Heat Pumps Are Not Boilers
AGENDA

• OVERVIEW
• END GAME
• WHAT’S AVAILABLE NOW
• PROBLEMS WE ARE SEEING
• MARKET DEVELOPMENT NEEDS
• QUESTIONS
MULTIFAMILY ENERGY END USES

Seattle 2014 Benchmarking Data
Median EUI (kBtu/SF/yr)

- Lowrise  EUI = 32
- Midrise   EUI = 36
- Highrise  EUI = 51

2009 Multifamily EUI (KBTU/Sf/Yr)
Breakdown By Energy End Use Type

1/3 OF THE LOAD IS TEMPERATURE MAINTAINANCE
“Heat Pumps Move Heat”

Optimize storage design to use coldest water possible

HEAT PUMP WATER HEATING
REFRIGERANT TYPES

ECOTOPE.COM

GWP OF SELECTED REFRIGERANTS
(Carbon Dioxide Equivalents, CO$_2$e)

- Refrigerants have 10% of the climate forcing impact of CO2 Emissions

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>GWP</th>
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<tr>
<td>R-717</td>
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<td>R-1150</td>
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<td>R-12</td>
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- CO2 Variable Capacity: SANDEN, MAYEKAWA, MITSUBISHI Eco-Cute
- Proposed HFO replacement refrigerant
- Fixed Capacity: MOST HPWH's, COLMAC, AO SMITH
- Variable Capacity: PHNIX, ALTHERMA, VERSATI
- Fixed Capacity: AERMEC
MAGNETO-CALORIC HEAT PUMP

- No Refrigerant
- 20-30% Less Energy
- Quiet
- GE/Oak Ridge Pilot
- Ready for Market - 2020

Replacing traditional fluid-compression refrigeration with longer-lasting magnetic refrigeration technology reduces energy consumption, eliminates coolant leaks, avoids damage to the ozone layer from chloro-fluorocarbons, and makes installation and service simpler.

Source: CoolTech Applications
Heat the water up to usable temp in a single pass.

Sanden (Inverter variable compressor)
Colmac RCC (throttling water flow)

Heat the water up 10-15 degrees per pass.

Inverter Air-to-Water (Daikin Altherma or sim. 410a)
Aermec Constant Volume 410a
### What’s Available Now

<table>
<thead>
<tr>
<th>Refrigerant/Compressor</th>
<th>Qty</th>
<th>Single Pass</th>
<th>Double Wall HX</th>
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<td>R-410a Inverter Driven Variable Capacity</td>
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<td>R-744 (CO2) Inverter Driven Variable Capacity</td>
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</table>
• Low GWP Refrigerant
• Variable and Fixed Capacity
• Air Source
• Plug and Play Design - Modular Setup
• Redundancy Built In
• High Performance Hot Water Distribution Design
• M&V Systems Temps, Power and Flow Meter
• Demand Response Capable

END GAME  -  CENTRAL HPWH
Heat Pumps Aren’t Boilers
What Do Gas Hot Water Boilers Do?

GAS HOT WATER BOILERS
- Can be Oversized
- Smart Controls
- Modulating Output
- Can Short Cycle
- Can be instantaneous heaters
- Compact Footprint
- Modular
- Plug and Play
- Don’t care about outside temp
- Incoming water temp isn’t an issue

Problem....
They Burn Fossil Fuels
Heat Pumps are Not Boilers

HEAT PUMPS ARE NOT BOILERS

- Efficiency impacted by Air and Water Temps
- Limited Temperature Ranges
- Output temperature limited
- Different refrigerants for different applications
- Larger Hot Water Plant Footprints
- Expensive Oversize
- Require Right Sizing (Both Loads)
- Shouldn’t cycle more than 6x/Hr
- Defrost Cycles
- Complex Controls
Stratification is Key to System and Heat Pump Performance and Longevity.

Problems:
• Selecting horizontal tanks that cannot stratify
• Storage is too small and leads to mixing at peaks when makeup water flows are highest.
• Poorly insulated tanks lead to degradation of hot water temp
Routing Recirculation through HW Storage

Risky to Route Recirc through hot water storage with current equipment offerings

Problems
- Recirculation Load is hard to calculate and setup
- If primary water heat plant goes down, your recirc line will deplete the storage in minutes
- Recirc into storage tanks up mixing tank and you get a big efficiency hit at the heat pump.
Do NOT size a heat pump using a Boiler sizing methodology.

- 2 Loads Present
  - Temperature Maintenance
  - Heating Hot Water
- If Heat Pump cannot modulate down to TM load, decouple it.
- Better to have smaller stages of primary heat pump to deal with part load and provide redundancy.
- Err on the side of less capacity and more storage

Swap Boiler With Heat Pump - Oversized
Redundancy in Plants

Do Not Allow a situation where a Building Loses the Hot Water Plant.

- Add multiple Heat Pump stages
- Ensure 100% backup electric capacity
- Install Alarms to alert maintenance

2 Primary Heat Pumps in stages
1 Backup Electric Stage

1 Primary Temperature Maintenance heat pump
1 backup Electric tanks
Inefficient Hot Water Distribution

Problems
• Un-Insulated hot water lines will use a factor of 6-8X more Temperature Maintenance energy than Code Insulated lines.
• Larger Temperature Maintenance Pit the building owner with a higher life-cycle cost system both equipment and operating cost, insulation is cost effective.
• Remote Located Heat Plants lead to excessive losses and energy use.
• The closer the heat plant is to the source, the less pipe UA
No HEAT TRAPS installed on both Cold and Hot side of Storage

Problems:
• Runaway Heat Loss as Hot Water migrates out of storage tanks
• Reduced Efficiency on the Heat Pump as our precious cold water entering heat pumps are hot.

Install Heat Traps on both Hot and Cold

NO HEAT TRAPS INSTALLED
RCC 3.0 (Revision 5)
RCC 3.0 M&V Data for Tuning
MARKET DEVELOPMENT NEEDS
DESIGN TOOLS

- Circulation loop losses and reheat sizing
- Primary plant sizing (capacity & storage) optimization
- Simulation Protocol
MARKET DEVELOPMENT NEEDS

TECHNOLOGY

- Double-wall heat exchangers integrated in current heat pump offerings
- 5-15 Ton low-GWP refrigerant air source heat pumps needed
- Variable capacity temperature maintenance heat pump designed to handle ~110 degree incoming water
RESEARCH

- Performance Test of Current Equipment
- Cost benefit analysis on piping insulation levels within de-Carb Environment
- Pilot projects of design innovation

MARKET NEEDS