Shaw Construction built 84 energy-efficient, affordable condominiums for the City of Aspen that achieved HERS scores of less than 62 with help from Building America's research team lead Building Science Corporation. *(Photo Source: Shaw Construction)*

Building America Best Practices Series

Volume 12. Builders Challenge Guide to 40% Whole-House Energy Savings in the Cold and Very Cold Climates

Case Study: Shaw Construction

Burlingame Ranch Phase 1 | Aspen, CO

BUILDER PROFILE

Builder: Shaw Construction
www.shawconstruction.net

Where: Aspen, CO

Founded: 1962

Development: Burlingame Ranch

Construction Dates: 2005–2007

Size: Phase 1: 84 units in 15 multi-family buildings. Total build out: 248 units in 30 multi-family buildings plus 10 single-family homes: one- and two-story, 1-, 2-, or 3-bedroom, avg. 1,325 ft^2

Price Range: Subsidized housing

Aspen, Colorado's winter wonderland setting has attracted myriads of the rich and famous, but the town's resort home prices have made subsidized housing a necessity for most of the working class families of the community. Over the past 30 years, the City of Aspen has organized dozens of affordable housing projects. In 2007, Aspen completed Phase 1 of its largest and most energy-efficient project to date, the Burlingame Ranch community, where it has achieved Home Energy Rating Scale (HERS) scores of 54 to 62 on 84 condominium units, with assistance from the U.S. Department of Energy's research team lead Building Science Corporation and the National Renewable Energy Laboratory.

To make homes that are truly affordable, the city has increasingly encouraged energy-efficient home construction. In 2004, the city took bids to design Phase 1 of Burlingame Ranch, an affordable housing development that will eventually number 258 units. For Phase 1 the city selected Shaw Builders of Grand Junction, Colorado, and the design team of Bill Poss Architects and DHM Design. The city also asked the Building Science Corporation to participate.

BSC helped design the project's energy-efficiency measures and solar hot water and heating systems, and reviewed energy code compliance reports. In 2007, BSC worked with DOE's National Renewal Energy Laboratory to conduct field testing of the mechanical, solar, and ventilation systems and short- and long-term monitoring of one of the buildings before and after homeowners moved in.

In Phase 1, all 84 homes met the Federal Tax Credit goal of 50% savings over the 2004 International Energy Conservation Code (IECC) and the Building America target of 40% savings over the Building America benchmark (a home built to the 1993 Model Energy Code).

Building America® U.S. Department of Energy

(top) Deep overhangs and deciduous trees provide shade from intense Colorado sun. Low-maintenance exterior materials like cement siding and composite decking are specified. *(Photo Source: Ed Hancock, National Renewable Energy Laboratory)*

(bottom) Even snow cover and lack of icicles show the roofs are well insulated with little air leakage from the sealed attics. Two layers of ice and water shield are used for ice dam protection. *(Photo Source: Shaw Construction)*

Building in Snow Country

- Reduce the need to move or store snow. Face entrances, driveways, and walkways to south.
- Don't locate balconies, stairs, parking, or entrances at eaves.
- Design to avoid ice dams – use two layers of ice and water shield on roof. Place any roof penetrations high toward the ridge. Air seal well.
- Avoid electric snowmelt systems and gutters.
- Protect entrances under overhangs or gable ends.
- Use evergreens for windbreaks and direct drifting away from entrances.
- Use low-maintenance, high-durability exterior cladding, decking, and roofing.

Energy-Efficiency Features

Energy-saving features include a spray-foamed building envelope for excellent air tightness and thermal performance. The 2x6 24-inch-on-center advanced framed walls were filled with high-density spray foam insulation to R-24. The unvented attics were spray foamed with R-50 worth of insulation in cathedralized roof sections and R-38 under flat roof sections.

The edges of the slab foundation were covered with R-13 of XPS rigid foam insulation. Some units had walk-out basements insulated with R-13 (2 inches) of polyisocyanurate on the interior of the basement walls. Basement floors were insulated to R-28 with 4 inches of high-density, closed-cell spray foam that was sprayed directly onto the 4-inch layer of gravel under the foundation slab; this foam served as a vapor barrier as well.

The one- and two-story units were clustered in buildings containing two, four, six, or eight units per building. Each building has a central mechanical room containing two 93% AFUE condensing gas-fired boilers to provide hot water for the hydronic baseboard heating systems as well as domestic hot water. The domestic hot water is preheated from a solar hot-water system consisting of 192 ft^2 of solar panels mounted on the roof of each building with a 120-gallon storage tank located in the mechanical room.

In Phase 2, the City will request individual water- and space-heating systems, said Steve Bossart, project manager of the City's capital assets department, because the City believes that individual furnaces and water heaters provide more incentive for individuals to conserve water and energy, and reduce homeowner association maintenance of the complex central systems. For Phase 2, the City is considering gas furnaces or electric baseboard heating. Because the building enclosures are so efficient, large furnaces are not needed. The City is also considering individual solar hot-water heating.

Ventilation is provided with continuous heat-recovery ventilators (HRVs) in each unit. There is no installed cooling system. Windows are low-emissivity, double-glazed, and fiberglass-framed. ENERGY STAR compact fluorescent lamps provide 90% of the lighting and units come with ENERGY STAR dishwashers, refrigerators, clothes washers, and ceiling fans installed. A passive radon-protection system was installed.

Each dwelling unit was tested for whole house air leakage by a third-party tester (Lightly Treading Inc. Energy & Design of Denver, who also did the ENERGY STAR rating certifications). Infiltration was found to be 2.5 $in.^2$ leakage area per 100 ft^2 of envelope.

One building was outfitted with a roof-mounted 10-kW photovoltaic panel array for electricity production.

Bossart noted that in Colorado, pounding sun and heavy snow loads can take a toll on building materials. "Our area has extreme sun exposure year round. Anything we can do to specify low-maintenance exterior materials saves time, money, and manpower for the owners. Also, shielding western exposures from intense afternoon sun is important," said Bossart.

The builder on Phase 1, Shaw Construction of Grand Junction, Colorado, took an especially proactive approach in developing a "sustainable culture" on the Burlingame project. Rock crushers were set up to crush rock onsite to use for backfill, rip rap, and gabion basket retaining walls. Long-lasting and sustainable building products were installed including bamboo flooring, wool carpet, Forest Stewardship Council (FSC) wood, finger-jointed studs, cement siding, metal roofs or 50-year shingles, fiberglass-framed windows, corn-based closed-cell insulation, prefabricated roof trusses, and offsite panelization of wood framing walls. Shaw used native grasses for landscaping and a planted, open-ditch concept for water runoff control. Shaw made a concerted effort to use local materials like local cement and drywall, and standing dead wood for columns.

"This project did not simply use sustainable products, everything about this project is sustainable. From the time workers carpooled in each morning to the time the workers cleaned up their work areas and put their trash into segregated recycle containers at the end of the day, the workers helped this project be "sustainable" in every way," said David Hall, project manager for Shaw Construction.

Dollars and Sense

Because homes in Aspen are so expensive, demand for the affordable homes at Burlingame Ranch was very high, with up to 30 applications for every unit. All of the units were sold before completion with buyers chosen by lottery. "The city sponsors these subsidized projects to sustain a professional working class in the city limits," said Bossart. Projects are funded via a real estate transfer tax or bonds.

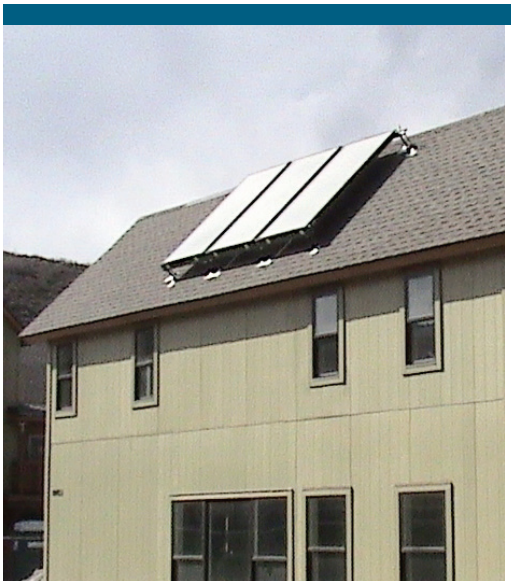
Building Science Corporation calculated the added costs of building to the designed level of 51% more efficient than a home built to the Building America benchmark (a home built to the 1993 MEC). For one unit the added cost was approximately $6,180 in upfront costs, with almost half of this coming from the solar hot water system (see Table 1 below).

Energy-Efficient Features

- 51% energy savings over Building America benchmark
- Estimated cost savings $775 per unit
- R-50 high-density foam at sloped roof, R-38 at flat roofs
- 2x6, 24-inch on-center advanced frame stud walls with 3.5 inches of high-density spray-foam cavity insulation (R-24)
- Slab insulation with 2 in. XPS perimeter insulation extending 2 ft below grade
- Milgard fiberglass-framed, double-pane windows, U = 0.37, SHGC = 0.33
- 10-kW PV system (on one building)
- Roof-mounted solar thermal panels for domestic hot water (on all buildings)
- 3rd party whole-house air-leakage testing of every unit. Infiltration averaged 2.5 $in.^2$ leakage area per 100 ft^2 envelope
- 93% AFUE condensing boiler in conditioned space
- Heat-recovery ventilator
- 90% hard-wired fluorescent lighting
- ENERGY STAR dishwasher, refrigerator, clothes washer, ceiling fans
- Water-conserving faucets, showerheads, and toilet

"Superior enclosures with heat-recovery ventilation have allowed us to reduce heating costs and maintain indoor air quality."

Steve Bossart, *City of Aspen*



Solar water heating panels were mounted on each multifamily building to provide domestic hot water and pre-heat water for the hydronic baseboard space heating system.

Table 1. Added Costs and Savings of Energy-Efficient Measures for Shaw Construction

Total Energy Savings	51%
Total Added Builder Costs (per unit)*	$6,178
Annual Mortgage Payment Increase**	$498
Annual Utility Savings	$775
Annual Net Cash Flow to Homeowner	$277

*Costs are based on builder estimates, RS Means, DEER, and manufacturers' data. These costs do not reflect rebates, incentives, and subsidies. Costs assume a 10% builder markup.

**The annual mortgage payment is an estimate based on a 30-year mortgage with a 7% fixed interest rate.

When these costs are spread over a 30-year fixed-rate mortgage at 7% interest, the increased annual mortgage cost is $498. The measures incorporated in the homes to achieve the 51% savings would provide $775 per year per unit in utility cost savings, based on local electricity and natural gas prices, which are relatively low. When the annual mortgage increase is subtracted from this, results still yield a positive cash flow to homeowners of $277 per unit.

The Bottom Line

"This project was a great model for us and has helped promote energy-efficient construction to all of our employees and clients. Staying at the forefront of energy-efficient construction helps keep Shaw ahead of our competition. It differentiates us from the pack," said David Hall, project manager for Shaw Construction.

For More Information

www.buildingamerica.gov
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
eere.energy.gov/informationcenter

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

PNNL-SA-76317 December 2010