EUROVENT
MIDDLE EAST

HVACR Leadership Workshops

Event Introduction: **Cooling Towers**

Markus Lattner
Managing Director
Eurovent Middle East

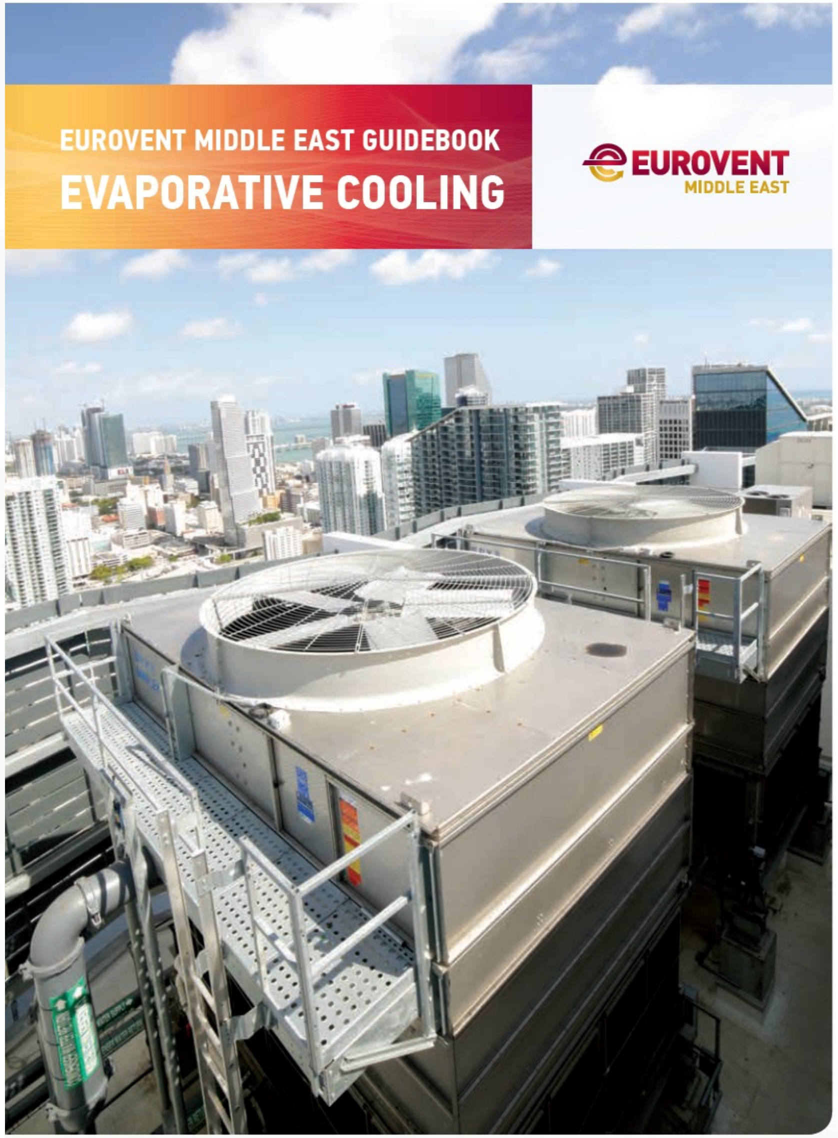
Workshop Partners

Media partner:

Agenda

1. Introduction: Guidebook Evaporative Cooling
2. Overview of advantages
3. Working principles
4. Critical aspects of design, installation, and operation
5. Case Study: Total Cost of Ownership
6. Cooling Tower Certification
7. Moderated Discussion

Introduction: Guidebook Evaporative Cooling



EUROVENT MIDDLE EAST

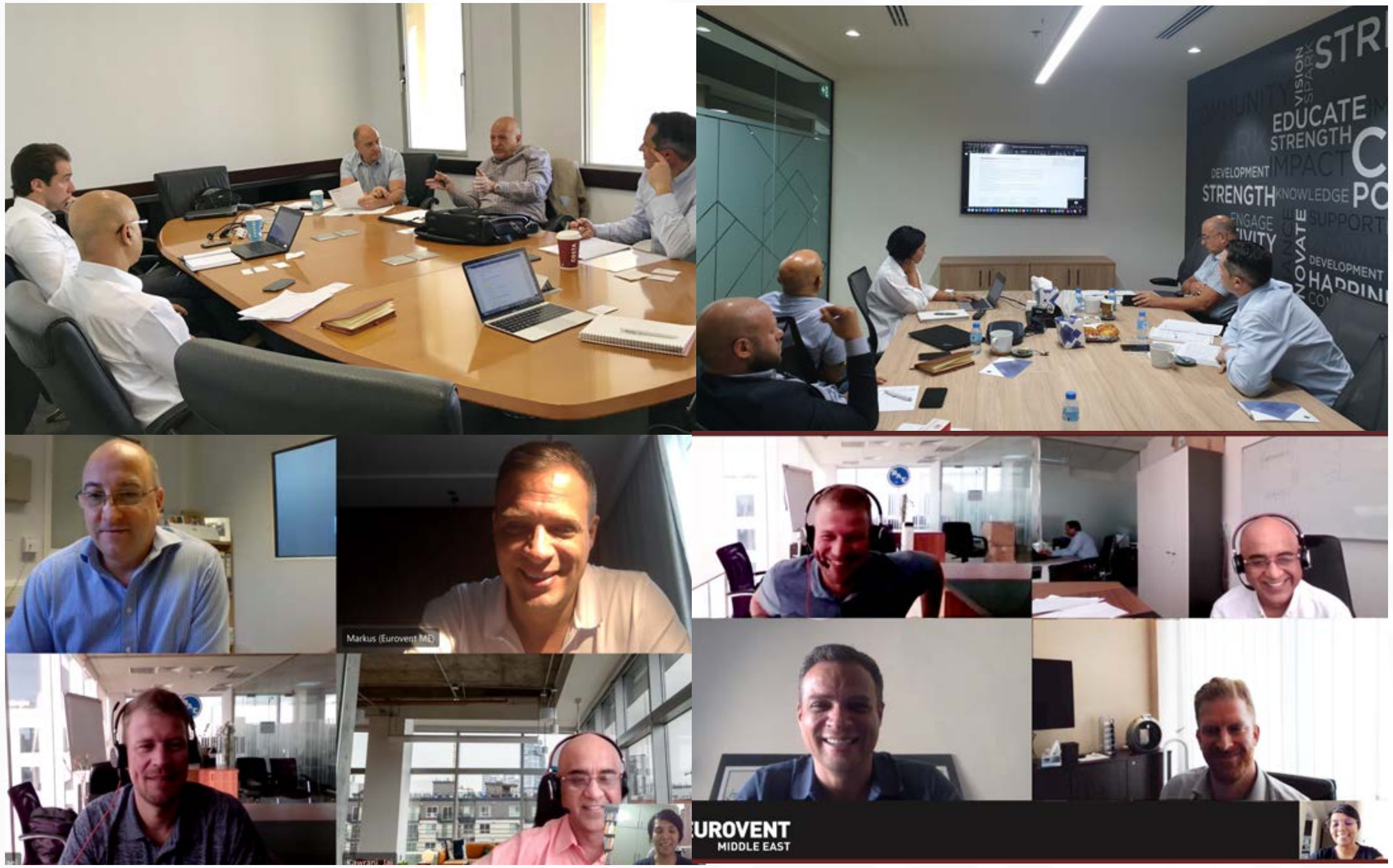
HVACR Leadership Workshops

Guidebook ‘Evaporative Cooling’

EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Guidebook ‘Evaporative Cooling’



EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Guidebook 'Evaporative Cooling'

BALTIMORE AIRCOIL COMPANY

SPX

HAMON

evapco for LIFE

Eurovent Certita CERTIFICATION

Guidebook 'Evaporative Cooling'

We appreciate your feedback!

office@eurovent.me

Agenda

1. Introduction to Eurovent Middle East's Cooling Tower Guidebook

2. Evaporative Cooling: Overview of advantages

3. Evaporative Cooling: Working principles

4. Critical aspects of design, installation, and operation

5. Case Study: Total Cost of Ownership

6. Cooling Tower Certification

Evaporative Cooling: Overview of Advantages

Mr Chukri Al Aani
Regional Sales Manager – MEA & Turkey
SPX Cooling Technologies Trading DMCC

What are your design goals?

- Comfort
- Efficiency
- Cost
- Reliability
- Sustainability
- All of the above?

Air-Cooled vs Water-Cooled Systems Comparison

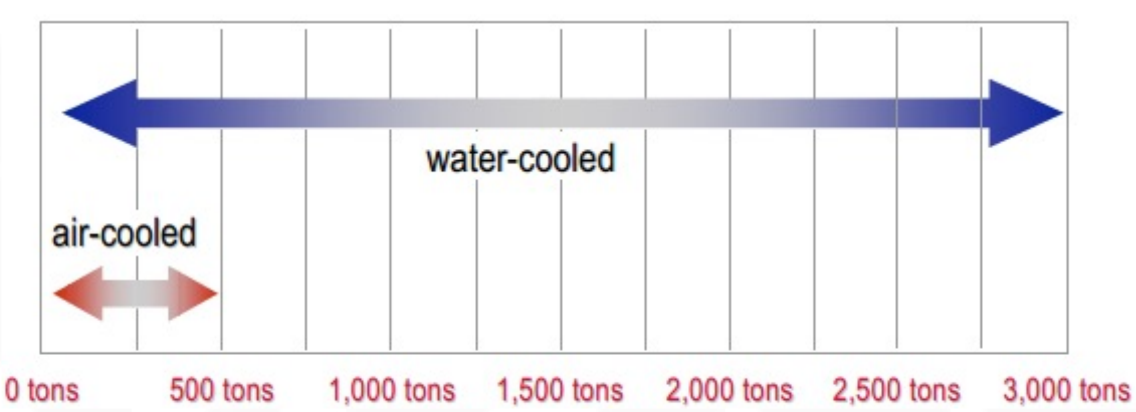
Air-Cooled Advantages

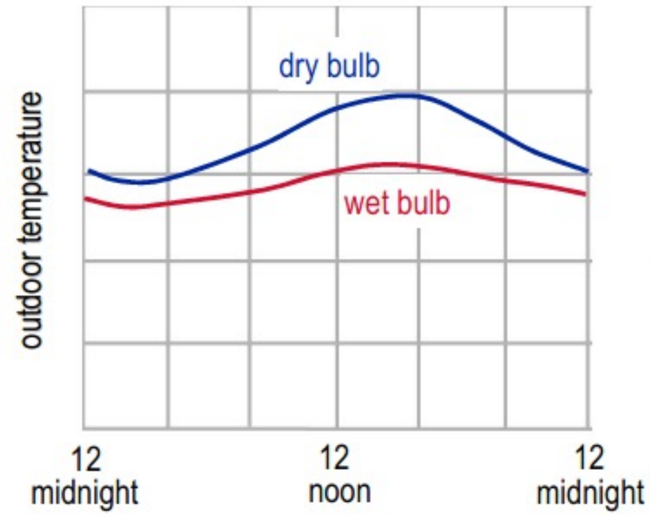
- Capital Cost
- Ease of Use/Maintenance Costs
- No Water
  - No Water Treatment
  - On-site water usage

Water-Cooled Advantages

- Evaluated Cost
  - Energy Use
- Capacity/Comfort/Control
- Noise and Maintenance Time
  - Fewer Fans
- Smaller Footprint
- Total Water Usage

System Definition: Water-Cooled vs Air-Cooled Chiller





- Air-cooled typically has lower upfront costs but are less efficient at rejecting heat therefore limiting their capacity.
- Utilisation of cooling tower requires extra piece of equipment but allows us to cool below the dry bulb temperature.

EUROVENT MIDDLE EAST

HVACR Leadership Workshops

The Value of Evaporative Heat Rejection

Vs. Air-Cooled

Highest energy efficiency	• 50% less energy usage on typical application
Lower GHG Emissions	• Significantly lower; less than half of the CO_2 footprint
Comparable or lower water usage	• Up to 40% less water consumption (high water usage in power production)
Other User Benefits	• Less noise – 2 fans vs. 20 fans, typical • Environmentally friendly materials – recycled PVC, less metal usage • Space – 2 - 5X less space for heat rejection

Typical Application – 400 Ton

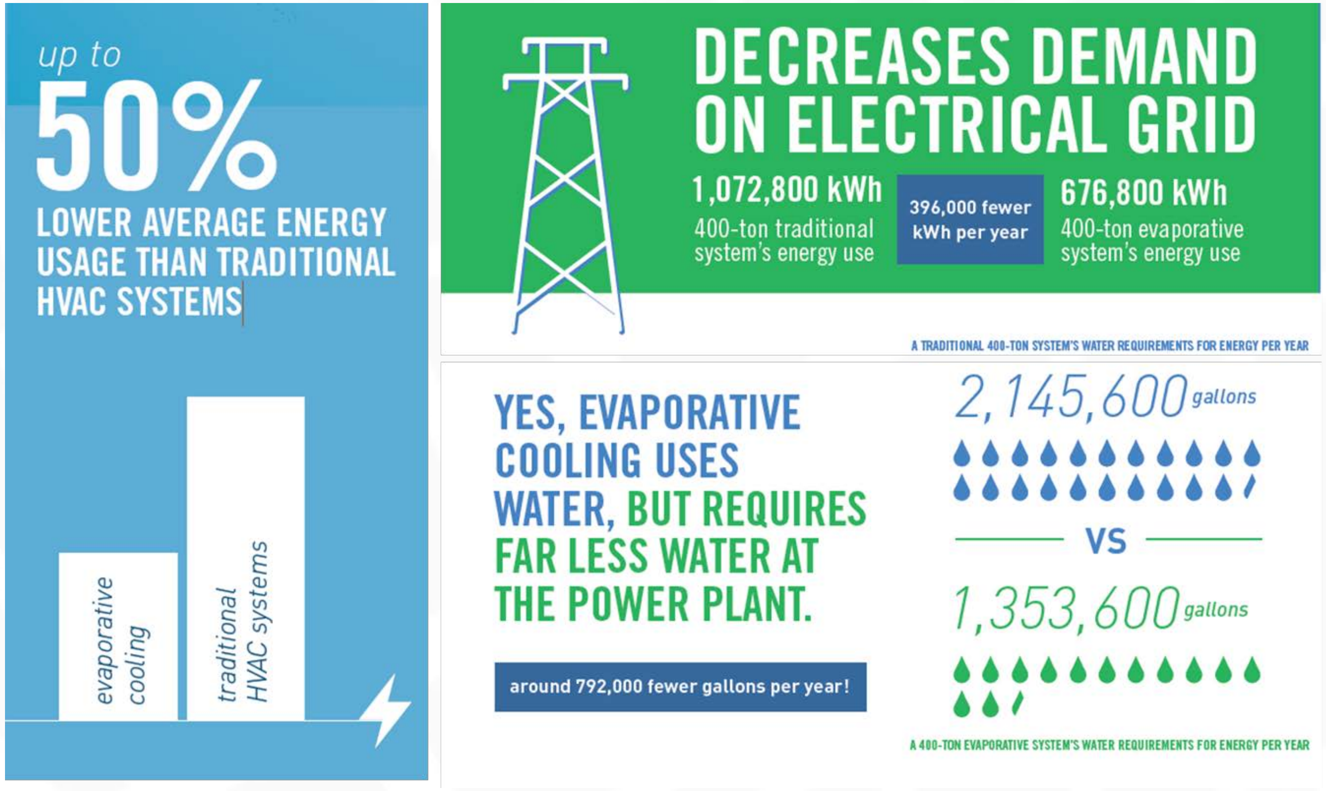
Annual	Air Cooled	Water Cooled	% Delta
Energy Consumption	440 MWH	190 MWH	(56.8%)
GHG Emission(2) lbs. of CO_2	682,000	294,500	(56.8%)
Total Water Usage In 0000s Gallons (on-site(3) + power generation(4))	1,944	1,530	(21.3%)

1. Assumes $0.1358/KWH.
2. Average US energy plant emits 1.55 lbs. of CO_2 for each KWH generated.
3. Site water includes water for blowdown, assuming 6 cycles of concentration, and make up.
4. In CA and many Western states each KWH produced consumes 4.42 gallons of water. On average in US each KWH produced consumes 2 gallons of water.

Source: *Buildings Magazine* 2008 quoting Pacific Gas & Electric Co. study including NREL data.

Evaporative Cooling is Sustainable with Significant Environmental and Water Usage Benefits

Benefits of Evaporative Cooling



Source: Alliance to Prevent Legionnaires' Disease

Agenda

1. Introduction to Eurovent Middle East's Cooling Tower Guidebook
2. Evaporative Cooling: Overview of advantages
3. **Evaporative Cooling: Working principles**
4. Critical aspects of design, installation, and operation
5. Case Study – Total Cost of Ownership
6. Cooling Tower Certification
7. Moderated Discussion

Evaporative Cooling: Working Principles

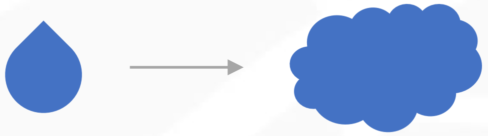
Mr Jai Kawrani
Application Manager – Middle East & India
Baltimore Aircoil Middle East LLC

Methods of Cooling

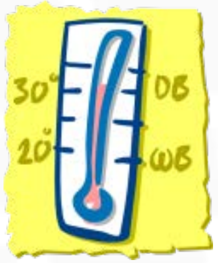
Air cooled

Dependent on ambient (dry bulb) temperature

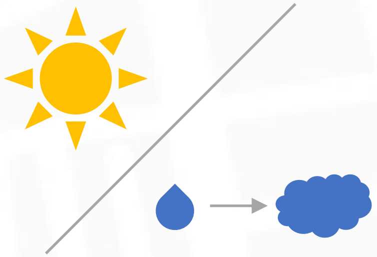
Evaporative cooled



Evaporative cooling, dependent on wet bulb temperature



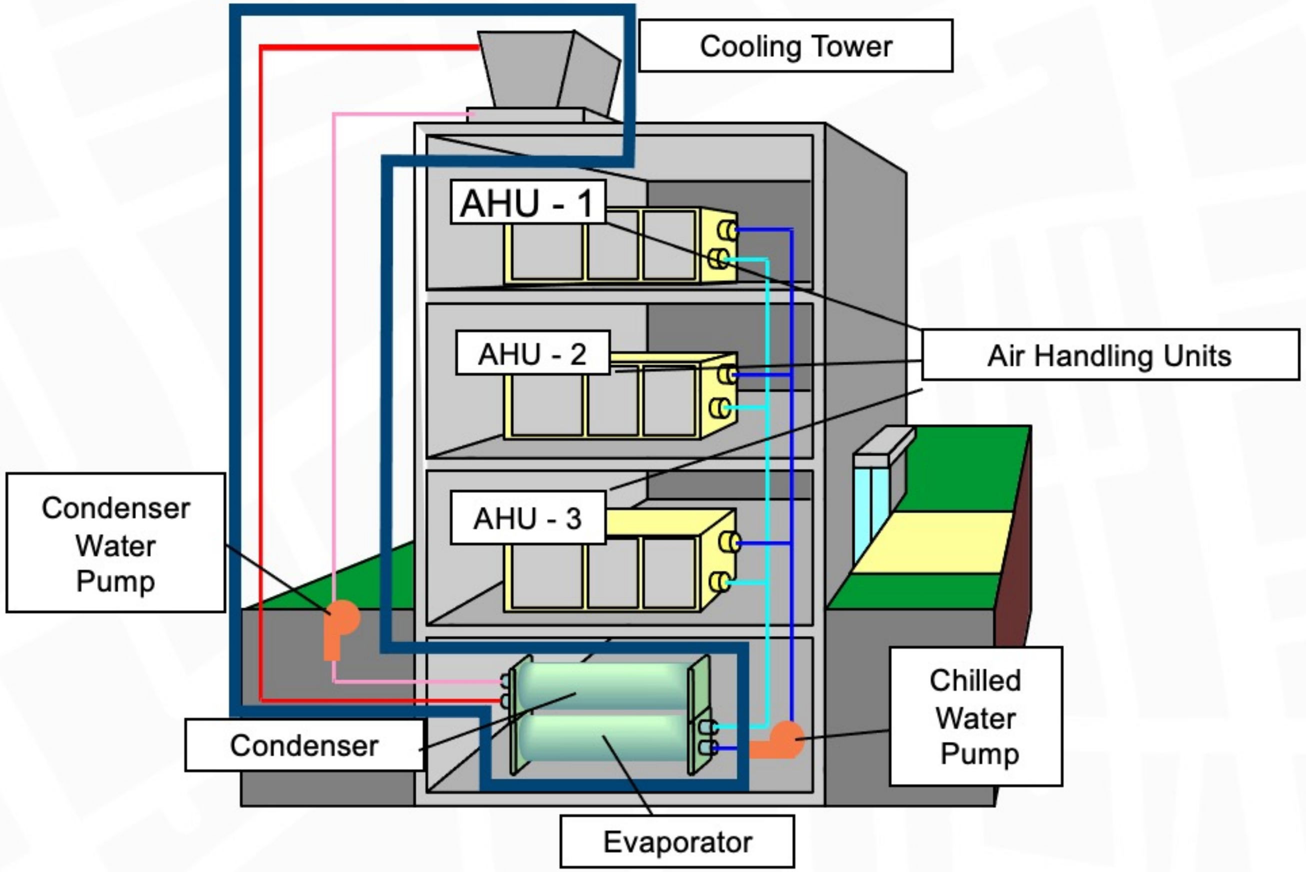
Hybrid, wet/dry, adiabatic



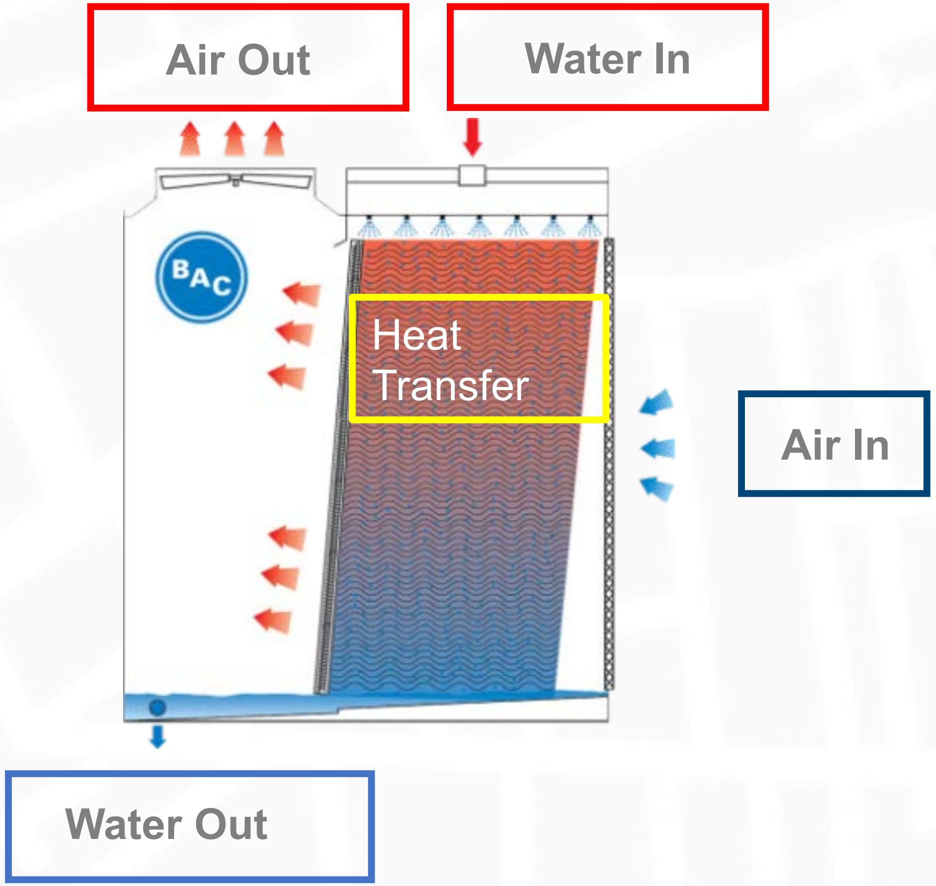
Dependent on both dry bulb and wet bulb temperatures

Typical >10°C difference between wet bulb and dry bulb

Traditional Water-Cooled HVAC System



Principles of Evaporative Cooling

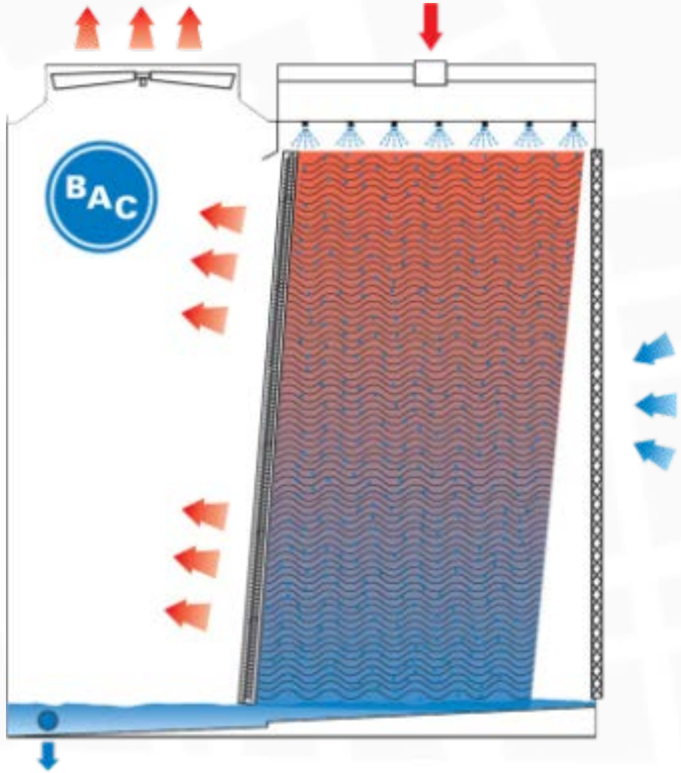


Principles of Evaporative Cooling

Heat transfer

- Sensible
- Latent

For every kg of water evaporated, 2256 kJ of heat is removed from the water



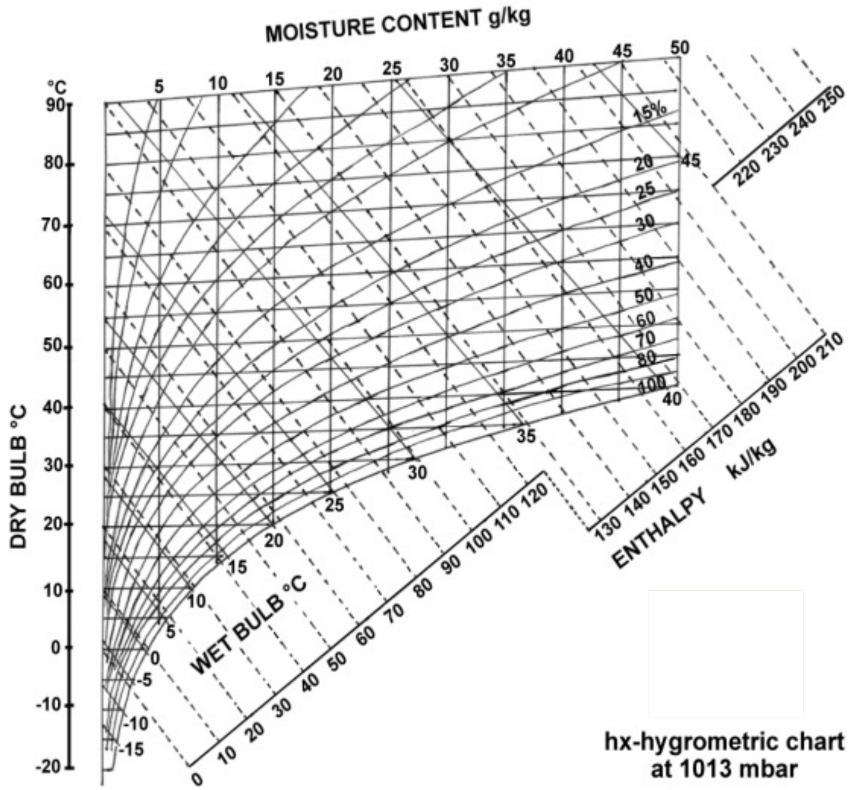
Principles of Evaporative Cooling

Dry Bulb

Wet Bulb

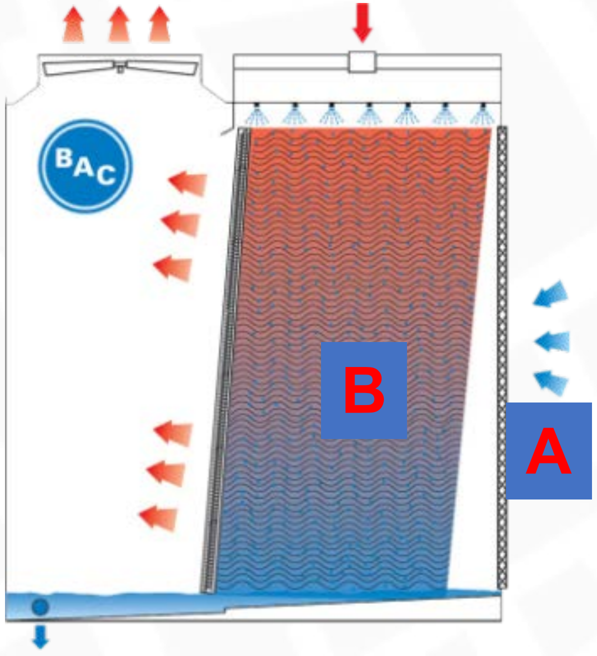
Enthalpy

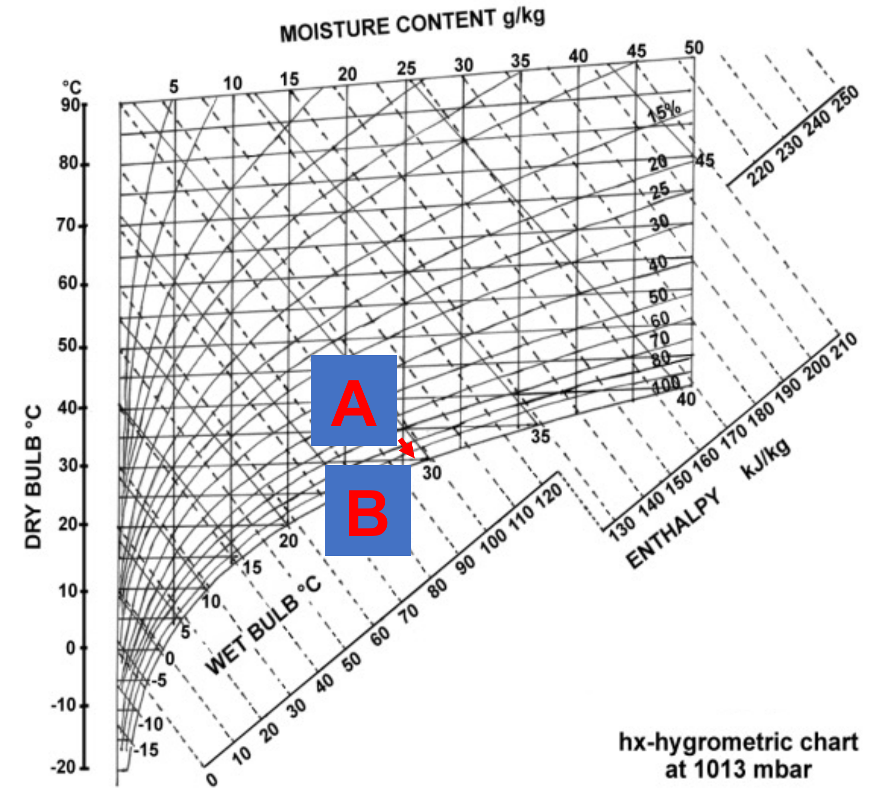
Moisture Content



Principles of Evaporative Cooling

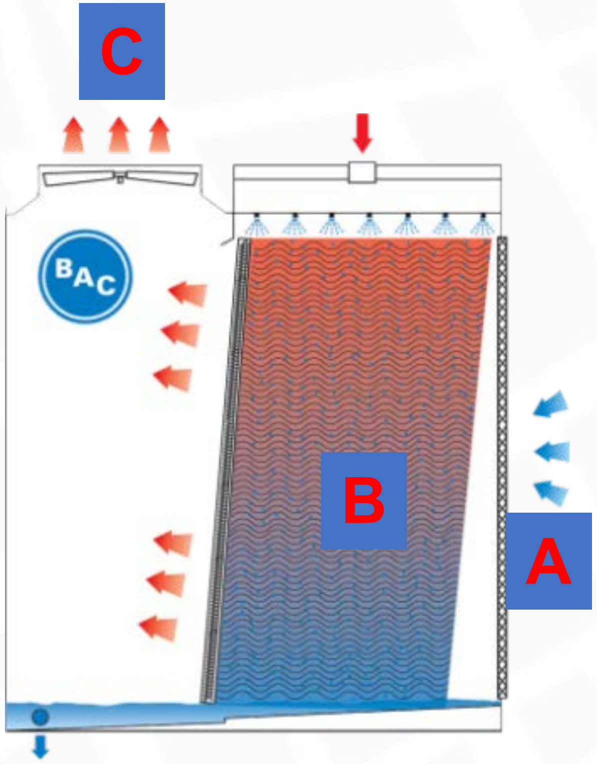
Air gets saturated

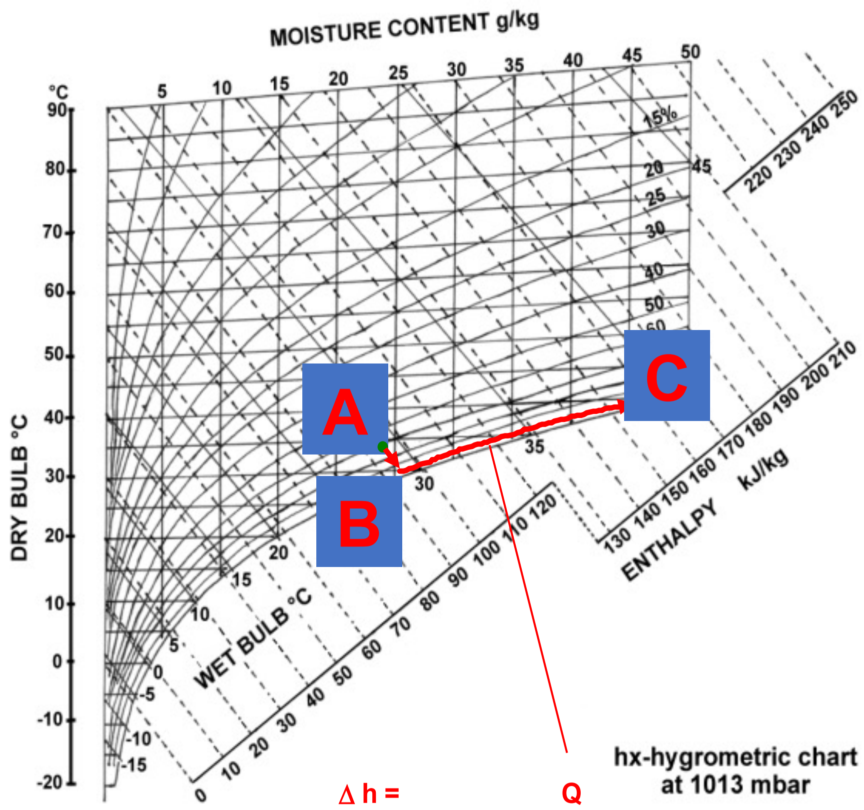




Principles of Evaporative Cooling

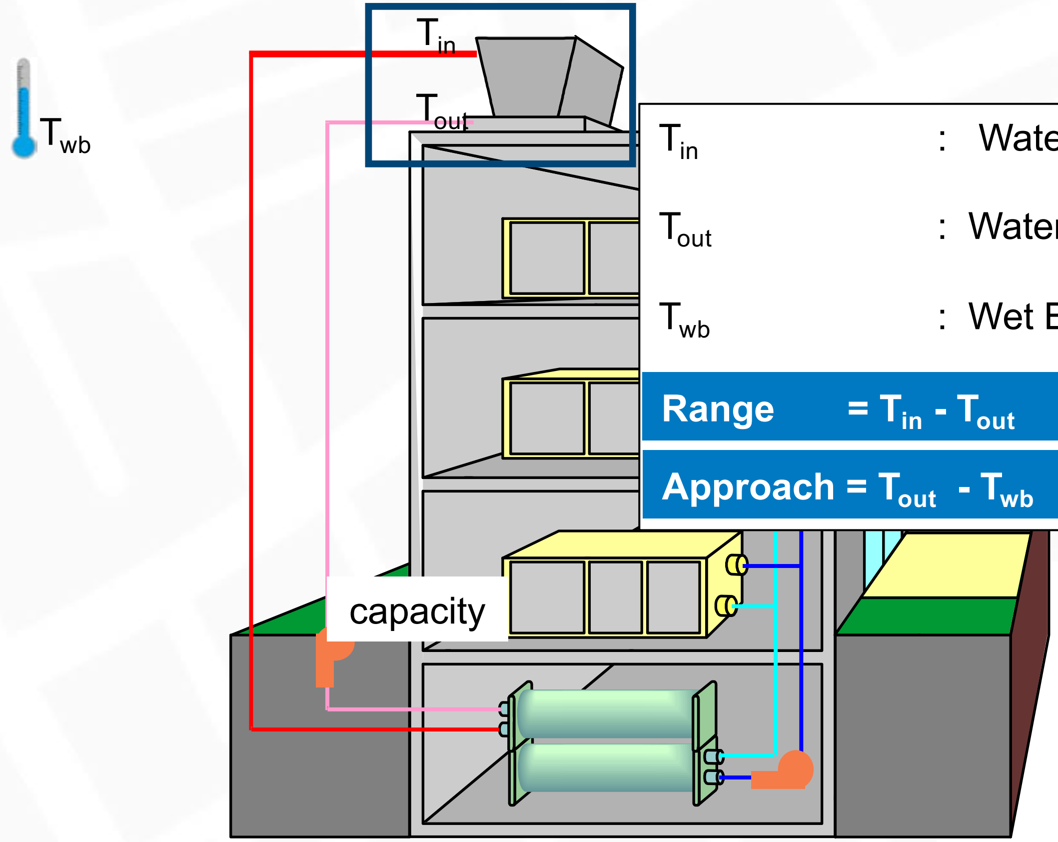
Air heats up





$$\Delta h = \frac{Q}{\text{AIRFLOW} \times \text{AIRDENSITY}}$$

Principles of Evaporative Cooling



T_{in} : Water Inlet Temperature (°C)

T_{out} : Water Outlet Temperature (°C)

T_{wb} : Wet Bulb Temperature (°C)

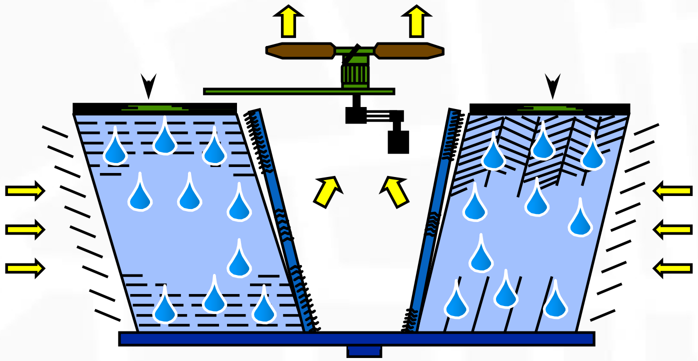
Range $= T_{in} - T_{out}$

Approach $= T_{out} - T_{wb}$

HVAC System

kW = flow (lps) x delta T x 4.186

- The cooling tower does not control the range (assumes constant condenser water flow)
- The cooling tower controls only the approach



HVAC System

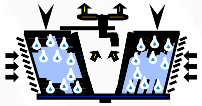
- Flow: 100 l/s
- Wet bulb: 21°C
- Range: 5°C
- Heat rejection: 2100kW

Multiple Cooling Towers can meet these conditions.
System Energy?

HVAC System

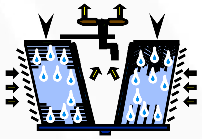
10°C Approach
Tin = 36°C
Tout = 31°C

15kW Fan motor



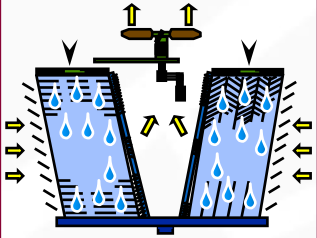
6°C Approach
Tin = 32°C
Tout = 27°C

22kW Fan motor



2°C Approach
Tin = 28°C
Tout = 23°C

45kW Fan motor



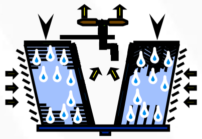
- Flow: 100 l/s
- Range: 5°C
- Heat rejection: 2100kW
- **Wet bulb: 21°C**

Constant Wet Bulb Larger Cooling Tower for Smaller Approaches

HVAC System

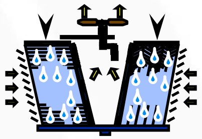
10°C Approach
Wet Bulb 8.2°C
Tin = 23.2°C
Tout = 18.2°C

22kW Fan motor



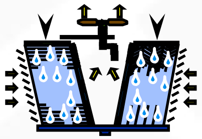
6°C Approach
Wet Bulb 21°C
Tin = 32°C
Tout = 27°C

22kW Fan motor



3.5°C Approach
Wet Bulb 31.5°C
Tin = 40°C
Tout = 35°C

22kW Fan motor



Higher Wet Bulb Easier for Smaller Approaches

Chiller duty is still related to Tout temperature

- Flow: 101,9 l/s
- Range: 5°C
- Heat rejection: 2100kW
- **Wet bulb: varies**

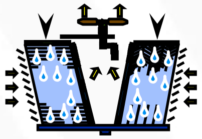
EUROVENT MIDDLE EAST

HVACR Leadership Workshops

HVAC System

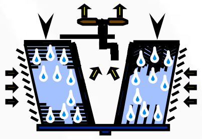
10°C Approach
10.1°C Range
4300kW
Tin = 41.1°C
Tout = 31.0°C

22kW Fan motor



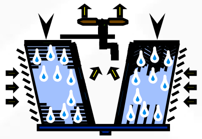
6°C Approach
5°C Range
2100kW
Tin = 32°C
Tout = 27°C

22kW Fan motor



3.5°C Approach
2.5°C Range
1100kW
Tin = 27°C
Tout = 24.5°C

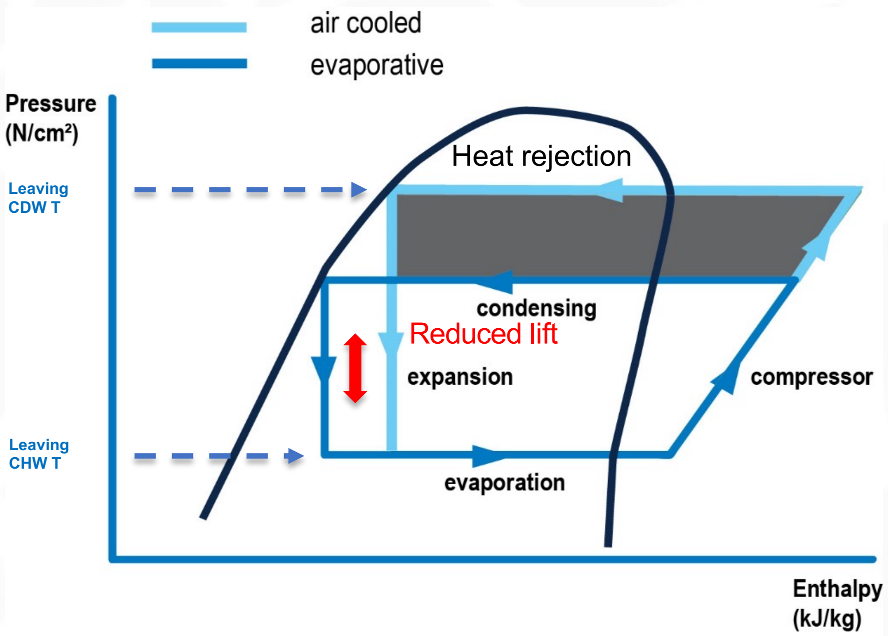
22kW Fan motor



- Flow: 101,9 l/s
- Range: varies
- **Wet bulb: 21°C**

If using same cooling tower, higher heat loads require a larger approach

HVAC System



For every 1°C increase in condenser water →
increases the energy usage of the chiller by approximately 3%

Agenda

1. Introduction to Eurovent Middle East's Cooling Tower Guidebook
2. Evaporative Cooling: Overview of advantages
3. Evaporative Cooling: Working principles
4. **Critical aspects of design, installation, and operation**
5. Case Study – Total Cost of Ownership
6. Cooling Tower Certification

Critical Aspects of Design, Installation and Operation

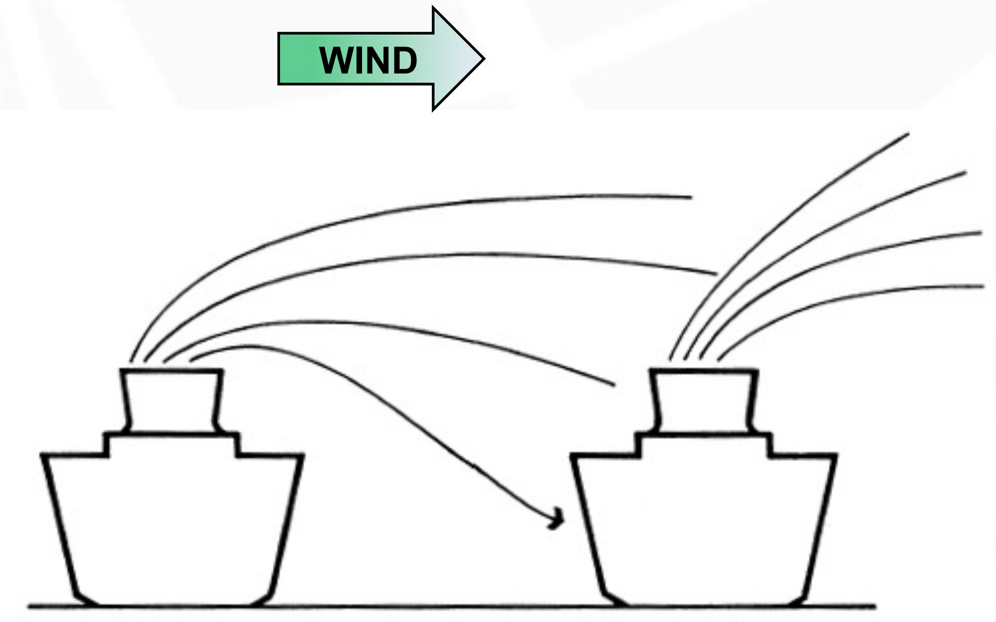
Mr Chukri Al Aani
Regional Sales Manager – MEA & Turkey
SPX Cooling Technologies Trading DMCC

Cooling Towers Design

- What space is available?
- What obstacles/other heat sources surround the site?
- What noise requirements are there?
- What plume requirements are there?
- What existing/new infrastructure do the cooling towers have to link into?
- How will the cooling towers be maintained?
- What types of cooling towers are possible to use?

Interference

It is wet bulb *at the tower air inlet* which matters

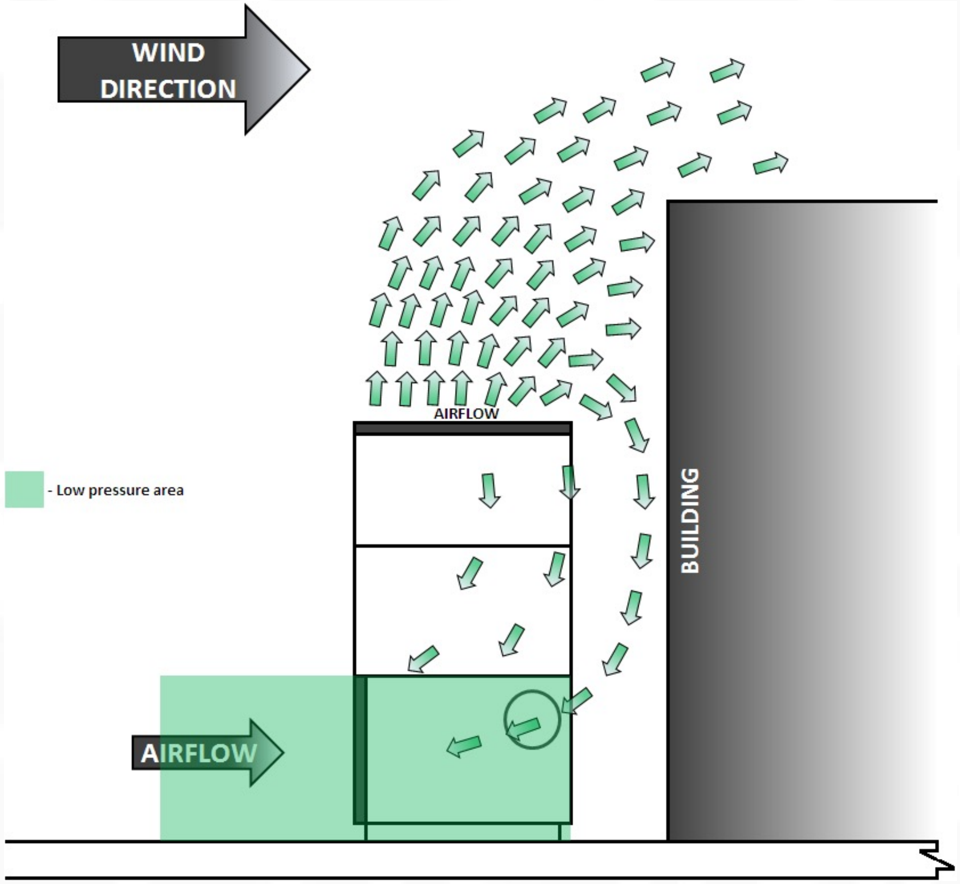


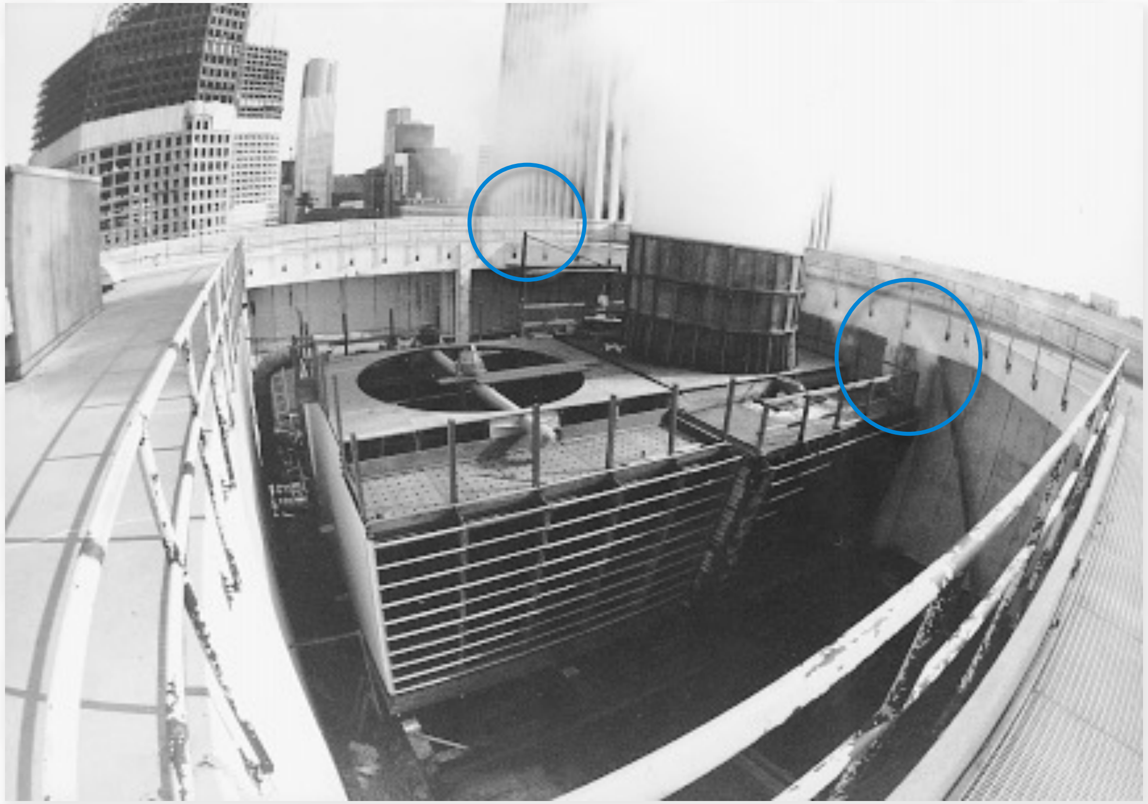
Local heat sources up wind of the cooling tower can elevate the wet bulb temperature of the air entering the tower, thereby affecting its performance. This could be an existing cooling tower, or another source of heat. This phenomenon is called “interference”.

Space and Obstacles

When siting a cooling tower next to a building, wind direction and discharge elevation need to be considered to avoid recirculation.

The higher building elevation, and low discharge velocity encourages the air back down towards the low-pressure area around the air inlet, created by the high inlet velocity of a forced draught configuration.



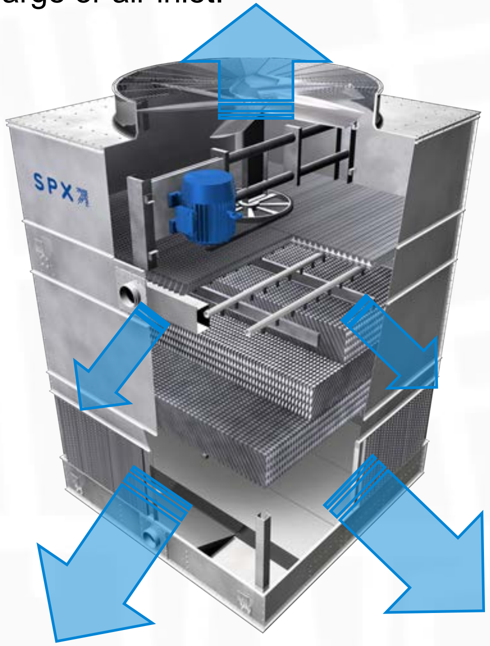



SPX
MARLEY

Primary Measurement Locations Breakout Sources

Crossflow

- Air inlets & fan discharge primary measurement locations.
- Because there is no falling water noise, air inlet noise is less prominent than a counterflow equivalent – lower frequency.
- Noise breakout will also occur through the casing, although much less than fan discharge or air inlet.



Counterflow

- Air inlets & fan discharge primary measurement locations
- Falling water noise produces higher frequencies at the air inlets, and on an induced draft tower this is typically on all 4 sides
- Again, noise breakout will also occur through the casing, although much
- less than fan discharge or air inlet

Cooling Tower Noise

Where is cooling tower sound important?

- Where people will be to hear it!
- Varies with every installation
- Considerations
  - •Near field: occupational safety
  - •Far field: property line sound levels

Properly defining sound requirements is critical to making sound decisions.

Sound Success Strategies

- Understand the project specific-requirements for noise
  - Where and what is the noise sensitive area
  - What options are there for where/how the tower can be oriented
  - Are there particular times of day that are more noise sensitive? – Running the fans at a lower speed at night will reduce noise
    - 50% speed = 12dB(A) approx
    - 66% speed = 8dB(A) approx

Cooling Tower Noise Treatment

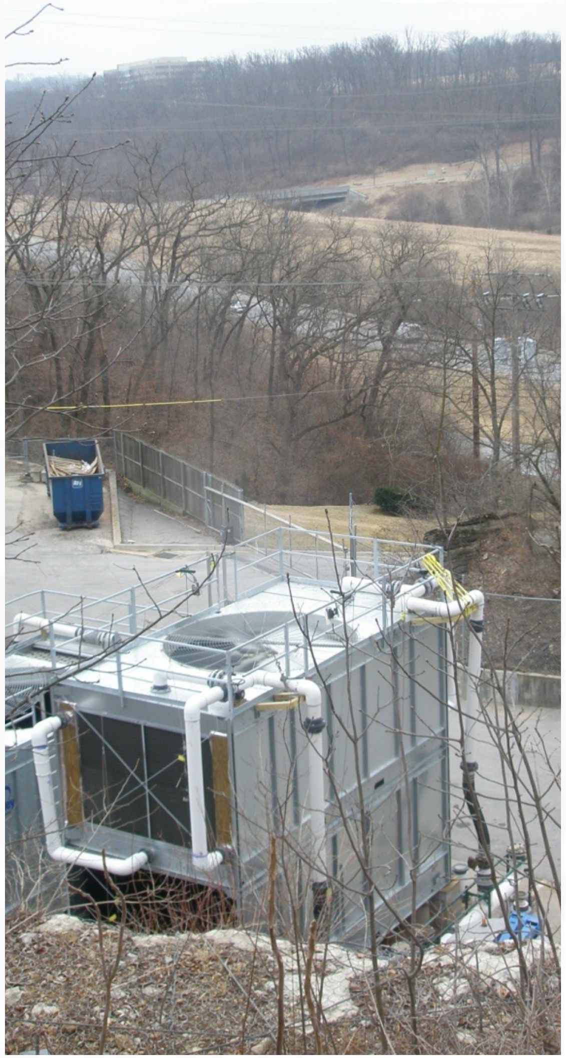
LOWEST COST

- Re-orientation of tower
- Lower air inlet height (typically field erected only)
- Splash attenuation mats (counterflow only)
- Low speed gearbox
- Incorporated and/or external barriers
- Low noise fan
- Inlet/outlet attenuators
- Super low noise fan

HIGHEST COST

Consider options to reduce noise in order of cost

Plume



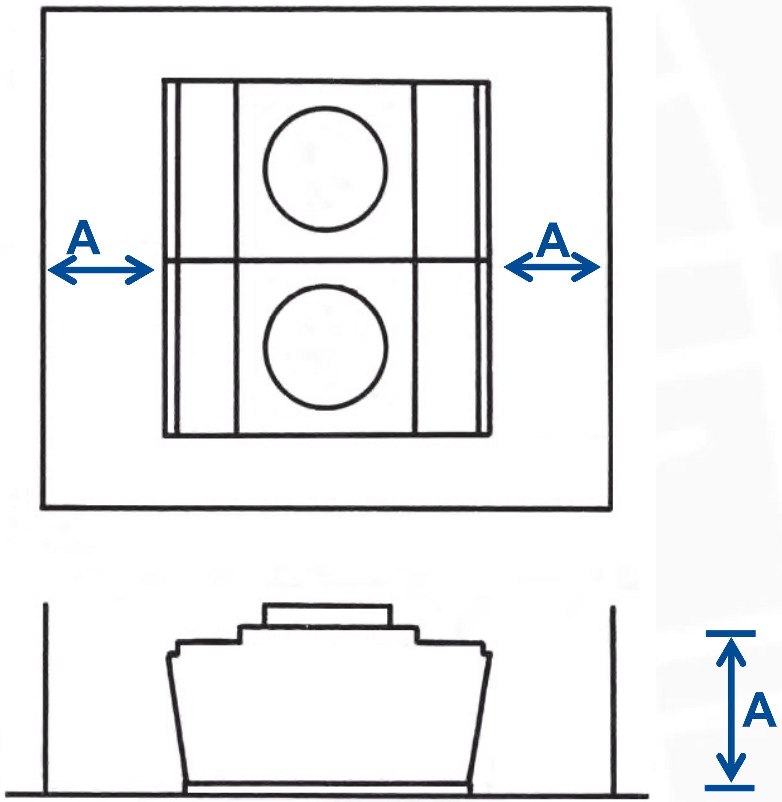
PAGE 44

Concrete/Supporting Steels: Decision Factors

- Existing concrete basin installation
- Pipework/pumping requirements
- Location load-bearing capabilities
- Size of duty – package/field erected
- Project lead time
- Available downtime
- Water storage requirements
- Customer budget
- Water quality

Rules of Thumb: Induced Draft Crossflow Tower

- In approximate terms, the distance from air inlet to nearest enclosure wall should be the same dimension as the air inlet height of the tower.
- Induced draft towers develop less total static pressure than forced draft towers.
  - more sensitive to the impact of external air losses
  - ***air inlet clearances must be governed by their potential to add system air losses***



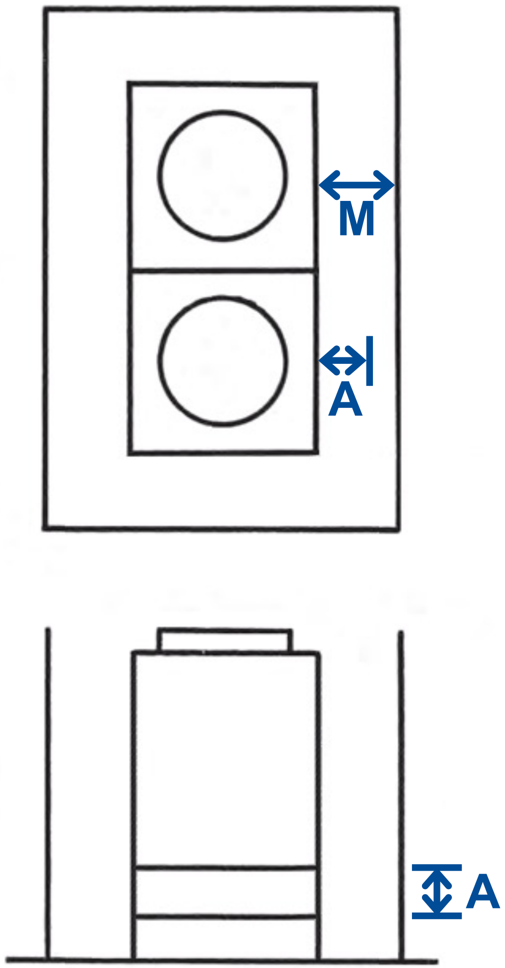
Rule applies to 1 or 2 cell towers only. For towers with more than 2 cells, add 15% to the dimension for every extra cell

Maintenance Access: Induced Draft Crossflow

- If hanging fill pack needs to be cleaned in between sheets, or removed, it must come out through the side casing panels.
- Just the end panel at each end of the side casing can be removed, but typically the next one in will be removed for improved access.
- 908mm is a standard fan deck bridging plate dimension – this forms the minimum distance possible to perform this task.

Rules of Thumb: Induced Draft Counterflow Tower

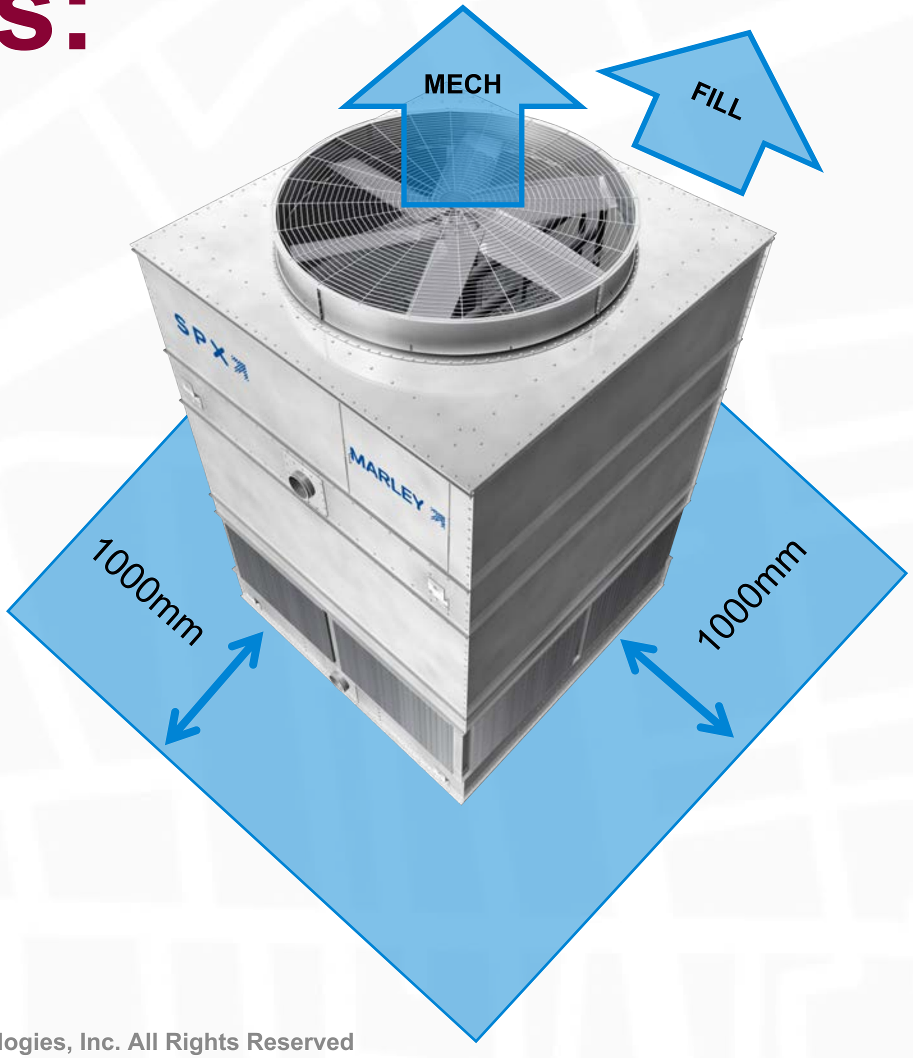
- In theory, the same rule applies as per an induced draft crossflow – distance to nearest wall should be equal or greater than air inlet height.
- Because this distance is so much smaller typically on an induced draft counterflow, maintenance access becomes the deciding factor, not airflow.
- Typical maintenance access for this type of tower would be a minimum of 1000mm. Under normal circumstances, more than this would be given to allow for comfortable working.



Rule applies to 1 or 2 cell towers only. For towers with more than 2 cells, add 15% to the dimension for every extra cell

Maintenance Access: Induced Draft Counterflow

- Tower requires minimum of 1000mm from each air inlet face to enable access through the air inlet to the basin.
- Fill pack removal and distribution inspection are possible through the access door on the side face of the tower.
- Mechanical equipment can be removed through the top of the tower, so consider crane locations when siting the tower.



EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Agenda

1. Introduction to Eurovent Middle East's Cooling Tower Guidebook
2. Evaporative Cooling: Overview of advantages
3. Evaporative Cooling: Working principles
4. Critical aspects of design, installation, and operation
5. **Case Study – Total Cost of Ownership**
6. Cooling Tower Certification
7. Moderated Discussion

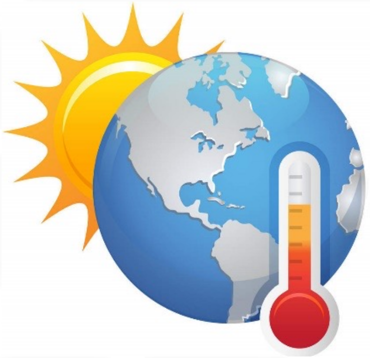
Case Study: Total Cost of Ownership

Mr Rafael Van Eijcken
General Manager - Middle East, Turkey and India
Baltimore Aircoil Middle East LLC

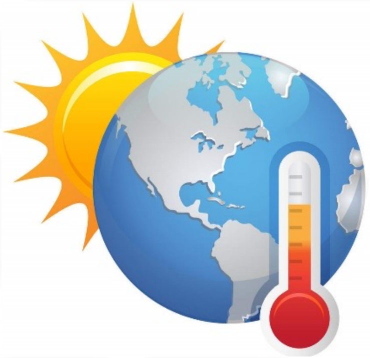
"If you want different results, do not do the same things!"

– Albert Einstein

Climate Change/ Global Warming



Climate Change/ Global Warming



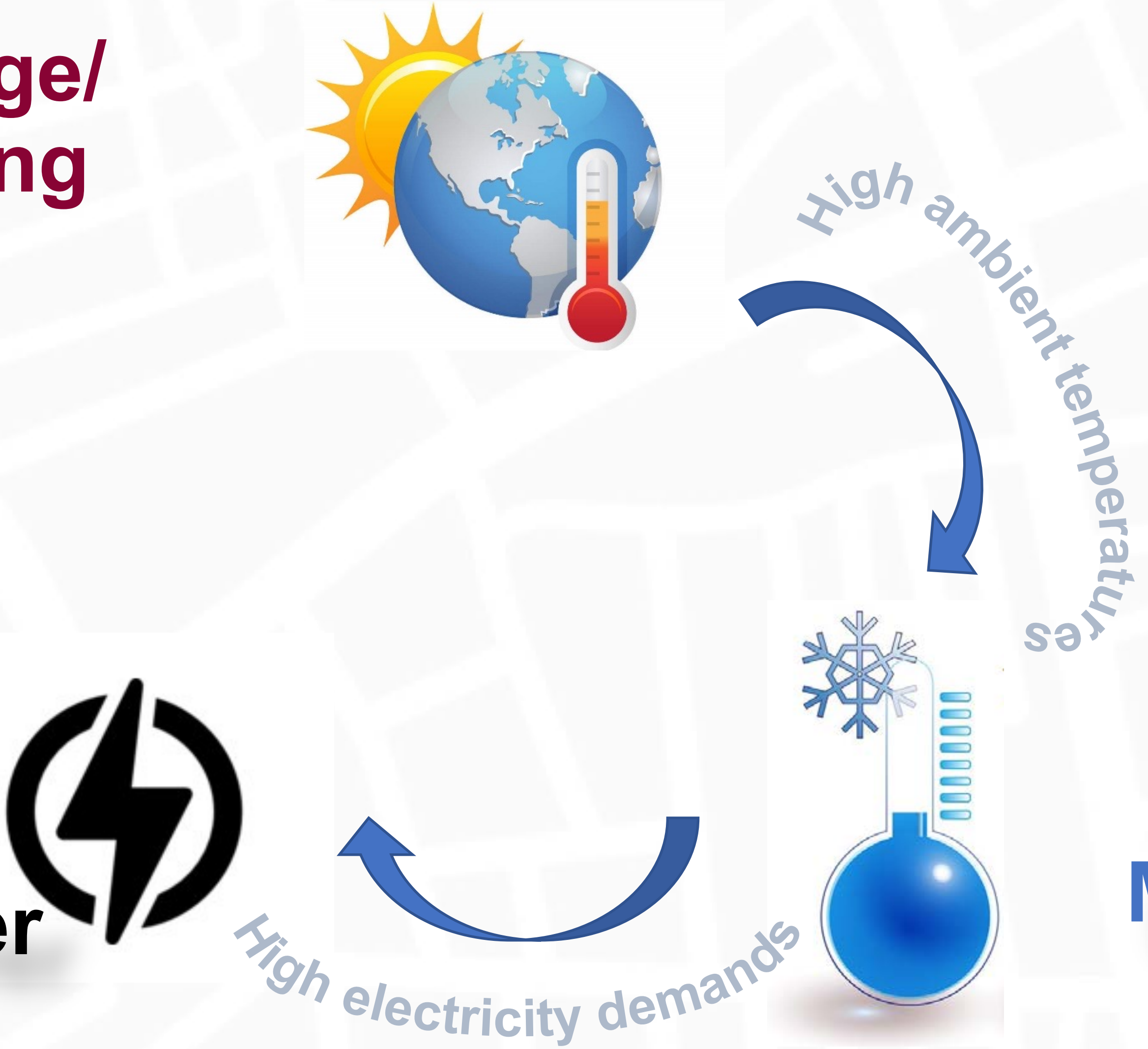
Climate Change/ Global Warming

More Cooling

EUROVENT MIDDLE EAST

HVACR Leadership Workshops

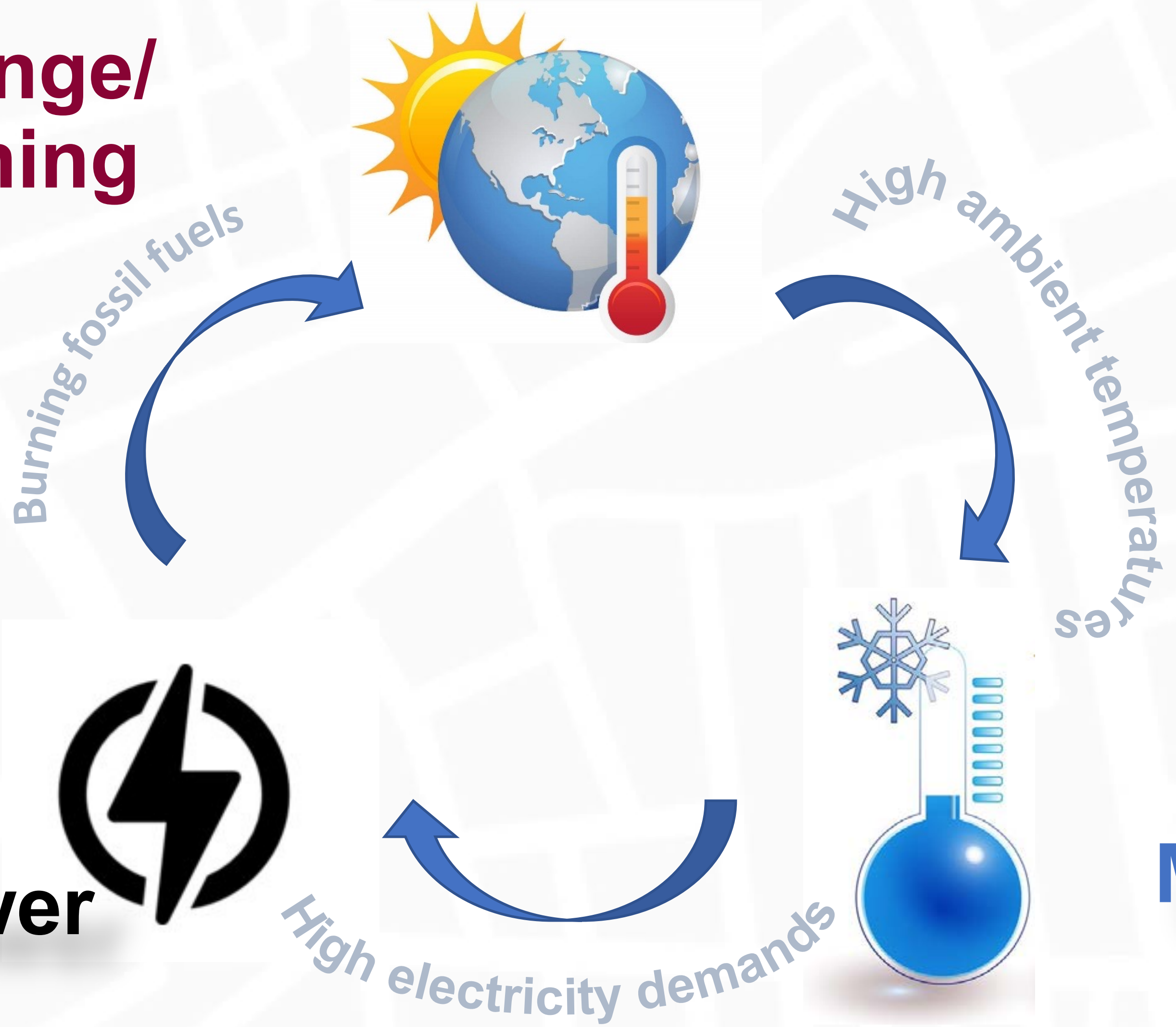
Climate Change/ Global Warming



More Cooling

Increasing power generation

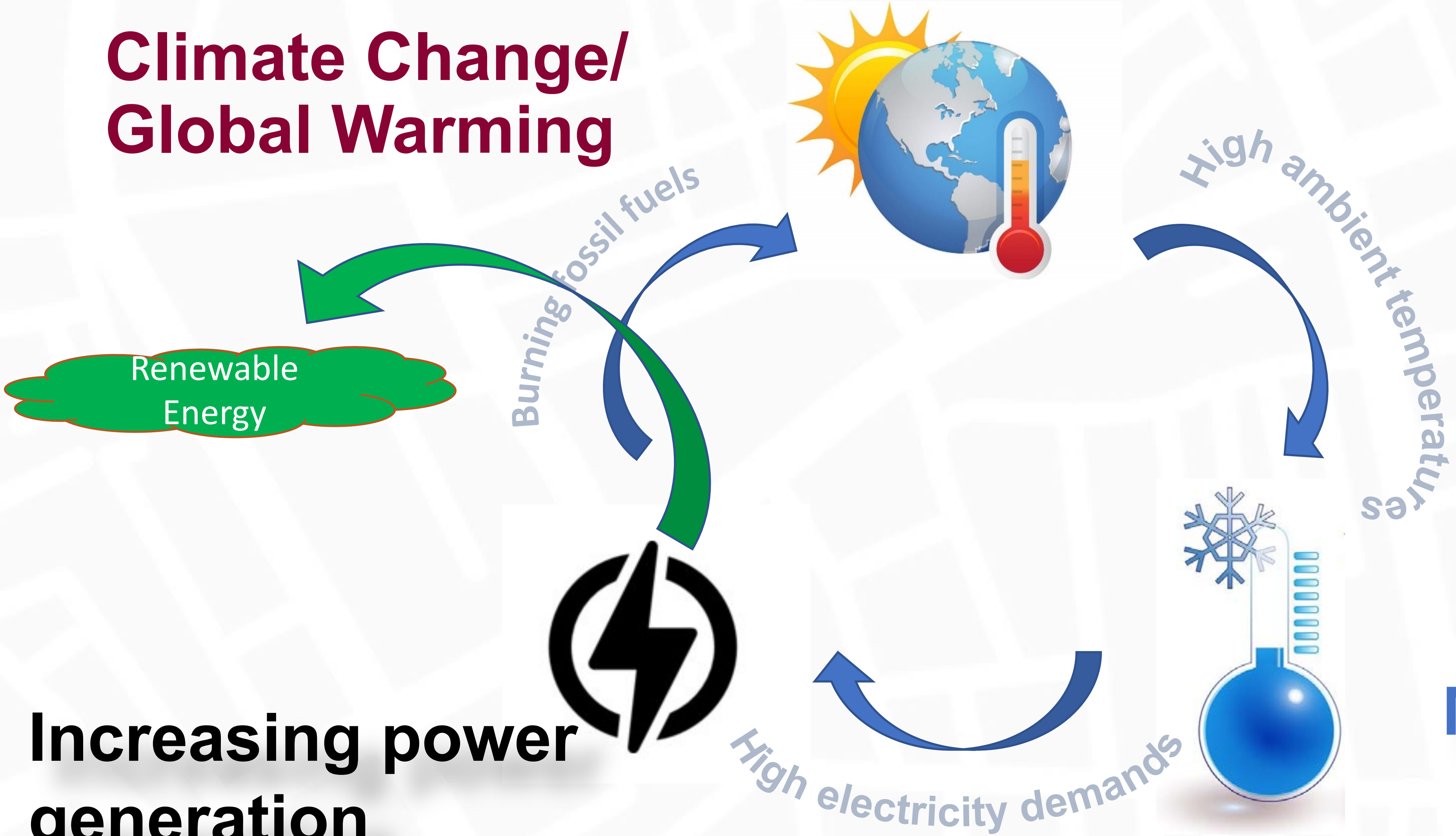
Climate Change/ Global Warming



More Cooling

Increasing power generation

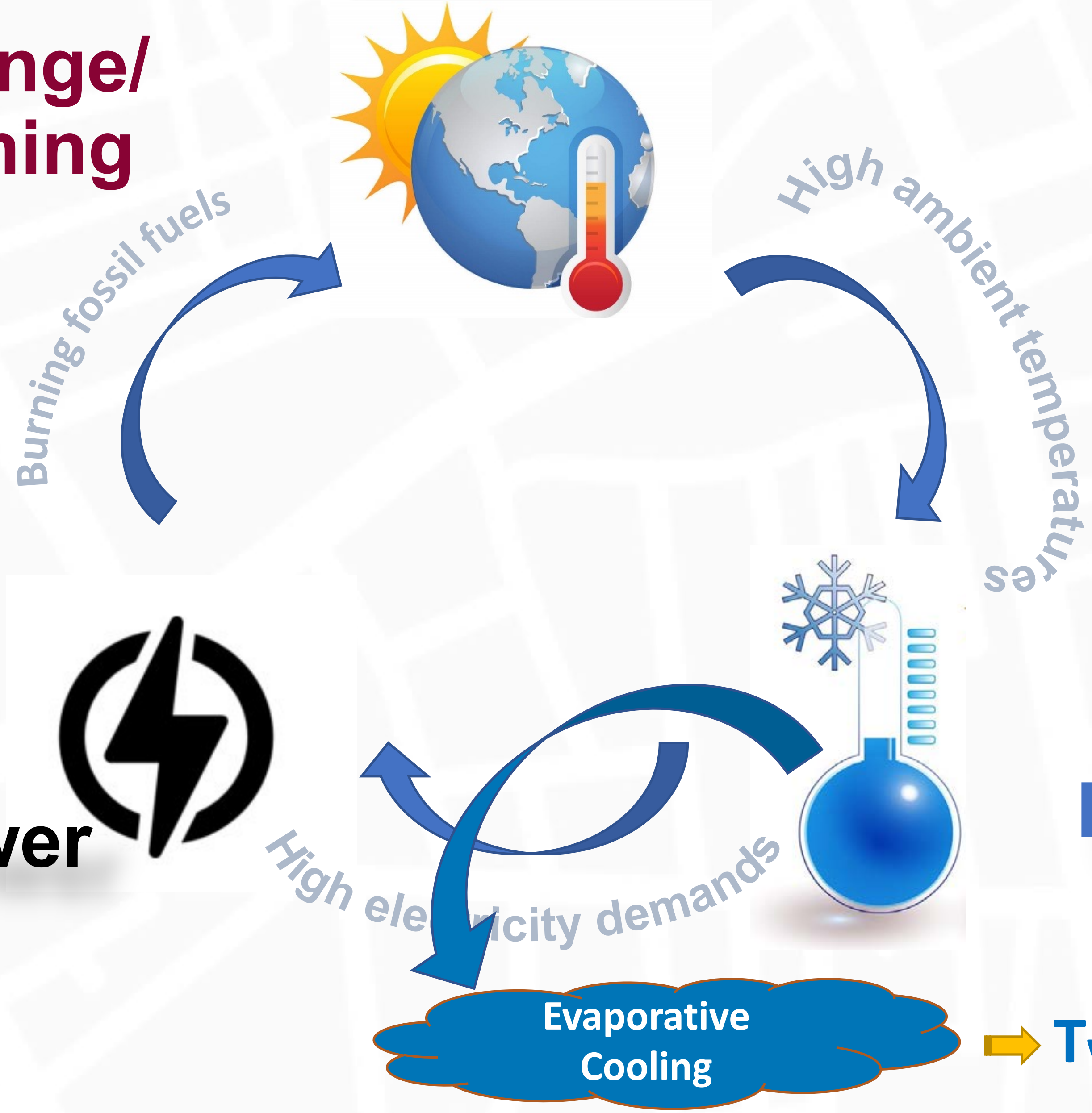
Climate Change/ Global Warming



Increasing power generation

More Cooling

Climate Change/ Global Warming



Increasing power generation

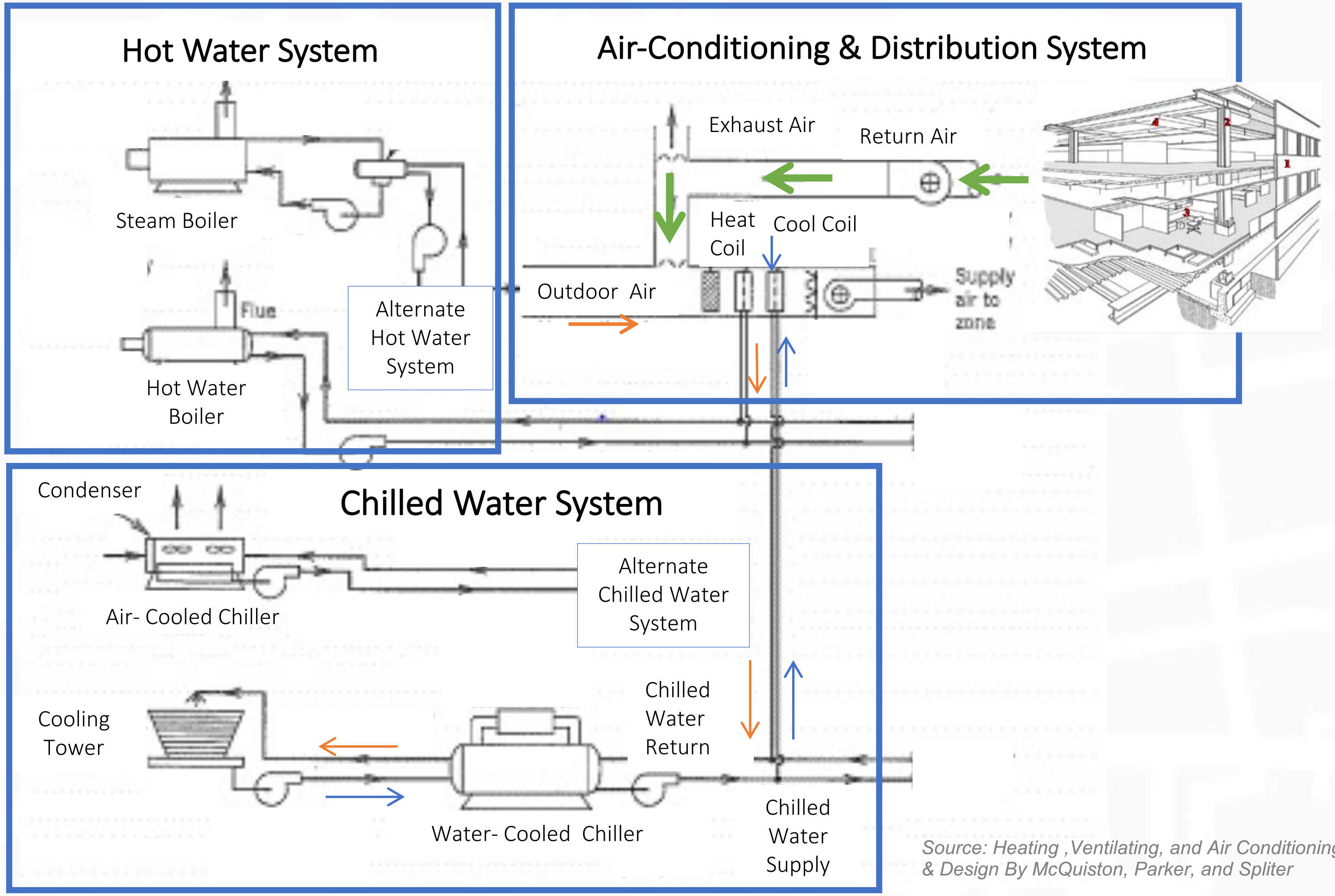
More Cooling

$T_{wet\ bulb}$!!!

Example: Typical HVAC System

Air-Cooled System

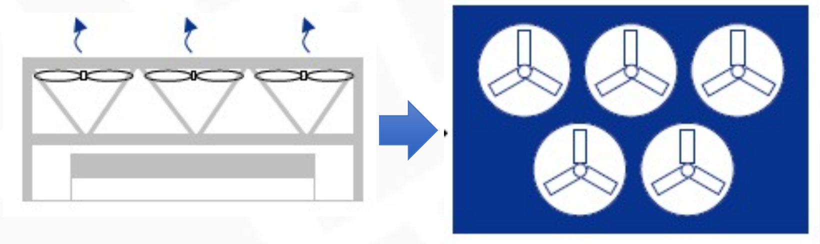
Water-Cooled System

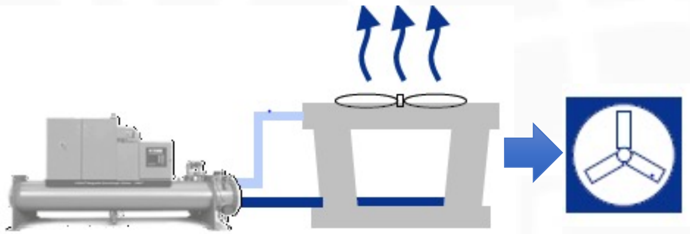


Source: Heating ,Ventilating, and Air Conditioning Analysis & Design By McQuiston, Parker, and Spliter

Air-Cooled vs Water-Cooled Heat Rejection

	AIR-COOLED SYSTEM	WATER-COOLED SYSTEM
1.	Design day is based on DRY bulb temperature	Design day is based on **WET Bulb** temperature
2.	Larger outdoor technical footprint (more surface area)	Smaller outdoor technical **footprint**
3.	Higher energy consumption	**Lower energy** consumption
4,	Higher noise emissions (many small fans)	**Lower noise** levels
5.	Consumes no water, at site (significant water usage at power plant)	Consumes water (Evaporative cooling) – TSE water

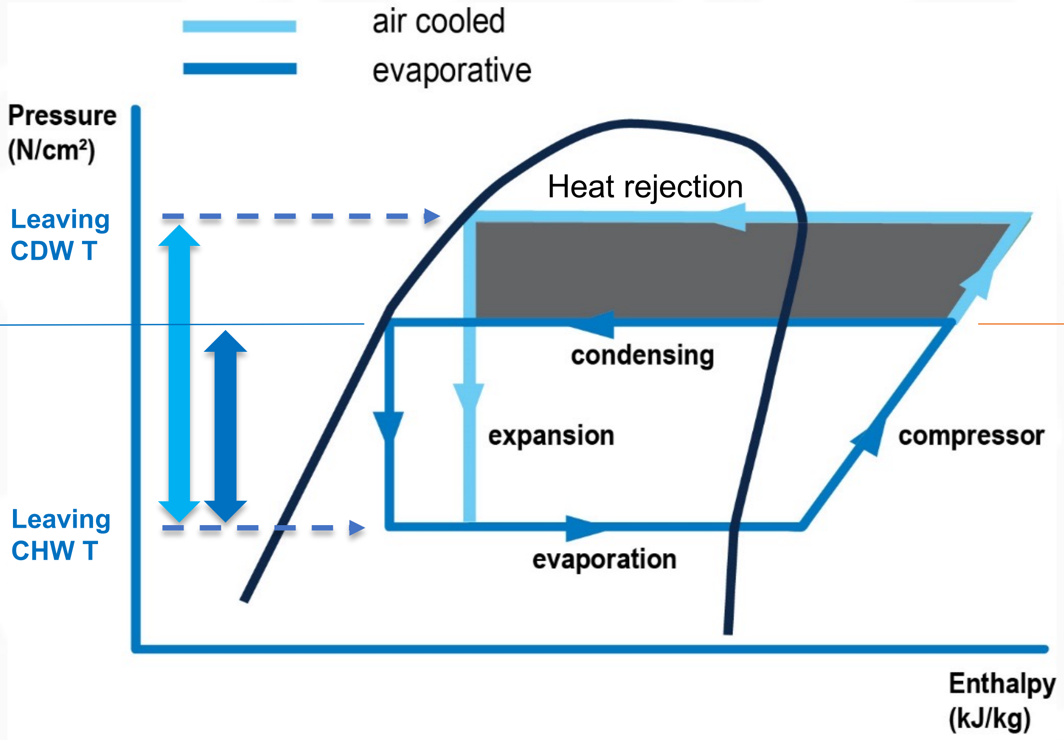




Air-Cooled vs Water-Cooled Heat Rejection

Air cooled
Tc = 58° C

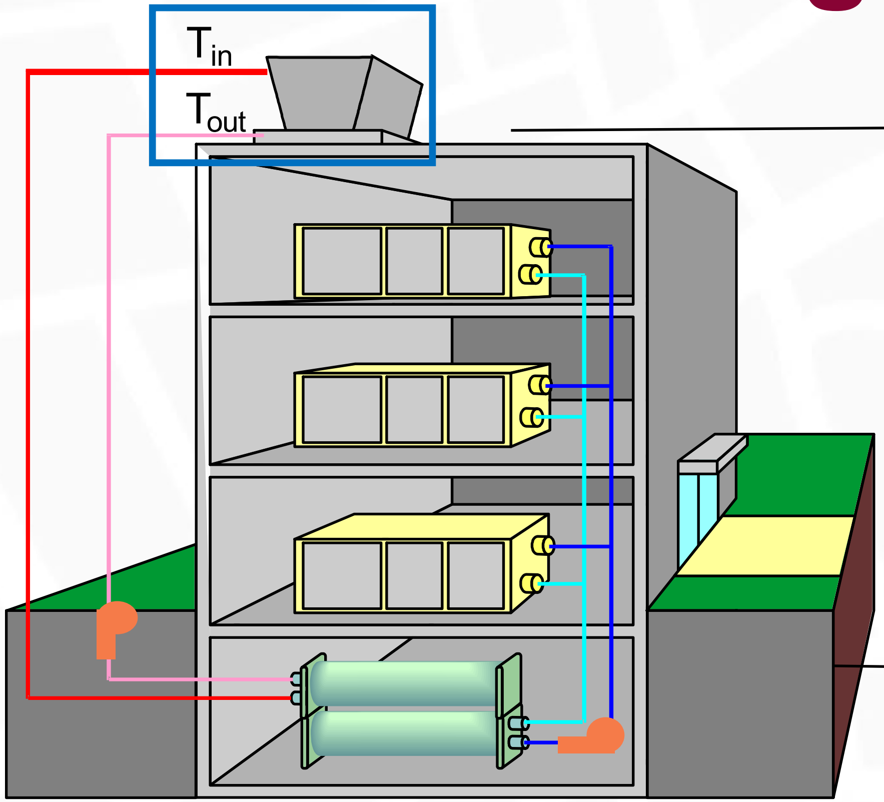
Tc = 42° C
Evaporative



Compressor Lift ↘

↘ 1° C Condenser water → ↘ 3% Energy chiller

Evaporative Cooling in HVAC



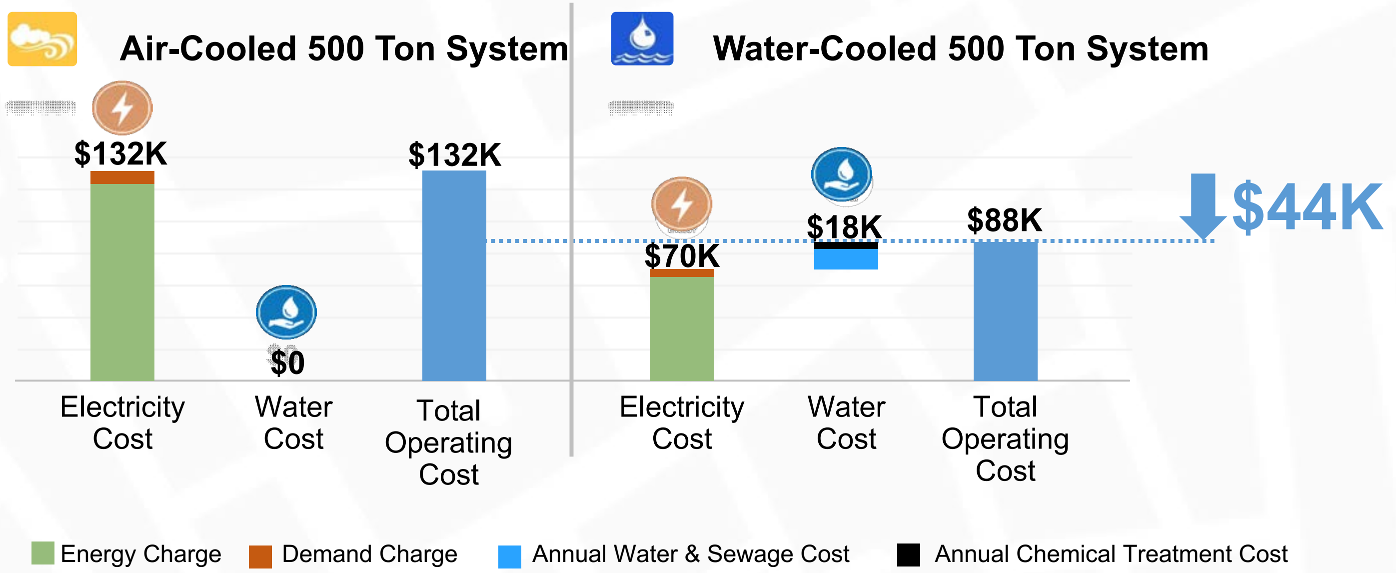
Cooling tower = kW

Up to 10 X

Chiller = kW

Chiller is the MAIN energy consumer in an HVAC system

Annual Operating Cost



Assumptions:
Energy rate $0.103/kWh. Demand Charge $13.44/kW. Water rate $2.9/1000gal.
Sewage rate $5.3/1000gal. Hrs of Operation (IPLV) 4380.
Considered system cleaning equal for systems as both HEX open to atmosphere

Water-Cooled Advantage:

- Savings of $44,000 annually
- 48% Energy Savings
- 33% savings on annual operating costs

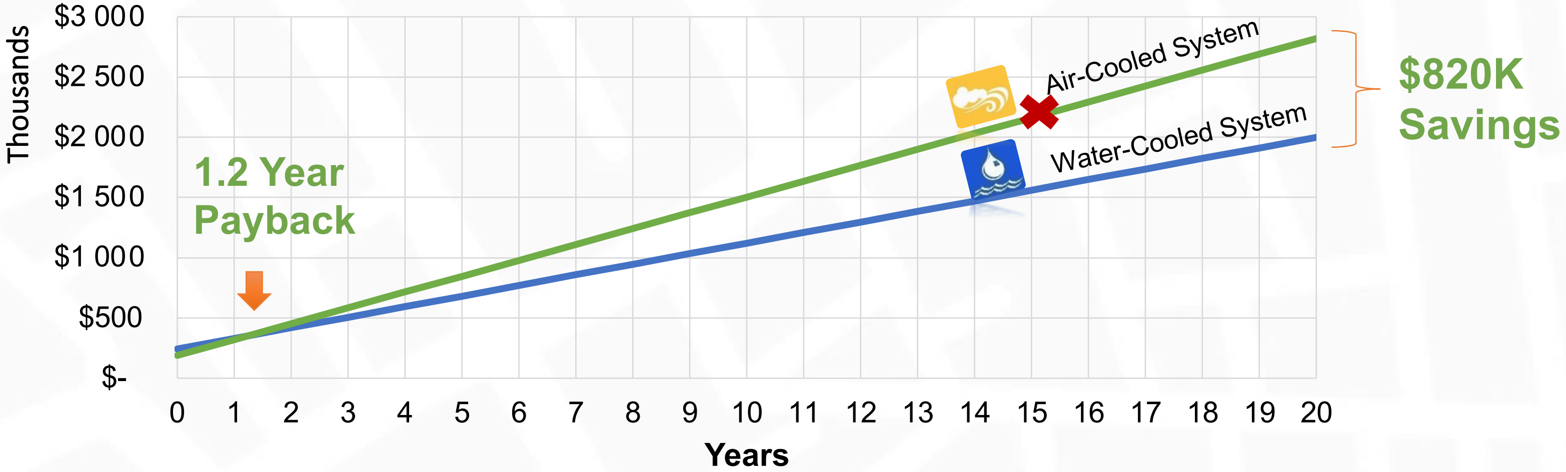
EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Annual Operating Cost

500 Ton System Cost	Equipment & Install	Annual Operating	Avg. Life*
Air-Cooled System	$188K	$ 132K	15-20 years
Water-Cooled System	$ 242K	$ 88K	20-30 years

** Selecting Chillers, Chilled Water Systems by David Grassl. https://www.csemag.com*



Water-Cooled Advantage:

- Payback Period of 1.2 years
- Life span of Water-Cooled > than Air-Cooled
- Total savings of ~$820K at the end of 20 years

Important Note:

Indirect costs linked to additional (valuable) spacing requirement and Sound reducing barriers/technologies can be very significant!

Benefits: Evaporative Cooling

Lowest
Energy Cost

Lowest
Operating Cost

Lowest
Installation Cost
&
Easy Transportation

Lowest
Environmental
Impact

Agenda

1. Introduction to Eurovent Middle East’s Cooling Tower Guidebook
2. Evaporative Cooling: Overview of advantages
3. Evaporative Cooling: Working principles
4. Critical aspects of design, installation, and operation
5. Case Study – Total Cost of Ownership
6. **Cooling Tower Certification**
7. Moderated Discussion

Cooling Tower Certifications

Mr Chukri Al Aani
Regional Sales Manager – MEA & Turkey
SPX Cooling Technologies Trading DMCC

Cooling Technology Institute (CTI)

The CTI establishes **standard testing and performance analysis systems and procedures** for cooling technologies. It also encourages and supports cooperative research to improve cooling technology and efficiency for the long-term benefit of the environment.

CTI STD-201

- The standard sets forth a program whereby CTI will certify that all models of a line of evaporative heat rejection equipment offered for sale by a specific Manufacturer will perform thermally in accordance with the Manufacturer's published ratings.

- Applies to Mechanical Draft Evaporative Heat Rejection Equipment such as Open Circuit Cooling Towers, Closed Circuit Cooling Towers and Evaporative Refrigerant Condensers.

Eurovent Certification and CTI Partnership

ECC – CTI Memorandum of Understanding
Mutual recognition Eurovent – CTI

"CTI and ECC endeavor to work together in the area of cooling tower certification in an effort to advance the certification programmes of both groups, be it therefore resolved, that CTI and ECC pledge to work cooperatively on all matter of mutual interest in the area of cooling tower certification."

- **Europe**
- **Middle East**
- **India**

CTI + EUROVENT CERTIFIED PERFORMANCE www.eurovent-certification.com

CONTRACT BETWEEN
COOLING TECHNOLOGY INSTITUTE
AND
EUROVENT CERTIFICATION COMPANY

Whereas Cooling Technology Institute (CTI) and Eurovent Certification Company (ECC) endeavor to work together in the area of cooling tower certification in an effort to advance the certification programs of both groups, be it therefore resolved, that CTI and ECC pledge to work cooperatively on all matters of mutual interest in the area of cooling tower certification. Further, CTI and ECC pledge to resolve any reasonable differences in the most professional and timely manner possible.

This contract is entered into this day, day, month, year, by and between the CTI whose address is 2611 FM1960 West, Suite A-101, Houston, Texas 77068, United States of America and ECC, whose registered address is La Kenweversstraat 21, 1050 Brussels, Belgium and whose office address is 62 Boulevard de Sebastopol, 75003 Paris, France.

Once significant interest is indicated by the above companies requesting the cooling tower certification program, the program will commence per the agreement indicated below.

In consideration of the promises of the parties contained in this contract, the parties agree as follows:

1. CTI and ECC each agrees, under the conditions specified herein, to cooperate with the certification of the other party with respect to covered product.
2. For the purposes of this Agreement:
   (a) Covered product means all products covered for certification in ECC publication OM-4-2008, which is a subset of the products covered in CTI STD-201.
3. Both CTI and ECC desire to affiliate per this contract. The ECC cooling tower certification program involves certification of published ratings on covered products by CTI. ECC will, in addition to the certification of published ratings using the CTI program, institute a complementary program to validate manufacturing according to the CTI official product data of record in the manufacturing facilities that may produce product for delivery or sale in Europe.

   Many benefits will be derived by all parties including the following:
   - Identical standards for cooling tower certification will be in use throughout the world;

Document Version 12-April-2010, Page 1 of 7

Scope of the Certification

General Purpose:

- To encourage honest competition
- Assure correctly rated equipment on the market

  - Separate and specific certification programmes for each product type.
  - Product performance tests through an independent third-party.
  - Application and participation open to all manufacturers.

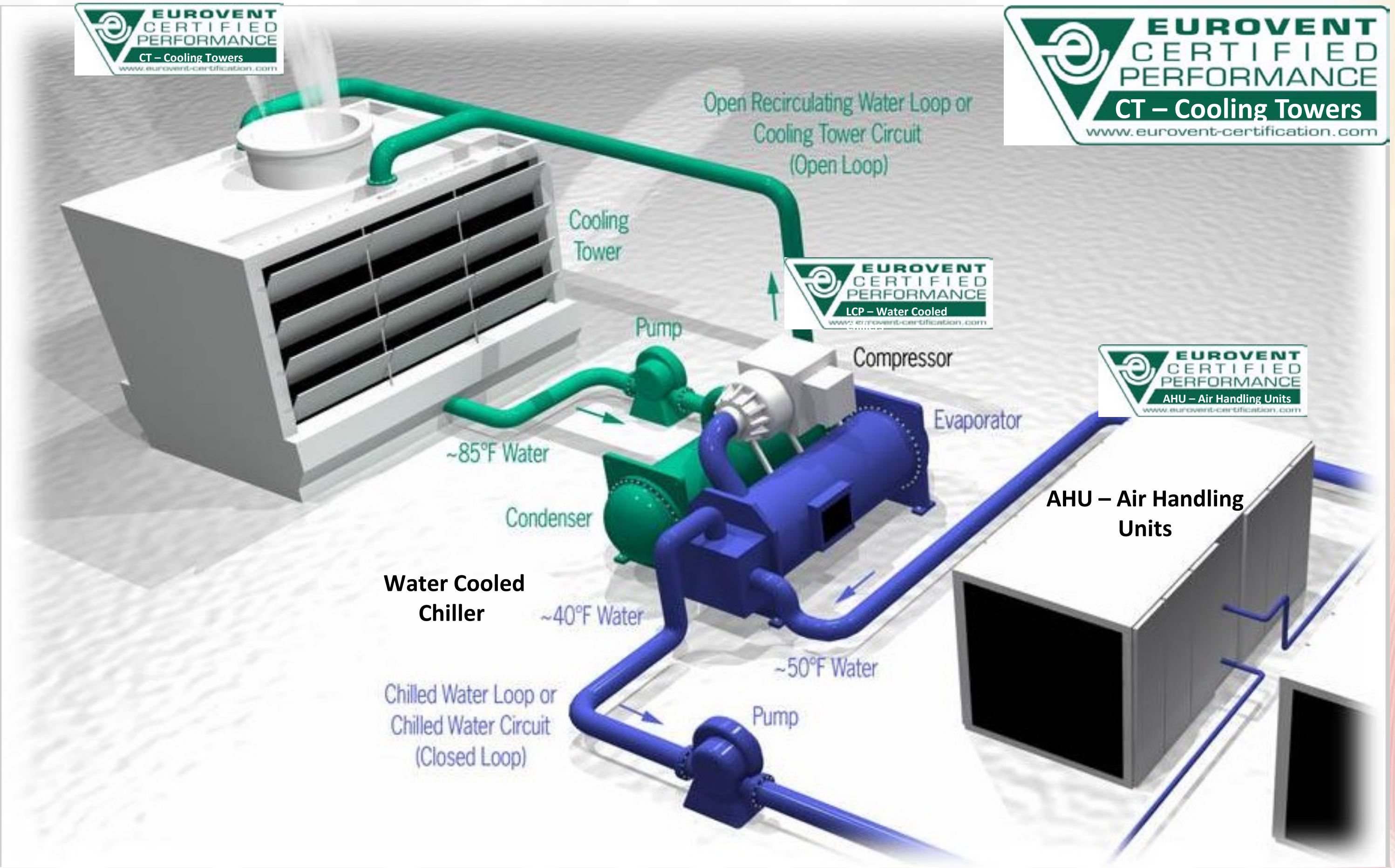
Initial Qualification Test

- **Thermal Performance Test per CTI ATC-105 Test Code**
  - Preparation per CTI FSP-156 Pretest Bulletin
  - Equipment Operation per CTI ATC-105 Test Code
  - Test Instrumentation per CTI ATC-105 Test Code
    - CTI owned flow measurement device

- **Capability Calculated Using Published Ratings**
  - Compares Measured Performance with Predicted Performance
  - 95% Minimum Capability Required to Pass Test

- **Verification of Physical "Data of Record"**
  - Inspection of Tower
  - Dimensional Comparison

Adding to System Design Performance – CTI Joins ECC



Formula For Success: Certified Efficient Products, Optimised System Designs, & Professional Installations

Some Key Issues:

- Air Recirculation
- Noise Amplification
- Control Strategy
- Poor Installation
- Regular Maintenance
  - Cleaning!

Verified performance:

EUROVENT CERTIFIED PERFORMANCE

Moderated Discussion

Final Remarks

Workshop Partners

BALTIMORE AIRCOIL COMPANY

SPX

Eurovent Certita CERTIFICATION

EUROVENT CERTIFIED PERFORMANCE

EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Media Partner

climate control MIDDLE EAST

KEY PERSPECTIVES ON THE REGION'S HVACR INDUSTRY


Thank You!
EUROVENT
MIDDLE EAST