When increasing enrollment caused Oakland University’s nursing and health sciences programs to outgrow their spaces, the university sought a facility that supported human and environmental wellness. Inherently energy-intensive demands of labs and healthcare equipment are countered by some of the industry’s most advanced energy-efficient technologies and sustainable designs such as solar heating and dehumidification. Open, sunlight-filled spaces provide students with space to engage each other or relax while taking in views of a grand oak tree and restored wetland. The $62 million project is designed with the goal of teaching patient-centered care.
The new five-story, 160,000 ft² facility features classrooms, a large auditorium, seminar rooms, a public clinic, teaching labs, and faculty and administrative offices.

It brings together the School of Nursing and the School of Health Science — two distinct schools with similar missions and educational opportunities — to enrich both programs. It also creates a flagship facility for a new health quadrant in the northwest corner of campus. The Human Health Building is the first of many facilities envisioned to support training, research and care.

**Inspiration**
With a program focused on health, sustainability became a primary design driver from an energy efficiency and “quality of life” perspective. This drove the design of integrated site, building massing and orientation, solar shading, and daylighting strategies. Some of the biggest contributors to energy savings include a geothermal heat pump system with variable refrigerant flow, solar thermal heating panels and high efficiency fan coil units.

**Integrated Strategies**
The building’s placement respects its natural site surroundings, including a landmark oak tree, which the southern façade bends around. A sloped landscape accommodates a one-story drop from north to south elevations.

**Layout and Orientation.** Organized over five stories, the layering of the Human Health Building concentrates student spaces on the top two. Massing plans employ dual stacked bars on the fourth and fifth floors, one 30 ft wide for classrooms and the other 40 ft wide for laboratories — both column-free for ongoing flexibility. An east-west building orientation admits abundant natural light and views of the outdoor spaces.

The building is organized by function rather than department. Faculty offices are placed together on the third floor, with shared support spaces. This arrangement creates the opportunity

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**BUILDING AT A GLANCE**

<table>
<thead>
<tr>
<th>Name</th>
<th>Oakland University Human Health Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Rochester, Mich. (30 miles NW of Detroit)</td>
</tr>
<tr>
<td>Owner</td>
<td>Oakland University</td>
</tr>
<tr>
<td>Principal Use</td>
<td>Mixed use university building including classrooms, offices, teaching labs</td>
</tr>
<tr>
<td>Employees/Occupants</td>
<td>Undergraduate and graduate students, teachers and general public</td>
</tr>
<tr>
<td>Expected (Design) Occupancy</td>
<td>4,259 undergraduate and graduate students</td>
</tr>
<tr>
<td>Percent Occupied</td>
<td>Nearly 100% (approximately 70% during summer term)</td>
</tr>
<tr>
<td>Building Efficiency Ratio</td>
<td>59.5%</td>
</tr>
<tr>
<td>Gross Square Footage</td>
<td>160,260</td>
</tr>
<tr>
<td>Distinctions/Awards</td>
<td>LEED NC 2.2 Platinum, 2013; Professional Projects Award of Merit—Architectural Engineering Integration Category, Architectural Engineering Institute (AEI), 2014</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$47.8 million (construction)/$62 million (total project)</td>
</tr>
<tr>
<td>Cost per Square Foot</td>
<td>$298 (construction)/$387 (total project)*</td>
</tr>
<tr>
<td>Substantial Completion/Occupancy</td>
<td>August 2012</td>
</tr>
</tbody>
</table>

*Total project cost includes soft costs including programming, planning, design and furniture costs.
for faculty in different departments to interact and discover shared interests and opportunities. In the future, as departments grow or change, shifting office requirements can be met simply by reassigning space.

Envelope. A rain screen of terra-cotta panels stretches across the building’s long east-west axis on the fourth and fifth levels. The terra-cotta tiles, measuring 2 ft high and varying in length from 1.5 to 3 ft, were prefabricated into panels prior to fastening to the façade to form a tight, energy-efficient envelope. Behind the terra-cotta tiles, the rain screen system consists of a 2 in. deep air space, with 3 in. of spray foam insulation installed over a vapor barrier, which is laminated to the back-up wall.

On the south elevation, the overhang of the fourth and fifth floors shades the two-story curtain wall of the second and third floors from summer southern solar exposure, reducing the amount of heat gain in the offices on those floors. In addition,

### VARIED LEARNING SPACES SUPPORT HEALTH PROGRAMS

The building includes 10 programs addressing human health, ranging from nursing to industrial safety. As a result, it features a variety of learning spaces, both structured and informal, including a public medical clinic, physical therapy clinics, clinical laboratories, simulation labs, team-based instructional labs, distance learning, classrooms, seminar rooms and faculty and administration space.

Specialized teaching spaces include a fire testing lab; a hydrotherapy space; and body composition lab, complete with a small pool used for determining body-mass composition. The nursing program has a number of skills labs, as well as high-fidelity patient care rooms.
window shading is provided by a 1.5-ft overhung louver system on the south elevation of the fourth and fifth levels, with vertical sunshades protecting the east and west façades.

**Lighting.** Perimeter offices include sunshades and fritted glass to control glare. All perimeter areas are naturally illuminated, and clerestory windows and atrium glass walls provide daylighting between the classroom and laboratory bars. In general, the artificial lighting throughout the building includes 4-ft linear fluorescent lamps, consisting of 32 Watt T8 lamps with color temperature of 4100 K and color rendering index of 85. Occupancy sensors control daylight harvesting and interact with the HVAC system.

**Water.** The roof on the north side of the building feeds a 10,000 gallon rainwater cistern, serving as the sole source for site irrigation. Inside, water-efficient plumbing fixtures account for a 39% reduction in potable water consumption.

‘Living Rooms.’ More than just a place to go to class, the Human Health Building provides a variety of indoor and outdoor spaces for students and faculty to further engage one another, study or relax. Student “living rooms” with two-story views to the south serve as the heart of the classroom and lab levels. Other student favorites include terraces, plazas, lawn areas, a restored wetland — and the oak tree.

**ENERGY AT A GLANCE**

Annual Energy Use Intensity (EUI) (Site) 60 kBtu/ft²
Natural Gas 8.3 kBtu/ft²
Electricity (From Grid) 48.6 kBtu/ft²
Renewable Energy 3.1 kBtu/ft²

Annual Source Energy 164 kBtu/ft²
Annual Energy Cost Index (ECI) $1.24/ft²
Annual On-Site Renewable Energy Exported 0 kBtu/ft²
Annual Net Energy Use Intensity 56.9 kBtu/ft²

Savings vs. Standard 90.1-2004 Design Building 35% energy cost/44% energy (modeled)*

Heating Degree Days (Base 65°F) 6,189
Cooling Degree Days (Base 65°F) 960
Annual Hours Occupied 4,000

**WATER AT A GLANCE**

Annual Water Use 428,000 gallons

*Note: An exact match for an actual baseline building is not available, so “actual energy savings” is not available.

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*September natural gas reading includes consumption for June, July, August and September.

**October electricity readings include the consumption for June, July, August and September in addition to October.
Upgraded and rehabilitated natural wetland areas with native vegetation improve the animal habitats and the overall green environment for the campus community. The wetlands control the storm water runoff from adjacent parking lots and provide water filtration to control sediment. A landscape bridge was designed to easily link the students from the main campus parking lot to the building’s south entry door through the restored wetlands.

RESTORING A WETLAND

Working through the Michigan Department of Environmental Quality wetland permitting process, the project team worked to eliminate invasive plant species from the existing low quality wetland. Because phragmites, the invasive plant that dominated the wetland, are difficult to eradicate, the existing wetland soils were removed from the area and stockpiled in an upland location on the campus.

Topsoil was imported to the reconstructed wetland, and a variety of plant materials was planted to increase diversity and create an amenity for the Human Health Building. The reconstructed wetland is designed to have open water and ephemeral ponding.

The team also designed a portion of the storm water management system in the parking lot north of the building to drain into the new wetland so that water is filtered as it flows into the watershed. The wetlands control the storm water runoff from adjacent parking lots and provide water filtration to control sediment.

Collaborations Push for Sustainability

The Human Health Building is an example of Oakland University’s efforts to drive environmental stewardship and sustainability on campus. Since the very early stages of the project, OU’s facilities management and engineering groups collaborated closely with the design firm to drive sustainable innovation within the this project.

They shared information about cutting-edge technology systems and their associated mechanical components like solar collectors, photovoltaic panels, geothermal wells, variable refrigerant flow fan coil units and heat pumps. The team also jointly pushed to create a high performance building that would remain operationally flexible and maintainable on a long-term basis.

Heat Pumps and DOAS

The classrooms, labs and equipment of contemporary health education impose significant energy demands on a facility. The new direction for the campus fostered exploration of new energy strategies to meet these demands.

During the schematic design phase, the university challenged the design team to generate energy-efficient building and system ideas with life-cycle cost savings commensurate with a LEED Gold certification. From the owner’s perspective, it was critical that these systems were easy to maintain and operate. Nearly 20 alternative mechanical systems were developed and compared against the university’s benchmark of central...
plant high temperature heating hot water (HTHW) and building-based absorption chillers.

After energy analysis and first cost comparison, the team selected a hybrid geothermal option (well field, boilers, and cooling towers) coupled with variable refrigerant flow (VRF) heat pumps. Two 23,500 cfm dedicated outdoor air system (DOAS) units provide fresh air into the building. Each DOAS unit uses desiccant cooling coupled with a solar array, 3-angstrom total heat recovery wheel, and CO₂ demand control system.

The DOAS units deliver ventilation air via flow-controlling VAV boxes to each occupied zone, with enthalpy wheels recovering sensible and latent energy from general building exhaust. Each DOAS unit has a pre and final

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### Key Sustainable Features

**Water**
- Storm water harvesting for landscaping: 10,000 gallon cisterns below-grade collect rainwater from the roof and store it for later irrigation use.
- Storm water management: Storm water runoff from parking lots and other areas is controlled by the natural wetland.
- Low flow plumbing fixtures: 0.125 gallon flush urinals; dual flush (1.1/1.6 gpf) water closets.
- Native trees and grass.

**Materials**
- Recycled materials used in metal castings, manholes, exterior concrete, reinforcing and structural steel, insulation, waterproofing, metal flashing, brick and other various components.
- A total of 22.8% combined recycled content value as a percentage of total materials cost.
- 95% of building construction material diverted from landfills by recycling.
- Use of rapidly renewable materials.
- Forest Stewardship Council certified wood products.
- Classroom furniture is locally sourced, has low chemical emissions and includes a high percentage of pre-consumer and post-consumer recycled content.
- Low VOC paints and sealants.

**Lighting**
- All of the perimeter areas are illuminated by natural light.
- The atrium uses clerestory windows, a highly reflective ceiling, and glass walls to illuminate the atrium and adjoining spaces.
- Occupancy sensors provide lighting control and daylight harvesting.
- LED lighting for roadways and parking; no lighting pollution into the sky; time clock and photocell with override switches were provided.

**Individual Controls**
- Provided for most spaces except private offices. Up to five private offices with similar load profiles share a thermostat.

**Transportation Mitigation Strategies**
- Two dual electric charging stations for four electric and hybrid vehicles on site.
- Bike racks, showers and lockers.

**Other Major Sustainable Features**
- Geothermal wells, solar collectors, photovoltaic panels, variable refrigerant flow fan coil units, heat pumps, high performance building envelope with high insulation values.

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### Building Envelope

<table>
<thead>
<tr>
<th>Roof</th>
<th>Concrete pavers on pedestal support system over continuous 3 in. high density polystyrene insulation (R-18), roofing membrane, sloped concrete “topping,” structural concrete slab, and metal roof deck.</th>
<th>Overall R-value 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflectivity</td>
<td>55 (light colored pavers)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Walls</th>
<th>Terra-cotta rain screen system with 3 in. closed-cell spray foam insulation (R-18), vapor barrier, and 8 in. masonry unit back-up wall.</th>
<th>Overall R-value 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazing Percentage</td>
<td>32%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basement/Foundation</th>
<th>Slab Edge Insulation R-value R-10</th>
<th>Basement Wall Insulation R-value R-10</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Windows</th>
<th>Effective U-factor for Assembly Estimated and average 0.4 (center of glass 0.29)</th>
<th>Solar Heat Gain Coefficient (SHGC) 0.29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Transmittance</td>
<td>62%</td>
<td></td>
</tr>
</tbody>
</table>

| Location               | Latitude 42° 40’ 22.7244°N | Orientation The building is oriented in an east/west direction to take advantage of the solar position and the sloping hillside. |
system to the new building, in part because it lies outside the campus ring road and attendant utility infrastructure. Another benefit is that smaller ductwork used with VRF lowered floor-to-floor heights enough to exclude the building from a Michigan high-rise construction classification.

Some 187 high-efficiency fan coil units with MERV 13 filters provide environmental control and clean air to the offices and classrooms, with approximately four fan coils served by each heat pump. Demand controlled ventilation strategies include CO₂ sensors in classrooms and conference rooms, and occupancy sensors in offices.

In comparing VRF to conventional water-source heat pumps, key VRF advantages include fewer compressors with better access (i.e. in planned equipment closets rather than above ceilings), and a first stage of simultaneous heating and cooling accomplished without compressor operation.
The heat pumps circulate a variable flow of refrigerant to/from fan coil units for local temperature control. The facility has 44 heat pumps with 22 refrigeration circuits.

During cool weather, while interior spaces still require cooling, perimeter spaces on the same heat pump unit are heated by simply circulating the refrigerant used to cool the interior. For the second stage of heat recovery — engaged between heat pump units — efficiency is similar to that of conventional heat pumps.

**Department of Energy Grant**

To pursue an even higher level of sustainability without breaking the budget, the team worked collaboratively with Oakland University to submit grant applications to the Department of Energy (DOE), which for a limited time had energy grants linked to the federal stimulus fund.

Ultimately, the DOE awarded the university a $2.7 million grant that funded the geothermal field. This, in turn, allowed the university to expand the size of the geothermal field (eliminating the cooling towers), add an innovative solar thermal driven desiccant dehumidification system, and design a full geothermal heat pump system with variable refrigerant flow heat pumps.

The scope included the modification of the DOAS from a simple heat...
DEHUMIDIFICATION METHODS

Three popular dehumidification methods include:

1. Subcooling and (Optional) Reheating — the most traditional process.
2. Dual Passive Enthalpy Wheels.
3. Active Desiccant Wheels — serving more industrial than commercial uses and used in Oakland University Human Health Building.

Respective psychrometric charts below illustrate the change in enthalpy in each process. Process 3 is 48% more efficient than Process 1 and 16% more efficient than Process 2.

The cost of passive enthalpy wheels over subcooling is often attractive for its increased efficiency and reduced cool plant size. The additional efficiency in going from passive enthalpy wheels to active regeneration may be attractive when “free” heat is available and/or other psychrometric processes are inadequate for the required duty.

For More Information:
2. 2012 ASHRAE Handbook—HVAC Systems and Equipment, Chap. 26, Fig. 10.

Psychrometric Charts

1. Past Approach
   No heat recovery. Energy inefficient.
   ΔH=15.5 Btuh/lb

   Mechanical Cooling
   Exhaust
   Space

2. New Approach
   Dual heat recovery wheels. Energy efficient.
   ΔH=9.5 Btuh/lb

   Free Cooling Heat Wheel
   Exhaust
   Space
   Mechanical Cooling
   Sensible Heat Wheel (Free Reheat)
   Outside

3. Human Health Building Approach
   Desiccant dehumidification with free heat source.
   ΔH=8 Btuh/lb

   Precool Coil
   Regen Heating Coil
   Free Cooling Heat Wheel
   Exhaust
   Desiccant Wheel
   Space
   Post Cool Coil

SUSTAINABLE FEATURES

Rainwater Collection in Cisterns for Irrigation Use
Solar Panels — Thermal Collectors
High Albedo Roof Surface
Vertical Sunshades and Fritted Glass on East and West Glazed Facades
Horizontal Sunshades on South Facing Windows
Deep Overhangs to Shade South Facing Offices
Reconstructed Wetland — Invasive Species Removed
Geothermal Well Field Under Existing Parking Lot

Solar Thermal and Storage

The use of 117 vacuum tube solar thermal panels provides approximately 504 million Btu/yr of heat, serving DOAS units, entrance vestibules and lobbies, pool heating, domestic hot water, and the sidewalk and exterior stairway snow melting system. The solar thermal panels reduce heating hot water energy by 40%. The university favored a concealed approach, so the 6,060 ft² of panels are aligned along the sides of the penthouse, inside a perimeter roof parapet.

Four 25,000 gallon insulated underground storage tanks act as a high-grade thermal flywheel. This design allows surplus heat gathered by the solar thermal system on sunny/dry days to be used on cloudy/humid days.

BUILDING TEAM

Building Owner/Representative
Oakland University

Architect, Mechanical Engineer, Electrical Engineer, Energy Modeler, Structural Engineer, Civil Engineer, Landscape Architect, Lighting Design, LEED Consultant — SmithGroupJJR

General Contractor — The Christman Company (Construction Manager)

Environmental Consultant — Testing Engineers & Consultants, Inc. (geotechnical engineer) and Strategic Energy Solutions, Inc. (geothermal consultant)

Commissioning Agent — LL Catey Engineering
**LESSONS LEARNED**

**Soffits and Stack Effect.** Ideally, building pressurization is maintained at a slight positive pressure. However, such control cannot overcome effects of strong winds, and may also be challenged by the chimney effect of a five-story 70°F building in a 10°F environment. Although the large soffit under the student levels was well-detailed and observed during construction, one spot leaked enough air to freeze sprinkler pipes above adjacent heated space sharing a common plenum, though fortunately without rupture. The lesson learned here is to pay close attention to soffit details and actual construction, especially in similar weather conditions.

**VRF Controls.** Though VRF manufacturers have recently improved the ability to accommodate some customization, at the time of design, control capabilities and flexibility were limited and varied between manufacturers. The VRF system was not able to communicate directly with associated VAV boxes providing ventilation air to each space as initially planned. Adding a second parallel BAS network throughout the building was not in the budget. As a result, the VAV boxes were installed with “stand alone” controls and no ability exists for the BAS to remotely monitor the ventilation VAV box operation. Also, VRF fan coil units may shut off and stop heating when return air temperatures are too low (a safety feature of the VRF system that the design team was not aware of until after it happened). When the soffit leak mentioned above reached nearby VRF fan coils, rather than adding heat, they shut off.

**Down to the Details.** A row of solar thermal panels was installed on the roof at a lower elevation than intended, creating more winter shading by a portion of the penthouse. There are no plans to make adjustments to this installation though, due to the associated costs of moving and reinstalling the panel equipment.

**Complexity and Cost.** The owner and design team recognized this would be a more complex project than most, in part because the DOE grant for geothermal related aspects of the HVAC system allowed the owner to add other energy-related sub-systems. And as expected for this relatively sophisticated owner, operation of the system was picked up right in stride. Nevertheless, other project funding scenarios, owners and designers will vary, and simpler may indeed be better.

**Solar Dehumidification**

Once the decision was made to invest in a solar thermal system, the team looked for ways to maximize useful summer heating capabilities, landing on desiccant dehumidification during warm and humid weather. In this method, “free” solar heat is used to regenerate (dry out) an active desiccant wheel that, by turning, dries out incoming ventilation air. The heat collected from the solar system is utilized to regenerate the desiccant.

Although typically not cost-effective unless “free energy” (in this case, solar) is available, this method of dehumidification requires less cooling energy than passive enthalpy wheels (see Dehumidification Methods, p. 14).

**Solar Photovoltaics**

Renewable energy for power is produced by 3,600 ft² of monocrystalline photovoltaic (PV) panels, representing up to 45 kW of power and 3% of annual building energy use. PV panels share the roof with solar thermal panels, each arranged in rows along the sides of a low penthouse, with service aisles for access.

Overall, the energy systems described above contribute to a net building energy use intensity (EUI) of 56.9 kBtu/ft² per year, which includes 8.3 kBtu/ft² for natural gas and 48.6 kBtu/ft² for electricity. The building uses an additional 3.1 kBtu/ft² from the on-site solar thermal and PV panels, resulting in a gross EUI of 60 kBtu/ft². The net EUI represents 45% less energy use than the average commercial building in this climate zone, and 50% less than one of similar size (Commercial Buildings Energy Consumption Survey 2003, Climate Zone 2 data).

**Conclusion**

The Human Health Building breaks traditions in planning, systems and funding with:

- A new medical campus that supports collaborative, patient-centered care for the next generation of healthcare professionals;
- A stand-alone geothermal VRF heat pump system with solar thermal harvesting, storage and dehumidification; and
- A $2.7 million DOE grant that allowed for the inclusion of a geothermal bore field, an innovative solar thermal driven desiccant dehumidification system and a full geothermal heat pump system.

Besides bringing together two schools to enrich each and launching a collaborative medical campus for the region, the building showcases human and environmental wellness. It’s proof that the built environment can become a catalyst for change for a university, its students and the community. ●

**ABOUT THE AUTHORS**

David Kistler, P.E., LEED AP, Member ASHRAE, is a principal and chief mechanical engineer with SmithGroupJJR in Detroit.

George Karidis, P.E., LEED AP BD+C, Member ASHRAE, is a vice president and corporate engineer with SmithGroupJJR in Detroit.
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