rise buildings in nearby surroundings.



3D Mesh of Chiller

Modeling & Analysis:

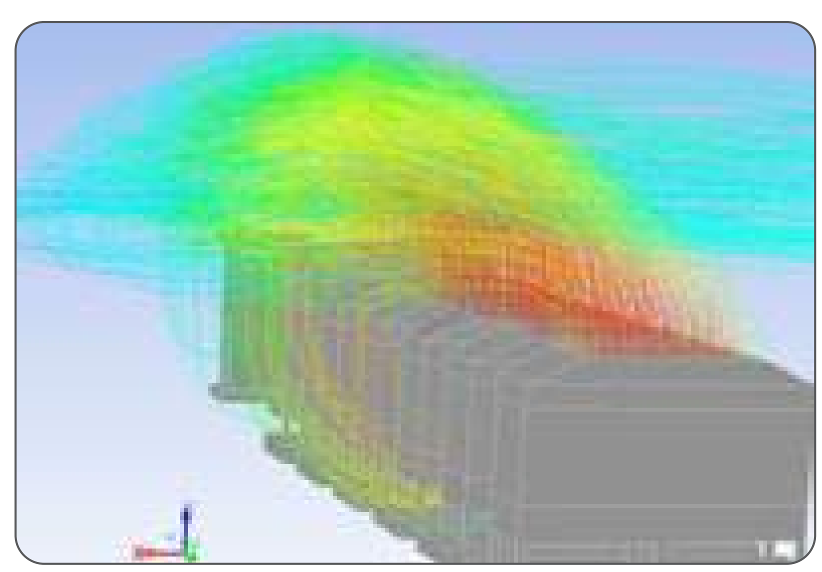
From the 2D plan view & sectional drawings details the 3D Model is prepared for the CFD study. After preparing the 3D model of the cooling tower's/chillers appropriate meshing tool is used to discretize the geometry for solving. Hybrid mesh is used in the Geometry. Then the meshed geometry is used for solving the flow, energy & species transport equations for different outside weather conditions. The CFD Analysis is carried out for the most pre-dominant & the Worst case weather conditions. The CFD steady state simulations were carried out with appropriate boundary conditions for each case respectively. The temp, Velocity & the Plume dispersion profiles were studied from the analysis & to analyze the placement of the cooling equipment to check their performance effect due to the re-circulation.



Velocity Profile of Chiller

Outputs:

- Velocity, temperature and RH profiles at different sections.
- Percentage of Recirculation in each cooling equipment unit.
- Design changes at the installation site of these cooling equipment, if required.

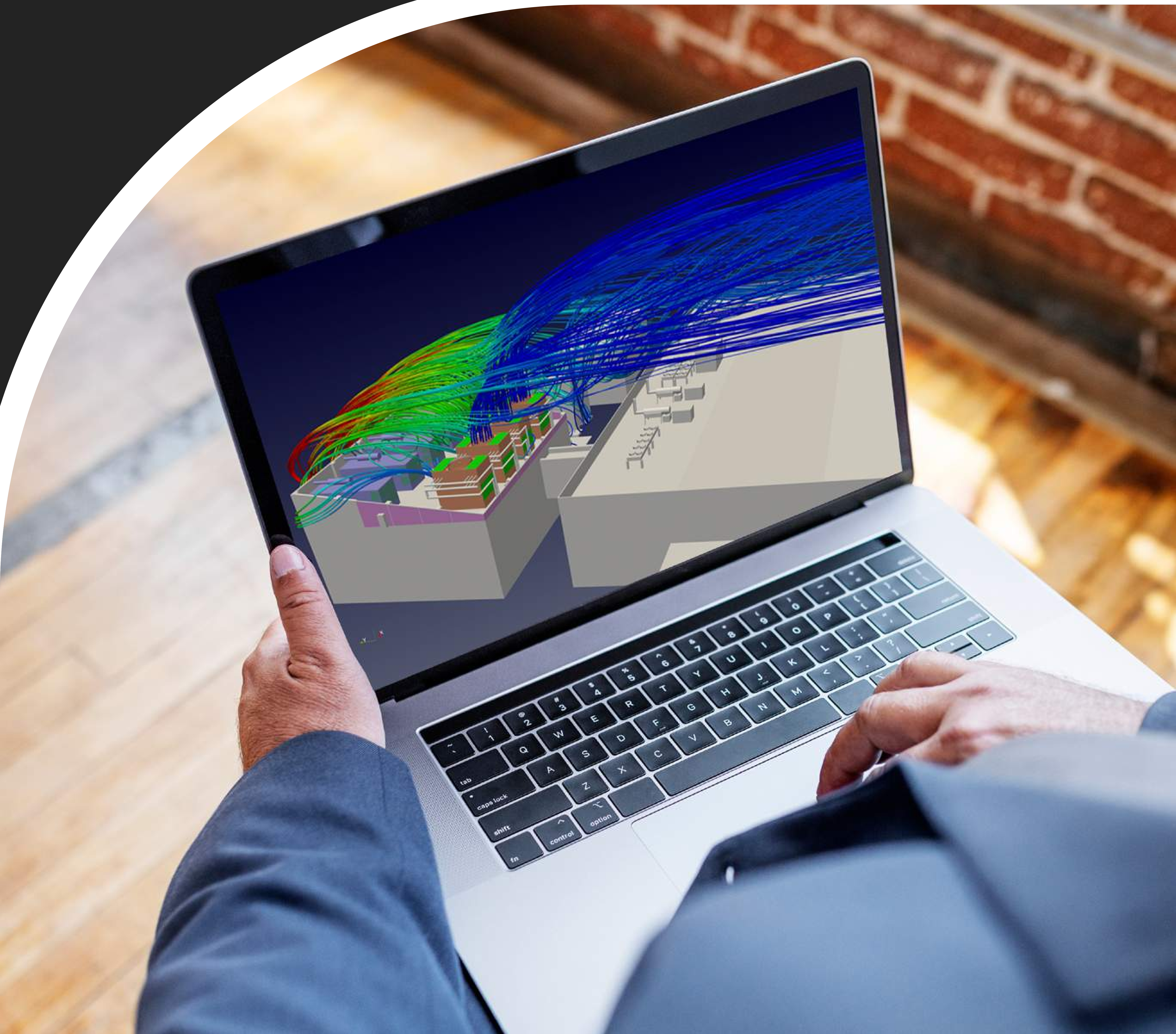


Temperature Profile of Chiller

Selected List of Similar Projects:

- Saadiyat Island Cooling tower project, Abu Dhabi, UAE.
- Qatar National Museum, Doha.
- ACC Units recirculation study on High Rise Building's in Mumbai & Manila.

Services by Mechartes



Services by Mechartes

- Pedestrian Comfort & Wind Engineering
- Cooling tower & chiller yard Re-circulation Study.
- UTCI & Shading Analysis
- Thermal Comfort CFD Analysis
- Flue dispersion Modelling
- Smoke and Evacuation Modelling
- Thermal Energy Storage Tank Design
- Acoustic Modelling
- Piping Stress & Support design
- Surge Analysis

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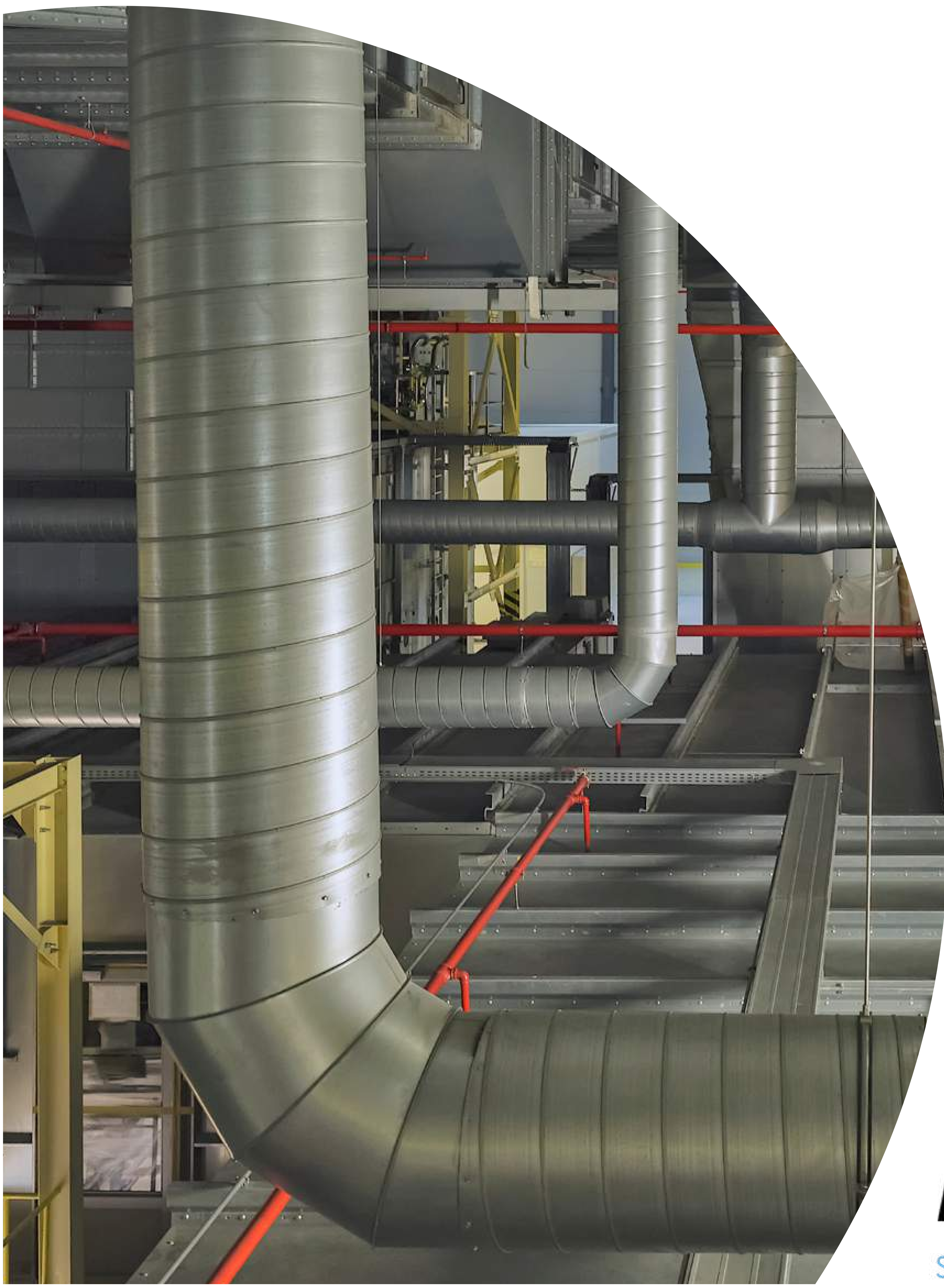
Hot Air Recirculation - Cooling Towers and Chillers



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