

CASE STUDY

Geo-Exchange System Powers Princeton's Path to Carbon Neutrality

Princeton University transformed its campus energy system through an electrified geo-exchange network and thermal storage. The TIGER system replaces steam-based heating, cuts emissions, improves efficiency and resilience, and demonstrates scalable decarbonization at community scale.



Challenge

Princeton University committed to achieving carbon neutrality by 2046, a target that coincides with the school's 300th anniversary. Meeting this goal would require a fundamental shift in how energy is produced and distributed across campus. While conservation projects had reduced overall energy consumption, the existing steam system and conventional heating and cooling were energy-intensive and reliant on fossil combustion. Opportunities for recovery and storage were limited, leaving the university short of the carbon reductions needed to reach its target.

At the same time, campus growth was accelerating. New research facilities, residential colleges and academic buildings added demand that could not be met by incremental upgrades. Continuing to invest in traditional boilers and chillers would prolong reliance on carbon-intensive infrastructure and embed long-term operating costs. Although the cogeneration plant helped maintain operations during regional outages, its dependence

Project Stats

Client

Princeton University

Location

Princeton, New Jersey

850

approximate depth, in feet, of each bore

1K+

geo-exchange bores installed

4.5–5

coefficient of performance observed in early operation

on natural gas and fuel oil conflicted with the university's carbon commitments.

Princeton needed an integrated utilities strategy that would support a larger campus, preserve resilience, and achieve deep, sustained reductions in greenhouse gas emissions.

Solution

An infrastructure master plan, developed beginning in 2016, outlined a shift from steam to district hot water, campuswide geo-exchange borefields, large-scale heat recovery chillers, thermal energy storage and advanced controls. Options were evaluated for life-cycle cost, carbon impact, reliability, constructability and fit with architectural context. The plan then guided the design and construction of TIGER, the Thermally Integrated Geo-Exchange Resource, and the conversion of the West Plant into a coordinated partner facility.

The project team designed TIGER to function as the all-electric primary plant. Ground-source heat pumps were incorporated to move energy to and from deep borefields, supported by two outdoor thermal energy storage tanks sized to manage daily hot- and chilled-water loads. By design, thermal production could be shifted to times that lowered both operating cost and carbon intensity. The West Plant was designed to partially retain conventional systems, providing operational flexibility and backup capability during periods of high demand or extreme weather.

The geo-exchange system was designed to operate as both a seasonal and daily thermal bank. During summer, heat is transferred from buildings into water and stored underground through 850-foot boreholes. In winter, that stored heat is returned to the system to warm buildings.

Results

The program is producing measurable reductions in Scope 1 and 2 emissions as buildings transition to low-temperature hot water and geo-exchange service. Early plant operation showed the system delivering roughly 4.5 to 5 times more energy for heating and cooling than the electricity it consumed, a performance level expected to improve further during summer operation. The dual-plant approach improves resilience. TIGER carries the electrified thermal load,

while the West Plant provides backup capacity that can be called on during extreme weather, grid instability or periods of unusually high demand. Shifting from steam to low-temperature hot water improves efficiency and simplifies operations, which supports staffing and long-term maintenance.

Campus integration is visible in both the construction approach and the finished facility, and TIGER's architecture reveals how modern utilities function, offering a learning opportunity for visitors and students. Faculty, as well as representatives from peer institutions and public agencies, continue to tour the plant, using real-time data and firsthand views to study applied decarbonization at community scale.

The program continues to expand with additional bores, new distribution piping and building conversions that broaden the electrified network. Ongoing measurement of borefield energy balance, the daily charging and discharging of thermal storage tanks, and overall plant efficiency will guide refinements to system operations and the balance between TIGER and the West Plant. Princeton's approach shows how widely available technologies, applied through disciplined planning and phased execution, can deliver campus-scale decarbonization while strengthening reliability.

Princeton's utilities transformation has moved from plan to performance. TIGER is operating and district hot water is replacing steam across the campus. The program is cutting emissions, improving efficiency and supporting resilience, while turning the energy system into a living classroom and a practical model for peer institutions.

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