70 - Village of Frankfort

Notice

MICROGRID

FEASIBILITY STUDY REPORT

THE VILLAGE OF FRANKFORT, NEW YORK

Final Report

October 2016

Submitted on the Behalf of:

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1.1 Introduction

The Village of Frankfort, NY, located in Herkimer County, owns and operates a municipal electric distribution company (i.e. Frankfort Electric Department). This distribution company is operated under the authority of the New York State Public Service Commission and the Village of Frankfort and currently services over 1,700 customers. The Village's distribution company has been in operation since 1901.

The Village's Electric Department operates two (2) substations within its service area and has constructed and maintained the entire electrical infrastructure system within the Village. These substations are fed by large inbound 46kV transmission lines, which are owned and operated by National Grid. The Village has experienced losses of inbound power from the transmission lines to their electrical infrastructure system in the past. Because of these past power and service interruptions, the Village wanted to explore mechanisms that could provide a more reliable and redundant electrical system. Such supplemental power generation, distribution and transmission measures would allow the Village to better serve their residential, public service and industrial customers. The Village chose to investigate and assess the feasibility of developing a microgrid within their existing electric infrastructure system.

The Village's power and service interruptions as well as the possible limitations on economic development could potentially be mitigated through the use of a distributed generation system connected to the Village's distribution system via a microgrid. To be cost effective and provide more than standby power, the generation could be a combined heat and power (CHP) system hosted, and utilized during normal grid operations by an industrial host. The industrial host would primarily use the CHP system (with a natural gas fuel source) to generate on-site power for its facility electric load, while capturing the heat from the CHP system operation to support other on-site processes. If the industrial host location could curtail its power load during emergency grid outages, it could then power a microgrid that could support the electric load of the Village's distribution system. The economic arrangement to provide emergency power to the microgrid would require a power purchase or other type of agreement between the industrial host location and the Village, with stipulations for demand response from the industrial during emergency grid outages.

An example industrial host to match these conditions could be a greenhouse. Highly controlled modern produce greenhouses have low base loads, but high peak loads due to their growing lights. Additionally, these facilities have large heat demands during colder periods, and can utilize heat for cold storage via utilizing absorption chillers. However, these facilities generally have the ability to shed load over short durations (i.e. not use grow lights) with acceptable economic impact to production. In order to provide a good match, the potential industrial host's peak demand and generation capacity would be sized to match the microgrid's peak demand. In the case of a greenhouse example, a 10-20 acre produce facility (for tomatoes, lettuce and cucumbers, etc.) is estimated to meet these requirements. Other potential industrial facilities such as a kiln or manufacturing plant may not be as well suited as a greenhouse for a microgrid application. For instance, an industrial host such as a kiln would have high heat demand, but would generally not have a great peak electric demand, and may not be able to curtail load without operational losses. Also, a manufacturing plant may have high electrical demands but may not be able to curtail load with economic losses.

Overall, several potential benefits of a greenhouse facility as an industrial host would include:

- Power supply (i.e. demand respond) to the Village's distribution system during emergency grid outages through load curtailment, which would decrease service interruptions within the Village.
- Economic development in close proximity to the Village with respect to local industry and jobs.
- The industrial host would not be dependent upon the Village's distribution system for its peak demand, nor would it significantly impact the Village's NYPA Allocation, but would still provide the economic benefits to the area.

New York Power Authority Allocation of the Village

In addition to the power and service interruptions that the Village of Frankfort experiences, they also fairly regularly exceed their New York Power Authority (NYPA) allocation. From NYPA through the ReCharge New York (RNY) economic development power program, the Village receives a 5 MW block of hydroelectric-generated power to sustain its base electric load. The relative cost range of this base power is approximately $0.04 – $0.05 per kWh. However, when the Village exceeds its NYPA allocation, the purchase price for power can range from approximately $0.05 – $0.7 per kWh (supplemental energy at $0.052/kwh and $7.00/kW of supplemental demand in 2015, **Appendix J**). While the generation at the industrial host would generally be reserved for its parasitic loads during normal operations, in the case of a host such as a greenhouse that maintains a low base load but high peak demand, the generation capacity could be available during certain periods to assist the Village to avoid NYPA usage and demand overages thereby containing costs for the Village and all the distribution system users. Additionally, if the Village cannot provide economically affordable power through its own electric distribution system, this shortfall has the potential to deter or prevent new job creating commercial or industrial customers (e.g. host facilities) from locating within the Village vicinity.

Proposed Feasibility Study and Potential Location of the Microgrid

The Village has assembled a project team of industry experts to investigate, manage and execute a Feasibility Study for developing a microgrid within their existing electric infrastructure system. Refer to **Section 3** for additional information on the Project Team. The Feasibility Study is Stage 1 of the proposed microgrid project. Future Stages of project development may include: detailed design, economic analyses and permitting as well as bidding, construction and start-up operations. Additional project partners including contractors and suppliers would be secured in the future as various Stages of the project are approved and moved forward for implementation.

Regarding the potential location of the proposed microgrid, the Village focused on available properties that would require the least amount of disturbance and site development, and that maintain existing infrastructure while promoting local economic growth. In addition, the Village was seeking to identify an industrial host that could curtail load to allow the distributed CHP generation to support a microgrid during grid emergencies. The proposed property for the industrial host is located just outside the Village, is serviced by the Village's electric distribution system and maintains other utility services, and is under the authority of the Herkimer County Industrial Development Agency.

The proposed industrial park property does not have any current tenants and is zoned as planned development/ manufacturing. The industrial park location also maintains access road roads, existing utilities and has the capacity for a 10-20 acre industrial host facility, such a greenhouse. Refer to the enclosed flyer (**Figure 0)** for an informational flyer regarding the industrial park property.

5S South Business Park

NYS State Route 5S, Town Frankfort, NY

HERKIMER COUNTY
Industrial Development Agency

Acreage: 200 ± (150 Developable) **Zoned:** Planned Development/Manufacturing

Access: NYS Route 5S at site, NYS Thruway 5 miles East to Herkimer Exit 30, 10 miles West to Utica Exit 31.

Municipality: Town of Frankfort, Herkimer County, Frankfort-Schuyler Central School District

Sanitary Sewer: Herkimer County Sewer District **Water:** Village of Frankfort **Electricity:** Village of Frankfort Municipal Power **Natural Gas:** National Grid **Fiber Optic:** Verizon **Telephone:** Verizon (at site) **Cable:** Time Warner

Nearest Commercial Airport: Syracuse Hancock International Airport and Albany International Airport, 1hr drive on non-congested rural Interstate 90 **Railroad Siding:** No **Line Adjacent:** Siding access in Utica 8 miles **Rail Carrier:** CSX and Conrail

Price: $20,000 per acre **Community Population:** 7,500 **Herkimer County Population:** 65,000

Additional Information: This site has received **Build Now-NY Shovel Ready Certification**. The following survey/ studies etc. have been completed by O'Brien & Gere Engineers, Inc.: Topo & Boundary Survey; Phase 1 ESA; Engineering Report & Environmental Review (SEQRA). Phase 1A and Phase 1B Archeological by Hartgen Associates. In addition a Geotechnical Evaluation has been completed by Maxim Technologies. All available upon request.

For further information please visit our website at www.herkimercountyida.com or contact:

Mark Feane, Executive Director, Herkimer County Industrial Development Agency (315) 867-1373

1.2 Minimum Required Capabilities

The purpose of this Feasibility Study is to investigate and assess mechanisms, specifically microgrids, to provide electrical power supply redundancy within the Village of Frankfort. A primary justification of the need of electrical system redundancy for the Village's electric distribution company is to ensure that critical facilities, necessary for the operation of required public service functions within the Village, have electrical power and are operational during grid emergencies. Such emergencies may be caused by natural events (e.g. storms, flooding, earthquakes, etc.) or other events like physical failure of the power supply grid infrastructure that feeds the Village's electrical grid at their substations. A secondary justification for the need of electrical system redundancy within the Village's electric distribution company is to ensure that residential, commercial and industrial customers within the Village have power during grid emergencies.

In consideration of these requirements, the proposed microgrid must, at minimum and if feasible, support one (1) of the critical public facilities within the Village as presented in **Table 1A**. **Table 1B** provides the estimated facility loading requirements for the referenced critical public facilities, as well as information regarding the residential, commercial and industrial properties.

Table 1A
Potential Properties Identified as Critical Tier I and II Facilities

ID	Critical Facility	Land Use Category
1	Reese Road (Frankfort Schuyler) Elementary School	Community Services
2	Frankfort Schuyler Central HS	Community Services
3	Public Library	Community Services
4	Frankfort Fire Dept./EMS	Community Services
5	(V) Frankfort Police Dept.	Community Services
6	(T) Frankfort Police Dept.	Community Services
7	Water Department	Community Services
8	Stewart's Shop	Gas Stations
9	Ron's Service Station	Gas Stations
10	Country Farm	Gas Stations
11	Nurod's Service Station	Gas Stations

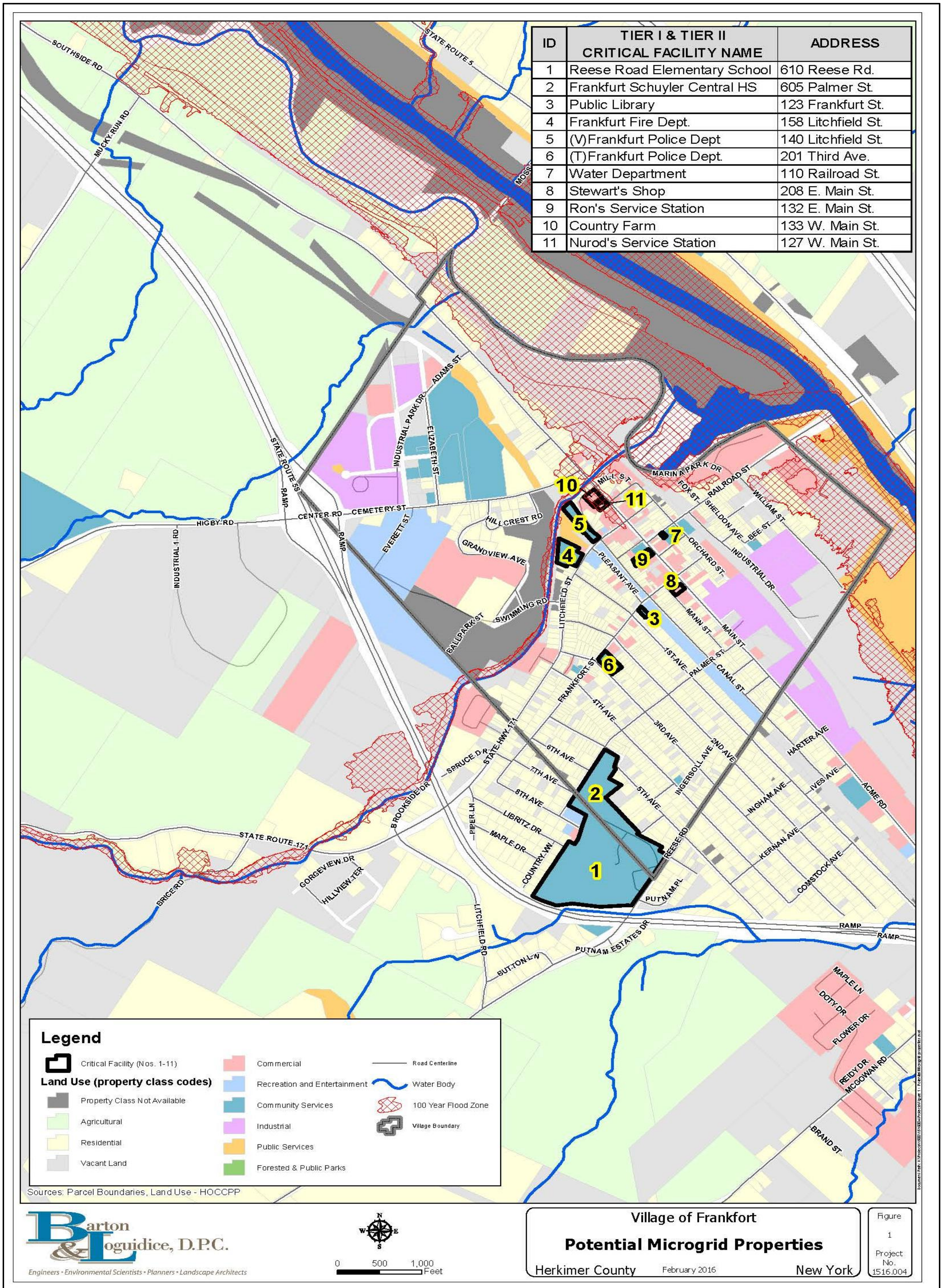
** There may be other critical facilities identified in the future that are beneficial to the Village and/or the microgrid project that are located beyond Village boundaries.*

Table 1B
Facility Loading for Potential Properties identified as Critical Tier I and II Facilities

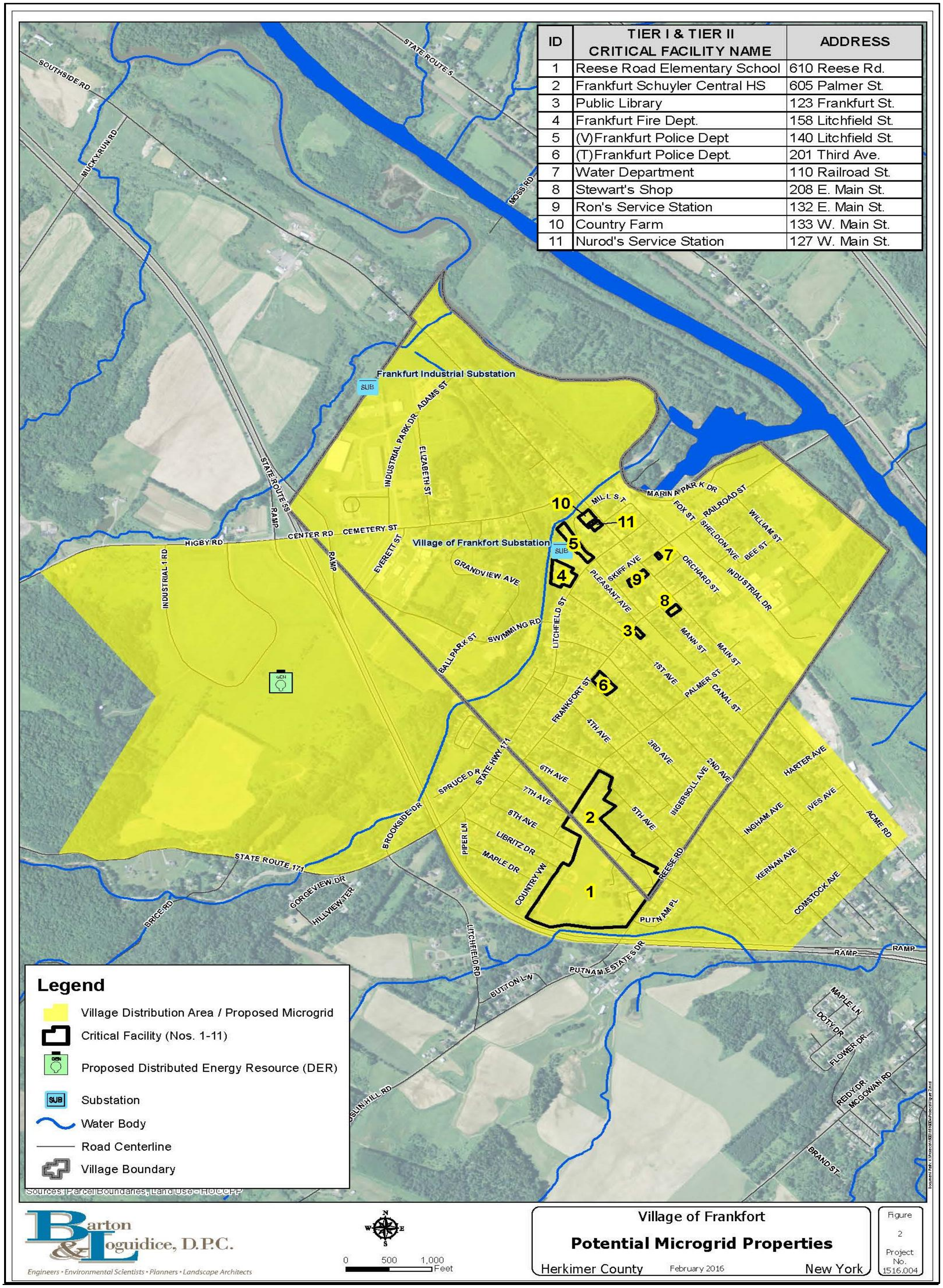
ID	Critical Facility	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Outage	Hours of Electricity Required Per Day During Outage
1	Reese Road (Frankfort Schuyler) Elementary School	89	0.06280	100%	24
2	Frankfort Schuyler Central HS	309	0.26080	100%	24
3	Public Library	10	0.00648	100%	0-10
4	Frankfort Fire Dept./EMS	37	0.03200	100%	24
5	(V) Frankfort Police Dept.	24	0.02000	100%	24
6	(T) Frankfort Police Dept.	19	0.01600	100%	24
7	Water Department	208	0.20000	100%	24
8	Stewart's Shop (Gas)	70	0.04100	100%	24
9	Ron's Service Station (Gas)	70	0.04100	100%	24
10	Country Farm (Gas)	70	0.04100	100%	24
11	Nurod's Service Station (Gas)	70	0.04100	100%	24
Tier III Facilities for Informational Purposes					
Residential Homes (1,183)*		12	3.78600	100%	24
Melrose Supermarket		283	0.16000	100%	24
Rite Aid		181	0.11200	100%	24
Commercial/Industrial (45)*		306	0.05400	100%	10

The peak electricity demand for these entities is an aggregate value for all residential homes and commercial/ industrial businesses in the Village of Frankfort. Individual data for these entities was not available. See **Table 2A for more detail on usage.*

The proposed critical facility end-users within the Village that would potentially utilize the microgrid include: two (2) schools, a public library, a fire department, a water department, two (2) police stations and four (4) gas stations. These facilities either provide emergency shelter (schools and library), command and control centers for vital services (fire/EMS and police) or vital resources to sustain functionality such as water and fuel. While these are the most critical public facilities, other facilities are envisioned and planned to be serviced by the microgrid such as the 1,183 residential homes and the 45 commercial/industrial businesses within the Village. In **Table 1B**, it was estimated that nearly all facilities or residences (with exception of the Public Library) would require up to 24-hours of emergency power during a grid outage to sustain a readily available supply of food, water, and fuel, as well as to prevent spoilage of existing food reserves. Refer to **Figure 1** for a location map of the Potential Microgrid Properties (i.e. the list of critical facilities). Refer to **Figure 2** for a delineation of the Village Distribution Area and Proposed Microgrid, along with critical facility and substation locations.



ID	TIER I & TIER II CRITICAL FACILITY NAME	ADDRESS
1	Reese Road Elementary School	610 Reese Rd.
2	Frankfurt Schuyler Central HS	605 Palmer St.
3	Public Library	123 Frankfurt St.
4	Frankfurt Fire Dept.	158 Litchfield St.
5	(V)Frankfurt Police Dept	140 Litchfield St.
6	(T)Frankfurt Police Dept.	201 Third Ave.
7	Water Department	110 Railroad St.
8	Stewart's Shop	208 E. Main St.
9	Ron's Service Station	132 E. Main St.
10	Country Farm	133 W. Main St.
11	Nurod's Service Station	127 W. Main St.



ID	TIER I & TIER II CRITICAL FACILITY NAME	ADDRESS
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Overview of Microgrid Design Concept

The proposed project design concept for the microgrid will include the supply of power to support the full extent of the Village of Frankfort's current electric distribution system. During emergency power outages, the microgrid would operate in island mode and provide power to the two (2) Village-owned substations. Microgrid power will then be distributed to the local customers via an existing overhead power line network. Metering during emergency power outages and microgrid operation would remain under normal existing conditions, through the use of existing electric meters at individual customer locations. Refer to **Sections 2 and 3** for more detailed information.

Currently, the Village's Electric Department provides power to approximately 1,700 customer accounts with a population of 2,600 individuals (according to the 2010 U.S. census). The microgrid has been evaluated to support Tier I-III users at a minimum, with an estimated electric power demand and usage as follows:

- Peak Demand: 4.41 MW.
- Ave. Demand: 2.27 MW.
- Ave. Annual Usage: 29,000 MWh.
- Ave. Monthly Usage: 2,420 MWh.
- Ave. Weekly Usage: 560 MWh.

To meet the electrical demands of the critical facilities and other potential electric users, the microgrid will require distributed energy resources (DERs) or generation sources at commercial, institutional, and/or industrial host locations. The DERs/generation sources will include four (4) CHP engine gensets (1,426 kWe each) that are fired (i.e. fueled) by natural gas. As renewable energy power are less consistent, weather dependent and are difficult to schedule, PV and wind generated power will not be included in the Benefit Cost-Analysis.

The primary generation source(s) for the microgrid will be sited and designed to meet peak electrical power demand (kW) and usage (kWh) of the entire microgrid (critical, residential and commercial loads) while in island mode. At full deployment of the DERs/generation sources, the total system capacity of the microgrid in island mode is expected to be as follows; assuming 90% annual availability of the CHP engine gensets (refer to **Sections 2 and 3 and Appendix I** for more detailed information):

- Peak Generation Capacity: 5.7 MW.
- Max. Achievable Annual Production (Normal Conditions): 45,000 MWh.
- Max Daily Production During Major Power Outage: 137 MWh.
- Annual Heat Output: 214,000 mmBTU.
- Weekly Heat Output: 4,120 mmBTU.

Annual production based on 90% availability, Max daily based on maximum potential output in a 24-hour period. Refer to the Process and Functional Diagrams included in* ***Section 2.2* *and in* ***Appendix G****.*

Customers who are considered generation sources as industrial host locations for CHP engine gensets will have the availability to use these power systems to significantly reduce their daily metered usage and demand behind their primary meters during normal grid operation. Additionally, these customers will have the availability to utilize the excess heat generated from the engine gensets within their industrial operations, thus offsetting and/or reducing their heating fuel purchasing requirements or heating costs.

Overview of DER/Generation Source Equipment

The DER/generation source equipment will include four (4) General Electric JGS 420 engine gensets (refer to **Figure 3**) with an electrical output of 1,426 kWe each that are designed for cogeneration. Cogeneration (i.e. combined heat and power – CHP) systems allow for the generation of both electrical power that can be used during an emergency outage as well as heat that can be used in an industrial process application. The CHP engine genets will be fueled by a dedicated and uninterrupted supply of natural gas from the local utility. The CHP engine gensets will be equipped with:

- Carbon steel casing with noise insulation and a module ventilation system.
- Thermal circuits and a plate heat exchanger.
- Lube oil system, exhaust gas piping and an exhaust silencer.
- Smoke/gas detection system, emergency dry cooler and anti-exposition actuated valves.
- SCADA System for Supervision and Control.
- Exhaust Gas Recovery System and a Hot Water Flow Metering System with heat dissipated at the locations below. Assuming 90% annual availability of the CHP engine gensets, it is estimated that only 60% of the useable recoverable heat (due to lower heat demand in the summer) will be reused as heat output in industrial process systems.
    - Engine and Jacket Water (*Available for heat recovery)*.
    - Lube Oil (*Available for heat recovery)*.
    - Intercooler 1st Stage (*Available for heat recovery)*.
    - Exhaust Heat Exchanger (*Available for heat recovery)*.
- Feeder and generator relay controls to ensure the dedicated systems of the primary grid and the microgrid are completely isolated and cannot backfeed power during times of grid emergencies and outages, system instability, maintenance, repairs or new installations.

- Island Mode and Black Start capability.
- The overall estimated exhaust emissions for these engine gensets per the manufacturer are: NOx: < 0.6 g/bhp.hr and CO: < 1.1 g/bhp.hr.

Figure 3
JGS 420 Engine Genset with CHP Capability

Overview of Microgrid System Sequence and Operation

As part of this Feasibility Study Report, the loads of the Village of Frankfort's electrical distribution system were characterized using the best available data. To meet the projected power demands and usage of the Village, the DERs/generation sources were also characterized to match the loading of the Village, but also for use at the industrial host location (during non-emergency and non-grid outage periods). Through analyzing this information, a total system capacity for the microgrid system (in island mode) was developed. Note that the loading estimates and projections for any industrial host locations are theoretical during this Feasibility Study Report, which would require further detailed analyses and engineering design. As previously mentioned, a greenhouse was envisioned as a potential facility to support the microgrid within the Village. Greenhouses have large electric and heat demands; however, these facilities have the ability to suspend portions of their industrial operation (i.e. curtail load) such as the grow lights for periods of time without impact to the overall facility operation. This type of scenario would provide demand response capabilities to the Village for generation in the event of an emergency grid outage.

The demand and usage of the target industrial host, a greenhouse, were sized to adequately handle the power required by the Village during an emergency grid outage, which would equate to the output of four (4) CHP engine gensets. The size of the proposed greenhouse industrial host would be approximately 10-20 acres. The greenhouse's load and associated demand and usage are provided below: This demand and usage is sized to match that of the CHP system, four (4) CHP engine gensets, which will be able to support the demand response of the Village's electric distribution system during grid emergencies.

- Peak Generation Capacity: 5.7 MW.
- Max. Achievable Annual Production (Normal Conditions): 45,000 MWh.
- Max Daily Production During Major Power Outage: 137 MWh.
- Annual Heat Output: 214,000 mmBTU.
- Weekly Heat Output: 4,120 mmBTU.

- Annual Heat Output: 214,000 mmBTU (at 90% availability).
  128,400 mmBTU (at 60% useable and recoverable heat).
- Weekly Heat Output: 4,120 mmBTU (at 90% availability).
  2,470 mmBTU (at 60% useable and recoverable heat for reuse).

The DERs/generation sources (CHP engine gensets) at the industrial host locations will be designed to operate 24/7/365 excluding scheduled maintenance. Scheduled maintenance does not have to occur during grid emergency/outage conditions. Such maintenance work, given it is not detrimental to the equipment or system, can be scheduled to limit the loss of capacity during microgrid operation.

During normal grid conditions, the generation source at the host industrial location will be used to offset normal demand and usage charges for the host facility. Thus, the proposed generation source will have the capability to provide on-site power in both grid-connected and island mode at a given industrial host location. The microgrid will also be designed to automatically disconnect from and reconnect to the primary grid power source, which are the transmission lines operated by National Grid. This process will also integrate the connecting or disconnecting of the CHP engine gensets so that the microgrid and the primary grid are kept safe for system operators, electric distribution company and utility workers, and customers. The integrated protection equipment may include feeder and generator relay controls to ensure the dedicated systems of the primary grid and the microgrid are completely isolated and cannot backfeed power during times of grid emergencies and outages, system instability, maintenance, repairs or new installations.

During grid emergencies/outages and as feasible, the microgrid system will be operated and controlled to limit the generation source load at the industrial host location. Such measures will allow power generation from the CHP engine gensets to be available to the microgrid and other priority loads, which may vary on the type of emergency/outage event. Also, as the generation sources for the microgrid system will likely be located at industrial host facilities, such load limitations to their essential and mission critical systems should be identified and developed under an emergency and contingency operating plan.

Additional power generation capacity throughout the microgrid system to account for downtime during scheduled maintenance of CHP engine gensets or other system components will be considered; however, as previously mentioned, the scheduled maintenance does not have to occur during grid emergency/outage conditions. Thus, significant additional capacity is not required to provide an effective microgrid system, when considering scheduled maintenance requirements of general source components.

The potential DERs/generation sources (CHP engine gensets) are proposed to be fueled by natural gas from the Niagara Mohawk Power Corporation d/b/a National Grid pipeline and distribution network that includes a 4-inch distribution pipe at 35 psig. The natural gas pipeline tie-in point to the DER/generation source would be located at an industrial host location (such as a Greenhouse) within the distribution area of the Village; specifically the industrial park known as the "pumpkin patch". The CHP engine gensets will need to be placed on an uninterruptable natural gas utility tariff to ensure the availability of gas for the operation of these microgrid systems, including operation in emergency conditions. The gas pipeline service can be considered an uninterruptable fuel supply for the purposes of this project, as supply of this fuel source will not be affected during a local electrical outage. Scheduled maintenance required on the natural gas pipeline that could cause a natural gas service outage, if any, will be conducted with prior notification to the Village of Frankfort.

It is anticipated that National Grid will communicate with the Village of Frankfort and the industrial host location during times of pipeline maintenance, gas supply emergencies, and other circumstances that may affect the natural gas distribution network and pipeline that will service the DER/generation source. The Village and the industrial host location will communicate with and notify National Grid during scheduled maintenance of the microgrid system and related emergency situations including the CHP engine gensets and the natural gas supply and connection-related issues. Scheduled maintenance on the CHP engine gensets will not occur during main grid or microgrid emergency outages or during times when there is a higher risk of grid emergencies.

The proposed microgrid network will be designed in accordance with NYS Department of Public Service's Standard Interconnection Requirements (SIR) and Institute of Electrical and Electronics Engineers (IEEE) 1547 standards, including technical standards for overcurrent protection, synchronization, voltage and power controls, and metering and monitoring. Once fully connected, the microgrid system will utilize its load management and control synchronization mechanisms to follow the system load of the industrial host location when in island mode and maintain system voltage in accordance with American National Standards Institute (ANSI) c84-1 during island mode (microgrid) operations. Automatic transfer switches, electrically actuated circuit breakers or reclosers will be utilized to disconnect the microgrid from the surrounding primary grid network and create an intentional island in the event of a failure of the electric grid.

Smart controls and relay protection will also be utilized to recognize when outside power is restored to reconnect the microgrid to the primary grid network. All interconnections will be coordinated within the microgrid, to facilitate connection and islanding with as little interruption of service as possible for microgrid users and local electric distribution company customers. Any control system communications will be encrypted or protected in accordance with accepted utility standards and homeland security requirements to maintain the integrity of sensitive data.

In order to operate independently of the local external electric supply (National Grid transmission lines) within the confines of the microgrid, the proposed generation sources (CHP engine gensets) at the industrial host location will require black start capability. Black start capability is necessary during the transition from primary grid power to the microgrid island mode as the CHP engine genset paralleling controls will likely turn off the engines and require a restart. This black start sequence will initiate once the generation source and the microgrid system sense instability conditions or an outage from the external primary grid, which will then open the circuits to isolate both the generation source and the microgrid to island mode. Then, the microgrid system will call for power from the generation source for the restart.

At designated Life Safety facilities, the fast response diesel powered backup generators that may have come on during this sequence, may run for a specified period of time to initiate or continue island mode within the microgrid. Once the generation source at the host industrial location is back in operation to support the microgrid, the existing diesel powered backup generators would be turned off to allow the diesel fuel to remain in reserve for future needs. As a point of clarification, the diesel powered backup generators are pre-existing within the Village (and within the proposed microgrid area) based on verified Life Safety needs. As such, the diesel powered backup generators are located at different facilities within the Village (and proposed microgrid area) than the generation source at the industrial host facility, and do not require integration into any portion of the microgrid systems.

1.3 Preferable Microgrid Capabilities

Support of Facilities within the Village of Frankfort

In addition to the minimum required capabilities for the microgrid as referenced in Section 1.1, the Village would like the microgrid to support and connect to as many critical facilities within the Village as practical and feasible. In addition to the critical public facilities, there are other facilities within the Village that are important. All the power users within the borders of the Village of Frankfort were evaluated utilizing GIS and census data for this microgrid Feasibility Study. To organize and prioritize users, four (4) tiers were used to determine the level of importance of the users. Tier I was considered to be the most critical facilities in the event of a grid emergency/outage, whereas Tier IV was considered least critical in the event of an grid emergency/outage.

The critical and other important facilities in Tier I included assisted living facilities, first responders and EMS service facilities, hospitals, prisons, water supply and treatment facilities, wastewater treatment facilities (if available), and communication facilities. In the Village of Frankfort, this included the following locations:

- Frankfort Fire Department.
- Frankfort Town Police Department.

- Village of Frankfort Offices and Police Station.
- Water Department and the Two Wells (water).

The critical and other important facilities in Tier II included schools, libraries (shelters) and gas stations. In the Village of Frankfort, this included the following locations:

- Frankfort-Schuyler Central and High School (emergency shelter).
- Frankfort-Schuyler (Reese Road) Elementary School (emergency shelter).
- Frankfort Free Library (emergency shelter).
- Four (4) local gas stations (supply fuel for vehicles in case evacuations are necessary).

Other important facilities in Tier III included hotels and motels (temporary shelter), grocery stores, pharmacies, and residential buildings. In the Village of Frankfort, this included the following locations:

- Melrose Supermarket (food, alternative water).
- Rite Aid (medications).
- 1,183 residential buildings (shelter in place).

The microgrid has been evaluated to support Tier I-III users at a minimum. However, there is an additional consideration with one group of the Tier III facilities, residential buildings. Because the Village of Frankfort has a municipal electric distribution company with affordable rates, the community as a whole relies heavily upon electricity for their heating needs. Interruption in electric service will have a much greater impact for Village residents than in other comparable communities. Loss of power during the winter months is a serious concern because of the high prevalence of electric heat utilized by Village residents. Senior citizens and the mobility impaired are at greater risk because of lower tolerances to the cold and/or inability to access public shelters. Thus, a more reliable and redundant electrical support system to provide power generation, distribution and transmission during grid emergencies/outages would greatly enhance the Village’s services to its residential customers.

Tier IV facilities included commercial and industrial businesses. There are approximately 45 commercial and industrial businesses in the Village of Frankfort. Other commercial and industrial users under the Tier IV classification would be requested and potentially required (via agreement terms and conditions) to curtail or decrease their individual demand load and close during declared emergencies events or grid emergencies/outages. This would not only reduce the need for additional power generation capacity, but it would also lessen the number of people traveling within and around the Village during emergency events, which will help free streets and resources for emergency support personnel.

Other Preferable Criteria for the Microgrid System

In addition to the minimum required capabilities for the microgrid as referenced in Section 1.1, there are other preferable capabilities of the microgrid system that can benefit the Village. In order to increase energy efficiency and maximize reliable service to critical facilities and customers, the microgrid system will need to incorporate technology to allow power generation to exactly match demand during microgrid operations. This could include measures to: reduce energy use of non-essential components during times of low generation or during grid emergencies/outages, communication on both the supply and demand ends to allow energy generation to exactly match users' needs, and automated transfer switches for seamless transitions in and out of island mode.

To the greatest extent practical, the microgrid will incorporate advanced and innovative technologies to allow for: integrated communication including demand response; customer interaction with the system; use of the existing distribution system infrastructure; the potential for private sector funding for the DERs/generation sources; the potential minimization of local impacts; the creation of local temporary and permanent jobs; and supporting State energy initiatives and utilizing clean power sources. Each of these capabilities and planning measures will aim towards providing efficient and reliable power during emergency grid outages to improve service of the Village's electrical distribution system to its residential, public-service and commercial/industrial customers.

- Integrated Communication System – The integration of the communication systems between the grid, the DER/generation source (industrial host location) and the Village substation switchgears will allow for demand response for peak usage times and either storage or decreased generation during non-peak usage times. With respect to demand response, a greenhouse was envisioned as a potential facility to support the microgrid. A greenhouse with an approximate 5.7 MWh power requirement would be serviced by four (4) CHP engine gensets (JGS 420s at 1,426 kWe each). Since greenhouses typically have the ability to suspend portions of their industrial operation (i.e. curtail load), this type of facility could provide demand response capabilities to support the microgrid and the Village's generation needs in the event of an emergency grid outage. For this arrangement, a PPA would be required between the Village and the industrial host location.

    - To assist with demand response and power management requirements within the microgrid, potential contracts or agreements could be in place with the major power users to control how much electricity they will use in an emergency situation to allow the DERs/generation sources (CHP engine gensets) to generate the required power to support the microgrid system. Refer to the "Integrated Customer Interaction Mechanisms" description for additional information.

    - The Village could also issue public service announcements (PSAs) and other forms of public education/outreach (e.g. flyers) to residents and businesses periodically regarding the importance of limiting electricity usage during an emergency grid outage. Such flyers could potentially contain guidance on:

raising thermostat temperatures during summer and lowering thermostat temperature during winter to decrease HVAC system use, turn-off household lighting when not in use, and having flashlights and candles on hand, etc. as well as other life safety measures (e.g. first aid kit, bottled water, etc.).

- ❖ The benefits of the microgrid would be passed along to the residents and community through increased efficiency and reliability of the electrical distribution system during emergency grid outages. Thus, the microgrid is envisioned to limit the number and/or duration of electricity outages experienced within the Village. At this time, if the industrial host location is responsible for the capital and operational costs of the CHP engine gensets and the Village's Electric Department maintains responsible for maintaining the distribution infrastructure associated with the microgrid, there are relatively few costs envisioned to the residents or local community generally limited to the communications equipment and some additional electrically actuated breakers and switches for upgrading the existing substations. Refer to **Section 3.4** for additional information.

In addition, the design of the microgrid to communicate with and energize a diversified customer base will aid in the optimization of supply and demand. Also, having a diverse end user base within the Village will allow for a microgrid design that can adjust to peak loads 24 hours a day, 7 days a week to maximize system availability and efficiency. This adaptive scenario is a better alternative than if the microgrid system had to be designed around a single end user peak load event that could possibly lead to an oversized and cost-prohibitive system. As feasible and practical, energy conservation and efficiency measures would also be recommended for implementation on the demand side in order to minimize the capacity of new generation sources that are required to serve the microgrid (ex. curtailment of non-critical industrial loads during grid emergencies).

- Integrated Customer Interaction Mechanisms – with the microgrid will be critical for increasing energy efficiency, as usage monitoring at residential, commercial and larger consumer facilities, will allow for self-evaluation of demand and increased incentive to reduce electricity usage. Computer software with real-time monitoring of electricity usage could be installed at non-critical facilities to reduce loading from secondary users of the microgrid or force curtailment. This approach will allow for increased reliability of the microgrid system without oversizing generation sources. Operation and maintenance of the existing infrastructure to be utilized in the microgrid will likely be performed by the Village Electric Department.

The Village Electric Department has previously implemented a program and has been successful in installing smart meters throughout their electric service area and system, which includes approximately 1,183 residential customers and 45 commercial businesses. Currently, it will be the responsibility of the residents and businesses within each smart meter grid to curtail their electricity usage as there is not a mechanism in place to regulate individual residential buildings through the smart meters. However, the next stage of design for the microgrid would evaluate the potential use of these smart meters for data collection and possibly load control (curtailment). Such users could then be requested or potentially required (via agreement terms and conditions) to curtail or decrease their individual demand load and close during declared emergencies events or grid outages. This would not only reduce the need for additional power generation capacity, but it would also lessen the number of people traveling within and around the Village during emergency events, which will help free streets and resources for emergency support personnel. Thus, allowing better conditions for the host industrial location to provide adequate demand response capabilities to the Village's microgrid.

- Use of Existing Distribution System Infrastructure – To the greatest extent possible, the proposed microgrid will use the existing Village-owned overhead 4.16kV distribution system feeders, poles, transformers, meters, etc. This approach would minimize construction-related activities to the local community and neighboring lands as well as minimize up-front expenditures to the Village.

    - Given the Village owns and operates an entire electric distribution system that is primarily overhead construction and to minimize up-front expenditures, this Feasibility Study focused on the use of existing infrastructure without any major additions or alternations. As a result, the network capabilities of additional underground networks, overhead loops and radial overhead integrated systems were not evaluated.
    - As the detailed design and cost estimate of the microgrid project continues to be developed and refined during Stage 2, the network capabilities of additional underground networks, overhead loops and radial overhead integrated systems could be assessed and evaluated for potential inclusion in the microgrid system.

- Potential Private-Sector Funding for the DERs/Generation Sources – Private capital should be considered to the greatest extent possible to fund the microgrid capital investment in order to minimize economic impact on the community, unless substantial grant funding can be obtained. For initial comparison efforts, a scenario with 50% funding by private capital will be used as a metric for comparison. Potential opportunities for partnerships or for siting generation sources will be identified with local industries and other community service providers in addition to the critical facilities.

In order to determine the feasibility of the local microgrid, a benefit-cost analysis (refer to **Section 4.7**) was performed as part of this Feasibility Study on the proposed system, incorporating the public- and private-sector costs to the Village, developers, industrial host facilities, and customers as well as the economic and other benefits to the community, developers, and the Village electric distribution company. Cost comparisons will include not only the capital and operational/maintenance costs to construct and maintain the new infrastructure and interconnects, but also the costs of providing backup generation to the critical facilities, the projected costs of continuing service through the Village electric distribution company, and any savings to be realized under the microgrid system. Although most benefits to the developer and end-users will be economic, additional social and environmental values of increased efficiency, reliability, the functionality of critical facilities and security as well as the use of cleaner energy sources and the implementation of energy conservation measures will be explored.

- The application of renewable power sources will continue be evaluated in the future, as feasible, but may potentially be limited due to site availability and locational constraints, seasonal and weather-related impacts, and economic feasibility.

- Potential Minimization of Local Impacts – The CHP engine gensets will be sited in previously developed areas or areas included for specific development in previous comprehensive planning, in order to minimize land use and social impacts. Siting of the CHP engine gensets will also make use of existing natural gas laterals in order to minimize the economic, environmental and social impacts of running new laterals from the pipeline to the generation source at the industrial host location. As described above, the proposed microgrid will use of the entire Village-owned overhead 4.16kV distribution system to minimize impacts on the environment.

- Local Temporary and Permanent Jobs – The development and construction of a local microgrid is estimated to create 2-3 permanent full-time jobs to maintain the microgrid system including CHP engine gensets within the Village areas and an additional 30-50 short-term construction jobs for microgrid and host facility construction. Permanent local employees will be required to operate and maintain the new CHP engine gensets at the host/generation source facilities and the updates to electrical infrastructure including energy efficiency retrofits and equipment maintenance, etc. Short-term positions will be required for the construction of the microgrid system and CHP engine genset sites, which may have a potential duration of 6-12 months.

- Supporting State Energy Initiatives – Regarding State supported initiatives related to the microgrid – Reforming the Energy Vision (REV) is an effort by the New York Public Service Commission to address issues stemming from centralized and largely degraded electricity infrastructure within the State. A key component of this program is the decentralization of electricity generation, distribution and transmission to decrease reliance on existing utilities and electric grids. Markets and regulations still favor utilities in New York State, making it difficult to implement distributed energy resources (DER). Revisions to the existing regulatory paradigm as part of the REV process will aid in the implementation of microgrid systems, such as the one proposed herein for the Village of Frankfort, to increase energy security and reliability as well as provide cleaner energy sources that may not currently be competitive. The exact framework under which these goals can be achieved will be determined as the REV effort proceeds; however, the successful operation and maintenance of a local microgrid could provide a stepping stone and/or precedent for other communities to implement similar policies and infrastructure innovations to increase the efficiency and reliability of their generation, distribution and transmission systems. The proposed microgrid to support the Village of Frankfort matches with the State's REVS goals.

- Utilization of Clean Power Sources – Clean power sources will be implemented to the maximum extent possible and all generation sources will be designed to minimize environmental impacts. The total goal for the microgrid project is to provide a minimum of 10% of the total power generation with non-fossil fuel renewable energy, and with at least 80% of the total project generation with low carbon options. Natural gas fired CHP engine gensets (providing power during primary grid connection or island mode) will provide the majority of the microgrid power. Although not carbon free, CHP systems are more efficient than conventional power generation due to the recovery of heat as well as its proximity to the end user, thereby decreasing distribution and transmission losses. Thus, this technology can be considered a lower carbon generation option.

Overall, the direct tangible community benefits of the proposed microgrid will include providing critical facilities and additional residential, commercial or industrial customers with reliable electricity, improved energy efficiency, decreased carbon footprint of local electricity generation and use grid, short-term and long-term local jobs, and the reduction in loss of services by critical facilities and other customer buildings within the Village during grid emergencies/outages. Implementing energy efficiency retrofits and decentralizing electricity production for the microgrid area will also increase energy efficiency by better matching of generation with demand while reducing waste. The use CHP engine gensets for primary electricity generation locally could also further decrease the carbon footprint of the Village. Overall, decentralizing electricity production, decreased distribution and transmission losses, and reliance on clean and safer energy sources will displace carbon-dense fossil-fuel derived electricity.

2.0 Preliminary Microgrid Design and Configuration

2.1 Proposed Microgrid Infrastructure and Operations

Under normal operating conditions, the microgrid will be connected to the main grid via National Grid's 46kV transmission lines and the Village's two (2) substations. Thus, the primary source of power for the microgrid will originate from the main grid. Electrical customers will receive their electrical service from the current Village infrastructure and feeders. Refer to the Electrical One-Line Diagram that follows this section, which is also included in **Appendix D**.

Meters at individual customers (typically) are utilized to determine normal usage and billing; this would remain under normal existing conditions. Customers who are considered generation sources as industrial host locations for CHP engine gensets will use these power systems to reduce their metered usage and demand behind their primary meters by offsetting their normal cost of electricity during normal grid operation. Additionally, these customers will have the benefit of being able to utilize the excess heat generated from the engine gensets within their operations, thus offsetting and/or reducing their heating fuel purchasing requirements or heating costs. This arrangement can be very beneficial to high energy users such as industrial facilities or greenhouse facilities. These facilities are also more likely to be able to curtail electric load during emergencies by reducing or stopping some of their operational processes, thereby freeing electric generation capacity for use within the microgrid.

The Village has an existing industrial park that it services that is not fully occupied, has natural gas service, and would be an excellent location for an industrial host location (generation source) for a CHP system or distributed energy resource (DER). If the industrial host location could curtail their site load during emergency conditions and provide the power generated by the CHP system back to the microgrid, the Village might be able create an economic and reliability package that would be beneficial to both parties. It is our understanding that the Herkimer County Industrial Development Agency (IDA) that encompasses the Village of Frankfort has investigated this type of project in the past with respect to municipal electric pricing only. With the advent of a microgrid, the benefits of having co-generation power operations adjacent to a prospective industrial/commercial customer may make the microgrid project a more feasible and economically viable option to attract industries with large heating/cooling requirements to locate within or adjacent to the Village.

Infrastructure and General Operation of the Microgrid

- Physical Function – related to the physical function of the microgrid, upon failure of the primary or main grid at the 46 kV level (outage, grid not within voltage/frequency, brownout or scheduled maintenance, etc.); the Village microgrid will detect these types of irregular operating conditions. At these times, electrically actuated breakers or reclosers at any feeder location will island the generation source, the four (4) CHP engine gensets (at 1,426 kWe each), to ensure that power can be safely generated within the microgrid independent of the outside grid status. The DERs/generation sources (CHP engine gensets) at the industrial host locations will be designed to operate 24/7/365 excluding scheduled maintenance. An example industrial host to match the demand and usage of the microgrid during emergency grid outages could be a greenhouse. Greenhouses have large electric and heat demands; however, these facilities have the ability to suspend portions of their industrial operation (i.e. curtail load) such as the grow lights for periods of time. This would provide demand response to the Village. Customers with Life Safety loads within the Village have existing diesel supplied backup generation, which will detect the absence of electricity supply from the Village grid and will automatically respond to supply the necessary power for those smaller critical loads via their current automatic islanding controls. Once main grid power is restored via the feeders from National Grid's 46kV transmission lines to the Village substations or the DER internal to the microgrid, those entities that were running on automatic diesel powered backup generators at their facilities will see the restoration of "grid power" (generated within the microgrid instead of from external sources) and the diesel operated backup system will automatically turn off to conserve those fuel supplies unless it is a Tier IV facility that has been curtailed from the microgrid. Thus, customer diesel standby operations would cease, and primary internal power to the microgrid would originate from the National Grid transmission line or DER to the Village's substations.

- Protection Controls – The feeder and generator protection controls as well as the switchgear controls at DER industrial host locations will recognize the loss of grid power and will execute an automatic load curtailment plan by opening breakers to non-critical loads. This process will occur at the industrial host location facility while simultaneously beginning the black start process for the CHP engine gensets. DERs will synchronize voltage, frequency and other parameters to a preprogramed reference within the microgrid. Once synchronized, relay controls at each DER point of contact will signal the individual isolation breakers to close, which will allow DER generation to flow back into the microgrid (site loads will remain locked out to ensure generation can support the higher priority loads within the microgrid).

- Loading Controls – To control loading of the CHP engine gensets, based DERs and electrically actuated breakers on each circuit within the substations will operate in a designated process order. During a detected power loss, the actuated breakers will open; this includes breakers on the main microgrid connection point and all system feeders. This sequence will be controlled at the Village's substations (refer to **Figure 1** for locations). The generation source (CHP engine gensets) will then black-start, the DERs will be engaged to start, and the engine gensets will power essential DER parasitic loads. The actuated breakers will then close sequentially in a controlled way, in order of high priority circuits to block load the generation source (CHP engine genset) and the DERs. This will allow for a controlled and automatic islanding of the microgrid. While many steps will take place during a power transition within the microgrid, the actual time elapsed will be very short due to the automatic controls of the system.

- Disconnect of Main Grid – Once the main grid (46kV electric supply) is restored and becomes stable (at least 15 minutes) to the Village's substations, the automatic controls of the CHP system will sense this, the feeder breakers will open, and the DER facilities will be disconnected from the microgrid. The microgrid interconnect will close, all system breakers will close and the entire microgrid system will be powered via the main grid. Once the main grid supply is back in normal operations, the DERs will sense the frequency and voltage being supplied by the Village electric distribution company and will synchronize and then reconnect in normal parallel operation and repower the previously curtailed or locked out demand loads at the industrial host location.

- Island Mode – the CHP system facilities would have the option to island themselves and utilize their own on site power but could not utilize the microgrid's supply. This means that host locations would either need to have back up generation or scale back to only very critical loads during the emergency because their CHP generation would be allocated for the microgrid.

- Metering – Since the metering structure within the microgrid will not be impacted, billing for demand and usage will remain the same during the outage unless individual Power Purchase Agreements (PPAs) or surcharges are in effect for certain customers during declared grid emergencies.

- Public Service Announcements – It is anticipated that prior training efforts and PSAs during a grid emergency/outage will be necessary to inform residents, businesses, industrial facilities and other critical facilities what is expected of them during an emergency condition. Such outreach measures will be conducted via: local TV, radio, text message, email, and automated phone calls. As can be anticipated, most businesses, commercial entities and industrial facilities within the microgrid would be requested and potentially required (via agreement terms and conditions) to operate on a limited power usage to assure enough electricity is available for the entire microgrid during an emergency situation.

2.2 Load Characterization

To characterize the electric load within the Village's current service grid, questionnaires were set to most facilities including critical facilities within the grid. The questionnaires were segmented into four (4) different types: General Facilities, Police Department Facilities, Fire Department and EMS Facilities and Water and Wastewater Facilities. Participation and completion of the questionnaires were minimal, such that only several incomplete questionnaires were returned. Therefore, loads within the Village were estimated based on various reference sources including electric bills from the Village's electric distribution company (Frankfort Electric Department). Using the best available data, demand and usage profiles were then developed into typical one-year time frames for the proposed microgrid system in the Village. Residential and commercial loads where estimated by the use of typical residential demand and usage extrapolated over the total population based on GIS and 2010 Census data.

Appendix A contains graphs that illustrate electric demand profiles and **Appendix B** contains graphs that illustrate electric usage profiles by customer type and in aggregate within the Village. **Table 2A** provides the total usage of the Village of Frankfort's facilities that were identified to be part of the microgrid system. These profiles include best-available data for hourly demand and usage to model sources of loading and conditions requiring microgrid support within the Village system. The Facility Questionnaires that were sent to facilities within the Village are included under **Appendix C.**

Table 2A
Total Annual Usage for the Village of Frankfort

Facility	Average Annual Total Usage (kWh)	Average Monthly Usage (kWh)	Average Weekly Usage (kWh)	Average Annual Usage Per Customer (MWh)	Average Annual Usage Total (MWh)
Water Dept. Office and Two Wells	207,800	17,300	4,000	200	200
Village Offices and Police Station	23,800	2,000	500	20	20
Frankfort Fire Department	37,000	3,100	700	40	40
Frankfort Town Police	19,200	1,600	400	20	20
Gas Stations/ Convenience Stores	271,600	22,600	5,200	70	300
Elementary School	89,200	7,400	1,700	100	100
High School	308,900	25,700	5,900	300	300
Library	8,900	700	200	10	10
Pharmacies	181,400	15,100	3,500	200	200
Grocery Stores	283,300	23,600	5,400	300	300
Residential Homes	13,847,400	1,154,000	266,300	10	13,800
Commercial Businesses	13,747,700	1,145,600	264,400	300	13,700
Total Microgrid Usage	**29,026,000**	**2,419,000**	**558,200**	**1,570**	**29,000**

Based on the information referenced above in **Appendices A-C** and in **Table 2A**, the estimated electric power demand and usage system parameters for the Village are as follows:

- Peak Demand: 4.41 MW.
- Ave. Demand: 2.27 MW.
- Ave. Annual Usage: 29,000 MWh.
- Ave. Monthly Usage: 2,450 MWh.
- Ave. Weekly Usage: 615 MWh.

These profiles represent the entire Village grid as currently served through two (2) substations; one primarily for the industrial park within the Village, and one for the other loads within the Village.

Heat generated by the DERs that will be part of the microgrid will normally be utilized by the host location in an industrial application such as a greenhouse, industrial boiler substitute, etc. Generally this will consist of heat exchangers connected to the high temperature jacket water cooling circuit on the CHP engine genset, and within the exhaust system to recover the majority of the heat generated from the engine gensets during operation. This heat is then transferred into the industrial facility's hot water system for use throughout the facility, and returned at a lower temperature to absorb more heat from the CHP engines gensets. This makes for a highly efficient use of the BTUs generated by combustion of the natural gas on the site.

At full deployment of the DERs (generation sources all four (4) CHP Engine gensets) to the microgrid system at the industrial host locations, the total system capacity in island mode is expected to be as follows, assuming 90% annual availability of the CHP engine gensets and 60% recovery of the useable recoverable heat output:

- Annual Heat Output: 214,000 mmBTU (at 90% availability).
  128,400 mmBTU (at 60% useable and recoverable heat).
- Weekly Heat Output: 4,120 mmBTU (at 90% availability).
  2,470 mmBTU (at 60% useable and recoverable heat).

A greenhouse sized at 10-20 acres is expected and has been modeled to use the estimated 60% annual heat output as referenced above. However, it is important to note that the heat demand for a greenhouse will vary between seasons, such that heat demand will be higher in summer and lower in winter. For additional information regarding the greenhouse concept for an additional host, refer to the **Section 1.1.**

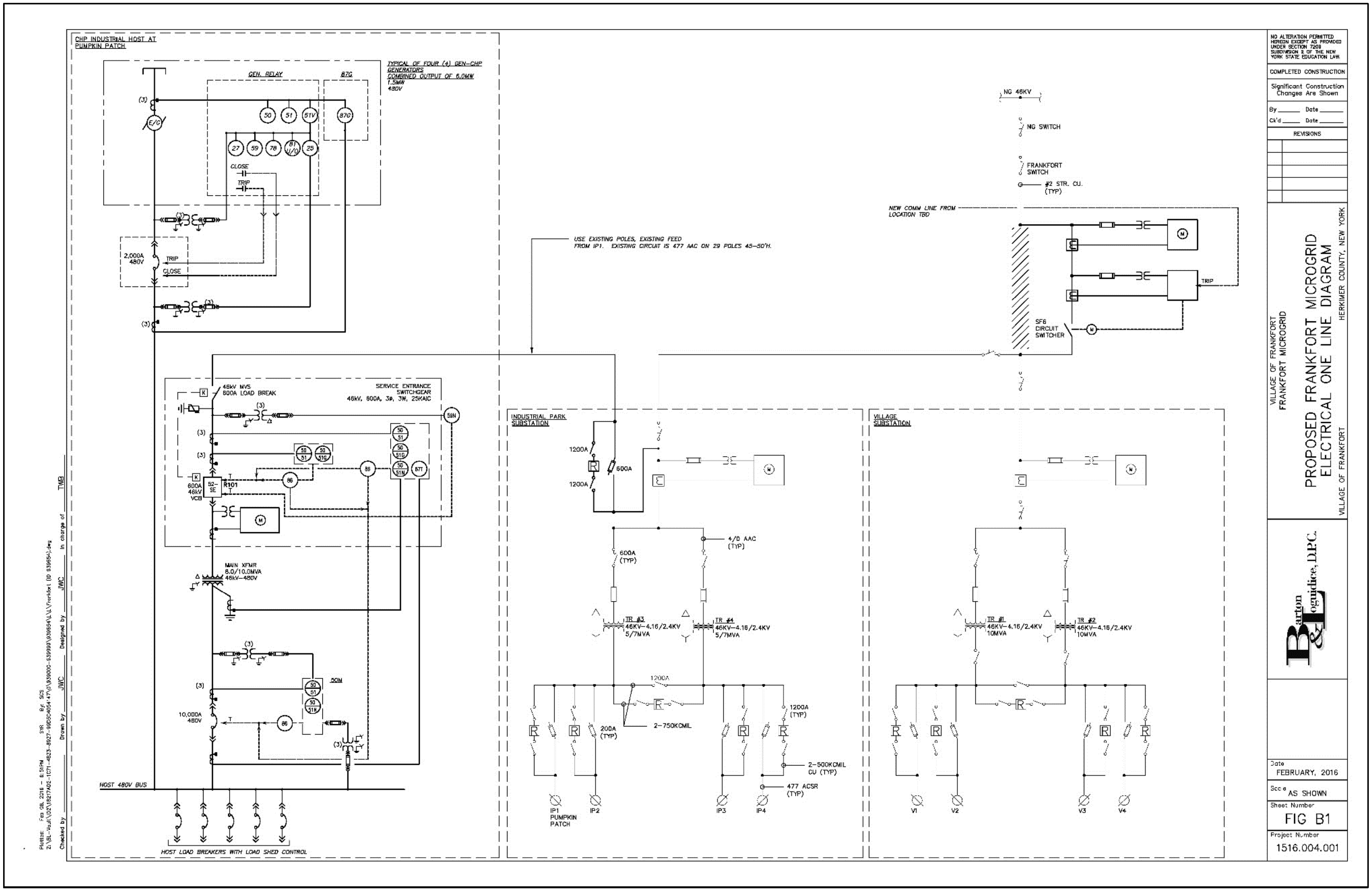
For an individual CHP engine genset, the Exhaust Gas Recovery System and a Hot Water Flow Metering System with heat dissipated at 90% availability. It is estimate that only 60% of the useable recoverable heat output below will be reused (due to lower heat demand in the summer), with the remainder available if a feasible use is found.

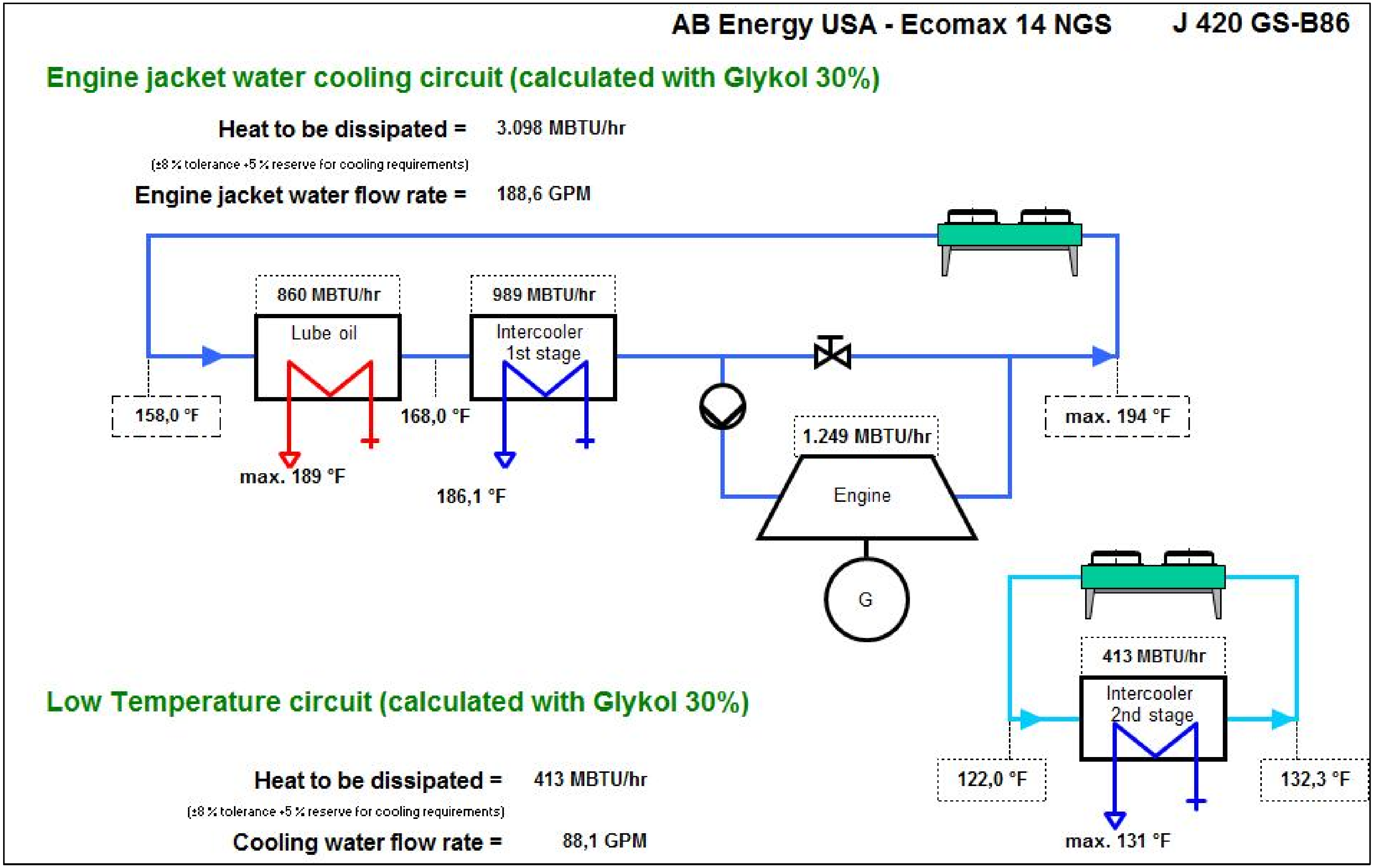
- Engine and Jacket Water 1,249 mmBTU/hr.
- Lube Oil 860 mmBTU/hr.
- Intercooler 1st Stage 989 mmBTU/hr.
- Exhaust Heat Exchanger 3,683 mmBTU/hr.

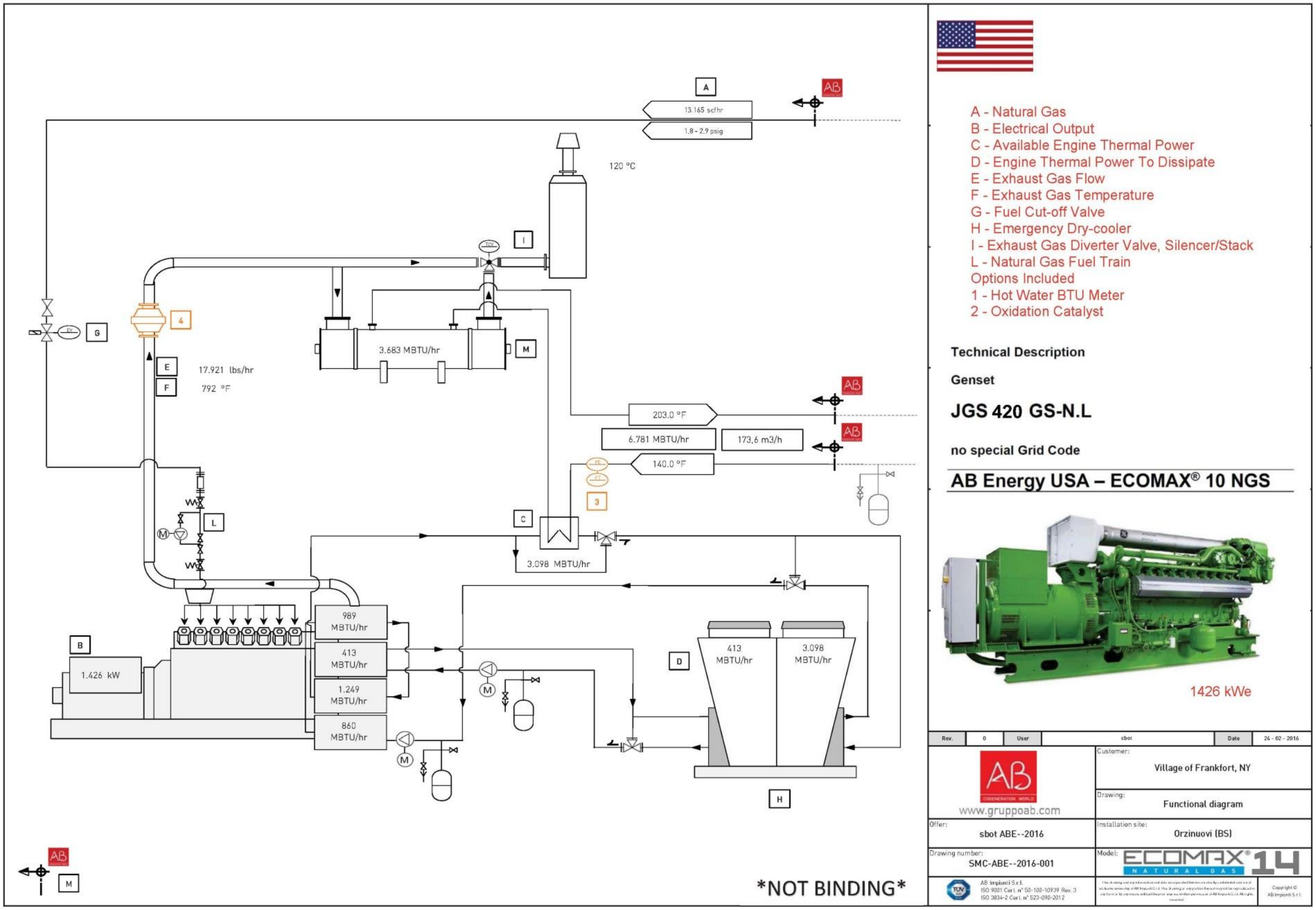
  6,781 mmBTU/hr.

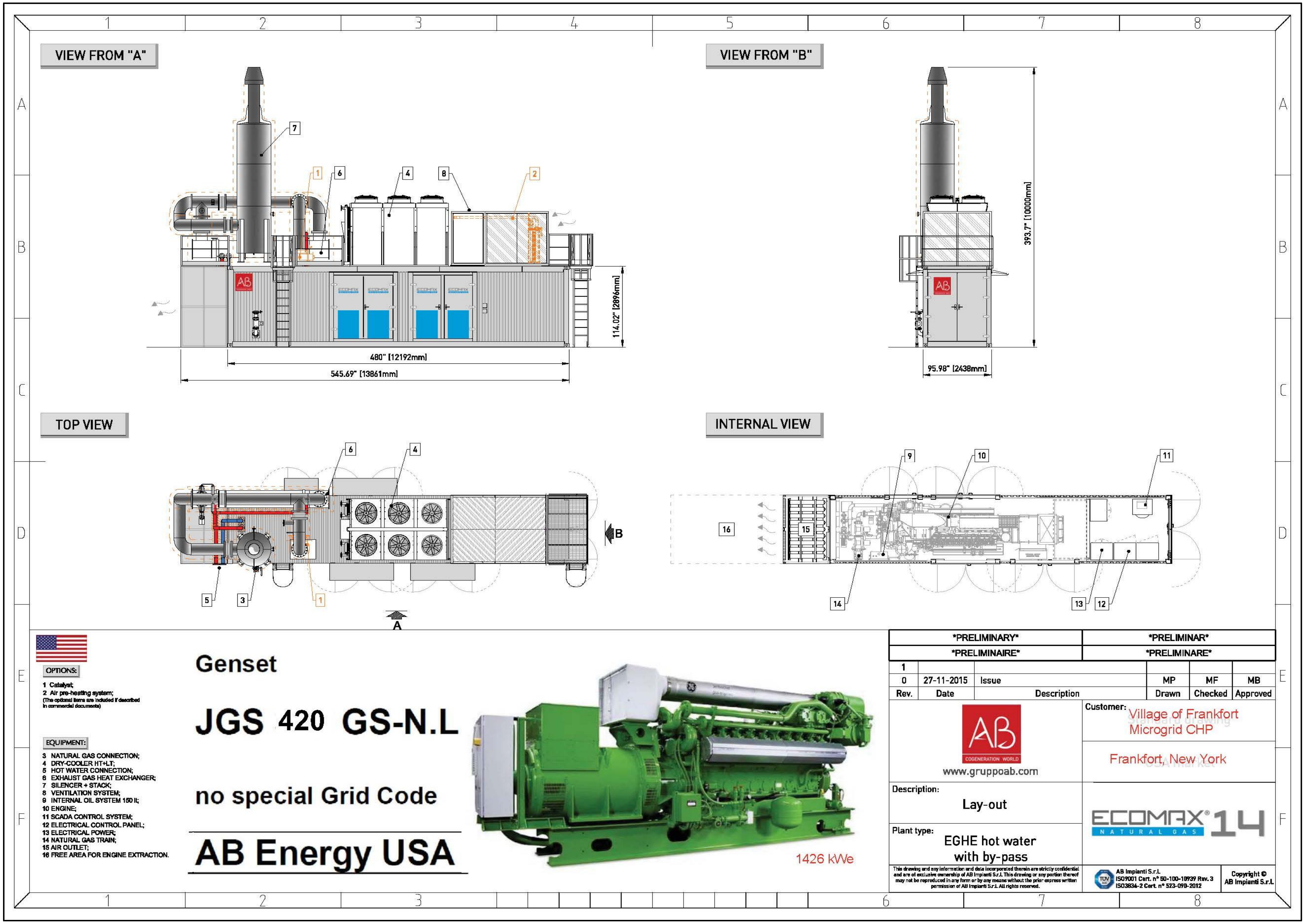
Note – there are four (4) CHP engine gensets projected for this project.

Refer to the Electrical One-Line Diagram and the Process/Functional/Layout Diagrams that follow this section, which are also included in **Appendix D** and **Appendix G**, respectively.


CHP INDUSTRIAL HOST AT PUMPKIN PATCH
TYPICAL OF FOUR (4) GEN-CHP GENERATORS COMBINED OUTPUT OF 6.0MW 1.5MW 480V
GEN. RELAY
HOST 480V BUS
HOST LOAD BREAKERS WITH LOAD SHED CONTROL
MAIN XFMR 6.0/10.0MVA 46kV-480V
SERVICE ENTRANCE SWITCHGEAR 46kV, 600A, 3ø, 3W, 25KAIC
46kV MVS 600A LOAD BREAK
USE EXISTING POLES, EXISTING FEED FROM IP1. EXISTING CIRCUIT IS 477 AAC ON 29 POLES 45-50'H.
NG 46KV
NG SWITCH
FRANKFORT SWITCH
#2 STR. CU. (TYP)
NEW COMM LINE FROM LOCATION TBD
SF6 CIRCUIT SWITCHER
INDUSTRIAL PARK SUBSTATION
VILLAGE SUBSTATION
TR #3 46KV-4.16/2.4KV 5/7MVA
TR #4 46KV-4.16/2.4KV 5/7MVA
TR #1 46KV-4.16/2.4KV 10MVA
TR #2 46KV-4.16/2.4KV 10MVA
2-750KCMIL
2-500KCMIL CU (TYP)
477 ACSR (TYP)
4/0 AAC (TYP)
IP1 PUMPKIN PATCH
IP2
IP3
IP4
V1
V2
V3
V4
NO ALTERATION PERMITTED HEREON EXCEPT AS PROVIDED UNDER SECTION 7209 SUBDIVISION 2 OF THE NEW YORK STATE EDUCATION LAW.
COMPLETED CONSTRUCTION
Significant Construction Changes Are Shown
REVISIONS
VILLAGE OF FRANKFORT FRANKFORT MICROGRID
PROPOSED FRANKFORT MICROGRID ELECTRICAL ONE LINE DIAGRAM
VILLAGE OF FRANKFORT
HERKIMER COUNTY, NEW YORK
Barton & Loguidice, D.P.C.
Date FEBRUARY, 2016
Scale AS SHOWN
Sheet Number FIG B1
Project Number 1516.004.001


AB Energy USA - Ecomax 14 NGS
J 420 GS-B86
Engine jacket water cooling circuit (calculated with Glykol 30%)
Heat to be dissipated =
3.098 MBTU/hr
(±8 % tolerance +5 % reserve for cooling requirements)
Engine jacket water flow rate =
188,6 GPM
860 MBTU/hr
Lube oil
989 MBTU/hr
Intercooler
1st stage
158,0 °F
168,0 °F
max. 189 °F
186,1 °F
1.249 MBTU/hr
Engine
max. 194 °F
G
413 MBTU/hr
Intercooler
2nd stage
Low Temperature circuit (calculated with Glykol 30%)
Heat to be dissipated =
413 MBTU/hr
(±8 % tolerance +5 % reserve for cooling requirements)
Cooling water flow rate =
88,1 GPM
122,0 °F
132,3 °F
max. 131 °F


A - Natural Gas
B - Electrical Output
C - Available Engine Thermal Power
D - Engine Thermal Power To Dissipate
E - Exhaust Gas Flow
F - Exhaust Gas Temperature
G - Fuel Cut-off Valve
H - Emergency Dry-cooler
I - Exhaust Gas Diverter Valve, Silencer/Stack
L - Natural Gas Fuel Train
Options Included
1 - Hot Water BTU Meter
2 - Oxidation Catalyst
Technical Description
Genset
JGS 420 GS-N.L
no special Grid Code
AB Energy USA – ECOMAX® 10 NGS
1426 kWe
13.165 scf/hr
1,8 - 2,9 psig
120 °C
3.683 MBTU/hr
17.921 lbs/hr
792 °F
203.0 °F
6.781 MBTU/hr
173,6 m3/h
140.0 °F
3.098 MBTU/hr
989 MBTU/hr
413 MBTU/hr
1.249 MBTU/hr
860 MBTU/hr
1.426 kW
413 MBTU/hr
3.098 MBTU/hr
NOT BINDING
Customer: Village of Frankfort, NY
Drawing: Functional diagram
Offer: sbot ABE--2016
Installation site: Orzinuovi (BS)
Drawing number: SMC-ABE--2016-001
Model: ECOMAX 14
www.gruppoab.com
Date 24 - 02 - 2016


VIEW FROM "A"
VIEW FROM "B"
TOP VIEW
INTERNAL VIEW
480" [12192mm]
545.69" [13861mm]
114.02" [2896mm]
393.7" [10000mm]
95.98" [2438mm]
OPTIONS:
1 Catalyst;
2 Air pre-heating system;
(The optional items are included if described in commercial documents)
EQUIPMENT:
3 NATURAL GAS CONNECTION;
4 DRY-COOLER HT+LT;
5 HOT WATER CONNECTION;
6 EXHAUST GAS HEAT EXCHANGER;
7 SILENCER + STACK;
8 VENTILATION SYSTEM;
9 INTERNAL OIL SYSTEM 150 lt;
10 ENGINE;
11 SCADA CONTROL SYSTEM;
12 ELECTRICAL CONTROL PANEL;
13 ELECTRICAL POWER;
14 NATURAL GAS TRAIN;
15 AIR OUTLET;
16 FREE AREA FOR ENGINE EXTRACTION.
Genset
JGS 420 GS-N.L
no special Grid Code
AB Energy USA
1426 kWe
PRELIMINARY
PRELIMINAR
PRELIMINAIRE
PRELIMINARE
Rev. 0 | Date 27-11-2015 | Description Issue | Drawn MP | Checked MF | Approved MB
COGENERATION WORLD
www.gruppoab.com
Customer: Village of Frankfort Microgrid CHP
Frankfort, New York
Description: Lay-out
Plant type: EGHE hot water with by-pass
ECOMAX 14
NATURAL GAS
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ISO9001 Cert. n° 50-100-10939 Rev. 3
ISO3834-2 Cert. n° 523-090-2012
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2.3 Distributed Energy Resources Characterization

As discussed in previous sections, the potential for the integration of various DERs was investigated. The proposed DERs in the Village of Frankfort's microgrid, located at an industrial host location, would provide the electricity needed to supply the proposed microgrid. DER industrial host locations that can shed their load and make their on-site generated power available to the microgrid provide redundancy to the Village's electrical system.

There are no proposed renewables such as photovoltaic (PV) or wind power as scheduled DERs within the Village of Frankfort's microgrid. More specifically, this means that renewable generation is a project goal, but such power will not be counted toward meeting demand and usage requirements during a grid emergency/outage. This is due to the fact that PV power by itself is not sufficiently reliable in certain conditions, such as emergency situations that occur after sunset and seasonal conditions (e.g. snow, ice, etc.), which have the potential to limit the effectiveness of PV power. Wind energy may also be affected by and fluctuate during seasonal and atmospheric conditions, and therefore, wind energy power may not be as reliable as other power supplies. Such limitations make the scheduling of power from PV, wind energy or other intermittent renewables very difficult as demand has to react to supply versus supply reacting to demand. PV and wind generated power will not be included in the Benefit Cost-Analysis.

While UPS battery storage could potentially address some of the issues with PV and wind renewable power generation to some degree, industry experience and available information has indicated it could be cost prohibitive to the initial capital investment of the microgrid project and during future operation and maintenance periods. Other renewables such as hydroelectric generation have also not been included as a DER within the microgrid. The primary reasons for excluding hydroelectric for this Feasibility Study includes: limited natural resources exist within the microgrid, available sites and siting requirements are not favorable within the Village, and that a microhydro system would be cost prohibitive.

As noted in the NYSERDA grant application, the Village of Frankfort may purchase a 12-acre land parcel in the future that has the potential to be used for PV renewable generation. It is reported that the 12-acre land parcel also has a small waterfall; however, as discussed above, the potential for small-scale hydroelectric power generation is minimal.

While renewables are not scheduled, any future proposed renewable generation technology coupled with UPS battery storage could potentially be utilized in the microgrid, in parallel operation during either normal grid operation or during grid emergencies/outages. In an emergency situation, any future proposed renewable generation would potentially be available to reduce the demand on the CHP engine gensets and they would adjust to the lower load but remain capable of picking up that load should the renewable source reduce output. Refer to **Table 2B** for a summary of potential DER options, which also includes potential renewable energy generation for informational purposes.

Table 2B
Distributed Energy Resources

Type of DER	Capacity (kWe)	Rating (BTU/kW)	Fuel (Gas, Oil, Etc.)	Location	New or Existing	Space Available
Reciprocating Engines CHP gensets	5,700	5,940	Gas	Industrial Park	New	Yes

**As renewables are not currently included in the design of the microgrid system and are not currently counted as part of total available power that can be scheduled on the microgrid during an emergency, they have been omitted from Table 2B.*

At full deployment of the DERs (generation sources) to the microgrid system at the industrial host locations, the total system capacity in island mode is expected to be as follows, assuming 90% annual availability of the four (4) CHP engine gensets (1,426 kWe each):

- Peak Generation Capacity: 5.7 MW.
- Max. Achievable Annual Production (Normal Conditions): 45,000 MWh.
- Max Daily Production During Major Power Outage: 137 MWh.
- Annual Heat Output: 214,000 mmBTU.
- Weekly Heat Output: 4,120 mmBTU.

Since net metering of CHP fired (fueled) on non-renewables such as natural gas is not currently allowed by the New York Public Service Commission rules, the CHP engine gensets at the industrial host locations will generally be operated to follow the site's normal load profile so as not to push power to the grid at a low generation value. During grid emergencies/outages, power would be put back onto the microgrid. Heat from the engine gensets may still be used at the industrial host location's facilities.

CHP engine gensets have proved to be a reliable source of electricity generation, as well as heat supply. The microgrid will be supplied using CHP engine gensets as such systems are easily scheduled and are not impacted by the vast majority of local environmental conditions in the way PV and wind energy may be impacted during emergency situations. CHP engine gensets are virtually unaffected by forces of nature as the units are typically installed inside a weather resistant enclosure or building. The enclosure is typically designed to withstand appropriate wind velocities and snow loads for the site location. The CHP engine gensets will be sited to avoid nearby trees, which may cause a hazard during storm events. CHP engine gensets will typically be installed on a raised concrete pad outside of flood zones, which limits rainwater/flood waters from gathering inside or around the enclosure. Proposed generation sources at industrial host locations would be sited and installed to be a minimum of 2-feet above the 100-year floodplain in accordance with FEMA and other recognized codes and standards for critical infrastructure systems. Any structures and or electrical components will be built according to Building Code with any necessary seismic design in order to prevent damage in the event of an earthquake.

The CHP engine gensets will be supplied by a buried natural gas pipeline with the compression source located far away from the industrial host location site such that local conditions will not have an impact on the supply of gas. Since the pipeline is buried, it will not susceptible to typical forces of nature such as wind, ice, snow, etc. that typically impact above ground infrastructure. Additionally, since the source of the gas and its pressure is not local to the Village of Frankfort, it is much less likely that both the Village and the remote compressor station will experience the same type of emergency at the same time. As a fuel source, utility supplied natural gas via pipeline is a very robust system and is virtually an uninterruptable fuel supply. It is anticipated that natural gas will be able to be supplied to the Village of Frankfort during an emergency situation continuously, for the duration of the emergency event lasting one week or longer.

A contractual agreement is envisioned between the Village of Frankfort and the natural gas supplier (National Grid) to guarantee a fuel supply to the Village's proposed CHP engine gensets during an emergency situation as uninterruptable service. Scheduled maintenance required on the natural gas pipeline that would cause a natural gas service outage, if any, would be conducted with prior notification to the Village of Frankfort and the electric distribution company. Scheduled maintenance would likely be in a way that would not cut service, and will not be scheduled during actual high risk periods for emergency outages. Because of their resiliency to local environmental conditions, CHP engine gensets are a continuously reliable source of power for the microgrid.

Like the natural gas pipeline, CHP engine gensets require scheduled maintenance, but typically the timing of this maintenance can be scheduled and adjusted around emergency events so this is an unlikely potential failure point of the microgrid. Typical routine maintenance may include changing filters (oil, air, etc.), changing oil and spark plugs, maintaining batteries and coolant, monitoring system performance parameters to identify potential system problems, etc. Other than an event of the actual failure of equipment, these maintenance tasks can be delayed if a grid emergency/outage should take place at the time scheduled maintenance. Additionally, excess capacity has been designed into the microgrid system so that the peak demand of the system should be able to be met at any time should an emergency arise.

Given these considerations, the greatest risk of failure of the microgrid is the existing Village-owned infrastructure. The DERs will be able to generate power, but if the rest of the microgrid infrastructure is exposed to extreme conditions, any overhead distribution lines would be the most likely point of failure. The Village Electric Department is responsible for operation and maintenance of the Village-owned electrical system. It consists of a newer substation that was installed in the late 1990s that services the industry park and an older substation that was installed in the 1960s-1970s that services the remainder of the Village grid. It also includes the entire Village-owned overhead 4.16kV distribution system feeders, poles, transformers, meters, etc. Although the Village's overhead system is well maintained and in satisfactory working order, it is the most exposed infrastructure in regards to the overall microgrid system reliability. As such, it is recommended that any new distribution lines be buried or be clear from any vegetation to increase overall reliability of the electrical system.

DER/Generation Source Capabilities

As previously noted in **Section 1.2**, the proposed microgrid network will be designed in accordance with the a variety of industry standards and requirement, which will be fully assessed and evaluated during the detailed design of Stage 2 of the microgrid project. At this time, the following standards and requirements have been identified:

- NYS Department of Public Service's Standard Interconnection Requirements (SIR) and Institute of Electrical and Electronics Engineers (IEEE) 1547 – for overcurrent protection, synchronization, voltage and power controls, and metering and monitoring.
- American National Standards Institute (ANSI) c84-1 – once the microgrid system is fully connected, it will follow system load and maintain system voltage.
- International Organization for Standardization (ISO) 8528-5 – during design for island mode (microgrid) operations of the engine gensets and related systems.

The DERs/generation sources (CHP engine gensets) include numerous functions and capabilities to meet the requirements of the microgrid. These include, but are not limited to: black start, load-following and part-load operation, maintaining voltage and frequency, the capability to ride-through voltage and frequency events in islanded mode, and the capability to meet interconnection standards in grid-connected mode. These functions and capabilities are further described below.

- Black Start – this capability is necessary to transition the CHP engine gensets from main grid power (National Grid transmission lines) to microgrid island mode. The paralleling controls of CHP engine gensets will likely turn off the engines and require a restart. This black start sequence will initiate once the engine gensets and the microgrid system sense instability conditions or an outage from the main primary grid. Paralleling controls will then open the circuits to isolate both engine gensets and the microgrid to island mode. The engine gensets will likely then turn off. The microgrid system will then call for power from the generation source for the restart. The CHP engine genset would be the prime mover to start-up, close the generator breaker and supply the power using an interrupted fuel source (natural gas). A black start can take place on an engine genset that was previously not in operation (cold start) or an engine genset that has been shut-down (hot start).

- Load-Following and Part-Load Operation – this capability is necessary to allow the CHP engine gensets to adjust or adapt their power output as the demand for electricity fluctuates throughout the day or through seasonal variations. This is critical for the Village's microgrid as the peak demand is 4.41 MW and the average demand is 2.27 MW along with the rated capacity of the CHP System at 5.7 MW for the microgrid. Based on the loading conditions, the Supervisory Control and Data Acquisition (SCADA) System and other controls would adjust the output or function of the four (4) engine gensets for 70% availability. Thus, the number operating engine gensets may decrease to match the loading and demand requirements and the other engine gensets may drop-off or be placed into an idle mode. The SCADA System will also provide for real-time and archive data logging, which can be used on a daily/weekly/monthly/annual basis or emergency grid outage basis to assess the functionality and performance of the microgrid system.

- Maintain Voltage and Maintain Frequency – the SCADA System of the CHP engine gensets maintain settings for voltage control and distribution during normal operation and load shedding that adjust to any variations in the settings protect the equipment and to ensure maximum power output. The CHP engine genset system also maintains synchronization controllers (that are also connected to the SCADA System) that monitor and adjust the equipment to maintain the required electrical frequency to ensure maximum power output.

- Capability to ride-through voltage and frequency events in island mode – the same systems and equipment referenced above to "maintain voltage and frequency" and monitor operating conditions will be in place for the CHP engine gensets and microgrid during main grid mode as well as in island mode.

- Capability to meet interconnection standards in grid-connected mode – the microgrid system and the CHP engine gensets will be designed and operated in accordance with NYS Department of Public Service's SIR. Feeder protection equipment and smart controls will be in place to separate main grid and microgrid inbound and outbound power at the interconnection point.

For more detailed information, refer to **Appendix I**: Technical Instruction Manual for Isolated Operation of Spark Ignition Gas Engines with DIA.NE (Type 4 Engines), TA 2108-0029 and Technical Instruction Manual for General Isolated Operation of Plants and Engines, TA 2108-0031 Page 5 of 19.

2.4 Electrical and Thermal Infrastructure Characterization

As outlined in an electrical One Line Diagram included in this Section and attached in **Appendix D**, the current Village electrical infrastructure includes feeders to two (2) substations from National Grid 46kV electrical transmission lines. These electric transmission lines to the substations are above ground infrastructure. One substation generally services the northern portion of the Village including the industrial sectors. The second substation services the remainder of the Village's service area. At each substation has step down transformers that drop the incoming voltage from 46kV to 4.16kV, 3-phase. The substations are set up in a "main-tie-main" arrangement to provide redundancy in the existing Village electrical system.

The proposed microgrid will connect to the substations via a (480V-4.16V) step up transformer and existing overhead poles and distribution lines will be used to connect the proposed industrial host location back to the substation serving the industrial park. New cabling and conductors will likely be required based on the capacity of the existing infrastructure feeding the industrial host. The microgrid will be interconnected on the feeder high side of the substation so that power can also be connected to the Village substation without running new cable between the substations. Communication lines will be connected to switches at the feeder from the National Grid transmission lines to provide necessary system control of connection and disconnection from the transmission line.

Currently, there is no heating district (e.g. steam loop) within the Village. Most commercial buildings and industrial facilities are heated by oil, natural gas or electric heat. Many residences are heated by electric heat. Those that heat with electricity are most vulnerable if there was an extended power outage during cold weather. The microgrid will safeguard that situation, and community facilities like schools and libraries will be available as shelter locations in such instances.

Heat generated by the DERs that will be part of the microgrid will normally be utilized by the host location in an industrial application such as a greenhouse, industrial boiler substitute, etc. Generally this will consist of heat exchangers connected to the high temperature jacket water cooling circuit on the CHP engine genset, and within the exhaust system to recover the majority of the heat generated from the engine gensets during operation. This heat is then transferred into the industrial facility's hot water system for use throughout the facility, and returned at a lower temperature to absorb more heat from the CHP engines gensets. This makes for a highly efficient use of the BTUs generated by combustion of the natural gas on the site. Regarding the combustion of natural gas through the DERs/generation sources (CHP engine gensets), estimated emissions based on the manufacturer's performance data is provided in **Section 4.3** and in **Appendix E**.

As discussed in previous sections, the generation portion of the microgrid has been envisioned to be fairly impervious to forces of nature and resilient to the disruption. The most likely risks to the system might include:

- High winds.
- Snow, ice, and very cold weather.
- Lightning.
- Transmission line damage in and out of the area (trees/limbs, animals, accidents).

The DER portion of the microgrid will be protected from the above referenced forces of nature by their location, design precautions and the facilities around them. Wiring, cables, controls and/or equipment can be protected by direct burial or protected with enclosures or structures placed around them, as feasible and cost effective. Additionally, effective protective equipment and system design will make the microgrid system resilient. Modern solid-state relays and controls on the generation source and the feeder breakers/reclosers allow for fast removal of equipment from the electrical systems during a ground faults and system anomalies, appropriately designed grounding systems, system lightning protection and other protective methods will be utilized.

Avoidance of problems and hazards are essential to the reliability and resiliency of the microgrid. As the Village maintains their own system, they control the staff, equipment, maintenance schedules and supplies to address problems as they arise. Should a portion of the microgrid system require repair, standard preventative and responsive maintenance practices like having a spare parts inventory (materials in stock), following manufacturer's recommended service intervals, maintaining current and correct industry-specific training for staff, utilizing asset management systems, etc. will help ensure that the microgrid system is robust, reliable, and easier to maintain and therefore keep outages to a minimum.

Another potential risk to the microgrid's functionality is the supply of fuel, natural gas. This is addressed both through the general robustness of the natural gas utility system, and the contractual agreements (for completion in the future) that facilitate continuous supply. Because both supply and the energy required to convey the gas through the piping networks are typically not local, weather related issues affecting both the microgrid and where natural gas compressor station is located (i.e. the delivery system) is unlikely. Additionally, the gas infrastructure is buried, which further protects it from wind, snow, ice, etc.

With proper protection of the generation sources, secure fuel supply, and protection and maintenance of the grid itself, the Village's system will be very resilient and reliable.

2.5 Microgrid and Building Controls Characterization

The controls that will manage the microgrid system will be located at the Village's two (s) substations, and at the DER/generation source locations (the industrial host). These controls have to automatically take the microgrid off its normal connection to 46kV transmission lines, and island the microgrid in order for it to operate off of internal generation. As outlined in **Section 2.1**, the controls normally included in the parallel interconnection of CHP engine gensets will be utilized at the DER locations. When the external transmission supply for power goes into outage or is out of specification and the microgrid is isolated, the DER controls will work the same as in parallel operation except that the industrial host locations will curtail load as their facilities so that excess generation will be available to power to the most critical loads within the microgrid. The paralleling controls will allow the excess power from the DER's to flow into the microgrid.

The microgrid will provide the ability for demand response, maintaining voltage and frequency as well as data logging. These functions and capabilities are previously described in this Feasibility Study and are summarized below.

- <u>Demand Response</u> – The DERs/generation sources at the industrial host location will provide demand respond for the Village's microgrid during a main grid emergency outage. The industrial host and the CHP System would curtail its base load by suspending portions of the facilities operation, and redirect the power output of the four (4) engine gensets (1,426 kWe) to the microgrid. An example industrial host to match these conditions could be a greenhouse that has the ability to the grow lights for periods of time without significant impact to the overall operation. Although the residential, public service and existing commercial/industrial customers of the Village are on smart meters, the meters do not have the capability of automated curtailment. The Village will utilize PSAs and public outreach to educate its electric customers to reduce usage during an emergency grid outage to reduce the demands of the potential microgrid system.
- <u>Maintaining Voltage and Frequency</u> – the SCADA System for the CHP engine gensets, the synchronization controllers and other related equipment will help maintain, monitor and adjust the microgrid system to maintain voltage and frequency in accordance with regulatory and industry standards.
- <u>Data Logging</u> – the SCADA System will provide for real-time and archive data logging, which can be used on a daily/weekly/monthly/annual basis or emergency grid outage basis to assess the functionality and performance of the microgrid system. Also, regarding the residential, public service and commercial/industrial buildings within the Village's distribution system, there are smart meters installed that record daily/weekly/monthly/annual usage data. The Village utilizes smart meters as their mechanism for billing to its electric customers.

The Electrical One Line Diagram in included in **Section 2.2** and **Appendix D** outlines the general connection and control scheme for the microgrid. Typical generator and utility protection relays and paralleling gear will be utilized at the DER industrial host locations. These systems interface with PLC controls, HMIs and data logging to control and monitor the systems. Regarding the existing primary power supply to the Village's substations, the National Grid transmission lines, are reportedly at their thermal limit and capacity (refer to **Appendix F**); therefore additional capacity by the transmission lines is unlikely.

The CHP systems have been designed around a system by AB Energy North American because this supplier has the most experience integrating CHP systems with the proposed industrial host location (greenhouses) in the world. **Appendix G** includes a technical description of the CHP system as well as the functional diagrams and layout that will be used to provide the necessary generation to support the heating loads of the industrial host location and the electricity needs of the microgrid during normal operation, or during grid emergencies. **Appendix G and Appendix I contain** technical data sheets for natural gas fired CHP modules and the protection control equipment that will be combined to provide the necessary generation for the microgrid.

In summer 2011, the Village of Frankfort reportedly completed a project for replacing residents' existing electric and water meters with "smart" meter technology and implemented an advanced metering infrastructure (AMI) network. The new meters and network communications systems allows the utility department to remotely collect information about customers' power use, and receive immediate alerts of any outages or other problems that indicate a need for repairs. The technology upgrades are helping the village save money, and improve customer service and accuracy. These system upgrades will allow for better monitoring of the microgrid system to match usage and demand.

2.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

The majority of the controls for the microgrid system are utility protection relay systems that can have UPS supply backup power so that they can continuously operate the microgrid's controls system whether externally connected to transmission electricity of the primary or main grid, or operating off of local microgrid power. The intended purpose of UPS supplies is to provide short-term backup power, a few minutes to a few hours, over variable and intermittent power conditions (such as from the primary power grid). UPS backup power supplies can be sized for longer durations, but due to the initial front capital costs and replacement operating costs, such measures are not typically implemented and it is assumed that the DERs will be utilized in island mode thereby powering the relay controls.

Communication between the substation circuit controllers and the DER control systems at the industrial host location is necessary to facilitate a smooth loading of the engine gensets during transitions to microgrid power to ensure that too much load is not placed upon the engines, which could result in a protective shutdown thereby causing a continuation of an outage. These communication system connections could be facilitated, achieved or installed in a number of ways; either through direct fiber or wire connections for point to point, or through cellular connections that would be encrypted and where communications equipment would have backup power storage or generation to ensure uninterrupted communications.

Because the IT system and its potential components (e.g. protective relay controls, HMI, SCADA systems, etc.) can be powered from various sources, and will be appropriately protected, along with the fact that much of the control equipment senses conditions locally so it is not dependent on coordinated communications makes the IT system for the microgrid more resilient and reliable. The communications system mostly serves to monitor the microgrid system rather than provide actual control. The monitoring system can be designed to provide remote access via a password protected virtual private network connection. This remote monitoring system allows for alarm autodial and troubleshooting by responsible employees who may be on call. The system will allow for monitoring but no control of the microgrid system to provide further system security.

3.0 Assessment of Microgrid's Commercial and Financial Feasibility

3.1 Commercial Viability – Customers

The Village of Frankfort's Electric Department services approximately 1,700 customer accounts in the Village with a population of 2,600 individuals according to the 2010 U.S. census. These individuals would all be affected in the event of a grid emergency or outage that impacts the critical loads within the community, in addition to the public service, the commercial and other electric users within the Village's electric distribution area. The development of a microgrid within the Village of Frankfort's electric distribution area will have a number of benefits, the greatest being increased grid reliability and resiliency. Since the local electric distribution company and the Village are one in the same, including many of the community's critical loads, the microgrid will allow the Village's Electric Department to continue to serve its customers even if the power supply has been lost upstream of the Village's two (2) substations.

The microgrid will cover the full extent of the Village's distribution area to ensure that all customers within the Village will be customers of the microgrid. It is expected that the industrial host locations with continuous (non-emergency) generation would be requested and potentially required (via agreement terms and conditions) to curtail normal demand to provide for excess generation during grid emergencies. The full microgrid and customer base includes: a water department office and wells, village offices and a police station, a fire department building, a town police station, telecommunications offices, gas stations and convenience stores, an elementary school, a high school, a library, pharmacies, grocery stores, , 1,183 residential homes and 45 commercial businesses.

At this time, the specific terms and arrangements between participants/customers of the proposed microgrid and the microgrid owner/operator have not been fully developed nor executed. There is a set of potential and/or proposed initial terms and arrangements that require additional technical research, financial and legal reviews, and evaluation for customer outreach and education by the Village of Frankfort and their Contractor representatives during the microgrid development process. Some of these potential and/or proposed initial terms and arrangements are presented below:

- It is envisioned that The Village of Frankfort will design, purchase, install, own, operate and maintain the smart metering and communication equipment across the microgrid.
- It is envisioned that The Village of Frankfort will contact and evaluate the viability of industrial host locations as generation sources for DERS and will establish commitments and subsequently, the terms and conditions of agreements.
- There is an option for the Village of Frankfort to be responsible for the design, construction, operation and maintenance of the entire microgrid system with their own staff and/or hired vendors. This would include the generation sources (CHP engine gensets)/DERs at the industrial host locations. Additionally, this scenario could include a power purchase agreement (PPA) with the industrial host location to provide a mechanism for the host site to purchase and utilize the on-site generated power and heat for its own facility operations.
- There is an option for the industrial host location to be responsible for the design, construction, operation and maintenance of the generation sources (CHP engine gensets)/DERS at their sites

and make that power available (while reducing their load) to the microgrid in an emergency/ outage. In this scenario, the industrial host location would potentially receive some form of economic benefit and/or incentive from the Village. The Village would potentially be responsible for the control system and integration in the existing electrical distribution infrastructure of the Village along with periodic testing/verification of the DER's run capability during grid emergencies.

- There is a final option for a combination of the above referenced scenarios between the Village, the industrial host locations and the other to-be-determined microgrid project partners.
- It is anticipated that the end-users of the microgrid will purchase electricity during both normal operation and islanded operation.
- It is projected that there will not be any additional microgrid stakeholders that are indirectly affected positively or negatively by the microgrid.

Since sufficient capacity is estimated to be available to support Tier I-III facility demands by the generation source at the industrial host location, it is expected no agreements will be needed for critical Tier I, II and III facilities, which includes the fire departments, the police stations, the water department (and wells) and the telecommunication facility, etc. Agreements are expected to be required with Tier IV facilities, which will specify how much electricity they can use during islanded microgrid operation and how load will be curtailed during declared grid emergencies. For example, industrial customers would be requested and potentially required (via agreement terms and conditions) to limit electricity usage during islanded operation through automatic demand response within their electric service panels.

Additionally, some businesses could potentially have the opportunity to opt out of electricity usage during islanded operation if they are able to operate independently from the microgrid; however, they will not be allowed to connect when internal generation is being used within the microgrid. It is assumed that some type of discount will be offered to the commercial businesses or industrial users that are willing to significantly limit their electricity usage during a grid emergency (demand response programs, etc.).

For planning purposes, to identify DER capacity at potential industrial host locations and assess overall economic viability of the microgrid system, it is recommended that the Village should approach individual entities to inquire about and/or to propose the installation of a CHP engine genset at their location. Furthermore, the Village may have to enter into negotiations and agreements with host locations to ensure the viability of the microgrid. The Village should initiate discussions and potential negotiations with the desired generation sources/host locations until Agreements are in place to support the microgrid. The benefits of locating a CHP system at prospective host locations would be discussed with the entity along with responsibilities of the entity during emergency situations. Such information should also be defined in the Agreements between the Village and the host location. Currently, the opportunity for site generation and heat to be supplied to an industrial host location is being used as a potential tool to invite certain types of compatible industries to available area within the microgrid. Facilities, such as large commercial greenhouses (> 10acres) raising crops such as lettuce, tomatoes, and cucumbers, etc. would likely be very compatible hosts as they can shed large loads, such as grow lights, without completely halting their production. Since these loads can be shed fairly quickly, the excess generation could be placed on the microgrid to service other users within the Village's electric distribution system.

3.2 Commercial Viability – Value Proposition

Regarding the potential value of the proposed microgrid, the Village will realize a number of benefits from the microgrid project.

- The implementation of the microgrid will increase the reliability and resiliency of power distribution within the Village to its current customer base.
- The microgrid will protect the health and safety of the Village's grid customers, particularly residents, as they heavily rely upon electricity for their heating needs during the winter months.
- The microgrid will also decrease potential future reliance on "dirtier" or high carbon generating-based electricity generation.
- The microgrid will allow for economic development within the existing Village electric service area (with additional electric demand) without exceeding current low cost electric supply limits (NYPA supplied hydro power) that would incur higher electric costs for the entire distribution system.
- The microgrid will help prevent the loss of public services as well as potential commercial revenue that may be incurred by prolonged electric outages.

This microgrid project can also positively benefit National Grid by deferring the need for upgrading their transmission lines that service the Village's electrical system. National Grid has previously indicated that their transmission lines are at their thermal limit and capacity (See **Appendix F**). Thus, National Grid would not be able to supply any additional power to the Village without infrastructure upgrades.

The primary potential costs of the microgrid project will generally center upon the upfront capital cost of the CHP engine genset system and the future operation and maintenance expenditures for that system. As referenced in Section 3.1, at this point in the project, there is the potential for the Village or the industrial host site to own, operate and maintain portions of the microgrid including the generation source (CHP engine gensets)/DERs. Project-related costs may be mitigated by a partnership, such as to share the cost of the generation source/DER equipment and thereby reducing the initial outlay of capital expenditures.

To initiate and support the implementation of the microgrid, there are a few characteristics of the Village, the potential generation source/industrial host locations and the technology that make the overall project unique and potentially more feasible. These characteristics include, but are not limited to:

- The Village owns and operates the electric distribution infrastructure within their service area which provides more control of the microgrid. A depiction of this infrastructure is located in **Appendix F**. The image in **Appendix F** shows the Industrial Park Substation and the Litchfield Avenue Substation and the switches and transformers that already exist as part of the existing infrastructure.
- There are multiple sites identified as potential industrial host locations that have available space on-site for the required CHP system equipment and infrastructure to support the microgrid. The most advantageous site is the 200 acres known as the Frankfort 5S South Business Park (formerly the South Pumpkin Patch Site), located just outside of the Village boundary, but still

within the electrical distribution network. The site is located just off of Industrial 1 Road and is shown on **Figure 2**.

- The identified equipment for generation within the microgrid, CHP engine gensets, are modular self-contained units with dedicated internal process and management systems. This type of set up helps to minimize the number of separate equipment installations and integrations.

This project is also important to allow the residents and the businesses within the Village of Frankfort to continue to function and operate during an emergency. There are no medical facilities within the Village of Frankfort, therefore, during an emergency; the Village of Frankfort must ensure that residents can leave the Village to obtain medical care when necessary. In order to do this, gas stations must be able to operate, traffic lights must function, and roadway lamps must be lit to allow drivers to safely navigate out of the village. Additionally, businesses must be able to function on a necessary level to allow residents to obtain needed medicine, food, supplies, etc. It is beneficial to be able to allow students to attend school during smaller emergencies and to allow these schools to function as shelters for those in need during larger emergencies. Since the Village of Frankfort is located in rural New York State, and the nearest towns which contain hospitals, EMS facilities, additional Fire Departments are approximately 10 to 20 miles away, establishing a microgrid that allows the Village to function independently on a necessary level is important when you consider the distance to the closest alternate locations for emergency services and necessary supplies.

This project promotes the state policy objectives of New York's Reforming the Energy Vision (REV) and the Renewable Portfolio Standard (RPS). Primary goals of the REV program include provision of more affordable energy for New Yorkers, development of a more resilient energy system, education of New York residents to make more informed energy decisions, creation of new jobs and business opportunities, improvement of existing infrastructure and energy initiatives, development of cleaner transportation, an 80% reduction of GHG emissions by 2050, protection of New York's natural resources, and growth of clean energy technological advancements. (Source: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument)

The proposed project requires electricity generation that cannot be solely provided by diesel-fueled generators. This supports the REV goals of cutting GHG emissions and helping clean energy innovation by pursuing cleaner or alternative energy sources. Use of the microgrid to power critical facilities, especially during power outages contributes to the REV goals of building a more resilient energy system and improving existing infrastructure, as upgrades to the existing distribution system will likely be required to implement the microgrid. The project will also aid in the creation of jobs. The overall development of the microgrid is itself a new business opportunity and will result in the creation of jobs, which is a central tenet of the REV program. The development of localized generation sources and potential addition of infrastructure will require additional personnel within the Village of Frankfort for installation, operation and maintenance of the new equipment and systems.

Additionally, the primary goals of the Renewable Portfolio Standard (RPS) include diversification of the New York State electricity portfolio through renewable electricity generation, use of in-state renewable resources to improve energy security, reduction of pollution from the electric sector, and stimulation of economic development through investment in New York State renewable resources and the reduction of out-of-state fossil fuel use (Source: http://energy.pace.edu/sites/default/files/publications/RPS%20Report.pdf).

The RPS specifically strives to increase the amount of renewable energy provided to electric retail customers with large-scale renewable generation for sale or use on-site, small-scale renewable generation for residences or businesses, and/or market activities such as renewable energy purchasing agreements (http://www.nyserda.ny.gov/About/Renewable-Portfolio-Standard). The microgrid will provide electricity from potentially cleaner or renewable sources on a small scale. The potential distributed energy resource for the microgrid includes CHP engines. The implementation of localized generation sources for the microgrid that do not rely solely on diesel generators supports the RPS goals of improving energy security through in-state renewable resources and the stimulation of the economy through in-state energy investments. Although not all of the distributed energy resources will be renewable, the localized nature of the project will allow for increased energy security, especially to critical facilities during power outages, as well as reduce GHG emissions associated with electricity production.

The Village's microgrid project helps to achieve these REV/RPS policy and program goals as it:

- utilizes clean or renewable energy resources,
- promotes energy diversification and security, and
- promotes local economic development and job creation through both construction of the system but also through the additional industrial jobs it may draw to the local area.

Another inherent regional benefit of The Village of Frankfort's microgrid project is its ability to be replicated for other small villages that have a relatively small microgrid and a municipally-owned electricity distribution and transmission systems. If new industry were to move into the Village, the microgrid system may be scaled to include their electricity usage by evaluating their needs and sizing the appropriate CHP engine genset to be located at their facility. Because new industrial facilities are behind the primary or main microgrid interconnects, it would be relatively easy to add additional generation sources to match these new loads. It is assumed that an evaluation of the electricity usage and a commitment to installing a CHP engine genset would become part of the building permits to be obtained by businesses and/or developers within the Village.

As part of the value proposition for commercial viability of the microgrid project, a SWOT Analysis was prepared (refer to **Table 3A**). A SWOT Analysis is a structured planning method used to identify internal and external influences of a given project, operation, company or community, etc. SWOT stands for Strengths, Weaknesses, Opportunities and Threats. The strengths and weaknesses are generally considered as internal factors of influence, whereas, the opportunities and threats are generally considered external factors. In using the SWOT Analysis, each of the internal and external factors will be evaluated and considered in determining the path forward, which could affect the success of the venture.

Table 3A
SWOT Analysis

Strengths	**Weaknesses**
• Available space for generation sources/host locations • Village control of electric distribution infrastructure • Demand Response during emergency grid outages • Short-Term and Long-Term job opportunities • Support REV and RPS policy objectives	• Lack of available funding sources • Difficulties with infrastructure tie-ins • Dependent on large industrial client operating within the Village limits to purchase and operate DER and use excess heat
Opportunities	**Threats**
• Improved electric service reliability and resiliency • Improved functionality of emergency support services • Increased customer interaction with the systems • Decreased carbon footprint of the Village • Commercial and industrial partnerships • Economic Development within the Village • Model project to be replicated by local jurisdictions	• Time delays impacting implementation • Environmental and nuisance constraints

3.3 Commercial Viability – Project Team

The current Project Team for the proposed microgrid Feasibility Study consists of the Village of Frankfort, Village of Frankfort Electric Department, the Herkimer County Industrial Development Agency, National Grid, JDA Associates and Barton & Loguidice, D.P.C. Sufficient support has been secured for Stage 1, to perform the Feasibility Study. Additional partners including contractors and suppliers will be secured at a later date when the design and permitting are finalized and then advertised for bidding, construction and start-up operation.

The Village of Frankfort will be the Contractor and the applicant for this microgrid project. They represent the local government and community. Their role in the Feasibility Study is community outreach to residents and local businesses and industry to garner support and provide input to the project. Other potential roles and responsibilities are outlined in Section 3.1, which includes potentially being the owner/operator of the microgrid systems or DERs once the microgrid is developed. The microgrid project is an example of advanced technology to improve service and infrastructure within the Village electric supply area. As referenced in **Section 2.5**, the Village of Frankfort used innovative technology to replace existing electric and water meters with "smart" meters. This project was reportedly funded by a $500,000 Community Development Block Grant. As this project resulted in increased efficiencies for the Village, the Village received a first place award in the Public Works Category from the New York State

Conference of Mayors and Municipal Officials' 24th Annual Local Government Achievement Award Program.

As previously noted, Village of Frankfort Electric Department is the local electric distribution company for the entire Village. They are an active partner in the Feasibility Study and are a resource for usage and demand data critical to sizing the microgrid generation sources. Frankfort Electric Department also provides information on the electric system and assists in identifying energy efficiency options to optimize consumption and demand as well as the evaluation of project viability. Frankfort Electric Department is currently responsible for maintenance of the electric distribution company infrastructure within the Village and will be responsible for the operation and maintenance of any additional infrastructure added as part of the microgrid project save for DER's owned and operated by customers within the grid.

The Herkimer County Industrial Development Agency (HCIDA) is a public benefit corporation created to create and retain local industry. The HCIDA also coordinates local, state, and federal lending and financing associated with area job creation and retention. This organization provides access to local organizations for information and support. In future development of the project, the HCIDA may be able to assist in finding financial resources or additional funding for the project.

National Grid currently owns the electric infrastructure outside the Village of Frankfort. The Village electric distribution company will provide technical advisement relating to existing distribution and transmission capacity, infrastructure, and historical system disturbance data, etc.

JDA Associates is a property management company located in Frankfort, NY and has been included on the study team for this project. They potentially will be involved in idea development and advisement for the project team.

AB Energy USA and its parent company Gruppo AB have over 25 years of experience with delivering global solutions with over 1000 reciprocating engine based Combined Heat and Power (CHP) and distributed energy systems totalling over 1,500 MW. Within the market place, AB is unique in that they bring together all the competencies under one organization to design, manufacturer, install, commission and provide complete support of the CHP system over the life of the project.

The engine technology AB utilizes is standardized around that of GE Jenbacher. This 'best-in-class' engine manufacturer is configured to unique project requirements through AB's modular CHP system. Marketed as the ECOMAX, this system brings together complete design and balance of plant equipment selection, all packaged and supported in a way that ensures decades of trouble free operation. Refer to **Section 2.2** and **Appendix G** for the Functional Diagrams and Layouts for the CHP Systems.

Barton & Loguidice, D.P.C. (B&L) has been retained as a subcontractor to the Village as the project lead. B&L is responsible for the overall management of the project and execution of the Feasibility Study.

There are currently no public/private partnerships as part of the Feasibility Study, with the exception of the Village's subcontractors. Additional partnerships with equipment and material suppliers or contractors will be pursued with later stages of the study if necessary.

Overall, the Village's partners and Project Team have significant experience qualifying them for this Feasibility Study and potential future project. National Grid has a history of successful operation of electric distribution and transmission systems to support millions of customers in the northeastern United States. B&L has experience in both alternative energy generation and substation and interconnect design, permitting and construction management. No additional contractors or suppliers have been identified at this time. Once the system design has been finalized and the funding obtained, the project will be put out to bid for construction. The contractor and any suppliers necessary will be chosen based on bids received and the contractor's qualifications.

Project funding, financiers or investors have not been identified at this time. It is envisioned that the industrial host locations will be an integral part of the Project Team both with respect to initial project financing through equipment procurement arrangements, but also as a long term partner for the use of heat and electric from the primary DERs, and potentially equipment maintenance, etc. Final project financing will be explored once the microgrid system design has been finalized. Project Team members (other than industrial hosts) may be used as resources to obtain funding but will not likely contribute financial resources directly to the project. The HCIDA may be used to find local, state, or federal financing or funding beyond that available through NY Prize. At this time, it is expected that the community will incur minimal cost as part of the development of the microgrid; mostly related to new communications and control equipment at the substation. It is estimated that funding for the generation portion of microgrid will largely come from private investments, partnerships with industrial users of the heat from the CHP engines and possible grant funding opportunities.

The Village's solicitor will serve as legal counsel for the microgrid project with potential assistance from other Project Team members and outside firms specializing in energy contracts and power generation projects.

3.4 Commercial Viability – Creating and Delivering Value

The microgrid creates value by generating cost effective electric power and heat that can be utilized by the residential, commercial and/or industrial facilities within the Village microgrid during normal grid operations, and during emergencies. Natural gas fired CHP engine genset units were specifically chosen for this microgrid because they provide easily controllable generation that is resilient during typical conditions that might cause grid emergencies/outages, but also can be easily controlled to match demand. Engine management systems can modulate the output of the CHP system so that the engine gensets will match the electrical demand that they detect to maintain the system within voltage and frequency requirements. These systems have been well proven across the United States with similar applications at other facilities, greenhouses, and industrial facilities. As such, the successful application of the CHP technology for this microgrid project greatly reduces the risk to the Village and other project partners, while enhancing the benefits of reliable and efficient power.

Contracts or agreements will be in place with the major power users within the microgrid to control how much electricity they will use in an emergency situation to allow the CHP engine genset generated power to be redirected to support the microgrid system. The Village could also issue public service announcements (PSAs) and other forms of public education/outreach (e.g. flyers) to residents and businesses periodically regarding the importance of limiting electricity usage during an emergency grid outage. Such flyers could potentially contain guidance on: raising thermostat temperatures during summer and lowering thermostat temperature during winter to decrease HVAC system use, turn-off household lighting when not in use, and having flashlights and candles on hand, etc. as well as other life safety measures (e.g. first aid kit, bottled water, etc.).

Residential communities may be monitored through the use of smart meters that were previously installed by the Village. At present, it will be the responsibility of the residents within each smart meter grid to curtail their electricity usage. Large industrial or commercial electric users may be curtailed during emergencies to ensure sufficient power for more critical users.

The Village Electric Department has previously implemented a program and has been successful in installing smart meters throughout their electric service area and system, which includes approximately 1,183 residential customers and 45 commercial businesses. Currently, it will be the responsibility of the residents and businesses within each smart meter grid to curtail their electricity usage as there is not a mechanism in place to regulate individual residential buildings through the smart meters. However, the next stage of design for the microgrid would evaluate the potential use of these smart meters for data collection and possibly load control (curtailment). Such users could then be requested or potentially required (via agreement terms and conditions) to curtail or decrease their individual demand load and close during declared emergencies events or grid outages.

- The Village of Frankfort will benefit from the installation of the microgrid through the availability of uninterrupted power during a major power outage. It reduces the need for backup generators for residential, commercial, industrial and institutional entities within the Village of Frankfort, which subsequently reduces the cost burden to these entities when budgeting for backup power. Allowing the Village to function on a nearly normal usage level during a major power outage allows residents to continue working during major power outages, supplies emergency services to residents within the Village of Frankfort during major power outages, and generally will provide a sense of comfort to residents and businesses within the Village knowing that their welfare will not be affected by a major power outage. The concept of a microgrid depends upon attracting a large industrial host or entity to operate within or in vicinity of the Village's limits. At this time, the Feasibility Report has identified a greenhouse as the most operational and economically feasible facility to house DERs (the CHP system). The greenhouse will add localized jobs to the nearby area and possibly increase economic growth within the Village of Frankfort. Additionally, with the interconnection of future potential DERs to the microgrid system, the Village's electric distribution system could potentially attract additional economic growth opportunities through promoting new business development within the Village limits. This is currently not feasible due to the Village's New York Power Authority (NYPA) allocation, which is currently exceeded on a regular basis. From NYPA through the ReCharge New York (RNY) economic development power program, the Village receives a 5 MW block of hydroelectric-generated power to sustain its base electric load.

- At this time, if the industrial host location is responsible for the capital and operational costs of the CHP engine gensets and the Village's Electric Department maintains responsible for maintaining the distribution infrastructure associated with the microgrid. The Village responsibilities will include communications and control upgrades at the substations which will be a relatively low cost to the residents or local community.

Based on the data provided, sufficient generation capacity has been provided to ensure that the generation capacity is not exceeded by demand. If it was somehow exceeded, the system would shut-down in a protective mode, and the system would attempt to reset automatically. As long as the industrial and large commercial customers have curtailed their normal loads in an emergency, there should be more than sufficient system capacity.

Implementation of the microgrid projects will start with solidifying participation of all of the microgrid partners, followed by detailed technical and financial design/planning to ensure that initial project assumptions are current and correct and that the project will achieve the desired outcomes. Any necessary permits or approvals (e.g. utility or non-utility power generation, building permits, use and occupancy, electrical/mechanical and air permitting, etc.) will be applied for as required regarding the installation and integration of CHP equipment and ancillary components. Permitting and approval requirements will continue to be evaluated and assessed during the detailed design stage of the microgrid project. If public funds were used for the project, a SEQRA approval might be required for the installation of the system.

3.5 Financial Viability

The financial goal of the microgrid project is to make arrangements that will not greatly increase the rates currently paid by customers of the Village's electric distribution company, while still providing the reliability improvements and public-service the benefits of the project. To accomplish this, a project host that can utilize the heat and electricity of the generation equipment (CHP engine gensets) during regular grid operations is important. In such a scenario, the Village or the host site may be able to support the purchase of the generation equipment or enter into an agreement with the project partners. Such an agreement would specify the sale of electricity and recovered heat from the generation equipment at an advantageous rate that makes it fair, reasonable and beneficial for the host site to significantly curtail electric load during times of grid emergencies, thus allowing the generation equipment to power the microgrid.

A key component of the viability of the microgrid system is if the project can either provide economic benefit during normal operations to the industrial host location or the Village, and/or pay for the up-front capital investment of system installation and construction without creating a financial hardship for the Village. The proposed microgrid has been compared against the current energy costs of the industrial host location during normal operations to determine if the microgrid can be financially competitive during regular operations. If this is possible, then the project can proceed and provide benefit not just during grid emergencies/outages, but also during normal operations, which would improve the return on investment (ROI) to the point where the project has the potential to pay for itself over time. The economic analysis was based on offsetting existing electrical and heating needs with on-site power generation.

For non-peak and non-emergency conditions, the industrial host will receive inbound power from the Village's (i.e. the municipal) electric distribution system. During peak demand grid emergencies, the microgrid will switch from on-site power generation and use into island mode to then provide power to the Village and its customers using the existing electric distribution system. Since the industrial host location will remain grid connected, standby rates/tariffs will be applicable. This means that customer charges, demand charges, and usage charges will still apply. Thus, electric generation behind the meter has to be able to maximize the reduction of demand and usage, which would create the opportunity to maximize the economics of the project, i.e. "revenue" or avoided/offset electric and heat costs.

The costs of fuel, operation, maintenance and other factors were also considered against "revenue" or the avoided/offset electric or heat costs at the industrial host location (refer to Section 1.1. to generate the projected cash flow for the microgrid project. The capital cost for the development of the microgrid will be approximately $6,920,000, which includes the CHP engine gensets. The initial planning and design costs were estimated to be approximately $350,000 and include engineering and permitting for the microgrid project. Operation and maintenance costs for the microgrid project will vary over the 20 year project life. The estimated annual O&M costs are shown for each year of the 20 year project life in Appendix H. The O&M costs include engine maintenance and interconnection maintenance, but do not include fuel costs (i.e. natural gas). The project should be cash positive with reasonable project pay back periods to be considered viable. In the case of the Village of Frankfort Microgrid, conservative electric and heat values were assumed and evaluated at a twenty (20) year project life with a 6-year simple project payback period assuming no grant funding. Costs were annualized on a project basis, not entity or project-partner basis.

An economic analysis was generated in tabular format for the microgrid project based on the required generation capacity along with the potential for avoided electric and heat costs. **Tables 3B1 and 3B2** (included at the end of **Section 3)** provide an estimate of the projected economics for the microgrid project, with and without grant funding. These tables demonstrate that the microgrid project can be economically favorable with conservative avoided cost assumptions, which generate positive cash flow (annual revenues exceed expenses) and reasonable project payback periods. This would indicate that the project has economic merit. At part of this Feasibility Study evaluation, an example industrial host to match the Village's requirements for the microgrid could be a greenhouse. It is envisioned that Village/industrial host arrangement would include the industrial host providing the up-front capital for the four (4) CHP engine gensets and related equipment and infrastructure. In turn, the Village would enter into a Power Purchase Agreement (PPA) from the industrial host during emergency grid outages when the industrial host would curtail load to power the microgrid. The Village would be responsible for maintaining the distribution system.

Refer to **Section 4** for a detailed benefit-cost analysis.

3.6 Legal Viability

The regulatory structure under which microgrids exist is dependent upon the ownership structure of the system. New York is an energy-deregulated state, and utilities are discouraged from owning generation assets to provide for better price competition for electric supply, which might not be the case if the utility controlled supply and distribution assets. The Village of Frankfort owns and operates its own municipal electric distribution company (Frankfort Electric Department) that is regulated by the New York State Public Service Commission (PSC). Although project partnerships and agreements are not finalized, it is proposed that the Village will be the owner of the proposed microgrid, and will continue to be responsible for the operation and maintenance of the existing electric distribution system. The Village may have full or partial ownership of the DERs, which could require justification and approval of the PSC due to the general prohibition on utility-owned generation after deregulations in the late 1990s. In order to obtain approval for ownership of generation assets, the Village electric distribution company must demonstrate "substantial ratepayer benefits together with [market power] mitigation measures" [NYS PSC Case 96-E-0099 (1998)]. However, if there is non-utility ownership of the DERs within the microgrid, the DERs might have to seek an exemption from the PSC public utility regulations as a "Qualifying Facility." Since the proposed DERs are to be co-gen systems from CHP equipment, which is a qualifying technology under the exemption, this would appear to be a pathway for approval by the PSC. More specifics on the regulatory structure of the microgrid will be defined after the ownership structure of the microgrid is determined.

The Village of Frankfort, other project partners, or the County currently own all of the sites contemplated for development of the microgrid. As noted in the NYSERDA grant application, the Village of Frankfort may purchase a 12-acre land parcel that has the potential to be used for PV renewable generation. The HCIDA owns approximately 200 acres known as the Frankfort 5S South Business Park (formerly the South Pumpkin Patch Site) that could be used for the development of a solar farm as a supplemental generation source for the microgrid.

Currently, the Village utilizes smart meters to collect monthly usage data for the purposes of billing from residential, public-service and commercial/industrial customers. This data is not made public and is under the use of authorized personnel only within the Village's Electric Department. During the microgrid's operation, the existing smart meter service will remain intact for purposes of usage data collection and billing. Thus, as customer interactions are not changing, the microgrid is not envisioned to impact the privacy of the customers within the Village.

Table 3B1
Economic Analysis of 5.7MW Electric Production with Heat Recovery (With Grant Funding)

	Year 1	2	3	4	5	6	7	8	9	10
Products										
Gas from NG Pipeline (Mcf)		380,632	380,632	380,632	380,632	380,632	380,632	380,632	380,632	380,632
Gas to Engines (5.7MW) (Mcf)*		(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)
Gas to Engines (5.7MW) (mmBTU)		(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)
Engine Electrical Output (MW)	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70
Engine Electrical Output (MWh)	44,939	44,939	44,939	44,939	44,939	44,939	44,939	44,939	44,939	44,939
Unmet Eledtric Demand (MWh)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)
Net Excess Generation (MWh)		18,659	18,659	18,659	18,659	18,659	18,659	18,659	18,659	18,659
Expenses	**Expenses ($)**									
5.7MW Natural Gas Engine Gen Set w/ Heat Recovery (equipment, installation and maintenance)	($5,000,000)	($150,000)	($150,000)	($150,000)	($480,000)	($150,000)	($2,500,000)	($150,000)	($480,000)	($150,000)
Distribution System Upgrades & Maintenance	($1,920,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)
Pipeline Natural Gas from Plant		($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)
Total	($6,920,000)	($2,279,893)	($2,279,893)	($2,279,893)	($2,609,893)	($2,279,893)	($4,629,893)	($2,279,893)	($2,609,893)	($2,279,893)
Revenue	**Revenue ($)**									
Grant Funding (NYSERDA PON 2701)	$2,500,000									
Electric Production Avoided Cost		$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400
Net Excess Generation to Grid		$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352
Waste Heat Value		$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571
Total	$2,500,000	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323
Pre-Tax Cashflow	**Total**									
	($4,420,000)	$1,141,430	$1,141,430	$1,141,430	$811,430	$1,141,430	($1,208,570)	$1,141,430	$811,430	$1,141,430
Running Total		($3,278,570)	($2,137,141)	($995,711)	($184,281)	$957,148	($251,422)	$890,008	$1,701,438	$2,842,867

	11	12	13	14	15	16	17	18	19	20	TOTAL
Products											
Gas from NG Pipeline (Mcf)	380,632	380,632	380,632	380,632	380,632	380,632	380,632	380,632	380,632	380,632	12,574,844
Gas to Engines (5.7MW) (Mcf)*	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(7,232,001)
Gas to Engines (5.7MW) (mmBTU)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(380,632)	(7,232,001)
Engine Electrical Output (MW)	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	
Engine Electrical Output (MWh)	44,939	44,939	44,939	44,939	44,939	44,939	44,939	44,939	44,939	44,939	853,837
Unmet Eledtric Demand (MWh)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(499,320)
Net Excess Generation (MWh)	18,659	18,659	18,659	18,659	18,659	18,659	18,659	18,659	18,659	18,659	354,517
Expenses											
5.7MW Natural Gas Engine Gen Set w/ Heat Recovery (equipment, installation and maintenance)	($150,000)	($150,000)	($2,980,000)	($150,000)	($150,000)	($150,000)	($480,000)	($150,000)	($2,500,000)	($150,000)	(16,370,000)
Distribution System Upgrades & Maintenance	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	(2,395,000)
Pipeline Natural Gas from Plant	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	($2,104,893)	(39,992,966)
Total	($2,279,893)	($2,279,893)	($5,109,893)	($2,279,893)	($2,279,893)	($2,279,893)	($2,609,893)	($2,279,893)	($4,629,893)	($2,279,893)	(58,757,966)
Revenue											
Grant Funding (NYSERDA PON 2701)											
Electric Production Avoided Cost	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	39,945,600
Net Excess Generation to Grid	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	$746,352	14,180,688
Waste Heat Value	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	$572,571	10,878,842
Total	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	$3,421,323	67,505,130
Pre-Tax Cashflow											
	$1,141,430	$1,141,430	($1,688,570)	$1,141,430	$1,141,430	$1,141,430	$811,430	$1,141,430	($1,208,570)	$1,141,430	8,747,164
Running Total	$3,984,297	$5,125,727	$3,437,156	$4,578,586	$5,720,016	$6,861,445	$7,672,875	$8,814,305	$7,605,735	$8,747,164	

Return on Investment (ROI)	**14.89%**
Simple Payback	**3.9**

Assumptions:

Assumes 90% up time on engine
Assumes $40/MWh for price to compare generation rate worst case against firm NYPA hydro
Assumes $80.00/MWh for retail offset of electric power based on the cost of supplemental power for Frankfort above hydro alotment
Electric production to grid price at 10% reduction of retail offset rate to account for unrecoverable fees from the utility etc
Unmet electrical need of the host facility during normal operations is based on a steady 3MW electric load
Engine Output and fuel usage based on typical CHP leanburn NG engines, 8.46 mmBTU/hr @ 100% load, 8.76 mmBTU/hr @ 75% load
Assumed HHV of natural gas = 1,000 BTU/cf
Mcf = 1,000 cf of gas
Assumes top end changeout ~ every 3yrs, and bottom end rebuild every 6yrs
Major engine maintenance costs estimated and may vary (top end, in frame, major overhaul)
Distribution system upgrades include 6,900' of new cable w/ control wire, transformers, and automatic switches
Assumed average 5MW net electric demand 24/7 unmet electric demand
Pipeline NG cost assumed at $5.53/mmBTU from NG pipeline
No price escalator has been assumed for any of the comodites
Waste heat value assumed at $5.53/mmBTU at @ 85% boiler efficiency for an adjusted value of $6.36/mmBTU
Useful waste heat recovery assumed HT and exhaust jacket heat loops and to be 21.92mmBTU/hr recoverable from the5.7MW installation
Assumes 60% usage of recoverable useful waste heat (>190F)

Table 3B2
Economic Analysis of 5.7MW Electric Production with Heat Recovery (Without Grant Funding)

	Year																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
								Products													**TOTAL**
Gas from NG Pipeline (Mcf)		400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	400,665	7,612,633
Gas to Engines (5.7MW) (Mcf)*		(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(7,612,633)
Gas to Engines (5.7MW) (mmBTU)		(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(400,665)	(7,612,633)
Engine Electrical Output (MW)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	
Engine Electrical Output (MWh)	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	47,304	898,776
Unmet Eledtric Demand (MWh)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(26,280)	(499,320)
Net Excess Generation (MWh)		21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	21,024	399,456
Expenses								**Expenses ($)**													
5.7MW Natural Gas Engine Gen Set w/ Heat Recovery (equipment, installation and maintenance)	($5,000,000)	($150,000)	($150,000)	($150,000)	($480,000)	($150,000)	($2,500,000)	($150,000)	($480,000)	($150,000)	($150,000)	($150,000)	($2,980,000)	($150,000)	($150,000)	($150,000)	($480,000)	($150,000)	($2,500,000)	($150,000)	(16,370,000)
Distribution System Upgrades & Maintenance	($1,920,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	(2,395,000)
Pipeline Natural Gas from Plant		($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	($2,215,677)	(42,097,859)
Total	($6,920,000)	($2,390,677)	($2,390,677)	($2,390,677)	($2,720,677)	($2,390,677)	($4,740,677)	($2,390,677)	($2,720,677)	($2,390,677)	($2,390,677)	($2,390,677)	($5,220,677)	($2,390,677)	($2,390,677)	($2,390,677)	($2,720,677)	($2,390,677)	($4,740,677)	($2,390,677)	(60,862,859)
Revenue								**Revenue ($)**													
Grant Funding (NYSERDA PON 2701)	$0																				
Electric Production Avoided Cost		$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	$2,102,400	39,945,600
Net Excess Generation to Grid		$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	$840,960	15,978,240
Waste Heat Value		$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	$602,706	11,451,413
Total	$0	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	$3,546,066	67,375,253
Pre-Tax Cashflow								**Total**													
	($6,920,000)	$1,155,389	$1,155,389	$1,155,389	$825,389	$1,155,389	($1,194,611)	$1,155,389	$825,389	$1,155,389	$1,155,389	$1,155,389	($1,674,611)	$1,155,389	$1,155,389	$1,155,389	$825,389	$1,155,389	($1,194,611)	$1,155,389	6,512,394
Running Total		($5,764,611)	($4,609,222)	($3,453,833)	($2,628,443)	($1,473,054)	($2,667,665)	($1,512,276)	($686,887)	$468,502	$1,623,892	$2,779,281	$1,104,670	$2,260,059	$3,415,448	$4,570,837	$5,396,226	$6,551,616	$5,357,005	$6,512,394	

Return on Investment (ROI)	**10.70%**
Simple Payback	**6.0**

Assumptions:

Assumes 90% up time on engine
Assumes $40/MWh for price to compare generation rate worst case against firm NYPA hydro
Assumes $80.00/MWh for retail offset of electric power based on the cost of supplemental power for Frankfort above hydro alotment
Electric production to grid price at 10% reduction of retail offset rate to account for unrecoverable fees from the utility etc
Unmet electrical need of the host facility during normal operations is based on a steady 3MW electric load
Engine Output and fuel usage based on typical CHP leanburn NG engines, 8.47 mmBTU/hr per 1MW
Assumed HHV of natural gas = 1,000 BTU/cf
Mcf = 1,000 cf of gas
Assumes top end changeout ~ every 3yrs, and bottom end rebuild every 6yrs
Major engine maintenance costs estimated and may vary (top end, in frame, major overhaul)
Distribution system upgrades include 6,900' of new cable w/ control wire, transformers, and automatic switches
Assumed average 5MW net electric demand 24/7 unmet electric demand
Pipeline NG cost assumed at $5.53/mmBTU from NG pipeline
No price escalator has been assumed for any of the comodites
Waste heat value assumed at $5.53/mmBTU at @ 85% boiler efficiency for an adjusted value of $6.36/mmBTU
Useful waste heat recovery assumed HT and exhaust jacket heat loops and to be 21.92mmBTU/hr recoverable from the5.7MW installation
Assumes 60% usage of recoverable useful waste heat (>190F)

4.0 Benefit-Cost Analysis

To assist with completion of the project's NY Prize Stage 1 Feasibility Study, Industrial Economics, Incorporated (IEc) conducted a screening-level analysis of the project's potential costs and benefits. Refer to **Section 4.7** and **Table 4.7** for a summary of the Benefit-Cost Analysis. Refer to **Appendix H** for the detailed Third-Party Benefit-Cost Analysis Reports.

4.1 Facility and Customer Description

Table 4A outlines the various facilities or groups that will be served by the proposed microgrid.

Table 4A
Facility and Customer Description

Facility Name	Rate Class	Sector	Multiple Meters	Annual Ave Usage (MWh)	Peak Demand (MW)	% of Ave Demand (MW)
Frankfort Fire Department	small commercial	municipal	no	37	0.032	100%
Frankfort Police Department (V)	small commercial	municipal	no	24	0.02	100%
Water Department	small commercial	municipal	yes	208	0.2	100%
Frankfort Police Department (T)	small commercial	municipal	no	19	0.016	100%
Gas Stations	small commercial	retail	no	272	0.164	100%
Frankfort-Schuyler Central and H.S.	large commercial	municipal	no	309	0.2608	100%
Frankfort-Schuyler Elementary School	large commercial	municipal	no	89	0.0628	100%
Frankfort Free Library	small commercial	municipal	no	10	0.00648	100%
Melrose Supermarket	large commercial	retail	no	283	0.16	100%
Pharmacies	small commercial	retail	no	181	0.112	100%
Residential Homes	residential	residential	no	3,462	3.786	100%
Commercial/Industrial Facilities	small commercial	retail/wholesale/ manufacturing	yes	76	0.054	100%

4.2 Characterization of Distributed Energy Resources

Table 4B lists the proposed distributed energy generation sources within the Microgrid.

Table 4B
Characterization of Distributed Energy Resources

DER Description	Fuel	Capacity (kW)	Ave Annual Production (MWh)	Ave. Daily Production (MWh/d)	Heat Rate (mmBTU/MWh)
Recip Engine CHP	Natural Gas	5,700	47,000	129	10.06

4.3 Capacity Impacts and Ancillary Services

Table 4C lists the capacity impacts, ancillary services estimated costs, and emissions for the proposed generation source(s) within the Microgrid. The emissions calculations are provided in **Appendix E**.

Table 4C
Capacity Impacts and Ancillary Services

Peak Load Support (MW/ year)	Demand Response Capacity (MW/ year)	Deferred Transmission (MW/year)	Deferred Distribution (MW/year)	Ancillary Services to Distribution	Estimated Annual Energy Savings MMBTU/ Year	Emissions Allowance Purchase	Emissions (lbs/MWh)			
5.7	0.5	4.8	4.8	Frequency, Voltage, Blackstart Support	115,200	$0.00	1.54	1,088	0.01	0.0004
							NOx	**CO2**	**SO2**	**PM**

4.4 Project Costs/Benefit Summary

An initial economic analysis was prepared as part of this Feasibility Study, which is separate from the NYSERDA Third Party review (refer to **Tables 3B1 and 3B2** and **Section 5**).

Table 4D lists the estimated installed system costs for the microgrid system and the planning and design costs. The annual fixed O&M costs vary from year to year and are shown in **Appendix H**. The estimated installed system costs include the costs associated with the purchase of the 5.7 MW Natural Gas Engine Genset units and installation. Additionally, this cost includes the distribution system upgrades and maintenance necessary to connect the gensets to the existing infrastructure. Planning and design costs include the costs associated with both the genset unit design and the distribution system upgrade design. Refer to **Section 4.7** for a summary of the Benefit Cost Analysis.

Table 4D
Project Costs

Installed System Cost	Service Life (years)	Planning & Design Costs	Annual Fixed O&M Costs ($/year)	Time to run in Island Mode
$6,920,000	20	$350,000	Varies (refer to **Appendix H**)	indefinite

4.5 Costs to Maintain Service during a Power Outage

Table 4E lists the information that was requested for the existing back-up power diesel generators within the Village. No information was provided obtained from the Village.

Table 4E
Costs to Maintain Service During Power Outage

Fuel Source of Existing Backup Generators	Capacity of Existing Backup Generators (kW)	% of Capacity Generator will run during Emergency	Ave. Production (MWh/ day)	Fuel used (mmbtu/ day)	One-time Costs to Start Generator	Daily Ops Costs ($/d)	Facility Costs for Emergency Operations ($/day)	
							On Backup Power	W/o Backup Power
Diesel Fuel	No Information or Data Received from the Village of Frankfort.							

4.6 Services Supported by the Microgrid

The microgrid within the Village of Frankfort is proposed to cover the full extent of the Village's distribution area to ensure that all customers within the Village, which includes approximately 1,700 customer accounts in the Village with a population of 2,600 individuals (according to the 2010 U.S. census). The full microgrid and customer base includes: a water department office and wells, village offices and a police station, a fire department building, a town police station, telecommunications offices, gas stations and convenience stores, an elementary school, a high school, a library, pharmacies, a grocery store, 1,183 residential homes and 45 commercial businesses.

The community as a whole relies heavily upon electricity for their heating needs. Interruption in electric service will have a much greater impact for Village residents than in other comparable communities. Loss of power during the winter months is a serious concern because of the high prevalence of electric heat utilized by Village residents. Thus, a microgrid that can service the entire residential population as well as other public-service building will provide benefits throughout the Village in the event of a grid emergency or outage situation.

4.7 Summary Results from Industrial Economics, Incorporated's (IEc's) Benefit-Cost Analysis

Table 4F provides the benefit-cost analysis as developed by IEc, a NYSERDA Third-Party Reviewer, of the proposed microgrid project. Refer to **Appendix H** for the Third-Party Benefit-Cost Analysis Reports.

Table 4F
Summary Results of IEc's Third-Party Benefit-Cost Analysis

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$350,000	$30,900
Capital Investments	$6,920,000	$610,000
Fixed O&M	$5,880,000	$519,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$36,600,000	$3,230,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$26,000,000	$1,700,000
Total Costs	**$75,800,000**	---
Benefits		
Reduction in Generating Costs	$30,500,000	$2,960,000
Fuel Savings from CHP	$8,920,000	$787,000
Generation Capacity Cost Savings	$5,270,000	$465,000
Distribution Capacity Cost Savings	$1,990,000	$175,000
Reliability Improvements	$1,300,000	$115,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$15,900	$1,410
Avoided Emissions Damages	$31,200,000	$2,030,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$79,100,000**	---
Net Benefits	$3,340,000	---
Benefit/Cost Ratio	1.0	
Internal Rate of Return	9.5%	

** The estimate of project benefits is slightly greater than 100 percent of project costs, with a Benefit/Cost Ratio (BCR) of slightly more than 1.00. A BCR rating at or above 1.0 typically indicates a revenue positive project, as long as costs as discounted appropriately at the opportunity cost of capital expenditures. The discount rate was 7% per year. Thus, the microgrid project does have the potential to positively impact the Village and improve the reliability and redundancy of their existing electric infrastructure system during an emergency grid outage.*

5.0 Findings and Recommendations

5.1 Feasibility Study Findings

1. The Village of Frankfort owns and operates a municipal electric distribution company (Frankfort Electric Department) and services over 1,700 customers. The maximum annual peak and average annual demand for the customer base were projected at 4.41 MW and 2.27 MW, respectively. The total annual usage for the customer base is estimated at 29,000 MWh.

   - ***The size of this customer base, and its demand and usage are sufficient to support a localized microgrid.***

2. The Village has experienced losses of inbound power to their two (2) substations from the 46 kV transmission lines, which are owned and operated by National Grid.

   - ***The single inbound power source and the type of power losses are sufficient justification to assess the feasibility of a localized microgrid.***

3. The Village initiated a Feasibility Study for the development of a microgrid within their existing electrical infrastructure to improve system reliability and to improve service to its customers, particularly during emergency events when primary grid power is compromised.

   - ***There is reasonable likelihood of finding sufficient industrial generation sources/host locations for CHP engine gensets for DERs within the Village to establish a microgrid. Generation sources/host locations are contingent upon various agreements and consent with the Village.***
   - ***An example industrial host to match the conditions of the proposed microgrid could be a greenhouse. Greenhouses have large electric and heat demands; however, these facilities have the ability to suspend portions of their industrial operation (i.e. curtail load) such as the grow lights for periods of time.***
   - ***The DERs/generation sources to match the requirements of the Village's proposed microgrid would be four (4) JGS 420 CHP engine gensets (1,426 kWe each).***

4. To support and fuel (i.e. fire) the CHP engine gensets for DERs within the Village for the microgrid, a continuous uninterrupted supply pipeline for natural gas is required.

   - ***There exists the technology and resources for the natural gas supply pipeline by National Grid. The supply pipeline is contingent upon various agreements and consent with the Village.***

5. The project economics were estimated on available information to help determine if the project was economically feasible. With grant support and without grant support for ROI and Simple Project Payback.

- ***With grant support, the microgrid project is economically viable. Private capital should be considered to the greatest extent possible to fund the microgrid capital investment in order to minimize economic impact on the community, unless substantial grant funding can be obtained.***

6. Findings – SWOT Analysis.

- ***Strengths and opportunities are strong, but project requires funding, mutual agreements by parties, etc. to be successful and fully viable.***

7. Findings – Economic Analysis (separate from Third-Party Benefit-Cost Analysis).

- ***CHP System (5.7 MW) Electric Production with Heat Recovery (With Grant Funding)***

    - ***Capital Expense Cost = $6,920,000 (Engines + Distribution System Upgrades/ Maintenance).***
    - ***Grant (NYSERDA PON 2568) = $2,500,000.***
    - ***Net Capital Cost = $4,420,000.***
    - ***Return on Investment = 14.89 %.***
    - ***Simple Payback = 3.9 Years.***
    - ***Refer to Table 3B1.***

- ***CHP System (5.7 MW) Electric Production with Heat Recovery (Without Grant Funding)***

    - ***Capital Expense Cost = $6,920,000 (Engines + Distribution System Upgrades/ Maintenance).***
    - ***Grant (N/A) = $0.00.***
    - ***Net Capital Cost = $6,920,000.***
    - ***Return on Investment = 10.70%.***
    - ***Simple Payback = 6.0 Years.***
    - ***Refer to Table 3B2.***

8. Findings – Benefit-Cost Analysis by IEc.

- ***The estimate of project benefits is approximately 120 percent of project costs.***

    - ***Total Costs over 20-year period = $75,800,000.***
    - ***Total Benefits over 20-year period = $79,100,000.***
    - ***Net Benefits – Present Value over 20-year period = $3,340,000.***

- ***Benefit/Cost Ratio (BCR) is slightly greater than 1.00.***

- ***A BCR rating at or above 1.0 typically indicates a revenue positive project, as long as costs as discounted appropriately at the opportunity cost of capital expenditures.***

- ***Internal Rate of Return is 9.5%***

5.2 Feasibility Study Recommendations

1. Investigate additional funding sources and mechanisms to support the microgrid and continue to identify mechanisms to attract potential industrial hosts to house the DERs.

    - ***B&L recommends that the Village investigate additional funding sources and mechanisms to develop the microgrid; assuming grant funding is not available. Given the current estimated capital costs for the microgrid project, it will be difficult for the Village to economically support this project alone. Sharing the benefits and costs of the DERs in a CHP system configuration (engine gensets) with an industrial host, other potential outside investors, would make the system more efficient and economically viable. It is recommended that the Village continue to try to identify and attract an industrial host with the right type of energy use profile. This should include the Village of Frankfort continuing to identify mechanisms, potential incentives and other measures to attract potential industrial hosts .***

2. Develop a basis for design for the microgrid.

    - ***B&L recommends that the Village develop a basis for design for the microgrid that will include specific siting requirements for the industrial host, sizing of the equipment, evaluating power purchase thresholds and assessing personnel requirements for O&M of both the engine gensets and the distribution system upgrades.***

3. Prepare agreements with industrial host(s) for housing the DERs.

    - ***B&L recommends that once a suitable industrial host has been identified and the basis of design for the microgrid has been conceptually agreed upon, the Village should proceed forward with the preparation of contractual agreements (e.g. power purchase). Prior to execution of agreements, a due diligence economic analysis should be performed to confirm the basis of design and previous analyses that justified the project in feasibility stage are still valid.***

4. Implement stakeholder engagement, design, permitting, bidding and construction activities for the microgrid project.

    - ***B&L recommends that once formal agreements have been executed by the Village, the industrial host, and any other third-party participant in the microgrid project, the Village should proceed with stakeholder engagement meetings. The Village may elect to contact various entities that may be part of the microgrid system to engage their input into the proposed project, funding opportunities and/or requirements of***

microgrid users and the proposed design. Once input has been gathered from these groups, the design of the project may be finalized and the permitting of the project may begin. As permitting is ongoing, bid documents can be developed which will be used to request proposals from interested Contractors for the microgrid project. Once the permitting is complete, the bid documents can be released to interested Contractors, bids may be received and construction schedules may be developed.

- ***It also may be beneficial to the Village to initiate these engagement meetings with stakeholders (e.g. residents, public facilities, commercial entities, etc.) at an earlier stage in the microgrid project. For example, education and outreach efforts could begin during part of the Basis of Design Development phase of the project that would allow questions, suggestions and/or recommendations from stakeholders to be received, evaluated and potentially incorporated into the project.***

5. Evaluate new building code requirements within the Village.

    - ***B&L recommends that the Village consider new building code and building permit requirements for new commercial or industrial facilities that move into the Village (e.g. businesses or developers) for perform an evaluation of the electricity demand and usage of their facility. In addition, for larger commercial and industrial facilities, the evaluation could potentially consider an economic benefits analysis for the Village as well as a feasibility assessment for installing a CHP system to support the microgrid.***

6. Alternatives to not pursuing the microgrid project.

    - ***The Village may decide not to pursue the microgrid, in which case, the Village may continue to operate as they currently do within their existing electrical distributions system – supplying the current residents and businesses within the Village's electric service boundaries with electric power under the NYPA allotment and with the existing infrastructure. In cases of emergency or extended power outages, Village residents and businesses will still have to rely on personal backup power that they have installed to continue electricity service. Many residents and businesses will, most likely, not make the investment in backup power, and will therefore lose power in these emergency grid situations. Gas stations and emergency medical services are assumed to have some form of emergency backup power currently. These entities will be able to operate during a power outage at a reduced capacity, as compared to the microgrid, where they would be able to operate at full capacity. Additionally, entities within the Village, such as local hotels and motels, grocery stores, schools, libraries, pharmacies, residential and small commercial businesses will be forced to operate at a reduced capacity, or no capacity, during power outages.***

    - ***New economic development within the Village boundaries will be limited if the Village as their existing NYPA allotment is at capacity and/or exceeded a significant amount of the time. The Village have some flexibility to develop additional small businesses and residential homes, connected to the existing infrastructure, as our estimates currently show their peak annual demand at 4.4 MW of 5.0 MW allowable, but it is quite likely***

that the Village may exceed the NYPA allotment more frequently if future development occurs within the Village boundary that connects to the existing infrastructure.

- ***If the Village does not implement the microgrid, there is not enough available electricity for large businesses or industries to move into the Village and connect to the existing electric distribution infrastructure, under the current NYPA allotment. New businesses would be responsible for providing their own electricity or paying for the overage to the NYPA allotment. This could severely hinder the Village from attracting new residential and business growth.***

6.0 Reference Documents

The following reference documents have been reviewed to collect and present information during the preparation of this Report. Refer to **Appendix I** for the reference documents.

1. General Electric – Technical Description Genset JGS 420 GS-N.L, date February 29, 2016 (as included in AB Technical Description document).
2. General Electric Energy – Technical Instruction Manual for Isolated Operation of Spark Ignition Gas Engines with DIA.NE (Type 4 Engines), TA 2108-0029, dated May 26, 2010.
3. General Electric Power & Water – Technical Instruction Manual for General Isolated Operation of Plants and Engines, TA 2108-0031, dated December 19, 2014.
4. Schweitzer Engineering Laboratories, Inc. – SEL-751 Feeder Protection Relay Data Sheet, dated April 10, 2015.
5. Woodward, MCA4 HighPROTEC Feeder Protection, Device Manual DOK-HB-MCA4E, dated November 2005.