LANDMARK CATHEDRAL GOES GREEN

At New York's Iconic St. Patrick's Cathedral, a State-of-the-art Geothermal System Improves Facility Performance while Preserving Historic Character

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With its soaring spires in the heart of Manhattan, St. Patrick's Cathedral is among the world's most iconic worship spaces, welcoming nearly 5 million visitors a year. Originally designed in the 1870s by James Renwick Jr. and last renovated in 1949, the cathedral's recent five-year-long, $177 million renovation combines stringent conservation methods with the city's largest-ever geothermal system to enhance worship and functionality, as well as improve sustainability and resiliency.

Led by MBB (Murphy Burnham & Buttrick Architects), New York, the comprehensive effort impacts the entire city-block-sized campus, achieving a 29 percent reduction in annual

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energy use while stabilizing significant historic fabric. Recognized with a 2019 National COTE Top Ten Award from the Washington, D.C.-based American Institute of Architects, the project offers valuable lessons for making significant historic buildings effective, relevant and resilient, as well as provides a compelling case study about creating sustainable building systems with a focus on long-term, flexible solutions.

Cathedral Upgrades

A designated city, state and federal landmark, the cathedral is one of New York's most visited destinations. Working closely with the Trustees of St. Patrick's Cathedral and clergy leadership, MBB approached the renovation with a focus on stabilizing the cathedral structure and providing a better experience for clergy, visitors and worshippers while respecting the character of this sacred and iconic building. The project scope included preservation of exterior and interior surfaces—marble, slate, metalwork, ornamental plasterwork, decorative woodwork, cast

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The geothermal system's pumps and compressors are located in a former boiler room in the basement and controlled by a building management system.

stone and stained glass. New architectural interventions include mechanized glass entry doors that reduce air infiltration and a glass wall that provides acoustic isolation for the Lady Chapel worship space while life-safety upgrades include the installation of a mist fire-suppression system in the attic and improving egress by upgrading exit paths and instituting a fire marshal program.

The extensive renovation also presented an opportunity to address the cathedral's energy usage in a comprehensive and holistic way. From the project's inception in 2006, the design team was charged by the Trustees of St. Patrick's Cathedral to evaluate the existing mechanical systems as part of a needs and conditions assessment of the cathedral campus. It was clear the air-conditioning system was overdue for an upgrade; much of the HVAC equipment dated back to the 1960s. Leaders sought a permanent solution with a high level of functionality that was also in keeping with how the cathedral building is used. Having a minimal impact on the historic fabric was important. As the renovation gathered steam, the project team assessed geothermal technology as a potential means to meet the trustees' objectives.

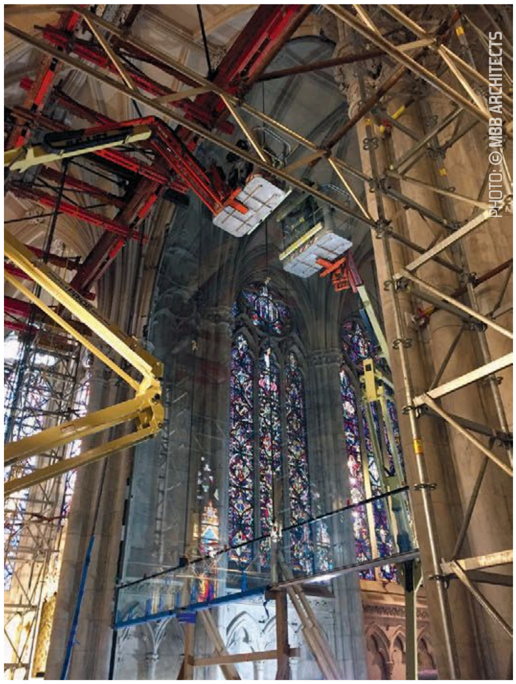
At the time, there were few examples in New York City of large, established institutions deploying this technology. The project team initially considered a design for a conventional system using a large fan wall adjacent to the Cardinal's Residence near the southeast corner of the block. Because of the required size of the plant, mechanical elements would have been visible; modifications to the cathedral architecture would have been required, along with extensive and costly rock excavation; and the fan wall would have generated noise—a series of modifications that would not only impact the city's Landmarks Preservation Commission approval process, but also the ongoing experience of cathedral visitors and clergy residents.

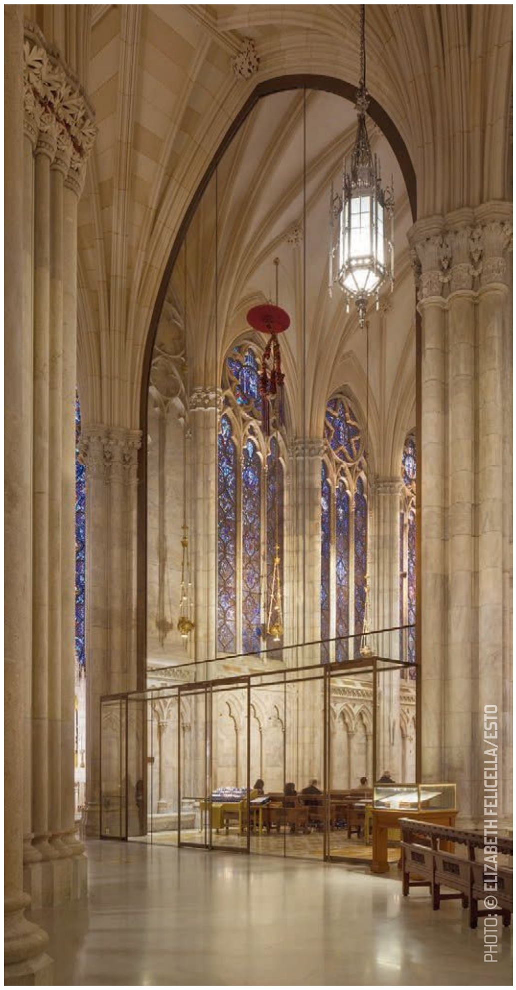
By contrast, a quiet, low-impact geothermal system obviated the need for noisy, obtrusive mechanical equipment and promoted efficient use of space. Conducted in collaboration with construction manager Structure Tone Inc., New York, the project team's feasibility study examined upfront costs; long-term costs, including equipment replacement, operation and maintenance; and qualitative and quantitative criteria, such as impact on the cathedral's fabric and the duration of the overall approvals process. The geothermal plant option brought the best long-term benefit in terms of cost, energy efficiency and minimal impact to people. Just as important, this proposal engendered the support of community groups and local officials, including the Landmarks Preservation Commission.

Geothermal Details

With the cathedral remaining open throughout construction to accommodate community members and 18 masses every week and given the complexity of designing and installing a geothermal system in a historic structure with such a high intensity of use, an experienced team of collaborators was key to the project's success. As design team leader, MBB enlisted a top-tier group of experts, including geothermal plant designer Landmark Facilities Group, Norwalk, Conn.; well-drilling consultant P.W. Grosser Consulting Inc., Bohemia, N.Y.; structural engineer Silman, New York; and geotechnical engineer Langan Engineering, Parsippany, N.J., who collaborated with Zubatkin Owner Representation LLC, New York, and construction manager Structure Tone to conceptualize and design the geothermal system.

The geothermal system itself comprises 10 wells in terraces flanking the north and south sides of the cathedral; Samuel Stothoff Co., Flemington, N.J., drilled 9-inch-diameter boreholes through dense Manhattan schist at a depth of up to 2,250 feet through bedrock. Pumps and compressors were located in a former





New architectural interventions include mechanized glass entry doors that reduce air infiltration and a glass wall that provides acoustic isolation for the Lady Chapel worship space. Top right: A rolling scaffold supported work on ducts and restoration of stained glass and the ceiling while keeping the cathedral open and its nave clear.

RETROFIT TEAM

ARCHITECT // MBB (Murphy Burnham & Buttrick Architects), New York, www.mbbarch.com

CONSTRUCTION MANAGER // Structure Tone Inc., New York, www.structuretone.com

GEOTHERMAL PLANT DESIGNER // Landmark Facilities Group, Norwalk, Conn., www.lfginc.com

WELL-DRILLING CONSULTANT // P.W. Grosser Consulting Inc., Bohemia, N.Y., www.pwgrosser.com

WELL DRILLING // Samuel Stothoff Co., Flemington, N.J., www.stothoffwellwater.com

STRUCTURAL ENGINEER // Silman, New York, www.silman.com

GEOTECHNICAL ENGINEER // Langan Engineering, Parsippany, N.J., www.langan.com

OWNER REPRESENTATIVE // Zubatkin Owner Representation LLC, New York, zubatkin.com

MATERIALS

SPRINKLER SYSTEM // ABCO Peerless Sprinkler Corp., www.abcopeerless.com

GLASS DOORS AND WALLS // Seele Glass, www.seele.com

HEAT-RECOVERY CHILLER // Multistack, www.multistack.com

CIRCULATOR PUMPS // Bell & Gossett Ecocirc, www.bellgossett.com

HEAT EXCHANGER // Alfa Laval (titanium plate), www.alfalaval.us

BUILDING AUTOMATION SYSTEM // Niagara, www.tridium.com

ENTRANCE DOORS // Narthex with Invisible Wall System by Vitrocsa USA, www.vitrocsausa.com

CHAPEL ENCLOSURE DOORS // CRL Jackson 900 Series Spring-powered Recess Floor Mounted Door Closer by C.R. Laurence Co. Inc., bit.ly/30P1t0P

boiler room in the basement, controlled by a building management system that determines whether and how much to heat or cool based on thermostats set around the cathedral, heating or cooling different zones independently.

Producing air conditioning and heating for the entire campus, the system is capable of generating 2.9 million Btus per hour of air conditioning and 3.2 million Btus per hour of heat when operating at full capacity. To increase durability and mitigate corrosion, stainless-steel pumps and an HDPE ground loop were used. To increase resiliency, the project team included gas-fired boilers and an evaporative fluid cooler to back up the primary system by adding extra cooling or heating to the wells at peak demand, if required. The geothermal plant itself was designed for longevity and ease of maintenance with durable titanium plate modular heat exchangers and other modular, small-scale elements. The modular design enables single wells to be taken offline to work on component parts.

Throughout the installation process, careful staging and an interim building system helped enlighten visitors about the work's scope and impact, even during presidential and papal visits. Construction sequencing minimized disruption to cathedral operations; for example, a rolling scaffold supported work on ducts and restoration of stained glass and the ceiling, keeping the cathedral open and its nave clear—and avoiding the cost of scaffolding the full interior. Respecting existing historic structures, geothermal system wells are piped through the undercroft and unused crawl space, increasing their utility and mitigating needs to build externally.

The project team's thoughtful approach emphasizes seamless integration of new HVAC elements, and the attention to detail is apparent throughout the renovated cathedral. New air-handling units were ducted to custom grilles fitted to the ribs of the triforium. Fan-coil units were built into millwork during the restoration, preserving the cathedral's original detailing, and piping was run in the undercroft, reducing run length and keeping them out of sight. This leveraging of existing space served preservation and environmental goals of the project team.

BLEED VERSUS NO-BLEED GEOTHERMAL

BLEED is the mechanism by which open-loop geothermal systems help keep maximum and minimum temperatures within operating range. It can be thought of as a "relief valve", which is accomplished by diverting some water to the sewer system and allowing "fresh" groundwater to enter the loop through the wells. Because St. Patrick's Cathedral's geothermal system was designed to operate without relying on bleed, New York-based MBB was able to avoid the associated water waste.

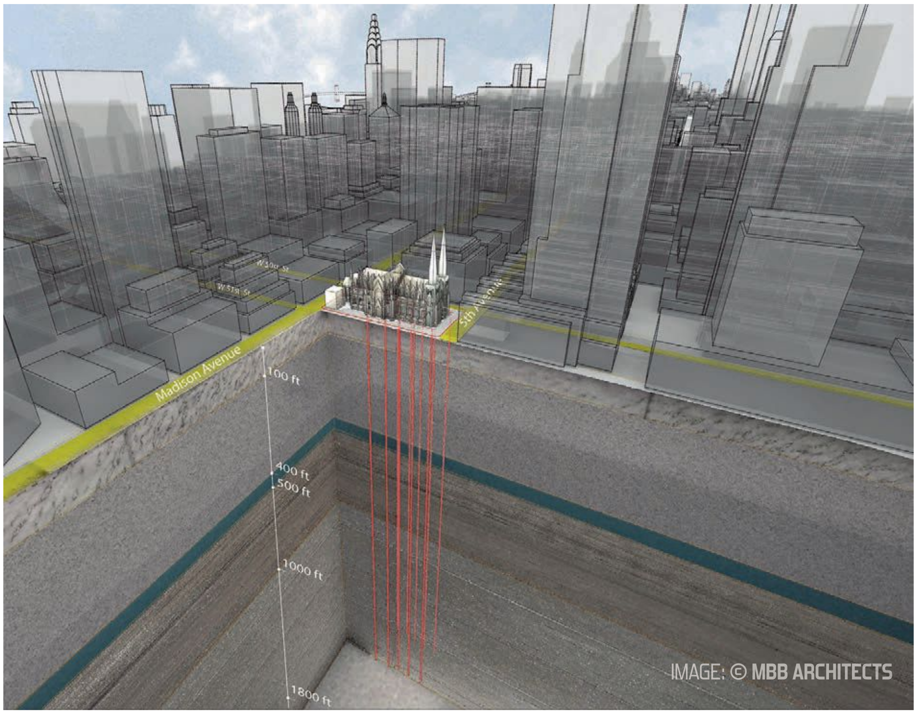
The choice of a no-bleed geothermal system represents a significant reduction of water use. A comparably sized cooling tower would have required 3.8 million gallons of makeup water annually and bleeding the geothermal system would have used 1.3 million gallons, but the system that was designed and installed at St. Patrick's uses only 300 gallons per year. Furthermore, the condensate losses inherent in district steam are eliminated by switching over to ground-source heat.

Installing the geothermal well field required removal of two planting areas marked by compacted soils and dense ivy mattings. This presented a further opportunity to improve the cathedral site's appearance, sustainability and functionality. With the geothermal system in place, the project team recreated planting areas, using absorbent soils and native plantings and trees. Consistent with local hydrologies, the new flora helps absorb runoff from adjacent hardscape and requires minimal irrigation. A 600-square-foot green roof covering the new secure vehicle entry further improves stormwater management while new soils and a native plant palette attract birds, squirrels, and other animal and insect life. New bluestone walkways and curbs aid pedestrian access.

Shining Example

A remarkable success story, since the geothermal system launched in 2017, it has provided all of the cathedral's heating and cooling, without the need to engage the backup system. Post-occupancy performance includes the cathedral's largest attendance ever, visits by heads of state, and expanded programming while maintaining stable environmental control and energy-use reductions equivalent to 772,211 kilograms of CO_2. Based on working environment metrics—temperature and ventilation control, acoustics, lighting and visitor response—cathedral staff report high levels of satisfaction in operations, and New York City Mayor Bill de Blasio has lauded its decreased emissions and support for a greener community.

The highly public modernization, which created national awareness of cutting-edge sustainability solutions, points in new and promising directions for retooling historically significant architecture and conserving natural resources. Ready to serve the public for generations to come, St. Patrick's Cathedral now shines as an example to other world-class organizations of how institutional leadership can harness technology to take a long-term, sustainable approach to architectural stewardship.



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