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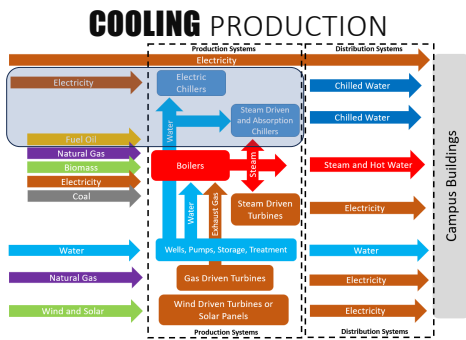
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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



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### Purpose of Today's Presentation

To provide a broad understanding of cooling production systems



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### Science

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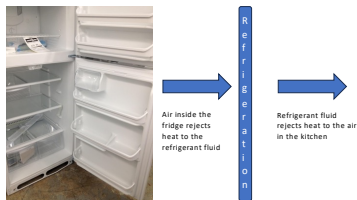
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### Cooling Production = Heat Rejection



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## Evaporation

- Water absorbs heat from the body
- Process of evaporation from liquid to gas
- AZ vs. FL



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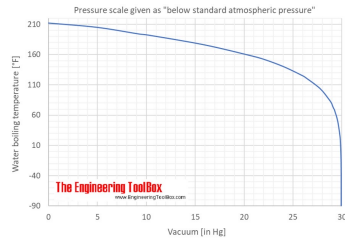
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## Pressure

- Boiling temperature of water 100°C or 212°F (sea level)
- Boiling temperature of water 203°F (mile-high)



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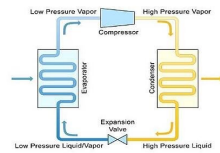
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## Vapor Compression Cycle



- Evaporation (or boiling)
- Pressure manipulation

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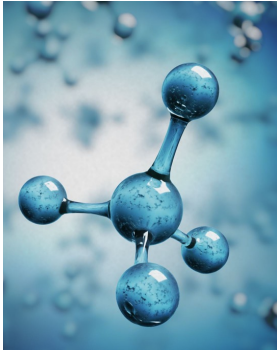
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### Common Refrigerants

- Chlorofluorocarbons (CFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Hydrofluorocarbons (HFCs)
- Natural Refrigerants

[https://en.wikipedia.org/wiki/List\\_of\\_refrigerants](https://en.wikipedia.org/wiki/List_of_refrigerants)

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### Risks with Refrigerants

REFRIGERANT TYPE	CLASS	OZONE DEPLETION POTENTIAL	GLOBAL WARMING POTENTIAL
CFC	Synthetic	High	Very High
HCFC	Synthetic	Very Low	Very High
HFC	Synthetic	Zero	High
HC	Natural	Zero	Negligible
CO2	Natural	Zero	Negligible

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### Refrigeration & Air Conditioning

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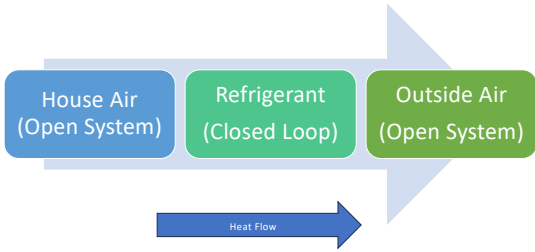
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### Residential air conditioners



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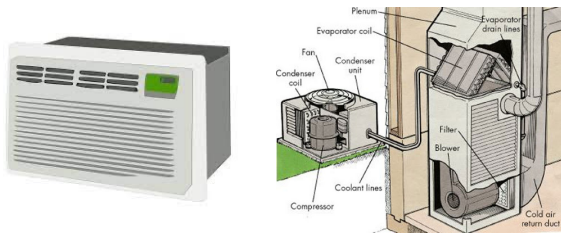
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### Residential air conditioners



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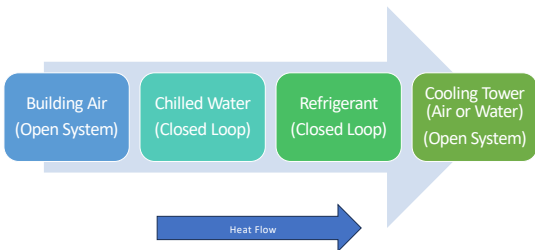
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### Commercial chillers



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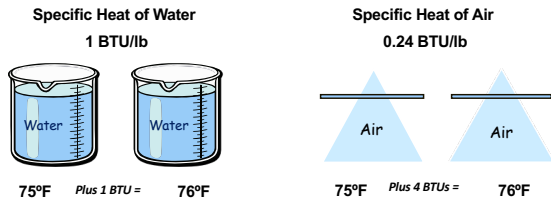
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## Water - Ideal Heat Transfer Fluid




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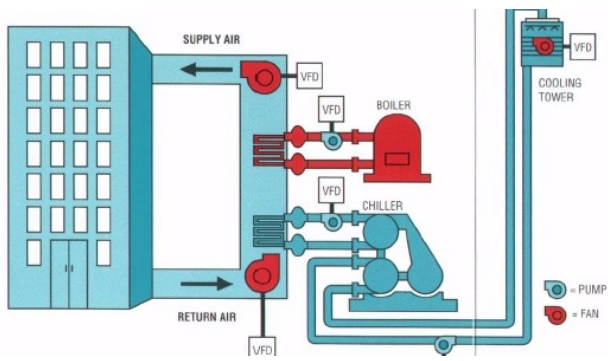
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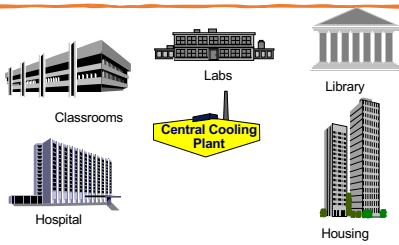
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## District Cooling




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### District Cooling (pros/cons)

- Integrated solutions
- Less equipment
- Lower service cost
- Better space utilization
- Alternate technological option
- Lower operating costs
- Better management and energy control
- Higher overall efficiency
- Multiple fuel capabilities
- Aesthetic
- High first cost
- Inflexible once constructed
- Distribution losses
- Need for specialized technicians

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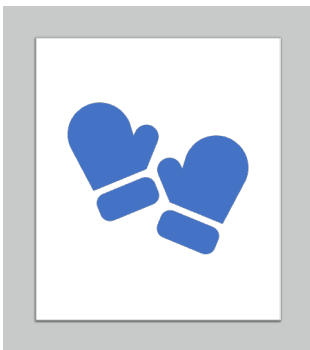
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### Chillers

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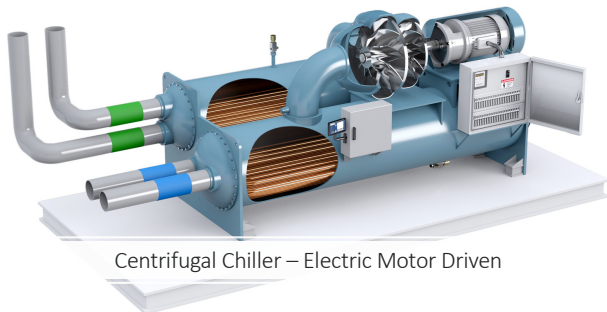
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Centrifugal Chiller – Electric Motor Driven

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Centrifugal Chillers

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22

2,500 Ton Centrifugal Chiller



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5,000 Ton Centrifugal Chiller



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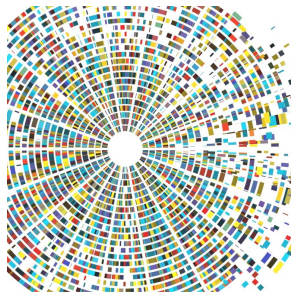
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### Types of Prime Movers

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



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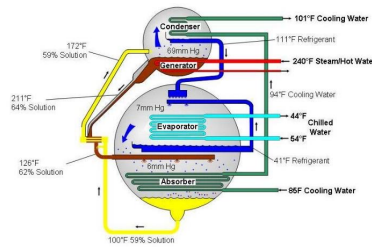
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### Absorption Chiller



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### Absorption Chiller



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# Condensers

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## Condenser Types

- Air Cooled
- Water Cooled

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## Air cooled condensers

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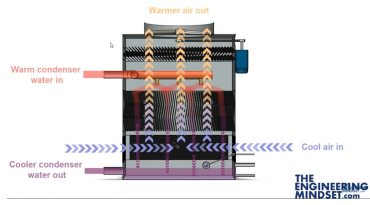
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# Water Cooled (Cooling Tower)



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# Cooling Towers Examples



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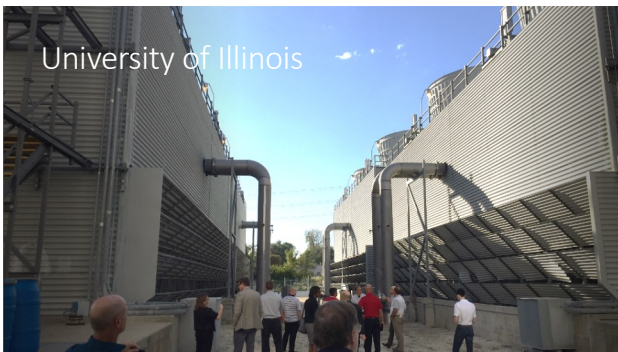
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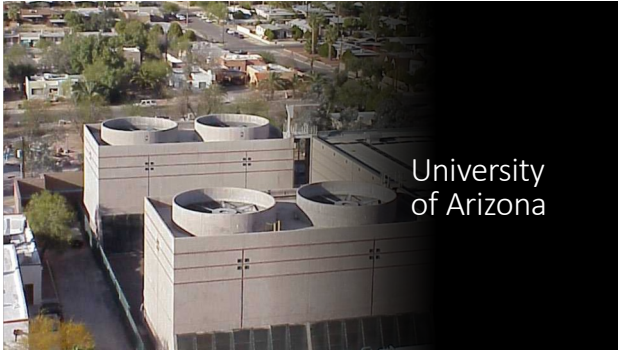
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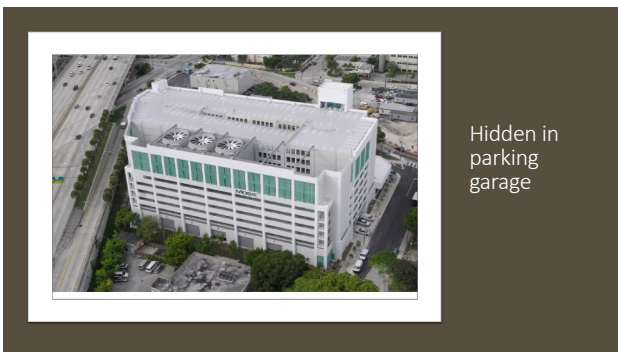
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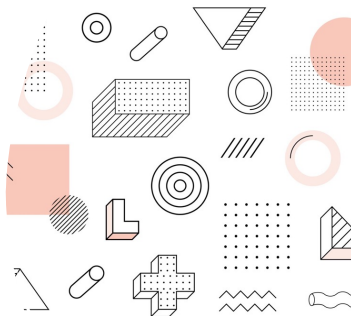
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Other  
Components  
&  
Technologies



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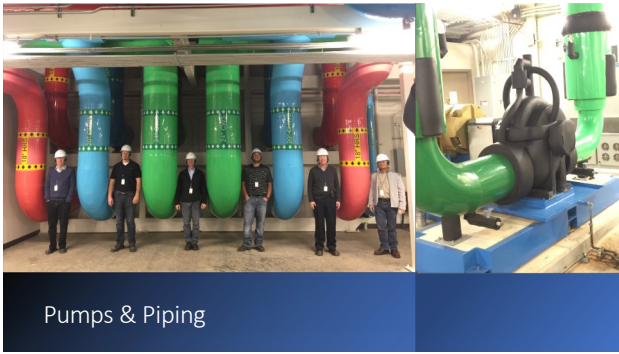
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Thermal Energy Storage

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### Thermal Energy Storage

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

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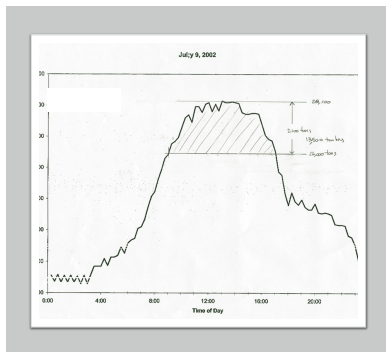
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Cooling Load Profile Shaving the Peak with TES



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# Efficient Chiller Operation

- 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

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# Questions

Lalit.Agarwal@EnergyCAP.com



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