Library Design Delivers Flexibility, Energy Savings

A new Minnesota library's design offers future flexibility and will use less energy than comparable buildings.

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Ramsey County Library set ambitious energy goals for its new branch library in suburban Shoreview, Minnesota, northeast of Minneapolis-St. Paul. As with many newer libraries, Ramsey County Library Shoreview provides multiple resources for a growing community—an educational resource for children, teens and adults; and a community gathering place for diverse groups and interests. The civic leader in sustainability and environmental stewardship uses 70% less energy compared to the Minnesota energy standard.

Opened in January 2017 on a civic campus that includes the City Hall, community center, school district offices and other public agencies, the 32,565 ft^2 (3025 m^2), single-story library consists of three architecturally distinctive, brick-clad volumes with expansive windows overlooking the campus. Inside, an open plan subdivides library and community spaces into varying scales to meet multi-functional programming, which includes:

- 22,000 ft^2 (2044 m^2) of library space for book stacks, a computer area, teen and children's sections, multiple study rooms, a marketplace, community room; and
- 11,600 ft^2 (1078 m^2) of administrative space for system-wide Ramsey County Library and Ramsey County technology services.

With this newest branch, the library recognized the opportunity to set ambitious energy-efficiency goals that would serve the community long-term, including:

- Meet Minnesota B3 Guidelines for site, water, energy, indoor environment, materials and waste.
- Achieve 70% reduction in energy use compared to a baseline building in Minnesota's energy standard, SB 2030.
- Design for flexibility to adapt to changing programming and energy needs.

The engineering and architecture team exceeded goals through integrated solutions that included underfloor air distribution, high-efficiency air-cooled chillers, controls tailored to occupant use in concert with the building envelope, passive solar control and 100% LED lighting. Energy-efficient planning resulted in 70% reduction in energy use, 41% reduction in water use, and 44% reduction in carbon output.

Mechanical System

The mechanical system (*Figure 1*) integrates several key components to achieve maximum efficiency, including:

A **Underfloor Air System.** This was pivotal in meeting the client's desire for future flexibility. In addition, it proved to be extremely energy efficient.

B **Zone Controls.** Motorized dampers in underfloor ductwork provide zonal control. The dampers open and close based on space thermostat setpoints. The variable volume air-handling unit ramps

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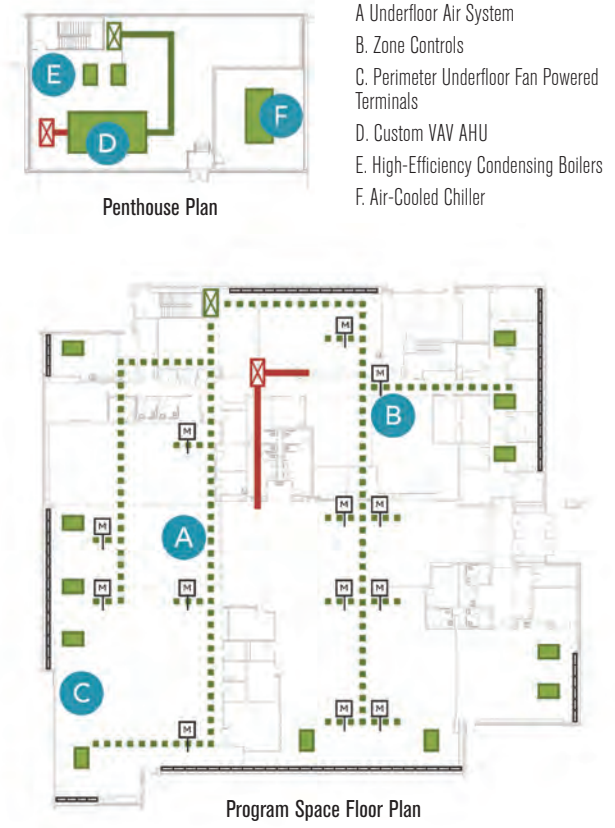

FIGURE 1 Penthouse and program space floor plan mechanical systems.

up and down as motorized dampers change position. A mixture of fixed, adjustable, and motorized floor diffusers was used to meet the varied levels of control required throughout the building.

C **Perimeter Underfloor Fan Powered Terminals.** Perimeter underfloor fan powered terminals were used to decouple the building envelope load from the primarily cooling dominant interior spaces. Separating the envelope load was especially advantageous on the large expanses of glazing on the south and west façades. The underfloor fan powered terminals feed linear bar grilles at the perimeter. Reheat at the terminals is from a loop of hot water supply and return piping routed below the floor.

D **Custom-Variable Volume Air-Handling Unit.** This 35,000 cfm (16 518 L/s) AHU serves the entire building and includes a total energy recovery wheel to pretreat the outdoor air. The supply and exhaust tunnels of the AHU are served by fan arrays. This provides the client with redundancy in the ventilation systems while also being efficient and quiet. Active field, polarized media air cleaners were used in lieu of traditional filters to reduce pressure drop and save on fan energy. A separate duct mounted fan serves as the building return, while also controlling building pressurization.

E **High-Efficiency Condensing Boilers.** The boilers serve the air-handling unit heating coil, fan powered reheat coils and perimeter heating units such as cabinet unit heaters and fin tube radiation.

F **Air-Cooled Chiller.** This provides the cooling for the building. There is an evaporative precooler on the condenser section. By allowing the condenser airflow to pass through the wetted evaporative media, the entering air temperature to the condenser is lowered. The installed air-cooled chiller has an impressive efficiency of 0.98 kw/ton (0.28 kW/kW). This was a cost-effective and energy-efficient solution for the project.

Energy Efficiency

Meeting the energy-efficiency goals of Ramsey County was truly a collaborative effort. With the assistance of early phase energy models, the architecture team designed a building with extremely limited glazing, only 21%, while creating open and light-filled spaces throughout the library. In addition, the majority of the building's south-facing glass is shaded during the summer by an exterior wood trellis that overhangs the building. The wall construction meets an R-value of 22, and the roof has an R-value of 40.

The mechanical systems—including underfloor distribution, high-efficiency air-cooled chillers, conditioning of outdoor air with a total energy recovery wheel and custom controls tailored to the building's use—work in concert with the building envelope, passive solar control and 100% LED lighting to achieve a 70% energy cost reduction over the Minnesota B3 SB 2030 standard.

The team used energy modeling to calculate anticipated energy use of the proposed systems and the energy-cost reduction. The proposed system was compared to two separate baselines; a Minnesota B3 Sustainable Building 2030 (SB 2030) Energy Standard baseline and an ASHRAE/IES Standard 90.1-2010 baseline.

The design team calculated the anticipated building's energy use intensity (EUI) to be 45.4 kBtu/ft^2·yr (515.6 MJ/m^2·yr). This met the SB 2030 target, is well below a typical code-compliant (ASHRAE Standard 90.1-2010) building, and far exceeded the

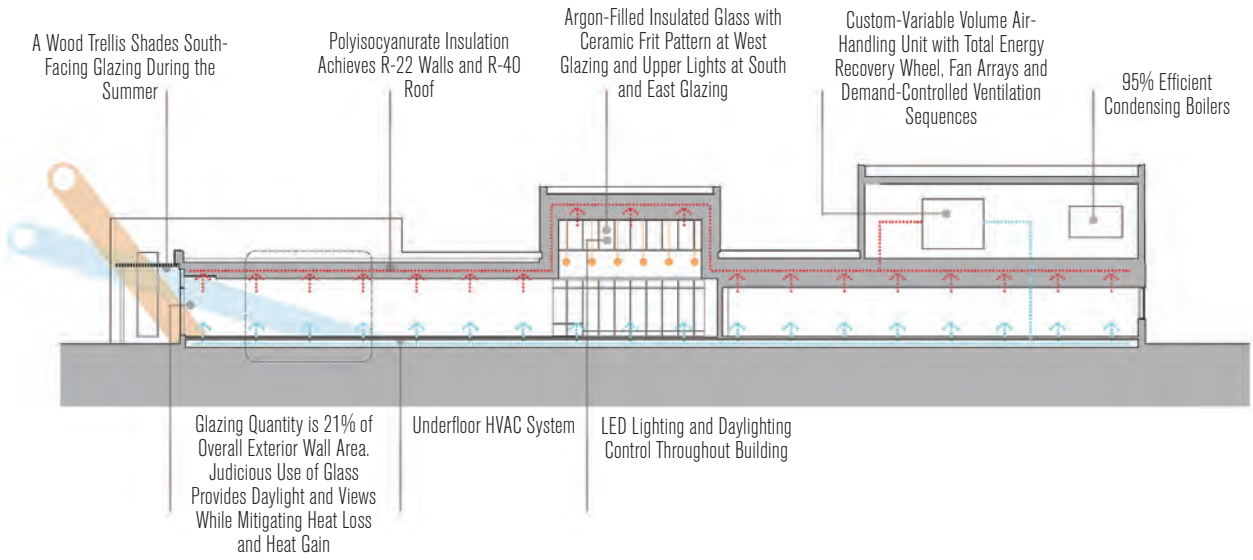

FIGURE 2 Integrated architecture and engineering systems worked together to meet the client's goals.

national average for existing libraries in the CBECS database.

The building's energy use from July 2017 through June 2018 resulted in an operational EUI of 48.4 kBtu/ft^2·yr (549.7 MJ/m^2·yr). This site EUI reflects a large reduction in energy use when compared to the ASHRAE Standard 90.1-2010 baseline, CBECS baseline and the SB 2030 baseline.

Indoor Air Quality and Thermal Comfort

The underfloor air system improved thermal comfort and indoor air quality. The freshest supply air is delivered directly to the breathing zone through floor-mounted, displacement-type diffusers. The air is returned at the ceiling level to leverage the natural buoyancy produced by heat sources and more effectively remove heat loads and contaminants from the spaces. Return grilles were integrated into the ceiling through perforated panels in alignment with the columns of the building. The perforated return grilles virtually "disappear" into the architecture.

ASHRAE Standard 55-2013 guided the selection of appropriate displacement-type diffusers for the variety of occupants and activity levels in the building. For example, the Tech Services department in the library handles and moves a large quantity of library materials every day, and the staff is at a higher activity level than typical office staff.

In contrast, the library's study and meeting rooms typically see low activity from the occupants. In many of the public library spaces, non-adjustable floor diffusers were used. However, in the private offices, staff conference rooms and break rooms, a mixture of manually operable and motorized floor diffusers responds to the variable load, occupant and activity levels in the space.

Ventilation rates for the library were calculated using ASHRAE Standard 62.1-2010's Ventilation Rate Procedure. The underfloor air distribution system and floor diffusers have a zone air distribution effectiveness of 1.0. The building's air-handling unit is ducted with separate connections for the minimum outdoor air and economizer outdoor air. The minimum outdoor air ductwork contains an airflow measuring station that continuously measures the ventilation airflow and provides an alarm at the building's automation system if it does not meet setpoint. The active-field, polarized media air cleaners in the AHU offer a MERV 15 performance while imposing a lower pressure drop on the system when compared to typical filter media.

The conference rooms, community room, break room, and other high-occupancy areas are controlled with CO_2 sensors. These rooms are served by underfloor fan powered boxes. During a CO_2 alarm, the boxes are automatically controlled to increase supply air, and the reheat coils prevent the boxes from overcooling.

The custom air-handling unit is also equipped with demand-controlled ventilation sequences. The building's outdoor air is reset based on CO_2 measurements

in the return air. This is especially useful when the public portion of the library is closed but the offices are open.

Operation and Maintenance

The design team worked closely with the Ramsey County operations and maintenance groups throughout the design and construction process. Ramsey County was involved in system selection, monitored construction to confirm systems were installed correctly and with adequate maintenance, and participated in a large part of the commissioning process. The complete engagement of Ramsey County's staff was pivotal in owner buy-in, education, and long-term success of the library.

Because the library has three rather distinct functions within the building—the branch library, the administrative offices, and the community room—the three parts have different operation and use schedules. The design team worked with the building operations group to develop a series of building control schemes within the BAS. The building's control schemes allow Ramsey County to fine-tune the air-handling unit and mechanical systems' operation to the varying schedules of the building and only condition the occupied areas.

Cost Effectiveness

As partners with the general contractor in a design-build relationship, the design team received real-time feedback on cost and budget through preliminary and schematic design to achieve the most cost-effective, energy-efficient solution for this building. Multiple mechanical schemes were analyzed, and energy savings were compared against first cost and life-cycle cost. A geothermal system was strongly considered and resulted in an EUI of 33.8 kBtu/ft^2·yr (383.9 MJ/m^2·yr). However, with a payback of over 20 years, it was undesirable for the client. Ultimately, the selected mechanical system strategies met the project's energy-efficiency goals and provided the client with the desired flexibility. The mechanical systems made up 65% of the building's overall energy reduction, and the strategies selected fell within the goal 15-year time line requested by the owner. ■