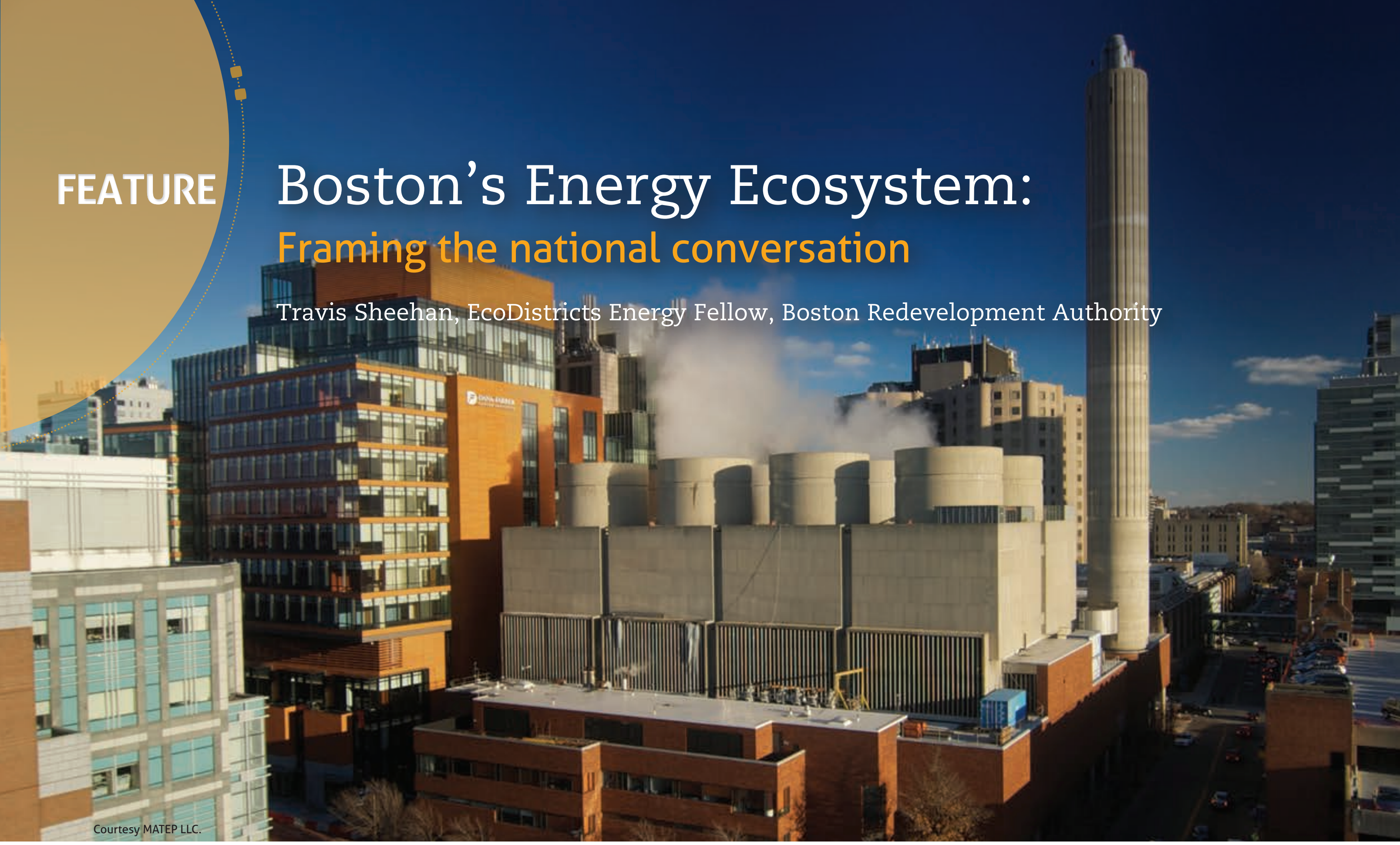
FEATURE

Boston's Energy Ecosystem:

Framing the national conversation

Travis Sheehan, EcoDistricts Energy Fellow, Boston Redevelopment Authority



Courtesy MATEP LLC.

The Medical Area Total Energy Plant sits just feet from its predecessor, the 1906 Harvard Powerhouse. Wrapped with a perimeter of offices, the plant is hidden in the urban medical campus.

Boston's economy is fueled by a complex and vibrant ecosystem of private-sector firms that require highly reliable and competitive energy services. The area's successful mix includes financial services, technology, pharmaceutical research and manufacturing that operate alongside world-class public institutions in health care and higher education. Reliability and resiliency are so essential that these entities are willing to pay a premium for better service than that provided by the traditional electricity grid. Given these urgent demands, it is not surprising to find thermal networks at the heart of Boston's campus energy systems. Under Mayor Martin J. Walsh, Boston's city government's energy system planning has focused on understanding how these combined electric and thermal networks operate within the local energy ecosystem and how they frame the national conversation.

Each of these systems arose over past decades out of a particular set of needs and opportunities. Largely out of sight and out of mind, they suddenly achieved prominence in the wake of Superstorm Sandy and other extreme weather events that exposed the fragility of the traditional electric grid. Now, other regions are starting to take notice.

From Manhattan to Maine, where severe storms have caused significant economic losses, states are beginning to leverage hundreds of millions of dollars in public financing to develop more localized energy solutions to better prepare for the next Sandy. Pilot projects are being funded to help institutions, neighborhoods and business districts to deploy district energy, combined heat and power and microgrids – features that have already proven their value in systems throughout the Boston area. These include large-scale CHP and microgrid solutions at the Medical Area Total Energy Plant (MATEP), the Biogen campus and Harvard University's Blackstone Steam Plant (fig. 1).

MEDICAL AREA TOTAL ENERGY PLANT

The Medical Area Total Energy Plant (MATEP) serves the hospitals and research facilities in a densely populated 213-acre area of Boston called the Longwood Medical Area (LMA). The LMA is home to prestigious institutions like Harvard Institutes of Medicine, Boston Children's Hospital, Brigham and Women's Hospital, Beth Israel Deaconess Medical Center, Dana-Farber Cancer Institute and others – all of which have mission-critical energy needs. In 2012, the LMA served more than 100,000 inpatients and 2.4 million outpatients, while researchers and clinicians performed hundreds of millions of dollars of world-class

Figure 1. Map of the MATEP, Biogen and Harvard University Blackstone Steam Plant Service Areas.

Source: Boston Redevelopment Authority.

medical and biomedical research in countless disciplines. To support this critical work, MATEP generates and distributes steam, chilled water and electricity to buildings in the area for space heating and cooling, domestic hot water, lighting, fans, humidity control and process applications. MATEP is designed to operate with a robust fleet of generators, boilers, chillers, steam turbine generators and combustion turbines fueled mainly by natural gas. Its design incorporates liquid fuel storage to allow for dual-fuel capability, which allows it to operate during natural gas service interruptions for as long as 10 days. Should it be necessary to isolate from the grid, MATEP is capable of operating in "island" mode while still meeting the energy needs of its customers.

MATEP's origins date back to 1906 when the original Harvard Powerhouse began providing energy services for Harvard Medical School, utilizing CHP as a primary source of highly efficient and reliable energy. In the mid-1980s, Harvard built the present structure based on diesel technology. The facility was sold, and gas turbine technology was added to the generation mix. Purchased in 2010 by subsidiaries of Morgan Stanley Infrastructure Fund (90 percent) and Veolia North America (10 percent), MATEP is now embarking on the next growth phase with the addition of a third gas turbine and the recent completion of a new standalone boiler. These investments address the growing energy needs of customers in the LMA for the long term. They also increase the facility's energy resiliency and reliability.

Unlike the other examples of campus energy systems in Boston, MATEP has a historical franchise on electricity sales, which approximates the boundary of the LMA. A district-scale franchise is very uncommon in the state of Massachusetts.

The plant can produce up to 84 MW of electricity and 1 million lb/hr of steam and has a chilled-water capacity of 42,000 tons. MATEP's distribution capabilities include 1.3 miles of steam pipe, 0.8 miles of chilled-water distribution pipe and 3.5 miles of 13.8 kV electric distribution lines serving six major customers.

MATEP's focus on reliability and resiliency has transcended its changes in ownership through the continuous application of new technology and its commitment to enhancing environmental performance, developing more on-site generation and hardening the asset.

BIOGEN ENERGY PLANT

The Biogen campus in Cambridge is home to a company that researches, develops and manufactures medical treatments. In 2002, Biogen was looking for a solution to its energy problem, chiefly the fact that electricity service was considered too expensive and not reliable enough for its specialized needs. With a campus expansion on the horizon, Biogen's leadership issued an RFP to develop a central energy plant. The company later decided to develop the central plant itself because of its expertise in capital planning and commitment to campus quality. Biogen retained Waldron Engineering & Construction Inc. to complete the engineering and oversee construction of the project.

The Biogen central plant includes a 5.4 MW gas turbine, a heat recovery boiler with a capacity of 50,000 lb/hr, two gas-fired boilers with a combined capacity of 50,000 lb/hr and a 1,200-ton absorption chiller. The campus systems include steam distribution, electric distribution and a chilled-water loop.

In August 2003, just as Biogen was poised to approve the construction funding for the central plant, the largest blackout in U.S. history occurred in the Northeast. Though the Boston area was spared from power outages, the wave of media reports about widespread blackouts validated Biogen's decision. The plant was integrated into the basement of a new building and completed in spring 2006.

A few years into its operation, the Biogen campus system was further improved when it was interconnected

The Biogen campus is located in the heart of Kendall Square, a hub of biotech innovation adjacent to the Massachusetts Institute of Technology campus.

The Harvard Blackstone Steam Plant, at the edge of the Charles River, is nestled within the dense and vibrant Cambridgeport neighborhood. The large structures in the background are famous dormitories designed by modernist architect Josep Lluis Sert.

with Veolia's adjacent steam system. The interconnection has allowed Biogen the option of removing its boilers formerly needed only for a few short peak periods during the year. This improvement has increased the system reliability on both sides of the interconnection valve.

The project paid itself off seven months ahead of schedule, in four and a half years. Because it was such a financial and operational success, Biogen is planning an expansion of the existing plant with the goals of achieving higher energy security, reducing greenhouse gas emissions and improving system financial performance.

HARVARD'S BLACKSTONE STEAM PLANT

When the local electric utility (then NStar) divested its generation assets in 2003, Harvard acquired a legacy steam system and central plant. The Blackstone Steam Plant included a dysfunctional turbine, two 1930s boilers and two 1960s boilers. After removing the two oldest boilers and making necessary investments in safety and reliability, Harvard was able to invest in the installation of a 5 MW backpressure turbine in order to dramatically increase energy efficiency and reduce electric costs. Environmental performance was significantly enhanced as Harvard switched fuel from oil to natural gas and began capturing the waste heat – previously exhausted into the Charles River – for steam.

Today, steam provides space heating, domestic hot water and process steam for 160 buildings in Boston and Cambridge. The steam emanates from four dual-fuel boilers that are blackstart-capable and is distributed through a network of steam tunnels. The steam system is complemented by a large district cooling system that provides chilled water for space cooling and process uses to 78 buildings (approximately 50 percent of the campus). Two chilled-water plants hold a total of seven chillers with a common distribution network comprising a radial supply to buildings.

The diverse campus energy loads include residences, office buildings and academic, entertainment and cultural facilities. Harvard's lab and research buildings use a disproportionate amount of heat and chilled water for process loads. Across the Charles River in Boston is Harvard's Alston Campus, which is home to student dormitories, athletic functions and the business school.

Electric transmission is supplied to seven "regional" switching stations owned by Harvard. Each station has multiple circuits distributing electricity to all 180 buildings on the Boston and Cambridge campuses. Two incoming 13.8 kV lines enter the Blackstone plant, where the breakers are managed by the local electric utility.

Harvard University has various capital plans for different districts of the campus. Although energy system planning is centralized, capital planning follows the will of each district, which leaves some areas of the campus "out of the loop" on district energy.

LESSONS FOR MULTI-USER MICROGRIDS

The value of the MATEP, Biogen and Harvard district energy/CHP microgrids has been proven over time and under extreme conditions. With their impressive track record for providing economic, environmental and reliability benefits, why are we not seeing more of these investments outside the campus setting? For example, one might expect Boston's downtown Business Improvement District to be exploring a trigeneration microgrid of its own. Unfortunately, the value streams associated with these integrated energy networks can best be captured by single-owner campuses. Campuses are commonly treated as a single electric meter, so when you bundle in renewables or CHP, it's easy for the incumbent electric utility to account. Each building in a business improvement district has a private electricity meter, which makes accounting for these benefits very complicated.

THE VALUE STREAMS ASSOCIATED WITH THESE INTEGRATED ENERGY NETWORKS CAN BEST BE CAPTURED BY SINGLE-OWNER CAMPUSES.

Regulatory, statutory and financing innovations are required to achieve the technology transfer of campus-scale energy systems into districts of privately owned buildings, forming multi-user microgrids (MUMs). Whereas 20th-century regulation enabled the grid to scale up into regional networks, 21st-century regulation will help ratepayers accrue benefits of clean and resilient locally deployed technology.

Compared to single-user microgrids (SUMs), MUMs face the following challenges:

- lack of a business model that includes retail-level electricity sales
- perceived threat to the utility business model
- absence of regulatory or statutory support to realize revenue streams
- risk aversion and lack of awareness among real estate developers
- energy planning process that typically does not include municipal government

In 2007, the Connecticut legislature passed an act that attempted to ameliorate these challenges. Under the legislation, municipalities are empowered with expanded financing options, tax exemptions and franchise clauses through the formation of Energy Improvement Districts (EIDs). Although the EID concept has been implemented, market activity to date has been minimal.

To spur interest in microgrid development, in 2014 the city of Boston co-hosted a series of microgrid workshops that convened regulators, utilities, customers, infrastructure investors and legal experts. The objective was to develop a business model for MUMs. A high-level consensus was reached as the group focused on the unique problems presented by Massachusetts statutes and regulations, setting the table for a respectful collaboration. Boston is working with its utility partners to further the MUM concept through a pilot project.

To identify potential districts for robust energy improvements, the Boston Redevelopment Authority released an RFP for a citywide energy study. Working with the Massachusetts Institute of Technology's (MIT) Building Technology Department and MIT Lincoln Labs, the study will model a range of scenarios with an emphasis on clean and resilient trigeneration microgrids. The study will explore zones of opportunity, citywide economic benefits, environmental benefits and resiliency impacts. District energy is also a key focus of Boston's 2015 Climate Action Plan Update, as is resilient hardening for the city's most vulnerable populations (for more information, visit www.bostonredevelopmentauthority.org).

Cities and towns wishing to encourage the development of microgrids within their jurisdictions should highlight the benefits of district energy in their discussions. These benefits include that district energy

- increases investment opportunity through private and municipal spending, most typically through public-private partnerships;
- increases the attractiveness and competitiveness of the city because firms value energy security, disaster preparedness and lower energy costs;
- reduces environmental impact through greater utilization of source fuel through cogeneration and eases the process of integrating local renewable energy resources; and
- keeps capital in the community by localizing production revenues and creating construction jobs.

As municipal energy planning continues to evolve, new policies can enhance the potential for growth of district energy. Municipalities are supporting the efforts of their state regulators and market development agencies, supporting pilot projects as a proof of concept for 21st-century energy services. In doing so, cities and towns can play their role in creating value for businesses and residents through collaboratively planning energy systems.

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Travis Sheehan *is a fellow at Boston's planning and economic development agency, the Boston Redevelopment Authority. He manages the city's strategic planning and programs for district energy, which entails the origination of pilot projects, stakeholder engagement and program development. Sheehan received a double master's degree in architecture and city planning from the Massachusetts Institute of Technology. He volunteers as a pianist and is still proud to be an Eagle Scout. He may be reached at travis.sheehan@boston.gov.*