15 - Hunts Point (Bronx)

June 2016

Notice

FINAL WRITTEN REPORT

Hunts Point Microgrid

NY Prize Stage 1 Feasibility Study

NYSERDA Agreement #: 64712

For Public Distribution

May 24, 2016

level

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Final Report

1. Capabilities and Configuration

1.1. Customers

Wholesale Markets

The Hunts Point (HP) Food Distribution Center (FDC) in the South Bronx is the largest food distribution center in the United States, a critically important regional resource that provides 60% of the metropolitan New York region's produce, meat and fish. The 329-acre site and the market buildings are owned by the City of New York (NYC) and administered by the NYC Economic Development Corporation (NYCEDC). The FDC is also a key employer in this part of the Bronx, employing more than 6,000 people in relatively high paying jobs. The wholesale markets are located within the 100-year flood plan and are not equipped with backup generators. During flooding or a regional blackout, the markets can only preserve inventory for a few hours by loading food into trucks and closing the doors before the region's food supply is impacted.

	Name	Area (SF)	Merchants	Employees	Revenue ($)
Markets	Meat Market	870,000	52	2,400	$3.2B
	Produce Market	800,000	47	3,000	$2.3B
	Fish Market	430,000	38	650	$1.0B

Table 1: Hunts Point Food Distribution Markets

Community

The Hunts Point peninsula has a residential population of more than 12,500 people with a median household family income of $23,679 (2013 American Community Survey). The Congressional District also has the highest poverty rate in the United States. During an emergency, residents can take shelter the designated Office of Emergency Management (OEM) Evacuation Center MS 424 or in two central community centers, The Point CDC and La Peninsula Head Start. Together, these facilities can provide shelter to 650 residents and serve as a hub for distribution of emergency supplies and information.

	Name	Location	Notes
Community	MS 424	730 Bryant Ave	OEM Evacuation Center
	The Point CDC	940 Garrison Ave	Community Development Corp.
	La Peninsula Head Start	711 Manida St	Community Center providing education and social services

Table 2: Hunts Point Community Facilities

Optional ancillary customers

The Hunts Point Peninsula is also home to several non-critical food businesses that could buy excess electricity from the Microgrid, including Baldor Specialty Foods, Krasdale Foods, Citarella, Sultana, Anheuser-Busch and Dairyland. Furthermore, it has been considered but not studied in detail to develop Parcel D with an Anaerobic Digester facility that produces biogas from organic food waste, or a Vertical Farming facility that uses electricity to grow food in close proximity to the markets. The total peak electrical load for the proposed facilities was 16.1MW in 2014. The table below lists potential ancillary customers and facilities:

	Name	Area (SF)	Notes
Ancillary	Baldor	300,000	Food Distributor opposite of Parcel D
	Anaerobic Digester	90,000	Optional AD customer on Parcel D
	Vertical Farm	60,000	Optional VF customer on Parcel D

Table 2: Optional ancillary customers

Diagram 1: Location of Microgrid Customers

1.2. Future Growth

The future growth of the Food Distribution Center is currently being planned by NYC Economic Development Corporation (NYCEDC) on behalf of the City of New York. On March 5, 2015, New York City Mayor Bill de Blasio announced a $150 million capital plan commitment over the coming 12 years to upgrade the Food Distribution Center. Since facility growth plans have not been finalized, the Level team developed growth projections for the purpose of the analysis in this study. The following assumptions were not provided by NYCEDC or from the markets. The Fish Market moved to Hunts Point just ten years ago, so major changes to this building are not expected. The team assumed that the old structures at the Produce and Meat Markets will be subsequently replaced by larger and more efficient buildings over the next twenty years. The total refrigeration load for the anchor tenants was 3,400 RT in 2014 and is expected to grow to 6,000 RT by 2030 based on growth assumptions used for this study.

	Name		2014	2020	2025	2030
Markets	Meat Market	Area (SF)	870,000	870,000	1,170,000	1,170,000
	Produce Market	Area (SF)	800,000	1,100,000	1,150,000	1,200,000
	Fish Market	Area (SF)	430,000	430,000	430,000	430,000

Table 4: Market Floor Area and Refrigeration Growth Assumptions

Diagram 2: Wholesale Market Growth Assumptions

1.3. Generation

The feasibility study of the Hunts Point Community Microgrid showed that solar PV and CHP can create a balanced mix of sustainable, flexible, resilient and efficient energy resources, especially in conjunction with the added refrigeration and process loads from the expanded markets. The large, flat and partly unused roofs of the warehouses in the FDC offer vast opportunities for 5.9 MW of solar PV installations. In addition, natural gas-fired turbines can be operated flexibly and at high overall efficiency to meet the electrical and steam loads of the customers in the microgrid. Together, solar PV can meet the base electricity demand during the busier daytime hours with low cost and emissions, while CHP turbines meet the thermal refrigeration load through co-generation of steam. The Meat and Produce Markets have a projected combined refrigeration load of 5,500 RT that can be met by two 3,000 RT chillers that each require 37,500 lb/hr of steam at full load. A small steam turbine, such as the SolarTurbine Centaur 50 CHP, can generate 7.7MW_t or 25,000 lb/hr of steam at 49.3% thermal efficiency in addition to 4.6 MW of electricity. In this case, three turbines are sufficient to meet the entire steam load while only generating 13.8MW_e of electricity that would be sold to customers across the peninsula.

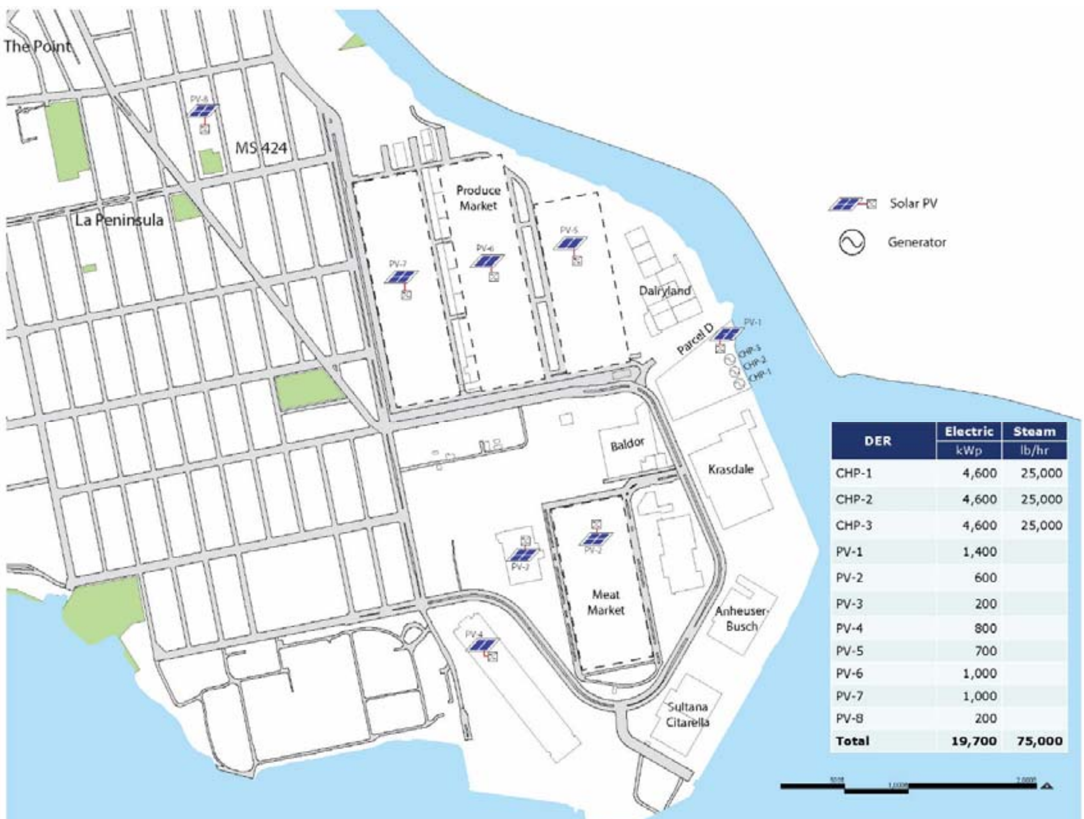


Diagram 3: Microgrid Generating Assets

1.4. Electrical Network

Anchor customers at Hunts Point FDC are currently connected to the ConEd electrical network by three 13.8 kV feeders that follow Food Center Drive and originate from the Mott Haven substation. The proposed CHP plant and Microgrid Control Center on Parcel D will be connected to the utility grid at a single Point of Common Coupling (PCC) by tying into two of the three existing feeders in Food Center Drive. New underground feeder lines will be laid from Parcel D to the Meat, Fish and Produce Markets, the Community Facilities and ancillary customers. The existing electrical infrastructure will be supplemented or replaced with new Intelligent Electronic Devices (IEDS). They will have three Ethernet communications ports and be able to communicate using multiple protocols (ModBus, DNP-3.0, IEC 61850, etc.) to provide reliable protection and control capabilities as required for Microgrid Control and Protection. All electrical infrastructure will utilize new breakers, switches and instrument transformers that are compliant with current standards.

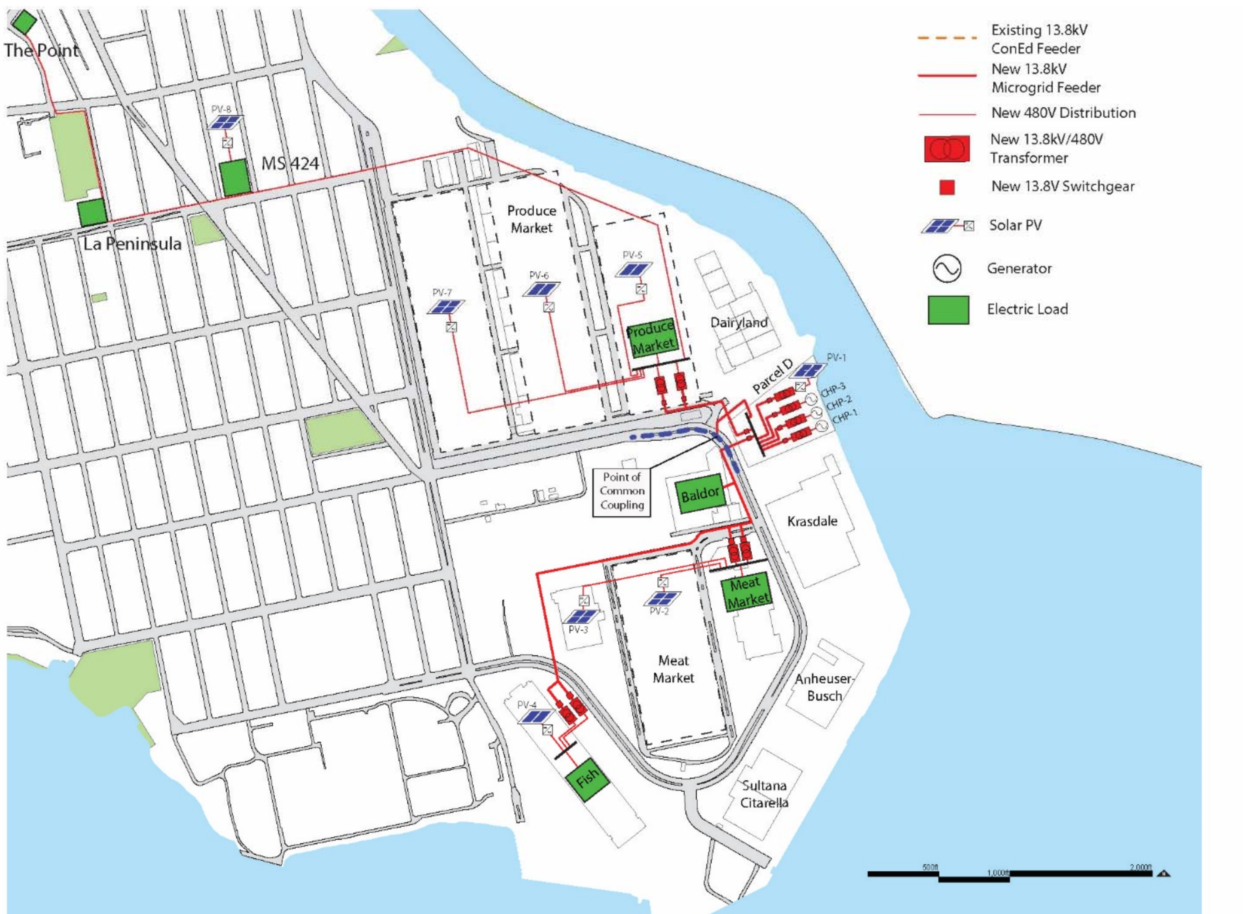
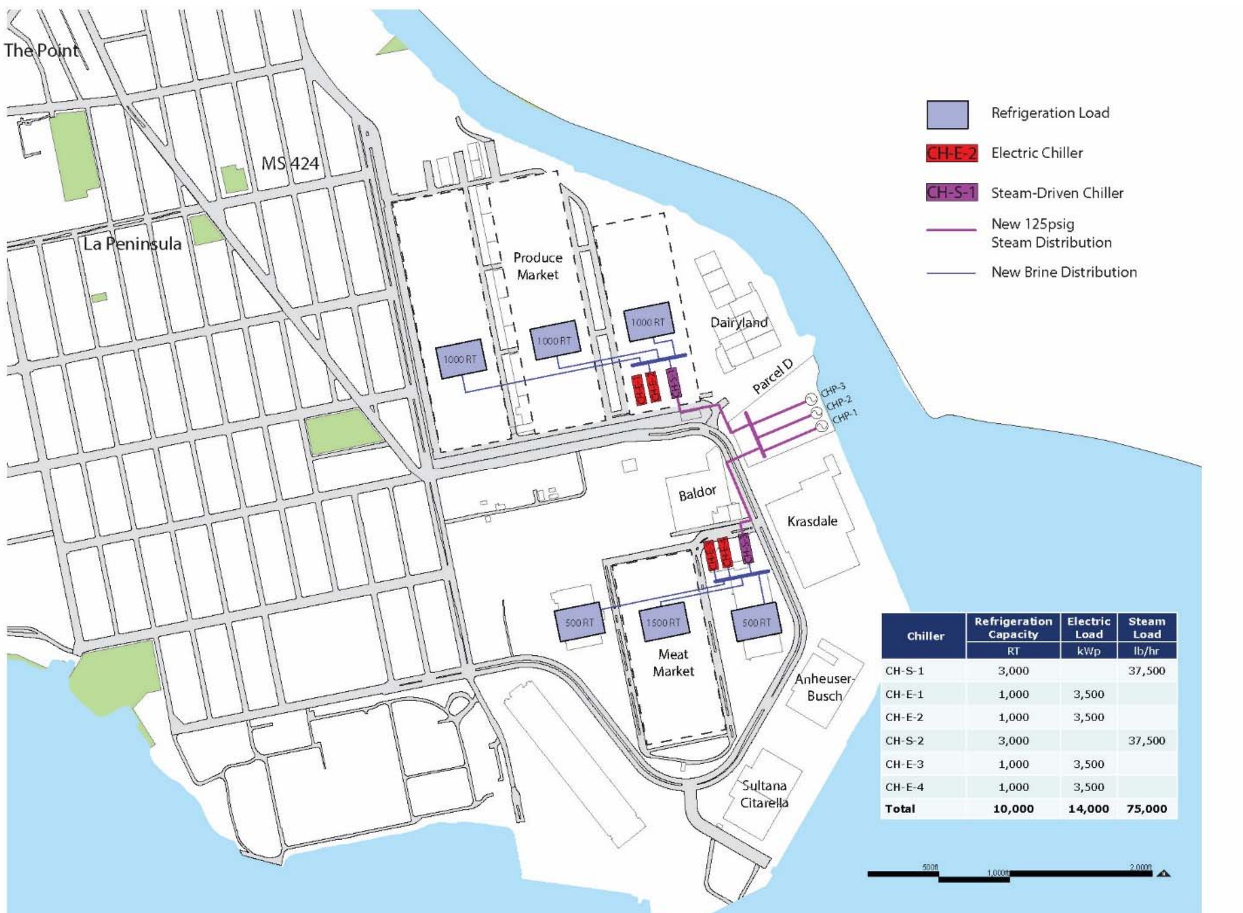


Diagram 4: Microgrid Electrical Distribution Network

1.5. Steam Network

A new steam distribution and condensate return system will be installed to deliver steam from the three CHP gas turbines with Heat Recovery Steam Generators to the steam-driven chillers at the Meat and Produce Markets. Both markets are comparably close and the steam pipes only have to cross one public right-of-way. A steam distribution system is more efficient, easier to meter, easier to maintain, and less expensive in upfront investment than a brine distribution system. By operating steam-driven chillers on site, the markets retain full control over their refrigeration system. Furthermore, steam can also be used for other purposes including industrial processing, space heating, and hot water heating. However, the disadvantage is that steam-driven chillers with the ability to generate -15°F brine, such as the JCI Titan Model OM, are custom-designed and expensive. Therefore, the markets can only buy one large chiller that has to be sized for the maximum load, while redundancy is created by having smaller electric backup chillers.



Chiller	Refrigeration Capacity	Electric Load	Steam Load
	RT	kWp	lb/hr
CH-S-1	3,000		37,500
CH-E-1	1,000	3,500	
CH-E-2	1,000	3,500	
CH-S-2	3,000		37,500
CH-E-3	1,000	3,500	
CH-E-4	1,000	3,500	
Total	**10,000**	**14,000**	**75,000**

Diagram 5: Microgrid Thermal Distribution Network

1.6. Operations

The Hunts Point Microgrid will normally operate in grid-connected mode. The CHP gas turbines will follow the total steam load from the steam-driven refrigeration chillers at the Meat and Produce Markets. Excess electricity will be used to drive electric backup chillers, feed back to the utility grid at ISO rates or serve secondary customers. As a result, the Microgrid will only need to buy electricity from ConEd if the refrigeration load is low and the electricity generated from the CHP turbines and PV systems do not meet the electric demand on cloudy winter afternoons. During an event of grid-outage, an intentional grid island will be formed that operates solely on electricity and steam supplied within the Microgrid by natural gas turbines and solar PV. The Microgrid CHP turbines are designed to meet both the maximum steam and electricity demand, thus ensuring resiliency even if the steam chillers were down for maintenance at this moment. The indefinite operation of the gas-fired turbines relies on the ConEd natural gas network with historically high reliability, but could be replaced with gas deliveries by truck. Blue-sky and islanded operations, the separation/reconnection with the grid and internal communication will be managed by a Microgrid Central Controller (MCC) that balances supply and demand.

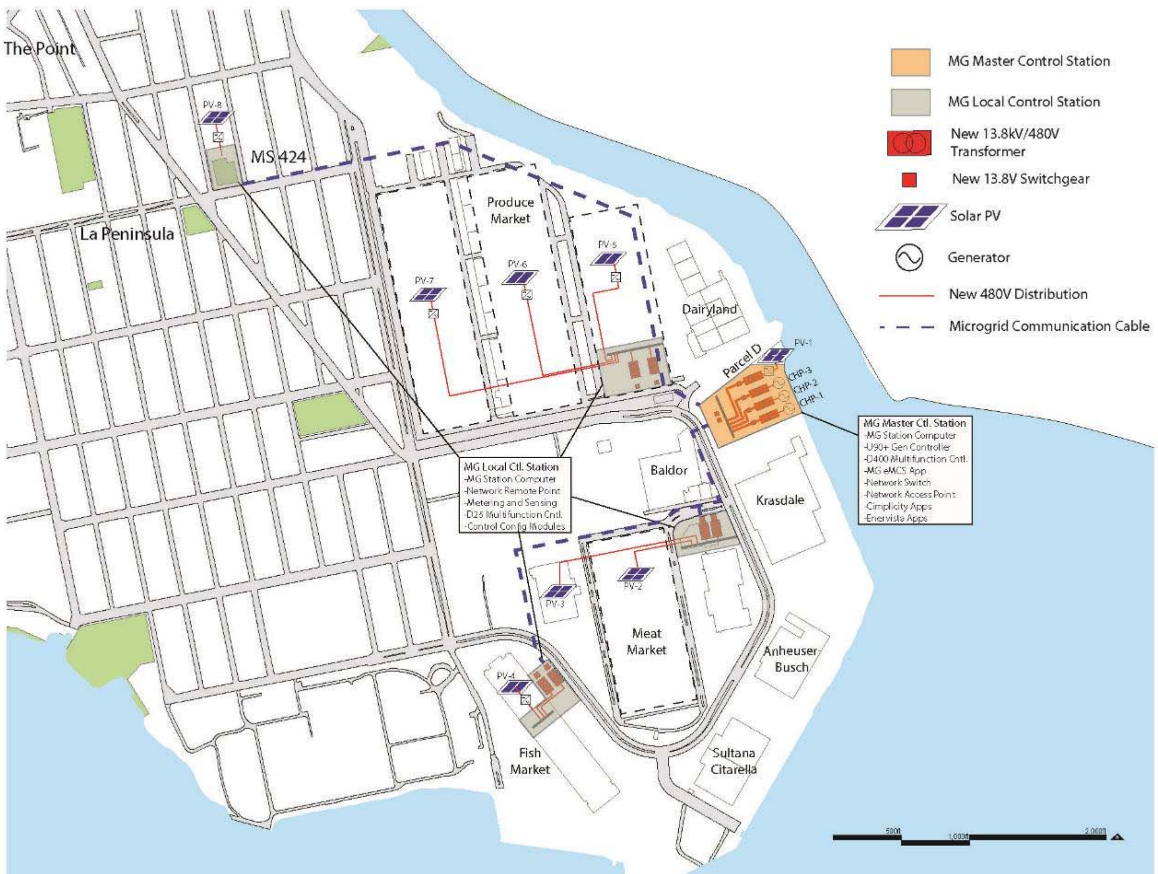


Diagram 6: Microgrid Control and Communication Network

2. Benefits and Results

2.1. Fuel and Carbon Savings

The benefits from fuel and carbon emission savings as a result of on-site cogeneration contribute significantly to the positive Benefit-Cost-Analysis (BCA) of the project. Without the Microgrid and CHP turbines, the projected refrigeration growth would need to be met entirely with electricity from the grid. Even though the New York City energy mix only emits 85 kg CO_2/GJ, the refrigeration load at Hunts Point will double within the next 20 years, increasing CO_2 emission from 45 Mlb to 99 Mlb per year. With the Microgrid and CHP gas turbines, the additional refrigeration load can be met with recovered waste heat driving steam-driven chillers. Even though CHP power generation has higher local CO_2 emissions of 188 kg Co_2/GJ, the reduced electricity demand reduces total CO_2 emissions by 9 Mlb per year. At the same time, the higher overall 78% efficiency of CHP reduces annual fuel consumption by 390,000 MMBtu per year when assuming an electric-only efficiency of 45%. These fuel savings provide the basis for the lower cost of energy for the Microgrid customers as discussed in the next chapter.

Source	Microgrid/CHP Mlb CO_2/yr	Business As Usual Mlb CO_2/yr	Delta Mlb CO_2/yr
ConEd	2,800	99,200	- 96,400
Microgrid	87,600	-	+ 87,600
Total	**90,800**	**99,200**	**- 8,700**

Table 6: Annual Market Energy CO_2 Savings for 2030

2.2. Energy Cost Savings

Engaging the Hunts Point residential community, FDC anchor customers, the asset manager NYCEDC and the electrical utility ConEd early in the design process was key for gaining support for the microgrid proposal. Each stakeholder values Microgrid benefits differently, including resiliency, energy efficiency, reduced air pollution, business continuity and tenant retention, but generally energy cost savings are necessary to gain common support. The higher efficiency of cogeneration is therefore vital for the financial feasibility of the Microgrid. These energy cost savings are estimated to reduce the annual energy spend of the anchor tenants in 2030 from $21.3M to $14.9M. As long as these savings are significant enough for each individual customer, they would be incentivized to join the Microgrid. The more customers a Microgrid attracts, the better it can utilize economies of scale in purchasing, administration, operation and sales, which ultimately drives project profitability and allows the provision of additional Microgrids resiliency benefits as discussed below.

2.3. Resiliency Benefits

The Hunts Point Community Microgrid is designed to improve the resiliency of the wholesale markets, the residential community and ultimately the food distribution system of New York City. Calculating the probabilistic damages from lost revenues and inventory for outages of different duration and likelihood is just a first step in estimating the value of resiliency. Without the Microgrid, an outage forces the markets to close the doors to preserve their inventory, resulting in in a loss of revenue in addition to the accumulating loss of inventory. Probabilistic damages amount to $2.2M per year with a net present value of $25M. The social consequences from disrupting the food supply to New York City are beyond measure. Furthermore, the Hunts Point Microgrid was designed as a Community Microgrid that provides resilient electricity to nearby community facilities that serve as community shelters during emergencies. As these facilities are located on three different blocks in the residential community, the extension of the Microgrid is therefore associated with significant financial, legal and operational challenges. Digging up the streets to run the feeders will cause at least a year of noise, traffic, and air quality disruption in an neighborhood that already has too much noise, traffic, and air quality issues. Running these feeders will cost millions of dollars and will provide benefits only during the most extreme power outage scenario. Finally, the Microgrid provides workforce continuity benefits to employees at the markets and ensures food delivery continuity to downstream restaurant and grocery store businesses.

Name	Revenue Loss $/yr	Inventory Loss $/yr	Indirect Loss $/yr
Meat Market	490,000	440,000	250,000
Produce Market	350,000	310,000	180,000
Fish Market	150,000	130,000	80,000

Table 7: Estimated Annual Market Resiliency Benefits in 2030

2.4. Project Financial Viability

The revenues from steam and electricity sales to customers and the utility make up the major part of the Microgrid revenues, while fees for demand response, ancillary services and other public benefits often only play a minor role. In the case of Hunts Point, the Microgrid electricity prices were set at $0.13 in 2020, $0.14 in 2025, $0.15 in 2030, while steam prices follow the projected natural gas cost. With the growth assumptions discussed above, the Microgrid generates a sales income from which operating expenditures for natural gas, ground lease, standby fees, repairs, staff, billing, legal, licenses, insurance and taxes have to be deducted. The resulting Net Operating Income is positive in every phase, but taking into consideration capital expenditures and financing cost, the overall Internal Rate of Return (IRR) is only 10% for a twenty-year investment. Assuming that capital and operating costs are fixed, the revenues and financing costs of a Microgrid determine the potential developer. A low return may be appropriate to public developers who have access to bond financing and also value public benefits such as resiliency, grid stability and environmental protection. Private developers could be won by uncovering additional revenue potential, such as fees for power quality and reliability, lease income and higher grid sellback prices.

Name	2016-2018	2019-2024	2025-2029	2030-2035
Revenues	$-	$52,634,000	$74,039,000	$115,476,000
OPEX	$-	$(38,800,000)	$(51,397,000)	$(70,178,000)
NOI	**$-**	**$13,834,000**	**$22,641,000**	**$45,299,000**
CAPEX	$(126,460,000)	$(7,177,000)	$(3,218,000)	$-
NCF	**$(126,460,000)**	**$6,657,000**	**$19,424,000**	**$45,299,000**

Table 8: Microgrid Cash Flow

2.5. Results from Benefit-Cost-Analysis

The Benefit-Cost Analysis (BCA) for this stage of NY Prize was conducted by a third-party consultant according to a methodology developed by NYSERDA and the third-party consultant. The BCA was conducted at a screening level of detail and intends to compare all NY Prize Stage 1 projects according to common metrics and assumptions. The BCA studied two scenarios: one with no major outage events, and one evaluating the required annual outage duration to result in a project benefit-to-cost ratio of 1.0. Further explanation of the methodology and detailed results can be found in the BCA Report in Appendix IV.

In summary, the Hunts Point Community Microgrid as outlined in this feasibility study scored a benefit-to-cost ration of 0.9 in scenario 1 with no major grid outages. In scenario 1 the net present value of the project costs were estimated to be $216,000,000, and the net present value of the project benefits were estimated to be $191,000,000. In scenario 2, the project required total grid outage of 0.6 days per year in order to take advantage of the project's resilience aspects and create further project benefits to increase the benefit-to-cost ratio to 1.0. In scenario 2 the net present value of the project costs were estimated to be $216,000,000, and the net present value of the project benefits were estimated to be $220,000,000. A summary of the scenario 2 project costs and benefits are show below in Diagram 7 below.

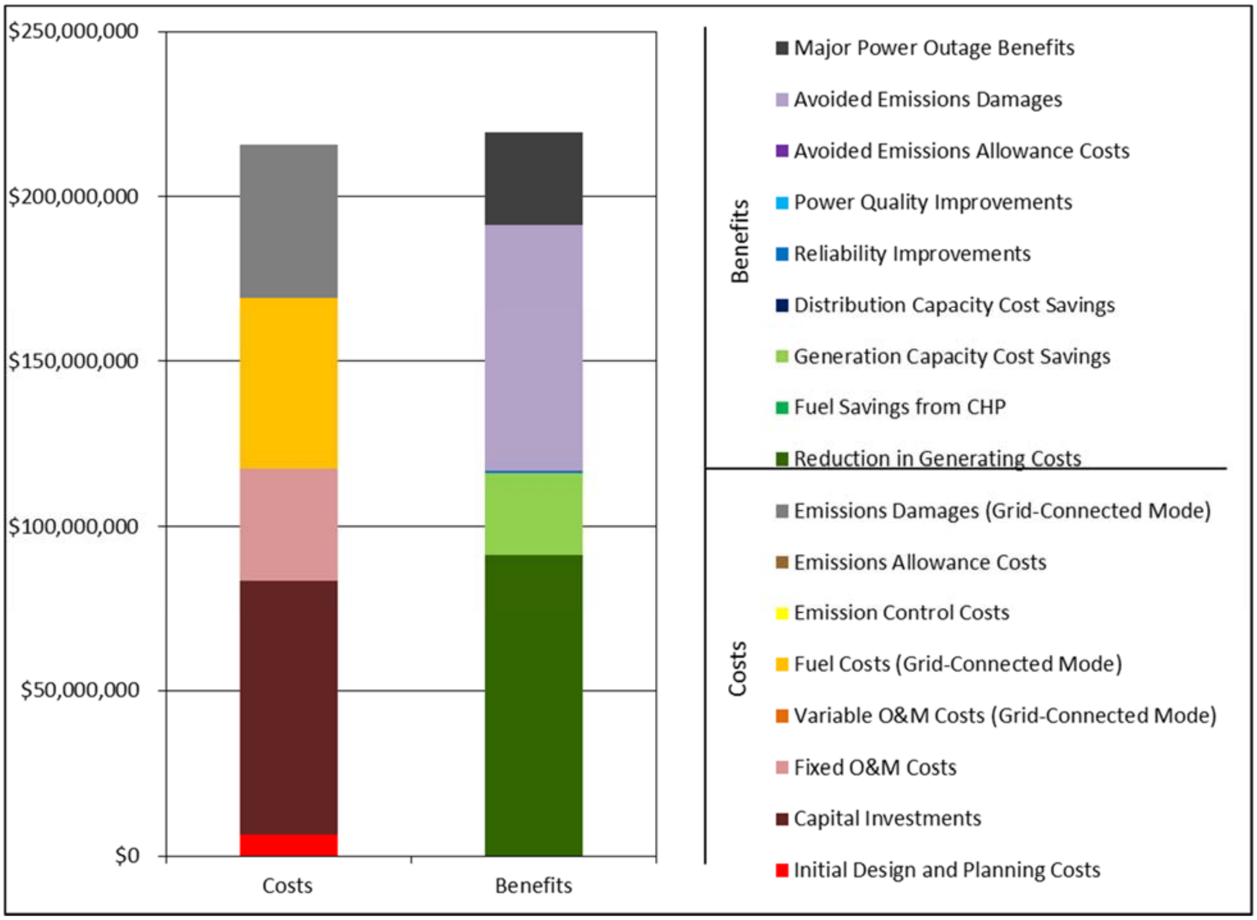


Diagram 7: BCA results for scenario 2 with 0.6days/year of major grid outage

3. Lessons Learned

3.1. Capabilities

The Hunts Point Community Microgrid is an innovative Microgrid proposal specifically designed for the Hunts Point Food Distribution Center (FDC) that requires special Microgrid capabilities. Wholesale food markets, the project's anchor customers, require substantial, year-round refrigeration and freezing capability in order to maintain FDA Cold Chain Compliance. The magnitude of the refrigeration demand creates a unique potential for on-site combined heat-and-power (CHP) capabilities to generate the refrigeration from co-generated steam. Steam-driven refrigeration equipment is, indeed, a rarely specified system, but custom-designed, multi-stage centrifugal refrigeration chillers are available on the market. Second, wholesale food markets often consist of a variety of food distributors that organize as cooperatives and obtain the energy for refrigeration either individually or collectively. This has implications for metering and billing capabilities, but also determines if central refrigeration plants or individual rooftop DX units are feasible. Third, maintaining the employee workforce to staff the food distribution center is as critical to maintaining operation as having power and refrigeration. Therefore, extending the microgrid to serve key Hunts Point community shelters to ensure the safety and well-being of families in Hunts Point will allow the local workforce to report to employment at FDC businesses. Finally, the load profiles in food distribution typically peak in the morning considering the peak hours of operation of the markets are in the early morning hours. This yields significant potential for afternoon demand response capabilities as on-site generation equipment sized to meet peak load in the early morning will have available capacity in the afternoon hours.

3.2. Distribution

A major challenge in Microgrid design is the reuse of existing distribution infrastructure and the interconnection with the utility during operation. This not only creates issues regarding the transfer of ownership and useful life of equipment, but also requires advanced metering, operation and security equipment. Installing new Microgrid infrastructure with a single Point of Common Coupling (PCC) greatly facilitates interconnection and design and accelerates utility approval processes, but may require significant capital expenses for excavation and material. In Hunts Point, a meeting with ConEd revealed that the existing feeders running along Food Center Drive also connect additional customers, existing manholes and trenches were not waterproof and transfer of ownership would be a major hurdle. On the other hand, installing new distribution cables to the markets and the community facilities would greatly facilitate interconnection and design and allow installation of a new steam distribution system to operate steam-driven refrigeration chillers at the Meat and Produce Markets from waste heat of the CHP gas turbines.

3.3. Pricing

As electricity and steam are generated from the same CHP gas turbines, defining a Microgrid price for each is challenging. Pricing has to take into consideration investment, fuel and operating costs, the energy mix of the customers and comparative prices from the utility. Customers are more likely to join the Microgrid if prices for electricity are below their current rates, which are partly subsidized by the New York Power Authority (NYPA). However, identical rates may benefit some customers more than others. Steam is generated virtually from waste heat, so a low price for steam can offset higher electricity cost, but would again give unfair advantage to customers with higher thermal loads. In Hunts Point, the price for steam was calculated by converting the cost per MMBtu for the gas used to generate it, while a common electricity price was set that is below the current rate of electricity-only customers such as the Fish Market. The Meat and Produce Markets with very good existing rates would pay more for electricity, but benefit from large cost savings by obtaining cheap steam for chilling. However, the right balance between electricity and steam prices has to be analyzed for each project under consideration of generating cost, energy mix and utility prices.

3.4. Customers

Since the CHP gas turbines are meeting the refrigeration load of the Meat and Produce Markets with thermal energy, following the steam load of the steam-driven chillers creates a fixed amount of electricity. This electricity can be sold to the utility grid at ISO prices that are considerably below market rates and thus reduce potential Microgrid revenues. However, adding more critical electric customers to the Microgrid may increase electricity demand beyond the steam load, resulting in wasted heat, reduced efficiency and increased fuel cost. Therefore, it is key for project profitability to include non-critical customers in the Microgrid that can be shed if the utility grid is disrupted and the CHP gas turbines work at capacity. At Hunts Point, optional ancillary customers include surrounding food businesses, such as Baldor Specialty Foods, as well as a proposed Vertical Farm (VF) and an Anaerobic Digester (AD) facility. As the additional electricity demand lies within the available CHP and solar PV capacity of the Microgrid, these businesses can also be served during a grid outage as long as the natural gas network is operational. Only when the Microgrid relies on gas deliveries by truck are these loads shed to secure continued operation for the critical market and community facilities.

3.5. Resiliency

Until recently, typical cogeneration proposals relied primarily on benefits from energy cost savings and carbon emissions savings which resulted in very few proposals making it past the initial feasibility study stage. Power continuity and resilience benefits were difficult to include when distributed generation systems could not operate independently in islanded mode to provide power during grid-outage conditions. By adding the benefits of resilience to projects with substantial energy cost savings and carbon emissions reductions, many more projects will be seen as cost-beneficial and be implemented. Therefore, the additional resiliency benefit of Microgrids will promote more sustainable and efficient cogeneration projects in the future, and thereby contribute significantly to “Reforming the Energy Vision”.

4. Next Steps

If the Hunts Point Community Microgrid gets awarded funding for NY Prize Stage 2, the projected energy demand, revenue potential and capital costs will be analyzed in further detail. The necessary legal and regulatory approvals will be studied to consider changes from the “Reforming the Energy Vision” process. SEQR, Title V air quality permits, CEQR, and potentially NEPA approvals will be required for this project to move forward. Since electricity and steam distribution lines will cross public streets the MG developer may be regulated as a public utility and requiring substantial reporting and filing requirements. Public and private operators and financiers will be evaluated and procured in cooperation with NYC EDC to deliver the project. The wholesale markets and community facilities will remain an integral part of the planning and implementation process in order to ensure support from critical customers.

Simultaneously, NYCEDC has been allocated $45 million from the US Department of Housing & Urban Development as part of the post-Sandy “Rebuild By Design” process to be partly invested in a resilient energy pilot project by the end of 2019. The Hunts Point Community Microgrid could play a role as such a pilot project to improve energy resiliency across the peninsula. Potential synergy effects could be reached by developing initial stages of the Microgrid, for example a small electrical and steam distribution system between the wholesale markets. Such a pilot project would not only improve the energy resiliency of these critical facilities, but also facilitate the future expansion into a Community Microgrid that provides resilient and affordable energy to the community refuge facilities in Hunts Point.

Appendix I: Capabilities Report

1. Minimum Required Capabilities

1.1. Critical Facilities

Serves at least one (1) but preferably more, physically separated critical facilities located on one (1) or more properties.

The Hunts Point (HP) Food Distribution Center (FDC) in the South Bronx is one of the largest food distribution centers in the world, providing 60% of New York City's produce, meat and fish and storing, on average, two and a half days of these foods. The 329-acre site and the market buildings are owned by the City of New York (NYC) and administered by the NYC Economic Development Corporation (NYCEDC). Surrounding the FDC are other ancillary food industry businesses as well as the Hunts Point residential community.

The four (4) critical facilities within and nearby to the FDC served by the HP Microgrid include:

- **Hunts Point Cooperative Market (Meat Market)**
  The Meat Market was opened in 1974 and consists of six large refrigerated and freezer buildings, including a central refrigeration plant. The market is home to 32 merchants and approximately 2,400 employees and has a floor area of approximately 870,000 SF. A majority of the ground floor area at the Meat Market is used for storage, trade, packaging, and distribution of meat products. The second floor is typically used for tenant offices and market administration, though some storage and processing does occur on the second level. The Meat Market supplies meat and meat products to the tri-state area and has nationwide and international distribution channels.

- **Hunts Point Terminal Market (Produce Market)**
  Opened in 1967, the Produce Market occupies 105 acres and consists of four long warehouse buildings totaling approximately 800,000 SF of floor area, making it the largest produce market in the country and possibly the world. The market is home to 40 cooperative merchants with roughly 3,000 employees, capturing an estimated $2.0B to $2.3B in revenue per year. The ground floor units have direct access to truck loading berths on both sides of the warehouse rows and is used for the display and sale of products. Each unit has corresponding office spaces on the second floor.

- **The New Fulton Fish Market (Fish Market)**
  The New Fulton Fish Market relocated to Hunts Point in 2005 from lower Manhattan, where it opened in 1807, making it the oldest and largest wholesale fish market in the country. The Fish Market has 32 cooperative wholesalers employing an estimated 650 employees. The market consists of a 430,000-SF facility with 19 bays and 8 separate entrances. The market captures an estimated $1.0B in revenue per year. The long building has a floor area of approximately 320,000 SF. The ground floor contains tenant units, loading berths, refrigeration and freezing rooms, and a central common area for display and sale of fish products. Each unit has a small unrefrigerated space on the second floor which is typically used as an office.

- **Community Facilities**
  The Hunts Point peninsula has a residential population of more than 12,500 people (2013 American Community Survey). The 2013 median household family income was $23,679, less than half of the comparable figure for New York State, making the Congressional District for the community having the highest poverty rate in the United States. During an emergency condition, Hunts Point residents can take shelter in Middle School 424 (MS 424) which is the designated Office of Emergency Management (OEM) Evacuation Center at 730 Bryant Ave. Additional critical Community Facilities that provide refuge to local residents are “La Peninsula” on 711 Manida Street and “The Point” on 940 Garrison Avenue.

Currently, none of the above critical facilities have backup generators, including the OEM Evacuation Center at MS 424. Furthermore, the Meat and Fish Markets are located within the 100-year flood plain and underground electrical distribution equipment has not been upgraded to be waterproof. The local distribution grid in Hunts Point has proven to be very reliable since the new Mott Haven substation was energized 2007. All distribution feeders are underground and a set of three 13.8kV feeders run through the extent of Food Center Drive. The two major risk events that would cause a power outage in the service territory include flooding of underground electrical vaults along Food Center Drive, and a regional blackout that impacts the Mott Haven substation. In those cases, the markets usually load as much perishable food into trucks as possible, and close the warehouse doors until power comes back. However, these mitigating strategies can only maintain USDA’s Cold Chain Compliance regulations for a few hours, before temperatures rise to above acceptable ranges. Considering the volume of fresh food that passes through these facilities, power outage poses a considerable risk to the region's food supply.

Other FDC food businesses including Baldor Specialty Foods, Krasdale Foods, Citarella, Sultana, Anheuser-Busch and Dairyland are also located on city-owned land, but are not deemed to be *critical* to New York City's food supply and the nearby vulnerable communities. However, due to their proximity and stable loads, they could potentially be part of a Microgrid as electric customers and thus improve the economics of the Microgrid. Additionally, an Anaerobic Digester on Parcel D and at the Wastewater Treatment Plant could produce biogas from organic food waste, while a new Vertical Farming could potentially offtake electricity to grow food in close proximity to the markets. The Hunts Point Wastewater Treatment Plant, the Department of Corrections Vernon C. Bain Center, the Department of Sanitation salt storage facility, and numerous auxiliary businesses located adjacent to the FDC on the peninsula are not proposed to be included as electricity customers in the Hunts Point Microgrid.

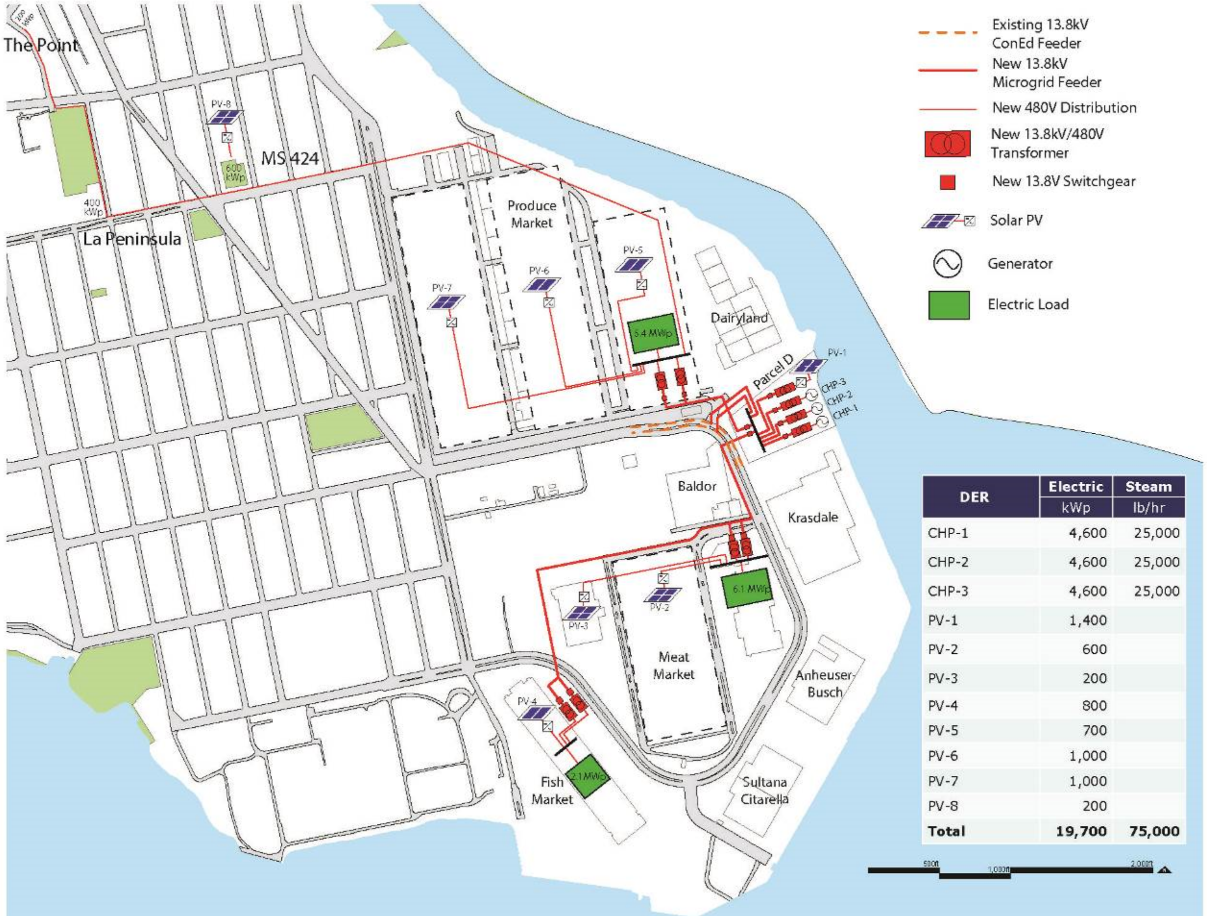
1.2. Generation Resources

The primary generation source capacity cannot be totally diesel fueled generators.

The proposed energy mix for the Hunts Point Microgrid is both sustainable and diversified. The large and flat rooftops on the markets, all located on land owned by the City of New York are ideal for large-scale installation of solar PV. This includes 4.5 MW rooftop solar PV on the Produce, Meat and Fish Markets as well as a 1.4 MW ground-mounted solar installation on Parcel D for a total of 5.9 MW of electricity from renewable resources.

A highly efficient natural gas-fired combined heat and power (CHP) facility will provide the bulk of the power and steam supply during normal operation and grid outage operations. Three 4.6 MW gas turbines that each generate 25,000 lb/hr of steam will be located on Parcel D, an ideal location due to its close proximity to the Meat and Produce Markets that makes the transport of steam more efficient. The CHP facility will be sized based on the anticipated steam load for warehouse refrigeration from steam-driven chillers at the Meat and Produce Markets.

Lastly, an Anaerobic Digester on Parcel D and at the Wastewater Treatment Plant could produce biogas from biodegradable food waste. This biogas can be used as a sustainable fuel source for the CHP gas turbines by mixing it in with the natural gas fuel supply.



DER	Electric kWp	Steam lb/hr
CHP-1	4,600	25,000
CHP-2	4,600	25,000
CHP-3	4,600	25,000
PV-1	1,400	
PV-2	600	
PV-3	200	
PV-4	800	
PV-5	700	
PV-6	1,000	
PV-7	1,000	
PV-8	200	
Total	**19,700**	**75,000**

1.3. Operations

A combination of generation resources must provide on-site power in both grid-connected and islanded mode.

The Hunts Point Microgrid will operate in grid-connected mode during blue sky conditions. The CHP facility follows the steam load of the steam-driven chillers at the Meat and Produce Markets. If the electrical power generated by the natural gas fired turbines and PV systems is greater than the combined electrical load of the facilities on the Microgrid, then power will flow back to the grid if allowed by the distribution utility. This may be the scenario during sunny summer afternoons since peak refrigeration load is in the morning and lower in the afternoons. On the other hand, if the steam refrigeration load is low and the subsequent electricity generated from the CHP turbines and PV systems does not meet the Microgrid demand, then the Microgrid may draw power from the grid to reduce waste heat and fuel consumption.

Electrical production during normal ‘blue sky’ conditions may also be optimized based on economic factors such as utility demand reduction incentives during summer afternoon peaks. Since the markets will have their peak refrigeration load in the mornings, the CHP and PV systems could generate more electricity and steam than needed for just the Microgrid if the grid price is profitable. Under the ConEd SC11 program, qualifying facilities may sell excess energy and capacity to NYISO at location-based marginal prices.

1.4. Islanding

Must be able to form an intentional island.

During an event of grid-outage or any event causing the tie breaker to open, an intentional grid island will be formed automatically and operate solely on energy supplied within the Microgrid by natural gas CHP and solar PV. In this case, the CHP turbines will be designed and operated to meet the entire electrical and thermal load within the Microgrid as long as the natural gas network is intact. In the unlikely case that the gas network is not operating either, the Microgrid receives truck gas deliveries and may have to shed secondary loads and reduce the number of refrigerated warehouses to ensure cold-chain compliance of critical food storage as well as electricity for critical community facilities.

1.5. Separation/Restoration

Must be able to automatically separate from grid on loss of utility source and restore to grid after normal power is restored.

Under normal operation, the Microgrid will be connected to the distribution utility at a single Point of Common Coupling (PCC) at Parcel D. The system voltage and frequency will be monitored at this point, and if a specific level of under frequency (UF) or under voltage (UV) is detected for defined period of time, the tie breaker will be automatically opened to separate the Microgrid from the utility and form an intentional island. Separation of the Microgrid from the utility will also be detected by tripping of the tie breaker for system faults external to the Microgrid. It is also planned that this separation could occur if a trip/separation signal is received from the utility dispatcher. The UF and UV values and times as well as tripping of the tie breaker for faults will be established based upon utility specified values/conditions.

The Microgrid Central Controller (MCC) will coordinate the response of the Microgrid upon separation from the utility. The MCC constantly monitors the status and power values of the Microgrid loads and generation. Upon detection of loss of the utility, the MCC will act to maintain the generation load balance of the Microgrid. The balance may be effected by various means including load shedding or generation dispatching depending upon the state of the Microgrid.

The MCC will also incorporate controls to detect that the utility system voltage and frequency has been restored. The MCC could initiate auto restoration to the utility, but we anticipate that a permissive signal from the utility will be communicated to the MCC to allow the restoration of the utility connection. The will incorporate an automatic synchronizer to assure frequency and voltage matching of the Microgrid with the utility system. Upon closing of the tie breaker, the Microgrid will revert to normal operation.

1.6. Maintenance and Resource Efficiency

Must comply with manufacturer's requirements for scheduled maintenance intervals for all generation; plan on intermittent renewable resources that will be utilized toward overall generation capacity only if paired with proper generation and/or energy storage that will allow 24 hrs per day and seven (7) days per week utilization of the power produced by these resources.

All systems of the Microgrid will be maintained in regular intervals according to the manufacturer's requirements. The central CHP, steam network and solar panels will be maintained by the Microgrid operator. The local solar panels on rooftops and refrigeration chillers will be maintained by the Markets themselves, under the supervision of the Microgrid operator. Redundant capacities ensure that the Microgrid is fully operational at all times, even if some chillers or turbines are down for maintenance (see chapter 3.2).

Up to 5.9 MW of solar PV energy will be integrated into the Microgrid. This electricity will always be used to meet the Microgrid internal demand or be sold to the grid to ensure 24/7 utilization of the generated solar electricity. The biogas generated at the Anaerobic Digester on Parcel D and at the Wastewater Treatment Plant will be blended in with natural gas at the CHP plant and contribute approximately 10% of the total gas demand. Finally, the CHP turbines will follow the steam load of the Markets to maximize efficiency by minimizing waste heat, thus making sure that the renewable resources are utilized sustainably.

1.7. Load-Following and Communication

Generation must be able to follow the load while maintaining the voltage and frequency when running parallel connected to grid. It also needs to follow system load and maintain system voltage within American National Standards Institute (ANSI) c84-1 standards when islanded.

Include a means for two-way communication and control between the community microgrid owner/operator and the local distribution utility through automated, seamless integration. Include processes to secure control/communication systems from cyber-intrusions/disruptions and protect the privacy of sensitive data.

The Microgrid central controller (MCC) coordinates the operation between the Microgrid and the main grid and to ensure system integration. By commanding local microsource controllers (MC) in response to forecasted and changing loads in the Microgrid, the MCC maintains system stability and can even contribute to the utility grid stability through frequency and voltage control. In normal operation, the MCC further optimizes energy generation to maximize renewable energy usage, fuel savings and return on investment. In case of a utility outage, the MCC will automatically control the separation and restoration of the Microgrid from/to the utility grid while maintaining a stable Microgrid. This requires seamless two-way communication interfaces with the main grid that meet NERC-CIP cyber security standards and DNP 3.0 utility communications control. A system that meets these requirements is the GE U90^{PLUS} Generation Optimizer.

1.8. Customer Diversity

Provide power to critical facilities and a diverse group of customers connected directly to the microgrid—diversity should apply to customer type (e.g. residential, small commercial, industrial, institutional, etc.) and overall demand and load profile.

By providing power to New York City's critical food distribution facilities, three community refuge facilities as well as auxiliary businesses in Hunts Point peninsula, a very diverse group of customers will be served electricity and steam.

The three wholesale markets are home to a variety of meat, fish and produce distribution businesses of different sizes that together employ over 5,000 people. While the central Meat Market refrigeration load is largest during the daytime, the Fish and Produce Market tenants have their main operating hours in the early morning, resulting in a diversified load curve with a combined coincident peak of 14 MW at 6am.

The three community refuge facilities (MS 424, La Peninsula Headstart and The Point CDC) serve a total population of slightly more than 12,500 residents (2013 American Community Survey) in the Congressional District with the highest poverty rate in the United States. During times of emergency and grid outage, the Hunts Point Microgrid would provide resilient power to about 600 of these citizens at the designated OEM Evacuation Center at MS 424 and the two community centers. In blue sky conditions, these important community facilities benefit from lower energy cost thanks to the higher efficiency of CHP.

Furthermore, the Hunts Point Microgrid offers to provide affordable and resilient electricity to an Anaerobic Digester and a Vertical Farm on Parcel D, as well as other businesses in the Hunts Point peninsula (e.g. Baldor Fresh Cuts, Krasdale Foods, and Dairyland) during blue sky and emergency conditions as long as the natural gas network is operating. Only if both the electric and gas network are disrupted will service be limited to the critical market and community facilities while receiving truck gas deliveries. These additional loads help diversify the Microgrid electricity demand and reduce excess electricity sales to the grid when following the steam load.

1.9. Fuel Supply

Must include an uninterruptible fuel supply or minimum of one (1) week of fuel supply on-site.

The primary generation fuel source is biogas and natural gas, which run the CHP turbines that provide the base electrical and steam load of the Microgrid. Two opportunities to purchase biogas include a proposed Anaerobic Digester on Parcel D and a planned Anaerobic Digester at the Hunts Point Wastewater Treatment Plant. Natural gas will be delivered via a ConEd natural gas network that will be extended to Parcel D at no cost and has high reliability. If the network should fail, the base load can be met with gas delivered by truck. At the final stage, the Microgrid will require 1,800 MMBtu of natural gas at full load, equaling to about 24,000 gallon or the capacity of two road tankers of Liquefied Natural Gas (LNG), which can be regasified with a portable vaporizer on site. Energy generated from solar PV will also be a substantial contribution to the Microgrid energy supply.

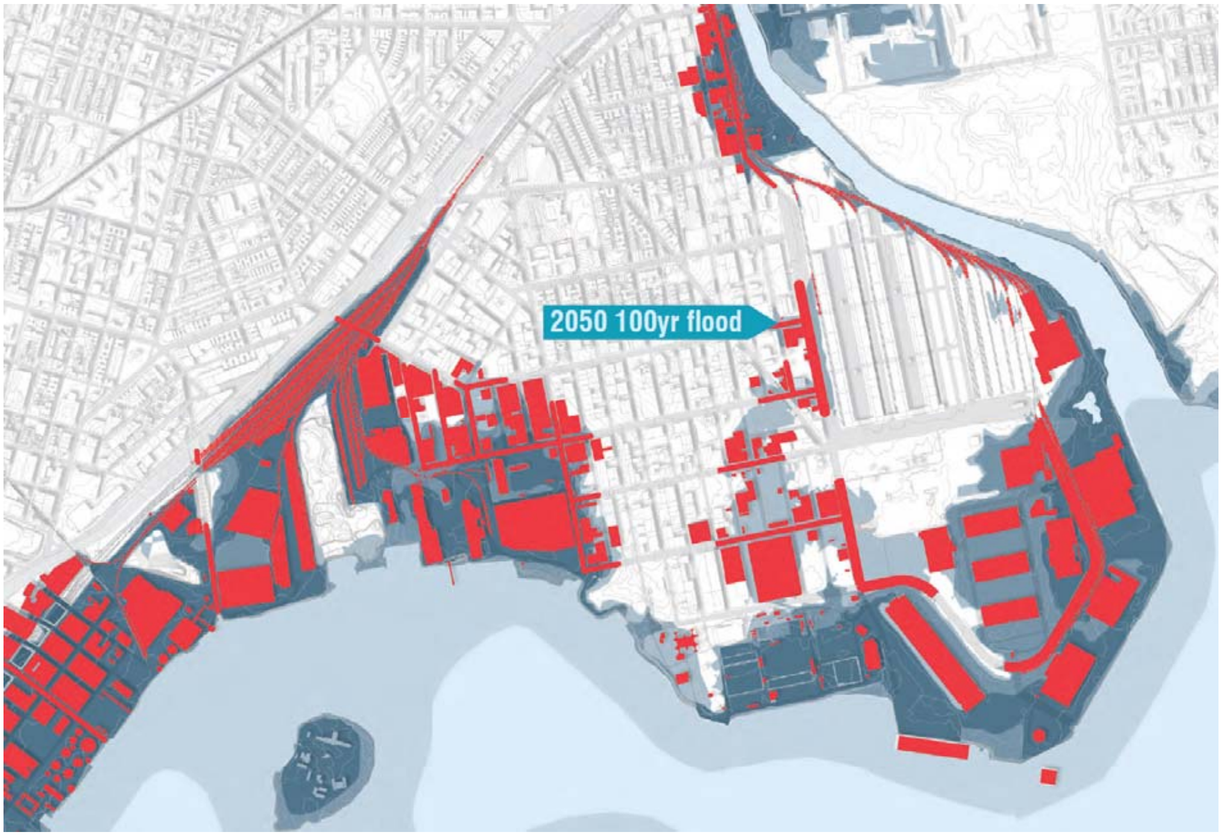
1.10. Resiliency

Demonstrate that critical facilities and generation are resilient to the forces of nature that are typical to and pose the highest risk to the location/facilities in the community grid. Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.

While the residential neighborhood in Hunts Point and the community facilities are well above the flood-plain, some of the critical commercial facilities are located within a 100-year flood zone adjacent to the Bronx River and East River. The U.S. Department of Housing and Urban Development's Rebuild By Design award of $45 million will be used in part to study flood protection measures, and part to implement a pilot project to build energy resiliency. Specific projects to be funded with the CDBG-DR award have not yet been determined, but proposals include various pilot projects for flood protection around the Food Distribution Center.

The Hunts Point Microgrid proposal for a tri-generation facility and Microgrid switchgear hub at Site D will include elevating the entire site to elevation +18.0' (NAVD88), which is above the projected 100-year floodplain in 2050 when considering a moderate estimate of sea level rise due to climate change. All Microgrid distribution cables and steam pipes will be installed underground in waterproof protected trenches. All new parcel-level switchgear throughout the Hunts Point Microgrid will also be designed above the +18.0' elevation requirement. Rooftop PV installations will be designed to withstand Category 3 hurricane force winds as the peninsula is exposed in an unprotected location. In summary, the Microgrid will be designed to operate indefinitely during a grid outage event provided that natural gas utility service can be maintained.

Other resilience challenges from earthquakes, drinking water supply disruption, tornados, severe winter snow and ice storms, and other climate-related events will continue to be studied during future stages of the project.



1.11. Black-Start Capability

Provide black-start capability.

There could be a scenario when generation sources within the microgrid are not energized for maintenance purposes and the utility grid connection provides full electrical service. If an outage occurs or an event causes the tie breaker to open in this condition, the generation sources within the microgrid will be required to start from a black-start condition without electricity from the grid. Solar PV system inherently begin charging from black start conditions upon solar insolation onto the panels generating current. Natural gas CHP turbines however require auxiliary power to start from a de-energized condition. If this power is not provided from solar PV, small diesel generators are necessary to provide power for controls and other start up power needs for natural gas-fired turbines to start up in a black start condition.

2. Preferable Microgrid Capabilities

Integrate and demonstrate operation of advanced, innovative technologies in electric system design and operations, including, but not limited to, technologies that enable customer interaction with the grid, such as Microgrid Logic Controllers, Smart Grid Technologies, Smart Meters, Distribution Automation and Energy Storage.

2.1. Network Control System

Include an active network control system that optimizes demand, supply and other network operation functions within the microgrid;

The Microgrid Central Controller (MCC) will optimize demand, supply and other network operation functions within the Microgrid. Manual control of the system by the Microgrid owner/operator will be incorporated into the MCC as will utility defined automatic and manual controls and voice communications. A proven product under consideration is the GE U90^{PLUS} Generation Optimizer. It communicates via fiber optic cables or a secure wireless network with intelligent local microsource controllers (MC) that regulate power output of energy generators. At the same time, the customers will be furnished with smart meters that communicate in real-time with the MCC to regulate energy generation and allow the customers to reduce their energy cost by consuming energy at times of low demand. These microgrid controllers, smart meters and the energy network will have to be newly installed.

2.2. Energy Efficiency/Demand Response

Include energy efficiency and other demand response options to minimize new Microgrid generation requirements;

The solar panels, gas turbines and steam chillers installed in the Microgrid will be the most energy efficient currently available in order to reduce necessary capacity and lifecycle cost. Additionally, the markets and businesses in the Microgrid will be encouraged to use energy efficient cooling and lighting systems, which will also be mandatory for new construction.

As described above, smart metering and communication with the Microgrid Central Controller (MCC) will allow the tenants to employ automatic demand response systems that regulate their energy consumption (mostly refrigeration), which will also minimize required Microgrid generation capacities. This is particularly feasible for planned new construction of centralized refrigeration plants at the Produce and Meat Markets.

2.3. Systems Interconnection

Address installation, operations and maintenance and communications for the electric system to which interconnection is planned (e.g., underground networks, overhead loops, radial overhead systems);

The Microgrid will only be connected to the utility at one Point of Common Coupling that is connected to the Microgrid Master Controller at Parcel D. The local generators and market customers will be connected to this Energy Center with a new electrical and steam distribution network. The existing utility distribution network will be preserved as a backup. The connections to the market and business electrical systems are equipped with smart meters with two-way communication that record energy usage and supply exact to the minute. These data will be remotely transferred to the Microgrid owner/operator for monitoring and billing.

2.4. Reforming the Energy Vision

Coordinate with the Reforming the Energy Vision (REV) work to provide a platform for the delivery of innovative services to the end use customers;

Reforming the Energy Vision (REV) aims to improve the resiliency and reliability of the grid by establishing new technologies and policies and integrating distributed energy resources in Microgrids. Such new technologies can support the stability of the main grid during normal operations, operate in island mode if the grid is disrupted, reduce transmission losses, integrate green energy resources, and help manage local demand. The proposed Hunts Point Microgrid would combine CHP and solar PV in a diverse Microgrid that is able to supply energy to the main grid during summer afternoon regional peak demand conditions. The Microgrid will operate at high efficiency to reduce daily energy costs for customers by utilizing waste steam from natural gas turbines to drive refrigeration chillers providing brine for warehouse cooling. Biogas from Anaerobic Digesters on Parcel D and at the Wastewater Treatment Plant can diversify the source of gas fuel for the turbines. Additionally, solar PV on a central site and local markets generate sustainable energy during sunny hours year-round. The Microgrid customers, mostly food wholesalers and community refuge facilities, will be actively involved by generating energy on their roofs and optimizing their electricity demand, thereby reducing their own energy cost. The lower cost and higher resiliency of food distribution will ultimately benefit the residents of the New York metro area, who obtain 60% of their food from the FDC at Hunts Point.

2.5. Benefits and Financing

Take account of a comprehensive cost/benefit analysis that includes, but is not limited to, the community, utility and developer's perspective;
Demonstrate tangible community benefits, including but not limited to, (e.g. jobs created, number of customers served, number of buildings affected, scale of energy efficiency retrofits, etc.)
Leverage private capital to the maximum extent possible as measured by total private investment in the project and the ratio of public to private dollars invested in the project;

The main customers of the Microgrid are the three food markets, the community refuge facilities, an Anaerobic Digester and Vertical Farm on Parcel D as well as auxiliary food distribution businesses in the Hunts Point Food Distribution Center. The Microgrid will provide a resilient energy supply in the event of a major power outage without having to individually invest into diesel generators. At the same time, the businesses will be able to reduce their energy cost by profiting from efficient, centralized CHP electricity and steam generation. The residential community will benefit from uninterruptable and affordable energy supply to MS 424 and two community centers that serve as refuge facilities.

The Microgrid developer, who builds and operates the central CHP plant and manages demand and supply in the Microgrid, will have an established customer base with high and stable electricity and steam demand. He will sell ancillary services to and buy natural gas from ConEd. The constant cashflow allows the Microgrid developer to attract private financing and generate a long-term return on a sustainable and resilient investment opportunity.

The utility will remain the backup energy provider for the Microgrid and each individual business, especially in early morning hours when the utility has excess capacities. Additionally, the Microgrid will be able to supply energy to the utility in the afternoon peak and support the utility with frequency and voltage control as well as demand response. The utility also benefits from significant natural gas purchases to operate the CHP turbines and from improved reliability ratings in a more diversified electrical grid.

The community, as a whole, benefits from sustainable and efficient solar PV and biogas energy generation, thereby reducing its carbon footprint, environmental pollution and protecting fossil fuel sources. The most important direct effect of the Hunts Point Microgrid is food security, as a resilient energy supply enables the food distribution center to maintain federally mandated cold chain regulations and ensures the safe and uninterrupted distribution of meat, fish and produce to the City of New York and its surroundings. Furthermore, the more resilient and efficient energy supply will contribute to maintain Hunts Point as a premier food distribution center, which will preserve more than 10,000 jobs, revenues and associated tax income in New York State.

The Microgrid developer will leverage public funding with private capital and financing mechanism in a Public-Private Partnership. For the development of the Energy Center and the distribution network, the developer takes advantage of traditional bank loans and mezzanine capital, long-term off-take contracts (Power Purchase Agreements), tax credits for solar PV systems and utility fees for ancillary services such as demand response and frequency and voltage control.

2.6. Clean Power Supply Sources

Involve clean power supply sources that minimize environmental impacts, including local renewable resources, as measured by total percentage of community load covered by carbon-free energy generation;

As discussed above, the solar PV and CHP gas turbines are clean power supply sources with minimal environmental impacts. The total percentage of the Microgrid electricity covered by carbon-free generation resources is approximately 50%, depending on the actual deployment of solar PV on business rooftops and the production of biogas by the Anaerobic Digesters. The remaining capacity will be supplemented by natural gas that also has half of the CO_2 emission rates of coal-fired generation (1,135 lbs/MWh, US EPA eGRID 2000).

2.7. Power Grid Support

Incorporate innovation that strengthens the surrounding power grid.

In case of a large-scale blackout, the Microgrid could support the surrounding power grid with black start capabilities by providing power required to power large scale generation facilities throughout the network. The gas turbines would energize regional transmission lines and provide enough energy to start and synchronize a base load plant in the surrounding power grid. However, as there are no large power plants in the proximity of the Microgrid, a black start support for the grid is not needed at this location.

The Microgrid will provide voltage and frequency control to the power grid. Maintaining a continuous balance between power generation and load demand requires advanced grid-interactive inverters as well as flexible energy resources. The Microgrid will include a microgrid Master Controller (MCC) that balances supply and demand within the microgrid by controlling local microsource controllers (MC). This system can be connected to the power grid with a disturbance observer and provide frequency and voltage control by regulating power generation and demand of the Microgrid. As this requires additional capital, operation, fuel and training costs, NYISO and ConEd have to compensate the Microgrid for this service at standard rates.

2.8. Customer Interaction

Incorporate innovation that increases the amount of actionable information available to customers - providing a platform for customers to be able to interact with the grid in ways that maximize its value.

The information collected at each customer's smart meters will be monitored by the Microgrid owner/operator, and be communicated to all customers. This data may be used for billing at time-of-use rates that reflect the current consumption and production of energy in the Microgrid as well as energy prices from the utility grid. This pricing information allows the markets and businesses to adjust their energy consumption and reduce energy cost by consuming and producing energy countercyclical. In order to do so, the markets can install automatic demand management systems that prepone or postpone energy use (e.g. for refrigeration). The energy managers at the markets will also receive training how to interpret the data and control energy consumption manually. As a result, the supply and demand of the Microgrid will be more balanced and have lower peaks, which reduces the necessary amount of energy generators while also increasing the potential for demand response services to the grid.

Appendix II: Technical Report

1. Proposed Microgrid Infrastructure and Operations

Description of Microgrid infrastructure and equipment

1.1. Existing Infrastructure

Electrical service to the three markets is delivered through three underground 13.8 kV feeders that run along Food Center Drive (FCD). The three feeders originate at the Mott Haven substation on East 144th Street, which was energized in 2007 and has substantial available capacity for the foreseeable future. Incoming service feeders branch out from the three feeders in FCD and feed into packs of three transformers at each incoming service location. Only the Meat Market receives and is metered on 13.8 kV incoming service voltage. The transformers deliver 480 V, three-phase electrical service to all of the other facilities throughout the FDC. ConEd also distributes natural gas in this area of the Bronx. Branching out from the nearby Iroquois Transmission line, the local natural gas distribution network also runs throughout Food Center Drive and has substantial available capacity. The local refrigeration infrastructure and billing system is different for each of the three markets.

The **Meat Market** has a central refrigeration and freezing plant with six electric refrigeration chillers: three chillers providing -15°F brine for freezing ; and three chillers providing +15°F brine for cooling . Additionally, two gas-fired steam boilers each have a nameplate capacity of 20 MMBtu/hr and generate 350°F steam for a local heating network. The Meat Market has a single electrical meter and a single gas meter for the entire facility. The cost for electricity, refrigeration, freezing and heating are pro-rated to each tenant on roughly a per-square-foot-basis (other pricing conditions do apply). A recently completed building G is not connected to the central refrigeration plant, instead refrigeration is provided here by packaged rooftop DX units using electricity.

The **Produce Market** tenants refrigerate their spaces at a variety of temperature levels with packaged rooftop DX units and have very little freezing demand. Electricity is provided from four central transformers and each tenant has an individual customer account with ConEd. Electricity for common areas such as cooling and lighting in corridors is partially supplied by the New York Power Authority (NYPA). Due to the layout of the facility and the low efficiency of the tenant-operated rooftop refrigeration units, some tenants cannot always maintain USDA and FDA Cold Chain Regulations at all times. Therefore, several tenants leave the fresh produce in refrigerated trucks that run standby from their diesel engines. This practice is very inefficient and impacts local air quality throughout Hunts Point by emitting exhaust from diesel engines.

The **Fish Market** Coop provides refrigeration to a central fish trading area with packaged rooftop DX refrigeration units, the cost of which are pro-rated to the tenants. Tenants individually refrigerate and freeze their units with packaged rooftop DX units on their own electricity meter. The Fish Market has 128 units and 32 tenants, but the four largest tenants occupy approximately 26% of the space and units. Consumption data has been obtained for the Coop and these four large tenants, the total electric demand and hourly profiles were extrapolated from this data.

The Community Facilities rely on the electric and natural gas utilities for electricity and natural gas supply. In case of an emergency, MS 424 on 730 Bryant Avenue serves as an Office of Emergency Management (OEM) Evacuation Center that obtains electricity from the grid to run air-cooled air-conditioning units. Three 5,000 MBH/hr steam boilers provide steam for central heating. The refuge facility has no backup emergency diesel generators and people would have to be transferred to another site in case of a grid outage. In case of an extended grid outage, the local community would most likely go to the two community centers, La Peninsula and The Point CDC, to look for information, power, heating and safety. However, these facilities also have no backup generators and would thus greatly benefit from the Microgrid. Additionally, providing electricity at affordable rates to these community centers on a daily base would greatly improve community support for the Microgrid at the FDC.

The diagram below illustrates the existing electrical infrastructure.

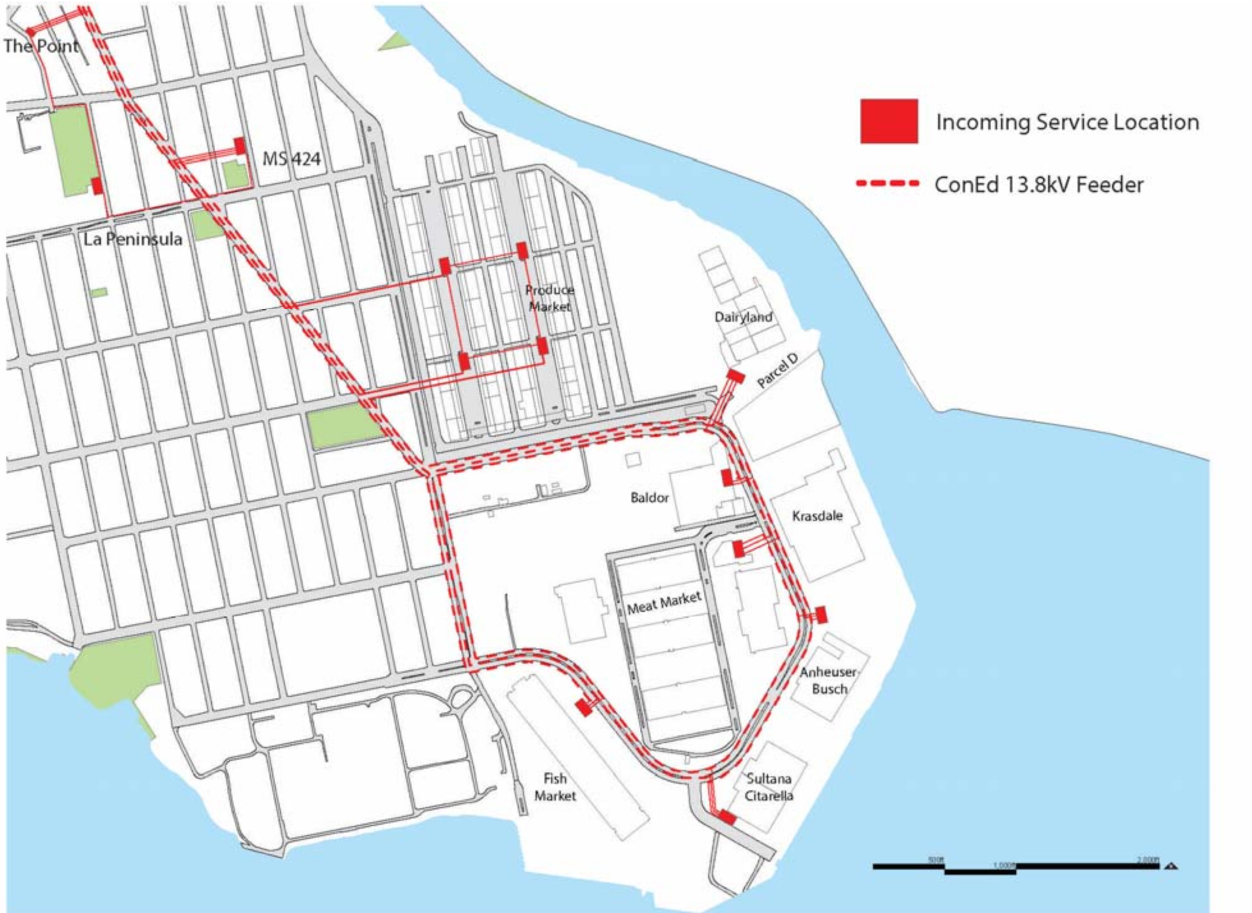


Diagram 1: Existing Electrical Infrastructure

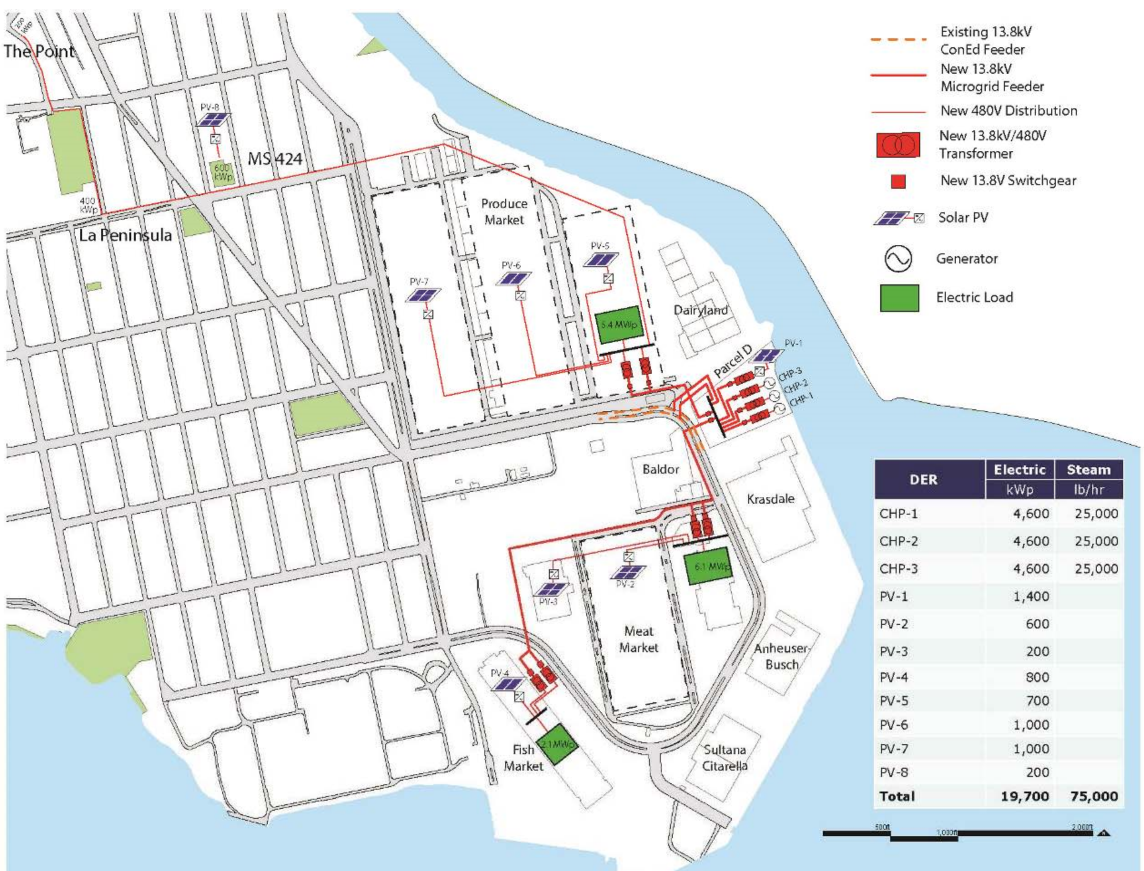
1.2. Proposed Microgrid Infrastructure

A Microgrid at Hunts Point would ensure the energy supply of the critical facilities and help improve the resiliency, economic competitiveness and environmental sustainability of the Food Distribution Center. By generating electricity and steam on-site with diversified distributed energy resources (DER), the Microgrid will maintain 100% of the load during a regional blackout. As the markets have significant refrigeration loads, a combined heat and power (CHP) facility can provide electricity and steam at high overall efficiency. Both will be transported to the markets, where electric and steam-driven chillers provide refrigeration from new central refrigeration plants at the Meat and Produce Markets. The electricity load will be locally supplemented by solar Photovoltaics (PV), as the large and flat rooftops of the markets are ideal for large-scale installation of solar PV systems that reduce the peak electricity load and increase peak shaving potential. Finally, for improved resiliency and reduction of waste and landfill, biogas will be generated from an Anaerobic Digester on Parcel D supplied by food waste from the markets.

Biogas from anaerobic digestion at the nearby Wastewater Treatment Plant could further supplement the gas supply for the gas turbines at the CHP plant.

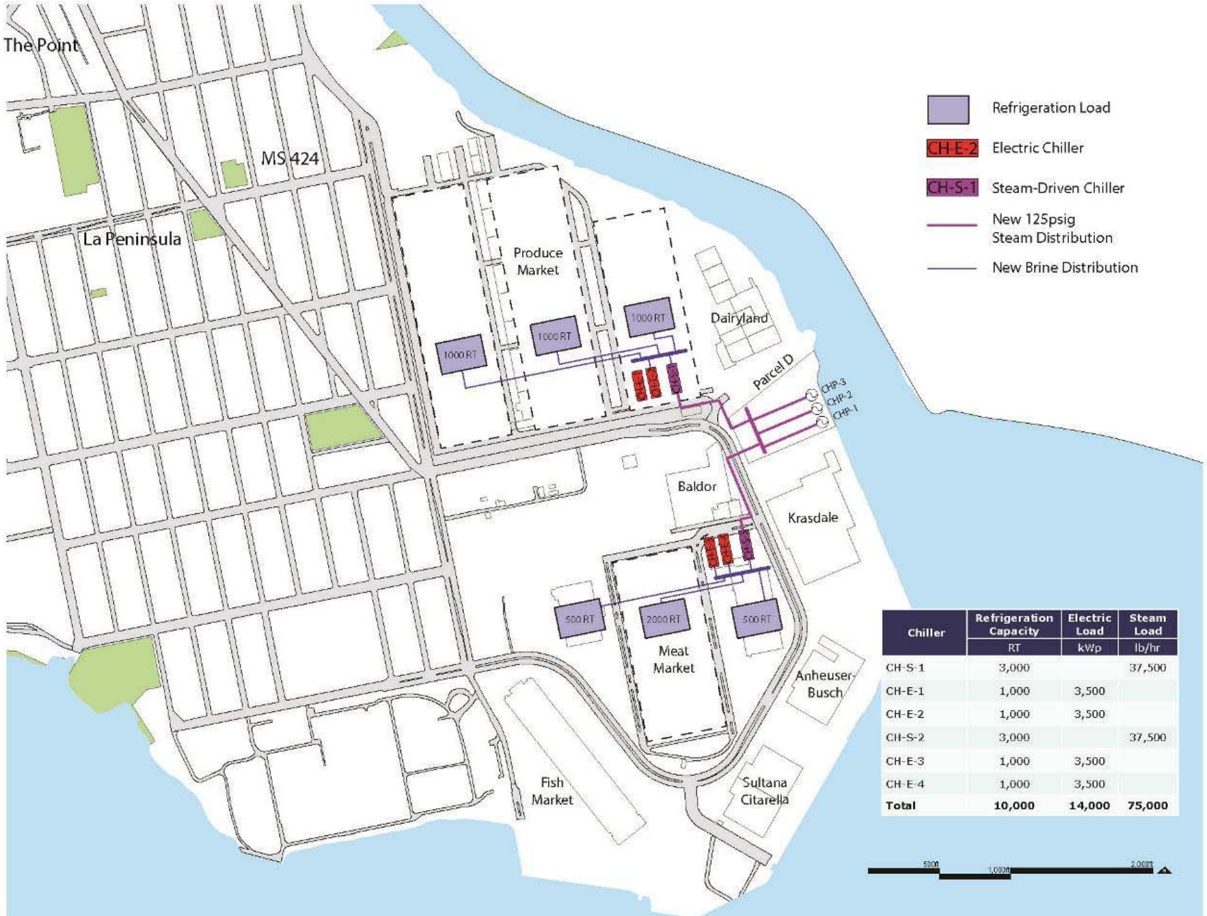
The currently undeveloped and contaminated Parcel D has been identified by NYC EDC as a potential location for housing the microgrid equipment, CHP plant, ground-mounted solar PV and potentially an separately owned and operated Anaerobic Digester and Vertical Farm. From a new Point of Common Coupling, the Microgrid will be connected to the ConEd 13.8 kV feeders in Food Center Drive with two new 13.8 kV feeders. From Parcel D, new electrical feeders and steam distribution will serve the Produce, Meat and Fish Markets from Parcel D. New steam-driven chillers, electric chillers, and rooftop solar PV will be located on the market properties. The Community Facilities will have a new electrical 480 V feeder from the Produce Market and pad-mounted ATS's to ensure electrical supply during a neighborhood grid outage.

The following diagrams illustrate a simplified equipment layout of the proposed electrical and thermal Microgrid infrastructure.



DER	Electric kWp	Steam lb/hr
CHP-1	4,600	25,000
CHP-2	4,600	25,000
CHP-3	4,600	25,000
PV-1	1,400	
PV-2	600	
PV-3	200	
PV-4	800	
PV-5	700	
PV-6	1,000	
PV-7	1,000	
PV-8	200	
Total	**19,700**	**75,000**

Diagram 2: simplified electric equipment layout



Chiller	Refrigeration Capacity	Electric Load	Steam Load
	RT	kWp	lb/hr
CH-S-1	3,000		37,500
CH-E-1	1,000	3,500	
CH-E-2	1,000	3,500	
CH-S-2	3,000		37,500
CH-E-3	1,000	3,500	
CH-E-4	1,000	3,500	
Total	**10,000**	**14,000**	**75,000**

Diagram 3: simplified thermal equipment layout

Apart from the existing ConEd 13.8 kV feeders in Food Center Drive to the Point of Common Coupling, all Microgrid infrastructure equipment will be new. This includes a central CHP plant with gas-fired turbines, electric and steam-driven chillers, and solar PV systems at the markets. Furthermore, new 13.8 kV feeders, transformers, switchgear, Microgrid controls as well as steam distribution to the Meat and Produce Markets will be installed.

New Microgrid control infrastructure includes a central control station similar to the GE Multilin U90+ controller, the GE cimplicity SCADA and the GE D400 Controller Gateway. The chillers and PV systems at the markets will be controlled with local microsource controllers. For communication, a GE MDS orbit 4G Network will be established with a central network access point, local remote control points and MLS2400 Ethernet Switches.

	Type	Location	No./ft./ft^2
New Distributed Energy Resources			
CHP Gas Turbines	CHP	Parcel D	3
Ground Solar PV	PV	Parcel D	200,000 ft^2
Roof Solar PV	PV	Meat Market	125,000 ft^2
Roof Solar PV	PV	Fish Market	125,000 ft^2
Roof Solar PV	PV	Produce Market	400,000 ft^2
Roof Solar PV	PV	MS 424	35,000 ft^2
New Electrical Infrastructure			
Primary Feeder (13.8 kV)	Electric	FCD to Parcel D	300 ft
Microgrid Feeder (13.8 kV)	Electric	Parcel D to Meat Market	900 ft
Microgrid Feeder (13.8 kV)	Electric	Parcel D to Prod Market	800 ft
Microgrid Feeder (13.8 kV)	Electric	MM to Fish Market	2,400 ft
Microgrid Feeder (13.8 kV)	Electric	MS 424	6,000 ft
Transformers (13.8kV to 480V)	Electric	Parcel D (CHP to S/S)	2
Transformers (13.8kV to 480V)	Electric	Meat Market	2
Transformers (13.8kV to 480V)	Electric	Fish Market	2
Transformers (13.8kV to 480V)	Electric	Produce Market	2
HV Switchgear & Protection	Electric	Parcel D	2
HV Switchgear & Protection	Electric	Meat Market	2
HV Switchgear & Protection	Electric	Fish Market	2
HV Switchgear & Protection	Electric	Produce Market	2
Electric Chillers	Chiller	Produce Market	2
Flywheel	Storage	Parcel D	1
New Thermal Infrastructure			
Steam-Driven Chillers	Chiller	Meat Market	1
Steam-Driven Chillers	Chiller	Produce Market	1
Steam Network	Thermal	Parcel D	1
Steam Distribution	Thermal	Meat Market	900 ft
Steam Distribution	Thermal	Produce Market	800 ft
New Microgrid and Building Controls			
MG Control Station Computer	Controller	Parcel D	1

Config/Maintenance/ Monitoring Utility	Controller	Parcel D	3
GE Multilin U90+ Central Microgrid Controller	Controller	Parcel D	1
GE Cimplicity SCADA	Controller	Parcel D	1
GE D400 Controller Gateway	Controller	Parcel D	1
Microsource Controller	Controller	Parcel D	2
BEMS Integration	Controller	Meat Market	1
Control Station Computer	Controller	Meat Market	1
Microsource Controller	Controller	Meat Market	1
Control Station Computer	Controller	Fish Market	1
Microsource Controller	Controller	Fish Market	1
Control Station Computer	Controller	Produce Market	1
Microsource Controller	Controller	Produce Market	1
New IT/Telecommunication Infrastructure			
GE MDS orbit MCR 4G Network Access Point	IT	Parcel D	1
GE MDS orbite remote control point	IT	Meat Market	2
GE MDS orbite remote control point	IT	Fish Market	2
GE MDS orbite remote control point	IT	Produce Market	2
GE MLS2400 Ethernet Switch	IT	Parcel D	4
GE MLS2400 Ethernet Switch	IT	Meat Market	2
GE MLS2400 Ethernet Switch	IT	Fish Market	2
GE MLS2400 Ethernet Switch	IT	Produce Market	2

Table 1: New and existing infrastructure

1.3. Operations

Brief description of operation under normal and emergency conditions

The Hunts Point Microgrid will normally operate in grid-connected mode. The CHP gas turbines will follow the total steam load from the steam-driven refrigeration chillers at the Meat and Produce Markets, which is key to the economical operation of CHP systems. Without additional customers, the CHP gas turbines will often generate more electricity than the total Microgrid electrical load from the Markets and community facilities. This electricity will be used to drive electric chillers if the steam chillers were down for maintenance or fed back to the utility grid at ISO rates. Furthermore, the Microgrid actively pursues secondary customers such as other FDC food businesses (Baldor, Dairyland, Krasdale), a proposed Vertical Farm and Anaerobic Digester, or mixed-use developments in Hunts Point that could offtake some of the electricity. Additionally, the Microgrid will only need to buy electricity from ConEd if the refrigeration load is low and the electricity generated from the CHP turbines and PV systems do not meet the electric demand on cloudy winter afternoons.

During an event of grid-outage, an intentional grid island will be formed that operates solely on electricity and steam supplied within the Microgrid by natural gas turbines and solar PV. In this situation it pays off that the Microgrid CHP turbines are designed to meet both the maximum steam and electricity demand, thus ensuring resiliency even if the steam chillers were down for maintenance at this moment. The operation of the gas-fired turbines relies on the ConEd natural gas network, but we assume that the ConEd natural gas network can supply full gas load and capacity even during a regional power grid outage. However, if the natural gas network is affected as well, the CHP plant will depend on the supply of biogas from the Anaerobic Digester as well as natural gas deliveries by truck. In this case, the Microgrid could also operate at reduced refrigeration levels to still meet operation and food-chain compliance in a limited number of critical warehouses and at the community facilities.

2. Load Characterization

2.1. Existing Electrical and Thermal Loads

Description of loads served by the Microgrid when operating in islanded and parallel modes:

- *Peak KW*
- *Average KW*
- *Annual/monthly/weekly KWh*
- *Annual/monthly/weekly BTU (consumed and recovered)*

The major energy loads in the Microgrid are the freezing, refrigeration and electrical loads of the Meat, Fish and Produce Markets. The electric loads of the Community Facilities are small in comparison. All loads are currently met with electricity and natural gas delivered by ConEd. For an analysis of existing loads, the Meat and Fish Market Coops as well as selected anchor tenants of the Fish and Produce Market authorized access to their ConEd electrical accounts. MS 424 provided 2014 consumption data that could be extrapolated for La Peninsula and The Point. Monthly demand information from Baldor Specialty Foods were analyzed to incorporate a secondary customer. Hourly data were available for the entire Meat Market and the main Fish Market Coop account as they were large enough to have interval metering. Tenants at the Produce and Fish Markets are relatively small and metered individually, so only monthly meter readings were available. Since not every tenant in the Produce and Fish Markets was asked for account access and energy information, the energy consumption of the Produce and Fish Market was extrapolated on a per-square-foot basis from the load data of the coop and anchor tenants.

2014 Annual Electric Loads

Currently, the peak electrical demand of the three markets is 14 MW with an average monthly demand of 12 MW. The Community Facilities and Baldor together add another 2,400 kW. The total annual energy use of the Markets, Baldor and Community Facilities sums up to 75,000 MWh per year with an average monthly use of 6,250 MWh. The combined annual electrical cost of the three markets is $8.6 million. The average cost per kWh in 2014 for all of the markets was $0.125/kWh.

The monthly variance of these loads and electrical use are estimated based on monthly data from ConEd, adjusted on a per-square-foot-basis for the tenants for which no data were available.

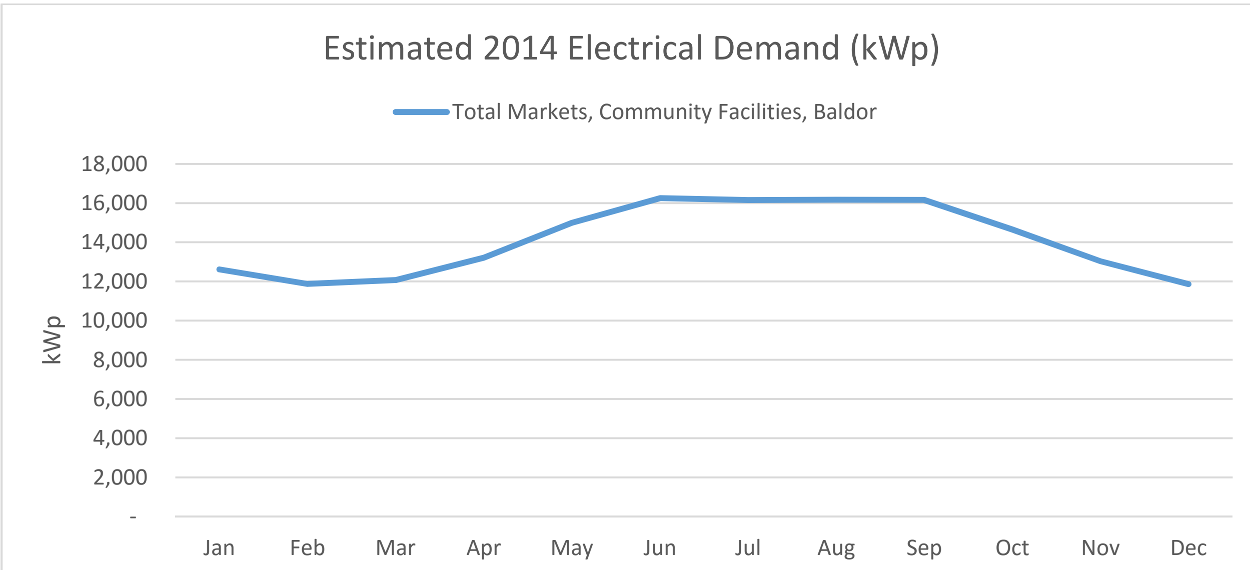


Diagram 5: 2014 Peak Electrical Demand

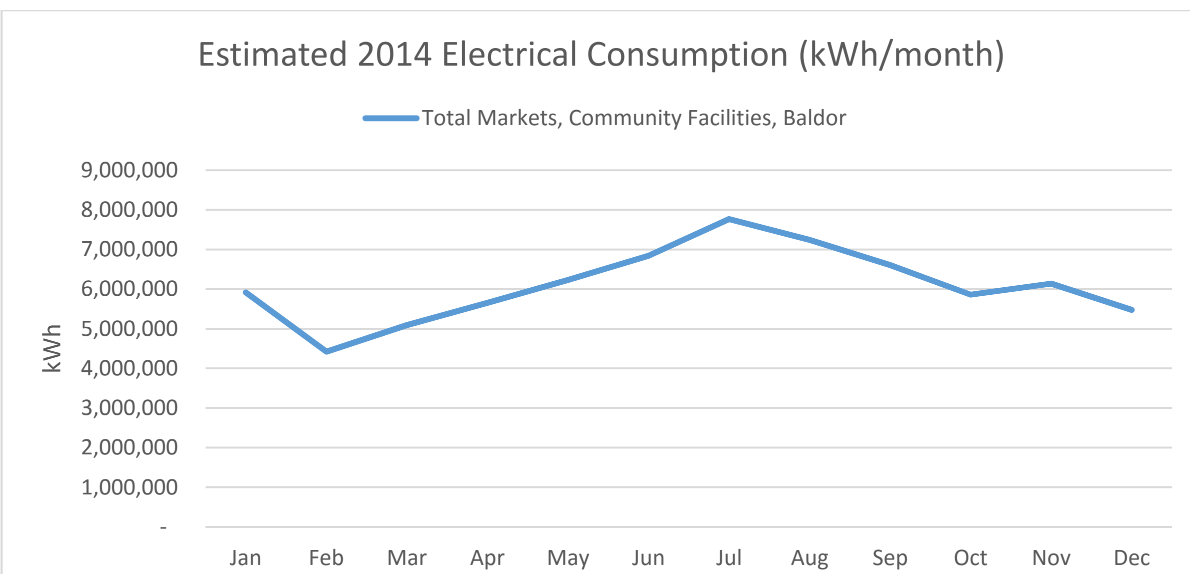


Diagram 6: 2014 Monthly Electrical Consumption

2014 Annual Refrigeration Loads

Most of the Market electrical demand described above is used for refrigeration and freezing. Based on site visits and interviews with the Market managers, it was assumed that 15-20% of electricity is used for comfort cooling, lighting and other electrical loads. With an assumed efficiency of 3 kW per refrigeration ton (RT) for the Meat Market with a central refrigeration plant and 4 kW per RT for the Fish and Produce Markets with packaged rooftop DX units, the peak summer refrigeration demand in the three markets amounts to 3,700 RT (11,200 kW) in 2014. The monthly average is lower at 3,150 RT (9,400 kW), while the winter refrigeration demand is as low as 2,400 RT (8,800 kW).

	Peak Demand (RT)		Avg. Demand (RT)		Winter Demand (RT)	
	RT	kWe	RT	kWe	RT	kWe
Total Markets	**3,700**	**11,200**	**3,150**	**9,400**	**2,400**	**8,800**

Table 3: Existing Refrigeration Loads

Hourly Electricity Loads

The combined electricity load profile during a typical summer weekday shows that the three markets balance each other quite well during the course of the day. While the Meat Market has its maximum load during the daytime hours, the Produce and Fish Markets peak in the early morning hours. As a result, the combined load profile has the peak load of 13.9 MW between 5 and 6 am, while the combined loads only reach 10.1 MW between 5 pm and 6 pm. The average load on a typical summer weekday is 11.8 MW.

In addition to electricity, the markets are connected to the local ConEd gas network and use natural gas for heating and hot water supply. In 2014the total gas usage of the three markets is estimated to be 87.4 million scf of natural gas per year.

Energy Efficiency Opportunities

The **Meat Market** is actively investigating energy efficiency investment opportunities under the guidance of Energywiz, Inc., so most low-hanging EE opportunities have been implemented over the past five years. A major lighting retrofit was completed in 2004 that included new fixtures, advanced lighting controls, and motion sensors throughout the facility. The Meat Market also participates in a voluntary load shed program with ConEd and operates a daily demand management program to reduce afternoon peak loads between 5pm and 8pm. Considering the potential for a new facility in the next 10 years, it is unlikely further EE investments would be made to the existing facilities. As new facilities are designed in the upcoming years, EE opportunities for the new facilities might include highly insulated and airtight construction, reflective roofing, LED lighting, motion sensors, VFD brine and de-icing circulator pumps, and heat recovery ventilation.

The **Produce Market** is also in need of a facility upgrade in the near-term, so EE investments in the existing facilities are unlikely. The biggest EE opportunity for the Produce Market that may prove to be beneficial in the near would be to partially replace truck refrigeration and install electrical service that would allow trucks to plug in to electrical power instead of powering them from their diesel engines as is current typical practice. As new facilities are designed in the upcoming years, EE opportunities for the new facilities would include measures similar to those suggested for the Meat Market: highly insulated and airtight construction, reflective roofing, LED lighting, motion sensors, VFD brine and de-icing circulator pumps, and heat recovery ventilation.

The **Fish Market** facility was constructed ten years ago, so an energy audit may uncover potential EE opportunities in equipment and operations. Lighting retrofits may prove to be cost-beneficial considering the scale of lighting installed in the central spine of the Fish Market. This could include either re-lamping, replacing fixtures or installing advanced controls. An ambitious EE opportunity would be the installation of a more centralized refrigeration plant to deliver refrigeration to the central spine as the packaged rooftop DX units are not the most energy efficient method of delivering refrigeration even though they are the easiest to maintain.

Monthly Variance

The refrigeration and electricity demand in 2030 are assumed to have a similar monthly variance as the current demand, but are adjusted for the cogeneration of electricity and steam that serve the higher refrigeration demand. With steam-driven chillers, the electrical loads of the Meat and Produce Markets only represent the constant demand for cooling, lighting and other electrical demands.

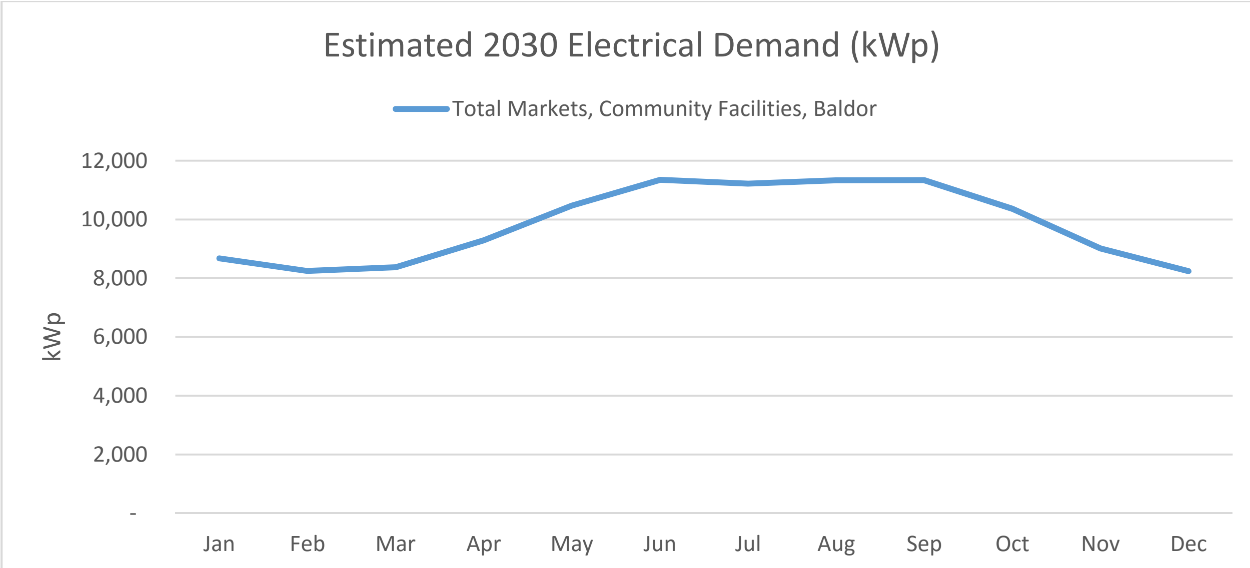


Diagram 12: Projected 2030 Monthly Electricity Demand

The steam demand of the Meat and Produce Markets varys significantly between 45,000 lb/hr in February and 62,000 lb/hr during the summer months:

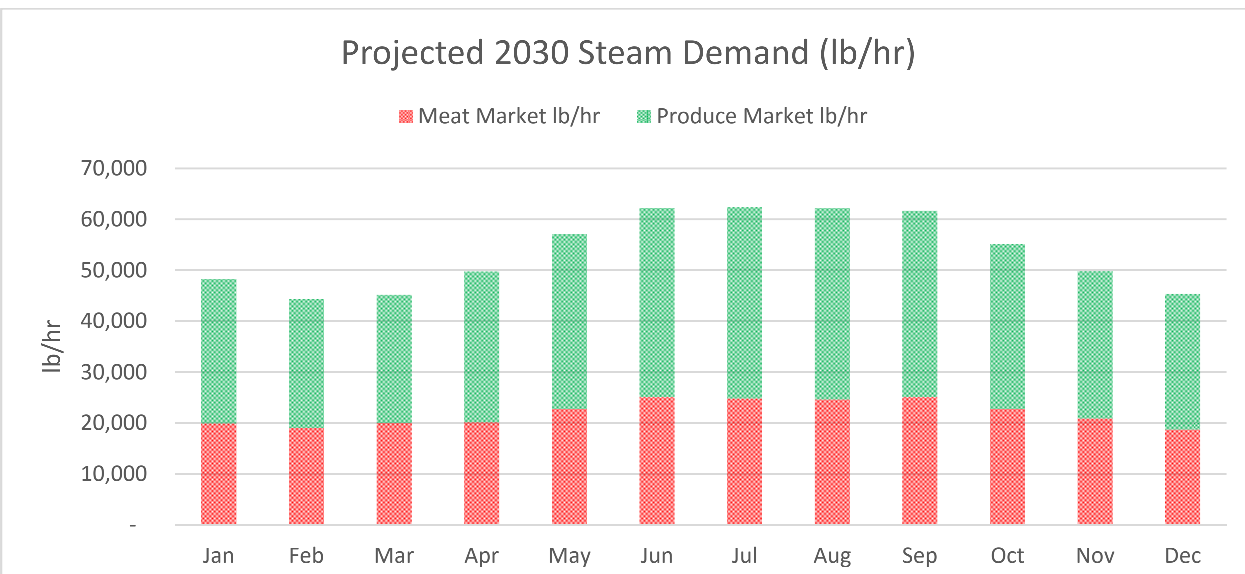


Diagram 13: Projected 2030 Monthly Steam Demand

The electricity consumption of the Fish Market and Community Facilities is not expected to change considerably, and electricity consumption of the Produce and Meat Markets is expected to be reduced considering the cooling load will be delivered through steam consumption. Annual electricity consumption is estimated to total 54 MWh in 2030.

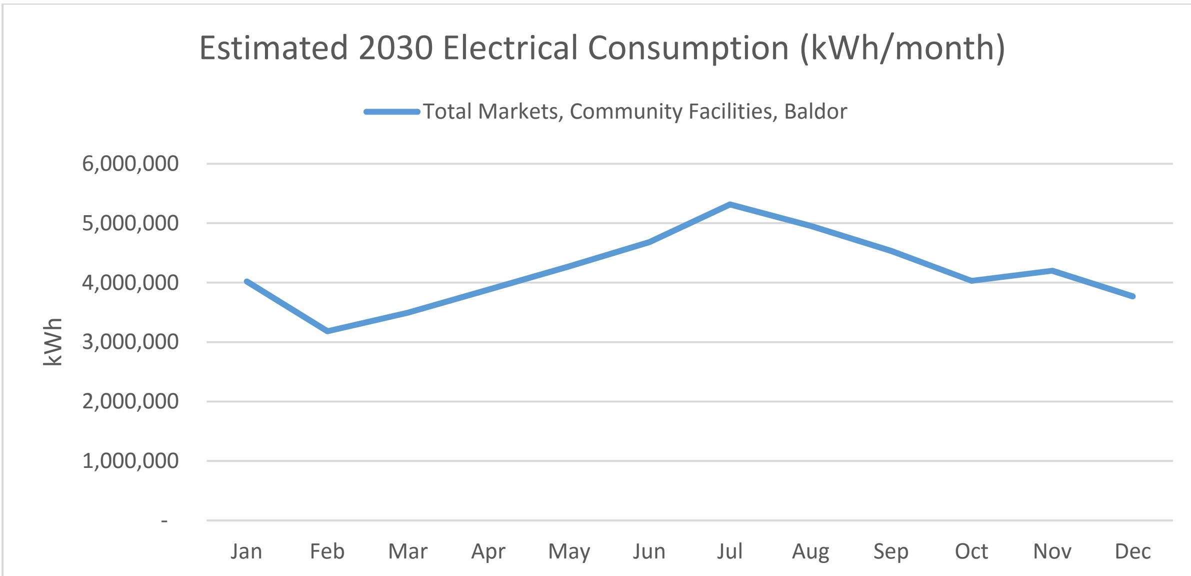


Diagram 14: Projected 2030 Monthly Electricity Consumption

Both the Meat and Produce Market will use steam to meet the increased refrigeration load. In July 2030, the Produce Market could require up to 15,000 Mlb of steam per month, while the Meat Market is expected to consume 17,500 Mlb at its peak in July. Annual consumption in 2030 sums up to 300,000 Mlb per year.

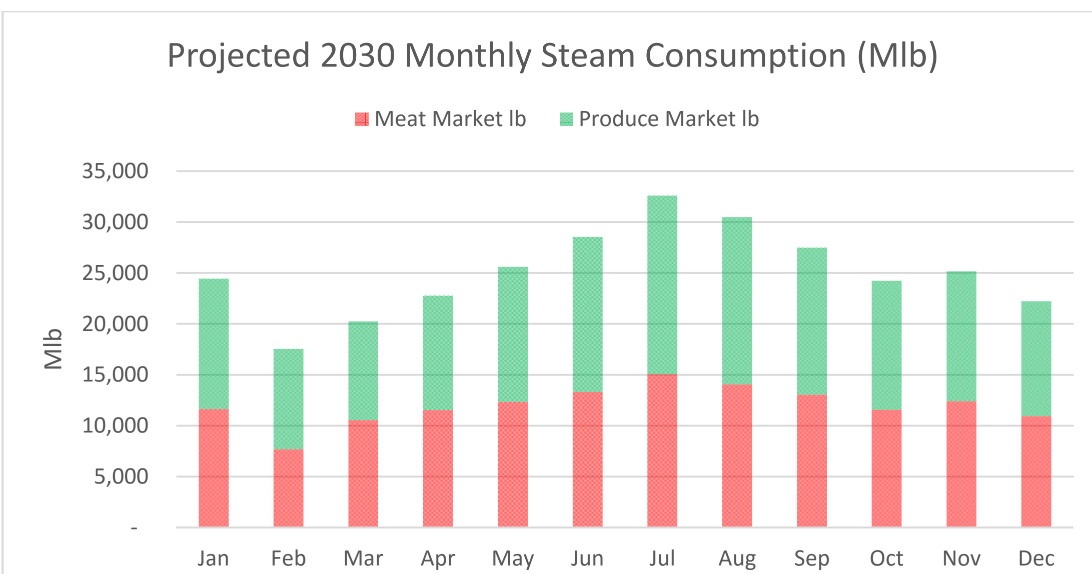


Diagram 15: Projected 2030 Monthly Steam Consumption

2.2. Projected Loads

Description of the sizing of the loads to be served by the Microgrid and any redundancy opportunities (ex: n+1) to account for equipment downtime

Growth Assumptions

The Microgrid has been sized to meet the projected peak loads in 2035. This long timeframe naturally involves a high degree of uncertainty and therefore requires conservative growth assumptions. The future growth of the Food Distribution Center is currently being studied by NYC Economic Development Corporation on behalf of the City of New York. Plans are still very much in discussion with stakeholders, but on March 5, 2015, New York City Mayor Bill de Blasio announced a $150 million capital plan commitment over the coming 12 years to upgrade the Food Distribution Center and make it more resilient and sustainable. Since facility growth plans have not been finalized, the Level team developed growth projections for the purpose of the analysis in this study. The following assumptions were not provided by NYCEDC or from the markets. The Fish Market moved to Hunts Point just ten years ago in a new building and the Meat Market has recently completed Building G, so major changes to these buildings are not expected. However, it can be assumed that the old structures at the Produce and Meat Markets will be subsequently replaced by larger and more efficient buildings over the next twenty years.

For the purpose of this study, we have assumed that the 800,000 SF building of the **Produce Market** from 1967 will be gradually rebuilt into 1,200,000 SF of modern market facilities. First, it could be supplemented by an approximately 300,000 SF building on the vacant parking lot in the East by 2020. This adds capacities that allow the incremental replacement of the existing warehouse rows with a more efficient 450,000 SF building by 2025 and 2030, resulting in a total floor area of approximately 1,200,000 SF. These buildings will likely have higher ceilings to facilitate the stacking of products, which will further increase the building volume refrigeration load, although this effect will be reduced by the higher efficiency of a new central refrigeration plant replacing rooftop chillers (see below). It is therefore expected that the refrigeration load will increase to 3,000 RT by 2030.

Built in 1974, the central **Meat Market** buildings are almost as old as the Produce Market and are therefore also likely to be replaced by larger and more efficient facilities. We assume that

100,000 SF of existing buildings will be demolished by 2025 and that new buildings with a total GFA of 400,000 SF will be constructed. Assuming that these buildings will be higher and contain more freezing the refrigeration load is expected to increase to 2,500 RT by 2030 under conservative assumptions, as the Meat Market is currently already employing energy efficiency measures such as central refrigeration, brine cooling and peak shaving (see below).

The load of the **Fish Market** is expected to remain constant as the building was completed in 2005 and is unlikely to be replaced within the next twenty years. Potential improvements in energy efficiency (see below), such as high efficiency rooftop DX units or Building Energy Management Systems (BEMS), are assumed to be offset by additional refrigeration demand from a projected occupancy increase from 82% in 2014 to 90-95% in 2035.

The growth assumptions for the three markets are summarized in the following table and illustrated in the diagram below.

		2014	**2020**	**2025**	**2030**
Meat Market	Existing Bldg. sf	870,000	870,000	770,000	770,000
	New Bldg. sf	-	-	400,000	400,000
Produce Market	Existing Bldg. sf	800,000	800,000	400,000	-
	New Bldg. sf	-	300,000	750,000	1,200,000
Fish Market	Existing Bldg. sf	320,000	320,000	320,000	320,000
Total	Refrigeration **RT**	**3,400**	**4,500**	**5,500**	**6,000**

Table 4: Market Floor Area and Refrigeration Growth Assumptions

Diagram 11: Growth Assumptions and Development Parcels (assumed for the purpose of this study and do not reflect actual development plans or footprints of proposed buildings)

The future refrigeration demand can be met with both steam and electric chillers that will be installed at the new Produce Market and the existing Meat Market central refrigeration plants. During normal operations, the steam chillers will provide the full refrigeration load at these markets, therefore significantly reducing the electricity demand to lighting, comfort cooling and other electrical uses. The electricity demand at the Fish Market will remain constant as energy efficiency measures offset expected growth in occupancy and electric appliances. The demand at Baldor is expected to increase as a new building is expected to be built on an adjacent parcel. An Anaerobic Digester and an Energy Center could be built on Parcel D by 2020, while a Vertical Farm might follow by 2030. The Community Facilities are not expected to use significantly more energy, even as La Peninsula Headstart might get a larger but more efficient building.

	Unit		**2030**
Meat Market	Electricity	kW	3,000
	Steam	lb/hr	25,000
Produce Market	Electricity	kW	3,000

	Steam	lb/hr	37,500
Fish Market	Electricity	kW	2,300
Vertical Farm	Electricity	kW	3,000
Baldor	Electricity	kW	2,000
AD	Electricity	kW	300
Energy Center	Electricity	kW	600
Community	Electricity	kW	1,200
Total	**Electricity**	**kW**	**15,400**
	Steam	**lb/hr**	**62,500**

Table 5: Electricity and Steam Growth Assumptions with Steam Chillers

Redundancy Opportunities

In the unlikely case that both steam chillers are down for maintenance, the electric chillers have to provide at least the base refrigeration load for all markets. With 3,500 kW electricity usage per 1,000 RT in refrigeration output, this significantly increases the electricity demand that needs to be generated within the Microgrid during islanded mode. With full refrigeration and other electric loads, the electrical peak to be served could be as high as 34,650 kW if both steam-chillers were down for maintenance. In this case, non-critical loads would have to be shed in order to meet all critical demand depending on solar PV generation. However, this would only happen in case of unscheduled maintenance, and normally at least one steam chiller would be operable.

	Unit		**2030**
Meat Market	Electricity	kW	11,750
Produce Market	Electricity	kW	13,500
Fish Market	Electricity	kW	2,300
Vertical Farm	Electricity	kW	3,000
Baldor	Electricity	kW	2,000
AD	Electricity	kW	300
Energy Center	Electricity	kW	600
Community	Electricity	kW	1,200
Total	**Electricity**	**kW**	**34,650**

Table 6: Electricity Growth Assumptions without Steam Chillers

3. Distributed Energy Resources Characterization

3.1. Proposed Distributed Energy Resources

Provide the following information regarding DER and thermal generation resources:

Table 4: i) Type (DG, CHP, PV,…)
ii) Rating (KW/BTU)
iii) Fuel (gas, oil, …)

Description of new DER, their location and space available.

A majority of the DER electricity and steam capacity will come from the natural gas-fired turbines on Site D. Ground-mounted and rooftop PV installations across the site will supplement up to 5.9 MW of electricity. The three gas turbines can operate flexibly at reduced loads and will follow the steam load from the steam-driven chillers at the Meat and Produce Markets. Having both electric and steam-driven chillers at the Meat and Produce Markets further increases flexibility to use the lowest cost fuel source and also ensures redundancy in case of equipment downtime.

The Caterpillar Solar Turbines Centaur 50 serves as reference model for the gas turbines. Each of the three gas turbines generates up to 4,600 kW of electricity (29.3% efficiency) and 7.7 MW (25,000 lb/hr) of steam (49.3% efficiency), resulting in a combined efficiency of 78.6%. The compact design includes a Heat Recovery Steam Generator (HRSG) that generates 25,000 lb/hr of steam at 125 psig and 375° F. Each turbines burns 12,270 kJ/kW$_e$h or (56,912 scf/hr) of natural gas or biogas at full load. These equipment output values are nameplate sizes and do not include parasitic losses.

The potential for Solar PV on the market rooftops can add up to 5.9 MW of installed capacity. The Sharp ND-250QCS solar panels with 250 W and an efficiency of 15.3% serves as a reference model. The Meat Market can use 20% or 124,000 ft^2 of its roof area for solar PV, while the Fish Market has less available rooftop area and can use 40% or 128,000 ft^2 of its total roof area. The future Produce Market buildings are assumed to be built over the next 15 years, which would allow to design rooftops for solar PV and use 50% or 390,000 ft^2 of the projected roof area. Additionally, 200,000 ft^2 of Parcel D could be dedicated for ground-mounted solar PV. With a power density of 153 W/ft^2, the total solar PV area of 842,000 ft^2 can provide 5.9 MW$_e$ of energy to the Microgrid.

The 19.7 MW_e of electric energy and 75,000 lb/hr of steam will be delivered to the markets via electric cables and steam pipes. At the new Meat and Produce Markets, electric and steam-driven chillers in central plants will generate the refrigeration and freezing loads. For the purpose of this study, the new Meat and Produce Market buildings are each assumed to have a central refrigeration plant with one steam-driven and two electrical chillers, while the Fish Market retains its existing rooftop chillers. The Composite CYK electric chiller by Johnson Controls is a packaged chiller that can generate +5° F brine with loads up to 1,000 RT. The JCI Titan Model OM steam-driven chiller can be designed to run with 125 psig steam and meet 3,000 RT of refrigeration (+15° F) and freezing (-10° F) loads with a steam input rate of 37,500 lb/hr. Local boilers can be replaced with steam heat exchangers to better utilize co-generated steam.

The supply of natural gas can be supplemented locally with biogas produced from an Anaerobic Digester (AD) on site. Anaerobic digestion is a natural microbiological process whereby bacteria decompose organic material in the absence of oxygen; the bi-products of this process are “biogas”, consisting primarily of methane, carbon dioxide and water vapor, and a nutrient-rich sludge product called digestate that can be dewatered and used as fertilizer. Food waste, particularly fatty and protein-rich waste, is particularly conducive to the anaerobic digestion process compared to other feedstocks often used in these facilities, producing significant biogas yields high in methane content. A feasibility study by R.W. Beck in July 2010 found that the three markets produce 32,000 tons of organic waste per year (TPY), of which 60% is food waste that well suited for anaerobic digestion. The markets alone, then, generate roughly 19,000 TPY of readily digestable waste. The same study found that this figure could be supplemented with food waste from nearby waste loads in Hunts Point, bringing the total wet weight of organic food waste to 36,000 tons / year. A food waste digester in the City of San Francisco regularly produces biogas at the rate of 6 scf per pound of dry organic waste, regularly producing gas that is 73% methane. Biogas production rates vary depending on the makeup of the feedstock, but the “high strength” – ie, high in fats and proteins – quality of the waste produced in Hunts Point is likely to yield similar results. With those assumptions, an anaerobic digestion facility could produce up to 127 million cubic feet of biogas each year, of which 92.5 million cubic feet will be methane, as shown in the table below. This is equal to 13% of the total estimated 2030 gas demand of the three CHP natural gas turbines.

Food Waste Generation Rate	36,000	wet tons / year
Food Waste Production Rate	9,700	dry tons / year
Biogas Yield	127	million ft^3 / year
Methane Yield	92.5	million ft^3 / year

Table 7: Anaerobic Digestion Waste Input and Biogas Generation

Furthermore, diverting organic waste from landfills to an on-site anaerobic digestion facility at Parcel D reduces the tipping fees for the markets as well as waste to landfill. Biogas produced on site also ensures resiliency, providing a minimal level of service if both the electricity and natural gas networks are interrupted. The primary components of an Anaerobic Digester facility in this setting would include a grinding facility to produce a waste slurry, the digester with a gas holder and mixing system, and a gas scrubbing facility to remove water vapor and hydrogen sulfide gas, both of which will corrode gas turbines. If the digestate is also processed on Parcel D, dewatering mechanisms can be used to produce fertilizer pellets that can be sold.

The new DER discussed above are listed in the following table and identified on the simplified layout below.

Location	Name	Type	Electric (kWp)	Steam (lb/hr)
Parcel D	CHP-1	CHP	4,600	25,000
	CHP-2	CHP	4,600	25,000
	CHP-3	CHP	4,600	25,000
	PV-1	Solar PV	1,400	
	AD-1	Anaerobic Digester	Biogas: 92.5 million scf	
Meat Market	PV-2	Solar PV	600	
	PV-3	Solar PV	200	
Produce Market	PV-5	Solar PV	700	
	PV-6	Solar PV	1,000	
	PV-7	Solar PV	1,000	
Fish Market	PV-4	Solar PV	800	
Community	PV-8	Solar PV	200	
	Total		**19,700**	**75,000**

Table 8: Generating Assets

Location	Name	Type	Electric (kWp)	Steam (lb/hr)	Refrigeration (RT)
Meat Market	CH-S-2	Steam Chiller		37,500	3,000
	CH-E-3	Electric Chiller	3,500		1,000
	CH-E-4	Electric Chiller	3,500		1,000
Produce Market	CH-S-1	Steam Chiller		37,500	3,000
	CH-E-1	Electric Chiller	3,500		1,000
	CH-E-2	Electric Chiller	3,500		1,000
	Total		**14,000**	**75,000**	**10,000**

Table 9: Refrigeration Assets

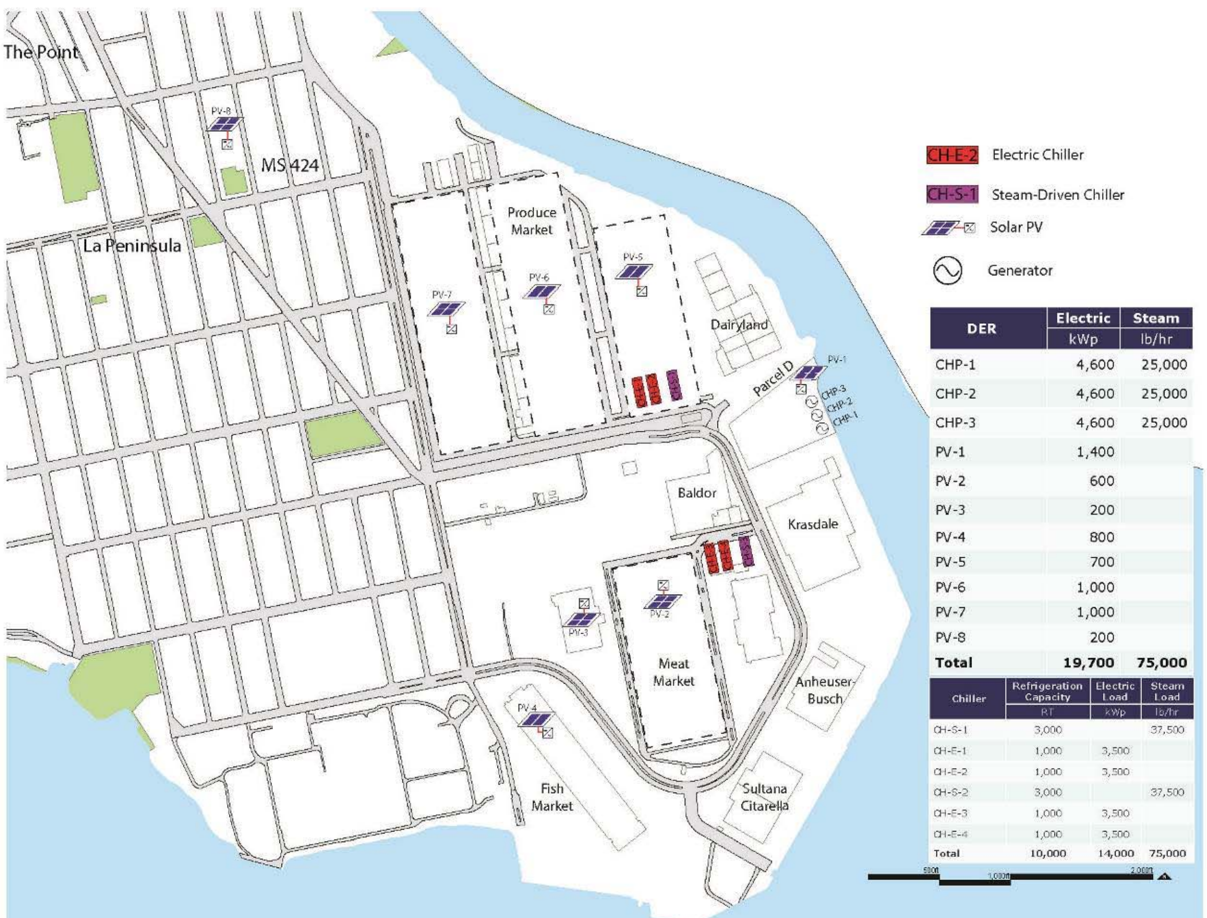


Diagram 16: Generating Assets Simplified Equipment Diagram

3.2. Sizing and Redundancy

Description of adequacy of DER and thermal generation resources to continuously meet electrical and thermal demand in the Microgrid.

Sizing

The total refrigeration demand of the Meat and Produce Markets can be met by two steam-driven centrifugal chillers that can provide 6,000 RT of brine with 75,000 lb/hr of steam from three gas turbines. Alternatively, the refrigeration demand at each market can be met by two electric chillers that can generate 1,000 RT of refrigeration each, for a total of 2,000 RT per market. With 3,500 kW per 1,000 RT, this would increase electricity demand by 7,000 kW and therefore mandate to buy electricity from the grid or – in case the Microgrid is islanded – to shed secondary loads or reduce refrigeration levels. The Fish Market load will remain electrical as rooftop DX units.

The table below compares the maximum electric and refrigeration demand and capacity using steam-driven chillers.

	Peak Electric Demand (kW)	Generating Capacity (kW)	Refrigeration Demand (RT)	Refrigeration Capacity (RT)
2014	16,100	-	3,400	3,400
2020	13,100	16,000	4,500	6,000
2025	13,400	18,700	5,500	6,000
2030	15,400	19,700	6,000	6,000

Table 10: Electric and Refrigeration Demand and Supply with Steam Chillers

Redundancy

The loss of one CHP turbine would reduce the CHP electricity output to 9,200 kW and the steam output to 37,500 lb/hr. This is sufficient to run steam chillers at 66% load (4,000 RT) plus an additional 2,000 RT from electric chillers to meet the 6,000 RT peak load at the Meat and Produce Markets. With solar PV or the grid as a backup, the peak demand can still be met completely and the gas turbines have n+1 redundancy. Without, secondary loads have to be shed but the critical market refrigeration and Community Facility loads can still be met.

For the electric chillers at the markets, n+1 redundancy is ensured as the steam-chiller alone could provide the peak load of 3,000 RT at the Meat and Produce Markets. If both steam chillers are out of operation, the electric chillers could only provide 4,000 RT, which would still suffice to meet the critical loads by consolidating products in fewer warehouses and reducing cooling temperatures. Nevertheless, maintenance for steam chillers should be scheduled during weekends or winter months to ensure full capacity when the refrigeration loads are highest.

Solar PV is not required to meet the critical and refrigeration loads, but instead serves as a renewable source of energy to supplement the gas turbines. As a result, n+1 redundancy is given for all proposed DER equipment even without the use of electricity from solar PV and the grid to maintain critical refrigeration and community services.

3.3. Fuel Sources

Description of fuel sources and how many days of continuous operation of the Microgrid can be achieved with the current fuel storage capability or which additional fuel storage is required.

The primary generation source is natural gas, which fuels the CHP turbines and, in turn, the electric and steam-driven chillers that provide the base load of the Microgrid. Under normal conditions, natural gas can be obtained from the ConEd natural gas distribution network. The three Centaur 50 natural gas turbines have a heat rate of 12,270 kJ/kW$_e$h, which translates to 170,740 scf of natural gas per hour. The ConEd natural gas network is highly reliable and unlikely to fail at the same time as the electric grid. Nevertheless, the establishment of an Anaerobic Digester facility on site could utilize 36,000 tons of organic waste generated on site to provide 92.5 million cubic feet of biogas per year, covering 9.5% of the annual natural gas demand, which is estimated at 989 million scf per year in 2030.

3.4. DER Resiliency

Parcel D houses most DER facilities, including CHP turbines, solar PV and the Anaerobic Digester, and is located in a 100-year flood zone adjacent to the Bronx River and East River. Flooding is therefore the highest local natural risk to the DER facilities on Parcel D. This risk could be reduced by elevating Parcel D to +18.0’ (NAVD88), which is above the projected 100-year floodplain in 2050 when considering a moderate estimate of sea level rise due to climate change. The U.S. Department of Housing and Urban Development awarded $20 million to improve resiliency at Hunts Point as part of the Rebuild By Design process. This award was supplemented in November 2014 by another $25 million by the City of New York. Specific projects to be funded with the award have not yet been determined, but the elevation of Parcel D would serve both community objectives of flood protection and energy resiliency. Rooftop PV installations at the Markets will be designed to withstand Category 3 hurricane force winds as the peninsula is exposed in an unprotected location.

Black start capabilities of the DER units contribute significantly to resiliency. Normally, the units can start with energy supplied from the grid or from other DER within the microgrid. However, there may also be a scenario when generation sources within the microgrid are not energized at the time of a grid outage. In this case, the tie breakers would automatically disconnect the Microgrid and the DER units have to black start during islanded mode. Solar DER inherently begin charging from black start conditions upon solar insolation onto the panels generating current. The natural gas-fired CHP DER will require auxiliary power to black start from a de-energized condition. This power will be provided by a small diesel generator, the cost of which are included in the CHP system. A supply of diesel and regularly maintenance and testing will be included in operating expenses. The black start of one gas turbine would provide enough energy to start the other turbines and thus provide enough electricity and steam to start the chillers in a controlled and stable sequence in cooperation with the Markets.

3.5. Ancillary Service Capabilities

Description of the capability of DER including black start, load-following, part-load operation, voltage and frequency maintenance, capability to ride-through voltage and frequency events in islanded mode, capability to meet interconnection standards in grid-connected mode

Theoretically, the Hunts Point Microgrid could provide black start capabilities to the utility. As the Microgrid would still be operating in islanded mode or be able to black start from within, this ancillary service would only require a coordinated reconnection and synchronization with the grid. However, the need for black start support depends on the proximity to power generation facilities. A meeting with ConEd revealed that there are no utility generating facilities in the proximity of Hunts Point that would require black start support from the Hunts Point Microgrid.

The operators of the utility as well as the Microgrid will have to continuously balance the voltage and frequency drops that are caused by unpredictable changes in energy demand and supply. This requires advanced grid-interactive inverters as well as flexible energy generation and storage resources. The Hunts Point Microgrid will have an intelligent Microgrid master controller (MCC) that balances supply and demand within the Microgrid by controlling local microsource controllers (MC) of the gas turbines and a flywheel. The gas turbines mostly follow the thermal load of the steam-driven chillers, where a drop/rise in steam pressure indicates higher/lower cooling demand and thus requiring more/less turbine power. The flywheel with adjustable spin rate will balance out the short-term effect on the electric voltage and frequency. Thanks to the modular setup of multiple gas-turbines, steam-driven and electric chillers, the Microgrid can follow the internal and external loads and also operate with partial loads by turning off some generators and running others at 35%-100% capacity. This flexibility also allows the Microgrid to ride through voltage and frequency events in islanded mode without the support of the utility grid.

Thanks to the internal stability of the Microgrid, it can also provide frequency and voltage control services to the utility grid when required. In this case, the grid operator will send a request to the MCC to increase or decrease power generation and thus to sell or buy energy from the grid. If the frequency and voltage differences become too large, the Microgrid will automatically disconnect from the grid and operated in islanded mode until the interconnection requirements are met and the Microgrid can resume grid-connected operation.

4. Electrical and Thermal Infrastructure Characterization

4.1. Electrical Infrastructure

High-level description of electrical infrastructure

Feeders

Every customer at Hunts Point is currently connected to the ConEd electrical network by three 13.8 kV feeders that follow Food Center Drive and originate from the Mott Haven substation. The proposed CHP plant and Microgrid Control Center on Parcel D will be connected to the utility grid at a single Point of Common Coupling by tying into two of the three existing feeders in Food Center Drive. This requires approximately 300 feet of new feeder lines that will be installed by ConEd to ensure that all interconnection requirements are met, but paid for by the Microgrid developer. These requirements for high-tension service are specified in publication EO-2022.

Microgrid Feeders

New underground feeder lines will be laid from Parcel D to the Meat, Fish and Produce Markets as well as to the Community Facilities. The total length of new Microgrid Feeder Lines is approximately 10,100 feet. Cost for these feeders will be borne by the Microgrid developer, while feeders to other customers are subject to negotiations as part of a Power-Purchase Agreement.

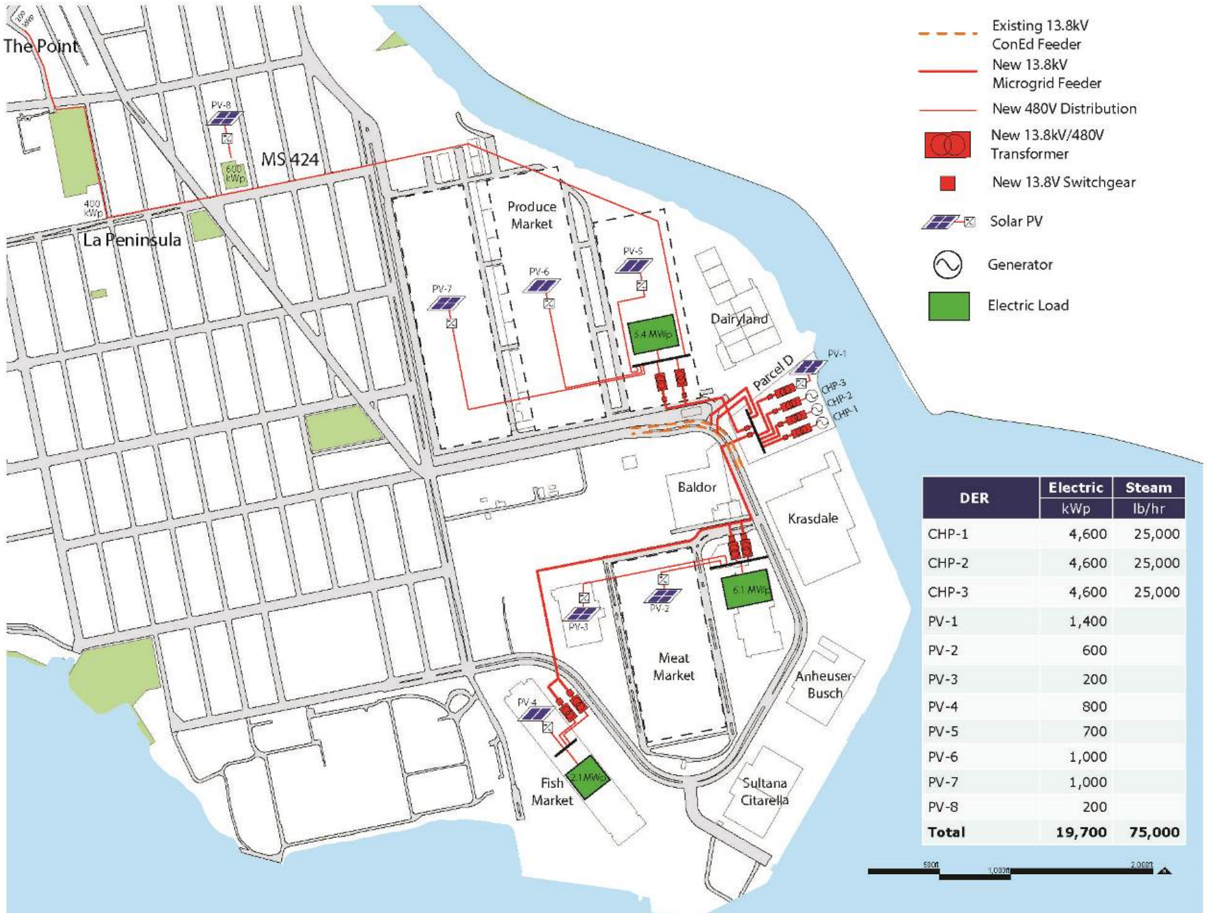
Relays

The existing electrical infrastructure will be supplemented or replaced with new Intelligent Electronic Devices (IEDS) as required. They will have three Ethernet communications ports and be able to communicate using multiple protocols (ModBus, DNP-3.0, IEC 61850, etc.) to provide reliable protection and control capabilities as required for Microgrid Control and Protection. The IEDS will be equipped with redundant communications and utilize GPS time synchronization to provide time-stamped data for analysis of the performance of the Hunts Point Microgrid. All relays will be equipped with waveform capture. The relays, such as GE UR relays, will allow for easy field repair by the exchange of defective modules thus providing quick and easy repair by field personnel.

Breakers, Switches and Instrument Transformers

All electrical infrastructure will utilize new equipment that is compliant with current standards (ANSI, IEEE, IEC, NEMA, etc). This equipment will utilize smart monitoring and control equipment that is fit for purpose. This will provide the Microgrid with additional reliability and resiliency. The existing equipment will be evaluated to assure that the Hunts Point Microgrid will meet the required level of performance and retrofitted with monitoring devices as necessary.

The location of new electrical infrastructure is illustrated in the diagram below.



DER	Electric	Steam
	kWp	lb/hr
CHP-1	4,600	25,000
CHP-2	4,600	25,000
CHP-3	4,600	25,000
PV-1	1,400	
PV-2	600	
PV-3	200	
PV-4	800	
PV-5	700	
PV-6	1,000	
PV-7	1,000	
PV-8	200	
Total	**19,700**	**75,000**

Diagram 17: Location of new electrical infrastructure on the simplified equipment layout

4.2. Thermal Infrastructure

High-level description of thermal infrastructure

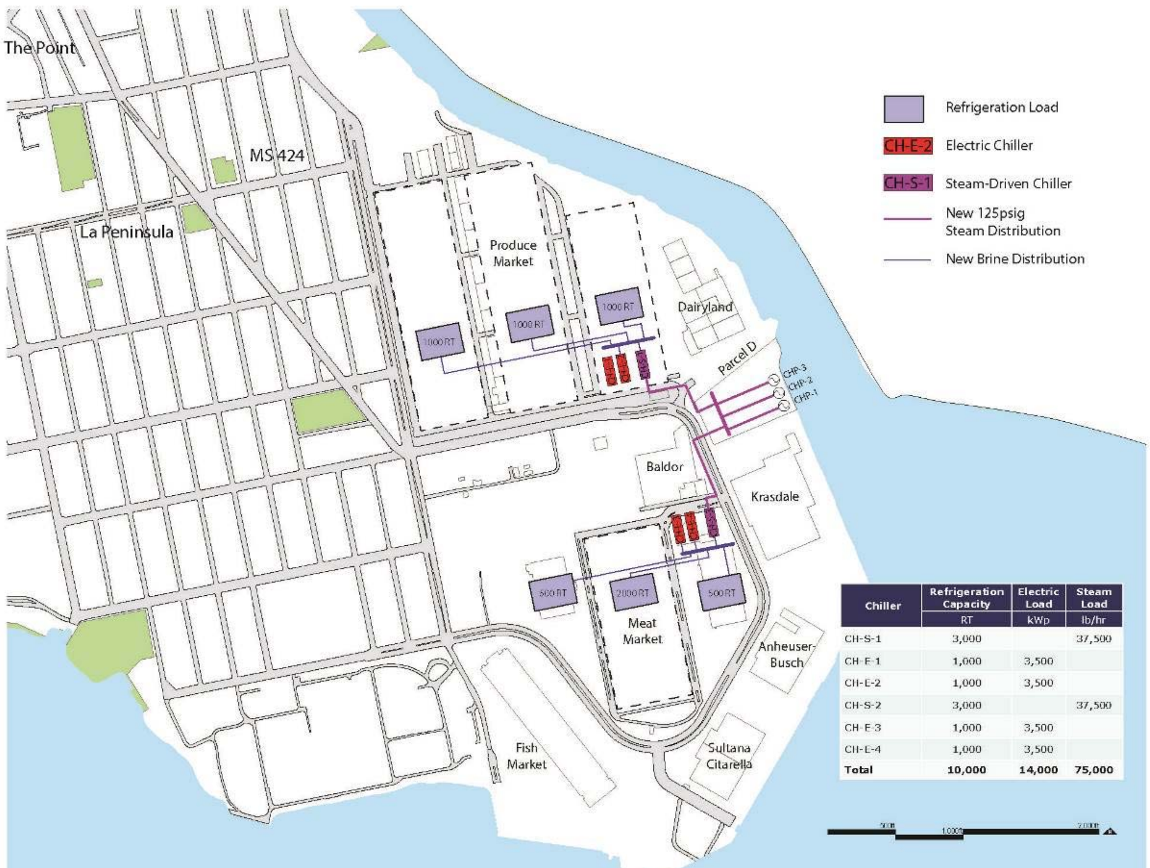
Steam Pipes and Condensate Return

To deliver steam from the three CHP gas turbines with Heat Recovery Steam Generators to the steam-driven chillers at the Meat and Produce Markets, approximately 3,000 feet of steam pipes and condensate return with pumps have to be laid from Parcel D. Both markets are comparably close and the steam pipes only have to cross one public right-of-way. Connecting the Fish Market would not only require an additional steam-driven chiller, which is considerably oversized for the smaller refrigeration load at this market, but also an additional 3,000 feet of underground steam pipes, which is why it has not been included in this Microgrid proposal.

Refrigeration Distribution

Both the electric and steam-driven chillers will generate brine at -15°F for freezing and +15°F for refrigeration at the Meat and Produce Market central plants. Since the brine is chilled at a central refrigeration plant, a brine network for both types of brine is necessary to distribute it to the individual buildings at the markets. This is already the case at the current Meat Market, but will also have to be implemented at the future Produce Market buildings. Since these pipes run within the markets, they are considered part of the capital investment into these markets and will not be included as part of the Microgrid within this feasibility study.

The new thermal infrastructure for steam and brine is illustrated in the following diagram.



Chiller	Refrigeration Capacity	Electric Load	Steam Load
	RT	kWp	lb/hr
CH-S-1	3,000		37,500
CH-E-1	1,000	3,500	
CH-E-2	1,000	3,500	
CH-S-2	3,000		37,500
CH-E-3	1,000	3,500	
CH-E-4	1,000	3,500	
Total	**10,000**	**14,000**	**75,000**

Diagram 18: location of new thermal infrastructure on the simplified equipment layout

4.3. Distribution Resiliency

Description of how resilient the electrical and thermal infrastructure will be to the forces of nature that are typical to and pose the highest risk to the location/facilities. Description of how the Microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time. Discussion of the impact of severe weather on the electrical and thermal infrastructure

As described above, major parts of the FDC are located within a 100-year flood zone adjacent to the Bronx River and East River. The existing ConEd feeders are laid underground, but many of the manholes, vaults and transformers are still not flood-proof. Flooding therefore poses the main risk to lose connection with the macro grid, especially since ConEd could intentionally interrupt electric service to prevent additional damage to electrical equipment. In this case, it could take days to energize feeders piece by piece after checking that there is no water damage.

Therefore, it is crucial for the Microgrid design that all distribution cables and steam pipes will be laid underground in waterproof protected trenches and manholes. All new parcel-level switchgear and transformer equipment throughout the Hunts Point Microgrid will be designed above the +18.0’ elevation and protected from flooding and storm damage. It is imperial to the whole Microgrid design that every step – from generation to distribution – is resilient to flooding, which is the main risk for the utility grid to fail and the reason for the existence of the Microgrid.

4.4. Grid Interconnection

Description of how the Microgrid will be interconnected to the grid (single or multiple points of interconnection?).
Summary of additional investments in utility infrastructure may be required to allow the proposed Microgrid to separate and isolate from the utility grid.
Description of the basic protection mechanism within the Microgrid boundary.

The Microgrid will be connected to the utility at single Point of Common Coupling (PCC) at Parcel D that ties into the two high voltage feeders in Food Center Drive. The capacity of the feeders will need to be studied by ConEd to determine if additional infrastructure investment is necessary apart from a 300 feet underground connection as specified in specification EO-2022.

The utility grid and Microgrid will be protected by monitoring voltage and frequency at this point. If a specific level of under frequency (UF) or under voltage (UV) is detected for a defined period of time, then a tie breaker will be opened automatically to separate the Microgrid from the utility. The Microgrid will also be disconnected from the utility if system faults external to the Microgrid are detected or if instructed to do so by the utility dispatcher. The UF and UV values and times as well as the tripping of the tie breaker for faults will be established based upon values/conditions specified by ConEd. The Microgrid Central Controller will coordinate the response of the Microgrid upon separation from the utility. The MCC will monitor the status and power values of the Microgrid loads and generation and act to maintain the generation load balance of the Microgrid. The balance may be effected by various means (load shedding or generation dispatching) depending the state of the Microgrid as discussed in chapter 3.4.

The MCC will incorporate controls to detect that the utility system voltage and frequency has been restored. The MCC could initiate auto restoration to the utility, but to protect the stability of the utility grid, the Microgrid operator will await a permissive communication signal from the utility dispatcher before restoring the utility connection. The MCC will incorporate an automatic synchronizer to assure frequency and voltage matching of the Microgrid with the utility system. Upon closing of the tie breaker, the Microgrid will revert to normal operation.

5. Microgrid and Building Controls Characterization

5.1. Control Architecture

High-level description of control architecture and how it interacts with DER controls and Building Energy Management Systems (BEMS)

The Microgrid Central Controller (MCC) will consist of an active network control system that optimizes demand, supply and other network operation functions within the Microgrid based on smart metering. Manual control of the DER system by the Microgrid owner/operator will be incorporated into the MCC as will utility defined automatic and manual controls and voice communications with the grid operator to facilitate seamless interconnection and islanding.

The Microgrid Central Controller coordinates the operation between the Microgrid and the main grid and thus ensures system integration. By commanding local Intelligent Electronic Devices (IEDs) at the Markets and Community Facilities in response to changing loads in the Microgrid, the MCC maintains the voltage and frequency required by the utility grid and can even contribute to its stability through frequency and voltage control. In normal operation, the MCC further optimizes energy generation to maximize renewable energy sources, fuel savings and return on investment. Incentive pricing systems both within the Microgrid and the main grid make sure that the DERs at the Markets and MS 424 are available when they are needed in order to maximize compensation and avoiding financial penalties.

This requires a dynamic metering system on both energy sources and loads within the Microgrid. At the new Meat and Produce Market buildings, one electricity meter and one steam meter will be installed at a single point of the incoming service location. The tenants will be billed for electricity and brine on a pro-rata share based on square footage, refrigerated area and temperature, similar to the current system at the Meat Market. The Fish Market tenants will continue to have individual electricity meters, but these will be upgraded to be smart meters and billing would be taken up by the Microgrid Developer, while building energy efficiency measures and Building Energy Management Systems are coordinated by the Fish Market Coop. The Community Facilities and all other customers will continue to be metered individually.

The new Microgrid controls are illustrated in the diagram below.

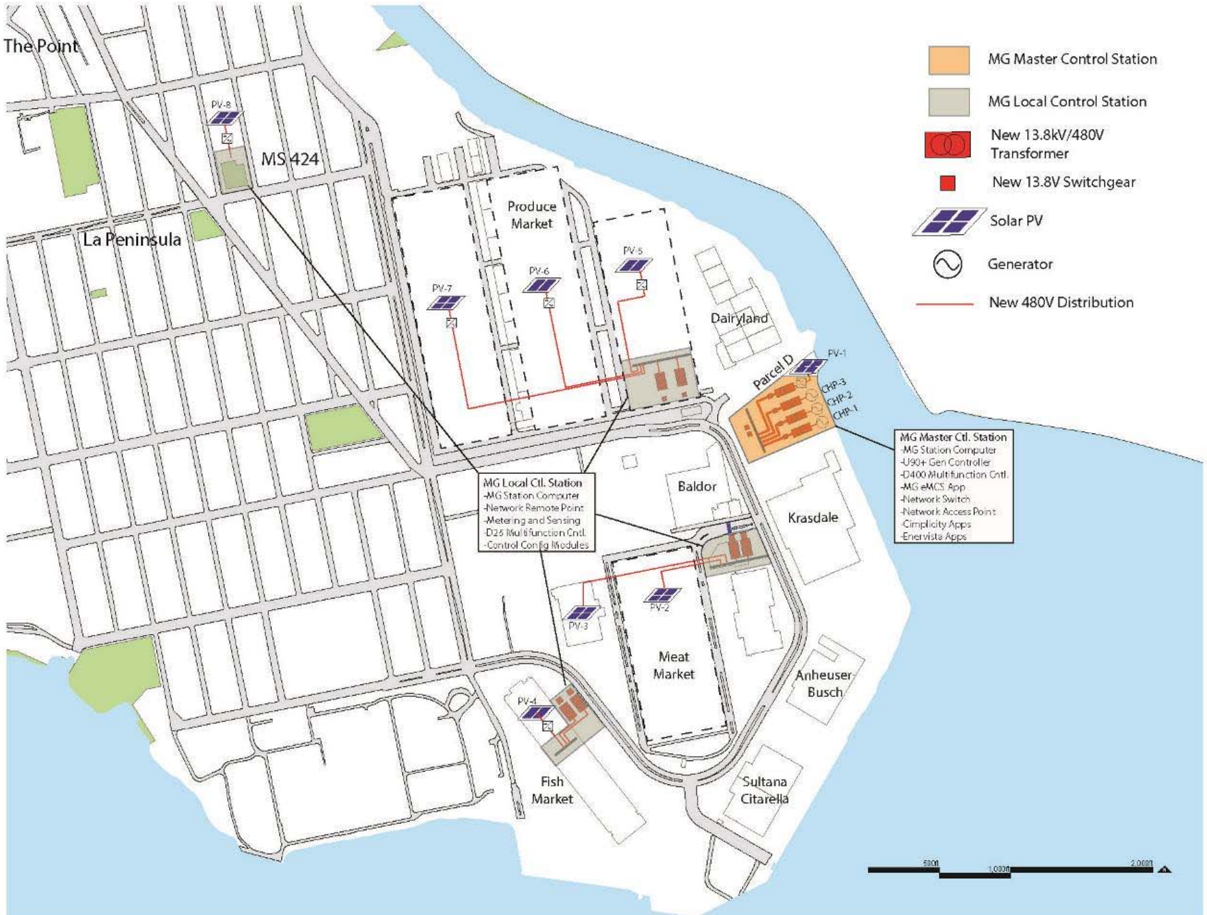


Diagram 19: New Microgrid and building controls on the simplified equipment layout diagram

5.2. Microgrid Control Services

Brief description of the services that could be provided by the Microgrid controls

A GE Grid IQ Microgrid Control System together with the U90Plus Generation Optimizer serve as reference Microgrid Controller. The core function is to monitor, track and forecast load and generation resources within the Microgrid. A smart dispatch system sends commands to local microsource controllers at gas turbines and solar PV to meet predicted load requirements at lowest cost while maximizing the use of renewable energy resources. This requires adequate load and generation forecasting based on past data logging and weather predictions, which influences cooling need and solar PV generation. The GE Grid IQ Microgrid Control System continuously monitors the frequency and voltage of the Microgrid and the grid connection and will automatically disconnect from the grid if defined UF and UV thresholds are met for a specified period of time. It will then operate the system in islanded mode until the Microgrid operator receives a signal from the utility to reconnect and synchronize with the grid. The U90^{Plus} Generation Optimizer will also control the electric and steam-driven chillers at the markets based on their specifications, which allows better demand management including previously negotiated economic dispatch, demand response and load shedding in islanded mode. With this optimized control of both generation and loads within the Microgrid, the GE Grid IQ Microgrid Control System is able to automatically coordinate frequency and voltage control services with the utility and sell excess electric energy to the grid if economically reasonable. This will be especially the case during hot summer afternoons, when the loads within the Microgrid are lower and the ISO offers higher electricity feed in tariffs.

GE is continuing to develop new capabilities within the Grid IQ Microgrid Control. GE Global Research Center is developing additional functionalities for an advanced eMCS for the Potsdam Resiliency Project. The timing of the Hunts Point Project should allow for the deployment of the eMCS as we look to build upon the Department of Energy and GE funded developments. GE GRC is evaluating the inclusion of market based participation service in the eMCS. These services can be supplemented with separate GE market participation software depending upon the requirements of the market.

The U90^{Plus} provides for optimized dispatch of all generating resources based upon economic dispatch and a unique load forecasting capability. The forecast and economic factors used can be adjusted externally to respond to market and weather conditions by the GE Cimplicity SCADA. This system will be coupled with external weather forecasts and the potential implementation of a PV forecast system to allow intra-hour forecasting of the PV system. These techniques will be evaluated during the detailed design stage to provide enhanced resiliency and control of the Microgrid when islanded.

The GE Cimplicity SCADA solution will provide the ‘window’ into the Microgrid and common point of coupling for all of the Microgrid Control Systems as well as all IEDS and Meter. GE has implemented hundreds of SCADA solution for utilities and industrial facilities with this solution. The system will include a separate Kepware OPC server to provide data storage and the common protocol interface with the updated building controls.

5.3. Controls Resiliency

Discussion of the resiliency of the Microgrid and building controls as well as the impact of severe weather on the Microgrid and building controls.

The Microgrid Controllers and communication system will be designed with redundancy built into the SCADA/Data servers as well as the communications architecture. End devices will utilize redundant communication ports and, if a controller or IED is deemed to be a critical element, redundant IEDs will be used. The decision to apply redundant controller/IEDs will be evaluated during the detailed design phase.

As with the Microgrid DER and Infrastructure (see chapter 3.4 and 4.3), all Microgrid controllers will be designed above the +18.0’ elevation and protected from flooding and storm damage. This includes the Microgrid Central Controller (MCC) on Parcel D, the Intelligent Electronic Devices (IEDs) controlling the energy resources and Smart Meters at the Market buildings and Community Facilities.

6. IT/Telecommunications Infrastructure Characterization

6.1. IT/Telecommunications Infrastructure

High-level description of the IT/Telecommunications Infrastructure

Wide area network (WAN)

The wide area network for communications will be installed both wireless and with a physical cable, thus complying with the requirements of ConEd and ISO-NY as well as local emergency management centers. Specific details of these systems will be identified during the detailed design phase. The specific communication architecture of the WAN will be developed in tandem with all external entities and will be fully defined during the detailed design stage. These solutions are well understood and we do not envision any significant issues in developing WAN for this project.

Access points

The CHP plant and Microgrid controller will be located on the central and currently unoccupied Parcel D. This will be the central access point for the Microgrid communication and control architecture. The Microgrid Operator and Dispatcher will be located here and have access to the external WAN communications with all external entities. The monitoring and control of the Microgrid will reside on the GE Cimplicity HMI/SCADA. The communication architecture for Hunts Point will utilize applications specific fiber optic rings. The control and monitoring of the Microgrid will utilize dedicated, redundant rings to provide for enhanced cyber security, reliability and resiliency. Each building and electrical equipment location facility will have dedicated, redundant Ethernet switches. These switches will then utilize fiber rings within the facility, if needed due to communicate with dispersed, multiple controller/equipment locations. The switches will utilize radial feeds to individual controllers and measurement devices. The IEDs will be equipped with redundant communication ports. Each port will be connected to a redundant Ethernet switch. Communication cables within cabinets will be fiber or Cat5/6 cable.

As previously indicated, the communication protocols for the control and data acquisition from the controllers, IEDs and meters will be device specific. The system architecture will utilize Modbus TCP, DNP-3.0, IEC 61850 or other protocols as required. Typical building controllers utilize BacNet protocol. The system will include protocol converters as needed and data collection will be to a common Kepware OPC server(s). Kepware offers a large library of protocol drivers making it an attractive choice for a data server.

The proposed Microgrid communication and control infrastructure is illustrated in the diagram below.

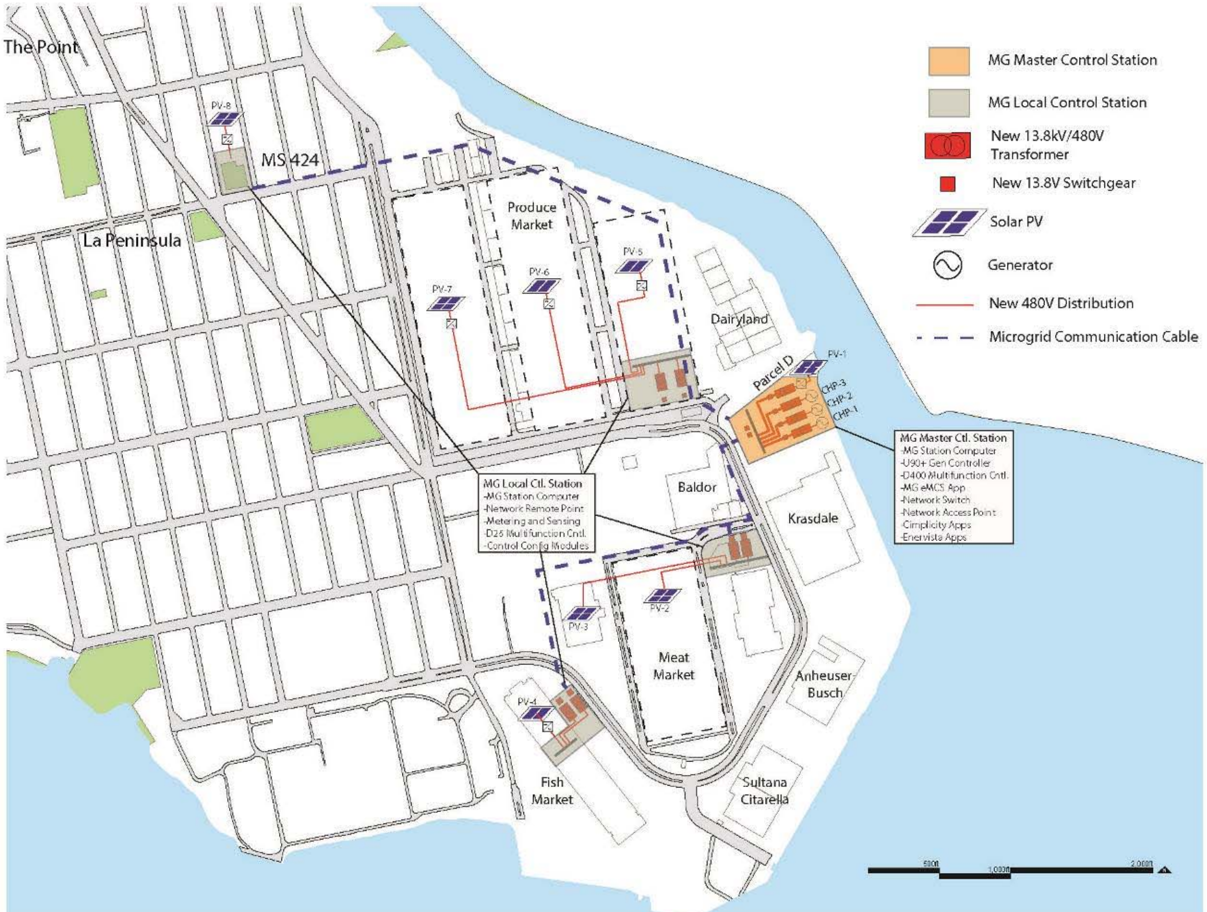


Diagram 20: New communication infrastructure on the simplified equipment layout diagram

6.2. Communications

Brief description of communications within the Microgrid and between the Microgrid and the utility and if the Microgrid can operate when there is a loss in communications with the utility

The communication of key Microgrid data to/from the utility will conform to the utility's standard requirements. This would typically include a Remote Terminal Unit/Gateway that communicates using the protocol defined by the utility, typically DNP-3.0. A GE Wurldtech Firewall or utility defined would be employed to provide the necessary cyber security.

An Operations Protocol will need to be developed in the situation where there is a loss in communications with the utility. If voice communications with the utility were lost, then the Microgrid Operator would need to monitor the performance of the Microgrid until these communications were restored. If the utility system is operating within normal limits, then the Microgrid would remain connected. Normal operation of the Microgrid would continue. If the utility system voltage and frequency were to deviate from normal, then the protection circuits would act automatically to island the Microgrid. The Microgrid would remain islanded until such time as voice communications were restored.

The failure of the control and monitoring communications to/from the utility would require the Operator to contact the utility operator. A joint decision would be made when and whether to island the Microgrid.

6.3. Communication Resiliency

Discussion of the resiliency of IT and telecommunications infrastructure

The IT and telecommunications infrastructure will be designed to use redundant paths to assure resiliency of these systems, as described above. The failure of the redundant paths will default to the Operations Protocols discussed in the previous section.

Appendix III: Commercial and Financial Report

1. Commercial Viability - Customers

1.1. Critical Customers

Identify the number of individuals affected by/associated with critical loads should these loads go unserved (e.g. in a storm event with no microgrid).

The Hunts Point (HP) Food Distribution Center (FDC) in the South Bronx provides 60% of New York City's produce, meat and fish and feeds nearly 22 million people in the region each day. The FDC stores, on average, three days' worth of meat and produce. As such, constant refrigeration and freezing at these facilities is therefore critical to business continuity and the integrity of the region's food supply.

The **Hunts Point Cooperative Market (Meat Market)** was opened in 1974 and consists of six large refrigerated and freezer buildings, including a central refrigeration plant. The market is home to 32 merchants with approximately 2,400 employees, capturing approximately $3.2B in revenue per year.

The **Hunts Point Terminal Market (Produce Market)** opened in 1967 and consists of four long warehouse buildings totaling approximately 800,000 SF of floor area, making it the largest produce market in the country. The market is home to 40 cooperative merchants with roughly 3,000 employees, capturing an estimated $2.3B in revenue per year.

The **New Fulton Fish Market (Fish Market)** relocated to Hunts Point in 2005 from lower Manhattan, where it opened in 1807, making it the oldest and largest wholesale fish market in the country. The Fish Market has 32 cooperative wholesalers employing around 650 employees and captures an estimated $1.0B in revenue per year.

If the refrigeration and freezing loads of these markets went unserved for more than a few days, over $30M worth of food would be lost, severely impacting all of the small businesses in the markets and the 6,000 living wage jobs based there. None of these distribution facilities currently has backup generators.

Other businesses in the food industry, such as **Baldor, Krasdale, Dairyland and Anheuser-Busch**, have located to Hunts Point in the proximity of the wholesale markets. These businesses are not as critical to the food supply of New York, but also generate significant revenues, tax income and living-wage jobs to the community. These businesses have diverse energy requirements and generation facilities, but due to their proximity to the wholesale markets, they could potentially be connected to the Microgrid and buy excess electricity.

In addition to the markets and other businesses in the food industry, the Hunts Point peninsula has a residential population of more than 12,500 people (2013 American Community Survey). The 2013 median household family income was $23,679, less than half of the comparable figure for New York State. The Congressional District for the community – NY15 – has the highest poverty rate in the United States. During an emergency condition, Hunts Point residents would be directed to take shelter in **Middle School 424 (MS 424)**, according to plans drafted by Office of Emergency Management (OEM), which is the designated Evacuation Center at 730 Bryant Ave. Many residents might also presumably seek shelter at the nearby community centers such as "**La Peninsula Headstart**" located at 711 Manida Street and "**The Point**" located a 940 Garrison Avenue, based on longstanding relationships between these facilities and the residents of Hunts Point. None of these three emergency facilities currently has backup power.

1.2. Direct Services and Indirect Benefits

Identify any direct/paid services generated by microgrid operation, such as ancillary services, or indirect benefits, such as improved operation, to the utility or New York Independent System Operator (NYISO)? If yes, what are they?

A 13.8 MW cogeneration plant will provide 100% of electricity and steam needs for the critical facilities described above. The Meat and Produce Markets will be served with steam and electricity from the Microgrid, while the Fish Market and Community Facilities will only be provided electricity from the Microgrid. With electric and steam-driven refrigeration chillers on site, the Meat Market will generate brine for refrigeration and freezing of meat products, and the Produce Market will generate brine for refrigeration of produce products.

The on-site cogeneration plant would provide a substantial resilience benefit through its ability to operate on natural gas supply during periods of electrical grid outage. The ability of the Hunts Point Microgrid to maintain full functionality in the markets regardless of the state of the regional power grid would provide direct benefits to the businesses and communities connected to the grid by maintaining business continuity and communications. And the entire New York metropolitan region would benefit by having an operational food distribution supply chain during times of regional power outage.

Microgrid customers will also directly benefit from the Hunts Point Microgrid every day, experiencing reduced rates for electricity and steam purchased from the Microgrid. The combined cost for electricity and steam will be lower than the prices the markets currently pay due to the fundamental efficiency of the proposed cogeneration plant. These cost savings will contribute to keeping Hunts Point a competitive location for the wholesale markets and their tenants, and thereby help preserving jobs and tax income in New York.

The Hunts Point Microgrid will also provide frequency and voltage control services to the utility grid when required. In this case, the grid operator will send a request to the MCC to increase or decrease power generation and thus to sell or buy energy from the grid. The Hunts Point Microgrid could also provide black start capabilities to the utility. However, the need for black start support depends on the proximity to power generation facilities. A meeting with ConEd revealed that there are no utility generating facilities in the proximity of Hunts Point that would require black start support from the Hunts Point Microgrid.

Furthermore, the Microgrid would provide indirect benefits such as higher network reliability and stable electricity demand while also deferring the investment for electric generation and infrastructure. The New York Independent System Operator benefits from low-cost electricity from the Hunts Point Microgrid, which often has excess electricity supply when following the markets' steam load. Finally, since Hunts Point is within both the ConEd Electricity and Gas service territories, ConEd, as a whole would, see an increase in demand for natural gas, which would partly compensate the reduced electricity sales

1.3. Microgrid Customers

Identify each of the microgrid's customers expected to purchase services from the microgrid. Indicate which party/customers will purchase electricity during normal operation. During islanded operation? If these entities are different, describe why.

The Hunts Point Microgrid will have four primary customers: the three wholesale food markets as well as the Microgrid Energy Center on Parcel D. The primary customers will be guaranteed affordable CHP-generated electricity and steam supply at all times, including periods of regional grid outage. The CHP operation follows the steam-load of the markets, who also generate the primary income and are indispensable for the economic viability of the Microgrid.

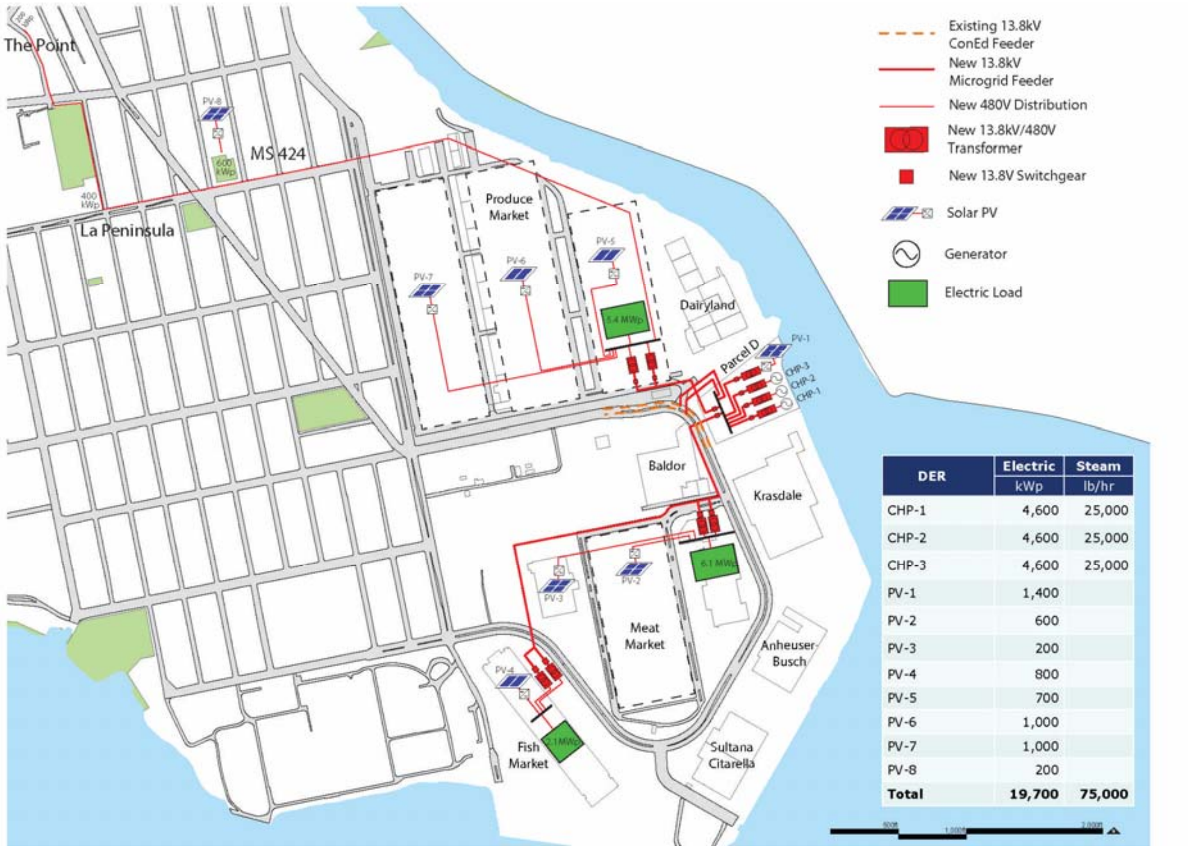
The three community refuge facilities constitute the second group of community customers. As the primary customers, the three facilities will always be guaranteed affordable CHP-generated electricity, including blue sky conditions and periods of regional grid outage. However, these customers do not primarily add to the economic viability of the Microgrid, but rather to its justification as a community Microgrid that improves the overall resiliency of Hunts Point and its businesses and residents.

Finally, a group of secondary customers, specifically Baldor, a Vertical Farm and an Anaerobic Digester, will receive electricity at Microgrid rates during normal operation. During a regional outage with intact supply of biogas, these customers will be included in the islanded operations and also enjoy an increased reliability benefit. However, if the gas supply is disrupted and the Microgrid depends on storage and truck gas deliveries, their loads will be shed to ensure continuous operation of the critical wholesale markets and community facilities.

These secondary customers fit well into the economic and energy picture of the FDC. The Vertical Farm (VF), an indoor growing operation with artificial lighting, requires 2-3 MW of electricity, which is within the scale of the excess electricity available from the CHP plant. The vegetables could be sold directly at the neighboring Produce Market as well as up the hill in the Hunts Point Community, significantly decreasing the storage and transportation cost and improving food security. An Anaerobic Digester facility could process the organic food waste from the markets and surrounding businesses into methane (biogas), which can be utilized by the nearby CHP gas turbines. The volume of organic waste generated by the markets and surrounding businesses may make an investment in such a facility relevant to a peninsula-wide energy strategy. Finally, other food businesses in Hunts Point, including Baldor, Dairlyland and Krasdale, may buy excess electricity and benefit from increased resiliency of the Microgrid.

	Name	Variable	Unit	2030
Primary	Meat Market	Building Area	SF	1,170,000
		Refrigeration	RT	2,500
		Electricity	kW	3,000
		Steam	lb/hr	25,000
	Produce Market	Building Area	SF	1,200,000
		Refrigeration	RT	3,000
		Electricity	kW	3,000
		Steam	lb/hr	37,500
	Fish Market	Building Area	SF	430,000
		Refrigeration	RT	500
		Electricity	kW	2,300
	Energy Center	Building Area	SF	120,000
		Electricity	kW	600
Community	MS424	Building Area	SF	55,000
		Electricity	kW	600
	La Peninsula	Building Area	SF	35,000
		Electricity	kW	400
	The Point	Building Area	SF	22,000
		Electricity	kW	200
Secondary	Vertical Farm	Building Area	SF	60,000
		Electricity	kW	3,000
	Baldor	Building Area	SF	300,000
		Electricity	kW	2,000
	Anaerobic Digester	Building Area	SF	90,000
		Electricity	kW	300
Total		**Refrigeration**	**RT**	**6,000**
		Electricity	**kW**	**15,400**
		Steam	**lb/hr**	**62,500**

Table 1: Microgrid Customers Growth Projection



DER	Electric kWp	Steam lb/hr
CHP-1	4,600	25,000
CHP-2	4,600	25,000
CHP-3	4,600	25,000
PV-1	1,400	
PV-2	600	
PV-3	200	
PV-4	800	
PV-5	700	
PV-6	1,000	
PV-7	1,000	
PV-8	200	
Total	**19,700**	**75,000**

Figure 1: Microgrid Electrical Schematic Plan

A general layout for Site D is illustrated in Figure 2 below:

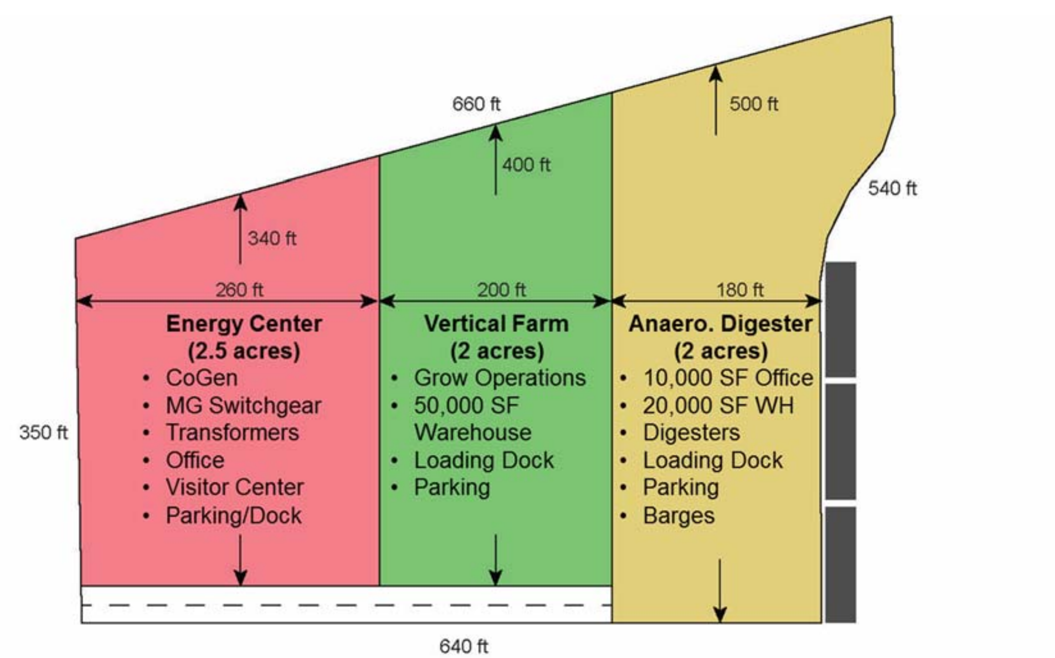


Figure 2: Site D Layout

1.4. Microgrid Stakeholders

Identify other microgrid stakeholders; what customers will be indirectly affected (positively or negatively) by the microgrid.

In addition to all of the above-mentioned Microgrid customers, the Hunts Point Community Microgrid has several key stakeholders that are directly affected by the proposed Microgrid. The City of New York by way of the New York City Economic Development Corporation (NYCEDC) owns and manages the property of the Hunts Point Food Distribution Center. The Microgrid helps ensuring that the FDC remains competitive with lower energy cost and higher resiliency, which is a critical location factor for the three markets. The construction of the Microgrid infrastructure could temporarily negatively affect the Markets and local businesses. During cleanup and construction on Parcel D, the traffic capacity of Food Center Drive might be reduced due to lane closures and increased construction traffic, potentially resulting in delays of food delivery to and from the Markets. These impacts will be minimized as much as possible by coordinating the construction schedule with the local stakeholders.

The community living within the Hunts Point peninsula is another primary stakeholder for the Microgrid. During a regional power outage or flooding event, the Microgrid would provide reliable energy to three community refuge facilities, where the affected residents can find shelter, information and electricity to charge their phones. Many of the residents of the Hunts Point community also work in the wholesale markets and associated businesses in Hunts Point, making them direct stakeholders of the economic viability of the market as a major employment center. On the other hand, residents of the area experience high rates of health impacts such as asthma and respiratory disease from low air quality, partly caused by the high volume of trucks that serve the markets and keep their engines idling to maintain refrigerated temperatures. The affordable steam from the Microgrid might help facilitating the development of a central refrigeration plant at the Produce Market and thus indirectly reduce truck idling. The emissions from CHP do not add to the problem, as respiratory diseases are mainly caused by Particulate Matter (PM) and natural gas turbines have very low PM-10-emissions (0.08 lb/MWh compared to 0.78 lb/MWh for diesel and 0.30 lb/MWh for coal). Furthermore, advanced emissions control equipment at the CHP plant will minimize any additional localized environmental impact. However, the development of an Anaerobic Digester could potentially increase truck volume if organic waste is delivered from outside the peninsula and not just sourced locally or delivered by barge, as intended in this proposal.

Since NYCEDC acts as property manager for the Food Distribution Center property, the City of New York would hold a ground lease for the Microgrid developer to operate the Microgrid Control Center and cogeneration facility on Parcel D. If the concept of an Anaerobic Digester fits within the overall energy plans for the district, NYCEDC may also consider leasing a portion of Parcel D to the operator of the Anaerobic Digester plant. If the concept of hosting a Vertical Farming (VF) business on Parcel D also aligns with the City's objectives for the FDC, then a third ground lease would be required.

NYCEDC is a primary stakeholder in the implementation of the Hunts Point Community Microgrid, therefore NYCEDC will have to conduct their own in-depth technical and economic feasibility study to confirm assumptions and results proposed in this stage of NY Prize. This next in-depth study may be conducted through NY Prize Stage 2 or through other planning initiatives conducted by NYCEDC.

The Hunts Point Wastewater Treatment Plant (WWTP) is another stakeholder of the Microgrid as a seller of excess biogas that is being generated from anaerobic digestion of wastewater and not being used at the WWTP directly. Having a constantly high gas demand on site allows negotiating a long-term biogas purchase agreement that generates a fixed income for the WWTP while being a stable and sustainable source of biogas for the Microgrid. The WWTP could potentially purchase electricity from the Microgrid, but has to operate its own emergency generators due to internal regulations of the Department of Environmental Protection (DEP). Finally, the WWTP could also accept other organic waste from Hunts Point and obviate the development of an Anaerobic Digester at Parcel D. However, that is currently not being considered by DEP due to the associated capacity, investment and risk requirements.

The utility will be affected both positively and negatively by the Hunts Point Microgrid. It will benefit from improved system reliability and ancillary services such as frequency and voltage control. When the Mott Haven substation, which was energized in 2007, reaches its capacity in a few decades, the Microgrid will benefit the utility by reducing congestion and deferring upgrades. Furthermore, ConEd gas will gain a large customer of natural gas and earn approximately $7M per year from the sale of natural gas to the cogeneration plant. On the other hand, the utility will lose valuable customers that previously generated a revenue of $8.5M per year and only collect $600K income from standby service (customer charge, contract demand charge and as-used daily demand charges).

1.5. Contractual Relationship and Agreements

Describe the relationship between the microgrid owner and the purchaser of the power.
What are the planned or executed contractual agreements with critical and non-critical load purchasers?

The Microgrid Developer will negotiate a Power Purchase Agreement (PPA) and a Steam Purchase Agreement (SPA) with the Meat and Produce Markets, specifying the reliability and quality of each service. The Microgrid Developer will also offer PPAs with similar conditions to the Fish Market tenants and the Community Refuge Facilities. The secondary customers, including the Vertical Farm, the Anaerobic Digester, Baldor and other businesses, are offered standardized PPAs for supplementary service of excess electricity under consideration of additional interconnection cost and islanding scenarios. Gas Purchase Agreements (GPA) will be negotiated with the Anaerobic Digester facility (in combination with a PPA), and the Wastewater Treatment Plant. Gas will be purchased from ConEd Gas through published gas rates for cogeneration. Finally, the Microgrid Developer will apply for the ConEd Standby Tariff (SC 9 Rate V) for the maxim um coincident demand of the Microgrid.

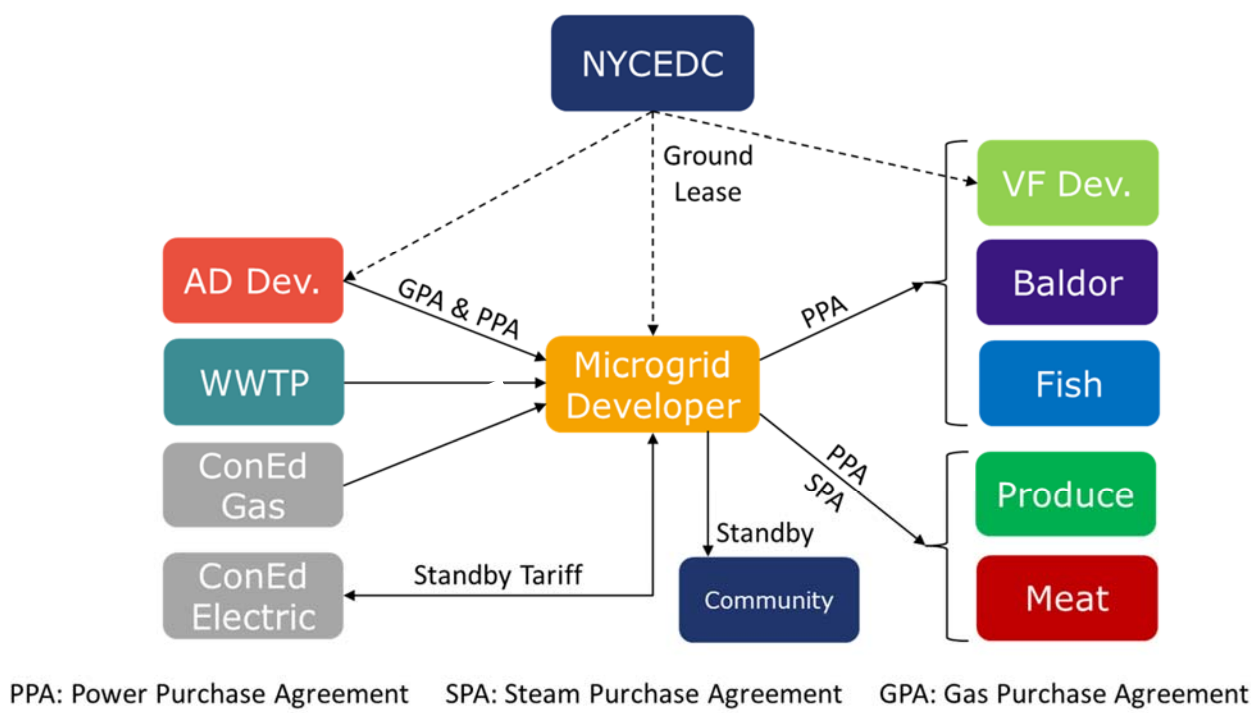


Figure 3: Contractual Relationships required for the Hunts Point Microgrid

1.6. Customer Solicitation

How does the applicant plan to solicit and register customers (i.e. purchasers of electricity) to be part of their project?

The Produce, Meat, and Fish Markets have been fully engaged in the development of the concept of the Hunts Point Microgrid. A Power Purchase Agreement and a Steam Purchase Agreement will be negotiated with the managers of the Meat and Produce Markets, which would require the approval of the tenants within each Coop. At the Fish Market, each tenant is procuring his own energy supplier, but tenants tend to follow the lead of the Market manager and may be solicited by offering resilient electricity at competitive rates as part of standardized PPAs. Initial conversations with other secondary customers (e.g. Baldor) have shown meaningful interest in reduced energy cost and improved resiliency, even if the negotiated PPAs would reflect additional infrastructure cost and not guarantee Microgrid electricity at all times. Finally, the Community Facilities will be approached by connecting with the facility managers, waiving interconnection charges and offering lower rates for resilient electricity supply. In summary, all potential customers of the Hunts Point Microgrid have already been included in this preliminary feasibility process and expect to continue to be involved in ongoing Microgrid feasibility, design, and development.

1.7. Other Energy Commodities

Are there any other energy commodities (such as steam, hot water, chilled water) that the microgrid will provide to customers?

As mentioned above, the Microgrid will sell steam as well as electricity to the Meat and Produce Markets. Refrigeration brine, chilled water and hot water will be generated by the customers themselves from steam and electricity. Figure 4 below shows the proposed steam component of the Hunts Point Microgrid.

Chiller	Refrigeration Capacity	Electric Load	Steam Load
	RT	kWp	lb/hr
CH-S-1	3,000		37,500
CH-E-1	1,000	3,500	
CH-E-2	1,000	3,500	
CH-S-2	3,000		37,500
CH-E-3	1,000	3,500	
CH-E-4	1,000	3,500	
Total	**10,000**	**14,000**	**75,000**

Figure 4: Proposed Hunts Point Microgrid steam generation and distribution network

2. Commercial Viability – Value Proposition

2.1. Community Benefits and Costs

What benefits and costs will the community realize by the construction and operation of this project? How would installing this microgrid benefit the utility? (E.g. reduce congestion or defer upgrades)? What costs would the utility incur as a result of this project?

For the residential community of Hunts Point, the Microgrid will provide a resilient source of electricity for the three refuge facilities at MS 424, La Peninsula Headstart and The Point. During a regional power outage, the residents will have three locations where they will be able to seek shelter, get information, charge electronic devices, and check in with their neighbors. Since many residents of Hunts Point also work at the FDC (60% of the Teamster Union Local 202 live south of the Cross Bronx Expressway and most of them presumably in the Hunts Point Community Board 2), maintaining employment and food supply during emergency conditions would be another important community benefit. A lower price of electricity and steam for all business customers served by the Microgrid ensures that the FDC remains competitive securing the future of the markets within New York City. Finally, the community would benefit from lower emissions from idling trucks that are currently being used to refrigerate food, as the affordable steam from the Microgrid could help facilitating the development of a more efficient central refrigeration plant at the Produce Market, which would be necessary to fully benefit from the low-cost steam generated by efficient CHP gas turbines. The natural gas turbines have very low concentrations of PM and therefore do not negatively affect the air quality. Other potentially negative environmental impacts from CHP emissions will be minimized with advanced emissions control equipment, high operating efficiency and the installation of solar PV. The development of an Anaerobic Digester could potentially increase truck volume if organic waste was delivered from outside the peninsula, but it is assumed that it is only sourced locally or delivered by barge.

The society, as a whole, benefits from increased food security for the entire New York City region. A resilient energy supply enables the food distribution center to maintain federally mandated Cold Chain Compliance regulations and to ensure the safe and uninterrupted distribution of meat, fish and produce to the City of New York and its surroundings. Thanks to efficient CHP and solar PV, the Microgrid reduces overall fuel consumption of approximately 500,000 MMBtu per year and generates fewer CO_2, SO_2, NO_X and PM emissions per kWh than the ConEd grid. Finally, the more resilient and efficient energy supply will help ensure that Hunts

Point remains a premier food distribution center, which will preserve more than 6,000 jobs in New York State and one of the least affluent Congressional Districts in the United States.

For the utility, the Microgrid would first improve the reliability performance, as fewer customers would be without electricity during a regional outage. Furthermore, the Microgrid provides ancillary services, such as frequency and voltage control, which help maintain a high standard of power quality. Thanks to the construction of the Mott Haven substation, the area currently does not experience congestion or requires updates and will not do so for a few decades. However, considering the expected energy growth from large mixed-use development in Hunts Point (for example, the proposed Spofford redevelopment), the Microgrid will eventually help reducing congestion and deferring upgrades. Finally, the Microgrid would provide significant amounts of natural gas from ConEd Gas ($8M annually in the final phase) and ConEd would provide free interconnection if the Microgrid chooses firm service. On the other hand, ConEd loses significant revenue from electricity sales ($8.5M today) and only collect standby charges to maintain the electrical infrastructure as a backup.

2.2. Business Model and SWOT

Describe the proposed business model for this project. Include an analysis of strengths, weaknesses, opportunities and threats (SWOT) for the proposed business model.

The business model for the Hunts Point Microgrid is to buy natural gas to fuel CHP turbines and generate electricity and steam that is sold to primary and secondary customers in Hunts Point with high reliability and quality. The main economic difference between the electricity and steam generated from the Microgrid CHP plant and utility-provided grid electricity is the cogeneration aspect, utilizing up to 70% of the energy in the natural gas rather than typical 30-40% efficiency seen in power plants that generate and sell electricity only. Selling the additional 30-40% of value of the gas in the form of steam allows the Microgrid to sell electricity at rates competitive with market rate electricity when typically it would be difficult to make the economic case for on-site gas-fired generation project that sells electricity only.

The business model for the Hunts Point Microgrid also relies on the underlying economic value and social benefit of increasing the region's food supply security. The cost and effort required to design, permit, build, and operate the microgrid distribution network will be substantial and will require administrative, financial, and political support from the City of New York, the State of New York, the communities within Hunts Point, and the businesses within the FDC. The business model for this proposed project requires valuing this public resilience benefit as the economics of the project cannot stand on energy cost savings alone. Since all markets are located on property administered by the NYC Economic Development Corporation on behalf of the City of New York, there should be fewer regulatory hurdles for installing Microgrid infrastructure and negotiating PPAs. Finally, all structures at the Food Distribution Center are flat and of comparable height, thus providing ideal conditions for solar PV.

The Microgrid will also generate revenues from Demand Response Programs, Frequency and Voltage Control Services and Offset Tariffs for excess electricity by the utility. Due to the markets' refrigeration load that peaks during the early morning hours, the Microgrid will be able to participate in afternoon demand response programs without additional investments. Additionally, the wholesale markets, other food businesses and the wastewater treatment plant generate significant amounts of organic waste that can be utilized for anaerobic digestion. The biogas produced in this process can be used locally to fuel the CHP gas turbines and thus reduces the demand for natural gas and the cost for transportation.
The Microgrid business model is illustrated in the diagram below:

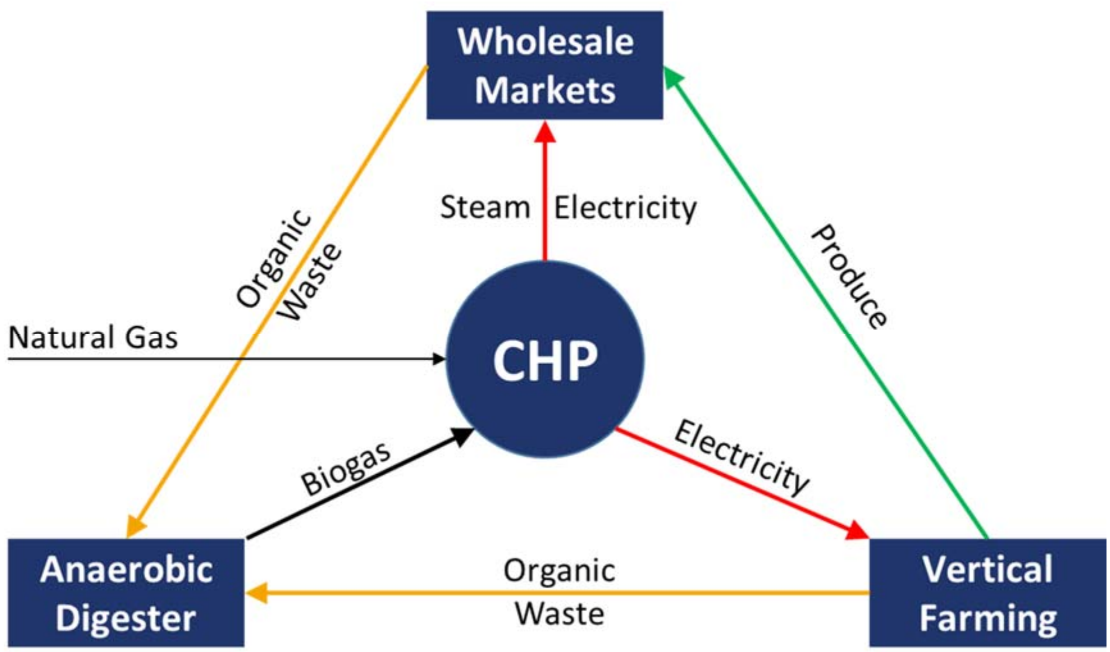


Figure 5: Microgrid Business Model

However, the Microgrid also has several weaknesses that need to be addressed. Firstly, the three wholesale markets each have between 30 and 50 tenants that form cooperatives, which makes the decision-making process complex and time consuming. Furthermore, the tenants at the Produce and Fish Markets currently purchase electricity individually and will need to grasp and embrace the value proposition of central plant generation and distribution of refrigeration and electricity. Thirdly, the profitability of cogeneration relies on a balanced demand for steam and electricity, but the demand for electricity is projected to decrease with the modernization of market buildings and the installation of solar PV. Finally, the sale of steam relies on the installation of specialized steam-driven refrigeration chillers at the Meat and Produce Markets, which are included in the Microgrid development cost but and will be borne by the Microgrid Developer.

The change from electric to steam-driven refrigeration chillers poses the opportunity to gradually include new electric customers into the Microgrid, thus increasing the economies of scale and stability of the Microgrid. By including other food businesses at Hunts Point (e.g. Baldor, Krasdale, Dairyland) as well as new concepts such as Vertical Farming, the Microgrid would have additional customers and the load curves would be more balanced. Furthermore, more ancillary services such as Demand Response and Voltage and Frequency Control as well as other revenues streams (e.g. waste management as part of the anaerobic digestion process) can be integrated into the Microgrid business model.

Even with biogas from anaerobic digestion, the Microgrid relies on natural gas to fuel the CHP gas turbines, therefore future natural gas prices compared to electricity prices (spark spread) poses a significant risk to the Microgrid profitability. Also, the Microgrid depends on the constantly high refrigeration demand of the three wholesale markets, which also attract other businesses in the food industry to Hunts Point. If these wholesale markets would move to another location or not include central refrigeration plants with steam-driven chillers, the Microgrid business model would be in jeopardy.

Strengths	Weaknesses
Competitive efficiency of Cogeneration Public benefit of food security & resiliency Markets' electrical peaks in the morning Property owned by NYC and managed by EDC Organic waste for Anaerobic Digestion biogas Flat roof structures for solar PV	Complex decision-making processes Steam/Electricity balance during development Specialized steam-driven refrigeration chillers
Opportunities	**Threats**
Include additional customers (other food businesses and vertical farming) Ancillary services and waste revenue streams	Natural gas price volatility (spark spread) Uncertainty of future central plant refrigeration Wholesale markets move to another location

Table 2: SWOT Analysis

2.3. Unique Microgrid Characteristics

Are there any characteristics of the site or technology (including, but not limited to, generation, storage, controls, information technology (IT), automated metering infrastructure (AMI), other, that make this project unique?

The most unique aspect of the Hunts Point Food Distribution Center is the size and consistency of the thermal refrigeration load throughout the year. There are few other thermal loads of this scale and consistency in New York City or anywhere in the region, so the opportunity for cogeneration and steam-driven refrigeration is substantial. Most other thermal loads in the region have a significant seasonality and daily load swings, while the refrigeration demands at the markets remain fairly consistent throughout the year.

The timing of the current capital planning in the FDC, particularly for the Produce and Meat Markets, also aligns well with the assumed timing of a microgrid and cogeneration plant. New market facilities could be designed with consideration for the microgrid, steam distribution network, and power reliability as part of assumed Market redevelopments within the next twenty years. If the market facilities and the Microgrid central plant were planned together in concert, there could be substantial capital cost and administrative cost savings for the projects.

The organic waste generated by the three markets also produces a unique opportunity for an anaerobic digestion system to produce biogas. Just the organic waste alone from the markets could provide 5 to 10 percent of the annual gas demand from the CHP turbines. The nearby Hunts Point Wastewater Treatment Plant has plans to expand their anaerobic digestion facility and may be another renewable supply of biogas for the CHP turbines.

Due to the technical aspects of the thermal and electrical demand, the sizing of the CHP plant has been designed to meet the peak thermal demand of the market, while the electrical output of the CHP plant generates more electricity than the peak electrical demand for the markets. Additional customers would be needed to consume the excess electricity capacity. A Vertical Farming (VF) operation with a 2-3MW electrical demand would be an excellent Microgrid customer and FDC tenant. The vegetables could be sold directly at the neighboring Produce Market and in the Hunts Point Community.

The Microgrid controls, communication, metering and information (IT) technology is well-proven and not a unique characteristic, as various campus Microgrids such as New York University, Columbia University or Hudson Yards have employed similar technologies. The main difference is the steam-following load management that requires a close interconnection of the Microgrid controller with the steam-driven chillers and the central refrigeration plant managers at the Meat and Produce Markets. However, the GE Grid IQ Microgrid Control System together with the U90^{Plus} Generation Optimizer can be adapted to meet these special requirements.

2.4. Replicability and Scalability

What makes this project replicable? Scalable?

The cogeneration aspect of the microgrid is generally replicable in campus situations or clusters of commercial or industrial customers with large and consistent thermal loads, such as wholesale markets or data centers. Projects with a cogeneration plant sized to meet the thermal demand and a single point of connection to the electrical utility, would have a lot in common with the proposed Hunts Point Microgrid and many of the lessons learned from the project could be translated to other projects. The anaerobic digestion waste-to-energy aspect of the project would be replicable at facilities generating large volumes of organic waste, such as food-processing businesses or wastewater treatment plants. The energy demand of these facilities as well as the Anaerobic Digester can then be met by burning the biogas to generate heat and electricity locally. The concept of Vertical Farming is replicable for Microgrids with CHP systems that generate excess electricity and require additional electric customers, especially at urban locations with limited space.

The whole potential of these individual technologies can be replicated and scales when combining them in an integrated Community Microgrid with a diverse portfolio of industrial, commercial and residential customers. While the industrial customers use steam to operate production machines and refrigeration chillers, the associated electricity can improve the energy efficiency and resiliency of commercial and residential users. An Anaerobic Digester can provide cheaper and more sustainable biogas while also solving the waste disposal problem and improving fuel independence. Local food production such as Vertical Farms can reduce the amount of truck traffic from outside and generate local jobs while also utilizing affordable and sustainable electricity from local cogeneration. As a result, this Microgrid can serve as an example for the integration of technologies and stakeholders in a Community Microgrid.

2.5. Resiliency

What is the purpose and need for this project? Why is reliability/resiliency particularly important for this location? What types of disruptive phenomenon (weather, other) will the microgrid be designed for? Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.

The Hunts Point (HP) Food Distribution Center (FDC) in the South Bronx is one of the largest food distribution centers in the world, providing 60% of New York City's produce, meat and fish. If the refrigeration and freezing loads of these markets went unserved for a prolonged period of time, this would not only destroy approximately $32M worth of food, but also put 6,000 jobs and 137 small businesses in jeopardy. In addition to the markets and other businesses in the food industry, the Hunts Point peninsula has a residential population of more than 12,500 people (2013 American Community Survey). During an emergency condition, Hunts Point residents would take shelter in the Evacuation Center at MS 424 or the community centers La Peninsula and The Point. As none of these facilities have backup generators, the 12,500 people living in Hunts Point would be left without emergency facilities in the case of a regional power outage.

The two major risk events that would cause a power outage in the service territory include flooding of underground electrical vaults along Food Center Drive and a regional blackout that impacts the Mott Haven substation. In those cases, the markets would load as much perishable food into trucks as possible, and close the warehouse doors until power comes back. These mitigating strategies can only maintain USDA's Cold Chain Compliance regulations for a few hours, before temperatures rise to above acceptable ranges. Considering the volume of fresh food that passes through these facilities, power outage poses a considerable risk to the region's food supply.

The Hunts Point Microgrid could provide electricity and steam to the markets and the community facilities during a storm event or a regional blackout by operating in islanded mode. The Microgrid DER, infrastructure and controls are designed to be flood and storm proof and the CHP gas turbines can generate enough electricity and steam to maintain Cold Chain Compliance regulations for unlimited time as long as the gas network is still in operation. Otherwise, the biogas produced on site in combination with gas deliveries by truck can generate enough electricity and steam to meet base refrigeration levels if warehouses are consolidated and non-critical loads (such as other food businesses on site) are shed. The three community facilities are comparably small loads and will always have sufficient electricity in case of an outage.

2.6. Stakeholder Value Proposition

Describe the project's overall value proposition to each of its identified customers and stakeholders, including, but not limited, the electricity purchaser, the community, the utility, the suppliers and partners, and NY State.

For the three wholesale markets and their tenants, the Microgrid provides steam and electricity at lower rates while also improving reliability and power quality. This is an important location factor that benefits NYC as the landlord, EDC as its manager and the community that is partly employed at these markets. The community also benefits from resilient electricity supply at the local Evacuation Center and community centers. The Microgrid Developer will see a profitable investment opportunity with large electricity and steam customers that allow to operate CHP turbines at high efficiencies and utilization rates. The Microgrid Developer can also generate revenues with Demand Response and Voltage and Frequency Control services that benefit the utility by deferring infrastructure and generation investments. The operator of the Anaerobic Digester can collect organic waste and sell biogas locally, while the operator of the vertical farming business benefits from cheap electricity and the proximity to the Produce Market. New York City and State in general get a more stable and resilient electricity grid, increased local employment and secure food supply for the region.

2.7. Purchaser Revenue Streams

What added revenue streams, savings, and/or costs will this microgrid create for the purchaser of its power?

The principal purchasers from the Microgrid will be the three wholesale food markets and their tenants. Currently, they are obtaining electricity from ConEd to power rooftop DX units or a central refrigeration plant to freeze and refrigerate food. With the Microgrid, the Meat and Produce Markets can purchase steam to run steam-driven refrigeration chillers at lower cost, while all markets will also benefit from electricity cost savings. Furthermore, they can generate additional revenue streams by participating in Demand Response programs through coordinating their chiller operations with the Microgrid operator and the utility grid. However, these additional revenues and savings require an initial investment into steam-driven and electric chillers as well as fees to the Microgrid operator to maintain and operate them as a service.

Name		Scenario	2030
Meat Market	Electricity (kWh)	MG Cogen	17,623,770
		No MG	63,441,698
	Steam (Mlb)	MG Cogen	150,030
		No MG	0
Produce Market	Electricity (kWh)	MG Cogen	10,467,667
		No MG	61,484,605
	Steam (Mlb)	MG Cogen	167,054
		No MG	0
Fish Market	Electricity (kWh)	MG Cogen	8,114,525
		No MG	8,114,525
Total	Electricity (kWh)	MG Cogen	36,205,962
		No MG	133,040,828
	Steam (Mlb)	MG Cogen	317,083
		No MG	0

Table 3: Electricity and Steam Consumption

The table above shows the electricity and steam consumption of the three markets in two cases: the Microgrid case with cogeneration and the base case of ConEd grid electricity supply. In the first case, the electricity used for refrigeration at the Meat and Produce Markets will be gradually replaced by steam-driven chillers, while in the second case the projected refrigeration loads will be fully met by electric chillers.

While the price for electricity in the second scenario can be calculated based on current rates and projected growth, the price for electricity and steam in the Microgrid will have to be set in a iterating process that considers the price for natural gas, the competitive grid price for electricity, the potential cost savings for the markets and the profitability for the developer. The first reference point is the price for natural gas that is used to determine the cost for steam generation. Based on current rates of the Meat Market and EIA's "America's Energy Outlook" for Henry Hub Prices, the current cost of $0.85 per therm is projected to increase to $1.30 in 2030. Converting this into the price for one MMBtu of natural gas and assuming the same price for one MMBtu of steam results in a price of $19/Mlb of steam in 2020, $25/Mlb in 2025 and $27/Mlb in 2030, as indicated below:

		Scenario	2030	Notes
Energy Center	Natural Gas Purchase Price fom ConEd	$/therm	1.3	Based on EIA Projections
		$/MMBtu	12.7	
	Steam Sale Price to MG Customers	$/MMBtu	12.7	Tentative Cost for Analysis
		$/Mlb	27.0	

Table 4: Gas and Steam Cost per Unit for the MG Developer

Next, the unit prices for electricity will be extrapolated for the four phases of development. In the Microgrid case, the price for electricity will be blended between electricity obtained at individual rates from the grid and electricity from cogeneration at $0.13/kWh in 2020, $0.14/kWh in 2025 and $0.15/kWh in 2030. The price for steam in the Microgrid case is based on the projected fuel cost as indicated above, while the reference ConEd steam price is calculated based on current tariffs and similar growth rates of fuel cost. It can be seen that, due to cogeneration, the Microgrid price for steam is significantly below the individual market rates, which are expected to increase and harmonize from $0.12/kWh to $0.16/kWh in 2030, as individual subsidies phase out and general fuel prices increase.

Name		Scenario	2030	Notes
Meat Market	Electricity (ct/kWh)	MG Cogen	15.0	
		No MG	16.6	
	Steam ($/Mlb)	MG Cogen	27.0	
		No MG	32.9	Reference Cost
Produce Market	Electricity (ct/kWh)	MG Cogen	15.0	
		No MG	15.4	
	Steam ($/Mlb)	MG Cogen	27.0	
		No MG	32.9	Reference Cost
Fish Market	Electricity (ct/kWh)	MG Cogen	15.0	
		No MG	16.2	
Total	Electricity (ct/kWh)	MG Cogen	15.0	
		No MG	16.0	
	Steam ($/Mlb)	MG Cogen	27.0	
		No MG	32.9	

Table 5: Electricity and Steam Cost per Unit

Finally, the projected consumption from Table 3 is multiplied with the unit prices from Table 4 to calculate the annual electricity and steam cost and compare the savings of the Microgrid case to the ConEd grid only case. Considerable savings can be achieved once the Meat and Produce Markets switch to steam-driven chillers that benefit from low steam cogeneration cost. Total savings compared to a scenario without a cogen and microgrid are estimated to amount to $7.3M or 34% per year in the final buildout.

Name	Annual Cost	Scenario	2030
Meat Market	Electricity ($)	MG Cogen	2,651,689
		No MG	10,543,705
	Steam ($)	MG Cogen	4,050,797
		No MG	0
	Total ($)	MG Cogen	6,702,486
		No MG	10,543,705
	Savings ($)		**3,841,219**
			36%
Produce Market	Electricity ($)	MG Cogen	1,571,713
		No MG	9,495,681
	Steam ($)	MG Cogen	4,510,446
		No MG	0
	Total ($)	MG Cogen	6,082,159
		No MG	9,495,681
	Savings ($)		**3,413,523**
			36%
Fish Market	Electricity ($)	MG Cogen	1,220,278
		No MG	1,312,377
	Savings ($)		**92,098**
			7%
Total	Total ($)	MG Cogen	14,004,923
		No MG	21,351,762
	Savings ($)		**7,346,840**
			34%

Table 6: Electricity and Steam Annual Cost Savings

2.8. Promotion of State Policy Objectives

How does the proposed project promote state policy objectives (e.g. NY REV, Renewable Portfolio Standard (RPS))?

Reforming the Energy Vision (REV) aims to improve the resiliency and reliability of the grid by establishing new technologies and policies of integrating distributed energy resources and microgrids. Such new technologies can support the stability of the main grid during normal operations, operate in island mode if the grid is out, reduce transmission losses, integrate green energy resources, and help manage local demand.

The proposed Hunts Point Microgrid would combine distributed CHP and solar PV resources in a diverse microgrid that is able to supply energy to the main grid during peak demand conditions. The Microgrid operates at high efficiency as waste steam from natural gas turbines drives refrigeration chillers providing brine for warehouse cooling, which reduces transmission losses and energy costs for customers. Biogas from anaerobic digestion processes in local AD facilities and the Hunts Point Wastewater Treatment Plant would diversify the source of gas fuel for the turbines. The remaining capacity will be supplemented by natural gas that also has half of the CO_2 emission rates of coal-fired generation (1,135 lbs/MWh, US EPA eGRID 2000). The solar panels, gas turbines and steam chillers installed in the Microgrid will be the most energy efficient currently available in order to reduce necessary capacity and lifecycle cost.

The Microgrid customers, mostly food wholesalers, will be actively involved by generating energy on their roofs, optimizing their electricity demand (smart metering) and reducing their own energy cost by employing efficient cooling and lighting systems. The lower cost and higher resiliency of food distribution will ultimately benefit the residents of the New York metro area, who obtain 60% of their food from the FDC at Hunts Point.

2.9. Promotion of New Technology

How would this project promote new technology (including, but not limited to, generation, storage, controls, IT, AMI, other)? What are they?

The Microgrid uses mainly proven technologies, such as natural gas turbines, flat-plate solar PV and electric centrifugal chillers. However, the steam-driven chillers for refrigeration will be custom-designed similar to the JCI Titan Model OM to produce brine for freezing and refrigeration. This design can serve as a reference for future application of steam-driven chillers for refrigeration purposes, thus further increasing the application of CHP in the industrial context. Additionally, the Microgrid will purchase biogas from a modern waste-to-energy Anaerobic Digester plant and sell electricity to a vertical farming operator, both of which are innovative technologies with great potential for sustainability in the urban context.

3. Commercial Viability – Project Team

3.1. Community Support

Describe the current status and approach to securing support from local partners such as municipal government? Community groups? Residents?

The Hunts Point community has an integral part of the Microgrid design process ever since the Rebuild By Design competition. Coordinated by Barretto Bay Strategies, various community representatives have participated in the Microgrid kickoff meeting and monthly community outreach meetings such as The Point, Sustainable South Bronx, NYC Environmental Justice Alliance, and others. On these occasions, the project team presented the design process and collected feedback that was then integrated into the Microgrid design. Issues of great importance to the community include resilient shelters, lower electricity cost, reduced truck air pollution, secure employment and community participation. As it is not possible to connect every house to the Microgrid, the community supports the idea to provide resilient electricity to three community centers that serve as shelters during an emergency. Furthermore, they agree that providing steam and electricity to the Markets would contribute to securing employment in the area while also reducing the air pollution from idling refrigeration trucks. The community is also actively involved in the allocation of grants from the Rebuild By Design process, which will distributed between flood protection and energy resiliency.

The tenants of the Meat, Fish and Produce Markets have been continuously informed on the progress of the Microgrid by the Coop Managers. Individual large tenants have been directly contacted by the project team to provide individual electricity demand information. Nevertheless, a continuous and active outreach by NYCEDC, the Microgrid Developer and the Market Managers will be necessary to convince all tenants to join the Microgrid, either as part of the Cooperative at the Meat and Produce Markets or individually through PPAs at the Fish Market. By offering more reliable and affordable electricity and steam as well as having the support of the Market Managers, the final approval of most tenants should be achievable if individual tenants concerns are considered during the next design phases.

Finally, the project team has continuously included NYCEDC, the Mayor's Office of Sustainability (MOS) and the Office of Recovery and Resiliency (ORR) in the design process. On regular meetings, all stakeholders have been informed on the progress and shared their feedback. Since

NYCEDC is administering the RBD CDBG-DR energy pilot project, the Hunts Point Community Microgrid may be an integral part of the RBD pilot project, thus NYCEDC would be the main point of coordination and leadership and is therefore continuously involved in the process.

3.2. Team Roles

What role will each team member (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners) play in the development of the project? Construction? Operation?

The New York City Economic Development Corporation (NYCEDC) manages the Hunts Point Food Distribution Center on behalf of the City of New York. Since the City of New York is an eligible recipient of Community Development Block Grant - Disaster Recovery (CDBG-DR) funding, and NYCEDC is the implementing agency for other CDBG-DR funds (from Rebuild By Design), NYCEDC is the likely applicant for subsequent stages of NY Prize if the Hunts Point Community Microgrid project is aligned to the broader goals and objectives of the City. NYCEDC would procure a consulting team to support the design and planning process of NY Prize Stage 2 through a competitive bidding process. The Level Infrastructure team would not necessarily continue on to Stage 2 of NY Prize unless contracted through an open, public bidding process.

After Stage 2, if the Hunts Point Microgrid moves on to implementation either through Stage 3 of NY Prize or independently, NYCEDC would hire consultants to compile a Request for Proposal (RFP) to invite tenders for a Microgrid Developer. The Microgrid Developer would finance, design, construct and operate the Microgrid in coordination with NYCEDC as the landlord representative and stakeholder. This could include working together with financiers, (general) contractors, architects, suppliers, operators, legal and regulatory advisors as well as the market managers and tenants.

Other implementation options include engaging a public entity such as NYPA, a utility such as ConEd, or even NYCEDC owning and implementing the project itself. NYPA could contribute experience with energy generation and supporting public-sector projects. ConEd has long experience with network operation, would not pay real estate taxes and could even be allowed to own generation assets in the REV process. NYCEDC and the City of New York have strategic interest in the resiliency and competitive energy cost for the Markets in Hunts Point. Private sector investors would contribute experience from other Microgrid projects as well as access to private funding. The preferred implementation option would likely be the result of detailed studies in Stage 2 of NY Prize.

3.3. Public-Private Partnerships

Are public/private partnerships used in this project? If yes, describe this relationship and why it will benefit the project.

If the process progressed as described above with NYCEDC procuring a private sector Microgrid Developer and the two parties shared some amount of project risk and project funding, the project would certainly qualify as a public-private partnership. Bringing a private sector developer into the project would bring deeper technical expertise to the project, private sector financing, and even private sector equity which would reduce the financial and management burden on the public sector while maintaining most of the public benefit of the project. Private sector financing, and equity, in particular, would likely be more expensive than public sector financing and would negatively impact the overall project economics and electricity and steam rates offered to the Microgrid customers.

Other implementation options with public ownership and management from NYPA, ConEd, or from NYCEDC themselves would not constitute a public-private partnership, though may bring other project benefits as indicated above.

3.4. Financial Strength

Describe the financial strength of the applicant. If the applicant is not the eventual owner or project lead, describe the financial strength of those entities.

The New York City Economic Development Corporation (NYCEDC) is a non-profit organization acting under annual contracts with the City of New York as the city's primary agent for economic development. Its principal mandate is to encourage investment and attract, retain, and create jobs in New York City. The Mayor of the City of New York appoints NYCEDC's president and chairman of the board, which includes representatives of City agencies as well as appointees recommended by the Borough Presidents and the Speaker of the City Council. NYCEDC finances and manages city-owned property and capital construction projects, including industrial parks, wholesale and retail markets, heliports, rail lines and waterfront development. In FY2014, NYCEDC participated in 583 projects that accounted for 6.2% of total employment in New York City, $26.6 million in private investment and $121.7 million in total rent from 88 leases, including the FDC markets and other food businesses at Hunts Point. The development of the Hunts Point Microgrid would be part of the asset management of this property and be backed by the financial strength of the City of New York.

If a private sector Microgrid Developer would be the implementation partner and provides additional funding for the development, this partner would need to be chosen carefully under consideration of their financial strength and track record. NYCEDC has significant experience in procuring such partnerships and thus ensure a rigorous, open, and transparent tendering process to find a private partner that would not increase project risk, but rather reduce it.

3.5. Qualification and Performance Records

For identified project team members, including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners, what are their qualifications and performance records?

As described above, NYCEDC has a strong track record in managing city-owned property and developing capital construction projects on behalf of the City of New York. With long experience in large public-private partnerships, NYCEDC would select a Microgrid Developer in a competitive tendering process that would result in an implementation partner with the highest qualifications and performance records. When choosing contractors, suppliers and partners, the Microgrid Developer would also be held to apply high qualification and performance record requirements.

3.6. Contractors and Suppliers

Are the contractors and suppliers identified? If yes, who are they, what services will each provide and what is the relationship to the applicant? If no, what types of team members will be required and what is the proposed approach to selecting and contracting?

Contractors and suppliers are not yet identified, but will be chosen by the Microgrid Developer in a competitive tendering process. This includes architects, general contractors, subcontractors, equipment suppliers, operators and service providers. Criteria for selection are previously compiled performance specifications, financial strength as well as qualification and performance records. The tendering process is of great importance to the project’s viability and will therefore be previously defined by NYCEDC as the applicant and project lead.

3.7. Project Financiers

Are the project financiers or investors identified? If yes, who are they and what is their relationship to the applicant? If no, what is the proposed approach to securing proposed financing? Will other members of the project team contribute any financial resources?

In addition to potential NY Prize Stage 2 and 3 funds, another source of public funding may be the CDBG-DR funding that resulted from the HUD-sponsored Rebuild By Design competition and has been allocated to build resilience in the Hunts Point peninsula. This particular funding stream will be administered by NYCEDC on behalf of the City of New York. Additional private funding will be provided by the Microgrid Developer, who will bring both equity and debt to the project. The debt component may be from funds focused on long-term infrastructure investments as well as innovative financing concepts such as energy-as-a-service, solar leases and PPAs. Additionally, the Microgrid Developer could apply for public subsidies such as Renewable Energy Tax Credits (RETC) or Tax Increment Financing (TIF).

3.8. Legal and Regulatory Advisors

Are there legal and regulatory advisors on the team? If yes, please identify them and describe their qualifications. If no, what is the proposed approach to enlisting support in this subject area?

In the current phase of the Microgrid feasibility study, Sustainable Energy Partnerships is providing advice on technical and regulatory matters, with input provided by experts at the Pace University Law School Energy & Climate Center. In subsequent stages, legal and regulatory advisors and other consultants will be chosen based on a competitive tendering process that ensures qualification, long track record and financial strength.

4. Commercial Viability – Creating and Delivering Value

4.1. Microgrid Technologies

How were the specific microgrid technologies chosen? Specifically discuss benefits and challenges of employing these technologies.

CHP natural gas turbines allow the Hunts Point Microgrid to operate in islanded mode for days or even weeks as long as the natural gas network supplies gas. The CHP turbines follow the steam load demand and synchronize with photovoltaic resources and sell electricity to a variety of electrical customers in the FDC. The CHP plant allows the Microgrid to operate at high efficiency as waste heat is utilized generate steam for the refrigeration loads at the Meat and Produce Markets. When choosing a CHP technology, turbines were selected because of the higher ratio of thermal output to electrical output. At Hunts Point, the thermal demand for refrigeration greatly exceeds the electrical demand, therefore a gas turbine with high thermal efficiency was selected. A potential turbine was specified as the Caterpillar Centaur 50 by Solar Turbines that generates 4,600 kW of electricity (29.3% efficiency) and 25,280 lb of steam per hour (49.3% efficiency) for a total efficiency of 78.6% at a Heat Rate of 12,270 kJ/kWh. The sizing of the gas turbine has to take into consideration the maintenance and serviced outage, therefore it is preferable to buy multiple turbines instead of one single turbine. Major challenges of CHP system of this scale include a high rate of fuel consumption (53 MMBtu/hr) and emissions from burning natural gas.

After having chosen a CHP technology, the next step was to select electric and steam-driven chillers that are able to meet the expected refrigeration demand with the given electricity and steam input. Since the Microgrid will primarily follow the steam load to maximize efficiency, the maximum CHP steam rate is the limiting factor for refrigeration output. For comfort cooling purposes, a packaged single stage steam-turbine centrifugal compressor such as the JCI Model YST can be used to produce chilled water at 36° F. However, for refrigeration purposes, it is necessary to generate brine as low as -15° F, which cannot be done with a single stage compressor. Instead, a two-stage steam-driven refrigeration chiller has to be designed based on the JCI Titan Model OM. The cost of this chiller is almost independent of capacity due to the complexity and custom nature of this chiller, so one chiller with a capacity of 3,000 Refrigeration Tons (RT) was selected to meet the full refrigeration load for each the Meat Market and one 3,000 RT chiller was selected for the Produce Market. To compensate for maintenance downtime and risk of failure, it is however necessary that the base refrigeration load can also be met by electric chillers. Here, two packaged JCI Model CYK with 1,000 RT capacity each can be used as a backup. As a result, CHP gas turbines were sized to provide enough electricity for the unlikely case that both steam-driven chillers could be out of service and four electric chillers were operating to meet the full refrigeration demand.

	Name	Location	No.	Electricity	Steam	Refrig.
				kW	lb/hr	RT
Electrical	CHP	Parcel D	3	13,800	75,000	
	Solar PV	Parcel D	1	1,400		
	Solar PV	Produce Market	3	2,700		
	Solar PV	Meat Market	2	800		
	Solar PV	Fish Market	1	800		
	Solar PV	MS 424	1	200		
Thermal	Steam Chiller	Produce Market	1			3,000
	Electric Chiller	Produce Market	2			2,000
	Steam Chiller	Meat Market	1			3,000
	Electric Chiller	Meat Market	2			2,000
	Total			**19,700**	**75,000**	**10,000**

Table 7: Microgrid Generation Technologies

4.2. Leveraged Assets

What assets does the applicant and/or microgrid owner already own that can be leveraged to complete this project?

The main assets of this Microgrid are the three wholesale markets as reliable customers with large electrical and thermal loads that peak in the early morning hours. Additionally, these markets are all located on city-owned land administered by NYCEDC, which facilitates tariff negotiations and infrastructure installation. Another valuable asset is the undeveloped Parcel D, which is large enough to house CHP gas turbines, Microgrid control infrastructure, vertical farming and an Anaerobic Digester plant while being close enough to the Meat and Produce Markets to minimize the infrastructure costs and pressure losses for steam distribution. Finally, the Microgrid design leverages the existing ConEd network, with a new substation at Mott Haven and three redundant feeders under Food Center Drive. As a result, only a short feeder is necessary to connect the Microgrid to the ConEd distribution network.

4.3. Energy Balance

How do the design, technology choice, and/or contracts ensure that the system balances generation and load?

The Microgrid Central Controller (MCC) will optimize demand, supply and other network operation functions within the Microgrid and with the utility grid. By commanding local Intelligent Electronic Devices (IEDs) at the CHP gas turbines, solar PV panels and electric and steam-driven chillers, it can respond to changing loads in the Microgrid and thus maintain the system voltage and frequency. In normal operation, the MCC will optimize energy generation to maximize renewable energy sources, fuel savings and return on investment, while in islanded mode the prime objective is system stability. As the main loads within the Microgrid (e.g. steam-driven and electric chillers at the Meat and Produce Markets) are controlled by the MCC and the Fish Market tenants are equipped with smart meters, it is possible to introduce time-of-use pricing to encourage load management and demand response.

4.4. Permits and Special Permission

What permits and/or special permissions will be required to construct this project? Are they unique or would they be required of any microgrid? Why?

There may be need for special permission to cross public right-of-way for delivery of electricity and steam. To connect the Meat and Fish Market as well as Baldor to the Microgrid, it is necessary to cross Food Center Drive, which is a mapped street within the FDC, even though the entire FDC section of the peninsula is owned by the City of New York. Additional, there may be additional regulatory permissions necessary to cross several public streets outside FDC property in order to connect the three Community Refuge Facilities to the Microgrid. There would likely be negotiated agreements/permissions needed with ConEd to use existing tunnels and vaults and connect the Microgrid to the existing feeder. Those agreements will also address the issue that some of ConEd's existing distribution equipment will be either less utilized, or abandoned, requiring an extensive negotiation about the current value of all existing infrastructure. Finally, while unlikely, the Microgrid Developer may be required to register as a Public Service Entity to sell steam and electricity to unrelated customers, even though they are all located on the property owned by the City of New York.

4.5. Development and Operations Approach

What is the proposed approach for developing, constructing and operating the project?

The development of the Hunts Point Microgrid will follow the growth and facility modernization of the Food Distribution Center. A capital plan is currently being studied by NYCEDC on behalf of the City of New York and on March 5, 2015, Mayor Bill de Blasio announced a $150 million capital plan commitment over the coming 12 years to upgrade the Food Distribution Center and make it more resilient and sustainable. However, plans are still very much in discussion with stakeholders and NYCEDC could not provide or confirm any growth assumptions. Since facility growth plans have not been finalized, the Level team developed growth projections for the purpose of the analysis in this study. The following assumptions were not provided by NYCEDC or from the markets. The project team assumed that the 800,000 SF building of the **Produce Market** from 1967 will be gradually rebuilt into 1,200,000 SF of modern market facilities with a refrigeration load of 3,000 RT by 2030. Built in 1974, the central **Meat Market** buildings are almost as old as the Produce Market, therefore we assumed that 200,000 SF of existing buildings will be replaced by new buildings with a total GFA of 400,000 SF and a refrigeration load of 3,000 RT by 2030. The load of the **Fish Market** is expected to remain around 500 RT, as the building was completed in 2005 and is unlikely to be replaced within the next twenty years.

Name	SF/RT	2014	2020	2025	2030
Meat Market	Existing Bldg. sf	870,000	870,000	670,000	670,000
	New Bldg. sf	-	-	400,000	400,000
Produce Market	Existing Bldg. sf	800,000	800,000	400,000	-
	New Bldg. sf	-	300,000	750,000	1,200,000
Fish Market	Existing Bldg. sf	430,000	430,000	430,000	430,000
	Total RT	**3,400**	**4,200**	**6,000**	**6,500**

Table 8: Market Floor Area and Refrigeration Growth Assumptions

Based on these assumptions, the development for the Hunts Point Microgrid will consist of four stages. It will take up to three years before the proposed Microgrid is designed, approved and financed, therefore the first stage will not include significant changes. In the second phase, a new Produce Market building with a central refrigeration plant will be completed that includes one steam and two electric chillers. At the same time, Parcel D will be developed to house three CHP gas turbines, Microgrid control infrastructure and an Anaerobic Digester plant. The Produce Market as well as the Community will be connected to the Microgrid and the Meat Market central refrigeration plant will be upgraded by one steam-driven chiller. In the third stage, the Meat Market buildings will be replaced in part and the Produce Market replaces another building. In the final phase, the Produce Market buildings are completely replaced and reach maximum steam refrigeration load, thus allowing the construction of Vertical Farming on Parcel D to offtake the excess electricity, in addition to other businesses at Hunts Point that might want to join the Microgrid. During all phases, new buildings will be planned with flat roofs for solar PV as well as energy efficient refrigeration and cooling systems.

	Name	Variable	Unit	2030
Primary	Meat Market	Electricity	kW	3,000
		Steam	lb/hr	25,000
	Produce Market	Electricity	kW	3,000
		Steam	lb/hr	37,500
	Fish Market	Electricity	kW	2,300
Secondary	Vertical Farm	Electricity	kW	3,000
	Baldor	Electricity	kW	2,000
	Anaerobic Digester	Electricity	kW	300
	Energy Center	Electricity	kW	600
Community	MS 424	Electricity	kW	600
	La Peninsula	Electricity	kW	400
	The Point	Electricity	kW	200
Total		**Electricity**	**kW**	**15,400**
		Steam	**lb/hr**	**62,500**

Table 9: Electricity and Steam Growth Assumptions with Steam Chillers

The development, construction and operation will be in the hands of a Microgrid Developer, which ensures that the development maximizes long-term operational efficiency and the promised benefits for NYCEDC, the markets and the community.

4.6. Realization of Community Benefits

How are benefits of the microgrid passed to the community? Will the community incur any costs? If so, list the additional costs.

The three Community Facilities will be connected to the Microgrid in the second stage together with the Produce Market. From this moment on, these facilities will receive resilient electricity and be able to provide shelter to the community in case of emergency. The cost for the physical connection to the Microgrid will be borne by the Microgrid Developer as part of the Performance Specifications included in the tendering process. The community centers furthermore have the option to obtain affordable electricity during blue sky.

4.7. Utility Support

What will be required of the utility to ensure this project creates value for the purchaser of the electricity and the community?

The support of ConEd has significant impact on the viability of the Microgrid. Firstly, it needs to provide technical support to connect the Microgrid to the feeder under Food Center Drive and define control and communication standards, based on specification EO-2022. Secondly, ConEd has to provide competitive tariffs that address standby services, offset tariffs, electricity and natural gas rates, demand response incentives and frequency and voltage control services.

4.8. Demonstrated Technologies

Have the microgrid technologies (including, but not limited to generation, storage, controls) been used or demonstrated before? If yes, describe the circumstances and lessons learned.

The Centaur 50 by Solar Turbines from Caterpillar has been demonstrated in various cogeneration projects, including a dairy cooperative in Tipton, California in 2005. In order to compensate for low power quality and reliability, California Dairies invested in a Centaur 50 cogeneration system to provide electricity and heat for the milk processing and refrigeration for storage that can operate in islanded mode. The plant successfully operated at 86% overall efficiency and improved reliability, reduced product wastage and realized significant energy savings. This demonstration project shows that a Microgrid based on the Centaur 50 CHP system can operate in island mode at high efficiency by generating electricity and steam for production and refrigeration.

The JCI CYK centrifugal chiller also has been demonstrated on various projects, including the St. Michael's Hospital in Toronto/Canada and the Novartis Flu Vaccine Facility in Holly Springs, North Carolina. The JCI Titan Model OM is a custom-designed chiller with a proven base design that is adapted to every application, including the English Channel Tunnel, the Pentagon, Kennedy Space Center and other prestigious projects that demonstrate its functionality.

The Microgrid Central Controller (GE Grid IQ Microgrid Control System with U90^{Plus} Generation Optimizer) is a well-proven technology that has been previously utilized in a campus Microgrid at State University of New York in Broome County, New York City Metropolitan Hospital and Housing Authority as well as the Rockland Microgrid. However, the control system will have to be adapted to follow the steam load of the Market refrigeration plants and manage the various critical and non-critical loads of the Markets, the community and the businesses at Hunts Point.

4.9. Operational Scheme

Describe the operational scheme, including, but not limited to, technical, financial, transactional and decision making responsibilities that will be used to ensure this project operates as expected.

The Microgrid will be operated by a Microgrid Central Controller (MCC), such as the GE Grid IQ Microgrid Control System together with the U90^{Plus} Generation Optimizer. The core function is to monitor, track and forecast load and generation resources within the Microgrid. A smart dispatch system sends commands to IEDs at gas turbines and solar PV to meet predicted load requirements at lowest cost while maximizing the use of renewable energy resources. This requires adequate load and generation forecasting based on past data logging and weather predictions, which influences cooling need and solar PV generation. The forecast and economic factors used can be adjusted externally to respond to market and weather conditions by the GE Cimplicity SCADA. This system will be coupled with external weather forecasts and the potential implementation of a PV forecast system to allow intra-hour forecasting of the PV system. The GE Grid IQ Microgrid Control System continuously monitors the frequency and voltage of the Microgrid and the grid connection and will automatically disconnect from the grid if defined UF and UV thresholds are met for a specified period of time. It will then operate the system in islanded mode until the Microgrid operator receives a signal from the utility to reconnect and synchronize with the grid. The U90^{Plus} Generation Optimizer will also control the electric and steam-driven chillers at the markets based on their specifications, which allows better demand management including previously negotiated economic dispatch, demand response and load shedding in islanded mode. With this optimized control of both generation and loads within the Microgrid, the MCC is able to automatically coordinate frequency and voltage control services with the utility and sell excess electric energy to the grid if economically reasonable.

4.10. Metering and Billing

How does the project owner plan to charge the purchasers of electricity services? How will the purchasers' use be metered?

The operational scheme described above requires a dynamic metering system. At the new Meat and Produce Market buildings, one electricity meter and one steam meter will be installed at a single point of the incoming service location. The tenants will be billed for electricity and brine on a pro-rata share based on square footage, refrigerated area and temperature, similar to the current system at the Meat Market. The Fish Market tenants will continue to have individual electricity meters, but these will be upgraded to be smart meters and billing would be taken up by the Microgrid Developer, while building energy efficiency measures and Building Energy Management Systems are coordinated by the Fish Market Coop. The Community Facilities will continue to be metered individually and also obtain electricity from the Microgrid during blue sky conditions.

The customers will be charged based on a time-of-use tariff for electricity and steam that is below the average ConEd rate. Since the Meat and Produce Market central refrigeration plant chillers are controlled by the MCC, they will operate at optimal levels based on the refrigeration requirements of the tenants. The Fish Market tenants are metered individually and have an incentive to reduce their energy consumption as much as possible. They will also be charged on a time-of-day basis, which is beneficial since they operate mostly in the early morning hours when electricity is cheaper. The urban farm will be connected to the MCC control system and can also optimize their plant lighting energy use based on TOU electricity rates within the Microgrid.

4.11. Business and Replication Plans

Are there business/commercialization and replication plans appropriate for the type of project?

Different business models have been developed for various types of Microgrids, including hospitals, university campuses, military bases or industrial parks. Based on the Microgrid purpose and ownership models, they accrue different benefits such as energy, reliability, power quality, environmental and public health, safety and security benefits.

The Hunts Point Microgrid is a non-utility Microgrid comparable to military, university, school and hospital Microgrid business models. Both the distribution infrastructure and DER are owned by a private entity, located on a large property with a cluster of buildings with favorable electrical and thermal profiles. The main purpose is to improve resilience with the ability to operate in islanded mode while decreasing electricity cost through cogeneration to finance the Microgrid development cost. The main difference to the Hunts Point Microgrid is the fact that the different buildings are not operated by the same entity, but this can be mitigated through the joint ownership of the buildings and land by the City of New York and the operational control of generators and loads by the MCC.

4.12. Market Entry Barriers

How significant are the barriers to market entry for microgrid participants?
Does the proposer demonstrate a clear understanding of the steps required to overcome these barriers?

There are various physical, financial and regulatory barriers to market entry to Microgrid participants, i.e. potential Microgrid customers at Hunts Point. First, a physical cable/pipe has to be laid to connect each customer to the Microgrid independently of the utility network. This may be sanctioned by the authorities (e.g. when crossing a public right-of-way) or technically and financially prohibitive. Second, the energy tariffs of some potential customers, such as the Meat Market, may currently be subsidized or tax-exempt and therefore lower than the Microgrid tariff, reducing the incentive to join the Microgrid only for improved resilience. Third, tenants at the Produce and Fish Markets are currently metered and billed individually by ConEd, thus making it difficult to convince every single tenant to join the Microgrid in the case of the Fish Market or to agree to a central refrigeration plant with pro-rata-billing in case of the Produce Market. Finally, the proposal assumes building redevelopments for the Meat and Produce Markets including a central refrigeration plant, which is currently not funded or planned to the extend assumed here.

However, there are several ways to overcome these barriers. For each potential customer, the cost to connect to the Microgrid can be compared to the benefits in resilience, energy cost savings and additional income on a case-by-case basis. Regulatory issues will be addressed in the REV process and solved in cooperation with ConEd. The subsidized energy tariffs are mostly of a temporary nature and Microgrid participants have to consider alternatives early on. Third, the tenants at the Produce and Fish Markets will all have to renew their leases eventually, which gives NYCEDC as the Microgrid applicant the opportunity to encourage obtaining electricity from the Microgrid on a pro-rata base. Finally, the potential cost savings and resiliency benefits from the Microgrid might facilitate the redevelopment of old Meat and Produce Market buildings in concert with the Microgrid Development in order to keep Hunts Point competitive in the future.

5. Financial Viability

5.1. Revenue Streams

What are the categories and relative magnitudes of the revenue streams and/or savings that will flow to the microgrid owner? Will they be fixed or variable?

The main revenues arise from the sales of electricity and steam to the wholesale food marketsas well as local businesses and community facilities. These tariffs will be negotiated in Power Purchase Agreements and include a fixed base rate and a variable consumption rate, related to but below the market electricity rate. Even with the expected growth of the Meat and Produce Markets, total expenses for electricity and steam in 2030 are expected not exceed the current electricity cost of the markets. Excess electricity can be sold to the vertical farming business and other businesses in the Food Distribution Center, such as Baldor or Dairyland. The remaining electricity will be sold to the utility grid based on ISO rates that vary by season, day and hour. Additional revenues can be generated by participating in demand response programs or by providing ancillary services such as voltage and frequency control. These revenues will have a fixed standby-rate as well as a variable rate when the service is actually used. The revenues detailed in the table below are estimates by the project team based on the growth assumptions above.

Name	2016	2020	2025	2030
Electricity				
Meat Market	$-	$1,154,000	$2,276,000	$2,540,000
Fish Market	$-	$646,000	$1,042,000	$1,164,000
Produce Market	$-	$2,072,000	$2,342,000	$1,499,000
Vertical Farm	$-	$-	$-	$1,718,000
Baldor	$-	$-	$704,000	$784,000
Anaerobic Digester	$-	$95,000	$154,000	$172,000
Community	$-	$159,000	$256,000	$286,000
ConEd Grid	$-	$-	$66,000	$353,000
Steam				
Meat Market	$-	$2,138,000	$3,751,000	$4,051,000
Produce Market	$-	$1,058,000	$2,784,000	$4,510,000

Other Income				
Demand Response	$-	$500,000	$500,000	$500,000
Ancillary Services	$-	$200,000	$200,000	$200,000
Total	**$-**	**$8,022,000**	**$14,075,000**	**$17,777,000**

Table 10: Microgrid Revenues

5.2. Incentives

What other incentives will be required or preferred for this project to proceed? How does the timing of those incentives affect the development and deployment of this project?

To ensure financial feasibility, the Microgrid requires both capital and operating incentives. Potential capital incentives have been outlined as the Rebuild By Design CDBG-DR funds and, potentially, NY Prize funds, both of which are focused on projects that build long-term resiliency. Additionally, Renewable Energy Tax Credits (RETC) can be applied for, as the Microgrid serves a low-income community with a large portion of solar PV panels. The timing of these incentives is important, as private financing would likely be contingent on public funds being in place. For the operation of the Microgrid, subsidized rates on natural gas and reduced demand charges impact the profitability of the Microgrid and thus the amount of private investment before its development. Furthermore, the Microgrid has to be able to provide lower combined rates for electricity and steam to the Markets in order to justify the additional investment, maintenance and risk. The REV process looking will therefore have a large impact on these operating rates and the financial feasibility of the Microgrid.

5.3. Capital and Operating Costs

What are the categories and relative magnitudes of the capital and operating costs that will be incurred by the microgrid owner? Will they be fixed or variable?

Most capital cost will be spent in the first development phase to construct the Microgrid infrastructure and Energy Center and upgrade/build the central refrigeration plants. Later capital cost incur when buildings at the Produce and Meat Markets are incrementally replaced. The total capital cost for three CHP gas turbines of $60M is the single largest expense. Ground and roof-mounted solar PV add another $22M for DER. The electrical infrastructure (feeder, switchgear and chillers at the Produce Market) is estimated to cost $14M, while thermal infrastructure (steam distribution and chillers) contribute $19M to the total cost. The Microgrid and building control and communication infrastructure is based on proven GE Multilin U90^{Plus} and GE

Cimplicity technology at a hardware price of $1.4M. However, their design, engineering and testing adds significantly to the soft development cost of $6.7M. Finally, the preparation and construction of the Energy Center on Parcel D is estimated to cost another $14M to the budget, with total capital expenditures potentially reaching $137M including 8% soft cost, 20% contingency and 15% escalation. ConEd will provide the connection to the natural gas network in order to secure additional business, while the operator of the Anaerobic Digester and the vertical farm are responsible for their investment and the connection within Parcel D. A proposal for the timing of capital expenditures is detailed below:

Name	2018	2024	2029	2034
Distributed Energy Resources				
CHP	$59,202,000			
Ground Solar PV	$5,005,000			
Markets Solar PV	$7,043,000	$6,256,000	$3,218,000	
Electrical Infrastructure				
Feeder	$7,436,000			
Switchgear	$2,717,000	$629,000		
Electric Chillers	$3,432,000			
Thermal Infrastructure				
Steam Distribution	$2,202,000			
Steam Chillers	$17,160,000			
Microgrid Infrastructure				
Microgrid Controls	$882,000			
Building Controls	$40,000	$235,000		
MG Communication	$189,000	$57,000		
Energy Center				
Construction	$11,440,000			
Site Improvements	$2,860,000			
Pre-Development				
Study, Design, Legal	$6,780,000			
Total	**$126,388,000**	**$7,177,000**	**$3,218,000**	**$0**

Table 11: Microgrid Capital Expenses

The capital costs used for the BCA, though, exclude the chiller costs, public educational building, and other facility costs that are not considered exclusively part of this project and would be required of any new facilities and buildings. The project soft costs for design and planning of $7.3M were not included in the project 'capital investments' component of the BCA. Then discounting the remaining costs to 2016 dollars results in a project capital cost of $76.9M for use in the BCA.

Operating expenses of the Microgrid Developer are dominated by the cost of purchasing natural gas from ConEd. The ground lease for the energy center is estimated at annual cost of $600,000, while other operation and maintenance cost account for approximately $2.4M per year in 2030. This includes maintenance of the Microgrid DER and infrastructure, administrative staff as well as legal and administrative fees in addition to gross revenue taxes, insurance and licenses. Maintenance cost also include capital expenses for repair and replacements.

Name	2020	2025	2030
ConEd Gas	$(3,225,000)	$(6,443,000)	$(7,009,000)
Ground Lease	$(600,000)	$(600,000)	$(600,000)
Standby Service	$(617,000)	$(617,000)	$(617,000)
Maintenance	$(527,000)	$(563,000)	$(579,000)
Staff	$(411,000)	$(723,000)	$(915,000)
Billing	$(82,000)	$(145,000)	$(183,000)
Legal+Admin	$(41,000)	$(72,000)	$(91,000)
Licenses	$(11,000)	$(14,000)	$(14,000)
Insurance	$(164,000)	$(289,000)	$(366,000)
Taxes	$(329,000)	$(579,000)	$(732,000)
Total	**$(6,007,000)**	**$(10,045,000)**	**$(11,106,000)**

Table 12: Microgrid Operating Expenses

5.4. Profitability

How does the business model for this project ensure that it will be profitable?

The 20-year cash flow projections based on all of the above revenues and expenses show an Internal Rate of Return of 10% for the Microgrid Developer. Considering the risk of complexity of the project, this return would be too low for most private developers, but potentially interesting for public owners such as ConEd, NYPA, or NYCEDC that look more to public benefit than profitability. There may be other incentives and operational changes that could improve the project economics and help attract private developers. For example, positive cash flow is not projected to commence until the Meat Market commissions the 3,000 RT steam-drive chillers, which is not until 2025. Therefore, bringing the sale of steam to the Meat Market as early as 2018 by upgrading the existing central plant did significantly improve project profitability.

The Net Operating Income is approximately $13M through to 2024, then $22M in 2025 and $44M in 2030. The capital expenses as outlined above are subtracted from the NOI to calculate the Net Cash Flow of the project, which is negative in the first phase but positive as soon as the Microgrid generates revenues. Finally, the financing structure and amount of public subsidies as described below will influence the debt service and thus the levered Net Cash Flow of the project, which requires financing until the projected NOI growth increases the asset value of the Microgrid based on a Capitalization Rate of 5.5% and finally allows the developer to sell the investment for $139M at an IRR of 9% after paying off all permanent loans

Name	2016-2018	2019-2024	2025-2029	2030-2035
Revenues	$-	$52,634,000	$74,039,000	$115,476,000
OPEX	$-	$(38,800,000)	$(51,397,000)	$(70,178,000)
NOI	$-	$13,834,000	$22,641,000	$45,299,000
CAPEX	$(126,460,000)	$(7,177,000)	$(3,218,000)	$-
NCF	$(126,460,000)	$6,657,000	$19,424,000	$45,299,000
Debt Service	$(3,574,000)	$(18,971,000)	$(21,253,000)	$(26,143,000)
Levered NCF	**$(130,033,000)**	**$(12,314,000)**	**$(1,829,000)**	**$19,156,000**

Table 13: Microgrid Cash Flow

5.5. Financing Structure

Describe the financing structure for this project during development, construction and operation.

The negative Levered Net Cash Flow in the first three phases of the development will have to be financed through a combination of private equity, bank loans and public subsidy. The first construction loan amount is comparably small, taking into consideration a Loan-To-Value ratio of

75% and the limited Net Operating Income at the beginning. In the second phase, the construction loan can be refinanced with a permanent loan at a more favorable interest rate considering the increased asset value. Tax Credit Equity and public subsidies, such as potential HUD CDBG-DR and NY Prize funding, could help fund the initial phase of the development in order to achieve the public benefits (energy resiliency, food security and employment) discussed above. Other options to increase Net Cash Flow include reducing the capital expenses for the Microgrid Developer, financial contributions of the City or the Markets, or increasing the rates for electricity and steam within the Microgrid. Any remaining financing gap will need to be filled by private equity investments that are recovered later as the Microgrid increases in value. The balance of these payments constitutes the IRR of the Microgrid Developer and determines, which type of Developer (public or private) would be interested in the development.

Name	2016-2018	2019-2024	2025-2029	2030-2035
Investment				
HUD CDBG-DR RBD	$35,000,000	$-	$-	$-
NY Prize	$7,000,000	$-	$-	$-
Private Equity	$31,643,000	$(18,789,000)	$1,644,000	$(108,645,000)
RETC Equity	$2,938,000	$-	$-	$-
Asset Sale	$-	$-	$-	$139,774,000
Financing				
Construction Loan	$50,564,000	$(50,564,000)	$-	$-
Permanent Loan	$-	$81,360,000	$-	$(50,331,000)
Total	**$127,145,000**	**$12,007,000**	**$1,644,000**	**$(19,202,000)**

Table 14: Microgrid Financing Sources (negative amounts indicate payout to developer or bank)

6. Legal Viability

6.1. Ownership Structure

Describe the proposed project ownership structure and project team members that will have a stake in the ownership.
Has the project owner been identified? If yes, who is it and what is the relationship to the applicant? If no, what is the proposed approach to securing the project owner?

The New York City Economic Development Corporation (NYCEDC) manages the Hunts Point Food Distribution Center on behalf of the City of New York. According to the project teams' proposal, NYCEDC could apply for subsequent stages of NY Prize and financially contribute to the Microgrid as a stakeholder with public funding. Furthermore, NYCEDC could conduct a RFP process to choose a Microgrid Developer, who designs, builds and operates the Microgrid, contributes own funds and organizes additional private investment. As a result, the Microgrid would be owned jointly by NYCEDC, the Microgrid Developer and – potentially – private investors with a long-term investment horizon. Current project team members will not have a stake in ownership.

6.2. Site Ownership

Does the project owner (or owners) own the site(s) where microgrid equipment/systems are to be installed? If not, what is the plan to secure access to that/those site(s)?

NYCEDC would retain management of the entire Food Distribution Center on behalf of the City of New York. Therefore, the Microgrid Developer would enter into a long-term ground lease for Parcel D with the City of New York.

6.3. Privacy Rights Protection

What is the approach to protecting the privacy rights of the microgrid's customers?

Privacy rights of customers will be the same as required for a PSC regulated energy supplier. However, the use of smart meters and the control of customer generation and refrigeration equipment poses additionally challenges to privacy rights protection. These have to be contractually defined with each customer and physically implemented through secure communication and data storage.

6.4. Regulatory Hurdles

Describe any known, anticipated, or potential regulatory hurdles, as well as their implications that will need to be evaluated and resolved for this project to proceed. What is the plan to address them?

While the current regulatory environment is expected to evolve during the period of the design and construction of the Hunts Point microgrid with the ongoing REV process, even today it is not expected that the Microgrid Developer would be a regulated utility under supervision of the Public Service Commission, as the steam and electricity is being sold to entities that are on land owned by the NYC EDC. In essence, this would be the same as a building owner submetering and billing tenants for energy use in a single building, or an industrial park developer selling thermal energy to tenants of that industrial park.

Another potential regulatory hurdle is the crossing of public rights-of-way, which would be necessary at least once when crossing Food Center Drive to connect the Meat and Fish Market to the Microgrid. With the EDC being an agency of New York City, utility easements across Food Center Drive may be a way of solving this regulatory issue. It is also possible that the REV process might result in reducing this issue in situations where both sides of the public road are owned by the Microgrid Developer. The transition of ownership of existing distribution wires and transformers poses a third hurdle that can likely be overcome in negotiations with ConEd by paying a price that reflects the lifetime and cost of this infrastructure, considering that much of it will be replaced anyway during new construction.

A series of environmental approvals for the project will likely be required as a 15MW cogen plant including SEQR, CEQR, and other permitting processes that require an Environmental Impact Statement (EIS). The facility will likely exceed the limits for SEQR Title V emissions levels of 25 tons/yr of NOx and 100 tons/yr of SOx. Considering the recent Title V permit granted to the Columbia University Morningside Heights 15 MW cogen plant, the environmental regulatory process is likely to be an achievable process for the Hunts Point Microgrid. NEPA approvals may also be required for this project if the CDBG-DR federal funds are included in the project funding.

Another regulatory hurdle may arise from the ground contamination of Parcel D. Although the long term responsibility for cleaning up the site lies is with ConEd as former operator of a gasification plant on the site, the process to remediate the site has not begun and the schedule for the cleanup has not been set. Finally, a major regulatory hurdle is the sale of electricity back into the utility grid under current tariffs. Tariffs reflecting standby charges, offset tariffs, demand response incentives and voltage/frequency control services will be addressed during the REV process and have a significant impact on the financial feasibility of the proposed Microgrid.

Appendix IV: Benefit-Cost-Analysis Report

By third-party consultant and attached below.

Benefit-Cost Analysis Summary Report

Site 15 – Hunts Point

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, Hunts Point has proposed development of the Hunts Point Community Microgrid, a project that would enhance the resiliency of electric service for several facilities in the South Bronx:

- A wholesale meat market with multiple cooperative tenants that share a central refrigeration system;
- A wholesale produce market with multiple cooperative tenants, each of whom maintains an individual customer account with ConEd;
- A wholesale fish market with multiple cooperative tenants, also with individual customer accounts;
- A specialty foods market (Baldor);
- A proposed anaerobic digester facility that will generate biogas from organic food waste;
- A proposed vertical farm that will grow hydroponic produce; and
- Three community refuge facilities: the Hunts Point Middle School (MS 424), La Peninsula Headstart, and The Point CDC.

The microgrid would be powered by three natural gas-fired combined heat and power (CHP) turbines, each with a nameplate capacity of 4.6 MW, and eight photovoltaic (PV) arrays with a combined generating capacity of 5.9 MW. The project would also involve development of a steam-based chilling system that would replace a large portion of the facilities' electricity demand by using steam from the CHP turbines to produce refrigeration for the food markets. The project's proponents anticipate that the microgrid's DERs would meet almost all of the served facilities' electricity demand during normal operations and that the system would have sufficient generating capacity to fully support all facilities during a major power outage. Project consultants also indicate that the system would have the capability of providing ancillary services to the grid.

To assist with completion of the project's NY Prize Stage 1 feasibility study, IEc conducted a screening-level analysis of the project's potential costs and benefits. This report describes the results of that analysis, which is based on the methodology outlined below.

METHODOLOGY AND ASSUMPTIONS

In discussing the economic viability of microgrids, a common understanding of the basic concepts of benefit-cost analysis is essential. Chief among these are the following:

- *Costs* represent the value of resources consumed (or benefits forgone) in the production of a good or service.
- *Benefits* are impacts that have value to a firm, a household, or society in general.
- *Net benefits* are the difference between a project's benefits and costs.
- Both costs and benefits must be measured relative to a common *baseline* - for a microgrid, the "without project" scenario - that describes the conditions that would prevail absent a project's development. The BCA considers only those costs and benefits that are *incremental* to the baseline.

This analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the costs and benefits of developing microgrids in New York State. The model evaluates the economic viability of a microgrid based on the user's specification of project costs, the project's design and operating characteristics, and the facilities and services the project is designed to support. Of note, the model analyzes a discrete operating scenario specified by the user; it does not identify an optimal project design or operating strategy.

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[1] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

With respect to public expenditures, the model's purpose is to ensure that decisions to invest resources in a particular project are cost-effective; i.e., that the benefits of the investment to society will exceed its costs. Accordingly, the model examines impacts from the perspective of society as a whole and does not identify the distribution of costs and benefits among individual stakeholders (e.g., customers, utilities). When facing a choice among investments in multiple projects, the "societal cost test" guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).

[1] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO_2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NO_x, and $PM_{2.5}$, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[2]

The feasibility study for the Hunts Point Community Microgrid outlines the anticipated evolution of the project over several years. The study's "final buildout" scenario projects growth in the supported facilities and development of two additional facilities (the anaerobic digester and vertical farm) as of 2030. The benefit-cost analysis focuses on the "final buildout" scenario, estimating the benefits and costs of the microgrid project assuming all development occurs as projected.[3]

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.6 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 1. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.6 DAYS/YEAR
Net Benefits - Present Value	-$24,300,000	$3,770,000
Benefit-Cost Ratio	0.9	1.0
Internal Rate of Return	2.2%	6.4%

Scenario 1

Figure 1 and Table 2 present the detailed results of the Scenario 1 analysis.

[2] The New York State Department of Public Service (DPS) requires utilities delivering electricity in New York State to collect and regularly submit information regarding electric service interruptions. The reporting system specifies 10 cause categories: major storms; tree contacts; overloads; operating errors; equipment failures; accidents; prearranged interruptions; customers equipment; lightning; and unknown (there are an additional seven cause codes used exclusively for Consolidated Edison's underground network system). Reliability metrics can be calculated in two ways: including all outages, which indicates the actual experience of a utility's customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility's control. In estimating the reliability benefits of a microgrid, the BCA employs metrics that exclude outages caused by major storms. The BCA classifies outages caused by major storms or other events beyond a utility's control as "major power outages," and evaluates the benefits of avoiding such outages separately.

[3] Because the benefit cost analysis uses projections of fuel prices, electricity generation prices, and capacity prices beginning in 2016, the analysis of the Hunts Point Community Microgrid essentially estimates benefits and costs under the assumption that the project achieves full buildout in 2016.

Figure 1. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

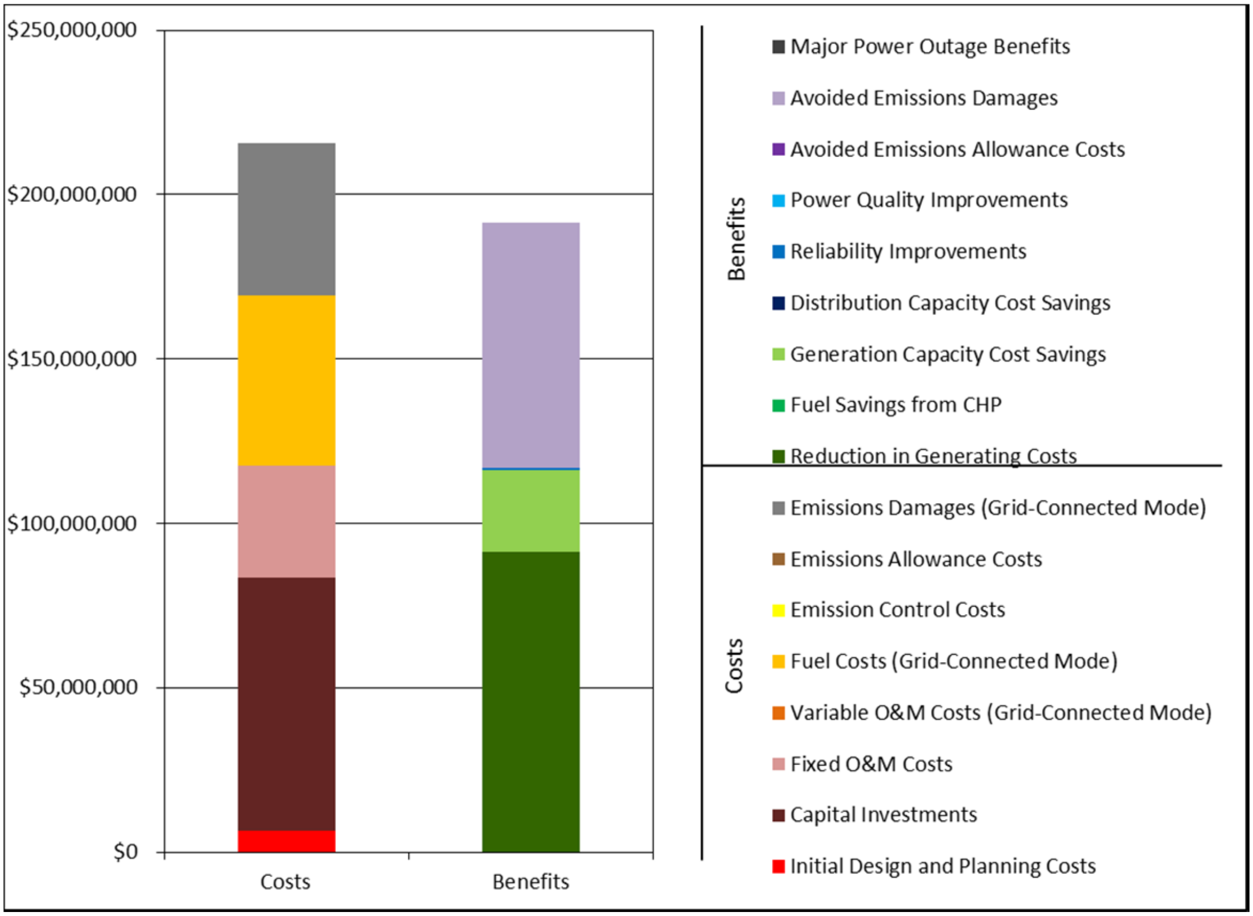


Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$6,700,000	$591,000
Capital Investments	$76,900,000	$6,710,000
Fixed O&M	$33,800,000	$2,980,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$51,900,000	$4,580,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$46,500,000	$3,030,000
Total Costs	**$216,000,000**	
Benefits		
Reduction in Generating Costs	$91,400,000	$8,060,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$24,900,000	$2,200,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$444,000	$39,200
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$50,200	$4,430
Avoided Emissions Damages	$74,600,000	$4,870,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$191,000,000**	
Net Benefits	**-$24,300,000**	
Benefit/Cost Ratio	**0.9**	
Internal Rate of Return	**2.2%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $6.7 million. The present value of the project's capital costs is estimated at approximately $76.9 million, including costs associated with acquiring and installing the new CHP generators and PV arrays; the steam chillers and distribution system; switches, panels, and cables; and controllers. The present value of fixed operation and maintenance (O&M) costs over a 20-year operating period – including periodic replacement and repair of capital components, the ground lease for the land where the microgrid controls will be housed, software licensing and labor – is estimated to be approximately $33.8 million.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of fuel for the system's three natural gas generators. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's State Energy

Plan (SEP), adjusted to reflect recent market prices.[4] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $51.9 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that the three natural gas generators would not be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the new generators are estimated at approximately $3.0 million annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $46.5 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. In the case of the Hunts Point Community Microgrid, the primary source of cost savings would be a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs. As noted above, the development of a steam-driven chilling system would significantly reduce electricity demands for the food markets served by the microgrid, with projected annual electricity purchases from ConEd decreasing (in the 2030 scenario) from about 152,250 MWh to about 4,300 MWh. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $91.4 million; this estimate uses average electricity prices to value the reduced demand for electricity from bulk energy suppliers, consistent with the operating profile upon which the analysis is based. The reduction in demand for electricity from bulk energy suppliers would also reduce emissions of CO_2 and particulate matter from these sources, and produce a shift in demand for SO_2 and NO_x emissions allowances. The present value of these benefits is approximately $74.6 million.[5]

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.[6] Based on the project team's application of standard capacity factors for PV systems and natural gas generators, the analysis estimates the present value of the project's generating capacity benefits to be approximately $24.9 million over a 20-year operating period. The project is not expected to have any impact on distribution capacity.

The project team has indicated that the proposed microgrid would be capable of providing ancillary services (real power support and reactive power support) to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the market for ancillary services is highly competitive, and that projects of this type would have a relatively small chance of being selected

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[4] The model adjusts the State Energy Plan's natural gas and diesel price projections using fuel-specific multipliers that are based on the average commercial natural gas price in New York State in October 2015 (the most recent month for which data were available) and the average West Texas Intermediate price of crude oil in 2015, as reported by the Energy Information Administration. The model applies the same price multiplier in each year of the analysis.

[5] Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO_2 using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency (EPA). [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO_2 and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

[6] Impacts on transmission capacity are implicitly incorporated into the model's estimates of avoided generation costs and generation capacity cost savings. As estimated by NYISO, generation costs and generating capacity costs vary by location to reflect costs imposed by location-specific transmission constraints.

to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing such services.

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $39,200 per year, with a present value of $444,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[7]

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[8]

The estimate takes into account the number of large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[9] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

It is important to note that the analysis of reliability benefits assumes that development of a microgrid would insulate the facilities the project would serve from outages of the type captured in SAIFI and CAIDI values. The distribution network within the microgrid is unlikely to be wholly invulnerable to such interruptions in service. All else equal, this assumption will lead the BCA to overstate the reliability benefits the project would provide.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.9; i.e., the estimate of project benefits is approximately 90 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the

[7] www.icecalculator.com.

[8] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Consolidated Edison.

[9] http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1.

incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[10]

As noted above, the Hunts Point Community Microgrid would serve four food market facilities (comprising multiple vendors), as well as two supporting facilities (an anaerobic digester and a vertical farm), and three facilities that serve as community refuge centers. The project's consultants indicate that at present, none of these facilities is equipped with a backup generator. If an extended outage occurred, all facilities would rent backup diesel generators (assuming rental units were available) sufficient to meet the full electricity needs for all supported facilities with no loss in operating capabilities. If these generators failed or if rental units were unavailable, the markets and support facilities would experience a complete loss in operating capabilities. Of the three refuge centers, MS 424 would experience a complete loss in operating capability, while La Peninsula Headstart and The Point CDC would experience a 50 percent loss in operating capabilities.

The information provided above serves as a baseline for evaluating the benefits of developing a microgrid. Specifically, the assessment of Scenario 2 makes the following assumptions to characterize the impacts of a major power outage in the absence of a microgrid:

- During an extended outage, the four food markets would close their doors to minimize the risk of spoilage, and during the first day of the outage would not need to run backup generators. Fuel costs for backup generators for the food markets would therefore only be incurred on days after the first full day of a major outage.
- For all facilities, the supply of fuel necessary to operate portable generators would be maintained indefinitely.
- For all rented backup generators, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. For the four food markets, the analysis uses estimates of daily revenue as a proxy for the value provided by the markets when operating normally. In doing so, the analysis may over- or under-estimate the social welfare benefits provided by these markets. Clearly, the loss in revenue that would result if the markets temporarily shut down would be offset, in part, by some savings in operating costs. Conversely, it is difficult to quantify the additional costs that would be incurred to provide food to the New York metropolitan area if the Hunts Point markets were closed for an extended period of time, or to estimate the adverse impact on consumers of higher prices or potential food shortages. In the absence of better data, reliance on daily revenue figures provides a reasonable basis for characterizing the economic importance of Hunts Point as the primary wholesale food distribution center for the New York area. The daily revenue estimates for each market are as follows:

- For the Meat Market, a value of approximately $17.2 million per day.
- For the Produce Market, a value of approximately $12.3 million per day.
- For the Fish Market, a value of approximately $5.4 million per day.

[10] As with the analysis of reliability benefits, the analysis of major power outage benefits assumes that development of a microgrid would insulate the facilities the project would serve from all outages. The distribution network within the microgrid is unlikely to be wholly invulnerable to service interruptions. All else equal, this will lead the BCA to overstate the benefits the project would provide.

- For Baldor, a value of approximately $3.1 million per day.[11]

For the two supporting facilities, the analysis employs the ICE Calculator to estimate the economic costs of a sustained interruption of service, based on each facility's location, economic sector, and average electricity use. The calculator estimates that the services provided by the two facilities would have a value of approximately $420,000 per day.

For the three community refuge centers, the analysis uses a standard value of $50 per person per day, based on American Red Cross data on the cost of providing overnight shelter.[12] Because the three refuge centers could support up to 580 people, the analysis assigns them a value of $29,000 per day.

Based on these values, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the nine supported facilities is approximately $4.14 million per day.

Summary

Figure 2 and Table 3 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.6 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.6 Days/Year; 7 Percent Discount Rate)

[11] In order to avoid double-counting, the analysis does not separately estimate the value of inventory losses that might occur during outages lasting longer than one day. The value of inventory losses is already accounted for in the estimate of lost sales.

[12] American Red Cross. Fundraising Dollar Handles for Disaster Relief Operations, Revised March 2014 – based on FY14 Figures.

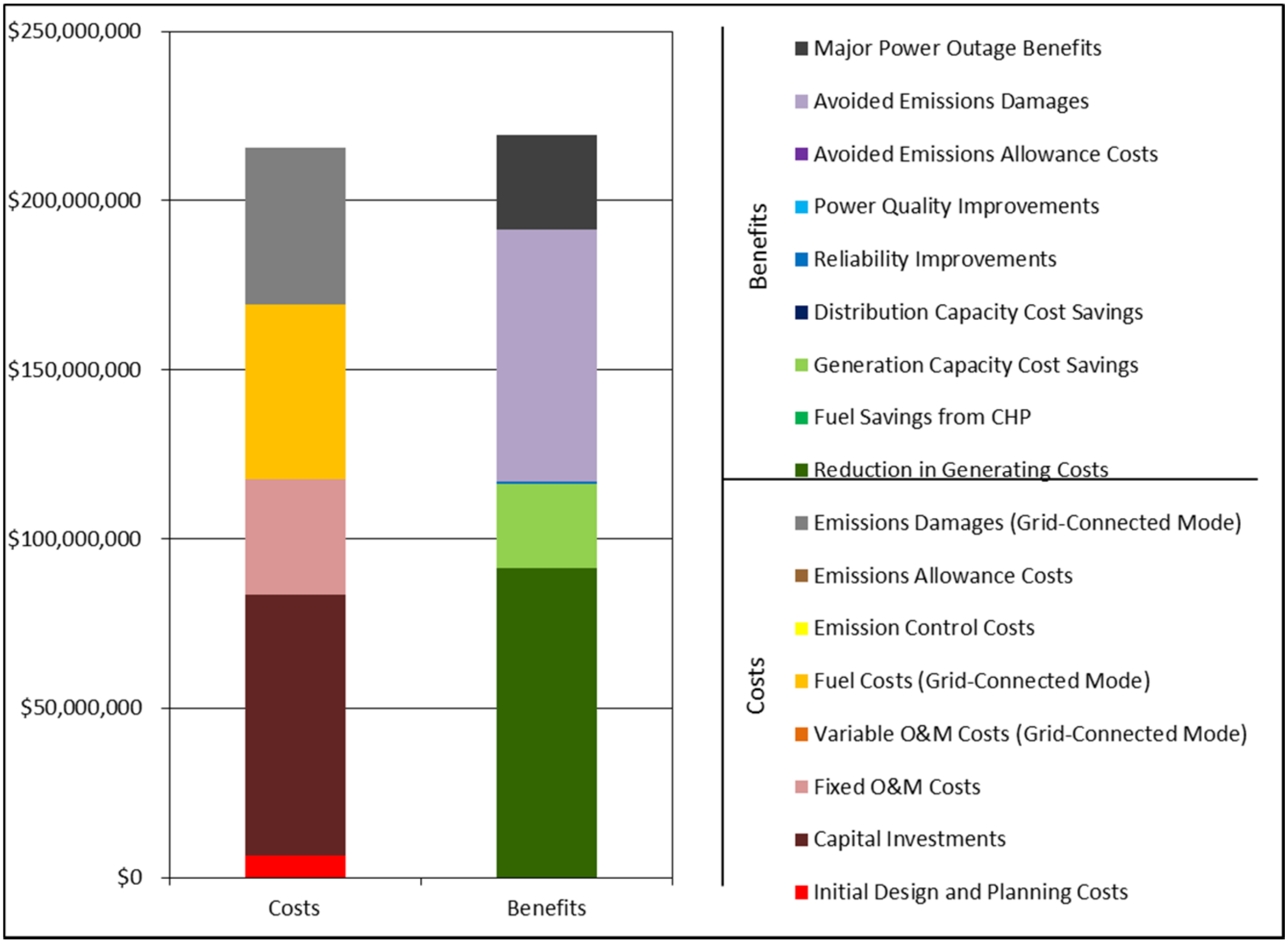
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$0
Costs
Benefits
Benefits
Major Power Outage Benefits
Avoided Emissions Damages
Avoided Emissions Allowance Costs
Power Quality Improvements
Reliability Improvements
Distribution Capacity Cost Savings
Generation Capacity Cost Savings
Fuel Savings from CHP
Reduction in Generating Costs
Costs
Emissions Damages (Grid-Connected Mode)
Emissions Allowance Costs
Emission Control Costs
Fuel Costs (Grid-Connected Mode)
Variable O&M Costs (Grid-Connected Mode)
Fixed O&M Costs
Capital Investments
Initial Design and Planning Costs

Table 3. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.6 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$6,700,000	$591,000
Capital Investments	$76,900,000	$6,710,000
Fixed O&M	$33,800,000	$2,980,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$51,900,000	$4,580,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$46,500,000	$3,030,000
Total Costs	**$216,000,000**	
Benefits		
Reduction in Generating Costs	$91,400,000	$8,060,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$24,900,000	$2,200,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$444,000	$39,200
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$50,200	$4,430
Avoided Emissions Damages	$74,600,000	$4,870,000
Major Power Outage Benefits	$28,100,000	$2,480,000
Total Benefits	**$220,000,000**	
Net Benefits	**$3,770,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.4%**	