E3T Energy Efficiency Emerging Technologies

Washington State University Extension Energy Program

Reverse Cycle Chillers for Domestic Hot Water in Multifamily Buildings

Emerging Technologies Showcase

June 18, 2014

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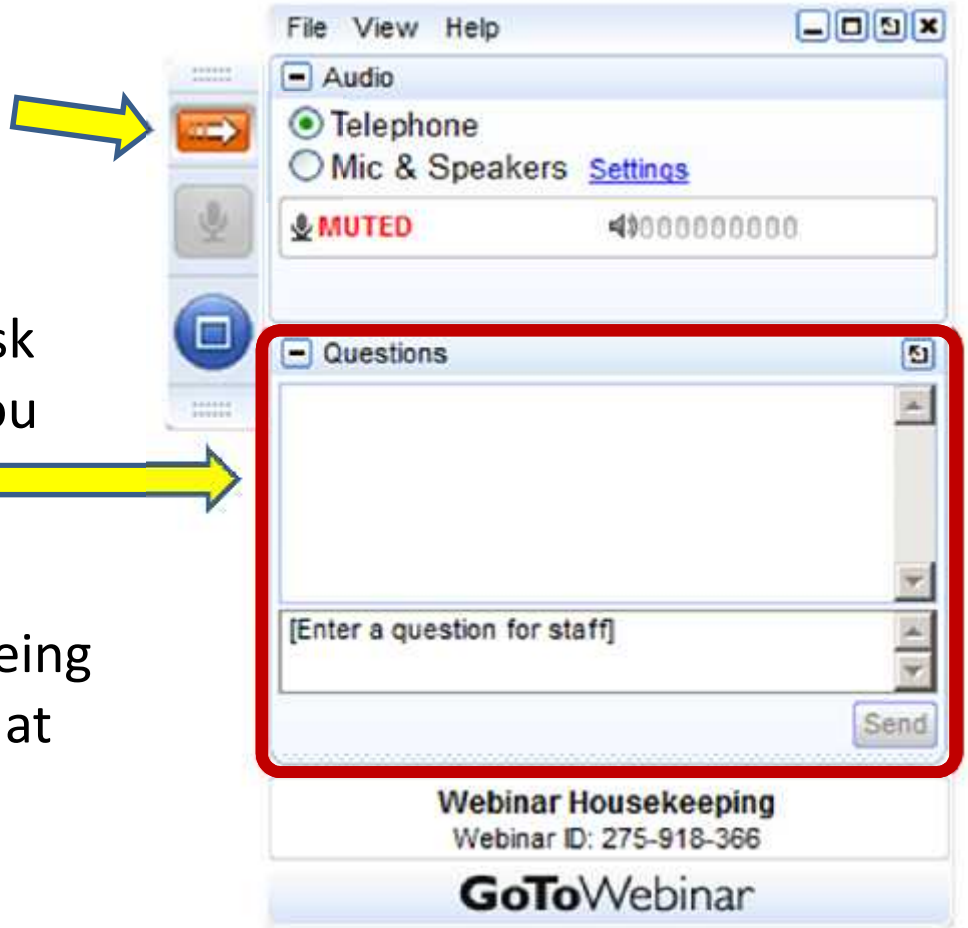

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E3T Energy Efficiency Emerging Technologies

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Reverse Cycle Chillers for Domestic Hot Water in Multifamily Buildings

Jerry Raitzer
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Seattle City Light

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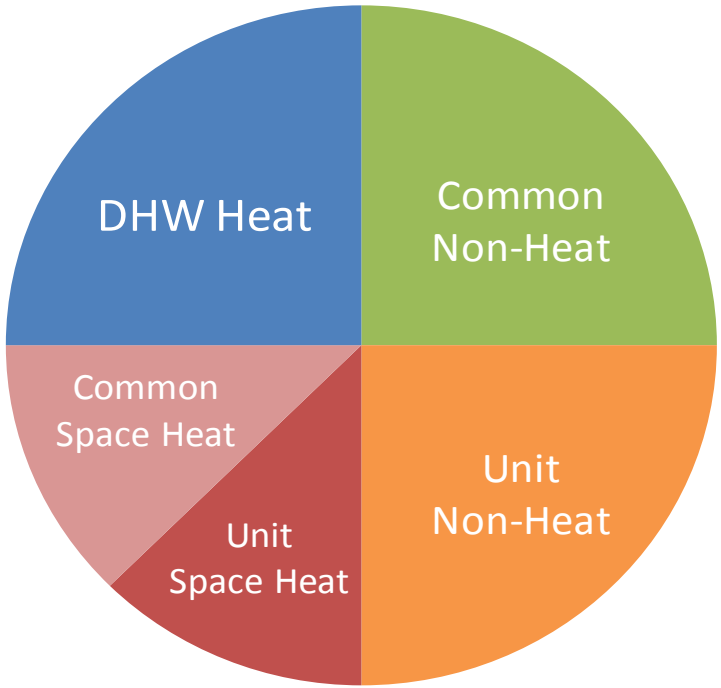
The Question: Where can we save more energy in Multifamily Mid-rise Buildings?

One Answer: Reduce energy used for hot water heating

Domestic Hot Water uses about 25% of total



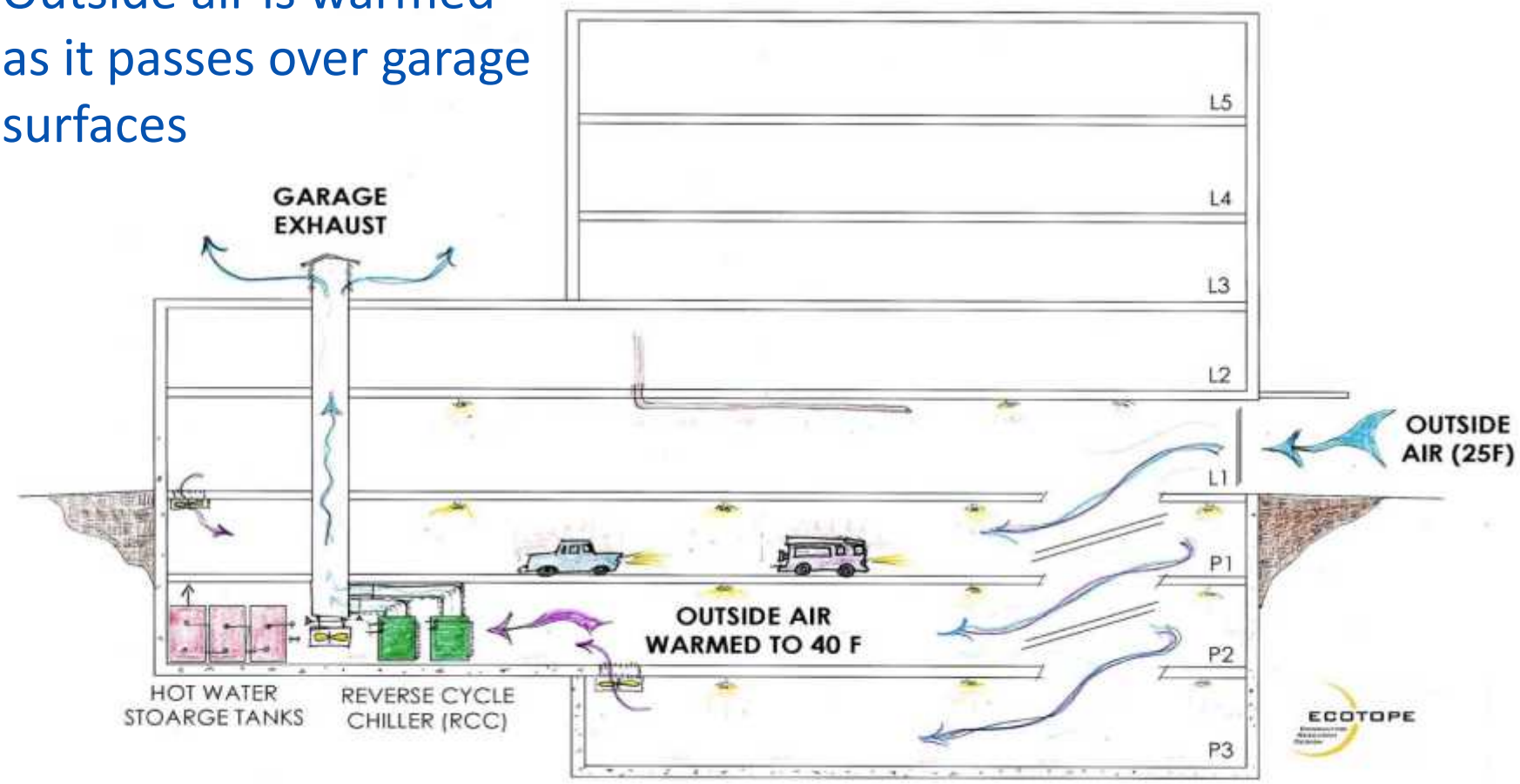
Average Total Energy Use in Multifamily

The Idea: Utilize a Reverse Cycle Chiller (RCC) (Heat Pump Hot Water Heater)

- RCCs have been used for process water heating or for domestic hot water, mostly in climates where temperatures are warmer than the Pacific NW
- Key to application in our climate: Utilize warm garage air as intake to the RCC to increase performance
- Take advantage of airflow through RCC to double as garage ventilation fan for added savings

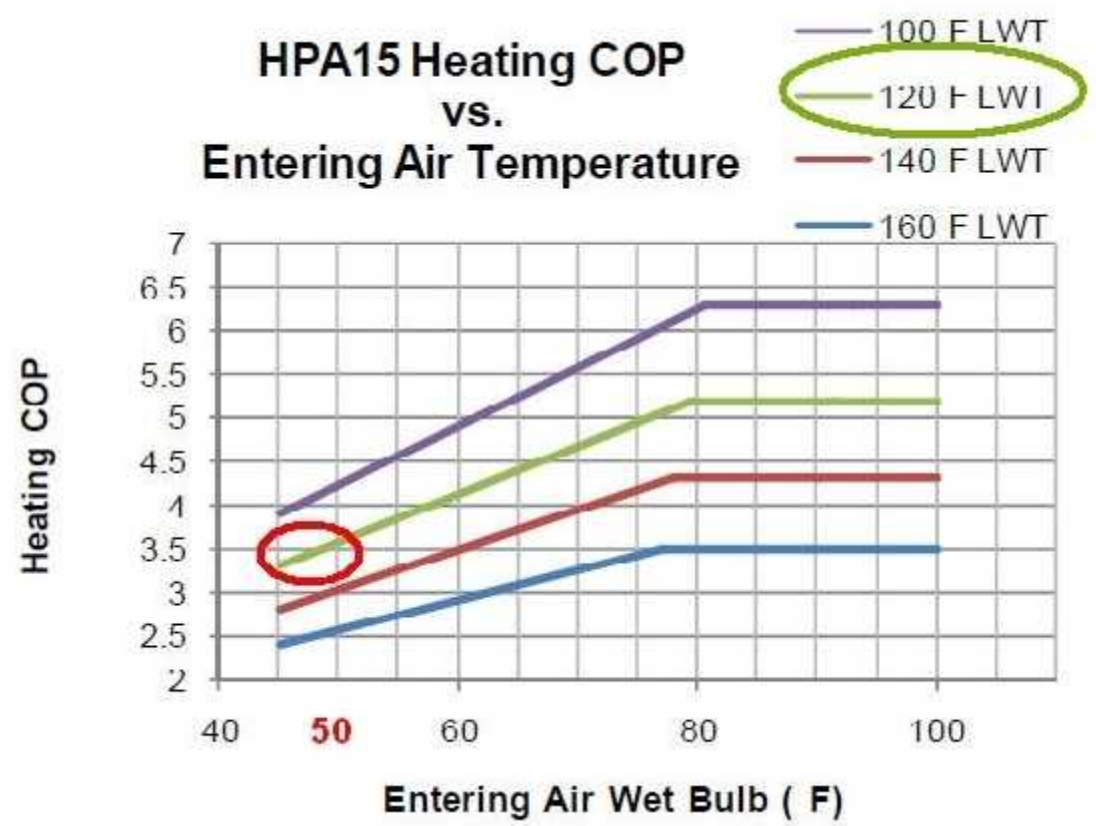
Model Garage Layout for RCC Installation

Outside air is warmed as it passes over garage surfaces



RCC Performance at Garage Temperatures

Performance at Minimum operating temperature in a garage results in COP >3 (3x the performance of electric resistance water heater)
More typical temps may be 60-65 degrees

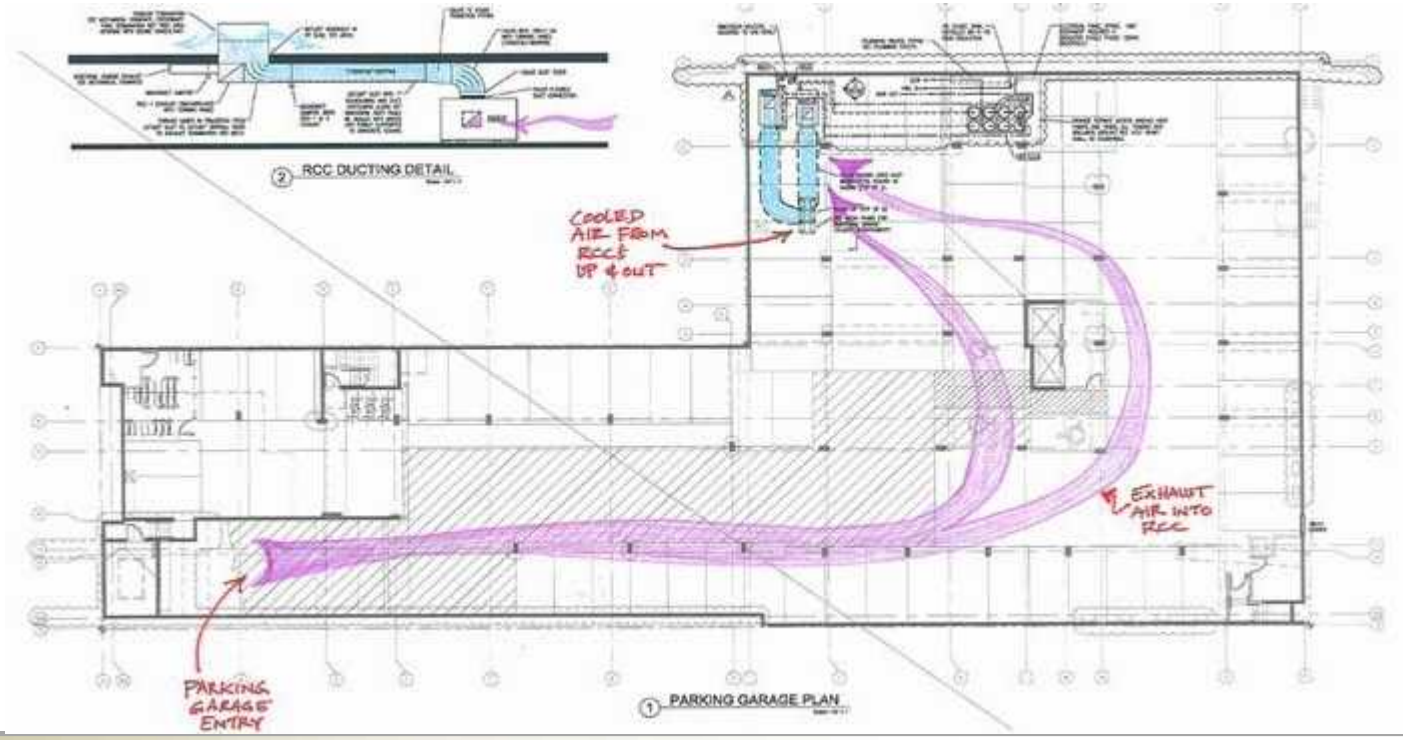


Garage Airflow for Project 1

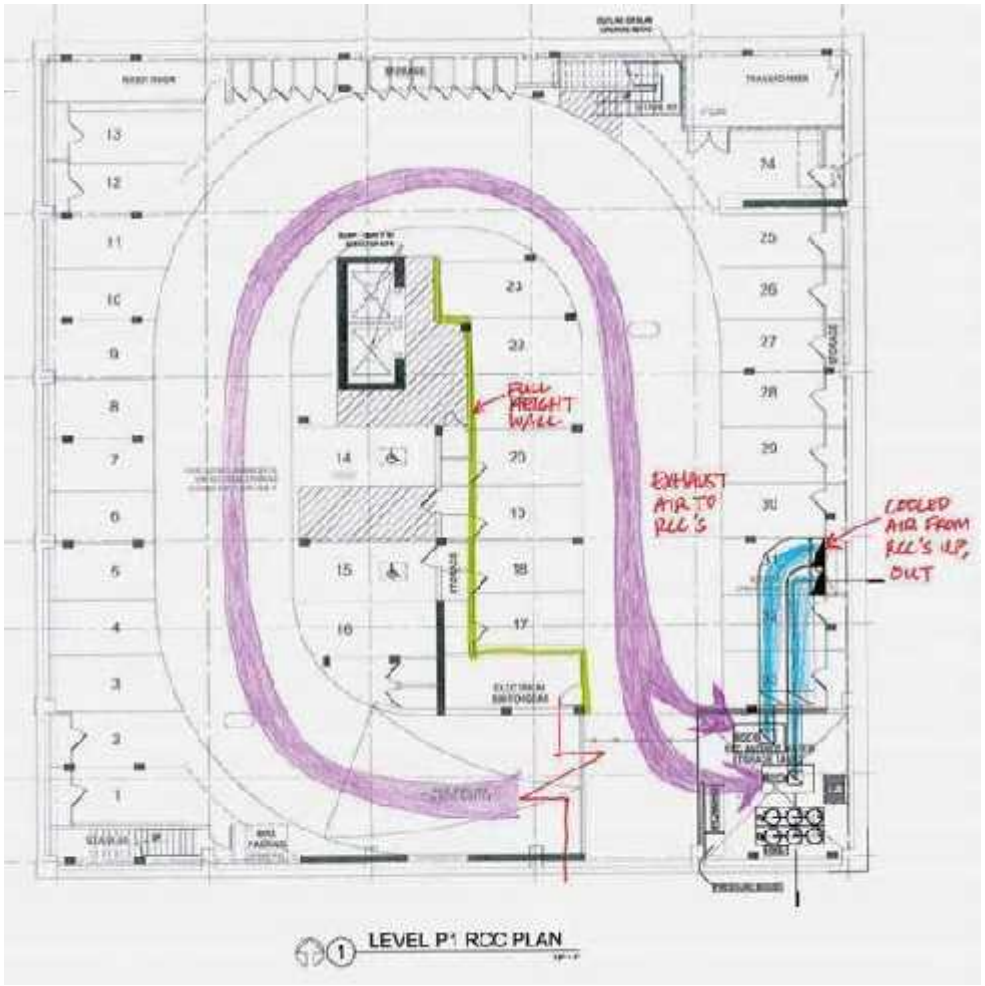
Airflow is from entrance to RCC in rear corner of garage

Sources of internal heat gain for RCC intake air:

- Garage lighting
- Cars
- Ground coupling
- Plumbing waste piping



Garage Airflow for Project 3



Airflow is from entrance down ramp to lower level

RCC and storage tanks are installed in space under entrance lamp

The Partnership: BPA Funding for Engineering Design and M&V for Pilot Projects

- BPA Emerging Technologies grant to Ecotope for Engineering and M&V
- Seattle City Light incentives for calculated energy savings to building developers
- Sunset Electric chosen as first pilot project but stalled in 2010
- Stream Uptown and Stackhouse projects selected as next phase pilot projects

ECOTOPE
CONSULTING
RESEARCH
DESIGN

BONNEVILLE
POWER ADMINISTRATION

Seattle City Light

Project 1: Stream Uptown

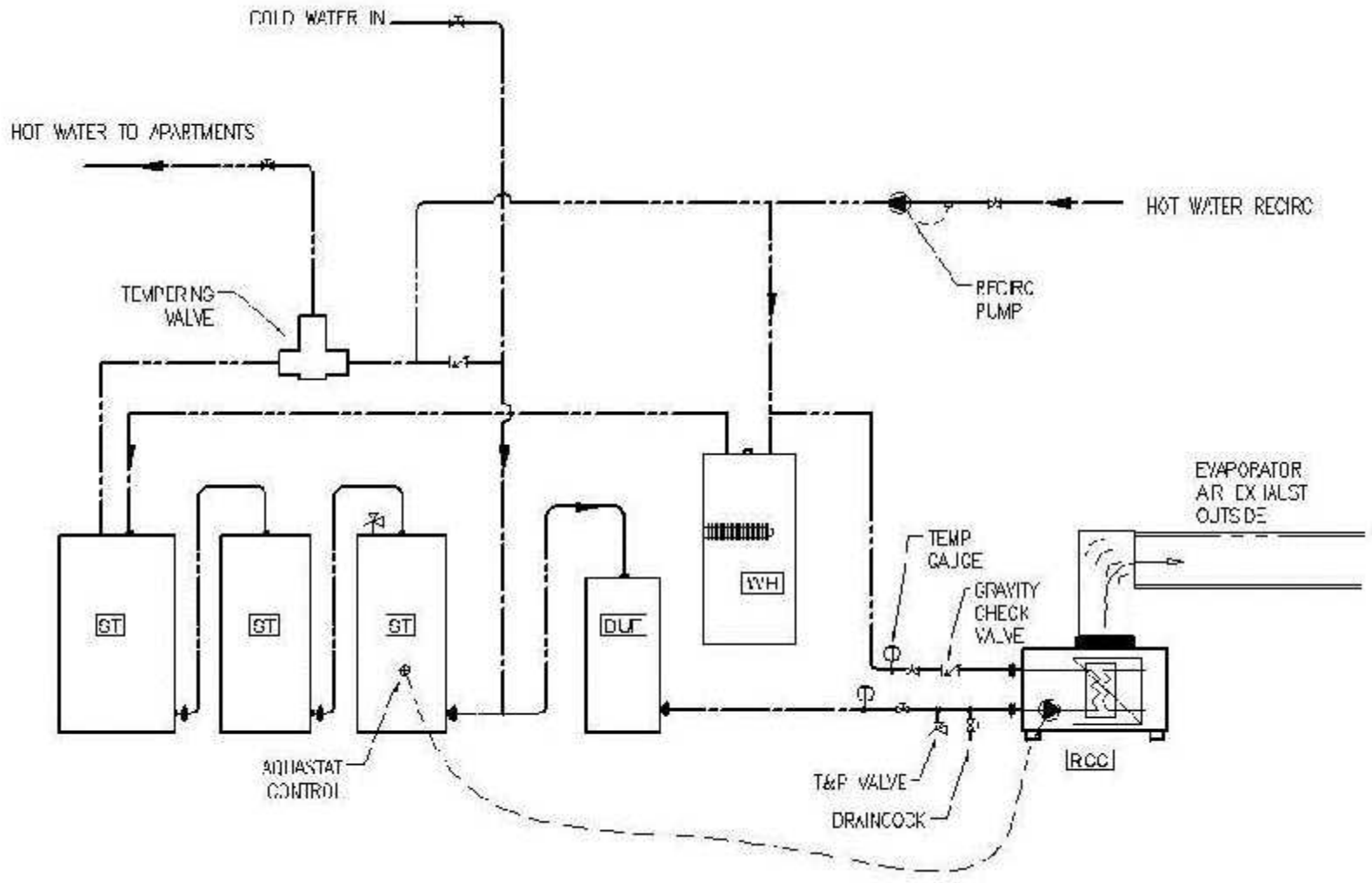
118 apartment units

Relatively small parking garage (96 stalls)

Garage not fully below grade; 4 ft of exposed concrete exterior wall

Competing air to air heat pump system in garage

Stream Uptown: Design Details



Stream Uptown: Design Details

- Two 15-ton RCCs, 800 gallons of storage (in accordance with ASHRAE design guidelines)

- Heat pumps in parallel, originally not connected

- Each heat pump served by three hot water storage tanks, a cold water buffer tank, and back up electric hot water tank.

Stream Uptown: M & V Specification

Data monitored:

- Water temperature in 3 places: at incoming cold water, hot water output from RCCs, tempered hot water for units
- Outside and garage air temperature
- Energy use: Current transducers for heat pumps, back-up heaters
- Water flow meter into hot water system

Goal:

- Measure actual energy consumption per gallon of hot water used at varying temperatures

Stream Uptown: Lessons Learned

Problem:

- Recirculation pumps flow rate set too high and ran continuously.
- Recirculation loop plumbed back to electric tank to make up recirculation losses. Led to unbalance of flow between sides, with one RCC and one electric heater doing all of the work.
- Tempering valves were oversized, creating water mixing issues.

Solution:

- Added aquastats to control recirculation pumps, pumps were converted to variable speed.
- Recirculation loop re-piped to return to the storage tanks instead of electric heater, eliminating use of electric heat.
- Storage tanks have been piped together to balance system.
- Replaced tempering valves with single digital valve to provide better temperature control.

Stream Uptown: Initial Results

- COP of hot water "delivered" during winter season is 1.6.
  - Heat pumps were performing at a COP of 2.2, 30% of heat lost in garage, recirculation system, or pipes in apartments.
  - Performance expected to be significantly better in summer. Measured "delivered" COP for May 2014 is around 2.3.
- System is significantly oversized. Peak flow rates do not approach the rates the system was designed for.
  - ASHRAE standard size calculations may be unnecessarily conservative for modern apartments with low flow fixtures.
- Temperature in garage did not fall below 50 F, including during a record-breaking cold snap.
  - Back-up electric resistance heat is likely not needed.

Stream Uptown:
Rebate and Expected Savings

Expected annual energy savings:	181,900 kWh
Annual savings per apartment:	1,541 kWh
SCL rebate at $.23/ kWh:	$ 41,800
Expected annual cost savings:	$ 12,733
Incremental Cost (approx.):	$ 54,000
Estimated Simple Payback:	1 year

Project 2: Stackhouse Apartments

188 apartments

97,744 sf parking garage (largest of the three)

Parking garage fully underground

No competing air to air heat pump system

Stackhouse Apartments: Rebate and Expected Savings

Expected annual energy savings:	260,800 kWh
Annual savings per apartment:	1,387 kWh
SCL rebate at $.23/ kWh:	$ 52,200
Expected annual cost savings:	$ 18,300

Project 3: Sunset Electric

92 apartments

12,500 sf parking garage (also relatively small)

Parking garage fully underground

No competing air to air heat pump system

Sunset Electric: Informed Design

- Piping between both storage banks and RCCs tied together
- Digital mixing valves provide more consistent output temperature
- Using two-sensor control strategy instead of single aquastat to improve heat pump performance
- Electric backup tanks moved into storage bank, turning them off (only to be turned on if RCCs fail)
- Smaller recirculation pump

Sunset Electric: M & V Specification

Data monitored:

- Water temperature in 3 places: at incoming cold water, hot water output from RCCs, tempered hot water for units.
- Outside and garage air temperature
- Current transducers for heat pumps, back-up heaters
- Water flow meter into hot water system
- BTU meters to RCCS to measure heat loss

Sunset Electric: Rebate and Expected Savings

Expected annual energy savings:	60,000 kWh
Annual savings per apartment:	1,304 kWh
SCL rebate at $.23/ kWh:	$ 13,800
Expected annual cost savings:	$ 4,296

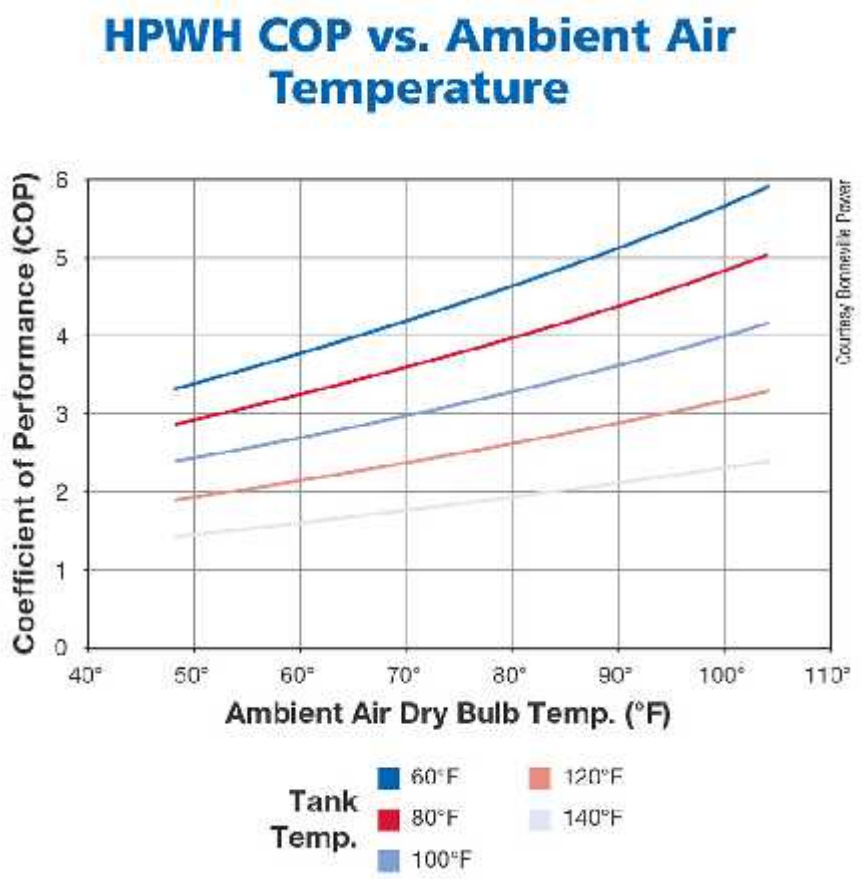
McLellan Apartments: Similar Technology, New Application

46 apartments, six stories

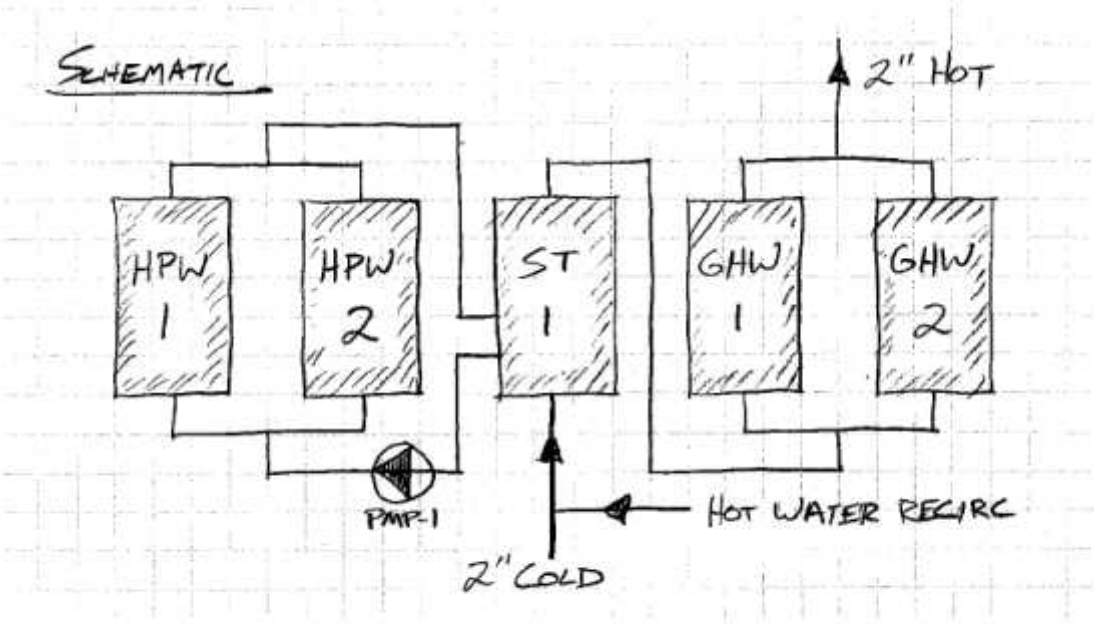
Transit-oriented development

6,824 sf parking garage (too small for RCC system)

McLellan Apartments: Rooftop atrium with passive solar assisted HP hot water heaters



McLellan Apartments: Rooftop atrium with solar assist HP hot water heaters



McLellan Apartments:
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Where Do We Go From Here?

Additional Heat Pump Applications for Multifamily Hot Water Systems:

- Continued refinement of RCC system with performance results from M&V study.

- Ground source heat pumps with closed loop ground well system

- Daikin Altherma split system HP used to preheat water for secondary water heater

- Residential-sized HP tank water heater used to preheat water for secondary water heater

Next Potential Partnerships

Currently proposed to BPA for E3T funding:

- Monitoring & Verification study of solar atrium application for HPWH (McLellan Apartments)

- Creation and publication of system design guidelines: "Heat Pump Water Heaters for Multifamily Buildings in the Pacific Northwest"

Questions?

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Upcoming Showcase Webinars

- *Engine Generator Block Heaters*
- *DHP New Construction Demonstration Project*
- *CEA 2045 – Standard Modular Communications interface for demand response*

(DATES YET TO BE DETERMINED)

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