Zero energy buildings (ZEBs) operate with high efficiency and produce enough clean energy on site to meet or exceed their energy usage on an annual basis.

HARC is a nonprofit conducting research on energy, air, water, and climate. Its headquarters is a certified ZEB and serves as a Living Laboratory.

See the full report by the Pacific Northwest National Laboratory

### BUILDING ENVELOPE

The highly energy-efficient envelope protects against thermal bridging and moisture problems in a hot, humid climate. Testing showed air leakage is 75% less (better) than the standard.¹

- **Walls:** HARC’s 21% window-to-wall ratio (WWR) is better than the 40% standard¹ and <30% guidance² for this climate. The wall U-value (0.058 Btu/h-ft²-F) is 30% better than the standard,¹ and the materials reduce condensation.

- **Roof:** Five-inch-deep polystyrene insulation over metal provides R-32—28% better than the standard’s R-25 value.¹

- **Continuous insulation and cladding:** Exterior wall insulation extends to the underside of the roof deck to minimize thermal bridging. A gap behind the metal rain screen lets heated air escape via a top vent—reducing solar gains and cooling loads.

### SOLAR ENERGY

The south orientation and sloped roof are suited for solar panels. HARC receives $1,000 in utility credits/year.

- **Solar panels:** The 252 roof-mounted PV panels (30% of gross floor area) generate 88kW of DC power using five inverters.

- **Cost/benefit:** The full PV system cost $157,000 ($8.46/ft² or ~$2 per Watt). It saves ~$11,000 on electricity and avoids over 85,000 pounds of CO₂ emissions each year.

¹ ANSI/ASHRAE/IES Standard 90.1-2019 ² AEDG
## DAYLIGHTING & FENESTRATION

One-inch, double-pane insulated windows are strategically placed to balance heat gains/losses with occupant comfort (based on outdoor views and daylighting).

- **Glazing**: Insulated glass windows provide a U-value of 0.29 Btu/h-ft$^2$-F.
- **SHGC/VT**: HARC balances a low solar heat gain coefficient (SHGC) of 0.27 with a high visible transmission (VT) of 0.64.
- **Framing**: Thermally broken aluminum provides a U-value of 0.92 Btu/h-ft$^2$-F.
- **Assembly U-Value**: The overall building assembly U-value is 0.315 Btu/h-ft$^2$-F.

## ELECTRIC LIGHTING

Technology, design, and controls help lower HARC’s lighting energy use to 30% below (better than) the standard.\(^1\)

- **Technology**: All fixtures use LEDs with >90 lumens/Watt.
- **Design**: Suspended fixtures provide direct/indirect linear lighting with minimal glare to assure comfort.
- **Sensors/Controls**: Simple occupancy and daylight sensors dim or turn off 95% of lights when not needed. Sensor settings adjust to suit occupant preferences.

## PLUG LOADS

Plug loads made up half of building energy use prior to active management. Constant monitoring helps halt incremental growth.

- **Plug load monitoring**: Portable meters and a commercial platform now monitor, analyze, and report loads.
- **Reconfiguration**: Monitoring platform now focuses entirely on variable rather than stable (essential) loads.
- **Ongoing monitoring**: Dashboards help staff to track and control plug loads as more devices are added.

## GROUND-SOURCE HEAT PUMPS (GSHPs)

Models helped to right-size the well field for reliability based on the field’s thermal conductivity and ground temperature response to heating and cooling loads.

- **Distributed GSHPs**: The 15 high-efficiency GSHPs use near-constant subsurface temperatures to dispel/absorb heat.
- **Wells**: The 36 heat exchange wells below the parking lot are 300 ft. deep and 20 ft. apart within a row, with 25 ft. between rows.
- **Temperature sensors**: Sensors placed at various depths in a ground-exchange loop and monitoring well send data to the building automation system for staff analysis.

## MECHANICAL SYSTEM

A fixed-plate energy recovery ventilator with enthalpy heat exchangers provides all ventilation and exhaust air and uses the return temperature of the heat pump to pre-condition incoming air.

- **Mechanical ventilation equipment**: After commissioning, the unit delivers a sensible cooling effectiveness of 85%, which is slightly greater than published values.
- **Distributed GSHPs**: GSHPs feature variable-flow fans with electronically commutated motors; two-stage compressors in the larger ones enable a good turndown ratio.
- **HVAC**: In 2019, the system achieved an energy use intensity (EUI) of 6.1 kBtu/ft$^2$ and accounted for just 41% of HARC’s total electricity use that year.

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See the full report by the Pacific Northwest National Laboratory or the DOE Zero Energy Buildings [webpage](https://www.energy.gov).