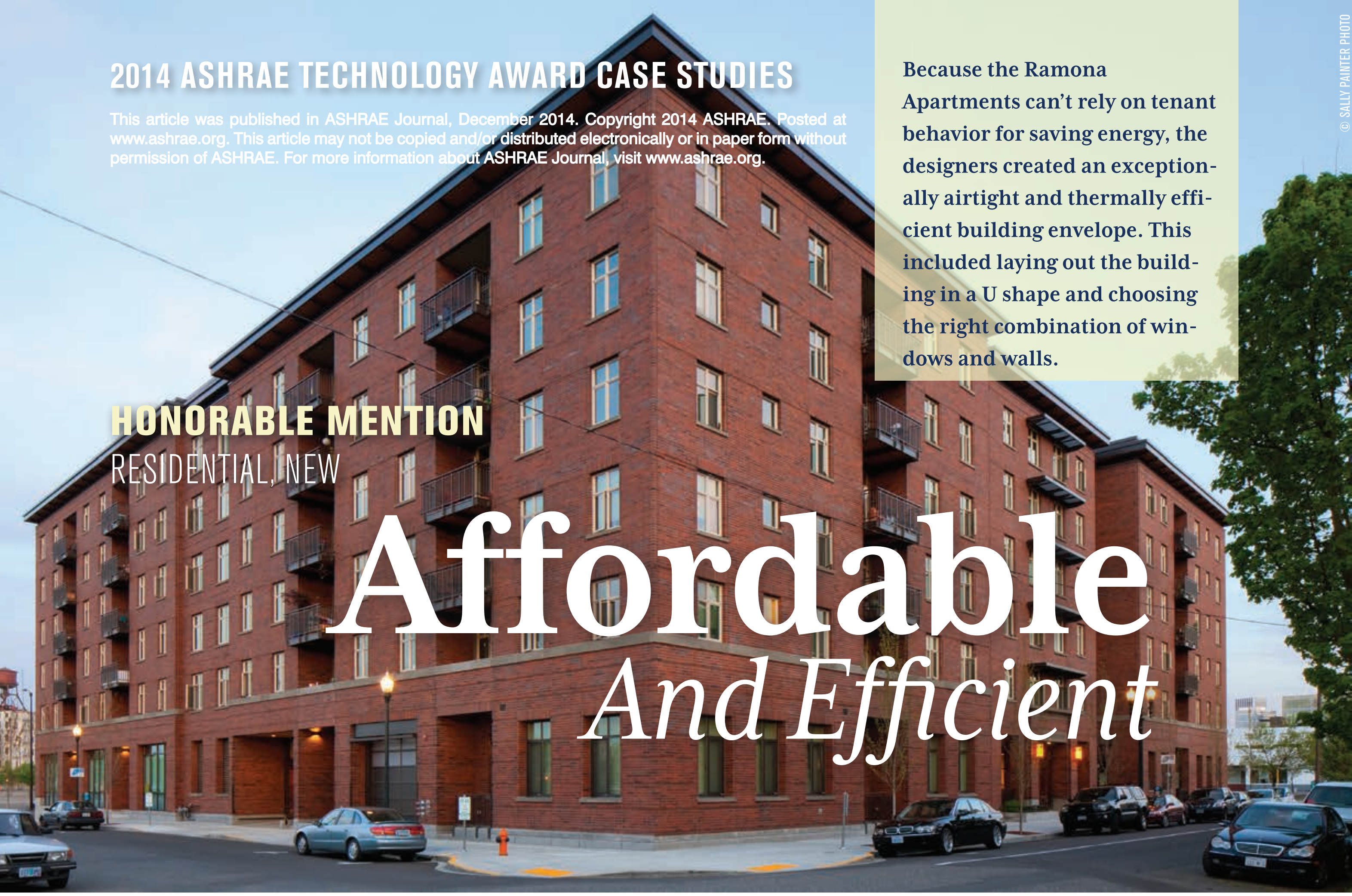

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Because the Ramona Apartments can't rely on tenant behavior for saving energy, the designers created an exceptionally airtight and thermally efficient building envelope. This included laying out the building in a U shape and choosing the right combination of windows and walls.

HONORABLE MENTION
RESIDENTIAL, NEW

Affordable *And Efficient*

BY ANDREW PAPE-SALMON, P.ENG., MEMBER ASHRAE; ED MCNAMARA; ARIEL LEVY, P.E., ASSOCIATE MEMBER ASHRAE

BUILDING AT A GLANCE

Ramona Apartments
Affordable Housing

Location: Portland, Ore.

Owner: Nurture 247 Limited Partnership

Principal Use: Rental housing (income-restricted)

Includes: Early Childhood Education Center on ground floor

Employees/Occupants: About 4 onsite staff and 363 occupants in 138 apartments

Gross Square Footage: 230,762

Conditioned Space Square Footage: 188,606

Substantial Completion/Occupancy: 2011

Occupancy: 99.25%

National Distinctions/Awards: Multifamily Executive—2012 Project of the Year Merit Award – Affordable Housing; NAHB – 2012 Pillar of the Industry—Finalist

The Ramona is a model for high-efficiency in a multifamily residential building with low incremental construction costs. The primary design objective for the Portland, Ore., apartments was to pursue a high performance building envelope as a precursor to whole-building energy efficiency.

Building Description

The Ramona Apartments provides 138 units of affordable housing that is targeted at families with children. Completed in March 2011, the Ramona is a 230,760 ft^2 (21 400 m^2), six-story building with one level of underground parking. There are five stories of wood frame construction above a concrete podium. The ground floor includes 12,864 ft^2 (1200 m^2) of space leased to Portland Public Schools for an early childhood education center and 1,760 ft^2 (164 m^2) leased to a non-profit community group. The upper floors contain apartments, mostly two-bedroom and three-bedroom units. The building is certified at LEED Gold.

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ABOVE At 31,597 ft^2, this was the largest contiguous ecoroof in Portland in 2011. The roof is planted with drought-tolerant native species, has PV panels on the south half and solar water heaters on the north half.

LEFT The courtyard sits above an underground parking garage, but is designed with a drainage system that filters all of the stormwater before it drains to the municipal storm sewer.

Problem to be Solved

The project team set out to meet the Architecture 2030 Challenge for reducing energy use by 50% from other existing, similar buildings (http://tinyurl.com/qaq66fy). Besides the technical challenges, there were two complicating factors:

- In an apartment building of this type, tenants control most of the energy use. The design could not rely on complicated systems or on central controls.
- The budget, already limited by the financing of affordable housing, was further constrained by the difficulty of obtaining financing in 2009.

The design and construction process aimed to maximize collaboration between team members who had worked together on several projects and could build on the relationships and on the lessons learned. From the very beginning of design, everyone was at the table and the major subcontractors were active participants. Before making design decisions, the team analyzed multiple options, modeled the energy savings, and tested the pricing. The team put a great emphasis on an airtight, thermally efficient building envelope. This was considered the most cost-effective way to get energy savings, the best way to reduce reliance on tenant behavior, and a good strategy to avoid future maintenance costs related to maintaining equipment.

Design Process and Decisions

Building Enclosure

The team's first step was to design an efficient building and an efficient envelope. The team began by studying eight to 10 massing models and assessing them for cost and energy efficiency as well as for aesthetics and for suitability for the site. The U-shaped design that was selected provided a high ration of floor area to skin and, therefore, provided the most energy-efficient shape. The team developed and priced 12 different options for framing and insulating the exterior walls. Each of the 12 wall assemblies was modeled, including calculation of an overall R-value for the opaque walls and glazing. Three different window performance levels were considered for the initial models (U-0.45, U-0.35, and U-0.29); a total of 36 possible assemblies were analyzed. The energy model showed that the windows were extremely important. The least performing opaque wall with the best window had a better R-value than the best performing opaque wall with the U-0.45 window.

Focus was put on finding energy efficient windows and reducing the overall window to wall ratio. Smaller windows were put in the bedrooms where they weren't needed as much during the daytime; larger windows were put in the living areas. Screens were added to shade living room windows on the south and west elevations (if they weren't already shaded by a balcony). The windows are vinyl casement with a high performance U-value of 0.26, exceeding the standard for ASHRAE Standard 90.1. The windows have low air infiltration as a result of a design that includes three layers of gasketing and cam locks that have three contact points. Balconies have fiberglass doors with U-value of 0.26 and air infiltration rating of 0.03 cfm/ft^2 (0.15 L/s·m^2).

Exterior wall insulation is blown-in cellulose within the stud cavity rated at R-23 nominal. The exterior cladding is brick veneer. The calculated effective overall R-value of the wood-framed walls, accounting for framing and thermal bridging, is R-16. Additional exterior insulation is installed outboard of sheathing in small areas of steel stud framing. Full exterior insulation was considered, budget constraints focused the team's attention elsewhere. The roof has two layers of rigid insulation under a two-ply SBS membrane over wood trusses for an effective R-32. Continuous layers of insulation minimize thermal breaks. The eco-roof (planted roof) includes soil and native vegetation to reduce summer heat gain. The interior apartment ceilings and party walls have R-11 batts installed for acoustic separation and to reduce heat transfer between units. Putty pads are wrapped around all electrical boxes on party walls to reduce airflow and sound flanking paths. All balconies are mounted on four knife-plates rather than more traditional cantilevered beam or ledger attachments to simplify detailing and improve rainwater management.

The building enclosure airtightness was achieved with a continuous building wrap air barrier with taped joints at exterior walls, sealant at vertical joints on wall sheathing for additional protection, detailed window wrapping with self-adhesive membrane and sealants and carefully detailed wall-to-roof membrane tie-in. Airtightness was tested at 0.22 cfm/ft^2 at 75 Pa as part of the research effort, "ASHRAE 1478 RP: Measuring Air-Tightness of Mid and High-Rise Non-Residential Buildings." The whole-building air testing and the thermal image photographs taken during pressurization revealed some leakage that the team corrected. The building was not retested after corrections, but was most likely improved.

Apartment Systems

The apartments use electric heat. Because there was so little heat loss through the envelope, this was the most sensible heating system. The heat is a combination of baseboard in sleeping rooms and wall-mounted, fan-forced units in living and dining rooms. Each room has its own heater that is sized to that space, and each heater is controlled by an electronic thermostat with digital settings and simple controls including an on/off switch.

One-hundred percent outdoor makeup air is conditioned and is ducted directly into each apartment. Central continuous exhaust fans pull air from bathrooms and kitchens and return it to an energy recovery ventilation system at the two roof-mounted central makeup air units.

The apartments do not have air conditioning. Each room has a ceiling-mounted fan with wall-mounted controls for turning the fan on and for controlling its speed.

Common Area HVAC

The makeup air system includes two air-to-air heat pumps to space condition hallways and lobbies (also providing the fresh air to the apartments). These are capable of providing 100% outdoor air to conserve

Large common laundry rooms on each floor have high-efficiency equipment. The front loading machines have lower costs for cold-water washes..

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energy for cooling service. Integrated energy recovery wheels are 65% to 70% effective. Blowers and fans are VFD controlled. There are separate air-source heat pumps for each laundry room (five units, 1.5 ton [5 kW] each) and for the fitness room and leasing office (2.5 to 4 ton [9 to 14 kW], with built-in economizers). All common area HVAC is controlled by programmable thermostats with local sensors and controls in secure office spaces.

Domestic hot water is supplied by high-efficiency central boilers.

The team selected a machine room-less elevator using one-third as much energy as a hydraulic system.

All lighting fixtures in the apartments are fluorescents with high-efficiency integral ballasts. Common area lighting uses high-efficiency ballasts and lamps. In addition, occupancy sensors are used to control the lighting in offices, bathrooms, recycling rooms, and other similar rooms. Photocells and timers are used to control exterior lighting.

Kitchen appliances in the apartments are Energy Star rated. Common area laundry rooms on each floor have high-efficiency front-loading washing machines and gas dryers with higher prices for warm and hot water modes. A separate MEP engineer was used to provide commissioning services that included:

- Review of the plans at 50% stage;
- Inspections of the work during installation;
- Written start-up procedures for major equipment and oversight of the start-up process; and
- Final commissioning of the installed equipment.

Water Conservation

Toilets use 1.28 gallons per flush, some of the most efficient toilets that were available at the time. As an example of the innovative and mindset of the

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developer, one floor has dual-flush toilets and the owner is collecting data for five years to track the difference in water use per floor. Showerheads use 1.5 gpm (95 mL/s), which is more efficient than required by code. Low-flow aerators at the kitchen and bathroom sinks help reduce water use. Water submeters are installed so that occupants pay their own water and sewer bills, promoting conservation and lowering rent.

TABLE 1 Energy baseline, actual consumption and reductions for the project in the first year of operations.

KWH PER YEAR	ELECTRICITY	NATURAL GAS	TOTAL ENERGY	ENERGY USE INTENSITY (KWH/FT²/YR)	ENERGY USE INTENSITY (KBTU/FT²/YR)
Year 1	812,761	385,497	1,198,258	5.48	18.71
Year 2	832,836	378,412	1,211,248	5.54	18.91
Year 3	844,042	419,157	1,263,199	5.78	19.72

Architecture 2030 EUI target (50%) for Northwest multi-family residential: 20.0.

Landscaping includes plants that minimize the need for irrigation. Efficient drip irrigation is installed where possible. Rain sensors are installed so that the irrigation won't run when it isn't needed. Overall, water use per capita is about one-third of the average use per capita reported by Portland's Water Bureau. This focus on efficient fixtures and appliances results in less energy needed for domestic hot water heating.

Indoor Air Quality (IAQ)

Given the attention to constructing an airtight envelope, it was imperative to pay extra attention to indoor air quality. The first step was to use materials (i.e., sealants, paints, adhesives, carpet and pads, formaldehyde-free cabinets) with little or no off-gassing of VOCs. The next step was to ensure good exhaust and fresh, balanced makeup air (MUA). As noted, there is a system for continuous exhaust ventilation from kitchens and bathrooms with MUA ducted directly into the apartments. This is superior to the conventional approach used in most apartments of relying on air leakage through the building enclosure for fresh air (causing cold drafts) and/or MUA coming under the apartment door from the hallways. IAQ is maintained without a significant impact on energy consumption due to energy recovery in the MUA system.

Renewables

After designing the envelope and selecting the most efficient equipment, the final step was to use solar energy to produce as much of the energy as was economically feasible:

- **Solar hot water.** An array of 64 panels (4 ft × 10 ft [1.2 m × 3 m]) on the north half of the roof supplies about 50% of the hot water heating.
- **Photovoltaic panels.** A 29.92 kW PV system is installed on the south half of the roof. Actual production over three years has averaged 34,195 kWh per year, approximately 8% more than forecast.

Energy Data (Residential Use Only)

The energy baseline, actual consumption and reductions for the project in the first year of operations are shown in *Table 1*. There are a few factors to consider in looking at the data.

- The energy use intensity (EUI) has increased slightly each year. Gas use is 3.8% higher than the first year and electricity use is 1.7% higher than the first year.
- **Increase in density.** The number of residents has increased over three years. At the end of 2011, there were 338 residents. A year later, there were 354. At the end of 2013, there were 360. At the end of July 2014, there were 363. This increase—7.4% over 2.5 years—could explain the increase in natural gas use because natural gas is used almost exclusively for water heating and the clothes dryers. The number of residents has increased over three years. At the end of 2011, there were 338 residents. In 2012, 2013 and 2014, there were 354, 360 and 363 residents, respectively. This amounts to an increase of 7.4% over that 2.5 years. This growth could explain the differing energy usage over that same timeframe, which increased by 5.4%. However, the actual energy use per capita actually decreased.

Innovation

The Ramona's innovation was a reliance on teamwork during the design and construction process. The developer's philosophy was that mechanical equipment will wear out every 15 years and will probably be replaced with more efficient models; but you only get one chance to build the envelope right. The design team focused extensively on a high performance building enclosure to improve building energy efficiency, affordability, comfort and acoustic separation from urban noise.

Reducing heat loss meant savings on capital costs of the HVAC systems. All aspects of the building enclosure and mechanical systems exceeded the building code energy efficiency standards. Careful attention was placed on making the air barrier as continuous as possible, noted in the energy efficiency section and demonstrated through the whole-building airtightness results.

When the original bike room with 180 racks got overcrowded, the developer removed three car parking spaces and added this second room for another 40 bikes.

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Cost Effectiveness

The capital cost of the Ramona—not including tenant improvement work—was \$127/ft^2 (\$1367/m^2) (a cost that was artificially high due to wage requirements that came with public financing). This is significantly lower than other high performance (green) buildings where costs can be at $250/ft^2 ($2691/m^2) or more. The incremental capital costs of the high-performance envelope and mechanical systems noted in this application are estimated at $4.2/ft^2 ($45/m^2) compared to a code-compliant building. The payback on investment is estimated to be under 10 years.

Conclusion

While the authors are cautious about drawing broad conclusions, some observations are as follows:

- **Importance of the building envelope.** In this climate and for this building type, a well-designed building envelope is a cost-effective way to achieve significant energy savings.
- **Importance of the air barrier.** The design team discussed many options for the air barrier system, but only clarified its performance at the time of whole-building airtightness testing. The industry would benefit from widespread whole-building airtightness testing, comparing various air barrier solutions.[1]
- **Changes in design.** Avoid design changes during construction. Given the inevitable, assess necessary changes carefully for their impact on the air barrier. During construction on the Ramona, changes to a cornice detail were implemented for constructability purposes, but air-barrier detailing modification was less successful. Whole building testing revealed the subsequent air leakage paths, which were later repaired.
- **Construction administration.** Many trades handle the air barrier before it is finally enclosed. It is important for the design team to communicate the importance of the air barrier to the entire construction team.

This case study demonstrates an achievement of the Architecture 2030 Challenge goal (20 kBtu/ft^2) for an affordable apartment building.

References

1. Jones et.al. 2014. "Building Enclosure Airtightness Testing in Washington State—Lessons Learned about Air Barrier Systems and Large Building Testing Procedures." ASHRAE Winter Conference. ■

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