DEVELOPING AND DESIGNING ultra-low energy mechanical systems and integrating them into innovative architecture was the challenge for the design team of Canada’s Taylor Institute for Teaching and Learning. The building sits on the foundation of a former museum and uses the university’s existing central heating and cooling plant.
Their goal was to achieve a net zero ready structure, which is a design that supports the future installation of renewable energy technology such as localized photovoltaic solar panels to offset the anticipated energy consumption of the building site.

With this ambitious goal in mind, the design team adopted an integrated design approach to achieve a more holistic understanding of efficient building methods. Using building energy modeling (EQUEST v.3.64), the team calculated window-to-wall ratios and building envelope materials.

Radiant tubing in the concrete floors, as well as a pressurized plenum space, provide efficient conditioning of the atrium without

The University of Calgary main campus is located in Calgary, Alberta, Canada, in the foothills of the Rocky Mountains. Established in 1966, the university continues to grow and develop into a prominent education and research facility, with a strategic vision to achieve a position within the top five research universities in Canada.

The design of the 48,000 square foot facility transcends the traditional models of postsecondary education by immersing students, educators, and researchers in an open and collaborative environment dedicated to enriching learning experiences and pedagogical innovation. A soaring glass atrium encompasses a three-story gathering space that harnesses natural daylight while also providing an evening glow, which beckons passersby at night. The architecture harmoniously integrates with highly efficient mechanical systems, while drought-tolerant exterior landscaping further reduces water consumption.

Energy Conservation Through Integrated Design

The University of Calgary follows an Institutional Sustainability Strategy to ensure that all new campus facilities align with energy conservation targets. Under this plan, a building’s minimum energy use target must exceed ASHRAE/IESNA Standard 90.1-2007 by 48%. Inspired by the innovative objectives of the building, the design team challenged themselves to surpass the minimum targets.
**BUILDING AT A GLANCE**

**Name**
Taylor Institute for Teaching and Learning

**Location**
Calgary, Alberta, Canada

**Owner**
University of Calgary

**Principal Use**
Post secondary academic

**Includes**
Integrated flexible classrooms, central atrium area, academic office space, presentation forum, server room

**Employees/Occupants**
500

**Expected (Design) Occupancy**
889

**Gross Square Footage**
48,000

**Conditioned Space**
48,000

**Distinctions/Awards**
2018 ASHRAE Technology Awards Second Place

**Total Cost**
$25 million

**Substantial Completion/Occupancy**
April 2016

**ENERGY AT A GLANCE**

**Annual Energy Use Intensity (EUI) (Site)**
51.8 kBtu/ft²

**Electricity (Grid Purchase)**
7.75 kBtu/ft²

**Natural Gas**
44.05 kBtu/ft²

**Annual Net Energy Use Intensity (Source)**
72 kBtu/ft²

**Annual Energy Cost Index (ECI)**
$0.504/ft²

**Savings vs. Standard 90.1-2007 Design Building**
48%

**Heating Degree Days (Base 65°F)**
5,052

**Cooling Degree Days (Base 65°F)**
36

**Annual Hours Occupied**
2,340

**WATER AT A GLANCE**

**Annual Water Use**
942,302 gallons

**KEY SUSTAINABLE FEATURES**

**Water Conservation**
Ultra low flow fixture

**Daylighting**
Daylighting control/lighting control integration

**Carbon Reduction Strategies**
Central campus combined heating/power (CHP) system connection

**Other Major Sustainable Features**
Radiant heating/cooling systems, DOAS with displacement ventilation, demand control ventilation, CO₂ monitoring and control, natural ventilation, heat recovery

**BUILDING ENVELOPE**

**Roof**
Type: IPDM
Overall R-value: 36.5
Reflectivity: SRI-88

**Walls**
Type: Metal clad with XPS insulation
Overall R-value: 13
Glazing Percentage: 38

**Basement/Foundation**
Slab Edge Insulation R-value: 20
Basement Wall Insulation R-value: 20
Basement Floor R-value: 10
Under-Slab Insulation R-value: 10

**Windows**
Effective U-factor for Assembly: 0.57
Solar Heat Gain Coefficient (SHGC): 0.23
Visual Transmittance: 0.56

**Location**
Latitude: 51.0486 N/114.0708 W
Orientation: East-west

**BUILDING TEAM**

**Building Owner/Representative**
University of Calgary

**Architect**
Diamond Schmitt Architects/
Gibbs Gage Architects

**General Contractor**
Cana Construction

**Mechanical Engineer**
Smith + Andersen

**Electrical Engineer**
SMP Engineering

**Energy Modeler**
MMM Group

**Structural Engineer**
Entuitive

**Landscape Architect**
O2 Planning + Design

**Lighting Design**
SMP Engineering

**LEED Consultant**
MMM Group

**Commissioning Agent**
MMM Group

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**CASE STUDY TAYLOR INSTITUTE FOR TEACHING AND LEARNING**

*Breakout pods* on the second level of the central atrium.
providing ventilation air and heating and cooling support through displacement floor diffusers. The design team used the ASHRAE Standard 55-2010 comfort tool to model air velocity and supply temperature for optimum occupant comfort.

Dispersed air is returned to the AHUs to circulate through a heat recovery wheel, and is then circulated as additional free cooling through the communications and electrical rooms.

An Innovative Approach
Cantilevered Vierendeel trusses at each entrance form a stunning gateway, inviting members of the university community into the airy, three-story central atrium. The expansive stretch of glazing and millwork is

Indoor Air Quality
The design team developed a dedicated outdoor air system (DOAS) consisting of two air-handling units (AHUs) that use free airside cooling from Calgary’s dry, moderate climate. The AHUs have the capacity to deliver the required ASHRAE Standard 62.1-2010 ventilation air, with an additional 30% capacity for future opportunities. The AHUs use fan array technology with heat recovery and CO₂ monitoring, with outdoor air supplied to the AHUs through a buried concrete earth duct.

Low-pressure drop ductwork delivers the supply from the first AHU to active chilled beams and displacement ventilation diffusers in the classrooms, office spaces and central atrium. Occupied spaces are equipped with variable air volume boxes with sensors that quickly respond to changes in occupancy and conditions.

The other AHU supplies a pressurized air plenum below the suspended concrete floor in the forum area, providing ventilation air and heating and cooling support through displacement floor diffusers. The design team used the ASHRAE Standard 55-2010 comfort tool to model air velocity and supply temperature for optimum occupant comfort.

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(BIM) to avoid service conflicts during construction. Additionally, the area has a flexible design to accommodate various uses, requiring additional heating and cooling capacity, as well as sensors to adapt and serve variable occupancies. Radiant heating and cooling systems in the concrete floor slab and social stair landings provide space conditioning, while a displacement ventilation system installed in the stair risers provides air movement without obstructing the view. Removable ceiling and wall panels blend with the millwork, maintaining the visual flow while allowing access to services for maintenance.

**Operation and Maintenance**

The Taylor Institute for Teaching and Learning uses the existing foundation of the former Nickle Arts Museum, achieving the goal to reduce new building construction material while preserving the site’s native soils. To accommodate use of the existing basement, the mechanical systems were required to fit through a 98 in. × 98 in. opening in the main floor slab. The university’s facility staff required equipment components, such as fans and motors, to fit through a standard door opening for future maintenance.

The design team decided on a two-tiered approach to reduce energy consumption and equipment size. First, the facility uses the university’s central heating and cooling plant and remote monitoring system to reduce equipment requirements on site. As a second step, the ventilation system is

**Main floor breakout room** with chilled beams integrated above the wood slat ceilings.

visually captivating, with mindful placement of HVAC equipment critically maintaining the aesthetic of the space.

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separated from the heating and cooling system, allowing the use of a dedicated outdoor air system (DOAS), and again reducing the equipment footprint. A fan array AHU was delivered to site in modules that were lowered through the tight floor slab opening. The modules were then assembled into their final configuration in the basement site.

A four-foot diameter concrete pipe, or earth tube, was installed six feet below grade, drawing in fresh outdoor air and eliminating the need for louvers on the building exterior. The earth tube also acts as a ground-to-air heat exchanger by preheating the air in cooler months, and precooling the air in warmer temperatures. The earth tube design was scaled back from an initial design due to budget and site constraints. However, the final installation remains an effective means of drawing in outdoor air to the building while providing a moderate level of preconditioning.

Cost-Effective Solutions

The project budget was established using a conventional mechanical system cost estimate, which did not include any considerations for the aggressive energy targets of the project. However, the integrated design approach allowed for the implementation of energy saving measures early in the design stage, which kept costs within the conventional system budget while producing a high-quality and low-energy design.

Local utility rates of $0.093/kWh for electricity and $5.34/GJ for natural gas were calculated to have a 71% utility cost reduction, and a $59,481 reduction in annual energy cost when compared against the ASHRAE/IESNA Standard 90.1-2007 baseline.

The Taylor Institute for Teaching and Learning has become an iconic campus structure. The university has seen unprecedented interest in hosting private events and campus functions in the visually captivating and highly adaptable facility. Although regular evening and weekend use increases the energy consumption of the mechanical and electrical systems, facility rental fees provide an additional source of revenue for the university to offset operation costs.
CASE STUDY  TAYLOR INSTITUTE FOR TEACHING AND LEARNING

Lessons Learned

Building System Setpoints. After building commissioning, it was determined that the original mechanical system setpoints did not meet the occupant’s requirements. The original cooling setpoints were too low and the heating setpoints too high to maintain a satisfactory level of occupant comfort. These setpoints were adjusted and monitored over the course of the initial year of occupancy. Final setpoints were actually higher in summer and lower in winter, reducing the load on the building mechanical systems.

Construction Management/Sequential Tendering. Due to the construction phasing, the mechanical systems were tendered and procured prior to final architectural finishing detail design. A second phase of coordination occurred once ceiling finishes and materials were selected. To address areas where chilled beams were installed above drop wood slat ceilings, the mechanical engineers worked with the interior designers and equipment suppliers to provide a solution that maintained functionality of the mechanical system while still maintaining the required aesthetic appearance.

Building Humidity with Radiant Systems. Due to the quantity of wood finishing and millwork within, building humidification was required to maintain certain parameters. This was a challenge for the mechanical system, as too high a humidity would create the potential for condensation on chilled beams. The mechanical engineer and controls contractor came up with a strategy to continuously monitor space humidity levels/temperatures, dew point, and chilled water piping temperatures. Chilled water supply temperatures automatically adjust to maintain separation from the dew point.

Building Reuse. Reusing the existing basement mechanical room created some unique challenges as the design team needed to work within the existing room’s size and configuration. The new building size increased by 25%, requiring the team to evaluate alternative mechanical systems designs and modular equipment to fit the space. All new equipment was required to fit through a 10 ft x 10 ft existing opening in the main floor slab for installation in the basement.

Building Turnover. After final building commissioning and turnover, it was identified that the system control sequences and parameters had been changed by building operators. When investigated further it was discovered that there is a lack of understanding from the building operators about how the mechanical systems were intended to operate. The design engineers scheduled a two-hour building presentation to go through the system design intent with the operators to ensure they understood the engineer’s intent and create buy in from the operations staff on effective and efficient building operation.

Unique Challenges

Integration with Architecture. The vision for the building was an open concept feel with minimal view of ducting and services, especially in the central atrium. The central atrium also cut the building in half, restricting service from one central mechanical room on the north side of the building. Overall, the mechanical design team worked extensively with the architect to integrate systems into a new service space below the main floor, adjacent to the basement mechanical room. This solution eliminates the need to run services through the atrium above.

System Flexibility and Adaptability. The design of the forum area created some unique challenges. The space was designed with a retractable 350 person seating system that allowed the space to be configured in both a raked (theater style) seating configuration and as flat floor banquette-style seating. The mechanical system serving the space consists of an underfloor pressurized air plenum with supply displacement floor diffusers throughout the space. The challenge was to design a system with the ability to adapt to both the occupant load and seating configuration to ensure occupant comfort. The underfloor system is supplemented with sidewall diffusers when the seating system is in the theatre configuration, and the building control system monitors an end switch on the seating system to determine which mechanical system operation to use.

Reducing the Environmental Footprint

One of the many sustainable features of the facility is the reuse of the existing Nickle Arts Museum foundation. Eighty-nine percent of demolition waste was reused or recycled, and the building’s new construction materials included 14% recycled material. Additionally, 99% of the interior wood finishes are certified by the Forest Stewardship Council.

Low-flow plumbing fixtures are located throughout the facility, which reduces water consumption by 33% (or 1,132,506 gallons annually). The building design reduces electricity use by 537,110 kWh, and reduces natural gas use by 1835 GJ, resulting in an annual greenhouse gas emission reduction of 437 ton CO₂e annually.

The facility’s HVAC system is tied into the university’s central 12 MW combined heating and cooling plant. The central plant is equipped with a waterside economizer system that uses water from the Bow River to mitigate the cooling plant operation.

Conclusion

The Taylor Institute for Teaching and Learning project was turned over to the University of Calgary under budget and six months ahead of schedule. The Taylor Institute for Teaching and Learning project was turned over to the University of Calgary under budget and six months ahead of schedule. The Taylor Institute for Teaching and Learning project was turned over to the University of Calgary under budget and six months ahead of schedule. The Taylor Institute for Teaching and Learning project was turned over to the University of Calgary under budget and six months ahead of schedule. The Taylor Institute for Teaching and Learning project was turned over to the University of Calgary under budget and six months ahead of schedule. The Taylor Institute for Teaching and Learning project was turned over to the University of Calgary under budget and six months ahead of schedule.

ABOUT THE AUTHOR

Regan Moffatt, P.Eng., LEED AP BD+C, is a principal with Smith + Andersen Engineering in Calgary, Alberta, Canada.