Reverse Cycle Chiller for Multifamily Pilot - Project Update

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A Report of BPA Energy Efficiency's Emerging Technologies Initiative

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Introduction

This report provides an update on each of the two BPA-sponsored pilot projects for the use of a Reverse Cycle Chiller (RCC) heat pump water heater system for production of domestic hot water (DHW) in multifamily buildings. The two RCC pilot projects have both been designed and permitted; Pilot #2 is currently under construction while Pilot #1 is still awaiting final HUD financing approval.

RCC Pilot Project #1: Sunset Electric

The Weber Thompson designed Sunset Electric building is a 92 unit, 6 over 1 project (6 floors of apartments over commercial and Live+Work units at street level) located in the Capitol Hill neighborhood in Seattle, WA. The project is currently awaiting final HUD financing approval. The project has a building permit, full construction documents, General Contractor and Sub-Contractors ready to begin construction. The developer (Pryde|Johnson) is anticipating starting construction in early spring of 2012.

Figure 1: Sunset Electric Rendering

Design Background

The project is a major renovation of an existing two story building over one level of below grade parking. The apartment configuration is in the shape of a doughnut, with a central courtyard at level L3 where the original building's roof was located. All residential units are located on the perimeter of this courtyard arrangement and have operable openings on the exterior and interior side of the courtyard for increased air movement. The project is seeking a Gold certification from the LEED for Homes Midrise rating system of the USGBC. The project is targeting a 60% reduction in site energy use over a typical code built apartment building.

The key energy measures are:

- RCC heat pump water heater for central DHW production
- Elimination of corridors and corridor systems (lights, pressurization, heating)
- Low-flow plumbing fixtures
- 2009 Seattle Energy Code envelope
- Occupancy sensors for the majority of lights in areas where typically left on 24/7

Sunset Electric has an existing below grade parking garage which will be used to buffer outside air for use in the RCC system. The RCC fans act as the primary garage ventilation system and will be setup to run when CO levels in the garage exceed design thresholds. The parking area was partitioned along the north/south axis (green line Figure 2) to force the outside air to sweep through the garage; picking up internal gains from garage lights, cars, and waste heat from plumbing waste piping as well as to maximize exposure to ground contact prior to entering the RCC.

The hot water heat plant is sized assuming ASHRAE Applications 2011 Chapter 50 Service Hot Water sizing guidelines. The guideline was developed 40 years ago based on extensive testing and metering of various buildings and is therefore conservative given the planned use of low flow plumbing fixtures. The sizing requirements for this design are:

- RCC output capacity (40°F entering wet bulb) = 320,000 Btu/hr (two @ 160,000 Btu/hr)
- Storage Size = 720 gallons (six tanks @ 120 gal)

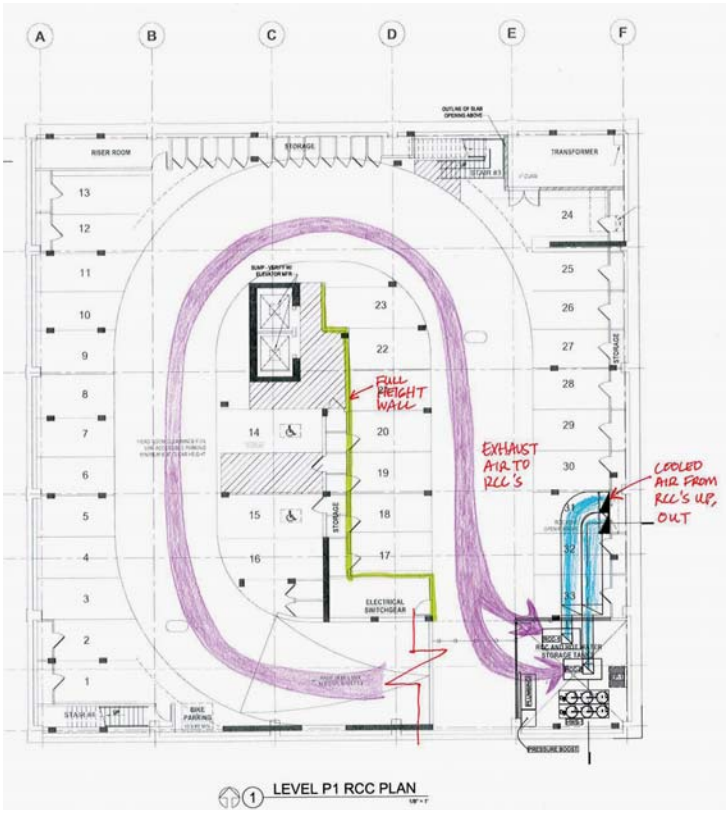

Figure 2: Sunset Electric Garage and Airflow Plan

RCC Pilot Project #2: 6th Avenue Mixed Use

This 118 unit, 6 story apartment project is located in the lower Queen Anne neighborhood of Seattle, WA. The project is currently under construction and is nearing completion of the street level PT Slab concrete pour. Contractor submittals for the RCC are being processed by Ecotope. The RCC heat plant is expected to be installed in early summer of 2012. The building is anticipated to be completed by spring 2013. Figures 3 and 4 show a 3D rendering and garage ventilation plan.

Figure 3: 6th Avenue Mixed Use Rendering (East/West)

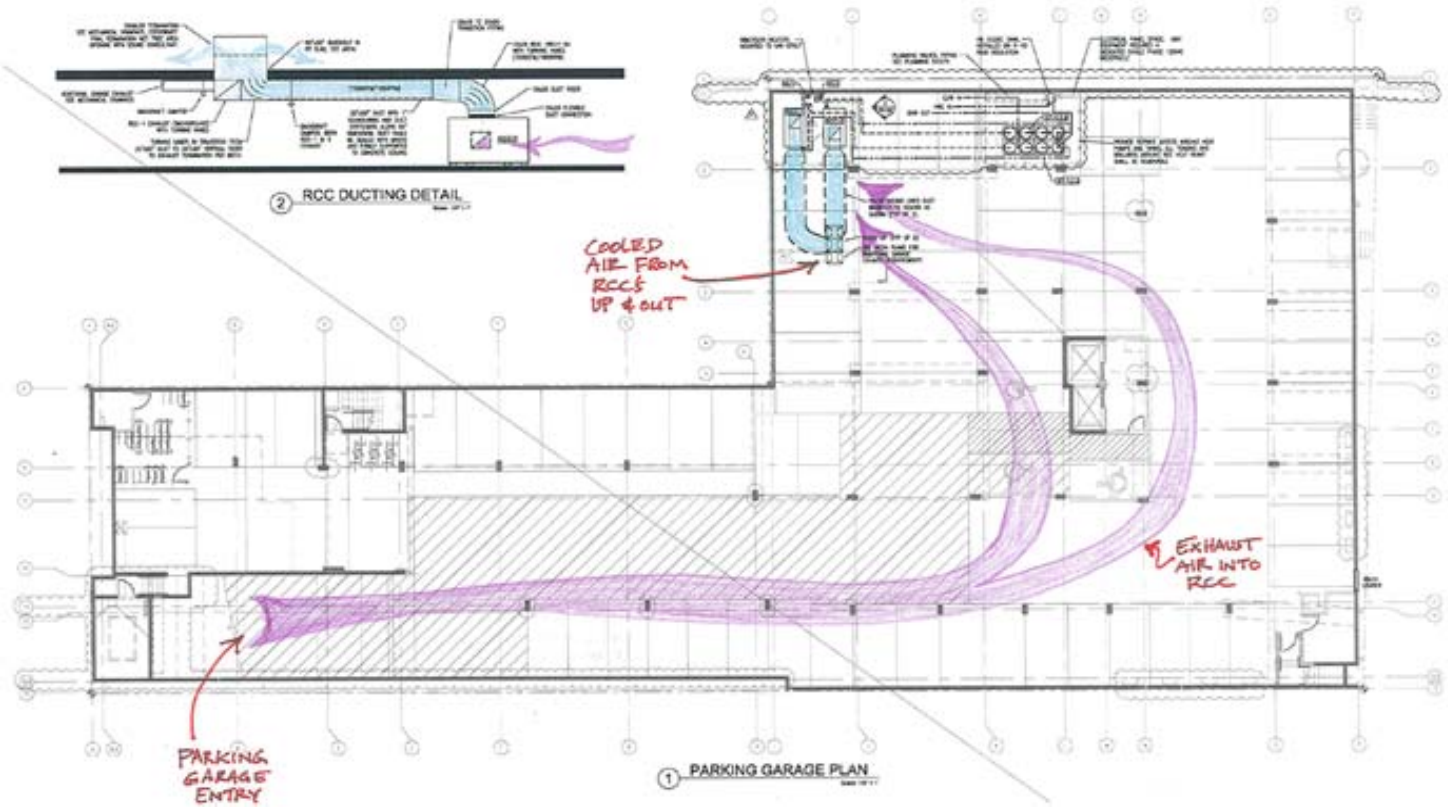

Figure 4: 6th Avenue Garage and Airflow Plan

Design Background

The 6th Avenue Mixed Use project will have 118 market rate apartments built on a currently abandoned parking lot. The apartment configuration is an L shaped design with 60% of the units in a 6-story double loaded corridor wing, and 40% as back to back apartments with motel style exterior entries of 4 stories. The project is seeking a Certified rating from the LEED NC v3.0 rating system of the USGBC. The project is targeting a 60% reduction in site energy use over a typical code built apartment building. The key energy measures are:

- RCC heat pump water heater for central DHW production
- 80% of the apartment units have ductless heat pumps
- Elimination of 40% of corridors and corridor systems (lights, pressurization, heating)
- Low-flow plumbing fixtures
- 2006 Seattle Energy Code envelope
- Occupancy sensors for common area lights (corridors and parking garages)

The 6th Avenue project has a one story below grade parking garage which will be used to buffer outside air for use in a RCC located in the garage. The RCC fans act as the primary garage ventilation system and will be setup to run when CO levels in the garage exceed design thresholds. This parking garage is larger than the Sunset Electric project and requires an additional exhaust fan to meet minimum parking garage exhaust rates. The RCC heat plant is placed in the opposite corner of the parking garage entry to force the outside air to sweep across all internal gains from garage lights, hot cars, and waste heat from plumbing waste piping, as well as maximizing exposure to ground contact prior to entering the RCC.

The hot water heat plant is sized assuming ASHRAE Applications 2011 Chapter 50 Service Hot Water sizing guidelines. The sizing requirements for this design are:

- RCC output capacity (40°F entering wet bulb) = 320,000 Btu/hr (two @ 160,000 Btu/hr)
- Storage Size = 830 gallons (two tanks @ 175 gal & four tanks @ 120 gal)

Pilot Project Design Challenges

Both RCC pilot projects wanted to push the bounds of their multifamily offerings and set out to design LEED rated apartments that use 60% less energy than a typical code built multifamily building. Both projects were very interested in the RCC system from a sustainability and marketing standpoint. The primary reasons for adopting this measure were marketing advantages, LEED points, operating cost savings, and utility incentives.

Because the designs are very similar, Ecotope encountered the following challenges for both projects during the design process.

1. Relocating the hot water plant to the farthest reach of the parking garage to maximize the heat transfer effectiveness (see Figures 2 & 4). The relocation required that a bit more cold water piping be installed as the RCC location is at the opposite corner of the cold water main (upper left corner Figure 2). In the Sunset Electric building, the parking garage was partitioned down the center to force the make-up air to sweep across more of the parking garage gains (lights, hot cars, waste piping losses and ground contact).

2. Locating the RCC exhaust to comply with building codes that require 10' separation from garage exhaust and any operable opening back into the garage or living spaces above. Though this challenge is not unusual for mixed-use buildings with below grade parking garages, some projects choose to install multiple smaller fans to lessen the impact of large louvers on the street front façade. Since the RCC utilizes all of the exhaust air, the larger single location louvers required planning and coordination with architectural and structural elements. For the 6th Avenue project, we made all operable windows within 10' of the exhaust fixed and moved entry doors to alternate locations.

3. Fitting the larger than normal DHW heat plant in the parking garage while providing adequate service access proved difficult. As a result, these two systems are sized for more storage with less capacity over other central water heating systems because adding more RCC capacity costs much more than additional storage.

4. Hot water storage tanks were designed to make maximum use of temperature stratification and to minimize the need for back-up heating. The heat pumps were set up as a single pass configuration to output a fixed delivery water temperature of 130F (adjustable from 120-160F). This was selected over the original design using a multi-pass arrangement. An additional small cold water buffer tank was added to the design to guarantee that cold City water always enters the heat pumps before mixing with warm water.

5. Ecotope worked with *Colmac Industries, Inc*. to modify their standard HPA-15 Reverse Cycle Chiller product line. Because Colmac builds their products based on a Just-In-Time demand schedule, the modifications are easily accommodated by the factory given ample lead time. The specific modifications that were required for this configuration are:

a. Centrifugal fans were selected in lieu of axial fans for primary air movement across the RCC evaporator coils. Since we are ducting this air to the outside through ductwork and louvers, we required a fan with at least 0.5" external static pressure.

b. The RCC cases had to be re-configured for upflow exhaust out of the top of the unit. The standard product is setup to draw air through one side and out the other side. The upflow exhaust design saves valuable floor space in the garage.

c. Colmac had to add control logic to the RCC's Programmable Logic Controller (PLC) to accommodate an external call to run fans only when the garage CO sensors makes a call for exhaust. Additional logic was required to set fan priority for DHW heat demands and alarm conditions.

Next Steps

The two pilot projects are about 8 months apart in construction schedules. The following next steps will apply to both of these projects as their respective construction schedules demand.

1. Drawing and cutsheet submittal review by Ecotope engineering staff
2. Procurement and Installation of M&V equipment
3. RCC Installation and Construction Administration
4. Commissioning
5. Performance monitoring
6. Final evaluation

The next pilot project progress update will occur when the 6th Avenue Mixed Use project has been installed and commissioned. This will be followed by the same deliverable for the Sunset Electric building, pilot project #1.