New and Existing Buildings Heating and Cooling Opportunities

Dedicated Heat Recovery Chiller
Creativity in problem-solving...
The Opposite of: “BECAUSE WE’VE ALWAYS DONE IT THAT WAY”

• Engineers are working Harder AND Smarter

• New Energy Economy

• Heating Is Where The Opportunity Is
39% of total US energy goes into non-residential buildings.

Gas for heating is about 60% of energy used in a building.

Gas for heating is at least 25% of total energy used in the US.
What's Wrong With This Picture?

Heat Generation System

Heat Disposal System

Heat Generation System

Heat Disposal System
Closing the Loop
Keep the heat IN the system
Don’t run main plant equipment until necessary!

Less rejected heat

Less gas consumption

Concept Refined
When We Need To Create Heat, What are the Choices?

High Temp >160°F with conventional boilers

Hydronic heating... condensing style modular boilers.

The entire heating system... designed for low temperature water, recommend maximum temperature of 135°F.
Why Hydronic Heat?

- Higher efficiency equipment
- Reduce Domestic Hot Water energy use
- Provide VAV reheat (HW coils at every box)
- Provide perimeter heat (when designed)
- Radiant Floors (when designed)
- Outside Air Tempering at OA AHU
Direct to the bottom line!

180F to Low Temp HW Fuel Bill

- 52% Savings
- 48% After Retro-fit

Steam to Low Temp HW Fuel Bill

- 68% Savings
- 32% After Retro-fit
All New and Renovated Buildings
(Even if you cannot afford DHRC now)

- All heating designed for 130F max.
  - Safer operation
    - 180F = 3\textsuperscript{rd} degree burn in 0.5 second
    - 130F = 2\textsuperscript{nd} degree burn in 17 seconds
  - Much higher efficiency
    - 50\% +/- of total building heat
  - Slightly larger heating coils
    - 0.02\% of building cost
- Plan for future Heat Recovery Chiller
  - 4 line size tees and valves
What has to change?

- Pumps, piping and valves are the same
- Coils have to be larger (more rows, more fins etc.)
- Slight increase in fan power needed
- Radiation and convection may need fan assist
What has to change?

And the MOST Challenging thing to change

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Engineers’ and manufacturers’ attitudes
Conclusion:

“...the old standard can be improved significantly...if a building is to be heated hydronically, use low temperature water from condensing boilers.”
What is a condensing boiler?

- High Efficiency – 95% +
- 130-140F output, ~80F return – USE all of the heat, DON’T exhaust it!
- Designed for low temperature operation
  - Metallurgy is immune to fire side condensation
  - Usually high turndown burners
- Most often gas is fuel source
What is a Dedicated Heat Recovery Chiller?

- Water cooled chiller – With year round Benefits!
- Elevated condensing temperatures > 125F
- Condenser connected to building heating system
- Replaces (or supplements) boiler to limit of DHRC capacity
- A 30+ year old concept made new (and better)
- Applicable any time there are concurrent heating and cooling loads
DHRC, Why now?

- Cost of gas...
  - 200% increase since 1998
- Tough enough machine to handle duty...
  - scroll & screw compressors, small size
- Smart enough controls to stay on-line...
  - fifth or sixth generation
- Before Condensing boilers - No good place to put low grade heat...
Reasons to Recover Heat

- ASHRAE Std. 90.1
- Cost of Energy
  - Electric = $0.12/kWh, $3.52/Therm
  - Gas = $1.20/Therm, $2.40/Therm (steam)
  - Gas = $1.20/Therm, $1.80/Therm (180F HW)
  - Gas = $1.20/Therm, $1.32/Therm (130F HW)
  - DHRC Heat = $0.85/Therm
- Reheating can be 10% of total Energy Bill – use the most cost effective source.
Dedicated Heat Recovery

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The advent of the small scroll or screw chiller, capable of producing condenser water as high as 140°F (60°C), created an opportunity for recovering heat from a dedicated heat recovery chiller’s condenser water circuit for heating or domestic water systems while providing beneficial cooling for the chilled water system. These systems are called “dedicated” heat recovery because 100% of the heat generated by the dedicated heat recovery chiller (DHRC) can be used for hot water heating applications. Also, the DHRC can be piped and controlled to produce the desired evaporator or condenser temperature. Transfer of the recovered heat in this article is limited to clean water applications, such as preheating, heating, reheating, domestic, pool water heating, or snow melting.

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Simple, Compact, “Retrofittable” Solution

Not a massive new chiller

$1.11 and 5.9 Kg CO2 per Therm

$0.10 and 1.6 Kg CO2 per Therm

STAND ALONE SYSTEM
**Scenario 1 - Existing**

Chiller Cooling = 0.6 kw/Ton @ $0.12/kwh
= $0.60/100 MBTU

Boiler Heating = $1.20 THERM Natural Gas @ 60% Eff.
= $2.00/100 MBTU

Total = $2.60

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**Scenario 2 – Efficient Boiler**

Chiller Cooling = 0.6 kw/Ton @ $0.12/kwh
= $0.60/100 MBTU

Boiler Heating = $1.20 THERM Natural Gas @ 90% Eff.
= $1.33/100 MBTU

Total = $1.93
Scenario 3 – Efficient Boiler + Economizer

Chiller Cooling = \(\sim FREE\)

Boiler Heating  = $1.20 \text{THERM Natural Gas @ 90\% Eff.}
  = $1.33/100 \text{MBTU}

Total  = $1.33

Scenario 4 – Heat Recovery Chiller

HR Chiller Cooling  = \(@0.85 \text{kw/Ton @ } $0.12/\text{kwh}\)
  = $0.86/100 \text{MBTU}

HR Chiller Heating  = Free (rejected heat you would have thrown away)

Total  = $0.86
-Summary -
Scenario 1 (Existing)  = $2.60
Scenario 2 (Better Boiler)  = $1.93
Scenario 3 (Add Economizer)  = $1.33
Scenario 4 (DHRC alone)  = $0.86

You save $0.47 (or more!) for EVERY therm of heat you use!

Outdoor Air Economizer is NOT necessarily the best choice! (If you need the heat…)}
Design Guidance

- Determine your summer heating loads (360,000 btu)
- Determine your winter cooling loads (240,000 btu)
- DESIGN FOR THE LARGER – INSTALL!
- (remember you already need cooling in the summer so the 30 tons of cooling is just added capacity)

-Results -
- Boiler does not run in the summer - uses less fuel year round
- Main chiller does not run in the winter
- DHRC runs all of the time.
Economics of Dedicated Heat Recovery Chiller

1-2 year payback very common (US installations)


US Embassy Santiago Chile

- Boilers used for domestic water and air distribution reheat.
- After DHRC installation – Boilers did not run for the entire year!
The Dark Side

- Good ideas can always be poorly applied!
- The DHRC has its own controller but controls will be more complicated
- Don’t penalize the efficiency of the entire system for the sake of saving some of the energy
- Don’t reject high temperature water
  - Chiller is less efficient
  - Scaling will increase
  - May impact other chillers on same tower
Santiago project was such a success that DHRC is now an integral part of our Standard Embassy Design Criteria and it is being embraced by our General Contractor’s mechanical design teams for new DOS projects as a means to help reach the new Federal Energy Goals in EPAct 2005, EISA 2007, and EO 14323

Just Remember......
You have to have a place to put the hot water in summer !!!
- VAV reheat
- Domestic water pre-heating
- Swimming Pools

You have to have a place to put the chilled water in the winter !!!
- Computer centers
- VAV, Terminal RH and Multi-Zone units are ideal
- Economizer coordination
You’ll know you’re on the right track when...

The gas company changes the meter.

Twice.
1 mil BTU/H DHRC
- Saves 40,000 Therms NG per year
- $50,000 Annual Energy Savings
- 300 Metric Tons CO2
- Equivalent of Saving 21,000 Gallons of Gasoline Annually
- And, Yes they did get Two New Gas Meters...

Oh, by the way: Runs Fully Loaded nearly Year Round
Creating opportunities for DHRC to run

Creating places to use CHW in winter HW in summer

Cost of heat $1.32 (Boiler) vs. $0.86 (DHRC)

For Multi Zone or VAV systems and spaces with high internal heat, make CHW valve the first call for cooling, rather than O/A damper.
BTUs = BTUs (Talking the talk)

Turn Gray BTUs into Green BTUs - Or....

Heat your buildings with BTUs from the people and the lights, BTUs that were being thrown away (i.e. rejected at the condensing units)
Other innovative ideas in use at State:

- Magnetic Levitation Bearing Chillers (Danfoss, Daiken/McQuay) Part load, maintenance, and start up power requirements benefits
- Air Cooled Chillers as a standard
- Condensing boilers as a standard
- And some old Standbys:
  - Solar HW
  - Photovoltaics

Thank you for your time!!

Questions?

David Langfitt

U S Department of State