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If You Can't Take the Heat

Utilizing Heat Recovery Effectively

Presented by

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turn to the experts

AGENDA

- What is Waste Heat?
- How Waste Heat is captured
- Benefits of Heat Reclaim
- Heat Reclaim definitions
- Systems
- Products
- Example
- Heat Reclaim misapplied

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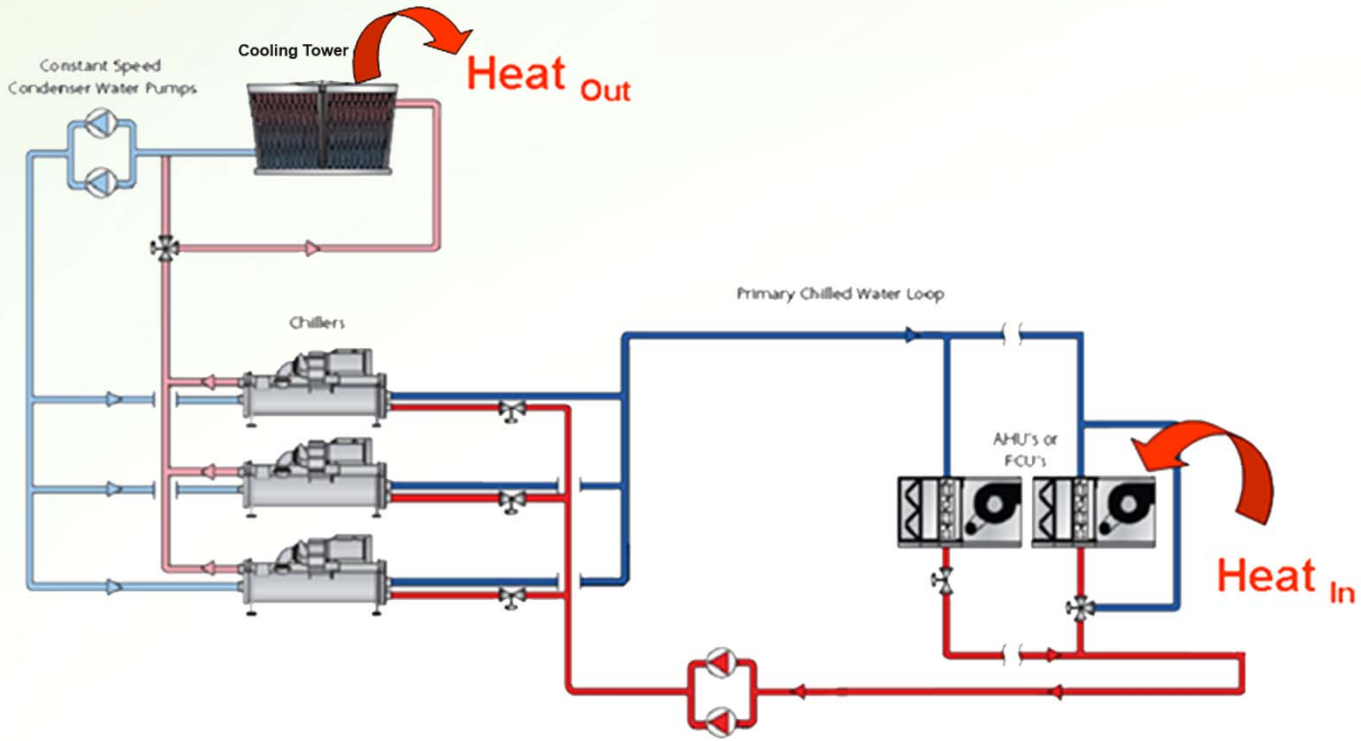
WHAT IS WASTE HEAT?



Chilled Water HVAC System

- Heat is released to the atmosphere through cooling tower
- Unwanted heat is drawn from space or process

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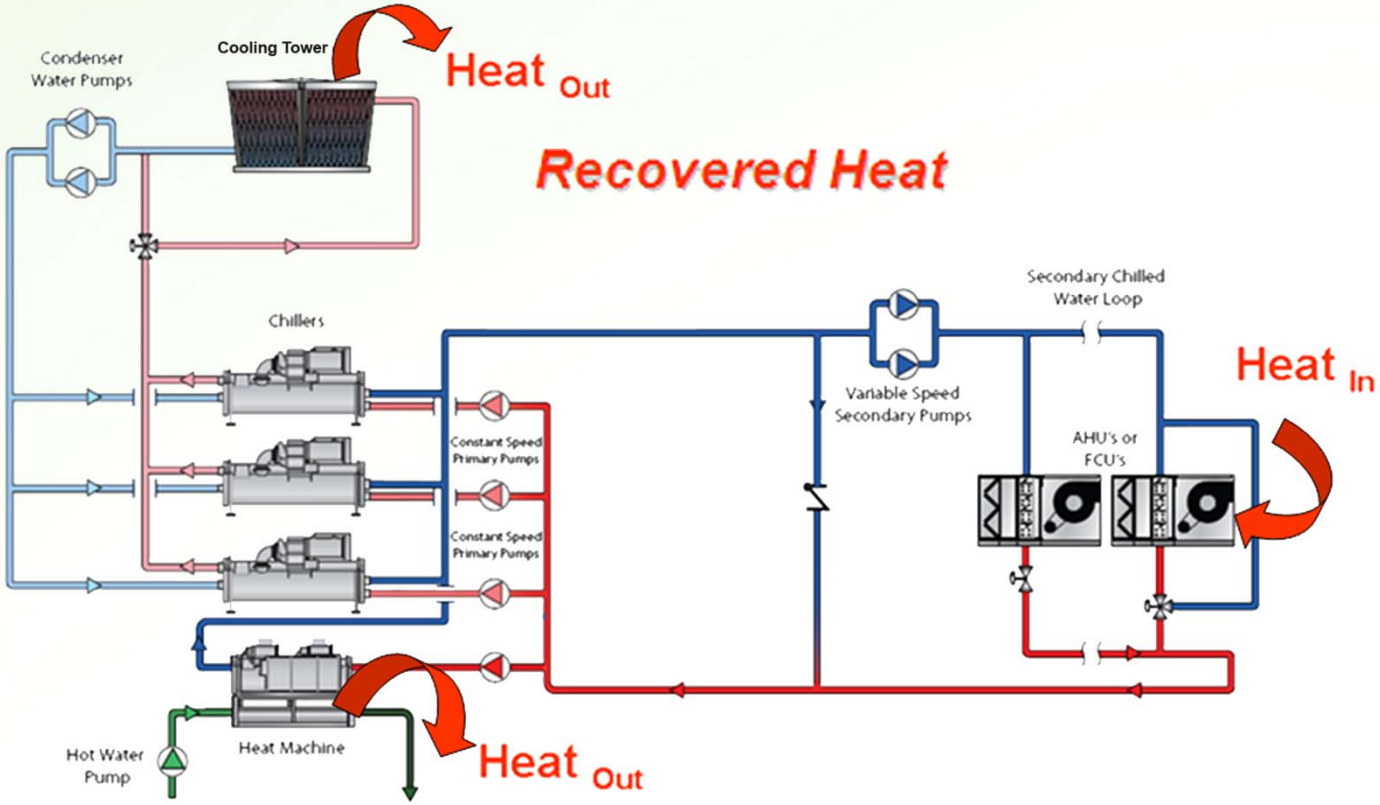
HOW WASTE HEAT IS CAPTURED?



Primary/Secondary Chilled Water System with the Heat Machine [3]

- Heat machine captures some of the wasted heat for useful purposes. Remainder is released through the cooling tower

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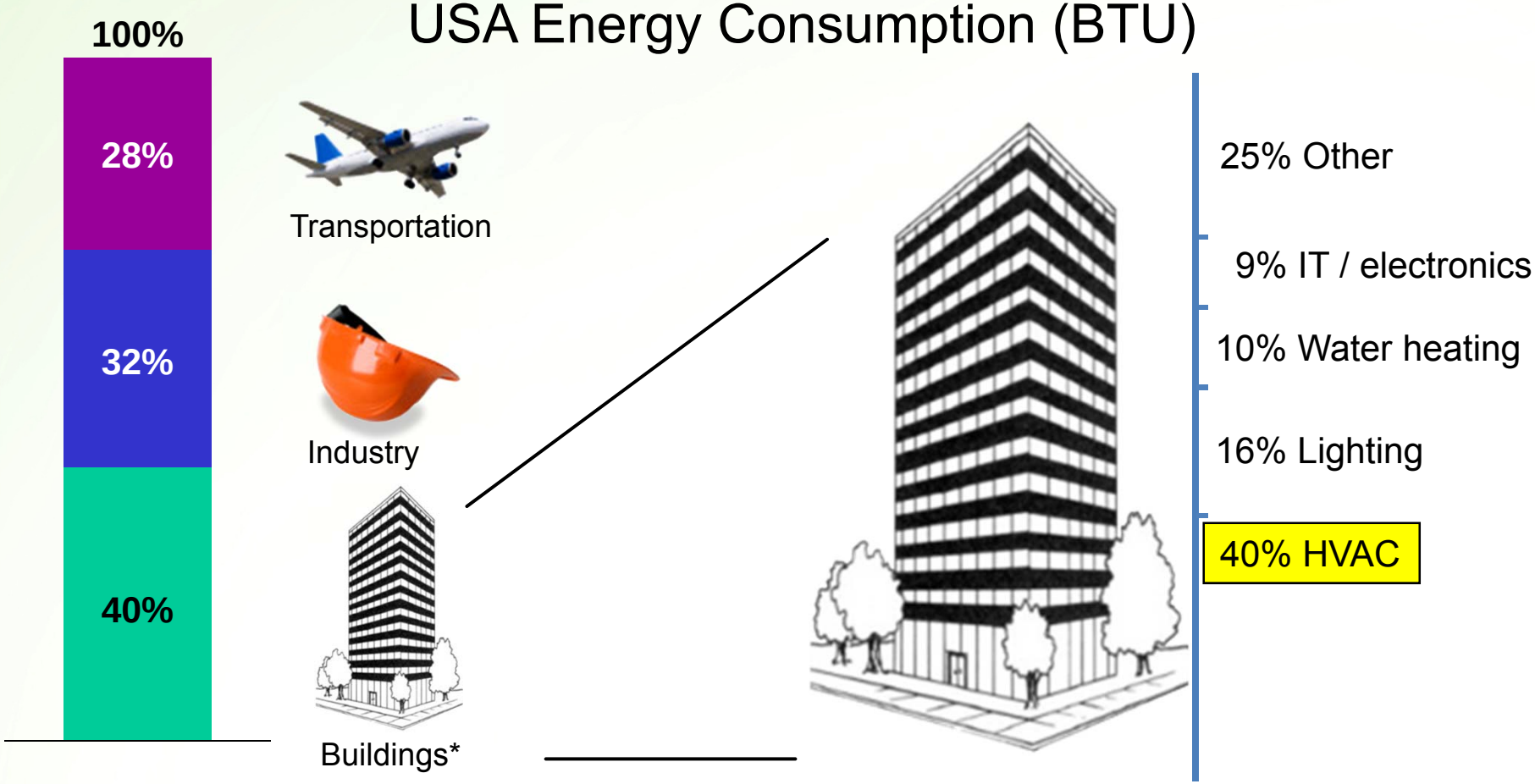
WHY IS HEAT RECOVERY IMPORTANT?

USA Energy Consumption (BTU)



Space and Water Heating is 50% of Total Building Energy

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Source: U.S. DOE, Buildings Energy Data Book, Mar. 2011

* Includes Commercial and Residential buildings

HEAT RECLAIM – WHY?

ASHRAE 90.1-2010

Heat Recovery for Service Water Heating, Section § 6.5.6.2

- Operates 24 hours a day
- Total heat rejection exceeds 400 tons of chiller capacity (6,000,000 Btu of heat rejection)
- Service water-heating load exceeds 1,000,000 Btu/h

Capacity to provide the smaller of:

- 60% of the peak heat rejection load at design conditions

or

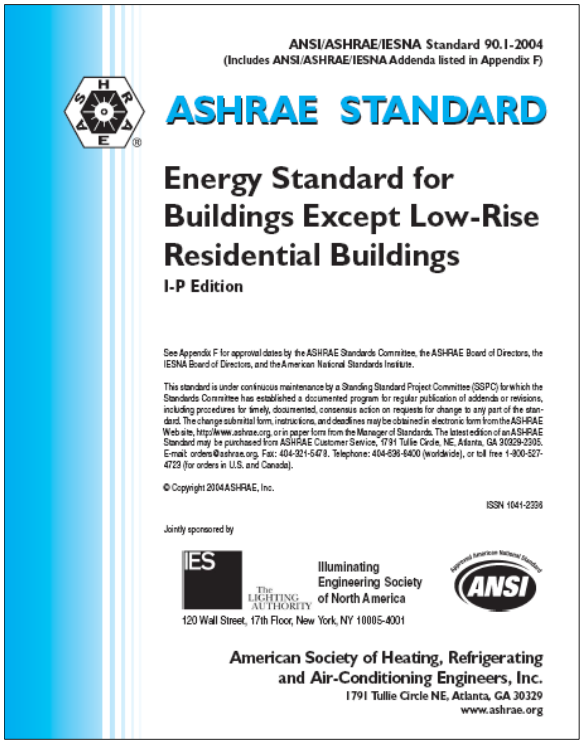
- Preheat of the peak service hot water draw to 85°F.

Exceptions:

- Use minimum 30% of peak condenser load at design conditions for space heating.

or

- 60% or more of service water heating from site solar or cogeneration, condensate subcooling, or solar panels.



Helps to earn LEED® points under EAc 1

Maintain ASHRAE 90.1 compliance

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LEED is a registered trademark of the U.S. Green Building Council.

QUESTION #1

According to the Department of Energy what percentage of the US building energy consumption is space and water heating (HVAC and space heating)?

A. 25%

B. 50%

C. 75%

D. 10%

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QUESTION #2

According to ASHRAE 90.1, what are the minimum building conditions that Heat Recovery is required in the building?

A. 200 tons of chiller capacity and service water-heating load exceeds 5,000 Btu/h

B. 500 tons of chiller capacity and service water-heating load exceeds 2,000,000 Btu/h

C. 400 tons of chiller capacity and service water-heating load exceeds 1,000,000 Btu/h

D. ASHRAE 90.1 recommends, but does not require heat recovery

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HEAT RECLAIM BENEFITS

- Uses waste heat to save energy
- Consumes less power during simultaneous heating and cooling
  - Using less boiler power consumption
- Has many uses
  - Heating building
  - Heating service water
  - Heating process water
- Capable of producing potable water
- Viable applications include
  - Hotels, college dormitories, indoor swimming pools, commercial laundries, hospitals
- LEED® Project, EAc1 Points
  - Optimized energy performance

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HEAT RECOVERY FUNDAMENTALS

Coefficient of Performance, the ratio of the output heat to the supplied work or

$$COP = \frac{|Q|}{W}$$

Where Q is the useful heat supplied by the condenser and W is the work consumed by the compressor.

Heat recovery not only captures sufficient heat for useful purposes, it also produces the additional benefit of chilled water.

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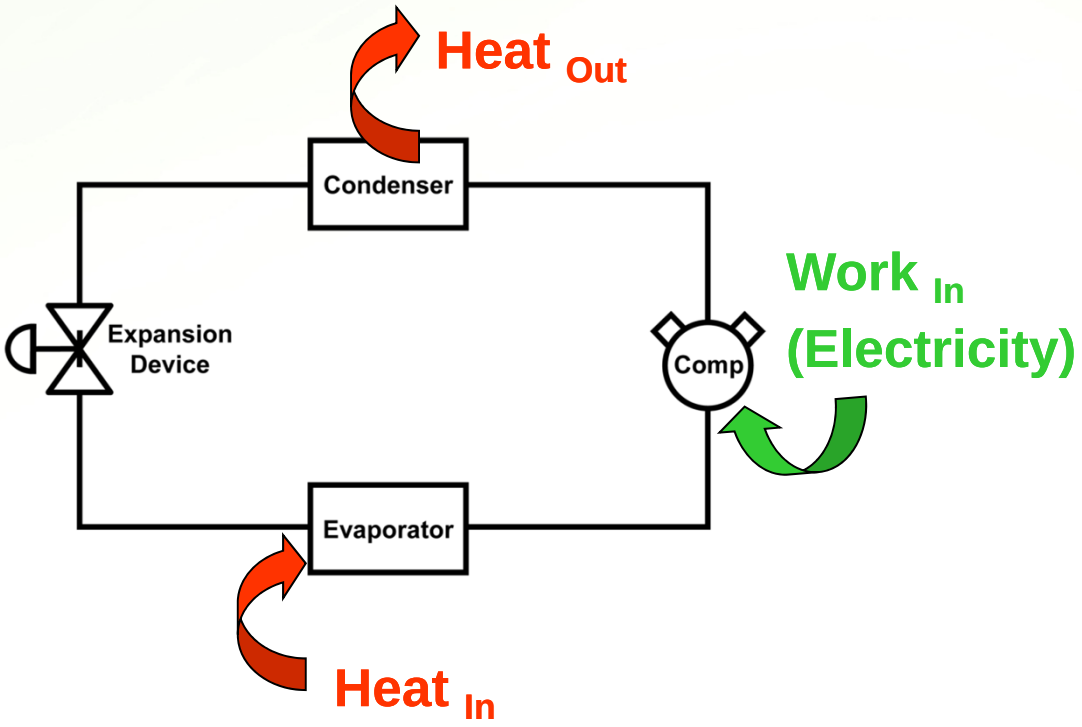
HEAT RECOVERY FUNDAMENTALS

$$COP_{heating} = \frac{Heat_{Out}}{Work_{In}}$$

$$COP_{cooling} = \frac{Heat_{In}}{Work_{In}}$$



$$COP_{total} = \frac{Heat_{Out}}{Work_{In}} + \frac{Heat_{In}}{Work_{In}} = \text{Energy Savings!}$$

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COP EXAMPLE

$$COP_{\text{Heat HR Chiller}} = \frac{742.0\ \text{kW}}{185.2\ \text{kW}} = 4.0^{*}$$

$$COP_{\text{Heat Electric Boiler}} = \frac{1\ \text{kW}}{1\ \text{kW}} = 1.0$$

$$COP_{\text{Heat Gas Boiler}} = \frac{.95\ \text{MBH}}{1\ \text{MBH}} = .95$$

HR Chiller uses refrigeration effect to gain efficiency/savings versus a boiler

*Chiller at 130°F leaving condenser Water and 44°F leaving chilled water

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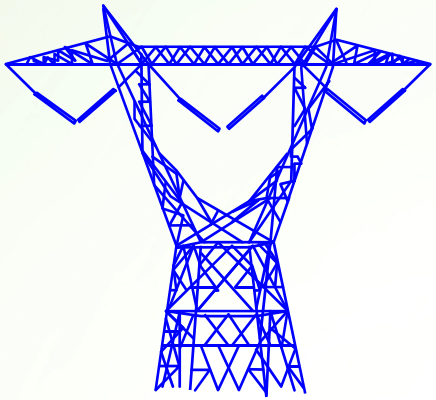
HEAT RECOVERY COMPARISON

Simultaneous heating and cooling:



Electric HW heaters/boiler add heat

(3.51 lkW / Ton)

+

Chillers remove heat

(0.6 lkW)

=

Total

(4.11 lkW / Ton)

Heat reclaim can chill water to 44F, while heating hot water to 140F for *1.48 kW/Ton*

Focus energy conservation effort on the bigger consumers: BOILERS

Over 2.6 kW/ton Savings!

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HEAT RECOVERY FOCUS

Simultaneous heating and cooling:

Gas Boilers add heat
(4.4 lkW / Ton)

+

Chillers remove heat
(0.6 lkW)

=

Total
(5.0 lkW / Ton)

Heat reclaim can chill water to 44F, while heating hot water to 140F for *1.48 kW/Ton*

Focus energy conservation effort on the bigger consumers: BOILERS

Over 3.5 kW/ton Savings!

Heat Machine saves as much as VFD Chiller if just 10% of ton hours are heat recovery

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CHILLER DEFINITIONS

- Cooling-Only
  - Standard water or air-cooled chiller
    - Leaving chilled water temp is controlled
- Heat Reclaim
  - Standard water or air-cooled chiller
    - Leaving chilled water temp is controlled
    - Reclaimed heat from condenser is used to produce hot water – not controlled
      - Reclaimed heat a function of cooing process
- Heat Machine
  - Water-cooled chiller option
    - Leaving hot water temp typically higher than cooling-only chiller
    - Leaving chilled water temp by-product of heating function – not controlled
      - Chilled water temp controlled by primary chiller downstream

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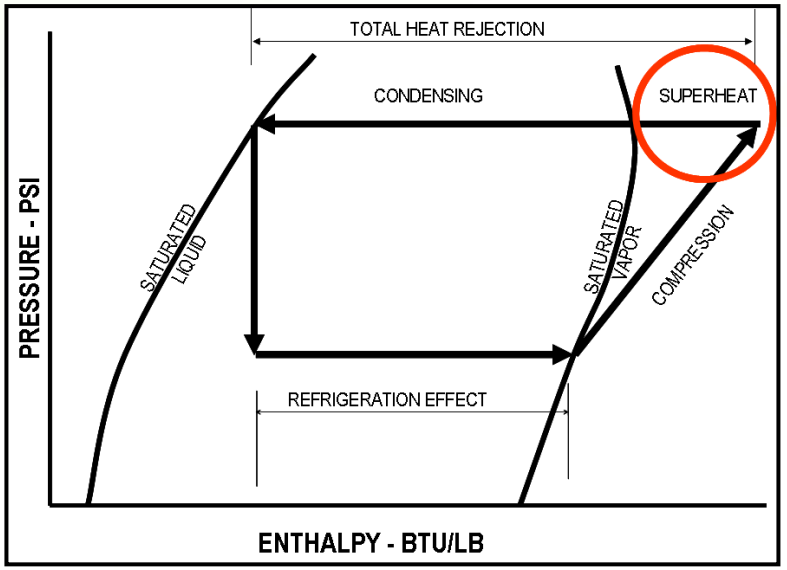
HEAT RECOVERY DEFINITIONS

Two common ways to perform heat recovery



1. Desuperheater
   - Refrigerant-to-water heat exchanger between compressor and condenser
     - Captures heat from superheated refrigerant
       - Provides uncontrolled hot water temp
     - Allows chiller to produce higher hot water temps
       - Transfer heat at discharge temp
     - Only small quantity of heat is available since only superheat is removed from refrigerant (25% heat of compression)

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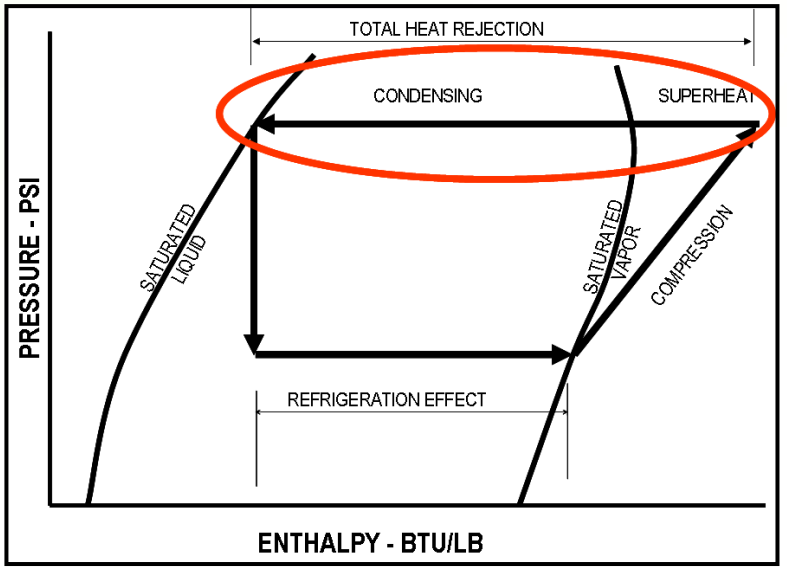
HEAT RECOVERY DEFINITIONS

Two common ways to perform heat recovery



2. Full Condensing

- Refrigerant-to-water heat exchanger
  - Captures heat from refrigerant condensing process
    - Provides uncontrolled hot water temp
    - Hot water temp a function of the condensing temp
  - Larger quantity of heat is available compared to desuperheater

HEAT RECOVERY EXAMPLE

- 550,000 sq.ft. Medical use space (hospital and office space)
- Efficiency key matrix
  - Maintain operability
  - Local Energy Incentives
- Simultaneous Heating and Cooling year around
- Humidity control with chilled water / reheat for hospital
- Peak CHW load 800 tons
- Peak HW Demand 5,000 MBH

Swedish Issaquah Hospital

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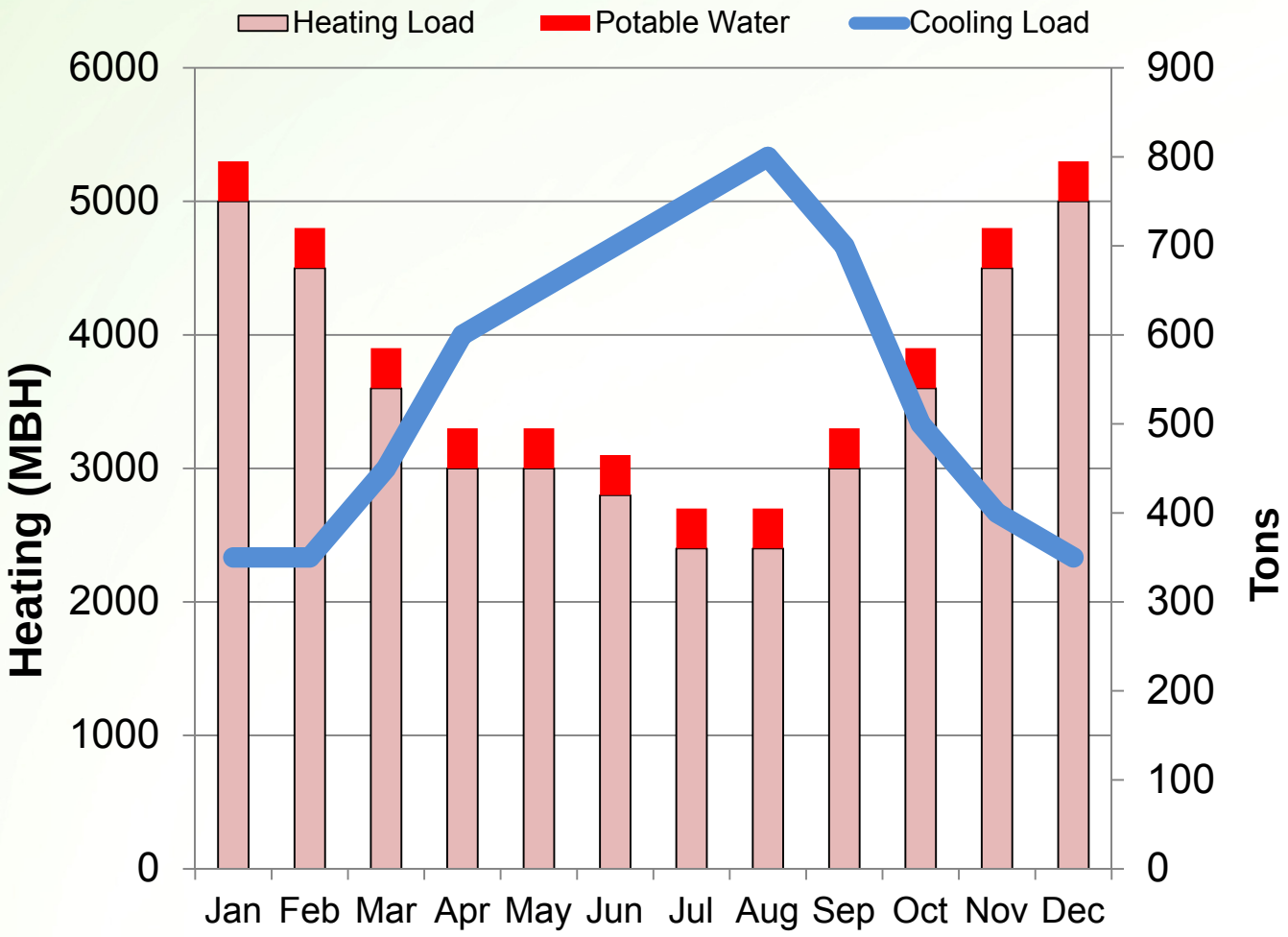
*ASHRAE Journal. June 2013. Pgs 36-44. Jeremy McClanathan, PE

HEAT RECOVERY SEASONALITY



What size HR chiller?

Size to maximize use, not peak demand.

Boilers augment HR chiller for peak load

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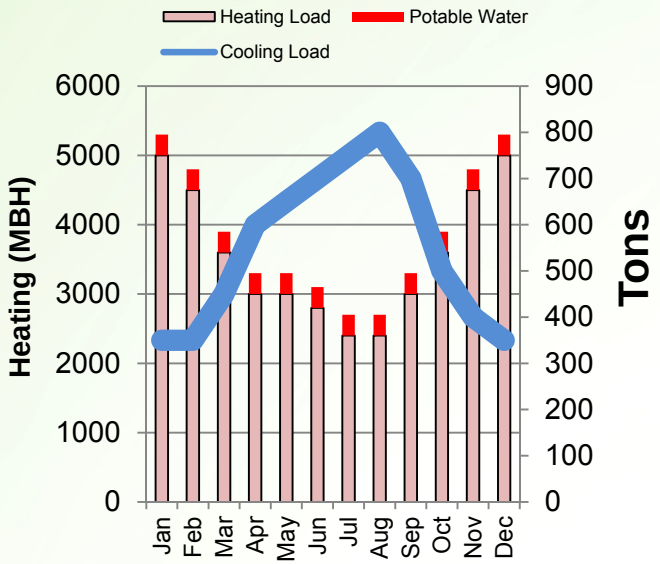
HEAT RECOVERY EXAMPLE



Enhance savings with HW storage tanks

Used a 300 ton HR chiller

Produces approximately 4,500 MBH of heating at maximum capacity

Increase the Mechanical budget by around 6%, $500k savings per year

Six year simple payback (without external incentives)

Less than one year payback with incentives

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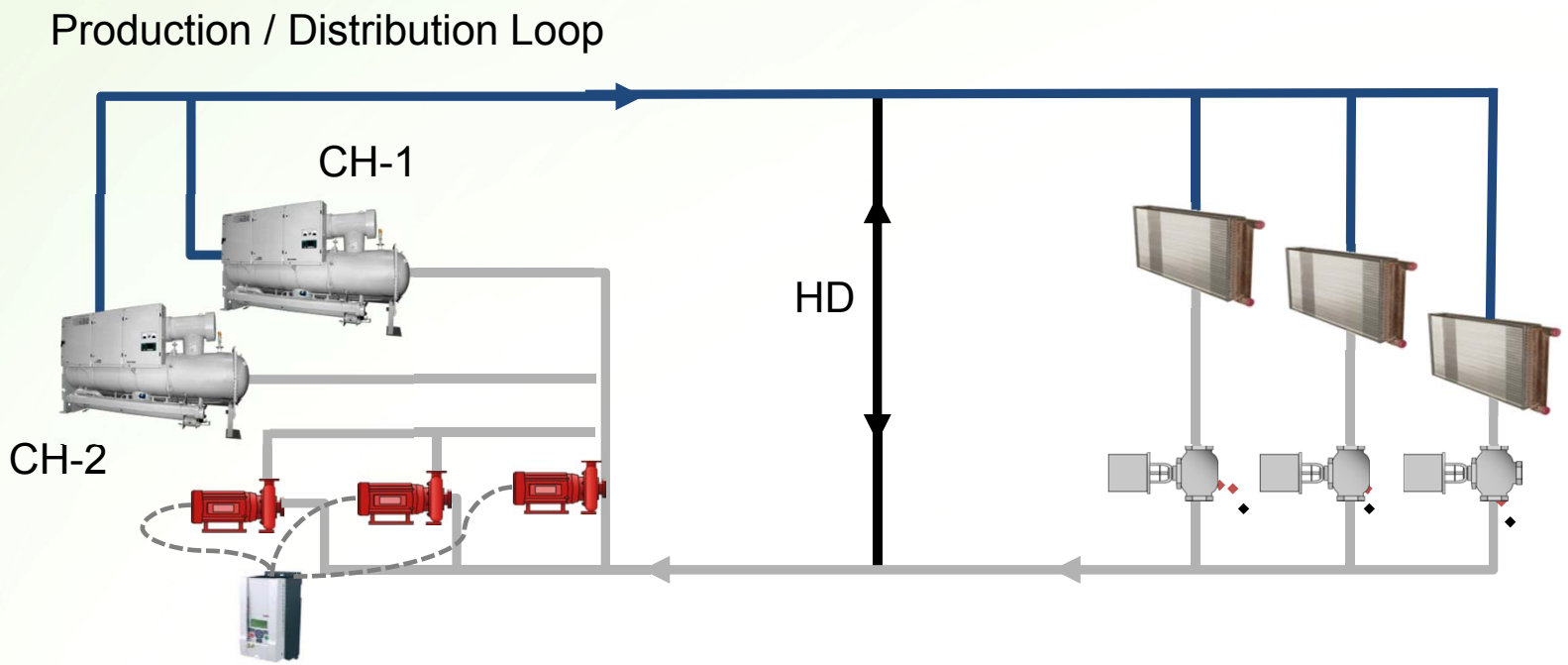
HR CHILLER OPTIONS



Owner request redundancy for 260 ton chilled water plant

Install two (2) identical High Efficiency (HE) chillers, each 260 tons.

What is the payback on CH-2?

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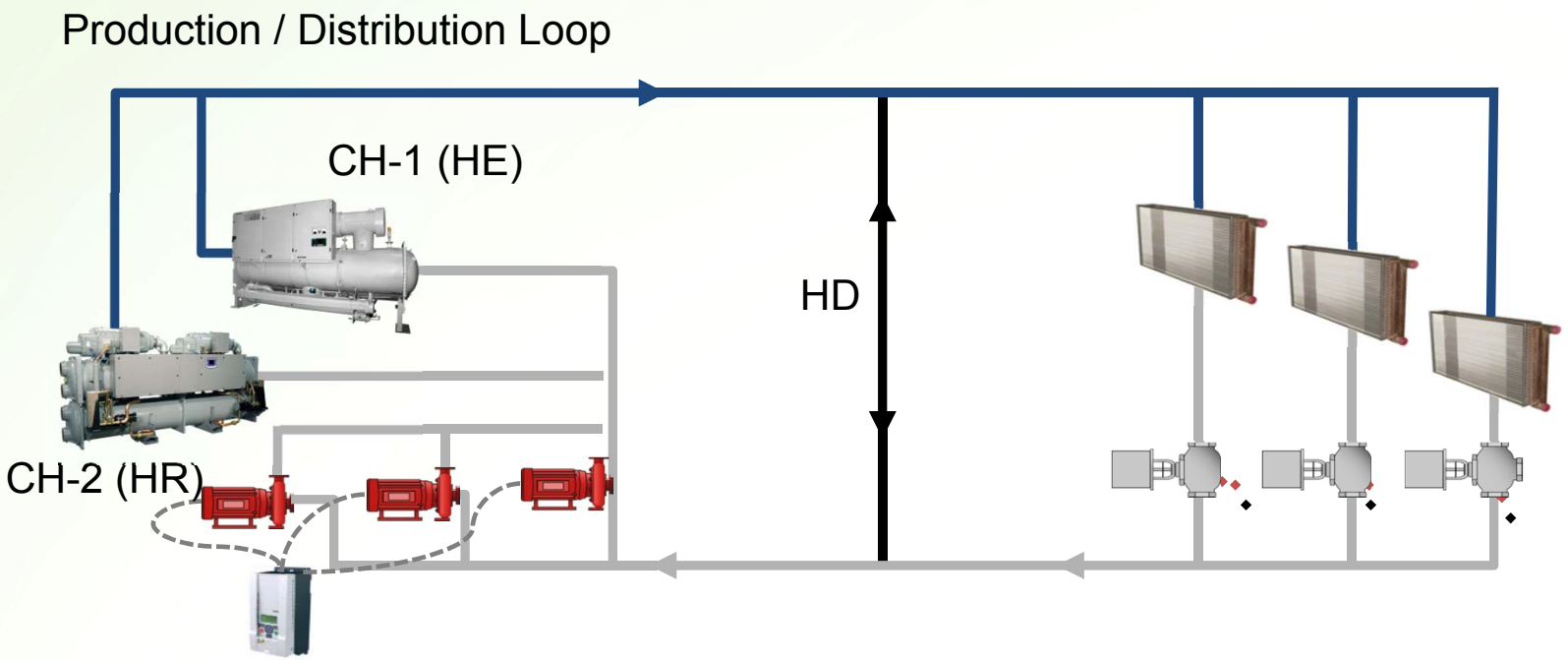
HR CHILLER OPTIONS



Owner request redundancy for chilled water plant

Install one (1) HE, one (1) Heat Recovery (HR) chiller.

What is the payback on CH-2? $$$$

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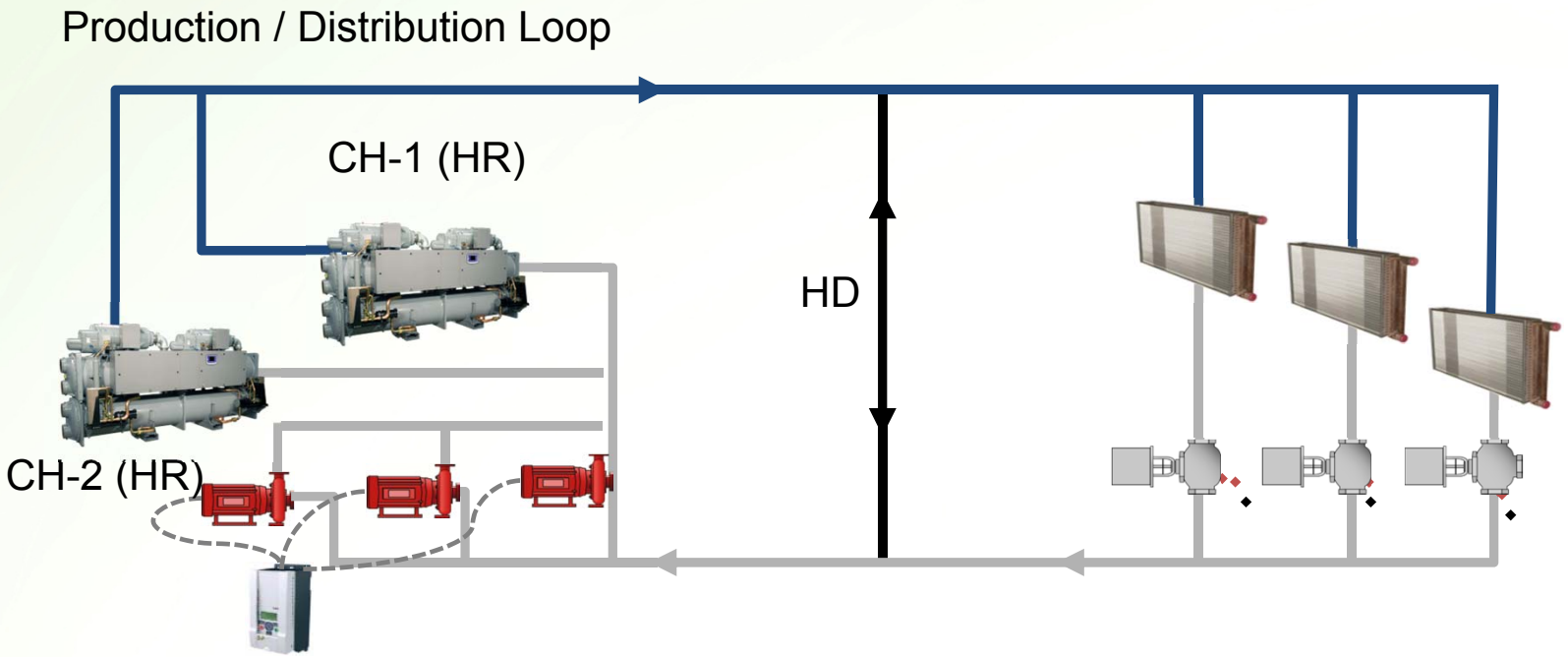
HR CHILLER OPTIONS



Install two (2) HR chillers.

What is the payback on CH-2?

Plant efficiency when you cannot utilize heat?

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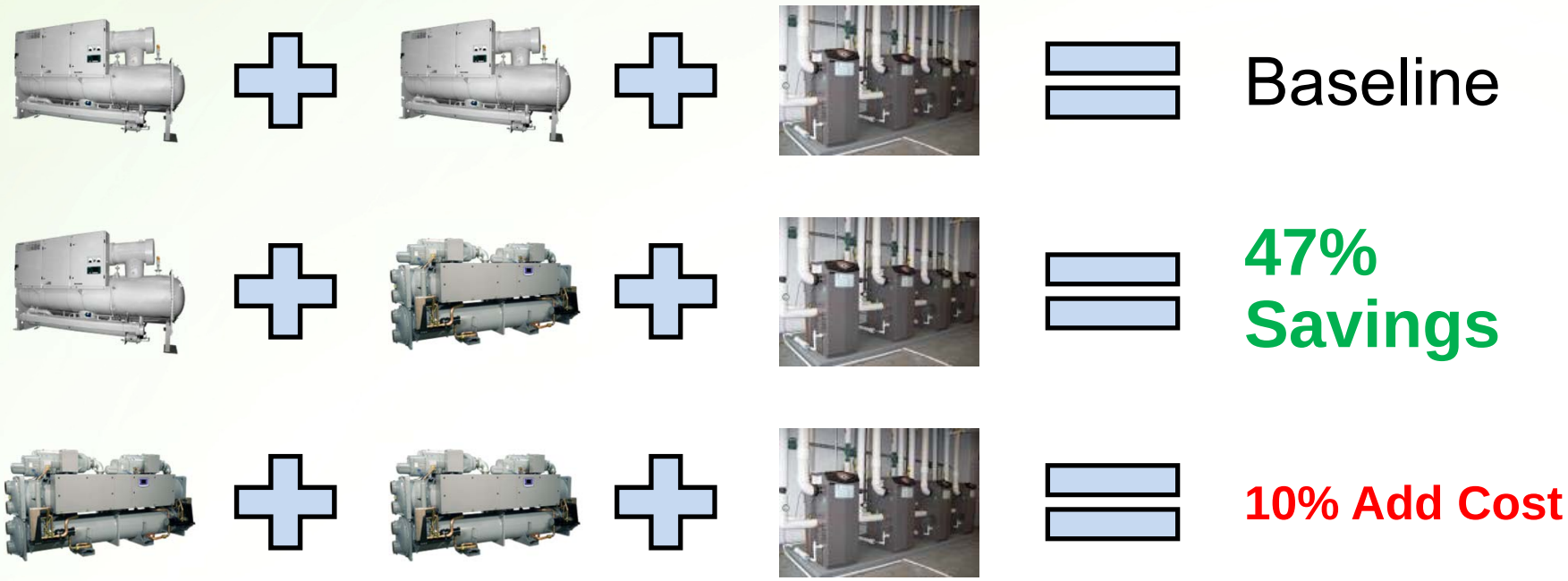
HR CHILLER EXAMPLE



Two HE chillers are the baseline for energy use.

Using a HE and HR chiller together sized appropriately saved 47% yearly energy consumption (in $$)

Two HR chillers actually cost more in energy. Why? Optimize lift in the machine (1.5 kw/ton vs. .35 kw/ton)

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CHILLER LIFT

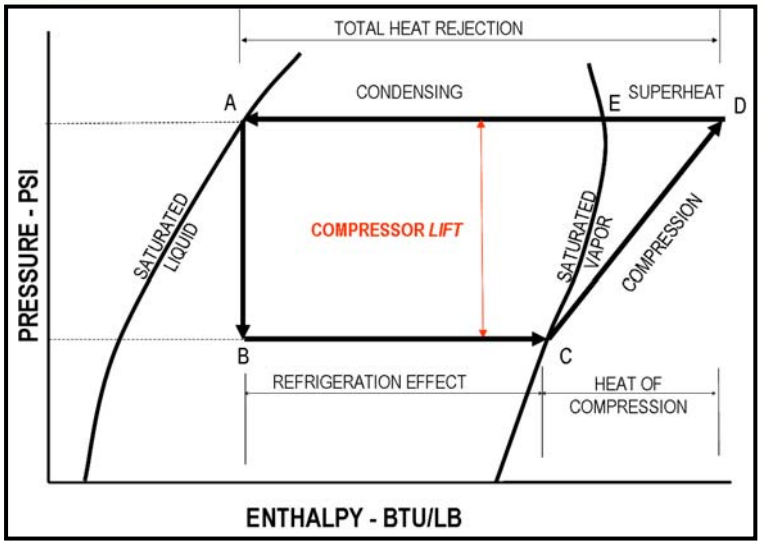
Lift = Amount of compressor work needed to overcome differences between leaving condensing water and leaving chilled water temperatures

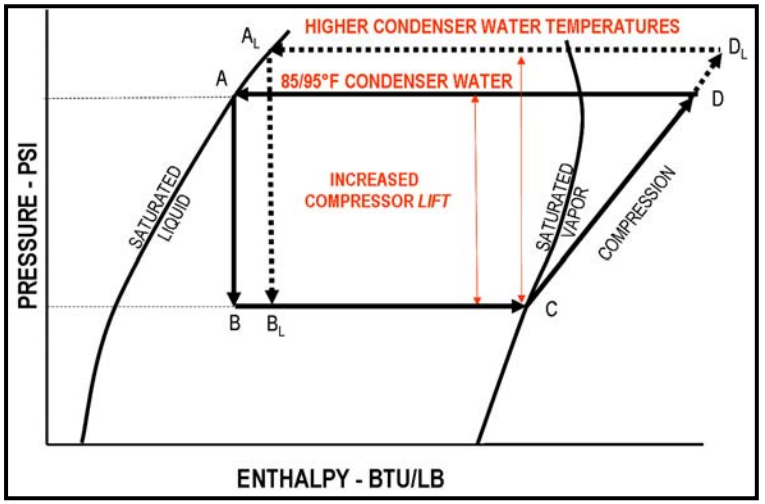
Lift (f) of SCT – SST

Lower Lift = Less Work = Lower kW

Minimize energy consumption

Maximizes energy savings!





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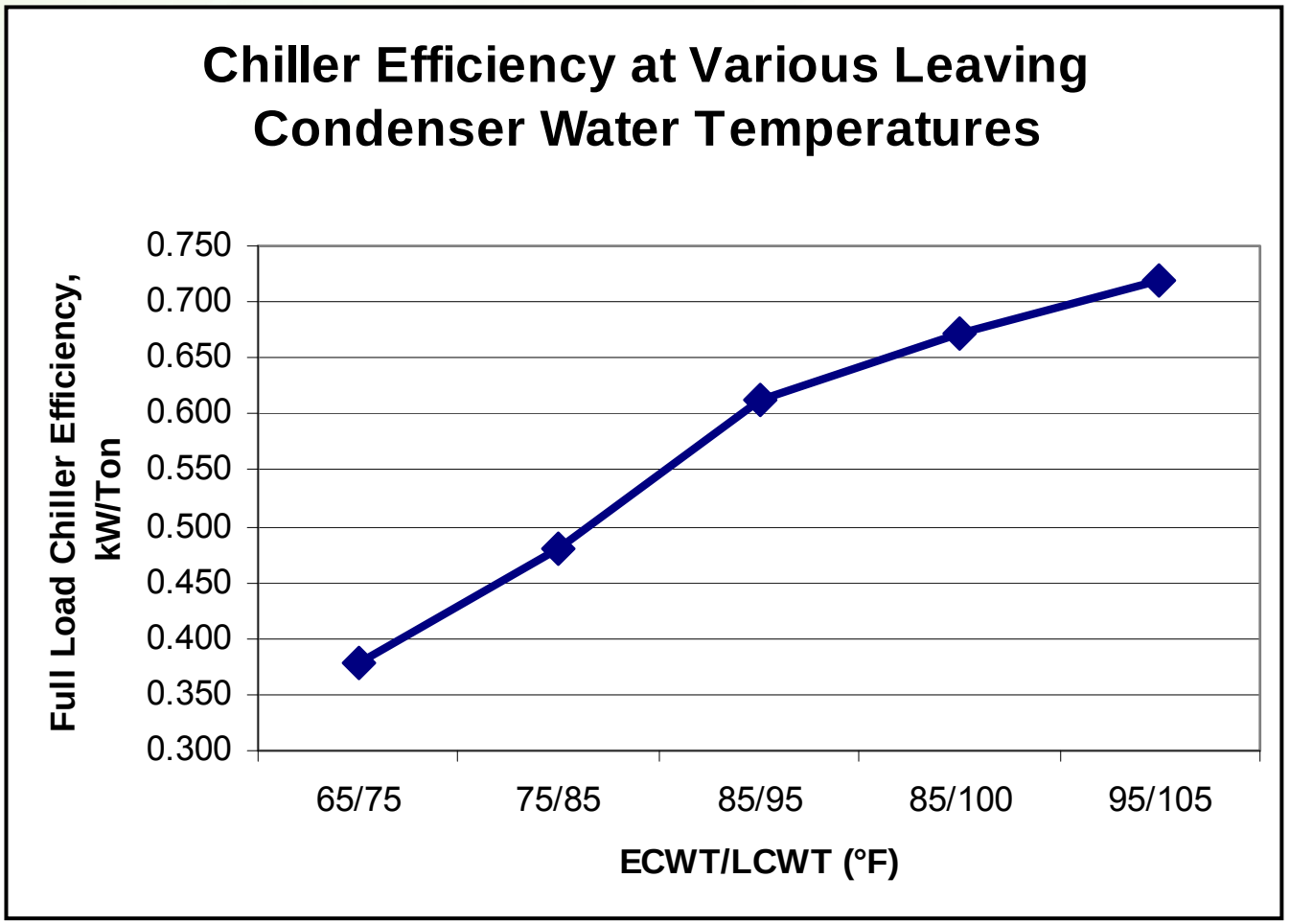
HIGHER LCWT = LOWER EFFICIENCY



Minimize LCWT, Maximize Efficiency

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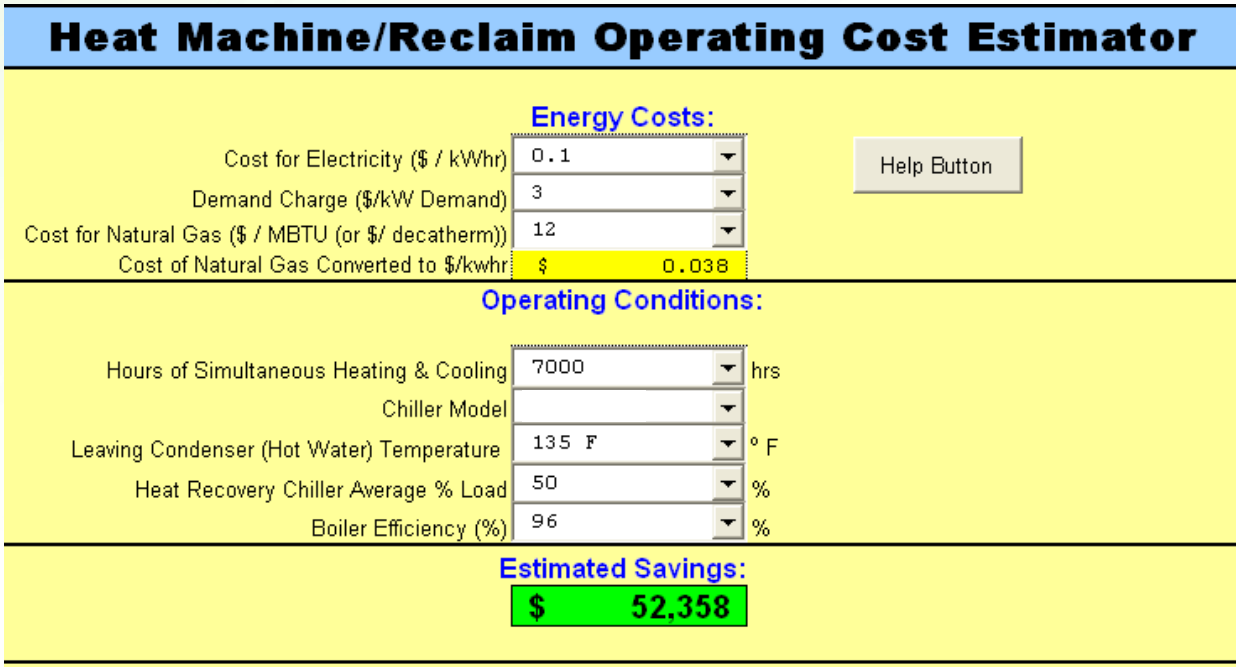
SAVINGS



Heat Machine/Reclaim Operating Cost Estimator

Energy Costs:

Cost for Electricity ($ / kWhr)	0.1	Help Button
Demand Charge ($/kW Demand)	3	
Cost for Natural Gas ($ / MBTU (or $/ decatherm))	12	
Cost of Natural Gas Converted to $/kwhr	$ 0.038	

Operating Conditions:

Hours of Simultaneous Heating & Cooling	7000	hrs
Chiller Model		
Leaving Condenser (Hot Water) Temperature	135 F	° F
Heat Recovery Chiller Average % Load	50	%
Boiler Efficiency (%)	96	%

Estimated Savings:

$ 52,358

Savings vary by application according to:

- Gas rate vs. electric rate
- Amount of heat recovery hours
- Hot water temperature
- Boiler efficiency and type
- Hydronic system design

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CONDENSER PIPING

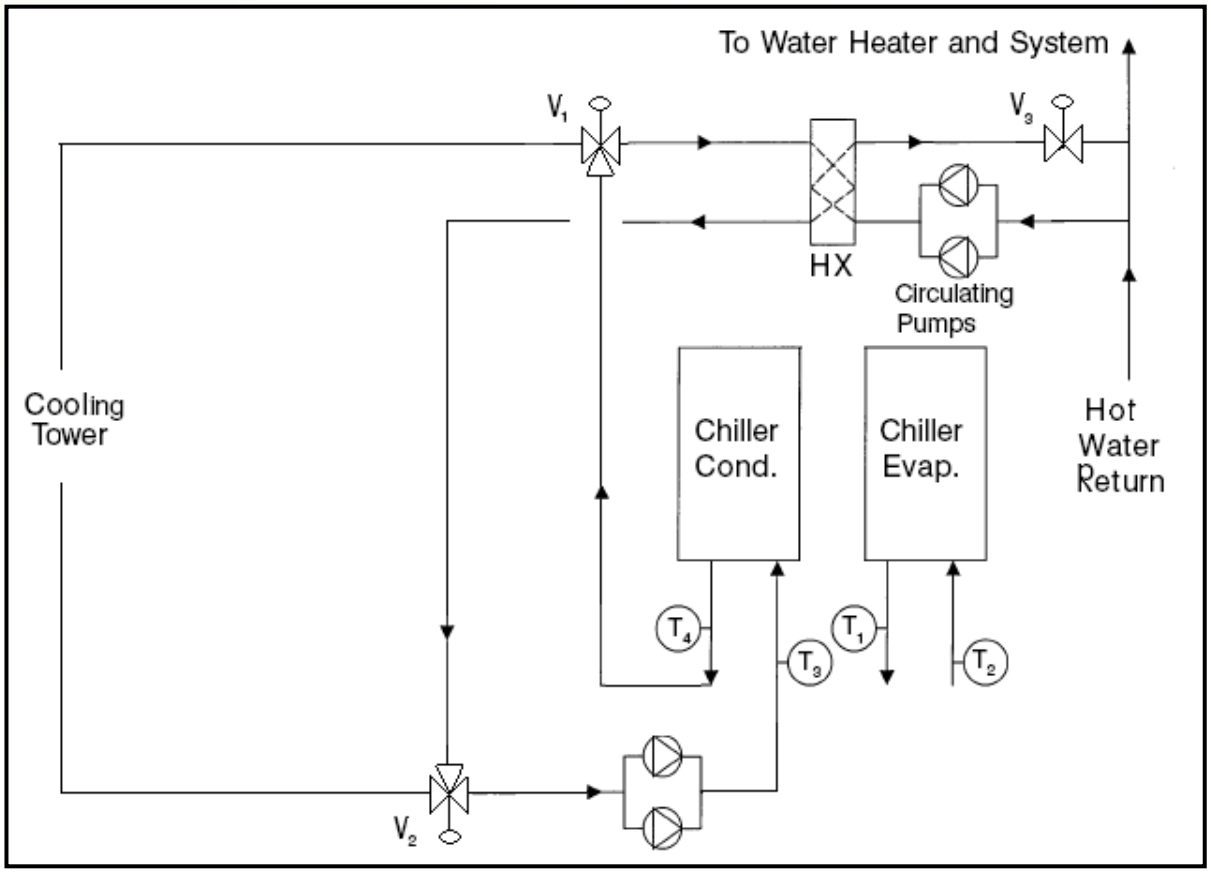
Dual Heat / Cool Piping Schematic

Chiller can operate in cooling or heating.

Control to T4 in *HEAT* mode.

Control to T1 in *COOL* mode.

Meet low winter loads with our tower or condenser pumps.



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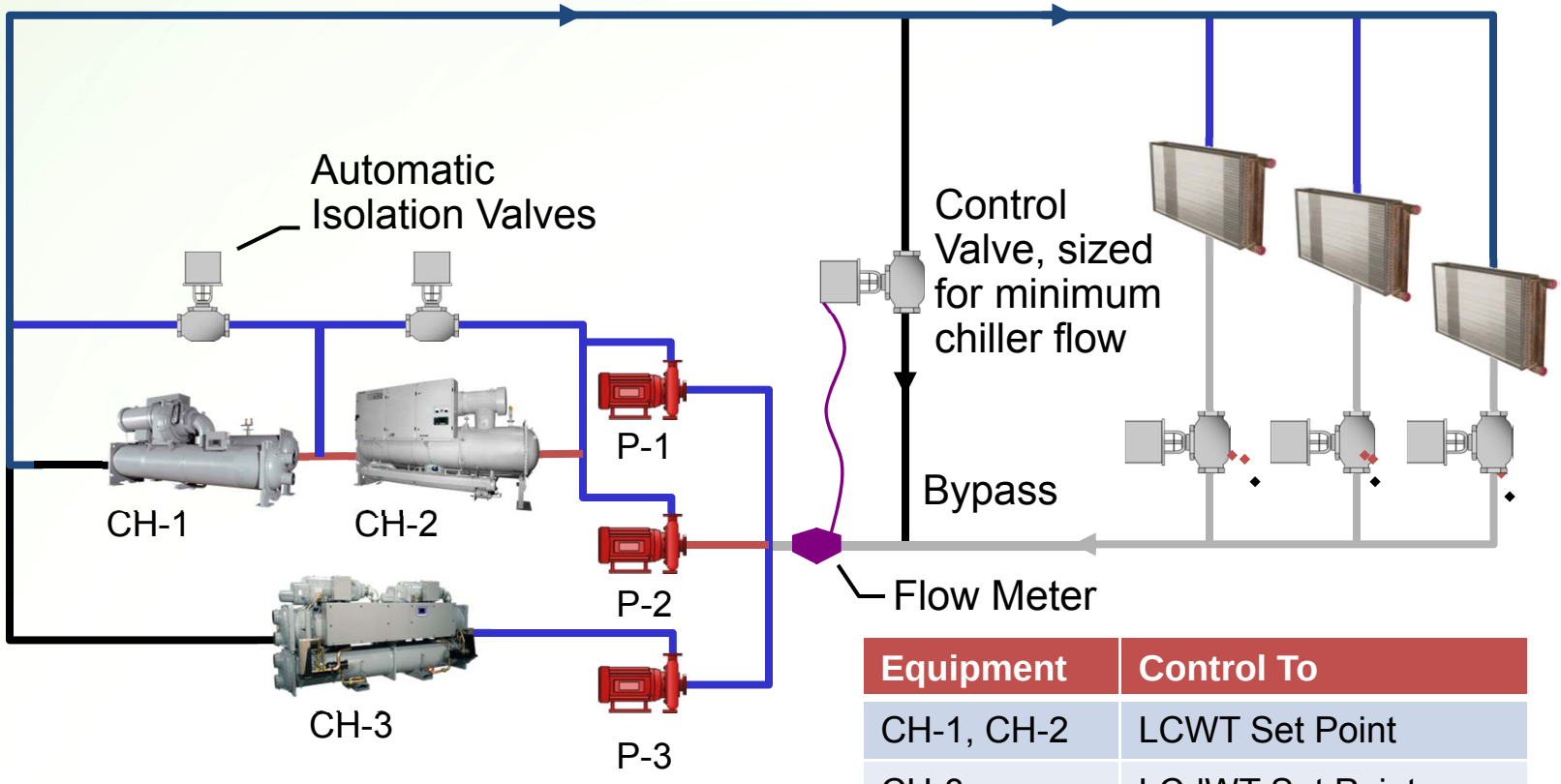
EVAPORATOR PIPING

Variable speed dedicated evaporator pump regulates chilled water temperature while chiller tracks heat load.



Equipment	Control To
CH-1, CH-2	LCWT Set Point
CH-3	LCdWT Set Point
P-1, P-2	Differential Pressure
P-3	CH-3 LCWT

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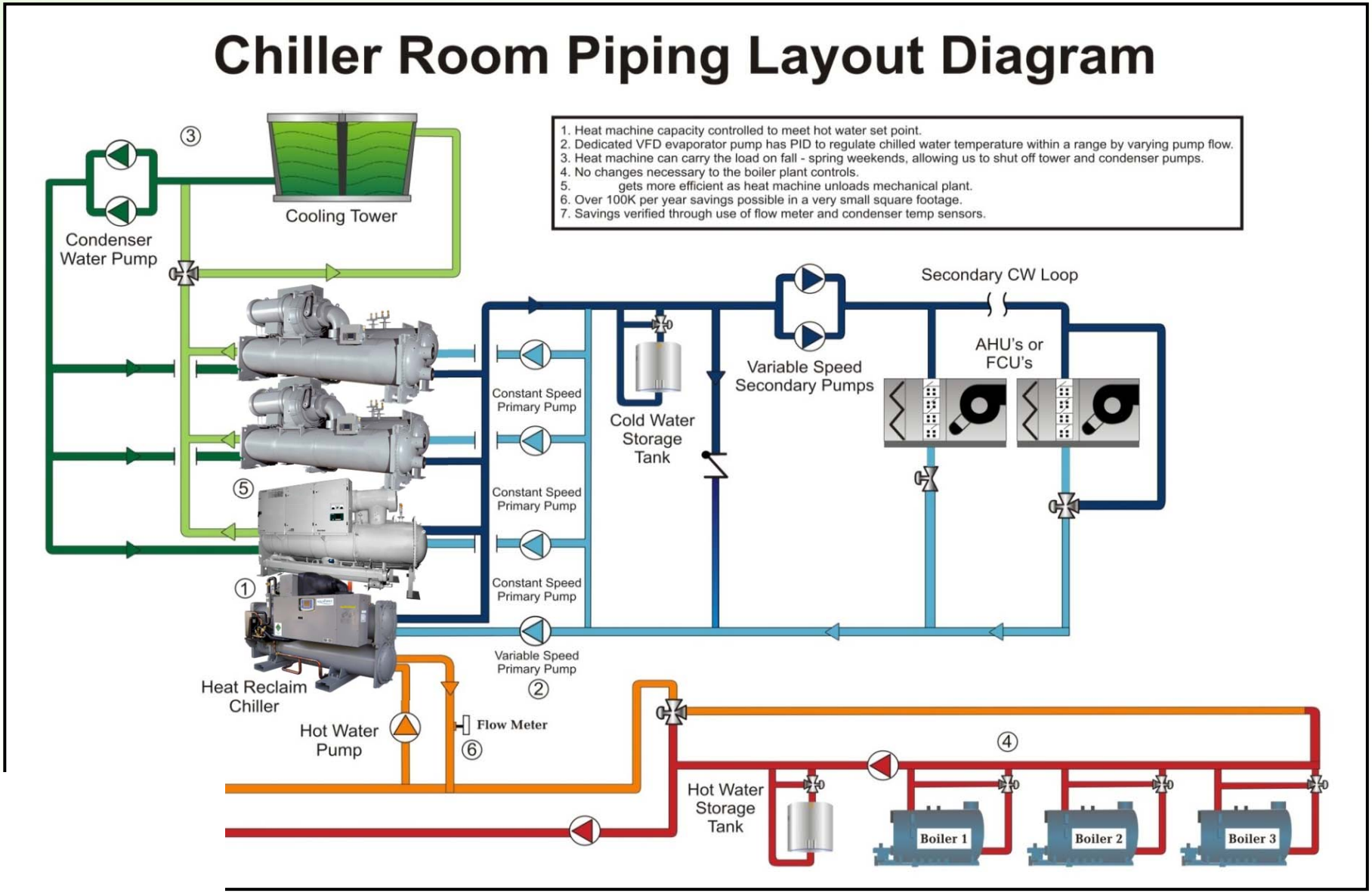
HEAT RECLAIM CHILLER



SIZING HEAT MACHINES

Hot water demand profile:

Use ASHRAE Applications manual “Chapter 50”
Service Water Heating.

Table 7 provides HW demands for various types of buildings.

Demand profile from Energy Analysis

- Size per lowest HW demand
- Size larger with storage tank (preferred)

Process load from customer.

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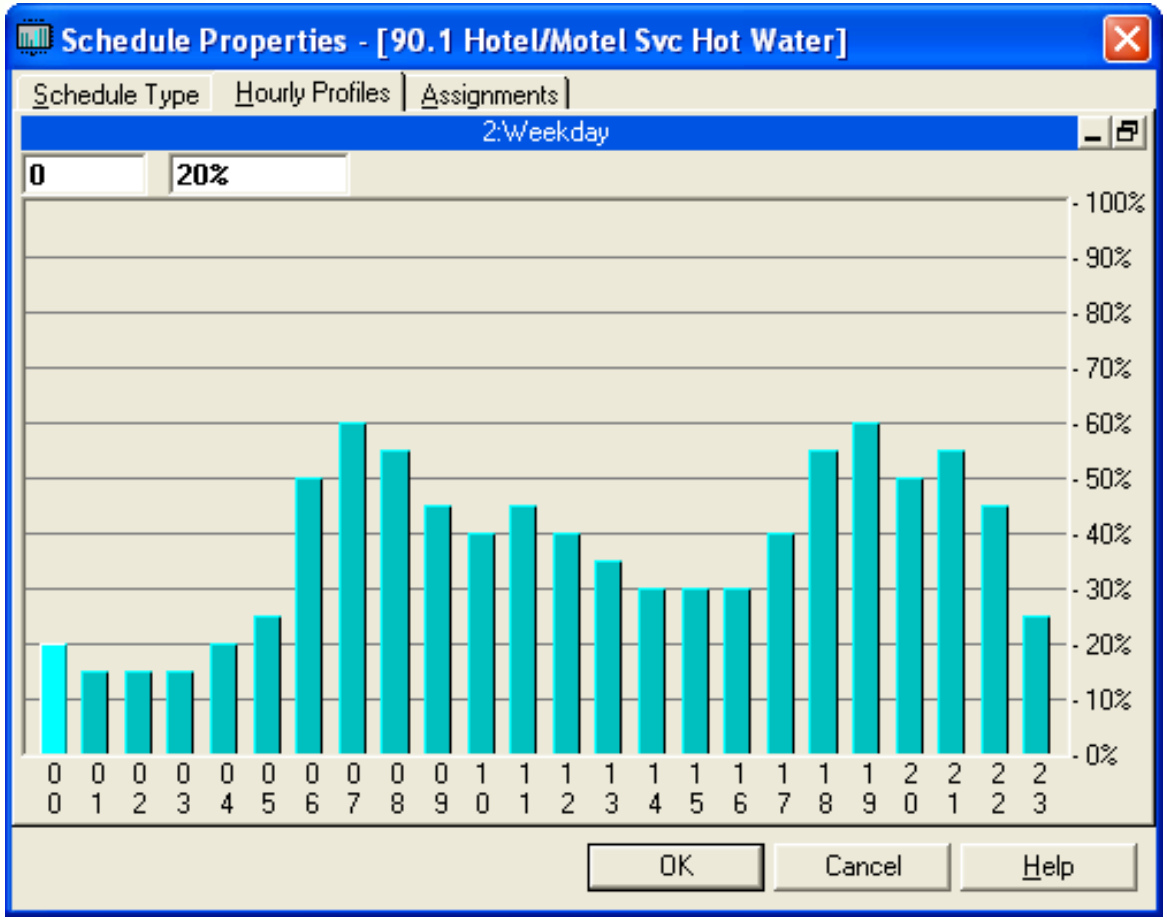
HOW TO SIZE A HEAT MACHINE

Hot Water Demand Profile

Sizing the Heat Reclaim Chiller (one way):

- Dedicated reclaim chiller
- Size always allows it to reject all heat into heat demand
- Trim heat demand with hot water heaters



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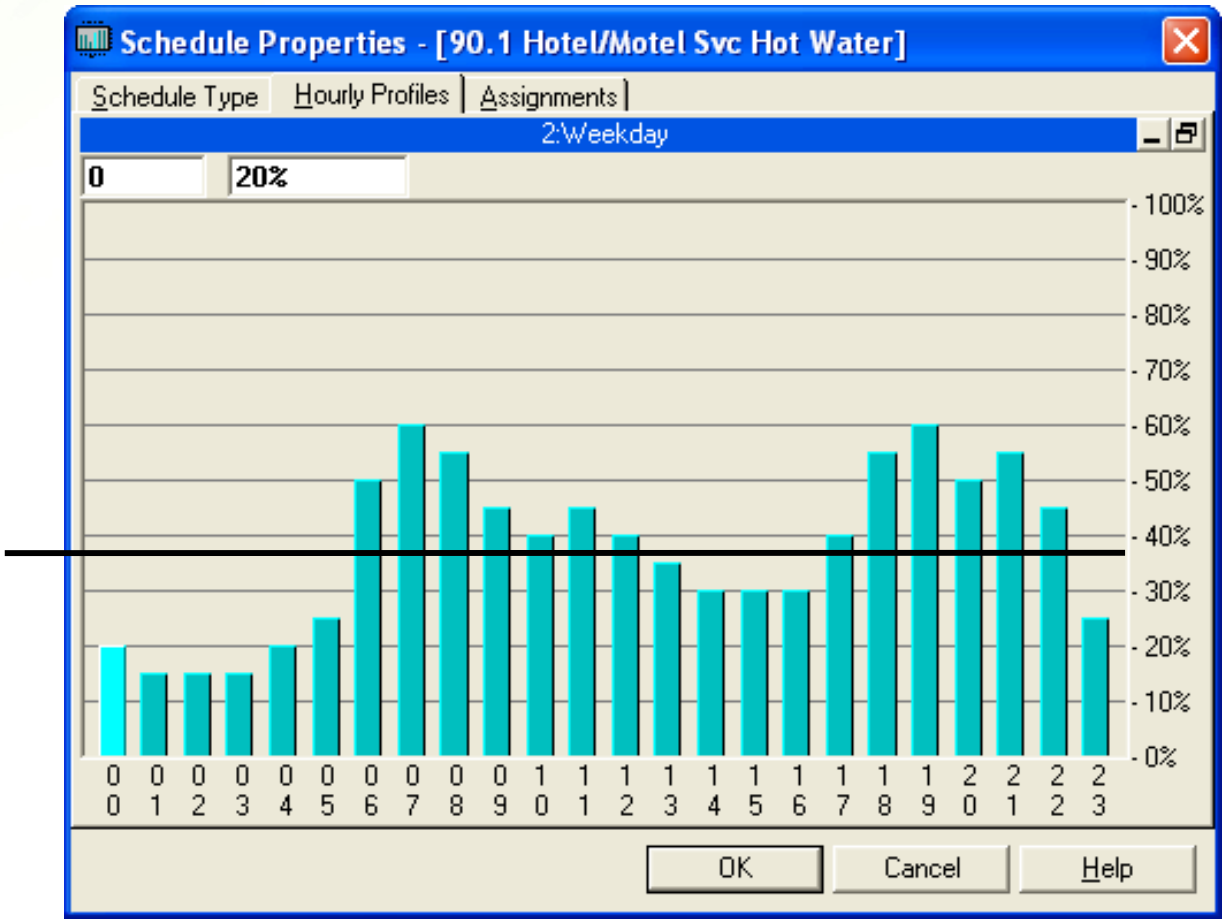
HOW TO SIZE A HEAT MACHINE

Hot Water Demand Profile

Sizing the Heat Reclaim Chiller (a better way):

- A larger dedicated heat reclaim chiller with preheat storage tank
- Size allows storage of heat during low demand for use at periods of high demand



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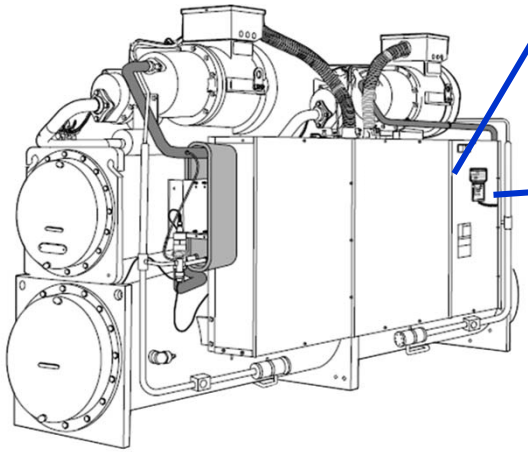
ONBOARD CONTROLS

The Heat Reclaim Chiller in Heating Mode

- **Controls the *Leaving Hot Water Temperature* and prevents overcooling of chilled water**
- **"Low Source Protection" feature prevents overcooling by reducing compressor stage if necessary**
- **Captures maximum heat while maintaining stable chiller plant operation**



Why is chiller plant stability important?

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QUESTION #3

When using a desuperheater heat exchanger for heat recovery, you are maximizing your heat recovery potential.

True

False

A full condensing heat exchanger maximizes your heat recovery potential

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QUESTION #4

The following are benefits of heat recovery except.

A. Energy Savings

B. Potential LEED® points

C. Can provide domestic or heating hot water

D. Makes steam efficiently from the chiller

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IF YOU CAN'T TAKE THE HEAT

QUESTIONS

REMEMBER TO FILL OUT AND TURN IN THE EVALUATION FORM

Reminder: If you are registered in Florida, New York, or North Carolina, you must also sign the sheets in the back at the end of the session. Please print your name, include your registration number, and sign the sheet.