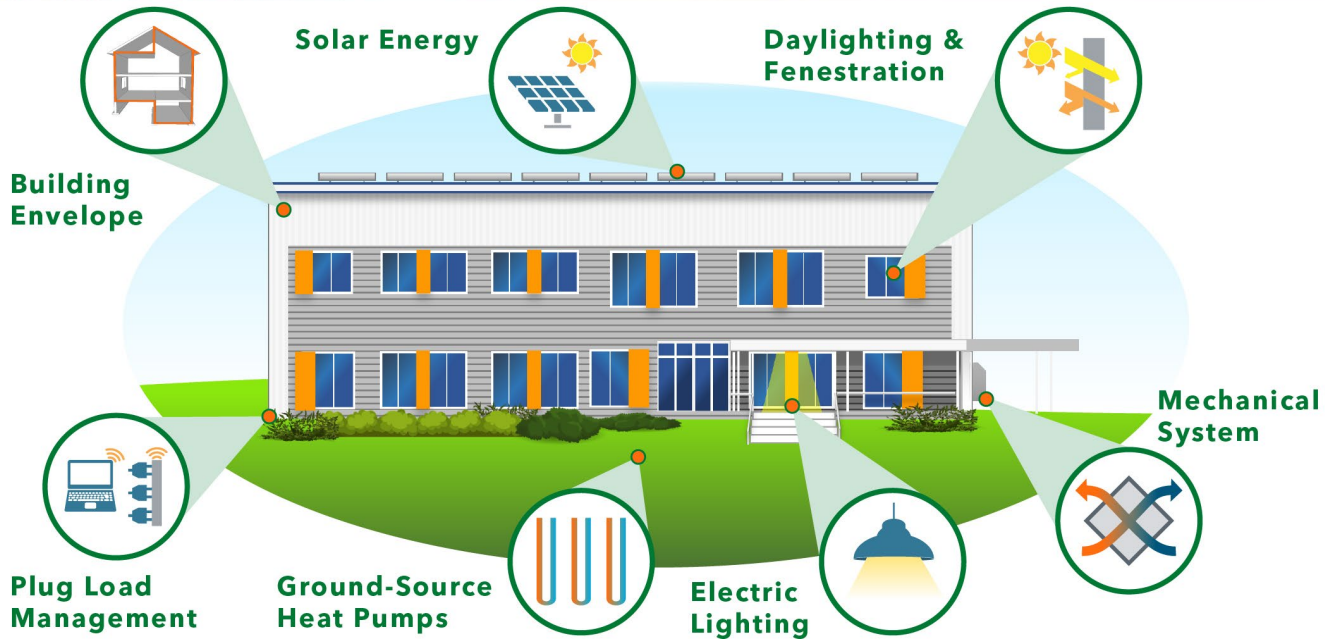
Zero Energy Building Highlight

Houston Advanced Research Center (HARC)



Building design by Gensler Architects

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% standard[1] and <30% guidance[2] for this climate. The wall U-value (0.058 Btu/h-ft^2-F) is 30% better than the standard,[1] and the materials reduce condensation.
- **Roof:** Five-inch-deep polyisocyanurate 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.

[1] ANSI/ASHRAE/IES Standard 90.1-2019 [2] AEDG

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/ft^2 or ~$2 per Watt). It saves ~$11,000 on electricity and avoids over 85,000 pounds of CO_2 emissions each year.

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).

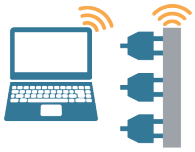
- **Glazing:** Insulated glass windows provide a U-value of 0.29 Btu/h-ft^2-F.
- **SHGC/VT:** HARC balances a low solar heat gain coefficient (SHGC) of 0.27 with a high visible transmission (VT) of 0.64.
- **Framing:** Thermally broken aluminum provides a U-value of 0.92 Btu/h-ft^2-F.
- **Assembly U-Value:**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

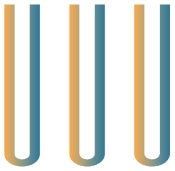
PLUG LOADS



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.

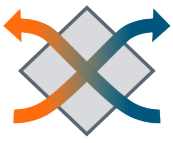
GROUND-SOURCE HEAT PUMPS (GSHPs)



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.