14 - Village of Freeport

Notice

NYSERDA
NYPrize Stage 1
Village of Freeport Downtown Microgrid
Task 5 - Final Report

April 27, 2016

Contents

Tables

Figures

Appendices

Appendix A

IEC BCA Analysis and Report

Executive Summary

Freeport is located in the Town of Hempstead on the south shore of Nassau County in Long Island, New York. Freeport covers approximately 4.5 square miles of land and maintains its own municipal electric and water utilities, police and fire departments.

Installation of the Freeport Downtown Microgrid as described in this assessment would provide electricity service to some 46 critical customers in the proposed microgrid area during a transmission interruption. Of these customers, 19 are designated “primary” and 27 are designated “secondary” critical assets. Primary critical assets include public schools, public housing, libraries, medical centers, emergency centers, and water/wastewater treatment infrastructure. Secondary critical assets included emergency services, banks, gas station, and super markets. The proposed microgrid would ensure the continuous operation of these facilities during interruptions, and benefit to all customers in the Village of Freeport and surrounding communities by ensuring the availability of essential services during any interruption. Other benefits include additional revenue opportunities for businesses by servicing the wider Long Island and the continuous operations of schools. It is this reason that the community recommended a Downtown Microgrid project as part of NY Rising Community Reconstruction (NYRCR).

Freeport’s current power requirements are imported from the LIPA/PSEG grid interconnect at the 4F Substation **[redacted]**. This gateway is a 138 kV connection that has been in service since 1996 and provides purchased power from the NY State Grid. The most severe condition occurs when power is not available from the 138kV interconnect and the Freeport distribution system operates as an islanded system. At this time, internal generation is required to utilize black-start capability at Power Plant 2’s (PP2) 16MW GT-3 engine, which is nearly 60-years old and in the floodplain.

The Freeport Downtown Microgrid will provide power to those critical facilities and key customers providing fundamental services for the community. The geographical area covered by the Freeport Downtown Microgrid is made of a mix of key critical and primary facilities, business and commercial buildings, and residential units. Overall, there are approximately 245 customers (defined as individual parcels and excluding parking areas, right of ways, and vacant lands). Of these parcels, approximately 54% are commercial, 35% are residential and 10% provide community services.

Primary generation sources for the Freeport Downtown Microgrid include a mix of solar PV, natural gas generators, and distillate fuel generators, augmented by battery storage. In addition, a 900kW wind turbine is recommended as an external source of power to the proposed microgrid. The table below contains a complete list of the proposed microgrid distributed generation resources.

Type	Location	Size
Rec Center Solar PV (Parking)	Freeport Rec Center	1.06
Rec Center Solar PV (Roof)	Freeport Rec Center	0.271
Industrial Park Wind Turbine	Industrial Park Wind Turbine	0.90
JMS 624 GS-N.L (A)	Power Plant 1	4.50
JMS 624 GS-N.L (B)	Power Plant 1	4.50

The Freeport Downtown Microgrid will be served by generation resources according to a prioritization protocol similar to that governing loads.

Microgrid Generation Resource Hierarchy

Tier 1 – Generation sources directly connected to the electrical busses supplying the new 13.8kV critical load circuits (i.e., PP1, recreation center, school solar PV)

Tier 2 – Generation sources directly connected to other downtown circuits (i.e., additional solar PV at parking locations)

Tier 3 – Generation sources able to provide power to Freeport Downtown Microgrid circuits through intermediate interconnecting feeders (i.e., industrial park wind turbine, PP2)

The study proposed the derivation of new, resilient, 13.8kV circuits from the PP1 substation to connect all currently identified downtown critical/priority loads. These critical circuits traverse a fairly broad portion of the downtown area, and thus could be expanded in the future, or reconfigured as critical facilities change over the course of time. Load flows within the microgrid will be monitored and controlled by a microgrid central controller. This is due to the fact that generation and load resources are both spread across the microgrid.

The results of the study culminated in a project that is estimated to cost approximately $35 million in up-front capital costs. Based on these results, NYSERDA's economic modeling consultant, Industrial Economics, Inc. (IEc) conducted a Benefit Cost Analysis (BCA) for the Freeport Downtown Microgrid. Their calculation of present value costs (capital and fixed/variable maintenance/operating costs) of the Freeport Downtown Microgrid is $79.7M and the Freeport Downtown Microgrid provides a present value benefit of $115M and a net present value benefit of $35.2M to Downtown Freeport. The results of the BCA indicate that the benefit-to-cost ratio is 1.44. The major financial benefits include power quality benefits, reduction in generating costs and avoided emissions damages. The project team removed a large amount of residential and commercial customers from the Freeport Downtown Microgrid while ensuring that critical facilities and enough basic services were met for the Village and the surrounding community. Removing residential and commercial customers also reduces political issues and the chance of prioritizing one residential or commercial customer on the Microgrid over another customer off the Microgrid. The additional customers would have yielded higher values for reliability improvements and power quality improvements. In addition, the high capital costs do not include incentives, grants and third-party tax benefits.

Additional benefits include the potential to defer or even nullify the need to replace Power Plant 1. Furthermore, the Freeport Downtown Microgrid is designed for and flexible enough to meet the demands of future load growth from increases in customers and increases in temperatures over the next 20 years.

Based on a purely financial economics evaluation of the project from the perspective of the Village of Freeport (assuming current market revenue streams are the sole recovery mechanism for the investment), the project would impact ratepayers in the area by approximately 9% based on assumptions of a 10% cost of capital and a $5 million grant as the sole source of external funding for the project.

The Freeport Downtown Microgrid is recommended because it has a positive benefit-to-cost ratio, will provide further benefits to the surrounding community during outages elsewhere (not included in IEc analysis), and Freeport Electric can expedite design and construction since they are a municipally owned utility.

1 Description of Microgrid Capabilities

The Incorporated Village of Freeport Community Microgrid Feasibility Study, conducted by the Incorporated Village of Freeport with its partners Freeport Electric, Anbaric Transmission, Arup and National Grid, will provide an assessment of microgrid options for the Incorporated Village of Freeport (Freeport). It will address the feasibility of building and operating a community microgrid for maintaining electric services for participating customers/facilities and the Freeport community at times when weather events or other emergencies severely disrupt the capacity of the local distribution and transmission system to serve essential community needs.

The study consists of four phases. The first is the initial planning phase of the microgrid configuration; it defines normal and emergency loads and identifies distributed energy resources and demand response needs. The second phase of the study provides a preliminary overview of microgrid technical costs and configurations, and will include:

- Sizing, quantity, and location of distributed energy resources;
- Electrical and equipment configurations;
- Performance studies for steady state and transient voltage;
- Impact of renewables or distributed generation;
- Microgrid operation modes;
- Analysis of outages;
- System protection strategy, failure mode and network configurations; and,
- Microgrid and building control performance requirements

The third phase includes an assessment of the project's commercial and financial feasibility. The fourth phase of the study is a benefit and cost analysis for the project. The final phase includes conclusions, recommendations and lessons learned.

1.1 Project Description

Freeport is located in the Town of Hempstead on the south shore of Nassau County in Long Island, New York. Freeport covers approximately 4.5 square miles of land and maintains its own municipal electric and water utilities, police and fire departments. The municipal utility Freeport Electric provides electricity services to the community, with approximately 13,200 residential and 1,800 customers and a summer peak load of about 62 megawatts (MW). Freeport electric can generate up to 70 MW depending on economic conditions, and is capable of maintaining power services to its customers through loss of interconnections to the central Long Island grid. However, if Freeport loses Power Plant 2 ("PP2") due to an event then load shedding and/or rolling blackouts would have to be implemented to maintain power.

The proposed Freeport Downtown Microgrid will establish a new precedent for energy supply on Long Island, and would provide a sustainable, reliable and resilient source of energy for local residents and businesses.

1.2 Microgrid Capabilities

A microgrid is an electricity distribution system composed of distributed energy resources (both generation and storage) that are used to support critical loads within a defined area. A key feature of microgrids is 'islanding', the ability to separate from a central electricity grid if that power supply is interrupted. This feature can maintain power to critical facilities during extreme weather conditions or system emergencies, bringing power to individual customers when necessary.

Microgrids have become an increasingly adopted as a solution to the growing impacts of hurricanes, coastal storms, nor'easters, blizzards, ice storms and transmission outages on electrical utility systems. By providing additional resilience to the electricity grid, microgrids can benefit the local economy by reducing losses due to power outages and attract new businesses interested in clean, cost-effective and reliable energy system.

1.1.1 Minimum Required Capabilities

The proposed Freeport Downtown Microgrid is characterized by the following attributes, which meet the minimum required capabilities identified by NYSERDA in Task 1 Development of Microgrid Capabilities, Sub Task 1.1 Minimum Required Capabilities.

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

   The proposed microgrid will serve 43 key critical and priority facilities in and around downtown Freeport (Table 2). Of these facilities, 19 are considered critical and are located in physically separated buildings on individual property parcels. Critical facilities include fire stations, the police headquarters, water/wastewater utilities, hospitals and nursing homes, schools, libraries and an emergency shelter. Priority facilities include additional utilities, banks, gas stations, grocery stores and pharmacies. A map of key facilities and facility types can be seen in Figure 3.

b. Generation Sources: *(The primary generation source capacity cannot be totally diesel-fueled generators.)*

   Primary generation sources for the proposed microgrid include a mix of solar photovoltaic systems, natural gas generators and distillate fuel generators, augmented by battery storage. In addition, wind turbines are being evaluated as an external source of power to the proposed microgrid. Generation sources and their locations are listed in Table 3. A map of generation sources and generation types is also shown in Figure 2 and Figure 5.

   Solar photovoltaic (PV) systems will include both rooftop installations and canopies located in municipal parking lots. The project anticipates additional PV systems available through the Village of Freeport Schools via the NYPA K-Solar program. It is anticipated that the Sun Edison supported project will provide an additional 1 MW of solar. Wind energy will be supplied by at least a single turbine located in the Freeport Industrial Park. An additional two 4.44 MW natural gas reciprocating engines will be located at Freeport Power Plant 1 ("PP1"). The repowering of PP1 would contribute a significant amount of power to the proposed microgrid project.

c. <u>On-site Power:</u> *(A combination of generation resources must provide on-site power in both grid-connected and islanded mode.)*

Combined, the proposed generation resources would be able to provide on-site power in both grid-connected and islanded mode, and form an intentional island. The existing PP2 and the repowered PP1 are black start capable, and battery storage and inverters will be used to provide islanded power support through peak shaving and generator start-up period support.

Control systems for switching between grid-connected and islanded mode will be developed so that, in the event of a power loss, the proposed microgrid is able to automatically separate from the grid and reestablish a grid connection after normal power is restored. It is envisioned that a system such as those offered by S&C and Schneider could be utilized for this task.

d. <u>Islanded Mode:</u> *(Must be able to form an intentional island.)*

Freeport Electric will manage the microgrid and have control over individual circuits and feeders. The Freeport Downtown Microgrid will have the ability to island and separate from the LIPA grid as well as other areas of Freeport.

e. <u>Power Flexibility:</u> *(Must be able to automatically separate from grid on loss of utility source and restore to grid after normal power is restored.)*

See above.

f. <u>Maintenance:</u> *(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 days per week utilization of the power produced by these resources.)*

The proposed resources will be designed for firm capacity support; intermittent resources would be used to shave peak loads and improve overall system variable costs where possible. Freeport Electric staff will maintain the distribution lines and components. Freeport Electric could maintain the generation resources but it is yet to be determined who would be the owner/operator of these sources.

g. <u>Consistent Operation:</u> *(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 ANSI c84-1 standards when islanded.)*

The intended control system and generation resources will provide load following capabilities while maintaining voltage and frequency when grid-connected, and within ANSI c84-1 standards for voltage when islanded. Reciprocating units such as the one intended to repower PP1 are typically capable of this performance.

h. <u>Control and Communication:</u> *(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.)*

A means of automated, integrated two-way communication and control between the proposed microgrid owner/operator and the local distribution utility is currently under development. The local utility, the municipal electric authority of Freeport Electric, would also directly control the microgrid assets.

i. Diverse Customers: *(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.)*

The proposed microgrid will provide power to a diverse group of customers with a range of load condition including the key critical and primary facilities listed above that are within the proposed microgrid area, some 245 customers (defined as individual parcels and excluding parking areas, right of ways and vacant lands) will be served directly and indirectly by the Freeport Downtown Microgrid. Of these parcels, approximately 54% are commercial, 35% are residential and 10% are community services (Table 1).

Table 1: Microgrid area customer types

Microgrid Area Land Use	Parcel Count	Percent Total
Commercial	133	54.3%
Residential	86	35.1%
Community Services	26	10.6%
Grand Total	245	

j. Fuel Supply: *(Must include an uninterruptible fuel supply or minimum of one week of fuel supply on-site.)*

PP1 will be repowered as a natural gas generating facility and provide an uninterruptible fuel supply. PP1 will benefit from significant residual gas supply in the local pipeline as well as the use of liquefied natural gas (LNG) as a delivered fuel. PP1 will also keep an existing distillate fueled generator with local liquid fuel stored on-site. Propane options are also being investigated.

k. Resilient to Disruption: *(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.)*
The proposed microgrid will serve the area in and around downtown Freeport, which is located out of the 100-year floodplain and will not be effected by most typical flood events (Figure 1). Additional resilience in microgrid network will be provided through measures such as undergrounding of overhead power lines and installation of additional switching.

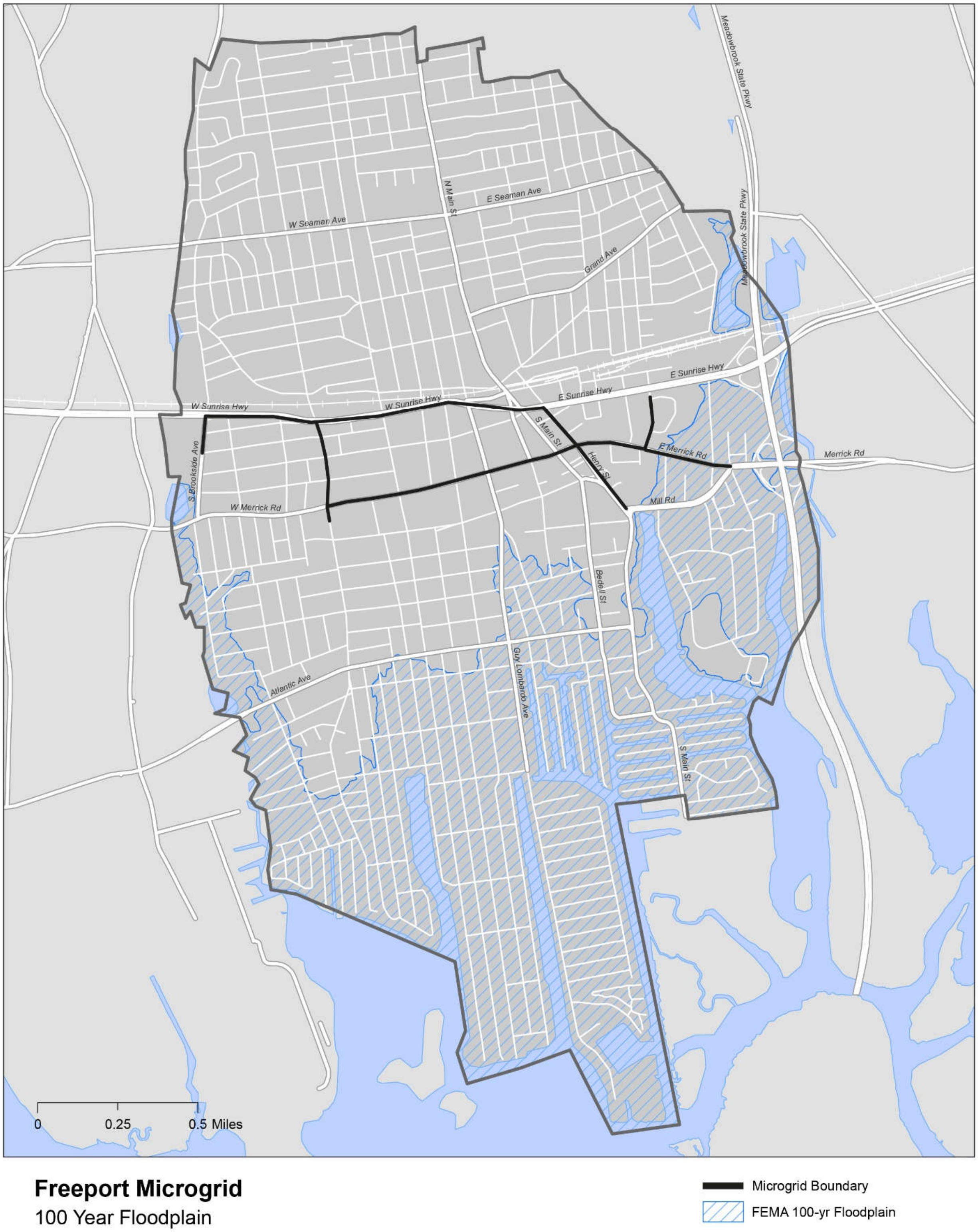


Figure 1: Freeport Downtown Microgrid and 100 Year Floodplain Map of Freeport

A redundant, newly installed, ring of circuits tying into Freeport's 138/13.8kV substation (Substation 4F) and spurring additional critical customer connections, where needed, is proposed.

l. Black-start capability: *(Provide black-start capability.)*

The Downtown Microgrid will have blackstart capability using one of the proposed PP1 4.44 MW engines. PP2, outside the microgrid, already has blackstart capability. This will provide the Village with two sources of power with blackstart.

2 Microgrid Technical Feasibility Design

Hurricane Irene and Superstorm Sandy brought significant damage to public infrastructure, homes, businesses, and the estuary environment. Both storms had different impacts on the Freeport in terms of the type and intensity of damages (precipitation and wind events, storm surge, etc.). More than 4,000 of Freeport's multi-family housing units and 130 of its homes were unsafe for habitation after Sandy. Some businesses sustained flooding and storm damage, while others suffered power outages and reduced economic activity.

Starting with a review of the current power supply arrangements for Freeport, this report introduces a proposed microgrid architecture and describes its various components (i.e., loads, generation, network and controls) and operation.

2.1 Freeport power supply arrangements

2.1.1 Normal operation

Freeport's power requirements are imported from the LIPA/PSEG grid interconnect at the 4F Substation **[redacted]**. This gateway is a 138 kV connection that has been in service since 1996 and provides purchased power from the NY State Grid. The maximum imported power is based upon the rating of the two redundant step-down transformers at 4F which are 72 MVA each. Freeport's highest record load was approximately 66 MW and occurred several years ago. Under normal conditions, Freeport does not run any of its own energy generation specifically for consumption by its customers. Generation is available at Plant 2 utilizing CT - 2 (46MW) and GT - 3 (a 1960 vintage 16MW unit) with emergency generation from older liquid-fueled units at the 1940's vintage Power Plant 1 ("PP1") (Unit 10 at 2MW, Unit 11 at 2MW, and Unit 12 at 4MW).

2.1.2 Emergency operation

The most severe condition occurs when power is not available from the 138kV interconnect and the Freeport distribution system operates as an islanded system. At this time, internal generation is required to utilize black-start capability at Power Plant 2's (PP2) 16MW GT-3 engine, which is nearly 60-years old and in the floodplain. Once auxiliary power is established, this unit then starts CT-2 at PP2 that is synchronized to the system and can supply up to 46MW of load.

If there is additional load demand, PP1 can also be synchronized to the system. One of the generation units is also capable of black-starting in case of failure of GT-3, which is located in the floodplain.

Should load requirements exceed generation capability in this scenario, load shedding and/or rolling blackouts would have to be implemented to maintain power to critical facilities and key customers.

The existing emergency operation configuration has a number of vulnerabilities which have been exposed by past extreme weather-related events. As became evident during Superstorm Sandy, PP2 is in an area subject to flooding.

The proposed downtown microgrid (the Freeport Downtown Microgrid) will replace venerable diesel engine capacity at PP1 with two 4.44 MW dual-fuel (natural gas/CNG) reciprocating engines with “black-start” capability. The microgrid will add diversity to the power supply with the addition of renewable energy including: 1.33 MW of solar photovoltaic power (solar PV) located on and around a critical facility, 1MW of wind power, and battery storage located at PP1. The microgrid will also add a layer of redundancy to the Freeport distribution system by creating a downtown 3-Phase 13.8kV circuit with spurs to critical facilities. This 13.8kV critical infrastructure will be made more resilient through the use of predominantly underground conductors and automated switching to isolate compromised segments.

The schematic below illustrates the proposed Freeport Downtown Microgrid architecture.

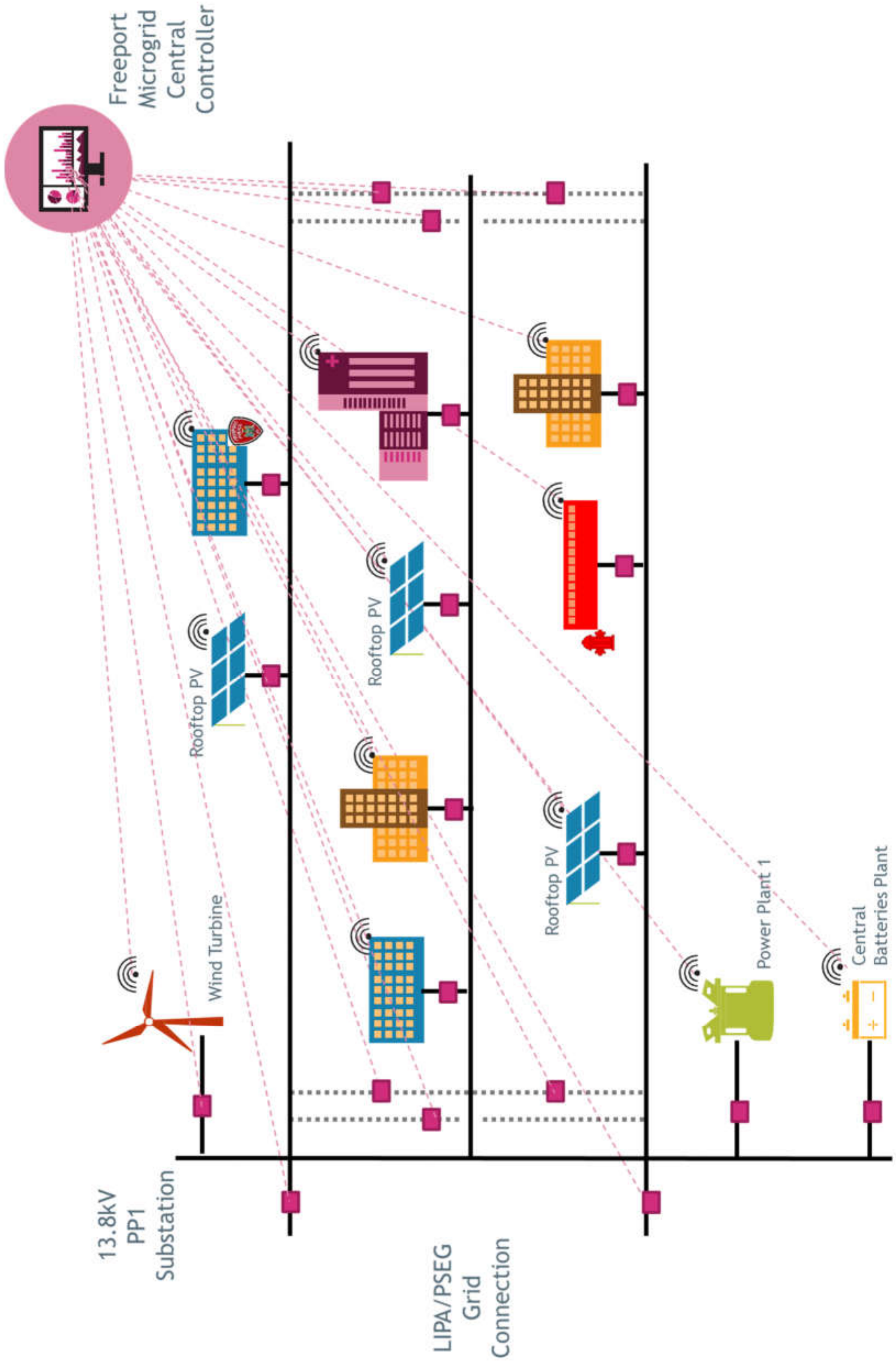


Figure 2: Freeport Downtown Microgrid schematic

2.2 Microgrid Load

2.2.1 Characterization

The Freeport Downtown Microgrid will provide power to those critical facilities and key customers providing fundamental services for the community.

The geographical area covered by the Freeport Downtown Microgrid is made of a mix of key critical and primary facilities, business and commercial buildings, and residential units. Overall, there are approximately 245 customers (defined as individual parcels and excluding parking areas, right of ways, and vacant lands). Of these parcels, approximately 54% are commercial, 35% are residential and 10% provide community services (Table 1).

Downtown Freeport has a high concentration of critical assets, infrastructure, and facilities instrumental to disaster response and recovery. Critical assets include Verizon telecommunications provider); the Long Island Rail Road (LIRR) Freeport station and associated substation providing power to the LIRR Babylon Branch; the Village Hall and police headquarters; three firehouses including Fire Department headquarters; three public schools; the Freeport Memorial Library; 28 traffic lights; a large number of street lights; and numerous health and community services and businesses that serve post-disaster functions (e.g., supermarkets, banks, gas stations). All of these facilities are essential to the economic and social well-being of the Community. The Freeport Recreation Center, Memorial Library and the JW Dodd School, all located within the microgrid project area, are proposed to serve as Community Assistance Centers (see project description below) after disasters.

The configuration of the Freeport Downtown Microgrid will be structured in multiple tiers on both the generation and load side. The generation configuration is discussed in subsequent sections. The load configuration follows.

<u>Microgrid Load Hierarchy</u>:

<u>Tier 1</u> – The downtown critical facilities will be served by a new, predominantly underground, 13.8kV circuit with redundancy and automated isolation switching. The intent is that this collection of facilities will be the loads of last resort and will be the last circuits shed and first circuits energized during islanded conditions. These facilities form the core of support to the broader community during outage events.

<u>Tier 2</u> – The balance of the downtown loads on specific existing feeder circuits could be islanded utilizing existing infrastructure and added controls. This would provide the balance of support facilities to the broader area during outage events.

The Freeport Downtown Microgrid will interconnect to the critical loads and downtown area in Freeport as shown in Figure 3.

The average consumption (MWh) and peak demand (kW) for each primary critical and secondary critical facility are detailed in Table 2. Estimated summer and winter hourly profiles for each facility are detailed in Figure 4. The maximum peak demand requirement for the critical facilities is approximately 8.5 MW.

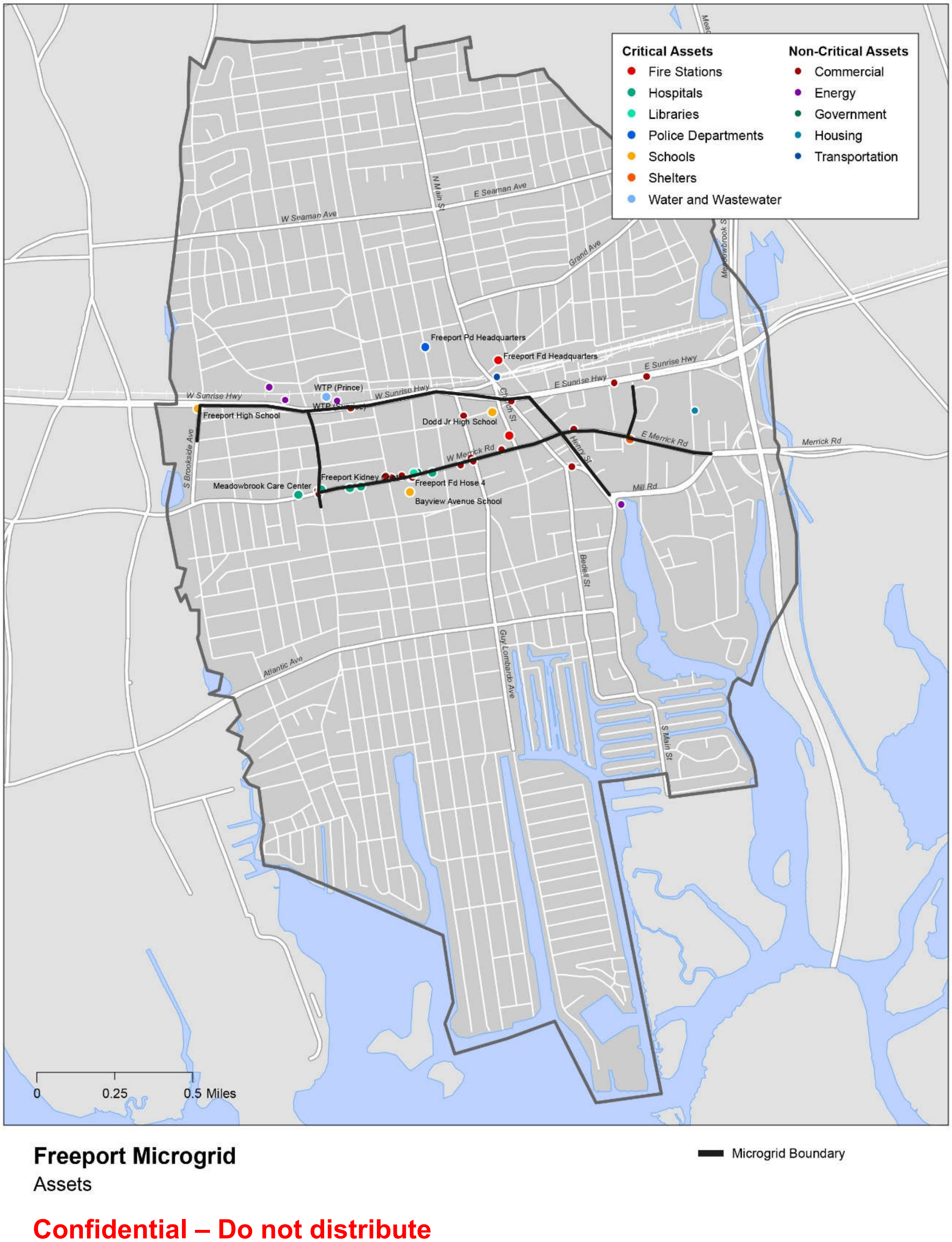


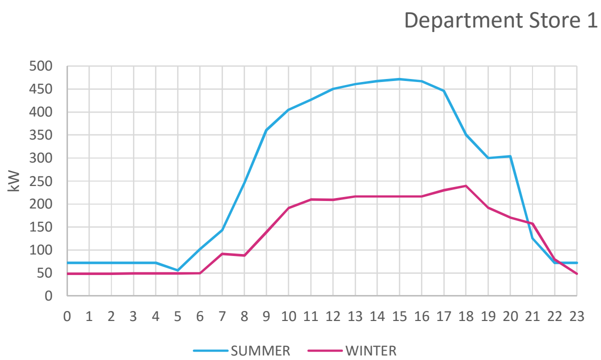
Figure 3: Freeport critical and non-critical assets

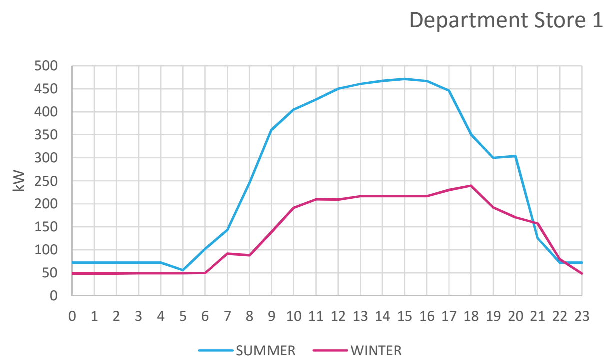
Table 2: Primary and secondary critical facilities in the Freeport Downtown Microgrid

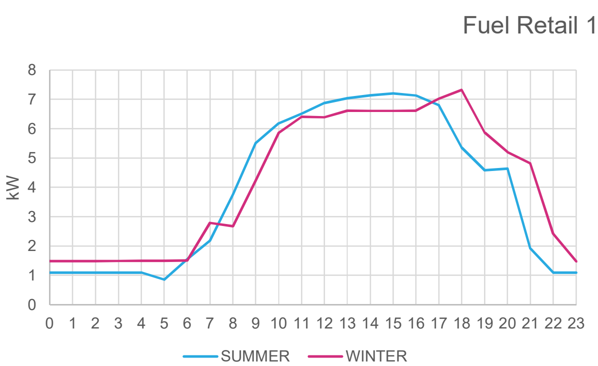
Proxy Name	Description	Rate Class	Critical	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)
Department Store 1	Standalone Retail	Large Commercial/Industrial	Secondary	1,552.80	0.530
Office Building 1	Standalone Retail	Small Commercial/Industrial	Secondary	1,641.60	0.286
Fuel Retail 1	Standalone Retail	Small Commercial/Industrial	Secondary	37.80	0.026
Recreation Building (Refuge)	Secondary School	Large Commercial/Industrial	Primary	3,615.12	1.045
Pharmacy 1	Standalone Retail	Large Commercial/Industrial	Secondary	501.76	0.093
Bank 1	Standalone Retail	Large Commercial/Industrial	Secondary	129.60	0.036
Bank 2	Standalone Retail	Large Commercial/Industrial	Secondary	224.28	0.102
Pharmacy 2	Strip Mall	Small Commercial/Industrial	Secondary	36.47	0.014
Gas Station 1	Standalone Retail	Small Commercial/Industrial	Secondary	28.28	0.018
Food Store 1	Super Market	Large Commercial/Industrial	Secondary	1,213.92	0.236
Government 1	Small Office	Large Commercial/Industrial	Primary	374.52	0.090
Library 1	Primary School	Large Commercial/Industrial	Primary	195.60	0.094
Bank 3	Standalone Retail	Large Commercial/Industrial	Secondary	575.28	0.129
Retail Center 1	Strip Mall	Large Commercial/Industrial	Secondary	166.19	0.059
Bank 4	Standalone Retail	Large Commercial/Industrial	Secondary	139.20	0.035
Health Care 1	Outpatient Hospital	Large Commercial/Industrial	Primary	225.60	0.068
Health Care 2	Midrise Apartment	Large Commercial/Industrial	Primary	734.40	0.216
Car Center 1	Standalone Retail	Large Commercial/Industrial	Secondary	104.66	0.020
Gas Station 2	Standalone Retail	Large Commercial/Industrial	Secondary	144.92	0.028
Health Care 3	Outpatient Hospital	Large Commercial/Industrial	Primary	2,708.10	0.833
School 1	Primary School	Large Commercial/Industrial	Primary	288.32	0.132

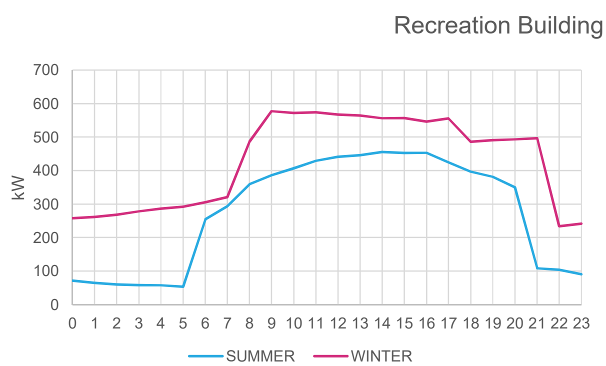
School 2	Secondary School	Large Commercial/Industrial	Primary	1,205.40	0.672
Pharmacy 3	Standalone Retail	Large Commercial/Industrial	Secondary	287.76	0.076
Bank 5	Standalone Retail	Large Commercial/Industrial	Secondary	115.44	0.028
Fire 1	Medium Office	Large Commercial/Industrial	Secondary	213.06	0.065
Fire 2	Medium Office	Large Commercial/Industrial	Secondary	242.56	0.087
Water 1	n/a	Large Commercial/Industrial	Primary	264.53	0.119
Gas Station 3	Standalone Retail	Small Commercial/Industrial	Secondary	20.57	0.011
Fire 3	Medium Office	Large Commercial/Industrial	Primary	50.36	0.022
Government 2	Medium Office	Large Commercial/Industrial	Primary	980.64	0.324
Department Store 2	Super Market	Large Commercial/Industrial	Secondary	3,463.50	0.864
Health Care 4	Outpatient Hospital	Large Commercial/Industrial	Primary	88.96	0.047
School 3	Secondary School	Large Commercial/Industrial	Primary	1,568.00	0.588
Health Care 5	Outpatient Hospital	Large Commercial/Industrial	Primary	70.44	0.040
Food Store 2	Strip Mall	Large Commercial/Industrial	Secondary	109.55	0.022
Transit Center	n/a	Large Commercial/Industrial	Primary	255.40	0.052
Food Store 3	Super Market	Large Commercial/Industrial	Secondary	1,940.40	0.410
Office Building 2	Standalone Retail	Large Commercial/Industrial	Secondary	2,958.30	0.483
Water 2	n/a	Large Commercial/Industrial	Primary	176.40	0.239
Water 3	n/a	Large Commercial/Industrial	Primary	383.50	0.120
Health Care 6	Outpatient Hospital	Large Commercial/Industrial	Primary	211.56	0.050
Food Store 4	Standalone Retail	Large Commercial/Industrial	Secondary	579.72	0.200
Housing 1	Midrise Apartment	Residential	Primary	643.68	0.300
Housing - all	Midrise Apartment	Residential	Secondary	69.80	0.004
Small Commercial	Standalone Retail	Small Commercial/Industrial	Secondary	18.64	0.012

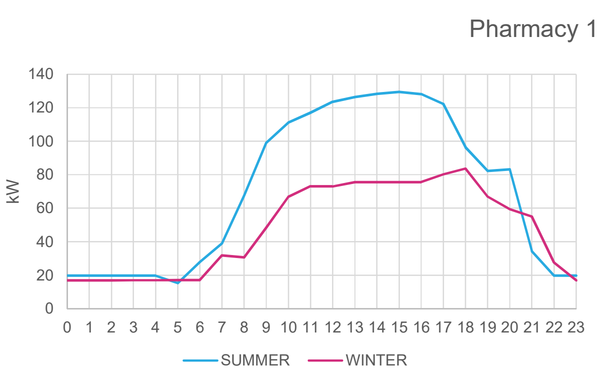
Large Commercial	Standalone Retail	Large Commercial/Industrial	Secondary	110.81	0.038
Traffic Lights (28)	Government	Small Commercial/Industrial	Secondary	284.48	0.017

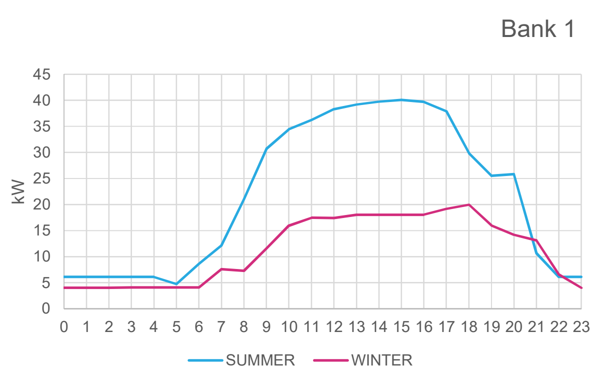


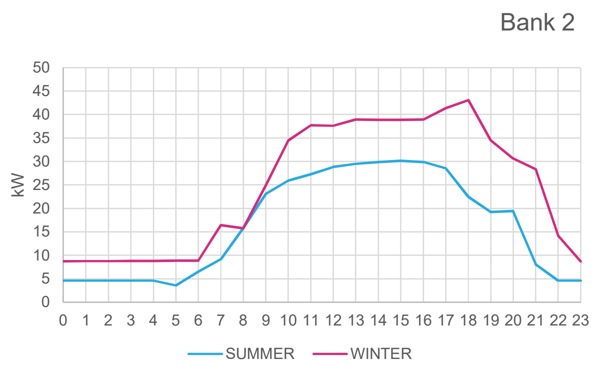








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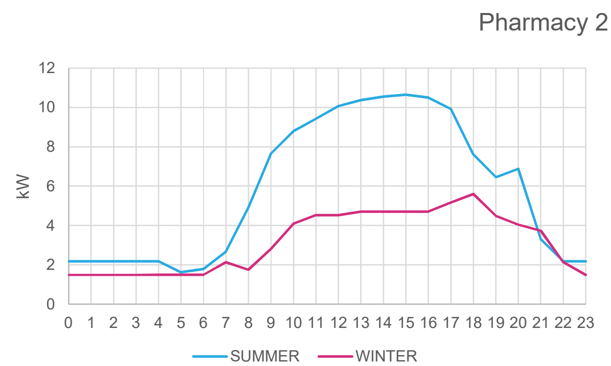
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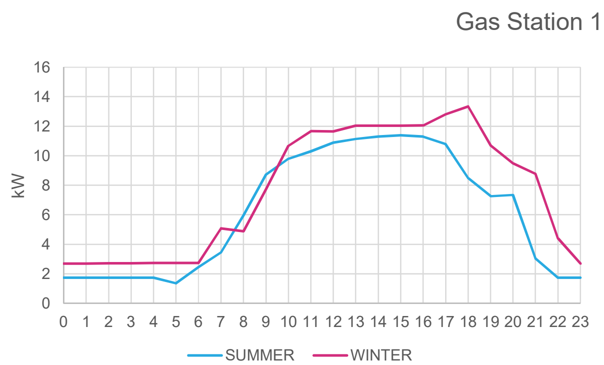
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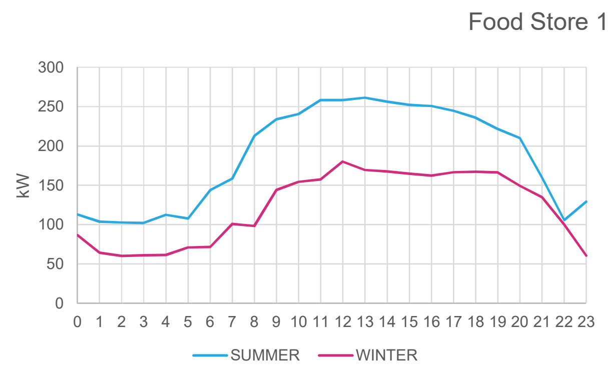
Food Store 1
kW
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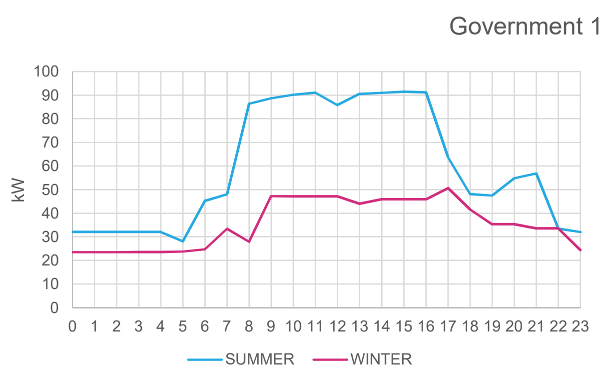
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER


Government 1
kW
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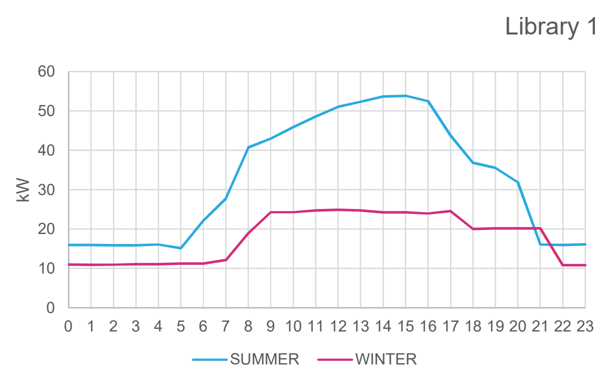
SUMMER
WINTER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kW
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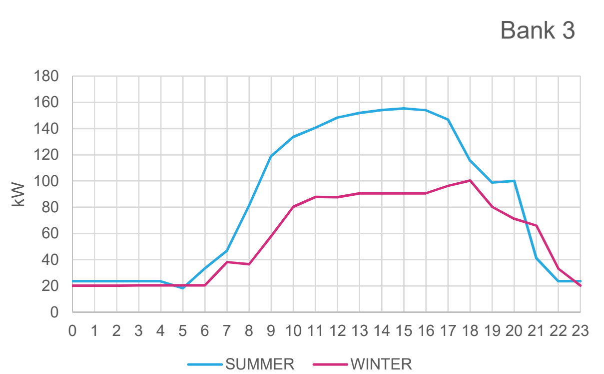
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER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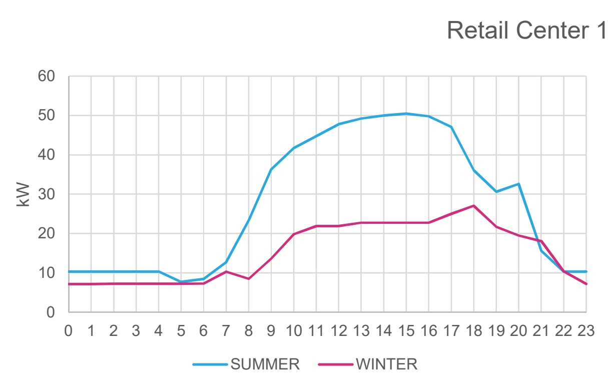
SUMMER
WINTER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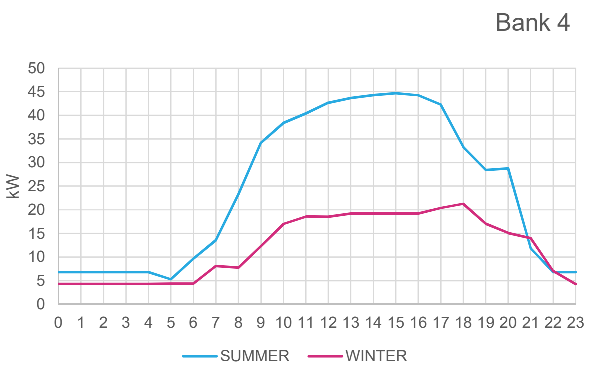
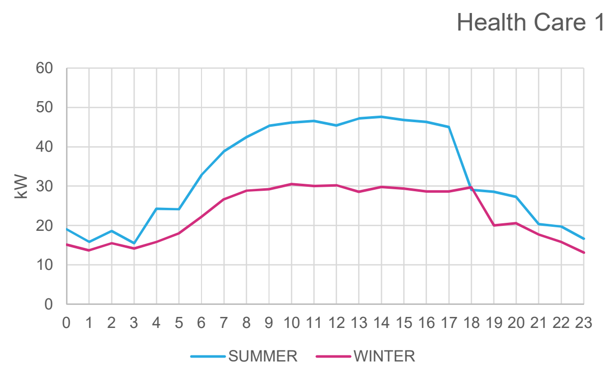
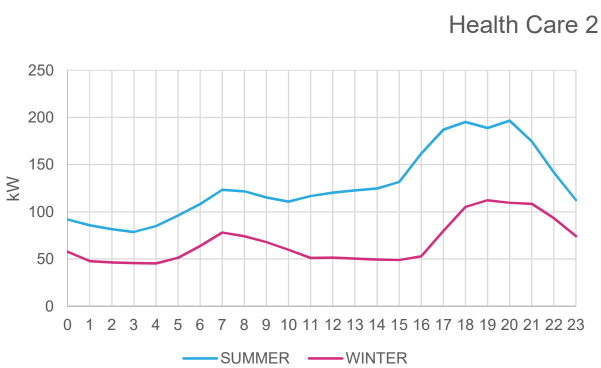
SUMMER
WINTER


Bank 4
kW
SUMMER
WINTER


Health Care 1
kW
SUMMER
WINTER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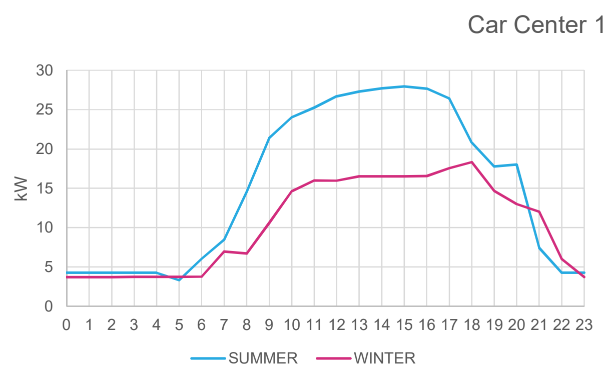
SUMMER
WINTER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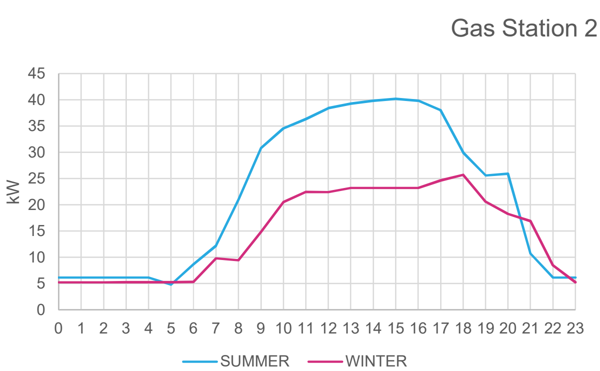
kW
SUMMER
WINTER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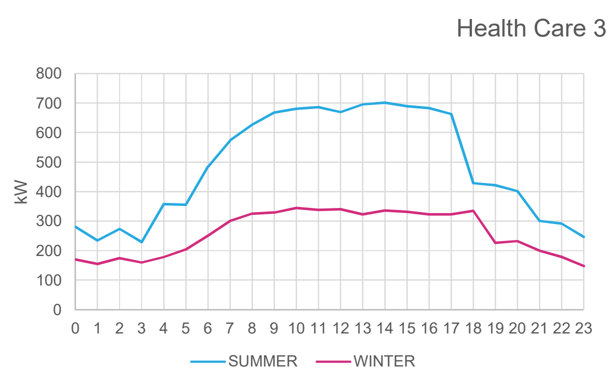
kW
SUMMER
WINTER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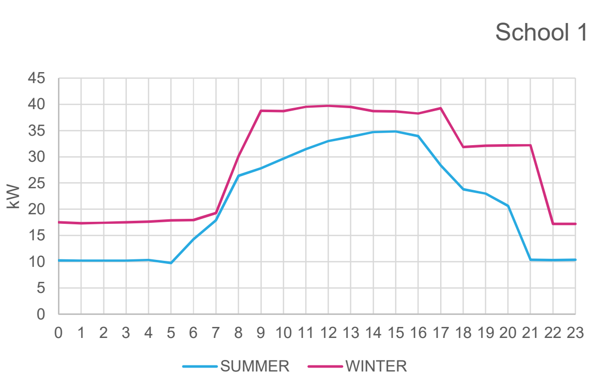
kW
SUMMER
WINTER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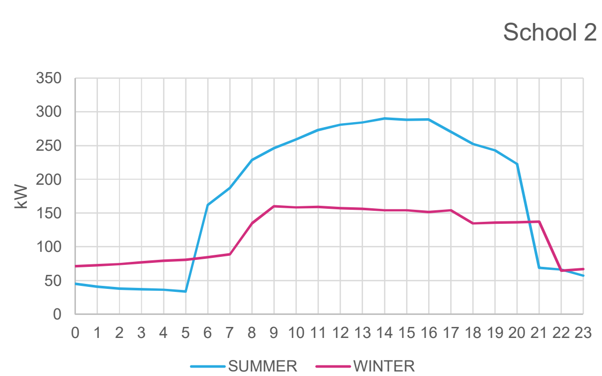
SUMMER
WINTER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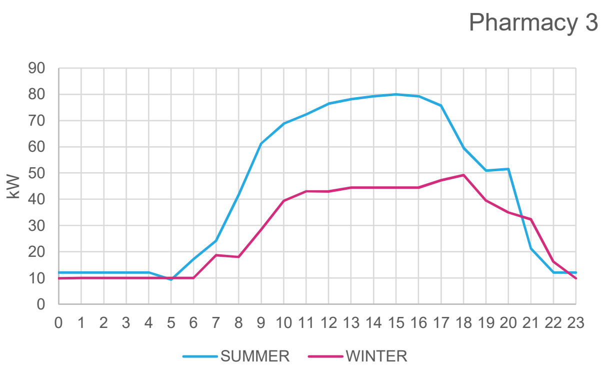
kW
SUMMER
WINTER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80
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60
50
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0
kW
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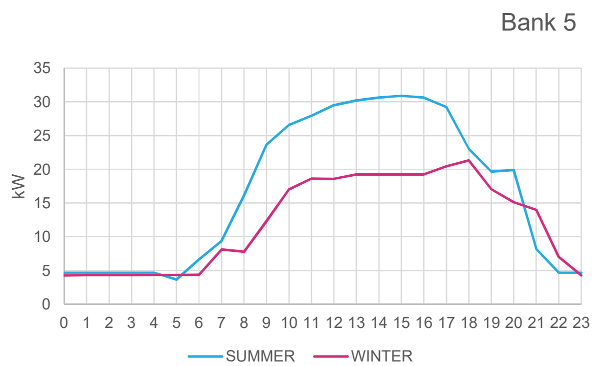
SUMMER
WINTER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kW
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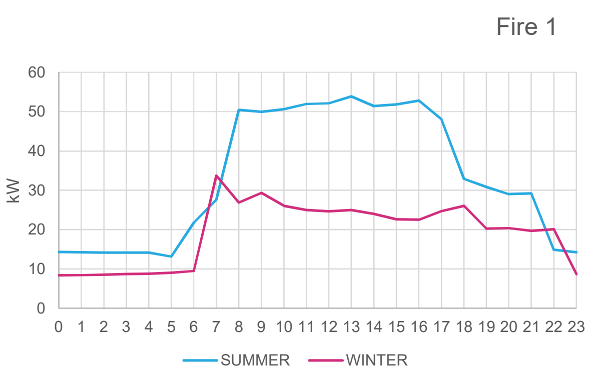
SUMMER
WINTER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kW
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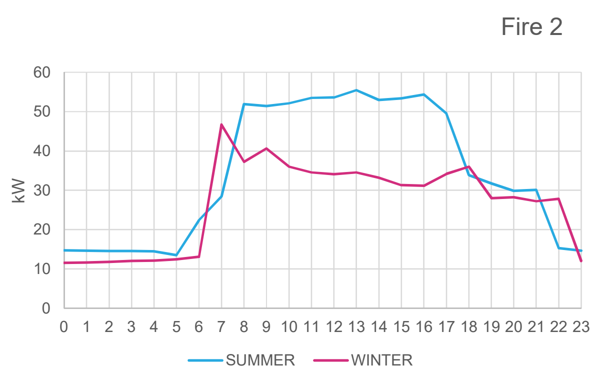
SUMMER
WINTER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50
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30
20
10
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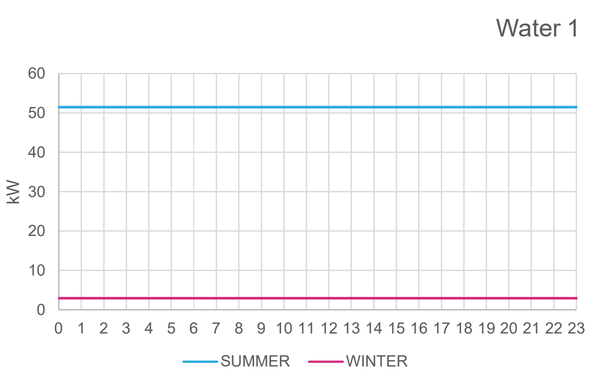
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER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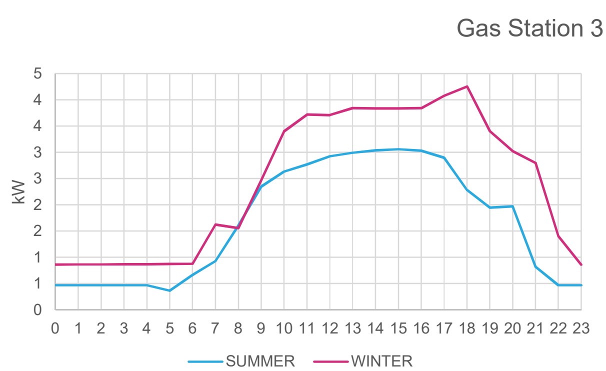
30
20
10
0
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER


Gas Station 3
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4
4
3
3
2
2
1
1
0
kW
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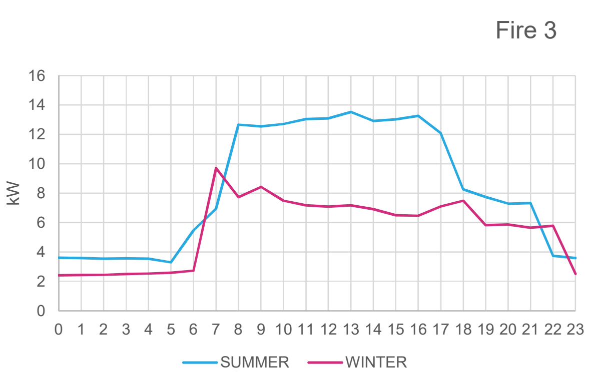
SUMMER
WINTER


Fire 3
16
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2
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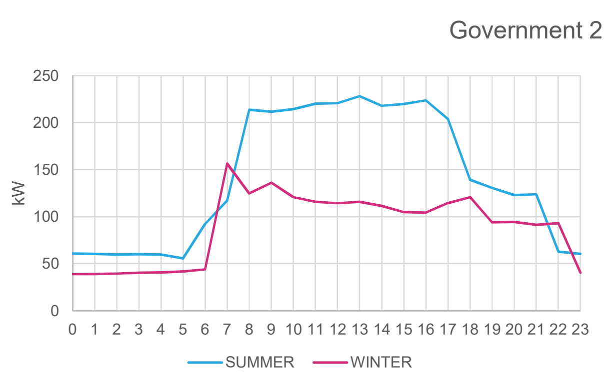
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER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250
200
150
100
50
0
kW
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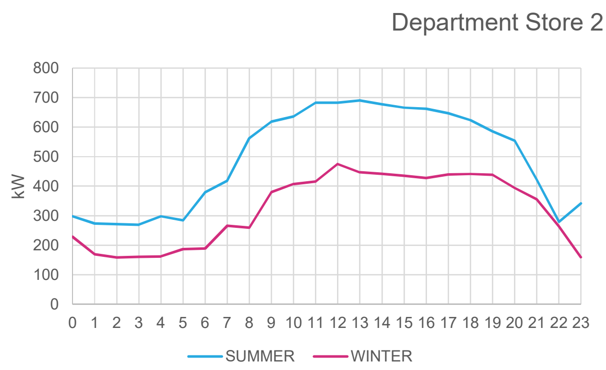
SUMMER
WINTER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kW
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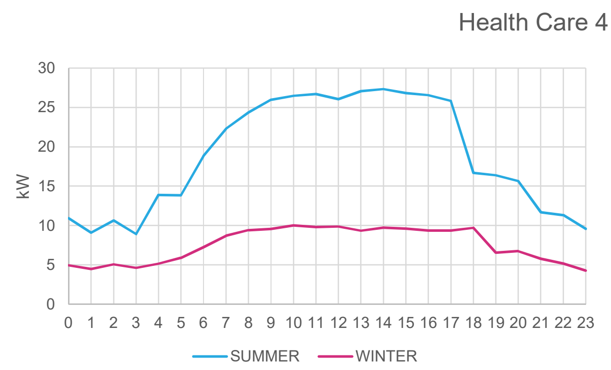
SUMMER
WINTER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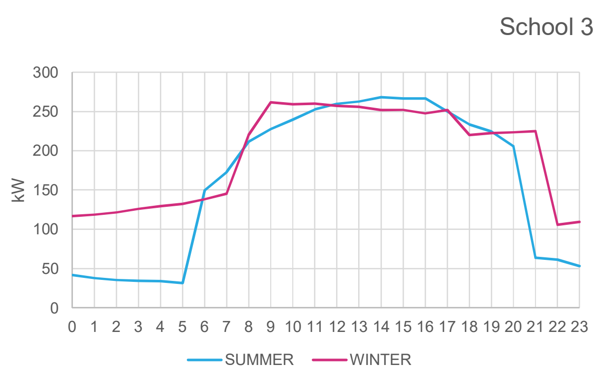
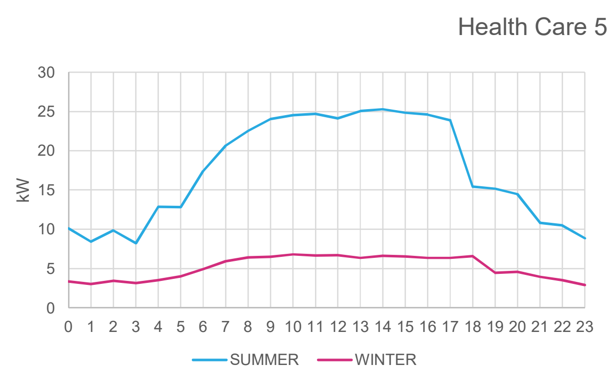
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER


School 3
300 250 200 150 100 50 0
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER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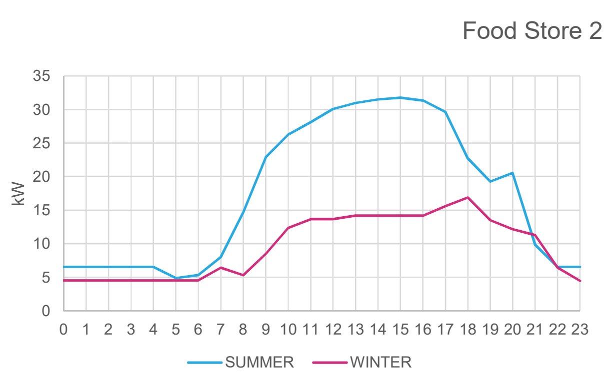
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER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kW
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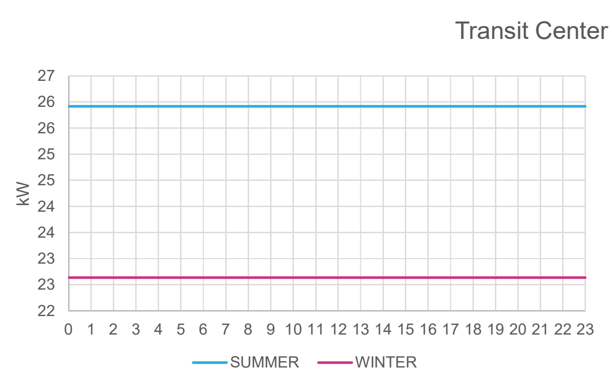
SUMMER
WINTER


Transit Center
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kW
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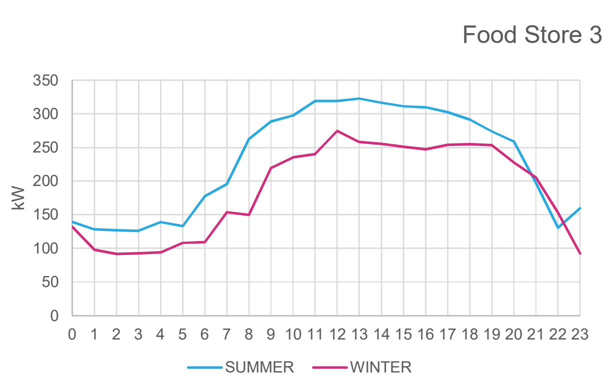
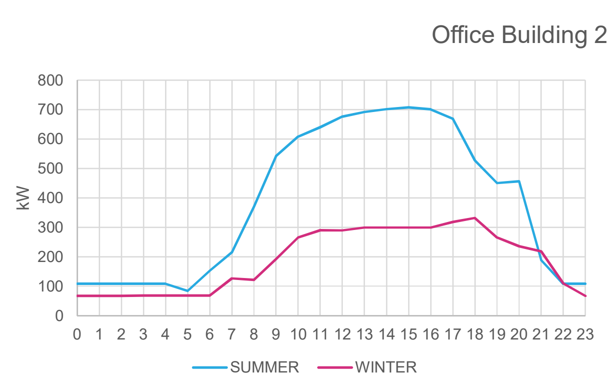
SUMMER
WINTER


Food Store 3
350 300 250 200 150 100 50 0
kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER


Office Building 2
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kW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
SUMMER
WINTER

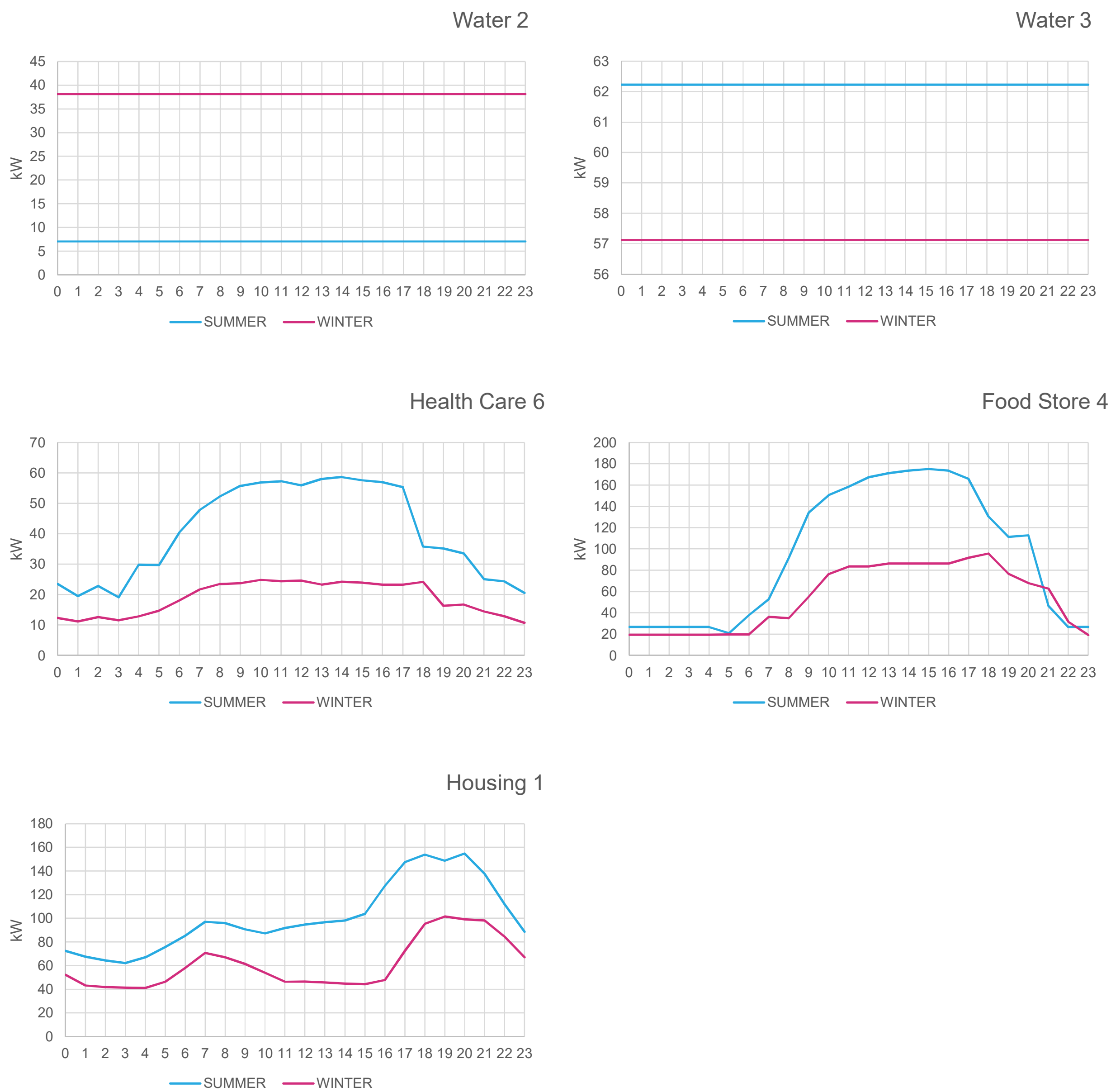


Figure 4: Estimated hourly demand profiles for critical facilities in the Freeport Downtown Microgrid

2.2.2 Energy-efficiency, load controllability and priority

2.2.2.1 Energy-efficiency

The Freeport Downtown Microgrid would enable the initial installation of AMI architecture to allow for customer interaction and energy-efficiency program development. While the full-scale deployment of AMI has not been considered a part of the microgrid scope due to economic factors, the core installation of AMI architecture to create functionality for critical facilities allows for the immediate implementation of energy-efficiency programs for these facilities and future expansion of the infrastructure.

2.2.2.2 Controllability

Load shedding on the Freeport Downtown Microgrid during islanded operation would be performed by automatic (preferred) and manual means subject the available microgrid capacity. The new 13.8kV critical circuits will be equipped with automatic load shedding and isolation equipment to allow for quick healing and reconfiguration of the circuits to minimize potential for broader interruption. Additional downtown area loads would be manually connected and shed from the microgrid to meet any surplus available generation capabilities.

Coordinated control and dispatch of the various generation sources is described in subsequent sections of this report.

2.2.2.3 Priority

As discussed previously, the priority of the Freeport Downtown Microgrid will be to keep the Tier 1 loads energized. Additional downtown circuits will initially be shed and only re-energized when on-line generation capacity is sufficient to support the added load. Conversely, should generation resources go off-line, the Tier 2 loads would be shed to preserve the Tier 1 load. Should generation somehow not meet the full Tier 1 load, Tier 1 facilities will be prioritized and those of lower priority shed at each facility service entrance through the AMI system.

These Tier 1 and Tier 2 loads are principally common resources to the residents of Freeport and the surrounding areas. Residential customers, predominantly single-family dwellings surrounding the downtown area, would be energized as a tertiary activity.

2.3 Microgrid Distributed Energy Resources

Primary generation sources for the Freeport Downtown Microgrid include a mix of solar PV, natural gas generators, and distillate fuel generators, augmented by battery storage. In addition, a 900kW wind turbine is recommended as an external source of power to the proposed microgrid. Table 3 contains a complete list of the microgrid distributed generation resources and Figure 3 maps their locations.

Table 3: Proposed new microgrid distributed energy resources summary

Type	Location	Size
Rec Center Solar PV (Parking)	Freeport Rec Center	1.06
Rec Center Solar PV (Roof)	Freeport Rec Center	0.271
Industrial Park Wind Turbine	Industrial Park Wind Turbine	0.90
JMS 624 GS-N.L (A)	Power Plant 1	4.50
JMS 624 GS-N.L (B)	Power Plant 1	4.50
Battery	Power Plant 1	1

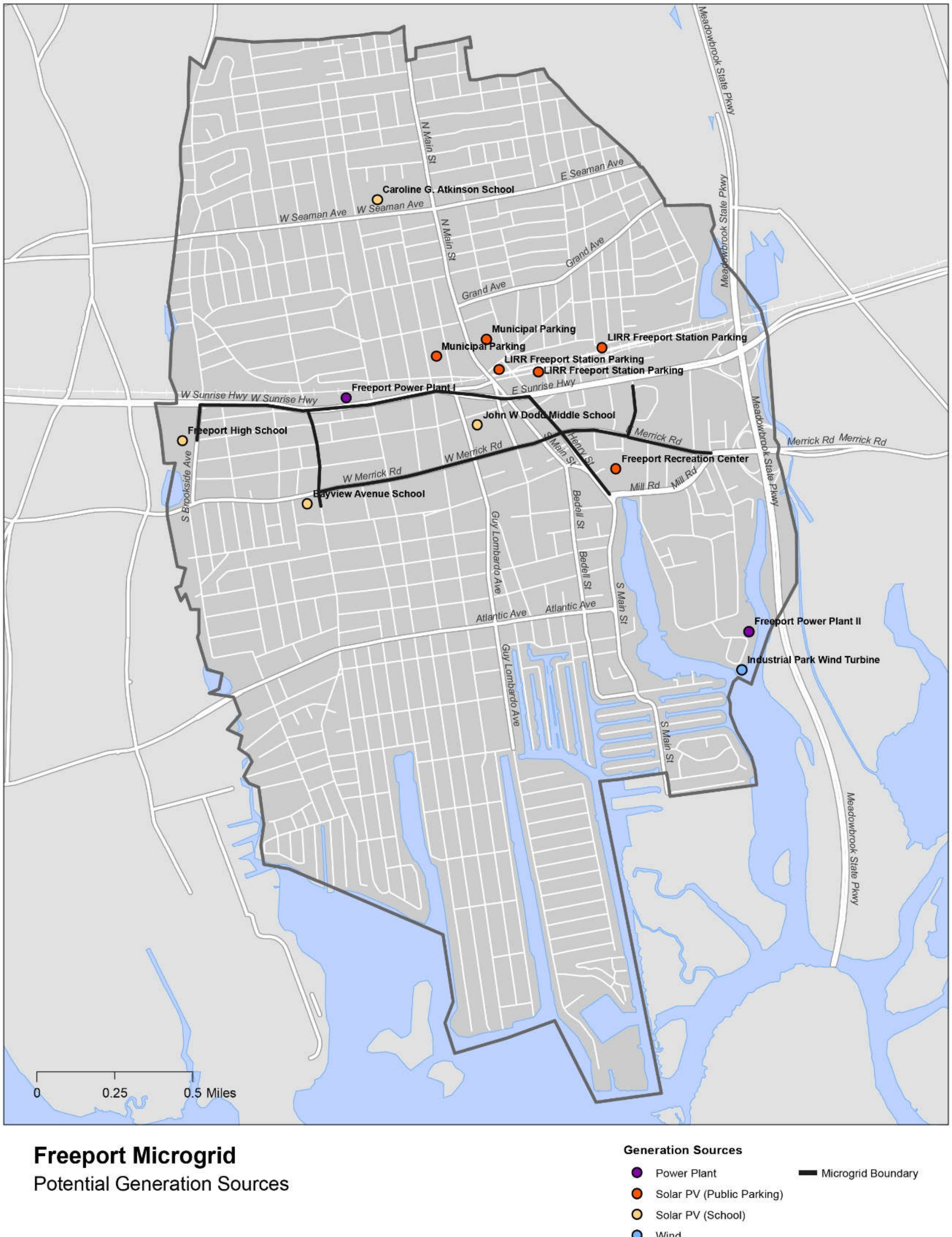
The Freeport Downtown Microgrid will be served by generation resources according to a prioritization protocol similar to that governing loads.

Microgrid Generation Resource Hierarchy

Tier 1 – Generation sources directly connected to the electrical busses supplying the new 13.8kV critical load circuits (i.e., PP1, recreation center rooftop solar PV)

Tier 2 – Generation sources directly connected to other downtown circuits (i.e., additional solar PV at parking locations)

Tier 3 – Generation sources able to provide power to Freeport Downtown Microgrid circuits through intermediate interconnecting feeders (i.e., industrial park wind turbine, PP2)



Confidential – Do not distribute

Figure 5: New and existing distributed generation resources

2.3.1 Solar Generation

A feasibility assessment was performed to determine the optimal location for solar photovoltaic panels throughout Downtown Freeport, specifically on critical buildings. Approximately 6 MW of new solar photovoltaic systems was proposed on both rooftops and canopies located in municipal parking lots (Figure 5). However, only 1.33 MW of photovoltaic systems is recommended due to cost. The project anticipates additional solar PV availability through the Freeport Schools via the New York Power Authority (NYPA) K-Solar program. It is anticipated that the Sun Edison supported project will provide an additional 1 MW of solar energy to the microgrid project.

The new solar generation will provide power during peak daytime hours, reduce the impact of load growth, and lower carbon dioxide (CO2), nitrogen oxide (NOx) and sulfur oxide (SOx) emissions.

Table 4: Freeport Downtown Microgrid solar potential

Location	Installed Array Capacity (kW)	Estimated Cost (Total Installed Cost)	Annual Output (kWh)
Freeport Rec Center (Parking)	1,060	$3,497,000	1,376,000
Freeport Rec Center (Roof)	0.271	$678,000	322,800
Total	**1.33 MW**	**$4,387,000**	1,698,400

Available solar PV electricity has the potential to improve resilience, reliability, diversify the electric supply, and reduce the amount of electricity purchased from day-ahead markets. The proposed solar arrays will be connected to the new, underground circuits. Under normal operation the new circuits will be grid-connected to PP1, when islanded, the solar PV feed the microgrid through the new circuits.

2.3.2 Wind Generation

Wind energy will be supplied by at least one turbine located in the Freeport Industrial Park. An analysis was performed to determine the potential for wind generation development in Freeport. This analysis assumes the installation of a single, commercial-scale wind turbine in proximity to existing electrical infrastructure between the Industrial Park and PP2. Alternative locations for the turbine were also reviewed.

2.3.2.1 Potential Generation

This analysis was performed based on the installation of a single Americas Wind Energy (AWE) 54-900 wind turbine, a 900 kW direct drive turbine. Direct drive, as opposed to gearbox turbines contain significantly less components; the rotor and generator rotate as one integrated unit. The absence of a gearbox simplifies maintenance procedures, and results in a less vulnerable machine.[1] An AWE 54-900 turbine with a rotor diameter, and a hub height of 75 m, was used for this analysis.

Monthly energy production estimates were calculated using the System Advisor Model (SAM), a renewable energy performance model developed by the National Renewable Energy Laboratory

[1] Americas Wind Energy Inc., AWE 54-900 Wind Turbine.
http://www.awewind.com/Products/AWE54900/tabid/62/Default.aspx

(NREL).[2] Wind resource data for Freeport, NY (40.65, -73.57) was obtained from the online NREL Wind Integration National Dataset (WIND) Toolkit. The WIND Toolkit provides wind speed and direction, ambient temperature, and atmospheric pressure at 100 m above the ground.[3] SAM calculates hourly electricity output for a single turbine using wind resource data and the selected turbine's power curve and hub height.

Wind resource data from the WIND Toolkit was verified against hourly wind speed measurements taken on the rooftop of Freeport's PP2 from January to October of 2012. On average, wind speed values from the WIND Toolkit dataset were 1.8 m/s higher than measurements taken at PP2. However, the WIND Toolkit provides wind speed values at 100 m above the ground, while measurements at PP2 were taken at 10 m above the ground. Additionally, there were numerous gaps in the PP2 data. Measurements for the months of November and December are unavailable. When measurements taken PP2 were scaled to account for greater wind speeds at higher elevations, wind speed values were on average 0.12 m/s lower than the WIND Toolkit dataset.[4] Differences in average monthly wind speed data can be seen in Figure 6.

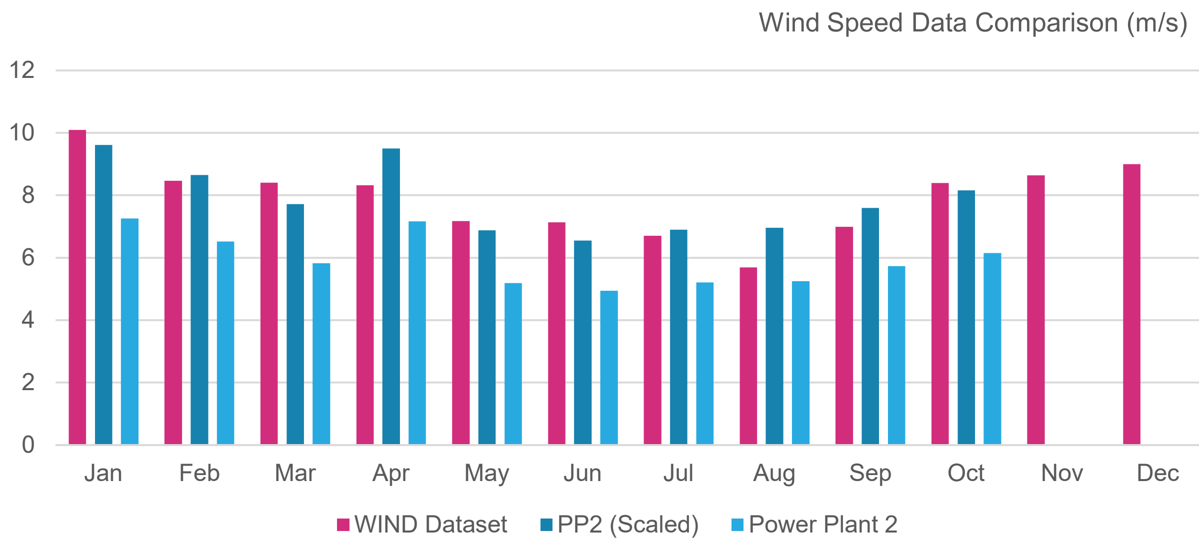


Figure 6: Comparison of average monthly wind speed by data source

Based on these inputs and assumptions, annual energy production was estimated at 2,909 MWh with a capacity factor of 36.9%. Capacity factor is the ratio of a system's predicted electrical output to its maximum possible capacity-based output. Contemporary wind turbines typically demonstrate capacity factors of 30-50%. The inputs, assumptions and the results of this analysis are shown in Table 5. Monthly energy production varied from nearly 400,000 kWh in winter months to almost 100,000 kWh in the summer. Estimated monthly energy production is shown in Figure 7.

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[2] National Renewable Energy Laboratory, System Advisor Model. https://sam.nrel.gov/

[3] National Renewable Energy Laboratory, Wind Integration National Dataset (WIND) Toolkit. http://www.nrel.gov/electricity/transmission/wind_toolkit.html

[4] Wind speeds were scaled using the formula $V_h = V_0 \left(\frac{h}{h_0}\right)^{\alpha}$ where V_h is the wind speed at the turbine height, V_0 is the wind speed measured, is the turbine hub height, $_0$ is the measurement height and α is the wind shear factor.

Table 5: Inputs, assumptions and analysis results

Wind Turbine	
Product	AWE 54-900
Rated Output	900 kW
Rotor Diameter	54 m
Hub Height	75 m
Shear Coefficient	0.14
Wind Resources	
Location	40.526, -73.502
Mean Annual Wind Speed	7.9 m/s (17.7 mph)
Estimated Output	
Annual Energy	2,909.79 MWh
Capacity Factor	36.90%
Estimated Installation Cost	
Capital Cost (not including incentives)	$2.9M (USD)
Service costs – commissioning, foundation, freight,	~$25,000 (USD)
Incentives – *NYSERDA*	*~$699,000 (USD)*

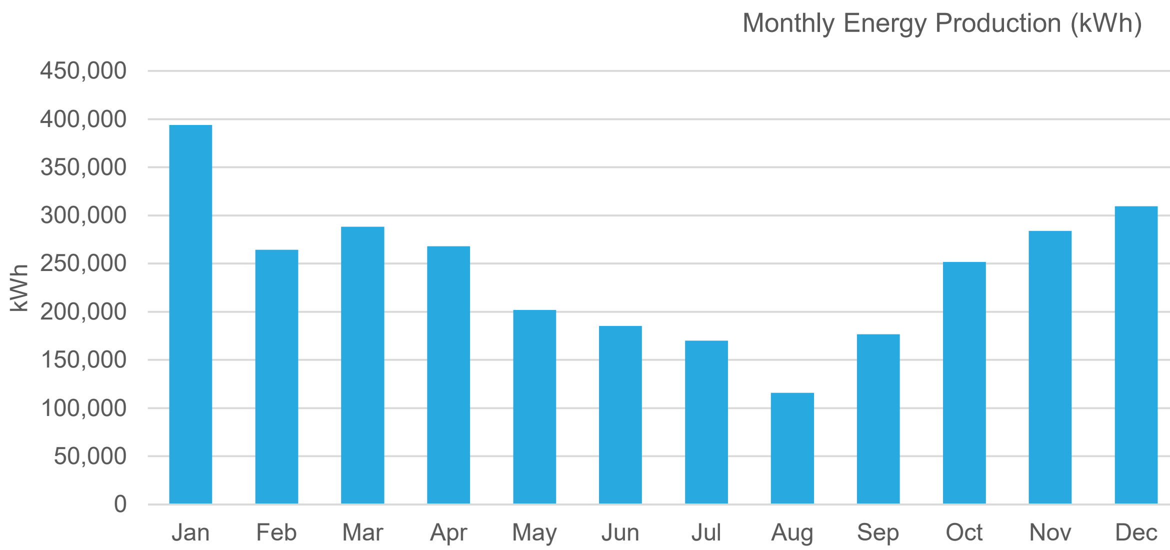

Figure 7: Estimated monthly energy production

2.3.2.2 Turbine Location

The feasibility of wind energy depends on a combination of geography and local wind resources. Areas with average annual wind speeds around 6.5 meters per second or greater, paired with a turbine at an 80 meter height (utility scale, land based wind turbines are typically installed at a height of 80 or 100 meters), are generally considered to be suitable for wind development. Small terrain features such as vegetation and buildings, or other atmospheric effects may also affect the availability of wind resources.[5] Locating wind turbines along ridges oriented perpendicular to the prevailing wind direction, on the highest elevations within a given area, or at points where local winds can funnel is likelier to result in greater mean wind speeds. Areas immediately upwind and downwind of higher terrain, the lee side or ridges, and excessively sloped terrain, should be avoided as increased turbulence may occur.[6]

Prevailing winds for the area originate from the northwest and south. Annual wind speeds and direction are shown as a wind rose plot in Figure 8. In winter months, December through February, prevailing winds come from the northwest. In summer months, June through August, prevailing winds come from the south. To avoid increased turbulence, which may lead to decreased output and lifespan, turbines should be located sufficiently far upwind and downwind from obstacles that align with the local prevailing wind directions. A general rule of thumb is that the lowest point of the turbine rotor should be at least 10 meters (30 feet) above any obstruction within 100 meters (300 feet).

[5] U.S. Department of Energy, Energy Efficiency & Renewable Energy: WINDExchange, Utility-Scale Land-Based 80-Meter Wind Maps. http://apps2.eere.energy.gov/wind/windexchange/wind_maps.asp
[6] NREL, "Wind Resource Assessment Handbook," 1997. http://www.nrel.gov/wind/pdfs/22223.pdf

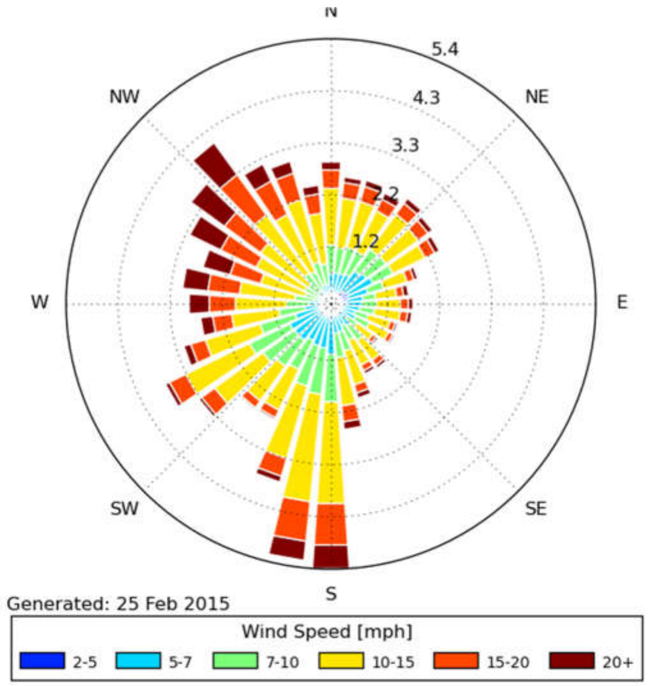

Figure 8: Annual wind rose plot for New York JFK[7]

Wind turbine noise measured at distances of 450 m and 900 m are well below the level of human perception.[8]

Potential locations for wind development in Freeport were assessed based on land ownership, elevation, and proximity to adjacent sites or structures. Parcels owned by Freeport and categorized as 'vacant' or 'community services' land uses were first identified. Of these parcels, three were found to offer a sufficient setback from neighboring activities and were not currently occupied by structures or active uses (e.g., sports fields).

- Recommended Location:
  - Freeport Electric Power Plant 2 **[redacted]**: Located adjacent to estuarine and marine wetland area. Adjacent buildings may cause turbulence at lower hub heights.
- Alternative Locations:
  - Freeport Water Department North East Water Shed **[redacted]**: Located adjacent to freshwater forested/shrub wetland area.
  - Brooklyn Waterworks / Millburn Pumping Station **[redacted]**: located adjacent to freshwater forested/shrub wetland area.

[7] http://mesonet.agron.iastate.edu/
[8] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4338604/

2.3.3 Reciprocating Engines

Two new GE JMS 624 H01 4.2 MW natural gas-reciprocating engines will be installed at Freeport PP1.

The proposed location of the engines will be next to the building housing the existing diesel engines on new concrete pads (Figure 9). Rather than constructing a building, sound-attenuated, weather-tight enclosures will be used to house the engine generator, controls, MCC's, and generator breakers as well as reduce noise pollution to the neighboring community. The SCR/Oxidation catalyst and silencer will be placed on the roof of the enclosures. The enclosures will be prewired and equipped with a fire suppression system approved by the Nassau County Fire Marshal.

The existing cooling towers will be used for engine cooling, thus reducing the cost for radiators and eliminating a potential source of noise. Two plate & frame heat exchangers will be installed in each enclosure, and use tower water for engine circuit cooling. A critical grade silencer would help to reduce far field noise from the engine exhaust. Because of the project size, exhaust emission controls will be required, which consists of a urea-based SCR catalyst and oxidation catalyst. A 6,000 gallon heat-traced insulated urea storage tank will be located at the fuel farm. The engines will be equipped for black-start and island operation.

It should be noted that the JMS 624 H01 version has recently been upgraded to 4,439 kW. We have also included two small pre-chamber gas boosters to provide an 86 psig natural gas supply for the engines' pre-chambers. This represents only 5% of the total gas use. The balance of the natural gas supply will be supplied at a lower pressure of 2-5 psig.

Figure 9: Location of new engines at Power Plant 1 **[redacted]**

The generators in PP1 are beyond their operating life and can only be used during emergencies. It is anticipated that two of the existing engines will be decommissioned upon completion of the repowering project. One unit is expected to remain operational strictly as a diesel-fueled back-up emergency generator to add additional diversity to the repowered facility. The repowering of PP1 would contribute a significant amount of power to the proposed microgrid project.

Table 6: New generation characteristics

Item	Unit	GE JMS 624 H01 Engines (two)
Capacity	kW	4.44 MW (8.88 MW)
Electrical Efficiency	%	45.7
Heat Rate	BTU/kW	7,468
Fuel Gas Pressure	psig	86
Costs	$/kW	$749

Since the generation uses natural gas, a new pipeline extension will be required east of Power Plant 1 (Figure 10).

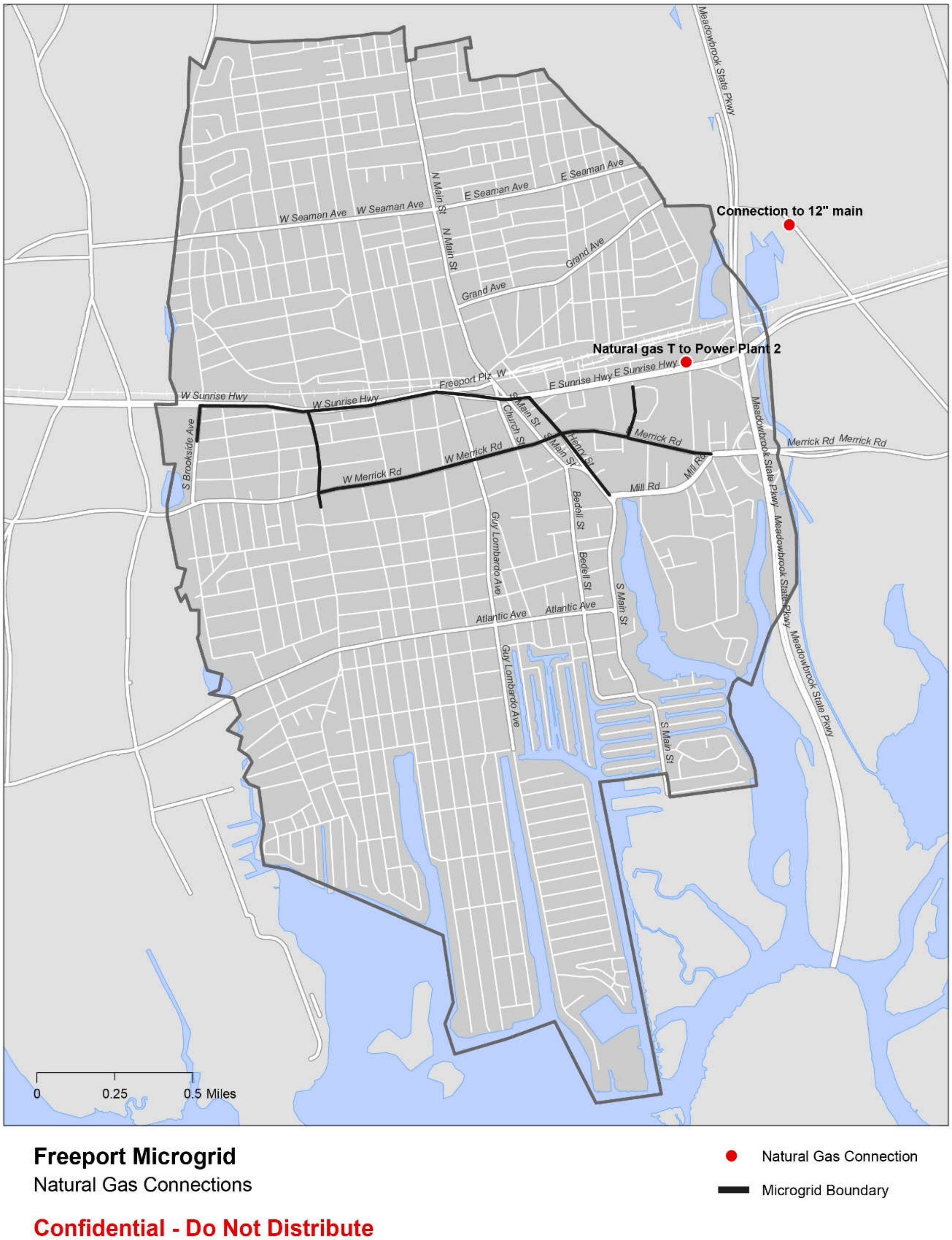

Figure 10: Existing natural gas connection to expand to Power Plant 1

The Freeport Microgrid analyzed the feasibility of a combined heat and power system (CHP). Due to the existing land use and density surrounding the new generation and a lack of existing centralized heating and cooling infrastructure, CHP is not feasible. There are potential opportunities for CHP in close proximity to PP2, but those will not be explored as part of this microgrid project.

2.3.4 Battery Storage

It is recommended that battery storage be made available at PP1 to help smooth peak demand and the solar PV generation profile. Under normal operations, the installation of the battery storage system will allow operational optimization by discharging the battery during hours of the day where the DAM prices are very high and then charge during the hours of the day that where the DAM prices are low. This peak shaving approach for the battery will lower Freeport's electricity costs and help recoup the costs of implementing the system. During islanded operation, the battery can be used to smooth the load and renewable generation and can be used as the frequency controller. The current expected battery size would be 1MW/1MWh, subject to further detailed engineering analysis. A battery of this size/capacity is expected to have an installed cost of approximately $2 million USD.

2.4 Microgrid Network

2.4.1 Existing network infrastructure

The existing network serving customers in Downtown Freeport is a combination of 4kV and 13.8kV feeders supplied from the 4F and PP1 substations. Many of the feeders emanating from these substations feed load outside of the identified downtown area. The project team considered the benefits and impacts of energizing these existing circuits in entirety and arrived at what was deemed a balanced solution.

Given that the existing distribution network does not have an optimal layout, is arranged in multiple feeders serving loads at different voltage levels, and ultimately connects both critical and non-critical loads, we recommend to lay and bury three new interconnected and self-healing 13.8kV circuits which would be connected to the PP1 13.8kV bus and dedicated to serve Tier 1 critical loads.

Figure 11: Existing circuits impacted by the Freeport Downtown Microgrid project **[redacted]**

2.4.2 Proposed enhanced network infrastructure

Due to initial concerns around fault current capacity at substation 4F, the study is considering the derivation of the new 13.8kV circuits from the PP1 substation. This will require the installation of the new 13.8kV feeders through existing and new duct banks installed in and around the downtown area. A minority of the critical facilities located outside of the immediate downtown area will be fed by overhead lines. While these lines are not located in vegetated areas, they could easily be equipped with automatic isolation switches should the overhead portion be subject to the very unlikely scenario of damage. These critical circuits traverse a fairly broad portion of the downtown area, and thus could be expanded in the future, or reconfigured as critical facilities change over the course of time.

All identified critical loads will be interconnected to the new 13.8kV circuits, which will require upgrades of customer transformers and connection laterals/drops.

Load flows within the microgrid will be monitored and controlled by a microgrid central controller. This is due to the fact that generation and load resources are both spread across the microgrid.

Other existing downtown and broader circuits would be energized from the core microgrid as generation resources and load allow, in a "boot-strapping" fashion.

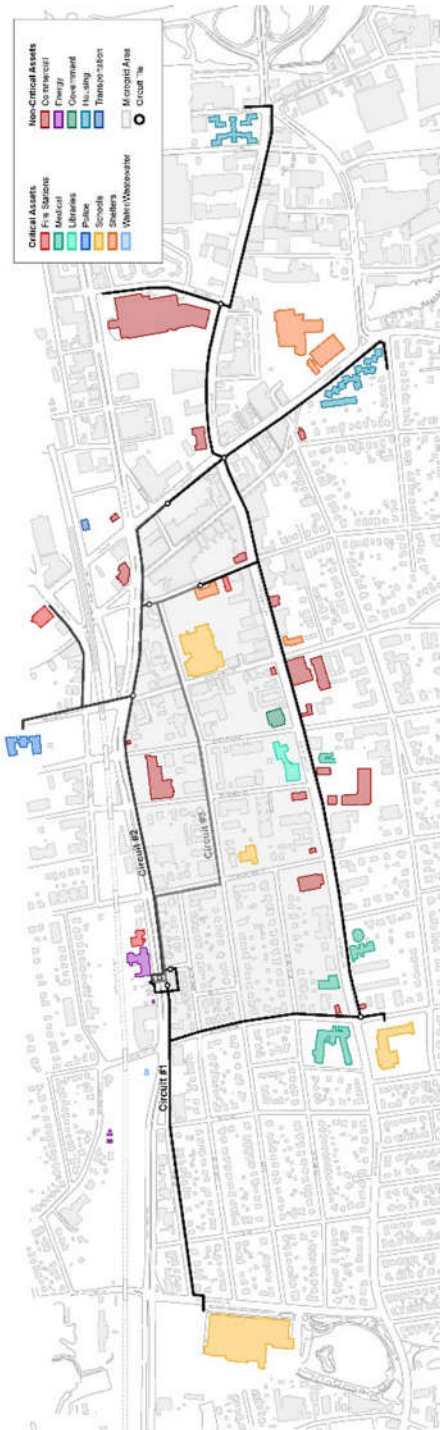

Figure 12: Critical and non-critical assets and new circuits

2.5 Microgrid Controls and ICT Infrastructure

2.5.1 Microgrid control functions

- Generation black-start capability
- Generation load following/balancing capability
- Microgrid infrastructure management including load shedding, isolation switching and generation dispatch
- Grid-forming generation (i.e., isochronous mode generation) and grid-following generation (i.e., droop mode generation or synchronous inverters)

2.5.2 Microgrid control architecture

2.5.2.1 Control System

The microgrid control system is a fundamental component as microgrids have different operating modes and have a flexible configuration which includes intermittent and variable generation.

Key control functions include system frequency and voltage control (i.e., control of active and reactive power balance) and can be divided as:

- Grid-following controls: as the grid sets reference voltage and frequency, the units simply produce active and reactive power;
- Grid-forming controls: as the grid connection is lost, the units must control system voltage and frequency.

Depending on the interaction between other distributed energy resources (DER) and the microgrid central controller (MCC), controls can be divided into:

- Non-interactive control methods - the control system on each DER or switching unit is stand-alone and does not receive/share actions with other systems;
- Interactive control methods - the units' controls work together to achieve a certain goal (e.g., voltage and frequency control in the droop control method).

The above control methods are all implemented at the component level (i.e., within the dedicated control system equipped with each generation resource or device). At the system level there is the MCC, which is responsible for managing the microgrid as a whole single controllable unit.

A MCC can be designed based on the system's specific infrastructure and the capabilities and operating limits of the separate constituent components (e.g., multiple agent systems, etc.). Depending on its application and the client's requirements, it can perform a number of tasks including:

- Balancing active and reactive power according to DER units availability and load demand
- Disconnection and re-synchronization of the microgrid from the main grid
- Black-start capability

- Managing transients and disturbances in the microgrid
- Managing energy storage and discharge profiles
- Provision of power quality services to sensitive loads
- Optimal power dispatch to include for minimization of energy production costs, response to market energy prices, and contractual obligations with the main grid (e.g., contracted provision of ancillary services)

The PowerLogic Microgrid Controller by Schneider Electric is an example of a proven MCC architecture that could be applied to the Freeport Downtown Microgrid. This device is a reactive, real-time controller that operates on the millisecond and second time scale. This control system is modular in structure and allows for expandable and flexible I/O. Future expansion could be implemented through the installation of a system similar to Schneider's StruxureWare, which utilizes predictive inputs (weather, market prices) to control and integrate demand-side solutions, including customer-sited generation dispatch and load reduction controls.

The MCC will be capable of autonomous operation in the event of loss of connection with the broader SCADA system. In addition, it will be located at PP1 in a secure and weather-protected location. This would create the benefit of collocating the critical control resources where key operating personnel are readily available.

The intent would be for the MCC to operate relatively autonomously and be integrated with existing network automation. The MCC would have full functionality and the robust responsiveness needed for real-time islanding, control and reconnection. The MCC would then be integrated into the broader SCADA system for oversight and information. This is typically how distributed control architecture is developed, allowing lower hierarchy processors to handle activities closer to the controlled device. Similarly, this control architecture is further supported by the delegation of equipment-level control to the packaged control systems supplied with the generators, inverters, etc.

2.5.3 Information Technology (IT)/Telecommunications Infrastructure Characterization

At present, Freeport utilizes a state of the art Advanced Control Systems SCADA system. The SCADA system will be used and expanded as described above for the Freeport Microgrid. The system reduces risk for extended outages and equipment failures. Freeport will receive real-time grid information to enable operating personnel to help prevent power outages and rapidly restore power when sags or outages occur. The SCADA system has the ability to communicate with smart relays via fiber cables, JMU and other IEEE standard communication methods to help maintain the new generation at PP1 and located throughout the microgrid.

Communications from the MCC to the controlled equipment can be accomplished by a combination of Modbus, Bacnet or other typical protocols over optical fiber connections run with the new 13.8kV critical circuits.

2.6 Microgrid Operation Scenarios

Flexible operation is one of the main features of the Freeport Microgrid. The MCC architecture, the various distributed generation, and the network reconfiguration made possible through controlled switching actions, allow the Freeport Downtown Microgrid to switch from grid-connection to islanded operation and be responsive to change in generation capacity (e.g., loss of one generator or intermittent renewable output).

Table 7 Freeport Downtown Microgrid operating scenarios

Id	Scenario	Microgrid Operation
1	Business as usual	Grid-connection
2	Loss of component	Grid-connection
3	Loss of utility grid	Islanded
4	Loss of utility and one PP1 generator	Islanded and load shedding

2.6.1 Microgrid business as usual operation

- Grid-connection
- Main import from bulk grid
- Solar PV is grid-connected and producing power, as available
- New PP1 in dispatchable state, ready for dispatch according to NYISO or grid requirements
- Wind turbine is grid-connected and producing power, as available
- Battery storage is grid-connected and operating to shave peak load
- New microgrid feeder circuits supplying loads
- Critical load AMI infrastructure in use to perform demand-side load reduction

2.6.2 Microgrid islanded operation

Initial Operations:

- System including generation disconnects from remainder of Long Island grid
- PP1, if not running, starts
- Battery discharges during PP1 start
- All loads except critical facilities shed to meet operating generation
- Solar PV is microgrid-connected and producing power, as available
- Wind turbine tripped or parked (if high wind event)
- Critical load AMI infrastructure activated to perform selective load shedding

Ongoing Operations:

- PP1 operating
- Solar PV is microgrid-connected and producing power, as available
- Wind turbine is microgrid-connected through external circuits and producing power, as available
- Battery storage is grid-connected and operating to smooth solar PV and shave peak load
- New microgrid feeder circuits supplying critical loads
- Additional loads connected as power generation permits
- Critical load AMI infrastructure in use to perform selective load shedding
- PP2 generation units brought on line, as conditions allow

2.6.3 Microgrid grid disconnection and re-synchronization

The single point of connection to the Long Island broader grid is at Substation 4F. The Freeport portion of this substation would be disconnected and reconnected from the LIPA portion through existing remotely operated disconnect switches and circuit breakers.

Upon disconnection, Freeport's SCADA system and the MCC would operate to shed interior feeders and bring on generation sources as described above. PP1 black-starting units would operate in isochronous mode to set frequency. Upon reconnection, the PP1 units would be controlled to synchronize with the external grid prior to reconnection. The PP1 units would then either shut down or switch to droop mode. Alternatively, the battery storage unit could be used as the grid-forming device (setting grid frequency) during islanded mode and used to re-synchronize.

2.7 Customer-Owned Resources

2.7.1 Peak Energy Savings and Energy-Efficiency Opportunities

The addition of AMI to Freeport customers will provide communication between the Freeport Electric Company and customers. The initial roll-out of the AMI will be to serve the critical facilities. Roll-out of additional capabilities can be performed over time. Remotely programmable firmware and remotely operated service disconnect switches will be available providing additional benefit to Freeport Electric. Freeport Electric will also be able to take advantage of the AMI's voltage measurements and alarms that will be integrated with their SCADA system. Benefit for the customer includes the potential for reduced electricity bills by using electricity more effectively.

Freeport also has the potential to take advantage of the ability to dispatch emergency generators located around the microgrid through a demand response program (Figure 13).

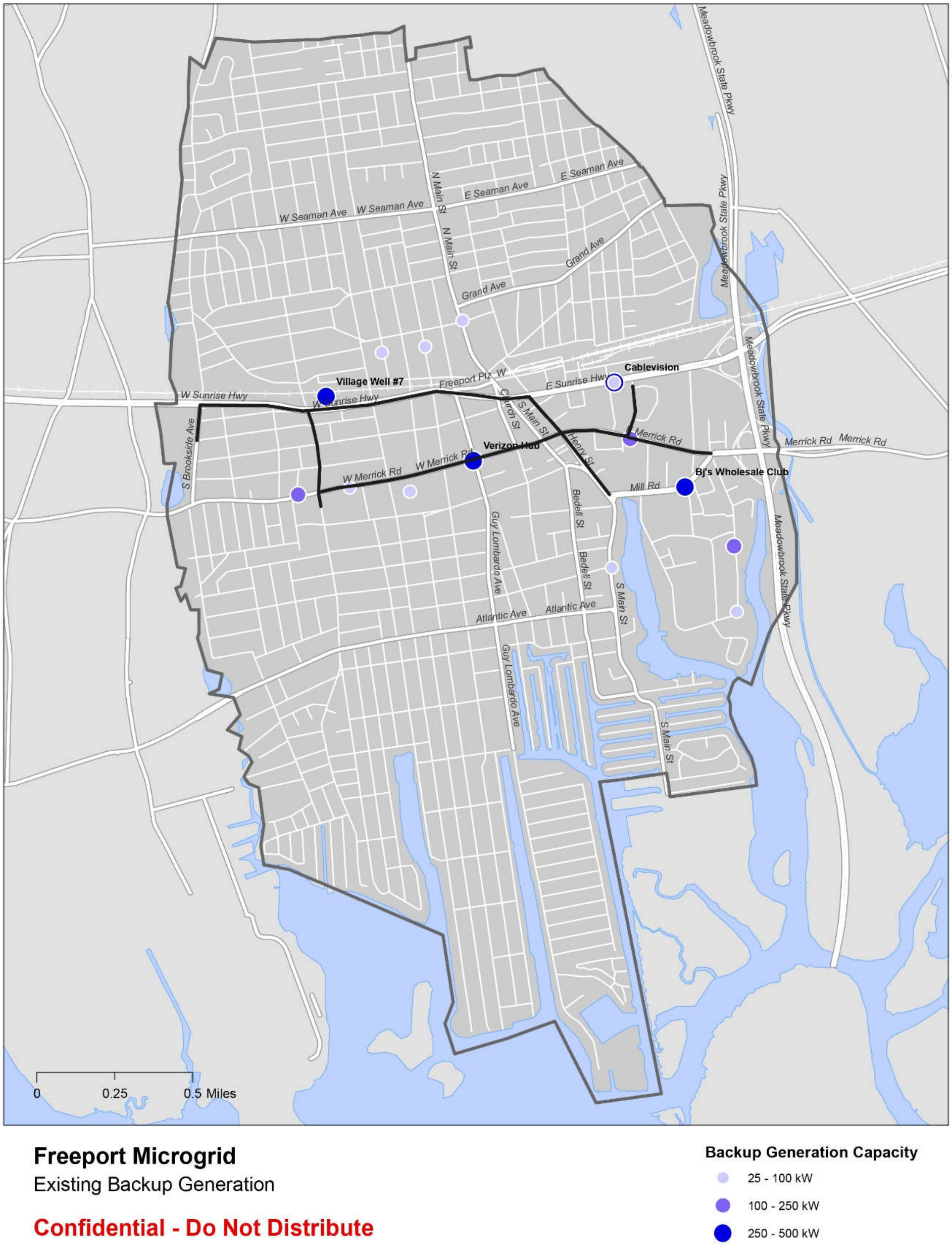

Figure 13: Emergency generation located throughout Freeport

3 Assessment of Microgrid's Commercial and Financial Feasibility

3.1 Commercial Viability – Customers

Installation of the Freeport Downtown Microgrid as described in this assessment would provide electricity service to some 46 critical customers in the proposed microgrid area during a transmission interruption. Of these customers, 19 are designated "primary" and 27 are designated "secondary" critical assets. Primary critical assets include public schools, public housing, libraries, medical centers, emergency centers, and water/wastewater treatment infrastructure. Secondary critical assets included emergency services, banks, gas station, and super markets. The proposed microgrid would ensure the continuous operation of these facilities during interruptions, and benefit to all customers in the Village of Freeport and surrounding communities by ensuring the availability of essential services during any interruption. Other benefits include additional revenue opportunities for businesses by servicing the wider Long Island and the continuous operations of schools.

Improved reliability is the primary benefit of the proposed microgrid, and a major part of the value proposition to all customers and stakeholders. This will be achieved through greater redundancy and new generation. The replacement of outdated diesel engines at Freeport Power Plant I with two new dual-fuel reciprocating engines will provide a reliable, clean power source with "black-start" capability. Renewable energy sources, primarily solar and wind, coupled with battery storage will add diversity to the power supply and reduce the impact of anticipated load growth. Integration of solar photovoltaic systems into existing electrical feeders does not pose significant challenges, and will have a minimal impact on microgrid customers.

The proposed microgrid will provide virtually uninterrupted power to the 46 critical facilities identified in Downtown Freeport – protected from flood events and wind events. During normal operations, the microgrid will connect to the Freeport Electric distribution system. Local requirements are met on a daily basis from imports obtained from the LIPA grid; under normal conditions, Freeport Electric does not use any of its own generation locally. When an interruption occurs, the microgrid will automatically trip all breakers connecting it to the LIPA grid and island. The new generators at Power Plant I will be black-started and all distribution feeders other than those associated with the microgrid circuit will automatically open to ensure power is provided to critical customers. Control systems will transfer loads back to the central grid after service is restored, and local generators will be turned down and taken offline, as necessary. While islanding, additional circuits may be engaged to power additional customers as generation and load balancing allow.

Existing infrastructure will be used where possible, but new automated switches will be installed for the new microgrid critical circuits. Freeport Electric staff will be used for a majority of installation activities to reduce capital costs. Microgrid customers will not be required to install, operate or maintain any new generation equipment; new capital infrastructure will be paid for by a combination of grants, project financing and other revenue streams, as necessary, and yet to be determined.

The agreements between Freeport Electric and customers will not require complex contracts because of the new microgrid project. The intent is that current Freeport Electric rate tariffs will not materially change for customers in the microgrid area, and there would be no differentiation between power pricing in "island" versus normal conditions.

Further analysis, including an economic dispatch model, needs to be performed to determine whether the new PP1 units would likely be dispatched and receive merchant energy and capacity revenues from the NYISO. Currently, capacity market prices in Long Island Zone K of the NYISO are very low and unlikely to generate significant offsetting revenues. Based on current pricing in the ICAP market, the repowered PP1 could raise $275,000 per year in capacity payments. The retirement of existing older units at PP1 would result in a corresponding loss of current capacity market revenues, however. The resulting net effect would yield minimal revenues unless the existing units remain in service on a very limited basis.

On an energy revenue basis, Freeport Electric should see benefits from two different conditions. The first is serving their native load rather than buying more expensive wholesale energy (above their NYPA contract amount). The second is when they do not need the power for their native load but Power Plant 1 energy is cheaper than the NYISO Zone K marginal units Power Plant 1 can dispatch into the wholesale grid.

Although a detailed production model would need to be run to determine actual dispatch, a quick analysis follows, which is helpful to understand the order of magnitude of potential energy revenues that can be achieved utilizing the repowered Power Plant 1. Using a 5 day x16 hour operating period, there are 4160 eligible hours in a year. Understanding that there are two shoulder months where the NYPA contract provides for most of Freeport's energy, this number of eligible hours should be reduced by 9 weeks of dispatch or 720 hours. The result is approximately 3440 potentially dispatchable hours. The profit spread for zone K (average DAM LBMP minus the Power Plant 1 units variable costs) is roughly $12/MWh. Therefore, $12 x 3440hrs x 8MW = $330,000 (a representative annual energy revenue amount for the repowered Power Plant 1).

The new generating resources would be eligible for ancillary services including black start and non-spinning reserves. The new resources could also provide peak load reduction to the region, providing a degree of relief to the Long Island grid in the Western Nassau area.

In addition to the foregoing, there exists the possibility for creation of a tiered customer rate with higher rates assigned to new customers connecting to the microgrid circuits. The microgrid could be further expanded over time as customers seeking the higher reliability of power supply locate businesses within critical circuit areas of Freeport.

3.2 Commercial Viability – Value Proposition

The Freeport Microgrid was first proposed in late 2013 as a key project in the New York Rising Community Reconstruction (NYRCR) Freeport Plan for recovery and resiliency. A planning committee was established to guide the development of material for the plan and the community engagement process, and held eight official meetings over the course of the project. The committee fully supported investment in microgrid technology and distributed generation from renewable sources. Potential microgrid co-benefits were the most appealing, specifically those related to downtown revitalization and improved resiliency.

The Village of Freeport is a densely populated waterfront community with a significant number of properties located in flood risk areas. The proposed microgrid will serve critical customers in and around downtown Freeport, which is located outside of the 100-year floodplain. Additional protection measures such as undergrounding overhead power lines and additional switchgear will provide further resiliency to disruptions. A stable power supply for critical assets in low-risk areas will enable residents in Freeport and neighboring communities to access vital services during disruptions and disaster events, and enable critical assets to remain operational throughout a prolonged outage such as the one cause by Superstorm Sandy in 2012.

Based on a survey conducted of business owners in the New York Metropolitan Region, a majority of respondents indicated that reliability of electricity was a factor in locating their businesses. While most respondents indicated that they were currently satisfied with the reliability of their electricity supply, nearly 25% (composed of manufacturing and utility industries) reported that they would be likely or very likely to relocate their businesses if guaranteed an uninterrupted power supply and faster recovery times after major event. Some 37% of respondents reported that they would be likely or very likely to relocate their business if electricity were to be supplied by increasingly more renewable sources.

Improved reliability provides the greatest value for individual customers and stakeholders, although economic benefits and co-benefits resulting from the proposed microgrid may be realized as well. The cost of interruptions to utility customers can be significant, especially for commercial and industrial customers. New generation sources can also reduce the costs of importing electricity. As the current engines in Freeport Power Plant 1 are past their operating life and are only used during emergencies, the capacity added by repowering could reduce the amount of electricity purchased from NYISO day-ahead markets. Additional generation from distributed renewable generation sources (solar photovoltaic and wind) will further reduce the amount of electricity purchased during peak daytime periods.

Renewable energy sources will also contribute to reduced carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur oxides (SO_x) emissions. Renewable generation supports the New York "Reforming Energy Vision" (REV) initiative by contributing to the penetration and wider deployment of distributed renewable energy resources, and is a main component of the 2015 New York State Energy Plan. By supplying renewable energy to the central grid, these sources will also help meet the goals of New York's Renewable Portfolio Standard Program (RPS). It is anticipated that photovoltaic systems installed on Village of Freeport public schools will be provided through the New York Power Authority (NYPA) K-Solar program. Incentives for commercial and industrial customers are also made available through the NY-Sun Initiative.

Freeport can begin the implementation of advanced metering infrastructure (AMI) through the initial deployment of AMI meters to critical customers on the microgrid. The coverage of this infrastructure can be expanded over time to include more and more of the area and would provide for the opportunity of further peak load reduction and savings on power purchased.

The utilization of a combination of energy technologies, including conventional generation, battery storage and renewables (solar and wind) create the opportunity to leverage centralized microgrid controls to provide real-time dispatch of units to follow load (when islanded) or to produce power to the grid (parallel operation) utilizing economic dispatch and capability curves for each resource. This project would further demonstrate the capability of microgrid control systems to perform this balance of resources and loads at the distribution level, further promoting the business model and creating a replicable and scalable demonstration.

SWOT Analysis

Strengths:

- Municipal Utility that has control of the infrastructure and the support of both the Village government and the community for this project
- Resilient hub for south shore, Nassau County;
- Support for community including low income housing;
- Potential ability to provide black-start resource to broader Long Island grid;
- A balance of generation, renewables and battery storage allow for optimization of energy usage
- Use of existing infrastructure at Power Plant 1
- Freeport Electric's familiarity with the electric infrastructure
- Cleaner energy generation at Power Plant 1 and across Freeport
- Reduction of emissions with new generators, solar energy and battery
- Reduction of exposure to the volatility of DAM prices
- Resilience of primary and secondary critical services during outages and major events
- An increase in public safety by maintaining traffic lights and street lights during outages
- Reduction of expense to primary and secondary critical facilities by preventing the need for backup generators
- Microgrid controller provides a more efficient grid operation
- Reduces expense to the Village and primary and secondary critical facilities to install, maintain and demobilize emergency generators.
- Power Quality improvements through reduced losses with new circuits

Weaknesses:

- Resiliency measures and renewable power capital costs are difficult to recover under current rates (which are relatively low due to NYPA delivered power to the municipality);

Opportunities:

- Repowered Power Plant 1 can potentially generate merchant revenues;
- Freeport would have potential to attract businesses seeking to relocate based on energy reliability – Most Resilient Grid on Long Island
- Downtown Freeport will now have the ability to support future growth
- Promotion of AMI infrastructure which can further be leveraged for demand reduction programs
- Addition of solar, wind and batteries will diversify Freeport's power supply during peak and off-peak hours, increasing resilience
- Reduction of losses in existing grid with new circuit
- Reduction of the reliance on transmission grid

Threats:

- Competing projects seeking similar resources for development
- Cost of decommissioning existing generators at Power Plant 1

3.3 Commercial Viability – Project Team

The Freeport Downtown Microgrid team is led by the Freeport Electric (Incorporated Village of Freeport with its consultant partners Anbaric Microgrid and Arup. Anbaric Microgrid is working with Freeport Electric on this proposal with the intent of ultimately arriving at a public-private partnership and private investment opportunity. The Freeport Downtown Microgrid has strong support from the Village of Freeport and Freeport Electric who have and will continue to play a large role in the development of this project. National Grid, the local fuel distributor, is also in support of the proposed microgrid project. Because of Freeport's ownership model, this microgrid project creates much less bureaucratic hurdles than the other proposed microgrid projects.

Freeport Electric currently owns and operates all electrical distribution infrastructure in the microgrid area. Construction will be managed by a combination of Freeport Electric personnel and experienced and reputable third party contractors and vendors (i.e. Schnieder, GE, ABB, Alstom). As part of this development activity, Freeport Electric has been in contact with Northeast Energy Systems, the regional representative for Jenbacher generators, a potential choice of technology for the Power Plant 1 repowering. Freeport Electric personnel will be available throughout the construction process to review design drawings and oversee installations. Freeport Electric will be primarily responsible for operating and maintaining the proposed microgrid, including the generators at PP1. New generators to be installed in Freeport Power Plant I will be financed through a public-private partnership. Third-party ownership and operation of solar photovoltaic systems is under consideration; New York State initiatives such as K-Solar will help facilitate these partnerships.

Freeport Electric is a branch of the Village of Freeport and carries the credit rating and financial strength of the Village. Anbaric is an experienced developer with committed financial backing for the development of and investment in microgrid projects.

3.4 Commercial Viability – Creating and Delivering Value

The Village of Freeport owns all of the locations of the proposed Microgrid's distributed generation (reciprocating engine, battery, solar and wind) and circuits. There will be no required easements or right-of-way (ROW) issues and therefore no negotiations between multiple parties for leasing or owning land and no additional permits for blocking or installing in public ROWs.

The technologies proposed will integrate into Freeport Electric's existing SCADA system and new microgrid controller. These technologies will also integrate with the proposed outage management system and AMI. Freeport Electric are knowledgeable of the technologies and will be able to manage the installation and connection of the technologies during normal and island modes. There will be no new special circumstances regarding connections, meters and switches.

The technologies chosen are all proven. The Jenbacher engines were chosen due to their high efficiency, reasonable capital cost, and availability. Although the specific battery technology is to be determined, the use of the battery will allow for peak load reduction and also serve as the voltage source for microgrid control during islanded operation, with the other energy resources synchronizing to the battery inverter (droop mode). This has been proven to provide reliable microgrid control when varying technologies are employed in parallel operation.

Since Freeport Electric already owns and operates the distribution infrastructure, the modification of the existing downtown circuits and addition of dedicated microgrid circuits is a known possibility and creates a large and flexible microgrid serving a wider community than a smaller, dedicated facility type configuration. The use of existing Freeport Electric operating personnel, land, and construction personnel also allows for reductions in construction and net operating costs.

Many of the project team members are already intact, reducing the number of contract negotiations with third parties. The ownership and knowledge of the system will create a short design and construction timeframe to implement the Downtown Microgrid Project – compared to other NYPrize Microgrid projects – reducing costs on the rate (tax) payers. The maintenance of the new microgrid may require additional staff. Should the project be advanced to subsequent stages of development, the conceptual design would be detailed through engineering and specification documents. Many of the components are packaged and would require minimal engineering for integration. The microgrid controls architecture and programming would be sourced by dedicated teams within competent suppliers of the systems. Anbaric has worked with Schneider Electric and their Struxureware platform, which has been proven to integrate the types of resources considered here. The team would seek similar results from the available vendors like Schneider who have architecture and track record demonstrating similar capability.

Since this project also has the potential to create load relief on the Long Island grid during periods of high peak demand, benefits from the utility and its ratepayers should be extended to the developers of the proposed microgrid (the value of grid upgrade deferrals).

3.5 Financial Viability

As discussed in Section 3.2 above, there are several potential revenue streams for the microgrid. Known initial potential revenue streams are the potential to collect energy and capacity revenues from the NYISO. Another revenue stream would be the potential for energy sales directly from the generators at Power Plant 1 to the Freeport Electric utility for providing energy to its customer base.

Future revenue streams could be derived from the potential to attract customers seeking to set up businesses connected to the microgrid, where they would incur a small premium in their rates over the remainder of the Village.

Cost savings could be initially seen through peak shaving functions of the battery storage facility and through low cost energy produced by the renewable resources. Longer term cost savings could manifest from the ability of AMI infrastructure to drive demand reduction programs.

In addition to the above, it is likely that the infrastructure capital costs (including circuiting, controls, fuel supply) and even the capital costs of the generating facilities will need to be offset through program funding (for resiliency purposes) or through the broader rate base due to the improvements made to the grid. The current NYISO Zone K Long Island capacity market is insufficient to provide compensation for the capital cost recovery of new generation on Long Island, which is why LIPA (or its grid operators) has issued RFPs to solicit development of resources that are compensated through long term power purchase agreements.

3.6 Legal Viability

The primary business model under consideration for the Freeport Microgrid identifies Freeport Electric as the project owner and operator. Freeport Electric operates and maintains the existing power plant and distribution grid that comprises the proposed microgrid. All new installations will take place on land currently owned by Freeport Electric; there will be no requirement for easements, rights of way leases, or land purchases for the project to proceed.

Implementation of the microgrid will have no effect on Freeport Electric customers. Microgrid customers may require new electrical services and service contracts.

4 Develop Preliminary Technical Design Costs and Configuration

4.1 Facility and Customer Description

The Freeport Downtown Microgrid will serve a number of primary (critical) facilities and secondary facilities essential for Freeport and the surrounding community. The facilities were selected based on a number of criteria including public health and safety, proximity to the new circuits, ability of the new circuit to connect to existing feeders, load and potential economic loss if an outage occurs. The Freeport Downtown Microgrid also includes 28 traffic lights. The facilities are listed in Table 2 and below.

Primary

Residential

- Freeport Housing Authority complex - 100 units
- Multi-family residential units – 6 units - based on location

Large Commercial

- Fire Departments – 3 – proximity to new circuits and public health and safety
- Government (City Hall) – public health and safety
- Police Station – 1 – public health and safety
- Health Care Facilities [kidney/dialysis center; Nursing Home (100-beds); senior home/a short-term, long-term and outpatient respite, ventilator care, hospice and palliative care center (280 beds); internal medicine and surgery centers; intensive and critical care rehabilitation center (30-beds)] – 6 – proximity to new circuits and public health and safety
- Library – 1 – public health and safety (refuge/meeting location)
- Schools – 3 – based on lessons learned from Superstorm Sandy (refuge and ability to send kids back to school)
- Recreation Building – 1 – public health and safety and based on lessons learned from Superstorm Sandy (Village refuge – approximately 2,000 people)
- Water (potable water pumping stations) – 3 – public health and safety
- Transit Center (multimodal transit station - LIRR Station and Bus/Taxi hub) – 1 – public health and safety, and based on lessons learned from Superstorm Sandy (train is on separate circuit, buses can operate and taxis available)

Secondary

Large Commercial

- Banks – 5 – based on lessons learned from Superstorm Sandy (people need cash during outages) and proximity to new circuits
- Car Center – 1 – based on location
- Large Department Stores – 2 – based on lessons learned from Superstorm Sandy (supplies)
- Supermarkets/Markets – 4 - based on lessons learned from Superstorm Sandy, proximity to new circuits and economic losses incurred
- Gas Stations – 1 – based on lessons learned from Superstorm Sandy (people need gas during outages), proximity to new circuits and economic losses incurred
- Government (Post Office) – 1 – proximity to new circuits and economic losses incurred
- Office building (commercial customers critical operations) – 1 – economic losses incurred
- Pharmacy – 2 – based on lessons learned from Superstorm Sandy (people need medical supplies and medicine during events/outages) and proximity to new circuits
- Retail Center (convenience and food stores) – 1 – proximity to new circuits and lessons learned from Superstorm Sandy
- Large Commercial – 5 – proximity to new circuits

Small Commercial

- Fuel Retail – 1 – based on lessons learned from Superstorm Sandy (people need fuel - diesel, propane, LNG and heating oil - during outages) and proximity to new circuits
- Gas Stations – 2 – based on lessons learned from Superstorm Sandy (people need gas during outages), proximity to new circuits and economic losses incurred
- Office building (commercial customers critical operations) – 1 – economic losses incurred
- Pharmacy – 1 – based on lessons learned from Superstorm Sandy (people need medical supplies and medicine during events/outages) and proximity to new circuits
- Small Commercial – 32 - proximity to new circuits

Table 8: List of primary (critical) and secondary facilities

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Bank 1	Large Commercial/Industrial	1	Commercial	129.6	0.036	100	17
Bank 2	Large Commercial/Industrial	1	Commercial	224.28	0.102	100	17
Bank 3	Large Commercial/Industrial	1	Commercial	575.28	0.129	100	17
Bank 4	Large Commercial/Industrial	1	Commercial	139.2	0.035	100	17
Bank 5	Large Commercial/Industrial	1	Commercial	115.44	0.028	100	17
Car Center 1	Large Commercial/Industrial	1	Commercial	104.66	0.02	100	17
Department Store 1	Large Commercial/Industrial	1	Commercial	1,552.80	0.53	100	17
Department Store 2	Large Commercial/Industrial	1	Commercial	3,463.50	0.864	100	17
Fire 1	Large Commercial/Industrial	1	Fire Stations	213.06	0.065	100	24
Fire 2	Large Commercial/Industrial	1	Fire Stations	242.56	0.087	100	24
Fire 3	Large Commercial/Industrial	1	Fire Stations	50.36	0.022	100	24
Food Store 1	Large Commercial/Industrial	1	Commercial	1,213.92	0.236	100	17
Food Store 2	Large Commercial/Industrial	1	Commercial	109.55	0.022	100	17

Food Store 3	Large Commercial/Industrial	1	Commercial	1,940.40	0.41	100	17
Food Store 4	Large Commercial/Industrial	1	Commercial	579.72	0.2	100	17
Fuel Retail 1	Small Commercial/Industrial	1	Commercial	37.8	0.026	100	17
Gas Station 1	Small Commercial/Industrial	1	Commercial	28.28	0.018	100	24
Gas Station 2	Large Commercial/Industrial	1	Commercial	144.92	0.028	100	24
Gas Station 3	Small Commercial/Industrial	1	Commercial	20.57	0.011	100	24
Government 1	Large Commercial/Industrial	1	Government	374.52	0.09	100	17
Government 2/Police 1	Large Commercial/Industrial	1	Government/Police	980.64	0.324	100	24
Health Care 1	Large Commercial/Industrial	1	Hospitals	225.6	0.068	100	24
Health Care 2	Large Commercial/Industrial	1	Hospitals	734.4	0.216	100	24
Health Care 3	Large Commercial/Industrial	1	Hospitals	2,708.10	0.833	100	24
Health Care 4	Large Commercial/Industrial	3	Hospitals	88.96	0.047	100	24
Health Care 5	Large Commercial/Industrial	1	Hospitals	70.44	0.04	100	24
Health Care 6	Large Commercial/Industrial	1	Hospitals	211.56	0.05	100	24
Housing - all	Residential	6 units	Residential (Total)	69.8	0.004	100	24
Housing 1	Residential	100 units	Residential (Total)	643.68	0.3	100	24
Large Commercial	Large Commercial/Industrial	5	Commercial	110.81	0.038	100	17
Library 1	Large Commercial/Industrial	1	Libraries	195.6	0.094	100	17

Office Building 1	Small Commercial/Industrial	1	Commercial	1,641.60	0.286	100	17
Office Building 2	Large Commercial/Industrial	1	Commercial	2,958.30	0.483	100	17
Pharmacy 1	Large Commercial/Industrial	1	Commercial	501.76	0.093	100	17
Pharmacy 2	Small Commercial/Industrial	1	Commercial	36.47	0.014	100	17
Pharmacy 3	Large Commercial/Industrial	1	Commercial	287.76	0.076	100	17
Recreation Building (Refuge)	Large Commercial/Industrial	1	Shelters (~2000 people)	3,615.12	1.045	100	24
Retail Center 1	Large Commercial/Industrial	1	Commercial	166.19	0.059	100	17
School 1 (Bayview Avenue School)	Large Commercial/Industrial	1	Schools	288.32	0.132	100	17
School 2 (Dodd Jr High School)	Large Commercial/Industrial	1	Schools	1,205.40	0.672	100	17
School 3 (Freeport High School)	Large Commercial/Industrial	1	Schools	1,568.00	0.588	100	17
Small Commercial	Small Commercial/Industrial	32 facilities	Commercial	18.64	0.012	100	17
Transit Center	Large Commercial/Industrial	1	Transportation	255.4	0.052	100	24
Water 1	Large Commercial/Industrial	1	Water and Wastewater	264.53	0.119	100	24
Water 2	Large Commercial/Industrial	1	Water and Wastewater	176.4	0.239	100	24
Water 3	Large Commercial/Industrial	1	Water and Wastewater	383.5	0.12	100	24

4.2 Characterization of Distributed Energy Resources

Table 9 describes the DERs in the Freeport Downtown Microgrid. The Freeport Downtown Microgrid is expected to reduce the need for bulk energy suppliers to expand generating capacity, by directly providing peak load support (Table 10) and enabling customers to participate in a demand response program through AMI (Table 21).

Table 9: Freeport Downtown Microgrid Distributed Energy Resources

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
JMS 624 GS-N.L (A)	Power Plant 1	Natural Gas/LNG	4.44	17,775.00	48.7	8	MMBTU/MWh
JMS 624 GS-N.L (B)	Power Plant 1	Natural Gas/LNG	4.44	17,775.00	48.7	8	MMBTU/MWh
Rec Center Solar PV (Parking)	Freeport Rec Center	Solar PV	1.06	1,375.67	3.77	-	-
Rec Center Solar PV (Roof)	Freeport Rec Center	Solar PV	0.271	322.76	0.884	-	-
Industrial Park Wind Turbine	Industrial Park Wind Turbine	Wind	0.90	2,909.79	7.97	-	-
Battery	PP1 Battery	Battery	1	1	1	-	-
Additional Solar	LIRR Parking, Muni Parking, Schools	Solar PV	4.86	6,179.00	19.9	-	-

Table 10: Freeport Downtown Microgrid Peak Load Support Facilities

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
JMS 624 GS-N.L (A)	Power Plant 1	4.44	Yes
JMS 624 GS-N.L (B)	Power Plant 1	4.44	Yes
Rec Center Solar PV (Parking)	Freeport Rec Center	0.16	Yes
Rec Center Solar PV (Roof)	Freeport Rec Center	0.04	Yes
Industrial Park Wind Turbine	Industrial Park Wind Turbine	0.34	Yes
Battery	Power Plant 1	1	Yes

Table 11: Facilities Participating in Demand Response Program

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
Bank 1	*0.5*	*0*
Bank 2	*1.5*	*0*
Bank 3	*1.9*	*0*
Bank 4	*0.5*	*0*
Bank 5	*0.4*	*0*
Car Center 1	*0.3*	*0*
Department Store 1	*7.6*	*0*
Department Store 2	*12.4*	*0*
Fire 1	*0.9*	*0*
Fire 2	*1.3*	*0*
Fire 3	*0.3*	*0*
Food Store 1	*3.4*	*0*
Food Store 2	*0.3*	*0*
Food Store 3	*5.9*	*0*
Food Store 4	*2.9*	*0*
Fuel Retail 1	*0.4*	*0*
Gas Station 1	*0.3*	*0*
Gas Station 2	*0.4*	*0*
Gas Station 3	*0.2*	*0*
Government 1	*1.3*	*0*
Government 2/Police 1	*4.7*	*0*
Health Care 1	*1*	*0*
Health Care 2	*3.1*	*0*
Health Care 3	*12*	*0*
Health Care 4	*0.7*	*0*

Health Care 5	*0.6*	*0*
Health Care 6	*0.7*	*0*
Housing - all	*0.1*	*0*
Housing 1	*4.3*	*0*
Large Commercial	*0.5*	*0*
Library 1	*1.4*	*0*
Office Building 1	*4.1*	*0*
Office Building 2	*7*	*0*
Pharmacy 1	*1.3*	*0*
Pharmacy 2	*0.2*	*0*
Pharmacy 3	*1.1*	*0*
Recreation Building (Refuge)	*15*	*0*
Retail Center 1	*0.8*	*0*
School 1	*1.9*	*0*
School 2	*9.7*	*0*
School 3	*8.5*	*0*
Small Commercial	*0.2*	*0*
Transit Center	*0.7*	*0*
Water 1	*1.7*	*0*
Water 2	*3.4*	*0*
Water 3	*1.7*	*0*

The Freeport Downtown Microgrid is anticipated to avoid expansion of the transmission network by approximately 10MW

4.3 Capital Costs

The capital costs of the Freeport Downtown Microgrid are listed in Table 12. Capital costs include the following:

- Reciprocating engines (2)
- Solar PV

- Wind turbine
- AMI
- New firm gas pipeline
- Distribution circuits including conduits
- Battery system
- Microgrid controller

Table 12: Freeport Downtown Microgrid Capital Costs

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Two Reciprocating Engines (4.4 MW each)	$13,029,670.00	30	Additional generation capacity (includes engine, urea storage tank, heat exchanger, transportation of unit, project management, construction management, sound attenuated weather tight enclosures, waste management, civil construction, mechanical installation, electrical installation, and testing)
Solar PV	$4,387,000.00	25	On-site generation and peak shedding
Wind Turbine	$2,750,000.00	25	On-site generation and peak shedding
AMI	$12,715.00	20	Smart meters. Additional smart meters are being installed in South Freeport and costs associated with collector and collector installation labor and equipment, RF kit and tools, licensing)
New firm gas pipeline	$3,168,000.00	75	1 Mile pipeline extension
Distribution Circuits (incl. conduit)	$6,797,700.00	50	Material, Installation of 15kV circuits, and 8 way 6” duct bank
Battery	$2,000,000.00	10	Material, Installation of 1MW/1MWh battery
Microgrid Controller	$1,500,000.00	25	Microgrid Controller

4.3.1 Planning and Design costs

Planning and design costs for the Freeport Downtown Microgrid are listed in Table 13. Planning and design costs include:

- Planning and design for the reciprocating engines
- Solar PVs
- Wind turbine
- AMI
- Battery system
- Air modeling
- Interconnection design

- Project management

Table 13: Freeport Downtown Microgrid Planning and Design Costs

Initial Planning and Design Costs ($)	What cost components are included in this figure?
$1,345,000.00	Planning and Design Costs for the Reciprocating Engine, Solar PV, Wind, AMI, Battery, air modeling, Interconnection Design, Project Management

4.3.2 Operation and Maintenance Costs

Operation and maintenance costs for the Freeport Downtown Microgrid are listed in Table 14. These costs include:

- Reciprocating engines (parts, preventative maintenance, and monitoring);
- Solar PV (scheduled maintenance/cleaning, and inverter replacement reserve every 10-20 years);
- Wind turbine (parts, preventative maintenance and monitoring);
- Battery system (system monitoring, data reporting /recording and preventative maintenance);
- AMI (AMI head-end annual maintenance)
- Two additional staff to Freeport Electric

Table 14: Freeport Downtown Microgrid Operation and Maintenance Costs

Fixed O&M Costs ($/year)	What cost components are included in this figure?
$395,050	Reciprocating Engine (Parts, Preventative Maintenance, Monitoring), Solar PV (Scheduled Maintenance/Cleaning, inverter replacement reserve), Wind Turbine (Parts, Preventative Maintenance, Monitoring), Battery (system monitoring, data reporting /recording and preventative maintenance), AMI (AMI Head-end Annual Maintenance), two additional staff

4.3.3 Variable O&M Costs

Variable operation and maintenance costs for the Freeport Downtown Microgrid are listed in Table 15. These costs include the operation and maintenance of the two, new reciprocating engines

Table 15: Freeport Downtown Microgrid Variable O&M Costs

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
6	$/MWh	Operations and Maintenance of new unit

4.3.4 Fuel Costs

Fuel costs for the Freeport Downtown Microgrid are listed in Table 16. These costs include the fuel costs for the two reciprocating engines. There are no fuel costs for the renewable energy systems.

Table 16: Freeport Downtown Microgrid Fuel Costs

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
JMS 624 GS-N.L (A)	PP1	Unlimited	8	MMBTU/MWh
JMS 624 GS-N.L (B)	PP1	Unlimited	8	MMBTU/MWh
Rec Center Solar PV (Parking)	Freeport Rec Center	Indefinitely	-	-
Rec Center Solar PV (Roof)	Freeport Rec Center	Indefinitely	-	-
Industrial Park Wind Turbine	Industrial Park Wind Turbine	Indefinitely	-	-

4.3.5 Emissions Control Costs

The Freeport Downtown Microgrid will not require mandates to purchase emissions allowances. The emissions control costs for the Freeport Downtown Microgrid are included in Table 17. These costs include the urea injection for NOx control. The anticipated emissions are in Table 18.

Table 17: Freeport Downtown Microgrid Emissions Control Costs

Cost Category	Costs ($)	Description of Component(s)	Component Lifespan(s) (round to nearest year)
Capital Costs ($)	-	Included in Capital Costs	-
Annual O&M Costs ($/MWh)	$0.35/MWh	Urea Injection	
Other Annual Costs ($/Year)			

Table 18: Freeport Downtown Microgrid Emission Factors

Emissions Type	Emissions per MWh	Unit
CO_2	772	lb/MWh
SO_2	N/A	N/A
NO_x	0.379	lb/MWh
PM	N/A	N/A

4.3.6 Ancillary Benefits

The Freeport Downtown Microgrid is designed to provide ancillary services for frequency support, voltage and reactive power support and black start capability (Table 19).

Table 19: Freeport Downtown Microgrid Ancillary Services

Ancillary Service	Yes	No
Frequency or Real Power Support		
Voltage or Reactive Power Support		
Black Start or System Restoration Support		

4.3.7 Power Quality and Reliability

The Freeport Downtown Microgrid will improve power quality for the facilities on the microgrid. On average, there will be approximately 36 power quality events that the new microgrid will avoid (e.g., voltage sags, swells, momentary outages).

The SAIFI and CAIDI of the existing grid is in Table 20.

Table 20: SAFI and CAIDI of existing grid

Estimated SAIFI	Estimated CAIDI
1.4201	1.6253

4.4 Backup Generation Capabilities

Table 21 lists the facilities on the Freeport Downtown Microgrid with back generation capabilities, available generation, fuel consumption and one-time and on-going operating costs.

Table 21: Facilities with backup generation capabilities

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Department Store 1	DS1	Diesel	0.045	75	3.4	2.4	Gal/hr	500	0.03
Office Building 1	OB1Unit 1	Diesel	0.275	75	20.6	14.9	Gal/hr	500	0.21
Office Building 1	OB1Unit 2	Diesel	0.045	75	3.4	2.4	Gal/hr	500	0.03
Office Building 2	OB2Unit 1	Diesel	0.435	75	32.6	23.5	Gal/hr	500	0.33
Health Care 2	HC2Unit 1	Diesel	0.08	75	6.0	4.3	Gal/hr	500	0.06
Health Care 3	HC3Unit 1	Diesel	0.25	75	18.8	13.5	Gal/hr	500	0.19
Government 2/Police 1	GOV2Unit1	Diesel	0.1	75	7.5	5.4	Gal/hr	500	0.08
Department Store 2	DEP2Unit 1	Diesel	0.5	75	37.5	27.0	Gal/hr	500	0.38

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Food store 3	FS3Unit 1	Diesel	0.06	75	4.5	3.2	Gal/hr	500	0.05

4.5 Costs of Emergency Measures Necessary to Maintain Service

Table 22 lists the facilities on the Freeport Downtown Microgrid with backup generation capabilities and the non-fuel costs incurred during an outage.

Table 22: Cost of Maintaining Service while Operating on Backup Power

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Office Building 1	Ongoing	Additional Staffing to supplement emergency electrical deficiencies	$2,000	per day	During power outage
Office Building 2	Ongoing	Additional Staffing to supplement emergency electrical deficiencies	$2,000	per day	During power outage
Health Care 2	Ongoing	Additional Staffing to supplement emergency electrical deficiencies	$1,500	per day	During power outage
Health Care 3	Ongoing	Additional Staffing to supplement emergency electrical deficiencies	$1,500	per day	During power outage
Government 2/Police 1	Ongoing	Additional Staffing to supplement emergency electrical deficiencies	$2,000	per day	During power outage

Table 23 lists the facilities on the Freeport Downtown Microgrid with no backup generation capabilities and the costs incurred during an outage.

Table 23: Cost of Maintaining Service while Backup Power is Not Available

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Bank 1	One-time	Weekly Rental of Portable Generator (40kW)	800	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Bank 2	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Bank 3	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Bank 4	One-time	Weekly Rental of Portable Generator (40kW)	800	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Bank 5	One-time	Weekly Rental of Portable Generator (40kW)	800	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Car Center 1	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
Department Store 2	One-time	Weekly Rental of Portable Generator (1000kW)	7000	$/wk	During power outage
	One-time	Installation, Demobilization	4000	$	During power outage
	On-going	Maintenance	640	$/day	During power outage
	On-going	Fuel Costs	3920	$/day	During power outage
Fire 1	One-time	Weekly Rental of Portable Generator (56kW)	900	$/wk	During power outage
	One-time	Installation, Demobilization	80	$	During power outage
	On-going	Maintenance	40	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Fire 2	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Fire 3	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	80	$	During power outage
	On-going	Maintenance	40	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
Food Store 1	One-time	Weekly Rental of Portable Generator (250kW)	2000	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	640	$/day	During power outage
	On-going	Fuel Costs	990	$/day	During power outage
	Ongoing	Cost of loss in food	3000	$/day	Only when loss of power for 8 hours
Food Store 2	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
	Ongoing	Cost of loss in food	3000	$/day	Only when loss of power for 8 hours
Food Store 3	One-time	Weekly Rental of Portable Generator (500kW)	3600	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	1970	$/day	During power outage
	Ongoing	Cost of loss in food	3000	$/day	Only when loss of power for 8 hours

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Food Store 4	One-time	Weekly Rental of Portable Generator (200kW)	1800	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	1360	$/day	During power outage
	On-going	Fuel Costs	790	$/day	During power outage
	Ongoing	Cost of loss in food	3000	$/day	Only when loss of power for 8 hours
Fuel Retail	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
Gas Station 1	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
	Ongoing	Loss in customer sales	450	$/hr	During power outage
Gas Station 2	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
	Ongoing	Loss in customer sales	450	$/hr	During power outage
Gas Station 3	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
	Ongoing	Loss in customer sales	450	$/hr	During power outage
Government 1	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
Government 2/Police 1	One-time	Weekly Rental of Portable Generator (500kW)	3600	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	2000	$/day	During power outage
	On-going	Fuel Costs	1970	$/day	During power outage
Health Care 1	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Health Care 2	One-time	Weekly Rental of Portable Generator (250kW)	2000	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	1500	$/day	During power outage
	On-going	Fuel Costs	990	$/day	During power outage
Health Care 3	One-time	Weekly Rental of Portable Generator (1000kW)	7000	$/wk	During power outage
	One-time	Installation, Demobilization	4000	$	During power outage
	On-going	Maintenance	1500	$/day	During power outage
	On-going	Fuel Costs	3920	$/day	During power outage
Health Care 4	One-time	Weekly Rental of Portable Generator (56kW)	900	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Health Care 5	One-time	Weekly Rental of Portable Generator (40kW)	800	$/wk	During power outage

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Health Care 6	One-time	Weekly Rental of Portable Generator (56kW)	900	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Housing 1	One-time	Weekly Rental of Portable Generator (500kW)	3600	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	2000	$/day	During power outage
	On-going	Fuel Costs	1970	$/day	During power outage
Housing – All (multifamily)	One-time	Average rental amount awarded by FEMA in Freeport for displaced residents who own or rent	4,300	$	Following a major power event
Large Commercial	One-time	Weekly Rental of Portable Generator (40kW)	800	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Library 1	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Pharmacy 1	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Pharmacy 2	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
Pharmacy 3	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Recreation	One-time	Weekly Rental of Portable Generator (1000kW)	7000	$/wk	During power outage
	One-time	Installation, Demobilization	4000	$	During power outage
	On-going	Maintenance	2000	$/day	During power outage
	On-going	Fuel Costs	3920	$/day	During power outage
Retail Center 1	One-time	Weekly Rental of Portable Generator (56kW)	900	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	160	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
School 1	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
School 2	One-time	Weekly Rental of Portable Generator (750kW)	5400	$/wk	During power outage
	One-time	Installation, Demobilization	4000	$	During power outage
	On-going	Maintenance	2000	$/day	During power outage
	On-going	Fuel Costs	2950	$/day	During power outage

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
School 3	One-time	Weekly Rental of Portable Generator (500kW)	3600	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	On-going	Maintenance	2000	$/day	During power outage
	On-going	Fuel Costs	1970	$/day	During power outage
Small Commercial	One-time	Weekly Rental of Portable Generator (20kW)	700	$/wk	During power outage
	One-time	Installation, Demobilization	40	$	During power outage
	On-going	Maintenance	80	$/day	During power outage
	On-going	Fuel Costs	90	$/day	During power outage
Transit Center	One-time	Weekly Rental of Portable Generator (56kW)	900	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	On-going	Maintenance	1000	$/day	During power outage
	On-going	Fuel Costs	220	$/day	During power outage
Water 1	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Weekly Rental of Portable Generator - Controls and chlorination (40 kW)	800	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	One-time	100ft of cable and shipping (to and from)	600	$	During power outage
	One-time	Inflatable Containment	300	$/wk	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage
Water 2	One-time	Weekly Rental of Portable Generator (250kW)	2000	$/wk	During power outage
	One-time	Weekly Rental of Portable Generator - Controls and chlorination (40 kW)	800	$/wk	During power outage
	One-time	Installation, Demobilization	2000	$	During power outage
	One-time	100ft of cable and shipping (to and from)	600	$	During power outage
	One-time	Inflatable Containment	300	$/wk	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	990	$/day	During power outage
Water 3	One-time	Weekly Rental of Portable Generator (100kW)	1300	$/wk	During power outage
	One-time	Installation, Demobilization	1000	$	During power outage
	One-time	100ft of cable and shipping (to and from)	600	$	During power outage
	One-time	Inflatable Containment	300	$/wk	During power outage
	On-going	Maintenance	320	$/day	During power outage
	On-going	Fuel Costs	410	$/day	During power outage

4.6 Services Provided

Table 24 lists each facility and level of service that can be maintained for each facility during an event when backup generation is available and when backup generation is not available.

Table 24: Percent loss in service when using backup generation and when backup generation is not available during outages

Facility Name	Percent Loss in Services When Using Backup Gen.	Percent Loss in Services When Backup Gen. is Not Available
Bank 1	*0%*	*100%*
Bank 2	*0%*	*100%*
Bank 3	*0%*	*100%*
Bank 4	*0%*	*100%*
Bank 5	*0%*	*100%*
Car Center 1	*0%*	*100%*
Department Store 1	*20% (Home Depot)*	*100%*
Department Store 2	*20% (BJ's Wholesale Club)*	*100%*
Fire 1	*80%*	*100%*
Fire 2	*80%*	*100%*
Fire 3	*80%*	*100%*
Food Store 1	*20%*	*100%*
Food Store 2	*20%*	*100%*
Food Store 3	*20%*	*100%*
Food Store 4	*20%*	*100%*
Fuel Retail 1	*0%*	*100%*
Gas Station 1	*0%*	*100%*
Gas Station 2	*0%*	*100%*
Gas Station 3	*0%*	*100%*
Government 1	*0%*	*100%*
Government 2	*69% (Village Hall)*	*100%*
Health Care 1	*0%*	*100%*
Health Care 2	*63% (South Shore Nursing Home)*	*100%*
Health Care 3	*70% (Meadowbrook Care Center)*	*100%*
Health Care 4	*0%*	*100%*
Health Care 5	*0%*	*100%*
Health Care 6	*0% (Maryhaven New Hope)*	*100%*
Housing - all	*0% (Freeport Housing)*	*100%*
Housing 1	*73% (Freeport Housing Authority - HUD)*	*100%*
Large Commercial (5 customers)	*0%*	*100%*
Library 1	*100%*	*100%*
Office Building 1	*0% (Cablevision)*	*100%*
Office Building 2	*10% (Verison Hub)*	*100%*
Pharmacy 1	*0%*	*100%*
Pharmacy 2	*0%*	*100%*
Pharmacy 3	*0%*	*100%*
Recreation Building (Refuge)	*80% (Freeport Rec Center)*	*100%*
Retail Center 1	*0%*	*100%*
School 1	*100%*	*100%*
School 2	*100%*	*100%*
School 3	*100%*	*100%*
Small Commercial (32 customers)	*0%*	*100%*
Transit Center	*0%*	*100%*
Water 1	*0%*	*100% (after 24 hrs)*
Water 2	*0%*	*100% (after 24 hrs)*
Water 3	*0%*	*100% (after 24 hrs)*

Fire: The three fire departments in the Freeport Downtown Microgrid serve a total of 43,000 people. During events and outages, the response time decreases for the fire departments since staff is put on alert during an emergency. The distance to the nearest fire department outside the Freeport Downtown Microgrid is approximately one mile.

Police: The one police station in the Freeport Downtown Microgrid serves a total of 43,000 people in a Non-Metropolitan County. During events and outages, the response time decreases for the police stations since staff is put on alert during an emergency. Under normal operations there are 20 staff including patrol officers, management staff, unit staff and dispatch staff working at the station. During an outage there are 40 staff including 20 patrol and 5 additional patrol in each category including traffic control staff. The percent reduction in service effectives during an outage is 40%.

Hospital/Medical: There is no hospital in Freeport but three hospitals surrounding Freeport - South Nassau Communities Hospitals and Oceanside Hospital which serves approximately 756,757 people across the County. There are a number of emergency healthcare facilities like dialysis centers, senior care/nursing homes, medical care and drug rehabilitation centers. The emergency medical services (Health Care 1 – 6) within the Freeport Downtown Microgrid.

Water: The three water pumping stations in the Freeport Downtown Microgrid serve a total of 43,000 residential and commercial customers.

Residential: The Freeport Downtown Microgrid serves 106 residential customers located in single and multi-family buildings. There is one large multifamily housing facility on the microgrid with 50 units.

Traffic and Street Lights: There are 28 traffic lights and a number of street lights on the Freeport Downtown Microgrid. These lights ensure the safety of the public and drivers through Downtown Freeport.

Retail: A number of commercial facilities such as grocery stores, convenience stores, restaurants, banks, pharmacies, gas stations and a fuel supply store that will be served by the Freeport Downtown Microgrid. These services will provide Freeport and surrounding communities' access to food, cash, medicine and fuel during outages. Financial losses to these businesses will also be reduced during power outages.

Government: The Mayor's Office and Emergency Management Center will be served by the Freeport Downtown Microgrid.

Transit Center: A Long Island Railroad (LIRR) station (power served by others) and the Nassau Inter-County Express (NICE) terminal will be served by the Downtown Microgrid. Train (if operating), bus and taxi services will be available for the entire community during an outage.

Library and Schools: The Freeport Downtown Microgrid serves the public library and schools. These facilities provide a refuge for the community and students have the potential to attend school through an event.

Recreation Center: The Freeport Downtown Microgrid serves the Recreation Center, which serves as a refuge and storm center during events.

4.7 Benefits-Cost Analysis

Industrial Economics, Inc. (IEc) conducted a Benefit Cost Analysis (BCA) for the Freeport Downtown Microgrid. The BCA report is in Appendix A. The present value costs of the Freeport Downtown Microgrid is $79.7M and the Freeport Downtown Microgrid provides a present value benefit of $115M and a net present value benefit of $35.2M to Downtown Freeport. The results of the BCA indicate that the benefit to cost ratio is 1.44. The analysis results are in Table 25.

The positive benefit to cost ratio did not require IEc to run another model for average annual duration of major power outages required for project benefits to equal costs. The project team ran a several scenarios of the BCA model to determine the outage benefit and benefit to cost ratio during major outages and events. For example, the major power outage benefit of Freeport Downtown Microgrid of a one-day power outage is approximately $17.2M with a total benefit of $132.1M, and the major power outage benefit of the Freeport Downtown Microgrid of a 14-day outage (experience during some areas of Long Island during Sandy) is approximately $237.4M with a total benefit of $349.6M. Reducing the probability of the event to 50 percent will yield a one-day major power outage benefit of $8.6M with a total benefit of $123.5M, and a 14-day major power outage benefit of $117.4M with a total benefit of $232.2M. The power outage scenarios are in Table 26.

Table 25: BCA Results

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,345,000	$118,653
Capital Investments	$34,661,784	$2,610,122
Fixed O&M	$4,478,127	$395,050
Variable O&M (Grid-Connected Mode)	$2,731,304	$240,949
Fuel (Grid-Connected Mode)	$22,030,025	$1,943,438
Emission Control	$159,326	$14,055
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$14,315,938	$934,229
Total Costs	**$79,721,503**	**$6,256,497**
Benefits		
Reduction in Generating Costs	$27,133,145	$2,393,623
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$18,009,134	$1,588,724
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$4,264,620	$376,302
Power Quality Improvements	$45,214,226	$3,988,694
Avoided Emissions Allowance Costs	$13,622	$1,202
Avoided Emissions Damages	$20,237,879	$1,320,683
Major Power Outage Benefits	$0	$0

Total Benefits	**$114,872,626**	**$9,669,228**
Net Benefits	**$35,151,122**	**$3,412,731**
Benefit/Cost Ratio	**1.44**	
Internal Rate of Return	**18.95%**	

Table 26: Major Power Outage Benefits

	100% PROBABILITY			**50% PROBABILITY**			**25% PROBABILITY**		
DAYS	**COST TO BENEFIT RATIO**	**MAJOR POWER OUTAGE BENEFIT PRESENT VALUE OVER 20 YEARS ($2014)**	**TOTAL BENEFITS**	**COST TO BENEFIT RATIO**	**MAJOR POWER OUTAGE BENEFIT PRESENT VALUE OVER 20 YEARS ($2014)**	**TOTAL BENEFITS**	**COST TO BENEFIT RATIO**	**MAJOR POWER OUTAGE BENEFIT PRESENT VALUE OVER 20 YEARS ($2014)**	**TOTAL BENEFITS**
1	1.66	$17.2M	$132.1M	1.55	$8.6M	$123.5M	1.49	$4.3M	$119.2M
2	1.87	$33.9M	$148.8M	1.65	$17.M	$131.8M	1.55	$8.5M	$123.4M
3	2.08	$50.7M	$165.5M	1.76	$25.3M	$140.2M	1.60	$12.7M	$127.5M
5	2.50	$84.1M	$199 M	1.97	$42.1M	$156.9M	1.70	$21.M	$135.9M
7	2.92	$117.6M	$232.5M	2.18	$58.8M	$173.7M	1.81	$29.4M	$144.3M
10	3.55	$167.8M	$282.7M	2.49	$83.9M	$198.8M	1.97	$42.M	$156.8M
14	4.39	$234.7M	$349.6M	2.91	$117.4M	$232.2M	2.18	$58.7M	$173.6M

Figure 14 illustrates the results of the benefits and costs of the Freeport Downtown Microgrid BCA analysis. The major costs are the capital investments for the two new engines and the new circuits and conduits, and the emission control costs associated with the new reciprocating engines. The major benefits are from the power quality improvements to the microgrid customers and reduction in generating costs.

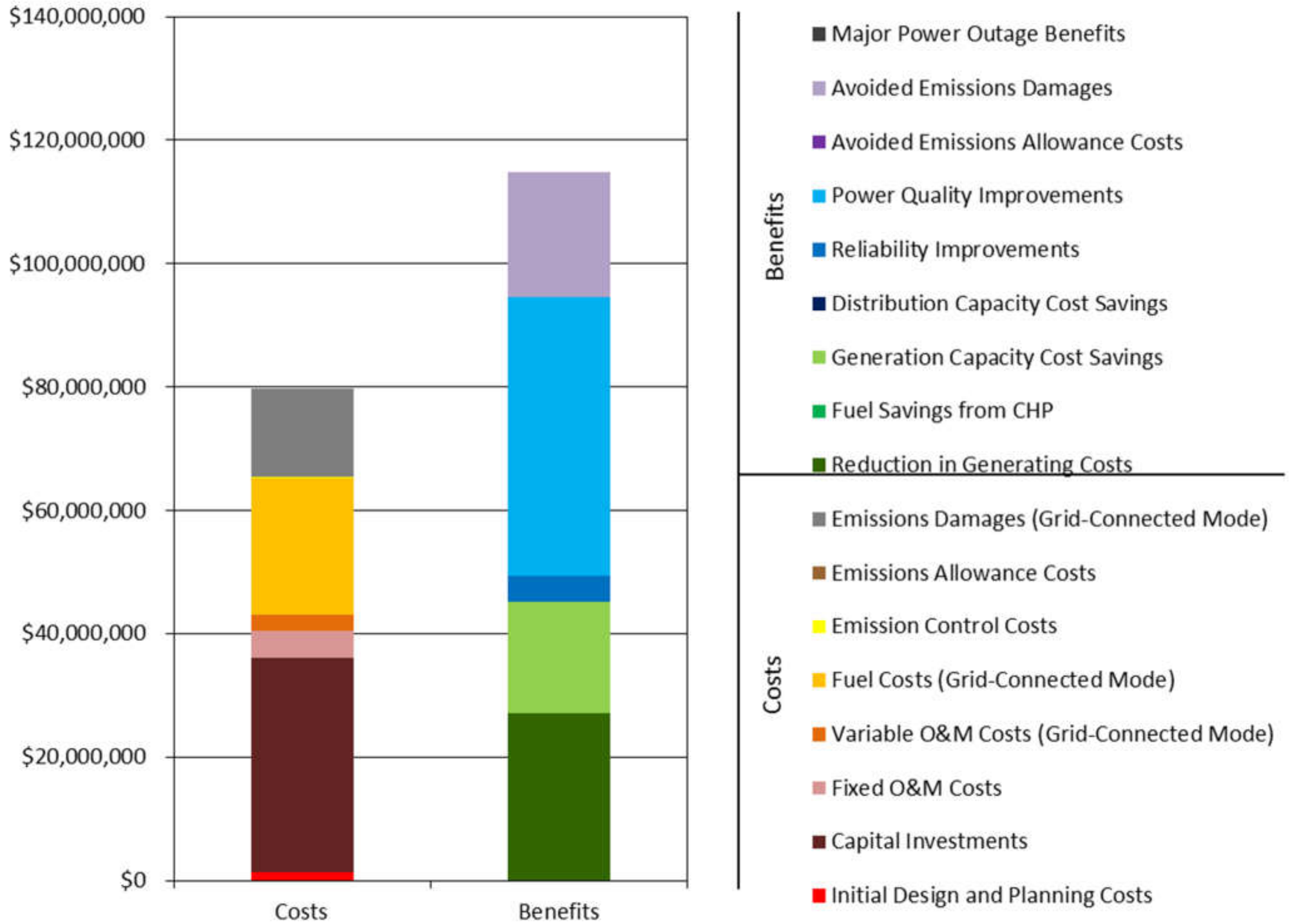

Figure 14: BCA Results

5 Conclusions, Recommendations and Lessons Learned

The Freeport Downtown Microgrid is an exciting opportunity to bolster a region's resiliency through the creation of a tiered microgrid infrastructure, whereby the core community critical and priority facilities are provided the highest tier of resiliency, thus providing a broader benefit to the area. Utilizing local generation, controls and dedicated microgrid circuits, these important facilities that are located throughout the downtown area can be selectively provided with the most resilient level of power, thus allowing for a "bootstrapping" of the broader region as more of the area is energized after an outage.

One benefit to this project is the direct involvement of the local electric delivery utility as the main stakeholder in the project. This sponsorship by the utility allows for unimpeded progress towards the mutual benefit to both the utility and the local community it serves.

While the project offers strong social benefits, the current avenues for revenues pose challenges to its realization. Based on our analysis of the project economics, we have arrived at the following conclusions:

- Project capital cost, as conceived, is approximately $35 million; total NPV of project cost (capital cost plus fixed and variable operating costs) at 10% discount rate is calculated at approximately $45 million
- The following factors impact project viability:
    - NYISO capacity payments for the new PP1 black-start efficient power plant would replace capacity payments already made for the existing old PP1 units; only the incremental capacity receives value
    - NYISO capacity payments for Zone K (Long Island) are far below the Net Cost of New Entry (Net CONE), thus do not provide sufficient fixed cost recovery to render new projects financially viable based on market revenues alone
    - Freeport energy is currently purchased from NYPA, which is priced at a discount to LIPA energy; dispatch of PP1 to serve Freeport load on an 8760 hour basis is not economically justified
    - Absorption of the net project costs (assuming the entire project scope is realized) by Freeport Electric's rate base would impact rates of Freeport customers by approximately 10%, assuming a 10% cost of capital and a $5,000,000 grant from NYSERDA for development of the microgrid; assuming just the PP1 repowering effort is performed and no infrastructure or renewable generation cost is incurred, the rate impact is anticipated to be about 3.6% based on the same assumptions
- To mitigate impact on ratepayers, the project would require additional benefit, including any combination of the following:
    - A revenue stream for its capacity (NYPA, NYISO, etc) that is more sufficient than current Zone K pricing
    - Access to far lower cost of capital than the 10% assumed above

  - A different award structure from the NY Prize
  - A reduced scope for the microgrid
  - Additional grants or programs to offset microgrid component costs

Appendix A

IEC BCA Analysis and Report

Benefit-Cost Analysis Summary Report

Site 14 – Village of Freeport

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Village of Freeport has proposed development of a microgrid that would serve 106 residential customers and 81 commercial customers in this Nassau County community. The critical service providers served by the microgrid include a police station, three firehouses, a recreational center that serves as an emergency shelter, four healthcare providers, and three water treatment facilities. Table 1 lists the commercial facilities that the proposed microgrid would serve.

Freeport's project consultants are currently considering two design options. Under Option 1, the team's primary option, the microgrid would be powered by two new natural gas generators (total capacity: 8.88 MW), two new solar photovoltaic arrays (total capacity: 1.33 MW), and one new 900 kW wind turbine. Each of these resources would produce electricity for the grid during periods of normal operation, as well as in islanded mode during power outages. The microgrid would also include a 1 MW battery and the installation of advanced metering infrastructure. The system as designed would have sufficient generating capacity to meet average demand for electricity from all facilities on the microgrid during a major outage. Project consultants also indicate that the system would have the capability of providing frequency regulation, reactive power support, and black start support to the grid. Option 2 would be similar to Option 1, but would include an additional 4.86 MW of solar photovoltaic capacity.

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. The analysis evaluates Option 1 as the primary option, but briefly discusses Option 2.

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.

Table 1. Facilities Served by Proposed Microgrid

Facilities	
Assisted Living Facility - Nursing Home	Office Buildings (2)
Assisted Living Facility - Senior Home & Palliative Care	Other Large Commercial (5)
Banks (5)	Other Small Commercial (32)
Car Center	Pharmacies (3)
Department Stores (2)	Police Station
Firehouses (3)	Public School - Bayview Avenue School of Arts & Sciences
Grocery Stores (4)	Public School - Freeport High School
Gas Stations (3)	Public School - J.W. Dodd Middle School
Government Building	Recreational Center & Emergency Shelter
Health Care Provider - Dialysis Center	Retail Center
Health Care Provider - Intensive and Critical Care	Retail Fuel Depot
Health Care Provider - Internal Medicine & Surgery Centers (2)	Transit Center
Library	Water Treatment Facilities (3)

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.

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[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 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.]

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).
- 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]

RESULTS

Table 2 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The table focuses on the site's primary design option, Option 1. The results indicate that even if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's benefits would exceed its costs by approximately 40 percent.[3]

Since the results for Scenario 1 suggest a benefit-cost ratio greater than one, the report does not present a detailed analysis of the impact of major power outages under Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio. The discussion that follows provides additional detail on these findings, focusing on Option 1.

Table 2. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$35,200,000	Not Evaluated
Benefit-Cost Ratio	1.4	Not Evaluated
Internal Rate of Return	18.9%	Not Evaluated

[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] Analysis of Option 2, which includes an additional 4.86 MW of photovoltaic capacity, also yields a positive benefit-cost ratio. The margin in this case, however, is smaller. The project team estimates that the additional solar capacity under Option 2 would increase capital costs by approximately $15.8 million, planning and design costs by $50,000, and annual fixed O&M costs by $11,000. The present value of these costs is greater than the present value of the incremental benefits the additional solar capacity is projected to provide. As a result, the present value of the project's net benefits would fall from $35.2 million under Option 1 to $26.5 million under Option 2.

Scenario 1

Figure 1 and Table 3 present the detailed results of the Scenario 1 analysis.

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

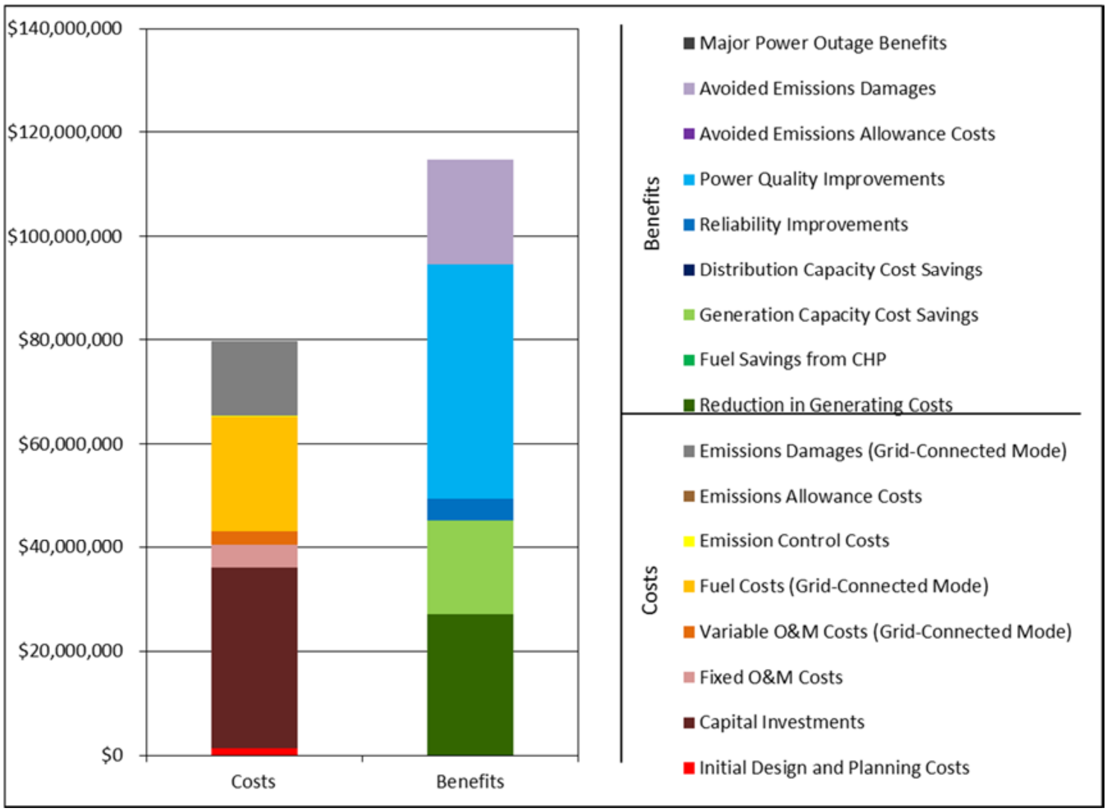

Table 3. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,350,000	$119,000
Capital Investments	$34,700,000	$2,610,000
Fixed O&M	$4,480,000	$395,000
Variable O&M (Grid-Connected Mode)	$2,730,000	$241,000
Fuel (Grid-Connected Mode)	$22,000,000	$1,940,000
Emission Control	$159,000	$14,100
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$14,300,000	$934,000
Total Costs	**$79,700,000**	
Benefits		
Reduction in Generating Costs	$27,100,000	$2,390,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$18,000,000	$1,590,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$4,260,000	$376,000
Power Quality Improvements	$45,200,000	$3,990,000
Avoided Emissions Allowance Costs	$13,600	$1,200
Avoided Emissions Damages	$20,200,000	$1,320,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$115,000,000**	
Net Benefits	**$35,200,000**	
Benefit/Cost Ratio	**1.4**	
Internal Rate of Return	**18.9%**	

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 $1.35 million. The present value of the project's capital costs is estimated at approximately $34.7 million. In addition to the two new natural gas generators ($13 million), significant investments include the costs of new distribution circuits ($6.8 million), the solar photovoltaic arrays ($4.4 million), a one-mile pipeline extension to supply natural gas to the new generators ($3.2 million), and the cost of the new wind turbine and battery ($2.8 million and $2 million respectively).

The present value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at $4.5 million (approximately $400,000 annually). These costs include parts, preventative maintenance, and monitoring for all energy resources, as well as scheduled cleaning and inverter replacement at the solar photovoltaic sites and the hiring of two additional staff members.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's two new 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 2015 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 $22 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M and emissions control costs (i.e., O&M and emissions control costs that vary with the amount of energy produced). These costs cover general operations and maintenance, including the cost of urea injections to control emissions. The present value of these costs is estimated at $2.89 million, or approximately $6.35 per MWh.

In addition, the analysis of variable costs 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 none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's fuel-based generators are estimated at approximately $934,000 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 $14.3 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $27.1 million. The reductions in demand for electricity from bulk energy suppliers would also avoid emissions of CO_2, SO_2, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $13,600 and avoided emissions damages with a present value of approximately $20.2 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] The project team estimates the capacity available for the provision of peak load support to be approximately 10.4 MW per year, based on estimates of output from the project's distributed energy resources during system peak. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by 10.8 MW as a result of new demand

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[4] The model adjusts the State Energy Plan's natural gas and diesel price projections using fuel-specific multipliers calculated 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 to 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.

response capabilities. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $18 million over a 20-year operating period.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of frequency regulation, reactive power support, and black start 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 markets for ancillary services are highly competitive, and that projects of this type would have a relatively small chance of being selected 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 $376,000 per year, with a present value of $4.26 million 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) – 1.42 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 97.52 minutes.[8]

The estimate takes into account the number of small and 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.

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. In the case of the Village of Freeport's proposed microgrid, the project team has indicated that approximately 36 power quality events would be avoided each year. Assuming that each customer in the proposed microgrid would experience these improvements in power quality, the

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[7] www.icecalculator.com.

[8] SAIFI and CAIDI values were provided by the project team for the Village of Freeport's municipal utility.

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

model estimates the present value of this benefit to be approximately $45.2 million over a 20-year operating period.[10] Power quality improvements therefore represent the largest category of benefits for the proposed Freeport microgrid.

In reality, some customers for whom power quality is important (e.g., medical facilities) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case in Freeport, the BCA may overstate the power quality benefits the project would provide. To test the sensitivity of the results to different assumptions about the project's impact on power quality, we conducted a breakeven analysis. We found that the project would yield positive net benefits as long as an average of eight or more system-wide power quality events are avoided each year. Conversely, the complete exclusion of power quality benefits would yield net *costs* of $10.1 million. In that event, the microgrid would need to provide additional benefits – e.g., by protecting the facilities it serves from major power outages – in order for its net benefits to remain positive.[11]

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 1.4; i.e., the estimate of project benefits is greater than that of project costs. Accordingly, the analysis does not consider the potential of the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

[10] Importantly, the model relies on average costs per power quality event for customers across the United States, based on meta-analysis of data collected through 28 studies of electric utility customers between 1989 and 2005. These costs therefore incorporate assumptions about the distribution of customers across economic sectors and other key characteristics, such as the prevalence of backup generation and power conditioning, that may not reflect the characteristics of the proposed microgrid. This is likely to be the case for the Village of Freeport. Based on information provided by the site team, Freeport's proposed microgrid will serve few, if any, customers in the construction, manufacturing, and mining sectors, which typically have the highest costs per power quality event. Instead, the proposed microgrid's customers are more likely to fall into the retail and public administration sectors, which typically have substantially lower costs of power quality events. [See: Sullivan, Michael J. *et al*. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.]

[11] Complete exclusion of power quality benefits would necessitate consideration of Scenario 2. Preliminary evaluation of that scenario suggests that the microgrid would need to protect its customers from an average of approximately 0.6 days of major power outages each year in order for the project to break even.