12 - Village of Rockville Centre -

Notice

Incorporated Village of Rockville Centre
NY Prize Phase I Feasibility Study

Final Report

Submitted to:
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Executive Summary

The Village of Rockville Centre (RVC or Village) encompasses a 3.2 square mile community located on Long Island. It was incorporated in 1893 and has grown to approximately 10,000 electric customers. RVC has its own Electrical Department which operates and maintains the Village-owned power distribution system (the RVC Grid) and a small power plant. The Village receives its base load power via three 15 MW, 33 kV, Long Island Power Authority (LIPA) overhead transmission lines, with a total import capacity of 45 MW. With a historical electric peak load of 58 MW, the Village must provide the balance of its power requirements by operating one or more of its aging reciprocating engine-generators installed at the Village power plant. The power plant, located adjacent to the electrical distribution system, was constructed in 1898, and currently houses 8 engines that were installed between 1941 and 1993. Busses 1 and 2 primarily feed the historic downtown area of the Village. Because of its geographic location on Long Island, RVC is particularly susceptible to violent storms that often cause outages on the LIPA transmission system delivering power to RVC. For example during Hurricane Sandy, many RVC customers were without power for a week. Options provided by PSEGLI/LIPA to increase the power import capability to RVC by either re-conductoring the existing transmission lines or constructing a new 30 MW 4th transmission line are $50M and $68M respectively (exclusive of RVC costs). Due to RVC's reliance on imported power and transmission redundancy, all or portions of the RVC Grid are required to operate in an islanding mode whenever there is an interruption of one or more LIPA transmission feeders (depending on load levels).

Recognizing that RVC owns and operates the electric infrastructure, the power import constraints, and noting the concentration of critical and key loads served by Bus 2, RVC has identified Bus 2 as the subject of this Microgrid Feasibility Study. Bus 2 customers include 14 critical customers, 21 key customers and over 2900 residential customers. The proposed RVC Microgrid is envisioned to include a new, highly efficient 7-8 MW gas reciprocating engine generator to power all of the critical customers served by Bus 2 plus other key commercial facilities such as supermarkets, drug stores, gas stations, plus some public safety services (street lighting and traffic signals) in the downtown area. The RVC Electric Department will have the ability to selectively deliver and prioritize power to specific circuits on Bus 2 and isolate damaged portions of the circuit as required. The continued operation of critical facilities and a fairly large number of key commercial customers during an emergency will also help approximately 7,000 remaining RVC customers not served by the Microgrid plus neighboring communities that likely experienced impacts from the same storm or emergency. The Microgrid also includes a Combined Heat & Power (CHP) component that utilizes the jacket water heat from the new engine to keep the other reciprocating engines at the power plant in hot standby. Also included in the planned Microgrid is up to 568 kW of rooftop photovoltaic (PV) generation capacity on RVC controlled buildings to help offset the system load growth, supplement conventional generation during the daytime and lower CO_2, CO and NOx emissions. The Village also plans to launch demand side management (DSM) programs that will reduce the peak load, during both islanded and normal mode, and possibly offset future load growth. For economy-of-scale reasons, the DSM programs would be offered Village-wide, not just to Bus 2 customers.

The proposed RVC Microgrid has an estimated total cost of approximately $14.7M. The business model of the new generator is to not only serve as the major Distributed Energy Resource (DER) of the Microgrid but also to compete in the wholesale electricity market and potentially generate approximately $1.6M in avoided electricity purchases per year by RVC. Included in the cost of the engine-generator is also a gas line reinforcement estimate of $533k. The line would increase the deliverable gas volume to RVC to support up to 30 MW of total gas fired engine generation. As part of the NYSERDA New York Prize Phase 1, IEc conducted a benefit cost analysis (CBA) on the RVC Microgrid which indicated a very favorable 4.85 benefit to cost ratio even with no major power outages over a 20 year period. The benefits of a one-day major power outage each year over the 20-year analysis period showed a benefit to cost ratio of 6.35. As the number of days of transmission interruption increase, the RVC Microgrid project value continues to increase. The significant Microgrid financial benefit can be attributable to the relatively large amount of residential and small/medium commercial RVC customers that will be provided reliable power during a major event. The results are based on a historic record of approximately seven power quality events (sags, swells, interruptions) per year. A significant benefit is the avoided cost of the re-conductoring of incoming transmission lines of $50M. The RVC Microgrid public benefits not captured in the IEc model include public safety from the ability of traffic lights and street lights to be powered, which can avoid accidents, vandalism, and insurance claims and the availability of key services for the entire Village, as well as for neighboring residents, such as gas stations, pharmacies, restaurants and food stores. The Microgrid cost is also relatively small because (a) the RVC Microgrid will utilize a significant amount of existing infrastructure (customer meters, wires, cables, transformers, power plant, etc.) that is already in place for normal power supply to Bus 2, (b) RVC has a seasoned, trained and qualified operations and maintenance staff already in place at the RVC Electric Department to operate the Microgrid equipment and can also assist in the installation oversight and (c) the entire Microgrid infrastructure, customers routes etc., is owned and operated by the Village and therefore minimal third party involvement is required to implement the RVC Microgrid.

Based on the findings and studies performed, the RVC Microgrid is an excellent Microgrid Project that will greatly improve the resiliency of an electric grid serving a very large customer base for a nominal cost of less than $15 M. The RVC Microgrid can be easily implemented and will bring reliable power to the RVC Bus 2 customers which include 14 critical customers, 21 key customers and over 2900 residential customers, plus some street lighting and traffic lighting. By virtue of the large number of commercial, institutional, government and safety related services electrified by the Microgrid, the remaining approximately 21,100 Village residents and neighboring communities will also be positively affected by the availability of medical services, security, food, gasoline, drug stores and other necessary supplies and services during a major event. The installation of the new reciprocating engine in the existing vacant engine bay will also avoid approximately $50M - $68 M in transmission upgrades as the alternative to the Microgrid to improve the resiliency and reliability of services to RVC. The RVC Microgrid, which is envisioned to include the new reciprocating engine with tier IV emissions compliance and CHP component; rooftop photovoltaic panels; new capacitors to improve distribution system power factor and an aggressive DSM program, would contribute greatly to achieving the Governor’s Reformed Energy Vision for NY State.

Task 1. Description of Microgrid Capabilities

1.1 Introduction

The Village of Rockville Centre Electrical Department is a municipal not-for-profit electric utility established in 1898. It provides power to the 3.2 square mile Village of Rockville Center (RVC) which is located near the south shore of Long Island (NYISO Zone K) roughly 5 miles east of New York City and serves approximately 11,000 electric accounts and 25,000 residents.

Historically, the RVC peak electric load is approximately 58 MW, which occurred in 2011 when the ambient temperature reached 103F. RVC's transmission import capacity is limited to 45 MW provided by three Long Island Power Authority (LIPA) overhead 33 kV interconnections, each capable of supplying approximately 15 MW. This limited import capacity requires RVC to operate its aging generators to meet its peak power needs when demand exceeds the import capability, in the event of outages, or in the case of an emergency. Outages may result from transmission interruptions due to necessary system maintenance, storm events such as Superstorm Sandy, or a transmission system failure such as the blackout of August 2003. Compounding the matter, one third of Village customers have no generation connected to the electric bus serving them, and are therefore solely dependent on LIPA transmission interconnections.

Because of its geographic location, Long Island is particularly susceptible to storms, including: coastal storms, nor'easters, blizzards, ice storms, and hurricanes. These storms often cause transmission outages within the LIPA system. According to studies performed by the Army Corps of Engineers, the Village is especially susceptible because it is located in a flood plain along the Mill River, and is close to the Atlantic Ocean.

While RVC currently owns and operates 8 small generators of various sizes and vintage, the combined capacity is only capable of serving approximately half of the Village peak load. The engine generators were all installed prior to the promulgation of Tier 1 EPA emissions standards in 1998. As a result, the annual hours and conditions under which most can operate are limited by their Title V Air Permit conditions (i.e., less than 100 hours/year in limited combinations, and/or emergencies only). This is of particular concern in the event of an extended outage requiring generators to operate at full capacity for many days. For example, following Superstorm Sandy, many RVC customers were without service for three days with some waiting as long as seven days.

<u>The creation of a microgrid represents a key solution in addressing the challenges faced by the RVC, offering the capability to:</u>

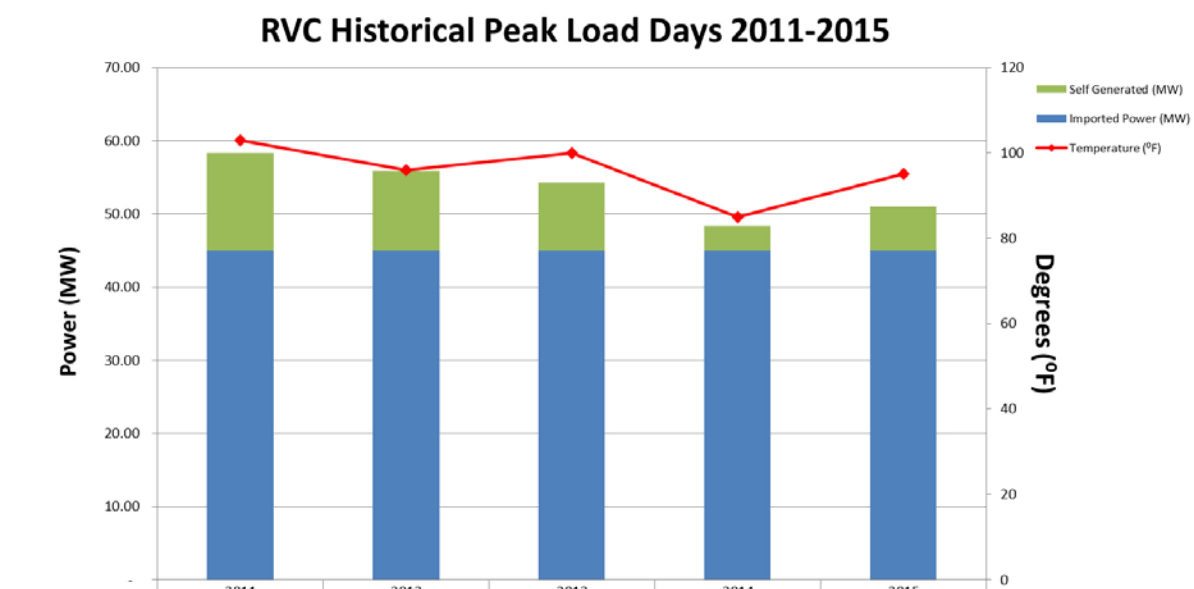
- Provide new clean, efficient generation for longer periods, delivering energy that will supplement the limited LIPA transmission, and enable maintenance of service to critical facilities and key RVC customers;
- Supplement RVC's aging fleet with at least one new Tier IV-compliant generator;
- Provide a source of black-start capable generation to the bus containing RVC's critical facilities;
- Provide emergency power to one third of its customers that currently have no backup generation;
- Incorporate new renewable energy generation that currently does not exist in RVC;
- Supply the Village with demand side management and energy efficiency programs that will reduce the overall load and possibly offset future load growth.

1.2 Microgrids

Microgrids are electricity distribution systems that employ a range of energy resources to support the critical loads required to meet essential needs within a service area. Due to the increasingly detrimental effects of coastal storms, nor'easters, blizzards, ice storms, and hurricanes on LIPA's overhead transmission systems, the microgrid concept has become an attractive solution for ensuring reliability. Microgrids have the ability to operate independently from the larger electrical grid during extreme weather conditions or system outages. They are the key component of a self-sustaining, flexible utility distribution system that can be leveraged to improve the resilience of the local distribution and generation infrastructure, while simultaneously providing reliability during major storms or events. Microgrids can maintain power strategically; ensuring critical facilities such as hospitals, fire and police services, water services, assisted living centers, and other medical facilities do not experience interruptions in supply. They are also capable of providing highly-reliable power to key commercial facilities such as supermarkets, drug stores and gas stations. Lastly, microgrids offer the opportunity to generate electricity during peak demand times at a lower cost than would be required to purchase electricity during these periods.

1.3 Existing RVC Electrical System Infrastructure

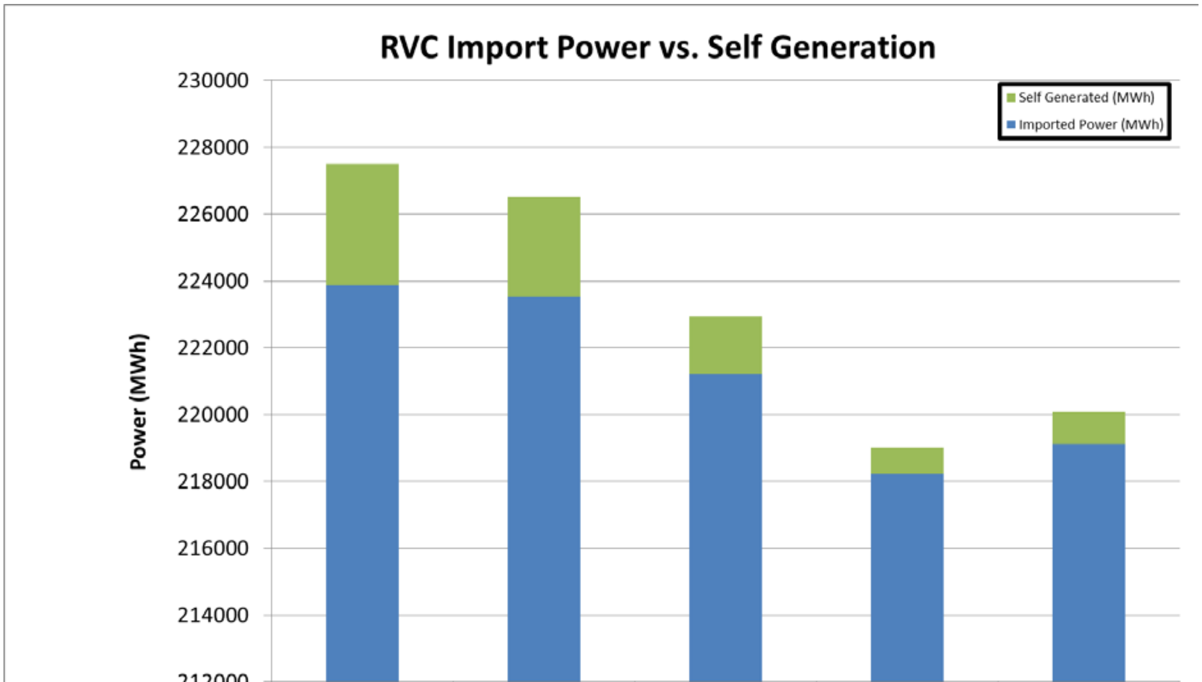
Currently, RVC imports power from the New York Power Authority (NYPA) and the New York Independent System Operator (NYISO) through three transmission lines. The three transmission lines originate in the Bellmore, Valley Stream and Barrett LIPA substations. Each line is capable of importing 15 MW, for a total import capacity of 45 MW. RVC has a long-term power purchase agreement with NYPA for an allocation of approximately 30 MW of hydro power, basically RVC's baseload power. Capacity needs over 30 MW are met by either wholesale purchases from the NYISO (of up to the 45 MW of import capacity) or RVC's own generation. The historic peak summer demand is approximately 58 MW which was realized in 2011 when the ambient temperature reached 103° F. This value is expected to grow at 1% per year for the next 10 years. A depiction of the historic loads is shown below in Figure 1-1.



	2011	2012	2013	2014	2015
Self Generated (MW)	13.30	10.90	9.20	3.30	6.00
Imported Power (MW)	45.00	45.00	45.00	45.00	45.00
Temperature (°F)	103	96	100	85	95
Humidity (%)	85	87	85	84	85
CDD	498	402	463	424	417

Figure 1-1: RVC Peak Summer Loads and Electricity Source

Each year RVC purchases on the Day Ahead Market (DAM) approximately 24-26% of its imported energy (up to 45 MW) and generates as much as 1.6% of its total annual energy needs, depending on weather (load) (see Figure 1-2). For approximately 200-300 hours/year RVC must self-generate to meet peak loads due to transmission import constraints.



	2011	2012	2013	2014	2015
Self Generated (MWh)	3622	2991	1711	777	968
Imported Power (MWh)	223880	223532	221219	218231	219109
Annual Power Self Generated (%)	1.59	1.32	0.77	0.35	0.44

Figure 1-2: RVC Electricity Imports vs. Self Generation

RVC owns and operates 8 diesel generators, units 7 through 14, with a total nameplate capacity of 33.6 MW. Five of the eight generators have very limited emissions controls. Due to emission constraints, three of the generators, otherwise capable of providing 10.2 MW in total, are permitted for emergency use only. The remaining generators are used to meet transmission capacity shortfalls, contingencies and emergencies. These restrictions, together with their high heat rate, significantly limit RVC's capability to avoid future high-cost wholesale power purchases and prevent rolling blackouts.

The RVC Electrical Distribution System is fed through six 33kV/4160 V substations which feed 4160 V busses. All of the RVC-owned engine generators are connected to either Bus 1 or Bus 2. Busses 1 and 2 are normally operated in parallel with a normally closed bus tie. Busses 3 and 4 and Busses 5 and 6 have no RVC generation directly connected to them. Bus 1 and Bus 2 can be connected to Busses 3 and 4, respectively, via normally open tie breakers during system outages and emergencies. Busses 5 and 6 can only receive power through 33 kV Substations 5 and 6, respectively. Because of this limitation, during Superstorm Sandy and other past major storms, the customers served by Busses 5 and 6 were without power for up to seven days. These customers did not get their power back until the LIPA transmission system was restored. Busses 5 and 6 primarily provide power to residential areas of RVC and have no generation connected to them. The addition of a bus tie to connect to existing generation is not feasible without exceeding equipment fault current ratings and other practical constraints.

1.4 The RVC Proposed Microgrid

In examining the existing RVC infrastructure, resources, and customer base, Bus 2 has been selected as the proposed location for the RVC Microgrid because of the large number of critical customers and other key loads it supplies. Figure 1-3 shows a simplified one-line diagram of the Bus 2 Microgrid. Bus 2 serves a majority of the critical facilities supplied by the RVC electrical distribution system including hospitals and critical care centers, nursing homes, police and fire stations, and water pumps, as well as nearly 3,000 residential customers, 500 commercial customers and 11 customers requiring life support. It has a nameplate capacity of 13.9 MW of connected generation, 2.2 MW of emergency-only permitted generation, and a significant percentage of underground distribution circuits. Furthermore, Bus 2 has already operated as a sub-network during major storms, emergencies and/or transmission system interruptions.

The following is a list of the RVC's critical facilities and key loads which are supplied by Bus 2:

- Medical facilities (hospitals/critical care centers/doctor & other medical offices)
- Police stations
- Two firehouses
- Two nursing homes
- Emergency centers
- The Electric Department office building and Power Plant
- Village Hall
- The Water Department, as well as two of four water pumps
- 15 traffic signals
- Three pharmacies
- Three super markets
- Two gas stations
- 715 street lights

Of these critical facilities, a limited number have emergency generation installed. RVC identified the peak loads, average loads and operating voltages of these facilities to determine what would be required to meet these demands during emergency events. These facilities include:

- Eight government facilities, including the recreation center
- One public library
- Five water pump stations and a well field
- Two medical facilities
- One grocery store
- Academic institution (Molloy College)
- One pharmacy
- Four gas stations
- Village schools

1.5 Key Project Objectives

The key objectives of the RVC Microgrid project are as follows:

- **Improve the reliability of the power supply, either via an additional transmission line or an additional generator**.
    - Solution: The new proposed generator project ($11 M) is significantly less costly than adding transmission supply ($50M). Designing and constructing the RVC Microgrid around Bus 2 will help to defer or possibly eliminate the need for a fourth transmission line.
- **Maintain critical services for the community during outages resulting from emergency situations or transmission system interruptions.**
    - Solution: In islanded mode, ensure critical facilities that service the community remain operational during outages.
- **Improve the low power factor currently experienced on Busses 1 and 2.**
    - Solution: Invest in capacitor banks on Busses 1 and 2 to correct the VAR issue and decrease the I^2R losses through the RVC Microgrid feeders and increase the overall efficiency of the RVC Microgrid and its ability to meet loads.

- **<u>Incorporate demand side management (DSM) strategies to help lower the peak load.</u>**
    - <u>Solution:</u> Institute DSM programs including smart thermostats to all the customers in RVC to help lower the overall load in the Village and possibly reduce the amount of time needed to run generation.
- **<u>Improve the resiliency of all the customers in the Village.</u>**
    - <u>Solution:</u> Install new generation on Bus 2 where most of the critical loads are and move one or two of the existing emergency-only generators to Bus 5 and 6, which currently have no directly connected generation. The estimated summer peak load of critical customers (only) on Bus 2 is approximately 6 - 6.8 MVA. A breakdown of the 2014-2015 peak loads of the critical customers on Bus 2 are shown in Table 1-1.
- **<u>Evaluate the potential for "green" resources such as solar, battery and CHP to improve the Village "carbon footprint".</u>**
    - Solution: Install rooftop solar photovoltaic arrays on Village owned facilities to supply peak power to the extent possible.
    - Recover heat from the new engine-generator to maintain the existing engine jacket water loops in hot standby, offsetting the oil fired boiler operation that currently serves that purpose.

Table 1-1: RVC Critical and other Key Loads Served by Bus 2

Cust #	AcctClass	Peak Demand	Avg Annual Demand	Peak Demand Date	Annual Energy Use	Avg Monthly
		[kW]	[kW]		[kWh]	[kWh]
1	E105OM	84.00	0.00	3/3/2015	188,400	15,700
2	E105OM	40.00	0.00	3/3/2015	171,040	14,253
3	E105OM	87.00	77.25	3/3/2015	155,280	12,940
4	E105OM	289.00	0.00	3/3/2015	111,365	9,280
5	E105	45.60	28.10	2/27/2015	98,040	8,170
6a or b	E105a or b	100.00	72.20	9/30/2014	212,000	17,667
7	E206	3024.00	2708.00	9/30/2014	19,164,000	1,597,000
8	E105	51.60	42.80	7/23/2014	251,280	20,940
9	E105	44.80	25.20	6/27/2014	150,400	12,533
10	E105	22.88	13.44	5/28/2015	55,579	4,632
11	E105	11.29	3.18	5/28/2015	6,591	549
12	E105	11.30	9.00	9/26/2014	24,907	2,076
13	E105	19.02	16.61	9/26/2014	42,469	3,539
14	E105	34.65	27.79	6/30/2014	91,413	7,618
15	E105	17.58	16.04	7/24/2014	44,824	3,735
16	E105	47.20	36.27	1/29/2015	218,720	18,227
17	E105	6.53	4.25	11/25/2014	9,903	825
18	E105	4.78	0.54	5/28/2015	2,696	225
19	E105	242.40	150.80	7/3/2014	926,640	77,220
20	E105	364.50	251.63	3/9/2015	1,120,500	93,375
21	E105	26.40	12.13	2/24/2015	24,400	2,033
22	E105	90.00	46.20	9/23/2014	289,800	24,150
23	E105	328.80	210.10	7/21/2014	1,394,640	116,220
24	E105	55.20	33.90	5/28/2015	155,760	12,980
25	E105	368.00	235.67	9/15/2014	1,940,400	161,700
26	E105	306.00	180.50	10/10/2014	1,902,000	158,500
27	E105	10.54	9.03	6/3/2014	27,177	2,265
28	E105	49.20	39.20	7/3/2014	242,520	20,210
29	E105	67.20	44.93	9/23/2014	299,200	24,933
30	E105	90.00	58.80	3/17/2015	82,200	6,850
31	E105	46.80	31.90	11/14/2014	164,160	13,680
32	E105	23.20	15.40	10/28/2014	78,240	6,520
33	E105	46.80	21.50	7/24/2014	216,840	18,070
34	Traffic Lights	17.40	17.40	N/A	N/A	N/A
Total Critical Loads (KW)		**6,074**				
MVA @ pf = 0.9		**6,761**				

1.6 Challenges and Goals of the RVC Microgrid

The following are challenges and goals of the RVC Microgrid:

Transmission/Generation: One critical limitation, which the RVC Microgrid is expected to alleviate, is the lack of sufficient transmission capacity to provide power greater than 45 MWs to meet the growing peak load, currently at 58 MW. There is limited redundancy capability should one of the three LIPA transmission lines experience a planned or unplanned interruption (depending on load levels). LIPA has been reducing the size and scope of the 33 kV (sub) transmission systems throughout Long Island in favor of the 69 kV sub-transmission systems. Interruption of any or all of the three (3) transmission lines is a major concern for RVC. During a recent maintenance project, 33 kV replacement parts were not available which extended the downtime of a LIPA transmission line. Furthermore, outages on the 33 kV transmission systems can impact RVC by creating control and/or protection issues, reactive maintenance, and equipment and line failures. RVC's existing generation is neither equipped, nor permitted for use, as regularly as needed to ensure a reliable, cost-effective electricity supply. RVC has had to resort to rolling blackouts during major transmission interruptions such as Superstorm Sandy and the blackout of August 2003. This shortfall requires that RVC either invest in upgrading its transmission import capacity or provide additional generation. PSEGLI/LIPA has conducted a study to assess the costs of installing a 4th transmission line. The cost of this addition carries an estimated cost of approximately $68M.[1] Upgrading the existing lines to support a 69 kV transmission system would be much more expensive.

In addition, Busses 5 and 6 are totally dependent on the LIPA transmission system for electric supply. There is currently no generation that can supply backup power in the event of a LIPA transmission interruption. By providing Busses 5 and 6 with some generation, customers can be supplied with some power during a local transmission issue, a LIPA system-wide interruption, or other system emergency.

Black-Start: Currently there is no black-start capability directly connected to Bus 2, which has been identified as the location for the proposed RVC Microgrid. All of the black-start capability is currently located on Bus 1. In the event of a failure on Bus 1 or the bus tie breaker, Bus 2 cannot be powered without backfeed through the LIPA system. Black-start capability is essential to providing a reliable microgrid.

Power Factor: Low power factor is also a major concern for Bus 2 (and Bus 1), sometimes reaching as low as 0.90. Low power factor makes the distribution of electricity less efficient as more current is required to supply a given load and ensuing voltage drops along the cables. The higher current also creates additional losses in the electric system. Raising the power factor with capacitors will help lower the RVC Microgrid electrical supply needs and costs. Switchable capacitors will also provide an additional benefit by regulating and controlling system frequency and voltage in response as needed to any load changes. This is especially important while the RVC Microgrid is in islanded mode.

Load Reduction: To mitigate the need for further generation, RVC is interested in promoting various demand side management and energy efficiency programs that will help reduce, offset, or shift peak load requirements. These programs could include battery storage.

Green Generation: New solar generation, added as part of the Municipal Solar Initiative associated with the RVC Microgrid Project, would help offset the system load growth and supplement generation during the daytime.

Battery Storage: Battery storage would help offset the peak demand and shift cheaper power to RVC peak demand times.

[1] Source: Excel Spreadsheet from PSEGLI to RVC

1.7 Required Microgrid Capabilities

a. Multi Fuel Engine/Generators:

RVC currently has eight generators burning gas and/or diesel. A new, dual-fuel engine generator with a minimum capacity of 5.5 MW with black-start capability and Tier IV EPA emissions performance is planned to replace Unit #13 (which is rated at 5.5 MW) on Bus 2. The new engine would provide equal or greater generation capacity, provide black-start capability to Bus 2 and be permitted to operate for more hours/year, providing expanded service to the Bus 2 (RVC Microgrid) customers. Unit #13 would then be shifted to Bus 1, and Unit #12 would be rewired to Busses 5 and 6, which currently has no generation, so that it can provide some power during LIPA and other transmission outages to the customers served by Busses 5 and 6. Five of the eight engines operated by RVC are dual-fuel reciprocating engines. They range in size from 3.2 MW to 6.3 MW, totaling 28.9 MW of dual-fuel nameplate capacity. The remaining two engines burn only diesel fuel. Units 7, 8, and 12 are only permitted to operate during emergencies due to their Title V permit limitations and emissions profiles. On Bus 2 there is currently 13.9 MW of dual fuel generation directly connected. None of these has black-start capability. As part of this project, engine 8 will be retired and engine 7 will be restricted to black-start and station light & power during emergencies.

b. On-site Power:

RVC currently operates as a microgrid within the Long Island and NY State grid, dispatching generation to meet its system load when adequate import capacity is not available or exceeds transmission constraints.

c. Islanded Mode:

The RVC grid can, and has, operated in island mode during past major emergency and outage events, and managed serving many electric customers with rolling blackouts. When islanded, the RVC Microgrid will use switches to serve specific, prioritized circuits that serve facilities providing critical services to the local community such as emergency shelters, emergency services (police and fire stations), and medical care (hospital and assisted living). By virtue of the existing circuitry, multiple retail businesses that provide important goods and services (i.e., 3 pharmacies, 3 gas stations and 2 supermarkets) will also be provided with power. Approximately 2,900 residential customers located on Bus 2 would also be served with power, capacity permitting.

d. Power Flexibility

Supported by RVC's operations procedures and equipment, as well as a well-trained staff, the entire RVC grid is currently capable of separating from LIPA in the event of a loss of transmission. Three existing under-frequency relays have the capability to automatically shed load on selected distribution circuits to prevent loss of power to the entire Bus 2.

e. Maintenance:

RVC maintains a technical staff of approximately 40. This staff is composed of linemen, plant/grid operators, electricians, mechanical maintenance personnel, and engineers, all of whom operate and maintain the Grid and power plant. In addition, RVC has a number of outside specialty service contractors who supplement maintenance and provide repairs as required. The existing RVC staff will be responsible for operating and maintaining the proposed RVC Microgrid equipment.

f. Consistent Operation:

Operations procedures, equipment, and the trained RVC staff will enable the RVC Microgrid to load follow when in islanding mode and supply all loads when power is not available from the LIPA grid.

g. Protection & Control/Communication:

RVC applied for, and was recently awarded, Department of Energy (DOE) funds from the DOE's Resilient Electricity Delivery Infrastructure Initiative (DOE REDI) to support the replacement of their obsolete SCADA system. The replacement will modernize RVC's distribution and substation control and protection system. The new system will provide real-time grid information to enable operating personnel to help prevent power outages and rapidly restore power when outages occur. The new SCADA system will communicate with smart relays via fiber cables and new communications equipment using IEEE standard communication methods.

h. Diversified Customers:

Bus 2 of the RVC grid already has a large diversity of existing customers, including 510 commercial, one large institutional, 2912 residential, and 11 on life support; for a total of approximately 3,422 customers. This includes 14 critical customers and 21 key facilities, such as pharmacies, food stores, gas stations, as well as a portion of the Village's traffic signals and street lighting etc., described in Section 1.4 and listed in Table 1-1. There are no industrial customers within the proposed RVC Microgrid.

i. Fuel Availability:

RVC is supplied with natural gas from National Grid via a 6-inch, 60 psi MAOP (Maximum Allowable Operating Pressure) as a primary source of fuel. Based on historical data provided by National Grid from 2007-present, the gas supply to the power plant has been very reliable with only five instances where the pressure dropped below 30 psig (four of which only lasted approximately one hour). None of those instances occurred during Superstorm Sandy. RVC also maintains fuel oil storage capacity (110,100 gal), which can support continuous operation of the RVC Microgrid at approximately 30 MW for 48 hours or 12 MW for 121 hours. RVC is within 5 miles of the bulk oil terminal in Inwood, NY, which enables prompt refilling. Additional resources, such as solar and energy storage, are other potential options planned for inclusion in the program that would provide some fuel diversity.

j. Environmental Impact:

In additional to bulk transmission system interruptions, the most frequent cause for extended power outages have been coastal storms, nor'easters, blizzards, ice storms, and hurricanes. RVC has a total of 53 circuits; 30 are primarily overhead and 23 are primarily underground. As shown in Table 1-2, Bus 2 has the largest amount of underground feeders, which are shielded from the environment. Also, Bus 2 experienced only 4 of the 99 RVC circuit outages recorded in the past 5 years where a distribution feeder lost power. However, the entire RVC grid is susceptible to the loss of LIPA and other transmission lines used to route power to RVC. The RVC Microgrid's underground feeders are less vulnerable to weather events.

Table 1-2: Circuit Breakdown

	BUS 1	BUS 2	BUS 3	BUS 4	BUS 5	BUS 6
Number of Over-Head Feeders	6	4	3	3	7	7
Number of Under-Ground Feeders						

k. Black-Start: *(Provide black-start capability).*

Of the eight generators at RVC, only Unit 7 and Unit 14 have black-start capability. Both generators are directly connected to Bus 1. Currently there are no black-start generators on Bus 2 to provide this critical feature. Note also that Unit 7 is permitted to operate as an emergency-only generator due to its age, limitations and emission profile. New generation is envisioned for Bus 2 that would be equipped with black-start capability.

1.8 Preferable Microgrid Capabilities

The following are the preferred capabilities of the RVC Microgrid:

1. Network Control System:

RVC has applied for and was recently awarded a DOE REDI Grant to deploy a state-of-the-art SCADA system, a cyber-security plan, firewalls, RTUs, and IED relays. This upgrade has the ability to improve RVC's system operation and efficiency. It will also reduce customer outage frequency and duration while significantly lowering risk. This system will actively support the RVC Microgrid and provide enhanced monitoring and control to meet new North American Electric Reliability Corporation (NERC) and Homeland Security standards and recommendations.

2. Energy-Efficiency:

RVC investigated opportunities to reduce energy demand in residential and commercial buildings, both on Bus 2 and other parts of the RVC electric system, through smart thermostats and other low maintenance/quick learning curve technologies. RVC recently initiated a program to replace High Pressure Sodium (HPS) and Mercury Vapor (MV) streetlights with Light Emitting Diode (LED) lights over the next 10-15 years to improve reliability and efficiency. RVC also investigated the possibility of installing a combined heat and power (CHP) unit for use as a base-load engine and to displace the power plant boiler, which provides space heating to the plant building and supplies heat to the plant's engine jacket water loop. Recovery of heat for the plant building space heating load was small and it only occurs during the winter. However recovery of heat for the jacket water loop was year-round and could significantly offset the boiler operation. Lastly, RVC is working with NYAPP (New York Association of Public Power) Utilities and NYPA (New York Power Authority) to investigate and deploy other energy-efficiency options as part of the Reforming the Energy Vision (REV) strategy.

In addition, a number of demand response and energy-efficiency options have been considered to reduce total energy consumption and shift peak energy use. Each of the solutions below complements the RVC Microgrid strategy and will help deliver more reliable and cost-effective electricity throughout RVC. In particular, the following solutions were considered:

- Programmable Thermostats and Smart Thermostat Programs (with Demand Response) delivering energy savings of 7-28% per residential and small commercial customer.
- Behavioral based energy-efficiency programs and targeted mailing strategies, with savings estimates of 1-4% per customer.
- Demand Response Programs including curtailment event pricing, critical peak pricing, and base interruptible programs for large commercial customers delivering 5-75% peak savings.
- Energy benchmarking, metering, and dashboard solutions offering real-time monitoring and fault detection, with potential savings of 10-30% per customer.
- Programs to shift water pumping infrastructure energy loads, potentially saving 30-75% of peak consumption for each well and tank.
- Programs to install advanced controls for commercial rooftop units (RTU), with average savings of 57% per unit.

3. Operation/Maintenance:

RVC has a well-trained, knowledgeable staff, requiring no staffing additions to support the RVC Microgrid project. The RVC Microgrid will use existing conduits that will obviate the need for additional ducts in most cases.

As previously stated, the DOE REDI grant will enable the replacement of the obsolete SCADA system controlling Busses 1 and 2. Furthermore, the addition of a new generator will allow RVC to move one of its emergency generators, Unit 7, 8 or 12, to Busses 5 and 6, which currently do not have any generation.

4. Innovative Services:

The municipal utility model simplifies many of the objectives of REV, providing the community with a lower cost and faster implementation process. Demand-side reduction strategies including automated and voluntary demand response, predictive load shifting with SCADA, smart thermostats, behavioral energy-efficiency, and advanced rooftop unit controls will be investigated to improve the functionality of the microgrid solution.

5. Benefit Cost Analysis:

A basic capital model has been constructed to evaluate the individual proposed programs. A rigorous Benefit Cost Analysis (BCA) developed by IEc for the NYSERDA New York Prize Phase 1 Feasibility Study was used to capture the societal benefits of the final proposed Microgrid configuration.

6. Capital:

RVC is planning to consider a range of funding options, including NYPA, NYSERDA, DOE and private investors for the RVC Microgrid.

7. Renewable Energy:

Solar and wind energy and battery storage were evaluated. Solar opportunities include 568 kW of rooftop solar photovoltaic (PV) arrays on RVC controlled municipal buildings and approximately 6.2 MW of solar "canopy" PV arrays over municipal parking lots (Phase II). Currently, no solar energy has been deployed by RVC. A potential solar thermal opportunity at the RVC Power Plant was also evaluated where the solar hot water panels would supplement the heating load to maintain the engine jacket water loop in hot standby. However the required jacket water temperature was not a good match for the solar thermal panel capability.

8. Community Benefit

Benefits to the community will include:

✓	***Critical Facilities***	Improved power reliability during major storms and other emergencies for water, police, fire, hospital, critical care and utility plant.
✓	***Utility***	Transmission investment deferral, improved quality of service, improved distribution system efficiency and operating cost mitigation
✓	***Public Organizations***	Improved power reliability during storms and system emergencies for Village services, improved quality of service to community
✓	***Commercial Customers***	Improved power reliability during storms and system emergencies for more than 10 commercial customers, avoided revenue losses, improved quality of service to customers.

- ✓ ***Institutional Customers*** — Improved power reliability during storms and system emergencies for two institutional customers, avoided revenue losses.
- ✓ ***Residential Customers*** — Improved power reliability during storms and system emergencies, reduced impact of outages for approximately 2912 residential customers.
- ✓ ***Ratepayers*** — Improved system reliability during major storms and system emergencies, access to services during outages for approximately 7,000 remaining RVC customers, help mitigate electricity rate increases.
- ✓ ***Community & Society*** — Reduced power plant emissions, access to critical goods and services during major storms and system emergencies to RVC residents and neighboring communities that may have also been affected by the outage, improved safety and security during outages
- ✓ ***Electric Industry*** — Model for other utilities to plan and operate a microgrid during emergency and normal conditions

Apart from moving some emergency generation to Busses 3 through 6, RVC has also determined that in order to increase the resiliency of the facilities outside the RVC Microgrid, RVC-owned or rented mobile generators could be used in the event of an extended outage on the distribution circuit or circuits supplying the additional critical facilities. RVC is assessing these critical facilities as a group and determining the number and size of the mobile generators that should be purchased, leased or rented to deal with these contingencies. This evaluation will include an analysis of the need for installing transfer switches and quick connect outlets at selected critical facilities such as the police station or water tanks. Note that this is a separate project to the RVC Microgrid project, but is necessary to meet the needs of these critical facilities in the event of an emergency or during transmission maintenance.

9. Innovation:

The proposed microgrid strategy is an innovative approach that will provide the Village with a resilient electric substation and distribution system that can more reliably provide citizens with electricity during major storms or emergencies, and ensure power to critical facilities and key service providers. Furthermore, the proposed microgrid strategy incorporates state-of-the-art renewable energy systems including rooftop solar photovoltaic units (solar PV).

Task 2. Develop Preliminary Technical Design Costs and Configuration

2.1 Proposed Microgrid Infrastructure and Operations

Three transmission lines deliver up to 45 MW of power to the six RVC busses during normal operations. Up to approximately 30 MW of that power is supplied under RVC's long-term contract with NYPA and the balance is bought on the wholesale market from the NYISO when needed. As the RVC power requirement approaches the 45 MW transmission limit,[2] Bus 2 (as well as the other Busses) will generally exceed 7-8 MW (45 MW/6 Busses). RVC will then start its planned new generator as well as existing generators, if necessary, to meet the load requirements. Import power requirements are expected to be reduced by demand side management, solar PV panels, and possibly battery storage, as described later in this section.

In some of the past system disturbances, such as have occurred during a major storm, RVC was unable to supply power to all of the critical loads on Bus 2 for two reasons: (1) the existing generators on Bus 2 do not have black-start capability; or (2) the existing generators can only supply power to Bus 1. The new RVC Microgrid Project will improve RVC's capability to respond to a Long Island or regional outage. In the case of a power transmission line disruption, Bus 2 will be isolated from the LIPA grid and other distribution loads. Upon confirmation that the RVC Microgrid was not negatively impacted by the power interruption, the new generator will be placed into islanding mode and started using its black-start capability. RVC will have the capability to close each of the distribution breakers to supply electricity to the RVC Power Plant house loads and the critical customers on Bus 2 (Table 1-1). Once the power plant house loads are energized, the existing generators without black-start capability could then be started.

RVC may also elect to be proactive and place Bus 2 in islanded mode if there is an eminent threat to the transmission system such as an approaching major storm. In this case the generator(s) would be brought on line, synchronized, ramped up and once the load is matched, disconnected from the transmission system. The decision by RVC to stay connected to the grid or island would take into account operating circumstances such as total available generation vs. projected load at that time and possibly other operating factors. Note that current Title V Permit engine operating conditions allow RVC to operate some of their current engines during "emergencies". This cannot be done currently for RVC's newer busses 5 & 6 as there is no generation currently connected to them. Once the new Bus 2 generator is installed and operating, some of the older generation, permitted for emergency operation only, would be repurposed to serve Bus 5/6.

2.2 Load Characterization

Bus 2 serves a predominant portion of the RVC critical loads and is the backbone of the RVC Microgrid. Table 1-1 contains the peak kW demand for each of the critical and key facilities on Bus 2. Operation of all critical facilities in Table 1-1 at maximum peak demand requires 6.1 MW of generation capacity, requiring the planned new generator to serve Bus 2 be sized to provide at least 6.8 MVA of capacity.

Figure 2-1 indicates the typical daily load profile for all customers on Bus 2 during a hot summer day in August and a cold winter day in February when the RVC Microgrid would be synchronized with the grid. During this typical hot summer day, the peak load for Bus 2 was 11,623 kW at 2 PM when the ambient temperature was 88^{o}F. During a typical cold winter day, the peak load was 8,458 kW at 12 PM when the ambient temperature was 21^{o}F. It is important to note that these values represent the peak coincident customer loads (not the sum of the customer peak loads). Higher summer ambient temperatures of 93^{o}F (typical NYISO summer design condition) will increase the coincident peak accordingly to approximately 12.5 MW.

[2] Alternately a single transmission line could also approach its line limit of approximately 15 MW.

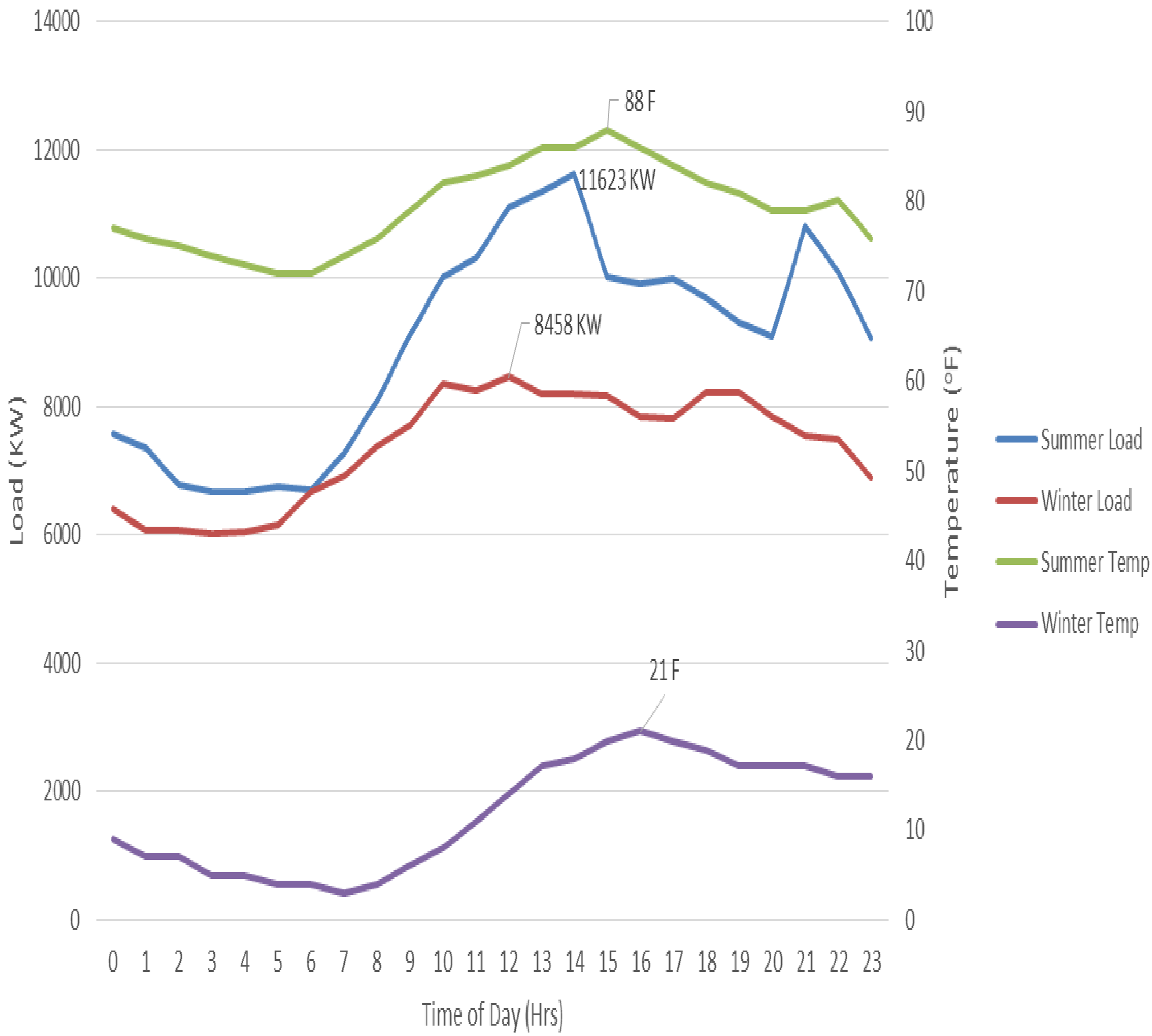


Figure 2-1: Bus 2 Typical Load Profile

Figure 2-2 displays the typical weekly load profile for Bus 2 during different weather conditions. As can be seen in this figure, the demand during a typical summer week can get as high as 11.8 MW whereas the shoulder season load only reaches approximately 7 MW. The peak loads normally occur during the work week. Based on the load profile data, Bus 2 should have a minimum generator capacity of 6.1 MW and a total generation on the bus of around 12 MW. However, due to the Bus 2 short circuit rating limits, 8.4 MVA[3] is the largest single generator that can be installed.

[3]2000A equipment design limit (2000A x 13800 V x √3) = 8.4 MVA

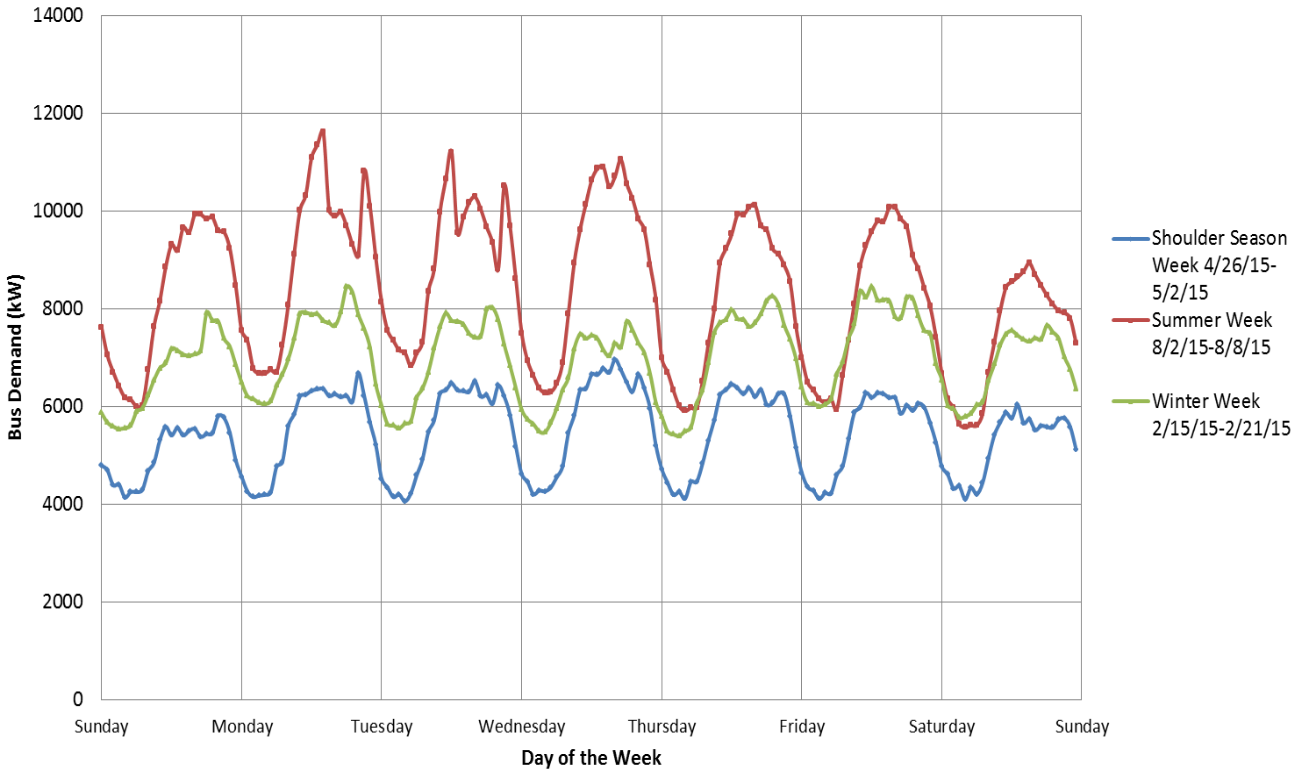


Figure 2-2: Bus 2 Typical Weekly Load Profile

2.3 Distributed Energy Resources Characterization

2.3.1 Reciprocating Engines

As previously stated, a new reciprocating engine would be installed as the main power source to the RVC Microgrid during times of transmission interruptions, major storms, summer peaks and other periods such as the 2014 winter polar vortex. The current engines owned by RVC are limited in operability. Unit 7, which is connected to Bus 1, has black-start capability, but is limited to operating only during emergencies under its air permit. Unit 14 is also connected to Bus 1 and also has black-start capability. In normal outage situations, Unit 7 or Unit 14 is started to provide power to Bus 1. However, a majority of the Village's critical facilities are fed from Bus 2. The tie breaker to Bus 2 would normally have to be closed to power these facilities. Due to the current layout, a fault on either Bus 1 or the Bus 1/2 tie breaker presents a major threat to RVC's ability to recover power to its critical facilities. To mitigate this risk, it is crucial to have a reliable black-start generator installed on Bus 2. The new reciprocating engine on Bus 2 would provide the black-start capability needed to enhance the reliability of the RVC Microgrid. The reciprocating engine efficiency is sufficiently high (~49%) to provide competitive priced power to the NYISO wholesale market. Some heat recovery from the engine can be included to serve the small thermal needs at the existing RVC power plant where the engine would be located.

RVC proposes to incorporate a highly-efficient 7-8 MW natural gas fired reciprocating engine with Combined Heat and Power (CHP) capability to power the RVC Microgrid. This engine will provide a sufficient amount of power to support all the critical and key customers and have additional power to selectively supply other customers on Bus 2. The engine will be placed in the vacant engine bay that exists in RVC's Power Plant. All engines evaluated would be equipped to have black-start capabilities.

A proposed CHP system option could be integrated into the existing plant heating loop that keeps the engines' jacket water warm as a pre-condition to startup ("hot standby"). By installing the heat recovery from the new engine upstream of the boiler, the CHP system will heat the water jacket system whenever the new generator is running. When the new generator is not running, the existing boiler will continue to function as it currently does to supply heat to maintain the jacket water temperatures. This proposed configuration will help cut fuel costs associated with operating the existing jacket water boiler.

Table 2-1: New Generator Evaluation

	Vendor A						Vendor B					
Capacity (KW)	5,000			7,500			4,169			7,434		
Electrical Efficiency (%)	49[3]			49[3]			44.74			45.11		
Heat Rate	7,347			7,347			7,627			7,564		
Fuel Gas Press (psig)	65.3			65.3			85			85		
	L	W	H	L	W	H	L	W	H	L	W	H
Footprint (ft.)	37	11	17	43	12	18	36	9	13	37	11	15

Another option that was evaluated is an Organic Rankine Cycle (ORC). As shown in Figure 2-3 below, the ORC recovers the jacket water and exhaust heat from the reciprocating engine to drive a bottoming cycle. In lieu of the steam which is used in a conventional bottoming cycle, the ORC uses Freon 245FA or CO_2 as the cycle's working fluid, depending on the manufacturer. The alternative fluids have unique thermodynamic properties better suited for the temperature ranges of the engine's waste heat. After being vaporized, the fluid passes through a custom expander (turbine) driving a permanent magnet generator that produces direct current (DC) electricity. The DC electricity is then converted to AC via an inverter. The ORC can be used alone or in combination with a CHP system. The ORC has the potential of raising the overall efficiency of the combined cycle by approximately 8-10%, depending on the selected size ORC. Due to the limited sizes available, customized design costs, space requirements and associated high costs, the ORC was not financially feasible at this time and is not a component of the proposed RVC Microgrid. RVC will continue to monitor the costs and availability of ORC units for potential opportunities in the future.

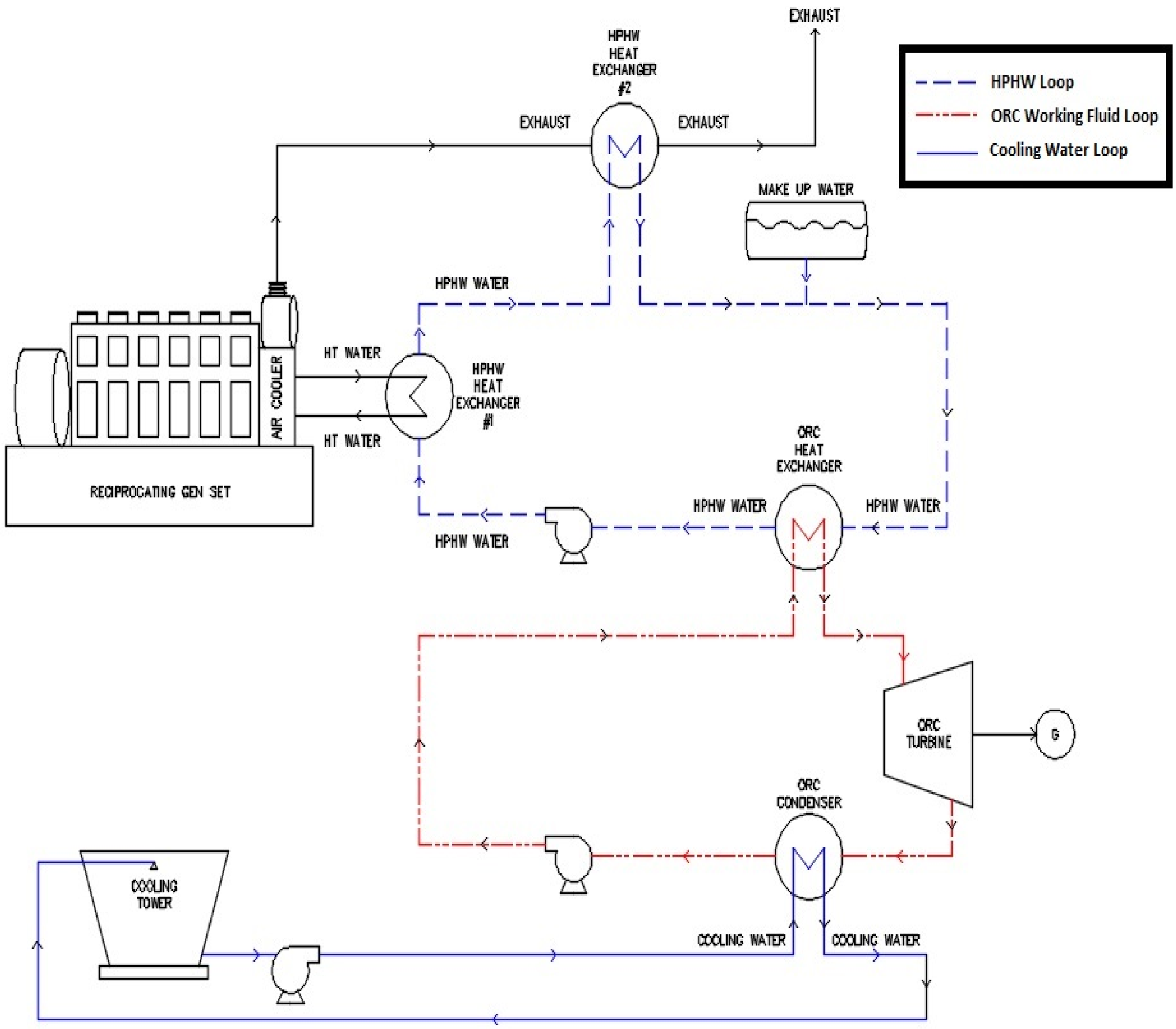


Figure 2-3: ORC Schematic

2.3.2 Battery Storage

As part of the RVC Microgrid project, RVC investigated the potential implementation of a 1 MW/4 MWh zinc hybrid cathode battery storage technology, which uses widely-available materials within a robust, scalable design and offers an expected 5000-cycle life. It is a fuel-neutral system, converting either purchased, solar-generated, or engine-generated energy produced either during normal operation or microgrid-islanding operation. The batteries can provide a storage media for the planned solar PV panels and enable load shifting when peak load demand does not coincide with available generation. Despite these benefits, the current cost of battery storage, the land space requirements per MW and the peak/off-peak differential pricing in NYISO Zone J does not allow for payback before the expiration of the expected battery cycle life as described below. RVC will continue to monitor the cost of the battery storage systems costs for potential opportunities in the future.

The addition of this battery storage system could provide the following advantages:

- **During Microgrid / Islanding Operation**
  - During peak days: supplementing the RVC Microgrid's available generation to meet electrical peaks and transients while recharging during low microgrid load times (nights and evenings usually) either through supply from the wholesale market or from local generation (depending on the wholesale market price).
  - During non-peak days: storing solar PV energy when PV power exceeds building needs and discharge during non-daylight hours.
  - Post outages and during emergency situations: provides long duration energy with up to 4 hours of power available that will allow time for RVC to start up a generator and recover their electrical distribution system.

- **During Normal Operation**:
  - **Load Cost Shifting:** Schedule charging (5-6 hours during low energy cost hours) and discharging (0-4 hours during high energy cost hours) each day when NYISO DAM pricing arbitrage exceeds the round-trip efficiency loss of the batteries. At times, this will help reduce RVC's need to run generators during peak demand when the aggregate RVC load approaches 45 MW. This operating strategy can be used whenever the load exceeds RVC's current NYPA contract, which happens as often as 9-10 months of the year.

The battery storage system comes in four shipping containers (8'x9.5'x40') that would be placed in the available lot behind the RVC Power Plant. They could be located within 200 feet of the existing RVC substations. The current average peak demand shown on Table 1-1 for all 14 critical facilities is approximately 4.5 MW. This exceeds the capacity of the 1MW/4MWh battery storage system. However, some of critical facilities located on the RVC Microgrid already have existing backup generation and therefore this battery storage system can supplement Bus 2 generation.

2.3.3 Solar PV

It is recommended that new solar generation be added as part of the Municipal Solar Initiative associated with the RVC Microgrid Project. The solar generation will help offset the system peak load growth, supplement conventional generation during the daytime and lower CO_2, CO and NOx emissions otherwise associated with engine generation. Additional solar "canopy" opportunities exist at Village parking lots, which could add up to 6.2MW of solar capacity. Rooftop installations are slightly less expensive (approximately 10 percent) than canopy installations due to the additional structural requirements for covered parking. Generating electricity on-site using solar PV has the potential to improve reliability, diversify the electric supply, and reduce the amount of electricity purchased on the open market. Table 2-2 summarizes the proposed rooftop solar locations and Table 2-3 summarizes the potential parking canopy solar locations.

As part of the RVC Microgrid Project, four municipal buildings were selected for evaluation as hosts for up to 568 kW of rooftop solar photovoltaic (PV) generation capacity. However, if structural analysis during the design phase determines that one or more of the buildings are unable to support the dead loads, some parking lot (canopy) installations can be substituted. The proposed buildings are already located on Bus 2, enabling the solar arrays to be easily integrated into the existing electrical feeders. RVC can use its own staff for some of the installation, plus all of the operation and maintenance, thus reducing the project development and operating costs. At full capacity, a 568 kW solar PV array would meet approximately 9.5 percent of the 6 MW daytime (only) summer peak on the critical loads. On the other hand, the canopy installations have the potential to generate an additional 6.2 MW which would support a majority of the peak critical loads on Bus 2 during the daytime (only). Canopy installations, however, are typically more expensive to permit, construct, insure, and operate. In addition, they present a challenge in gaining public acceptance, and are more vulnerable to vandalism and tampering, as compared to rooftop-mounted solar PV panels. The structural support for canopy PV installations can also result in the permanent loss of parking spots. Canopy PV installations are therefore not a preferred choice.

When available, the PV power generated would be provide “baseload” power, offsetting the need for fossil generation, thus reducing the carbon footprint of the Village.

The use of solar “hot water” thermal panels at the RVC Power Plant was examined to provide thermal needs of the power plant. Due to the higher fluid temperatures needed to satisfactorily meet the jacket water loop “hot standby” condition, thermal solar panels were found to be ineffective.

Table 2-2: Summary of Rooftop Solar PV Potential

Location	Installed Array Capacity (kW)	Annual Output (kWh)	Available Rooftop Area (ft^2)
PV Site 1	76	90,515	5,163
PV Site 2	236	280,504	16,000
PV Site 3	71	84,151	6,000
PV Site 4	185	220,897	21,000
Total	**568**	**676,067**	**48,163**

Table 2-3: Summary of Potential Phase II Canopy (covered parking) Solar PV Potential

Location	Installed Array Capacity (kW)	Annual Output (kWh)	Available Rooftop Area (ft^2)
Lot A	742	962,971	84,000
Lot B	131	169,666	14,800
Lot C	848	1,100,538	96,000
Lot D	477	619,053	54,000
Lot E	389	504,413	44,000
Lot F	904	1,172,761	102,300
Lot G	175	226,986	19,800
Lot H	146	189,155	16,500
Lot I	161	208,644	18,200
Lot J	459	596,125	52,000
Lot K	291	378,310	33,000
Lot L	538	698,154	60,900
Lot M	424	550,269	48,000
Lot N	495	641,980	56,000
TOTAL	**6,180**	**8,019,025**	**699,500**

2.4 Electrical and Thermal Infrastructure Characterization

RVC plans to utilize the entire existing Bus 2 electrical distribution infrastructure such as the feeders, lines, relays, breakers, switches, and current and potential transformers. No incremental wiring, poles, or breakers are required. The only change to the existing electrical infrastructure would be the interconnection and/or modifications needed for the new Distributed Energy Resources (DERs) and capacitor banks. All DERs can be easily integrated into the existing electrical infrastructure considering the fact that they would be located at either the RVC Power Plant or an RVC controlled building served by Bus 2. Some of the electrical installation work can be performed in-house by RVC staff to help defray costs. The new generator will be placed in the vacant generator bay located in the RVC Power Plant.

As mentioned above, capacitor banks are also planned to improve the low power factor on Bus 1 and 2, which typically drops to as low as 0.9[4]. Low power factor, typically caused by inductive loads on the system (e.g. motors), causes greater system currents which result in resistive losses and voltage drops. This ultimately limits the current-carrying capacity of the system and requires slightly more generation and/or purchased power to overcome the system inefficiencies. Utilizing existing load data, the number of both fixed and automatic (switchable) capacitors that should be added to Bus 1 and 2 to achieve unity power factor (Table 2-4) has been estimated. The two capacitor types will allow RVC to selectively regulate the power factor on Bus 2 both when in parallel and islanded modes, improving system efficiency and providing more stable voltage system-wide.

RVC currently has the vehicles and technical personnel needed to install the new capacitor banks.

Table 2-4: Number of Required 300 kVAR Capacitors to Achieve Unity PF[5]

	Existing (Fixed)	New (Fixed)	New (Auto)
Bus 1	5	6	8
Bus 2	2	7	10

[4] Bus 1 is included since the normal operation of the RVC Grid has the Bus1/2 tie normally closed, so the power factor on Bus 1, affects the power factor on Bus 2.

[5] Excludes recommended spares

2.5 Microgrid and Building Controls Characterization

RVC plans to utilize the existing infrastructure with the exception of the new solar PV equipment. Since all of the buildings with proposed solar panels are already fed from Bus 2, the rooftop solar panels could easily be connected to this existing circuitry with the entire assembly potentially installed by RVC staff. The solar panels can supply continuous AC power to the buildings they are installed on. Any excess power can be supplied to other customers on Bus 2. The solar panels work as a standalone power source once installed and require very little manual operation or control. The new 7-8 MW generator will be placed in the empty generator bay in the RVC Power Plant. This new generator will be operated and maintained by the RVC Power Plant staff. Given the fact that RVC already operates eight other units on natural gas and/or diesel fuel within the power plant, very little training on engine operations and control will be necessary. All controls for the new generator will be located in the RVC Power Plant.

As previously stated, RVC was recently awarded a DOE REDI Grant to replace their obsolete SCADA system with a state-of-the-art system. This new SCADA system will improve RVC's ability to identify problems in their electric system with faster, more accurate diagnostics (e.g., voltage, power factor, frequency). This will, in turn, improve their ability to provide better system control, whether in parallel mode or islanded mode. The resulting improvements to data acquisition and control will provide the Village with a more reliable electric grid and shorten the time needed to recover from a system outage or emergency.

The new SCADA system will also provide the following:

- reduced risk of extended outages and equipment failures on the RVC Microgrid and other busses,
- support industry standard protocols (such as Distributed Network Protocol (DNP)),
- security firewalls to reduce the potential for unauthorized access,
- smart relays through RVC's fiber cables, which will permit RVC to visualize, understand and act on outages through enhanced graphical displays, as well as reduce the potential for operator errors,
- allow RVC to program routines to respond to loss of supplies, substation transformer and incoming breaker failures,
- provide direct communication and control of RVC Microgrid equipment with Programmable Logic Controllers (PLCs) - generators; Automatic Throw-Overs (ATOs), etc.,
- faster reporting,
- improved cyber security to meet appropriate NERC & Homeland security standards & recommendations,
- capability to send e-mail for events (or critical alarms that require immediate attention) through automated and manual alerts,
- single point of entry & maintenance through archiving, collection, report building, analyzing, and publishing reports,
- a global view of the grid, displaying past events in a time lapse sequence as they actually happen,
- automatic monitor and control of individual switchable capacitor banks to minimize overhead feeder losses,
- utilization of historical load and weather data to forecast the system load,
- allow RVC to intuitively create and test switching plans in advance of their implementation, and automatically issue voltage reduction commands through the voltage reduction monitor system,
- compliance with the latest Disturbance Monitoring Equipment (DME) requirements of the NYISO, including waveform capture capability.

The new SCADA system and Remote Terminal Units (RTUs) will have the capability to support the below additional features on the RVC Microgrid:

- greatly reduce wiring and test labor, as well as engineering costs associated with RTU replacement,
- eliminate substation wiring drawing revisions and master station database and display revisions,
- eliminate most failure–prone or unsupported electronics with extremely reliable and fully-supported NTX series hardware and software,
- reduce the time required to modernize existing installations from weeks to hours,
- obtain many more years of useful life from existing substation equipment,
- take advantage of modern open protocols,
- take advantage of modern communications digital interface mediums,
- segregate vast amounts of data into separate virtual RTU addresses,
- supply this data and control capabilities to multiple master stations,
- integrate Intelligent Electronic Devices (IEDs) inside and outside the existing substations, and
- integrate with RVC's current ESRI GIS System, Volt/VAR management or load management system.

The new Relays (IED relays) will directly provide the RVC Microgrid with the following capabilities & benefits:

- replace the 20+ year old electromechanical relays that are at, or near, end of life,
- smart relays (IEDs) and communication via fiber cables and other current IEEE standard communication methods, and
- more accurate control & protection capabilities that do not require calibration as there are no moving parts to wear in the digital relays. The generator breaker relays provide protection, integration, and control features in a flexible, compact, and cost-effective system.
- numerous current, voltage, frequency, distance, power, and out-of-step elements providing comprehensive protection for large, medium, and small generators,
- built-in automatic synchronizer eliminating the need for external synchronizer equipment - frequency, voltage, and phase control of the generator are automatically synchronized and connected to the power system,
- detection of ground faults on high-impedance grounded generators using a conventional neutral-overvoltage element with a third-harmonic voltage differential detection scheme for 100 percent stator winding coverage,
- current differential elements detect stator faults using a secure, sensitive current differential function,
- sensitive power elements protect against reverse power, overload conditions, or low forward power,
- Resistance Temperature Detector (RTD)-based thermal protection acquires thermal data for alarm, monitoring, and trip functions,
- viewing generator auto synchronizer, record events, and wave capture event reports to analyze generator startup, shutdown, or system faults. Measure electrical, thermal, and generator run-time quantities.

The new SCADA system will continue to provide the following existing features of the RVC Microgrid:

Automatic Connect/Disconnect from the Grid:

- During normal operations, the RVC Microgrid will be connected to the electric grid with power coming from NYPA and the NYISO purchases. In the event of an emergency or outage, the RVC Microgrid will automatically trip open all the breakers connected to the grid resulting in an islanded microgrid. Once the new generator is black-started and connected to the Bus, all the associated feeder breakers to the critical and key customers can be closed by RVC staff in a predetermined sequence.
- To reconnect to the grid, RVC will synchronize the generators with the grid and close the LIPA breaker. The generator output(s) can then be reduced and then taken off-line and shut down.

Load Shedding Scheme:

- During a system emergency or outage, RVC staff will begin following their standard operating procedure to recover their electric grid. Once in islanded mode, RVC staff can regulate the load based on available generation by selectively tripping open breakers to non-critical customers. This load shedding scheme will be organized by RVC such that the customers will be ranked by their importance to the community. This will allow RVC staff to effectively reduce load and not lose any critical facilities in the process.

Black-Start and Load Addition:

- The new black-start generator will be connected directly to the RVC Microgrid. This will provide a reliable and energy-efficient source of power that can help RVC recover from an outage, storm or emergency. Likewise, there are currently two aging generators with black-start capability that are connected to Bus 1 that will provide additional power to other customers in RVC.

Perform Economic Dispatch and Load Following:

- RVC will perform economic dispatch by starting their new generator whenever the NYISO DAM prices are above their cost of local generation. The generator will operate at high load to result in their highest electrical efficiency.

Demand Response:

- RVC will operate the new generator during days where the load is expected to be above 45 MW, when Bus 2 approaches 12 MW when connected to the grid or when transmission lines or station equipment are out of service for maintenance. Additional generators would operate as load dictates. In island mode, after the new generator is black-started and serving Bus 2 critical loads, the remaining generators will be started to help supplement the remaining RVC customers.

Storage Optimization:

- The potential future 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 charging during the hours of the day that where the DAM prices are low. This peak shaving approach for the battery will lower RVC’s costs of electricity and help recoup the costs of the system. Current battery costs and peak/off peak arbitrage pricing (including capacity payments) do not justify the cost of batteries.

Maintaining Frequency and Voltage:

- Additional capacitor banks will improve the low power factor situation and will also help maintain voltage on the RVC Microgrid, in particular during island mode. The additional capacitors will improve voltage regulation when in islanded mode as well as during peak operation.

PV Optimization:

- Solar photovoltaic roof installation locations were evaluated based on their sunlight exposure, solar generation capabilities, and ease of integration at Village-controlled buildings. Selections were made to lower costs when connecting these systems into the RVC Microgrid. The selected roofs are high enough off the ground to prevent any interference from trees and other buildings to maximize the energy generated.

Protection Settings:

- The implementation of this DOE REDI Project will enable RVC to replace their obsolete protection system with state of the art equipment that will improve reliability during major storms and electrical system events, reduce maintenance, and help identify a problem before it occurs.

Selling Energy and Ancillary Services:

- RVC will be utilizing the new generator to produce energy at a lower cost for their customers. The new generator is expected to be dispatched whenever the NYISO DAM prices are above the engine's marginal cost to operate (based on fuel cost), or approximately 2500 hours/year based on historic pricing analysis (described later in this report). This will allow RVC to save money by locally generating power at a lower cost than it would cost for market-rate power.

Data Logging Features:

- RVC's existing SCADA system, installed in the 1990's, requires significant manual intervention to retrieve system data (i.e., voltage, current, KW, KVAR) for some of the individual busses. The installation of the new SCADA system will be able to collect, store, graph, telemeter, analyze multiple data simultaneously, and improving efficiency, operation, troubleshooting, safety and outage response time.

Resiliency:

- The resiliency of RVC's electrical infrastructure will be greatly improved due to the new equipment and systems being installed in association with the RVC Microgrid. The addition of a new generator onto Bus 2 will allow RVC to re-purpose one or more of their existing emergency generators to Busses 5 & 6, which currently have no emergency generation. These busses and associated loads were without power for over a week during Hurricane Sandy. Likewise, the potential future installation of a battery storage system will provide a source of stored energy that can be utilized whenever needed. The installation of solar PVs will diversify RVC's generation, providing additional, renewable energy supply.

  The installation of the new SCADA system will create a dynamic and flexible microgrid capable of drawing from a diverse suite of power sources and buildings controls. The system will be designed to isolate circuits during system disturbances and provide immediate communication to RVC.

2.6 Peak Energy Savings and Energy-Efficiency Opportunities

An effective and low-cost solution to add resilience to the electrical distribution system is to increase energy-efficiency and conservation to reduce demand. There are several building and infrastructure technologies that improve energy conservation and also reduce peak demand for existing buildings. RVC has a number of opportunities to reduce peak demand and overall energy consumption. This section summarizes the potential demand response and energy-efficiency programs that complement a microgrid solution. Based on the research conducted of various DSM programs in the marketplace, and their success rates, the design and implementation of the following programs to reduce peak energy demand and total energy consumption are recommended:

- ***Smart Thermostat and Utility Reporting Programs for commercial and residential customers***. It is recommended that the Smart Thermostat be able to accommodate RVC data gathering, learned behavior, remote connection, cycling/set-point algorithms, and other features such as smart device access points. The program should start with commercial facilities in the Village.

- ***Demand Response programs for larger customers*** including a combination of pump deferral, base interruptible, and critical peak programs. This program is dependent on availability of customers and their willingness to participate. Programs for smaller commercial and residential customers would be captured through the Smart Thermostat programs.
- ***Energy-Efficiency Programs*** including *energy monitoring and benchmarking, school energy pledge programs, residential energy-efficiency rebate programs, and commercial sector rebate and educational programs* to reduce peak energy consumption and promote total energy savings opportunities. Program savings depend on uptake, marketing, and size, but the efficiency programs outlined in Table 2-5 have the potential to reduce total energy consumption and demand during peak events.
- ***Water and Energy Utility Collaboration*** to reduce peak energy demand and improve overall water and energy-efficiency. Example programs can be found in Florida, Southern California, Oswego, New York, and Darlington, Wisconsin. Various software tools exist to interface SCADA information with demand response programs. Savings estimates vary, but some utilities have found as much as 30% reductions during peak events through coordination between electric and water utilities.

Savings and costs of implementation in the Village will vary depending upon program design, electricity pricing, frequency of curtailment, and technologies deployed. However, our research is summarized in Table 2-5 with savings ranges for each program.

2.7 Information Technology (IT)/Communications Infrastructure Characterization

RVC has been awarded a DOE grant through the DOE REDI Initiative that will replace their current obsolete SCADA system. All of the existing SCADA infrastructure will be removed and replaced with an all new SCADA infrastructure, enabling all the new equipment that is intended to be installed into the RVC Microgrid to be easily integrated. This will allow RVC to receive real-time grid information empowering operating personnel to help prevent power outages and rapidly restore power when outages occur. The new SCADA system has the ability to communicate with smart relays via fiber cables, switches and other IEEE standard communication methods to help maintain the RVC Power Plant. During an outage or emergency, RVC will automatically disconnect from the grid and be placed into islanded mode. Consequently, RVC will have a standalone system that will be self-sustaining during an outage or emergency. Once power has been restored to the transmission grid and communication has been established between PSEGLI and RVC, RVC would then reconnect to the grid.

Table 2-5: DSM Analysis

Thermostat and Behavioral Programs			
Program Type	**Peak Savings Estimates**	**Energy Savings Estimates**	**Estimated Cost Range**
Programmable Thermostat	~0.07-0.08 kW/home during weekday peak period (4-6PM)[i]	4-6% below baseline consumption per building[ii, iii]	$400-700/unit; $0.11-0.53/kWh savings[iv]
Smart Thermostat with Utility Control (Residential)	0.1 kW per device during weekday peak period (4-6PM)	7-23% below baseline consumption per building[v]	
Smart Thermostat with Utility Control (Commercial, Institutional and Retail)	0.13- 1.06 kW per customer during weekday peak period (4-6PM)	5-11% below baseline consumption per building[vi]	
Utility Energy Reporting Conservation Program	1-4% reduction in consumption per household during peak events; .07 kW per home during peak period (4-6PM)	0.27-5.2% savings per householdvii; 2-4% utility-wide savings[viii, ix]	$0.033-0.05/kWh[x] $5-10/participant per year[xi]
Demand Response Programs xii,xiii			
Program Type	**Peak Savings Estimates (kW/customer)**	**Peak Savings Estimates**	**Estimated Program Costs**
Base Interruptible Program	859.1	74%	
Summer Discount Plan (Commercial)	33.3	14%	On average: $50-75/kW-year nationally[xiv] $4.42-5.13/kW-month
Summer Discount Plan (Residential)	3.1	27%	
Dynamic Pricing	13.1	6%	
Demand Bidding Program – Demand Buy-back program	60.5	8%	
Energy-Efficiency Programs (including water infrastructure) xv, xvi, xvii			
Program Type	**Energy Savings Estimates**	**Energy Savings Estimates (% savings)**	**Estimated Program Costs**
Water Pumping Efficiency through SCADA and pump-shifting	n/a	30-75% peak load reductions	
Water and Energy Utility Program Collaboration	n/a	15-30% total energy savings[xviii]; 10-75% peak savings (kW)	Depends on design, region, and collaboration.
Advanced Rooftop Unit Controls	0.47-7.21 kWh per hour with average 2.39 kWh per hour per RTU; 3000-5000 kWh-year per RTU replacement	22-90% savings with an average of 57% savings for all RTUs; 20-50% savings on cooling and ventilation[xix]	Incentives for RTU replacement with high SEER range from $20-150/ton + administrative and marketing costs

Benchmarking, Metering, and Dashboard for Real-time Monitoring	**~10-20% savings in certain building applications (schools, public facilities, restaurants, etc.)**	**Advanced fault detection in large facilities. Estimates range from 10-30% depending on building type and baseline.**	**$500-1000/building (42 sensors) with $50-150/mo. service fee**
School Pledge Programs	3W per student per year peak demand reductions; 100 kWh per student per year	n/a	$5-10/student (incentives) and $4000-5000/school (administrative costs)[xx]
Residential Energy-Efficiency Rebate Programs[xxi]	Variable depending on program size and marketing budget.	Variable depending on program size and marketing budget.	On-Peak Demand Reduction (Cost of program per kW peak demand reduced): $3,000-4000 Energy Savings (Cost of Program per kWh saved): $0.15-0.25
Commercial Sector Energy-Efficiency Incentive and Education Programs	Variable depending on program size and marketing budget.	Variable depending on program size and marketing budget.	On-Peak Demand Reduction (Cost of program per kW per peak demand reduced): $800-1000 Energy Savings (Cost of Program per kWh saved per year): $0.10-0.20

Task 3. Assessment of the RVC Microgrid's Commercial and Financial Feasibility

3.1 Commercial Viability - Customers

Directly and Indirectly Serves a Large Population: The installation of the RVC Microgrid would help maintain key services available to the entire Village and neighboring communities during a transmission interruption or an outage due to a major storm. Bus 2 currently serves over 3,422 customers, including 510 commercial, one large institutional, and 2,912 residential (including 11 households hosting life support). Of these, 14 are deemed critical customers (See Table 1-1). Under normal conditions, an estimated 190,000 cars pass through the Village each day. During the aftermath of Hurricane Sandy, because RVC was able to provide rolling power (i.e., rolling blackouts) to critical and key customers, Village residents and visitors from neighboring areas were able to take advantage of gasoline stations, refrigerated food services, restaurants, pharmacies and other services available in the Village. Rather than limit the RVC Microgrid to serving just the 14 critical customers, it has been planned to serve an additional 21 key facilities. For the relatively small incremental cost required to install a larger engine-generator, the RVC Microgrid can provide consistent service to these additional 21 key facilities on Bus 2, expanding the benefits of the microgrid to indirectly serve a much larger customer population. By maintaining service to key service providers, the RVC Microgrid will positively impact customers and residents in the Village and neighboring communities.

Partially Serve Remaining Customers With "Rolling Power": Other non-critical or non-key customers (commercial and residential) that are connected to Bus 2 may be provided with power from the RVC Microgrid to the extent generation is available (e.g., during relatively low load periods). Note that during most of the year the RVC total system electric load exceeds the available RVC-owned generation. This will continue to be the case after installation of the planned new 7-8 MW generator and additional 568 kW of PV generation. During transmission interruptions, the remaining RVC generators will be used to provide power to the balance of the RVC customers on a rotating basis (a.k.a. rotating "blackouts"). However the critical loads on Bus 2 would not be part of the rotational blackouts. It is important to note that currently there is no generation at all on the other busses. While power can be provided to two busses via bus ties, an ancillary project would be to connect one or two of the older, existing RVC generators to provide some "rolling power" capability to the predominantly residential customers on Busses 5 and 6. The RVC Microgrid project would therefore indirectly provide other customers, not on Bus 2, with access to power during emergencies.

Seamless Use of Existing RVC Infrastructure: The RVC Microgrid generating equipment will be located at the RVC Power Plant and/or on RVC-owned municipal buildings or property and will be operated by RVC staff. The RVC electric infrastructure including transformers, switches, breakers, wires, poles, duct banks, etc., currently being used to deliver power during normal operations will be used for the RVC Microgrid[6] to deliver power to the critical facilities and key customers on Bus 2. Customers will not require new electrical services or switches to be brought into their facilities, new generator equipment, or be required to enter into special service contracts. Any new capital infrastructure required by the project will be paid from the RVC capital program, be 3rd party-financed, or be funded by a combination of both. As is currently the case, the RVC rate tariff would be the same for power consumed, whether in "islanded mode" or "normal mode". It is anticipated that a rate case proceeding will be required to implement the Microgrid Project. The responsibility to own, operate and maintain the RVC Microgrid will be carried out by RVC staff. The RVC Microgrid installation will be virtually seamless to the RVC customers.

Improved Reliability: One of the major benefits of installing the RVC Microgrid is the improved reliability of the power supply with the addition of new generation. With a 58 MW historic peak load and only 45 MW of transmission import capability, the generation will provide unrestricted operation in lieu of the old, inefficient

[6] Additional capacitor banks are planned and there may be some minor system interconnection needs determined during the detailed design phase

generation that has been significantly limited due to operating constraints under the Title V air permit. Currently, only two generators at the RVC Power Plant have black-start capability and neither is connected to Microgrid Bus. Unit 14, the newest black-start capable generator, has an intermittent history of failed black-starts. The other black-start generator at the RVC Power Plant was built in 1941. The proposed new black-start generator would provide a much more reliable energy black-start source for the RVC Microgrid.

Lower Electrical Generation Costs: The high efficiency of the planned new engine-generator can produce power more economically vs. purchased power for an estimated 2,500 hours/year when in normal operating mode in addition to emergencies. The energy cost savings could help reduce RVC's overall energy purchase cost, creating the opportunity for the generator to partially fund the cost of the RVC Microgrid project. There will be no change in the way customers are billed for their power in islanded or normal mode.

Capacity Payments: The ability to bid the new generator into NYISO capacity auctions should qualify the unit to receive Installed Capacity (ICAP) payments. This revenue could help reduce RVC's total delivered cost of power, a benefit which will be passed on to RVC ratepayers.[7]

3.2 Commercial Viability – Value Proposition

A SWOT (Success, Weakness, Opportunities and Threats) Analysis for the RVC Microgrid is provided in Appendix B. Detailed descriptions of the major items from the SWOT Analysis are discussed below.

Reduced Energy Costs: With the abundance of gas in the United States, the forecast for gas prices is that they will remain relatively low and stable. However, bulk transmission prices are expected to rise with the planned construction of new bulk electric transmission in NY State. The new generator associated with the RVC Microgrid project, in particular, will be able to generate savings for RVC as compared to the DAM pricing for an estimated 2500 hours/year, enabling RVC to hedge against rising transmission costs for the customers in the Village. The new generator would also utilize natural gas, displacing several oil-fired RVC generators currently in use which are associated with a much higher and more volatile fuel costs.

Reduced Emissions: By displacing the need to operate RVC's oil-fired generators with 7-8 MW of gas-fired generation, the total emissions and greenhouse gases will be reduced.

Improved System Power Factor: New capacitor banks on Bus 1 and Bus 2 (which are normally connected to each other via a bus tie) will decrease the I^2R losses in the system, provide better voltage control, increase the overall efficiency of the RVC Microgrid and improve its ability to serve loads. Additionally, the switchable capacitors will provide a more resilient system in islanded mode, ensuring changes in load will not affect system frequency and voltage.

Supplement Existing (limited) Transmission: The installation of a microgrid would aid RVC in serving its customers during transmission line interruptions, and when RVC system load exceeds the incoming transmission lines capability of 45 MW.

Avoided Transmission Cost: The estimated cost of $50-68 million for the re-conductoring of the existing transmission lines, or installation of a fourth 33 kV line to deliver the needed power to the Village would be avoided. [8]

Displace more expensive generation: The proposed new engine-generator (7-8 MW generator, 568 kW solar) would displace more expensive existing generators. The resulting electrical efficiency of the new engine would be

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[7] This is clearly possible for generation installed "in front of the meter", i.e., on the LIPA side of the import meters. Discussions are underway at the NYISO to provide credit to generation installed "behind the meter".

[8] PSEGLI/LIPA estimate, Dec 14, 2015 of $50 M and $68 M.

over 45% vs. approximately 32% efficiency for the current engines. The new engine would also result in reduced emissions and reduced greenhouse gases (CO_2) as a result of the improved efficiency.

More effective use of gas service: The gas service from National Grid is from a 60 psig main which is only capable of delivering approximately 160 decatherms/hour. With the existing generators, this equates to approximately 15 MW of power ([160x10^6BTU/hr.)/(10,700 BTU/kWh]). Using the proposed new 7-8 MW reciprocating engine with a heat rate of 7800 BTU/kWh, the amount of gas-driven power generation can be raised to 17.0 MW (7,500 kW x 7800 BTU/kWh + 9,500kW x 10,700 BTU/kWh). A $533k gas system reinforcement would double the volumetric capacity of the current gas service, enough to fuel 30-34 MW of generation, depending on the engine efficiency.

Existing Fuel Oil Storage: RVC maintains up to 110,000 gallons of ultra-low sulfur diesel (ULSD) fuel storage capacity for use in its boiler and most of the reciprocating engines in the Plant. The oil storage can provide back-up fuel for gas line interruptions and qualify RVC for interruptible gas delivery service, which is lower cost.

The RVC Microgrid is scalable: The RVC Microgrid can be easily expanded to include other busses. The RVC Power Plant currently has 8 aging generators that can be replaced with new highly-efficient generators and potentially higher power output utilizing the same footprint as the current generators. The new generators would also produce considerably less emissions than the current units. Additional expansion capability could also come from solar canopy PV installations over RVC owned parking lots.

3.3 Commercial Viability – Project Team

The RVC Microgrid team is small, agile and commercially simple: The RVC Microgrid team will consist of RVC and a team of consultants and engineers. The RVC Microgrid, as currently proposed, will be solely owned by RVC. The electrical distribution infrastructure of cables, conduits, poles etc. are already owned and operated by RVC. Neither NYPA, LIPA, National Grid, nor any other utility entity is required to be involved, however, ownership of the generator by a third party is being explored as one of the new options.

The new generator and equipment will be located in the existing RVC Power Plant and will be operated and maintained by RVC Power Plant staff, all of whom have experience operating and maintaining gas reciprocating engines. During the development and construction phase of the RVC Microgrid, RVC staff will play a role in incorporating these technologies into the existing electric grid. To the extent available, RVC staff will be available to participate in the design, and to manage, review drawings, oversee installations, operate & maintain the equipment and potentially perform some of the electric equipment interconnect work.

Improve Purchasing Power: RVC anticipates teaming with other NY Prize winners to leverage buying power for equipment to the extent possible. This would include reciprocating engines, controls, solar panels, batteries and thermostats, and is expected to reduce the overall costs per unit. RVC is willing to take the lead on organizing and negotiating the purchases.

3.4 Commercial Viability – Creating and Delivering Value

The cumulative savings to the businesses, security and continued commerce to the local businesses:

Land Control: RVC currently controls and operates the existing RVC Power Plant and electric distribution system. Any additions (such as capacitors) are not expected to require additional easements, waiver or ROW. RVC owns the property upon which all new equipment will be installed. The proposed generator installation is planned for the existing empty bay of the RVC Power Plant. The roof-mounted PV solar panels are planned to be installed on the RVC-owned municipal buildings. The capacitors would be mounted on poles or in vaults for underground feeders owned and maintained by RVC.

Ease of Integration: The new technologies and equipment proposals for the RVC Microgrid were selected based on ease of integration, ease of operability, and limited accessory requirements. Additionally, the staff has the ability to assist with some of the electrical installations, including the rooftop solar panels electric connection, capacitor bank installations, and the connection of the new generator to Bus 2.

Rapid Time to Implement: Because of the simplicity of installing the RVC Microgrid within an operating Electric Municipal System, the RVC Microgrid project can be executed in a relatively short time frame. The following hurdles will be avoided: (a) contractor negotiations with multiple parties, such as land purchases, land, leases, ROWs, operations staffing, maintenance contracts; (b) special service connections, meters, switches and associated coordination procedures; and (c) equipment such as multiple small generators, system metering, relaying, controls that don't already exist. RVC has the capability to deliver the RVC Microgrid within a relatively short period of time and at a lower cost due to its Municipal Utility status.

No incremental staffing: RVC already has a staff of trained professionals capable of operating and maintaining a power plant, the electric substation infrastructure and distribution system. No incremental staffing will be required for these functions.

Synergetic Technologies: RVC currently has eight generators, making the addition of another generator an extension of existing equipment. The RVC Power Plant already offers the auxiliary equipment necessary to support the new generator, including a jacket water heating loop system (to enable the engines to start quickly), lube oil storage tanks, compressed air, ventilation system and plant lighting. The new generator will require modification to the RVC Title V air permit that governs how the other generators at the RVC Power Plant are permitted to operate. However the new generator will be permitted to operate more hours per year to obtain a higher runtime per year than the existing generators due to its higher efficiency and significantly lower emissions.

The installation of rooftop solar PV, will provide additional generation. Since RVC tends to experience their peak loads during hot summer days, the rooftop solar PV will provide another source of power generation when it is needed most. The solar panels will require building permits for rooftop installation.

Regulatory Approval: The addition of this equipment will require permit modification prior to installation including an Environmental Impact Statement (EIS), emissions modeling and rate case approval by the NY PSC and NYS DEC as well as notification to other local municipal agencies including Nassau County and the Town of Hempstead.

3.5 Financial Viability

Reciprocating Engine: The installation of a new 7-8 MW gas engine generator was evaluated for its ability to generate revenue streams for RVC if bid in the NYISO DAM market. The engine has a heat rate (HHV) of 7737 $\frac{BTU}{kWh}$ at full load. Based on RVC's average gas rates for 2014 and 2015, the new generator can operate at approximately 61 $\frac{\$}{MWh}$ and 44 $\frac{\$}{MWh}$ respectively. As such, the generator would only be dispatched whenever the market pricing exceeds 61$\frac{\$}{MWh}$ in 2014 and 44 $\frac{\$}{MWh}$ in 2015. As shown in Table 3-1, the new engine can generate an average savings of $1.2M/year vs. NYISO DAM that was collected from 2014-2015. Likewise, RVC can generate revenue from the ICAP market. Based on the ICAP prices from 2014-2015, RVC could have generated $373,875/year on average solely on capacity payments. At a total of $1.6M per year in potential revenue, RVC's payback period for the new generator would be approximately seven years, at an installed cost of $11.392 M (including gas compressors, gas line reinforcement, delivery, project and construction management, waste management, and civil, mechanical and electrical installation and testing).

Table 3-1: RVC Estimating Savings Resulting From a New 7-8 MW Generator

	Number of Days DAM cost of generation	Amount Saved vs. DAM Purchases Per Year	Capacity Payments	Total
2014	154	$ 1,537,451	$ 388,950	$ 1,926,401
2015	180	$ 864,978	$ 358,800	$ 1,223,778
	Total:	**$ 2,402,429**	**$ 747,750**	**$ 3,150,179**
	Average/Year	**$ 1,201,215**	**$ 373,875**	**$ 1,575,090**

The addition of this new generator requires a higher inlet gas pressure than the existing generators at the RVC Power Plant. Currently, natural gas is supplied by National Grid via a 6-inch, 60 psig service. The receiving pressure at the RVC Power Plant is typically only 45 - 57 psig. The new generator may require an inlet gas pressure 65-80 psig. Therefore, RVC must invest in gas compression to boost the pressure needed for the new generator. The maximum gas volumetric flow rate that can currently be received by the RVC Microgrid is 160decatherms/hour which can generate approximately 15 MW. To produce the equivalent volumetric flow rate at a higher inlet gas pressure of 65 psig, RVC will need two 100% rotary screw compressors that will result in an additional $1.12M of equipment cost plus an estimated $75k for installation. On an installed basis the overall cost of the new 7-8 MW generator, two new gas compressors and associated piping, electric work etc. will equate to approximately $1,519/kW. These are preliminary estimates to be firmed up during the detailed engineering and bid phases.

Battery Storage: To evaluate the economical investment of a battery, NYISO DAM data was collected for 2014 and 2015 to identify the times during each day that would be the lowest cost and most expensive to charge and discharge the battery system respectively. See Figure 3-1.

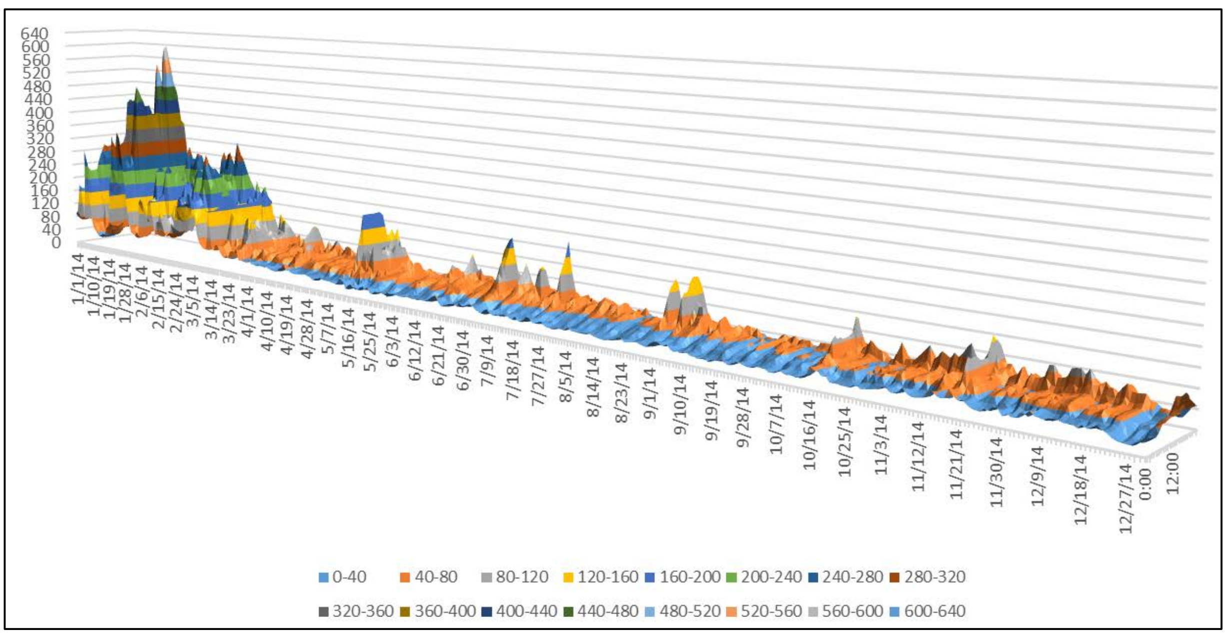


Figure 3-1: 3D Depiction of CY2014 NYISO DAM Prices, Zone K, $/MWh

The 1MW/4MWh battery storage system was used as the basis for our analysis. This system has an estimated installed cost of approximately $1.8 million. As shown in Table 3-2, using various charge/discharge hours and actual DAM prices, the battery would only generate approximately $50,000 in savings per year. Since the life cycle of the battery is limited to 5,000 cycles. With a planned daily discharge of the battery, the system would only last approximately 13.5 years. With an annual savings of $50,000, the lifetime savings of the battery would only generate $680,000 (38% of the initial costs) in savings.

Table 3-2: Battery Economic Evaluation Summary

Battery Economic Evaluation Summary			
Discharge Hours	3	4	4
Charge Hours	5	6	7
Efficiency	80	80	80
2014 Savings	$ 45,387	$ 54,491	$ 52,200
2015 Savings	$ 36,678	$ 41,898	$ 42,558

Various NYISO DAM on-peak/off-peak price differentials were also investigated to provide the best return for the 5,000 cycles. Based on NYISO data from the previous years (2014 and 2015), as shown in Table 3-3, and Table 3-4 below, RVC would not be able to get a return on investment within a reasonable timeframe. Therefore, the incorporation of a battery storage system for the RVC Microgrid will likely not proceed without vendor, NYSERDA or third party subsidies, or significant changes in the project's economic drivers.

Table 3-3: Battery System Operation Savings Based on 2014 DAM Daily Price Differentials

DAM Battery Discharge Price Threshold [$/MWh]	Days per Year Discharged	Annual Savings	Average Saved per 4 hour Discharge Cycle	Lifecycle Savings over 5000 Cycles	ROI (yrs.)
25	365	$54,491	$150	$746,450	*
50	267	$47,219	$177	$884,250	*
75	97	$28,919	$299	$1,490,651	*
100	79	$25,563	$324	$1,617,920	*
125	62	$21,830	$352	$1,760,453	*
150	50	$17,886	$358	$1,788,553	*
175	45	$16,071	$357	$1,785,634	*
200	35	$12,927	$369	$1,846,664	69.6

*Payback exceeds battery lifetime

Table 3-4: Battery System Operation Savings Based on 2015 DAM Daily Price Differentials

DAM Battery Discharge Price Threshold [$/MWh]	Days per Year Discharged	Annual Savings	Average Saved per 4 hour Discharge Cycle	Lifecycle Savings over 5000 Cycles	ROI (yrs.)
25	357	$ 43,925	$ 123	$ 615,195	*
50	133	$ 27,263	$ 205	$ 1,024,950	*
75	79	$ 19,305	$ 244	$ 1,221,861	*
100	49	$ 13,100	$ 267	$ 1,336,831	*
125	35	$ 10,504	$ 300	$ 1,500,653	*
150	24	$ 7,306	$ 304	$ 1,522,197	*
175	17	$ 5,227	$ 307	$ 1,537,387	*
200	8	$ 2,060	$ 257	$ 1,287,504	*

*Payback exceeds battery lifetime

Solar Thermal Heating: Solar thermal heating was investigated and analyzed to replace the RVC Power Plant boiler currently used to heat engine jacket water and reduce the time for startup. The dedicated boiler has the following nameplate data:

- Gross Output: 1,054 MBH
- Net Output: 791 MBH Steam / 917 MBH Water
- Fuel to Gross Output Efficiency of 80%

Based on a monthly oil consumption of approximately 3,500 gallons per month, it can be assumed that the boiler operates at a 50% load factor. A typical load profile for this type of boiler is shown in Figure 3-2 below.

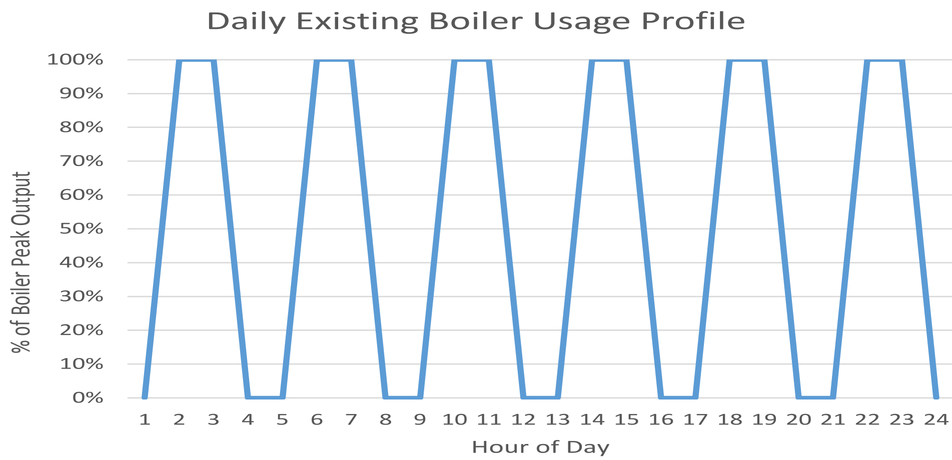


Figure 3-2: Typical Boiler Load Profile for Jacket Water Heating

Based on information gathered from the Department of Energy and a local vendor, a square footage of collector panels was chosen to match the estimated peak existing system load (approximately 90% of the existing peak boiler capacity). The following was calculated based on the assumptions listed in Appendix A.

- Roof Area: 3,550 ft^2
- Installation Costs: $407,100
- Annual Fixed O&M: $9,060

Figure 3-3 below shows the possible daily solar yield for selected days throughout the year versus the assumed daily demand profile. It can be seen that a supplementary energy source would still be required to meet the entire load. Any solar energy used by the system represents a fuel savings. For the purposes of this analysis it was assumed that almost all of the solar energy can be put to use by means of a storage system. The system analyzed here could provide 25% of the annual jacket water heating energy required. This equated to energy savings (not including annual O&M costs) of $29,674 and a payback of 19 years (including the annual O&M costs). Therefore, due to the long payback period and the need to continue utilization of the existing boiler, solar thermal panels have been eliminated from the RVC Microgrid design.

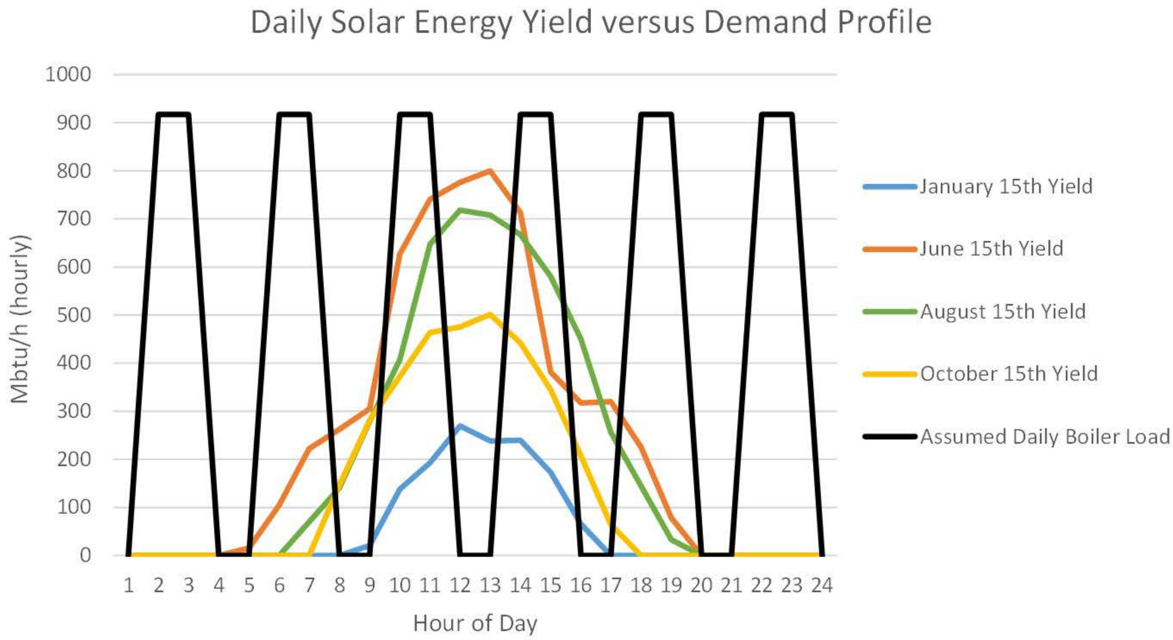


Figure 3-3: Solar Heating Displacement for Jacket Water Heating

Capacitors for Power Factor Correction: Due to the low power factor experienced on Bus 1 and 2, the addition of capacitor banks on the RVC electrical distribution system was examined to help make the RVC Microgrid more efficient. During microgrid operation the RVC system is "soft", meaning the RVC-connected generation will react more to a disturbance of any kind compared to normal operation when there are many more megawatts of generation connected. With the LIPA transmission lines connected to the RVC Microgrid, a larger, more stable and more resilient system is created in which changes in load will not affect system frequency and voltage as much as they would when the microgrid is operating in an islanded mode. It is not easy to quantify cost of voltage sags as they primarily affect customer electrical equipment.

Since the bus tie is normally closed between Busses 1 and 2, the reactive power of the two busses track each other. Reactive power data was gathered for both Busses 1 and 2 during various load conditions. Based on this information, the base reactive load was identified on each bus to help identify the quantity of fixed capacitor banks that could be installed. Likewise, the peak reactive loads on these busses were used to identify the number of automatic (switchable) capacitor banks that can be controlled by RVC staff as needed. For each bus the number of fixed capacitors was determined based on the minimum kVAR recorded, assuming each 3-phase capacitor bank can absorb 300kVAR. The kVAR capacitance provided by the fixed capacitors is then subtracted from the peak kVAR for the respective Bus. The difference is divided by 300 to calculate the number of switchable capacitors needed. As shown in Table 3-5, 3-6 and 3-7 RVC will need to purchase 13 fixed capacitors and 18 automatically-controlled (switchable) capacitors.

Table 3-5: Bus 1 Required Capacitors

Date	Min kVAR	Max kVAR	Min # of Capacitors
2/15/2015	1,914	1,943	6.4
2/20/2015	2,119	3,185	7.1
7/20/2015	2,593	4,293	8.6
	# of Fixed Capacitors		**6**
	# of Auto Capacitors		**8**

Table 3-6: Bus 2 Required Capacitors

Date	Min kVAR	Max kVAR	Min # of Caps
2/16/2015	2,277	2,951	7.6
2/20/2015	2,119	3,185	7.1
8/3/2015	2,623	5,125	8.7
	# of Fixed Capacitors		**7**
	# of Auto Capacitors		**10**

Table 3-7: Recommended Additional Capacitors

	Existing (Fixed)	New (Fixed)	New (Auto)
Bus 1	5	6	8
Bus 2	2	7	10
TOTAL	7	13	18

*All Capacitor Units are assumed to be 300 kVAR in size

One benefit of regulating the amount of reactive load demand in the Village is that it will reduce the current being carried by the distribution cables. The reduced I^2R losses that would result after the installation of these capacitor banks were analyzed. Analysis was conducted based on the cable size and length of all the feeders connected from Busses 1 and 2. As shown in Table 3-8, at an electricity price of $0.06 per KWh, the installation of these capacitor banks results in a net savings of approximately $2,100 per year. The equipment cost for the banks is approximately $185k. Assuming installation by RVC staff at an average labor rate of $93/man-hour the total installation cost is estimated to be $259k (Table 4-5). If installed by a third party, the estimated cost is $311k or $52k more. As part of RVC's obligation as a municipal utility to serve the Village with an effective electric distribution system, the new capacitor banks are a recommended investment to improve the RVC electrical system efficiency, particularly during microgrid-islanded operations.

Table 3-8: Estimated I^2R Savings Resulting From Power Factor Correction on Bus 1 & 2

Type of Wire	# of Wires	Total Length (ft.)	Total Power Saved (Watts)
1000	1	1,125	31.09
800	1	3,800	98.46
350	13	40,110	828.11
4/0	29	52,653	808.00
3/0	41	73,043	1,158.61
1/0	47	56,219	821.47
#2	17	5,733	76.85
#4	9	7,116	95.97
#6	10	5,601	66.58
#8	1	425	5.59
Total:	169	245,825	3,991
		Price ($/kWh):	$ 0.06
		Savings ($/yr.):	**$ 2,098**

Using load information during two summer days the estimated location for the new capacitors was developed and is shown in Table 3-9 and 3-10 for Busses 1 and 2, respectively. For the detailed designed and installation phase, circuit voltage drops will be needed to optimize the placement of the capacitors on the respective circuits. Circuit voltage drop information was not available for the feasibility study.

Table 3-9: Bus 1 Recommended Capacitor Locations

	D N-7	E N-5	F N-6	K N-13	L N-12	N N-9	S N-15	T N-16	U N-17
MIN CURRENT (A)	20	110	100	10	20	150	105	100	35
MAX CURRENT (A)	180	195	270	130	170	290	300	280	265
AVG CURRENT (A)	101	160	183	79	90	227	209	185	160
Existing Fixed		1	1				2		1
New Fixed		1	1			1	1	1	1
New Auto	2			2	2				2
TOTAL	2	2	2	2	2	1	3	1	4

Table 3-10: Bus 2 Recommended Capacitor Locations

	A S-7	B S-6	G S-13	H S-12	I S-10	J S-9	P S-16	R S-18	S-21	S-22	S-24
MIN CURRENT (A)	100	50	45	30	50	110	120	30	54	60	184
MAX CURRENT (A)	290	200	190	210	170	280	300	180	99	196	246
AVG CURRENT (A)	185	151	131	163	92	204	197	100	75	133	216
Existing Fixed	1								1		
New Fixed	1	1	1	1		1	1				1
New Auto		2	2	2	1			2		1	
TOTAL	2	3	3	3	1	1	1	2	1	1	1

3.6 Legal Viability

The primary business model that the Village is evaluating is that RVC would own, operate and fund the RVC Microgrid construction and installation. An alternative option, being explored to assist in the financing of the installation, is to have a third party fund and assume full or majority ownership of the RVC Microgrid's new engine-generator. As such, any new capital infrastructure required will be paid from the RVC capital program, third party financed, or funded through a combination of these sources.

Unlike many municipalities, the Village owns the electric utility, which owns the existing RVC Power Plant, substation and distribution grid that is the core of the proposed RVC Microgrid. RVC constructs, operates and maintains the substation, power plant, distribution and some of the transmission infrastructure. The RVC Microgrid will not require the purchase or lease of any additional property. The new reciprocating engine would be installed in the RVC Power Plant. The proposed sites for the solar PV panels are also owned by RVC.

The RVC Microgrid is not anticipated to meet any legal impediment to its implementation. Air Modeling and an Environment Assessment (EAF/EIS) will be required along with NYS DEC and EPA approvals. PSC approval of the Rate Case to implement the project is also required. Nassau County and the Town of Hempstead are being contacted to solicit input on the Project, Environmental Assessment and permitting. The RVC Microgrid Project is within the control of RVC and its subcontractors (e.g., engineers, equipment providers, installation contractors and other consultants). Regardless of the ownership model, the responsibility to operate and maintain the microgrid will be carried out by RVC staff. The RVC Microgrid project requires no further staffing for the operation and maintenance of the microgrid as RVC already has staff that service the power plant's reciprocating engines and distribution system. This includes managers, supervisors, technicians and the operations staff. The implementation of the microgrid system will utilize the existing electric distribution system that is owned and operated by RVC. This includes the transformers, switches, breakers, wires, poles, duct banks etc. that are used to deliver power during normal operations to the critical and key customers on Bus 2.

As a municipality, RVC's Electric Utility charter has the obligation and responsibility to provide utility services within the Village. In fact, the Village provides other utility services as well such as potable water, sewer and street lighting. The ownership and control of these utilities will allow RVC to easily coordinate among the various Departments as needed. The RVC Microgrid installation will be virtually seamless to all of the RVC customers. Customers will not require new electrical services or enter into special service contracts. RVC requires no special customer contracts to implement the microgrid as the critical and key customers are already being provided with electric service under existing RVC tariffs.

RVC anticipates that the existing power plant's Title V Permit will need to be revised as part of the addition or replacement of an engine generator. The revised permit will require approval by NY DEC and the US EPA. The Permit change will likely require both NOx and CO catalysts for the new engine generator along with emissions modeling. No significant issues are anticipated in revising the Title V Permit. An Environmental Assessment will be required along with the preparation of an Environmental Impact Statement and a rate case approval by the NY PSC.

There is an existing natural gas supply to the RVC Power Plant sufficient to power approximately 15 MW of existing engine-generators. While limited in throughput, the addition of a much more efficient engine generator will allow the current gas service to support approximately 10-17% more generation capacity depending on the generator selected. Estimates have been provided by National Grid for gas distribution system reinforcements that would improve the gas delivery capacity on a firm or interruptible basis to support approximately 30 MW of generation. The cost estimates provided by NGRID Gas were $1.8M and $533k respectively.

The ability to sell capacity, energy and ancillary services into the NYISO market would make any new generation financially more attractive. To enable the engine-generators to sell power back to the market when the Village does not require the energy, the engine generators would have to be connected directly to the transmission system. Alternatively, "behind the meter/net generation" regulations are currently being discussed in the NYISO committee(s) to recognize resources installed "behind the meter". If promulgated, the regulations could permit partial or full recognition of the capacity, energy and ancillary services of the behind-the-meter resources in the market. Installation of the engine generator “in front of -the-meter” would increase the installation cost by an estimated $0.5 M. Behind-the-meter recognition would also possibly recognize the planned solar generation.

The creation of a “K Solar” type program for municipalities by either NYSERDA and/or NYPA would help reduce costs and help achieve economies of scale and accelerate installation across NY State. A similar program for battery storage sponsored by NYSERDA and/or NYPA would also help lower costs and speed implementation as well.

Task 4. Develop Preliminary Technical Design Costs and Configuration

4.1 Facility and Customer Description

As previously described, the RVC Microgrid project will supply power to the existing Bus 2. Bus 2 serves critical facilities, key commercial facilities and residential customers supplied from these circuits. The ability to provide power to the critical and key customers during an electric outage or emergency event will directly and indirectly benefit the well-being of all of the Village customers as well as adjacent communities who can avail themselves of the many critical and key services that will be provided with power from the Microgrid. The facilities designated as critical were selected based on their function, RVC's experience during Superstorm Sandy and the impact of other major transmission interruptions. The key customers were designated on the same basis. These include: (a) 22 critical facilities (e.g., police, firehouse, water/wastewater services and medical facilities), (b) more than 10 key commercial customers (pharmacies, gas stations, restaurants, and food stores), (c) four government (Village, postal) service buildings, (d) safety (15 traffic lights and some street lighting) and (e) 2912 residential customers connected to Bus 2. The RVC Microgrid will support a variety of economic sectors that will help the Village maintain essential services during an outage or emergency. A major advantage of the microgrid is that RVC owns and operates all of the electric distribution lines within the Village. As a result, they have the ability to selectively deliver and prioritize power to specific circuits and isolate damaged portions of the circuit that may have been otherwise impacted by an event. The continued operation of critical facilities and key customers during an emergency will leverage our ability to help neighboring communities that may experience impacts from the same outage or emergency. Therefore, the beneficial effects of the RVC Microgrid reach far beyond the Village itself and represent an additional benefit of the project.

Examples of each customer rate class served by the RVC Microgrid follow. The benefits to the Village and neighboring communities associated with each are as follows:

<u>Large Commercial:</u>

Hospitals and other Medical Facilities

- Maintain medical care to those currently hospitalized
- Ensure availability of emergency medical services to those that may require services during an event or have been impacted by the outage or emergency situation
- Maintain medical services to people on life support

Food Stores

- Availability of food, water and essential supplies to the Village and surrounding residents
- Prevent spoilage of refrigerated inventory

Gas Stations

- Fuel for residents, commuters, taxis, buses and commercial vehicles
- Fuel for emergency vehicles and equipment
- Fuel for the transportation of goods and services to and from the Village

Village Services (Water, Sewer, Electric, etc.)

- Improved quality of service and information to the community
- Ability to provide power to an emergency shelter for those severely impacted or displaced by the incident
- Allow Village personnel to focus on other utility infrastructure, service restorations, operations and maintenance, including those served by Bus 1 plus Busses 3 through 6
- Allow Village personnel to focus on recovery plans and restoration of transmission services

- Provide power to some traffic lights, reducing traffic jams, congestion, accidents and general chaos
- Maintain street lighting to reduce vandalism, accidents and other street crimes
- Maintain water and sewer services to the Village customers

Police Station

- Respond to emergencies and customer calls
- Continued operation, protection and safety oversight
- Maintain stability within the community
- Reduce police staff and associated overtime costs required to maintain orderly traffic flow
- Assist in carrying out the recovery plan

Fire Department (including Ambulance Service)

- Respond to emergencies, accidents, and fires
- Continued operation, protection and safety oversight
- Maintain stability within the community
- Assist in carrying out the recovery plan

Post Office

- Continued operation of fleet, and distribution of mail and deliveries

<u>Small Commercial:</u>

Pharmacies

- Enable prescriptions, and emergency care supplies be kept available to the public
- Enable food, water and essential supplies be kept available to the Village and area residents

<u>Residential:</u>

Nursing Homes, Eldercare Facilities, and other Senior Housing

- Maintain medical and home services for the elderly
- Preclude the need to evacuate elderly care patients
- Maintain power to the homes on life support served by Bus 2

Residential Customers (single and multi-family dwellings)

- 2,912 residential customers will receive power by virtue of being served by the same feeders as a critical load (Bus 2)

4.2 Characterization of Distributed Energy Resources

7-8 MW Gas Reciprocating Engine Generator

A proposed 7-8 MW or similar sized gas engine generator will be the heart of the RVC Microgrid. The capacity is sufficient to support all the critical and key loads within RVC and can be installed at the existing power plant and easily integrated into Bus 2. The proposed medium-speed engines have a very high efficiency at a relatively low cost. The unit would be equipped with black-start capability that will allow RVC to recover from a system interruption or emergency in a short period of time. During normal operations, the new generator could compete in the NYISO DAM. The new generator will dispatch whenever the DAM prices exceed the RVC engine's cost of generation, thereby reducing RVC's cost of purchased power. When dispatched, the generator will be operated at a full load heat rate of approximately 7,700 BTU/kWh. This heat rate is comparable to that of "mid merit" combined cycled power plants installed across Long Island.

Based on an analysis of the historic gas and DAM pricing for 2014 and 2015, the engine is predicted to competitively produce power approximately 2500 hours/year (see Table 4-1). In the years studied, the DAM prices exceeded $61/MWh (i.e., the calculated cost to produce power with the new generator based on historical 2014 RVC gas prices) approximately 2,502 hours in 2014 and exceeded $44/MW (based on historic 2015 gas prices) approximately 2,572 hours in 2015. Thus, the new generator has the potential of operating an estimated 2,537 hours per year on average which will yield approximately 19,028 MWh generated in normal operation mode.

During islanded mode, the new generator will run continuously to supply all of the critical loads. The average daily production of the generator will generally be near its maximum capacity of 180 MWh in order to serve as many customers as possible. Depending on the load demands of the critical customers during the major outage event due to climate, day of week, etc., the number of non-critical customers served will vary with service being provided on a rotation bases. The new black-start capable generator will also enable RVC to start existing generators to support any additional loads required during a major outage.

Table 4-1: Estimated Runtime Hours for New Generator

	Hours
2014	
2015	2,572
Annual Average	2,537
Potential Energy Produced (MWh)	19,028

Rooftop Solar PV

The RVC Microgrid will be served by solar panel assemblies on four municipal building rooftops offering the potential for generating an estimated total of 676 MWh per year. The solar panels will provide approximately 568 kW of clean renewable energy. During normal mode, each solar PV will supply power to the building it is located on. The amount of power supplied to the building will depend on the weather conditions in the area at any given time. Typically on Long Island, rooftop solar panels can generate approximately 17.5 kWh/ (ft^2 year) which results in approximately 675 MWh annually. Any power generated in excess of the buildings' loads will be delivered to Bus 2 to serve other loads on the Bus. During islanded mode, the solar panels will operate in a similar fashion. The generated power will be supplied to either their associated buildings, which have been identified as critical loads, or supplement the power needs to other critical loads on Bus 2 through the Microgrid system. Despite the fact that the solar panels will not be able to support a large portion of the critical loads in the Village, they provide a peak source of energy that requires no fossil fuel input, offsetting the need to obtain fuel oil during an emergency or outage event. Additional solar generation potential exists in canopy parking lots controlled by RVC.

4.3 Capacity Impacts and Ancillary Services

The new engine generator will provide 7-8 MW of clean, gas-fired generating capacity with state of the art Tier IV emission controls. The new engine will be the most efficient of the RVC fleet, and is expected to be permitted to run baseload, if necessary. As such it will be the lead engine for all operations. With the new solar panels and eight existing RVC generators (7 of which have operating limits due to air permit restrictions) the total generation capability will be approximately 36.4 MW (following retirement of engine 8 or restriction of engine 7 to black-start and station light and power). RVC's total generation capability will barely meet the Village's peak demand during non-summer months and be notably less than the Village's historic peak demand of 58 MW. With DSM this shortfall is expected to be reduced approximately 1.5-2 MW. To meet the Village's electric load during peak periods, RVC must start one or more of their on-site generators to pick up the remaining load. Due to their age and emissions profiles, these generators have Title V permits with limited operating hours, typically only 100 hours or less per year. Furthermore, three of the generators are considered emergency-only generators that cannot be used to meet peak loads > 45 MW. As a result, RVC would require a new fourth transmission line, to import approximately 30 MW or additional power to support the rising load demand within the Village. A new 4th transmission line has been projected to cost approximately $68M by PSEGLI.[9] Another option is to re-conductor the existing three transmission lines to increase the import capacity; PSEGLI/LIPA estimates this work to cost approximately $50M.[10] Therefore, the completion of the RVC Microgrid project will help defer a large amount of capital funds required to upgrade LIPA's existing transmission lines that serve RVC.

The RVC distribution system capacity and efficiency would be improved by the installation of capacitor banks on Bus 1 & 2. The installation of both fixed and switchable capacitor banks will improve the system's resiliency by ensuring operation of the distribution system at closer to unity power factor, thereby reducing voltage sags and swells, and reducing unnecessary current flow, especially during peak periods and islanded operation. The I^2R losses will be reduced through the distribution feeders by approximately 4 kW, which will reduce the RVC electric system operating costs by approximately $2,100 per year.

In addition to power factor correction, the RVC Microgrid will provide a variety of other ancillary services including reactive load support, voltage regulation, and black-start capability from the new generator that will improve the resiliency of the microgrid in islanded mode. The black-start capability will be essential during major power outages to allow RVC to recover in a short period of time. It is a necessity considering the two existing black-start units at RVC are connected to a different bus (Bus 1), have a history of failed black-starts, and the fact that a single fault on either Bus 1 or the bus-tie could prevent power from getting to the Village critical customers served by the Microgrid Bus. .

The RVC Microgrid project will have a smaller carbon footprint within the Village (over 7,000 metric tons of CO_2 per year) since one Distributed Energy Resource (DER) (solar PV) will have no emissions and the other DER will meet Tier IV emissions requirements. The efficiency and emissions of the new generator will be on par with the most efficient combined cycles located on Long Island. The pre- and post-SCR (Selective Catalytic Reduction) emission ratings are shown in Table 4-2. As part of the RVC Microgrid project, an SCR system and CO catalyst will be incorporated into the exhaust of the engine to help further reduce the emissions. Additionally, a continuous emission monitoring system (CEMS) will be located in the stack for continuous monitoring and reporting. The low emission ratings from this new generator will also send a message to the public that investing in new generators is an important step in reducing the Village's carbon footprint. It also supports a vision where a scaled-up version of the RVC Microgrid might eventually have enough capacity to support all the customers in the Village.

[9] Source: Excel Spreadsheet from PSEGLI to RVC. Excludes additional project cost e.g. land, easements etc.
[10] Source: Excel Spreadsheet from PSEGLI to RVC

Table 4-2: Emissions Rating for 7-8 MW Gas Fired Engine Generator

	Pre SCR (lb./MWh)	Post SCR (lb./MWh)
NO_x	3.2	0.125
CO_2	1042	891
SO_2	N/A	N/A
PM	0.088	0.088

*Emissions based on operating at 100% load in an environment of 77F @ 30%RH

The incorporation of the high-efficiency reciprocating engine will also include a small combined heat and power (CHP) system. This CHP system will be used to assist RVC's existing boiler that currently maintains the jacket water warm for all the on-site engine generators. Currently, the boiler operates intermittently consuming approximately 42,000 gallons of fuel oil a year. Based on the specifications of the existing boiler and the fact that approximately 3,500 gallons of fuel oil is being consumed each month, the boiler has an estimated load factor of 50% (i.e., annual runtime of approximately 4,380 hours). As previously discussed in Section 4.2, the new generator has the potential of operating approximately 2,537 hours per year. During these run hours the heat from the new engine will be used to heat the other engine jacket water loops, eliminating the demand on the oil-fired boiler. This will reduce the amount the boiler needs to operate by approximately 58%, and result in an estimated annual fuel savings of 24,360 gallons. At a fuel cost of approximately $2/gal, the CHP system will displace an estimated $48,720 per year in fuel oil costs and 150 metric tons per year of CO_2 emissions.

4.4 Project Costs

7-8 MW Gas Reciprocating Engine Generator

The new 7-8 MW or similarly-sized reciprocating engine generator is the most costly item of the RVC Microgrid project. As part of the feasibility study, RVC evaluated various similarly-sized reciprocating engines. This price includes all the additional ancillary equipment necessary to run the machine as well as an SCR for NOx reduction and CO catalyst. The emissions controls will provide top of the line emissions control technology that will help regulate the release of NOx, CO, CO_2 and VOC to the environment and allow RVC to obtain a Title V permit for these engines without restriction. This will enable RVC to operate the new generator more often than their existing generators and allow RVC to generate more savings by competing with the DAM energy market. To obtain the Title V permit modification, the new generator will require permitting consultants/engineers, dispersion modeling and an environmental assessment form. In addition, a gas compressor is required to boost the utility gas to a higher inlet gas pressure (65-80 psig) (which is higher than RVC's existing generators). Therefore, RVC will need to purchase 2 x 100% (for redundancy and reliability) gas compressors that will cost an additional $1.3M installed. In islanded mode, the new generator will consume approximately 6,390 scf/MWh of natural gas. If operating at full load for 24 hours a day, the new generator will consume 1.15 million scf/day of natural gas. Additionally, the new generator will have a fixed annual O&M cost of approximately $30,000, which is consistent with the typical O&M costs of the existing generators at RVC, and a variable annual O&M cost of $32.50 per run hour and $7 per MWh.

The new generator will be able to generate revenue streams by competing with the NYISO DAM during normal routine operation. The new generator will be able to operate continuously in islanded mode. As previously discussed in Section 3.5, the new generator could yield approximately $1.6M per year cost savings due to the new engine's low heat rate compared to the average regional cost of purchased power. The potential revenue stream (cost reduction) comes from (a) competing in the DAM by dispatching whenever the DAM price exceeds the engine's cost of generation at the time; and (b) from capacity sales to the NYISO ICAP market. Likewise, as previously discussed, the CHP system will be able to reduce the fuel consumption of the water jacket boiler and save approximately $49,000 per year. This provides the RVC Microgrid with a payback period of approximately 7 years. This is attractive considering its ability to support all of the Village's critical facilities during a major outage event and continue to provide annual financial benefits throughout its equipment life of 30 years.

Rooftop Solar PV

The rooftop solar PV systems of the RVC Microgrid will cover four municipal buildings for a total of 38,500 ft^2. As shown in Table 4-3, this equates to approximately 568 kW of renewable solar generation. At an installation price of approximately $3.67 per watt (typical rooftop solar cost on Long Island including equipment and installation), the overall cost is shown in Table 4-3. Prior to installation, an engineering evaluation must be conducted to confirm the structural integrity of all four buildings to withstand the dead weight of the solar panels and associated wind loads. Therefore, an additional $100,000 must be added to the total installation costs of the solar panel units for a structural analysis. As shown in Table 4-4, the solar panels have associated O&M costs. The majority of the cost is for maintaining the cleanliness of the solar panels, approximately $12,000. Typically, the inverters need to be replaced every 5-10 years which results in a total fixed O&M cost of approximately $17,000 per year.

Table 4-3: Rooftop Solar Installation Cost Estimate

Rooftop Solar PV	
Available Roof footprint (ft^2)	38,500
Generation Capability (kW)	568
Installed Solar PV Costs ($/W)	$ 3.67
PLANNING & DEVELOPMENT	**Costs**
Structural Analysis	$100,000
EQUIPMENT & INSTALLATION	
Solar PV Installation	$2,100,000
CONTINGENCY	**$220,000**
TOTAL:	**$2,420,000**

Table 4-4: Rooftop Solar Fixed Annual O&M Cost Breakdown

	Costs ($/year)
Scheduled Maintenance/Cleaning	$12,000
Inverter Replacement Reserve	$5,000
TOTAL	**$17,000**

The solar panels will offset the purchase of generated electricity. The capital cost will be subsidized through an incentive program. At an average RVC electricity purchase price of $0.065/kWh, the solar panels can generate an annual savings of approximately $44,000 per year for the first 10 years. Likewise, through an incentive program at $0.10/kWh, a total of approximately $67,600 can be generated per year for the first 10 years. Therefore, the solar panels will generate approximately $111,600/year for the first 10 years and $44,000/year for the following years. This puts the simple payback at 32 years with the incentive program. While the simple payback is high, other benefits not captured here include: (a) reduced reliance on fossil fuel; (b) zero emissions; (c) use of a renewable fuel source; and (d) reduced electric daytime peak (summer) demand. The solar PV installation will offer a 'lead by example' initiative for expanding the solar renewable energy installations throughout the Village, such as above parking lot canopies as previously discussed.

Capacitors

To improve the operating power factor and thereby increase the overall distribution efficiency of the microgrid, particularly in islanded mode, RVC will be purchasing 300 kVAR capacitor banks to install on Bus 1 and 2. As shown in Tables 4-5, there will be a total of 13 fixed banks, at a unit price of $2,845, and 18 auto (switchable) banks, at a unit price of $8,244. The capacitor banks will be installed and maintained by RVC staff. The installation, operation and maintenance will be performed in-house by RVC staff. The locations of the capacitor banks will be determined in three or four stages. Voltage records will be used to identify the location of the largest sags and swells on the system, as well as the quantity (size) and type of capacitor banks to have the greatest beneficial effect. Once installed, the system voltages across the system will then be tracked to determine to next best target locations and so on. This will optimize the effectiveness of the capacitor banks.

The estimated labor cost to complete the installations in-house is approximately $72,000 based on RVC's Electric Department estimates. This represents an estimated labor savings of over $94,000, if RVC installs the capacitor banks versus enlisting a third party installing them (see Table 4-5). The total cost of all the equipment and labor is approximately $320,000 (Table 4-6). The annual cost to operate and maintain the capacitor banks is estimated at $5,000.

Table 4-5: Estimated Costs to Install Recommended Capacitor Banks

		FIXED	AUTO	TOTAL
1	**Number of Banks**	13	18	32
2	**Hours to Install**	6	10	n/a
3	**# of workers**	3	3	n/a
4	**Cost per Bank**	$ 2,845	$ 8,244	n/a
5	**Cost for Capacitor Banks**	$ 36,985	$ 148,392	$ 185,377
6	**Labor Cost if by RVC**	$ 21,762	$ 50,220	$ 71,982
7	**Labor Cost if by 3rd Party**	$ 35,100	$ 81,000	$ 166,100
8	**Equipment to Install if by RVC**	$ 500	$ 1,100	$ 1,600
9	**Equipment to Install if by 3rd Party**	$ 2,925	$ 6,750	$ 9,675
10	**Total Cost if by RVC (line 5 + line 6 + line 8)**	$ 59,247	$ 199,712	$ 258,959
11	**Total Cost if by 3rd Party (line 5 + line 7 + line 9)**	$ 75,010	$ 236,142	$ 311,152

*A bank includes 3 capacitors, 100 kVAR per phase

Table 4-6: Capacitor Bank Installation Cost Summary Using RVC Labor

PLANNING & DEVELOPMENT	**Costs**
Load Flow Study & System Voltage Variation Survey	$30,000
EQUIPMENT & INSTALLATION	
Fixed Bank Equipment	$37,000
Fixed Bank Installation	$22,000
Auto Bank Equipment	$150,000
Auto Bank Installation	$51,000
CONTINGENCY (10%)	**$30,000**
TOTAL	**$320,000**
Annual Fixed O&M	**$5,000**

Demand-side Management

The four demand-side management programs that will be implemented into the RVC Microgrid will be the Smart Thermostats (for both residential and commercial applications), the Utility Reporting Information, and the School Pledge Programs. As shown in Table 4-7, the total installed costs for all four programs equates to $512,500 ($185,100 cost at Year 1) with an annual fee of $14,500 for the Smart Thermostat and School Pledge Program. The economic breakdown for each individual program is discussed below.

Smart Thermostats (Residential and Commercial)

This program has a one-time setup/training fee of $16,800 ($8,400 each) as well as an annual operating expense of $20,000 per year ($10,000 each). The program will require additional outreach costs of approximately $30,000 per year ($15k/program) to increase the participation rate of customers. Since the Smart Thermostat units are very modular in design, they can be easily integrated into both existing residential and commercial heating and cooling systems. The Smart Thermostats program has the highest first year program costs for residential customers due to the high cost per unit of $180 per participant, as well as the large percentage of the RVC residential customers expected to participate in this program. While the residential Smart Thermostats program has the highest initial investment, it also has the potential of generating $94,700 per year in peak and annual energy savings at year one (5% participation rate) due to the amount of customers that can participate in the program.

RVC has many restaurants, diners, pubs, etc., that drive up the Village's peak load demand in the late afternoon and evening, which are also expected to participate. The load profile is shown in Figure 2-1. If 20% of the current total of 1,640 commercial customers in RVC participates in this program, the total installed cost would be $67,418 with the potential of generating $146,900 in savings per year. With commercial facilities representing a large percentage of the critical facilities served by the RVC Microgrid, the incorporation of these smart thermostats would be a significant asset in reducing the Village's afternoon load.

Utility Reporting Information

Out of all four DSM programs, the Utility Reporting Information program by a National Vendor, a company that provides software to a utility and their customers, is projected be the most valuable energy-saving program in the RVC Microgrid project. It provides the lowest cost per participant of the four programs evaluated and has the highest potential for customer participation at nearly 9,000 customers. This program will allow RVC to generate approximately $651,100 per year in potential savings for an initial investment of $44,500. It is a simple program that will allow RVC, which is the owner of all the distributed energy resources in the RVC Microgrid, the ability to communicate with each customer individually to help regulate the demand throughout the Village. The program also allows customers to obtain their own real-time energy consumption rate and identify specific ways they can reduce their load to generate energy savings. There are no O&M costs associated with this program and no required annual fees.

School Pledge Programs

The school pledge program has the lowest initial investment of $39,600 out of all four programs due the low cost per participant at $8. However, the program only has a potential of generating $37,800 per year since only one school will be participating. Thus, despite the fact that the amount of savings this program will produce is considerably lower than the other programs, the payback period is still very attractive and the main reason the program will be implemented as part of the RVC Microgrid project.

Overall, all four programs together have the potential for generating approximately $811,200 in savings per year at year one and $900,000 in savings per year at year five with 50% of that coming solely from the Utility Reporting Information program. Once installed and operating, the annual O&M costs will be approximately $44,500. Additionally, all the DSM programs propose an attractive payback period that will be beneficial for the RVC Microgrid as well as the RVC customers.

Table 4-7: DSM Program Cost Estimates

	Average Annual Program Participants Added	Total Number of Projected Participants at Year 5	Equipment & Installation Cost ($/participant)	One-time Program Setup fee + training [$]	Annual Fees/ Operating Expenses [$/yr.]	Annual Community Outreach Program [$/yr.]	Total Year 1 Program Cost	Customer Utility Bill Savings ($/year)	Value of Reduced Capacity to RVC ($/year)	Value of Reduced Energy Purchase by RVC ($/year)	Total RVC Avoided Cost ($/year)	NPV of DSM Program (at Year 5 Participation Rate)
Smart Thermostat (Residential)	374.4	1,872	$180	$8,400	$20,000	$15,000	$95,800	$73,400	$19,400	$1,900	$21,300	$1,880,900
Smart Thermostat (Commercial)	65.6	328	$180	$8,400	$20,000	$15,000	$40,200	$5,000	$20,400	$2,000	$22,400	$562,600
Utility Reporting Information	8670	8,893	$5	$0	$0	0	$44,500	$294,200	$324,900	$31,900	$651,100	$3,060,000
School Pledge Program	n/a	n/a	$8	$0	$4,500	n/a	$39,600	$29,700	$7,300	$700	$37,800	$141,500
TOTAL	**N/A**	**N/A**	**N/A**	**$16,800**	**$44,500**	**$30,000**	**$220,100**	**$402,300**	**$372,000**	**$36,500**	**$811,200**	**$5,645,000**

Overall Costs

As shown in Table 4-8, the initial planning and design costs for Phase 2 of the NY Prize is expected to cost approximately $1.7M. The majority of the Phase 2 costs are for the design and permitting of the new generator. For Phase 3, the overall equipment and installation costs, including a 10% contingency, for the entire RVC Microgrid project is shown in Table 4-8 with an annual O&M cost of approximately $96,500. The RVC Microgrid has the potential of generating annual savings as shown in the last row of Table 4-10. This results in an attractive simple payback period of 5.5 years. The plan for the RVC Microgrid is that it will be owned, operated and maintained by the RVC Electric Department. Due to the large cost for the new generator, RVC is open to exploring opportunities in which a third party would fund the purchase and installation of the new generator. The new generator will be located at the RVC Power Plant, and be operated and maintained by RVC staff. Additionally, RVC is investigating opportunities to partner with other NY Prize winners with the hopes of reducing the purchase pricing of the equipment to achieve economies of scale.

Table 4-8: Overall RVC Microgrid Costs

		TOTAL
PHASE 2	Initial Planning & Design Costs	$ 1,675,000
PHASE 3	Equipment & Installation Costs	$ 11,881,000
	CONTINGENCY (10%)	$ 1,206,000
	Project Costs	$ 14,762,000
OPERATIONAL	Annual O&M	$ 96,500
	Revenue Stream ($/year)	$ 2,653,100

Benefit Cost Analysis

As part of the NY Prize Stage 1 Feasibility Study, Industrial Economics, Inc. (IEc) conducted a screening-level Benefit Cost Analysis (BCA) of the RVC Microgrid as shown in Appendix C. The analysis considered 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.

For Scenario 1, as seen in Table 4-9, the overall costs of the RVC Microgrid project are estimated at $28.9 M (including NPV of fuel, O&M and emissions “damages”) while providing approximately $140 M in benefits to the Village. Therefore, the net benefits of the RVC Microgrid are approximately $111 M. The results indicate that even if there were no major power outages over the 20-year period analyzed, the project’s benefits to cost ratio would be 4.85. An analysis was conducted on the potential of the RVC Microgrid to mitigate the impact of major power outages (Table 4-10) based on the number of days and probability of the event. The benefits of a one-day major power outage each year over the 20-year analysis period is approximately $43 M in present value terms with a total benefit to cost ratio of 6.34. Reducing the probability of the event to 50 percent still provides a benefit of $21.6 M in present value terms. As the duration of a possible event increases, the RVC Microgrid project becomes more valuable. The breakdown of the costs and benefits is shown in Table 4-9. IEc has stated that their analysis is based on data collected through 28 studies of electric utility customers which may or may not reflect the characteristics of RVC’s proposed Microgrid. For example the RVC Microgrid will not serve customers in any construction, manufacturing, or mining sectors. Instead, RVC customer base is more retail, small commercial, residential, institutional and public administration sectors which typically have substantially lower cost per power quality events. Assuming 7 power quality events per year as the input to the model, the benefits from power quality (stability) improvements for the RVC Microgrid are shown below. The avoided PSEGLI/LIPA transmission upgrades of $50M are included in the "Transmission/Distribution Capacity Cost Savings'. The BCA results presented here reflect both these changes from the original BCA model performed by IEc which can be found in Appendix C.

Table 4-9: BCA Scenario 1 Results

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,250,000	$110,000
Capital Investments	$13,000,000	$1,010,000
Fixed O&M	$1,090,000	$96,500
Variable O&M (Grid-Connected Mode)	$941,000	$83,100
Fuel (Grid-Connected Mode)	$6,870,000	$606,000
Emission Control	$941,000	$75,900
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$4,790,000	$313,000
Total Costs	**$28,882,000**	**$2,294,500**
Benefits		
Reduction in Generating Costs	$8,150,000	$719,000
Fuel Savings from CHP	$271,000	$23,900
Generation Capacity Cost Savings	$18,100,000	$1,600,000
Transmission/Distribution Capacity Cost Savings	$50,000,000	$4,410,000
Reliability Improvements	$11,600,000	$1,030,000
Power Quality Improvements	$45,600,000	$4,020,000
Avoided Emissions Allowance Costs	$4,090	$361
Avoided Emissions Damages	$6,260,000	$408,000
Major Power Outage Benefits	(see Table 4-11 below)	(see Table 4-11 below)
Total Benefits	**$139,985,090**	
Net Benefits	**$111,103,090**	
Benefit/Cost Ratio	**4.85**	

Table 4-10: BCA Scenario 2 Results

DAYS	100% PROBABILITY COST TO BENEFIT RATIO	100% PROBABILITY MAJOR POWER OUTAGE BENEFITS PRESENT VALUE OVER 20 YEARS ($2014)	100% PROBABILITY TOTAL BENEFITS	50% PROBABILITY COST TO BENEFIT RATIO	50% PROBABILITY MAJOR POWER OUTAGE BENEFITS PRESENT VALUE OVER 20 YEARS ($2014)	50% PROBABILITY TOTAL BENEFITS
1	6.34	$43,159,000	$183,144,090	5.59	$21,579,000	$161,564,090
2	7.79	$84,918,000	$224,903,090	6.32	$42,459,000	$182,444,090
3	9.23	$126,678,000	$266,663,090	7.04	$63,339,000	$203,324,090
4	10.68	$168,437,000	$308,422,090	7.76	$84,219,000	$224,204,090
5	12.12	$210,197,000	$350,182,090	8.49	$105,099,000	$245,084,090
6	13.57	$251,957,000	$391,942,090	9.21	$125,978,000	$265,963,090
7	15.02	$293,716,000	$433,701,090	9.93	$146,858,000	$286,843,090

Figure 4-1 is a stacked column depiction of the breakdown of the costs and benefits associated with the RVC Microgrid. As shown, the majority of the costs for the project are the capital investments and fuel costs (grid-connected mode). The bulk of the capital investments are due to the purchase of the new 7-8 MW generator. However, the new generator is the heart of the RVC Microgrid and, considering RVC already has a power plant, a staff of operators, and an existing (empty) engine bay; the relative costs are very low compared to those associated with a greenfield microgrid installation. The magnitude of the fuel costs can be misleading considering the fact that RVC will actually be generating saving for approximately 2500 hours/year by locally producing power at a lower cost than their normal method of purchasing power from the DAM.

It is noted that the majority of the benefits of the project comes from the distribution capacity cost savings and the power quality improvements since the RVC Microgrid project covers a significant amount of critical and non-critical customers. The distribution capacity cost savings includes the deferral of the re-conductoring of the existing transmission lines required by PSEGLI/LIPA ($50 M). This work includes upgrading transmission poles & towers as part of the re-conductoring project. The power quality improvements 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). Power quality improvement benefits are high due to the fact that the RVC Microgrid is comprised mostly of large (>50 annual MWh) and small (<50 annual MWh) commercial and industrial facilities. As shown in Table 4-11, in the IEc BCA model, the average customer interruption cost per annual kWh for small commercial/industrial customers is one hundred times higher than for residential customers; for medium to large commercial and industrial customers, this number is ten times higher. The added capability delivered by the RVC Microgrid to support a large population of these customer segments, in both islanded and normal mode, has produced a large benefit by preventing future costs associated with power interruption.

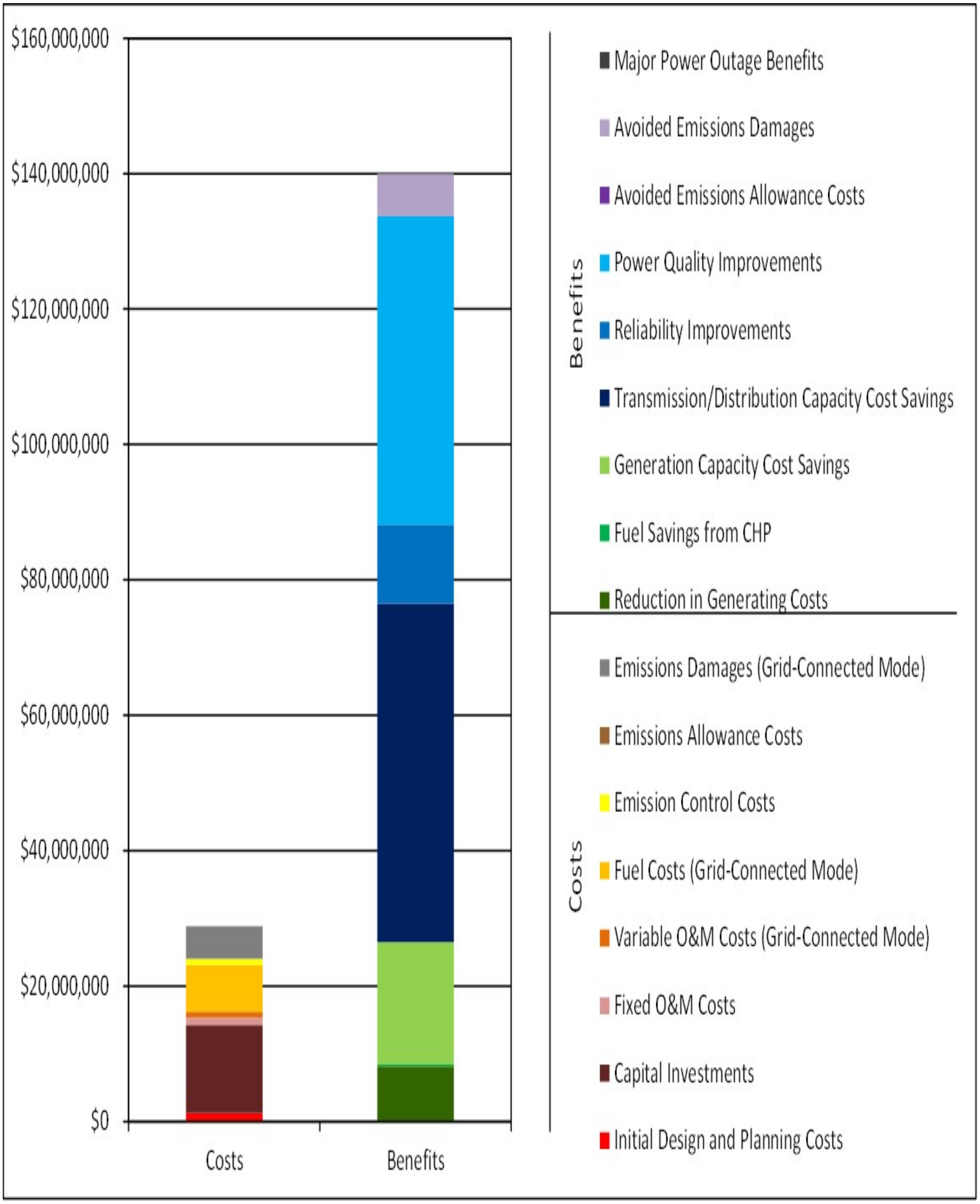


Figure 4-1: BCA Breakdown

Table 4-11: IEc BCA Model Parameters for Estimating Customer Interruption Costs

Values are estimated for the average-sized customer in each rate class, and are in 2008 dollars.

MEASURE OF INTERRUPTION COST FOR SUMMER WEEKDAY AFTERNOON	COST OF MOMENTARY INTERRUPTION ($)
Medium and Large C&I	
Cost Per Event	$11,756.00
Cost Per Average kW	$14.40
Cost Per Un-served kWh	$173.10
Cost Per Annual kWh	**$0.002**
Small C&I	
Cost Per Event	$439.00
Cost Per Average kW	$200.10
Cost Per Un-served kWh	$2,401.00
Cost Per Annual kWh	**$0.023**
Residential	
Cost Per Event	$2.70
Cost Per Average kW	$1.80
Cost Per Un-served kWh	$21.60
Cost Per Annual kWh	**$0.0002**
Source: Sullivan, Michael J. et al. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.	

4.5 Costs to Maintain Service during a Power Outage

The customer's costs for emergency services were captured in the customer surveys. The RVC Microgrid has a few critical customers who own and maintain backup generators capable of providing some emergency power. Most are sized to provide emergency lighting and elevators, but are not sufficient for maintaining 100% of their needs.

Of the facilities with existing back-up generators, the hospital requires additional emergency measures during a power outage in order to maintain operation. This includes the additional electrical staff necessary to operate the backup generation.

The critical facilities without backup generation require additional equipment in order to maintain operations. From the questionnaire results, and estimates from temporary emergency generator vendors, the costs to operate the facilities with temporary power during outages were determined. This includes the weekly rental of the backup generators (including shipment), cost of installation, maintenance and removal of the generators by RVC staff, cost of fuel for the generators, cost of weekly rental of containment for the generators, and cost of cables. Additional costs include the cost of spoilage at grocery stores (after 4 hours), cost of loss in customers at gas stations and the cost of car accidents.

Since the RVC Microgrid is on Bus 2 of the RVC electrical distribution system, all costs to operate and maintain the Microgrid during islanded operation would be comparable to maintain and service the distribution system and power plant during normal operation. RVC staff would be available to maintain the Microgrid. Additional overtime or specialty contractors may be required, on occasion, depending on the duration of the islanded operation.

Task 5. Conclusions and Recommendations

5.1 Conclusions

The Village of Rockville Centre's Electric Utility Department was established in 1893 and supplies approximately 10,000 electric customers (25,000 residents) with electricity. RVC imports much of its power from the New York Power Authority and the New York Independent System Operator through three transmission lines, each capable of importing 15 MW of energy. RVC has its own power plant with 8 generating engines, however 3 of the engines are limited to emergency use only under the Title V Air Permit. Four of the five remaining engines are limited to 50 hours/year for non-emergency use. Of the six 4 kV distribution busses that serve RVC, Busses 1 & 2 primarily feed the downtown area of the Village along with most of the Village's critical customers.

The Village's proximity to the south shore of Long Island makes it susceptible to outages caused by major coastal storms, Nor'easters, blizzards, ice storms and Category 2 and 3 hurricanes. Superstorm Sandy left customers in the Village without power from 3-7 days. The 3 transmission lines that supply the Village were interrupted. The power plant was used to supply power to customers on substations 1, 2, 3 and 4 during this and other emergencies. The other substations and customers served by them were without power until the transmission was restored (they have no generation connected to them).

With a historic peak load of 58 MW and anticipated growth of 1% per year over the next 10 years, reliance on the LIPA transmission system and susceptibility to major storms, RVC is looking for cost effective, efficient and environmentally sound ways to maintain the level of electric service for our customers. RVC has determined that a majority of the Village's critical facilities are all located on Bus 2. This includes the Electric Department offices and Power Plant, Police Department, 2 firehouses, the Water Department including water tanks, a hospital and approximately a third of the traffic signals in the Village. During prolonged outages, it is critical that these facilities continue to receive power. The customers suppled from Bus 2 also include many key facilities such as 3 pharmacies, 3 supermarkets and 2 gas stations which can serve not only the Village residents but residents from neighboring communities. During the aftermath of Hurricane Sandy, because the Village was able to provide power to critical and key customers, visitors from neighboring areas came to RVC to take advantage of gasoline stations, refrigerated food services, restaurants, pharmacies and other services available in the Village. The ability to serve a larger customer base directly, and/or indirectly, provides great value to the RVC community and the neighboring areas. There are also approximately 2900 residential customers on Bus 2. The installation of a Microgrid on Bus 2 would benefit other residents in the Village as well as neighboring communities by keeping these critical and key facilities operating during major storms and system emergencies.

The key objectives of the RVC Microgrid Project are to improve the reliability of the power supply, maintain critical services for the community during outages, improve the power factor, incorporate demand side management (DSM) to help lower peak load, improve the resiliency of all the customers in the Village and incorporate some green resources such as solar power.

Through this Feasibility Study, the Village has determined that the best way to achieve these objectives is to install a new 7-8 MW generator with black-start capability connected to Bus 2. Currently the only black-start generators are connected to Bus 1. By installing new generation on Bus 2, RVC would be able to move one or more emergency generators to serve portions of the other busses (which are currently without generation). This would enable customers from these busses to receive rolling power during major storms and system emergencies.

RVC would also utilize rooftop solar PV which would provide 568kW of power. Several DSM strategies such as Smart Thermostats, Energy-Efficiency Rebate Programs and School Pledge Programs which will reduce peak load will also be deployed.

The proposed RVC Microgrid is a highly cost effective enhancement to the RVC electric utility system that will improve power availability, power quality and system resiliency during outages and emergencies for a large number of critical and key customers. This is demonstrated by the high benefit-to-cost ratio of 4.85 calculated by the IEc BCA model. By utilizing a significant amount of existing electric distribution infrastructure owned and operated by RVC, the Microgrid can be implemented at a very modest cost of approximately $15M. The RVC Microgrid customer base is very large, providing a broad base of critical services (hospital, police, fire, water etc.) and key essential services including medical, pharmacies, gas stations, food stores, restaurants, traffic safety, and street lighting. Providing non-interrupted power to these commercial, institutional and government facilities, plus approximately 2900 residential customers also served by the RVC Microgrid will benefit more than just the RVC customers connected to the Microgrid. It will also benefit the approximately 7,100 remaining RVC electric customers and the neighboring communities who likely would also be impacted by the major storms and emergencies. Since the Microgrid will include new distributed energy resources (DERs) in the form of a reciprocating engine, solar photovoltaic and demand side management programs, the Microgrid will also defer the $50-$68 M capital expense that would be needed to upgrade the PSEGLI transmission lines. The transmission upgrades are needed to increase the power import capability from the present limit of 45 MW to 60-70 MW in order to accommodate the Village's historic peak summer capacity of 58 MW and future load growth. The addition of fixed and switchable capacitors to the RVC Microgrid will improve the distribution system efficiency by raising the average power factor of the system closer to 1.0 and thereby lowering the resistive losses in the system.

The proposed RVC Microgrid includes a 7-8 MW gas reciprocating engine with a small CHP, 568 kW of rooftop solar PV and an aggressive demand side management program that is expected to yield up to 2 MW peak reduction in 5 years throughout the Village. In addition, capacitors will be utilized to improve the power factor on Bus 2, thereby improving the deliverability and distribution system efficiency, avoiding voltage sags. The Microgrid aspects are responsive to Governor Cuomo's Reforming the Energy Vision (REV) to have 50% of New York's energy generated by renewable resources by 2030. Other unique aspects of the RVC Microgrid include (a) utilizing RVC's existing Bus 2 cabling, a significant portion of which is underground. Underground cabling makes the islanded grid resilient to wind, rain, snow and ice; (b) During outages or system emergencies, the ability to black-start the reciprocating engine allows for quick restoration of power and islanded operation; (c)The natural gas primary fuel source is extremely reliable with no historical interruptions. For example there was no interruption of the gas supply or drop in pressure during Superstorm Sandy; (d) 120,000 gal of on-site storage of Ultra Low sulfur Diesel (ULSD) is currently available at the RVC power plant; (e) The Village plans to augment its response capability by purchasing and/or leasing portable engine generators that can be transported when needed in emergency situations; (f) an existing power plant staffed with personnel familiar with reciprocating engine operation and maintenance (g) an available engine foundation where an old engine was removed years ago and a new engine can be installed (h) the recently awarded DOE REDI grant will provide RVC with a new SCADA system that will assist in monitoring and maintaining operations during routine operation and islanded mode.

In addition to providing reliable power during islanded operation, the new engine will provide lower cost peak energy for approximately 2,500 hours/year. This unit is expected to qualify for NYISO capacity payments as a "behind-the-meter resource".

The RVC Microgrid will be owned, and operated by RVC. The RVC Microgrid will not require the purchase or lease of any land. It is not anticipated to meet any legal impediment with implementation. Regulatory approval for Air Modeling and modifications to the NOx RACT Plan or Title V Air Permit along with the PSC Rate Case are required. The RVC Microgrid Project is within the control of RVC and its subcontractors (e.g., engineers, equipment providers, installation contractors and other consultants). The Microgrid does not require the implementation of any third party infrastructure (e.g. PSEGLI) except for a short gas main extension. No additional staffing is required since the existing, experienced RVC Electric Department staff will operate and maintain the Microgrid during normal and islanded operation. The Electric Department can selectively distribute the power to different circuits on Bus 2 (the proposed Microgrid) to ensure critical customers are being served during transmission outages.

The RVC Microgrid is a seamless integration into the existing RVC electric distribution system that allows for modularity in design and future expansion. The proposed Microgrid infrastructure for Phase 1 of the RVC Microgrid identifies the most cost effective way to create a resilient electric system for the Village to combat any further interruptions of the transmission system that feed RVC. It allows for expansion and future investments that can be easily implemented to increase the overall population served by the Microgrid and further benefit the Village. Nonetheless, the RVC Microgrid provides a vision for other utilities in the State of New York to further develop their distribution systems to better serve and protect their customers from potential outages and system emergencies.

NYSERDA funding the RVC Microgrid development project provides the best way for New York State to publicly display their efforts to avoid future power interruptions of large populations from natural disasters and system emergencies at a very low cost. Since RVC already has ownership and control over the distribution lines in the Village, existing fuel storage, an existing (empty) engine bay, and an experienced staff to operate and maintain the proposed equipment, a significant amount of the costs that many Greenfield projects may have will not be applicable to RVC. RVC has the ability to become a standalone and self-sustaining Village during a major outage so that, not only will the Village recover in a timely fashion, but residents from neighboring communities will be able to come to RVC to utilize the critical supplies and/or services supplied by the RVC Microgrid. **Therefore, RVC is an ideal candidate for developing a self-reliant Microgrid.**

5.2 Recommendations

The RVC Microgrid should be constructed and operated utilizing the following components:

- **A new state of the art reciprocating engine capable of approximately 7-8 MW (gas or dual fuel depending on permit process results)**
- **Recover heat from the new engine's jacket water to be used to displace the heating of the jacket water loop currently provided by the Plant oil fired boiler (to assure the RVC engine fleet is in "hot standby")**
- **Install an estimated 568 kW of rooftop PV solar panels on RVC controlled facilities (pending structural analysis findings)**
- **Install approximately 13 fixed and 18 switchable 300 kVAR capacitors to improve the electrical distribution system efficiency**
- **Promulgate proven demand side management programs, smart residential thermostats, smart commercial thermostats, utility reporting and a school pledge program**

As RVC continues on to the remaining phases of the NY Prize, there are several aspects of this first phase that were discussed and analyzed and will need to be evaluated in further detail.

Battery Storage: Battery storage systems were investigated in this phase but excluded from the RVC Microgrid because of their very high capital costs which resulted in payback periods well beyond the replacement life of the batteries. Battery storage could be a valuable resource to (a) store off-peak power for use during on-peak periods; (b) reduce RVC's need to run their generator fleet, resulting in reduced emissions; (c) avoid power purchases during peak pricing (which may not be coincidental with RVC's peak needs); (d) solar energy storage during off-peak periods (holidays, off hours) (e) load shifting, and (f) provide additional voltage regulation during islanded operation. Battery storage systems have gained a lot of interest over the recent years as they continue to be implemented into commercial systems. The price of battery storage systems are predicted to drop significantly over the coming years with improving technology and economies of scale. RRT is currently involved in a battery storage system design in NYSIO Zone J which could reveal application synergies. **It is recommended that NYSERDA, working with NYPA and other State agencies (SUNY etc.), should establish a Municipal and School ("M & K") Storage Program to help lower the soft costs of storage and realize purchasing discounts for equipment and installation service by aggregating installations across multiple entities.** This would help RVC and other government agencies across NY State conform further to the Governor's Reformed Energy Vision and his mandate of meeting 50% of energy needs with renewable resources by 2030.

PV Solar: While solar PV prices have continued to drop over the years, the installation of canopy solar PV in the RVC parking lots do not provide an attractive payback for the inconvenience of losing parking spaces and exposure to vandalism. **It is recommended that NYSERDA, working with NYPA and other State agencies, should establish an "M" Solar Program for government facilities, similar in concept to the "K" Solar for schools in NYS.**

The program could benefit State, County, City, Town, Village, Federal and other government facilities to help lower the cost of implementation of solar PV systems across NY State. This would help RVC and other government agencies conform further to the Governor's REV.

Capacitor Study: A load flow study (voltage drop study) should be conducted during the design stage to better determine the target location of the capacitors, i.e. where the voltage sags are most severe. The installation of the fixed and auto capacitor banks should then be phased in over several years, targeting the feeders where there are large reactive power loads first. Once it is understood how the system reacts, the next group of capacitor banks can be added. This will prolong the purchase and installation of all the capacitor banks but it is the best method for optimizing the installation and performance of the capacitor banks.

DSM & Energy Efficiency Programs: The paybacks provided for the DSM programs recommended were based on an estimated percentage of the customers participating in the program to obtain a reduction of approximately 1.5-2 MW. After the first phase of deployment of these DSM programs within the Village, the electric usage profile within the Village must be tracked to ensure load demand drops are indeed a result of the DSM program and not another reason.

Organic Rankine Cycle: Supplementing the power plant jacket water boiler with CHP using the new proposed generator is a good way to make use of the waste heat, boosting the overall efficiency of the generator, and reducing RVC's fuel oil expenses for the boiler. However, the heat load of the jacket water systems in the RVC power plant is very low. The use of an organic rankine cycle was evaluated in this phase of the project but found not to be cost effective. As the project continues, new technology or different methods of recovering waste heat may become available and should be evaluated as a potential option for the CHP component.

Microgrid Scalability: **The RVC Microgrid is easily scalable, which is one of the major benefits of NYSERDA funding a municipally owned electric utility.** RVC currently has eight existing generators, three of which are designated as emergency only, and 4 with very limited operating restrictions. The Microgrid can easily be expanded by replacing these limited capacity generators with cleaner, more efficient, generators and approximately 6 MW of canopy solar to provide power to RVC and further improve its resiliency). As mentioned earlier in this report, engine 8 will be retired and engine 7 will be limited to black-start and station light & power during emergencies as part of this project.

Best Practices: It is recommended that the winners of Phase 2 and 3 be encouraged to share best practices and encourage team work amongst them. This can result improved methods, new ideas and lower equipment, design and possibly installation costs through economies of scale and cooperation.

IEc Model Improvements: RVC believes that the IEC Model, in the case of larger microgrids, may overstate the costs of power quality disturbances. This is based on our understanding that the model assumes that electrically all the customers on the microgrid are powered from a common circuit. In larger microgrid projects that have multiple circuits, such as the RVC Microgrid, a power quality disturbance on one circuit will not necessarily impact the customers on adjacent circuits. Also as stated on page 7 of the IEC report, "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[11]. The distribution network within the microgrid is unlikely to be completely invulnerable to such interruptions in service. This assumption will lead the BCA to overstate the reliability benefits the project would provide." Hence the number of power quality events was reduced from 27 in the original IEc model to 7 in the revised RVC BCA presented in this report. In addition, $50M was added to the benefit category "transmission/distribution capacity capital savings" that would be avoided with the Microgrid construction and operation. This change was made in consultation with IEc personnel.

In addition, the IEc model does not measure or assess the impacts of outages during major storms (e.g. hurricane Gloria, Bob and Superstorm Sandy) or major system emergencies (e.g. Northeast blackout, Aug 2003). Per IEc BCA footnote no 2, in Appendix C, "the BCA employs metrics that exclude outages caused by major storms. The BCA

[11] The RVC SAIFI of 1.38 and CAIDI of 359.16 minutes were used in the IEC BCA model

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". These major events will have different impacts based on the type of event, type of stakeholder and that stakeholder's relationship to the microgrid project. In preparation for, during and after an event there is a multitude of costs that require an extensive amount of time to prepare for and restore to original, functional conditions. Long Island and other Tri-State utilities experienced the following issues during recent major storms (Hurricanes Gloria and Bob and Superstorm Sandy):

- Duration of pre-outage preparation, outage, and post outage restoration of up to 1-3 weeks (not 1-3 days);
- Additional staff required to fix and operate the grid during outages;
- Hotel and travel costs associated with utility staff from outside contractors, utilities etc.;
- Post storm construction activities to either rebuild the systems in locations with significant damage or "return the system to normal" work such as replacing damaged poles and other damaged facilities that did not result in outages.

No adjustment for the costs of major power outages were made to the IEc model.

Other model shortcomings include valuing the security benefits of a microgrid such as avoided vandalism and other street crimes with the electrification of street and traffic lighting, and possibly lower insurance costs due to reduced frequency of interruptions. No adjustment for the added security benefit was made to the IEc model.

5.3 Summary

Participation in this Feasibility Study has given the Village of Rockville Centre the opportunity to develop plans for the future of their Electric Utility and respond to many issues affecting it including its current distribution system configuration, aging generators, US EPA and NY DEC requirements and susceptibility to major storms. The installation of a Microgrid will enable the Village to improve the reliability of the power supplied to its customers, maintain critical services for the community and its neighbors during outages, employ methods to help manage the growth of peak load through the use of demand side management strategies and incorporate environmentally friendly technologies to help meet the Governor's mandate of meeting 50% of energy needs with renewable resources by 2030.

One of the benefits of installing a microgrid in RVC is that the electrical distribution infrastructure of cables, conduits, poles etc. are already owned and operated by RVC, as well as a power plant with an available space for a new generator. With an estimated cost of $15 M to install the new generator, rooftop PV solar panels (on Village owned buildings), DSM programs and new capacitor banks, analysis indicates that even if there were no major power outages over the 20-year period analyzed, the project's benefits to cost ratio would be 4.85. The benefits of a one-day major power outage each year over the 20-year analysis period is approximately $43 M in present value terms with a total benefit to cost ratio of 6.34. Additionally, RVC already has a staff of trained professionals capable of operating and maintaining a power plant, the electric substation infrastructure and distribution system. No incremental staffing will be required for these functions.

Adding a microgrid to RVC's electric distribution system would serve as a model for other utilities around the nation. This project has the potential to provide a model that is highly replicable and can be adopted by other public utilities with the ability to own generation, provide potentially cost-effective strategies for meeting demand and valuable resiliency benefits to the communities they serve. RVC intends to share our experiences with other members of the New York Association of Public Power (NYAPP) and the American Public Power Association (APPA) as well as others that have interest.

The Village of Rockville Centre respectfully requests that the Design Phase of the NY Prize be approved and funded by NYSERDA. The cost effective, efficient and environmentally sound plan that has been developed during this Feasibility Study will ensure that the Village continues to supply its customers with the reliable, resilient electric service that they have come to depend on, now and into the future.

Appendix A: Fuel Oil Boiler Replacement With Solar Hot Water

1. Assumptions:

Energy Costs:

• Assumed Gas Costs: $0.75 per therm
• Assumed Fuel Oil Cost: $2.77 per gallon

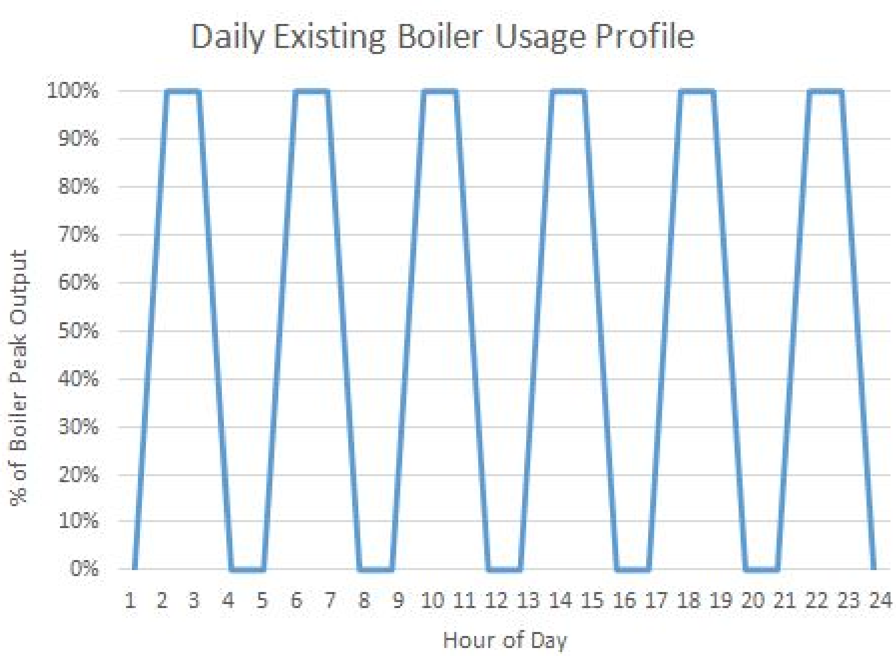
Existing System:

• The fuel oil heating is performed by a dedicated boiler with the following nameplate data:

- Gross Output: 1054 MBH
- Net Output: 791 MBH Steam / 917 MBH Water
- Fuel to Gross output Efficiency of 80%

• The boiler has a reported load factor of approximately 50%
• Load profile:

- A theoretical hourly heating demand profile for the system was developed to achieve the 50% load factor.
- It is unknown what time of day the boiler heating demands typically occur at or whether there is a reasonably regular demand at all. An initial assumed profile of the daily heating demand was made that best aligned the heating demand with the daily coincident solar energy profile – a daytime heat load.
- This demand profile achieves the estimated 50% annual load factor.



Solar Energy System:

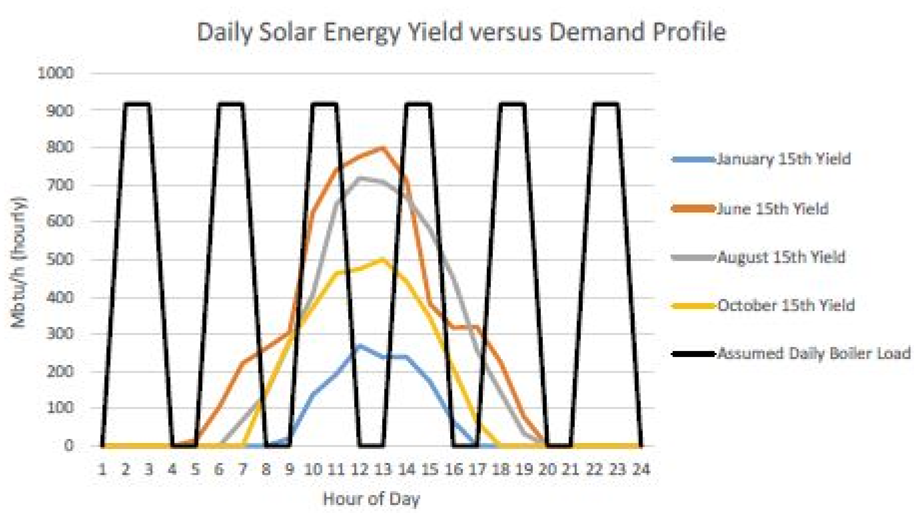
• The annual solar energy exposure for the site was obtained from the Department of Energy via TMY3 data for a local weather station.
• For the purpose of determining the useful solar energy yield a product was chosen from a database.
• The following was assumed for the system: o Optical efficiency (Fr(tau alpha)): 0.72

- Thermal Loss Factor (Fr UL): 3.5 W/m2/oC
- Gross Collector area per panel: 27 ft2
- Active Aperture area per panel: 25 ft2
- Installed system Cost factor1: $106 / ft2

• A square footage of collector panels was chosen to match the estimated peak existing system load (approximately 90% of the existing peak boiler capacity). Any higher and the system would be over-sized compared to the peak demands. This size of collector system would: o require a collector roof area of approximately 3,550 ft2

- have an installation cost of approximately $407,100
- have annual average fixed operation and maintenance (O&M) costs of approximately: $9,060

• The graph below shows the possible daily solar yield for selected days throughout the year versus the assumed daily demand profile. It can be seen that a supplementary energy source would still be required to meet the entire load.



[1] Dept of Energy Cost and Vendor Price List

Appendix A: Fuel Oil Boiler Replacement With Solar Hot Water - Continued

2. Results:

System Savings and Costs:

• Any solar energy used by the system represents a fuel saving. For the purposes of this analysis it is assumed that almost all of the solar energy can be put to use by means of a storage system.

• The system analyzed here could provide 25% of the annual heating energy required. This equated to energy savings (not including annual O&M costs) of:

- $29,674 if the system were running on oil
- $10,675 if the system were running on gas

• With annual O&M costs included, this would yield a simple payback of:

- 19 years if the system were running on oil
- 252 years if the system were running on gas

Appendix B: RVC Microgrid SWOT Analysis

RVC MICROGRID SWOT ANALYSIS

Strengths	Weaknesses	Opportunities	Threats
Avoided cost $50-68M for LIPA transmission interconnect upgrade	Fairly high capital cost requirements for additional generation	Demonstration of resilient energy system as model for Long Island for major storms and other electric system emergencies	Ability to permit additional on-site generation
Location and foundation available for new engine in existing power plant	Relatively low RVC power purchase costs results in longer paybacks for on-site generation and new resource technologies (ORC, Solar PV, Batteries, DSM)	New business opportunities during major outages and events - additional revenue from existing or new customers	May require RVC to issue bonds to entice 3rd party owners to finance new generation
Electric infrastructure and power plant under RVC control	Limited percentage of days when Microgrid islanding is required, limiting savings opportunities	High reliability of power during island wide blackouts can attract new business to RVC	Reduction in Zone K capacity and energy market prices will delay return on investment of Microgrid technologies
No new physical facilities required at critical and key customer sites	"Green" solutions (Solar PV, batteries etc.) have extended payback periods	Financing, incentives, and other grants available from NYSERDA and others sources to support microgrid, solar PV, energy storage, and other renewable energy technologies	Installed cost estimates may be higher which could negatively impact the return on investment.
RVC Microgrid has significant operating benefits during islanding AND normal operating modes	Renewable energy generation will be intermittent during peak demand periods without a storage component	Businesses (manufacturing, industrial, and other high-energy users) enticed to move to RVC due to affordable rates during peak hours	Potential increase in the future cost of fuel, transmission, NYPA contract, or NYISO fees
New generation can bid into the NYISO Capacity Market	On-site generation has larger carbon footprint impact than current NYPA supplied power and some DAM sourced electricity purchases	Community solar program can provide a forum for RVC to better engage with its customers	Future tightening air quality standards may be affect cost of on-site generation
High efficiency on-site generation can reduce fuel costs	Some critical customer outage costs are not excessively high	Customer savings through energy efficiency and demand side management programs -- attracts new customers/businesses	RVC load growth may be higher than the regional average (due to lower electricity costs) which could put pressure on power import and on-site generation beyond capacity of designed
Displace old on-site generation systems with more efficient, cleaner technologies	Shifts the cost of back-up generation from customers to RVC (not to customers)	On-site solar PV diversifies generation and will help manage peak loads more efficiently	Additional on-site generation and greater reliance on RVC infrastructure means RVC now has a responsibility to protect those systems from man-made and natural threats.
Reduced emissions by planned new generation with (a) generator with tier IV emission controls, (b) solar PV and (c) DSM programs	On-site generators may decrease local air quality during operation	Potential for on-site energy storage can help reduce peak DAM purchasing requirements	Poor customer participation in load shedding programs and perceived increase in rates may contribute to loss in customers for RVC.
Addition of black start capabilities for reduced downtime and starting reliability on Bus 2	Many benefits of the improved power reliability provided by the municipal Microgrid are realized by customers (behind the meter), but do not enure to RVC (who pays for the Microgrid)	Increase in customer engagement through demand-response programs	Availability of fuel (natural gas, diesel) may be limited during a major event.
New generation reduces risk in electricity price increase in future long-term contracts with NYPA		Innovative financing mechanisms to lease land for 3rd party solar developer	Potential cost to decommission and remove older generators
RVC will become a more energy efficient, sustainable community through DSM and EE programs		Opportunities to collaborate with water utility for load shifting and reductions in peak demand	If power demand exceeds 60MW, RVC has few options to meet the requirements (e.g. Import max 45MW and on-site gen 15MW)
Continuation of RVC electric revenue from critical customers and key customers during islanding operation		Increase on-site generation capacity - reduce reliance on transmission imports	RVC is still susceptible to interruptions/failures on any one or all of the 3 aboveground transmission lines due to storms, maintenance or major events
Preservation of critical services (police, fire, healthcare, food, etc.) to maintain safety, health and welfare during major events		Regional growth and additional on-site generation could present greater opportunities to increase size of RVC's Microgrid	Success of DSM and EE programs could significantly impact RVC revenue
Ability to power some traffic lighting and street lighting during major events for public safety		Public relations opportunity to highlight RVC's power reliability, affordable rates, and integration with renewable energy	Loss in revenue due to community-solar PV program
Reduces (or removes) costs associated with most backup generation at the critical/key customer level. No additional generator or fuel purchasing requirements for these facilities by customers.		Solar PV provides fuel diversity to protect against price fluctuations in the market and transmission cost increases	

RVC MICROGRID SWOT ANALYSIS

Additional RVC on-site generation available to serve peak loads		Protection against the increase in transmission costs to RVC which are expected from planned upstate transmission projects (e.g. TransCo.)	
Reduce electricity purchases on DAM during peak periods (load shifting opportunities)		Potential to reduce RVC O&M Costs through upgraded infrastructure/controls/equipment	
New SCADA will provide improved control, quicker data acquisition and diagnostics and compliance with NYISO disturbance monitoring capability		Future increase in air quality standards may make solar and battery storage more cost effective	
Advanced controls allow for more efficient grid operation and optimization of power system based on performance metrics - economics, carbon footprint and reliability			
Balance system supply and demand more efficiently with advanced controls and alternate energy resources. Reduce need for real time power purchases			
Power quality improvement through reduced system losses and more consistent voltage supply with new capacitors			
Reduces additional staffing, patient relocation, and fixed costs of purchasing and maintaining backup generators at healthcare facilities.			
RVC has the resources to develop this microgrid quicker than other projects due to ownership of generation, electric infrastructure, as well as O&M staff			
On site Backup fuel oil storage already in place			
Large variety of commerical, instituional and government services will benefit all RVC customers and neighboring communities that can utilize the services and products during widespread outages			

Appendix C: IEC Initial Benefit Cost Analysis Results*

***The Benefit Cost Analysis (BCA) presented in the RVC Microgrid Feasibility Study has two modified assumptions compared to the attached initial BCA performed by IEc in February 2016:**

(1) The Feasibility Study utilizes a lower frequency of power quality interruptions (7 per year versus 27 per year used for the original IEc BCA Analysis), and

(2) the avoided transmission re-conductoring cost of $50 M was added to the (Transmission)/Distribution Capacity Cost Savings in the Feasibility Study BCA.

All modifications to the model were made in consultation with IEc representatives.

The **initial** Benefit Cost Analysis received from IEc is presented on the following pages.

Benefit-Cost Analysis Summary Report

Site 12 – Village of Rockville Centre

5.4 PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Village of Rockville Centre has proposed development of a microgrid that would serve nearly 3000 residential customers and more than 500 commercial customers, including:

- The South Nassau Communities Hospital and 14 other medical facilities;
- A police station;
- Two fire stations;
- Three water treatment facilities; and
- 15 traffic lights.

The project consultants are currently considering four design options. Under Option 1, the team's primary option, the microgrid would be powered by three existing dual fuel generators (total capacity: 13.9 MW), four new solar photovoltaic arrays (total capacity: 682 kW), and one new 7.5 MW natural gas generator. Each of these eight resources would produce electricity for the grid during periods of normal operation, as well as in islanded mode during power outages. The system as designed would have sufficient generating capacity to meet average demand for electricity from all included facilities 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.

The three other options under consideration are as follows:

- Option 2 reduces the size of the new natural gas generator and adds a 3 MW photovoltaic array. This design is expected to result in additional environmental benefits.
- Option 3 follows the same design as Option 1, but incorporates two additional, existing dual fuel generators to increase system resilience.

- Option 4 follows the same design as Option 2, but also incorporates the two additional, existing dual fuel generators from Option 3. This design is expected to increase both environmental benefits and system resilience.

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 the other design options.

5.5 METHODOLOGY AND ASSUMPTIONS

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

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

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

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[12] It also calculates an annualized estimate

[12] 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.]

of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- 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.[13]

5.6 RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that 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 a factor of more than seven. As a result, the analysis does not evaluate Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio.

In addition, the analysis considers whether the alternate design options are likely to change this result. Although the project team has indicated that project costs would increase under Options 2 and 4, the estimated increase in costs is substantially smaller than net benefits under Option 1. As a result, project benefits are expected to outweigh project costs under any of the four design options.

The discussion that follows provides additional detail on these findings in the context of the site's primary design option, Option 1.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$192,000,000	Not Evaluated
Benefit-Cost Ratio	7.8	Not Evaluated
Internal Rate of Return	N/A	Not Evaluated

[13] 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.

5.6.1 Scenario 1

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

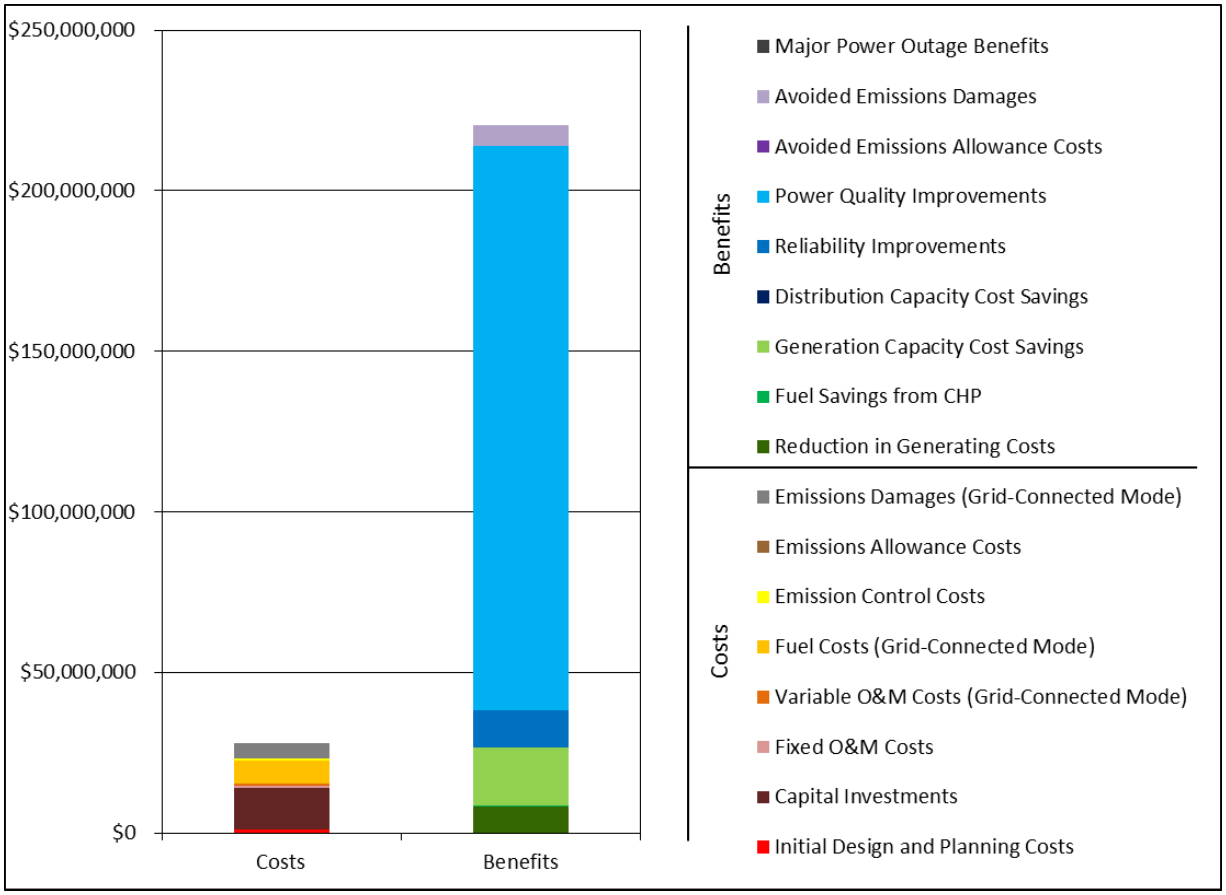


Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,250,000	$110,000
Capital Investments	$12,600,000	$978,000
Fixed O&M	$703,000	$62,000
Variable O&M (Grid-Connected Mode)	$941,000	$83,100
Fuel (Grid-Connected Mode)	$6,870,000	$606,000
Emission Control	$941,000	$75,900
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$4,790,000	$313,000
Total Costs	**$28,100,000**	
Benefits		
Reduction in Generating Costs	$8,150,000	$719,000
Fuel Savings from CHP	$271,000	$23,900
Generation Capacity Cost Savings	$18,100,000	$1,600,000
Distribution Capacity Cost Savings	$1,660	$146
Reliability Improvements	$11,600,000	$1,030,000
Power Quality Improvements	$176,000,000	$15,500,000
Avoided Emissions Allowance Costs	$4,090	$361
Avoided Emissions Damages	$6,260,000	$408,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$220,000,000**	
Net Benefits	**$192,000,000**	
Benefit/Cost Ratio	**7.8**	
Internal Rate of Return	**N/A**	

5.6.1.1 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 $1.25 million. The present value of the project's capital costs is estimated at approximately $12.6 million, including costs associated with installing fixed and switchable capacitor banks on the distribution system; smart thermostats and other equipment necessary for demand-side management programs; the new 7.5 MW natural gas unit; four new photovoltaic arrays; and system controls. The new natural gas generator will also require the installation of emissions control equipment. The project team's best estimate of capital costs for emissions control is approximately $550,000; an additional $34,500 will be required each year for urea injections. The present value of these emissions control costs is approximately

$941,000. 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 $703,000, or $62,000 annually.

5.6.1.2 Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas and diesel to fuel operation of the system's four fuel-based 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.[14] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $6.87 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M costs (i.e., O&M costs that vary with the amount of energy produced). The present value of these costs is estimated at $941,000, or approximately $6.89 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 $422,000 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 $4.79 million.

5.6.1.3 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 $8.15 million; this estimate assumes the microgrid provides base load power. In the case of the Village of Rockville Centre's proposed microgrid, this assumption is consistent with the project's team operating profile for the proposed photovoltaic arrays

[14] 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.

and natural gas generator; the dual fuel generators, however, are expected to operate for less than one percent of the year, and could therefore offset more expensive production during system peak periods.[15] Cost savings would also result from fuel savings due to the combined heat and power system powered by the new natural gas generator; the BCA estimates the present value of fuel savings over the 20-year operating period to be approximately $271,000. These reductions in demand for electricity from bulk energy suppliers and heating fuel 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 $4,090 and avoided emissions damages with a present value of approximately $6.26 million.[16]

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.[17] The project team estimates the capacity available for the provision of peak load support to be approximately 7.6 MW per year, based on estimates of the new photovoltaic arrays' and natural gas generator's output during system peak. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 13.7 MW each month as a result of new demand response capabilities. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $18.1 million over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately $1,660.

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

[15] On the other hand, because the dual fuel generators exist in the baseline, the model could overstate cost savings if these generators would produce a similar amount of electricity even absent development of the microgrid. Zeroing out these generators' annual production to test the sensitivity of the results to this assumption only increases the benefit-cost ratio, as fuel costs and O&M costs decrease by more than the reduction in avoided generating costs.

[16] 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.

[17] 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.

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, in particular black start support, 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 this service.

5.6.1.4 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 $1.03 million per year, with a present value of $11.6 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:[18]

- System Average Interruption Frequency Index (SAIFI) – 1.38 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 105.42 minutes.[19]

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.[20] 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.

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[18] www.icecalculator.com.

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

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

5.6.1.5 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 Rockville Centre's proposed microgrid, the project team has indicated that approximately 27 power quality events would be avoided each year. Assuming that each customer in the proposed microgrid would experience these improvements in power quality, the model estimates the present value of this benefit to be approximately $176 million over a 20-year operating period.[21] Power quality improvements therefore represent the largest category of benefits for the proposed Rockville Centre microgrid. In reality, some customers for whom power quality is important (e.g., hospitals) may already have systems in place to protect against voltage sags, swells, and momentary outages. This assumption could therefore lead the BCA to overstate the power quality benefits the project would provide. Of note, however, the reduction or exclusion of power quality benefits would not change the overall result of this analysis; i.e., that the project's benefits outweigh its costs.

5.6.1.6 Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 4.9; i.e., the estimate of project benefits is more than seven times 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.

[21] 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 Rockville Centre. Based on information provided by the site team, Rockville Centre'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.]

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