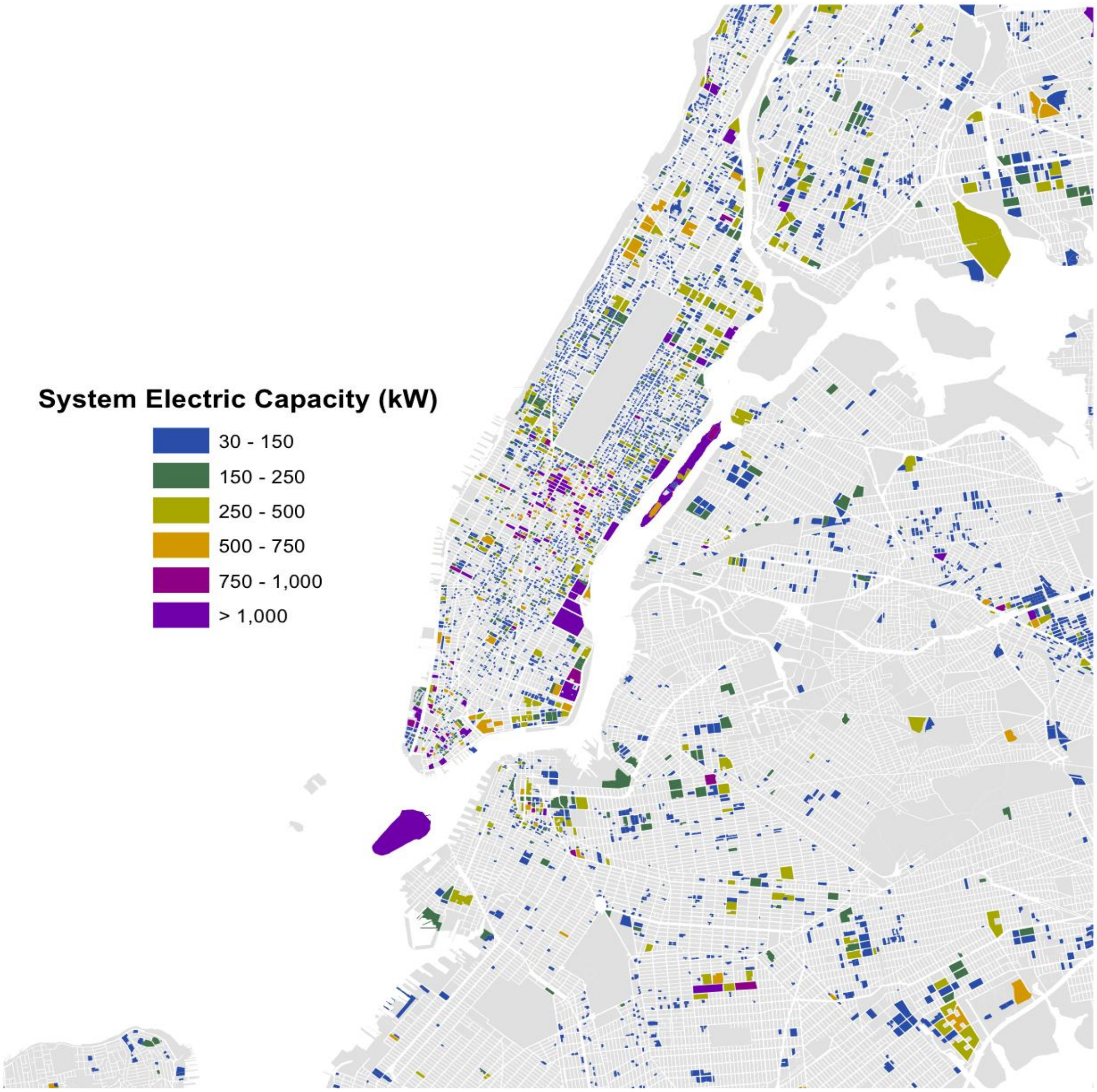
The Opportunities for and Hurdles to Combined Heat and Power in New York City



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Introduction

Combined heat and power (CHP or cogeneration) is the simultaneous production of electricity and thermal energy from a single fuel source.[1] The most common CHP systems in New York City use natural-gas fired turbines or reciprocating engines to generate electricity and then capture heat from the combustion generator's exhaust stream and cooling systems. Less common is the generation of electricity as the byproduct of heat generation (i.e., using steam turbines).

CHP systems in New York City typically range from 60 kilowatts (kW) for many multi-family residential buildings to 4-7 megawatts (MW) for many hospitals, college campuses, and big office buildings to 10-15 MW for even bigger loads.[2] There are around 150 CHP systems in New York, with the biggest being the Brooklyn Navy Yard at around 300 MW (aside from Con Edison's 500 MW East River facility[3]). Excluding these larger utility-scale systems, there exists about 220 MW of CHP within New York City. According to Con Edison, approximately 160 MW of that base load capacity is connected to the grid, while the remainder operates in isolation.[4] Some well-known buildings or campuses partially[5] powered by CHP include: One Bryant Park, One Penn Plaza, the New York Times Company, New York Presbyterian Hospital, the Bronx Zoo, JFK Airport, New York University, and soon to come, Columbia University, the Bronx VA Medical Center, and 60 Hudson Street.

The benefits of CHP are numerous. By utilizing both the thermal and electrical energy of electricity generation, CHP systems are able to operate at 60 to 80 percent efficiency, whereas conventional fossil fuel power plants operate at around 30 to 35 percent efficiency.[6] New combined-cycle natural gas plants can have efficiencies around 60 percent, according to turbine manufacturers;[7] however, in practice the plants likely operate around 50 percent, with the efficiency decreasing a few percentage points below that due to losses in transmission and distribution. CHP systems are directly connected to the customer, thereby avoiding such losses. The efficiency of CHP systems reduces primary fuel consumption, thus decreasing air pollution. CHP also contributes to grid reliability and serves as a demand response tool because it allows

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[1] For more information on CHP, see: U.S. EPA Combined Heat and Power Partnership, http://www.epa.gov/chp/; NYSERDA, http://www.nyserda.ny.gov/en/Page-Sections/Research-and-Development/Combined-Heat-and-Power.aspx, U.S. Clean Heat and Power Association, http://www.uschpa.org/i4a/pages/index.cfm?pageid=1.
[2] *See* ICF International, Combined Heat and Power Units located in New York, http://www.eea-inc.com/chpdata/States/NY.html.
[3] The East River CHP facility provides electricity to the grid and steam to Con Ed's district energy steam system, which services 1,800 customers in Manhattan. The steam system was started in 1882 and is the largest district steam system in the United States. *See* Con Edison Steam System, http://www.coned.com/newsroom/energysystems_steam.asp.
[4] For information about synchronous and induction generation, see Con Edison, Distributed Generation: Concepts for Generation, http://www.coned.com/dg/configurations/generation.asp.
[5] Very few buildings and campuses generate their full electric loads with a CHP system, causing most of them to purchase standby power from Con Ed to supplement the CHP generation.
[6] *See* U.S. EPA Combined Heat and Power Partnership, Efficiency Benefits, http://www.epa.gov/chp/basic/efficiency.html.
[7] *See* David Biello, *A Spin on Efficiency: Generating Tomorrow's Electricity from Better Turbines*, SCI. AM., May 10, 2010, *available at* http://www.scientificamerican.com/article.cfm?id=a-spin-on-efficiency-with-better-turbines.

buildings to produce some of their own electricity, thus relieving stress on the grid and, during times of peak power use, displacing some of the need for costly, polluting power generation. CHP also can protect against health and security disasters when used to provide electricity and thermal energy to critical infrastructure.

As local, state, and federal levels of government set and work toward greenhouse gas emissions reduction targets, CHP has taken on a further significant role. President Obama issued an executive order in August 2012 that established a national goal of developing 40 gigawatts (GW) of new CHP capacity by 2020.[8] New York City's sustainability plan, PlaNYC, includes a goal of developing 800 MW of clean distributed generation, mostly in the form of CHP, by 2030.[9]

In many ways, New York City is a hospitable environment for CHP development. The City's mixed-use buildings and neighborhoods allow for full use of the thermal and electrical power produced by CHP systems, and the hot summers and cool winters create a need for space chilling and heating (in addition to year-round hot water heating) and therefore a steady thermal load. Sophisticated building owners and operators run hundreds of big commercial and residential buildings in all and can be educated on the value of CHP and the installation process. For large buildings in NYC, Con Ed can often provide detailed data on the buildings' electric and steam use, which can be used to identify the coincidence of a building's electric and thermal loads—information that is necessary for accurate sizing of a CHP system. The city government is interested in energy efficiency and dedicated to reducing greenhouse gas emissions, as demonstrated by its 800 MW of distributed generation goal. The New York State Energy Research & Development Authority (NYSERDA) provides a variety of incentives for CHP, some of which are discussed below.

Nonetheless, there are also many characteristics of New York that make it a difficult place to advance CHP. The utility infrastructure is dense and complex—and largely underneath a dense and complex built environment. This situation can make adding electrical capacity to the grid or extending natural gas lines difficult and highlights the importance of public safety considerations. The City's electricity grid was engineered for traditional distribution in one direction: to the customer; this presents technical challenges for adding distributed generation that can send power back into the grid. There are many city and state agencies as well as utilities that require permits and approvals for every step of the development process. Building owners may be unfamiliar with utility standby tariffs for electricity and steam and may not have experience using natural gas. As discussed above, large buildings in New York can access robust energy data through Con Ed; however, small customers, which collectively represent significant CHP growth potential, may have to work harder to determine their load profiles and therefore to properly size a CHP system. Any uncertainty creates risk that might deter customers and investment, especially if incentive programs themselves require frequent renewal. In addition, New York City's electricity is already relatively "clean," coming largely from hydropower,

[8] *See* Exec. Order No. 13,624, 77 Fed. Reg. 54,779 (Sept. 5, 2012).

[9] *See* PlaNYC: A Greener, Greater New York 113 (Apr. 2011), *available at* http://www.nyc.gov/html/planyc2030/html/theplan/the-plan.shtml. The PlaNYC goal includes not only CHP but also other types of distributed generation, meaning on-site generation such as small-scale wind and solar power. Based on the City's CHP working group meetings in March and April 2012, it appears that the emphasis is largely on CHP to meet the goal.

nuclear power plants, and combined cycle natural gas plants that produce no or relatively low amounts of greenhouse gases.[10] The electricity generated by a CHP system will decrease the need for electricity generated by the least efficient plants that operate during times of peak electricity use, thus not directly putting CHP in competition with New York's generally clean generating sources; however, with increasingly efficient utility-scale generation over time in New York, CHP will have to keep pace.

Some of these factors that make CHP development expensive and time-consuming in New York present themselves as hurdles—aspects of the development process that can be altered through policy changes, rather than accidental difficulties that may arise during the development process. The hurdles identified in this report include:

- Substantial influence of standby power cost on system feasibility.
- Lack of clarity in project approval and permitting processes.
- Insufficient financial mechanisms to manage upfront costs.
- Substantial financial outlay for shop drawings.
- Substantial cost of extending new natural gas pipes.
- Lack of team continuity and consistent adherence to guidelines in the interconnection process.
- Delays with the interconnection process due to technical hurdles.
- Unclear statutory language.
- Length of time to identify permitting and approval requirements.
- Length of time to obtain permits and approvals.
- Compliance cost and time associated with additional demands.
- Costs of last-minute approval and design changes.

Many of these hurdles stem from a lack of organized information easily accessible to building owners, project planners, utilities, and government agencies. While policy changes are certainly needed to facilitate CHP development, the increased accessibility and analysis of information can inform such decision-making and provide the support necessary to take full advantage of CHP's potential.

This paper first seeks to quantify the potential for CHP development in New York City and describe the primary hurdles to optimal deployment in Parts I and II. Part III provides policy solutions for overcoming these hurdles and recommendations for how stakeholders can use information and analysis to maximize the opportunities for CHP.

I. Potential for CHP in New York City

New York City boasts a wide array of CHP systems, and despite the myriad hurdles introduced above, there is a potential for even more CHP development. This section discusses the

[10] *See* JONATHAN DICKINSON & ANDREA TENORIO, MAYOR'S OFFICE OF LONG-TERM PLANNING AND SUSTAINABILITY, PLANYC: INVENTORY OF NEW YORK CITY GREENHOUSE GAS EMISSIONS 21 (Sept. 2011), *available at* http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/greenhousegas_2011.pdf.

magnitude of future CHP opportunities through a technical analysis of the energy demands in New York City.

CHP systems produce electrical energy and capture and use the resulting thermal energy, which in most cases leads to higher efficiencies relative to traditional electricity and heat generation. A gas turbine, microturbine, or reciprocating engine, termed the system prime mover, will generate electricity by burning fuel, and a heat recovery unit will capture heat from the combustion generator's exhaust stream and cooling systems.[11] The typical fuels used to power these systems are natural gas or fuel oil.

Microturbines are typically used to power small buildings, and their capacity can range from 30 kW to 250 kW. These systems typically are less efficient than large central power plants at producing electricity, leading to a larger fraction of waste heat available for heat recovery. Typical electrical efficiencies (the fraction of heat input converted to electricity) range from 20-30%, and CHP efficiencies (the fraction of heat input converted to electricity and useful heat) range from 70-75%. These systems are capable of producing hot water and low-pressure steam. Internal combustion engines can be larger systems ranging from 100 kW to 7 MW. These have higher electrical efficiencies, ranging from 25-45% with larger systems being more efficient. These systems, in conjunction with heat recovery equipment, are capable of producing hot water, lower pressure steam, and district heating and cooling. Gas turbines are larger installations typically used for industrial or utility scale applications, and they have capacities ranging from 1 MW to 200 MW, electrical efficiencies ranging from 25-40%, and CHP efficiencies ranging from 75-85%. There are additional characteristics of CHP equipment that will make it more or less favorable for a distributed CHP system. Detailed comparisons can be found in the Catalog of CHP Technologies and Sustainable On-Site CHP Systems: Design, Construction and Operations. Only microturbines and internal combustion engines were used in our analysis.

System Viability

The technical feasibility of CHP depends on a variety of factors, many of which are specific to the site at which the system would be installed, such as the existing type of heating system, availability of high-pressure gas, and physical constraints of the space that would house the equipment. Installing a CHP system requires a detailed engineering and financial feasibility analysis, the basics of which are discussed in Part II. Retrofitting an existing building for CHP requires significant consideration of the local conditions, as the system must physically fit within the confines of the building, must be accompanied by proper exhaust ventilation, and must meet New York City building, fire, and air pollution codes. There may be additional permits and time delays associated with bringing in a natural gas line, if the building is not already connected to the natural gas systems of Con Edison (Con Ed) or National Grid. If the building is already connected to a natural gas system, the point of service interconnection to the gas mains and the electricity grid must be altered to accommodate the CHP system. Noise and vibration reduction materials and structural reinforcement might also need to be installed, depending on where the CHP system is located in the building.

[11] *See* U.S. EPA Combined Heat and Power Partnership, Basic Information, http://www.epa.gov/chp/basic/index.html.

In addition to the local conditions, engineers must determine what type of CHP prime mover to install, the desired capacity of the system, and the best way to operate the system to ensure high utilization, energy efficiency, and economic viability. There are many strategies for how to best operate and size a CHP system such as maximizing revenue, maximizing system efficiency, and minimizing the carbon footprint of the system. Each of the objectives would result in utilization of different types of prime movers, numbers of generators used to meet the loads, uses of additional heat recovery systems, as well as operational strategies. For example, when designing a system to maintain maximum plant efficiency, the use of additional systems to recover the most energy from the thermal energy stream may be justified. For an economic analysis, the additional energy recovered may not justify the cost, and the system components may therefore be less extensive. Researchers have developed methods to determine the optimal operating strategies and system components for CHP systems depending on the desired outcome and load profiles (time of use energy demands) of the buildings to be sized. These methods typically deploy linear, mixed-integer linear, and non-linear programs to determine the optimal strategy.

Since neither detailed load profiles for each building nor information about the local conditions constraining the deployment of various equipments are available for use in this study, the current method of analysis relies on a simpler methodology. Two of the more general methodologies for operating a CHP system are to meet either the thermal or electric base load. For these methods, the CHP system is operated year round, satisfying the minimum constant electric or thermal demand. This method ensures that the system is sized in such a way to always run at peak load and efficiency. Two additional sizing methodologies are electric and thermal load following strategies. These methods size the system to follow either the electric or thermal loads for a major portion of the year. There are then times of the year when the CHP system might have to shut down part or all of the supply system. Typically systems utilizing these strategies must have high part load efficiencies. The part load efficiency is a measure of how well the system operates when not running within the range of optimum load conditions. Internal combustion engines have high part load efficiencies as long as the load does not drop below 60% of the peak load. For all four sizing methods—electrical base load, thermal base load, electrical load following, and thermal load following—there will be instances when the systems will need supplementary power for electrical or thermal needs. For the purposes of the current analysis, the supplementary demand was assumed to be supplied by boilers that create energy at 85% efficiency and electricity distributed through the New York City grid.

To determine which of these general sizing and operational strategies to utilize, a preliminary analysis was conducted to see how accurate the base loading and load following strategies could estimate the size of CHP systems. The estimates were calculated for and compared to the current CHP installations that obtained incentives from the New York State Energy Research and Development Authority (NYSERDA). NYSERDA provides incentives for implementing CHP in New York City that play a crucial role in helping to finance CHP projects. The most notable programs are the CHP Demonstration Program and the Peak Load Reduction Program. To be eligible for those incentives, the proposed system must have an annual CHP efficiency of 60%, which is a ratio of the usable energy output (both electricity and thermal in common units) to the energy input to the system, which in this case is natural gas. Any system that received incentives was required to place information about the system characteristics online. We used this set of CHP systems for our analysis because of the availability of information. Since these systems were installed to meet specific and different goals leading to different sizing for similar buildings, only the aggregate capacity of systems located in New York City was used to compare the results of the different sizing methods.

Of the four general sizing methodologies, the thermal base load methodology was immediately discarded since, even when considering space heating, space cooling, and domestic hot water as the thermal loads, the CHP systems were dramatically undersized. The figure below provides sample load duration curves of a 50,000 square foot multi-family building to illustrate this sizing method. The load duration curves show for how many hours the energy demand is at a particular value throughout the year; this is the hourly demand sorted from high to low.

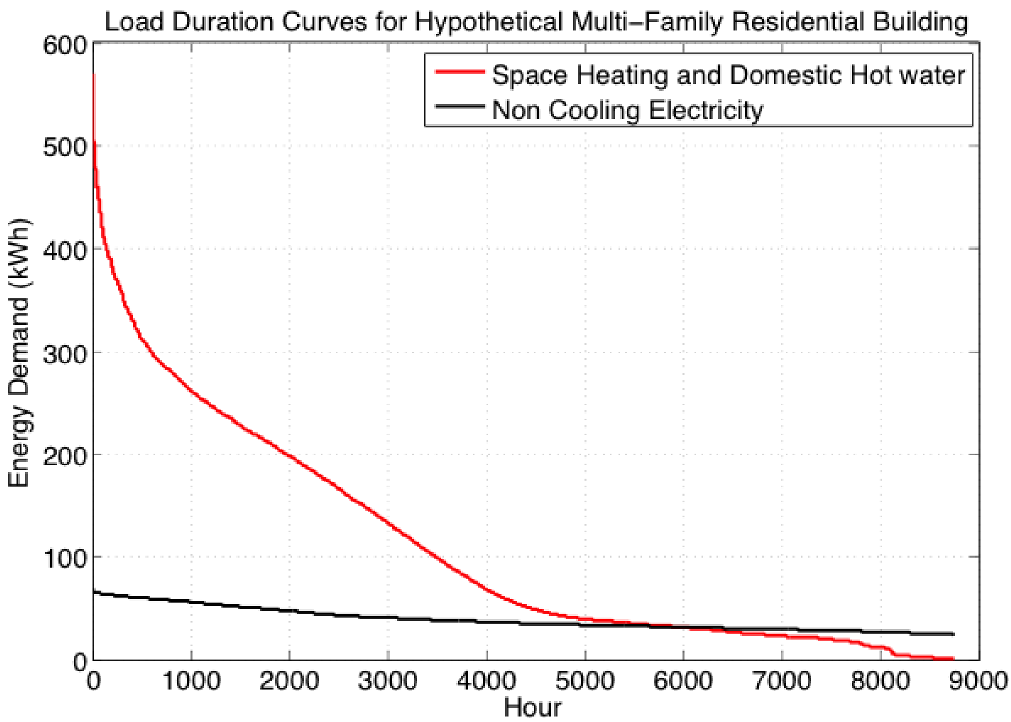

Figure 1. Load duration curve for hypothetical 50,000 sq. ft. multi-family building.

This figure shows that the thermal base load would be fairly close to zero, as shown by the lowest values on the right side of the figure. Residential buildings utilize a large amount of energy for space and water heating, although not as much for space cooling as do office buildings. Load profiles for office buildings yielded similar results as well. The electric base load, however, is non-trivial, although smaller than typical installations at 24 kW. A detailed description of the methods used for the electric base load, electric load following, and thermal load following can be found in the Appendix, although it is important to note that a minimum 60% HHV annual efficiency was imposed for the building and microgrid scales or else a system was not selected. A comparison of the aggregate capacities for the electric base load, electric load following, and thermal load following sizing to the actual systems in the NYSERDA database is shown in Table 1.

Table 1. Comparison of different sizing methodologies with installed CHP systems with NYSERDA incentives.

	NYSERDA	Electric Base Load	Electric Load Follow	Thermal Load Follow
Aggregate Capacity (kW)	16,410	8,880	17,266	24,066
Percent Difference	-	46%	5%	82%

These analyses were performed utilizing only the estimated space heating and base electric energy demands for each of the buildings. From this preliminary analysis, the electric load following methodology provided the closest aggregate estimate. Also, adding the water heating and space cooling demands resulted in even higher differences between the estimates and actual systems. Therefore, the electric load following method considering only space heating as a thermal load was used to estimate the potential for the remaining tax lots and future microgrid scenarios. A minimum size of 30 kW was maintained to reflect the smallest microturbine technologies. The other sizing methods as well as incorporating the additional loads are not incorrect but rather alternative sizing methods that will lead to different results (i.e., citywide potentials). The goal here is to provide an estimate that reflects the sizes of current systems. It is important to note that the current sizing methods reflect the current economic framework and policy implications. Changes to these fundamental drivers of system size and utilization that would make CHP easier to install would only increase the potential for CHP citywide.

To emphasize, this technical analysis is meant to show the potential for CHP across New York City but may not, and in many cases will not, reflect how an actual system would be deployed at the site. The current set of results represents one of the many possible sizes of CHP systems that could be engineered to supply the desired demands, although the methodology provides aggregate estimates that are similar in magnitude to CHP systems currently implemented in buildings.

In addition to determining the potential capacity of systems throughout the city, we also estimated the potential greenhouse gas emissions reductions using the avoided burden approach. This method compares the emissions of the electricity and thermal energy that would have been supplied to serve the energy demands with the emissions produced by the CHP system. In this case, the avoided emissions would be the total emissions from electricity produced by the grid and emissions from a local boiler minus the emissions from the CHP plant. For our analysis, the emissions coefficient (CO_2e/energy produced) for non-base load electricity generation for the New York City and Westchester regions and from thermal energy from boilers operating at 85% efficiency was utilized to calculate the reductions. The non-base load values were used; although for a particular building the CHP system may be providing a portion of base load electricity, in comparison to the electricity demand of the entire city, at the magnitudes of the systems we have identified, these systems would be offsetting non-base load power. A study performed to determine the impacts of adding a 500 MW CHP system in the New York City area calculated by running electric dispatch models mimicking the local grid operations found that only non-base load power would be offset. See the Appendix for a more detailed explanation of the emissions calculations.

CHP Opportunities

With the viability criteria established (thermal and electrical load, minimum size requirement, and minimum efficiency requirement), we were able to begin analyzing the opportunities for CHP in New York City.

In the buildings database used for the analysis, the smallest unit is the tax lot. While most tax lots are only associated with one building, there are instances where a tax lot will contain multiple buildings. For this analysis, tax lot-level opportunities will be discussed as building-level opportunities. Block-level opportunities will be discussed as microgrid-level opportunities. While limiting the microgrids to a block may not illuminate every possible microgrid configuration, it does provide an estimate of the magnitude of microgrid opportunities.

At the building level, the electric load following methodology previously discussed identified 2,348 potential CHP systems with an aggregate electrical capacity of 1,579 MW, resulting in an average reduction in site emissions (emissions produced by energy production at the specific location) of 47% and an overall reduction of 6.6 million metric tons of greenhouse gas emissions. At the microgrid level, the electric load following strategy identified 4,714 systems with an aggregate capacity of 3,042 MW, resulting in an average reduction in site emissions of 48%. If each system were installed, an overall reduction of 14.6 million metric tons of greenhouse gas emissions. A side-by-side comparison of the number of systems, aggregate capacity, average site emissions reductions, and emissions reduction potential for each of the scenarios is shown in Figure 2.

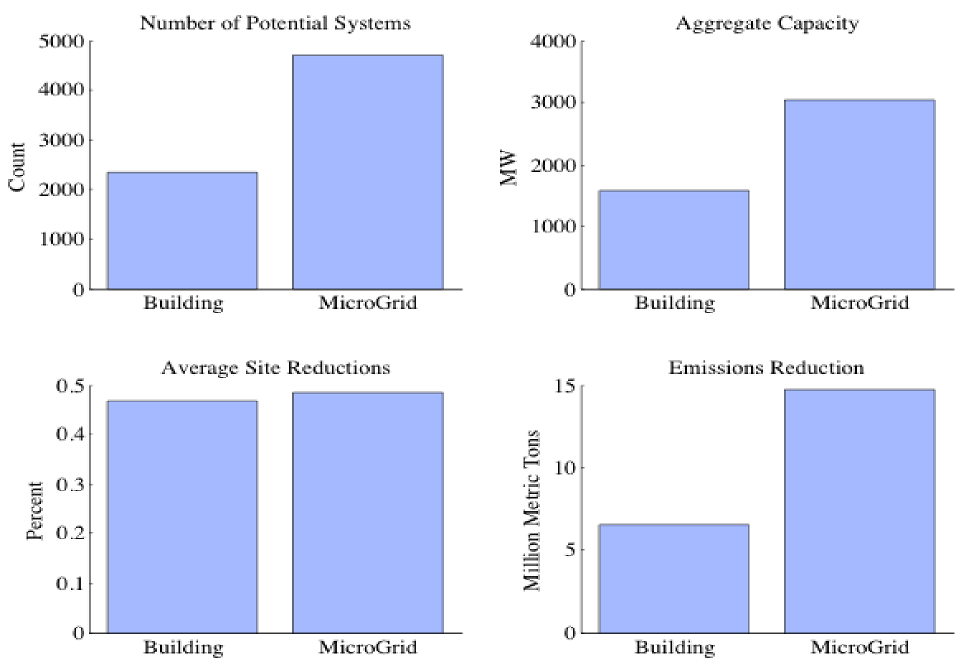

Figure 2. Number of CHP systems, potential CHP electrical capacity, average percent site emissions reductions, and global greenhouse gas emissions reductions at the building and microgrid levels.

In addition to the aggregate capacity, the number of systems between a certain range was calculated and is shown in Figure 3. The total capacity that falls within those ranges is shown as well. The distribution of system size is fairly similar between the building and microgrid scenarios, although the magnitude of the potential microgrid systems in number and capacity is larger. The majority of systems in each case fall within the 100-250 kW capacity range, although the largest capacity is within the 1,000-2,500 kW range. This indicates that there are opportunities for distributed CHP development at both the small and large scales.

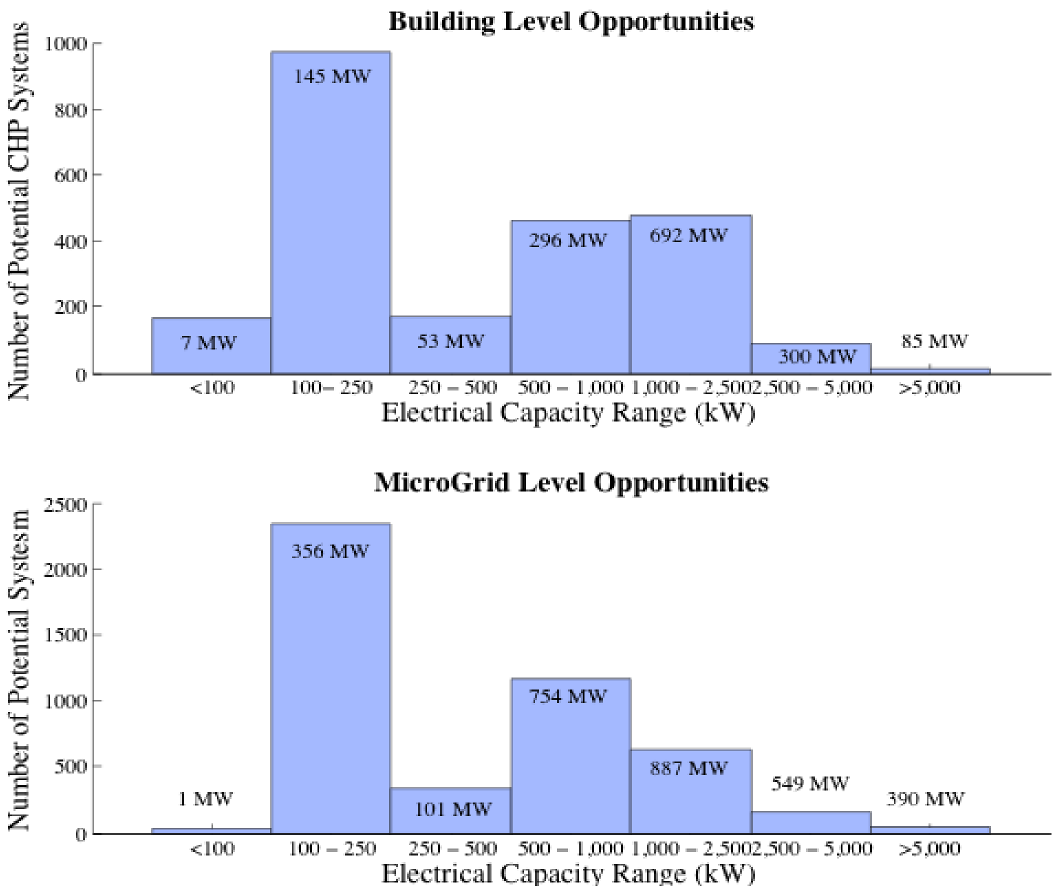

Figure 3. Number of CHP systems within a certain capacity range for the building- and microgrid-level CHP opportunities. Aggregate capacity shown for each range in MW.

In terms of building floor area, the majority of floor area served by the potential CHP systems is residential, followed by office buildings and health facilities. The breakdown of the opportunities by building floor area for the building-level and microgrid-level scenarios is shown in Figure 4. Since residential building floor area dominates the building stock in New York City, it is not surprising that there are a large number of systems serving residential buildings.

In terms of geographic placement, the majority of CHP systems for all scenarios are located in Manhattan, which has the highest building density and the most energy-intensive buildings. Maps of the potential CHP systems for both the building and microgrid levels are shown in Figures 5 and 6.

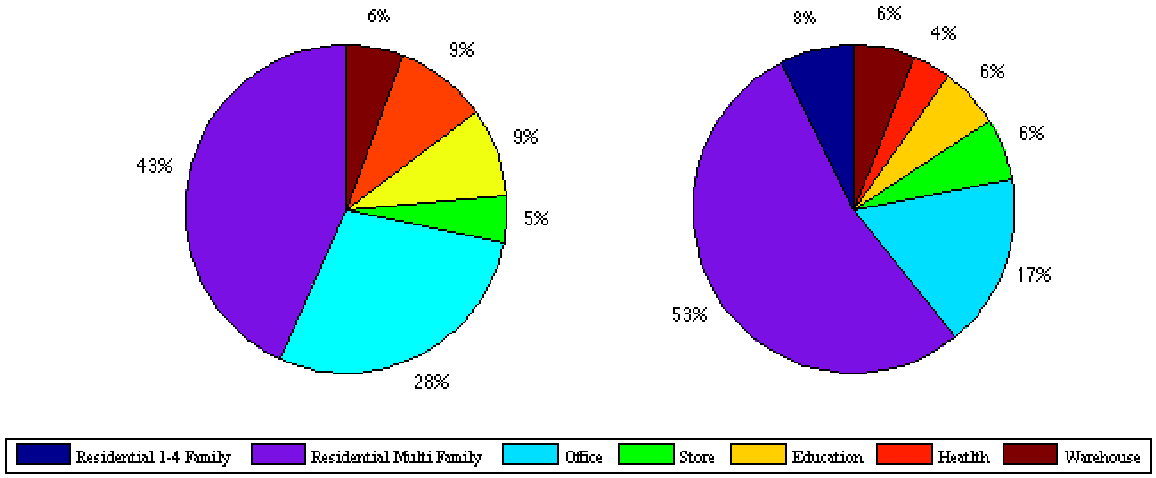

Figure 4. Distribution of building floor area served by potential CHP systems by building type.

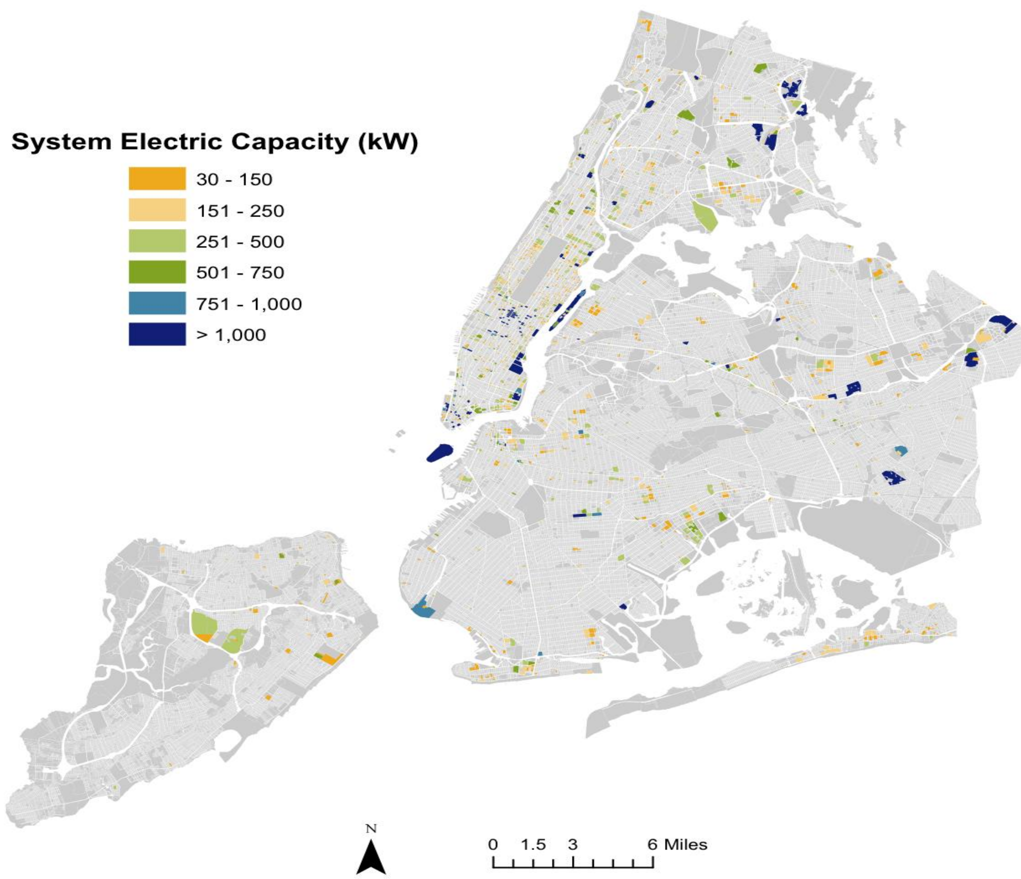

Figure 5. Map of the building-level CHP opportunities colored by system capacity (MW).

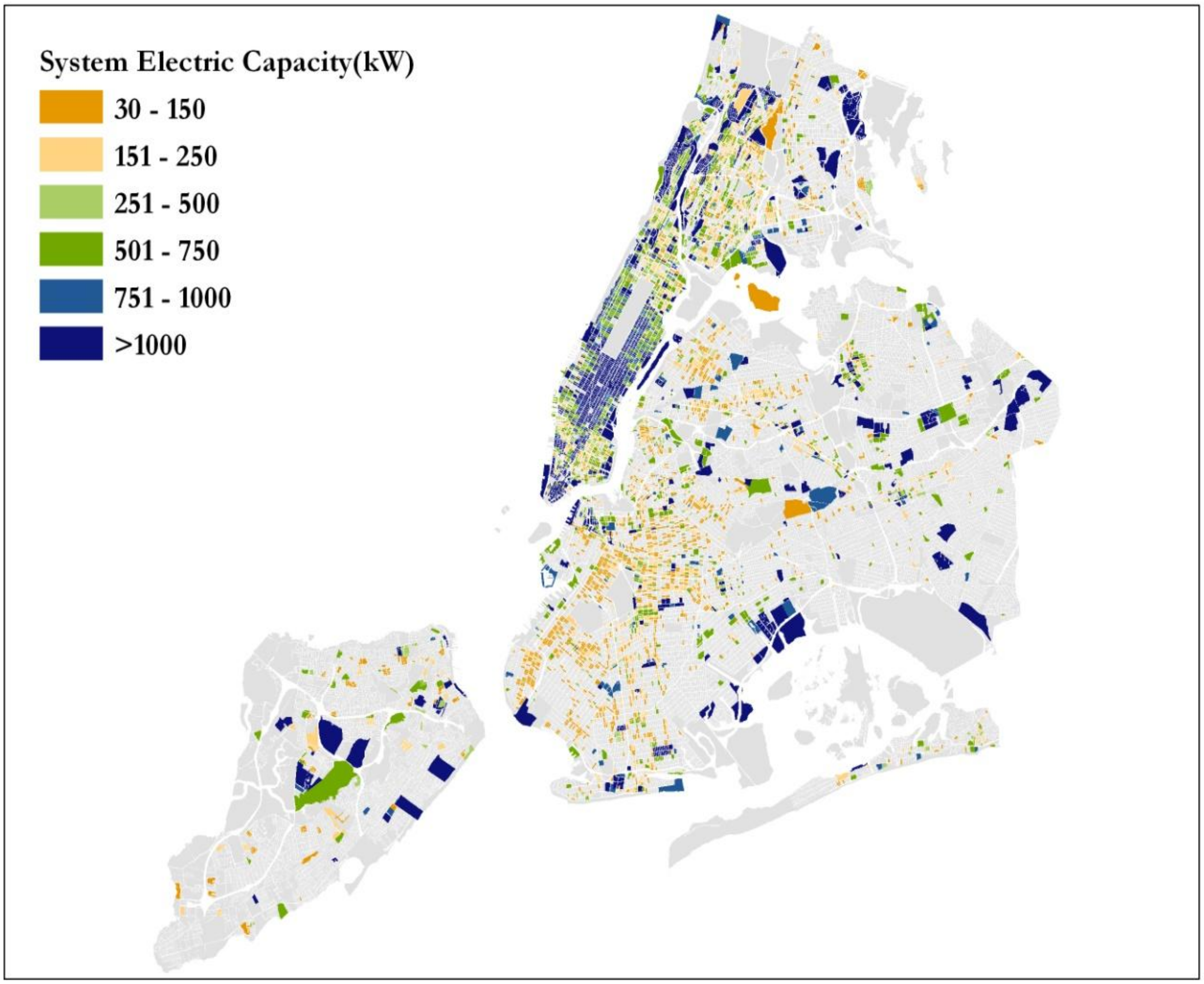

Figure 6. Map of the microgrid-level CHP opportunities colored by system capacity (MW).

The potential for CHP systems to serve space heating and electric loads of buildings in New York City was estimated to be 1,580 MW at the building level and 3,038 MW at the microgrid level, depending on the viability criteria and scale of the systems. The installation of this capacity could result in up to a 12% and 27% reduction in citywide greenhouse gas emissions at the building and microgrid levels, respectively. These estimates, however, are based on comparing a single sizing methodology to an entire city; therefore, different sizing methods may result in larger or smaller individual systems and aggregate capacity. In addition to the sizing methodology, the local conditions and economics of the site may prevent many of these sites from utilizing CHP. Although we do not attempt to estimate how many of these systems will eventually get installed, we can conclude that there are many opportunities for CHP in the existing fabric of New York City. Although the potential is clear from a technical perspective, there are many policy and regulatory hurdles to developing CHP systems in New York City.

II. CHP Development: Procedures and Hurdles

While the development of each CHP project is unique, there are some standard stages that each present hurdles in the New York City market. This section establishes the general development process and identifies roadblocks along the way. While the information below is enumerated, implying that number one must come before number two, for example, the reality of the development process is more flexible. Agencies and utilities advise engineers and developers to engage the relevant authorities immediately to ensure that regulatory requirements inform the feasibility and design processes and to save time and money later on. Therefore, the stages described below are a general framework, and the development process is very fluid in practice.

Feasibility and System Design

1. Decision to consider CHP

   The building manager will identify CHP as a potential energy source at the project site, a decision that can be influenced by factors such as the potential for energy cost savings, capital availability, the cost of retrofits to an existing system, or the manager's or owner's interest in a sustainability agenda and technical expertise, for example.

2. Preliminary feasibility assessment and initial financial evaluation

   The manager first hires an engineering firm to conduct a preliminary feasibility assessment. NYSERDA's FlexTech program will provide half of the funding for the assessment.[12] The feasibility study includes an examination of the building's electrical and thermal load profiles (discussed in detail in Part I), the availability and price of natural gas, and the status of electric and steam standby tariff prices,[13] among others. The study must also take into account the geometric constraints of the building, which involves consideration of space on the roof and in the basement for the equipment—and subsequently how venting of the combustion byproducts and interconnection with gas and electric lines will work given the placement of the equipment. The feasibility assessment will provide information regarding the optimal size of the CHP system, where it can be located in the building, the rough capital costs of development, and the rough annual energy cost savings, among others.

   The engineering firm often involves a financial company and/or development company at this point as well to begin assessing the funding options, as the financial feasibility of a project is as important as the technical feasibility. All of the factors considered in the engineering feasibility assessment influence the potential costs of the CHP system and

[12] *See* NYSERDA, PON 1746 - FlexTech Program, http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-1746-FlexTech-Program.aspx.

[13] Utilities provide standby service to supplement the CHP's electricity and heat when the CHP system cannot meet the load demand or when the CHP system is out of service. (Supplementary heat can also be met by installing a boiler or maintaining an existing boiler.) The rate schedule the utilities charge for this service is called a standby tariff. The amount charged depends on the amount of service the customer contracts for; the sizing of the CHP system will influence the amount of power produced and therefore the amount and price of standby service needed. *See* CONEDISON, DISTRIBUTED GENERATION GUIDE 10 (Vol. 1, Sept. 2011), http://www.coned.com/dg/process_guide/processGuide.asp for more information.

therefore how much and what type of financing is needed. In addition to utility and agency approvals and permits, discussed below, another significant consideration for financing is the ownership structure of the CHP system. The two primary scenarios include ownership and operation of the CHP system by the building owner versus ownership and operation by a third party. The building owner must have the financial and technical ability to support substantial upfront design, permitting, and approval costs as well as long-term construction and operations costs and equipment operations and maintenance. If the building owner is unable or not interested in taking on these responsibilities, it can consider alternative ownership models. The three primary models are outlined well in a 2007 report by Columbia University's Center for Energy, Marine Transportation and Public Policy: power purchase agreement model, lease and energy services agreement, and joint-ownership model.[14]

- **HURDLE: Substantial influence of tariff cost on system feasibility.** The cost of standby tariffs (i.e., the amount that a building must pay for standby power, even if not used) heavily influences the feasibility of a project, as indicated in an October 2012 New York Times article discussing the impact of changes in electric rates on CHP cost effectiveness.[15] A variety of factors must be balanced to efficiently and cost-effectively size a CHP system, from the thermal/electrical load profile to potential emissions. These factors produce an estimate of optimal system size; however, if at that size, the system would fall within a tariff level that would be difficult to finance, then the system would likely be downsized below that threshold, even if the revised system is less efficient based on the load profile. The project developers utilize the engineering and financial models to find the suitable system size. It is important for Con Ed and all of its ratepayers that the utility charges a rate for standby service that reflects the actual cost of supplying electricity and steam, even if the service is ultimately not needed. However, many developers claim that the tariff prices weigh too heavily in their decisions about system sizing and financing relative to efficiency considerations and that the steam tariff in particular is difficult to plan around. Developers can propose new tariffs by petitioning the New York State Public Service Commission (PSC) for a declaratory ruling,[16] but as discussed in point 1 under Permitting and Approvals below, projects must have the financial ability and the time to pursue this route.
- **HURDLE: Lack of clarity in project approval and permitting processes.** Lack of clarity about what Con Ed and New York City agencies require for project approval and permitting as well as how long decision-making will take creates uncertainty about the project completion time and cost of compliance, which can discourage financial investment necessary for project development. As discussed in the Permitting and Approvals section below, the utilities and agencies have taken some

[14] STEPHEN HAMMER AND JEANENE MITCHELL, COLUMBIA UNIVERSITY CENTER FOR ENERGY, MARINE TRANSPORTATION AND PUBLIC POLICY, CHP IN NYC: A VIABILITY ASSESSMENT 35–37 (2007).
[15] *See* Patrick McGeehan, Midtown Developer Accuses Con Ed of Overcharging, N.Y.Times, Oct. 9, 2012.
[16] *See* New York State Administrative Procedure Act § 204; 16 NYCRR § 8.1 ("(a) Declaratory rulings may be issued with respect to: (1) the applicability to any person, property, or state of facts of any rule or statute enforceable by the commission or the validity of any such rule; (2) whether any action by the commission should be taken pursuant to a rule; and (3) whether a person's compliance with a Federal requirement will be accepted as compliance with a similar State requirement applicable to that person. (b) A declaratory ruling may also be issued whenever the commission determines it is warranted by the public interest.").

steps to standardize the decision-making process. For example, Con Ed and the PSC have established standardized interconnection requirements for systems under 2 MW and over 20 MW, and Con Ed estimates the cost of electrical interconnection through a Coordinated Electric System Interconnection Review (CESIR).[17] Developers and engineers interviewed for this report welcome these standards but comment that increased transparency and standardized legal requirements are needed to better plan for a CHP project and, as discussed below, design a CHP system. Con Ed has been increasing outreach to stakeholders about its approval process—through an interconnection seminar in October 2012, for example—which will likely begin to facilitate understanding among all parties.[18] The NYC Development Hub launched by the City of New York in October 2011 aims to streamline construction projects throughout New York City by allowing permit applicants to submit materials electronically, in one place, and by virtually bringing together six City agencies (including the New York City Department of Buildings, Fire Department, and Department of Environmental Protection, among others) to review the application materials and discuss project plans.[19] Development Hub begins to help streamline the approval process.

- **HURDLE: Insufficient financial mechanisms to manage upfront costs.** There are not sufficient financial mechanisms that help property owners and project developers manage the significant upfront costs of a CHP project. Part III describes expired NYSERDA incentives and tax relief programs that if reinstated and expanded, would go a long way in keeping investors from foregoing CHP's long-term savings for quicker returns.

3. System design

If the preliminary feasibility assessment is agreeable to the building manager, the engineering firm will put the project out to bid for designers, equipment providers, and subcontractors. If a development company already started work on the project, it will lead the project from here. These parties will begin a preliminary design of the CHP system and will initiate communication with relevant agencies for permits and with relevant utilities for approvals. Depending on the size of the system, the development company will meet with a separate consultant about air emissions permits and requirements.

- **HURDLE: Substantial financial outlay for shop drawings.** Shop drawings for the CHP equipment must be incorporated into the initial project designs, but before the equipment supplier will release the shop drawings, the CHP owner must make a substantial financial commitment to the vendor. This big financial outlay is risky, as project completion is not guaranteed at this stage.
- **HURDLE: Lack of clarity in project approval and permitting processes.** Lack of clarity about what Con Ed and New York City agencies require for project approval

[17] For more information about CESIR and Con Ed's interconnection process, see CONEDISON, DISTRIBUTED GENERATION GUIDE 10 (Vol. 1, Sept. 2011), http://www.coned.com/dg/process_guide/processGuide.asp.
[18] *See* ConEdison, Distributed Generation Presentation, http://www.coned.com/dg/presentation.asp.
[19] *See* New York City Department of Buildings, About the Hub, http://www.nyc.gov/html/dob/html/development/about_the_hub.shtml.

and permitting makes it difficult to design the system without the risk of major future alterations. See point 2 above and the Permitting and Approvals section below for more information about steps taken to standardize the permitting and approval processes.

Permitting and Approvals

1. Utility connections

In New York City, Con Ed provides all of the steam service, which is limited to Manhattan, and nearly all of the electrical service. The New York Power Authority (NYPA) provides electrical service to government entities including the New York City government and New York City Housing Authority. Con Ed also provides gas service in the Bronx, Manhattan, and Queens (Long Island City/Astoria and Flushing/Bayside wards), whereas National Grid provides gas service in the rest of Queens, Brooklyn, and Staten Island. A CHP system using natural gas as its fuel must be connected to Con Ed's or National Grid's gas lines. Most likely, a CHP system will not be supplying all the heat and electricity needs for the building(s); if there is no generator and boiler to provide the remaining service (or to supply service when the CHP system is down), then the system must also be connected to Con Ed's electrical and steam services. Con Ed has published a Distributed Generation Guide that enumerates the steps of the gas and electrical interconnection process,[20] and the New York City Department of Buildings (DOB) has published information about the requirements for gas and electric connection.[21] Con Ed and National Grid have published technical specifications.[22]

Each utility has its own electrical interconnection requirements, although CHP systems smaller than 2 MW are covered by the PSC's Standardized Interconnection Requirements (SIR)[23] and systems larger than 20 MW are covered by the New York Independent Systems Operator (NYISO) Standard Large Facility Interconnection Procedures (LFIP).[24] Systems that can follow standardized interconnection procedures are often easier, cheaper, and faster to design and install because developers know the requirements from the beginning and do not need an individual review by Con Ed. Systems 25 kW and smaller undergo an expedited application procedure.[25]

[20] CONEDISON, DISTRIBUTED GENERATION GUIDE 10 (Vol. 1, Sept. 2011), http://www.coned.com/dg/process_guide/processGuide.asp.
[21] NEW YORK CITY DEPARTMENT OF BUILDINGS, INSTALLING NATURAL GAS-FUELED COMBINED HEAT AND POWER (CHP) SYSTEMS 8–11 (Dec. 2010), http://www.nyc.gov/html/dob/html/sustainability/resources.shtml.
[22] Con Edison, Contractor Resources, http://www.coned.com/es/resources.asp; National Grid, Bluebook Specifications and Requirements for Gas Installations, Jan. 31, 2011, http://www.nationalgridus.com/bluebook.
[23] New York State Public Service Commission, Distributed Generation Information, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/DCF68EFCA391AD6085257687006F396B?OpenDocument.
[24] The NYISO Standard Large Facility Interconnection Procedures (LFIP) are contained in Attachment X of the NYISO Open Access Transmission Tariff (OATT). http://www.nyiso.com/public/markets_operations/documents/tariffs/index.jsp.
[25] PSC DG Information, *supra* note 23.

There are two primary technical considerations with electric interconnection. The first is that Con Ed allows a maximum of 10 MW of distributed generation to connect to a distribution feeder and 20 MW to a network feeder.[26] Inadequate electric distribution capacity on Con Ed's system may extend the interconnection process. The second technical consideration is that some substation circuit breakers and network protectors are at their fault current limits, meaning that if there is a fault (or failure) on one part of the grid, the circuit breakers and network protectors might not be able to prevent the electricity from flowing to the fault. The addition of electricity from a CHP system in these stressed areas can compound the problem. The inability of the system to handle excess current puts Con Ed repair crews at risk and can damage equipment on the line. Adding fault current mitigation measures to the CHP project design may extend the interconnection process and increase the cost of the project. In 2005, the PSC ordered Con Ed to establish a schedule for replacing all of its stressed substation circuit breakers,[27] and maps are available online indicating when replacements will occur at what locations.[28]

- **HURDLE: Substantial cost of extending new natural gas pipes.** It can be very costly and time consuming for the customer when utilities have to extend new natural gas pipes, which is the case if the project site is not already serviced by adequate gas. Utilities are especially overwhelmed with interconnection applications because New York City's recent phased ban of fuel oils #4 and #6 has prompted many building owners to switch to natural gas as a heating fuel;[29] however, Con Ed is working to lessen the impacts of the transition by indentifying multiple users who might benefit from an extended gas line and share the costs. Con Ed also has a five-year plan for replacing leaky pipes or pipes at risk for failure.[30] The Main Replacement Prioritization program estimates the likelihood of failure of individual main segments, while the DIMP Risk Rating program estimates the relative risk in a geographic area. These programs include replacement priority maps that could be overlaid on maps of buildings and blocks with CHP potential in order to identify areas where CHP development could happen most efficiently. If a customer finds the interconnection process to be unreasonably long, it can file a petition for a declaratory ruling with the PSC to accelerate the process, but developers interviewed for this article claim that

[26] *See* Con Edison, Specification EO-2115, Revision 8: Handbook of General Requirements for Electrical Service to Dispersed Generation Customers, Mar. 2006, ¶ 1.3. The distribution feeder is the distribution network after the substation step down transformer, and the network feeder is the transmission network after the generating step up transformer and before the substation step down transformer. *See* U.S.-CANADA POWER SYSTEM OUTAGE TASK FORCE, FINAL REPORT ON THE AUGUST 14, 2003 BLACKOUT IN THE UNITED STATES AND CANADA: CAUSES AND RECOMMENDATIONS 5 (Fig. 2.1) (Apr. 2004), http://www.ferc.gov/industries/electric/indus-act/reliability/blackout/ch1-3.pdf.

[27] *See* State of New York Public Service Commission, Case 04-E-0572—Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Consolidated Edison Company of New York Inc. for Electric Service, Order Adopting Three Year Rate Plan (Mar. 24, 2005).

[28] Con Edison, Synchronous Generation Placement Availability by Region, http://apps.coned.com/dg/configurations/maps.asp.

[29] *See* New York City Department of Environmental Protection, Heating Oil, http://www.nyc.gov/html/dep/html/air/buildings_heating_oil.shtml; Environmental Defense Fund, Clean Heat for New York City, http://www.edf.org/cleanheat.

[30] Presentation, Con Edison's Gas Distribution System & Replacement Strategy, Thomas Riviello, *available at* www.northeastgas.org/pdf/t_riviello_replacement.pdf.

they will only undergo the petition process if they have the money upfront to cover the legal costs of filing the petition and any application and construction costs while the PSC deliberates.

- **HURDLE: Lack of team continuity and consistent adherence to guidelines in the interconnection process.** The utilities are big corporations with many contact people who frequently move around within the companies, making it hard for developers to identify necessary contacts and to build lasting relationships. Many developers have cited instances where new utility representatives join the review team at various stages of project development and impose new requirements or design changes, increasing the inefficiency of the interconnection process. Contacts may not respond quickly or with clear instructions on the utilities' requirements, leading to project delays and costs.
- **HURDLE: Delays with the interconnection process due to technical hurdles.** Delays with the interconnection process due to the technical hurdles described above (not enough capacity in the lines to accommodate additional distributed generation or design changes related to fault current mitigation) can be costly. Again, a customer can file a petition for a declaratory ruling with the PSC regarding the timely updating of substation circuit breakers and network protectors, but there must be upfront financing to cover any construction costs while the PSC deliberates.

2. Exemption from regulation as a utility

FERC and the PSC have authority over utilities, which includes regulation of rates, quality of service, billing, and corporate finance and structure, among others.[31] For a CHP system to avoid such detailed regulation, it must be certified as a "qualifying cogeneration facility" under the Public Utility Regulatory Policies Act (PURPA)[32] and as a "cogeneration facility" under the New York State Public Service Law (PSL). Under PURPA, a qualifying cogeneration facility "means equipment used to produce electric energy and forms of useful thermal energy (such as heat or steam), used for industrial, commercial, heating, or cooling purposes, through the sequential use of energy."[33] The CHP system can be of any size, but there are efficiency requirements.[34] Under the PSL, a cogeneration facility is defined as "**any facility with an electric generating capacity** of up to eighty megawatts . . . **together with any related facilities located at the same project site**, which . . . simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy which is used solely for industrial and/or commercial purposes."[35] The term "related facilities" within this definition means "any land, work, system, building, improvement, instrumentality or thing necessary or convenient to the construction, completion or operation of any co-generation . . . facility and include also such transmission or distribution facilities as may be

[31] *See* 16 U.S.C. Chapters 12 and 46; New York State Public Service Law (PSL) §§ 66 and 80.
[32] *See* 16 U.S.C. § 824A–3. PURPA is designed to promote energy conservation and the increased energy efficiency of electric utilities, and it aims to accomplish these goals, and others, by giving special regulatory treatment to CHP (and other small power production facilities). FERC, What is a Qualifying Facility?, http://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp.
[33] 18 C.F.R. § 292.202(c).
[34] 18 C.F.R. §§ 292.205(a), (b), and (d).
[35] PSL § 2(2-a) (emphasis added).

necessary to conduct electricity, gas or useful thermal energy to **users located at or near a project site**."[36]

There are two phrases within these PSL definitions that have been somewhat refined by PSC decisions. The first is within the definition of cogeneration facility: the facility and the related facilities must be "located at the same project site." A 1992 decision found that an 11.2-mile long gas line was not located at the same project site as the CHP facility, but it provided no rationale for this conclusion.[37] A 2006 decision noted that the PSC had not yet defined the phrase but found that wind turbines, collection lines, and a substation were located at the same project site; the property was owned by a single lessor, the equipment was within a mile of the turbines, and "the unity of property interests and proximity of generators and other electric equipment [was] consistent with a reasonable design for a small wind project."[38] A 2007 decision affirmed the previous year's ruling in evaluating a very similar wind project configuration.[39]

The second phrase that has been clarified by PSC decisions is within the definition of related facilities: the related facilities must be necessary to conduct electricity, gas, or thermal energy to users located "at or near a project site." Decisions in 1989 and 1993 indicate that users connected by steam transmission lines of 1.5 and 1.9 miles that cross public streets are considered at or near a project site.[40] Neither decision provides a rationale for this conclusion. The PSC's 2007 declaratory ruling for Burrstone Energy Center LLC clarified the term in the context of a CHP microgrid.[41] The decision found that the electric and steam distribution facilities in that case, "with an electric distribution line extending across a property line and a public street to serve one of a number of multiple users," were related facilities because the distribution facilities were located "near" the project site (across the street) and because the different owners constituted "users."

- **HURDLE:** [for CHP microgrids] **Unclear statutory language.** The PSC in its 1993 decision clearly advised that its conclusions were limited to the project configuration presented in the case and might not apply to other configurations.[42] While the PSC's 2007 Burrstone decision provides strong precedent for the proposition that unaffiliated buildings connected across streets[43] constitute a qualifying facility, the decision is fact-specific and may not apply in all circumstances. For example, the definition of "located at the same project site" is still quite vague and could pose a

[36] PSL § 2(2-d) (emphasis added).
[37] *See* State of New York Public Service Commission, Case 92-G-0049—Seneca Partners, L.P., Order Concerning Regulation as a Gas Corporation (May 19, 1992).
[38] State of New York Public Service Commission, Case 06-E-120—Steel Winds Project LLC, Declaratory Ruling on Electric Corporation Jurisdiction (Dec. 13, 2006).
[39] *See* State of New York Public Service Commission, Case 07-E-0674-- Advocates for Prattsburg, Declaratory Ruling on Electric Corporation Jurisdiction (Aug. 22, 2007).
[40] *See* State of New York Public Service Commission, Case 89-E-0148—Nassau District Energy Corporation, Declaratory Ruling (Sept. 27, 1989); State of New York Public Service Commission, Case 93-M-0564—Nissequogue Cogen Partners, Declaratory Ruling (Nov. 19, 1993).
[41] *See* State of New York Public Service Commission, Case 07-E-0802—Burrstone Energy Center LLC, Declaratory Ruling on Exemption from Regulation (Aug. 28, 2007).
[42] *See* Nissequogue, *supra* note 40.
[43] The modeling described in Part I only considered the potential for microgrids within a block, not crossing a street.

problem for related facilities connecting unaffiliated users; however, the Burrstone decision did not discuss this phrase at all, potentially indicating that as long as users are at or near the project site, the related facilities will be considered at the same project site. It is also unclear how far beyond 1.9 miles users can be situated to be considered at or near the project site. The risk that a microgrid project will not be approved by the PSC due to this unclear language in the PSL and agency's decisions can deter investment.

3. Environmental quality review

The New York State Environmental Quality Review Act (SEQRA) requires all state and local government agencies to assess the environmental significance of all actions they have discretion to approve, fund, or directly undertake.[44] The New York City Environmental Quality Review (CEQR) is the New York City version of SEQRA and requires all City agencies taking discretionary action or making discretionary approvals to assess the environmental significance of these actions.[45] Either a state or city environmental review is necessary if the CHP system produces emissions in excess of 12.5 tons NOx/year or if the system produces less than this amount but is part of a construction project that, in total, will produce emissions in excess of this amount.[46]

Whether SEQRA or CEQR must be followed depends on whether the "lead agency" is a state or city agency. The lead agency is "an involved agency principally responsible for undertaking, funding or approving an action, and therefore responsible for determining whether an environmental impact statement is required in connection with the action, and for the preparation and filing of the statement if one is required."[47] SEQRA sets forth the procedures for selection of the lead agency where actions involve city and state agencies.[48] Where multiple city agencies are involved, the agencies themselves must determine which is the lead according to the procedures in 62 RCNY § 5-03(h).[49]

In order to get a discretionary government permit, the SEQRA or CEQR review must result in a negative declaration based on the Environmental Assessment Form or a findings statement if there is an Environmental Impact Statement.[50] The criteria for assessing the environmental significance of actions are included in 6 NYCRR § 617.7(c) for SEQRA and 43 RCNY § 6-06 for CEQR.

[44] *See* New York State Department of Environmental Conservation, Introduction to SEQR, http://www.dec.ny.gov/permits/6208.html. The first step is to complete an Environmental Assessment Form. *See* New York State Department of Environmental Conservation, Stepping Through the SEQRA Process, http://www.dec.ny.gov/permits/6189.html.
[45] *See* New York City Mayor's Office of Environmental Coordination, CEQR Basics, http://www.nyc.gov/html/oec/html/ceqr/basics.shtml.
[46] *See* Section 4: New York State and City permits below. Facilities producing less than 12.5 tons NOx/year must undertake Minor Facility Registration through the New York State Department of Environmental Conservation, in lieu of obtaining an air emissions permit. This registration is a non-discretionary action and therefore is not subject to SEQRA or CEQR review.
[47] *See* 6 NYCRR § 617.2(u).
[48] *See* 6 NYCRR § 617.6. *See also* 62 RCNY §§ 5-03(j) and 5-04(d).
[49] *See* 62 RCNY § 5-03(g)(2).
[50] *See* New York State Environmental Conservation Law (ECL) § 8-0109; 6 NYCRR § 617.3(a); 44 RCNY § 6-12.

4. New York State and City permits

The developer or engineer must obtain permits and approvals from the New York City Department of Buildings (DOB), Fire Department (FDNY), and Department of Environmental Protection (DEP) as well as the New York State Department of Environmental Conservation (DEC).[51] DOB has published information about its own requirements as well as those for FDNY and DEP.[52] Applicable city codes and rules include:

- New York City Administrative Code
  - Title 24, Chapter 1: Air Pollution Control Code
  - Title 24, Chapter 2: Noise Control Code
  - Title 27, Chapter 1: Building Code (especially Subchapter 7, Article 5 and Subchapters 12-16)
  - Title 27, Chapter 3: Electrical Code
  - Title 28, Chapters 1-5: Construction Codes (especially Chapter 1)
  - Title 28, Chapter 6: Plumbing Code (especially Chapters 3, 5, 6, and 9)
  - Title 28, Chapter 8: Mechanical Code (especially Chapters 3, 4, 7, 8, and 10)
  - Title 28, Chapter 9: Fuel Gas Code
  - Title 29: Fire Code (especially Chapters 1, 6, 27, 30, and 35)
- Rules of the City of New York
  - Title 1: Department of Buildings (especially Chapters 19-22, 34, and 41)
  - Title 3: Fire Department (especially Chapters 1, 14, 30, and 35)
  - Title 15: Department of Environmental Protection (especially Chapters 7, 9, 28, and 42)

As of this writing, DOB and FDNY are working on a 2012 update to the Fuel Gas Code, which will include an appendix that centralizes information about requirements relating to high pressure gas.

DEC has three tiers of air pollution permits:

a. Minor facility registration – when the facility's actual NOx emissions are below 12.5 tons/year + a fuel usage limit of 45 million cubic feet/year for natural gas[53]
b. State facility permit – when the facility's actual NOx emissions are above 12.5 tons/year but below 25 tons/year + a fuel usage limit of 45 million cubic feet/year for natural gas[54]
c. Major facility Title V permit – when the facility's potential and/or actual NOx emissions are above 25 tons/year[55]

[51] U.S. EPA has delegated to DEC the authority to administer a permit program for relevant sources subject to the Clean Air Act. *See* ECL § 19-0311.
[52] *See* NYCDOB CHP GUIDE, *supra* note 21, at 8–11.
[53] 6 NYCRR §§ 201-4.1(a), 201-7.3(e) and (h).
[54] 6 NYCRR §§ 201-5.1(a), 201-7.2.
[55] 6 NYCRR §§ 201-6.1(a), 201-2.1(b)(21).

These emissions limits (and therefore the permits) apply to the entire facility, not the CHP system alone. Therefore, new construction of a small CHP system will likely only require a registration (a non-discretionary action) that DEC will automatically issue after submittal of a one-page form. One of the two permits will be required for larger CHP systems or construction of a small CHP system in a facility with emissions that are above 12.5 tons/year. CHP equipment vendors tend to be cautious in their estimates of potential emissions, not wanting to guarantee a low emissions level based on testing that the equipment could exceed in actual use. Therefore, some small systems might have to obtain a permit based on these projected emissions, even if actual emissions are under 12.5 tons/year. Getting a permit, versus registering, is a more time-consuming process because the permit is site-specific and DEC may attach certain conditions. DEC has a high volume of permits to review, and Title V permit applications are entitled to public notice and comment[56] and possibly to a public hearing, depending on the nature of the comments.[57]

DEP air pollution permits differ from DEC's in that they do not establish emissions controls and a set of permit conditions but rather require the submittal of certain information to DEP for approval.[58] The DOB's handbook for CHP development contains information about obtaining an air permit and notes that the following documents must be submitted to DEP: (1) construction documents detailing connections to the vent stack as well as vent stack and exhaust termination and (2) calculations of emissions produced.[59]

- **HURDLE: Length of time to identify permitting and approval requirements.** It can be time-consuming to identify all the permitting and approval requirements, as state and city agencies often "regulate" through guidance documents and other sources not contained in official statutes and regulations.
- **HURDLE: Length of time to obtain permits and approvals.** It can also be time-consuming—and costly—to obtain the required permits and approvals. As discussed in the preliminary design section, lack of clarity about what city agencies require for project approval and permitting sometimes can lead to major design and construction changes that hold up approval. Engineers and developers interviewed for this report consistently comment that the process for obtaining an FDNY high pressure gas permit is particularly challenging in this regard. The new appendix in the Fuel Gas Code is expected to lend welcomed clarity.

5. Revocable consent agreement [for CHP microgrids]

The developer must apply for a permit and execute a revocable consent agreement with New York City Department of Transportation (DOT) to install and use infrastructure within a public space. Most significantly, this involves running pipes and wires under a public street, which would occur in the microgrid context where the buildings being connected are not

[56] *See* 6 NYCRR § 621.7.
[57] *See* 6 NYCRR § 621.8.
[58] *See* New York City Administrative Code §§ 24-120–122, 24-109(b)(3) and (4). *See also* New York City Department of Environmental Protection, Air Code Related Forms, http://www.nyc.gov/html/dep/html/air/air_code_related_forms.shtml.
[59] *See* NYCDOB CHP GUIDE, *supra* note 21, at 19.

limited to a block. Other parties that own infrastructure in that public space, mainly utilities, can challenge the petition for revocable consent.

- **HURDLE: Compliance cost and time associated with additional demands.** Con Ed owns much of the steam, gas, and electric infrastructure underneath New York City streets and often imposes demands additional to those from DOT that make it costly and time-consuming to design and install infrastructure that does not interfere with Con Ed's space.

6. Inspection and approval by DOB, FDNY, Con Ed Electric, and the gas utility

DOB must inspect and approve the electric system,[60] the plumbing system (which includes gas and fire standpipes),[61] the gas piping for CHP systems using gas over 15 psig,[62] and a fire protection plan.[63] FDNY must also approve the fire protection plan.[64] The gas utility must complete a pressure test of new gas lines.[65] Once both agencies and the gas utility have signed off on the project, Con Ed Electric will perform electrical interconnection testing and must approve the project.[66]

- **HURDLE: Costs of last-minute approval and design changes.** According to developers and engineers contacted for this report, agencies and utilities frequently impose additional requirements and design changes late in the development process, which can delay a project and increase costs.

III. Recommendations for Minimizing Hurdles and Maximizing Opportunities

There are two ways to begin minimizing the hurdles to CHP development and maximizing the opportunities for expanded deployment: policy changes that clarify and streamline specific aspects of the development process and policy changes that significantly change the way CHP development happens in New York. Both methods also represent two courses of action that New York City could take to meet its PlaNYC goal of 800 MW of installed distributed generation by 2030, a goal the City is not set to meet with business as usual. The City does not yet have a roadmap for achieving this goal, and it is unclear if policy tweaks to the development process will be sufficient without a larger investment by all stakeholders to significantly shift the way CHP development happens.

[60] *See* EC § 27-3018. *See* New York City Department of Buildings, Electrical Applications and Permits, http://www.nyc.gov/html/dob/html/development/electrical_apps_permits.shtml; New York City Department of Buildings, Forms, Electrical, http://www.nyc.gov/html/dob/html/development/forms_electrical.shtml.
[61] *See* New York City Department of Buildings, Plumbing Applications and Permits, http://www.nyc.gov/html/dob/html/development/plumbing_apps_permits.shtml; New York City Department of Buildings, Forms, Plumbing, http://www.nyc.gov/html/dob/html/development/forms_plumbing.shtml.
[62] *See* RCNY § 22-01.
[63] *See* New York City Administrative Code Article 109.
[64] *See id.*
[65] *See* NYCDOB CHP GUIDE, *supra* note 21, at 20; CONEDISON DG GUIDE, *supra* note 13, at 7.
[66] *See* NYCDOB CHP GUIDE, *supra* note 21, at 21; CONEDISON DG GUIDE, *supra* note 13, at 7.

The following two sections explore these methods. The first section briefly reviews the most vexing hurdles to CHP development and suggests solutions. The second section explores two big picture changes that could be made to maximize the numerous opportunities for CHP development.

Potential Solutions to Primary Hurdles

1. Financial feasibility

HURDLES:

Many factors influence whether or not a CHP project will produce a cost savings. Some factors, such as the price of natural gas, cannot be controlled, but those that can, such as tariff prices, constitute potential hurdles that can be overcome. Addressing the following hurdles could speed up the development process and decrease costs, thereby encouraging investment that is necessary for any CHP project.

- Electric, gas, and steam tariffs may be prohibitively costly and may change during project development, which could alter the financial feasibility of a project.
- The quick payback period required by many investors may not align with the payback period for a CHP project.
- Lack of clarity about what utilities and New York City agencies require for project approval and permitting as well as how long decision-making will take creates uncertainty about the project completion time and cost of compliance.

POTENTIAL SOLUTIONS:

- ***State:*** Create a mechanism on the PSC website through which interested parties can receive alerts about the development and modification of tariffs that impact their projects. Con Ed posts its tariffs and rates online,[67] and the PSC website allows users to search for tariffs;[68] however, given the large number of filings with the PSC, it would be helpful for interested parties to be able to more directly track applicable tariff filings and modifications.
- ***State:*** Alter the Con Ed steam tariff to encourage use of Con Ed steam as backup heat for CHP systems installed by current and new steam customers. Con Ed has begun to move in this direction with a small pilot project that allows CHP facilities to export excess steam back through the Con Ed system.[69]
- ***State and Local***: Clarify and streamline the approval and permitting processes. (See points 2 and 3 below.)
- ***Federal:*** Reinstate the grant in lieu of tax credit program so that non-profit entities can be similarly positioned as for-profit entities that can take advantage of a 10 percent investment tax credit, which runs through January 1, 2017. The Energy

[67] *See* Con Edison, Rates & Tariffs, http://www.coned.com/rates/.
[68] *See* New York State Public Service Commission, Electronic Tariff Search Menu, https://www2.dps.ny.gov/ETS/search/presearch.cfm.
[69] *See* ConEdison, Pilot Program, Customer Sited Supply, http://www.coned.com/steam/pilot_program.asp.

Improvement and Extension Act of 2008 (EIEA, part of the Emergency Economic Stabilization Act) revised the Internal Revenue Code to allow CHP systems up to 50 MW and with over 60% efficiency to qualify for an investment tax credit equal to 10 percent of the costs of the first 15 MW of qualifying CHP equipment, such as equipment needed t o generate power and steam.[70] Only entities that pay taxes can take advantage of this tax credit, so the American Recovery and Reinvestment Tax Act of 2009 (part of the American Recovery and Reinvestment Act) allows taxpayers ineligible for the EIEA investment tax credit to receive a grant from the U.S. Treasury Department instead of taking the tax credit.[71] The grant is only available to CHP systems that are placed into service in 2009, 2010, or 2011, or after 2011 if construction on the property began in 2009, 2010, or 2011 where construction began prior to December 31, 2011.

- ***Federal:*** Create an incentive for non-profit entities that mirrors the five-year depreciation deduction program that for-profit entities can use. The EIEA added CHP to the five-year schedule of the federal Modified Accelerated Cost-Recovery System, which allows businesses to recover investments in certain property through depreciation deductions; [72] as with the investment tax credit, the depreciation deduction is only available to entities that pay taxes.

2. Approvals from utilities

HURDLES:

The main interface with utilities happens with the electric and gas interconnection process (and perhaps steam, depending on a project's needs and service territory). Any microgrid projects that have infrastructure crossing a street may also have to work with the utilities that intervene in the revocable consent process with NYCDOT.

- The utilities are big corporations with many staff who frequently move around within the companies, making it hard for developers to identify necessary contacts and to build lasting relationships. Contacts may not respond quickly or with clear instructions on the utilities' requirements, leading to project delays and costs. Con Ed has hired a Distributed Generation Ombudsperson to serve as a central point of contact once an application is filed with the Customer Project Manager. Developers and engineers interviewed for this study report that the ombudsperson position is a significant first step in facilitating communication within Con Ed but that gaps still exist.

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[70] *See* Energy Improvement and Extension Act of 2008 § 103(c). *See also* U.S. EPA, Federal Incentives for Developing Combined Heat and Power Projects, Tax Provisions, CHP Investment Tax Credit, http://www.epa.gov/chp/incentives/index.html.

[71] *See* American Recovery and Reinvestment Tax Act of 2009 § 1603. *See also* U.S. Department of Treasury, 1603 Program: Payments for Specified Energy Property in Lieu of Tax Credits, http://www.treasury.gov/initiatives/recovery/Pages/1603.aspx.

[72] *See* Energy Improvement and Extension Act of 2008 § 103(c). *See also* Database of State Incentives for Renewables and Efficiency, Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation (2008–2012), http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F.

- The interconnection requirements for CHP systems between 2 MW and 20 MW are developed on a case-by-case basis. Although each CHP system is unique and safety is a significant concern with gas and electric lines, the lack of clarity in the interconnection process can delay the design and construction phases and introduce high and unexpected costs to project planning.

POTENTIAL SOLUTIONS:

- ***State:*** Create standardized interconnection requirements for CHP systems between 2 MW and 20 MW. The requirements might not be as comprehensive as those for systems outside of that size range due to the variability in design, permitting, interconnection, and construction details; however, engineers and project developers consistently explain that industry and the utilities have enough familiarity with CHP at this level to create some standardized procedure. Con Ed is currently drafting standardized interconnection requirements in the 2-20 MW range.

➢ NOTE: NYSERDA has established a CHP Acceleration program that pre-qualifies CHP "modular kits" 1.3 MW or smaller for $20 million of NYSERDA incentives available to customers who purchase and install the systems. The approved systems "must be capable of acquiring proper air permits . . . and capable of interconnecting to New York State electric utilities," meaning that the systems will be proven to already meet some regulatory and utility requirements.[73] The packaged equipment will improve the comfort of agencies and utilities with CHP and streamline the permitting and approval processes. The funds for the program are in-hand, and NYSERDA recently issued a Request for Information. NYSERDA expects to launch a catalogue of pre-qualified systems plus provide associated incentives in October 2012.

3. Approvals and permits from city agencies

HURDLES:

The primary New York City agencies that provide permits and approvals for CHP projects are DOB, DEP, and FDNY.

- Similar to the utilities, these agencies are big with many staff who frequently move around, making it hard for developers to identify necessary contacts and to build lasting relationships. Contacts may not respond quickly or with clear instructions on the agencies' requirements.
- While DOB's permitting guidebook lists requirements for all three agencies, it does not do enough to clarify the permitting and approval processes, according to developers and engineers interviewed for this report. City agencies often "regulate" through guidance documents and other sources not contained in official statutes and regulations, making it difficult to understand what actions are required for compliance.

[73] NYSERDA, RFI 2568: CHP Acceleration Program – CHP System Pre-Qualification, http://www.nyserda.ny.gov/en/Funding-Opportunities/Current-Funding-Opportunities/RFI-2568-CHP-Acceleration-Program-CHP-System-Prequalification.aspx.

POTENTIAL SOLUTIONS:

- ***Local:*** Clarify and streamline the permitting processes by creating a single handbook that contains information about the permitting and approval requirements for each New York City agency including the legal source of the requirements, the forms and documentation needed for compliance, timelines for submittal of information, online resources, and contact information. While the NYC Development Hub described in Point 2 under *Feasibility and System Design* above begins to streamline the permitting process, it could be an even more effective tool when paired with a permitting and approval handbook, such that applicants could enter Development Hub with as much information and preparation as possible.
- ***Local:*** Designate a CHP coordinator in a New York City agency or the Mayor's Office to facilitate CHP regulation among the agencies and to coordinate the agencies' and utilities' work. While the DG Ombudsperson position at Con Ed is fairly new, this position serves as a good model for what would be helpful at the city agency level. There are so many agencies involved in regulating CHP that no single entity is a point of contact and ultimately responsible for facilitating CHP development. The CHP coordinator would have to be given the authority and respect necessary to implement effective changes.

Potential Approaches for Maximizing CHP Opportunities

The potential solutions outlined above address specific hurdles that developers find consistently delay or impede installation of CHP, and the solutions would greatly clarify, streamline, and reduce risk in the CHP development process. Nonetheless, the tools and technology are available to not only fix the problems but also maximize the opportunities for CHP in New York. Below we describe two ways to significantly shift the way CHP development happens: increase access to information and analyses and facilitate the development of CHP microgrids.

1. Increase access to information and analyses regarding financial incentives, regulatory requirements, and the opportunities for CHP development.

   The overarching message in Part II and in Part III above is that the CHP development process needs to be streamlined. The policy changes recommended above could go a long way in clarifying the process and thereby reducing the risk that can deter project developers and investors. However, increased access to information and analyses regarding financial incentives, regulatory requirements, and the opportunities for CHP development can empower all stakeholders to make faster, more educated, and ultimately more successful decisions.

   The energy analysis and mapping described in Part I demonstrate the benefits of increased access to quantified information—in this instance, a representation of building energy use in New York City and an accurate assessment of the amount of potentially viable CHP based on load profiles and regulatory requirements. That basic framework can be enhanced with the addition of information about permitting requirements, financial incentives, and any other data that illuminate where CHP development is easiest and cheapest. Four discrete examples are included below, but with the cooperation of utilities, agencies, and developers, accurate and comprehensive mapping can occur that includes information such as gas and steam line locations, electrical grid congestion, areas of needed and scheduled infrastructure repair, city-owned properties that could be first movers, parking lots that could house the physical CHP systems for adjacent buildings, and the like. Any geographic and quantifiable information can be layered on the basic energy map. Such a collaborative effort would promote CHP projects that are most likely to succeed for the customers and most likely to benefit the utilities.[74] Con Ed told the authors of this paper that it would like to work with NYSERDA to determine if there are areas where CHP could benefit the grid and to develop incentives in these areas. Ultimately, such analysis and mapping could be used to create CHP zones in geographic areas that have features conducive to CHP development, similar to New York City's solar empowerment zones.[75]

The following four examples reveal the substantial role for increased access to information and analysis in streamlining CHP development and maximizing the opportunities for expansion in New York.

- Example 1: Financial incentives

  Any financial incentive that has a CHP system size or efficiency requirement can be translated into quantifiable information about the number, size, and character of CHP systems that fit that requirement in New York City. For example, NYSERDA has developed multiple incentive programs that reduce the upfront capital costs to developers and can help facilitate CHP development. Two of its primary CHP-specific programs, the DG/CHP Demonstration Project and the Existing Facilities Program, have recently expired; however, quantifying and mapping the CHP systems that could take advantage of these programs demonstrates the potential for increased access to and analysis of financial information. The DG/CHP Demonstration Project was developed to support the permanent installation of CHP systems,[76] while the Existing Facilities Program was designed to reduce summer peak electricity demand.[77] Each of the incentives would cover up to 50% of the total project costs. These incentives helped reduce the payback periods for CHP, making investments by financial stakeholders less risky. Through the engineering analysis, we located 1,580 MW of CHP that would meet the 60% efficiency standard required by both incentives. A map of these opportunities can be found in Figure 7 below.

[74] *See* MARK TORPEY, DEPLOYMENT OF DISTRIBUTED GENERATION FOR GRID SUPPORT AND DISTRIBUTION SYSTEM INFRASTRUCTURE: A SUMMARY ANALYSIS OF DG BENEFITS AND CASE STUDIES (prepared for NYSERDA, Feb. 2011).

[75] *See* The City University of New York, Solar Empowerment Zones, http://www.cuny.edu/about/resources/sustainability/solar-america/sez.html; Press Release, Office of the Mayor, Mayor Bloomberg and Buildings Commissioner LiMandri Announce Creation of Three Solar Empowerment Zones (June 8, 2012).

[76] *See* TRACEY DESIMONE, PROCESS EVALUATION: DISTRIBUTED GENERATION AND COMBINED HEAT AND POWER DEMONSTRATION PROGRAM (prepared for NYSERDA, Dec. 2011).

[77] *See* NYSERDA, PON 1219 - Existing Facilities, http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-1219-Existing-Facilities-Program.aspx?sc_database=web.

Mapping can also be used in the opposite direction—to locate sites preferable for CHP development, such as those sites that will have the most benefit to the electric grid, and target financial incentives to these areas.

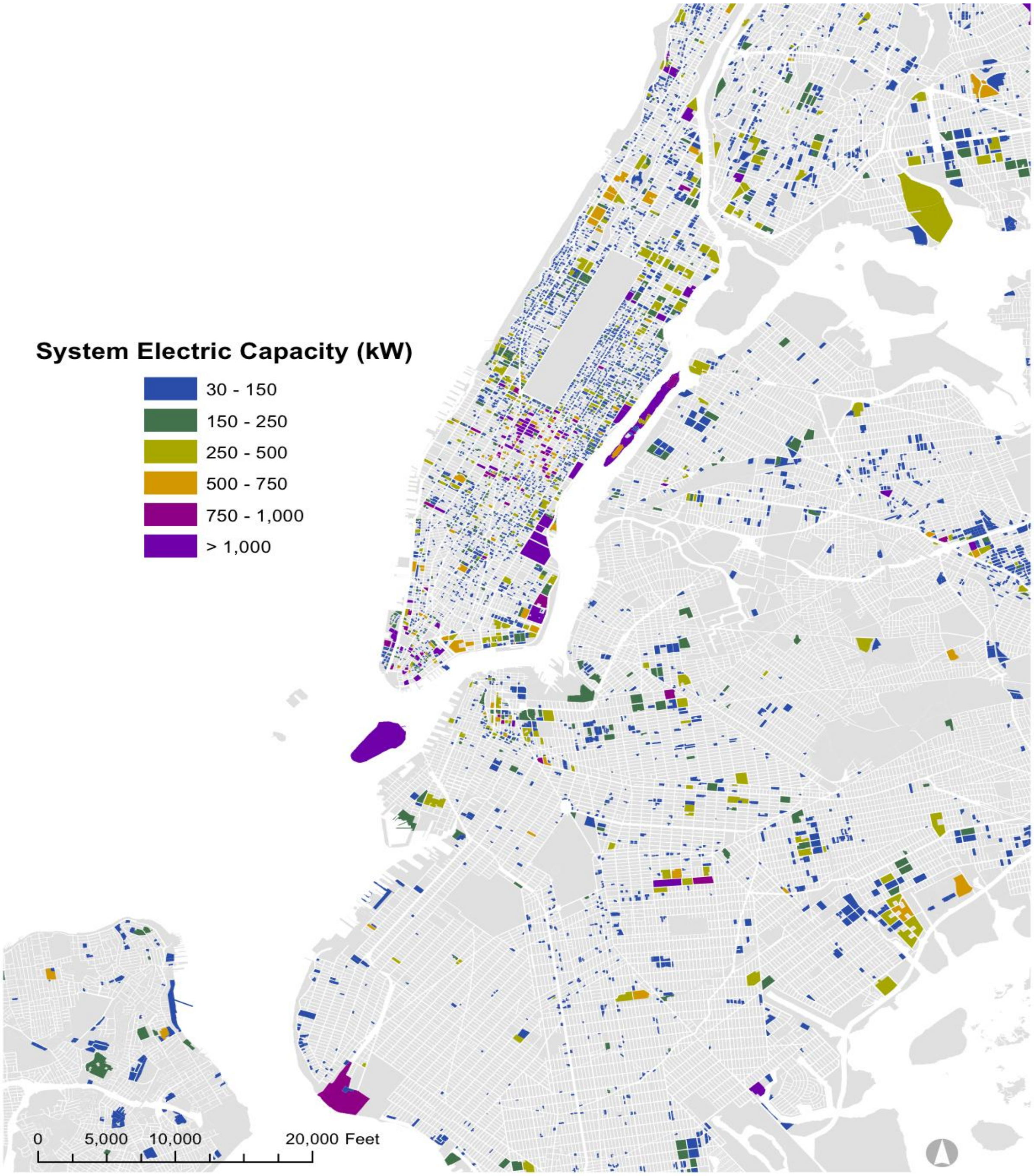

Figure 7. Potential tax lot (building) level CHP opportunities in New York City using the NYSERDA efficiency standards (60%) colored by electric capacity, centered on the borough of Manhattan.

- Example 2: Infrastructure upgrades

Any information about the location of relevant infrastructure upgrades and repairs can be mapped in relation to the buildings and blocks in New York City that are viable for CHP development. For example, in New York City, many residential buildings are heated with fuel oil types #4 and #6. The City recently instituted a phased ban of these fuel oil types because of their high emissions of fine particulate matter.[78] Due to this ban, many buildings that use fuel oil #4 and #6 are switching to natural gas, making them ideal candidates for CHP systems supplied by natural gas. Figure 8 contains a map of buildings that currently use fuel oil #4 and #6 in conjunction with the identified block level CHP opportunities. The significant upgrades at these buildings due to the fuel conversions would ease the way for CHP development and decrease costs, especially given the significant gas distribution capacity required to support CHP development.

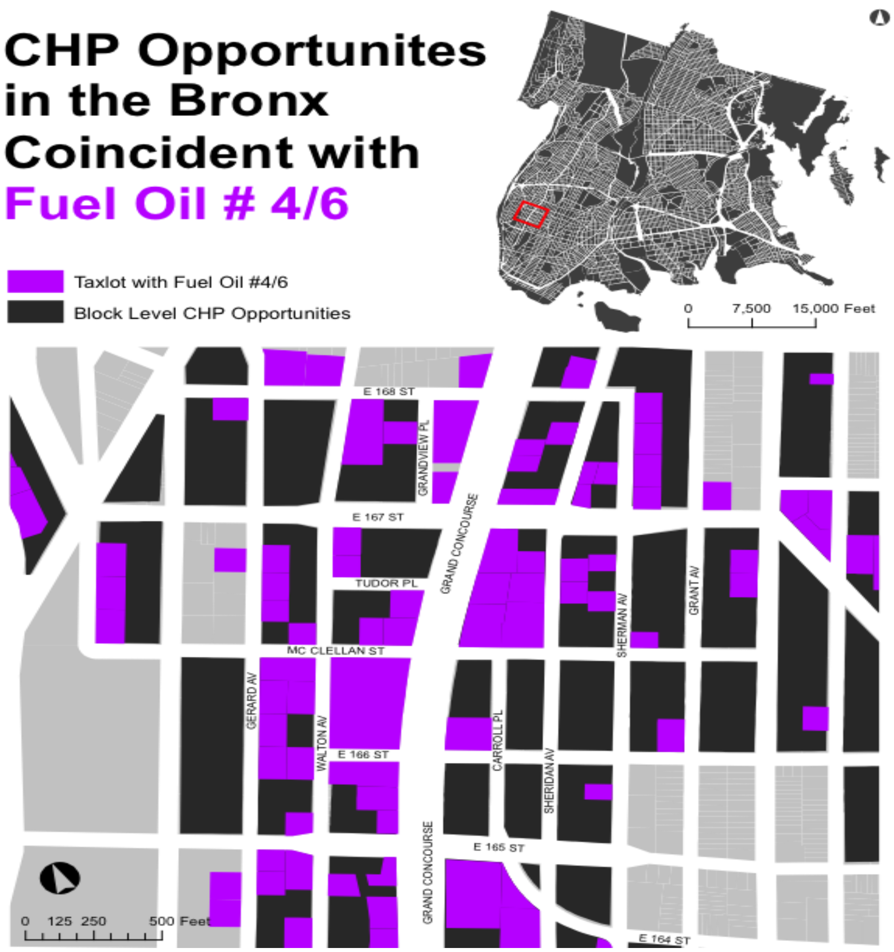

Figure 8. Map of CHP opportunities coincident with fuel oil #4 and #6 use in the Bronx.

[78] *See supra* note 29. Under New York City Department of Environmental Conservation rules, the Commissioner of Environmental Protection will not renew a Certificate of Operation for a boiler or burner that uses #6 oil, which means that fuel oil #6 use will be phased out between July 2012 and July 2016, given that such certificates are valid for three years under New York City Administrative Law § 24-122(d). Fuel oil #4 will be phased out between July 2012 and January 2030. Rules of the City of New York § 2-15.

- Example #3: Standardized interconnection procedures

  CHP systems smaller than 2 MW are covered by the PSC's Standardized Interconnection Requirements (SIR), which as described in Part II, generally allow the development process to proceed more quickly and with less risk because the interconnection requirements are known from the beginning of development. Table 2 shows the number of systems for each engineering viability scenario that would be allowed to follow the SIR. At both the tax lot and block levels, the majority of systems are less than 2 MW, with 93% and 94%, respectively, of systems qualifying for use of the SIR.

Table 2. Number of CHP systems that qualify for use of standard interconnection requirements versus total number of potential systems.

	Number of CHP Systems that Qualify for Use of Standard Interconnection Requirements (< 2 MW)	**Total Number of Potential Systems**
Building Level	2,175	2,348
C **Microgrid Level**	4,423	4,713

CHP systems larger than 20 MW are covered by the New York Independent Systems Operator (NYISO) Standard Large Facility Interconnection Procedures (LFIP), which allow for streamlined development similar to the SIR. In between these two size capacities (2MW and 20MW), systems would require case-by-case interconnection analysis by the utility. From the estimates in Part I, 542 to 1,118 MW of potential CHP capacity at the building and microgrid levels respectively would not be covered by any standard interconnection procedures and therefore would likely undergo a longer interconnection process than those systems covered by standard interconnection procedures.

- Example #4: Permit requirements

  Any permit requirement that can be translated to a CHP system size or efficiency value can also be translated into quantifiable information about the number, size, and character of CHP systems that fit that requirement in New York City. For example, there are three tiers of air permit requirements, as described in Part II: one is actually a registration requirement (Minor Facility Registration) and two are permit requirements (State Facility Permit and Major Facility Title V Permit). Because the size of the CHP system will correlate with air emissions levels, we can estimate the number and capacity of CHP systems required to register or obtain permits at both the building and microgrid levels. These estimates are shown in Table 3, while the locations of these potential systems are shown in Figures 9 and 10. For each scenario, the majority of CHP systems identified would be exempt or only require minor facility registration. However, at the microgrid scale, there is a significant amount of capacity that would require a permit.

The building and microgrid level systems requiring a permit (versus registration) would likely take longer to develop because of the time entailed in the permitting process and because this issuance of a permit triggers SEQRA or CEQR review, which also adds time and possibly cost to the development process. This additional time might also affect the payback time of the CHP system, influencing the financial feasibility of the project. Therefore, mapping the air permitting requirements can indicate which buildings and microgrid configurations are considered trivial sources or require only a registration—and therefore would likely be relatively fast and cheap to develop, from an air permitting perspective.

Table 3. Number of potential CHP systems falling within the different air permitting levels.

	Exempt/ Trivial Source # | MW	**Minor Facility Registration # | MW**	**State Facility Permit # | MW**	**Major Facility Title V permit # | MW**
Building Level	847 | 94	742 | 266	419 | 408	340 | 811
Microgrid Level	1,614 | 203	1,786 | 638	804 | 738	509 | 1,459

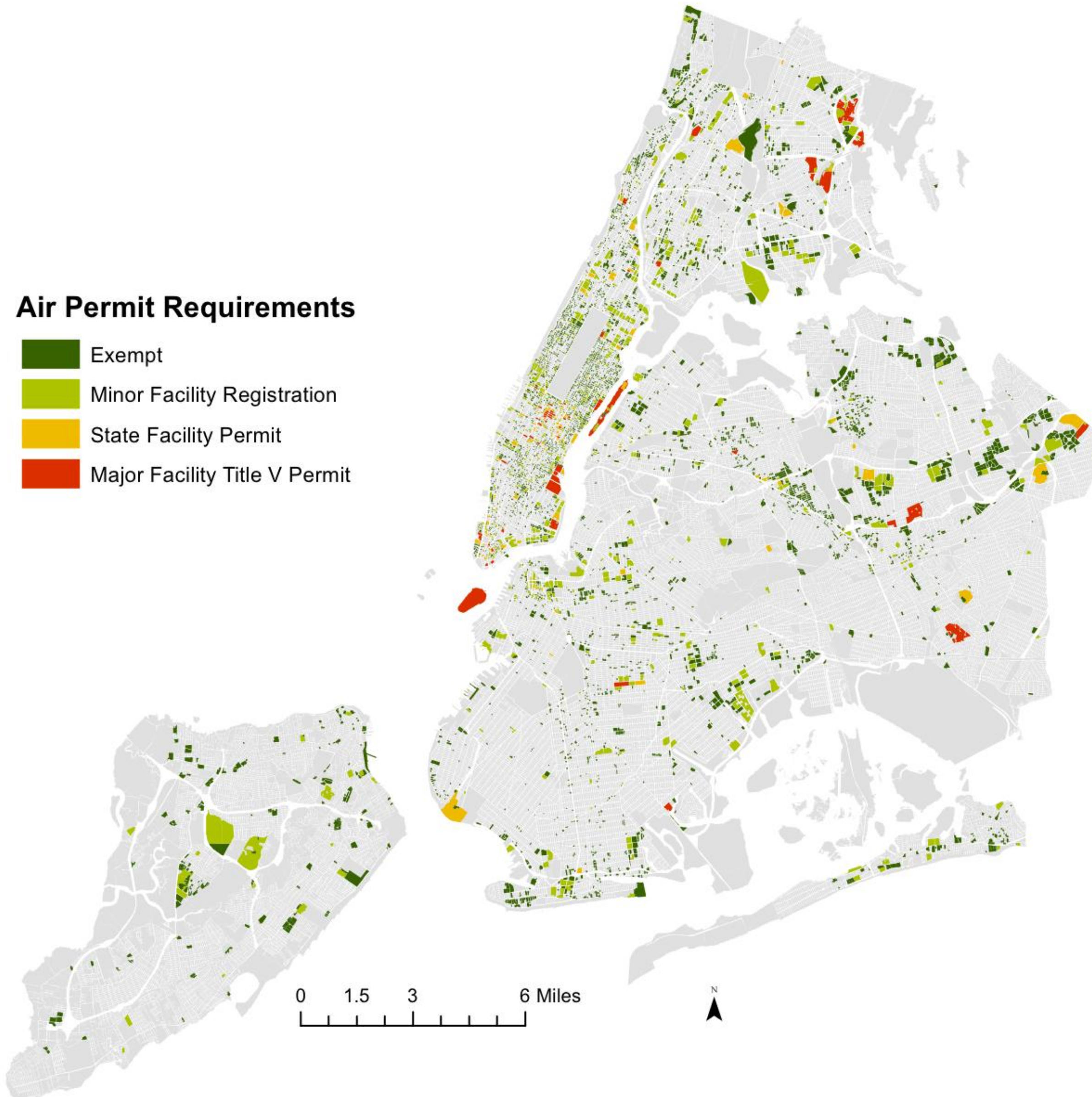

Figure 9. Map of air permit requirements for the potential building-level systems.

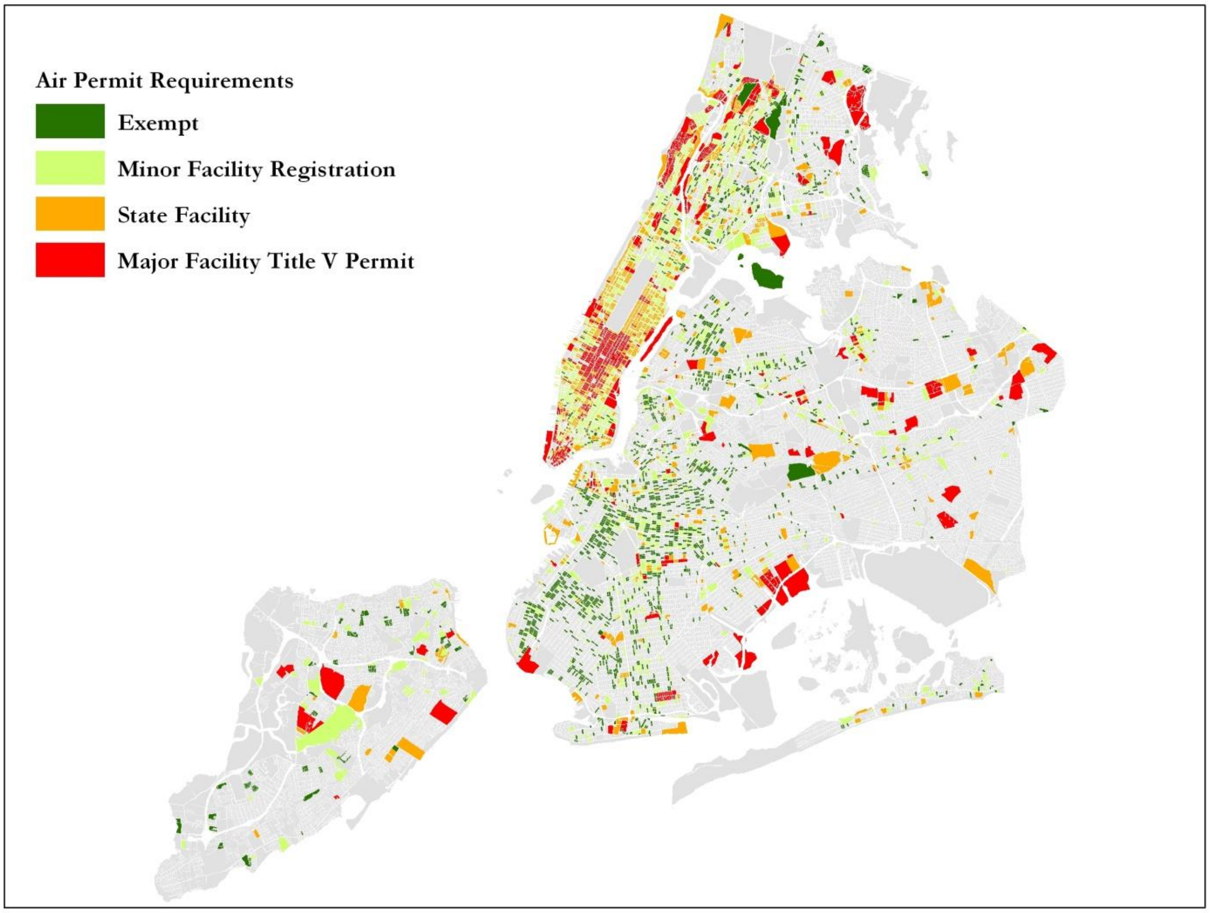

Figure 10. Map of air permit requirements for the potential microgrid-level systems.

2. Facilitate the development of CHP microgrids.

   As described in Part I, New York City is an optimal environment for CHP microgrids because of the dense and mixed use building stock and neighborhoods. Microgrids are beneficial because they allow multiple buildings with different uses to be served by one CHP system, thereby maximizing use of electric and especially thermal loads. Below are three solutions for facilitating the development of CHP microgrids.

   - Clarify the definition of "related facilities" in the PSL.

     Microgrid CHP projects have to be considered "qualifying facilities" by the PSC to not be regulated as utilities. The relevant language in the definition of qualifying facilities is: "any facility with an electric generating capacity of up to eighty megawatts . . . together with any related facilities,"[79] which are "facilities as may be necessary to conduct electricity, gas or useful thermal energy to users located at or near a project site."[80]

[79] PSL § 2(2-a) (emphasis added).
[80] PSL § 2(2-d) (emphasis added).

While the PSC's 2007 Burrstone decision provides strong precedent for the proposition that unaffiliated buildings connected across streets constitute related facilities because they are "users located at or near the project site," the decision may not apply in all circumstances.[81] The risk that a microgrid project will not be approved by the PSC due to unclear language in the agency's decisions can deter investment. A solution is to clarify the definition of related facilities, particularly the language "at or near a project site," in the PSL by amending the PSL itself or by initiating a rulemaking to change the PSC's regulations.

On October 18, 2012, the PSC approved the "campus offset tariff,"[82] which will facilitate CHP microgrid development among buildings under common ownership. The tariff allows low-tension electric customers to connect a CHP facility serving multiple accounts located within a single premises to Con Ed's high-tension electric distribution system, as long as the CHP system is between 2 MW and 20 MW in aggregate.[83] The accounts must be established under a single customer name, and the accounts and CHP facility must be located within a single premises, defined as buildings or lands "proximate to each other if there is common use." It is unclear how much the new tariff provisions will apply to CHP systems connecting unaffiliated buildings, as the PSC in its order approving the tariff amendments noted that its intent was to "limit the expanded standby rate provisions to single customers with multiple buildings or occupying campus style settings."[84] .

- Map the characteristics that make a region optimal for a CHP microgrid.

  The energy analysis and mapping discussed in Part I provides the basic thermal and electrical load information needed to conduct analyses on where microgrids would be possible and optimal from a load perspective. Other information could be added to that analysis to provide an even more accurate picture of microgrid feasibility. For example, many management companies in New York manage multiple buildings. Connecting buildings managed by the same company with one CHP system would greatly eliminate the transaction costs associated with connecting buildings owned by unaffiliated entities.

  Figure 11 shows buildings under common management in midtown Manhattan as well as tax lot-scale CHP opportunities. In the map, there are multiple buildings on a block with common management that could be aggregated to create a microgrid organized by a single third party.

[81] *See* Burrstone decision, *supra* note 41.
[82] The campus offset tariff is really a set of amendments to Con Ed's electric tariff schedule, P.S.C. 10 – Electricity, that expand the applicability of Service Classification (SC) 14-RA – Standby Service Special Provision E, now referred to as General Rule 20.2.1(B)(7).
[83] For all documents filed in the case, see New York State Public Service Commission, Case 11-E-0299—Con Edison Standby Service Rates, http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=11-E-0299&submit=Search+by+Case+Number. *See also* Con Edison, Distributed Generation, Offset Info and Resources, http://www.coned.com/dg/resources.asp; Con Edison, Webinar, New Electric Tariff for Campus/Multi-building Distributed Generation Customers: Offset Standby Tariff (Apr. 10, 2012), http://www.slideshare.net/dlogsdon/offset-webinar-4-1012.
[84] New York State Public Service Commission, Case 11-E-0299—Con Edison Standby Service Rates, Order Approving Tariff Amendments with Modifications and Granting Petition for Rehearing, at 15 (Oct. 18, 2012).

- Revise the PSL to require utilities to accommodate and/or facilitate virtual microgrids.

  As is made clear in Part II, there are many hurdles associated with the design and construction of physical infrastructure needed for CHP systems to connect to gas, electric, and steam lines. A virtual microgrid "is one that uses the existing utility's distribution wires and aggregates locally sited distributed generation to offset a group of customers' energy needs."[85] A 2010 study produced by Columbia University and the Pace Energy and Climate Center discusses the potential for virtual microgrids in New York City.[86] The study explains that virtual microgrids act like energy service companies (ESCOs), which provide electricity and possibly natural gas or oil through existing utility transmission and distribution facilities[87] and "develop, install, and fund projects designed to improve energy efficiency and reduce operation and maintenance (O&M) costs for their customers' facilities."[88] ESCO regulation might provide a model for virtual microgrid regulation.

  There are examples of community renewable energy legislation in Colorado and Massachusetts. In 2010, Colorado passed the Community Solar Gardens Act, which allows groups of at least 10 retail customers to own a "subscription" (a proportional interest) in solar electric generation facilities and receive credits on their electricity bills.[89] The solar gardens operate by virtual net metering, allowing customers to collectively produce solar power remotely and sell it back to the grid, as if all the customers had solar panels on their roofs. Massachusetts allows "neighborhood net metering for . . . [wind or solar photovoltaic] facilities that are owned by (or serve the energy needs of) a group of 10 or more residential customers in a single neighborhood and served by a single utility."[90] Similar to the Colorado solar gardens customers, the Massachusetts neighborhood net metering customers receive credits on their electricity bills for the excess electricity produced and sold back to the grid.

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[85] MICHAEL A. HYAMS, MICROGRIDS: AN ASSESSMENT OF THE VALUE, OPPORTUNITIES, AND BARRIERS TO DEPLOYMENT IN NEW YORK STATE 54 (prepared for NYSERDA, Sept. 2010).
[86] *Id.*
[87] *See* New York State Public Service Commission, Energy Choices – The Facts from the PSC, http://www.dps.ny.gov/energychoices.htm#Choosing.
[88] U.S. Department of Energy, Federal Energy Management Program: Energy Service Companies, http://www1.eere.energy.gov/femp/financing/espcs_companies.html.
[89] *See* Colo. Rev. Stat. § 40-2-127. *See also* The SolarGardens Institute, http://www.solargardens.org/.
[90] Massachusetts Department of Energy Resources, Net Metering, https://sites.google.com/site/massdgic/Home/net-metering-in-ma.

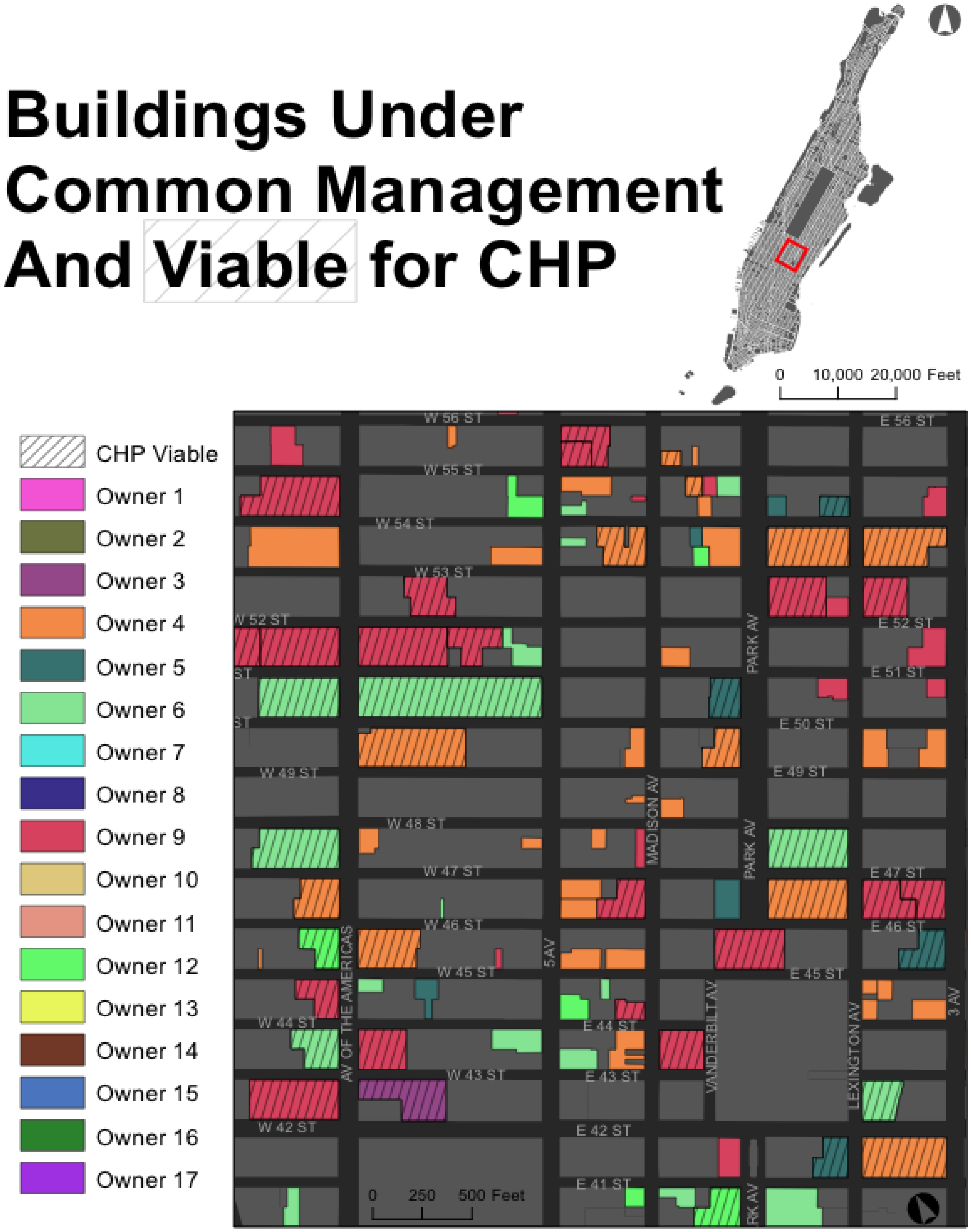

Figure 11. Buildings under common management and viable for CHP.

Conclusion

The opportunities for CHP development in New York City are numerous, from single building installations to microgrids connecting unaffiliated owners. At the building scale, there is an opportunity for about 1,580 MW of CHP with an average site greenhouse gas reduction of 46.7%. Considering the blocks as opportunities to implement microgrids, these systems could potentially add 3,038 MW of CHP with an average site greenhouse gas reduction of 48.4%. Implementing each of these systems at the building and microgrid levels would achieve citywide emissions reductions of 12% and 27.2%, respectively.

Despite this significant room for growth, there are hurdles that slow the development process, increase costs, and add risk that may deter the use of CHP entirely. There are potential policy solutions for each of these hurdles, from reinstating the grant in lieu of tax credit program to designating a coordinator to facilitate CHP regulation among New York City agencies. In addition to these policy solutions, there are big picture changes that can be made to maximize the numerous opportunities for CHP development—increase access to information and analyses regarding financial incentives, regulatory requirements, and the opportunities for CHP development as well as facilitate the development of CHP microgrids. Implementing these changes truly requires the collaboration of utilities, agencies, and developers to create the environment necessary for streamlined, and therefore more successful, CHP development.

The analyses and mapping above demonstrate that while the opportunities for and hurdles to development are wide spread, there are locations were CHP may be particularly feasible—and therefore cheaper and faster to develop. The addition to analyses and maps of information such as gas line locations, electrical grid congestion, areas of needed and scheduled infrastructure repair, and the like would minimize existing hurdles and maximize the great potential for CHP in New York City. By embarking on targeted policy changes, sharing information, and enhancing analytical tools, all stakeholders to CHP development in New York can collectively tackle existing hurdles and open the door to vast energy savings and electrical grid reliability.

Appendix: CHP Viability Analysis

The viability of a CHP system depends on many factors. One of the most important is the temporal characteristics of the thermal and electrical loads. To efficiently utilize the energy provided, the ratio of thermal to electric energy demand should coincide with the ratio of thermal and electric energy that the CHP system can supply for most of the year. Otherwise only a single energy stream, electric or thermal, would be fully utilized. These thermal to electric ratios fluctuate on a day-to-day and hour-to-hour basis. Characterizing how these ratios change throughout the year is very important in determining the type, size, and operation scheme of a CHP system. Not including this variation could lead to oversized systems with low annual efficiency.

Governing the characteristics of the thermal and electrical load profiles is the building use. For example, in the middle of the day when people are at work, residential buildings have low electrical demands relative to office buildings, were people are utilizing equipment. In New York City, there are many buildings that have multiple uses or are located next to buildings of different use. These individual buildings or groups of buildings if aggregated together could result in load profiles that would allow a CHP system to run efficiently because there would always be thermal and electrical loads.

In the following technical analysis, we sought to estimate the potential for CHP systems in New York City by incorporating hourly energy profiles to building energy demands and considering annual system efficiency as criteria for a feasible CHP system. We performed this analysis on two different spatial scales: the tax lot and the block. The tax lot level analysis considers a more traditional model where the CHP system would be used to supply a portion of a building's thermal and electrical load. A tax lot typically includes only one building, but there are instances when a tax lot contains more than one building. For this analysis, we did not differentiate between the two scenarios. The block scale analysis considers a less traditional model where a CHP system is sized to meet a portion of the thermal and electrical loads of the aggregate demand on the block. This model addresses the concept of creating microgrids on each block within the existing electric distribution infrastructure.

The following describes the methodology for estimating the energy demand profiles, how the CHP systems were sized, the criteria used to determine if a system was viable, as well as the methodology for estimating greenhouse gas emissions reductions.

Estimating Energy Use in New York City Buildings

To analyze the potential viability of CHP systems, we first developed an estimate of each building's energy demand. Initially annual energy demands were determined for each building using the energy intensities developed from previous analyses. Then the annual values were modeled to hourly profiles utilizing the profiles developed for the U.S. Department of Energy (DOE) commercial reference buildings. The next paragraphs briefly discuss the development of the annual energy intensities as well as the development of the hourly thermal and electric profiles.

Annual building energy intensities (energy per building floor area) were estimated for (1) seven different building types: residential 1-4 family (Residential 1-4), residential multi-family (Residential Multi), office, store, education, health and warehouse and (2) four end uses: base electric, space heating, space cooling and water heating.[91] In addition to estimating intensities for individual building types, estimates were also made based on location. New York City (NYC) is comprised of five boroughs: Manhattan, the Bronx, Brooklyn, Queens, and Staten Island. Due to the history of building development, there was a significant difference between the energy intensities of residential multifamily and office buildings in Manhattan, residential multifamily buildings in the Bronx, and the remainder of the boroughs. Those energy intensities are shown in Figure 1 as Residential Multi MN (Manhattan), Residential Multi BX (the Bronx), Residential Multi BK/QN/SI (Brooklyn, Queens and Staten Island), Office MN (Manhattan), Office NYC-MN (the Bronx, Brooklyn, Queens, and Staten Island). These intensities were applied to the building area of every tax lot in New York City to estimate the annual base electric and space heating energy consumption. The annual building energy intensities are shown in Figure 1. These building types represent 91% of the building area in New York City meaning that estimates of energy consumption were not provided for 9% of the building area. This 9 percent was excluded from the analysis meaning that 9% of the building area in New York City was not considered for CHP systems. This exclusion could lead to an under estimation of the CHP potential since hotels, which have large electricity and space heating loads, were included in the 9 percent.

Hourly energy intensities were extrapolated using the DOE commercial reference building load profiles. These reference buildings were created to model the behavior of typical commercial buildings. The building energy consumption was estimated for 16 buildings types in 16 different climatic regions.[92] These prototypical buildings were intended not to provide information about a specific building but rather to provide an estimation of how a building with particular characteristics would behave on average. The building prototypes were created using the energy modeling software EnergyPlus[93] using inputs from various sources.

The current analysis used load profiles from a subset of these buildings to estimate the hourly behavior of New York City buildings based on building type. The intention of using these hourly profiles was not to accurately estimate the hourly energy consumption for every building in New York City but rather to obtain a general picture of the variation of electricity and space heating energy consumption in time. While the annual energy intensities and therefore annual energy consumption figures are representative of New York City, the hourly breakdown is not.

[91] *See* B. Howard et al., *Spatial Distribution of Urban Building Energy Consumption by End Use*, ENERGY AND BUILDINGS, Feb. 2012, at 45, 141–151.
[92] For more information about the methodology used to develop the estimates, see: U.S. Department of Energy, Commercial Building Initiative: Commercial Reference Buildings (2011), http://www1.eere.energy.gov/buildings/commercial/index.html.
[93] *See* D. Crawley et al., *EnergyPlus: Creating a New-Generation Building Energy Simulation Program*, ENERGY BUILD, 2001, at 33, 243.

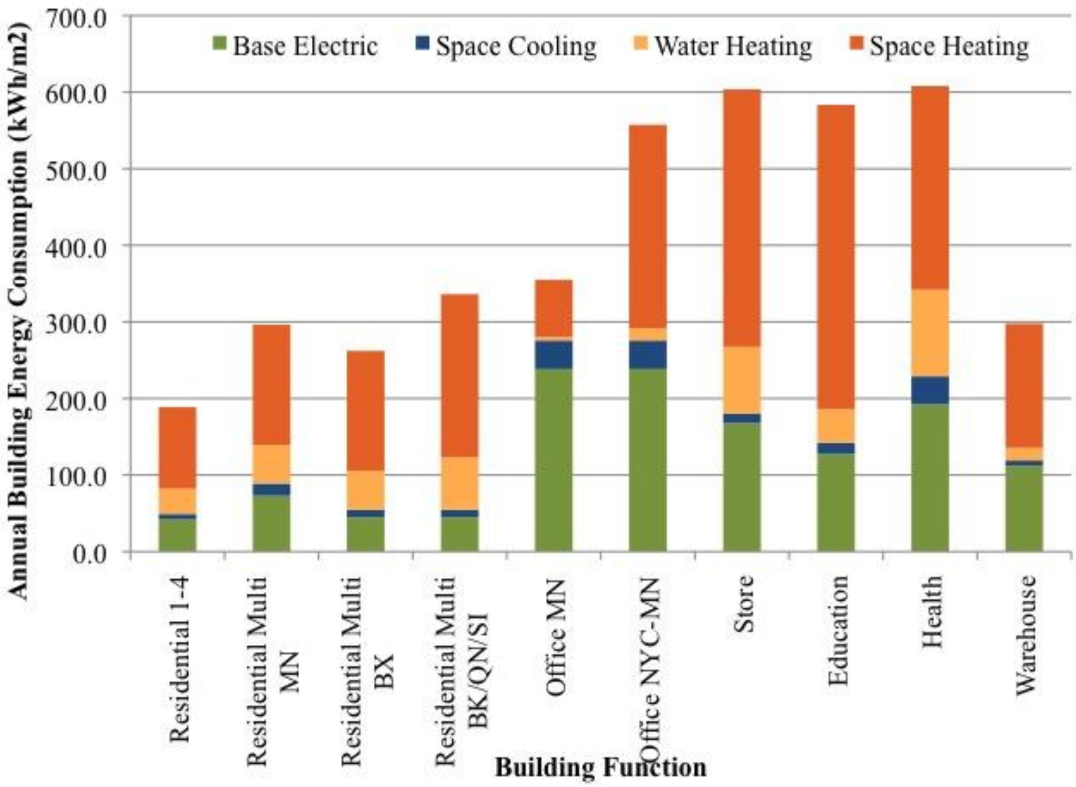

Figure 1. Annual building energy intensity estimates by building function and end use.

The DOE commercial reference buildings provide more building types than buildings types used to estimate New York City annual energy intensities. Therefore, only the prototypical buildings that corresponded with the building types used to estimate annual intensities were considered. The annual energy intensity building types and the corresponding DOE commercial reference building types are shown in Table 1. The climate region used for the DOE commercial reference buildings was 4A, whose representative city was Baltimore, Maryland. The 4A region includes New York City within its boundaries. In addition to specifying more building types, the EnergyPlus model provided estimates of additional end uses. The estimated New York City annual end uses and the corresponding end uses from the EnergyPlus model are shown in Table 2. For this analysis, only space heating and base electric loads, which consist of electricity used for lighting, refrigeration, and plug loads (but not cooling), were considered.

The following equation was used to create New York City-specific hourly energy consumption intensities:

$$e^{nyc}{}_{h,b,u} = r_{b,e} * e^{doe}{}_{h,b,u} \quad ,$$

where $e^{nyc}{}_{h,b,u}$ is the New York City-specific energy consumption for hour, h, building type as in the first column of Table 1, b, and end use as in the first column of Table 2, u, $r_{b,e}$ is the ratio of the annual New York City energy intensity to the annual intensity from the DOE commercial reference building for building type, b, and end use, u, and $e^{doe}{}_{h,b,u}$ is the energy intensity from the DOE commercial reference buildings for hour, h, building type as in the second column of Table 1, b, and end use as in Table 2, u.

Table 1. NYC and DOE commercial reference building types.

Annual NYC Building Types	**DOE commercial building types**
Residential 1-4 Family	Mid-rise Apartment
Residential Multi Family	Mid-rise Apartment
Office	Small Office, Medium Office, Large Office
Store	Stand-Alone Retail
Education	Primary School
Health	Outpatient Health
Warehouse	Warehouse

Table 2. NYC and corresponding DOE commercial reference end uses.

Annual NYC end uses	**DOE commercial end uses**
Base Electric	Electric -cooling
Space Heating	Gas + Electric Space Heating

The hourly base electric and space heating demand intensities for the residential multifamily and large office buildings (> 9,290 m^2) are shown in Figures 2 and 3, respectively. This methodology assumes that the load profiles scale linearly with building size, which may create load profiles with more variation for larger buildings or less variation for smaller buildings.

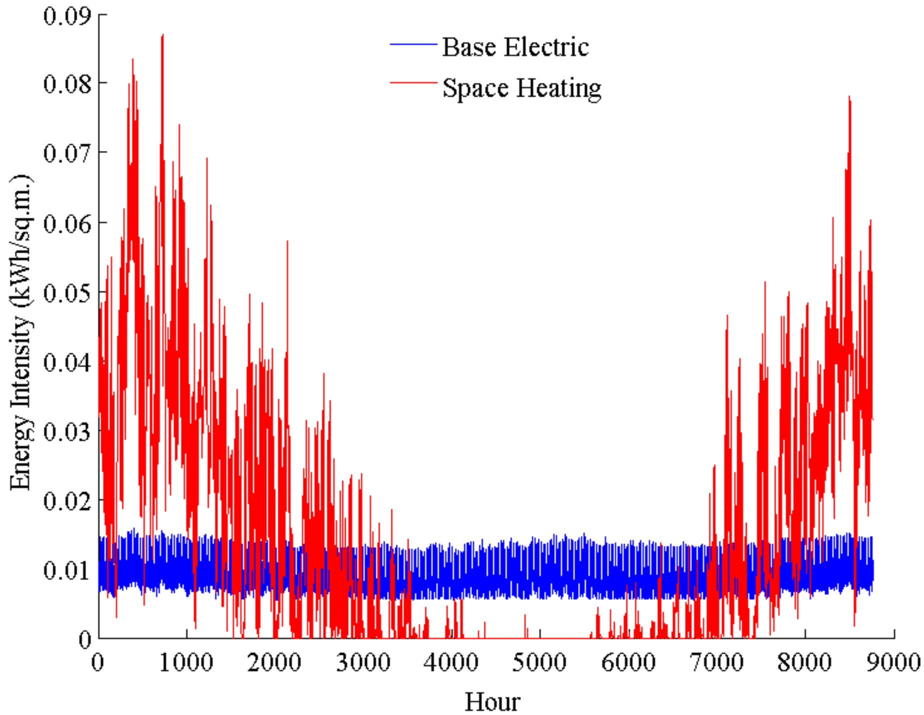

Figure 2. Hourly residential energy intensity estimates for space heating and base electric energy demand.

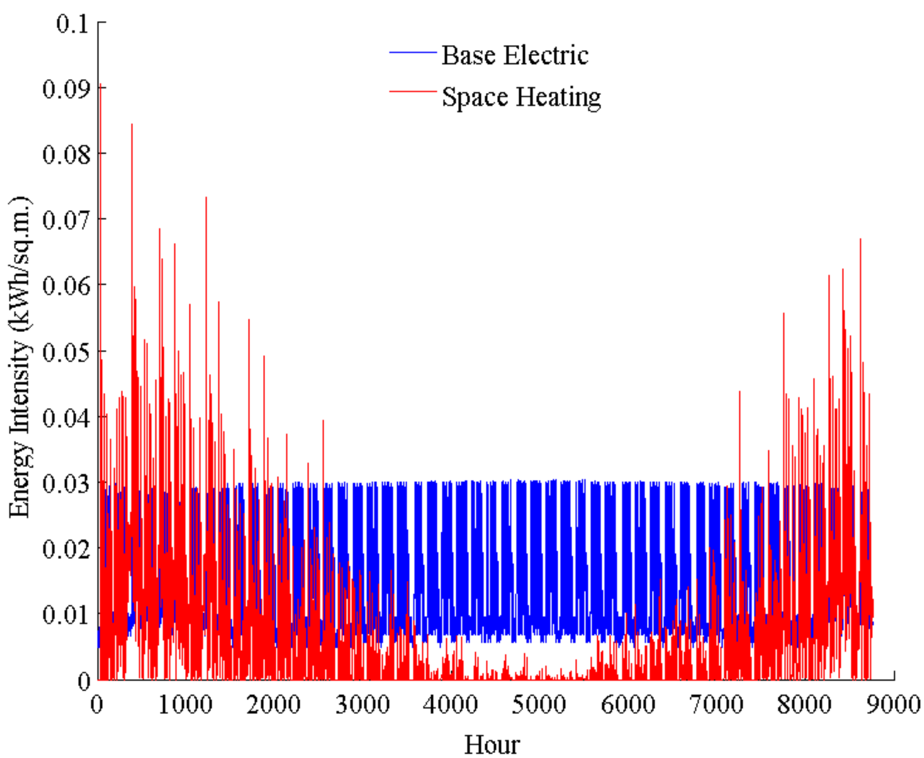

Figure 3. Hourly large office energy intensity estimates for space heating and base electric demand.

Combined Heat and Power Technical Specifications

There are many different CHP technologies that can be used to satisfy building energy demands. The four main types are steam turbines, internal combustion engines, microturbines, and fuel cells. The U.S. Environmental Protection Agency Catalog of CHP Technologies provides an extensive overview of the various CHP technologies commercially available as well as of their unique specifications. For the current analysis, we considered internal combustion engines and microturbines since those technologies are typically dispersed in sizes for distributed generation, from 30 kW to 5 MW, and are compatible with existing infrastructure, as they can be fuelled by natural gas. Since the electrical and thermal efficiencies change with the capacity of the system, we have specified characteristics to be used for various system capacities, which are shown in Table 3. The specifications were taken from the GE Jenbacher Technical Specifications[94] for the internal combustion engineers and the EPA Catalog of CHP Technologies for the microturbine.[95]

Table 3. Representative efficiency characteristics of CHP systems in different capacity ranges.

Electrical Capacity	Prime Mover	Electric Efficiency	Thermal Efficiency
<100 kW	Microturbine	24.6%	46.9%
100 – 500 kW	Internal Combustion Engine	35.9%	44.8%
500 – 1,000 kW	Internal Combustion Engine	38.3%	49.2%
>1 MW	Internal Combustion Engine	45.3%	41.7%

System Sizing Methodology

There are many ways to size a CHP system. Two of the most common are economic dispatch and thermal base loading. In an economic dispatch, the CHP system is operated to offset the more expensive peak electric power of building's electrical load; supplemental electricity is taken from the grid, and on-site boilers provide additional thermal needs. In thermal base loading, the CHP system is operated to meet the thermal demand that is needed throughout the year with supplemental thermal needs coming from local boiler and electrical needs from the grid. This method implies that there is a cooling load that can be satisfied by thermal cooling technologies such as absorption cooling.

Economic dispatch depends on the price of electricity and requires significant load following by the CHP system. It can potentially lead to low thermal utilization since the thermal demand may not coincide with the times of peak electricity demand. Thermal base loading requires a cooling load to be satisfied by an absorption cooling technology. While office buildings most frequently

[94] GE Energy, Jenbahcer Type 2 Technical Specifications (2011), http://www.ge-energy.com/products_and_services/products/gas_engines_power_generation/.
[95] U.S. Environmental Protection Agency, Catalog of CHP Technologies (2008), http://www.epa.gov/chp/basic/catalog.html.

use absorption cooling technology because of their significant cooling loads, residential buildings with absorption cooling are less common.

Another method different than the previous two and the method used in this analysis is to size the CHP system to meet the electric base load demand. This method sizes the CHP system to be able to meet the building(s) minimum electricity demand with supplemental electricity coming from the grid and thermal demand from on-site boilers. The current analysis used this methodology because it results in the CHP systems running continuously year round, which can help alleviate load during peak hours, and because operating a system at peak load year round allows for the highest annual CHP efficiencies.

The electric base loading methodology is less common than the economic dispatch and thermal base loading models because it will inherently underestimate the potential capacity for CHP systems in New York City for many reasons. The current analysis does not consider thermal storage, meaning that thermal energy produced in a particular hour must be used in that hour. In actual installations, hot water tanks allowing for a few hours of thermal load shifting would be coupled with these systems to allow for thermal storage. Also, the sizing methodology does not incorporate any load following. In many CHP applications, the system is sized to efficiency follow the peak electricity demand, which requires a system with larger capacity and typically consists of multiple generation systems.

CHP Viability Criteria

For a CHP system to be considered viable in this analysis, it was required to have an electrical generation capacity larger than 30 kW and meet a minimum efficiency standard. The minimum size requirement was used to represent the lower bound of commercially available CHP systems. The efficiency standards used considered the FERC regulatory standards and the NYSERDA CHP incentives.

The FERC regulatory standard was used to ensure that the identified systems would be considered a qualifying cogeneration facility. A qualifying cogeneration facility is exempt from regulation as a utility, which allows the facility to avoid onerous requirements and oversight. To be considered a qualifying cogeneration facility, a CHP system using natural gas as its primary fuel must have CHP efficiency greater than 42.5% as well as utilize half of the available thermal energy. In addition, the system must prove that the energy is going toward commercial and industrial uses, which are the primary uses for the current analysis.

NYSERDA has developed many incentive programs to help facilitate CHP development. Two of the agency's major CHP programs were the DG/CHP demonstration project and the existing facilities program. The DG/CHP demonstration project was developed to support the permanent installation of CHP systems, while the existing facilities program was designed to reduce summer peak electricity demand. Each of the incentives would cover up to 50% of the total project costs. There are many criteria to be eligible for these incentives, but the metric that is common to both is a minimum annual CHP efficiency of 60%.

The different FERC and NYSERDA efficiency requirements will identify different amounts of CHP systems but are both important depending on the objectives of the owner. Therefore, two analyses were performed, one utilizing the FERC efficiency standard of 42.5% annual efficiency and utilization of half of the thermal energy and another requiring a minimum CHP efficiency of 60%.

The annual CHP efficiency was defined using the following equation:

$$\eta_c = \eta_{he} + \eta_{tp} \frac{E}{E},$$

where η_{chp} is the annual CHP efficiency, η_e is the electrical efficiency of the CHP system, η_t is the thermal efficiency (useful thermal out divided by fuel energy in), E_u is the thermal energy utilized over a year and E_p is the useful thermal energy produced in a year. This means that the CHP efficiency is only reduced when thermal energy produced is not used. This methodology does not take into account part load efficiencies or reduced efficiencies due to operation.

Global CO_2e Emissions Calculations

For the current analysis, we attempted to determine the benefits of the potential CHP systems in terms of greenhouse gas emissions. We used the carbon dioxide equivalent (CO_2e) to estimate the reduction potential. Accounting for emissions benefits is very dependent on local conditions. Using an avoided burden approach[96] requires an understanding of the existing electricity generation infrastructure as well as the local thermal energy generators.

The emissions coefficient used to represent greenhouse gas emissions released during electricity production was developed by the 2012 eGrid Assessment.[97] This assessment determines the mix of electricity generation technologies serving a particular region and creates a weighted emissions coefficient based on the amount of electricity generated from each source. In addition to determining the average emissions produced, they have also developed coefficients for base load and non-base load electricity demands. The generators used to serve the portion of demand always required, the base load, are typically larger systems with different emissions characteristics than the systems used to supply the time varying peak demands, non-base load. Since in New York City a large portion of base load is supplied by nuclear and hydropower, there is a significant difference between the base load and non-base load emissions. A study performed in 1997 estimated the impacts of incorporating 330 MW of combined heat and power into the New York City area in terms of the effects on the electricity generation and emissions.[98]

[96] The avoided burden approach estimates the reduction potential of a technology by estimating the impact of the energy that would have been supplied if the system CHP were not used. This means accounting for the emissions from the electricity currently being generated as well as the emissions and fuel used for the current boilers supplying thermal energy.

[97] For more information on the eGrid Methodology, see: The Emissions and Generation Resource Integrated Database for 2012 (eGRID2012) Technical Support Document, http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012_year09_TechnicalSupportDocument.pdf.

[98] *See* CENTER FOR CLEAN AIR POLICY, PROMOTING CLEAN POWER, CLEAN AIR AND BROWNFIELD REDEVELOPMENT (Jan. 2001).

The study found that the CHP system would displace electricity generated by non-base load power plants. Since the analysis we performed identified similar magnitudes of electricity generation, we utilized the non-base load eGrid greenhouse gas emissions coefficients to estimate the potential impacts of distributed CHP systems in New York City.

The emissions reductions for the potential CHP systems were determined using the following equation

$$E_r = c_{grid} e_e + \frac{c_{therm}}{\eta_b} e_t - \frac{c_{ng}}{\eta_{chp}} e_e,$$

where E_r is annual CO_2e emissions reductions, c_{grid} is the non base load New York City/Westchester CO_2e emission coefficient as reported by the 2012 eGrid assessment, e_t is the annual amount of thermal energy utilized by the building or block from the CHP system, e_e is the annual amount of electricity produced by the CHP system, η_b is the assumed boiler efficiency of 85%, c_{therm} is the average CO_2e coefficient for non electricity building energy use (steam, fuel oil, and natural gas), η_{chp} is the electrical efficiency of the proposed CHP unit, and c_{ng} is the CO_2e coefficient for natural gas, the CHP fuel source. All CO_2e emissions coefficients were from the year 2009.