Yale University

RESPONSE FROM ECOSYSTEM

Request for Qualifications for Science Hill Energy Services

May 4, 2023

30 Years

ecosystem

Contents

Mr. Michael Ghilani, P.E.
Senior Energy Engineer
Yale University
2 Whitney Avenue
New Haven, CT 06510

Dear Mr. Ghilani,

Ecosystem Energy Services is thrilled to participate in Yale University's Request for Qualifications for Science Hill Energy Services.

Over the past 30 years, Ecosystem has gained extensive insight and knowledge by working on similar high-profile campuses like yours on ambitious, innovative projects in the built environment. In fact, we were just recently awarded two transformational projects at the University of Toronto and Sanofi, both with extensive, sophisticated lab facilities. At a high level, both of these clients have objectives similar to Yale's – to design and implement comprehensive solutions that advance net-zero readiness goals and EUI reduction initiatives, while addressing asset renewal and deferred maintenance needs.

The level of success Ecosystem achieves for our clients is a direct result of open communication and collaboration, strong alignment of interests, and a results-driven mindset. There is a high level of satisfaction knowing that the goals Yale is aspiring to achieve are directly aligned with Ecosystem's expertise and core business competencies, as a specialist in complex energy systems.

This project is another example of Yale's continued leadership role and a defining moment for the University. Selecting the best company to serve you is crucial. Throughout every stage – investigation, design development, and project implementation – you'll be able to count on Ecosystem's proven experience as the leading integrated design engineering construction company in North America to bring creative and innovative solutions that unlocks the full value of your project.

Thank you for considering Ecosystem for your project. Our entire company is excited about delivering outstanding results for Yale. We welcome the opportunity to work together to help achieve your goals in the most intelligently engineered, innovative, cost-effective, and professionally rewarding ways.

Sincerely,

Bob Mancini
Director of Business Development, Higher Education
rmancini@ecosystem-energy.com • 401-808-0589

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Team Experience

The Ecosystem Approach

At Ecosystem, we believe everything can and should be more efficient. This holds true for buildings, energy systems, the project delivery approach, and collaboration with our clients. In response, we have built a business that integrates engineering design, construction, and commissioning with a total focus on delivering results; this way, we can contractually guarantee the outcomes that matter.

Our clients include North American leaders in the higher education sector, many of whom are confronting the same issues as Yale University: the need to implement comprehensive zero-carbon readiness projects that will significantly reduce energy use intensity (EUI). As specialists in high-performing energy retrofits, we have a dedicated role to play in helping them along the path to carbon neutrality. Over the last three decades, we have gained extensive experience delivering successful energy projects at higher education facilities—our team focuses on delivering your targeted outcomes as we tackle inefficiency and create strategies that simply work.

Integrated engineering & construction approach: With the ambitious EUI reduction targets listed in the RFQ (~50%), we believe that Yale will benefit from a fully integrated team. Our team is never siloed; our designers, construction managers, and controls and commissioning specialists are all experienced engineers who work together to deliver all aspects of our clients' complex energy projects. We believe our engineers should be accountable for results. While the typical design-build approach has many benefits compared to the traditional design-bid-build, integrated engineering and construction with one company acting as the single point of contact, and is responsible for the entire project, provides more potential for innovation and a better alignment of interests. Throughout each of the pre-design and design phases, we perform constructability reviews into our process ensuring that our designs can be built.

With Ecosystem, Yale will benefit from having one partner -- an expert in both the design and implementation of complex energy projects -- that will take full responsibility for delivering project outcomes from start to finish. Every choice we make in project design and implementation contributes to better outcomes – and true alignment of interests.

Experienced in live and sensitive environments: All Ecosystem projects have been completed in occupied buildings, including many universities, scientific, and critical-care hospital facilities that require uninterrupted operability. This experience has allowed our company to develop an exceptional level of expertise in dealing with the unique challenges of restrictive and sensitive work environments. We understand that a campus, especially with renowned science research facilities, is a “live” environment, that each building's energy system is unique, and most importantly, that building occupants and activities must be respected.

One major benefit of our integrated engineering and construction approach is our ability to design and plan with specific results in mind. This allows us to create phasing and construction plans that are more efficient and faster than those created by teams that are siloed between design and construction.

We have also developed many best practices in construction to minimize impacts, such as:

- Shortening the duration of service interruptions and facilitate connections, piping is passed as close as possible to the connection points.
- Performing the conversion zone by zone, system by system. The intervention plan is customized based on the needs in each zone. The work teams are strategically scheduled to reduce the intervention time in each sector.

During our project at Brown University, we successfully planned and phased building work to avoid disrupting student life and academic initiatives. This was especially crucial when working in campus spaces that house sensitive research facilities. For each building, the collaboration between Ecosystem and engineering, facilities, and faculty was essential to implementation success. An implementation schedule was carefully reviewed to ensure that the design could be installed without disruption and with minimized shutdowns. Sometimes designs were even altered, without compromising outcomes, to accommodate critical campus needs. See Appendix A for more information on this project.

During our project at The Ohio State University (OSU), operational impact was considered in terms of interruptions, disruptions, and ease of maintenance during and after projects. A focus on avoiding shutdowns minimized campus interruptions through careful scheduling arranged well in advance of the project approval.

Dedicated to taking a holistic view: Our specialists are set apart by deep training in carefully examining a campus's entire interconnected electromechanical infrastructure. This uniquely equips them to uncover hidden value and opportunities. We also address your entire deferred maintenance backlog—exploring solutions beyond straight one-to-one equipment replacement.

Focused on outcomes: The outcomes Yale and your stakeholders seek define how a project develops. We stand by you from project conception to construction and follow-up, ensuring that these outcomes are achieved.

The success of our approach, expertise, and determination to achieve results for our clients is reflected in our track record of award-winning solutions customized for higher education institutions, as well as other specialized buildings and campuses.

Case Studies & References

The following case studies showcase Ecosystem's expertise and ability to design integrated systems for optimal performance. Yale is looking for a partner to implement zero-carbon readiness projects, with building conversions to low-temperature hot water and deep-retrofit EUI reduction projects. This has been our core business for 30 years.

ENGIE – The Ohio State University

One of the largest public universities in the US, The Ohio State University (OSU) enrolls 60,000 students and employs 40,000 staff. Its sprawling 25M sqft2 campus comprises 485 buildings.

OSU sought to both expand its utility systems and make a major shift toward sustainable development. It wanted a partner to take over campus energy management and improve energy costs and use. Ecosystem was selected as a key member of the partner team led by Ohio State Energy Partners (formed by ENGIE North America and Axium Infrastructure). In a first-of-its-kind project in North America, the partner team will operate and maintain the heating, cooling and electricity infrastructures on campus and sell the energy back to OSU for 50 years. As part of our remit, Ecosystem demonstrated exceptional performance in carefully handling sensitive work across multiple laboratories (Physics Research Building, McPherson Chemical Laboratory, and Newman-Wolfrom Laboratory).

Client Name	ENGIE – Ohio State University
Address	110 Enarson Hall, 154 West 12th Avenue Columbus, OH 43210
Contact Information	Robert Cary Program Manager, ENGIE North America Robert.cary@ENGIE.com 614-937-8375
Total Contract Cost	$84M
Completed within the Last 5 Years / Ongoing with at Least 75% Complete at the Time of the RFQ	✓
Scope of Services	· Heat recovery systems · Heating and cooling systems deep retrofit & optimization · Steam to hot water conversion · Ventilation deep retrofit and optimization · Centralized controls modernization · Renewable & distributed energy resources
Performance Outcomes	· EUI reduction – 30% · Number of Buildings - 40 · Asset renewal · Reduced water use · Improved O&M · Energy cost savings/avoidance · Improved resiliency

Brown University

Brown University aimed to reduce GHG emissions by 42% by 2020 and selected Ecosystem to lead a campus-wide net zero readiness and GHG reduction project focused on the central heating plant, distribution network, and building-level improvements.

In this project, there were two main challenges: converting steam loads to hot water and operating the heating system at a lower temperature. The project's energy measures overlapped with Brown's deferred maintenance and utilities master plans while solving asset renewal challenges. When proven viable, we ensured the incorporation and reuse of existing assets and materials. For instance, Brown had invested in updating its hot water piping network only a decade earlier, and maintaining this network was more cost-effective than replacement. Ecosystem's engineers also aligned the project with other projects on campus, delivering more outcomes at a lower total cost.

This project reduced GHG emissions by more than 4,700 mTons and included significant energy cost savings and water usage reduction. With a lower-temperature system and compatible buildings, the campus is prepared for the implementation of further technologies to move toward net zero in the future. This project was awarded the 2021 SCUP Award for Excellence in Planning District or Campus Component.

We have been selected as the ongoing specialist to optimize the in-building conversions and costs to lower hot water temperatures at Brown. We are conducting a detailed analysis of building loads and developing innovative designs for future implementation.

Client Name	Brown University
Address	295 Lloyd Avenue, Providence, RI 02912
Contact Information	Michael Guglielmo Vice President, Facilities Management Michael_guglielmo_jr@brown.edu 401-863-1297
Total Contract Cost	$24.8M
Completed within the Last 5 Years / Ongoing with at Least 75% Complete at the Time of the RFQ	✓
Scope of Services	· Steam to hot water conversion · Work in laboratories · Dedicated steam boiler · Electric humidification · Heat recovery loop · Steam to hot water boiler conversion · Building Automation System (BAS)
Performance Outcomes	· Annual Savings - $1M · Reduced GHG emissions · Asset renewal · Reduced operating costs · Improved O&M · Campus master planning & net-zero strategies

Vassar College

Building on Vassar College's 2016 Climate Action Plan that targets carbon neutrality by 2030, the college undertook a study with Ecosystem to identify the best path toward deep decarbonization. The goal of the study was to ensure that the campus made the right investment and took the proper first steps to progress to net zero. Vassar aimed to minimize lifecycle cost, improve resiliency and safety, enhance the campus experience, reduce GHG emissions, and maintain long-term flexibility.

Over six months, Ecosystem and Vassar collaborated on an iterative and analytical design process. The targeted outcome was an actionable plan based on potential scenarios and associated infrastructure upgrades. Ecosystem focused on the decarbonization of heating, replacing natural gas and fuel oil with renewable energy sources. The study also evaluated modifications to the district energy network and the scope of work to the buildings' heating, ventilation, and air-conditioning infrastructure required for compatibility with renewable energy sources.

This study set the stage for future campus projects and proposed a six-step Investment Roadmap to Net Zero. In 2020, the Ecosystem team proceeded to the next stage and implemented the proposed changes. The project included the installation of heat pumps and modification of building heating systems, including in laboratories. Ecosystem is near completion of this step and looking at the second phase of building improvements for the electrification of heating.

Client Name	Vassar College
Address	124 Raymond Ave, Poughkeepsie, NY 12604
Contact Information	Bryan Swarthout VP for Finance and Administration brswarthout@vassar.edu 845-437-5506
Total Contract Cost	$11.85M
Completed within the Last 5 Years / Ongoing with at Least 75% Complete at the Time of the RFQ	✓
Scope of Services	• Central heating plant optimization • Distributed heat recovery • Central cooling plant optimization • Ventilation optimization • Lighting upgrade • Cooling system retrofit • Air handling unit replacement
Performance Outcomes	• GHG Emissions reduction – 21% • Reduced operating costs • Improved O&M • Roadmap to net zero

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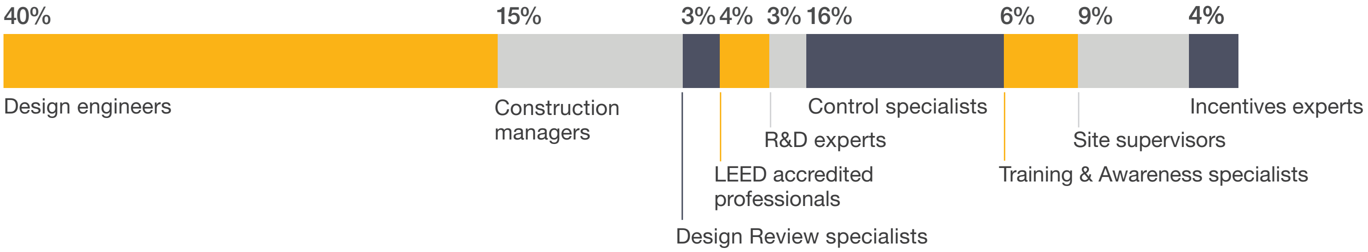
Team Profile

Ecosystem's People

Ecosystem's singular focus on the comprehensive design, implementation, and optimization of highly efficient buildings has allowed us to build multidisciplinary teams that include specialists for each phase of our projects. These include engineers, CEMs, CMVPs, PEs, drawings experts, construction managers, site supervisors, commissioning specialists, and specialized teams dedicated to incentives, savings tracking and verification, awareness programs, and technical training programs. These in-house capabilities generate efficiencies and a communal body of knowledge that create significant value for our clients from the study phase through project implementation.

Our expertise is based on the technological knowledge and understanding of our multidisciplinary staff combined with the insight we have gained from every measure we have designed, implemented, optimized, and monitored over the past 30 years. Our specialized knowledge base, unique in North America, enables us to deliver optimal results.



Constant Collaboration with Yale University

Constant collaboration with all Yale stakeholders will be instrumental in the success of the project. We want to align ourselves with Yale so that we can act as an extension of your team in the planning, design, and implementation. Through our experience, we have found that the most successful projects are the result of effective collaboration from the beginning. This should start prior to the execution of the contract and permeate through all departments and stakeholders of Yale. We appreciate that this type of partnership requires sensitivity, and sometimes discretion, when working with teams that take great pride and ownership of their work at Yale.

Subject Matter Experts

In addition to our local engineers and construction managers, Ecosystem's team of subject matter experts will be called upon regularly to help conceptualize, design, and implement specific measures and programs as needed. Our results-driven, integrated approach means that the people with the best and most relevant experience will be on-site and working within the team to deliver best-in-class projects.

*Resumes can be found in Appendix B.

Key Personnel

Ecosystem has identified three points of contact who will be managing the project to facilitate and expedite the process. They are presented below.

Senior Project Director

Andre-Benoit Allard

Andre-Benoit will act as the senior resource, overseeing the engineering and implementation of the project while ensuring proper transition between each of the phases.
Phone: 1-401-578-2777
Email: aballard@ecosystem.ca

Senior Project Development Lead – Higher Education Sector

Jean-Philippe (JP) Drouin

JP will be involved in initiating and maintaining strong communication with all stakeholders, leading stakeholder engagement sessions, making sure Yale's needs and goals align with project outcomes, and will be heavily involved in the design process to ensure project alignment.
Phone: 1-418-570-5088
Email: jpdrouinbouffard@ecosystem.ca

Client Liaison

Robert Mancini

Bob will manage the client experience beginning with the RFQ/RFP and contract execution phases, all the way through to project completion.
Phone: 1-401-808-0589
Email: rmancini@ecosystem-energy.com

About the Team

The team presented in the organizational chart will work to develop projects that will advance the university's goals. This team was selected based on their combined multi-disciplinary experience (energy master planning, design, and construction) in higher education. Throughout the process, the team will collaborate on all aspects of the project to ensure a smooth transition and project delivery.

Ecosystem • Yale Team

Andre-Benoit Allard
Senior Project Director

Jean-Philippe Drouin
Senior Project Development Lead - Higher Education Sector

Robert Mancini
Client Liaison

Construction Team

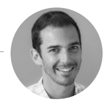
Kevin Fortin
Construction Director

Trevor Smith
Construction Manager
*Licensed PE in CT

Max Lamirande
Senior Project Engineer

Ted Holden
Site Supervisor

Engineering Team



David Bonneau
Lead Design Engineer

Simon Lessard
Lead Design Engineer

Max Lamirande
Senior Project Engineer

Lucas Taub
Project Engineer

Incentives

Adam Shelly
Lead Incentives Engineer

Controls & Comissioning

Marc Trepanier
Senior Mechanical Systems Optimization Specialist

Community Awareness

Stephanie Schwartz
Communication and Marketing Director

Subject Matter Experts

Richard Tremblay
Cofounder

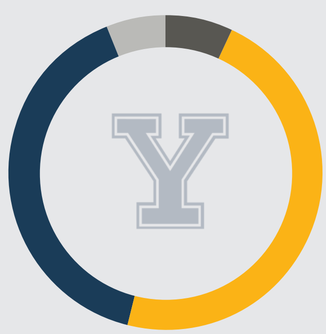
Simon Lessard
Senior Director Technical Solutions

Jean-Philippe Guay
Team Lead – Electrical Engineering

Daniel Robidoux
Project Support Specialist

Jerome Harvey-Bergeron
Director Health & Safety

Gabriel Teyssedou
Senior Project Director



You are Surrounded by 24/7 Support from the Entire Company

- 7% Project Development
- 47% Design
- 40% Construction
- 6% Training & Awareness

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Team Approach

Team Approach

As an integrated engineering and construction company that has been specializing in decarbonization projects and deep energy retrofits for the past three decades, Ecosystem has spent a lot of time developing and refining its own strategies and innovations.

At Ecosystem, we have established a tailored approach for the development, design, implementation, and optimization of our projects, specifically for laboratory environments across our various higher education and healthcare projects. In this section, we address how our approach will relate to the goals and needs set forth by Yale, ensuring EUI reduction and carbon-readiness of the selected laboratory buildings.

With respect to this RFQ, the following list details how Ecosystem understands and proposes to approach Yale's key goals and project challenges:

1. Adapt the six laboratories' building energy systems to enable the supply of low-temperature hot water via central heat pumps in an effort to decarbonize heating. Optimize the in-building energy systems to maximize future central heat pump performance by lowering the return hot-water temperature, increasing ΔT, and reducing peak heating demand. Find innovative ways to convert buildings to keep costs under budget.

2. Perform deep energy retrofits of the six buildings to reduce EUI by approximately 50% (from 296 kBtu/sqft to less than 150 kBtu/sqft). Maximize internal heat recovery from within the building and integrate multiple innovations to reach and exceed this ambitious EUI reduction goal.

3. Maintain a highly collaborative and open dialogue with the stakeholders involved throughout the project life, especially the laboratory buildings' community. Identify project objectives and KPIs (this includes ensuring lab safety and minimizing impact on activities), and ensure they are achieved.

4. Finally, execute the planning, engineering, and construction of the above in an integrated way to maximize project outcomes and the overall experience for all stakeholders involved.

Energy Investigations Specific to Lab Buildings

Understanding that laboratories have varying applications and end uses that include sensitive work, Ecosystem prioritizes close collaboration with the facilities and faculty teams to properly coordinate the required audits and ensure minimal disruption to ongoing operations. The primary factors driving energy and safety for labs are the fume hoods and air changes. As such, investigations begin with a proper understanding of these systems and the end-user requirements.

The general investigation process begins by reviewing all available data, such as drawings, HVAC balancing reports, utility information, and other details we can gather from the BMS. Additionally, a proper understanding of the contaminants and/or research being conducted is imperative to properly design and optimize the systems in a safe manner. Once the initial data is gathered and analyzed, a plan is developed, and we will coordinate with on-site staff to schedule initial site visits to help identify potential solutions. These site visits enable us to better understand the actual operation of the labs, such as proper air flow (negative vs positive pressurization) or fume hood utilization (i.e., are they variable or locked in place, or being bypassed, etc.). In many instances, lab spaces have been modified from their original design to accommodate growth and new research, while leaving the original ventilation system relatively untouched. This can cause air flow issues that increase energy consumption and can potentially be a safety issue. During these investigations, time is taken to validate the proper air flow patterns in the labs and ensure that the fume hoods, general exhaust, and diffusers are all working as intended.

A code review is also conducted to assess the proper air changes and if reduction is possible. ASHRAE standards, Yale's laboratory design requirements, and other codes and guidelines such as ANSI and NFPA, are analyzed and used to determine the possibility of reduction in air changes based on biosafety levels and laboratory ventilation design levels.

Our in-house team also uses these on-site investigations to understand the level of complexity that will be required for each energy conservation measure (ECM) to be implemented, which helps develop accurate project costs. Specific equipment and/or items that are investigated in the labs are included but not limited to:

- Supply air flow rates
- Number and location of fume hoods, diffusers (including type), and exhaust grills
- General heating and cooling systems
- Type of contaminant

In summary, our approach to lab analysis can be described as follows:

1. Understand end users' needs and safety requirements of specific labs
2. Develop a code review chart for each lab that includes the required ACH based on needs and safety
3. Investigate specific laboratory equipment and air flow patterns

4. Develop an energy model with the potential impacts of various ECMs

5. Focus on reducing waste at the source, followed by heat recovery and low-temperature hot water conversions

Submetering Exercises

The submetering requirements will depend on available information from the facilities. We start by looking at BMS trends and information to determine exactly what needs to be submetered. Typical submetering efforts include the installation of BTU meters and monitoring/clipping existing drives on HVAC systems, for example.

Whole Building Energy Modeling

Ecosystem's approach to energy modeling is based on extensive implementation experience. We use the knowledge gained from 30 years of designing, implementing, and guaranteeing results to develop the most efficient methods to model actual building usage and the impact of various ECMs, such as steam and high-temperature hot water systems to low-temperature hot water systems and electrification. The first step in developing our energy models is conducting an extensive building survey to properly identify building characteristics, energy-consuming equipment, and submetering and occupancy patterns and/or usage; data is collected from the BMS (when available) as well as the utility bills. Next, a detailed energy model (based on bin hours of 8,760 hours) reflecting the previous information is developed and calibrated based on the utility information, ensuring the model is accurate.

We have also developed methods to identify implementation costs for building low-temperature hot water conversions and other ECMs. Together with the energy model, we can provide accurate project savings and implementation costs, all based on actual project implementation information.

We have experience using modeling software such as HAP, eQuest, and EnergyPlus. These can help maximize tax benefits and certain incentives.

Smart Lab Implementation

Ecosystem has not used the smart laboratory implementation method per se, although we find it closely matches our own natural approach to:

- Build stakeholder engagement
- Develop a plan
- Assess with energy modeling and/or investigation as detailed above
- Implement projects
- Follow-up and track performance

Thermal Electrification of Laboratory Buildings

Ecosystem has three decades of experience in delivering thermal electrification projects in laboratories. Over time, we have refined our strategy.

When we undertake energy roadmaps/audits, we take a three-tiered approach:

1. **Conservation First**
   Reduce building-side energy consumption, EUI, and demand through ECMs. This typically includes lighting, controls optimization/upgrades, building envelopes, etc. Eliminating waste at the source helps optimize the financial performance of the project by avoiding oversizing the renewable generation sources, for example. While designing the ECMs, we take the existing infrastructure and assess whether certain elements or components can be reused or repurposed. The benefits of this include an accelerated project timeline, reduced disruption, improved system performance, and reduced cost. For more information on capturing existing asset value, see Appendix C.

2. **Building conversion**
   First, we ensure that we deeply understand the thermal loads: their nature (i.e., terminal reheat coil, pre-heat coil, peripheral unit, domestic hot water, process loads, etc.); their energy use profile (i.e., peak demand, winter demand, summer demand); their location in the building; their original design characteristics (are they oversized or not); and their actual performance (can they take lower temperatures and still meet the demand, and if so, at what lower temperature and in external condition). We do the same for the in-building piping system (i.e., condition, pipe size, life expectancy, etc.). Once we have a detailed understanding of all loads, we run what we call data-driven scenarios analysis; some scenarios might attempt to reduce hot-water temperatures to a certain point by reusing more assets in the building (i.e., coils and pipes), whereas other scenarios will model the replacement of more assets to reach even lower temperatures. Sometimes, through a good understanding of the loads and testing in the winter, we find that certain buildings can take a lower temperature by changing only a fraction of the assets instead of replacing all building components, saving large sums of money. We perform lifecycle cost analysis and compare scenarios by their Capex and Opex to get a holistic view. For instance, lower hot-water temperature profiles will result in more efficient heat pump operation and a lower Opex, or bigger building ΔT will result in smaller district piping and lower Capex. That way, we can identify the optimal hot-water temperature profile to minimize Capex in building conversions, as well as Opex at the plant. We find that this systematic approach usually delivers the most cost-effective concept. We always strive to identify the scenario that maximizes the desired outcomes in a building conversion.

3. **Carbon Reduction – Electrification**
   Once the waste has been eliminated at the source, we look to reduce the use of fossil fuels where possible. Typically, in healthcare and higher education, there is usually a fair amount of simultaneous heating and cooling that can be utilized to minimize the use of boilers and chillers. Given the high use of absorption chillers at the campus, we will look to maximize the utilization of heat recovery chillers and capture waste heat as applicable.

In this approach, we will also look at the lifecycle cost analysis of the options considered to help guide decision making and move into the project development phase.

Laboratory Equipment Evaluations

Fume hoods are one of the biggest contributors in a lab's energy use as it drives the general exhaust and supply air requirements. We begin by analyzing the working order of these fume hoods, which includes determining conditions of the air valves, the sash, and face velocities, and VAV vs constant volume, for example. After that, we work our way up to the general exhaust system, followed by the supply air systems. To achieve the desired EUI targets indicated in the RFQ, proper balancing of all these systems will be imperative.

Community Engagement within Laboratory Buildings

Engagement with the students, academics, and professionals conducting research and using the labs is an essential step toward safely reducing energy usage in the buildings and lowering the overall EUI. Ecosystem has ample experience holding stakeholder alignment meetings, allowing everyone to communicate their priorities and requirements, and process toward developing a shared vision of the project and keeping everyone informed. Labs need to be classified by the biosafety risks, and design ventilation conditions need to be properly assessed at the beginning of the investigations and/or audits. Furthermore, discussions with the end users can also help identify existing issues with the heating, cooling, and air flows of the spaces, which can help identify possible ECMs. Communication is also essential, as it allows us to plan implementation that does not disrupt sensitive scientific research. Ecosystem has extensive experience on university campuses and has implemented strategies to minimize disruption.

Commissioning

The start-up and optimization phase is critical in each of our projects. For optimal performance, our in-house commissioning process programs the sequences of operation based on our whole-building understanding of systems. Our control specialists excel at reconfiguring and refining sequences of operation and remain in constant contact with your operations staff to test and validate system performance.

Ecosystem uses the Commissioning and Optimization period to ensure that all equipment and control systems operate as designed and mitigate long-term issues that could potentially arise after the completion of a project. As part of this phase, Ecosystem will maintain close involvement with the university's staff.

All systems will be commissioned to industry-leading standards, and we will prepare a document package with the assistance of the project management team. Specifically, Ecosystem uses commissioning check-sheet templates that can be completed, saved, and printed. These templates are also used to document the inspections, tests, contractors' start-up programs, verification, performance evaluation, and balancing reports. The operations and maintenance manuals are updated to reflect all changes to the affected systems. The optimization team monitors equipment and systems to bolster reliability and efficiency with input from the engineering team.

Post-Occupancy Monitoring

As soon as the project is underway, we will assign a performance team led by a CMVP professional to monitor the implemented measures and report on savings. This team will work in close coordination with any third-party commissioning and M&V agent, if required. If we notice that the measures are not performing as expected, Ecosystem goes back to the source to identify and eliminate the root cause of the deficiency. This approach allows us to ensure optimal performance of the newly installed equipment and guarantee the best possible energy savings.

As an additional benefit of Ecosystem's measurement and verification methodology, Ecosystem will continue to work with our clients for the duration of the contract. Ecosystem firmly believes in alignment of interests: If a project does not succeed in the long term, Ecosystem does not succeed.

Automatic Fault Detection & Diagnostics

Laboratories are a good candidate for integration of an automatic fault detection and diagnostics (FDD) system due to their high energy use and safety concerns. FDD can also be used for the early detection of issues and correct any problems quickly, reducing energy costs, increasing system lifespan, improving occupant comfort, and providing enhanced data analytics. It is a good solution for a smart lab program. Ecosystem remains vendor agnostic and we will strive to identify the best possible system that will fit Yale's needs.

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Team Management

Cost Estimating

Ecosystem's cost estimating is based on three decades of real-world experience designing and implementing projects, with the majority completed in a turnkey, guaranteed price contract for our clients.

Our estimates are developed by finding up-to-date pricing for equipment, with extensive awareness of market-specific conditions and previously conducted, similar jobs. During our walk-throughs, our engineers look for existing infrastructure components that can be reused and/or repurposed to reduce costs (both Capex and Opex).

The cost-estimating process proceeds as follows:

- Before cost estimating, Ecosystem conducts on-site audits. Auditing tools, including 3D laser scanners and 360-degree cameras, help create detailed visual references of key systems and spaces. These assets help reduce exploitable "gray areas" for interpretation by subcontractors — both in the provision on budget quotes and later at the procurement stage — that could lead to project cost overruns.
- Detailed cost estimates are prepared at the onset of ECM conceptual design, using a bottom-up (parametric) estimation of costs via budget quotes obtained from reputable equipment suppliers and subcontractors.
- A top-down analysis is then made using comparative cost data from similar projects. External, per-unit indices, such as market activity affecting equipment supply and/or components, are also factored into this analysis.

Cost Management

Ecosystem's cost management process permeates the life of the project. A multidisciplinary team composed of design engineers and construction engineers is involved together throughout all project phases, integrating our expertise early in the process to help reduce construction costs.

Cost Control during Project Design Development

Effective cost control starts with the determination of construction costs during the project development phase to provide the most accurate, investment-grade budget. This methodology described above is an important first step in cost control; our team owns the process through completion.

Cost Control during Procurement

Ecosystem's procurement processes are designed to control project costs and ensure the best value for our clients. All construction activities are subcontracted directly by Ecosystem, and each subcontract will be overseen by Ecosystem's project and construction managers. Ecosystem will also structure equipment prepurchase tenders wherever possible as a solution for cost and schedule control, and to maintain equipment manufacturer consistency.

Scheduling Approach & Organization during Construction

Ecosystem designs scheduling to meet agreed objectives, aligning with the academic calendar and contractual milestones. The schedule will be made collaboratively with Yale, and the flexibility level is shared. We develop realistic schedules, allowing for some contingency.

The approach to building a project schedule is normally iterative and collaborative: an outline or the main format is shared for comments; from there, the client and Ecosystem work on sub-layers, with attention to areas of sensitivity. Only one schedule is created: we are fully transparent, and there is no "behind-the-scenes" working schedule. To establish a relationship founded on trust, it is essential to have strong alignment on the project roadmap.

In the schedule, key tasks are linked to illustrate the critical path, which is then highlighted for easy comprehension. A lifeline is added to easily identify tasks that are either behind or ahead of schedule.

Updates on the schedule are shared every two weeks, and master schedule revision is suggested every month. During each update session, the critical path is discussed and analyzed. Sub-action items are shared to ensure milestones are met. So there are no surprises, all stakeholders have visibility on upcoming tasks that may become part of the critical path.

Use of Project Management and/or Construction Management Software Tools

Ecosystem has used various project management tools over the years, including Fieldwire, BIM360, and Procore. Among the construction management tools Ecosystem has used are MS Project and Primavera. Ecosystem can either adapt to the tools Yale University is already using or propose tools to be used. A shared online platform such as SharePoint or similar can allow all parties to share documents and track version history and approvals.

Periodic Reports of Key Project

Ecosystem recommends agreeing a project reporting cadence that meets the needs of Yale University and the project specifics. This allows all stakeholders to remain informed, share their concerns, be empowered, be ambassadors for the project, and contribute to shared success. We propose weekly meetings with the project manager, biweekly meetings with operations, and monthly meetings with executives.

A macro view is reported periodically by Ecosystem. KPIs of the whole program are reviewed and compared with objectives. KPIs not met are reviewed in detail, down to the individual project level. Following the review of the program and the KPIs, individual projects are benchmarked against their own performance indicators, allowing a both a macro and a project-specific perspective.

Design Development & Management

Ecosystem's approach to design development builds on deep collaboration with Yale's key stakeholders. We encourage frequent, interactive communications with your team to share information, explore all potential opportunities, and incorporate your facility knowledge into the overall solution.

From the start, design charrettes and workshop sessions will facilitate the free flow of ideas and information, and will be used to gather feedback and drive consensus and alignment. This ensures that key stakeholders also become key supporters.

Communication during design development will be maintained among participants through regular meetings and deliverables as outlined in an agreed schedule. Biweekly coordination meetings will track work to make sure it is on schedule and allow us to review progress. Decision gate meetings will be used for reviews, feedback loops, and final acceptance. We will also provide regular progress reports, meeting minutes, including budget and schedule updates, and monthly invoices.

Stakeholder Engagement & Communication

Working in live, complex environments like Science Hill requires an elevated level of communication and collaboration. This is where our team excels. We value open communication to ensure that all project stakeholders have the information required to limit disruption, keep campus users safe, and move the project forward. We lead and moderate stakeholder engagement sessions early in the design process and again later during project implementation.

Additionally, working on your campus requires a dedicated focus on broader outreach and engagement to ensure that students, staff, and faculty are personally invested in the project whenever possible. We will collaborate with your communication team to keep campus users informed of project progress.

Dispute Resolution Management

Ecosystem has carefully developed strategies to mitigate the possibility and impact of potential disputes on our projects in order to reduce disruptions. When disputes or conflicts arise, Ecosystem has a clear approach in place to de-escalate and resolve issues.

Establish clear roles, responsibilities, and measurable project objectives: Ecosystem is effective in managing relationships with clients, partners, subcontractors, and suppliers. Well-written and negotiated contracts will ensure there is no ambiguity around accountabilities between Yale and Ecosystem, and between Ecosystem and our suppliers. The same applies for setting clear performance objectives with regards to budget, schedule, savings, client comfort, etc.

Be a true partner and keep communication: As Ecosystem shoulders the risk of achieving outcomes, our interests will be aligned with those of Yale. As a result, our employees and suppliers act as an extension of your team. Constant communication will also be a factor in prevent conflicts.

Safety Program Management

Safety is a core priority for Ecosystem. During project implementation, the health and safety of workers and occupants comes first. We use the following key processes to ensure compliance with regulations and coordinate the construction work with our clients:

Ecosystem's health and safety prevention program: Ecosystem will develop a health and safety program that aligns with relevant regulations. This program will address legal requirements, and a site-specific prevention program is included for each worksite.

Forms and procedures: Forms for mandatory safety worksite orientations, safety break meetings, site audits, permits for hot work, procedures for work in confined spaces, etc. are used to facilitate communication and compliance regarding health and safety procedures.

Work plans: We implement work plans to identify risks and preventive measures, and designate which subcontractors are in charge (and obtain their contact information). Work plans, defined in collaboration with subcontractors, must be approved before the work is carried out.

Site safety audits and disciplinary measures: A formal written site safety audit is performed monthly by our construction manager. Our site supervisors inspect the worksites daily and record any noncompliance; if a worker is found to be non-compliant, the site supervisor meets with the worker to discuss the regulations that have been violated and ensures that they understand the risks and potential consequences. If the issue recurs, Ecosystem sends a written notice to the subcontractor and may impose disciplinary measures.

Safety compliance verification and internal audits: On a monthly basis, Ecosystem's project director, with the OHS director, verifies that safety activities have been performed accordingly by our field's personnel and reports safety KPIs to Yale. Our OHS director will perform regular site visits for safety audits.

Recruiting & Onboarding of New Team Members, Including Workforce Diversity

For every project, Ecosystem strives to assemble local teams that reflect the communities in which we operate. We give priority to local subcontractors, especially those who have good working relationships with Yale, and a historical knowledge of both the region and your facilities; Our onboarding process for new team members and partners ensures that we always work together as a unified team.

We value the strength that comes from diversity in our people and our partners, and we have implemented several initiatives, such as tracking MWBE partners.

Ecosystem is also committed to gender equity in the engineering space. We are a woman-led firm and 27.3% of senior leadership positions are held by women within the company. We are continuously seeking ways to improve this metric.

Appendix

Brown University's Thermal Efficiency Project

Brown University's Thermal Efficiency Project

The institution has charted a path to transform its aging heating system and reduce emissions.

Jessica Berry, Director, Office of Sustainability, Brown University; J.P. Drouin, CEM, DBCP, Director of Project Development, Ecosystem Energy Services; Benjamin Milbank, Project Development Engineer, Ecosystem Energy Services

Photo Nagel Photography/Shutterstock.com.

Van Wickle Gates (1901), Brown University.

In 2008, Brown University in Providence, R.I., set an ambitious goal to reduce campus greenhouse gas emissions by 42 percent from 2007 levels by 2020. Ruth Simmons, the university's president at the time, stated, "Brown is committed to doing our part to create a more sustainable environment. It is important to lead by example, taking action to preserve and protect the planet."

This mandate empowered the university's Office of Sustainability, which is housed in and is a key part of the Facilities Management office, with clear institutional goals and support. The office embarked on a comprehensive program of energy efficiency measures to lower Brown's carbon footprint. It proved to be a major success, eliminating nearly 20,000 metric tons of carbon dioxide equivalent emissions in the past 10 years. To meet the president's promised 42 percent reduction goal on time, however, a plan to improve the energy efficiency of Brown's 1960s-vintage campus heating system was also needed.

That plan, the Thermal Efficiency Project, was launched in 2018. It involves converting Brown's existing high-temperature hot water system – based on centrally produced high-pressure steam – to modern, highly efficient, lower-temperature hot water.

TARGETING ENERGY EFFICIENCY

After Brown University announced its 42 percent emissions reduction target, the Office of Sustainability established a program to fund the energy efficiency measures. Utility incentives received as rebates from National Grid are directed into the fund, enabling future initiatives. This supplemental source of funding for the university's annual greenhouse gas reduction budget allows the Office of Sustainability to support facilities improvements to provide greater value, by combining asset renewal with additional energy efficiency.

IT WAS CLEAR THAT SMALL, INCREMENTAL STEPS WOULD NOT HAVE SUFFICIENT IMPACT. A TRANSFORMATIONAL PROJECT OF THE DISTRICT HEATING SYSTEM WAS NECESSARY.

Thus far, the energy fund has paid for lighting retrofits, controls optimization and retrocommissioning of HVAC systems across the campus, and fuel-switching from oil to natural gas at the campus heating plant. To date, 527 projects of various sizes and scope have been completed, are in progress or are under development. Since 2008, Brown's $27 million investment in these projects has reduced CO_2e emissions by a total of 19,723 metric tons (27 percent) and resulted in annual energy expense savings of more than $4 million.

While these are impressive results, achieved over a short period of time, the path to attaining the full 42 percent greenhouse gas emissions reduction goal by 2020 was less clear. By 2015, many of the "low-hanging-fruit" measures had already been implemented, and little more could be achieved on that front. The sustainability department's attention turned to the elephant in the room: the campus district heating system. It was clear that small, incremental steps would not have sufficient impact. A transformational project of the district heating system – potentially involving re-engineering and overhauling the central heating plant, distribution network and some building HVAC systems – was necessary.

TRANSFORMING A 1960s-VINTAGE SYSTEM

Brown University's existing district steam heating system, commissioned in 1967 to replace an earlier steam system, provides 350 degree F high-temperature hot water to approximately 4.5 million sq ft of the roughly 6.5 million sq ft of floor space on campus. It serves a variety of heating needs, from hot water space heating to high-pressure steam generators used for important processes such as sterilization of lab equipment. The range of demands on the district heating system requires operating conditions that lead to certain inefficiencies – such as more energy- and labor-intensive startup and greater thermal losses in the piping networks, due to the higher-temperature hot water generation and distribution.

Inefficiencies aside, however, Brown University was fortunate to have a hot water district heating system – an asset that could certainly be built upon (piping was recently overhauled) and not replaced. Similar institutions across the northeastern states typically have district steam systems. Comparing the total efficiency of these legacy steam systems, not just boiler efficiency, reveals an average yearly efficiency of around 50 percent – meaning that half of every dollar of natural gas they burn is wasted. Brown University's high-temperature hot water system was a generation ahead of such systems: Analysis of campus data showed that the system averaged a yearly efficiency of around 66 percent, better than the cohort average but still representing significant inefficiencies.

In addition to the central heating plant, any plan to upgrade Brown's campus energy system had to take the distribution network into account. The campus relies on more than 30 district energy hubs – dedicated mechanical rooms that take energy from the high-temperature loop and convert it for a medium-temperature hot water loop and/or process steam generators. In fact, some of these hubs convert the high-temperature hot water into low-pressure steam, only for that steam to then be converted to medium-temperature hot water closer to the heating load. Out of all the district energy hubs, only 11 generate any steam. Six of these hubs, which date from the 1950s and predominately supply steam for space heating, are on the priority list for renewal per the university's utility master plan; the cost to replace five of these six steam hubs (including a small amount of work at the central plant) was estimated at $16.8 million. (The other five steam-generating hubs are more modern and produce steam for process loads.)

In 2014, Brown commissioned a study of opportunities to raise efficiency at its central steam plant. This study was completed in early 2016. As expected, it determined that Brown's campus steam/hot water heating system – designed in an era when energy costs and associated emissions were not as much a priority as they are today – had a significant efficiency penalty associated with the high temperatures and high operating pressures.

Engineers from Ecosystem Energy Services received this study and, working closely with members of Brown's sustainability office and Facilities Management team, started developing possible paths forward to improve the efficiency of the whole district heating system. The analysis began with a key question: What and where is the energy's destination? It quickly became apparent that although the system was designed within parameters to serve high-pressure steam loads, these loads accounted for only a small amount of the plant's total energy consumption. In a nutshell: The system could only be as efficient as its weakest link – the steam loads.

The next step was establishing a preliminary understanding of all the steam and high-temperature hot water loads served by the district system. Was it feasible to eliminate the need for steam loads served from the high-temperature loop? Was it possible to lower the district hot water heating loop below 350 F? Could the satellite steam hubs be eliminated? Could the steam heating be converted to something else, or decoupled? Ambient spaces are maintained at around 72 F, and domestic hot water is heated up to 140 F; so, leaving aside process loads (sterilization, humidification, kitchen equipment), did the campus really need 350 F hot water and steam to heat its buildings?

The team realized there were significant advantages to medium- or lower-temperature hot water (over high-temperature hot water and steam) heating. They include

- improved efficiency of generating assets (lower-temperature heating equals more heat extracted from combusted gases),
- improved efficiency of distribution systems (reduced radiation and steam flash losses, etc.) and
- improved efficiency at the building level (e.g, less overheating).

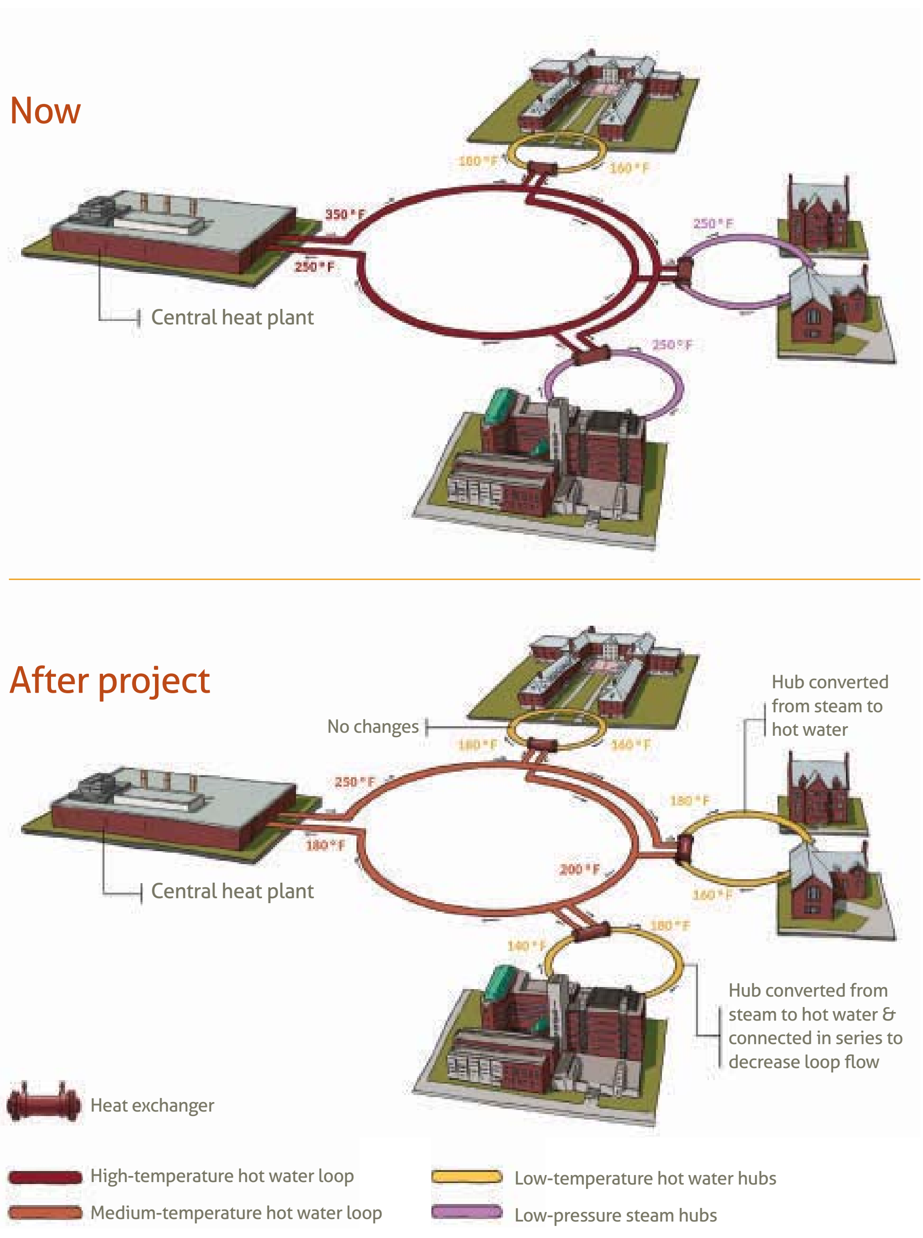
Courtesy Brown University.

At Brown's central plant: one of the three boilers to be modified to hot water as part of the Thermal Efficiency Project.

Courtesy Brown University.

Out of 30 district energy hubs on the Brown campus, 11 generate steam; six of these, including the one shown here, date from the 1950s and will be replaced.

FIGURE 1. Before and after the Thermal Efficiency Project: Brown University's district energy system.



Source: Ecosystem Energy Services.

Hot water systems also introduce the potential to use newer heating technologies, such as heat pumps, solar heating and even thermal storage. However, these advantages are only applicable to district energy loops well below 200 F, and the benefits compound at lower heating temperatures.

LEVERAGING THE UTILITY MASTER PLAN

The next strategic questions were framed around leveraging the university's broader plan for asset renewal to develop a transformational project that would deliver great energy-saving value and align with the institutional greenhouse gas emissions goal. In late 2016, Ecosystem Energy Services was contracted by Brown to further study and perform the engineering necessary to design a district energy system upgrade. Typically, asset renewal needs and deferred maintenance present some of the greatest facilities challenges. Often asset renewal budgets are directed toward the gravest outstanding issues on campus, without necessarily tackling energy and greenhouse gas reduction.

The utility master plan that Brown University had commissioned earlier proved to be a significant advantage when it came to developing a project that addressed university asset renewal concerns in the context of a broader energy savings mandate, making it easier to generate value for the campus. This carefully conceived plan enabled Brown to avoid a piecemeal approach to the district heating system asset renewal and potential upgrades and instead pursue a holistic and transformational project.

Thus, the basic goals of the district heating upgrade project were to

- eliminate steam loads from the district heating loop,
- lower the temperature of the distribution and
- convert the central heating plant to hot water instead of high-pressure steam.

This project thus became known as the Thermal Efficiency Project (fig. 1).

CAMPUS CHALLENGES

One of the big challenges Brown University and Ecosystem faced was logistical, i.e., planning to manage energy demands in sensitive environments. The areas with the most energy consumption, and thus most important for the project, are also the most critical spaces on campus, including those that house important research facilities. Installing temporary HVAC equipment for these buildings while they undergo deep retrofits would eliminate some of the financial value that this project is set to achieve. Thanks to close collaboration and communication, strategies have been devised to ensure that this project achieves a win-win on asset renewal and energy reduction.

For each building, collaboration between engineering, facilities and faculty determined the acceptable level of impact to building operations. For instance, a time frame for equipment shutdown during certain seasons was agreed on by all parties involved. An implementation schedule was then carefully reviewed to ensure that the design could be installed during these time windows. Sometimes designs were altered to accommodate critical campus needs. In one instance, when heat recovery and preheating outside-air systems were to be installed, requiring two separate coils, a custom coil was developed instead that would need only one installation and shutdown.

In terms of engineering design, there were two main challenges with the Thermal Efficiency Project: converting steam loads to hot water and operating the existing district heating system at a lower temperature.

THERE WERE TWO MAIN DESIGN CHALLENGES: CONVERTING STEAM LOADS TO HOT WATER AND OPERATING THE EXISTING HEATING SYSTEM AT A LOWER TEMPERATURE.

Steam-to-hot-water conversions

The challenges of converting steam loads in any building can be significant, from effectively managing construction and mitigating occupant disruption to planning and implementing intrusive work to access steam equipment/piping. This challenge is magnified when trying to implement this work as part of an investable energy efficiency project on a bustling university campus that is largely occupied throughout the year.

However, the Thermal Efficiency Project team was confident it could be done. The following strategies were selected for inclusion in project plans to minimize the impacts of the conversion on Brown's students, faculty and staff:

- performing piping modifications during the evening and at night in areas of buildings that experience high daytime occupancy
- bringing piping as close as possible to the connection points to shorten the duration of service interruptions and facilitate connections
- identifying critical areas of buildings (for example, laboratories) before the work begins and carefully planning service interruptions or building disruptions to take minimal intervention time
- performing the conversion from steam to hot water in live areas, zone by zone, system by system, to avoid shutting down critical buildings, customizing the implementation plan based on the needs in each zone and strategically scheduling the work teams to reduce the intervention time in each sector

During the design phase, it was essential to follow a case-by-case approach, as some buildings required institution-specific plans or represented greater value overall for conversion. Across the campus, each individual steam load, whether a building or process, was analyzed. First, potential building-level energy savings were calculated to determine the standalone payback for a building's conversion to hot water. This payback was then compared to any options for installing standalone steam equipment. Each building and its specific steam need were carefully analyzed to quantify the benefits and value of either converting the load and remaining with the district heating system or installing standalone steam. It was determined that all required steam loads, such as sterilization, would, of course, require standalone steam equipment.

Reducing temperature without increasing water flow in piping

The next design challenge involved utilizing the existing district system, which had been designed for a 100 F delta T, meaning a lot of energy could be passed through the pipes for little flow rate from the plant. Reducing the plant's operating temperature would require lowering this temperature differential, so subsequently more flow would have to pass through the existing piping. In some cases, this change would increase flow rates beyond what was appropriate for the size of pipe.

To analyze piping demand, a simulation was developed, including all the piping of the district plant and location-specific energy loads. This problem was resolved by re-engineering sections of the district loop: specific high-energy-load buildings were identified and ana-

Built in the 1770s, University Hall is one of the oldest buildings on campus. It will be converted to hot water heating as part of the Thermal Efficiency Project.

The Thermal Efficiency Project includes installation of heat recovery to ensure a lower delta T at the Bio-Med-Sidney E. Frank Hall Complex for Life Sciences and other buildings.

lyzed for the potential to convert to lower-temperature heating. With this understanding, high-energy-load buildings could be connected to the return piping of the district energy loop, meaning more energy could be extracted from the loop, increasing the temperature differential and reducing the flow rates below the limit of what the section of piping could accept. Existing hubs were re-engineered, again to reduce the temperature at which energy could be utilized, improving the delta T of the prospective new lower-temperature system.

Reducing energy demand at the hub/building level was another key strategy. Local heat recovery systems could be installed across high-energy-consumption buildings and at locations with restricted pipe sizing. This measure can reduce the amount of energy that needs to be carried through the piping and further mitigate the potential flow issue.

A key example of this solution has already been implemented at the Sidney E. Frank Hall for Life Sciences and the Center for Biomedical Engineering. The two linked buildings are among the largest on campus, in terms of both square footage and energy consumption. Their location on the district heating system – close to the central heating plant on the main line before piping splits and branches across campus – placed significant demand on the flow from the plant. They are also both research-intensive spaces, so they are HVAC- and energy-intensive. Both buildings also require a significant amount of 100 percent fresh-air ventilation.

Ecosystem designed a runaround loop across several HVAC systems that recovers heat from the building's exhausted air, while also taking advantage of the opportunity to install a low-temperature building-level heating system. The new system incorporates a single heating coil that prioritizes exhaust heat recovery and gets supplemental heating from the return of the campus network. This design ensured a significant amount of flow from the central heating plant could be reduced, an essential step in enabling the district system to function at a lower, more efficient temperature.

A TRIFECTA OF WINS

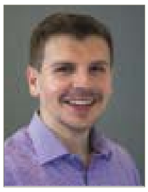
Overall, the key lessons from the development of the Thermal Efficiency Project, and recipes for success, were already starting to be evident toward the end of the design phase. They include the following:

- Long-term master planning and asset renewal plans can turn piecemeal or response-based projects into something more transformational that delivers financial gains through energy efficiency that are beyond the sum of the project's parts.
- Empowering a sustainability department that is aligned closely with the facilities management of an institution allows institutional goals to be met.
- Involving all campus stakeholders in the design process ensures that the project can be developed with all needs in mind.

Brown University's leadership was committed to turning the liability of district heating asset renewal into a trifecta of wins: reducing operating costs, lowering greenhouse gas emissions and renewing assets at the end of their service life while modernizing the system. The three-year Thermal Efficiency Project launched in 2018 will not only reduce operations costs but will also open the door to newer, greener technologies, compounding the environmental and economic benefits of the project. Brown University expects to reach its 2020 greenhouse gas emissions goal. With the Thermal Efficiency Project underway, the institution is in a much stronger position to address the next big challenge that the future holds for the campus, whatever it might be.

***Jessica Berry** is the director of the Office of Sustainability at Brown University. She provides leadership across the institution to identify, advise on, manage and implement sustainability best practices. Additionally, she is responsible for utility and waste management including identifying and implementing waste and greenhouse gas reduction strategies. Berry holds a Bachelor of Science degree in natural resources and environmental studies from the University of Vermont's Rubenstein School of Environment and Natural Resources and a Master of Science degree in environmental studies from The Evergreen State College. She has over 15 years of experience in the environmental sector including nonprofit management, international environmental consulting and higher education. She may be contacted at jessica_berry@brown.edu.*

***J.P. Drouin, CEM, DBCP,** is director of project development at Ecosystem Energy Services. He specializes in transformational energy measures and deep building retrofits such as steam-to-hot-water conversions, heat recovery chiller applications, district energy networks, and combined heat and power. He holds a bachelor's degree in mechanical engineering from McGill University and is a recognized engineer by Ordre des ingénieurs du Québec (Quebec Order of Engineers). Drouin received the 2016 International Young Energy Professional of the Year Award from the Association of Energy Engineers. He can be reached at jpdrouin@ecosystem-energy.com.*



***Ben Milbank** is a project development engineer in the New York City office of Ecosystem Energy Services. He was a member of the engineering team for the Brown University Thermal Efficiency Project. Originally from the U. K., Milbank came to the U.S. to study for his master's degree in mechanical engineering at Columbia University, having graduated with first-class honors from the University of Sussex, where he studied mechanical engineering. At Columbia, he focused on energy systems design and thermofluids and was a Columbia Business School Social Enterprise Fellow, developing several energy efficiency projects for local churches and community centers. He can be reached at bmilbank@ecosystem-energy.com.*

Team CVs

André-Benoit Allard
Senior Project Director

As Senior Project Director, André-Benoit positions his teams for success, resulting in high-performing projects and satisfied clients. He acts as a point of contact for clients and equipment providers, overseeing the design of energy efficiency measures, implementation of plans and specifications, and construction.

André-Benoit is an internationally recognized design engineer. The extensive retrofit of the Montreal Biodome earned him the 2013 International ASHRAE Technology Award for exceptional engineering design. He is fascinated by the variety in each process and finds creative solutions based on his comprehensive experience with all project phases.

Representative Projects

Humber College (2021-ongoing)

Preliminary Phase Design Services

Detailed design study to decarbonize with a district energy and steam to hot water conversion project. Outcomes include reduced GHG emissions, integration of islanded buildings, improved O&M, energy and water use reduction.

Vassar College (2020 -2022)

Project Value: $11,850,000
Annual Savings: $905,000
Guaranteed Incentives: $1,850,000

Lighting upgrades, distributed heat recovery, decentralized chiller, chiller plant optimization, operating pressure reduction, ventilation optimization, controls optimization, air handling unit replacement, cooling system retrofit.

Massachusetts Trial Courts (DCAMM) (2019-2022)

Project Value: $4,304,716
Guaranteed Annual Savings: $236,898
Incentives: $372,760
Number of Buildings: 4

Lighting upgrade, lighting controls, premium efficiency motors and VFD, high-efficiency boiler replacement, chiller replacement, DDC control system, low flow water fixtures, plug load controllers.

DYS Connelly Youth Center (DCAMM) (2020)

Project Value: $5,625,575
Guaranteed Annual Savings: $49,809

Installation of biomass boiler, hot water and steam distribution piping upgrades, installation of variable frequency drives.

Experience

20 years

Education

- Bachelor of Mechanical Engineering, Sherbrooke University, 2001

Previous Functions

- 2003-2005: Process Engineer, Central Heat and Recovery, Smurfit-Stone
- 2002-2003: Coordinator, Jaakko Pöyry ABGS
- 2001: Project Management Intern, Baxter Corporation
- 2000: R&D Project Management Intern, Waterville TG

Brown University (2017-2021)

Project Value: $24,800,000
Guaranteed Annual Savings: $1,011,000
Guaranteed Incentives: $1,200,000
Number of Buildings: 37

Campus district heating loop conversion from high-temperature hot water to medium-temperature hot water, steam to hot water conversions, dedicated steam boiler, electric humidification, BAS upgrades.

AWARDS

★ **2021 SCUP Awards, Excellence in Planning, District or Campus Component**

Massachusetts Emergency Management Agency (MEMA) 2018-2020)

Project Value: $5,134,815
Annual Savings: $225,171
Incentives: $363,351
Number of Buildings: 1

AHU replacement, demand control ventilation, PV canopy, lighting upgrade, BAS upgrade, real-time metering, EV charging station, chilled water pumps and VFD, cooling tower, heat pumps, demand response and fire system replacement.

Barry Callebaut (2017-2018)

Project Value: $3,400,000
Guaranteed Annual Savings: $199,190
Guaranteed Incentives: $900,000

Heat recovery, installation of biomass boiler.

AWARDS

★ **2019 Innovative Energy Project of the Year - Canada Region, AEE**
★ **2019 Eureka Award, Ecotech Quebec**

Calgary Board of Education (2015-2018)

Project Value: $18,500,000
Guaranteed Annual Savings: $888,330
Number of Buildings: 102

Installation of centralized controls, optimization of existing systems, installation of ventilation systems, new domestic hot water network, lighting conversion.

Olympic Park (2015-2018)

Project Value: $22,754,425
Guaranteed Annual Savings: $1,296,476
Guaranteed Incentives: $680,000

Steam to hot water conversion of heating system, peak demand management, heat recovery, retrofit of chilled water system, controls upgrade, lighting conversion, recommissioning, heat pump replacement, ventilation optimization, building envelope improvement.

AWARDS

★ **2019 International Technology Award, ASHRAE**
★ **2018 Energy Project of the Year - Canada Region, AEE**

University of Quebec in Trois-Rivières (UQTR) (2012-2014)

Project Value: $6,336,326
Guaranteed Annual Savings: $412,703
Number of Buildings: 13

Heat recovery, installation of efficient boilers, conversion of the high-temperature hot water heating system to low temperature, optimization of chilled water systems, installation of energy-efficient hoods, ventilation optimization, humidification system optimization, efficient lighting, measurement, installation of a BTU meter.

AWARD

★ **2017 Energia Award, AQME**

Saint-Sacrement Hospital (2011-2014)

Project Value: $5,580,714
Guaranteed Annual Savings: $443,111
Area: 657,901 ft^2

Steam to hot water conversion, geothermal energy, optimization of heat pump system, steam system optimization, optimization of chilled water systems, ventilation optimization, efficient lighting, addition and optimization of centralized controls.

AWARDS

★ **2018 Technology Award, ASHRAE**
★ **2017 Wayne McLellan Award, Canadian Healthcare Engineering Society (CHES)**
★ **2017 Energia Award, AQME**

Enfant-Jesus Hospital (2011-2014)

Project Value: $11,963,478
Guaranteed Annual Savings: $636,802
Area: 1,009,719 ft^2

Steam to hot water conversion, geothermal energy, heat recovery, installation of efficient boilers, steam system optimization, cooling tower replacement, installation of stack economizers, optimization of heat pump system, humidification system optimization, ventilation optimization, fresh air preheating using solar energy, efficient lighting, recommissioning.

AWARDS

★ **2018 Technology Award, ASHRAE**
★ **2017 Wayne McLellan Award, Canadian Healthcare Engineering Society (CHES)**
★ **2017 Energia Award, AQME**

Niagara Health System (2010-2015)

Project Value: $10,998,263
Guaranteed Annual Savings: $1,200,000
Number of Buildings: 6
Reduction of GHG emissions: 3190 metric tons of CO_2

Steam to hot water conversion, heat recovery, optimization of boiler room equipment, installation of solar thermal collectors, installation of variable frequency drives, ventilation optimization, humidification system optimization, optimization of centralized controls.

Lakeridge Health (2010-2014)

Project Value: $25,000,000
Guaranteed Annual Savings: $1,460,000
Number of Buildings: 4

Steam to hot water conversion, cogeneration, steam system optimization, installation of solar thermal collectors, installation of high-efficiency heat pumps, installation of energy-efficient hoods, installation of static heat recovery loops, installation of variable frequency drives, chiller conversion, humidification decentralization, optimization of the domestic water heating systems, city water hookup modifications, efficient lighting, solar photovoltaic power generation, optimization of centralized controls, replacement of make-up air unit for OR and other critical hospital areas.

AWARDS

- ★ **2021 ASHRAE Technology Award, Existing Healthcare Facilities, Toronto Region**
- ★ **2021 Institutional Energy Management, Association of Energy Engineers, Canada**
- ★ **2017 Best Overall / Collaboration Award, Powerup Durham**
- ★ **2015 Top 15 Green Projects in Canada Clean50**
- ★ **2014 Environmental Achievement Award, Durham Environmental Advisory Committee**
- ★ **2013 Green Hospital of the Year, Ontario Hospital Association**

Haliburton Highlands Health Services (2010-2012)

Project Value: $2,000,000
Guaranteed Annual Savings: $185,800
Number of Buildings: 2

Geothermal energy, ventilation recommissioning, variable frequency drives, solar photovoltaic power generation, efficient lighting retrofit, optimization of controls.

Hauts-Bois-de-l'Outaouais School Board (2010-2012)

Project Value: $7,655,102
Guaranteed Annual Savings: $398,000
Number of Buildings: 25

Lighting conversion, boiler replacement, heat recovery, geothermal energy, installation of electric boilers, biomass heating, ventilation control, secondary heat plant, insulation of domestic hot water network, heat pump.

Design

Montreal Biodome – Space For Life (2009-2010)

Project Value: $9,627,753
Guaranteed Annual Savings: $1,000,000
Number of Buildings: 3

Geothermal energy, heat recovery, off-peak heating, optimization of heating systems, optimization of chilled water systems, installation of variable frequency drives, ventilation optimization, efficient lighting.

AWARDS

- ★ **2015 International Energy Project of the Year, AEE**
- ★ **2013 International Technology Award, ASHRAE**
- ★ **2012 Pilier d'Or, AGPI**
- ★ **2012 Sustainable Communities Award, FCM**
- ★ **2011 Energia Award, AQME**
- ★ **2011 Honourable Mention, Innovation Award, Contech**

J.P. Drouin

Project Executive

J.P. Drouin is passionate about finding creative and impactful solutions for his clients' complex energy ecosystems and is committed to delivering results. He is an engineer who specializes in transformational energy measures and deep building retrofits such as steam to hot water conversions, heat recovery chiller applications, district energy networks, and combined heat and power. He helps building owners develop and implement their energy vision by reducing energy consumption and GHG emissions, facilitating operation and maintenance, renewing assets, or improving occupant comfort.

Representative Projects

Tufts University (2021-ongoing)

Project Value: $5,000,000
GHG reduction measures that are NPV-positive.

Tufts University (2020)

Development of a Master Plan for a campus district energy system, cumulating in net-zero carbon heating. Conversion of building to low-temperature heating and integration of heat pumps.

ENGIE - The Ohio State University (2017– ongoing)

Project Value: $84,000,000
Energy Bill Reduction: 30%
Number of Buildings: 40

Ventilation deep retrofit and optimization, heat recovery systems, heating and cooling systems deep retrofit and optimization, lighting system upgrades, centralized controls modernization, renewable and distributed energy resource, building envelope upgrades.

Vassar College (2020 -2022)

Project Value: $11,850,000
Annual Savings: $905,000
Guaranteed Incentives: $1,850,000

Lighting upgrades, distributed heat recovery, decentralized chiller, chiller plant optimization, operating pressure reduction, ventilation optimization, controls optimization, air handling unit replacement, cooling system retrofit.

Vassar College (2019)

Preliminary study and in-depth analysis to define the path to a net-zero campus, including district network
and building-level technologies and energy source analysis.

Experience

16 years

Education

- Bachelor of Mechanical Engineering, McGill University, 2006

Qualifications

- Certified Energy Manager
- Distributed Generation Certified Professional
- Engineer, Ordre des ingénieurs du Québec (Quebec Order of Engineers)

Awards

- International Young Energy Professional of the Year Award, Association of Energy Engineers, 2016

Brown University (2017-2020)

Project Value: $24,800,000
Guaranteed Annual Savings: $1,011,000
Guaranteed Incentives: $1,200,000
Number of Buildings: 37

Campus district heating loop conversion from high-temperature hot water to medium-temperature hot water, steam to hot water conversions, dedicated steam boiler, electric humidification, BAS upgrades.

AWARDS

★ **2021 SCUP Awards, Excellence in Planning, District or Campus Component**

Mineola Public Schools (2018-2020)

Project Value: $7,268,590
Guaranteed Annual Savings: $373,390
Number of Buildings: 8

Interior and exterior lighting upgrade, steam to hot water conversion, new unit ventilator, hot water boiler upgrade, controls upgrade, oil to gas heating conversion, computer energy manager, solar photovoltaics.

Rockland Community College (2016-2019)

Project Value: $8,440,000
Guaranteed Annual Savings: $518,000
Number of Buildings: 9

Interior and exterior lighting upgrade, boiler plant upgrade, integrated building management system, variable speed drives, automatic seasonal changeover, water efficiency, fresh air intake improvement, computer load management, combined heat and power generation, installation of high-efficiency centrifugal chiller, installation of natural gas engine driven chiller.

University of California - Davis (2017-2018)

Energy Master Plan Peer Review

Determining the best path to achieve the university's 2025 carbon neutrality goal. Solutions considered included steam to hot water conversion, heat recovery chillers, geothermal heating and cooling, air source heat pumps, and solar PV.

Barry Callebaut (2017-2018)

Project Value: $3,400,000
Guaranteed Annual Savings: $199,190
Guaranteed Incentives: $900,000

Heat recovery, installation of biomass boiler.

AWARD

★ **2019 Innovative Energy Project of the Year - Canada Region, AEE**
★ **2019 Eureka Award, Ecotech Quebec**

Adelphi University (2015-2016)

Project Value: $13,500,000
Guaranteed Annual Savings: $1,600,000

CHP plant, boiler replacement, ventilation optimization.

AWARD

★ **2019 Energy Project of the Year Award - Long Island Chapter, AEE**

Jewish General Hospital – Phase II (2013-2014)

Project Value: $7,062,043
Guaranteed Annual Savings: $369,884
Area: 1,199,193 ft^2

Open-source geothermal energy, heat recovery from the open-source geothermal system, laboratory exhausts and stack economizer, steam to hot water heating conversion, system network optimization.

BronxCare Hospital Center (2013-2014)

Project Value: $3,610,000
Area: 447,195 ft^2

Construction of mechanical room, chiller installation, new electric service, installation of variable flow pumping system, rebuilding existing cooling tower.

New York City School Construction Authority (2012-2014)

Project Value: $8,591,000
Guaranteed Annual Savings: $146,300

Comprehensive energy audits and lighting upgrades (part of Phase 1 of the Department of Education's $780M comprehensive energy conservation and upgrade program).

Mount Sinai Brooklyn – Kings Highway Division, Brooklyn, New York (2011-2012)

Project Value: $4,100,000
Annual Savings: $600,000
Number of Buildings: 4

Cogeneration, steam to hot water heating conversion, lighting retrofit, controls upgrade, installation of variable frequency drives, water conservation measures.

AWARDS

★ **2015 EBie Award**
★ **2014 Regional Energy Project of the Year, AEE**
★ **2013 NYC Energy Project of the Year, AEE**

Maisonneuve-Rosemont Hospital (2013-2015)

Project Value: $7,241,783
Guaranteed Annual Savings: $530,000
Area: 1,482,137 ft^2

Geothermal energy, heat recovery, steam to hot water conversion, heat pump installation, efficient lighting, boiler replacement, peak demand management.

Laurentides Health Center (2010-2012)

Project Value: $12,815,230
Guaranteed Annual Savings: $1,036,227
Number of Buildings: 3

Geothermal energy, heat recovery, biomass, installation of efficient boilers, steam system optimization, installation of energy-efficient hoods, recommissioning of existing electric boilers, efficient lighting.

Samares School Board – Phase III (2009-2011)

Project Value: $5,561,690
Guaranteed Annual Savings: $422,000
Number of Buildings: 36

Geothermal system, biomass heating, lighting conversion, centralized controls, efficient domestic hot water heating, thermal storage, installation of electric boilers, and meters merging.

Bob Mancini

Client Liaison

A quintessential sales professional, Bob joined Ecosystem in 2016 to spearhead continued growth in New England. Through a discovery process that is rooted in developing win-win outcomes, he consistently helps clients achieve their goals, satisfy needs, and solve problems by mapping them against Ecosystem's core competencies. Bob's exceptional communication skills, coupled with an innate situational awareness and unquestionable integrity, helps to build lasting, mutually beneficial relationships. Bob's extensive experience in both the environmental and energy industries, combined with his engineering education, adds significant value to clients focused on energy, operating expense, and greenhouse gas reduction. High standards, a glass-half-full mindset, a practice of continuous self-improvement, and the desire to contribute to the greater good make working with Bob a positive experience.

Bob has delivered over $250M in contracted revenue working with commercial and industrial clients, mostly serving the Higher Education and Healthcare sectors.

Representative Projects

Brown University Jewelry District (2022-2023)

Detailed Feasibility Study & Action Plan
Analyzed potential pathways, including standalone solutions, a decarbonized central heating and cooling plant, and a fifth-generation mitigated loop with distributed low-carbon heating technologies.

Vassar College (2020 -2022)

Project Value: $11,850,000
Annual Savings: $905,000
Guaranteed Incentives: $1,850,000
Lighting upgrades, distributed heat recovery, decentralized chiller, chiller plant, ventilation and controls optimization, operating pressure reduction, air handling unit replacement, cooling system retrofit.

Tufts University (2021-ongoing)

Project Value: $5,000,000
GHG reduction measures that are NPV-positive.

Tufts University (2020)

Development of a Master Plan for a campus district energy system, cumulating in net-zero carbon heating. Conversion of building to low-temperature heating and integration of heat pumps.

Experience

33 years

Education

- B.S. Civil and Environmental Engineering, University of Rhode Island
- Certified Energy Manager (C.E.M.) 2013

Previous Functions

- 2013-2015: Sr. Director, Strategic Sales East Coast, Enlighted
- 2004-2013: Sr. Business Development Manager, EnerNOC
- 1993-2004: Sr. Advisor, Triumvirate Environmental

Brown University (2017-2020)

Project Value: $24,800,000
Guaranteed Annual Savings: $1,011,000
Guaranteed Incentives: $1,200,000
Number of Buildings: 37
Campus district heating loop conversion from high-temperature hot water to medium-temperature hot water, steam to hot water conversions, dedicated steam boiler, electric humidification, BAS upgrades.

AWARDS

★ **2021 SCUP Awards, Excellence in Planning, District or Campus Component**

Vassar College (2019)

Preliminary study and in-depth analysis to define the path to a net-zero campus, including district network and building-level technologies and energy source analysis.

Harvard Faculty of Arts & Sciences (2017-2018)

Preliminary design and detailed study using decentralized heat pumps within the district energy steam network.

Kevin Fortin

Construction Director

Bringing his experience as a Construction Manager for large-scale energy performance projects to his current role as Director of Operations, Kevin matches critical technical resources to projects and teams that deliver guaranteed results. He tracks the company's key performance indicators, keeps projects on course for achievement, and coordinates activities for operational efficiency and continuous improvement.

Kevin is pragmatic, meticulous, and organized. Those who work with him appreciate his patience and strong communication skills. Known for his ability to take a 360-degree perspective, he provides solutions in a variety of areas, including corporate operations, team structure, organization of corporate resources, and legal issues. He is passionate about developing every team's leadership and autonomy to support growth and development.

Representative Projects/ Construction Management

International Tailoring Company Building (2021-2023)

Project Value: $7,700,000
Incentives: $1,650,000
GHG Reduction: 80% of onsite emissions

Heat recovery, air-source heat pump, condensing boiler system, adiabatic dry cooler & hybrid water-cooled heat pumps.

Bedford Central School District (2019-2023)

Project Value: $8,200,000
Guaranteed Annual Savings: $559,000
Incentives: $555,000
Number of Buildings: 8

Interior lighting upgrade, exterior lighting upgrade, steam-to-hot-water conversion, heat pumps, controls upgrade.

Glen Cove City School District (2021-2022)

Project Value: $7,856,000
Guaranteed Annual Savings: $470,332
Incentives: $122,503
Number of Buildings: 9

Solar PV, lighting upgrades, boiler upgrades, VFDs and motor replacement, ventilation upgrades, BMS & controls upgrades, computer energy manager, plug load managers, envelope and insulation improvements.

Experience

15 years

Education

- Master of Business Administration (MBA), International Emphasis, Laval University, Quebec, Kennesaw State University, Kennesaw GA, 2009
- Bachelor of Mechanical Engineering, Laval University, Quebec, 2007

Licences & Qualifications

- P.Eng., Professional Engineers Ontario
- Engineer, Ordre des ingénieurs du Québec (Quebec Order of Engineers)

Previous Functions

- 2009: Graduate Research Assistant, Michael J. Coles College of Business, Kennesaw State University, Kennesaw GA
- 2007: Graduate Research Assistant, Mechanical Engineering Design Office, Laval University, Quebec
- 2006: Project Manager, Ressorts Liberté, Montmagny
- 2005: Process Validation Technician, Stryker Medical LP, L'Islet

City of Toronto - City Waterfront Building (2020-2022)

Project Value: $3,084,973
Annual Savings: $95,068
Incentives: $850,000

Lake-based hydrothermal system, BAS replacement, RCx, & standard efficiency measures.

City of Toronto - EMS Headquarters (2020-2022)

Project Value: $5,163,000
Annual Savings: $289,000
Incentives: $100,000

Geothermal heating and cooling, heat recovery including garage ventilation heat recovery, air-source heat pumps, LED lighting, heating and cooling systems upgrade, controls optimization, solar PV

North Shore Central School District (2019-2022)

Project Value: $7,200,000
Guaranteed Annual Savings: $397,000
Incentives: $52,000
Number of Buildings: 7

Interior lighting, exterior lighting, heating network optimization, building envelope improvements, DDC controls optimization, plug load management, addition of air-conditioning, solar PV.

Massachusetts Trial Courts (DCAMM) (2019-2022)

Project Value: $4,304,716
Guaranteed Annual Savings: $236,898
Incentives: $372,760
Number of Buildings: 4

Lighting upgrade, lighting controls, premium-efficiency motors and VFD, high-efficiency boiler replacement, chiller replacement, DDC control system, low flow water fixtures, plug load controllers.

Toronto Community Housing Corporation (2018-2021)

Project Value: $29,327,662
Incentives: $4,774,000
Number of Buildings: 24

Installation of cogeneration units, replacement of generators with natural gas units.

Toronto Community Housing Corporation – Kendleton Drive (2019-2020)

Project Value: $1,945,000

Replacement of 785 radiators and boiler optimization /controls.

Slovak Village (2019-2020)

Project Value: $1,440,000
Guaranteed Annual Savings: $24,559
Incentives: $176,985

Window replacement, MAU replacement, boiler replacement, LED lighting conversion.

Toronto Community Housing / The Atmospheric Fund (2019-2020)

Project Value: $2,300,000

Energy retrofit of 120 townhouse units in Toronto. Measures include installing air-source heat pumps, low-flow toilets, and heat pump water heaters.

Canam Group – Saint-Gédéon Plant (2017-2018)

Project Value: $2,799,045
Guaranteed Annual Savings: $355,890
Guaranteed Incentives: $1,469,000

Heat recovery from exhaust systems, addition of off-peak electric boilers, unification of boiler rooms, conversion to electric heating in gatehouse and garage.

Canam Group - Quebec Plant (2015-2017)

Project Value: $863,000
Guaranteed Annual Savings: $92,186

Heat recovery, installation of VFDs, optimization of centralized controls.

Saint-François d'Assise Hospital (2014-2017)

Project Value: $9,398,644
Guaranteed Annual Savings: $523,036
Area: 756,703 ft^2

Aerothermal energy and heat recovery, steam to hot water conversion, optimization of chilled water network, ventilation optimization, installation of intelligent hoods, optimization of domestic hot water production, lighting conversion, laundry optimization, steam system optimization, piping replacement.

AWARD

★ **2017 Energia Award, AQME**

Laval University Hospital Center (CHUL) (2011-2016)

Project Value: $21,190,158
Guaranteed Annual Savings: $2,106,000
Area: 1,121,599 ft^2

Steam to hot water conversion, geothermal energy, heat recovery, steam system optimization, optimization of chilled water systems, installation of energy-efficient hoods, conversion of kitchen equipment, decentralization of sterilization equipment, ventilation optimization, ventilation control, fresh air preheating using solar energy, efficient lighting, optimization of centralized controls.

AWARDS

★ **2018 Technology Honorable Mention, ASHRAE**
★ **2017 Wayne McClellan Award, CHES**
★ **2017 Energia Award, AQME**

Mount Sinai Brooklyn – Kings Highway Division, Brooklyn, New York (2011-2012)

Project Value: $4.1 million
Annual Savings: $600,000
Area: 130,494 ft^2

Steam to hot water heating network conversion, cogeneration, lighting retrofit, controls improvement, installation of variable frequency drives, water conservation measures.

AWARDS

- ★ **2015 EBie Award**
- ★ **2014 Regional Energy Project of the Year, AEE**
- ★ **2013 NYC Energy Project of the Year, AEE**

Hauts-Bois-de-l'Outaouais School Board (2010-2012)

Project Value: $7,655,102
Guaranteed Annual Savings: $398,000
Number of Buildings: 25

Lighting conversion, boiler replacements, heat recovery, geothermal energy, installation of electric boilers, biomass heating, ventilation control, secondary heating plant, insulation of domestic hot water network, heat pump.

Sir Wilfrid Laurier School Board – Phase II (2009-2010)

Project Value: $5,610,175
Guaranteed Annual Savings: $319,751
Number of Buildings: 12

Heat recovery, geothermal energy, air-source heat pump, efficient lighting retrofit, replacement of boilers, addition of centralized controls.

Trevor L. Smith, PE

Construction Manager

Trevor joined Ecosystem after seven years of energy engineering and project management experience in the public sector, where he managed the design and implementation of a broad range of energy efficiency and renewable energy technologies across the five boroughs of New York City. As a project manager, he has been part of small working groups that developed new specifications to aid in implementing cutting-edge technologies including LED lighting and Solar Photovoltaics. He was a key manager in the development and oversight of an innovative expedited rooftop Solar Photovoltaic implementation program in New York City.

Trevor is an ardent supporter of sustainable energy efforts to minimize the harmful effects of anthropogenic climate change.

Representative Projects

Bedford Central School District (2019-2023)

Project Value: $8,200,000
Guaranteed Annual Savings: $559,000
Incentives: $555,000
Number of Buildings: 8

Interior lighting upgrade, exterior lighting upgrade, steam-to-hot-water conversion, heat pumps, controls upgrade.

Stuyvesant Town – Peter Cooper Village (2017-2022)

Project Value: $19,284,000
Guaranteed Annual Savings: $2,625,000
Guaranteed Incentives: $1,382,000

Combined heat and power units, high-efficiency boilers, steam peak optimization, electricity resiliency and redundancy, electrical systems upgrade, new gas service, centralized controls for CHP plant.

Rockland Community College (2015-2018)

Project Value: $8,440,000
Guaranteed Annual Savings: $557,000
Number of Buildings: 9

Interior and exterior lighting upgrade, boiler plant upgrade, integrated building management system, variable speed drives, automatic seasonal changeover, water efficiency, fresh air intake improvement, computer load management, combined heat and power generation, installation of high-efficiency centrifugal chiller, installation of natural gas engine driven chiller.

21 Clark Street (2018-2019)

Project Value: $3,500,000

Expedited design-build of steam to condensing hot water boiler conversion and chiller replacement in a historic residential building during its renovation into luxury senior assisted living.

Experience

13 years

Education

- Bachelor of Science, Mechanical Engineering and Mechanics Major, Material Science and Engineering Minor; Drexel University

Professional Licences

- Professional Engineer, CT, DC, MD, NH, NY, RI, MA, IN, ME

Certification

- Certified Energy Auditor
- Certified Energy Manager
- Certified Building Commissioning Professional
- NABCEP Entry-Level Solar Photovoltaic

Training

- OSHA 30-Hour Safety

Memberships

- Association of Energy Engineers

Awards

- AEE NY Renewable Energy Project of the Year 2013
- AEE Northeast Region Renewable Energy Project of the Year 2014

Adelphi University (2015-2016)

Project Value: $13,500,000
Guaranteed Annual Savings: $1,600,000

CHP plant, boiler replacement, ventilation optimization.

AWARD

★ **2019 Energy Project of the Year Award - Long Island Chapter, AEE**

Previous Experience

NYC DOE Rooftop Solar Initiative

Project Value: $22,000,000
Energy Savings: $1,175,000

6.25MW of solar PV on 24 NYC schools

Max Lamirande

Senior Project Engineer

Having been responsible for project development in the New York City area, Max is now spearheading Ecosystem's growth in California. He is responsible for building relationships with our clients on both coasts, qualifying opportunities, and figuring out what value we can bring to their projects.

As part of the Ecosystem project development team, Max has worked on many different types of projects and has been exposed to a wide range of innovative solutions. He collaborates with his colleagues across the company, exchanging knowledge and information.

Experience

11 years

Education

- Bachelor of Mechanical Engineering, ETS - University of Quebec, 2014

Representative Projects

San Diego Padres - Petco Park Stadium (2022-2023)

Project Value: $5,865,000
Guaranteed Annual Savings: $1,000,000

Installation of a new chiller plant, advanced control optimization

Scripps Mercy Hospital (2021-2022)

Detailed Study

Resiliency-focused generation and energy efficiency project including microgrid study for solar batteries and combined heat and power. Steam to hot water conversion and heat recovery chiller.

International Tailoring Company Building (2021 – 2023)

Project Value: $7,700,000
Incentives: $1,650,000
GHG Reduction: 80% of onsite emissions

Heat recovery, air-source heat pump, condensing boiler system, adiabatic dry cooler, hybrid water-cooled heat pimps. This project will achieve full Local Law 97 compliance through 2050, avoiding any potential fines.

Stuyvesant Town – Peter Cooper Village - Phase II (2020-2024)

Project Value: $64,850,000
Guaranteed Annual Savings: $9,600,000

Combined heat and power units, high efficiency boilers, disconnection from central steam network, new steam and hot water district heating network installation

Stuyvesant Town – Peter Cooper Village (2017-2022)

Project Value: $19,284,000
Guaranteed Annual Savings: $2,625,000
Guaranteed Incentives: $1,382,000

Combined heat and power units, high-efficiency boilers, steam peak optimization, electricity resiliency and redundancy, electrical systems upgrade, new gas service, centralized controls for CHP plant.

21 Clark Street (2018-2019)

Project Value: $3,500,000

Development, design, and construction support for a new boiler and chiller plant in a residential building converting to assisted living.

University of California - Davis (2017-2018)

Energy Master Plan Peer Review

Determining the best path to achieve the university's 2025 carbon neutrality goal. Solutions considered included steam to hot water conversion, heat recovery chillers, geothermal heating and cooling, air source heat pumps, and solar PV.

Estee Lauder Study (2016-2017)

Air conditioning and water conservation study for the company's Long Island, NY, manufacturing hub.

Brooklyn Hospital Center (2015-2016)

Design and construction management for chiller replacement and cooling system optimization.

Adelphi University (2015-2016)

Project Value: $13,500,000 • **Guaranteed Annual Savings:** $1,600,000

CHP plant, boiler replacement, ventilation optimization.

AWARD

★ **2019 Energy Project of the Year Award - Long Island Chapter, AEE**

St. Luke's Hospital (2015)

Project Value: $31,918,000
Incentives: $2,604,000

York College - DASNY (2014)

Detailed Feasibility Study

Control systems upgrade for VFDs and hybrid pneumatic-electronic control system.

Ted Holden, EIT

Site Supervisor

Ted is a mechanical engineer with a demonstrated background in the construction field. Throughout his education, he held leadership positions focused on philanthropic projects both in the local community and abroad. At Ecosystem, he is proud to combine his experience with technical understanding to produce creative, practical, and sustainable energy solutions.

Representative Projects

ENGIE - Georgetown University (2021-Ongoing)

Project Value: $5,324,427
Energy Use Intensity Reduction: 43%
Number of Buildings: 5

Heat recovery chiller, heating and cooling system upgrades, control system upgrades, kitchen smart hoods.

Stuyvesant Town – Peter Cooper Village - Phase II (2020-2024)

Project Value: $64,850,000
Guaranteed Annual Savings: $9,600,000

Combined heat and power units, high-efficiency boilers, disconnection from central steam network, new steam and hot water district heating network installation

Stuyvesant Town – Peter Cooper Village (2017-2022)

Project Value: $19,284,000
Guaranteed Annual Savings: $2,625,000
Guaranteed Incentives: $1,382,000

Combined heat and power units, high-efficiency boilers, steam peak optimization, electricity resiliency and redundancy, electrical systems upgrade, new gas service, centralized controls for CHP plant.

Blackstone - Kips Bay Court (2020-2021)

Project Value: $7,400,000
Guaranteed Annual Savings: $814,000
Number of Buildings: 8

High- to low-pressure district steam heating conversion, high-efficiency boilers with low-emissions burners, steam peak optimization, electricity resiliency and redundancy, electrical systems upgrade, new gas service.

Mineola Public Schools (2018-2020)

Project Value: $7,268,590
Guaranteed Annual Savings: $373,390
Number of Buildings: 8

Interior and exterior lighting upgrade, steam to hot water conversion, new unit ventilator, hot water boiler upgrade, controls upgrade, oil to gas heating conversion, computer energy manager, solar photovoltaics.

Experience

3 year

Education

- Bachelor of Mechanical Engineering, Rensselaer Polytechnic Institute, 2019

Previous Functions

- 2018: Mechnical Engineering Intern, Syska Hennessy Group
- 2017: Intern, Fresh Meadow Mechanical Corporation
- 2016: Intern, The LiRo Group

Certification

- Engineer in Training (EIT)

David Bonneau

Lead Design Engineer

Early in his career, David Bonneau worked as a Computer Aided Design (CAD) specialist for several fields including aeronautics, heavy transport, and the plastics industry.

David is an efficient engineer with exceptional analytical abilities. He focuses his efforts on delivering high-performance projects that meet his client's needs within the established timelines.

Representative Projects

San Diego Padres - Petco Park Stadium (2022-2023)

Project Value: $5,865,000
Guaranteed Annual Savings: $1,000,000

Installation of a new chiller plant, advanced control optimization

Côte-Nord Integrated Health Center (2021-ongoing)

Project Value: $10,504,490
Guaranteed Annual Savings: $986,044
Guaranteed Incentives: $3,822,122
Number of Buildings: 8

Steam-to-hot-water conversion, boiler rooms retrofit, ventilation optimization, heat recovery, LED lighting conversion, controls optimization, aerothermal energy.

ENGIE - The Ohio State University (2017– ongoing)

Project Value: $84,000,000
Energy Bill Reduction: 30%
Number of Buildings: 40

Ventilation deep retrofit and optimization, heat recovery systems, heating and cooling systems deep retrofit and optimization, lighting system upgrades, centralized controls modernization, renewable and distributed energy resource, building envelope upgrades.

Scripps Mercy Hospital - Detailed Study (2021-2022)

Resiliency-focused generation and energy efficiency project including microgrid study for solar batteries and combined heat and power. Steam to hot water conversion and heat recovery chiller

Stuyvesant Town – Peter Cooper Village (2017–2022)

Project Value: $19,284,000
Guaranteed Annual Savings: $2,625,000
Guaranteed Incentives: $1,382,000

Combined heat and power units, high-efficiency boilers, steam peak optimization, electricity resiliency and redundancy, electrical systems upgrade, new gas service, centralized controls for CHP plant.

Experience

14 years

Education

- Bachelor of Mechanical Engineering, Laval University, 2008

Qualifications

- Engineer, Ordre des ingénieurs du Québec (Quebec Order of Engineers)

Previous Functions

- 2008-2009: CAD Specialist, Creaform.
- 2006: Mechanical Engineering Intern, Usimax.

Saint-François d'Assise Hospital (2014-2017)

Project Value: $9,398,644
Guaranteed Annual Savings: $523,036
Area: 756,703 ft^2

Aerothermal energy and heat recovery, steam to hot water conversion, optimization of chilled water network and ventilation, installation of intelligent hoods, optimization of domestic hot water production, lighting conversion, laundry optimization, steam system optimization, piping replacement.

AWARD

★ **2017 Energia Award, AQME**

Pays-Des-Bleuets School Board (2016)

Project Value: $740,000

Cooling tower replacement

Outaouais Health Center (2013-2014)

Project Value: $4,288,932
Guaranteed Annual Savings: $228,596
Number of Buildings: 3

Geothermal energy, heat recovery, steam to hot water heating conversion, domestic hot water heating optimization, cooling system optimization, optimization of centralized controls, efficient lighting, ventilation optimization, off-peak electric heating.

Bell / SNC Lavalin – 930 Aiguillon St., Quebec City (2012)

Project Value: $477,256
Guaranteed Annual Savings: $120,300

Heat recovery, ventilation optimization, recommissioning.

Laval University Hospital Center (CHUL) (2011-2015)

Project Value: $21,190,158
Guaranteed Annual Savings: $2,106,000
Area: 1,121,599 ft^2

Steam to hot water conversion, geothermal energy, heat recovery, steam system optimization, optimization of chilled water systems, installation of energy-efficient hoods, conversion of kitchen equipment, decentralization of sterilization equipment, ventilation optimization, ventilation control, fresh air preheating using solar energy, efficient lighting, optimization of centralized controls.

AWARDS

★ **2018 Technology Honorable Mention, ASHRAE**
★ **2017 Wayne McClellan Award, CHES**
★ **2017 Energia Award, AQME**

Vieille-Capitale Health Center (2011-2014)

Project Value: $6,650,074
Guaranteed Annual Savings: $565,000
Number of Buildings: 3

Heat recovery, geothermal energy, installation of efficient boilers, steam network optimization, hot water system optimization, installation of energy efficient hoods, off-peak water heating, lighting conversion.

Pays-Des-Bleuets School Board (2010-2011)

Project Value: $7,862,040
Guaranteed Annual Savings: $481,101
Number of Buildings: 15

Geothermal energy, heat recovery, aerothermal energy, biomass, efficient boiler installation, off-peak hot water heating, heating system conversion, off-peak hot water heating, replacing of ventilation units, electrical inlet repair, peak electric demand control, efficient lighting.

Simon Lessard

Lead Design Engineer

Known for his exceptional technical expertise, Simon has developed engineering studies and designs that have contributed significantly to successful multi-million-dollar projects. He is Ecosystem's resident expert in highly complex networks as well as ventilation and cooling systems.

Simon understands the potential and limitations of each building and delivers creative solutions even when time is limited. Because he has worked in many sectors across the US and Canada, he efficiently evaluates situations, preventing errors in project design and correcting systematic problems.

Dedicated to meeting clients' needs, Simon develops relationships with providers that allow him to obtain the best equipment and prices. He enjoys working in teams and provides invaluable technical support and resources. Since he approves the financial data on each project, he is knowledgeable about savings and performance verification as well as incentives.

Representative Projects

University of Toronto (2022-ongoing)

Detailed engineering and design for U of T's Project LEAP. This project will transform the generation, distribution, and consumption of energy at the St. George campus without impacting operational expenses and reducing GHG emissions significantly.

Mineola Public Schools (2018-2020)

Project Value: $7,268,590
Guaranteed Annual Savings: $373,390
Number of Buildings: 8

Interior and exterior lighting upgrade, steam to hot water conversion, new unit ventilator, hot water boiler upgrade, controls upgrade, oil to gas heating conversion, computer energy manager, solar photovoltaics.

ENGIE - The Ohio State University (2017 - ongoing)

Project Value:: $84,000,000
Energy Bill Reduction: 30%
Number of Buildings: 40

Ventilation deep retrofit and optimization, heat recovery systems, heating and cooling systems deep retrofit and optimization, lighting system upgrades, centralized controls modernization, renewable and distributed energy resource, building envelope upgrades.

Experience

21 Years

Education

- Bachelor of Science in Mechanical Engineering, Sherbrooke University, 2001
- Diploma in Natural Sciences, Thetford College, 1997
- General Health and Safety on Construction Sites, ASP Construction, 2001
- Introduction to Financial Statements, Sherbrooke University, 2000

Qualifications

- Certified Energy Manager
- Certified Measurement and Verification Professional
- Engineer, Ordre des ingénieurs du Québec (Quebec Order of Engineers)
- P.Eng., Professional Engineers Ontario

Previous Functions

- 2000: Production Engineering Intern, Teraxion
- 2000: Product Engineering Intern, Nortel Networks

DePauw University (2017-2021)

Campus Energy Master Plan and Core Project
Project Value: $14,758,000

Masterplan to achieve a minimum of 25% reduction in energy costs over three years. The Plan identifies immediate infrastructure initiatives that will lower energy use, reduce energy waste, decrease energy costs, cut greenhouse gas emissions, and address critical deferred maintenance needs. Measures in the Plan include steam to hot water conversion and centralization of the chilled water network. Work completed by Ecosystem includes a new campus-wide underground heating and cooling network, replaced boilers and cooling towers, LED lighting upgrades, and controls optimization.

AWARD

★ **2021 IDEA Innovations Awards - Honorable Mention**

Rockland Community College (2016-2019)

Project Value: $8,440,000
Guaranteed Annual Savings: $518,000
Number of Buildings: 9

Interior and exterior lighting upgrade, boiler plant upgrade, integrated building management system, variable speed drives, automatic seasonal changeover, water efficiency, fresh air intake improvement, computer load management, combined heat and power generation, installation of high-efficiency centrifugal chiller, installation of natural gas engine driven chiller.

Enfant-Jésus Hospital (2011-2014)

Project Value: $11,963,478
Guaranteed Annual Savings: $636,802
Area: 1,009,719 ft^2

Steam to hot water conversion, geothermal energy, heat recovery, installation of efficient boilers, steam system optimization, cooling tower replacement, installation of stack economizers, optimization of heat pump system, humidification system optimization, ventilation optimization, fresh air preheating using solar energy, efficient lighting, recommissioning.

AWARDS

★ **2018 Technology Award, ASHRAE**
★ **2017 Wayne McLellan Award, Canadian Healthcare Engineering Society (CHES)**
★ **2017 Energia Award, AQME**

Sherbrooke Regional School Board (2013-2014)

Project Value: $7,879,109
Guaranteed Annual Savings: $660,738
Number of Buildings: 26

Aerothermal energy, heat recovery, heating system steam to hot water conversion, adding and optimizing centralized controls, ventilation optimization, geothermal energy, efficient boiler installation, hot water heater installation, off-peak hot water heating, coil conversion, boiler replacement, pump optimization, steam network optimization, power factor correction.

Samares School Board – Phase IV (2011-2012)

Project Value: $2,484,041
Guaranteed Annual Savings: $144,875
Number of Buildings: 32

Geothermal energy, heat recovery, biomass, installation of thermal storage units, installation of solar walls, efficient lighting.

Saint-Sacrement Hospital (2011-2014)

Project Value: $5,580,714
Guaranteed Annual Savings: $443,111
Area: 657,901 ft^2

Heating system steam to hot water conversion, geothermal energy, heat pump network optimization, steam network optimization, chilled water system optimization, ventilation optimization, efficient lighting, adding and optimizing centralized controls.

AWARDS

★ **2018 Technology Award, ASHRAE**
★ **2017 Wayne McLellan Award, Canadian Healthcare Engineering Society (CHES)**
★ **2017 Energia Award, AQME**

La Tuque Hospital (2011-2014)

Project Value: $3,285,663
Guaranteed Annual Savings: $239,000
Area: 75,719 ft^2

Heat recovery, pre-heating of domestic hot water and laundry, lighting retrofit, biomass, hydroelectric turbine.

Laurentides Health Center (2010-2012)

Project Value: $12,815,230
Guaranteed Annual Savings: $1,036,227
Number of Buildings: 3

Geothermal energy, heat recovery, biomass, installation of efficient boilers, steam system optimization, installation of energy-efficient hoods, recommissioning of existing electric boilers, efficient lighting.

Montreal Neurological Hospital – Phase I & II (2005-2010)

Project Value: $7,565,920
Guaranteed Annual Savings: $982,000
Area: 276,237 ft^2

Steam to hot water conversion, heat recovery, off-peak heating, optimization of the hot water system, installation of variable frequency drives, installation of humidification system equipment, addition and optimization of centralized controls, installation of a cooling system, linking of heating systems, efficient lighting.

Jewish General Hospital – Phase I (2006-2007)

Project Value: $1,600,000
Guaranteed Annual Savings: $417,000
Area: 1,199,193 ft^2

Off-peak mode electric boiler, heat recovery, low-temperature heating network, replacement of coils.

Scarborough Grace Hospital (2006)

Project Value: $1,885,000
Guaranteed Annual Savings: $302,000
Area: 439,996 ft^2

Heat recovery in the summer with two (2) new 125-ton heat recovery chillers, dismantlement of 300 HP steam boiler, installation of new 150 HP bi-fuel cast iron hot water boiler, installation of new low-temperature heat pumps, installation of chilled water pumps, installation of VFDs.

St. Michael's Hospital, Toronto (2004-2005)

Project Value: $7,900,000
Guaranteed Annual Savings: $1,900,000
Area: 1,388,544 ft^2

Steam to hot water conversion, heat recovery, optimization of the domestic water heating systems, ventilation optimization, humidification system optimization, optimization of sterilization equipment, efficient lighting.

AWARDS

★ **2006 Green Health Care Award, OHA**
★ **2006 National Health Care Management Award, CCHL & OEE**

Design

Adelphi University (2015-2016)

Project Value: $13,500,000
Guaranteed Annual Savings: $1,600,000

CHP plant installation, boiler replacement, ventilation optimization.

AWARDS

★ **2019 Energy Project of the Year Award - Long Island Chapter, AEE**

Maisonneuve-Rosemont Hospital (2013-2015)

Project Value: $7,241,783
Guaranteed Annual Savings: $530,000
Area: 1,482,137 ft^2

Geothermal energy, heat recovery, steam to hot water conversion, heat pump installation, efficient lighting, boiler replacement, peak demand management.

Samares School Board – Phase IV (2011-2012)

Project Value: $2,484,041
Guaranteed Annual Savings: $144,875
Number of Buildings: 32

Geothermal energy, heat recovery, biomass, installation of thermal storage units, installation of solar walls, efficient lighting.

Marguerite-Bourgeoys School Board (2003-2006)

Project Value: $8,000,000
Guaranteed Annual Savings: $1,300,000
Number of Buildings: 17

Heat recovery with thermal pumps, boiler replacement, chillers and cooling towers with high efficiency, reliable new equipment, air conditioning system optimization, lighting conversion for gymnasiums.

Beauceville Hospital Center (2004-2005)

Project Value: $1,580,000
Guaranteed Annual Savings: $238,000
Area: 246,927 ft^2

Steam to hot water conversion, heat recovery, steam system optimization, off-peak heating, humidification system conversion, optimization of the domestic water heating systems.

Harricana School Board (2010-2011)

Project Value: $6,822,412
Guaranteed Annual Savings: $324,781
Number of Buildings: 14

Lighting conversion, centralized controls, geothermal system, heat recovery, centralized heating systems optimization, chiller removal, ventilation optimization, installation of a hot water boiler plant, centralization of domestic hot water production, thermal storage, electric boiler control optimization.

Montreal Neurological Hospital – Phase I & II (2005-2010)

Project Value: $7,565,920
Guaranteed Annual Savings: $982,000
Area: 276,237 ft^2

Steam to hot water conversion, heat recovery, off-peak heating, optimization of the hot water system, installation of variable frequency drives, installation of humidification system equipment, addition and optimization of centralized controls, installation of a cooling system, linking of heating systems, efficient lighting.

Montreal General Hospital – Phase I & II (2006-2009)

Project Value: $9,564,000
Guaranteed Annual Savings: $1,500,000
Area: 913,253 ft^2

Steam to hot water conversion, heat recovery, installation of efficient boilers, installation of stack economizers, off-peak heating, combining heating systems, installation of heating systems, conversion of coils, electrical connections.

Douglas Institute (2006-2008)

Project Value: $5,000,000
Guaranteed Annual Savings: $650,000
Area: 678,655 ft^2

Heat recovery, heating conversion, steam system decentralization, off-peak heating, optimization of the domestic water heating systems, installation of humidification system equipment, power factor correction, replacement of ventilation units, efficient lighting.

City of Lévis (2004-2005)

Project Value: $3,675,000
Guaranteed Annual Savings: $625,000
Number of Buildings: 18

Installation of efficient boilers, optimization of heating systems, optimization of chilled water systems, optimization of the domestic water heating systems, installation of humidification system equipment, optimization of pool heating system, efficient lighting, installation of centralized controls.

Lucas Taub, EIT, CEM

Project Engineer

Lucas brings insight developed through experience in both design and construction to ensure that the transition between project phases is smooth and that no details are overlooked. Inspired by the quest of efficiency, Lucas is motivated to integrate newer, high-efficiency systems into existing infrastructure to achieve energy and cost savings, while eliminating excess in the construction process.

He takes pride in making measured, informed decisions, and steering projects with control and a calm persona. His areas of expertise include heat pumps, ventilation and heat recovery, cogeneration system, hydronic distribution systems, and solar PV arrays.

Previous Experience

North Shore Central School District (2019-2022)

Project Value: $7,200,000
Guaranteed Annual Savings: $397,000
Incentives: $52,000
Number of Buildings: 7

Interior lighting, exterior lighting, heating network optimization, building envelope improvements, DDC controls optimization, plug load management, addition of air-conditioning, solar PV.

Glen Cove City School District (2021-2022)

Project Value: $6,220,238
Guaranteed Annual Savings: $21,100
Incentives: $405,659
Number of Buildings: 9

Solar PV, lighting upgrades, boiler upgrades, VFDs and motor replacement, ventilation upgrades, BMS & controls upgrades, computer energy manager, plug load managers, envelope and insulation improvements.

Stuyvesant Town – Peter Cooper Village (2017-2022)

Project Value: $19,284,000
Guaranteed Annual Savings: $2,625,000
Guaranteed Incentives: $1,382,000

Combined heat and power units, high-efficiency boilers, steam peak optimization, electricity resiliency and redundancy, electrical systems upgrade, new gas service, centralized controls for CHP plant.

21 Clark Street (2017-2018)

Project Value: $3,500,000

Development, design, and construction support for a new boiler and chiller plant in a residential building converting to assisted living.

Experience

8 years

Education

- Bachelor of Science, Chemical Engineering, Washington University in St. Louis, 2016
- Masters of Engineering, Mechanical Engineering, Washington University in St. Louis, 2017

Qualifications

- Engineer in Training (EIT)
- Certified Energy Manager (CEM)
- LEED Green Associate

Previous Functions

- 2016: Energy Analyst, Energy Resources Group, Inc.
- 2015: Mechanical Engineering Intern, AeroValve, LLC.
- 2014: Research Assistant, Columbia University

Mineola Public Schools (2018-2020)

Project Value: $7,268,590
Guaranteed Annual Savings: $373,390
Number of Buildings: 8

Interior and exterior lighting upgrade, steam to hot water conversion, new unit ventilator, hot water boiler upgrade, controls upgrade, oil to gas heating conversion, computer energy manager, solar photovoltaics.

Adam Shelly, PE

Project Development Director

Adam is driven to improve his clients' energy environments while reducing the impact on the climate and their balance sheets. His design process is informed by his ability to think both creatively and logically, leading to innovative, high-performance designs. With a strong vision and balanced judgment, he leverages the assets, skills, and needs of all stakeholders in designing solutions. Adam is also known for taking complex technical concepts and communicating them effectively. Adam was awarded AEE's International Energy Engineer of the Year.

Representative Projects

ENGIE - Georgetown University (2021-Ongoing)

Project Value: $5,324,427
Energy Use Intensity Reduction: 43%
Number of Buildings: 5

Heat recovery chiller, heating and cooling system upgrades, control system upgrades, kitchen smart hoods.

International Tailoring Company Building (2021-2023)

Project Value: $7,700,000
Incentives: $1,650,000
GHG Reduction: 80% of onsite emissions

Heat recovery, air-source heat pump, condensing boiler system, adiabatic dry cooler & hybrid water-cooled heat pumps.

Mineola Public Schools (2018-2020)

Project Value: $7,268,590
Guaranteed Annual Savings: $373,390
Number of Buildings: 8

Interior and exterior lighting upgrade, steam to hot water conversion, new unit ventilator, hot water boiler upgrade, controls upgrade, oil to gas heating conversion, computer energy manager, solar photovoltaics.

Rockland Community College (2015-2018)

Project Value: $8,440,000
Guaranteed Annual Savings: $557,000
Number of Buildings: 9

Interior and exterior lighting upgrade, boiler plant upgrade, integrated building management system, variable speed drives, automatic seasonal changeover, water efficiency, fresh air intake improvement, computer load management, combined heat and power generation, installation of high-efficiency centrifugal chiller, installation of natural gas engine driven chiller.

Experience

15 years

Education

- Master of Science in Sustainable Engineering, Villanova University, 2012
- Bachelor of Science in Mechnical Engineering, Washington University in St. Louis, 2008

Qualifications

- Professional Engineer (PE): NY, PA, RI, DC
- Certified Energy Manager (CEM), AEE
- Certified Energy Auditor (CEA), AEE
- Certified Commercial Mechanical Inspector, International Code Council
- LEED AP BD+C, US Green Building Council
- Electrical Contractor License, City of Philadelphia

Associations

- ASHRAE; AEE; Urban Green, USGBC and DVGBC; ASME; AIA

Previous Functions

- 2017-2019: Shelly Electric Company, Inc., Vice President, Operations and Project Manager/Estimator
- 2010-2014: Urban Engineers, Inc., Sustainability Project Manager
- 2008-2014: MEP Design Engineer

Brooklyn Hospital Center (2015-2016)

Project Value: $2,930,000
Guaranteed Annual Savings: $62,000

Chiller installation, optimization of chilled water network.

Marc Trepanier

Senior Mechanical Systems Optimization Specialist

With over 40+ years of experience in the Building Automation System industry, Marc has gained expertise in project management, application engineering, sales and estimating, programming and graphic design, and electrical and mechanical design-builds. Before working at Ecosystem, he successfully completed 183 Building Automation projects of all sizes and complexity for Automated Building Systems. Marc has been recognized for providing top quality, integrity, and commitment, resulting in strong repeat and referral business and the highest confidence in his performance.

Relevant Projects

Tufts University (2021-ongoing)

Project Value: $5,000,000
GHG reduction measures that are NPV-positive.

North Shore Central School District (2019-2022)

Project Value: $7,200,000
Guaranteed Annual Savings: $397,000
Incentives: $52,000
Number of Buildings: 7

Interior lighting, exterior lighting, heating network optimization, building envelope improvements, DDC controls optimization, plug load management, addition of air-conditioning, solar PV.

International Tailoring Company Building (2021-2023)

Project Value: $7,700,000
Incentives: $1,650,000
GHG Reduction: 80% of onsite emissions

Heat recovery, air-source heat pump, condensing boiler system, adiabatic dry cooler & hybrid water-cooled heat pumps.

Massachusetts Trial Courts (DCAMM) (2019-2022)

Project Value: $4,304,716
Guaranteed Annual Savings: $236,898
Incentives: $372,760
Number of Buildings: 4

Lighting upgrade, lighting controls, premium efficiency motors and VFD, high-efficiency boiler replacement, chiller replacement, DDC control system, low flow water fixtures, plug load controllers.

Experience

40+ years

Education

- Bachelor of Science, Computer Engineering and Technical Writing, Roger Williams College
- Associate of Science, Computer Science, Community College of Rhode Island
- Electronic Engineering and Design, New England Technical Institute

Previous Functions

- 2013 - 2022: Senior Project Manager and Acting Operations Manager at Automated Building Systems Inc.
- 1979 - 1991: Lead Draftsman, Engineer’s Assistant, Application Engineer, Project Manager’s Assistant, and Project Manager at Johnson Controls Inc.

Stephanie Schwartz

Communication & Marketing Director

Calling on a diverse background that combines education, journalism, magazine and book publishing, and copywriting, Stephanie is able to help craft effective print and digital communications for Ecosystem and our clients. She enjoys creating learning opportunities for students and community members interested in our projects, inspiring others to share her commitment to sustainability and environmental responsibility.

Representative Projects/Implementation & Management of Awareness Campaigns

University of Toronto (2022-ongoing)

Detailed engineering and design for U of T's Project LEAP. This project will transform the generation, distribution, and consumption of energy at the St. George campus without impacting operational expenses and reducing GHG emissions significantly.

Humber College (2021-ongoing)

Preliminary Phase Design Services

Detailed design study to decarbonize with a district energy and steam to hot water conversion project. Outcomes include reduced GHG emissions, integration of islanded buildings, improved O&M, energy and water use reduction.

Tufts University (2021-ongoing)

Project Value: $5,000,000
GHG reduction measures that are NPV-positive.

International Tailoring Company Building (2021-2023)

Project Value: $7,700,000
Guaranteed Incentives: $1,650,000
GHG Reduction: 80% of onsite emissions
Heat recovery, air-source heat pump, condensing boiler system, adiabatic dry cooler, hybrid water-cooled heat pimps. This project will achieve full Local Law 97 compliance through 2050, avoiding any potential fines.

DePauw University (2017-2021)

Campus Energy Master Plan and Core Project
Project Value: $14,758,000

Infrastructure initiatives that will lower energy use, reduce energy waste, decrease energy costs, cut greenhouse gas emissions, and address critical deferred maintenance needs. Measures include steam to hot water conversion and centralization of the chilled water network.

Experience

25 years

Education

- Master of Arts, Kings College, University of London
- Bachelor of Arts, University of Pennsylvania

Previous Functions

- Americas Correspondent, IPE Real Estate
- Editorial Consultant, Lienhard School of Nursing, Pace University
- Instructor, Pace University Writing Center
- Managing Editor, Reader's Digest
- Project Editor, Marshall Cavendish Reference

Coxsackie-Athens Central School District (2019-2021)

Project Value: $2,700,000
Guaranteed Annual Savings: $148,000
Guaranteed Incentives: $49,970

Steam-to-hot-water conversion, ventilation upgrades, condensing boiler plant, controls optimization, electrical network optimization, interior and exterior lighting upgrades, computer energy manager, building envelope improvement.

Rockland Community College (2016-2019)

Project Value: $8,440,000
Guaranteed Annual Savings: $518,000
Number of Buildings: 9

Interior and exterior lighting upgrade, boiler plant upgrade, integrated building management system, variable speed drives, automatic seasonal changeover, water efficiency, fresh air intake improvement, computer load management, combined heat and power generation, installation of high-efficiency centrifugal chiller, installation of natural gas engine driven chiller.

Capturing Existing Asset Value Reusing & Repurposing

CAPTURING EXISTING ASSET VALUE

Reusing & Repurposing

Reusing and/or repurposing existing infrastructure components is often ignored or overlooked as part of the spectrum of tools and options that can maximize value in energy projects.

Traditionally, existing equipment and systems are replaced with new ones in these types of projects on the assumption that this eliminates risk. However, this traditional approach forfeits the intrinsic value of existing infrastructure and any related benefits associated with equipment that is already in place.

By taking a holistic approach when assessing electromechanical systems and their interconnected parts, it is possible to determine which elements or components can be reused for their original intent or repurposed to add value to the new system.

Thoughtful inclusion of existing assets can add significant value to projects if implemented correctly. Benefits include accelerated project timelines, reduced disruption, improved system performance, and reduced costs (capital and operating expenses). There are also added environmental and sustainability benefits that come with reusing or re-purposing existing assets.

Opportunity Cost

Overlooking existing assets may cost your organization in time and money, resulting in significant opportunity cost.

While it may be technically simpler to replace existing assets, it may also be less financially prudent for the owner as measured by opportunity cost and lost benefits of reusing and re-purposing existing assets – especially in projects where existing equipment and systems can be maximized without sacrificing quality.

Disposing of assets that can fit into the new electromechanical system is wasteful for the following reasons:

1. There may be less capital- and labor-intensive alternatives (re-engineering parts of the existing system to optimize performance) that yield the same or better results than adding new components.

2. Implementation and operations may be simplified by reusing or repurposing existing equipment.

3. Unnecessary replacement of a viable asset forgoes capturing the full value or sunk cost of the asset.

The Status Quo

Project teams often overlook the value of existing assets during energy and sustainability projects.

The traditional approach is to replace the old with the new – irrespective of the intrinsic value of existing assets in electromechanical systems. There are several factors underlying this common approach:

1. **Payment structure –** Contractor and engineer fees are typically structured as a percentage of total contract value in traditional procurement models. In these cost-plus models, smaller project costs translate to smaller contractor fees and vice versa. This does not incentivize the contractor to reduce project costs. The contractor may make decisions that maximize fees – in this case, replace old equipment with new and perhaps overdesigned options to drive project cost up within allowable limits.

2. **Risk –** There is perceived risk in reusing or re-purposing existing assets. If the system does not function as intended or achieve the desired results, the project owner ultimately bears the risk, especially if the project is implemented by multiple engineers and contractors. As a result, it is often deemed safer to purchase new equipment that may promise certain performance but does not necessarily make the system more efficient or reliable than the existing equipment.

3. **Project complexity –** Particularly in complex energy projects, replacing the entire system can be a simpler (although not better) way to achieve the desired results. It takes innovative thinking and a deep understanding of electromechanical systems and their interconnectivity to maximize the value of existing assets while delivering the project's intended outcomes.

The basis for overlooking existing assets – while seemingly practical – ultimately does not serve the owner or the project. What is often ignored is the opportunity cost in time, money, and lost value of existing assets.

The Right Mindset

The intent of reusing and repurposing existing assets is to add project value by maximizing the value of what is already in place. This strategy is not intended to reduce project costs at the expense of quality.

Within this context:

- **REUSE** means continuing to use equipment for its original intent

- **REPURPOSE** means adding value by using existing equipment for a new purpose or function

With this understanding, project teams must think of the opportunities within ageing systems and uncover solutions that use existing assets without compromising the quality of the project.

Instead of throwing out the entire electromechanical system, parts of the system within walls, underground, or in mechanical rooms can be reused or repurposed to meet today's performance standards. For example, in steam to hot water conversions, steam pipes can be repurposed as hot water pipes, eliminating the need to install a new piping network.

Reusing and repurposing requires careful planning.

It takes a deep understanding of the electromechanical system, its interconnecting parts, and how they function to determine what combination of strategies will best serve a project.

Design and construction engineers must work closely together, relying on techniques and strategies to develop solutions that will indeed maximize existing asset utility while deliver the project outcomes. For example:

- **Steam pipe repurposing –** In steam to hot water conversions, repurposing steam pipes for hot water use eliminates the need for new pipes. In existing buildings, this reduces disturbance to the structural integrity of the facility and reduces disruption to occupants during implementation.
- **Using existing terminal networks –** When switching from a high- to a low-temperature network, it is possible to re-engineer the terminal network to function efficiently by cascading loads; engineering a high delta T network can eliminate the need to replace high-cost terminal equipment.
- **Refurbishment of select high-value equipment –** Certain high-quality and costly equipment that fits into future requirements of energy systems should be considered over lower-quality replacements.

Risk Mitigation

To reduce the risk associated with extending the useful life of existing assets, it is important to conduct thorough tests and assessments that ensure the quality and integrity of the existing asset.

Cost reduction should not be the sole driver when deciding to reuse or repurpose existing assets. The decision must be justified by fully accounting for risk and ensuring that the asset will function as intended.

Some important risk mitigation strategies to ensure integrity of assets include:

- **Planning –** Invest the time upfront during the early design and engineering phases of the project to determine the value of existing assets and how they fit into the proposed new system.
- **Facility Condition Index –** Review asset renewal needs and deferred maintenance backlogs to determine components that can be used while satisfying capital planning requirements.
- **Physical testing –** Visually inspect, pressure test, conduct a systems assessment, check control compatibility, verify code compliance (CSA, UL), and sample for corrosion and wear as part of the consideration process.
- **Terminal equipment –** Test the operating condition of terminal equipment to ensure it can meet new system requirements.
- **Commissioning –** Include commissioning and controls specialists early in the process when system modifications are part of the plan.

Advantages

Once risk has been properly mitigated and quality verified, there are benefits to reusing or repurposing existing assets. These advantages should be viewed as benefits of the approach and should not drive the decision to reuse or repurpose assets.

Some important advantages include:

1. **Maximized outcomes –** Organizational objectives and goals can be maximized by optimizing the use of existing assets within new systems – essentially doing more with less. This strategy can drive project costs down while still delivering the intended outcomes, including addressing asset renewal and deferred maintenance backlogs.

2. **Reduced disruption –** Reusing or repurposing assets is less disruptive since entire systems do not have to be removed and replaced. In some cases, existing components may need to be re-engineered to fit within the new system. In others, only specific parts of the system need to be replaced. The result in either case is reduced disruption to facilities and their occupants.

3. **Easier change management –** System operators, already familiar with existing systems, do not have to relearn entirely new components, reducing the learning curve associated with energy modernization projects. This leads to quicker and easier adoption.

4. **Accelerated project timeline –** By investing time in the planning and design effort upfront, the implementation timeline can be reduced. This is especially true if the existing assets that can be reused or repurposed would require disruptive processes that add to the project timeline, such as large-scale trenching or working within walls.

5. **Sustainability –** By reusing or repurposing existing assets, the project's environmental impact is reduced. This strategy avoids having to dispose of useful assets and eliminates the environmental footprint created by the manufacture, packaging, and installation of unnecessary new equipment.

Takeaways

1. Existing assets have value that should be considered when planning asset renewal projects
2. Reusing and repurposing is a tool worth considering in complex energy retrofit projects
3. The implementation of new energy networks should not equate to the wholesale disposal of old networks
4. Analyze the entire system and its inter-connected parts holistically when making decisions.
5. Redesign energy networks by considering the future energy landscape.
6. Reusing and repurposing should not be treated as a goal, but rather as a tool to achieve intended outcomes — it adds value when applied correctly.

CASE STUDY Olympic Park

Located in the heart of Montreal, the Olympic Park welcomes more than four million visitors annually. Its facilities include the Olympic Stadium, built for the 1976 Olympics, and the Biodome Space for Life, a unique nature museum in the former Olympic Velodrome that showcases five distinct ecosystems under one roof.

Faced with rising energy costs, aging assets, and high energy use intensity (EUI), the Olympic Park needed to dramatically reduce energy consumption as well as GHG emissions. The park's highly variable heating and cooling loads added complexity to an essential HVAC infrastructure upgrade. Measures included a major steam to hot water conversion of the heating system, along with improved heat recovery and a completely redesigned chilled water system.

By repurposing kilometers-long steam piping, reusing terminal equipment by re-engineering the system, and reusing high-quality equipment, the project was completed in 30 months for a fraction of the projected cost.

The project won the 2018 AEE Energia Project of the Year Award and the 2019 ASHRAE Technology Awards.

Reuse & Repurpose Strategy	Results
• Repurpose steam piping for steam to hot water conversion – Low carbon technology • Reuse of terminal equipment – Increased ΔT • Refurbish select high-quality equipment	• 57% GHG reduction • Improved operation and maintenance • Uninterrupted operations • 26% energy cost savings

CASE STUDY University of Quebec in Trois Rivieres (UQTR)

The extensive UQTR campus relied on four independent chilled water loop networks with eight chillers at the end of their useful life. The university wanted to reduce energy consumption but also faced several operational challenges, especially the complex maintenance and operation of its extensive high-temperature hot water system. Because of the size of the campus, recovering and transferring heat between buildings was both a challenge and the key to unlocking significant energy savings.

To solve multiple problems, the heating network was converted to a lower temperature, heat recovery and transfer was optimized, cooling was added in several locations, and outdated equipment removed.

Instead of installing eight new chillers, the four chilled water loop networks were connected, two chillers were installed with the capacity to provide cooling to the entire system, and the network was re-engineered. The chilled water network was re-engineered into a heat recovery network to displace the use of fossil fuels. The project eliminated inefficiencies and addressed the operating issues caused by decentralized equipment -- the lower-temperature hot water network is not only safer but also simpler to operate and maintain. UQTR is now one of the most energy-efficient campuses in Quebec.

Reuse & Repurpose Strategy	Results
• Re-engineer existing chiller network	• 53% GHG reduction • Improved operation and maintenance • Asset renewal • 25% energy cost savings

CASE STUDY Quebec City University Hospital Center

Consisting of five hospitals, the Quebec City University Hospital Center (CHU) provides care for 2 million people annually. With its aging infrastructure, the Center needed to modernize obsolete electromechanical equipment in critical areas like emergency rooms and operating theaters and reduce costs and its environmental footprint.

Deep energy retrofits of four of the five hospitals were complex due to their size, ambitious scope of work, and need for continuity of critical operations. A steam to hot water conversion allowed new sources of heat recovery to be installed. This configuration maximized equipment efficiency and the use of the heat pumps in winter while taking full advantage of Quebec's low hydro prices to reduce the use of natural gas.

The project also included renewable energy measures such as a solar wall to preheat fresh air during the winter and a geothermal system that leveraged an existing 30-mile (50 km) network of underground piping.

The project won the 2017 Wayne McClellan Award and 2017 Energia Award and received honorable mention from ASHRAE in 2018.

Reuse & Repurpose Strategy	Results
• Replace terminal radiators with minimal disruption	• 56% GHG reduction • Uninterrupted operations • 30% energy cost savings

CASE STUDY Brown University

In 2008, Brown announced its intent to reduce greenhouse gas (GHG) emissions by 42% by 2020. By 2016, a focus on thermal efficiency was the final stage to reach the reduced emissions goal.

In response, a transformational campus-wide energy efficiency and GHG reduction project focused on the central heating plant and distribution network as well as building-level improvements. The project's energy measures overlapped with Brown's deferred maintenance and utilities master plans while solving asset renewal challenges.

The design ensured incorporation and reuse of existing assets and materials to maximize the value of Brown's recent capital expenditures. For instance, Brown had invested in updating its hot water piping network only a decade earlier, and maintaining this network was more cost-effective than replacement. The project was also aligned with other initiatives on campus, reducing total cost.

This project is estimated to reduce GHG emissions by more than 4,700 metric tons. Other benefits include significant energy cost savings and water usage reduction.

Reuse & Repurpose Strategy	Results
• Re-engineer the heating loop • Repurpose steam piping in steam to hot water conversion • Refurbish select high-quality equipment	• Asset renewal • 40% GHG reduction • Improved resiliency • Improved operation and maintenance

CASE STUDY Lakeridge Health

Located 50 kilometers east of Toronto, Lakeridge Health (LH) provides care for 650,000 people in five hospital locations. A deep energy retrofit of four of its sites renewed energy infrastructure, improved efficiency, and enhanced patient comfort.

Due to the sensitive nature of hospital environments, it was essential to minimize disruption. For this project, repurposing existing steam pipes in the steam to hot water conversion, and re-engineering the existing cooling loop network made both functional and financial sense.

The project won multiple awards including the 2013 Green Hospital of the Year, 2014 Environmental Achievement Award, and 2017 Best Overall / Collaboration Award and was a top 15 green project in 2015.

Reuse & Repurpose Strategy	Results
• Repurpose steam piping in steam to hot water conversion – low carbon technology • Re-engineer cooling loop	• 25% energy cost savings • Maintaining patient welfare • Asset renewal • Improved resiliency

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