District Energy: Building-Level Strategy

Much of the cost and complexity of retrofitting a district heating system comes from building-level projects. Rather than treating them as an afterthought, building retrofits, as part of a district energy strategy, provide an opportunity to address crucial comfort, operational, and maintenance issues, while leveraging asset renewal budgets and incentives. These retrofits also result in a district energy system that will keep pace with future technological advancements and shift toward lower-temperature hot water heating systems.

Rethinking Net Zero Strategies

Leading colleges and universities across the US are rising to the climate challenge and exploring paths toward becoming Net Zero Campuses. Typically, they focus on campus central heating facilities and other related energy infrastructure. Converting a legacy system, which can be upward of 100 years old, to a Net Zero system can be a long and challenging process, requiring an energy switch to a clean energy source.

The two main types of clean energy sources, biofuels or clean electricity, have considerably different advantages and disadvantages. Biofuels can be more easily integrated into existing heating infrastructure, as they maintain combustion-style heating. Implementing a system with clean electricity, on the other hand, can require more significant changes to an existing district energy system, including re-engineering building-level HVAC systems.

Maintaining existing building level infrastructure and switching to biofuels can be the quickest and least disruptive path to Net Zero and can represent a significant step forward in terms of GHG reduction without having to look at building-level systems. This is the solution that many institutions are initially exploring: large-scale district energy projects that transform the way energy is procured and generated, while maintaining their legacy HVAC systems across the campus' buildings.

But there are downsides to taking the easy path. For example, it is difficult to integrate efficient heat recovery technologies like heat pumps into legacy HVAC systems, and it will not be possible to run the systems at their most cost-effective and efficient parameters. The typical existing building-level HVAC systems set tough constraints on the entire system, as their legacy design typically utilizes hot water (with temperatures around 180F) or even steam. Heat pumps operate with a higher coefficient of performance (COP) than legacy systems and are uneconomical to run at temperatures greater than 160F. The potential value in reducing the temperature at which buildings heat can be very high -- for example, reducing the temperature of the heating system from 160F to 110F would decrease the electrical consumption to heat that building by more than half.

Another challenge in converting building-level systems to lower temperatures is the complexity of implementation. Campuses often have many intensively utilized buildings and little leeway to take a building offline, so a lot of the construction must be completed in live buildings. Working in live and sensitive spaces creates significant challenges when traditional silos exist between design and construction. To implement a project in a live building, it is essential to have close integration and alignment not only between engineering design and construction teams but also with other campus stakeholders. Strategies that can minimize disruption to campus activities and to the student experience need to be incorporated in the planning and design process.

Prioritizing Building-Level Energy Systems

Designing a Net Zero system without first considering the value in re-engineering the building-side energy systems could lead to a sub-optimal design, one that will be a part of the campus' legacy for decades. Re-engineering building equipment to enable lower-temperature heating and energy intensity multiplies the value as part of the Net Zero system.

Benefits of a Building-Level Strategy

- Increased energy system flexibility and adaptability: lower temperatures will enable the implementation of multiple heating technologies, including emerging and future technologies.
- Reduced complexity: higher-temperature Net Zero systems often use biofuel boiler systems, which can be labor-intensive and present supply-chain challenges.
- Reduced operating expenses: reduced energy consumption from more efficient lower temperature systems creates meaningful cost savings.
- Reduced capital costs: a reduction in energy requirements can mean a smaller Net Zero system.

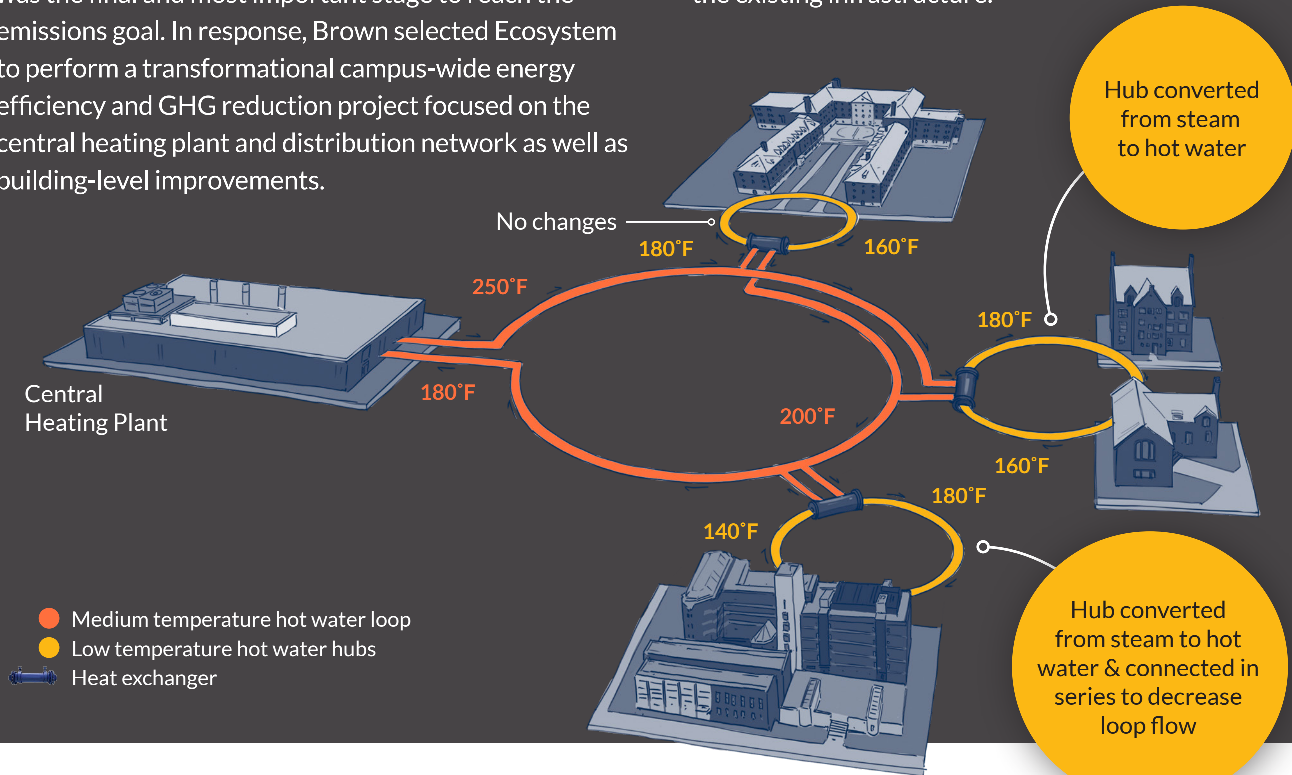
The right approach includes uncovering the potential value in building-side energy systems first. Finding synergies in energy savings enables a more effective Net Zero system, tackling deferred maintenance needs and improving overall project value.

Project value, based on net present value (NPV) or a life cycle cost analysis (LCCA), is often used to find the right balance between investments in buildings and in the new Net Zero system. Building-level energy modeling can quickly quantify the costs of converting buildings to lower temperatures, along with the value of the benefits of each associated temperature, defining an optimized scenario.

Case Study: Brown University's District Energy Building-Level Strategy

Brown University is an Ivy League institution with 10,000 students and a 146-acre campus. In 2008, Brown announced its intent to reduce greenhouse gas emissions by 42% by 2020. By 2016, a focus on thermal efficiency was the final and most important stage to reach the emissions goal. In response, Brown selected Ecosystem to perform 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.

Ecosystem implemented building-level measures across the campus. Building and energy transfer stations were optimized to lower the temperature of the existing district heating network, while maintaining a significant amount of the existing infrastructure.



Finding Synergies within the Net Zero Project

- **Reduce energy use**
  - Other energy conservation measures (ECMs) should be implemented at the same time as the temperature of the heating hot water system is reduced, allowing for a holistic approach. It is also less expensive to install everything in tandem, and it might even be possible to combine systems.
- **Rethink HVAC systems**
  - Increase the ΔT across the building heating system. This can be done by distributing heat in series, instead of in parallel, through the building, and by rerouting where heat is fed to first. A higher ΔT between the inlet and outlet of the building can result in increased efficiency and will provide more options when retrofitting the distribution system, such as re-using existing pipes that would otherwise be too small in diameter.
  - The optimal design is based on the right input temperature, the best compromise between installation cost and energy savings. The lower the temperature of the building's heating hot water system, the larger the heating coils required. So, the lower the design temperature of the new heating system, the higher the cost of installing it. However, a lower-temperature system is more efficient and results in greater energy savings over time. This temperature can be optimized, balancing energy savings and installation cost against temperature.
- **Recover waste heat**
  - Maximize heat recovery potential to reduce energy consumption.
  - Eliminate free cooling, which throws useful heat out of the building. That heat could be transferred to areas of the building that require heating.
  - Centralize the cooling network and evaluate the possibility of expanding it and adding additional loads. The more areas connected to the centralized cooling network, the more heat can be extracted and transferred to the centralized heating network.
- **Reuse certain assets**
  - Experiment with setpoints. Testing out lower and lower setpoints can ensure that only equipment that needs to be replaced is, reducing cost and disruption.
  - When reusing existing distribution piping, lower-temperature heating often requires higher flow, but these strategies may ensure piping does not need to be replaced.

Why is it important to focus on the buildings?

1. Future Proofing

Reducing the temperature of the building heating system can open the door for multiple Net Zero technologies so the system remains relevant in the future.

2. Reduced Cost

By retrofitting the buildings, the energy load will be reduced. As a result, the distribution and supply system can be downsized, reducing the total project cost.

3. Efficiency

Building-level retrofits are where the greatest complexity is, and often a significant amount of the project cost. For a project to succeed, building retrofits can't be an afterthought; cost-effective and correct building retrofits demand care and expertise.

Enabling a Successful Net Zero Project with a Building-Level Strategy

A transformational Net Zero system requires a comprehensive energy partnership between an integrated engineering firm and the campus.

It takes commitment to undertake the deep dive needed to identify the smaller projects across multiple buildings that reduce the larger Net Zero system project. In the traditional energy services model, energy systems are evaluated in silos, especially when the district Net Zero system is designed on its own without considering building-level systems. An integrated engineering and construction firm will look at the entire campus, finding energy savings in areas that others would miss, and evaluating the impact and value-add that improvements downstream of the plant could realize.