Roadmap to Distributed Generation: Innovative Tools for CHP Adoption

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ABSTRACT

Combined heat and power (CHP) is becoming an important strategy to help buildings reduce energy costs and increase resiliency while achieving greenhouse gas (GHG) emissions reductions on a system-wide level. NYSERDA's CHP Acceleration Program assists New York customers with installing CHP by offering a catalog of vetted systems in the small to medium size range. The outreach contractor for the program has been tasked with acquiring participants and assisting multifamily buildings, hospitals, nursing homes, and hotels with realizing the benefits of CHP as well as navigating the complex installation process. Unlike other programs, which often include a variety of technologies, the CHP Acceleration Program provides an incentive for a single technology, which is only viable when significant coincident electric and heat loads are present.

In order to achieve wide-spread CHP adoption, the contractor has developed a comprehensive data-driven market assessment tool, based on building loads and geography, to identify buildings in New York City that would make ideal candidates for CHP. The tool provides information on key decision-makers at those buildings in order to facilitate program outreach. It also includes a preliminary screening analysis that simulates the energy and economic impacts of CHP installations of varying sizes on building loads and operating costs. The tool allows the team to engage in targeted outreach and to quickly screen buildings for CHP potential taking into account n+1 configurations, energy prices, and other factors.

This paper describes the methodology for the tools and initial successes with their use through the NYSERDA program.

Introduction

CHP, also known as cogeneration, is the use of a single fuel input to create multiple energy outputs. This technology is not inherently novel; in the 1880s the Pearl Street Station in lower Manhattan became the world's first CHP plant. While the popularity of this solution for energy efficiency has varied since its first implementation over a hundred years ago, building owners and efficiency program administrators have recently renewed interest in utilizing CHP projects as a strategy for overall GHG emissions reductions, resiliency, and energy savings. There are however, still several technical and social barriers to CHP's widespread adoption that must be addressed if the technology is to be utilized to its full potential.

CHP Technology Overview

CHP presents the opportunity for efficiency by the production of two energy outputs from a single source of fuel. CHP plants consist of a few basic elements: the prime mover, electricity generator, the heat recovery system, and the control system. Most CHP plants consist of either a gas turbine or engine with heat recovery or a steam boiler with a steam turbine.

Benefits

By generating two energy outputs from a single fuel source CHP is often able to achieve efficiency over the traditional generation scenario. In a conventional generation framework a building receives power from the grid and uses another fuel (gas or perhaps oil) for a boiler. Due to transmission line losses and boiler efficiency, the conventional generation scenario is typically only 49% efficient. The use of a CHP system, however, could achieve the same energy outputs with less input – transmission losses are avoided and the waste heat from the on-site electric generation process can be used to offset fuel consumption of boilers and hot water heaters that would have otherwise been operating to produce steam or hot water. Including both the heat recovered and the electricity produced, CHP systems can easily achieve 75% efficiency. Greater system efficiency is directly related to a reduction in GHG emissions.

In addition, CHP has the potential to result in significant energy cost savings. In certain markets, the low cost of natural gas and high cost of electricity make gas-fueled CHP systems lucrative for system operators. By using natural gas to generate electricity on-site *and* by using the waste heat for domestic hot water, absorption chillers, or other thermal uses, building owners and operators can use CHP to effectively reduce operating expenses at their facilities. This relationship between electricity and natural gas rates is known as the spark spread and, in places like New York City, it is favorable for CHP adoption.

In addition to the potential for energy and cost savings, installers can configure CHP systems to provide resiliency benefits to buildings. In the wake of increasing extreme weather events, on-site generation technologies like CHP can be assets for buildings that are seeking to increase tenant safety and reduce economic losses due to power outages. CHP systems can tie in to critical loads allowing occupants to shelter in place or evacuate successfully. This benefit has been a key selling point for buildings seeking to install CHP in the New York City region post Superstorm Sandy. CHP systems have the added benefit of being operational and achieving energy cost savings during normal operation, while typical back-up generators sit idle during non-emergency times. In addition, installing CHP on a widespread basis also promotes grid reliability and can be an asset to utilities that have grid-constrained areas.

Limitations

CHP's many potential financial, environmental, and resiliency benefits can diminish dramatically when the technology is used in the wrong application. One of the most common shortfalls of CHP implementation occurs when a facility lacks a thermal load, as this results in dramatically diminished energy savings and emissions reductions. Therefore, one of the key criteria for a successful application of CHP is that the facility must have year round and coincident needs for *both* electricity *and* heat.

For most facilities, designing the CHP system to meet thermal needs (instead of electric needs) allows for the best project economics. Matching these loads can create confusion for customers, and mismatches could result in poor project payback periods.

There is a range of practical and physical constraints as well. In many real estate markets, buildings often do not have the space to accommodate CHP systems. Building owners would rather have more usable/rentable/sellable space than have a CHP system. In addition, project costs dramatically increase if the existing building infrastructure needs to be modified dramatically to support a CHP system.

Maintenance costs can also be onerous for buildings that implement CHP. CHP engines require regular maintenance to operate successfully (and to provide persistent energy cost savings). These costs can be hefty and many customers often forget to factor them into the economic analysis of the project.

Ultimately, these limitations create uncertainty for customers considering CHP systems, which in turn often results in dead ends for potential CHP projects.

NYSERDA's CHP Program

NYSERDA's CHP Acceleration Program addresses persistent barriers to CHP adoption and operation. The goal of the program was to simplify the planning and implementation process and relieve some of the barriers to adoption, in addition to providing financial incentives to reduce first costs. The program features a catalog of eligible pre-packaged CHP systems and vendors that NYSERDA has vetted. There is a set incentive for each system in the catalog that is based on the system size.

NYSERDA's pre-packaged approach helps to alleviate uncertainty over CHP plant component compatibility. By vetting prepackaged and pre-engineered systems NYSERDA is providing customers with the assurance that the components will work together. By requiring a single vendor be responsible for successful CHP installation and operation, they have simplified the communication chain should any component fail. Additionally, the program requires that a customer engage in a 5-year maintenance agreement with the vendor who installs the system. By making this a program requirement NYSERDA was able to address the lack-of-maintenance issue and ensure persistence of savings.

While NYSERDA's mission is to transform the market for CHP, educate potential buyers, and accelerate adoption of CHP on a widespread basis to achieve energy cost savings and grid reliability benefits and promote building resiliency, they also partnered with Con Edison to identify potential CHP targets in grid-constrained networks such as Con Edison's Brownsville substation. CHP systems installed in this area have the dual benefits of energy cost savings and resiliency for customers and demand reduction during the substation's peak times.

Outreach and Technical Assistance

NYSERDA identified a lack of customer understanding of CHP technology as a barrier to overcome. In order to assist customers in exploring CHP, they hired an outreach and technical assistance contractor to guide customers through the process of learning about CHP, determining if their building is a good fit for the technology, analyzing preliminary feasibility, and connecting with vendor and pre-approved systems. NYSERDA selected ERS as the outreach and technical assistance contractor.

ERS's main goals are to identify and engage interested customers (in New York State, but primarily in New York City and Westchester), provide technical assistance to assess if CHP could benefit their building, and guide them through the process of exploring CHP options. In order to engage customers, ERS has taken on a multipronged approach:

- Host and present at CHP seminars and installation tours.
- Approach industry allies, stakeholders, and trade groups in viable building sectors: multifamily, hospitals, nursing homes, and hotels.

- Make use of ERS's and NYSERDA's preexisting contacts from past energy efficiency program participation.
- Leverage publicly available data sets to target and identify potentially good candidates for CHP technology.

Lead Generation and Data Mining

One of the program's primary objectives is to identify potential participants beyond the participant blend of previous programs, which typically revolve around large industrial and commercial facilities. Of particular interest is the application of CHP in the multifamily sector. ERS has developed a framework for extracting relevant information from private and public data sets on the building stock in New York to identify specific facilities that could support CHP, as well as to broadly characterize the region's potential for CHP.

In order to accomplish this, ERS utilized a combination of public and private data sets, including Local Law 84 reports, Dunn & Bradstreet, and CoStar. Local Law 84, a publicly available data set of New York City mandated benchmarking for facilities greater than 50,000 sq ft, was used as the primary data source to characterize the energy usage at the facilities while Dunn & Bradstreet and CoStar were used to determine qualitative characteristics and relevant contact information.

Fundamentally, the methodology behind this lead generation framework involves the deconstruction of total annual energy consumption data provided for approximately 30,000 buildings in the Local Law 84 benchmarking reports into simulated 8,760 hourly electric and hot water loads using DOE OpenEI profiles defined based on building type characterization. Using each of these building-specific simulated profiles, ERS established an appropriate CHP system size range using the number of hours above a given load level as the sizing criteria. This sizing system is based on the historical observation that the most successful systems fully utilize the electric and the steam or hot water outputs of the CHP system for many hours of the year.

Given that this methodology was based on generalized facility profiles, it was important to test the validity of the analysis against historical CHP installations in the greater New York City region. Fortunately, NYSERDA has maintained an extensive and readily available set of records and an associated database of metering for systems installed through previous programs. ERS used this broad assortment of data to accurately calibrate the lead generation model, ensuring that it was neither conservative nor generous in its assumed capacity for CHP. In addition to the generation of a filtered and prioritized lead list for direct outreach, this methodology allowed the outreach team to tailor the program's overall engagement strategy based on the geographic and characteristic trends observed.

(Note: This has not been completed, but a thorough description will be added in the next paper draft. Included in this analysis will be a breakdown of CHP potential by facility types, geographic region, and other miscellaneous building characteristics.)

Participant Screening and Assistance

In addition to identifying opportunities for CHP implementation throughout New York, ERS also developed a framework of technical support at the individual participant scale. As an unbiased representative of NYSERDA, ERS provided technical guidance for potential participants, including a site-level preliminary assessment of potential for CHP, educational engagement on the available technologies, and assistance navigating the bid procurement and selection process. In order to accomplish all of these tasks, ERS developed and utilized an innovative load modeling and CHP system simulation tool.

Requiring nothing more than monthly utility consumption records and a basic qualitative description of the facility and its end uses, the tool is able to characterize the hourly electric and hot water or steam loads that can be offset by the CHP system. This methodology revolves around a combination of empirical and physics-based simulations to accurately deconstruct monthly consumption records into approximated hourly loads. This methodology is similar to the methodology used in the lead generation task, with the added benefit of greater resolution building consumption data. By observing consumption at a monthly, rather than an annual resolution, the tool is able to isolate and distinguish the space heating and domestic hot water components of the facility's hot water usage, which are applied to distinct hourly load profiles. Once the electricity and thermal loads at the facility have been accurately modeled, the tool simultaneously simulates an assortment of user-defined CHP system sizes and configurations using a physics-based approach. This is achieved using an iterative numerical simulation method to match the modeled hourly loads with the electric and thermal output of the simulated CHP system, resulting in an accurate assessment of CHP system operation, energy and demand savings, and GHG impacts.

Similar to the lead generation tool, ERS effectively leveraged previous evaluation results to further refine and calibrate the preliminary screening model. This was accomplished by comparing the outputs of the simulation tool with actual records of CHP system operation at a variety of facilities, spanning multiple geographic regions and business types.

Perhaps the single greatest benefit of the participant screening simulation model is that it facilitates discussion and engages with potential program participants. By varying several input parameters such as system control strategy, prime mover technology, utility rate structure, thermal storage capacity, and maintenance contracts, the outreach staff can easily demonstrate the implications of a number of subtle design and purchasing decisions. This ability provides the participant with a degree of comfort around the technology, which is one of the primary objectives of the outreach contract.

Conclusions

While CHP technology implementation has many obstacles, it still has tremendous potential to reduce energy consumption and emissions and provide resiliency. Of particular importance in the implementation of an energy efficiency incentive program for such a complex technology is an emphasis on rigor in the participant selection process, followed by adequate support for those facilities that are eligible candidates.

ERS has effectively accomplished and is still currently engaged in this subtle balance between screening and support that is so necessary for the technology's continued success. By going beyond the conventional approach to program outreach, the CHP acceleration program will be effective at aiding the development of sustainable and resilient communities.