nationalgrid

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January 31, 2019

VIA ELECTRONIC DELIVERY

Honorable Kathleen H. Burgess
Secretary
New York State Public Service Commission
Three Empire State Plaza, 19th Floor
Albany, New York 12223-1350

RE: Case 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision (REV)

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID: COMMUNITY RESILIENCE REV DEMONSTRATION PROJECT – FINAL REPORT

Dear Secretary Burgess:

Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid") hereby submits for filing its Final Report for the Community Resilience REV Demonstration Project, which includes any updates covering the period September 30, 2018 through December 31, 2018, as required by the REV Demonstration Project Assessment Report filed by the New York State Department of Public Service Staff with the Commission on February 10, 2016 in Case 14-M-0101.

Please direct any questions regarding this filing to:

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Respectfully submitted,

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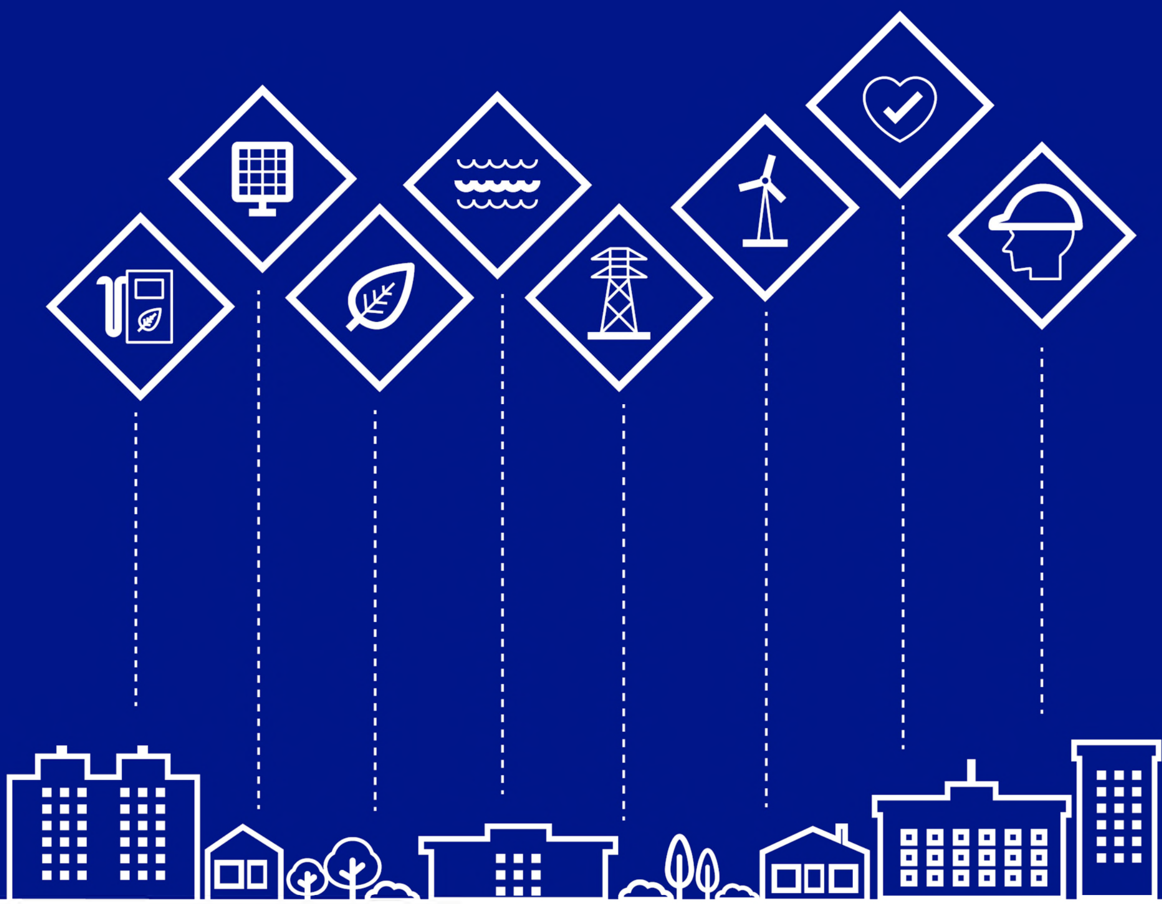
Potsdam, New York

Community Resilience REV Demonstration Project

Final Report | January 2019



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Executive Summary

Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid" or the "Company") led a team of contractors and subcontractors, as well as internal staff, to complete the Community Resilience REV Demonstration Project (the "Project"). This Project consisted of developing an engineering analysis and an investment-grade (-50/+200%) financial model to build and operate a community resilience microgrid in the Village of Potsdam, New York (the "Village"). The microgrid design used in this Project was developed in a Conceptual Design study that commenced prior to the implementation of this Project. The portion of that overall microgrid design on which this study focused was modified during the term of the Project as cost data and existing generation data became available.

The microgrid was intended to provide resilience to the community following extended electrical service outage events occurring within the Village; particularly events lasting longer than twelve (12) hours. During such events, the microgrid was designed to provide electricity to essential infrastructure, which per the Conceptual Design study included a hospital, local police and fire departments, drinking water and wastewater treatment plants, Village of Potsdam government offices, two (2) higher education institutions, a high school, a bank, a drug store, a grocery store, a hotel, and a gas station.

One aspect of the Project was to develop a new economic model involving hybrid asset ownership and operation between the utility and the owners of distributed generation (DG) assets that support the community microgrid. Another segment of the Project included creating a unique tiered tariff designed to recover from customers the capital and operational costs associated with the utility-owned microgrid assets based on the amount of essential services available to those customers during microgrid operation. Customer tiers were ultimately established based on the geographic limit of operation of various essential public services, with those receiving more of such services paying a greater share of microgrid costs.

This Project tested two (2) hypotheses. The first postulated that customers would value the resilience provided by the microgrid enough to accept the proposed bill increase to pay for the microgrid. While commercial and municipal customers liked the idea of being able to receive the benefits resulting from their microgrid connection, and were supportive of a microgrid concept, Project surveying revealed the majority of those customers would not agree to pay additional monthly charges associated with construction and operation of the microgrid.

The second hypothesis tested whether or not customers would accept the electric utility as the provider of services that may be required for microgrid deployment in New York State.
More specifically, the hypothesis postulated customers would choose the utility to provide the following four (4) services:

1. A tiered cost recovery for a storm-hardened, underground wires;
2. Central procurement for distributed generation (DG);
3. Microgrid control and operations; and
4. Billing and financial services.

This hypothesis was affirmed for services 2-4. Customers were supportive of the concept of service 1, but, as noted above, unwilling to pay the estimated cost for such service via their monthly utility bills.

Cost analysis conducted by an internal focus group showed that constructing the entire microgrid described in the Conceptual Design in one undertaking resulted in an unacceptably-large customer bill increase. The construction scope was subsequently modified to use a phased approach, with the first construction phase consisting of only the microgrid segments that include the essential services forming the basis of the tiered cost recovery approach. The resulting cost estimate for constructing Phase 1 of the microgrid was approximately $15.4M, as of July 2018. The cost to purchase and install the additional DG needed to supply the microgrid was $3.78M, based on June 2018 pricing, customer electric load and generation data.

Additionally, energy audits of the three (3) largest electric loads proposed for microgrid connection were completed; they identified energy conservation measures (“ECM”s) and demand response (“DR”) opportunities. Distributed energy resource (“DER”) sizing analysis was completed to determine the amount of DER needed to operate the microgrid. It utilized these ECM and DR data, along with load analysis data, and calculated 2.9 megawatts (“MW”) of DG would be needed to supply the entities that would be connected under Phase 1 of microgrid construction. A set of four (4) natural-gas powered reciprocating generators sequenced to operate based on the instantaneous demand and the availability of connected renewable DG resources was determined to be the lowest-cost system meeting the Project’s technical requirements.

Other key Project findings included:

1. Effective microgrid development requires:
    a. Customers motivated to connect to a microgrid to obtain tangible business value or purpose; and
    b. Project governance by a trusted party, which could be the utility, a group of connected load customers, or a trusted 3rd party.

2. Some customers expect their existing electric service to be 100% reliable, so they believe paying an additional fee for microgrid connection is unwarranted and unreasonable. They feel the utility should pay for a microgrid, as it would serve as a backup system in the event the utility’s existing system fails.

3. Following completion of the detailed technical studies and simulations (capacity sizing, power flow, transients), as well as financial analysis based on the technical analysis findings, a microgrid project on this scale is technically feasible, but also expensive compared to how customers value the reliability it provides.

Based on the outcome of this Project, National Grid continues to explore microgrid models that share the costs of a microgrid backbone (assets for connectivity) between the utility, customers and third parties based on the benefits derived by each party.

Finally, it should be noted that the Project clearly achieved several successes. Although it did not include constructing any capital assets, the Project successfully developed a method for establishing a tiered cost recovery approach, defined customer sentiment on bill increases they would pay under that approach, and identified customer preference of whether a utility or a third party should provide various microgrid services. It also explored the design and operation of a hybrid ownership model in which the utility owns the microgrid distribution system wiring and controller and a private developer owns DG to power the microgrid, and determined customers accept their utility providing microgrid operation services.

1.0 Synopsis of the REV Project

1.1 Project Background

The Village and Town of Potsdam, New York and surrounding St. Lawrence County have experienced multi-day power outages resulting from microbursts and winter ice storms; most notably the "Ice Storm of 1998" which left more than 100,000 customers in that region without power for as long as 3 weeks. In November 2012, following Superstorm Sandy, New York State established a commission under the Moreland Act; the responsibilities of which included investigating the response, preparation, and management of New York's power utility companies during and after major storms impacting the State. The Moreland Commission report called for "*using stronger and more storm resilient components and equipment*"[1]. Additionally, the report stated, "*The Commission also believes that utilities should determine areas where selective undergrounding of infrastructure would be appropriate*."[11] Based on this directive, various studies were initiated to assess microgrid development in the Potsdam area.

1.2 Initial Microgrid Concept Studies

Three (3) studies supporting the concept of constructing a microgrid in the Village of Potsdam were underway prior to inception of this REV Project, as listed in Table 1-1. This REV Project built on data and decisions identified in those reports.

Table 1-1: Previous Potsdam Microgrid Analysis Studies

Project	Project Lead	Supporting Organizations	Project Funding	Actual Implementation Dates	Purpose
National Science Foundation ("NSF") Project	Clarkson University ("Clarkson")	National Grid; Electric Power Research Institute ("EPRI")	National Science Foundation	10/1/15 – 9/30/19	Develop a "smart scheduler" application, which coordinates microgrid operator and local disaster response team to maximize the microgrid performance during disaster recovery. Also funded community benefits analysis.
Development and Design of an Enhanced Microgrid Control System	GE Global R&D	National Grid; National Renewable Energy Laboratory ("NREL"); Clarkson.	US Department of Energy ("DOE") Office of Electric Delivery and	2015 - 2017	Develop and design an Enhanced Control System that brings a microgrid's renewable power sources online and effectively manages

[1] Moreland Commission on Utility Storm Preparation and Response, Final Report, June 22, 2013. https://utilitystormmanagement.moreland.ny.gov/sites/default/files/MACfinalreportjune22.pdf

			Energy Reliability		them and any other generation resources to provide stable backup power during microgrid operation.
Conceptual Design of a Resilient Underground Microgrid in Potsdam	Clarkson	NOVA Energy Specialists, LLC; National Grid	NYSERDA PON 2715; National Grid	2014 – July 2017	Develop a conceptual design for an underground microgrid proposed for construction in the Village of Potsdam.

1.3 Project Description

As stated by NYSERDA, the hybrid utility model describes a microgrid "where the distribution facilities are owned by the utility but at least some of the microgrid's internal Distributed Energy Resources ("DERs") are owned by a non-utility entity." Concurrent to choosing to participate in NYSERDA's Program Opportunity Notice (PON) process, National Grid recognized that a prototype of the hybrid model would need to be developed, and that the Potsdam microgrid was a feasible trial candidate site. Additionally, National Grid recognized various services would be created as a function of an operating microgrid. Based on the microgrid design work already underway by Clarkson University, National Grid submitted a proposal to conduct a microgrid engineering design analysis and cost estimation under the New York Public Service Commission's ("PSC") "Reforming the Energy Vision" ("REV") proceeding. Ultimately, the Project scope evolved to contain the following major components:

- Develop financial and engineering plans for a community microgrid.
- Conduct energy efficiency ("EE") audits of customers having the three (3) largest electric loads, then use this data to define a lower DG requirement.
- Obtain data per the proposal requirements set forth in NYSERDA's NY Prize Stage 2 RFP, per the request of NYSERDA and Department of Public Service ("DPS") Staff ("Staff")[2]

The predominant microgrid model at the time this Project was being designed was based on a single-customer model, serving clusters of buildings on a single campus (corporate, military, or university). Community microgrids involving multiple customers require a substantially higher degree of coordination due to the required aggregation and optimization of customer load and DER, with a financial structure that appropriately shares the burden of incremental cost and benefit. This demonstration Project sought to test customer acceptance of utilities providing the required coordination and aggregation services, using a novel rate recovery, to enable a financially-

[2] NY Prize Community Grid Competition – Stage 2 Request for Proposals ("RFP") 3044. file:///C:/Users/nickersonj/Downloads/3044Summary.pdf

sustainable community microgrid via the hybrid utility microgrid ownership model. The four new services evaluated for customer acceptance under this REV demonstration consisted of:

1) Tiered recovery for storm-hardened, underground wires;
2) Central procurement for DER;
3) Microgrid control and operations; and
4) Billing and financial transaction services.

The Project objective is summarized by the overarching test statements and hypotheses shown in Table 1-2.

Table 1-2: Overarching Test Statement and Hypotheses

Overarching Test Statement	If...	Then...
The utility can effectively enable a community resilience microgrid through the design of hybrid utility microgrid services that allocate incremental costs primarily to those who benefit from the services.	**Hypothesis 1:** National Grid's proposed microgrid services can enable more convenient, effective backup service for critical facility loads (vs. individual facility backup options), at a modest incremental cost to current service costs.	Prospective microgrid-connected customers and other stakeholders will support the continued development of National Grid's proposed microgrid services at specified demonstration checkpoints.
	Hypothesis 2: National Grid's proposed utility microgrid services offer higher value than any comparable services available to Potsdam customers from non-utility market participants.	Prospective microgrid-connected customers and Village residents (not connected to the microgrid) will agree to service scope and pricing.

1.4 Project Roles

National Grid partnered with GE, and OBG (formerly O'Brien & Gere). GE subcontracted Nova Energy Specialists, LLC ("Nova Energy") and Clarkson. GE's used NYSERDA's NY Prize Stage 2 outline as a basis for their data collection. Nova Energy was responsible for calculating grid effects, while Clarkson's team addressed microgrid operation governance. OBG conducted EE audits of the three (3) largest load customers; Clarkson University, the Canton-Potsdam Hospital, and the State University of New York ("SUNY") Potsdam; and also obtained and prepared all equipment cost estimate data.

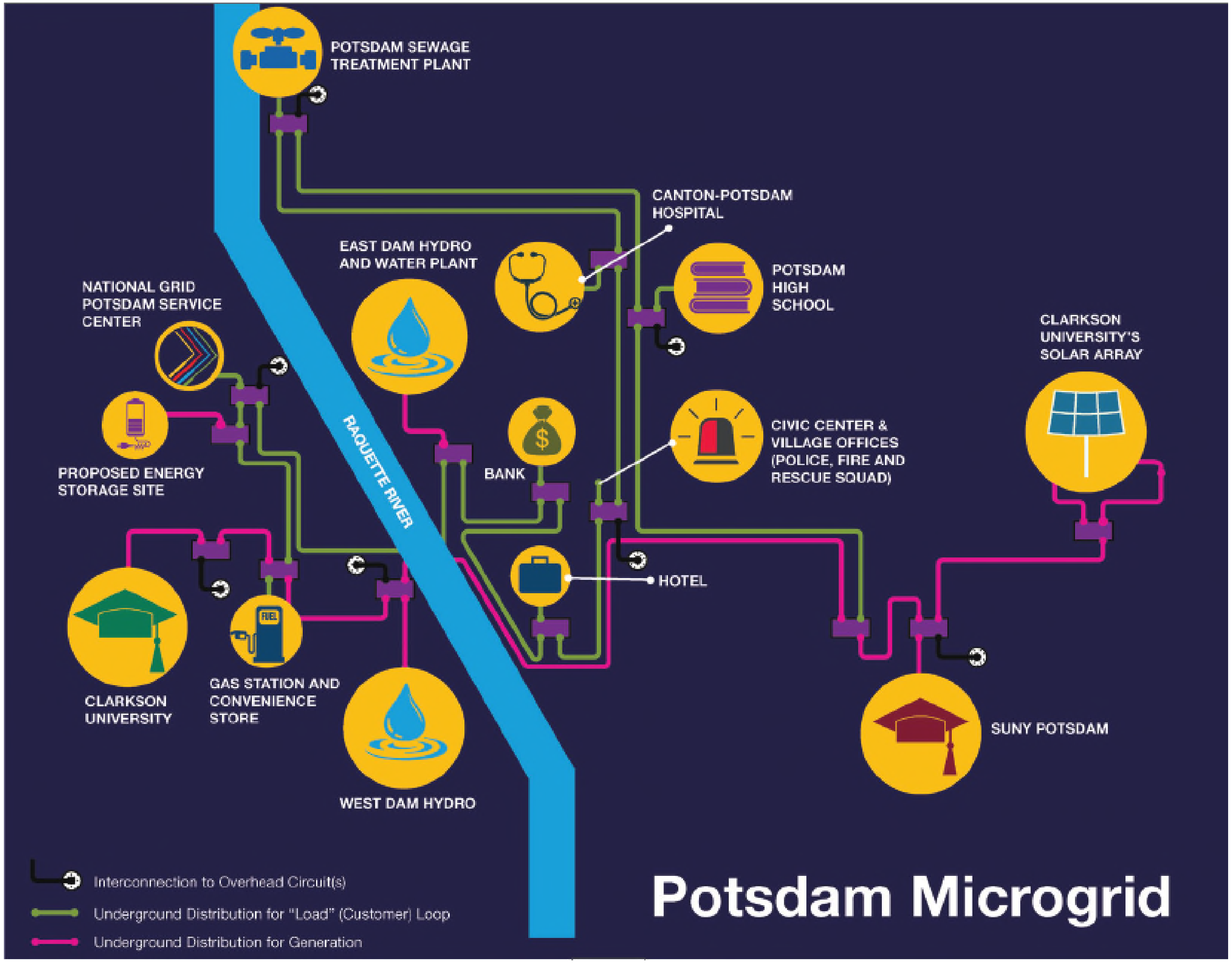
1. 5 Project Goals

Project assessments were based on the connected customer participation list presented in Clarkson's Conceptual Design study listed in Table 1-3. The microgrid configuration stated in the Conceptual Design is presented in Figure 1-3.

Table 1-3: Proposed Connected Customers and Services Provided

Category	Proposed Connected Customer	Intended Service Provided
Universities	Clarkson University	Emergency shelter
	SUNY Potsdam	Emergency shelter
Village of Potsdam Municipal Buildings	Police Department	Police services
	Fire Department and Civic Center	Fire protection/First Responder and Municipal Government Office Operation
	Water Treatment Plant	Drinking water
	Wastewater Treatment Plant	Wastewater treatment
Other Public Entities	Potsdam High School	Emergency shelter
Critical Commercial Services	The Clarkson Inn (a Hotel)	Lodging for emergency crews
	IGA	Grocery Store
	Canton-Potsdam Hospital	Emergency health services
	Stewart's Shops	Convenience store and fuel sales
	North Country Savings Bank	Cash source
	Kinney Drugs	Pharmacy services
Utility	National Grid Service Center	Electric grid restoration

Figure 1-3: Microgrid Configuration Provided In the Conceptual Design



1.6 REV Goal Support

This Project addressed several REV goals, as shown below noted in Table 1-4.

Table 1-4: REV Goals Supported by the Community Resilience Demonstration Project

REV Goal	Supported by Project?	
	Yes	No
Make Energy more affordable		X
Build a more resilient energy system	X	
Empower New Yorkers to make more informed energy choices		X
Create new jobs and business opportunities	X	
Improve New York's existing initiatives and infrastructure	X	
Support cleaner transportation		X
Cut Green House Gas emissions by 80% by 2050		X
Protect New York's natural resources		X
Help clean energy innovation grow	X	

Source: Reforming The Energy Vision, Learn More; https://www.ny.gov/reforming-energy-vision/learn-more

2.0 Project Tasks and Key Findings

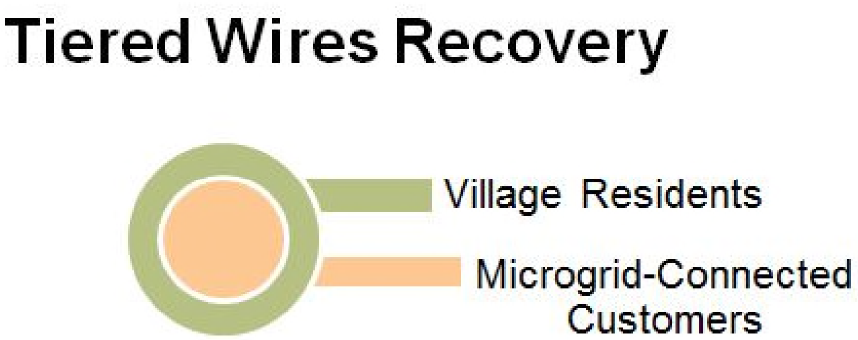
Each major task is described below. The nature of some tasks required an iterative process of development, as some outcomes resulting from later tasks impacted the original findings of earlier tasks.

2.1Tiered Recovery Financial Model Approach Development

Rather than use a traditional rate-based approach in which an equal rate is applied to all customers to pay for the microgrid infrastructure investment, this Project explored a cost allocation model using cost levels, or tiers. As explained below, tiers were originally selected using a geographic basis. This approach was found to be cost prohibitive and indefensible. The tier basis evolved to ultimately be based on the quantity of benefits a customer could receive from microgrid operation; the greater the quantity of benefits received, the greater the addition to the monthly bill. Developing this model required building a tool that estimated the cost for each customer group based on customer data and tier-specific parameters. Rates for customers connected directly to the microgrid were also calculated.

Figure 2-1 illustrates the conceptual model using a 2-tier approach, in which customers physically connected to the microgrid pay the greatest portion of the microgrid construction costs, while customers located within the Village of Potsdam, but are not connected to the microgrid, would pay a smaller portion of the wires investment costs.

Figure 2-1: Generic Tiered Recovery Model



The Project team initially calculated an amortized rate for the connected and the non-connected customers. Bill impact analysis revealed that allocating the entire Project cost to the connected and non-connected customers would result in monthly bill increases that in some cases were nearly thirty-three percent (33%) of a customer's current delivery service charge. National Grid's internal focus group determined that such increases would to be excessive, and therefore unacceptable. National Grid subsequently expanded the cost recovery model to consist of a 4-tiered approach, adding two (2) new customer categories:

- Customers located between the Village border and five (5) miles of the Village border, and
- Customers located between five (5) and ten (10) miles of the Village border.

The premise of this model was for customers located a greater distance from the Village to pay less than customers located closer to the Village. However, this was determined not to be viable or rational, since some customers from both sets would enjoy the same benefits, while others in the same set would enjoy fewer benefits. Ultimately, a third approach establishing cost tiers based on microgrid connection and availability of particular essential services was developed, as follows:

- Tier 1 customers would be connected to the microgrid. They were divided into two (2) groups:
    - Tier 1a customers would be connected load customers capable of self-generating power; and
    - Tier 1b customers would be connected customers who were not capable of self-generating power.

- Tiers 2, 3, 4, and 5 were defined based on the geographical area served by a particular service, with service availability decreasing with each progressively higher tier level. For example, Tier 5 customers would only receive the benefit of having the hospital and the Tier 1 business services. However, in addition to the hospital services and Tier 1 business services, Tier 4 would also include available Rescue Squad services. Tier 3 would include Tier 4 services, as well as available Fire Department services. Tier 2 would include the same services as Tier 3, while adding in available police services. Table 2-1 lists services that define each tier and the estimated tier customer count, while Table 2-2 lists the tier compositions.

Bill impact analysis using a 5-Tier cost recovery approach also presented a very significant bill impact to customers. The Project team analyzed the proposed microgrid configuration to determine if a more economically feasible approach could be achieved by dividing the microgrid into segments that could be constructed sequentially. This analysis identified three (3) segments containing most of the essential services, and identified segments containing customers having some capability to self-generate. Approaching microgrid construction in stages rather than all at once resulted in lower incremental bill increases. Furthermore, by constructing the segment containing the essential services on which the tiered recovery is based, after the core is built, if one of the remaining microgrid stages were eventually not selected for construction, the remaining microgrid portion would still be financially viable.

The Project team conducted financial modeling based on a staged construction approach. Figure 2-2 shows the geographic location of each microgrid construction stage, while Table 2-2 lists the customers that would be connected in each of those stages. The first three (3) stages, which connect the essential services on which the tiered cost recovery approach is designed, were grouped into Construction Phase 1. All Project engineering analysis and cost reporting was completed based on just Construction Phase 1. The composition of future construction phases would be defined following construction of Phase 1.

Table 2-1: Tier Criteria and Customer Counts

Tier	Customer Tier Participants[1]	Criteria	Customer Accounts
Tier 1a	Clarkson University, SUNY Potsdam, Village Government	Connected load with some elf-Generation	3
Tier 1b	Canton-Potsdam Hospital, Clarkson Inn, North Country Savings Bank, IGA Grocery, Kinney Drug Store, Stewarts Gas Station, PVRS, Potsdam High School, National Grid Service Center	Connected Load only	9
Tier 2	Village of Potsdam Border	Police	2,575
Tier 3	Town of Potsdam Border	Fire	3,425
Tier 4	Village of Norwood, Town of Pierrepont, Town of Colton, Town of Stockholm (portion), Town of Norfolk (portion)[2]	Rescue Squad	3,595
Tier 5	Zip codes: 13625, 13695, 13639, 13635, 13684, 13652, 13630, 13687, 13672, 13617, 13676, 13699, 13660, 13668, 13696, 13697, 12965, 12967, 13613, 13667, 13621, 13694, 12922, 12927, 13677, 13647, 13678	Hospital	14,130
	Total Customer Accounts Paying A Microgrid Fee:		**23,737**

- [1] *All tiers are exclusive of previous tier's customers.*
- [2] *Tier 4 based on Potsdam Volunteer Rescue Squad's (PVRS) service territory, which covers portions of the Towns of Stockholm and Norfolk.*

Figure2.2 – Staged Roll-Out Map

Table 2.2 – Staged Roll-Out Segments and Customer Groups

Construction Phase	Stage	Start/Finish Point	Route (Streets)	Proposed Load Connections	Possible Generation Connections
Phase 1	Stage 1	Clarkson University (feeder 51) to Village Civic Center	Maple St. -> Main St.	Clarkson University, Kinney Drug Store, Stewart's Shops Gas Station, The Clarkson Inn, North Country Savings Bank, IGA Grocery, Civic Center/Rescue Squad	West Dam Hydro and Clarkson's new DERs, one available
	Stage 1b	Maple St. to East Dam Hydro	Market St. -> Raymond St.	Stage 1 + Water Treatment Plant	West Dam Hydro + East Dam Hydro
	Stage 2	Village Civic Center to Canton-Potsdam Hospital ("CPH")	Park St. -> Elm St. -> Lawrence Ave. -> Leroy St.	Stage 1 + Potsdam High School and CPH	West Dam Hydro + East Dam Hydro
Future Phase(s)	Stage 3	CPH to Wastewater Treatment Plant	Grove St. -> Cherry St. -> Lower Cherry St.	Stage 2 + Wastewater Treatment Plant	West Dam Hydro + East Dam Hydro
	Stage 4	Village Civic Center to SUNY Potsdam	Main St. -> SUNY at Morningside Dr.	Stage 3 + SUNY Potsdam	West Dam Hydro + East Dam Hydro + SUNY Combined Heat & Power ("CHP").
	Stage 5	SUNY Potsdam to solar PV via overhead line	Morningside Dr. -> Elm St.	Stage 4 + PV	West Dam Hydro + East Dam Hydro + SUNY CHPs + PV
	Stage 6	Clarkson to National Grid Service Center	Pine St.	Stage 5 + National Grid Service Center	West Dam Hydro + East Dam Hydro + SUNY CHPs + PV

2.2 Energy Auditing

NY Prize Stage 2 requires energy auditing of the three (3) largest loads proposed to be connected to the microgrid. Data collected for these audits was used to estimate the potential impact on the microgrid's DG requirements that could result from decreasing the load through ECMs and implementing DR actions. Based on this requirement, National Grid hired OBG to conduct energy audits of the Canton-Potsdam Hospital, SUNY Potsdam, and Clarkson University's main campus. The auditing consisted of conducting analyses, determining electric EE improvement options, and identifying electric DR options for each facility. Findings were published in separate reports and presented to the respective facility managers.

Collectively among the institutions audited, ECMs totaling nearly 1.3MW in load savings and more than 800kW in DR options were identified. Table 2-3 reports the ECM and DR kW reduction findings.

Table 2.3 –ECMs and DR Findings from Energy Auditing

	ECM (kW)	DR (kW)	Total (kW)
Clarkson University	612	425	1,037
SUNY Potsdam	580	427	1,007
Canton-Potsdam Hospital	105	26	131
Total	**1,297**	**878**	**2,175**

2.3 DER Needs Analysis

Among the connected load customers, the need for additional DER was recognized early in the Conceptual Design project conducted under NYSERDA PON 2710. This task consisted of quantifying that additional DER need, followed by determining the most cost-effective DER equipment and approximate installed price. GE conducted the DER analysis using the Distributed Energy Resources Customer Adoption Model ("DER-CAM")[3], which is an economic and environmental model that evaluates adoption of DER assets in grid-connected and off-grid microgrid systems. (A detailed description of the DER-CAM model is provided in the Q2 2017 Project quarterly report.) Several iterations of DER-CAM, followed by several iterations of DER-CAM2, which was released during the Project, were performed as new data became available. The analyses utilized the audit's EE and DR data, as well as data on large renewable DG resources existing in the Village or on Village property. Once the approximate amount of additional DER was defined, OBG conducted product surveying to identify generation alternatives suitable for the proposed microgrid, and the associated product costs.

Existing generation sources within the Village of Potsdam include CHP, photovoltaic (PV) solar and two hydro-electric plants (East Dam and West Dam). These were initially believed to make the Village an ideal fit for a microgrid project based on an expectation these sources would supply the microgrid.
The preliminary microgrid design presented in Clarkson's Conceptual Engineering Design study thus included using these DERs.

As of the time of GE's analysis, the East Dam hydro plant was out of service, with repair planned, but not completed. Analysis determined that the questionable availability of this hydro generation

[3] Distributed Energy Resources Customer Adoption Model ("DER-CAM"). (n.d.); retrieved from https://building-microgrid.lbl.gov/projects/der-cam.

station posed a significant risk to the microgrid Project's viability. It was therefore removed from the microgrid's DER resource list. As for the West Dam hydro plant, although not consistently functioning due to mechanical issues, all power from the plant is already sent to Clarkson under a power purchase agreement Clarkson holds with the Village to purchase remote net-metered electricity from the Village's West Dam. If the proposed microgrid were to be called into service, power from the West Dam Hydro plant would continue to be sent to Clarkson, provided the generator is functioning when the microgrid is needed.

The 2MW solar array located on a village-owned parcel east of the Village limits was considered as 'possibly available' for the DER-CAM analyses because it is connected to the grid by an overhead cable which is susceptible to breakage from ice. The cost of connect this solar array to the microgrid by installing an underground cable was explored and determined to be cost prohibitive compared to the benefit it would provide. Furthermore, investing in an underground cable overlooks the PV productivity decrease resulting from snow or ice covering the solar PV panels during and immediately following an ice storm or snow storm. Lastly, while SUNY Potsdam's CHPs remain available, the staged construction approach adopted did not include connecting SUNY Potsdam in Construction Phase 1 because the segment to connect this customer does not contain any essential service customers used to define the cost recovery tiers.

Recognizing that the existing DERs could not definitively be available to power the microgrid when needed, GE's analysis defined the total additional DER generation requirements assuming no existing DG would be available. DER-CAM analysis concluded that an additional 2.9 MW of DER would be required to operate the section of the microgrid containing the essential services (*i.e.,* Phase 1). It also showed the optimal DER design would consist of a multi-generator sequenced approach that draws upon all existing available renewable DERs first, and then meets the remaining electric load by operating as many of the four (4) natural-gas powered reciprocating generators as needed. While the total DER need is based on the maximum demand, the maximum demand is expected to only occur for short durations each business day that the microgrid operates. A multi-generator staged operation approach would allow operating an amount of generation that more closely matches the microgrid's prevailing load at different times of the day.

DER equipment analysis revealed that 1MW generators operate at between 800 and 900 kW of output depending on various factors. Thus, four (4) such generators would be needed to meet the peak 2.9MW peak demand. Additionally, the 2.9MW estimate was based on Clarkson University, SUNY Potsdam, and Canton-Potsdam Hospital implementing the most impactful EE measures identified by the energy audits conducted under this Project. The peak demand could exceed 2.9 MW if all major EE upgrades were not implemented by the time the microgrid operated. Conversely, additional EE upgrades could be identified in the future, thereby reducing the peak demand below 2.9MW. Lastly, energy curtailment could also be implemented, further reducing the peak demand. The proposed multi-generator staged operation approach effectively addressed each of these load variables.

2.4 Engineering Design and Financial Model Report Preparation

GE led the Project report development effort to produce a report that was structured per the NY Prize Stage 2 requirements. GE's internal and external contractors prepared and contributed sections specific to their expertise. Additionally, National Grid also prepared and submitted report sections. Report sections prepared by National Grid's contractor, OBG, were assembled into a separate document from that produced by GE.

One important distinction between the Potsdam microgrid and microgrid projects involved with the NY Prize Stage 2 process was that the Project was strictly a conceptual proposal. In contrast to other concurrent microgrid projects in various stages of development, this Project did not yet include a developer holding either secured construction funding or customers who had signed formal microgrid connection agreements. The absence of a developer with a confirmed governance plan and secured customers prevented some NY Prize State report sections from being fully completed.

2.5 Microgrid Engineering Design Development

National Grid developed a complete engineering design of the proposed microgrid, including equipment models and quantities, which were subsequently used for developing the microgrid's cost estimate. The design was updated several times as the locations for DER and grid tie-in evolved. The design was also adjusted to permit using a staged construction approach. The design required selection of the appropriate control and communications ("C & C") equipment, which was reviewed to ensure compatibility with the existing system. The effort culminated with complete one-line diagraming and a cost estimate.

2.6 Stakeholder Outreach/ Customer Engagement

Stakeholder opinions and preferences regarding microgrid services provided essential input throughout the Project. The structure of the proposed microgrid depended on acceptance of both connected and non-connected load customers. Rejection by either party would lead to redesigning the microgrid and recalculating its costs or reconfiguring the overall microgrid planning approach. National Grid began with the connected load customer group because, without the agreement of these customers, there would be no value to the microgrid, and thus there would be no need to seek residential customer input on the proposed microgrid.

Outreach consisted of a blend of public meetings, individual customer meetings, fact sheet preparation/distribution and newspaper article development/publishing. Table 2-4 lists the dates, objectives, and outcomes of the completed stakeholder meeting events. Note the individual customer meetings were held in person when possible but were also conducted via telephone calls when customer schedules did not permit an in-person meeting.

Table 2-4: Stakeholder Outreach Efforts

Outreach Effort	Outreach Date	Invitees or Attendees	Outreach Objective
Town Hall Meeting #1	March 2016	All customers proposed to be connected, per the Conceptual Design.	Introduce microgrid concept.
Town Hall Meeting #2	October 2016	All customers proposed to be connected, per the Conceptual Design.	Provide update on Microgrid planning.
Individual customer one-on-one meetings	Dec 2017 – Jan 2018	One connected customer per meeting.	Determine the value of microgrid connection to customers.
Individual customer one-on-one meetings	Aug-Sept 2018	One connected customer per meeting.	Introduce the Microgrid Service Survey and encourage completion.

General findings from these outreach efforts include:

a. Several businesses desire to always being available to serve the community. Even if only a few customers come to the business during an outage event, some business operators stated that demonstrating to customers that their enterprise remained open during its normal operating hours, regardless of whether or not the Village had power, holds significant reputational value.

b. If a microgrid operator can guarantee there will be 100% reliable power, some customers stated they would opt out of carrying certain insurance.

c. Some entities already own enough backup generation to meet their minimal electric supply needs. Their microgrid connection interest lies in reducing or eliminating their cost of owning, maintaining, and operating their backup power systems. Additionally, some of these customers want a microgrid connection to meet the remainder of their existing electric load, to enable 100% operation during a power outage.

The August-September 2018 individual customer meetings were held after the financial modeling was completed. Tier 1a and Tier 1b customers were asked to complete a written survey to determine their position on each of four (4) proposed microgrid services. The first service consisted of the tiered recovery approach, and the customers were asked about willingness to pay for the value they perceived a microgrid would provide to them. The other three (3) survey questions were structured to ask questions about ‘a utility’, rather than naming National Grid, thereby allowing the data to reflect general customer sentiment rather than seeking feedback in the context National Grid specific services. Survey details were presented in the Q3 2018 quarterly report.

2.7 Data Analysis Go/No Go Decision Making

National Grid utilized data collected over the course of the Project to determine whether or not each of the four (4) new services evaluated should be considered as possible new revenue streams for utilities located in New York State. The Project’s decision making elements are set forth below in Table 2-5.

Hypothesis 1 was tested via the first one-on-one meetings, in which customers were asked what value they perceived they would receive from being connected to a microgrid. All but one (1) customer identified business value as the value they perceived, and they were thus supportive of the continued design and financial analysis of a microgrid. The sole customer who did not perceive connecting to a microgrid as providing value to their operation stated they would close during any power outage expected to last an hour or longer, particularly if the outage occurred during hon-business hours.

Table 2-6 presents the set of test statements used to provide a focused evaluation of the perceived value of the four (4) proposed microgrid services addressed in Hypothesis 2. The italicized ‘Then’ statements formed the basis of the related customer survey questions.

Hypothesis 2 involved data collection and was divided into two (2) efforts; one (1) to collect data from the prospective connected customers, and another to collect data from residents living within the Tier zones. The second set of one-on-one meetings with Tier 1a and Tier 1b customers were used to distribute surveys that captured connected customer acceptance of the monthly bill increases, as well as their preferences on who should provide the other three (3) microgrid services being surveyed.

Table 2-5: Project Test Statements

Overarching Test Statement	If…	Then…
The utility can effectively enable a community resilience microgrid through the design of hybrid utility microgrid services that allocate incremental costs primarily to those who benefit from the services.	**Hypothesis 1:** National Grid's proposed microgrid services can enable more convenient, effective backup service for critical facility loads (vs. individual facility backup options), at a modest incremental cost to current service costs.	Prospective microgrid-connected customers and other stakeholders will support the continued development of National Grid's proposed microgrid services at specified demonstration checkpoints.
	Hypothesis 2: National Grid's proposed utility microgrid services offer higher value than any comparable services available to Potsdam customers from non-utility market participants.	Prospective microgrid-connected customers and Village residents (not connected to the microgrid) will agree to service scope and pricing.

Table 2-6: Microgrid Service Supporting Test Statements

Supporting Test Statements	If…	Then…
Proposed service 1: A tiered cost allocation can recover a majority of incremental distribution infrastructure costs from prospective microgrid customers and beneficiaries.	Infrastructure will enable critical load customers to operate for up to two (2) weeks after a prolonged outage event.	Those customers will see improved business continuity and ability to provide critical emergency services.
	A tiered approach allocates the utility's revenue requirement proportionally to those who receive value of business continuity, emergency services and restoration benefit.	*Required stakeholders will agree to tiered recovery tariff terms that correspond to the anticipated value.*
Proposed service 2: A utility central procurement model for DER can enable the development of incremental, cost-effective capacity needed for a multi-customer microgrid.	National Grid offers a long-term tariff for the purchase of energy from new generation and/or storage capacity, with an associated service fee.	This model will overcome the barriers of time/effort and capital/cost encountered in bilateral contracting for the required incremental DER capacity.
		Prospective microgrid customers and other beneficiaries will bear any above-market costs associated with the new generation (if required).

Proposed service 3: The utility is well-suited for the control and operations of a hybrid utility microgrid.	National Grid offers microgrid control and operations service (maintaining frequency, voltage, and power quality) with an associated service fee.	*Prospective microgrid customers and stakeholders will select National Grid as the most qualified and cost-effective company to provide this service.*
Proposed service 4: Current utility capabilities offer the optimal solution for hybrid utility microgrid billing and financial transaction services.	National Grid leverages existing utility services including metering, billing, credit and collections for microgrid customers, with an associated service fee.	*Prospective microgrid customers and stakeholders will select National Grid as the most qualified and cost-effective company to provide this service.*

Survey Findings
Tier 1a and Tier 1b connected customer survey results indicate there was minimal interest in paying to connect to a microgrid. However, having the utility provide the three (3) other services would be acceptable. Table 2-7 presents the Tier 1a and 1b Customer Survey reply quantities.

Table 2-7: Connected Customer Responses to Microgrid Services Survey

Question		Yes	No	Undecided	No Response
1. Would you participate as a microgrid customer if your bill increased by:	Base Cost	1	8	0	3
	Slightly reduced cost	1	8	0	3
	50% of Base Cost	1	7	1	3
2. Would you prefer the utility provide central procurement for a DER?		6	1	0	5
3. Would you prefer the utility be in control of the microgrid and its operations?		7	0	1	4
4. Would you prefer the utility provide billing and financial services?		7	0	1	4

Consistent with the Implementation Plan, National Grid considers the three (3) microgrid services that were deemed a “Go” as possible commercial offerings available to other communities interested in pursuing a hybrid utility microgrid model. Future microgrid projects could start their own evaluation of customer acceptance of microgrid services utilizing data collected within this Project. Table 2-8 lists the Go/ No-Go analysis findings based on the survey outcomes.

Table 2-8: Go/ No-Go Outcomes of Microgrid Services Survey Questions

Question	Go	No-Go
1. Would you participate as a microgrid customer if your bill increased?		X
2. Would you prefer the utility provide central procurement for DER?	X	
3. Would you prefer the utility be in control of the microgrid and its operations?	X	
4. Would you prefer the utility provide billing and financial services?	X	

Discussions with, and written comments received from, surveyed customers included the following reasons why some customers would choose not to accept the microgrid connection under the proposed tiered recovery program:

1. Some customers can purchase and operate a portable generator or install a permanent standby generator for a cost that would equate to ten (10) or fewer years of their proposed monthly microgrid bill increase. The microgrid monthly bill increase would exist for seventy-five (75) years, making the customer-owned generator more financially attractive to these customers; and

2. A connected customer may choose to shut down their operation during any outage lasting longer than four hours. Certain customers felt it would not be practical to remain open throughout such power outage events.

Those findings indicated a general unacceptance among connected customers to paying for the microgrid. National Grid recognized that surveying the residents would not be appropriate because the connected customers would not accept paying a microgrid-specific additional monthly cost.

Overall Data Interpretation
The following factors indicate that construction of the proposed Potsdam microgrid, or some component of the Potsdam microgrid, will not be constructed in the near-term.

1. An electric service interruption event (herein termed 'outage') history review shows that, contrary to anecdotal stories, there have been few outages lasting longer than two (2) hours in the Village over the past eight (8) years (the starting date of detailed outage history collection). From January 1, 2010 through December 31, 2017, forty-two (42) outages occurred. Three quarters of these outages lasted two (2) hours or less; and all but one (1) of these 42 outages lasted fewer than four (4) hours (See Table 2-9). The one outage lasting more than four (4) hours lasted four and one half (4.5) hours.

Table 2-9 Electric Power Outage Durations Occurring in the Village of Potsdam for the Period of January 1, 2010 – December 31, 2017

Outage Duration	Outage Quantity	Outage Quantity as a Percent of All Outages
0-1 hr.	18	43%
1-2 hrs.	14	33%
2-3 hrs.	5	12%
3-4 hrs.	4	10%
4-5 hrs.	1	2%
Totals:	**42**	**100.0%**

Five (5) primary outages causes were identified, as listed in Table 2-10. The sole outage lasting more than four (4) hours was caused by an automobile accident and affected one (1) of the thirteen (13) proposed connected-load customers. The outage review also revealed that during the entire December 2013 ice storm, the most recent large ice storm occurring in the area resulted in one (1) outage event occurring in the Village. It lasted less than one (1) hour.

Table 2-10: Causes of Electric Power Outages Occurring in the Village of Potsdam for the Period of January 1, 2010 – December 31 2017

Power Outage Event Cause	Outage Event Quantity	% of Total Events
Equipment Failure	18	43%
Tree-Related Event	8	19%
Weather-Related Event	7	17%
Unknown	4	10%
Vehicle	4	10%
Maintenance	1	2%
Totals:	**42**	**100%**

2. As noted above, there is no developer leading construction of the proposed microgrid at this time, nor is there a governance structure for a microgrid agreed-upon by the connected load customers and affected residents. Various governance structures were explored during preparation of the GE's report. These included a model based on establishing a consortium consisting of connected load customers, and a model in which an external developer provides the DER, and takes the lead on driving the microgrid design and construction process, including obtaining all permits, executing stakeholder engagement, and leading the next engineering design steps.

3. The customer feedback survey conducted as a final step in the Project work scope showed a general lack of customer interest in paying an additional monthly fee to be connected to the microgrid. The survey also revealed that most of the connected load customers providing essential community services could either handle an outage of up to two (2) weeks on their own, would rent portable generation, or would close for the duration of the outage because need for their services would be reduced or absent during a major storm (*e.g.,* the high school may not open due to transportation safety issues).

4. The electric transmission and delivery system serving the Village has proven sufficiently robust to be relatively unaffected by weather events (including microbursts). This electric service continuity has likely contributed to customer confidence that the existing electric system will continue to be reliable, and therefore, a microgrid is not needed in the Village.

2.8 Major Lessons Learned

Multiple lessons learned during this Project are transferrable to other microgrid projects, both internal and external to National Grid. Each quarterly report includes a listing of the lessons learned that quarter. Table 2-11 lists the key lessons learned.

Table 2-11 Key Lessons Learned from the Community Resilience REV Demo Project

Issue or Change	What was the Resulting Change to Project Scope/Timeline?	Strategies to Resolve	Lessons Learned
Customer interest in Microgrid participation fluctuates.	One (1) customer's interest has receded now that they more fully understand the perceived versus actual community benefit, in relation to their connection cost. Another customer is developing expansion plans within the next five (5) years, which if constructed, will require additional generation. One (1) additional customer was identified by the Project team.	The underground design must possess flexibility to accommodate the addition and subtraction of customers. Also, a procedure for developing a customer addition fee needs to be created, as each addition's construction cost is unique based on several physical and electrical parameters.	Management staff changes, overall Project impact understanding, and Project design evolution all can impact participation interest level. The engineering design must therefore be sufficiently flexible to accommodate participation and generation requirement changes.

Issue or Change	What was the Resulting Change to Project Scope/Timeline?	Strategies to Resolve	Lessons Learned
Customers reported electric loads used to calculate microgrid generation needs but have not consistently reported developments in their backup generation plans.	The decreased load meant a smaller amount of generation would be needed for designing the microgrid's peak generation capacity.	Establish contractual agreements with customers interested in connecting to a proposed microgrid, and obligate the customers to report within one (1) month any significant load or available backup generation changes. Institute a mechanism to identify load and generation changes occurring through the Project's final design stage, then be able to modify the microgrid generation size as needed.	Microgrid planners must assume load changes will occur among connected load customers. This Project's load may change between the final reporting and yet-to-be-determined microgrid construction date.
Surveys were not received from some customers.	The tallied survey results are less representative than intended.	The Project manager contacted customers via telephone to discuss the survey, and customers emailed their surveys to the Project manager.	Not all customers who express willingness to provide requested information will actually provide it.
Historical outage analysis revealed the Village of Potsdam has experienced one power outage lasting >4 hours over the past eight (8) years.	Historic outage data numerically supported the lack of customer interest in an additional microgrid fee, as the public perceives strong electric reliability exists.	Historic outage analysis should span a longer time frame to provide a more representative data set.	Shorter term perspectives can obstruct understanding the overall issue.

2.9 Project Evolution

National Grid modified the Project approach several times based on various Project tasks and sub-tasks findings, as well as information gathered during Project execution. Listed below are the most significant changes to the Project approach.

A. The cost of constructing the total microgrid as originally stated in the Conceptual Design was found to yield an unacceptable monthly customer bill increase. Analyzing the construction costs and determining which services are essential to the resilience of the area showed a staged construction approach to the microgrid could be used, provided the first stage includes connecting all customers selected as Tier 1a, 1b, and Tier 2 customers.

B. A detailed analysis of microgrid services was not conducted because the analysis would have been purely hypothetical, as there is no confirmation a microgrid will be constructed. Investing in a detailed hypothetical analysis was therefore deemed economically unviable.

C. Based on the lack of a Tier 1a and Tier 1b customer willingness to pay an additional monthly fee for microgrid connection, binding agreements for microgrid services were not sought from these customers.

D. Based on the lack of Tier 1a and Tier 1b customer willingness to pay an additional monthly fee for microgrid connection, Village residents were not surveyed to determine their willingness to pay an additional monthly fee for microgrid construction within the Village.

2.10 Project Accounting

Incremental costs consisted primarily of labor and contractors hired specifically for this Project. The Incremental project budget was $1,606,000. Table 2-12, below, lists the total Project cost, the incremental cost budget, and the funded non-incremental costs.

Table 2-12: Community Resilience REV Demo Project Costs

Project Task	Amount
CapEx	
	$0
OpEx	
Total Project Cost (Incremental and Non-incremental Cost	$1,447,133
Estimated Close-out Cost	$5,000
Total Project Cost	$1,452,133
Incremental Budget	$1,606,000
Funded Non-Incremental Costs	$502,213
Total Operating Budget	$2,108,213
Unspent Project Funds	$656,080
Percent Under Budget	**31.1%**

3.0 Microgrid Financial and Value Review

3.1 Microgrid Cost Estimates and Cost Allocation
The load size of the connected customers, the connected customer quantity, and linear length of the microgrid dictate the estimated cost and configuration of the microgrid construction. Several costs estimates were developed as the size of the microgrid evolved. Based on the final engineering design for constructing Phase 1 of a resilient microgrid, the estimated microgrid capital cost is $13.63M, and the estimated controller capital cost is $1.51M, estimated as of July 2018. The sum of these two (2) costs, $15.14M, represents National Grid's Project capital cost, which would be recovered using the tiered recovery approach described in Section 2 of this document.

In addition to the microgrid distribution system equipment purchase and installation, the utility will potentially incur costs and revenues for other microgrid services it provides (See Table 3-1).

Table 3-1: Possible Utility Revenues and Costs Associated with Microgrid Operation

REVENUES	COSTS
Payments from the community for electric distribution using multi-tiered surcharge design (based on kW and kWh).	Distribution equipment and installation.
Payments from microgrid entity for standard SC7 distribution service (based on kWh / kW).	Protection equipment and installation.
Payments from microgrid entity for microgrid control (MaaS fee).	Controller equipment and installation.
Payment from microgrid entity for metering, billing, and settlements (service fee).	Metering, billing, and settlement.
	Various taxes.
	Cable system operations and maintenance.

3.2 DER Cost Estimate
Based on the calculated peak load, National Grid's contractor OBG estimated the total purchase and installation cost of four (4) 1000kW natural-gas fueled reciprocating engine generators to be $3.782M, based on June 2018 price data. This cost would be borne by a 3rd party service provider (DG developer), and recovered in two (2) ways: sale of power to the NY ISO; and sale of power to microgrid-connected customers when the microgrid is active. Historic electric price analysis in the Potsdam area revealed there were, based on the 2017 NYISO hourly average 5-minute real-time LBNP of the Sissonville Hydro Plant, which is located outside of the Village of Potsdam, 469 hours per year in which the NY ISO price exceeds the estimated cost of operating the DG. The developer could therefore sell power to the NY ISO at a profit during those hours, provided the DG equipment was not supplying the microgrid. Additionally, the developer would be selling power to the microgrid whenever it was needed, and that sale price would be at a rate pre-negotiated with National Grid. A more robust cost recovery plan for the DG could be

constructed once a DER developer has been selected and an overall microgrid governance plan has been finalized. Table 3-2 provides a more complete list of DG developer revenues and costs associated with powering a microgrid.

Table 3-2: Possible DG Developer Revenues and Costs Associated with Powering a Microgrid

Revenues	Possible Costs
Payments from customers for energy sales (based on kWh).	DER equipment and installation.
Revenues from NYISO market participation (energy, capacity, and ancillary services).	DER fuel.
Payments from NYISO or National Grid for participation in DR programs	DER fixed operations and maintenance ("FOM").
	DER variable operations and maintenance ("VOM").
	DER emission related costs
	Cost of power purchase
	Payments to Utility for distribution, controller, and metering/billing/settlement services.

4.0 Conclusions

4.1 Hypothesis Verification
This REV Demonstration Project posed the following two hypotheses:

> Hypothesis 1: If National Grid's proposed microgrid services can enable more convenient, effective backup service for critical facility loads (vs. individual facility backup options), at a modest incremental cost to current service costs, then prospective microgrid-connected customers and other stakeholders will support the continued development of National Grid's proposed microgrid services at specified demonstration checkpoints.
>
> Hypothesis 2: If National Grid's proposed utility microgrid services offering higher value than any comparable services available to Potsdam customers from non-utility market participants, then prospective microgrid-connected customers and Village residents (not connected to the microgrid) will agree to service scope and pricing

Hypothesis 1 was disproven. While customers proposed to be connected to the microgrid embraced the benefits resulting from microgrid connection, most would not accept paying an additional monthly fee to cover the cost of the microgrid.

Hypothesis 2 was partially proven, as only connected customers were surveyed, as described in earlier sections of this report. Connected customer surveying concluded these customers accept paying the local electric utility a fee for microgrid operation services.

4.2 Project Scalability
While the customer survey data collected in the Project indicates that the microgrid, as designed, will not progress until it becomes economically attractive to all or most of the proposed connected load customers, and has a project leader, the tiered recovery model itself was found to be acceptable. Therefore, the proposed microgrid model, consisting of a pre-defined suite of customers expected to enroll, but which had not provided written commitment to do so, is not a scalable microgrid approach.

Appendix A Project Studies/Reports

Date	Author	Title
April 29, 2016	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q1 2016 Report
July 31, 2016	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q2 2016 Report
October 31, 2016	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q3 2016 Report
January 31, 2017	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q4 2016 Report
April 30, 2017	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q1 2017 Report
July 31, 2017	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q2 2017 Report
October 31, 2017	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q3 2017 Report
January 31, 2018	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q4 2017 Report
April 30, 2018	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q1 2018 Report
July 31, 2018	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q2 2018 Report
October 31, 2018	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Q3 2018 Report
May 2017	OBG	Task 1.1 B-1 Preliminary Energy Use Analysis and Walk-Through Survey, Clarkson University
May 2017	OBG	Task 1.1 B-1 Preliminary Energy Use Analysis and Walk-Through Survey, SUNY Potsdam
May 2017	OBG	Task 1.1 B-1 Preliminary Energy Use Analysis and Walk-Through Survey, Canton-Potsdam Hospital
September 2018	GE Energy Consulting	Potsdam Community Resilient Microgrid REV Demonstration Project Final Report
August 2018	National Grid	Potsdam Community Resilient Microgrid REV Demonstration Project Equipment Costs
January 2019	National Grid	Community Resilience REV Demonstration Project, Potsdam, New York; Final Report