APPA Institute for Facilities Management

Energy & Utilities

Cooling Production (316)

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Purpose of Today's Presentation

To provide a broad understanding of central cooling production systems

Why Use Chilled Water for Cooling?

Water - Ideal Heat Transfer Fluid

Specific Heat of Water

1 BTU/lb

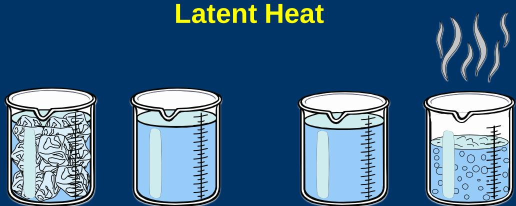
Specific Heat of Air

0.24 BTU/lb

75ºF *Plus 1 BTU =* 76ºF

75ºF *Plus 4 BTUs =* 76ºF

Latent Heat

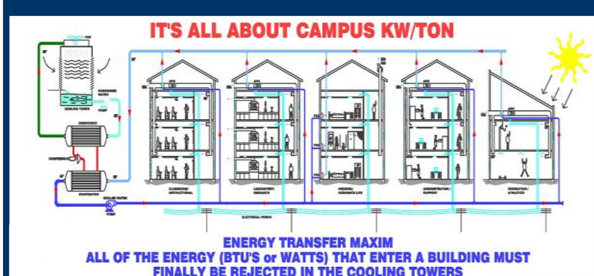


32ºF

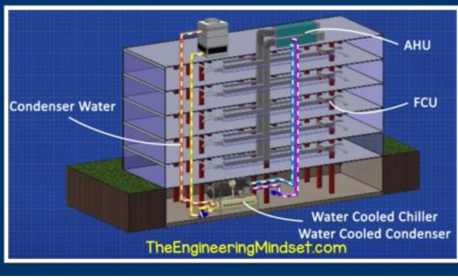
Heat of Fusion
144 BTU/lb

212ºF

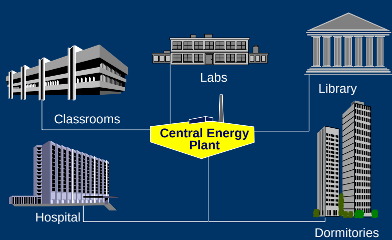
Heat of Vaporization
970 BTU/lb



Central “*Stand Alone*” Chilled Water System



Central (District) Energy



Central Energy Systems

Advantages

- **Integrated solutions**
- **Less equipment**
- **Lower service cost**
- **Better space utilization**
- **Alternate technological option**

Central Energy Systems

Advantages (cont.)

- Aesthetic options
- Lower operating costs
- Better management and energy control
- Higher overall efficiency
- Multiple fuel capabilities

Central Energy System

Disadvantages

- High first cost
- Inflexible once constructed
- Distribution losses
- Need for specialized technicians

Why is this important?

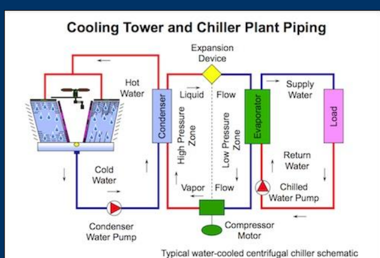
- Nearly 50% of the energy consumed in a building can be attributed to the HVAC system.
- In the U.S., HVAC systems are estimated to account for 20% of the total energy used.

Source: Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings, 40*(3), 394-398.

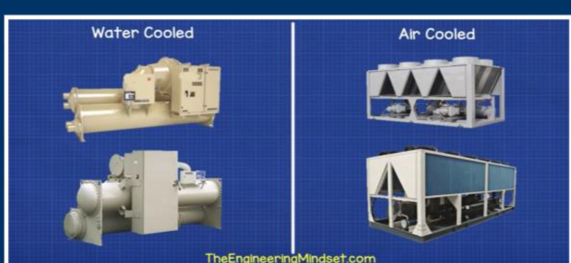
Chilled Water System Components

- **Chillers**
  - ➢ **Vapor compression**
    - **Variety of compressor designs**
  - ➢ **Absorption**
  - ○ **Condensers** (air cooled *or* water cooled)
  - ○ **Evaporators** (the heat sponge)
- **Pumps & Piping**
- **Air Handlers**

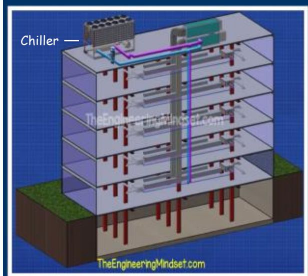
Chilled Water System

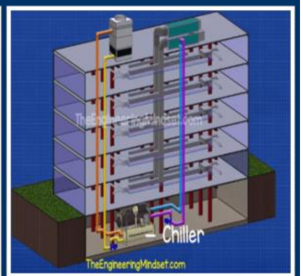


Chillers



Air Cooled Chiller / Water Cooled Chiller

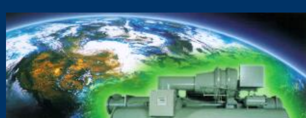




Refrigerants

Issues

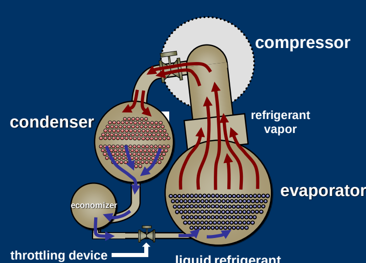
- Increasing cost of refrigerants
- Global warming vs. ozone depletion
- Alternative refrigerants
- Regulatory



Refrigeration Cycle

Primary Components:

- compressor
- condenser
- evaporator
- throttling device



Types of Prime Movers Used for Modern "Pumps"

- Electric motor
- Steam turbine
- Combustion turbine
- Combustion engine (diesel or gasoline)

Chilled Water System Components

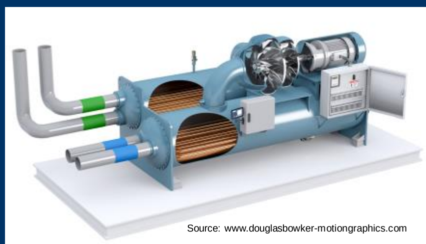
Chillers

3 Types:

- Centrifugal
- Rotary/Screw
- Absorption

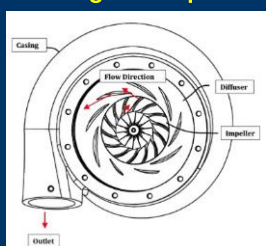
Centrifugal Chiller

Chilled Water System Components: Chillers



Centrifugal Chiller, Electric Motor-Driven

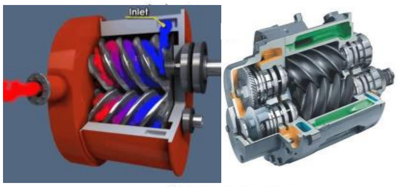
Chilled Water System Components Centrifugal Compressor



Chilled Water System Components: Chillers

Screw Chiller, Electric Motor-Driven

Chilled Water System Components: Chillers

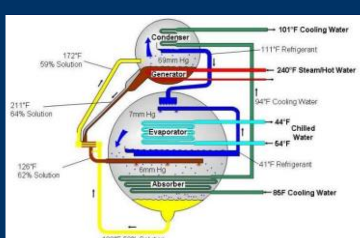


Screw compressor cut-away

Chilled Water System Components: Chillers

Absorption Chiller

Chilled Water System Components: Chillers



Single Stage Steam-Fired Absorption Chiller

Horsepower, Voltage, Tons of Refrigeration Correlation

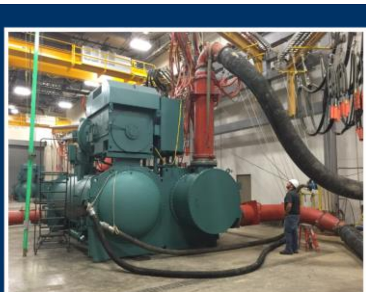
Horsepower Range	Voltage	Tons of Refrigeration
100 - 500	480 - 2,400	21 - 106
500 - 5,000	2,400 - 5,000	106 - 1,060
5,000 - 10,000	5,000 - 12,000	1,060 - 2,120

Source: www.kylesconverter.com

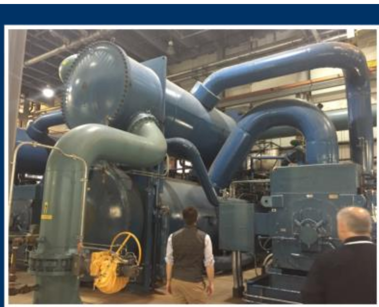
Horsepower Required for Common Chiller Sizes

Common Chiller Sizes	Horsepower Required
600 Tons of Refrigeration	2,830
1,200 Tons of Refrigeration	5,659
2,000 Tons of Refrigeration	9,432
5,000 Tons of Refrigeration	23,580

Source: http://www.kylesconverter.com



2,500 Ton Centrifugal Chiller – 4,160 Volt



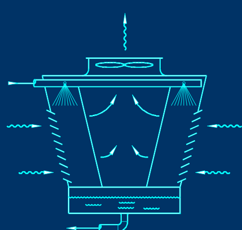
5,000 Ton Centrifugal Chiller - 13,800 Volt

Chilled Water System Components

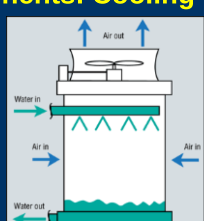
Condensers

- Air Cooled
- Water Cooled

Cooling Towers



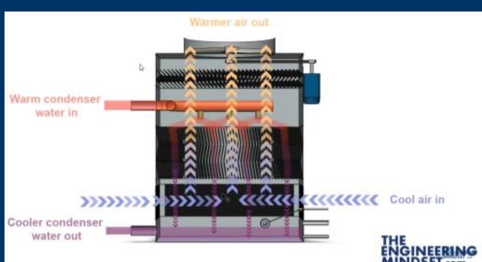
Chilled Water System Components: Cooling Towers



Rejects unwanted heat from campus

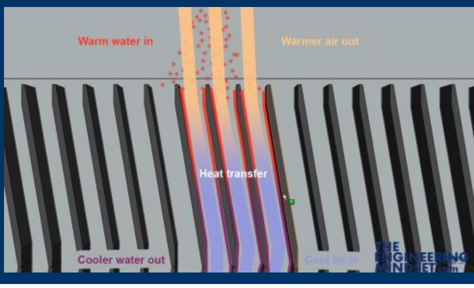
Cooling Tower

Cooling Tower



Cooling Tower

Cooling Tower



Chilled Water System Components: Cooling Towers

Chilled Water System Components: Cooling Towers

The University of Illinois

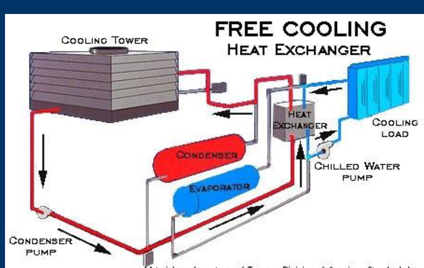
The University of Arizona

Pumps & Piping

Air Handlers

Source: www.douglasbowker-motiongraphics.com

Free Cooling?



Thermal Energy Storage

Chilled water storage tank

Thermal Energy Storage

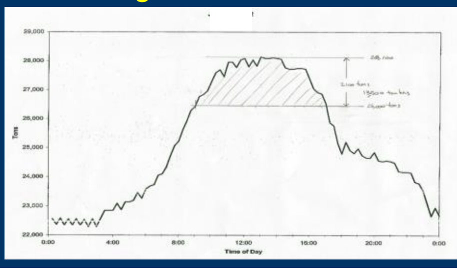
Ice Storage Tanks

Thermal Energy Storage

Benefits

- Shifting system load demand
- Stability of cooling capacity
- Dual-duty operation
- Managing energy costs
- Reduction in demand charges

Cooling Load Profile
Shaving the Peak with TES



Control / Reduce Energy Costs

- Chillers
  - Variable speed drive
  - Mechanical unloading
- Towers
  - Variable speed drives on fans and pumps
- Distribution Pumps
  - Variable speed drives on pumps
- Good Maintenance
- Metering / Analytics
- Thermal Energy Storage
- Free Cooling

Questions / Comments

Evaluation Forms

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

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Course Description

Higher education campus buildings are primarily cooled by equipment that produces chilled water using chillers. These chillers can be located within the building or in a central utility plant and distributed to the buildings using piping infrastructure. Cooling production is typically cyclic in nature peaking in summer and plunging in winter. Depending on the climate the winter requirements can be as low as 10% of summer peak or lower. This requires the utility plant (or individual building) to have capacity for the peak need but underutilized equipment during winter time, providing opportunity for equipment maintenance in winter time. In addition to the chillers, most chiller plants need pumps to push the water from the utility plant out to the campus buildings. The heat transferred from the buildings to the chilled water is finally rejected in cooling towers. This course will explore the various components that entail the cooling production system and the challenges that go along with operations of such systems.

AIA Continuing Education Provider

Learning Objectives

- Learning Objective 1:
  Discuss how weather plays a major factor in cooling and heating production.
- Learning Objective 2:
  Discuss the best opportunities for equipment maintenance.
- Learning Objective 3:
  Discuss the various components that entail the cooling production system.
- Learning Objective 4:
  Learn the challenges that go along with operating and cooling systems.

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This concludes The American Institute of Architects Continuing Education Systems Course

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