CASE STUDY **WESTSIDE SCHOOL**

Lara Swimmer

FROM CHURCH TO SCHOOL

MORGAN HEATER, ASSOCIATE MEMBER ASHRAE; AND GLADYS LY-AU YOUNG, AIA

THE HILLCREST PRESBYTERIAN CHURCH, located in a residential neighborhood southwest of downtown Seattle, found itself in an awkward position in 2012. Its congregation had decreased in size over the years, but remained in a large well-loved, but inefficient 1970s era facility. Maintenance and operations bills for the poorly insulated building, heated with outdated electric furnaces, were beginning to overwhelm the organization. At the same time the nearby Westside School, a pre-kindergarten through eighth grade school serving 360 students, was about to lose its lease. A plan was born: the church would co-locate with another church down the street then sell its facility to the school to finance ongoing operations. The soaring, vaulted wood roof structures of the church would be resurrected as a school and new home for Westside.

Ceiling fans and daylight glazing feature in the library.

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ABOVE Material salvaged from the church retrofit was recycled into a screen for a play area in the lobby.

RIGHT Auditorium HVAC ducts run beneath the peak of the nave and above the library walls and corridor lights.

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Adaptive Reuse

The drafty old church was to be converted into a modern, energy efficient, joyful place for learning. Plans were developed with the school community to recycle and adapt the best parts of the old structure. Eight classrooms were placed inside the 45 ft tall arched nave, with an auditorium and library filling the remaining 35 ft tall volume. State of the art mechanical and lighting systems were added, with increased thermal insulation and modern envelope upgrades. The result is a unique setting for students and teachers that leverages the character of the old building while at the same time providing the most energy-efficient school building in the region.

Approach to Energy Savings

All aspects of energy savings were looked at in the design, including lighting, daylighting, HVAC, natural ventilation and future PV panel mounting provisions. Lighting throughout the building is entirely LED, with an installed lighting power density of less than 0.3 W/ft^2. After consulting with Seattle's Integrated Design Lab, carefully oriented and sized skylights were introduced into the nave roof to reduce electric lighting loads in the newly created auditorium and library.

The philosophy for the mechanical system design was a Design For Off™ approach, focused on

BUILDING AT A GLANCE

Name Westside Elementary School

Location Seattle

Owner Westside School

Principal Use Elementary School

Employees/Occupants 385

Expected (Design) Occupancy 385
Percent Occupied 100%

Gross Square Footage 52,826
Conditioned Space 49,904

Year Built 1970

Major Renovation 2015
Renovation Scope Retrofit and Expansion

Total Renovation Cost $9,650,000
Cost per Square Foot $182.68

ENERGY AT A GLANCE (U.S)

Annual Energy Use Intensity (EUI) (Site) 14.32
Electricity (Grid Purchase) 14.32

Annual On-Site Renewable Energy Exported 0

Annual Net Energy Use Intensity
14.32 kBtu/ft^2

Annual Source (Primary) Energy
45 kBtu/ft^2

Heating Degree Days (Base 65˚F) 3,800

Cooling Degree Days (Base 65˚F) 474

Annual Hours Occupied 2,080

WATER AT A GLANCE

Annual Water Use Data Not Available

KEY SUSTAINABLE FEATURES

Water Conservation Low flow fixtures

Recycled Materials Materials from demolition recycled into space dividers for the school

Daylighting Daylighting studies performed to optimize classroom and auditiorium glazing.

Carbon Reduction Strategies Retention of the embodied energy of the existing foundation and structural bents, roofing materials. Efficient lights and equipment.

BUILDING ENVELOPE

Roof
Type Built-up
Overall R-value R-38 (New Roof)
Overall R-value R-10 (Old Roof - gym)
Reflectivity SRI = 85

Walls
Type Wood framed
Overall R-value R-14 (including bridging)
Glazing Percentage 20%

Basement/Foundation
Slab Edge Insulation R-value R-10 (24 inches in areas where new slab was poured)
Basement Wall Insulation R-value R-17 (weighted avg.)
Basement Floor R-value Uninsulated
Under-Slab Insulation R-value Uninsulated

Windows
Effective U-factor for Assembly 0.33
Solar Heat Gain Coefficient (SHGC) 0.31
Visual Transmittance 0.45

Location
Latitude 47
Orientation North-South

BUILDING TEAM

Building Owner/Representative
Westside School

Architect Sundberg Kennedy Ly-Au Young Architects (SKL)

General Contractor Kirtley Cole

Mechanical Engineer Ecotope Inc.

Electrical Engineer
Travis, Fitzmaurice & Associates, Inc.

Energy Modeler Ecotope Inc.

Structural Engineer
Quantum Consulting Engineering

Civil Engineer PACE Engineers

Landscape Architect
Thomas Rengstorf and Associates

Lighting Design Pacific Lighting System

Commissioning Agent Ecotope Inc.

Design/Build Mechanical Contractor
Emerald Aire

Envelope Design RDH

Daylighting Integrated Design Lab

Acoustics BRC Associates

Cost Estimator JMB Consulting Group

right-sized zonal equipment that can operate independently from neighboring spaces for heating, cooling and ventilation.*

New portions of the envelope were built to meet strict Seattle Energy Code requirements, and the majority of the gym and nave roofs and walls were replaced and/or re-insulated. New classrooms feature operable windows to take advantage of Seattle's moderate climate and high outdoor air quality. Ceiling fans help evenly distribute the fresh air in classrooms and provide air movement for improved thermal comfort.

Mechanical System Design

The architects sought an energy-efficient HVAC system that would not upstage or disrupt the architecture they were preserving. The mechanical engineers proposed a design flexible enough for retrofits, and well suited to multi-zone buildings. The small physical size of the zonal HVAC equipment simplified integration with the existing structure and helped save precious head space, especially on existing lower levels.

Space conditioning in the majority of the school was provided by variable refrigerant flow (VRF) heat pumps with ductless indoor fan coil units. The indoor VRF fan coils were placed where they were most effective and run independently of ventilation to maintain occupant comfort. When zone temperatures are satisfied, the fans cycle off. The small diameter of the refrigerant piping simplified installation in an existing building when compared to a large central air system.

*The Design for Off approach is for equipment to be off most of the time, turning on only to satisfy loads when and where needed. Refer to "Designing for Off," Shawn Oram and Carmen Cejudo, *High Performing Buildings*. Summer 2013. P. 56–67.

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ABOVE LED lights, new apertures and the HVAC ducting support the function of the auditorium without upstaging the architecture of the structural vaulting.

RIGHT New mechanical systems, existing structure and recycled enclosures co-exist in the lobby.

Additionally the VRF system provides the school with cooling, a feature often absent in school designs in the region for budget reasons. Cooling has become more important as the climate in Seattle has changed to longer warmer summers overlapping with the school calendar. This also allows for improved thermal comfort for expanded school programs during the summer months.

Ventilation air was provided to the classrooms, libraries, office spaces, and gathering spaces using a dedicated outdoor air system (DOAS) approach with small energy recovery ventilators (ERVs) in each zone that typically operate at low speed. The zonal ERVs react directly to space indoor air quality conditions based on CO_2 sensors. Each zone can ramp up fan speed without over-ventilating the rest of the building and incurring heating and fan energy use penalties.

The ERVs were carefully selected to provide neutral air at design conditions without supplementary heating or cooling. If teachers want to use operable windows instead of the ERVs for ventilation, they can manually switch off the ERV fans and open the windows. The ERVs, ceiling fans, and VRF equipment

BEFORE

The existing seventies era West Seattle Hillcrest Church provided the base for the school expansion.

AFTER

SKL

The school needed 26 classrooms, a gym, auditorium, library, lunch room, and offices. To accommodate the new functions of the building, the existing church was enlarged and reorganized.

BEFORE

SKL

The original building consisted of two large volumes connected by an entry lobby.

AFTER

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The adaptive reuse maintained the organization of the original structure, while adding a modern third large volume for the central lobby.

ADAPTIVE REUSE

This project conserves embodied energy by not building anew where existing structure could be reused, diverting waste from construction and demolition.

SKL

A modern envelope with higher insulation values was introduced at the old perimeter to buffer the existing structure.

Figure 1
ENERGY USE COMPARISON OLD SCHOOL VS. NEW SCHOOL

The new school uses just 30% of the energy of Westside's previous facility. The majority of these savings are in HVAC.

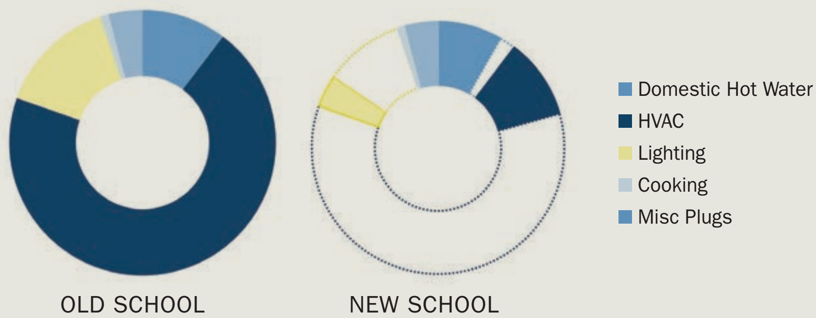
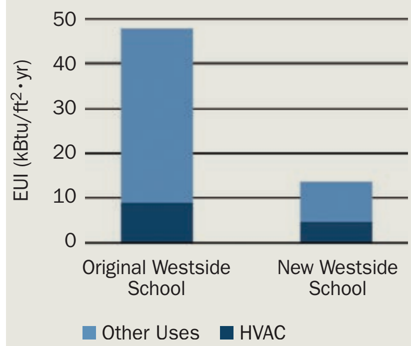


Figure 2
ENERGY PERFORMANCE

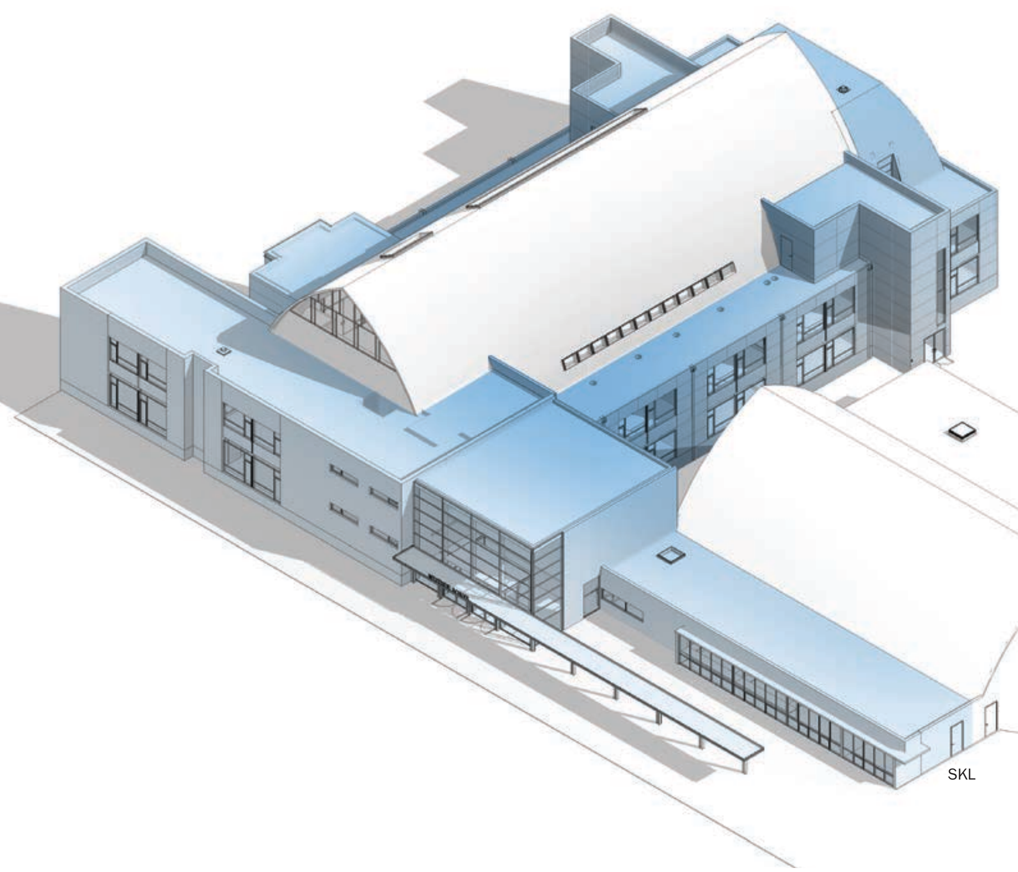


Actual energy use of Westside school's leased city of Seattle building and the newly completed Westside school.

Ecotope

Efficient Envelope

The building maximizes future energy savings by embedding the existing structure in an efficient envelope. Blue regions indicate where new construction wraps the original church building.



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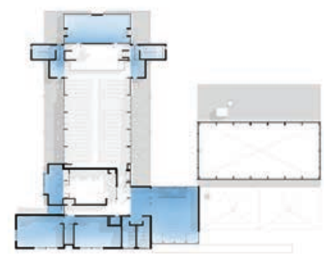
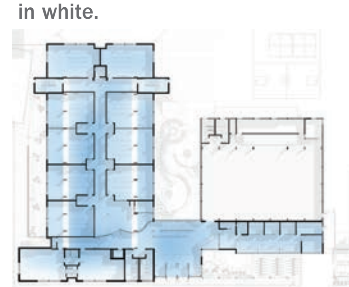
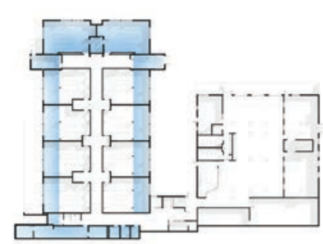


LEVEL TWO The old church nave and meeting area accommodate the new auditorium and gymnasium, shown in white.



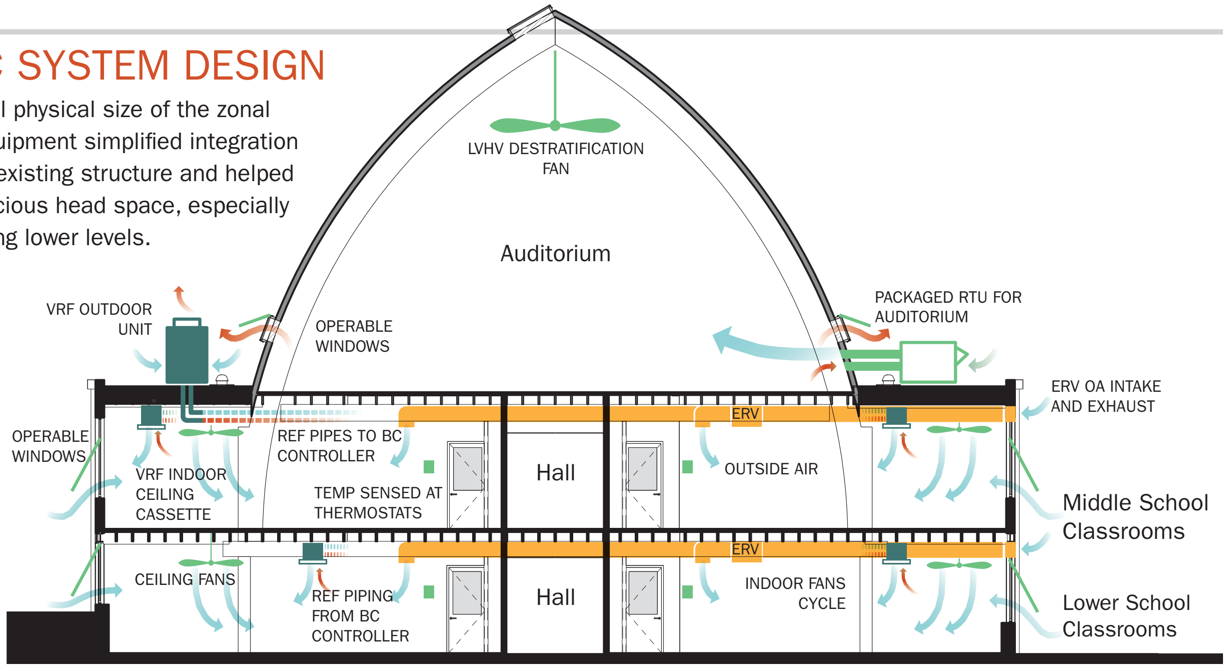
LEVEL ONE On the ground floor, new classrooms and support areas shown in blue, reach into the volume of the church nave.



BASEMENT LEVEL New construction, shown in blue, wraps the foundations of the original nave.

HVAC SYSTEM DESIGN

The small physical size of the zonal HVAC equipment simplified integration with the existing structure and helped save precious head space, especially on existing lower levels.



are all controlled by the VRF control system. ERVs and ceiling fans are swept off at night and the ductless indoor units cycle to maintain night setback temperatures.

Two spaces, the performance hall and the gym, are conditioned by packaged rooftop heat pumps. The auditorium is used less often, so the unit is left in setback mode (no outside air, fans cycle to meet space temperature) most of the time and only put into occupied mode when there is an event in the space. A large low velocity, high volume fan circulates air to destratify the warm air at the ceiling level in the winter months, and provides air circulation for comfort in the warm months. The gym unit operates on the same schedule as the rest of the school.

Both packaged rooftop heat pumps include demand control ventilation (DCV) controls to limit outside air during the heating season to match occupancy.

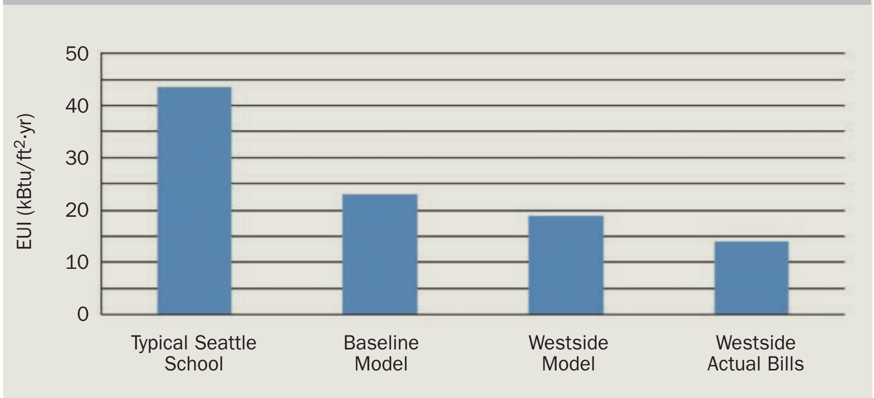
Modeled vs. Actual Performance

The HVAC system was not designed with economizers, as the indoor units are ductless, and there were portions of the existing gym envelope that could not economically be brought up to meet current energy code requirements. These variances from standard design meant that meeting the energy code required energy modeling following the 2009 City of Seattle Energy Code c407, Total Building Performance path.

This code compliance option allows designers to demonstrate that their building will perform better than the same building built to the Seattle prescriptive energy code requirements. The Westside school prescriptive code baseline building included packaged single zone heat pumps with 100% OA economizers; commonly used in northwest region schools.

The EUI for this comparison baseline building was 23 kBtu/ft^2·yr. However, note that the average EUI for Seattle K–12 schools is 43.5 kBtu/ft^2·yr. This indicates that the typical school in the area includes significant inefficiencies not captured by a typical energy model. The proposed Westside School model showed a predicted energy use intensity (EUI) of 19 kBtu/ft^2·yr, somewhat higher than the actual first-year performance EUI of 14 kBtu/ft^2·yr.

Figure 3
K–12 SCHOOL ENERGY USE COMPARISON



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The HVAC design realized greater comfort than conventional school HVAC systems, at comparable cost, using ductless heat pump technology to shrink fan and heating energy and deliver an efficient building. The cost per square foot for the HVAC installation was just \$12.75/ft^2. The total transformation of the church facility into a school cost only \$182/ft^2.

Lessons Learned

- DOAS with VRF is not the standard HVAC approach for Seattle-area schools. Introducing a new HVAC system type in a school takes a client willing to try new things. Demonstration of the system for operators and managers to gain familiarity, as well as showing the success of the system design in saving energy in other buildings gave the owners the confidence to trust the designers and go forward with the design.

- To facilitate the integration of old and new buildings, VRF with DOAS was used because the system distribution equipment is small and easily threaded through existing structure while interior fan coils can be flexibly positioned and customized for each space served. Extensive coordination to integrate the HVAC equipment with the existing structure was still required by the construction team.

- As a non-profit with much of its funding coming from individual family donations, Westside School required all decisions to be carefully evaluated for cost and benefit. The original design included VRF and DOAS-ERVs in both the gym and the auditorium, but as a cost saving measure, those spaces were ultimately served with packaged rooftop equipment. The auditorium unit ended up being very loud, which negatively impacted the use of the space as a performance hall. Post-construction sound treatments then offset most of the savings associated with the cheaper packaged equipment.

- An operating EUI of 14 kBtu/ft^2 exceeded the modeled performance of 19 kBtu/ft^2, proving the DOAS/VRF combination can perform extremely efficiently for schools.

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J.F. Woodruff

TOP Classrooms feature LED lighting, operable windows, overhead VRF indoor units and operable fans.

BOTTOM Classrooms nestled into the nave save headroom with exposed structure sheltering the mechanical equipment.

Significant Energy Savings

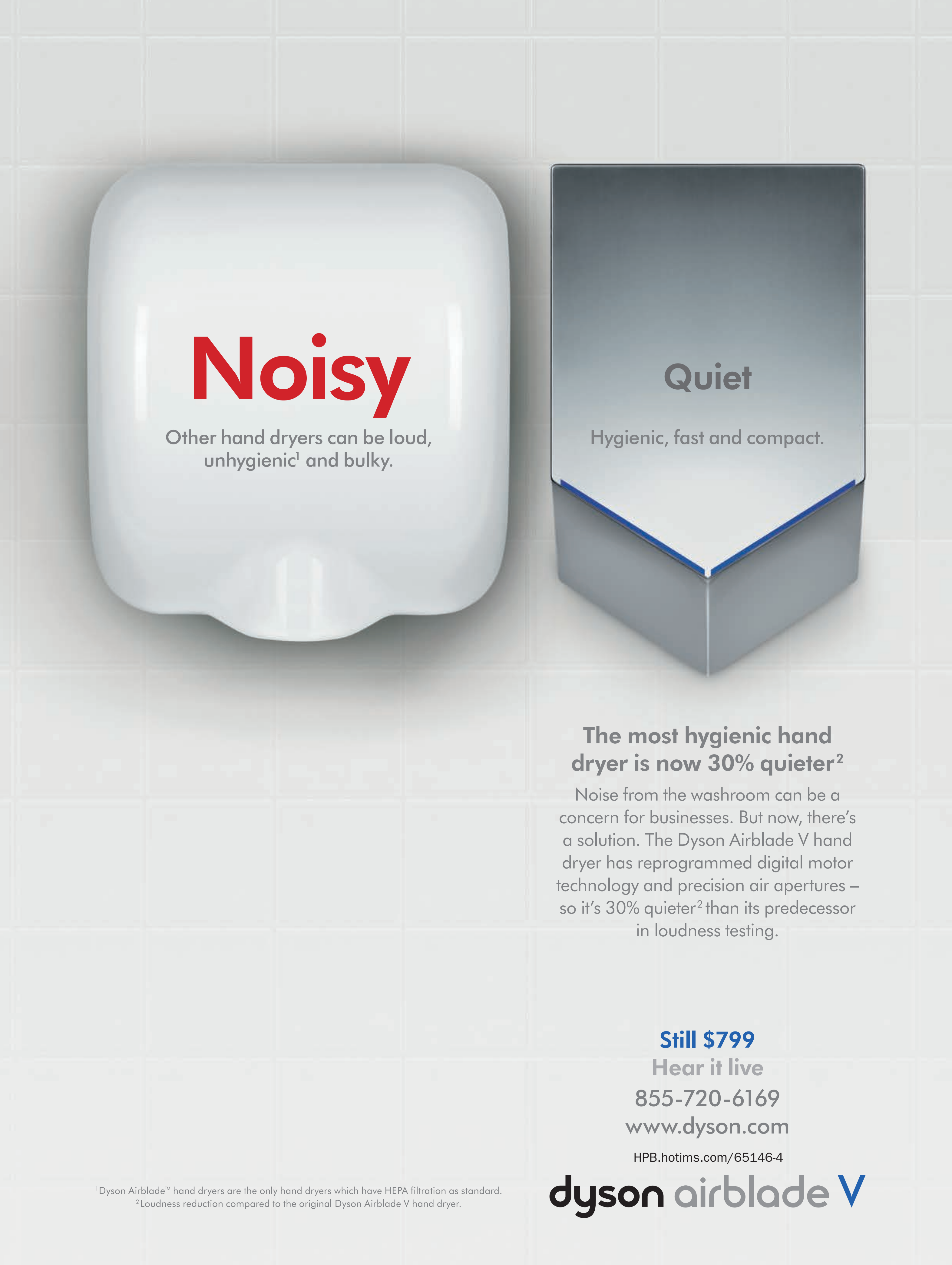
With completion of its first school year, the operating building has achieved a remarkable measured EUI of only 14 kBtu/ft^2·yr. The old Westside School building operated at 48 kBtu/ft^2·yr, 39 kBtu/ft^2·yr of which was space and DHW heating. The new building is 70% more efficient than the school's former building.

Westside School is now the most energy-efficient school in the Northwest region, created with an extremely small HVAC budget by concentrating on introducing energy efficiency where it would count the most. The report from the facilities manager is that this is the best system he has used in his 30 years at Seattle-area schools. The report from the staff and students is that they love their new building.

Westside School is proof of concept that a reasonably priced efficient mechanical system can be tailored to respond simultaneously to the conditions of new and old construction while fully conditioning a complex program. The Westside School's DOAS/VRF system accomplished this while achieving record setting energy performance for a Pre-K–8 school in the Pacific Northwest. ●

ABOUT THE AUTHORS

Morgan Heater, BEMP, is a mechanical engineer at Ecotope Inc., in Seattle. **Gladys Ly-Au Young, AIA,** is a principal at Sundberg Kennedy Ly-Au Young Architects in Seattle.


Noisy
Other hand dryers can be loud, unhygienic[1] and bulky.
Quiet
Hygienic, fast and compact.
The most hygienic hand dryer is now 30% quieter[2]
Noise from the washroom can be a concern for businesses. But now, there's a solution. The Dyson Airblade V hand dryer has reprogrammed digital motor technology and precision air apertures – so it's 30% quieter[2] than its predecessor in loudness testing.
Still $799
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dyson airblade V
[1]Dyson Airblade™ hand dryers are the only hand dryers which have HEPA filtration as standard.
[2]Loudness reduction compared to the original Dyson Airblade V hand dryer.