



Industrial Systems
A Johnson Controls Company

*Makes the World
A Very*

COOL
Place

Proven Ways to Reduce Operating Costs and Greenhouse Gas Emissions

Energy 2006
Chicago

Ian Spanswick
Product Manager – Industrial Systems

Excellence in Energy Efficiency



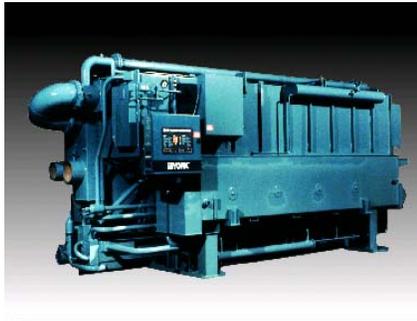
Body Shop:
Building
Strategies

- Energy Supply Diversification
- Heat Pumps
- Onsite Thermal and Power Generation
- Comparison study - Economic and Environmental Benefits

Energy Supply Diversification



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Hybrid Chiller Solution



**Body Shop:
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Strategies**



High Efficiency Electric Chillers



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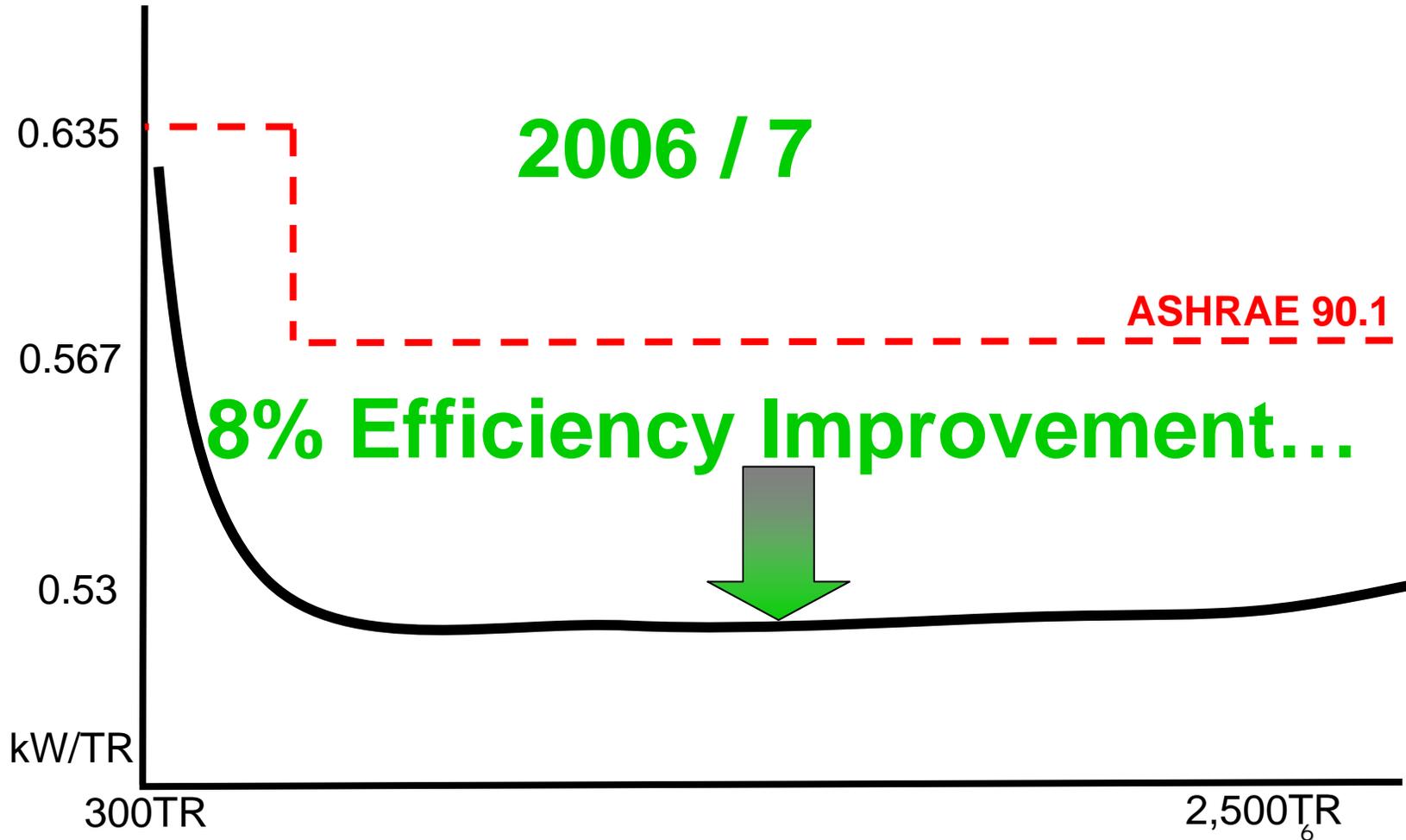


250 to 3,000 TR / 880 to 10,000 kW

Improving Chiller Performance



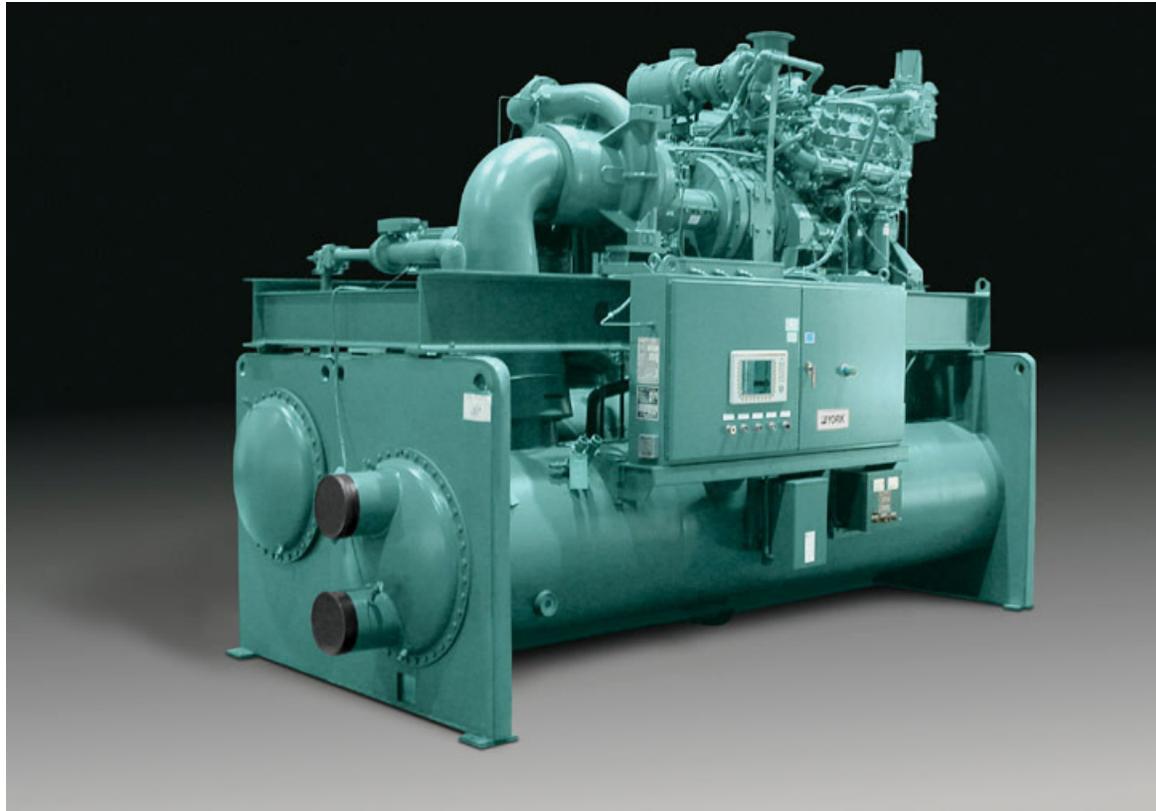
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Gas Engine Drive Chillers



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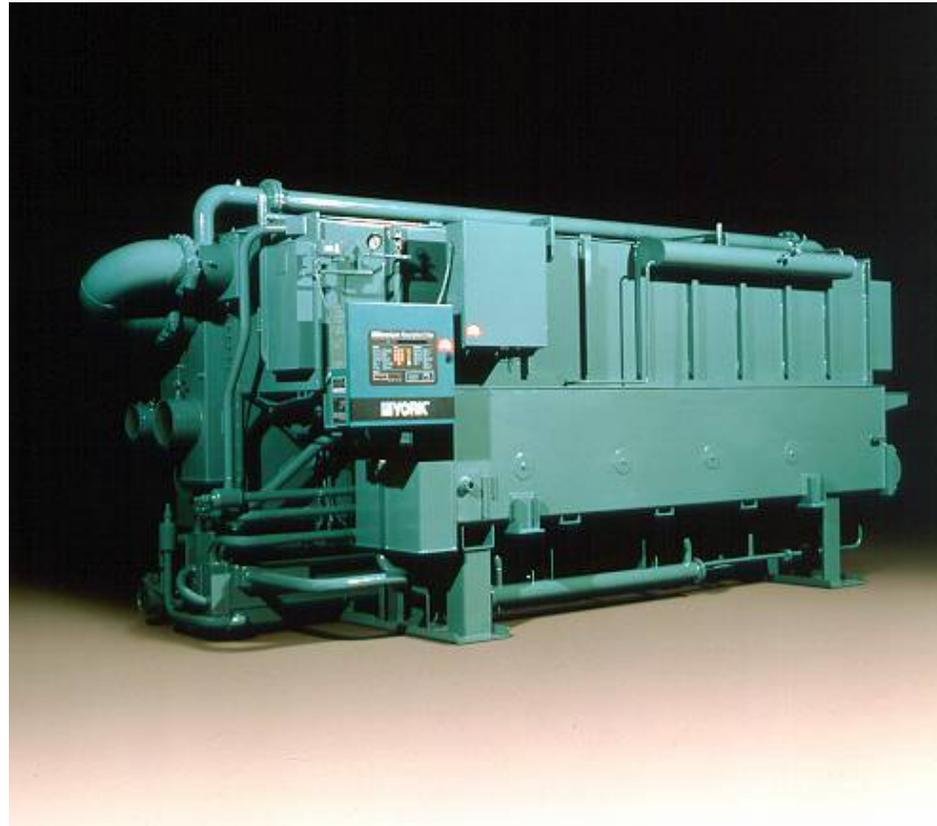


400 to 1,900 TR, 1,400 to 6,700kW

Double Effect Absorption Chillers



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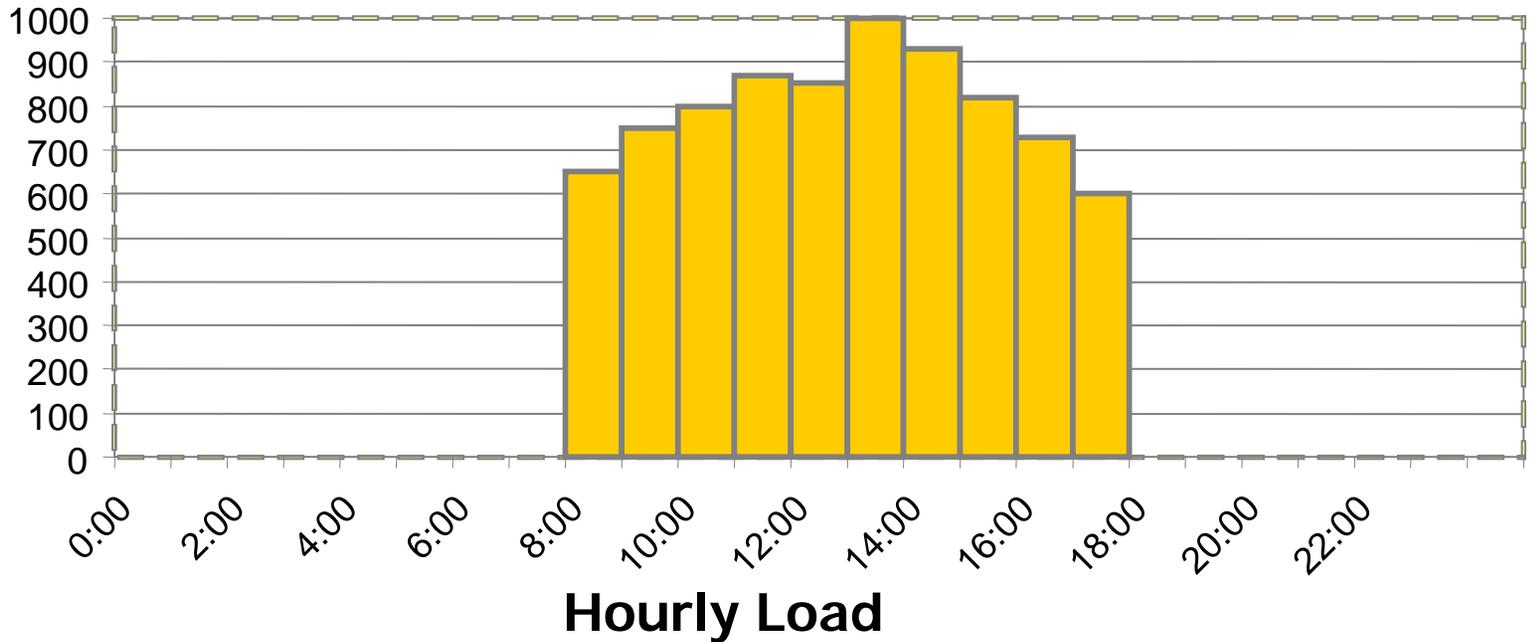
200 to 700 TR, 700 to 2,400kW
Gas / Oil or MP Steam



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Load (TR)

Typical Building Hourly Cooling Load

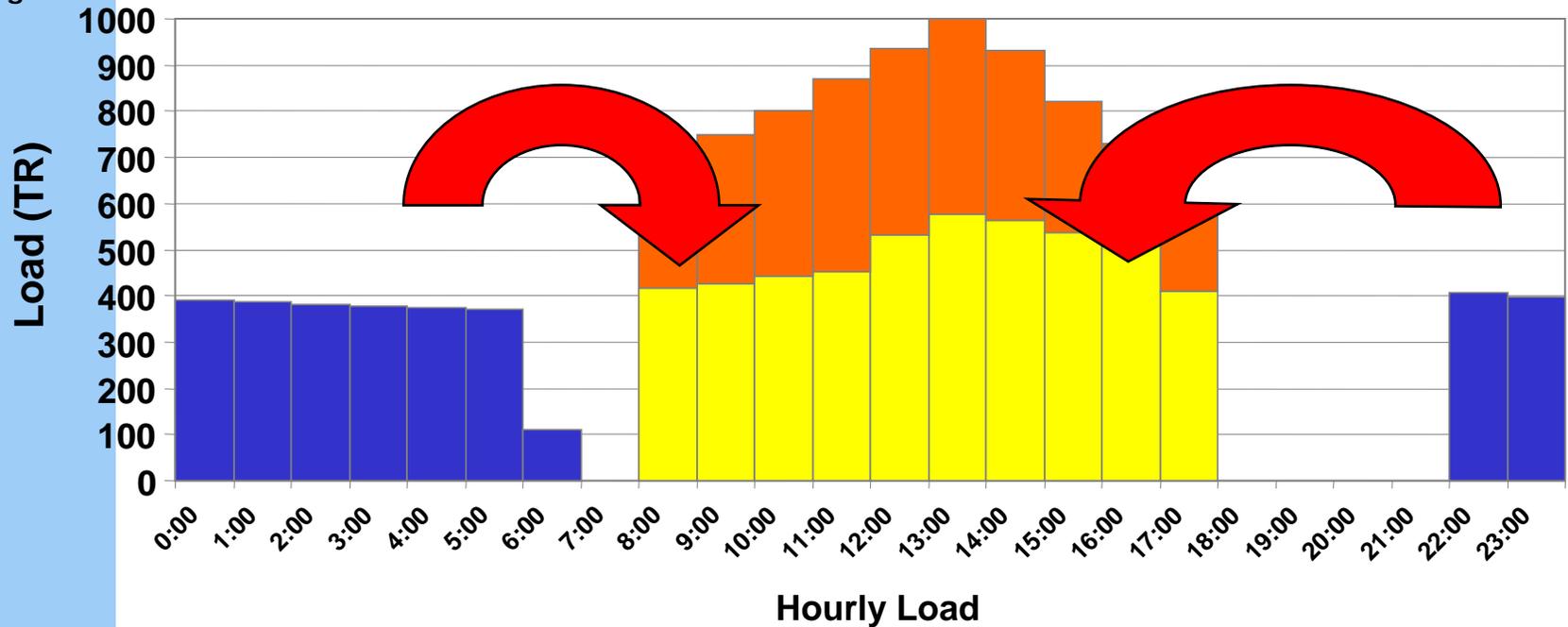


What is Ice Storage System?



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Usage of Ice Storage System



Compound Chillers



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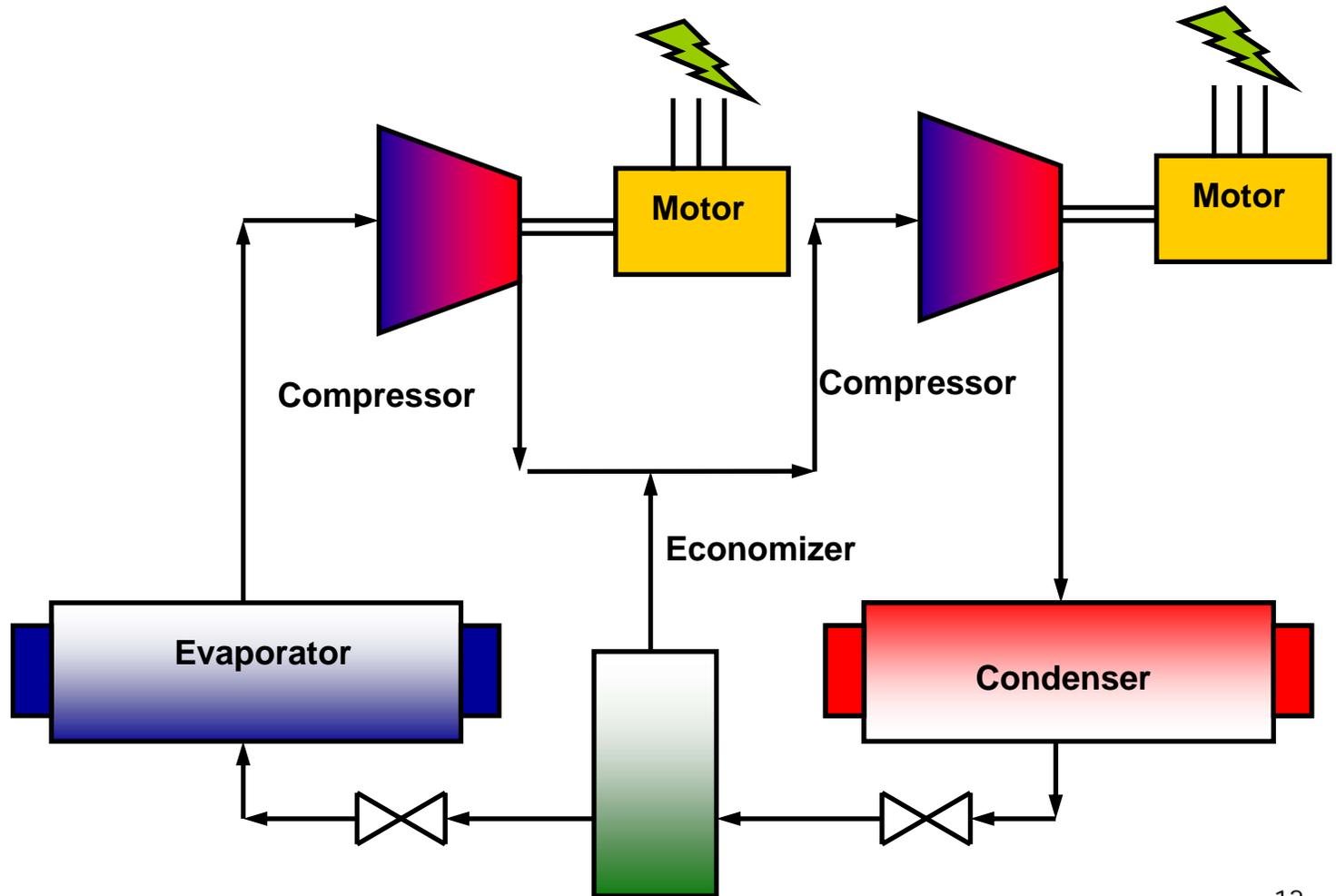


500 to >2000 TR, 1,800 to >7,000kW

Thermal Storage Needs Flexibility



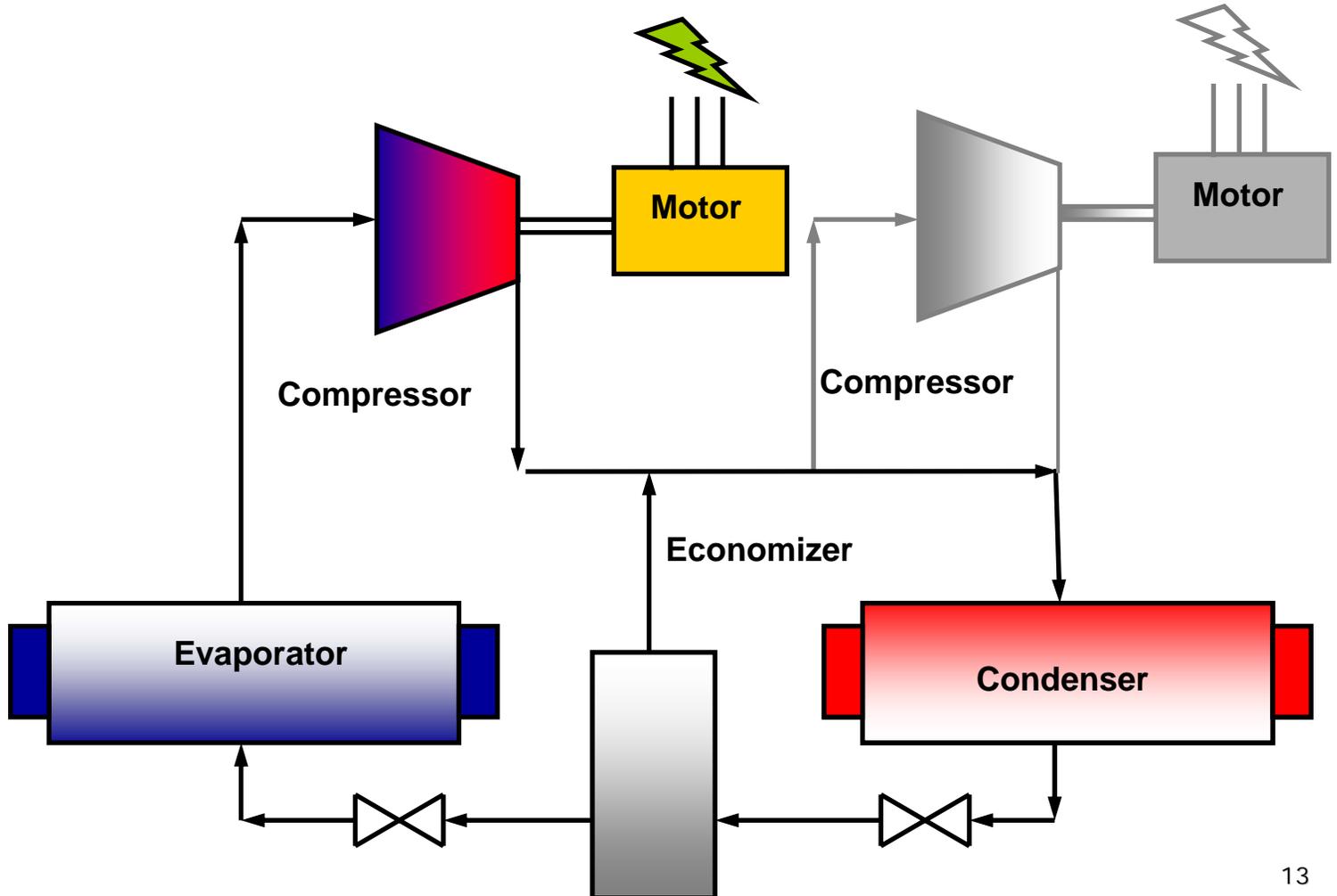
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Thermal Storage – Daytime



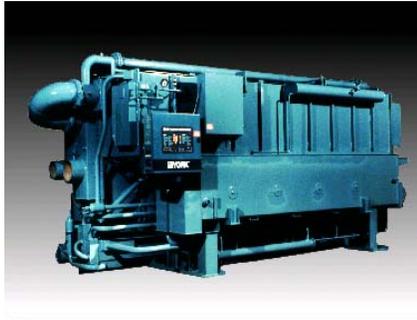
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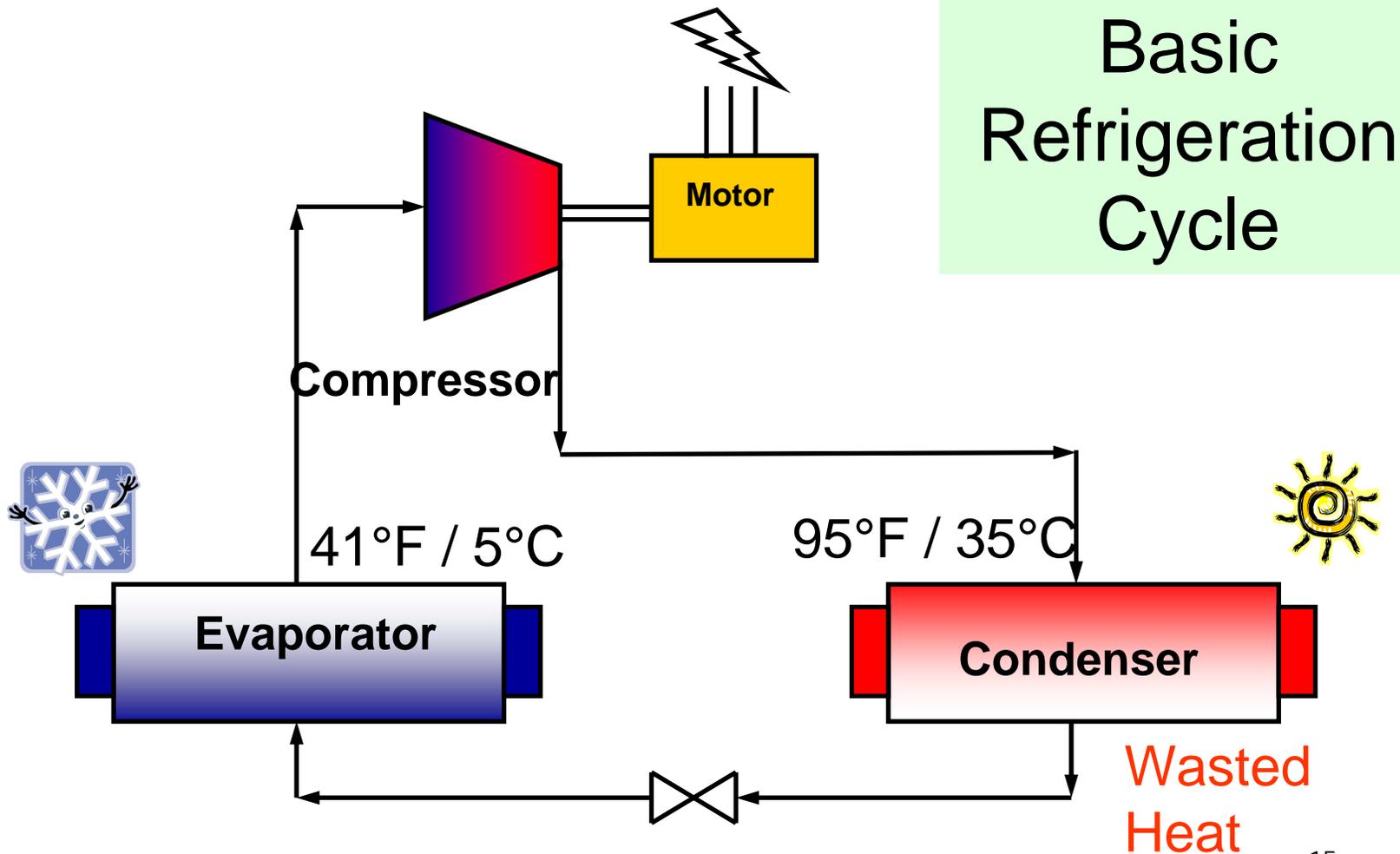
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Heat Pumps





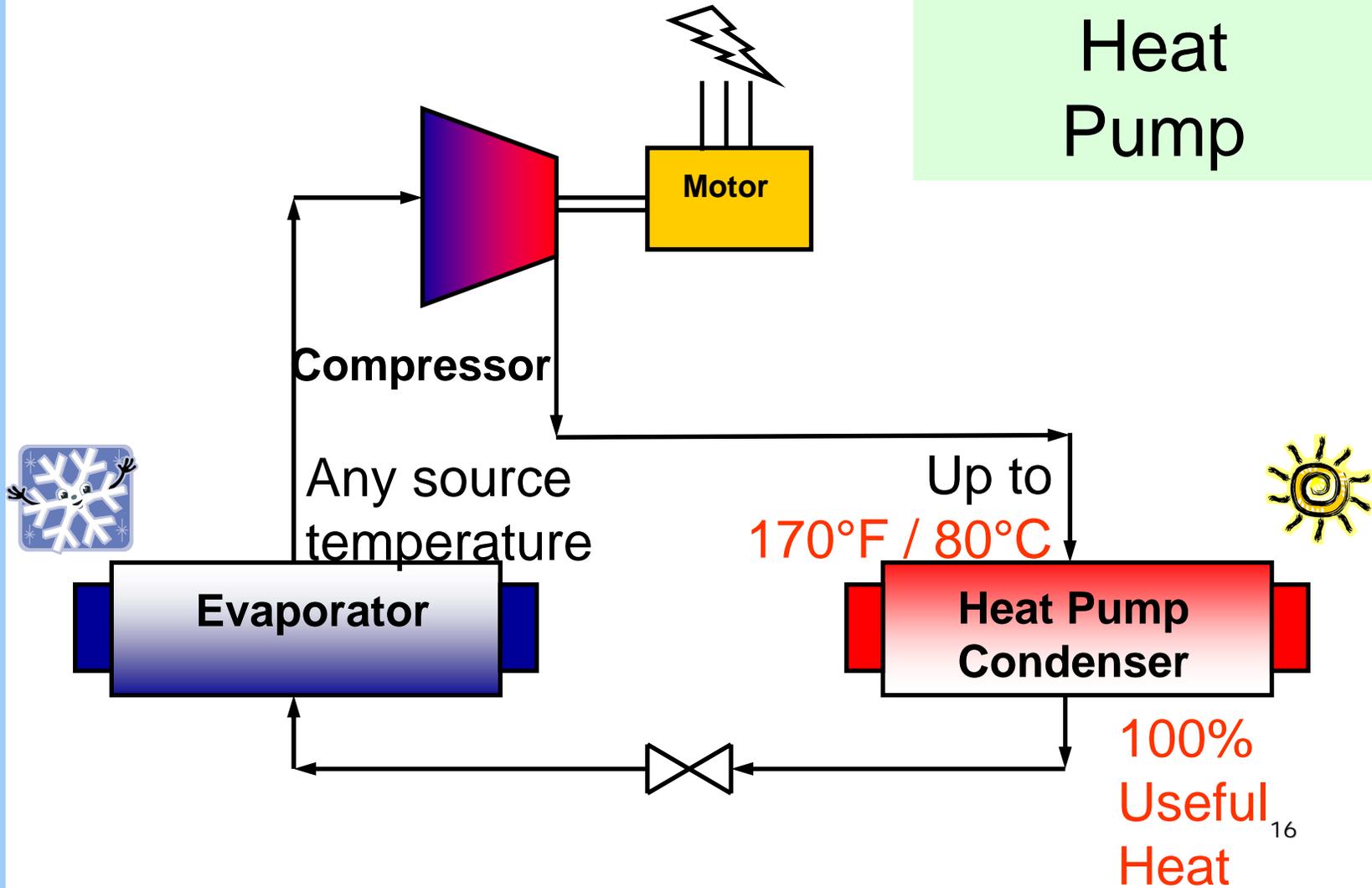
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Heat Pump



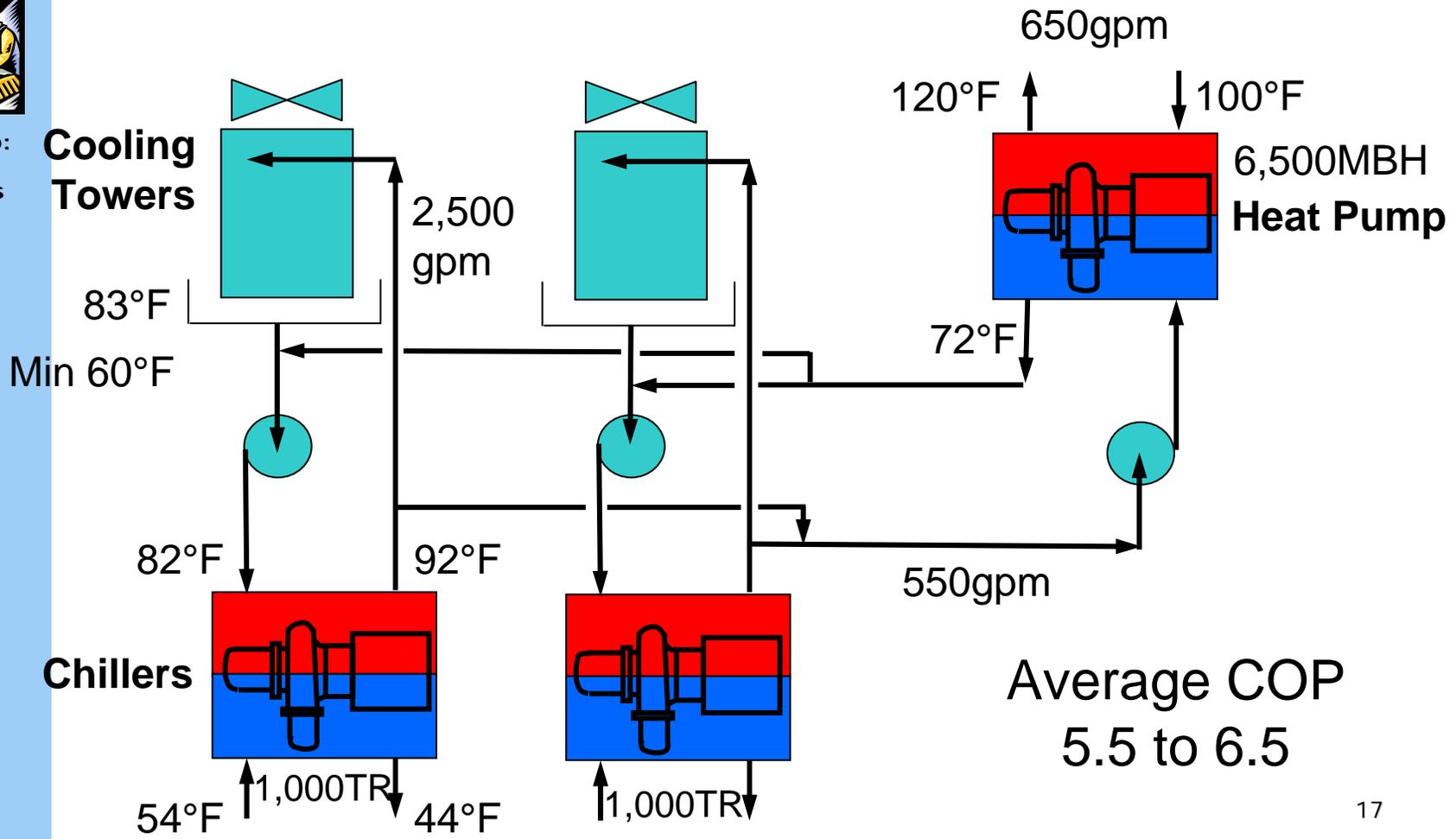
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Heat from Cooling Towers



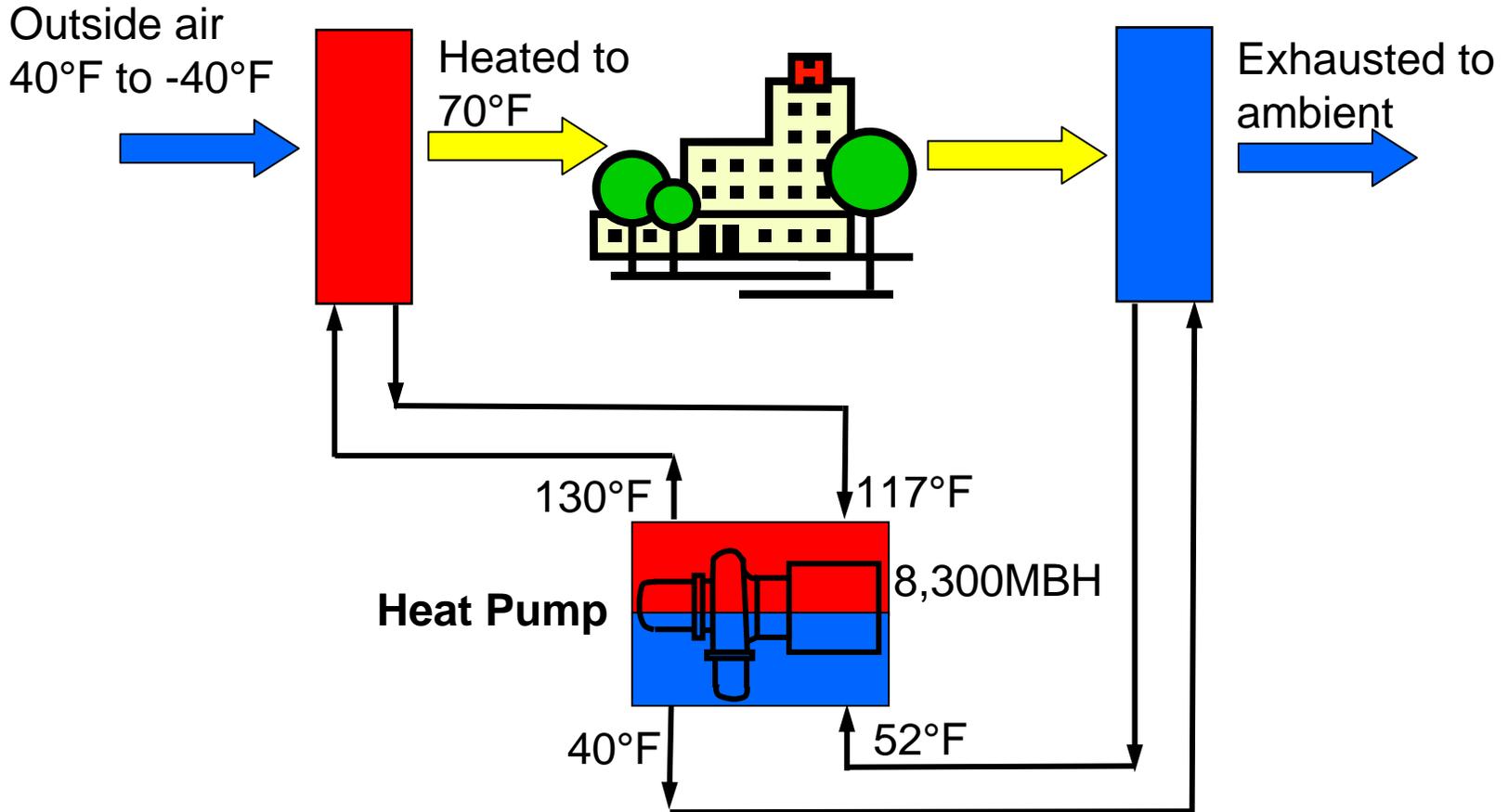
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Heat from Exhaust Air



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Strategies

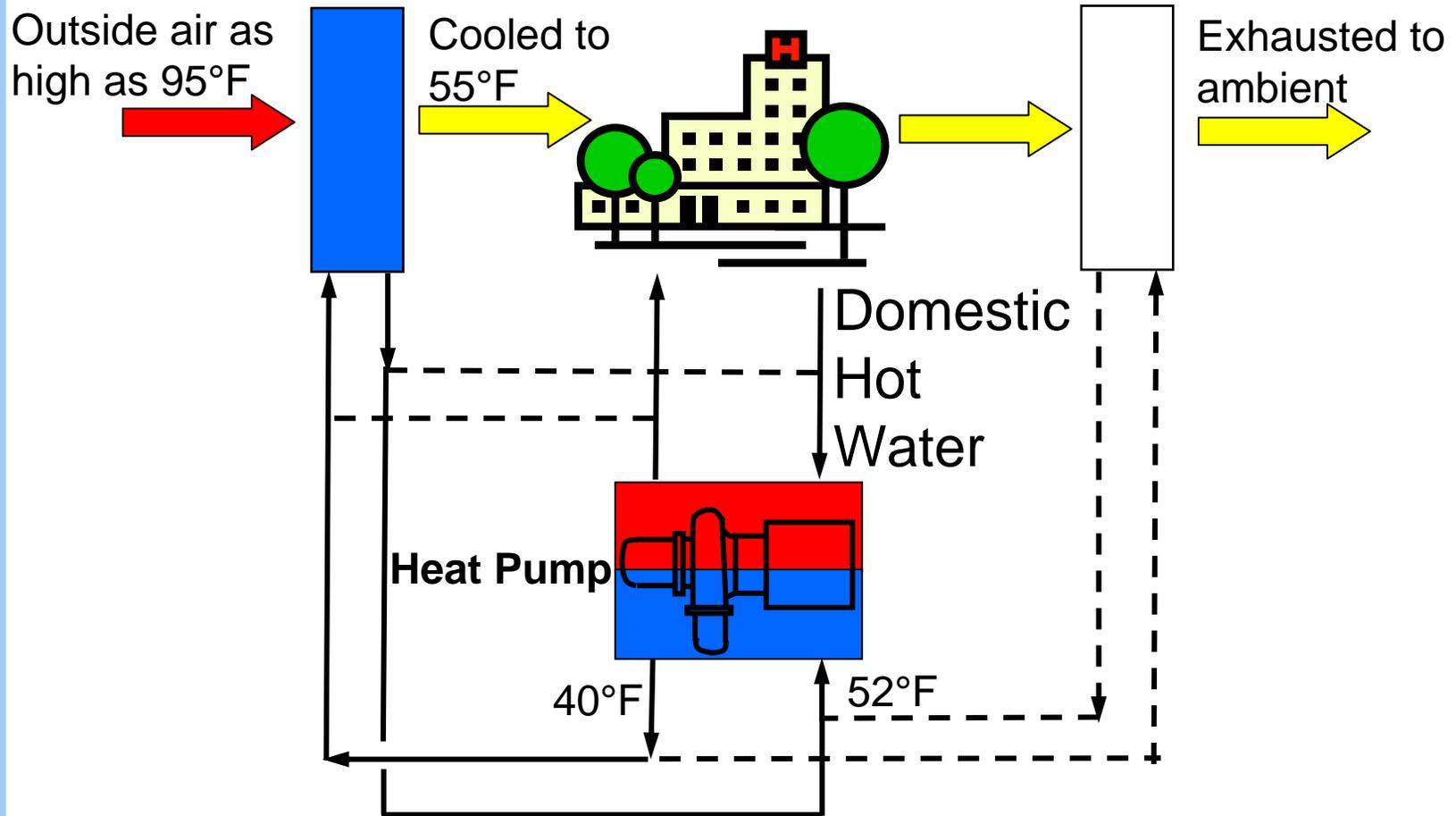


Winter operation

Heat from Exhaust Air



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Summer operation

Cost to produce 100,000 BTU



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- Natural Gas Water Heater
 - $100,000 \text{ Btu} / 85\% \text{ efficiency} / 1000 \text{ Btu/ft}^3 / \$10.00/1000 \text{ ft}^3 = \mathbf{\$1.18}$
- Fuel Oil Water Heater
 - $100,000 \text{ Btu} / 85\% \text{ efficiency} / 140,000 \text{ Btu/gal} / \$2.60/\text{gal} = \mathbf{\$2.19}$
- Electric Water Heater
 - $100,000 \text{ Btu} / 95\% \text{ efficiency} / 3412 \text{ BTU/hr/kW} / \$0.12/\text{kW.hr} = \mathbf{\$3.70}$
- Heat Pump
 - $100,000 \text{ Btu} / 600\% \text{ efficiency} / 3412 \text{ BTU/hr/kW} / \$0.12/\text{kW.hr} = \mathbf{0.59}$

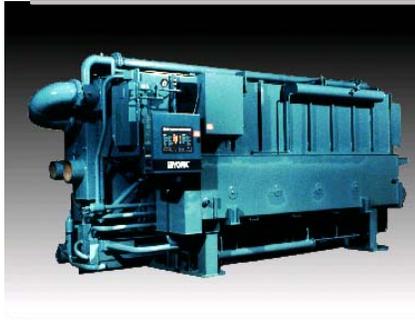
COP = 6.0 (with cooling credit)

Onsite

Thermal and Power Generation

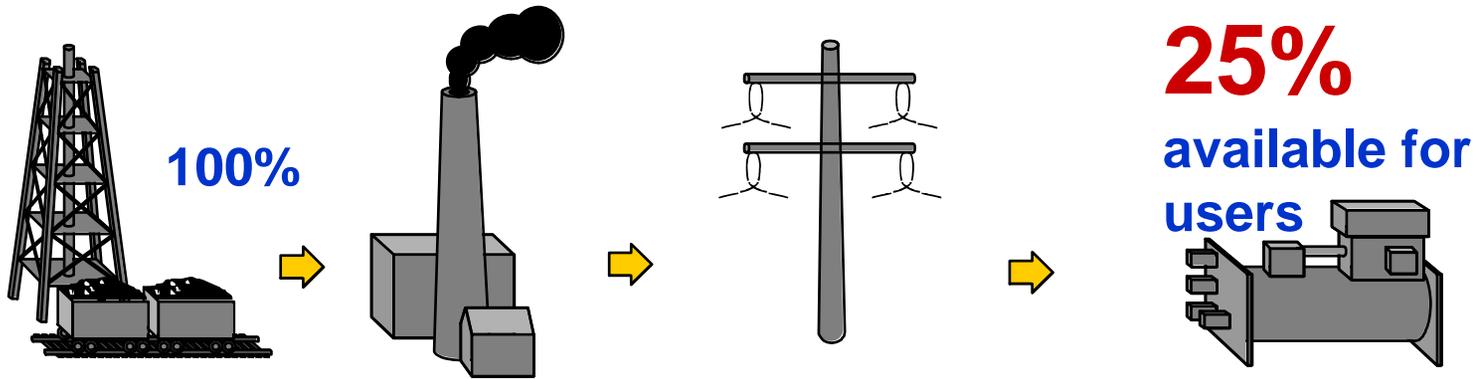


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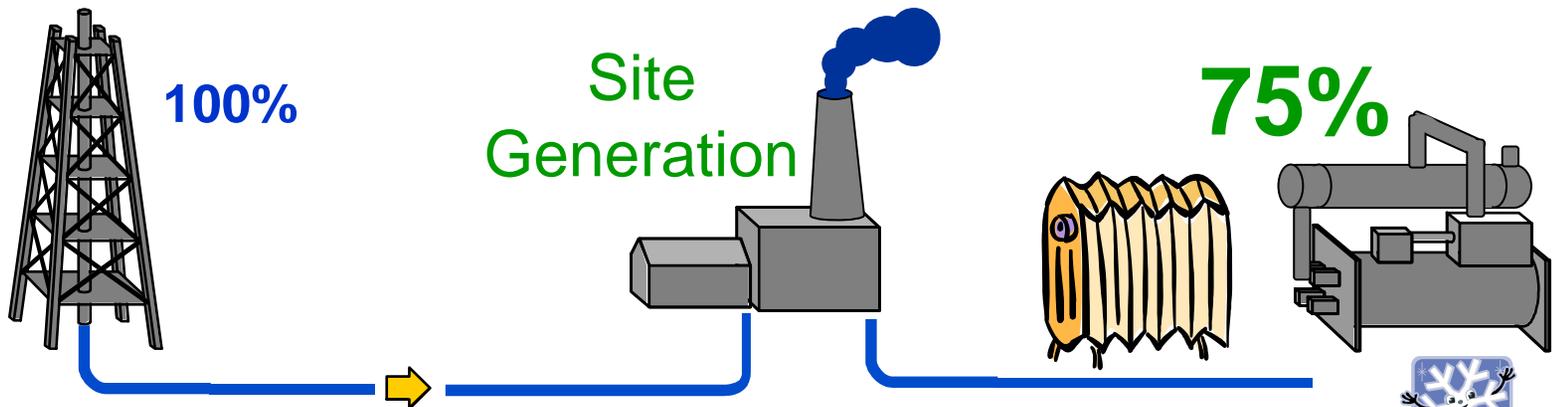


Energy Independence - CHP

Traditional Power Generation



Distributed Generation, Heating & Cooling



Overall Reduction in CO₂ Emissions



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Thermally Activated Technologies



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Distributed Generation Technologies



Gas-turbine



Micro-turbine



I.C. Engine

800°F

600°F

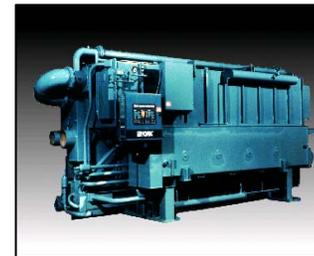
360°F

180°F

Thermally-Activated HVAC Technologies



*Steam Turbine
Centrifugal Chiller*



*Double-Effect
Absorption
Chiller*



*Single-Effect
Absorption Chiller*

Thermally Activated Technology

CHP Output Efficiency is generally higher for Combustion Turbine based CHP system than IC Engine based systems.



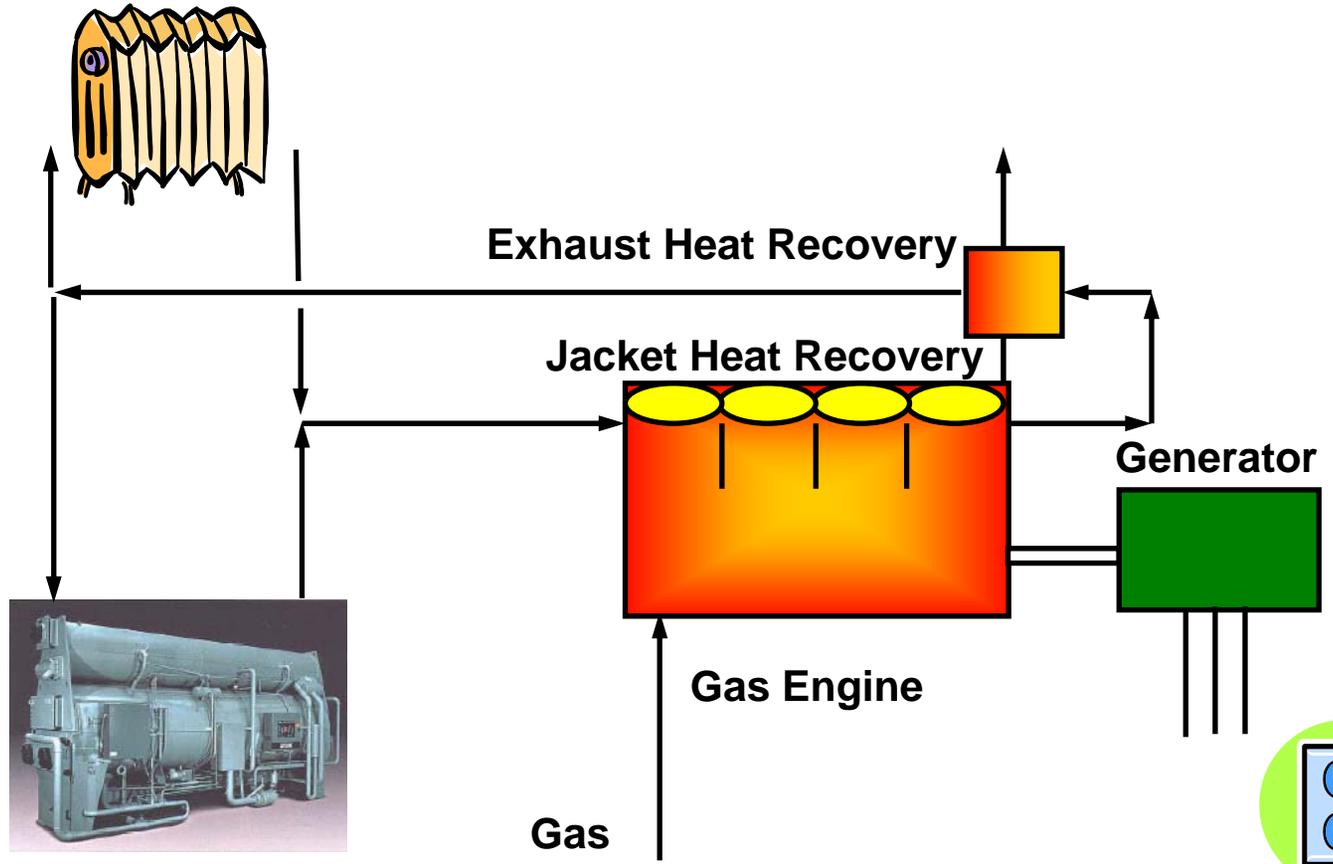
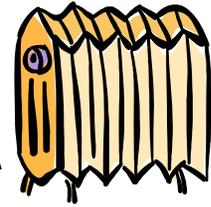
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Generating Technology	Thermal Technology (Chiller)	Electrical Output (MW)	Thermal Electric Ratio (TR/kW)	CHP Output efficiency, HHV
Large Combustion Turbine	Steam Turbine	>2.5	0.6	77%
Small Combustion Turbine	Double Effect Absorption	1 to 2.5	0.7	69%
Microturbine	Double Effect Absorption	0.25 to 0.5	0.5	60%
Reciprocating Engine	Double Effect Absorption	1.5 to 5	0.2	50%
Reciprocating Engine	Single Effect Absorption	0.25 to 5	0.3	58%
Microturbine	Single Effect Absorption	0.25 to 0.5	0.4	44%

$$\text{CHP Output Efficiency} = (\text{Total busbar kW} + \text{Cooling converted directly to kW}) / \text{Fuel Input (HHV)}$$



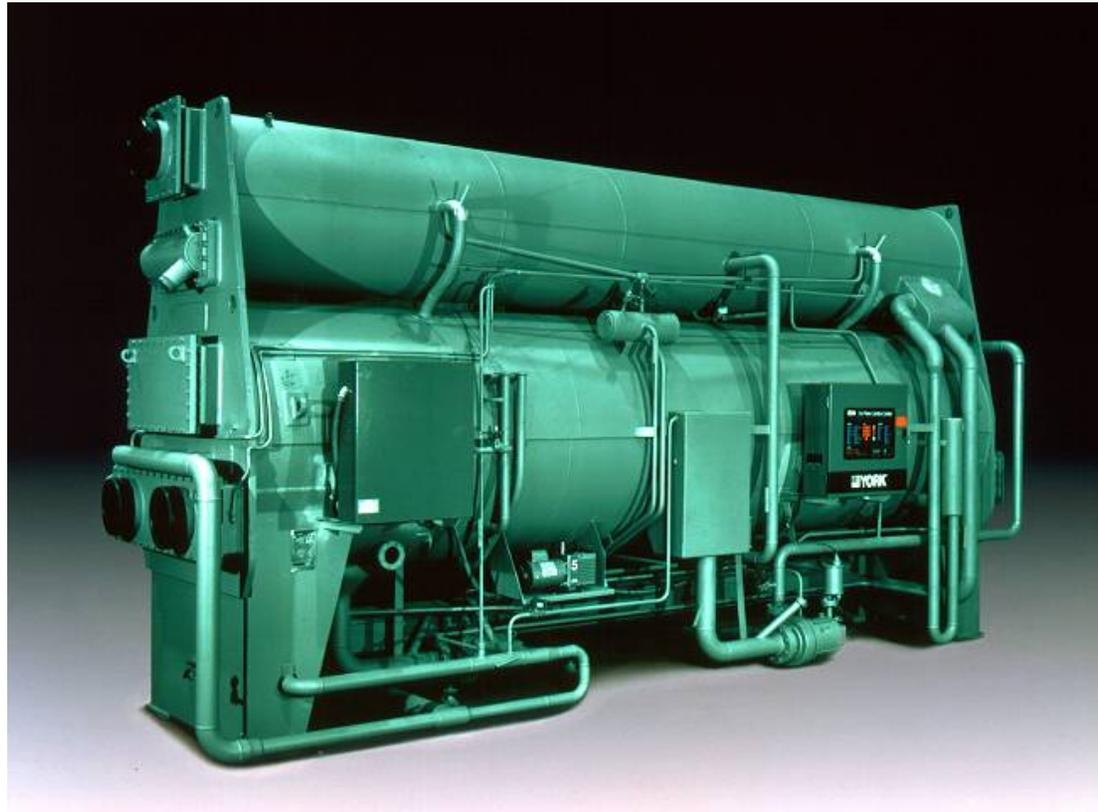
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Single Effect Absorption Chillers



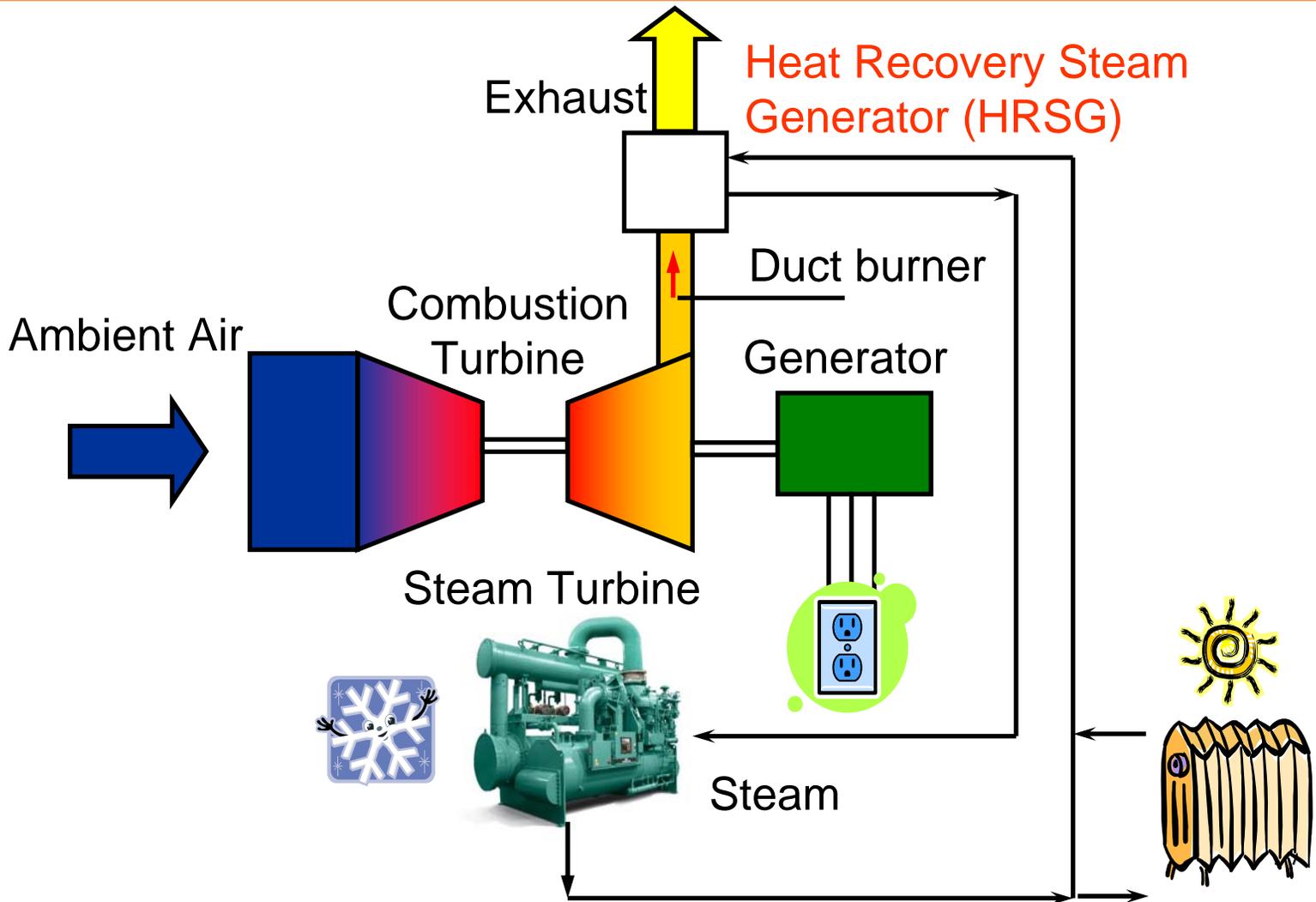
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100 to 1,300 TR, 350 to 4,500kW
Hot water & LP Steam



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Strategies



Steam Turbine Chillers



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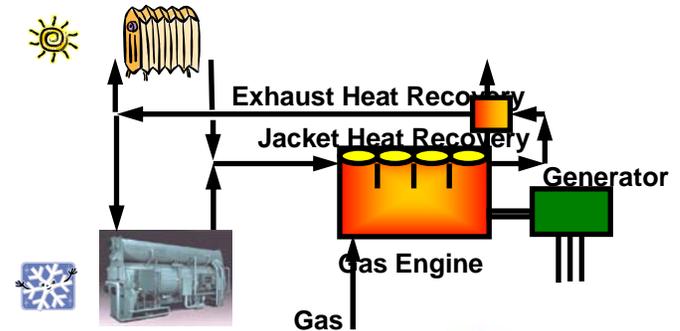


700 to 5,000 TR / 2500 to 18,000 kW



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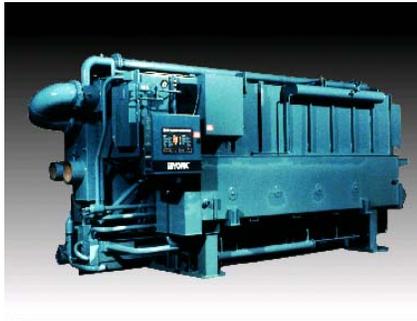
- Traditional CHP has required complex integration
 - Generator / Heat Recovery
Chillers / Controls
Interconnection
 - Opportunities for failure ~ !!!
- Move to Modular Systems
 - Generator & Heat Recovery Module
 - Power side generation, integration and control
 - Heat recovery
 - Thermal Module
 - Heating – Cooling components
 - Heat rejection management
 - Distribution and Controls
- Pre-Designed Solutions Make it Easy
- **Watch this space!**



Economic & Environmental Benefits

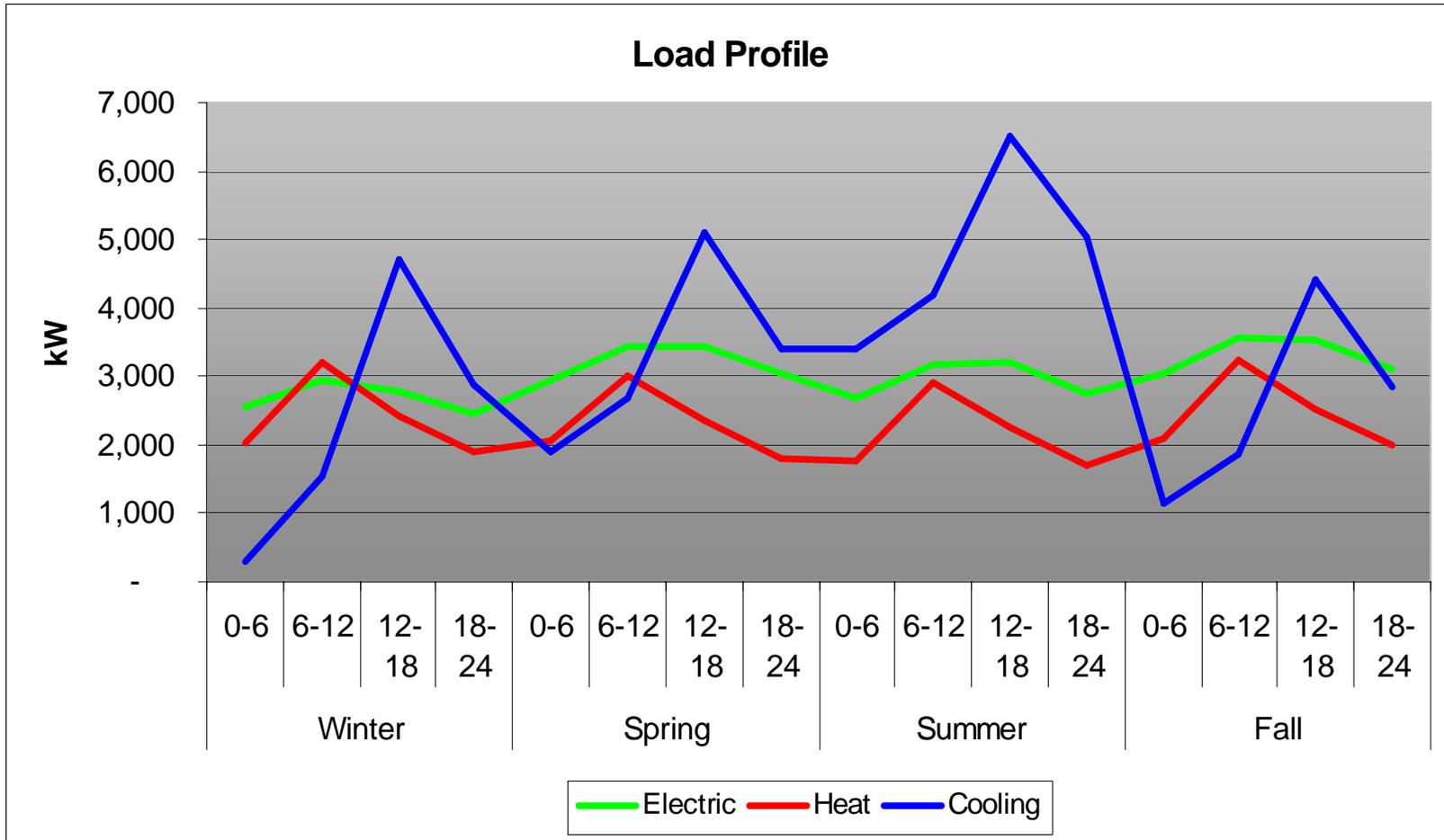


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Body Shop:
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Utility Data



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Electric Rate
\$0.12/kW.hr

\$33.3/GJ

Gas Rate
\$1.00/therm

\$9.98/GJ

CA CO₂ Emissions
0.80lb/kW.hr

101.4kg/GJ

Gas CO₂ Emissions
11.7lb/therm

US CO₂ Emissions
1.3lb/kW.hr

165kg/GJ

53.0kg/GJ



Body Shop:
Building
Strategies

- 5,000kW electric supply
- 3 x 800TR (8,400kW) electric chillers
- 17,000 MBH (5,000kW) heating boiler

Heating & Cooling

- \$1,142,000 per year
- 6,100 tons / year CO₂

Power, Heating & Cooling

- \$4,340,000 per year
- 16,800 tons / year CO₂



Scenario 1 – Gas Engine Drive Chillers



Body Shop:
Building
Strategies

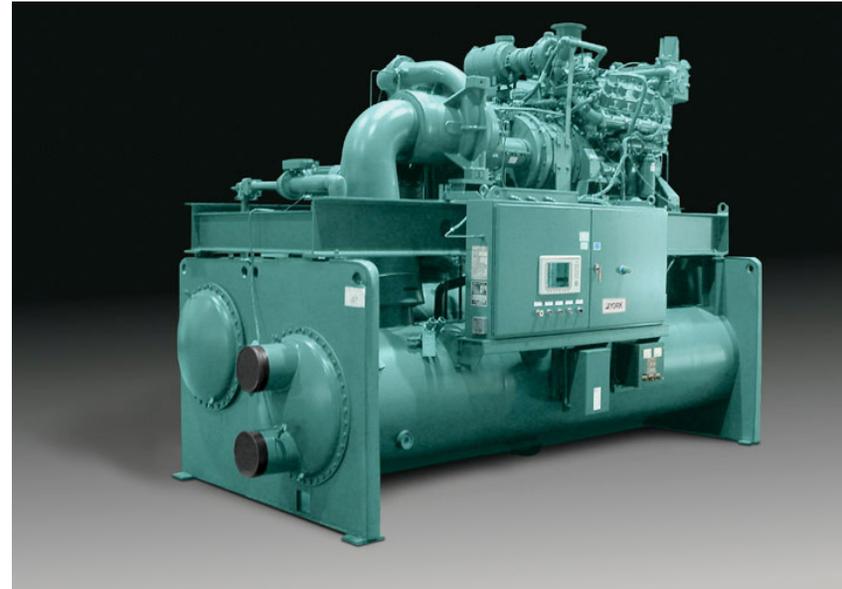
Heating and Cooling

- 3 x 800TR gas engine chillers
- No electric chillers
- 10,000 MBH (3,000kW) heating boiler

Heating & Cooling

- \$909,000 per year
- 5,300 tons / year CO₂

Capital Add - \$910k
Energy Savings - \$232k/yr
Maintenance - \$37k/yr
Simple Payback – 4.7yrs





Body Shop:
Building
Strategies

Heating and Cooling

- 2 x 600TR heat pump chillers
- 2 x 600TR electric chillers
- 7,000 MBH (2,000kW) heating boiler

Heating & Cooling

- \$839,000 per year
- 3,070 tons / year CO₂

Capital Add - \$170k
Energy Savings - \$303k/yr
Maintenance - \$negligible
Simple Payback – 0.6yrs



Scenario 3 – Gas Engine CHP



Body Shop:
Building
Strategies

Electric, Heating and Cooling

- 2 x 1.2MW engine generators & heat recovery
- 1 x 600TR absorption chiller
- 2 x 900TR electric chillers
- 3,500 MBH (1,000kW) heating boiler



Power, Heating & Cooling

- \$3,240,000 per year
- 7,070 tons / year CO₂

Capital Add - \$1,500k
Energy Savings - \$1,100k/yr
Maintenance - \$173k/yr
Simple Payback – 1.6yrs



Scenario 4 – Gas Turbine CHP



Body Shop:
Building
Strategies

Electric, Heating and Cooling

- 1 x 1.5MW gas turbine generators & HR
- 1 x 1000TR steam turbine chillers
- 2 x 700TR electric chillers
- 3,500 MBH (1,000kW) heating boiler



Power, Heating & Cooling

- \$3,750,000 per year
- 8,770 tons / year CO₂

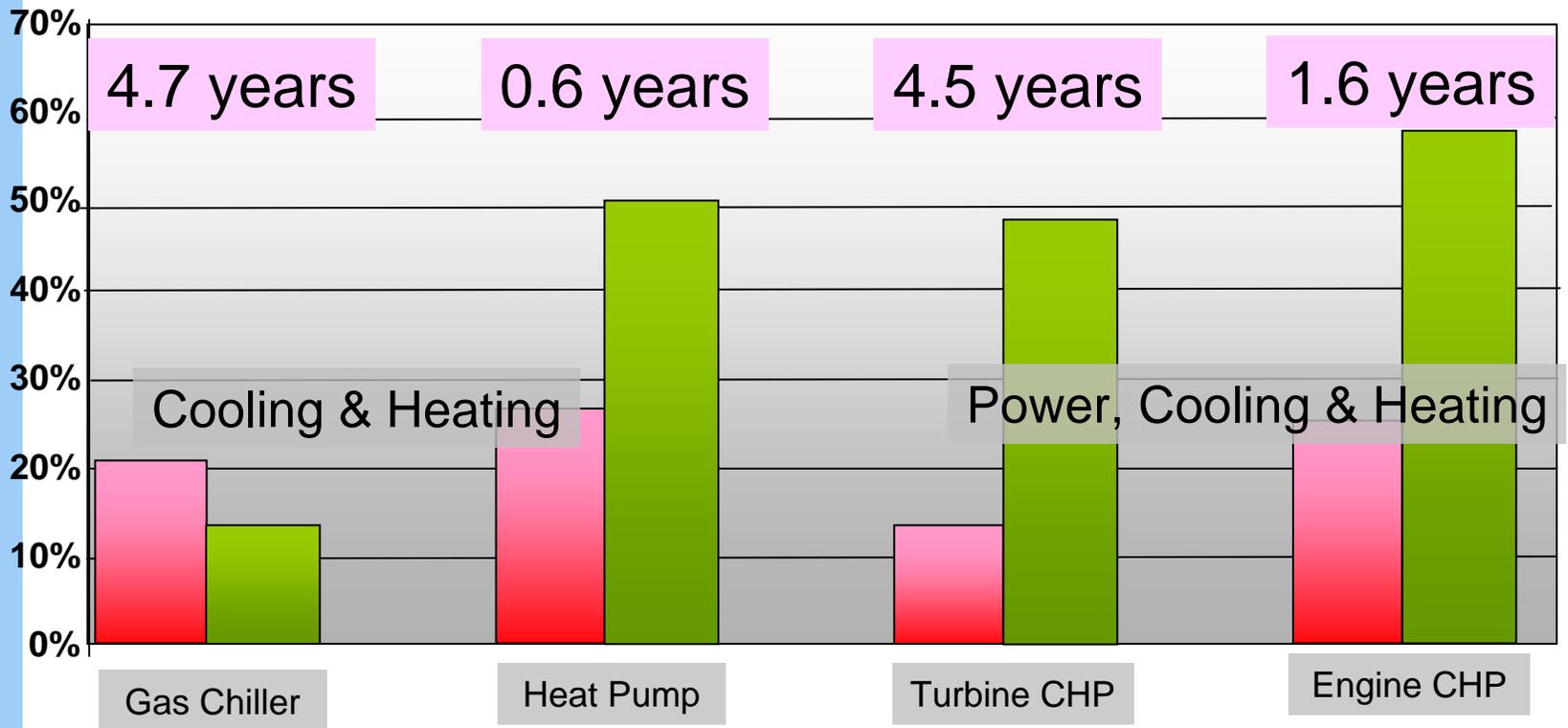


Capital Add - \$2,200k
Energy Savings - \$600k/yr
Maintenance - \$104k/yr
Simple Payback – 4.5yrs

2006 Energy Summary



Body Shop:
Building Strategies



789 ton/yr

3,040 ton/yr

8,050 ton/yr

9,740 ton/yr

Electric \$0.12/kW.h
Gas \$1.0/Therm

Key

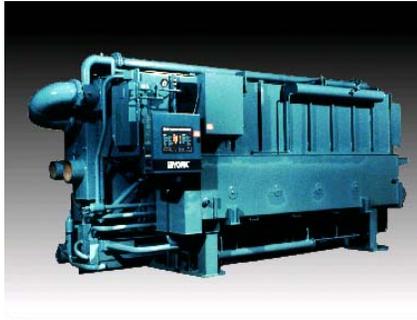
Cost Savings

CO₂ Savings

Thank You!



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