HIGHLAND PARK - BRITE:

BEING RESILIENT IN TEMPORARY EMERGENCIES

FINAL REPORT:

BPU TC-DER MICROGRID
FEASIBILITY STUDY

SUBMITTED BY: THE BOROUGH OF HIGHLAND PARK

DECEMBER 21, 2018

Mark Warner
Vice-President
Gabel Associates, Inc.
Phone: 732-296-0770
mark@gabelassociates.com

Gayle Brill Mittler
Mayor
Borough Of Highland Park
Phone: 732-572-3400
brillmittlerhp@gmail.com

Executive Summary

This report documents the results of a Conceptual Feasibility Study for a Town Center Distributed Energy Resource (TC-DER) microgrid proposed for development in Highland Park. The study identifies project requirements, provides design analysis to identify optimal solution configurations, and assesses overall feasibility. The study evaluates feasibility based on regulatory factors, technical considerations, and a commercial/financing framework developed as part of the project. Key findings include:

- The proposed microgrid solution will deliver substantial resiliency benefits to the community. Municipal leadership anticipates that they can expand their emergency management plan to take advantage of the ability of crucial infrastructure to remain operational during an extended grid outage.

- There are significant existing assets in place that can be incorporated in the project, especially a new Solar-For-All solar array (with integrated storage) is already approved and moving into construction. Making use of this solar asset means that under favorable conditions the microgrid loads will be supported by solar energy, with the backing of a dispatchable generator to ensure reliability. In addition, a convenient arrangement of existing utility circuits can be used to create isolated sub-loops that provide a significant fraction of the necessary backbone. These existing assets minimize the new costs associated with developing the proposed solution, while enabling the use of solar electricity.

- The Highland Park application is a classic Level Three community microgrid, as defined in the BPU Microgrid Report, consistent with the focus of the feasibility study award. These solutions are faced with key regulatory challenges that have commercial and technical implications. The study team has developed an innovative solution based on microgrid elements combining dynamically when the grid goes down to implement the resiliency solution. This Dynamically Organized Microgrid Architecture (DOMA) creates flexibility for addressing regulatory barriers for Level Three microgrids, and facilitates commercial frameworks that facilitate procurement and financing. The DOMA strategy addresses microgrid development challenges in a generic way, which means that the Highland Park project will pioneer an approach that is highly replicable to other NJ communities.

- Based on the DOMA strategy, the team identified a variety of possible microgrid configurations, and modeled energy balance and asset requirements under a variety of seasonal and loading scenarios. This analysis allowed for identification of a nominal configuration, and two alternative scenarios with lower cost. Asset sizing and estimated costs have been quantified for all three scenarios. Financing approaches have been identified for all microgrid elements.

- The study teams finds that the proposed Highland Park microgrid will address the goals identified by the BPU. The study addresses the questions contained in the study award MOU, and this report provides all the information specified in the report requirements.

Based on these results, the feasibility study confirms that Highland Park benefits from a unique combination of factors that make it an ideal Level Three community microgrid application. The Borough has exceptional characteristics that make the proposed microgrid **highly feasible**, and **highly impactful** on the community it serves:

- Highland Park is a very compact municipality: the majority of residents are within a 5-minute/half-mile walk of the resilient infrastructure proposed for development. Highland Park is unique in that these **core municipal services are centrally embedded in a predominantly residential area** with an **exceptionally high degree of accessibility**. This minimizes the scale of distribution assets required to construct the microgrid, and makes the development of the system much more feasible due to manageable scope.

- The proposed project is unique because it will incorporate a substantial solar array, so that under favorable conditions a **fraction of the microgrid will be solar powered**.

- The microgrid configuration being proposed will **leverage existing assets to provide resilient operations for the municipal cluster**. In short, Highland Park already has many of the assets needed to create the proposed resiliency solution, making the project much more feasible, especially from a financing perspective, than is typically the case.

- The proposed microgrid project has been under development and discussion for several years, so there is a **solid planning foundation in place, and strong community leadership support, for pursuing the project**. Highland Park has demonstrated its commitment to advanced energy solutions in a variety of past projects, and has a proven track record of taking innovative concepts through to completion.

- The project team has developed several novel concepts that will make this project feasible from a business model and regulatory perspective, including solutions that depend upon the public utility acting as an active partner in the solution development and realization. Despite its compact physical size, the HP-BRITE microgrid will test and **demonstrate a fully functioning, Level Three, Community microgrid, with exceptional emergency management benefits to the surrounding community**. The elements of this advanced "proof of concept" will be **replicable and scalable for larger more complex projects anywhere in the state**.

1 Table of Contents

2 Project Name

This Feasibility Study Report is submitted by the Borough of Highland Park, New Jersey, in fulfillment of an award made to the Borough by the Board of Public Utilities (BPU) for a Town Center Distributed Energy Resource (TC-DER) Microgrid feasibility study. The project is named **Highland Park - BRITE: B**eing **R**esilient **I**n **T**emporary **E**mergencies.

3 Project Applicant

The municipal sponsor of the TC-DER feasibility study, and applicant to the NJ BPU TC-DER Feasibility Study solicitation, is the Borough of Highland Park (the "Borough"). The Borough was approved as an award recipient on July 10, 2017, and executed a Memorandum of Understanding (MOU) with the NJ BPU on July 11, 2017.

4 Project Partners

The Borough of Highland Park is the municipal sponsor for the proposed TC-DER microgrid project. Highland Park is in one of the nine designated Sandy impacted counties, and suffered extensive energy disruptions during that storm. The Borough experienced extended outages of public electricity service and interruptions in all critical functions that depend on electricity. Power was not restored to many residents, and critical municipal infrastructure, until nearly two weeks after the storm. Shortly after power was restored due to the Sandy disruption, a local substation fire brought down power to most of the town for an additional 10 days. Due to these back-to-back events, this community of approximately 14,000 residents and over 3,000 buildings was without power for most of the month of November 2012.

In response to these events, Borough leadership has aggressively pursued a variety of strategies for improving resiliency of critical infrastructure that can better support the community during extended events where the public grid may be unavailable. The Borough has a variety of unique conditions that make it an ideal microgrid application, including convenient clustering of municipal infrastructure in very close proximity, municipal infrastructure embedded within a predominantly residential area within walking distance from these assets, and existing distributed energy resources that can be used as a basis for an advanced microgrid application.

The Mayor of the Borough has aggressively pursued the planning and organization of the proposed project over a period of several years. As a result, the project is well supported by a strong set of project partners that have agreed to participate in the proposed feasibility study.

The "load site" partners include crucial municipal buildings that are under direct municipal control (borough hall, policy and fire stations, senior center), all three schools (elementary, middle, high schools, and the BOE offices), the municipal library, two senior and disabled housing facilities whose residents must shelter in place (the Housing Authority and AHEPA senior housing), the Stop and Shop (food store), and the municipal DPW. Please see Sections 5 and 6 for additional details on the load sites participating in the project.

The local utility, for both electricity and natural gas (PSE&G) was an active participant in the study, including project review discussions and supporting engineering discussions regarding the current distribution infrastructure. The EDC provided circuit maps to support the backbone design efforts.

As authorized by the Borough, the majority of the Conceptual Feasibility Study was conducted by subject matter experts retained for that purpose. The Borough has engaged Gabel Associates as the lead consultant for the project. Offices for Gabel Associates are physically located in Highland Park, and principals of the firm have a long-standing relationship with the Borough and its residents. The firm is therefore ideally suited for this particular project, in addition to their relevant and specialized subject matter expertise and extensive experience. Gabel Associates has partnered with Burns Engineering to provide technical and engineering support for the project, building on their unique experience and track record with microgrid development.

Please see **Appendix A** for copies of the Letters of Support noted above, and the authorizing resolution for consulting services being provided by Gabel Associates for the project.

The most critical element in a project of this type is active support by the project partners, and the proposed project benefits from an exceptionally high level of well aligned support. The Mayor's office has provided leadership on developing the project over a multi-year period, and has the support of the Borough Council, the school district, the utility, management of critical senior and disabled housing facilities, and two consulting firms with both local presence and unmatched experience and expertise.

5 Project Location

Highland Park is a compact, predominantly residential community in Middlesex County, New Jersey. The Borough is the third-densest town based on population, and the second-densest town based on housing, in the county. HP-BRITE proposes the creation of a small but highly impactful core of critical municipal infrastructure in a Level Three Community Microgrid configuration[1]. This "island of resiliency" will be able to operate virtually indefinitely during an

[1] The "Level Three" definition is based on the categorization in the NJ BPU Microgrid Study report, November 30, 2016. The TC-DER application required that the municipality implement a Level Three configuration, or an advanced microgrid that includes several different buildings that are not on the same utility meter, typically separated by multiple rights-of-way, served by a variety of Distributed Energy Resources through a connecting distribution backbone that can be separated (islanded) from the public grid during an outage.

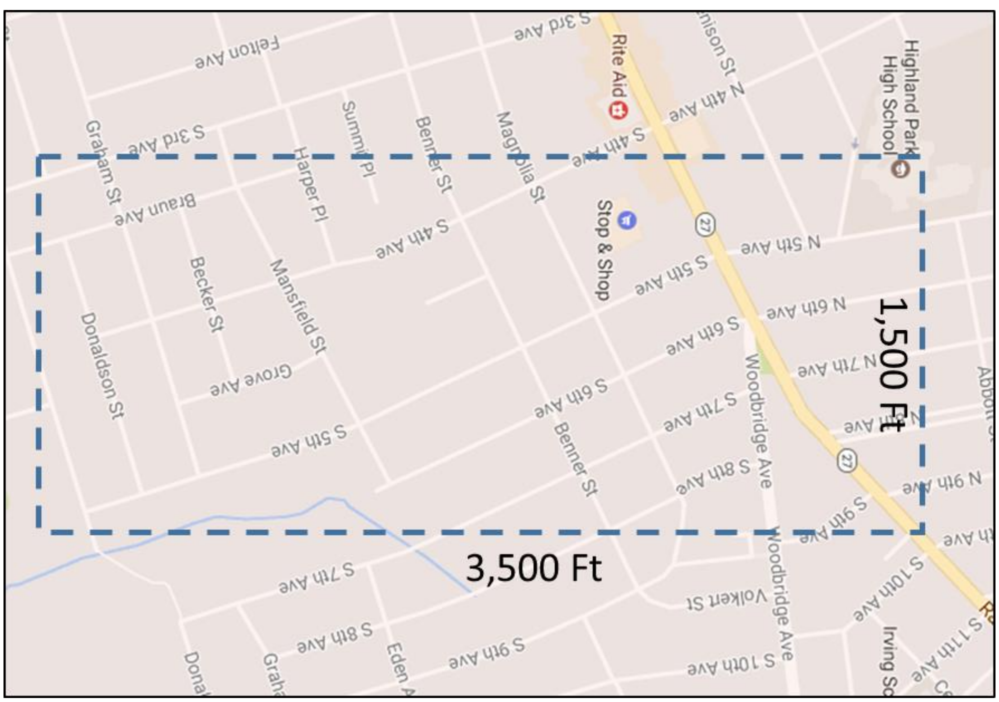
extended outage of the public grid, providing critical services to residential areas within convenient walking distance. The fact that Highland Park is a walking community, and within convenient access of the proposed microgrid facilities, makes this project uniquely impactful in providing emergency services during an extended outage of the public grid.

The Highland Park area was identified as a potential high priority microgrid project in the New Jersey Institute of Technology (NJIT) study, and the facility configuration being proposed has been confirmed to meet the screening criteria used in the NJIT study.

The group of facilities to be served by the microgrid has been refined, prioritized, and expanded as part of the feasibility study. The proposed microgrid will ensure full functionality for Borough Hall, key first responder facilities (police and fire), three schools, the municipal library, the Department of Public Works, housing for senior and disabled citizens that must shelter in place, and the primary food store for the community. This portfolio of essential facilities is planned to be augmented with high power DC Fast Charging equipment for Electric Vehicles to allow vehicle recharging during a grid outage. Most of the project facilities are within three city blocks of each other, while the other facilities are within 2,000 feet of this central core.

The following map summarizes the boundaries of the primary microgrid configuration. Note: the boundaries shown represent the rectangle that includes all sites planned for the nominal configuration, but not all buildings within that area are supported by the microgrid. See section 6.1 for more information about the included sites.

Figure 5-1: Nominal Configuration Boundaries



The following site map, overlaid on a satellite image of the area, identifies all the key sites to be included in the microgrid.

Figure 5-2: Nominal Configuration Load Site Locations

All the necessary success factors are in place to make this a highly feasible, highly impactful Level Three community microgrid project, which in addition to the direct resiliency benefits provided to the residents of Highland Park, will prove advanced concepts and provide learning that can be applied to other projects. This project therefore aligns strongly with the goals established for the BPU's TC-DER Microgrid Feasibility study project, addresses energy resiliency goals established by the state after Super-storm Sandy, and supports objectives in the State's Energy Master Plan.

6 Project Description – Overview

The original study proposal identified a collection of Borough facilities and other assets that could form the foundation for a community microgrid project. As part of the feasibility study, the study team worked with municipal leadership and staff to refine, expand, and prioritize the set of load sites to be included in the project, as well as other Distributed Energy Resources (DERs) that can be used to provide a reliable source of electricity during public grid outages. This section summarizes the study work plan, and the inventory of load sites and supporting DERs that will make up the HP-BRITE Microgrid.

6.1 Study Work Plan

The study team worked with all project stakeholders to collect the necessary data, prioritize and refine project scope, brain-storm alternative designs and assess trade-offs, and completed conceptual design work on the recommended project configuration. Consistent with the work program outline in the study proposal, and the study requirements included in the award MOU,, the team completed the following work functions:

1. Develop a detailed regulatory strategy for addressing challenges inherent in Level Three TC-DER applications. The regulatory framework informed subsequent technical and commercial strategy development.

2. Collect building and energy usage information from all load sites. Where data was missing, extrapolate or estimate the detail needed as needed to support analysis.

3. Collect information about existing Distributed Energy Resources (solar, backup generators, etc).

4. Work with municipal and load-site staff to identify operating profiles for each site during an extended emergency event. Adjust building-use profiles to reflect these dark-sky operating conditions.

5. Meet with the electric utility to review key design assumptions and project development concepts. Based on the team's projection of impacted facilities, get detailed circuit maps.

6. Review circuit maps in detail to identify potential backbone configurations, and opportunities for re-use of existing distribution infrastructure in the microgrid project.

7. In parallel with the microgrid feasibility study, work continued on development of a PSE&G solar-for-all project near the municipal core (by the DPW). As that project gained final approvals, incorporate those project details into the microgrid solution.

8. Given detailed information about load sites, a collection of DERs, and existing utility circuit maps, identify a variety of backbone configuration/project-scope scenarios. These scenarios vary by microgrid project size and cost. Detailed topologies and related switchgear were developed to use existing utility distribution assets in an optimal way.

9. Develop use-case scenarios that combine seasonal energy use by supported facilities with generation profiles which are also seasonal (especially the solar-for-all asset). Complete

energy modeling for twelve cases that represent different project-scope and time-of-year combinations. Scenarios with and without the use of the solar arrays were considered to ensure maximum reliability. Both spreadsheet based and DER-CAM models were used to quantify system performance and asset sizing under a variety of conditions.

10. Based on the energy modeling, and comparative resiliency value delivered by each alternative, work with municipal leadership and staff to prioritize project focus. This process resulted in identification of the "nominal case" to be used for design, along with secondary alternative designs that offer less resiliency value but also lower cost.

11. Develop a commercialization plan for the nominal configuration, including details about ownership, financing, operational responsibility, and municipal procurement.

12. Throughout the project, work with municipal leadership and staff to provide updates, collect input from stakeholders, and prepare the final study report.

6.2 Load Sites

The Borough anticipates that it will be able to expand and strengthen its existing Emergency Management Plan based on the new capabilities enabled by the HP-BRITE project. The following facilities are planned for inclusion in the nominal microgrid project configuration:

- **Borough Hall (221 S. 5th Avenue):** the center for municipal functions, and a key command and control facility during an emergency. This building provides a place for leadership and emergency support staff to meet, and serves as a central point for disseminating information to the community.

- **Police Department Headquarter (222 S. 5th Avenue):** the central headquarters for all first responder activities during an emergency period.

- **Fire Station (220 S. 5th Avenue):** critical first responder support during an emergency, tightly integrated with the nearby Police Department headquarters.

- **Senior Center (220 S. 6th Avenue):** a recreational facility that is a known gathering location for the community, and has "event space" and meeting rooms that can be used for a variety of purposes during an emergency, as well as a computer lab. Key functions during an outage include: a) warming location, b) cell phone charging, c) information source for residents, d) internet access, e) supply distribution point (water, etc.), and f) basic shelter in extreme events. This facility is used as a heating center when there are "code blue" alerts. This building is also known as "The Recreational Center" and "The Community Center".

- **Housing Authority (242 S. 6th Avenue):** A municipal entity that provides housing for 112 full time senior and disabled residents that meet low-income requirements. These residents must shelter in place, and are highly dependent on an electric elevator to service the multi-story building.

- **AHEPA Senior Housing (239 S. 6th Avenue):** A housing facility for 67 low income seniors that must shelter in place, and are highly dependent on an electric elevator to service the multi-story building.

- **Bartle School, and Board of Education (BOE) District Offices (435 Mansfield Street):** a local elementary school that can provide key support functions during an emergency, including: a) warming location, b) cell phone charging, c) supply distribution point, and d) basic shelter in extreme events. The BOE offices are integrated in the same building, and continued operation during an emergency is critical to make decisions and coordinate overall school district response.

- **The Department of Public Works (DPW, 444 Valentine St, at the southern terminus of Fifth Avenue):** includes a garage for key municipal vehicles, and control center for dispatch and coordination.

- **The High School and Middle School (102 North 5th Avenue):** a significant physical asset that can expand warming and charging and distribution functions, and provide services closer to other north-side residents. This facility is approximately 1/3 mile to the core microgrid cluster, and essentially doubles the amount of emergency support space enabled by the microgrid.

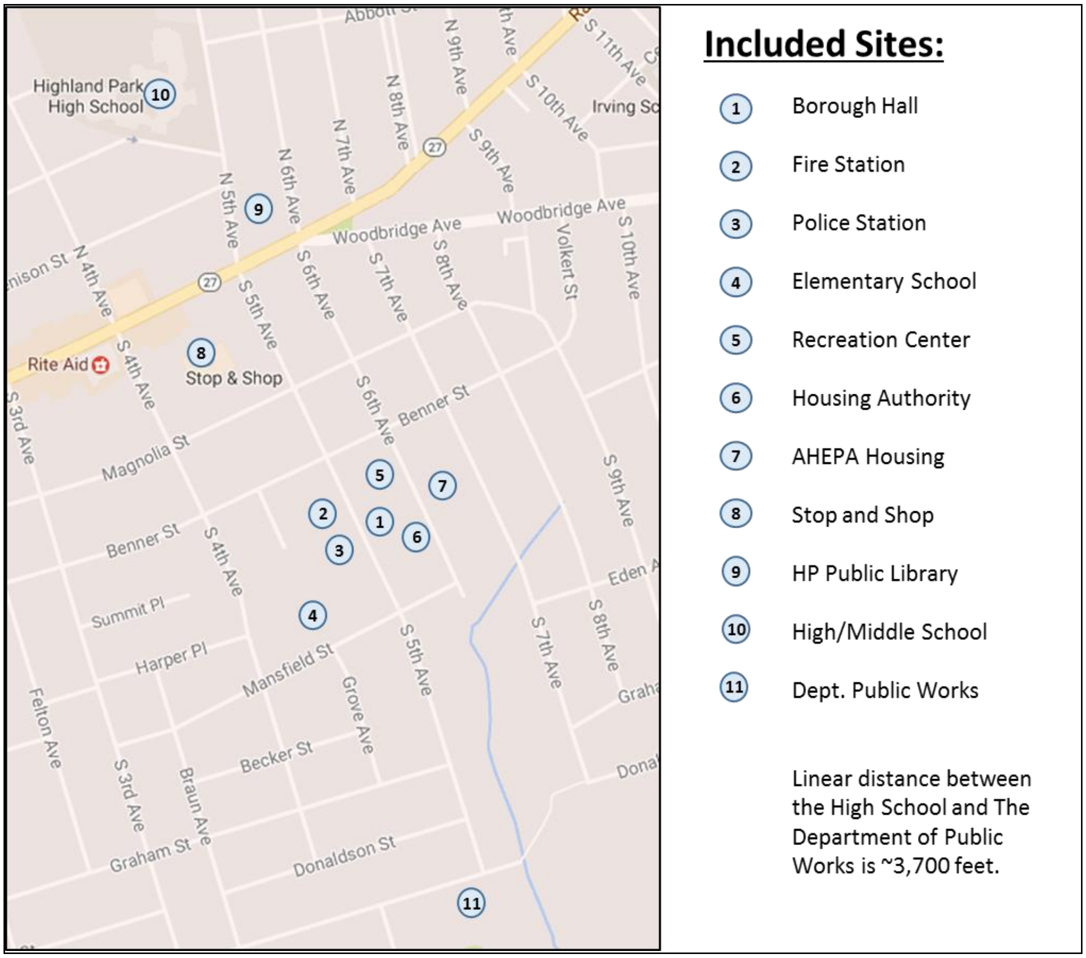
- **The Public Library (31 North 5th Avenue):** near the high/middle school, is able to provide internet and computer access to residents during an emergency, in addition to basic warming and phone-charging support.

- **The Stop and Shop grocery store (424 Raritan Avenue (Rt-27):** this is a large food retail outlet that is the primary source of groceries and other supplies; continued operation of this location has a large impact on the community during an emergency event. The store currently has limited back-up power, insufficient to support refrigeration and other operations as is needed for extended outages.

- (**New facility, expected to be located near the Stop and Shop**): The Borough anticipates installation of high powered DC Fast Charging equipment to allow for public charging of Electric Vehicles full time. The charging equipment is planned to be included as part of the microgrid project to allow for vehicle charging during a widespread public grid outage.

The following map summarizes the load sites to be included in the project and their relative location.

Figure 6-1: Included Sites (Nominal Configuration)



The set of facilities listed above represent the nominal (primary) configuration under consideration for the microgrid project. Two other sub-set variants have been identified that reduce the number of sites so as to reduce project costs.

- **Alternative A:** A subset of the nominal configuration that eliminates the high/middle school and public library to avoid backbone costs associated with crossing Rt-27.

- **Alternative B:** A subset of the nominal configuration that eliminates the high/middle school, public library, and Stop and Shop to avoid backbone costs.

Load Site Information

The study team collected energy usage information for all the load sites, and completed physical engineering visits to all sites. Key information on all the load sites is summarized below.

Figure 6-2: Load Site Information

Load Sites	Address	Nominal	Alt-A	Alt-B	FEMA	Heated Sq-Ft	KWhr	Peak (KW)	Therms
Borough Hall	221 S. 5th Ave	X	X	X	IV	7,750	130,368	49.0	5,753
Police Station	222 S. 5th Ave	X	X	X	IV	5,120	147,872	71.2	7,530
Fire Station (main bldg only)	220 S. 5th Ave	X	X	X	IV	5,170	25,080	12.6	
Elementary School (Bartles)	435 Mansfield	X	X	X	III	94,325	536,434	97.6	5,305
Senior Center	220 S. 6th Ave	X	X	X	IV	7,450	149,395	40.2	3,380
Housing Authority	242 S. 6th Ave	X	X	X	III	70,512	1,451,986	517.3	15,261
AHEPA Housing (common area)	239 S. 6th Ave	X	X	X	III	48,957	128,216	37.1	22,019
Highland Park DPW - Main Bldg.	444 Valentine St	X	X	X	III	15,768	106,620	33.6	4,839
Highland Park DPW - Salt Shed	444 Valentine St	X	X	X	III	N/A	21,042	10.8	N/A
Stop and Shop	424 Raritan Ave	X	X		III	27,913	956,184	228.0	21,680
(NEW) Public DCFC EV Chargers	TBD	X	X		N/A	N/A	TBD	300.0	N/A
High/Middle School	102 N. 5th Ave	X			III	223,030	837,086	529.4	80,476
Public Library	31 N. 5th Ave	X			I	13,580	176,989	53.1	4,047
Project Total (Nominal):						**519,575**	**4,667,272**	**1,980**	**170,289**

The nominal configuration of buildings consumes approximately 4,668 MWHrs annually, and 170,289 Therms annually, based on metered utility consumption information for most locations, and estimates where necessary. Maximum <u>coincident</u> electric load for all buildings combined is approximately 1,568 KW (including the planned DCFC EV chargers), supporting 519,575 heated sq-ft. For reference, the simple sum of peaks (i.e. non-coincident load) is 1,980 KW, including the anticipated EV chargers. Electricity consumption shown is net of any on-site solar. Heating is all piped utility-supplied natural gas providing both space heat and domestic hot water.

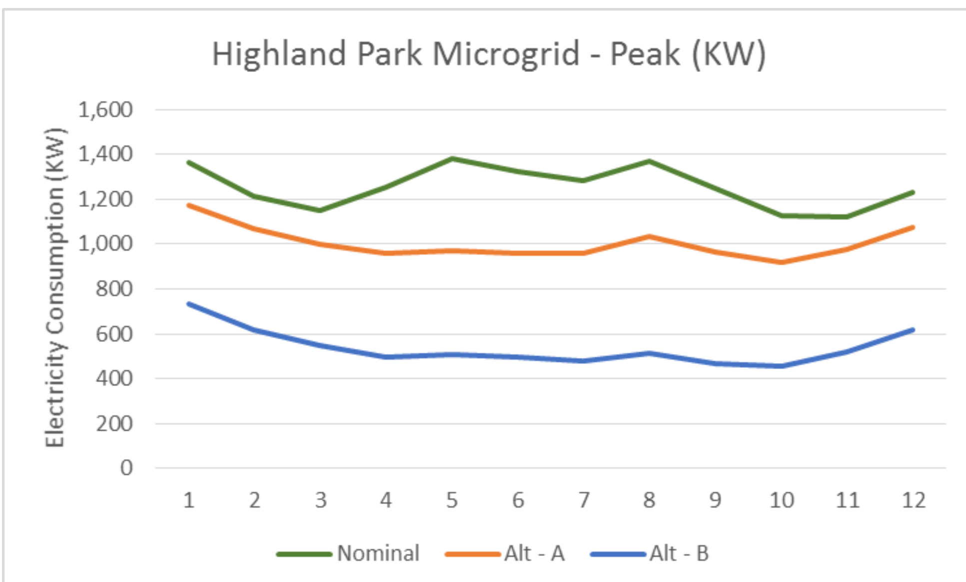
Figure 6-3: Energy Costs By Building

	Borough Hall		DPW			Fire Department		Police Department		Senior Center	
Month	Electric	Gas	Electric	Electric	Gas	Electric	Gas	Electric	Gas	Electric	Gas
January	$1,503.94	$1,104.15	$1,447.83	$150.48	$1,130.63	$262.27	$1,282.86	$2,481.03	$1,270.36	$958.92	$861.12
February	$1,380.47	$848.60	$1,162.86	$121.59	$919.42	$259.24	$1,068.32	$2,159.71	$971.72	$882.37	$648.09
March	$1,463.95	$790.10	$1,247.29	$147.42	$726.32	$4.23	$733.28	$2,127.64	$931.19	$906.90	$567.81
April	$1,527.99	$336.08	$1,016.36	$101.40	$336.08	$4.23	$605.27	$1,854.04	$609.99	$928.92	$381.77
May	$1,665.08	$12.39	$794.79	$97.40	$45.51	$718.02	$24.48	$1,677.87	$160.62	$901.10	$51.77
June	$2,358.91	$12.39	$825.82	$157.62	$29.50	$299.50	$14.16	$2,209.92	$16.95	$1,347.48	$25.87
July	$2,493.17	$12.39	$877.87	$146.14	$27.87	$347.23	$11.88	$2,432.59	$13.29	$1,522.58	$23.64
August	$2,381.12	$12.39	$873.35	$140.23	$29.17	$304.48	$14.16	$2,297.09	$12.39	$1,328.82	$22.86
September	$2,169.51	$12.42	$799.36	$106.50	$28.96	$280.59	$11.88	$2,101.72	$23.95	$1,114.82	$23.81
October	$1,511.33	$12.44	$602.76	$111.51	$128.56	$213.78	$24.48	$1,664.74	$122.42	$867.96	$101.27
November	$1,398.94	$333.17	$731.18	$120.80	$482.87	$201.80	$605.27	$1,584.89	$435.59	$773.12	$362.63
December	$1,476.72	$1,116.63	$1,316.95	$140.65	$626.39	$233.70	$873.36	$2,138.20	$880.28	$865.31	$520.57

	Housing Authority		AHEPA Housing		Library	High School/Middle			Bartle & BOE		Stop & Shop
Month	Electric	Gas	Electric	Gas	Electric	Electric-1	Electric-2	Gas	Electric	Gas	Electric
January	$20,442.92	$868.55	$1,397.02	$2,405.95	$1,503.94	$2,255.91	$8,177.17	$15,879.27	$4,088.58	$5,293.09	$11,448.04
February	$17,335.85	$776.23	$1,229.04	$1,934.82	$1,380.47	$2,070.71	$6,934.34	$12,769.81	$3,467.17	$4,256.60	$9,708.08
March	$16,000.00	$740.24	$1,283.89	$1,678.57	$1,463.95	$2,195.93	$6,400.00	$11,078.56	$3,200.00	$3,692.85	$8,960.00
April	$15,000.00	$675.85	$1,286.09	$1,222.11	$1,527.99	$2,291.98	$6,000.00	$8,065.93	$3,000.00	$2,688.64	$8,400.00
May	$12,500.00	$630.79	$1,223.06	$316.16	$1,665.08	$2,497.62	$5,000.00	$2,086.66	$2,500.00	$695.55	$7,000.00
June	$10,500.00	$540.68	$1,806.01	$317.45	$2,358.91	$3,538.37	$4,200.00	$2,095.17	$2,100.00	$698.39	$5,880.00
July	$10,435.37	$458.98	$2,162.51	$259.69	$2,493.17	$3,739.76	$4,174.15	$1,713.95	$2,087.07	$571.32	$5,843.81
August	$9,619.04	$353.87	$1,984.19	$221.02	$2,381.12	$3,571.68	$3,847.62	$1,458.71	$1,923.81	$486.24	$5,386.66
September	$9,044.22	$377.00	$2,166.31	$363.69	$2,169.51	$3,254.27	$3,617.69	$2,400.37	$1,808.84	$800.12	$5,064.77
October	$7,285.45	$396.48	$3,179.01	$554.37	$1,511.33	$2,267.00	$2,914.18	$3,658.82	$1,457.09	$1,219.61	$4,079.85
November	$10,718.47	$489.66	$1,082.60	$773.61	$1,398.94	$2,098.41	$4,287.39	$5,105.81	$2,143.69	$1,701.94	$6,002.35
December	$17,127.98	$688.43	$1,264.86	$1,549.15	$1,476.72	$2,215.08	$6,851.19	$10,224.39	$3,425.60	$3,408.13	$9,591.67

The study team worked with municipal staff to scrub historical usage information of outlier data points, and to characterize how building usage might change under emergency conditions. These modified "emergency condition" load profiles were used for microgrid energy modeling. The following chart shows the combined loads overall an annual period, for each of the three microgrid configurations.

Figure 6-4: Site Load Peak (KW)



Interval data was not available for any of the sites under consideration. To allow for the detailed energy modeling necessary, the team took representative consumption profiles (for 8,760 hours per year) for buildings of similar type and size[2], and created simulated profiles for each building scaled to known kwhr-consumption and peak conditions. Summary graphs of those load profiles are provided in **Appendix B**. As described more fully in Section 7, this data was used to model critical design-boundary use cases (winter, summer, etc) to determine DER requirements to support the microgrid loads. Note that in most cases entire building loads are being supported,

[2] Reference profiles came from the EIA Commercial Buildings Energy Consumption Survey (CBECS)

not “critical circuit” subsets. The one exception is the AHEPA Housing facility where the microgrid will be energizing the common areas (and the elevator), since individual units are metered separately. In the case of these buildings that was considered appropriate since a) generally speaking, the entire building was in use during emergency operations, and b) it would impose significant additional costs, with minimal reductions in load, to separate critical circuits. A one-line diagram for the current arrangement of facilities included in the microgrid project is included in **Appendix C**.

One unique aspect of the project is the inclusion of publicly accessible DC Fast Chargers (DCFC), connected to the microgrid, to “fuel” electric vehicles during an outage scenario. These DCFC facilities offer substantial public benefit during normal operation, and will allow electric vehicle owners to remain mobile during emergency conditions. This is an ideal location for public DCFC, since it is near the Stop and Shop and Rite Aide, other town center retail, and Rt-27 and Rt-18, as well as proximity to both Rutgers and Robert Wood Johnson medical center. The Study Team has unique expertise in developing DCFC facilities, which will increase the benefit and market development impact of the proposed effort. The charging facilities are assumed to be in continuous use 12 hours a day during an outage.

6.3 Distributed Energy Resources And Other Microgrid Equipment

The HP-BRITE microgrid project benefits from a significant number of EXISTING assets that can be incorporated through slight re-organization and augmentation. The fact that there are substantial assets, and that additional required elements can be easily added, make the overall project highly feasible.

Existing Assets: There are a variety of existing assets already in place that will be re-purposed for use within the new microgrid configuration:

- **Solar PV:** net metered solar PV on the roof of Borough Hall, 6 KWdc

- **Solar PV:** net metered solar PV at the Fire Station, on a parking lot structure, 28 KWdc

- **Backup Generator**: currently at the Fire Station, 150 KWac (diesel)

- **Backup Generator**: currently at the Senior Center, 125 KWac (piped natural gas)

- **PSE&G Solar Array:** the utility is implementing a significant Solar-For-All project at the south end of 5th Ave, near the DPW. This project includes a 605KWdc fixed ground-mounted solar array, with estimated production of 608,785 kwhrs/year (first year). The system will incorporate a Tesla storage system capable of discharging at 500KW for 4 hours (2,000 kwhrs). Under blue-sky conditions, this facility provides wholesale electricity and power quality support on a local circuit. When the public grid is down, this solar array and integrated storage will connect to the microgrid and be a primary source of electricity for the site loads, along with storage to manage power quality and transitional evens on the microgrid. All permits necessary to start construction of this facility have been obtained, including approval for SRECs and DEP permits, and construction is planned for 2019. The availability of this large renewable generation system can reduce the use of, and dependence on, fuel by other generators on the microgrid.

- **Existing Distribution Facilities:** Based on a detailed analysis of existing circuits as represented in maps provided by the utility, there is a convenient configuration of feeders that serve the municipal core. The addition of isolation switches at key locations will allow a subset of the existing distribution system to provide the heart of the microgrid backbone at relatively modest expense. A manageable number of "non-participating transformers" are on those feeders, but not anticipated for inclusion in the microgrid project. They will be separated from the microgrid through isolation switches (or functional equivalent). The proposed switches are automatic and equipped with programmable protective relay functionality. The ability to make extensive use of existing circuits makes the HP-BRITE project highly feasible.

New Assets: proposed new infrastructure will include (see Section 7 for more details):

- **New distribution assets:** The isolated sub-sets of existing circuits provide the essential core of the microgrid, but specialized extensions will be needed to serve the full extent of facilities planned. Two dedicated microgrid extensions are required: one going from the municipal core south to the DPW and Solar-For-All project, and another going north to connect the Stop and Shop, Library, and high/middle school locations.

- **New switchgear:** components as needed to interconnect the buildings with the microgrid, especially automatic transfer switches to connect buildings to either the public grid (for normal operation) or the microgrid (for resilient power operation).

- **A dispatchable generation asset**: Although the Solar-For-All asset provides significant power for microgrid, it does not fully meet the upper limit of load requirements, and is both seasonable and intermittent. Under extreme weather events (especially involving snow), it could be unavailable. To ensure a high degree of reliability and fully support planned load, an additional dispatchable asset is required, sized to fully support the microgrid load if required. A variety of configurations for this generator were considered, and the best alternative at this stage of planning is a 1.5MW piped natural gas generator (for the nominal configuration) installed as a grid connected facility serving the wholesale market[3]. Under blue-sky conditions, this generator will earn revenue as a distributed wholesale generation asset participating in the PJM capacity markets. Given that this

[3] The team considered a wide variety of options for the required dispatchable generation asset, including several behind-the-meter and CHP scenarios. Those were not deemed feasible at this time, although those options will be more fully considered as part of detailed design.

generator will have been engineered to serve the microgrid (i.e. as a resiliency asset), and will be supported by a firm (non-curtailable) fuel supply contract, it is ideally suited for participation in the PJM capacity markets. When the microgrid is operating (and islanded from the public grid), this generator will be sufficient (if necessary) to power the full microgrid, or (more likely) to provide capacity to compliment solar generation when it is available. The final location for this generator is to be determined, although it will be proximate to the microgrid backbone and near existing piped natural gas infrastructure.

- **Sensors, Communications, and Controls:** sensing equipment and a central microgrid controller. Communications will be provided to control systems at PSE&G as required.

Additional information about the load sites, generation assets, the microgrid backbone, and required switchgear is provided in Section 7.

6.4 Permitting Requirements

As described above, and in more detail in Sections 7 and 8, many of the assets necessary to create the microgrid are either already in place, or already planned for construction independent of the microgrid project itself. The microgrid project represents a reconfiguration of these assets to deliver additional resiliency value. The primary new elements for the project include a) utility work to create the microgrid backbone (through isolation of existing feeders and new extensions) and related switchgear, b) construction of the new dispatchable generator used to complement the Solar-for-all solar array, and c) implementation of the microgrid control and communications system.

The utility work does not require permitting in the traditional sense, and will be scheduled as per standard utility practice. The controller implementation is not a significant installation, and essentially represents the addition of a new computer and related communications equipment, probably at the police/fire facility. No permitting will likely be required for that installation, or if so, only local construction permits will be necessary.

The primary new permitting obligation for the project will be the installation of the new 1.5MW natural gas generator serving the wholesale market. See Section 7 for further details. Permitting requirements for that asset are consistent with installation of any small-scale PJM-recognized grid-connected generation asset. Other than local construction permits that may be required, the primary approval requirements are a) interconnecting the 1.5MW generator as a qualified facility with PJM, and b) obtaining NJ-DEP permits for operation of the asset with the required scheduling profile. Small scale generators (<10MW) can be interconnected through an expedited PJM process that typically takes 6 – 9 months. Given the (relatively) small size for the generator, and the intention to include appropriate environmental controls, it is expected this asset can be installed under a “minor source” permitting protocol. DEP guidance in that case is approximately 90 days. Further detail on permitting intervals will depend on detailed design specifications that will be developed as part of the “phase two” detailed design process.

6.5 Related Energy Projects

Highland Park is an extremely progressive municipality when it comes to sustainable energy, and it has been at the forefront of implementing advanced projects whenever feasible. Both town-wide energy reduction programs, and energy efficiency measures for borough buildings (through the Direct Install program offered as part of the New Jersey Clean Energy Program) have been implemented. Both of these projects were submitted to Sustainable Jersey as part of the Borough's Silver certification, and are described in more detail below:

- **Home Performance with Energy Star Municipal Program:** With the support of a Climate Showcase Communities grant from the U.S. Environmental Protection Agency (EPA), the Borough of Highland Park was able to develop and staff an effort to encourage residents to get a home energy audit and take advantage of the incentives provided by the Home Performance with Energy Star program. As part of this effort, the Borough issued an Request for Proposals (RFP) to select a certified contractor to perform high-quality audits at a fixed price for Highland Park residents. A letter was then sent to more than 2,500 households announcing the home energy assessment program. The program was also promoted on a billboard as well as in multiple community newsletters. On May 24, 2012, a workshop was held for residents that reviewed all of the home improvement programs available through the Borough, including the home energy assessment program. The workshop was captured on video and can be seen on YouTube at the following link: http://www.youtube.com/watch?v=JrSwsg4EAtA.

- **Direct Install for Borough Buildings:** Highland Park has enrolled all its municipal buildings in the Direct Install program: municipal building/borough hall, senior center, fire/police, public works, and the library. Scope of work, performed by Tri-State Light and Energy in 2011, included lighting upgrades, high efficiency AC on selected buildings, occupancy sensors, programmable thermostats, and electronic economizers. The Borough recently took advantage of the BPU's Local Government Energy Audit and is planning a second round of Direct Install projects for 2019.

- **Net Metered Solar PV:** Borough Hall and the Fire Station both contain net metered solar PV projects of 6 KWdc and 28 KWdc, respectively.

Highland Park has earned its reputation at the "First Green Community in NJ", and has implemented a wide variety of sustainability projects over a multi-year period. The Borough passed a resolution to buy only Energy Star appliances to reduce energy use, achieved Silver certification with Sustainable Jersey in 2017 (and is ready for re-certification in 2019), partnered with its schools to support their successful certification the Sustainable Jersey for Schools program, and most recently, moved to re-purpose a portion of a portion of a former municipal landfill to host a large solar installation. The Borough has been recognized for its distinguished leadership in sustainability, including a 2003 Innovation in Governance award from the NJ League of Municipalities, the 2005 Environmental Leadership Award from the NJ DEP, and being the 2005 Clean Energy Municipality of the Year as awarded by the NJ Office of Clean Energy. Many businesses in the community share this commitment to sustainable energy – for example, the Orchard Garden (a private apartment complex) recently implemented an upgraded to more efficient HVAC equipment. These results demonstrate both a strong and enduring commitment to advanced sustainable energy solutions, and a proven ability to execute on complex projects. This track record is a strong success factor for the proposed HP-BRITE project.

7 Project Description – Microgrid Design and Operation

Based on the collection of critical facilities summarized in Section 6, and the set of existing assets already in place, the team identified a variety of design configurations focused on developing the microgrid at the lowest possible cost. This section summarizes the detailed design and its planned operating profile, and the trade-off decisions and design analysis completed to develop the proposed solution.

7.1 Microgrid Design Challenges

A Level Three microgrid, also called a "community" microgrid or an "advanced" microgrid, is the most challenging to implement. There are significant legal and regulatory barriers that limit applications at this scale, which also have both technical and commercial implications. The Highland Park BRITE project is a classic Level Three configuration, including load sites with their own independent utility meter and account, and load sites and generation assets separated by multiple rights of way. As noted in the BPU Microgrid Report (November 30, 2016), this type of application faces several essential challenges:

1. **Utility Franchise**: As a general matter, the utility franchise granted in existing statutes (and supporting regulations) prevent an on-site generator from providing electricity to end-consumers separated by a right of way (ROW). This restriction represents a profound limitation on Level Three microgrid configurations, which by definition, include sites separated by multiple ROWs. There are two known exceptions to this restriction which are frequently invoked to enable a Level Three microgrid:
    a. District Heating or CHP applications: there is an exception granted in cases where heat is delivered to end-consumers across ROWs, such that electricity may also be provided to any customer for which heat is provided. This exception can be used for district heating configurations, or for multi-site CHP applications.
    b. Contiguous Properties: A distributed energy resource may physically exist on one site but be connected so as to serve an adjacent property that shares a border. This approach is common for net metered solar systems that are hosted on one property but serve the load of a contiguous neighboring property.
    c. Highland Park is not able to take advantage of either of these special case exceptions. In fact, the exact circumstances required to take advantage of either

of these exceptions, at “community scale” were multiple sites are being served, are relatively rare. Most municipalities in New Jersey, including Highland Park, are not arranged to take advantage of these allowed distribution architectures. A more general solution for connecting widely located sites and generation assets is required if Level Three community microgrids are to succeed in New Jersey.

2. **Utility Support**: Utilities (EDCs) have generally been cautious about supporting advanced microgrid development in New Jersey, for a variety of reasons including the franchise concerns noted above. In many cases, microgrid proposals include development of new distribution infrastructure which could be outside utility control, introducing significant concerns about the efficiency, safety, and reliability of the distribution system. Level Three microgrids will be more feasible if the EDC is included as an essential partner in development of the microgrid solution.

3. **Financing**: The primary focus of the microgrid solution is resiliency, i.e. the ability to provide power to critical municipal facilities in the event of a widespread failure of the public grid. Although an ability to operate when the grid is down has strong strategic value, it is difficult to identify liquid revenue potential that can be used to secure project funding. Just as it is difficult to justify a backup generator using a traditional business case, it is difficult to fund microgrid development based exclusively on reliability and the ability to operate when the grid is down. Microgrid development therefore depends heavily on finding alternative financing strategies, including the capture of value during normal operations (i.e. during blue-sky conditions).

The study team recognized that the Highland Park BRITE project was a classic Level Three microgrid topology, and solutions would need to be found to the three challenges noted above.

7.2 Design Approach

As noted in Section 7.1, there are profound statutory and regulatory limitations that restrict how a Level Three microgrid can be constructed. The typical approach is to focus on special case configurations based on heating districts or contiguous properties, but those configurations are rare, especially for Level Three microgrids, and not scalable to the more general market as exemplified by the Highland Park BRITE project. The study team has developed an innovative strategy that addresses these concerns, which also establishes a framework that guides technical and commercial components of the design. The solution architecture is based on microgrid elements that operate in stand-alone mode under blue-sky conditions, but which reconfigure during a grid failure to create an islanded collection of facilities operating in a microgrid arrangement. Under this architecture, the microgrid essentially doesn’t exist when the grid is operating (although its key generation assets are functioning fully under blue-sky conditions), and only forms and operates when the public grid is down. The “as needed” formation of the solution is its essential characteristic, referred to as the **D**ynamically **O**rganized **M**icrogrid **A**rchitecture (DOMA).

The DOMA solution proposed for the Highland Park BRITE project is structured as follows:

1. **Blue-Sky Independence**: All the load sites participating in the microgrid have independent utility meters and accounts, and buy electricity (and natural gas, where applicable) as per standard practice. All support elements – particularly including generation assets – are designed and operated to "stand alone" under blue-sky conditions. As an example, the PSE&G Solar-For-All project is financed and operated indepent of its role in the microgrid, and serves to provide electricity and power quality support to the local circuit – and it is funded on that basis. This structure avoids issues about delivering electricity across ROWs while the grid is active, and provides a framework for structuring the financing needed to implement the project. As noted above, the microgrid essentially doesn't exist operationally when the public grid is operational. A small number of microgrid components – particularly small parts of the backbone and the microgrid control system – are inactive under blue-sky conditions. Note there is no interaction between the public grid and the microgrid during normal operation (when the grid is up).

2. **Dynamic Configuration:** When the public grid goes down, all key elements of the microgrid (both load sites, and supporting assets such as backbone conductors and generators) reconfigure into the required microgrid configuration. This configuration process is accomplished by sequenced activation of switches, and result in a localized distribution architecture that serves only the microgrid loads, and which is isolated (islanded) from the public grid. There is no interaction or exchange of power between the microgrid and the public grid during an outage – other than the grid outage event that triggers microgrid formation, and the restoral event that converts the system back to routine (blue-sky) operating mode.

3. **Un-Bundled Economics:** The microgrid project is not organized or financed as a single project. Instead, there are a collection of coordinated projects that are financed independently depending on the nature of the asset and its blue-sky operation. These financing structures also determine operating roles for different parties depending on operating mode. This un-bundled strategy allows for more flexibility in financing, and creates opportunities to match investment/operating entities with asset types and roles. In particular, the utility is contemplated to construct the backbone infrastructure, and any conductors and switchgear related to that backbone would be considered part of the utility distribution system.

The study team believes this approach creates an opportunity to address concerns about delivery of electricity across ROWs. We assert that when the grid is not operating, and that when a given collection of assets are operating in a form that is completely independent (islanded) from the public grid, special conditions can be said to apply. The rules that govern these matters when the grid is operating require additional flexibility during the relatively rare intervals when the public grid is down and providing backup power to critical infrastructure is a priority.

Given the state's priority for improving resiliency through the use of Level Three TC-DER microgrids, and the essential need to deliver power across ROWs inherent in the Level Three configuration for most municipal settings, it would be appropriate to grant temporary operating rights to an approved TC-DER to deliver electricity across multiple ROWs, but only during a public grid outage and only when the affected set of load sites are physically isolated from the public grid. The DOMA strategy creates an opportunity for authorizing this bounded resiliency operating mode, as justified by the exceptional conditions that exist during a widespread public grid outage and the importance of keeping crucial municipal infrastructure operational, due to its dynamic formation only when the grid goes down. This strategy also establishes a framework for the technical design (see the rest of Section 7), and the commercial framework that defines ownership, operating role, and financing (see Sections 8 through 11).

This approach also addresses traditional utility concerns regarding microgrid implementation. First, the DOMA strategy doesn't reduce utility operating revenues – when in normal operating mode, all load sites buy electricity from the utility as usual, and when the grid is down, the utility wouldn't be providing electricity to those customers anyway. So there are no negative revenue impacts from DOMA-based microgrid solutions. Second, the DOMA strategy is based on the utility owning and constructing all the microgrid backbone elements, including related connecting switchgear. Consistent with N.J.S.A. 48:3-77.1, all electricity delivery through the microgrid is making use of infrastructure owned and operated by the franchised public utility.

7.3 Microgrid Backbone And Connections

Based on the load sites identified in Section 6, and detailed engineering review of the circuit maps supplied by the utility, a strategy for providing the microgrid backbone (for use only during a grid outage) has been identified. A fortunate situation exists in Highland Park in that most of the core municipal facilities are served by the same distribution feeder, and that only minor extensions are needed to reach other sites (that are normally served by other circuits). In addition, only a small number of "non-participating transformers" (NPTs) are also on this circuit, which implies relatively minimal effort to isolate those loads from the circuit when the microgrid is operational. This fortunate situation implies that the majority of the microgrid backbone can be created by creating an isolated backbone from existing distribution feeders, as augmented by relatively modest aerial extensions. **The feeder configuration in Highland Park is radial.**

The following diagram summarizes the backbone configuration for the nominal microgrid configuration, with reference to the utility circuits being used and related extensions. The backbone, and related connections to both load sites and generation assets, are accomplished through the following means:

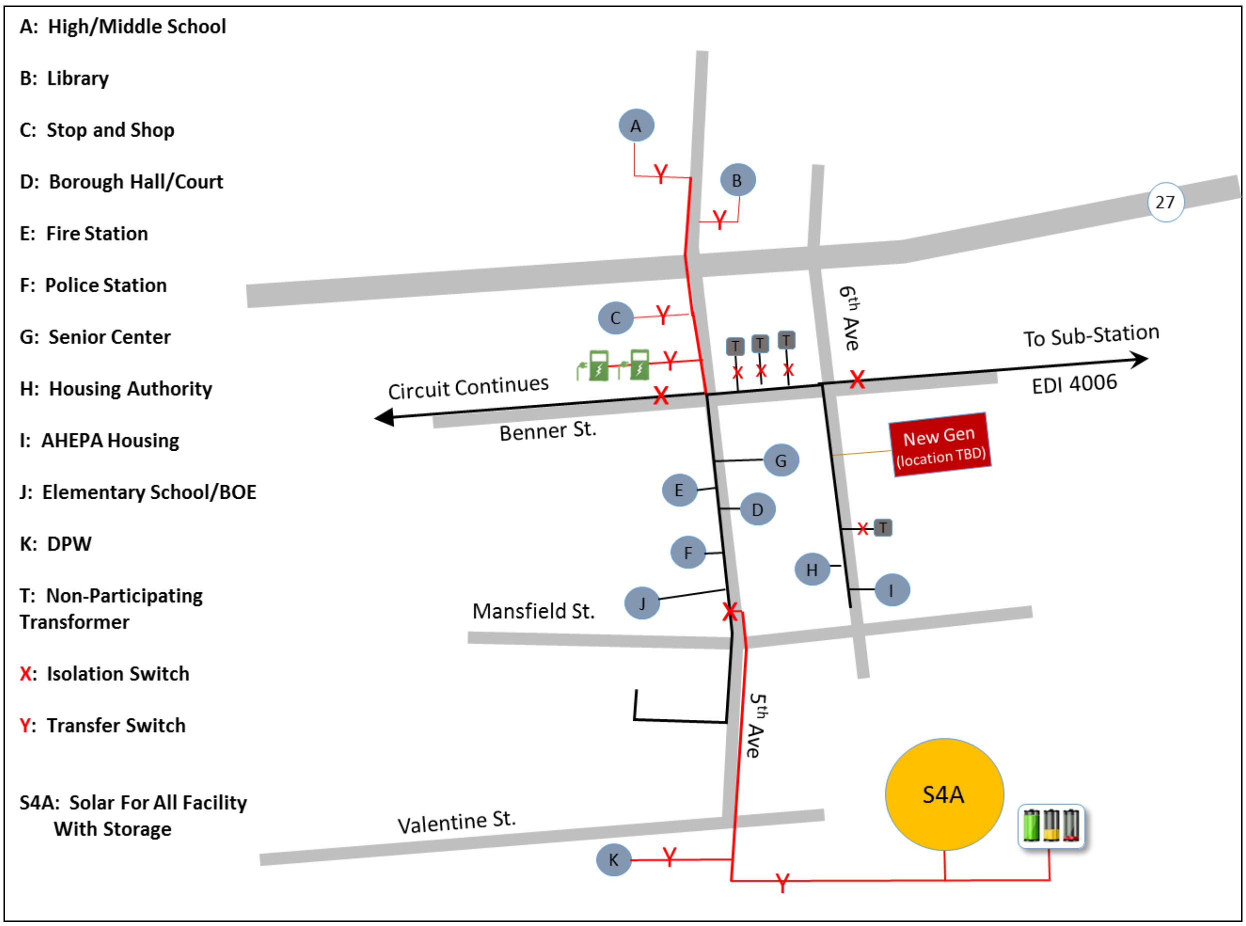
1. **Isolation Switches** that create an open in a specific conductor under remote control. These isolation switches (or functional equivalent) can be applied to separate part of an

existing feeder into an insolate sub-circuit, or to isolate NPTs from microgrid participation. This function is currently contemplated to be realized through pad-mounted distribution switchgear operating in "source transfer" mode.

2. **Transfer Switches** that change conduction paths to create a single circuit among three or more circuits. These transfer switches are used to switch either loads and/or generation assets in and out of the microgrid configuration.

3. **Extensions**: newly installed aerial conductors, running on existing utility poles (and one underground route to transition Rt-27), to connect more remote load sites with the microgrid core.

Figure 7-1: Backbone for Nominal Configuration



The nominal configuration represents the most complete form of the microgrid project. A one-line diagram for nominal configuration of microgrid implementation is included in **Appendix D**.

The study team also identified sub-set configurations of this solution which eliminate some sites in exchange for reduced cost.

1. **Alternative A** eliminates the high/middle school and library load sites, and avoids the need for the backbone to cross Rt-27. It includes the municipal core (with the three feeder isolation switches and the isolation switches for the four NPTs), the extension circuit south to the DPW and Solar-For-All asset, and the northern extension that connects with the EV charging stations and the Stop and Shop. Sites now on the core circuit (EDI 4006) will be equipped with transfer switches to change connection from the usual utility circuit into the Microgrid (the DPW, the Solar-For-All project, the EV chargers, and the Stop and Shop).

2. **Alternative B** is the smallest configuration, and reduces Configuration A even further to eliminate the northern extension to the EV chargers and the Stop and Shop. This configuration includes only the municipal core, the southern extension to connect with the DPW and Solar-For-All project, and related isolation and transfer switches.

The following diagrams summarize the Alternative A and Alternative B variations. The project is focused on developing the full nominal configuration, and these alternative designs have been identified to provide lower cost system configurations (with reduced resiliency value) should they become necessary.

Figure 7-2: Alternative A Backbone

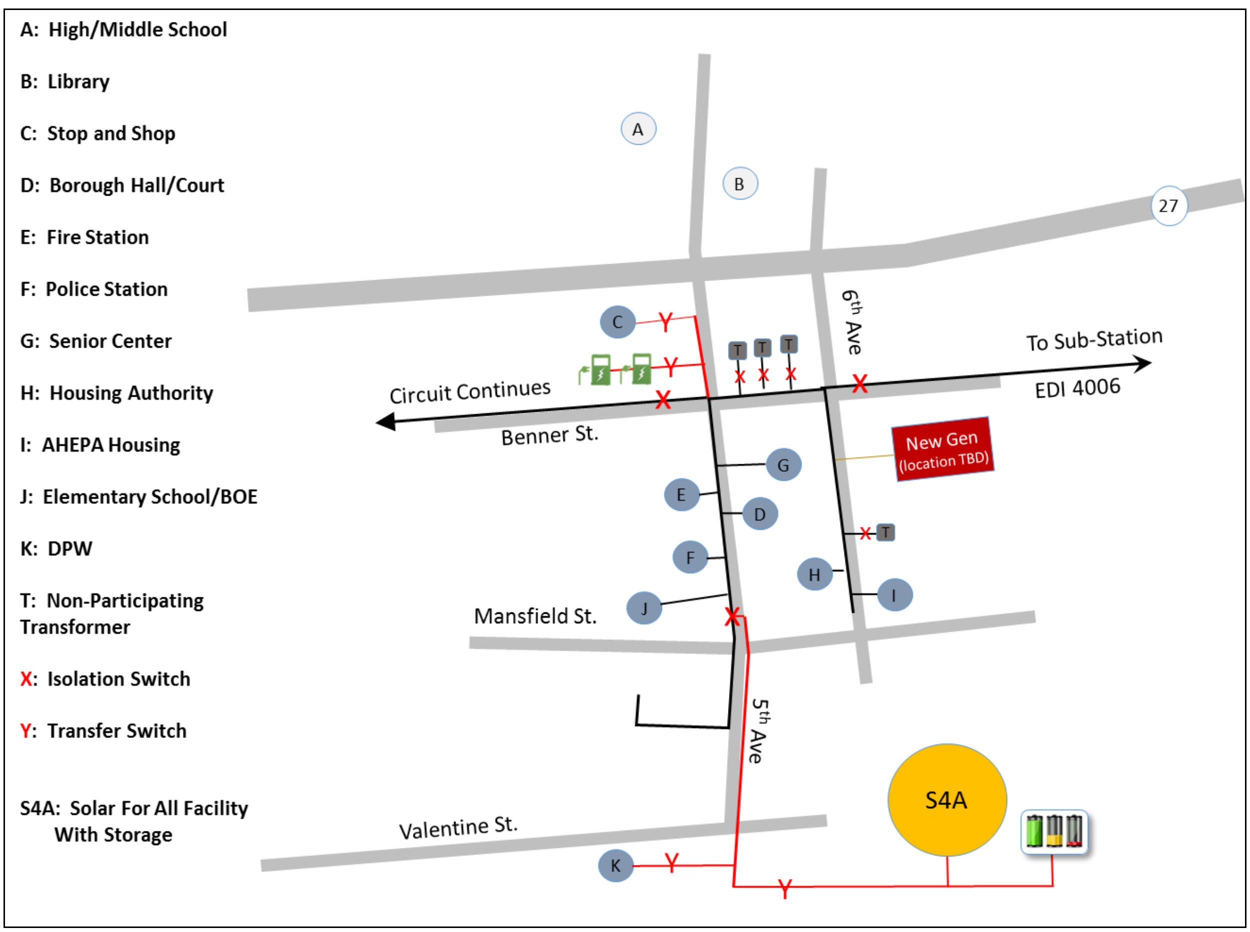
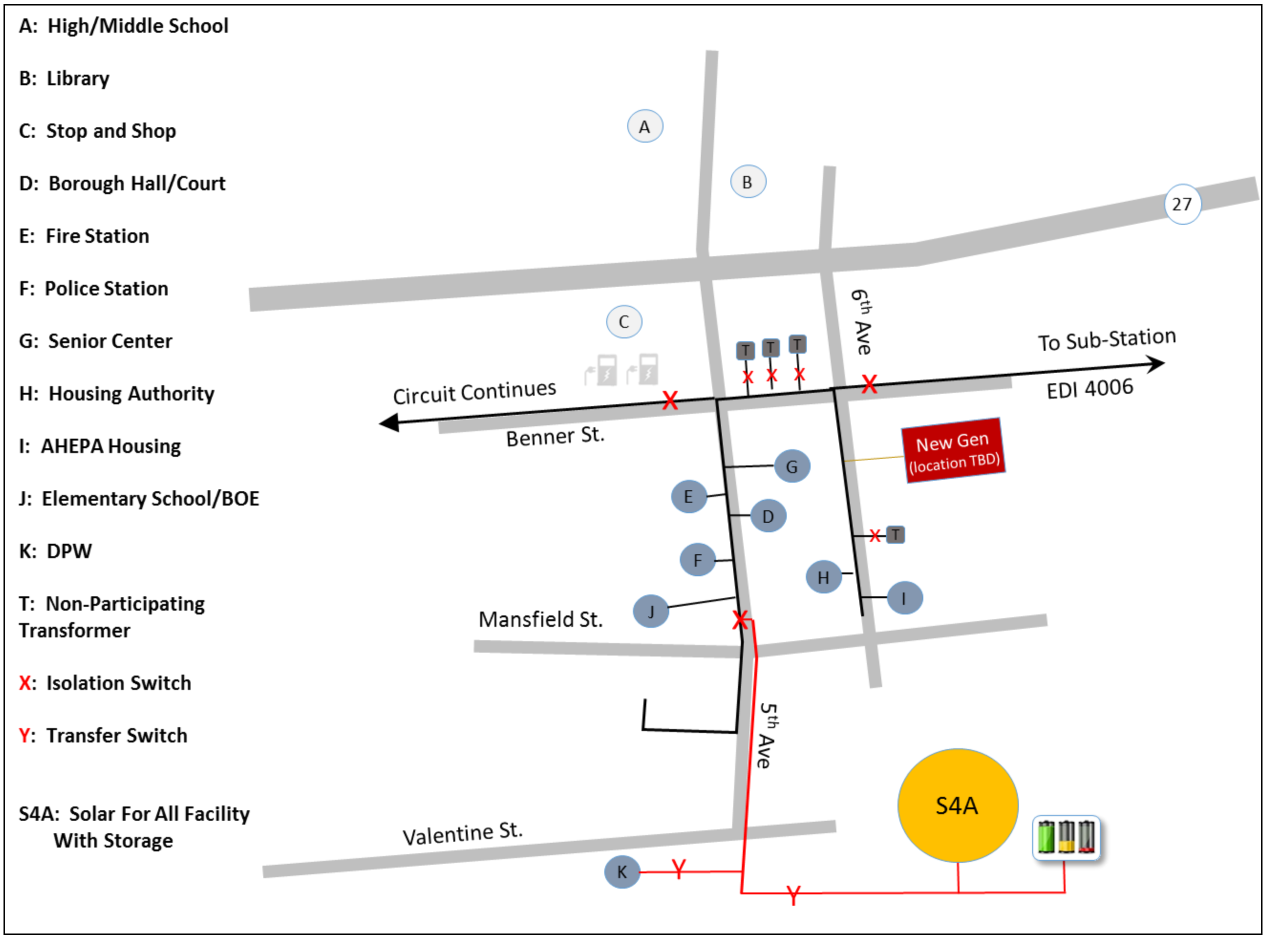


Figure 7-3: Alternative B Backbone



7.4 Operating Profile

Consistent with the DOMA concept, all sites and generation assets connect to the grid through normal means, with independent utility accounts and meters. All microgrid components re-configure when the public grid goes down, resulting in an isolated (islanded) microgrid that runs independently during the outage. After the outage, the microgrid transitions back to normal operation. The following sections summarize these operating and transition modes.

Normal Operation (grid available): During normal operations, all load sites are connected to the public electricity grid (and, in most cases, piped natural gas) and will operate as usual. They each have separate utility accounts and meters. The two existing net metered solar assets (at the fire station and borough hall) operate as per usual practice, reducing the consumption of grid-supplied electricity for those buildings. The Solar-For-All system (solar PV and integrated storage) operates as a grid connected generation asset, providing electricity and power quality support to a local circuit as operated by PSE&G. Similarly, the 1.5MW natural gas generator operates as a small scale grid-connected resource providing capacity services to PJM). During normal operation, the microgrid effectively doesn't exist. The only microgrid components that don't function during normal operation are the two backbone extensions (which are un-used in this mode), and the microgrid control and communication system.

Transition to Microgrid Mode: During an outage of the public grid, both load sites and generation assets will disconnect from the public grid and connect to the microgrid backbone. Specifically:

- The three isolation switches on the existing circuit (EDI 4006) operate and re-configure automatically to create an isolated loop supporting the municipal core. The existing service connections between those buildings and the circuit are unaffected – those buildings can tell no difference between grid operation and microgrid operation, and no specialized switchgear is needed for those service entrances.

- The four isolation switches (or functional equivalent) on the non-participating transformers (NPTs) open to remove those loads from the microgrid[4]. This small number of sites will experience outage conditions, like the rest of the public grid.

- Transfer switches for load sites that are NOT part of the municipal core (DPW, library, Stop and Shop, High/Middle school) will switch those buildings from the public grid to the isolated microgrid backbone.

- Transfer switches for the two generation assets (the Solar-For-All system (both solar PV and storage) and the 1.5MW natural gas generator) disconnect from the public grid, and connect to the microgrid.

The transition to microgrid mode, and the operation of both isolation and transfer switches to accomplish that reconfiguration, are under utility control as triggered by a public grid outage. Utility responsibility (for microgrid functionality) ends after the microgrid is formed. As of the completion of this reconfiguration, the entire microgrid, and all facilities (load sites and generation assets) are completely isolated from the inoperable public grid. Full building loads are expected to be supported for all load sites, not just critical circuits.

Microgrid Mode: Once the microgrid is formed, the microgrid controller takes over and begins managing the overall system. Primary focus is on balancing supply (from the Solar-For-All system, its integrated storage, and the 1.5MW natural gas generator) to meet the load of all connected

[4] At the conceptual level, isolation switches functionally separate the NPTs from the rest of the microgrid when required. Physically, depending on additional specifications developed during detailed design, this isolation function may be accomplished by a reorganization of the three phase feeder in these locations, depending on a) utility preference, and b) cost. The current cost estimate assumes this approach.

sites. The generation assets have been sized to fully support these loads under a wide range of situations. Key elements of this operating profile include:

- Once the microgrid is formed, and the "backbone transition" is completed by the utility, operating responsibility passes to the microgrid controller.

- If the generation assets are not operating at the time of the microgrid transition, the microgrid controller will initiate black-start operations. The solar inverters will operate as normal, since the microgrid will function like the normal grid. The dispatchable generator (or the storage unit) will provide the "grid signal" necessary for inverter operation, and the storage unit will absorb excess solar generation if necessary.

- Operating priority will be on using renewable electricity from the solar array (as augmented by the integrated storage) to the greatest extent possible to serve all microgrid loads. The dispatchable asset will be operated as necessary to ensure all loads are met. The existence of the solar array reduces the use of, and dependence on, fuel for the dispatchable generator.

- The existing net metered solar arrays (on the fire station and borough hall) function as usual – no changes are needed to those systems, since those inverters will recognize the microgrid as if it were the public grid. These assets are only connected to the buildings they serve directly (i.e. there is no separate connection to the microgrid backbone), and reduce the load of those buildings when solar power is available.

- The existing backup generators (on the fire station and senior center) remain connected to the buildings they serve directly (i.e. there is no separate connection to the microgrid backbone). Under normal operation, they are not expected to be used since the microgrid will fully support operation of those buildings. IF NEEDED, the microgrid controller will engage those generators and disconnect those buildings from the microgrid (through existing transfer switches) to reduce load on the microgrid. Given the sizing of the generation assets on the microgrid, this situation is not expected to arise – but these generations provide a second level of back up support if needed.

- The dispatchable generator is sized to support all microgrid loads if necessary, and will be served by firm (non-interruptible) piped natural gas supply. The microgrid can operate indefinitely if needed, as long as that natural gas supply is maintained.

Re-Connection With The Public Grid: When the emergency event is over and public grid function is restored, all primary sites will reconnect to the public grid and resume normal operation. The timing of this restoration event will be controlled by the utility – the microgrid can continue to function as an isolated system as long as necessary. The restoral process is essentially the reverse of the microgrid-transition sequence outlined above, and proceeds as follows:

- Once triggered by the utility for the restoration cycle, the microgrid controller will put all generation assets into a mode appropriate for transition.

- The transfer switches on load sites, and on generation assets, are reversed to re-establish connection with the public grid.

- The transfer switches on all isolated site loads are reversed to re-establish connection to the public grid.

- The isolation switches for all Non-Participating Transformers (NPTs) are closed to re-establish connection of those facilities to the public grid.

- The isolation switches for the sub-loop of the circuit that serves the municipal core are operated and re-configure automatically to re-establish those conductors as part of the existing feeder (EDI 4006).

As with the microgrid formation sequence, restoral is under the control of the utility. The utility will have some flexibility in how and when these loads are reconnected to the public grid, providing increased control in overall restoral operations.

In summary, the system operates in several distinct (mutually exclusive) modes:

Normal Operation (Blue Sky): the public grid is operational, and all load sites are buying energy as usual based on separate utility accounts. Other microgrid assets – such as the solar array and the natural gas generator, are providing energy market services independent of the microgrid both technically and commercially. The microgrid essentially does not exist in this mode.

Microgrid Transitions: when the public grid goes down, all microgrid load sites and assets connect into the microgrid arrangement and begin operating independently of the public grid. The microgrid comes into existence – from technical, regulatory, and commercial perspectives – during this formation process. After the public grid returns to normal operation, the microgrid is disbanded to allow return to normal operation. The utility is in control of both the formation and restoral transitions, based predominantly on public grid conditions.

Microgrid Operation – Solar Only: under ideal conditions (high solar generation, low load), the microgrid could be operating exclusively from the solar array as firmed by the integrated storage. This operating is expected to be extremely rare.

Microgrid Option – Solar and Generator: in most cases, the solar array (and integrated storage) will be supporting microgrid loads as augmented by the dispatchable natural gas generator. Priority will be given to maximizing the use of solar electricity when available, with the generator output varied to ensure all loads are properly served. The fraction of electricity provided by solar will vary depending on seasonality and cumulative site load. This will be the most common operating mode when the microgrid is functional.

Microgrid Operation – Generator Only: in cases where the solar asset (and its integrated storage) is not available for any reason, the generator has been sized to support the full microgrid loads.

The transition between the three operating modes happens automatically as conditions dictate. The storage asset plays a crucial role in maintaining power quality, maximizing solar energy use, and ensuring continuity across all operating modes.

Loading Profiles: The study team modeled the energy balance of the microgrid when operational, considering the use cases that represent design boundary conditions. Four primary cases were developed: summer and winter days (on the solstice in each case), both with and without the presence of the solar array. The summer/winter configuration captures both site loads during those days, as well as generation capability of the solar array at those times of year. These four configurations allowed for sizing of the dispatchable asset under the worst case conditions (when solar is not available). Modeling was based on a combination of spreadsheet based analysis and DER-CAM. The site loads are based on the profiles described in Section 6.3, and summarized in Appendix B. Note that these load profiles assume heavy use of the high power DC fast chargers to support EV charging by the community – 100% loading 12 hours a day. These chargers are significant loads on the microgrid. The following load profiles provide a one-day snapshot of loading under boundary use cases.

Figure 7-4: Nominal Configuration, Summer

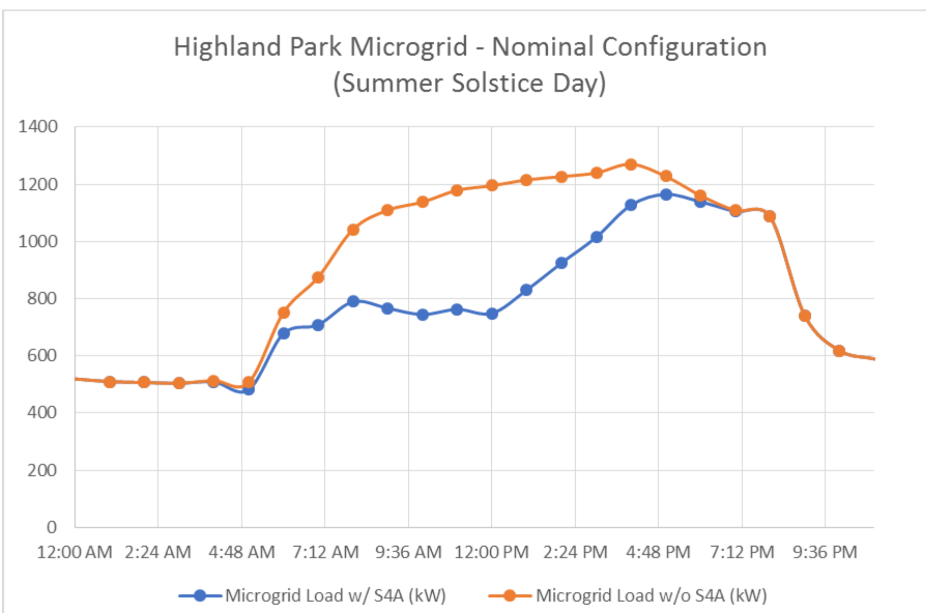


Figure 7- 5: Nominal Configuration, Winter

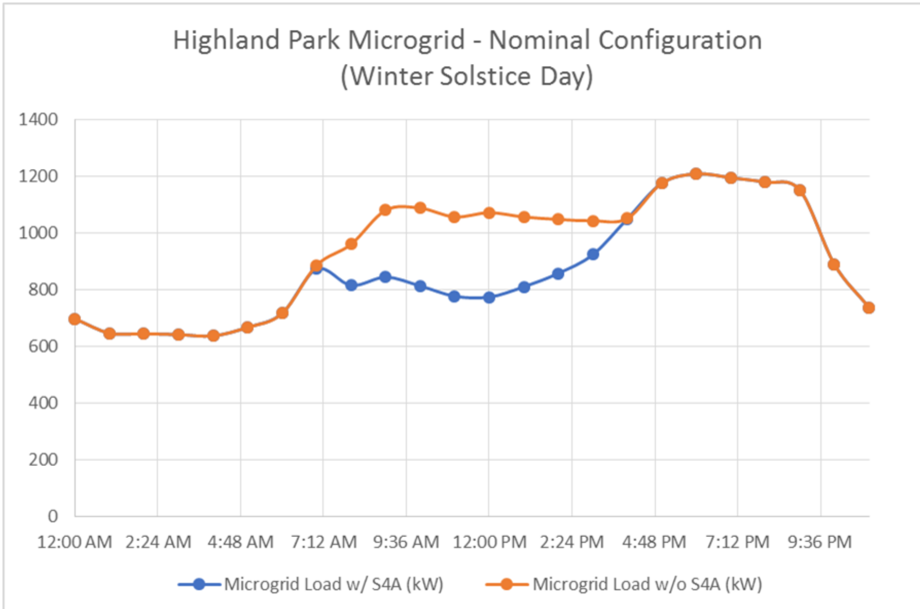


Figure 7-6: Alternative A Configuration, Summer

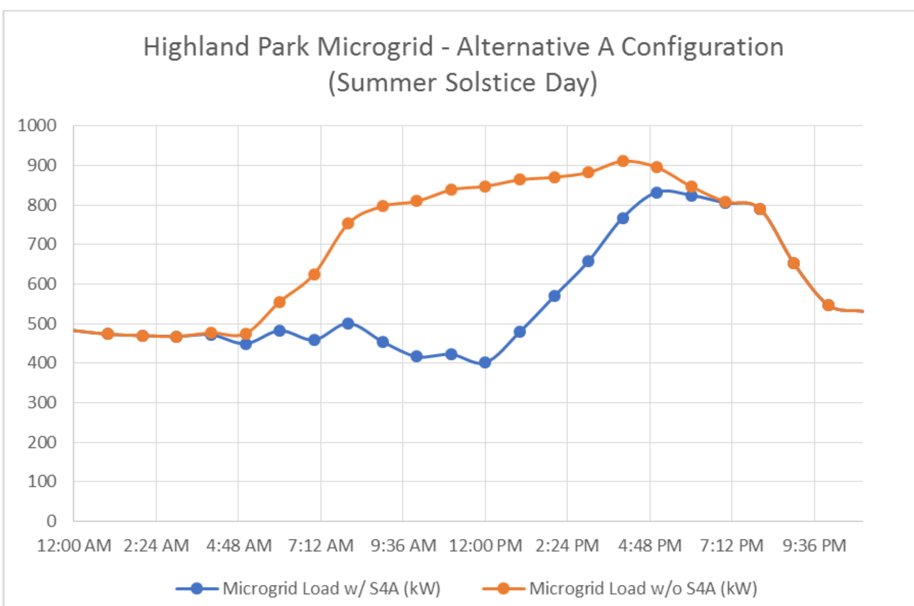


Figure 7-7: Alternative A Configuration, Winter

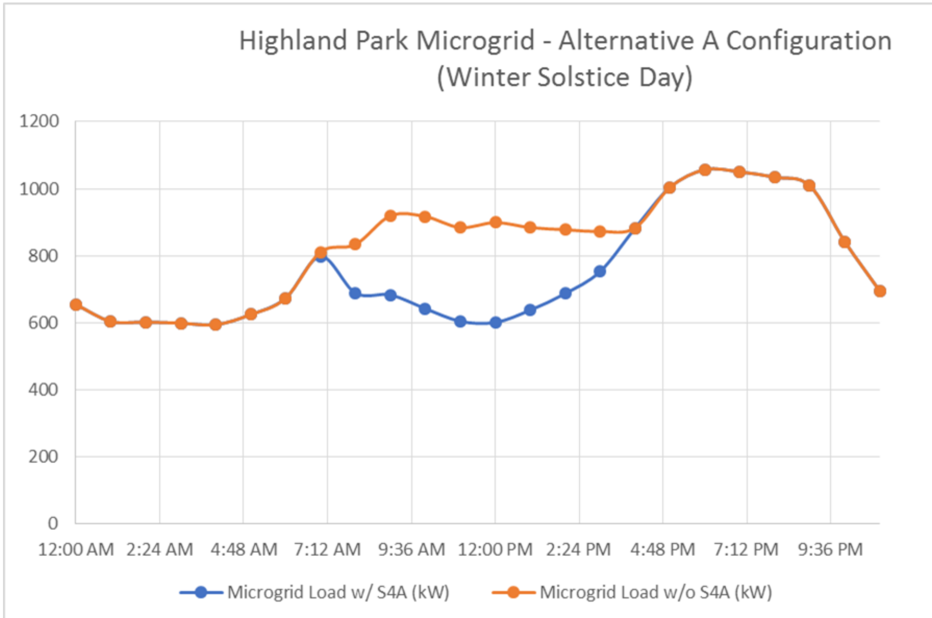
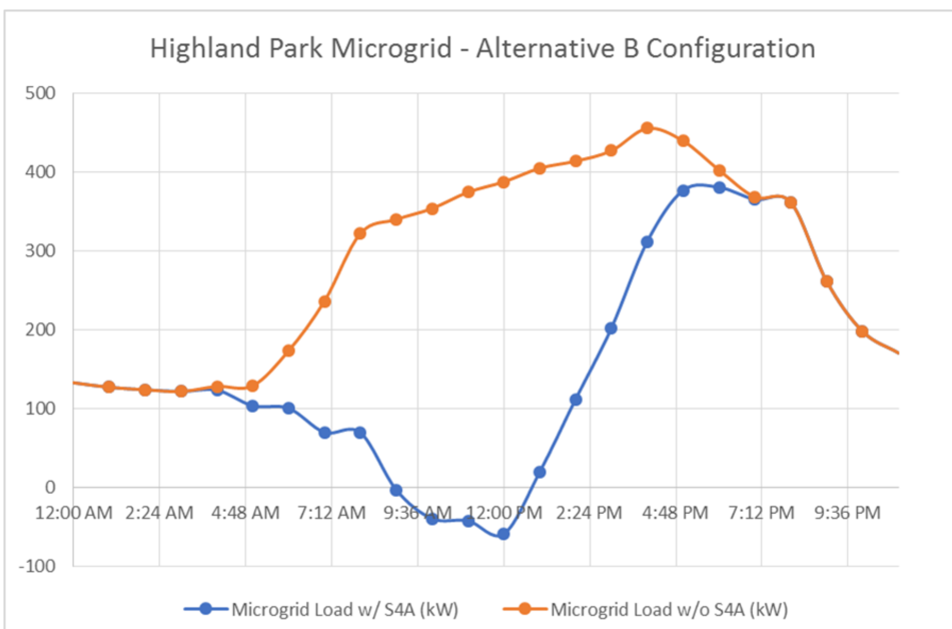
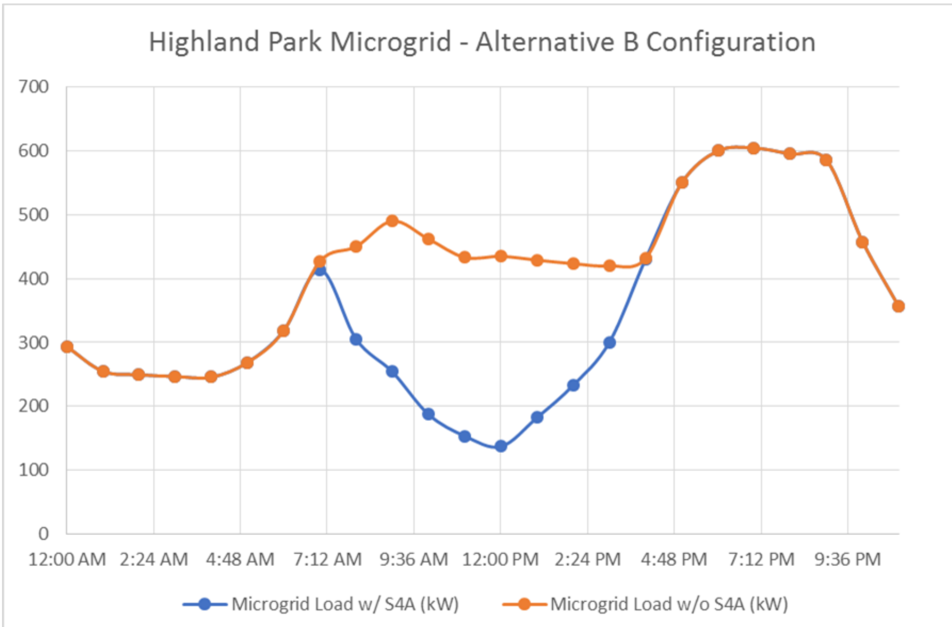


Figure 7-8: Alternative B Configuration, Summer



Note: During optimal conditions during the summer for Configuration B (the smallest load configuration), solar generation may exceed projected load – but only for a few hours each day, less than 100KW of excess. This will be absorbed by the battery, or the solar array will be curtailed.

Figure 7-9: Alternative B Configuration, Winter



The fraction of energy provided by the Solar-For-All array varies by microgrid configuration and time of the year, as summarized in the chart below.

Figure 7-10: Fraction Of Daily Load Served By Solar-For-All Asset

Configuration	Time Of Year	% Solar
Nominal	Summer	14.9%
Nominal	Winter	8.0%
Alternative A	Summer	19.6%
Alternative A	Winter	9.1%
Alternative B	Summer	47.6%
Alternative B	Winter	18.0%

The above charts are a primary output that was used to ensure appropriate match between the load and the generation assets, and in particular, to size the dispatchable generator. This analysis indicated that a 1.5MW generator is required for the Nominal and Alternative A configurations, but only a 1.0MW generator is required for the smaller Alternative B Configuration.

7.5 Regulatory Implications

As noted in Section 7.1 and 7.2, an essential requirement for Level Three microgrids that can't take advantage of district heating or distributed generation contiguous property special cases is to be able to deliver electricity across multiple rights of way. The Dynamically Organized Microgrid Architecture (DOMA) approach enables a solution to this challenge by sharply distinguishing between "normal" operating modes (when the public grid is operational), and operation when the grid is down. Based on the intention to have the utility own and construct the microgrid backbone (and related switchgear) and make that part of the distribution system, all electricity delivery within the microgrid happens over distribution infrastructure owned by the franchised utility. In addition, the microgrid only functions when the public grid is down, and only when fully islanded from the public grid. By restricting microgrid operation to the rare cases when the grid is down and microgrid value (based on resiliency) is at its highest, justification can be made for issuing temporary operating rights to TC-DER microgrids exclusively under those conditions.

The Highland Park BRITE project will require regulatory approval for this solution strategy. This flexibility, along with approval of the EDC building key backbone elements as part of the distribution system, could be addressed as part of an Advanced Microgrid DER Tariff (as contemplated in the BPU Microgrid Report), although pioneer project may be implemented under more limited filings short term. Note that this approach is highly replicable, and would allow development of TC-DER microgrids for the many New Jersey communities that are not conducive to the heating or contiguous-property special cases.

There are regulatory requirements that must be met for installation of the dispatchable natural gas generator serving the wholesale market in PJM. Based on initial modeling as part of this conceptual feasibility study, current projections are that this generator would participate in the PJM Capacity Market under existing provisions. While no exceptions or specialized approvals are needed, the project may benefit from PJM clarification about rules that govern operation of an asset of this type in the capacity market when also serving as an emergency support asset.

8 Commercial Framework – Ownership and Operating Roles

The DOMA solution creates a framework for naturally identifying roles for both financing and operations, and the resulting procurement efforts that will be required for project implementation. In the case of the Highland Park BRITE project, the commercial framework is further simplified by the fact that many of the assets required are either already in place or planned for implementation. Consistent with the DOMA strategy, most microgrid assets operate independently when the grid is up, which provides a basis for their financing and operation. In particular:

- **Existing Assets:** the two net-metered solar arrays (for the fire house and borough hall), the existing back-up generators (for the fire station and senior center), and the Solar-For-All projects (including the solar PV and the storage system) are either already in place, or already planned for construction. They do not need to be built or financed as part of the microgrid project. Some interconnection modifications will need to be made to the Solar-For-All asset, but that will be covered as part of the microgrid backbone noted below.

- **EV Chargers:** The town is contemplating installation of high powered DCFC EV chargers for public use, based on a) incentives under development for that purpose by PSE&G, and b) the use of a third party owner-operator engaged by the Borough through an RFP. These chargers will operate as a public charging station and will recover investment on that basis (along with the utility incentives). They therefore do not need to be funded as part of the microgrid project directly.

- **Microgrid Backbone:** the utility is contemplated to build the backbone extensions required, and the switchgear needed to create the isolated sub-loop of the existing circuit (EDI4006) and all building/generator connections. These assets are proposed to become part of the distribution system itself, and those costs would be recovered by the utility as per usual practice based on a filing for the Highland Park microgrid project. Given the utility basis for ownership and implementation, and assuming BPU approval of the associated utility filing, these assets do not need to be financed directly by the microgrid project.

- **Dispatchable Generator:** the natural gas generator (1.5MW for the Nominal and Alternative A configurations, or 1.0MW for the Alternative B configuration) must be financed by the microgrid project. That asset will be able to generate revenue during normal grid operation through participation in the PJM wholesale market, which will contributes to the financing for that investment. This will be accomplished through a public-private partnership in which a third party investor designs, builds, owns, and operates the generator as engaged through a municipal RFP. The microgrid controller, and operational responsibility during microgrid operation, will also be made part of this work element.

This structure creates a natural alignment between asset ownership, financing, and operational responsibility. The utility owns and operates the microgrid backbone and related switchgear, and is responsible for starting and stopping microgrid operation based on conditions of the public grid. The dispatchable generator, along with the micgrogrid control system, will be owned and operated by a third party who will have operational responsibility when the microgrid is functioning. Linking the dispatchable generator and overall microgrid function enables strong alignment of operating responsibility. The EV chargers are installed and operated by a third party for normal operation (when the grid is up), but temporarily connect to the microgrid when the grid is down.

The primary implementation phases, building on this conceptual feasibility study, are therefore a) detailed design engineering and procurement planning, including coordination with the utility on the related filing, b) implementation of the backbone by the utility based on an approved filing for that purpose, c) a municipal RFP for an owner-operator of the EV chargers, ideally with support of the utility incentives currently being developed, and d) a municipal RFP to engage a third party in a public-private partnership for the generator and microgrid control system (including operational support when the microgrid is engaged during a grid outage).

9 Project Cost Estimates

As noted in Sections 7.1 and 7.2 and Section 8, the DOMA strategy enables significant flexibility regarding how the microgrid project is structured commercially and financed. In general, most project elements are funded independently, separate from their microgrid function (when the microgrid is operating), based on value provided during normal (blue sky) conditions. In the case of Highland Park, the cost structure/financing challenges are also addressed since significant assets are either already in place, or already planned for construction – those costs are not estimated for the project since they are already financed separately. Consistent with the commercial framework in Section 8, the cost budgets are organized to account for several sub-projects for a) the EV chargers, b) the utility work related to the microgrid backbone, and c) a project for other microgrid components, including the dispatchable generator and the microgrid controller.

9.1 Electric Vehicle Chargers

The EV chargers are a separate sub-project, contemplated for implementation independent of the microgrid project financially. Those costs do not need to be included as part of the microgrid budget. For completeness, however, an estimate of those costs are summarized below for each of the three configurations. Note: the EV chargers are connected to the microgrid in the Nominal and Alternative A configurations, but not in the minimalist Alternative B configuration.

Figure 9-1: Electric Vehicle Charger Costs

Description	Quantity	Unit	Unit Price		Total Price		Sub-Total	Total W/
			Material	Labor	Material	Labor		COP
Electric Vehicle Chargers (150KW each)	2	EA	$125,000	$12,500	$250,000	$25,000	$275,000	**$330,000**

9.2 Utility Backbone Construction

An essential component of the microgrid is the backbone conductors and related isolation and transfer switchgear. The backbone conductors themselves are based on a combination of reuse of sub-loops of the existing distribution system and new aerial extensions. The DOMA strategy contemplates construction and ownership of these elements by the public utility, and inclusion of those assets as part of the distribution system itself. All electricity transfers during microgrid operation are therefore taking place over franchised utility assets. All of the following estimates include a 20% mark-up for Contingency, Overhead, and Profit (COP). Project cost estimates are provided by Burns Engineering.

The scope of the backbone varies by configuration – with the nominal case being the most complete, Alternative A slightly smaller, and Alternative B the most minimal solution. The following charts summarize projected costs for the HP BRITE project for these utility elements.

Figure 9-2: Backbone Work By The Utility, Nominal Configuration

Description	Quantity	Unit	Unit Price		Total Price		Sub-Total	Total W/
			Material	Labor	Material	Labor		COP
Backbone - Conductors								
Line Extension of EDI-4006 from Municipal Core to DPW Building	1,750	LF	$50	$140	$87,500	$245,000	$332,500	**$399,000**
Alternate #1A - Extension of EDI-4006 to Stop & Shop	1,000	LF	$50	$140	$50,000	$140,000	$190,000	**$228,000**
Alternate #1B - Extension of EDI-4006 from Stop & Shop to HS/MS and Library	1,400	LF	$50	$225	$70,000	$315,000	$385,000	**$462,000**
Sub-Total: Backbone Conducters:								**$1,089,000**
Backbone - Utility Line Switching and Isolation								
Reconfiguration of 3P Line and 1P,50kVA XFMRs to support NPTs on Benner & 6th	1	LS	$3,750	$15,000	$3,750	$15,000	$18,750	**$22,500**
Auto Padmount Switching on Benner St.	2	EA	$125,000	$25,000	$250,000	$50,000	$300,000	**$360,000**
Auto Padmount Switching on Mansfield South of Municipal Core (to DPW)	1	EA	$85,000	$15,000	$85,000	$15,000	$100,000	**$120,000**
Sub-Total: Line Isolation:								**$502,500**
Backbone - Building Connections								
ATS/Microgrid Connect - Borough Hall	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Fire Department	1	EA	$15,000	$5,000	$15,000	$5,000	$20,000	**$24,000**
ATS/Microgrid Connect - Police Department	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Bartle Elementary	1	EA	$40,000	$8,000	$40,000	$8,000	$48,000	**$57,600**
ATS/Microgrid Connect - Senior Center	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - AHEPA Housing	1	EA	$15,000	$5,000	$15,000	$5,000	$20,000	**$24,000**
ATS/Microgrid Connect - Housing Authority	1	EA	$50,000	$10,000	$50,000	$10,000	$60,000	**$72,000**
ATS/Microgrid Connect - HS/MS	2	EA	$50,000	$10,000	$100,000	$20,000	$120,000	**$144,000**
ATS/Microgrid Connect - Library	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Stop & Shop	1	EA	$50,000	$10,000	$50,000	$10,000	$60,000	**$72,000**
ATS/Microgrid Connect - DPW and S4A	1	EA	$25,000	$10,000	$25,000	$10,000	$35,000	**$42,000**
Sub-Total: Line Isolation:								**$555,600**
Total Utility Costs:								**$2,147,100**

Figure 9-3: Backbone Work By The Utility, Alternative A Configuration

Description	Quantity	Unit	Unit Price		Total Price		Sub-Total	Total W/
			Material	Labor	Material	Labor		COP
Backbone - Conductors								
Line Extension of EDI-4006 from Municipal Core to DPW Building	1,750	LF	$50	$140	$87,500	$245,000	$332,500	**$399,000**
Alternate #1A - Extension of EDI-4006 to Stop & Shop	1,000	LF	$50	$140	$50,000	$140,000	$190,000	**$228,000**
Sub-Total: Backbone Conducters:								**$627,000**
Backbone - Utility Line Switching and Isolation								
Reconfiguration of 3P Line and 1P,50kVA XFMRs to support NPTs on Benner & 6th	1	LS	$3,750	$15,000	$3,750	$15,000	$18,750	**$22,500**
Auto Padmount Switching on Benner St.	2	EA	$125,000	$25,000	$250,000	$50,000	$300,000	**$360,000**
Auto Padmount Switching on Mansfield South of Municipal Core (to DPW)	1	EA	$85,000	$15,000	$85,000	$15,000	$100,000	**$120,000**
Sub-Total: Line Isolation:								**$502,500**
Backbone - Building Connections								
ATS/Microgrid Connect - Borough Hall	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Fire Department	1	EA	$15,000	$5,000	$15,000	$5,000	$20,000	**$24,000**
ATS/Microgrid Connect - Police Department	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Bartle Elementary	1	EA	$40,000	$8,000	$40,000	$8,000	$48,000	**$57,600**
ATS/Microgrid Connect - Senior Center	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - AHEPA Housing	1	EA	$15,000	$5,000	$15,000	$5,000	$20,000	**$24,000**
ATS/Microgrid Connect - Housing Authority	1	EA	$50,000	$10,000	$50,000	$10,000	$60,000	**$72,000**
ATS/Microgrid Connect - Stop & Shop	1	EA	$50,000	$10,000	$50,000	$10,000	$60,000	**$72,000**
ATS/Microgrid Connect - DPW and S4A	1	EA	$25,000	$10,000	$25,000	$10,000	$35,000	**$42,000**
Sub-Total: Line Isolation:								**$381,600**
Total Utility Costs:								**$1,511,100**

Figure 9-4: Backbone Work By The Utility, Alternative B Configuration

Description	Quantity	Unit	Unit Price		Total Price		Sub-Total	Total W/
			Material	Labor	Material	Labor		COP
Backbone - Conductors								
Line Extension of EDI-4006 from Municipal Core to DPW Building	1,750	LF	$50	$140	$87,500	$245,000	$332,500	**$399,000**
Sub-Total: Backbone Conducters:								**$399,000**
Backbone - Utility Line Switching and Isolation								
Reconfiguration of 3P Line and 1P,50kVA XFMRs to support NPTs on Benner & 6th	1	LS	$3,750	$15,000	$3,750	$15,000	$18,750	**$22,500**
Auto Padmount Switching on Benner St.	2	EA	$125,000	$25,000	$250,000	$50,000	$300,000	**$360,000**
Auto Padmount Switching on Mansfield South of Municipal Core (to DPW)	1	EA	$85,000	$15,000	$85,000	$15,000	$100,000	**$120,000**
Sub-Total: Line Isolation:								**$502,500**
Backbone - Building Connections								
ATS/Microgrid Connect - Borough Hall	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Fire Department	1	EA	$15,000	$5,000	$15,000	$5,000	$20,000	**$24,000**
ATS/Microgrid Connect - Police Department	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - Bartle Elementary	1	EA	$40,000	$8,000	$40,000	$8,000	$48,000	**$57,600**
ATS/Microgrid Connect - Senior Center	1	EA	$20,000	$5,000	$20,000	$5,000	$25,000	**$30,000**
ATS/Microgrid Connect - AHEPA Housing	1	EA	$15,000	$5,000	$15,000	$5,000	$20,000	**$24,000**
ATS/Microgrid Connect - Housing Authority	1	EA	$50,000	$10,000	$50,000	$10,000	$60,000	**$72,000**
ATS/Microgrid Connect - DPW and S4A	1	EA	$25,000	$10,000	$25,000	$10,000	$35,000	**$42,000**
Sub-Total: Line Isolation:								**$309,600**
Total Utility Costs:								**$1,211,100**

9.3 Other Microgrid Components

This sub-project includes the dispatchable generator, bundled with the microgrid controller and related communications equipment. This sub-project will be implemented through a public-private partnership supported by a third-party investor. The municipality contemplates contracting for this sub-project through a municipal RFP process. The costs for these elements depend on the configuration, which affect generator sizing. The following chart summarizes these sub-project costs for each configuration.

Figure 9-5: Dispatchable Generator and Microgrid Controller

Description	Quantity	Unit	Unit Price		Total Price		Sub-Total	Total W/
			Material	Labor	Material	Labor		COP
Nominal - Other Microgrid Components								
1.5MW NG Generator	1,500	KW	$400	$225	$600,000	$337,500	$937,500	**$1,125,000**
MG Controller and Communications	1	LS	$0	$75,000	$0	$75,000	$75,000	**$90,000**
Sub-Total - Nominal:								**$1,215,000**
Alternative A - Other Microgrid Components								
1.5MW NG Generator	1,500	KW	$400	$225	$600,000	$337,500	$937,500	**$1,125,000**
MG Controller and Communications	1	LS	$0	$75,000	$0	$75,000	$75,000	**$90,000**
Sub-Total - Alternative A:								**$1,215,000**
Alternative B - Other Microgrid Components								
1.0MW NG Generator	1,000	KW	$400	$225	$400,000	$225,000	$625,000	**$750,000**
MG Controller and Communications	1	LS	$0	$75,000	$0	$75,000	$75,000	**$90,000**
Sub-Total - Alternative B:								**$840,000**

Given that all existing assets are funded, the EV chargers will be funded independently, the utility work will be recovered as part of the distribution system, this sub-group represents the primary financing challenge for the Highland Park BRITE project.

10 Cash Flow Projection

Consistent with the DOMA approach, different project elements are financed independently with each capturing unique economic value. A variety of assets – such as the existing net metered solar arrays and back-up generators, already exist. The Solar-For-All plant (with integrated storage) will be owned and operated by the utility, and does not need to be financed directly as part of the microgrid project. The backbone of the microgrid, including significant reuse of existing infrastructure, will be constructed by the electric utility and owned as part of the distribution system with cost recovery through rates. The primary direct new investment for the project includes the dispatchable natural gas fired generators and the microgrid controller. This project element will be developed through a public-private partnership organized by the Borough through a competitive RFP process. A third party investor will own and operate the generator the controller, and ensure operating support during a grid outage when the microgrid is functional. The cash flow estimate for the project is focused on the economics of this third party project.

To compliment the intermittent and seasonal generation of the Solar-For-All PV plant a natural gas RICE (Reciprocating Internal Combustion Engine) generator is planned. Under blue-sky conditions, this generator will be operated in the PJM capacity market, managed within the operating boundaries typical for RICE generators.

The capacity market revenues are sufficient to finance the generator-storage-controller combination, achieving a 7.3% IRR over 15 years, and simple break even in year 10. A summary of the cash flow for this investment profile is summarized below.

Figure 10.1 Cashflow (Generator & Controller Investment)

	1	2	3	4	5	6	7
Investment	-$1,215,000	$0	$0	$0	$0	$0	$0
Revenues	$124,246	$127,352	$130,536	$133,799	$137,144	$140,573	$144,087
Operating Costs	-$37,995	-$38,565	-$39,144	-$39,731	-$40,327	-$40,932	-$41,546
Federal Tax Impacts:							
Depreciation (SL, 15 yrs)	$24,300	$24,300	$24,300	$24,300	$24,300	$24,300	$24,300
Net Annual Cashflow ($ in-year)	-$1,104,450	$113,086	$115,692	$118,368	$121,117	$123,941	$126,841
Cummulative Cashflow	-$1,104,450	-$991,363	-$875,672	-$757,304	-$636,187	-$512,246	-$385,405
Internal Rate Of Return (%)	**7.30%**						

	8	9	10	11	12	13	14	15
Investment	$0	$0	$0	$0	$0	$0	$0	$0
Revenues	$147,689	$151,381	$155,166	$159,045	$163,021	$167,097	$171,274	$175,556
Operating Costs	-$42,169	-$42,802	-$43,444	-$44,095	-$44,757	-$45,428	-$46,109	-$46,801
Federal Tax Impacts:								
Depreciation (SL, 15 yrs)	$24,300	$24,300	$24,300	$24,300	$24,300	$24,300	$24,300	$24,300
Net Annual Cashflow ($ in-year)	$129,820	$132,880	$136,022	$139,250	$142,564	$145,969	$149,465	$153,055
Cummulative Cashflow	-$255,585	-$122,705	$13,317	$152,567	$295,131	$441,100	$590,564	$743,619

While the project is profitable and within feasibility for a friendly investor, it is not a strong IRR for third party investment. Depending on further details to be refined as part of detailed design, a variety of improvements to this investment profile are anticipated:

1. The generators are only operated in the capacity market. Depending on the exact operating profile, those generators may be able to operate in other parallel PJM markets that could deliver additional revenue.

2. Consistent with the public-private partnership basis for the project, inexpensive debt-capital may be available for the project, which would provide leverage for improving the IRR.

3. The generator asset is grid connected, and participates in the PJM wholesale market. Depending on more detailed analysis and final installation location, the generator may be able to provide either electricity or heat to nearby load sites, thereby capturing additional "behind the meter" revenues.

4. The project delivers substantial resiliency value for the Borough which is not economized in any way directly through the model summarized above. Any grants or financing programs made available to help realize the state's resiliency goals could be used to improve project economics. This includes possible federal funds, including block grants.

The direct investment required by the project is profitable based on a simple cash flow analysis that minimizes project financing assumptions. Depending on final design details, the profitability of the project may be improved in a variety of ways to strengthen the attractiveness of the project to a third party investor as currently contemplated.

11 Project Financing

See sections 9, 10, and 11 for details about how different elements of the microgrid are financed.

This proposed project is consistent with the use of the Societal Benefit Charge (SBC) as set forth in N.J.S.A. 48:3-60(a)(3) since all identified load sites pay regulated utility power bills and therefore contribute to the SBC fund.

12 Project Benefits

The Highland Park BRITE project provides significant benefits in two areas: a) benefits to the community during an grid outage, by delivering power to critical municipal infrastructure, and b) benefits to the grid itself.

12.1 Benefits For The Community

Highland Park currently has extremely limited energy resiliency for critical infrastructure. The Borough is committed to significantly expanding the level of support it provides to the community during grid outage events. This project is both highly feasible and highly impactful, and represents an exceptional opportunity to dramatically improve the level of emergency support services provided to the community.

Most importantly, the core critical facilities (Borough Hall, Police Station, Fire Station, the Senior Center, two nearby senior/disabled housing facilities, the nearby school (and BOE district offices), the middle/high school, the library, and the DPW) provide a kernel of emergency management function that serves the entire community. Most of the 14,000 residents of Highland Park live within walking distance of this core of expanded emergency support services the project will make possible.

The proposed microgrid will be able to provide un-interrupted power to critical facilities for an indefinite period of time[5]. The use of renewable generation assets will reduce dependence on fuel supplies. Note that support will be provided for "full building" functionality at all critical facilities, not just "critical loads".

With the availability of expanded and more reliable power for critical facilities, the Borough will be able to significantly increase the level of support it provides to the community during an outage event, especially for events of long duration. Key benefits **DURING AN OUTAGE** include:

1. **Emergency Management:** Assurance of back-up power for Police and Fire stations, which serve as the core for emergency management operations across the entire community.

2. **Community Coordination:** Assurance of back-up power for the Borough Hall, which also plays a central role in coordinating numerous support functions during an extended outage. This facility serves as a meeting place for community leadership and response coordinators, and a primary source of information for residents during an extended event.

3. **Warming Center/Distribution Points:** The Senior Center, also known as the "Recreational Center" or "Community Center", has meeting space and is designated as a "warming center" for residents. It can also serve as a community gathering point, a charging point for cell phones, and a distribution point for supplies (water, etc.). The nearby Bartle School currently does not provide emergency support due to the lack of power, but as a result of the microgrid, it will also be able to provide warming/distribution/cell phone charging functions, and if needed in extreme cases, shelter functions. The Middle/High school buildings can provide similar functions for the community as well.

4. **Senior and Disabled Housing:** Both the Highland Park Housing Authority and the nearby AHEPA housing facility contain nearly 200 full time senior, disabled, and low income residents. Most of these residents must shelter in place during an outage event, and these facilities today have limited ability to support their residents when the power is out. This is especially critical since these are multi-story facilities served by an electric elevator. Ensuring reliable power supply for these facilities ensures that the community's most vulnerable residents can be cared for and protected during an extreme event.

[5] The system is capable of providing "uninterrupted" service once the microgrid is formed. There maybe brief outage intervals during the transition to and from microgrid mode. The generator will be supported by a "firm" (non-curtailable) fuel supply contract.

5. **Impact on Surrounding Communities:** Creating an island of resiliency in Highland Park impacts more than just the immediate Borough population. Many Highland Park residents work in nearby New Brunswick, both at the Rutgers campus, and at nearby critical medical facilities (especially RWJ University Hospital and the Children's Specialized Hospital). Providing this dense residential area with more resilient energy infrastructure has a direct impact at critical nearby facilities where those residents work.

6. **Proof of Concept and Project Learning:** While this project is compact in physical size, it will be a fully functional Class Three community microgrid. This facility will serve as a proof of concept for a quintessential microgrid implementation, with working demonstration of key technical elements, regulatory concepts, and financial strategies. These advancements and learnings can then be scaled up and replicated for other more complex projects. Particular benefit will be realized through the combination of renewable and dispatchable generation assets in a microgrid configuration, which is a key strategic priority for New Jersey.

The residents of Highland Park will therefore have significantly stronger municipal support during an extended power outage, including better command and control, additional warming and cell phone charging capability, better supply distribution arrangements, potentially shelter and food supply facilities (if needed), and support for senior and disabled housing that must shelter in place. There is high need for the resiliency benefits that will be enabled by the HP-BRITE project, since the Borough has limited ability to provide many of the services and support functions described above. By combining these critical facilities into a "resiliency island", the microgrid meets a critical emergency management need in a highly cost effective way compared with other alternatives.

12.2 Benefits To The Grid

Key microgrid assets will also deliver benefits and economic value during normal operation, when the microgrid itself isn't functioning. The Solar-For-All system delivers locally generated electricity and improves local power quality. The generator will be participating in PJM capacity markets, and as a result is available to relieve congestion on local LMP-nodes when called upon. Since the portfolio of facilities on the microgrid can be operated indefinitely, thereby allowing utility resources to be prioritized to other circuits during an outage event. Most importantly, the existence of the microgrid provides the utility with additional flexibility in handling restoration of service during an outage: the utility can control the sequence of restoring microgrid loads to normal operation, thereby allowing for a smoother restoral transition.

13 System Communications

Under some architectures considered for a TC-DER microgrid, there may be a need for significant communication and coordination between the public grid utility (EDC) and the microgrid itself. This tight coupling is necessary when the microgrid is interacting with the public grid (exchanging power in either direction) during blue-sky conditions.

That requirement doesn't exist under the DOMA strategy, because the overall microgrid entity does not exchange power with the grid under blue sky conditions. The microgrid only functions when fully isolated from the public grid, in which case control-level communications are not necessary. Both the natural gas generator and the Solar-For-All array will interact with PJM and the EDC for control of their "normal operation" modes under blue-sky. That communications and control infrastructure will be implemented as part of those stand-alone energy services projects, relatively independent of the microgrid project. Communication requirements for the microgrid project overall are therefore fairly minimal.

The one exception is during the transition modes, when the grid goes down (and is eventually restored), and the microgrids starts (and then terminates) operation. The best method for coordinating these start-up and shut-down transitions will depend on further details to be determined as part of detailed design, and will depend heavily on utility preference/requirements.

14 Estimated Schedule

Following this conceptual feasibility study, the implementation of the project will include several phases (this schedule assumes that the Solar-For-All and EV charger projects are independently, since they will proceed regardless of the microgrid project):

1. **Detailed Design:** with the design created during the Conceptual Feasibility Study, developed a detailed design sufficient to drive actual implementation and related municipal procurement activities. Coordinate with the utility on all technical design matters. This effort is expected to be funded by BPU second stage funding.

2. **Utility Project Implementation:** construction of the microgrid backbone. This project also includes any modifications and integration of the Solar-For-All project with the microgrid.

3. **Municipal Procurement:** an RFP-style process for a third party owner/operator for construction of the natural gas generator and the microgrid controller.

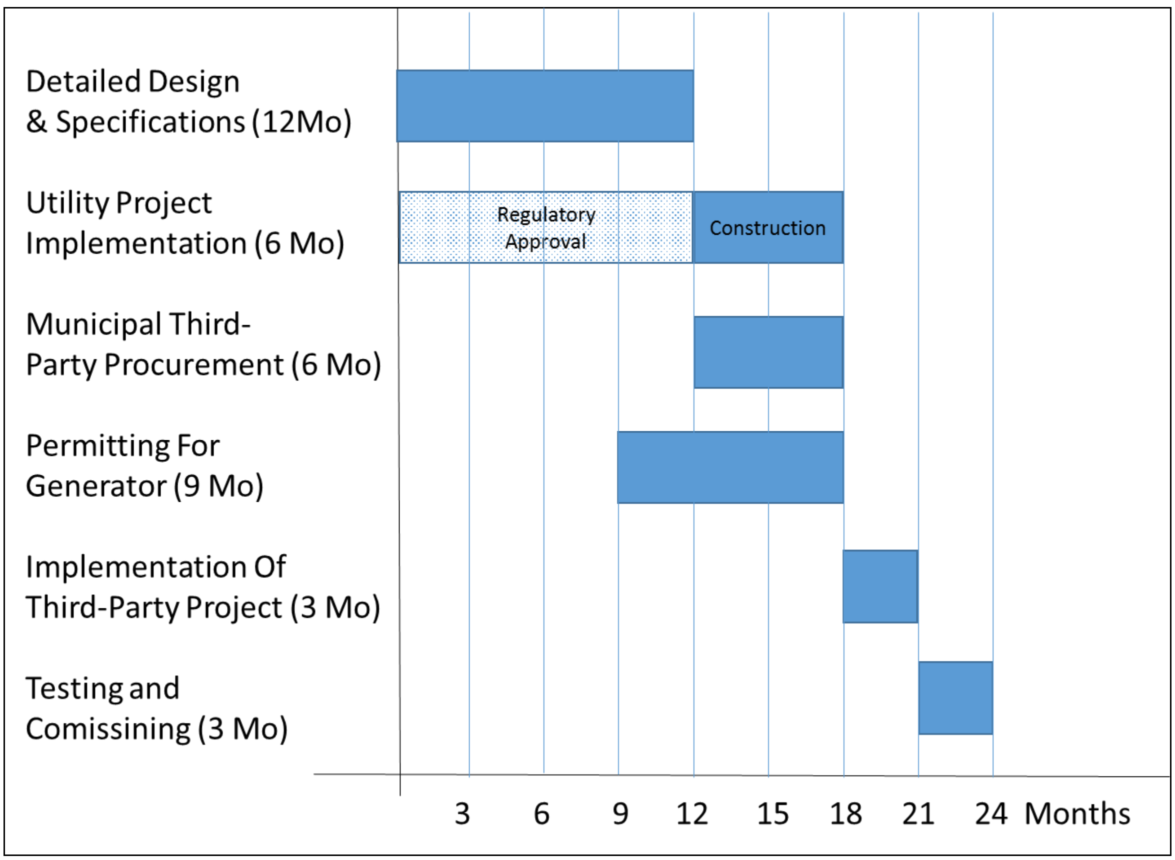
4. **Permitting for Generator:** including PJM interconnection and NJ-DEP emission permits, along with any local permits required.

5. **Construction of the Generator:** physical construction of the generator and microgrid controller, implemented in coordination with utility construction of the backbone.

6. **Testing and Commissioning:** After construction is completed, testing of microgrid operation and training of staff for operation.

This schedule does not account for regulatory approval of the DOMA strategy, and utility filing/approval of backbone construction activities, the timing of which is difficult to estimate at this stage. The following bar-chart summarizes high level estimates for each work phase:

Figure 14-1: High Level Schedule



15 Utility Involvement

As noted in Section 7, the DOMA strategy assumes significant involvement by the EDC in the construction of the microgrid, with a focus on designing, building, operating, and owning the backbone as an integrated part of the distribution system. Recovery of those investments would happen consistent with other distribution system investments, and may (longer term) be supported by a TC-DER Advanced Microgrid Tariff. Shorter term, initial (pioneer) projects may depend on more specific filings to achieve the same purpose.

In the case of the Highland Park BRITE project, the backbone is built through a combination of a) isolated sub-loops of existing circuits, b) new aerial extensions to connect more remote load sites (the schools and DPW), and the provision of both isolation and transfer switching to enable interconnection with both load sites and generation assets included as part of the microgrid. Utility involvement will be critical for the detailed design phase, construction of the backbone, and operation of the microgrid transitions as described in Section 7. Note that under the DOMA strategy, a) the utility does not lose revenue, b) they have an active role in project development and construction, and can expand their rate-base with the new backbone assets (both conductors and switchgear), and they c) implement, and control the the transitions to and from the microgrid operating modes.

16 Appendix A: Letters of Support and Authorization

Letters of support are provided from the following project partners:

- **The local utility, PSE&G**
- **The Highland Park Board Of Education**
- **The Housing Authority**
- **AHEPA Senior Housing**
- **Stop and Shop (Ahold USA) – a secondary site, included for completeness**
- **Resolution engaging Gabel Associates as project consultant**

Appendix A-1: Letter of Support from PSE&G

Public Service Electric and Gas Company
80 Park Plaza – T8, Newark, NJ 07102

PSEG

March 21, 2017

The Honorable Gayle Brill Mittler
Mayor, Highland Park
221 S. Fifth Avenue
Highland Park, NJ 08904

Dear Mayor Brill Mittler:

This correspondence will serve to demonstrate PSE&G's support of your application to the Town Center Distributed Energy Resource Microgrid Feasibility Study Incentive program. PSE&G will work with Highland Park officials and its consultant to develop and submit your feasibility study, if selected for funding.

PSE&G will support your study in the following ways:

- PSE&G will provide building load data for all buildings included in your microgrid feasibility study, contingent on receiving approval from the owners of each of the buildings to release its electric and gas load data to the community or its consultant.
- PSE&G will provide technical support to Highland Park's consultant in the development of your feasibility study. Release of any confidential or proprietary technical information will require the execution of a Non-Disclosure Agreement between all parties.

Mr. Frank Lucchesi will be the primary point of contact for PSE&G to coordinate our efforts with your team. Please feel free to reach out to me at 856-778-6705 if you have any technical questions.

Sincerely,

Michael Henry
Distribution Business Team Leader

Appendix A-2: Letter of Support from Highland Park Board of Education

HIGHLAND PARK
PUBLIC SCHOOLS
www.hpschools.net

SUPERINTENDENT DR. SCOTT TAYLOR
taylor@hpschools.net
435 Mansfield St, Highland Park NJ,08904
(732) 572-2400, EXT 2813

March 20, 2017

The New Jersey Board of Public Utilities
44 S. Clinton Avenue
Trenton, NJ 08625

Highland Park Borough, the community in which I have lived for over 22 years and that I currently serve as school district superintendent is preparing a proposal to the board of public utilities for funding of a Town Center Microgrid Feasibility Study. The Highland Park Public School District Central Office located in the Bartle School, the Highland Park Middle School and the Highland Park High School are being considered for inclusion as part of the study.

The school district fully supports the idea of a microgrid in Highland Park since it will provide much needed resilient power in the case of extended outages. I have worked closely with the mayor to offer my support as district representative for participation in the study effort. The school district central office and schools play vital roles in our community since they are the hubs of communication with the parent/guardian community and because the schools house the computer network's primary servers (email, student information, etc.).

Highland Park's schools look forward to participating in the proposed study to explore this opportunity further and will be engaged in discussions and planning with borough leadership every step of the way.

Respectfully,

Dr. Scott Taylor
Superintendent- Highland Park Public Schools
Adjunct Professor- Rutgers University and Montclair University
Facilitator- Academy for Social Emotional Learning in Schools (sel.cse.edu)

Appendix A-3: Letter of Support from Highland Park Housing Authority

HOUSING AUTHORITY
OF THE
BOROUGH OF HIGHLAND PARK

242 SOUTH SIXTH AVENUE
HIGHLAND PARK NJ 08904

EQUAL HOUSING OPPORTUNITY

March 17, 2017

To: The New Jersey Board of Public Utilities

From: Highland Park Housing Authority

Samuel Kronman Building, 242 South 6th Avenue

Re: Letter of Support for Micro grid Study

We understand that our community is preparing a proposal to the BPU for funding of a Town Center Micro grid feasibility study. Based on preliminary conceptual studies for the project, our facility is being considered for inclusion as part of the solution. We support the idea of a micro grid in our town to provide more resilient power in the case of extended outages, and offer our support for participation in the study effort. Our facility plays a vital role in our community. We have a total of 112 residents living at the Samuel Kronman building. They are either senior or disabled. Our residents are proud residents of this Borough and many of them are actively involved in the community and the senior center. We look forward to participating in the proposed study to explore that opportunity further.

If you have any further questions or need further clarification, please do not hesitate to call me at (732) 572-4420.

Sincerely,

Runi Sriwardena

Runi Sriwardena, Director of Housing HPHA

Appendix A-4: Letter of Support from AHEPA Senior Housing

AHEPA-HIGHLAND
APARTMENTS

Friday, March 17, 2017

To: The New Jersey Board Of Public Utilities
From: Ahepa Highland Apartments
Re: Letter Of Support For Microgrid Study

We understand that our community is preparing a proposal to the BPU for funding of a Town Center Microgrid feasibility study. Based on preliminary conceptual studies for the project, our facility is being considered for inclusion as part of the solution. We support the idea of a microgrid in our town to provide more resilient power in the case of extended outages, and offer our support for participation in the study effort. Our facility plays a vital role in our community, our building is an, 'independent senior living community for seniors 55 and older' some of our seniors have medical challenges that require machines and a guarantee of constant energy flowing into their unit. Having the security of a power grid will make our community a much safer living environment for our aging tenants.
We look forward to participating in the proposed study to explore that opportunity further.

Thank you.

Sincerely,

Jeniffer Saavedra
Property Manager
Ahepa Highland Apartments

CC; Richard Maygua
District Manager

a conifer community.
www.ahepahighlandapartments.com
239 SOUTH SIXTH AVENUE, HIGHLAND PARK, NJ 08904
[E] ahepahighland@coniferllc.com [P] (732) 572-0700 [F] (732) 572-0850 [TTY] (800) 852-7899

Appendix A-5: Letter Of Support From Stop and Shop (a secondary site)

Ahold
USA

March 22, 2017

To: The New Jersery Board of Public Utilities

From: Ahold USA

Re: Letter of Support for Microgrid Study

We understand that the community is preparing a proposal to the BPU for funding of a Town Center Microgrid feasibility study. Based on preliminary conceptual studies for the project, our facility is being considered for inclusion as part of the solution. We support the idea of a microgrid in the town to provide more resilient power in the case of extended outages, and offer our support for participation in the study effort. Our facility plays a vital role in the community, and we look forward to participating in the proposed study to explore that opportunity further.

Thank You,

Craig Besse
Manager of Energy and LEED
Ahold USA
Craig.besse@aholdusa.com

Appendix A-6: Resolution Authorizing Engagement Of Gabel Associates, Inc.

BOROUGH OF HIGHLAND PARK
NO. 9-16-254

RESOLUTION: Finance Committee

WHEREAS, "The Electric Discount and Energy Competition Act," P.L. 1999, c. 23 ("EDECA") authorizes the New Jersey School Boards' Association ("NJSBA") to obtain electricity and other energy-related services for local boards of education on an aggregated basis; and

WHEREAS, NJSBA has formed the Alliance for a Competitive Energy Services, hereinafter referred to as "ACES," a Cooperative Pricing System (E88-01-ACESCPS) to effectively obtain electricity and other energy-related services for its members; and

WHEREAS, N.J.S.A. 40a:11-10(b) authorizes municipalities to enter into cooperative pricing agreements; and

WHEREAS, ACES, has offered voluntary participation in a cooperative pricing system for the energy-related services to municipalities and counties; and

WHEREAS, the Borough of Highland Park ("Participant"), desires to participate in the ACES Cooperative Pricing System; and

WHEREAS, NJSBA and the New Jersey Association of School Administrators ("NJASA") has created, and is also offering, the ACESplus Program, which is designed to assist participating government entities with the evaluation and implementation of certain energy related programs; and

WHEREAS, Participant desires to participate in the ACESplus Program; and

WHEREAS, the NJSBA, as the Lead Agency, via its professional energy consultant, will work with the Participant to evaluate, develop and administer an RFP process for energy related services and provide related services all in accordance with the requirements of the Local Public Contracts Law (N.J.S.A. 40A:11-4.6 & 4.1), EDECA and a proposal on file with the Borough Clerk and which is available for inspection during regular Borough business hours.

NOW, THEREFORE, BE IT RESOLVED by the Borough Council of the Borough of Highland Park, as follows:

1. This resolution shall be known and may be cited as the "ACES Cooperative Pricing and ACESplus Program Resolution of the Borough of Highland Park."

2. Pursuant to the provisions of N.J.S.A. 40A:11-10(b), the Mayor and Clerk of the Borough of Highland Park are hereby authorized and directed to enter into the ACES Cooperative Pricing System Agreement and accept and execute the Proposal from Gabel Associates on file in the Office of the Borough Clerk.

Kathleen Kovach, Administrator/CFO, or her designee is hereby authorized and directed to work with the Lead Agency, via its professional energy consultant for the Participant under the ACESplus Program, as authorized by, and in accordance with the requirements of, the Local Public Contracts Law (N.J.S.A. 40A:11-4.6 and 4.1), EDECA and the Proposal.

Appendix A-6 (pg 2): Resolution Authorizing Engagement Of Gabel Associates, Inc.

Resolution No. 9-16-254
Page 2

3. The New Jersey School Boards Association, through ACES and its professional energy consultant, shall be responsible for complying with the "Local Public Contracts Law," N.J.S.A. 40A:11-1.1 *et seq.* and all other applicable laws in connection with the preparation, bidding, negotiation and execution of contracts in connection with the ACES Cooperative Pricing System and the ACESplus Program.

ADOPTED: September 6, 2016
ATTEST:

Joan Hullings
Joan Hullings, Borough Clerk

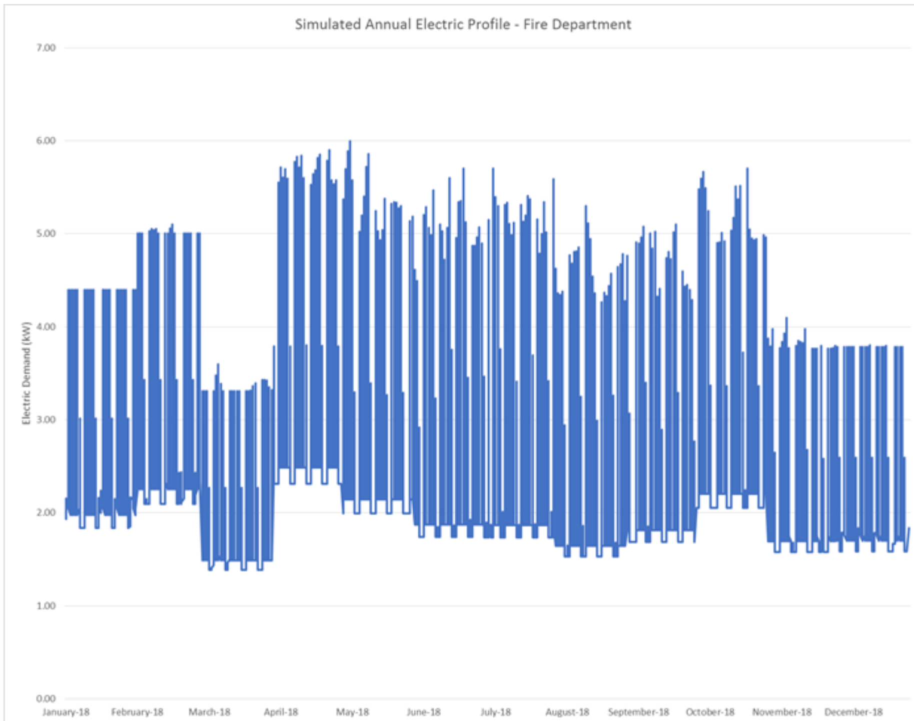
I, Joan Hullings, Borough Clerk of the Borough of Highland Park, County of Middlesex, New Jersey, do hereby certify the above to be a true copy of a Resolution adopted by the Borough Council of said Borough at its meeting on the 6th day of September, 2016.

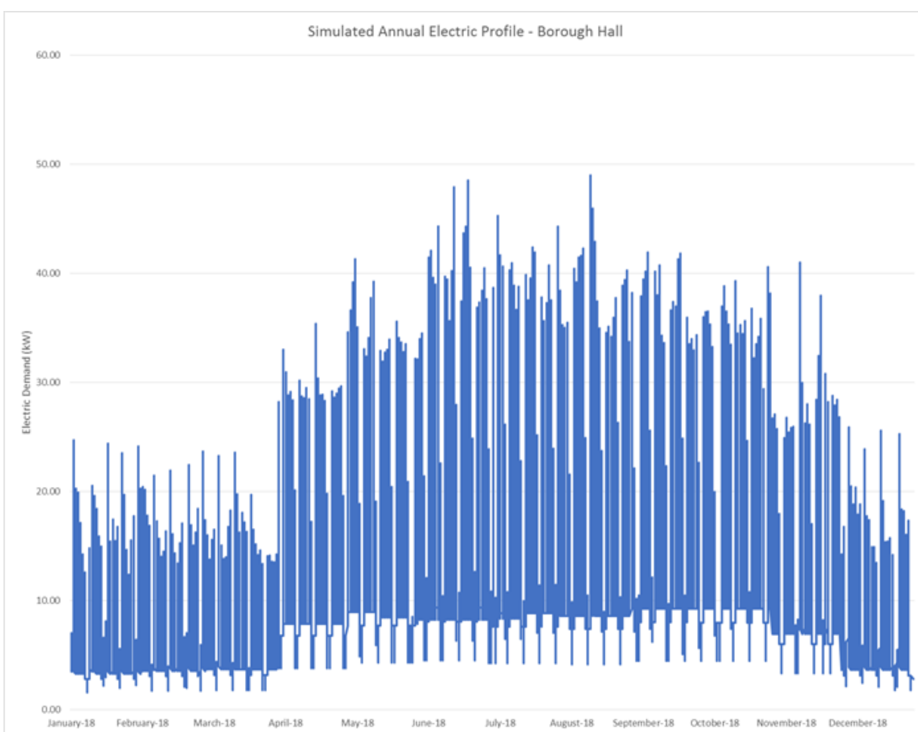
Joan Hullings, Borough Clerk

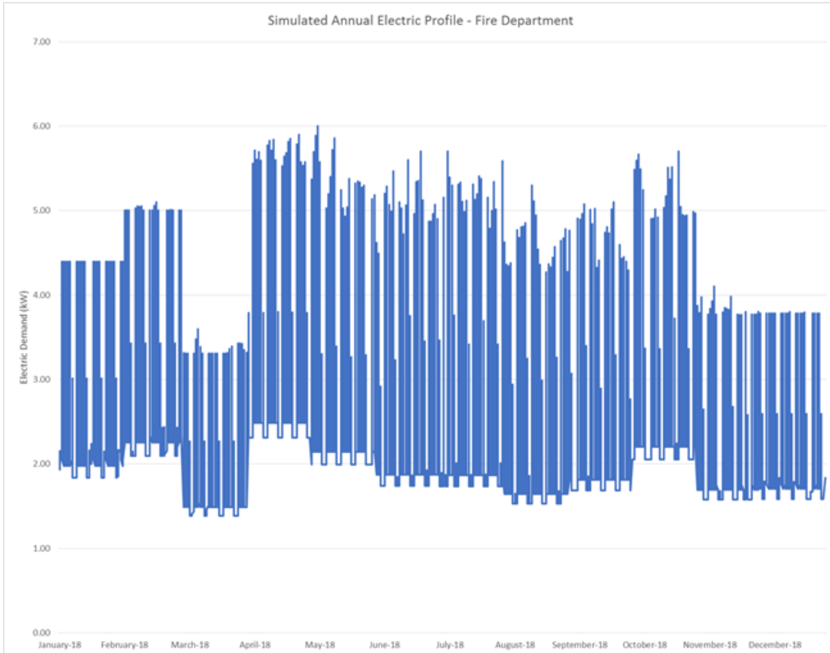
RECORD OF COUNCIL VOTES

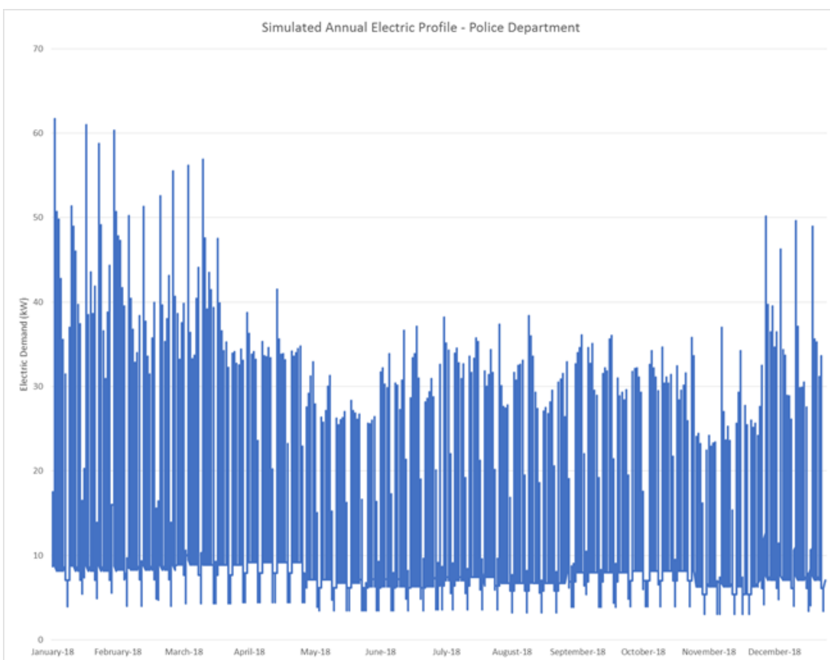
Council Member	Ayes	Nays	Abstain	Absent
Erickson	✓			
Fine	✓			
Foster-Dublin	✓			
George				✓
Walsh	✓			
Welkovits	✓			

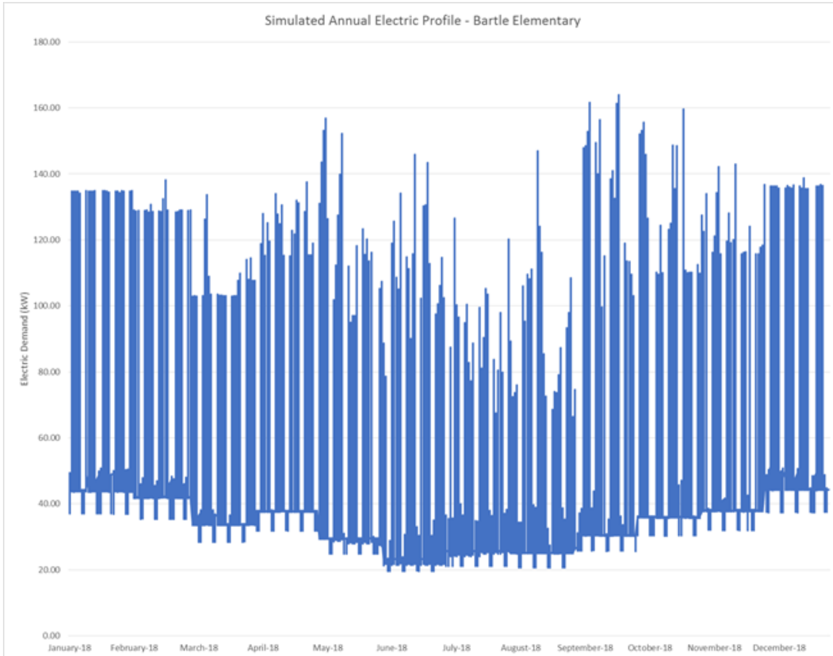
17 Appendix B: Load Sites – Time-Of-Day Profiles

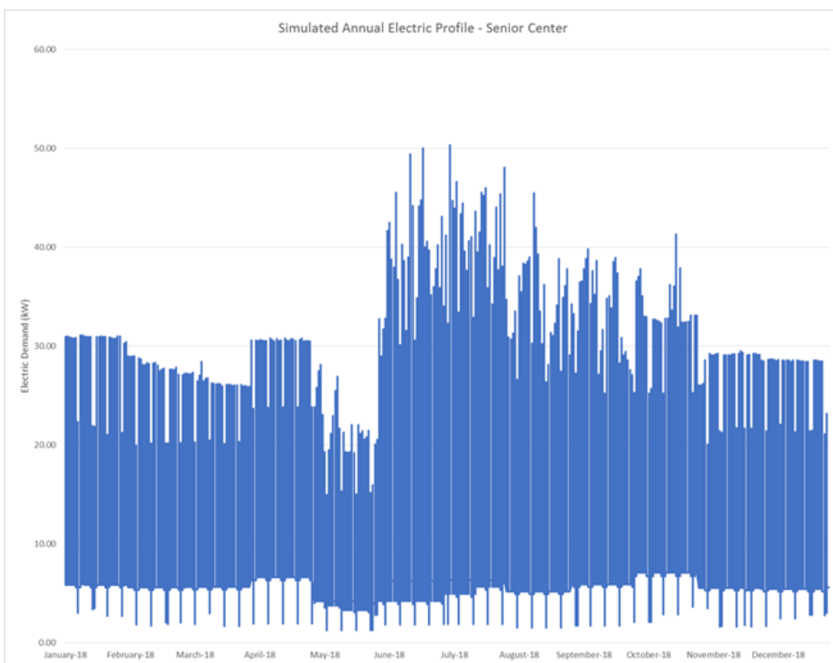


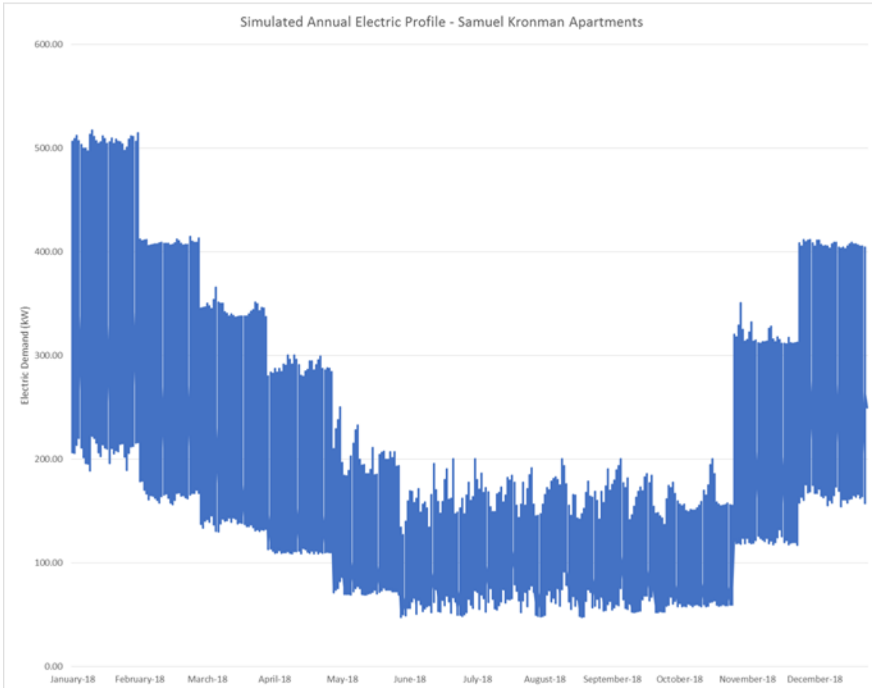


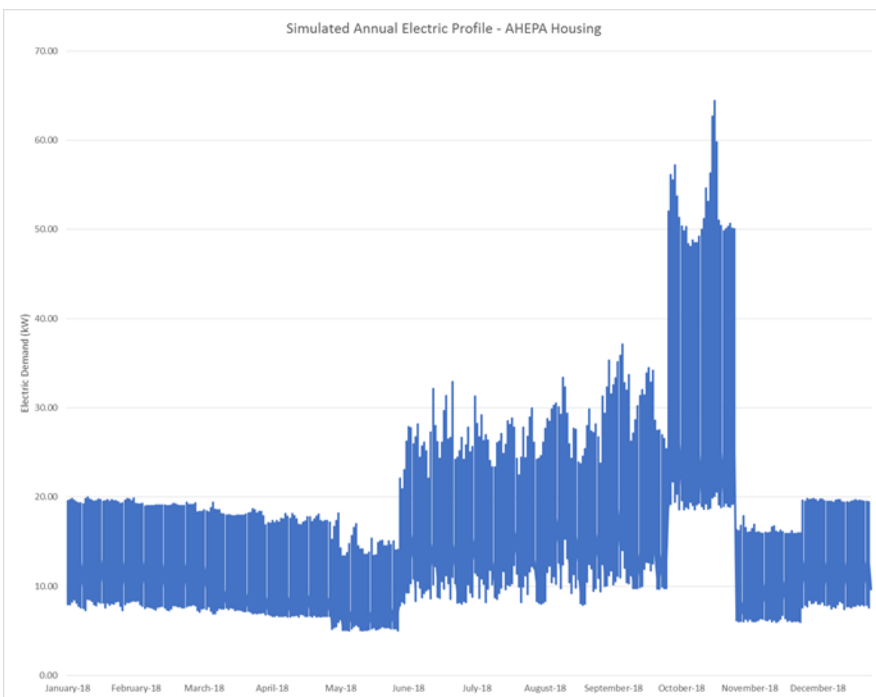

Simulated Annual Electric Profile - Fire Department
Electric Demand (kW)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

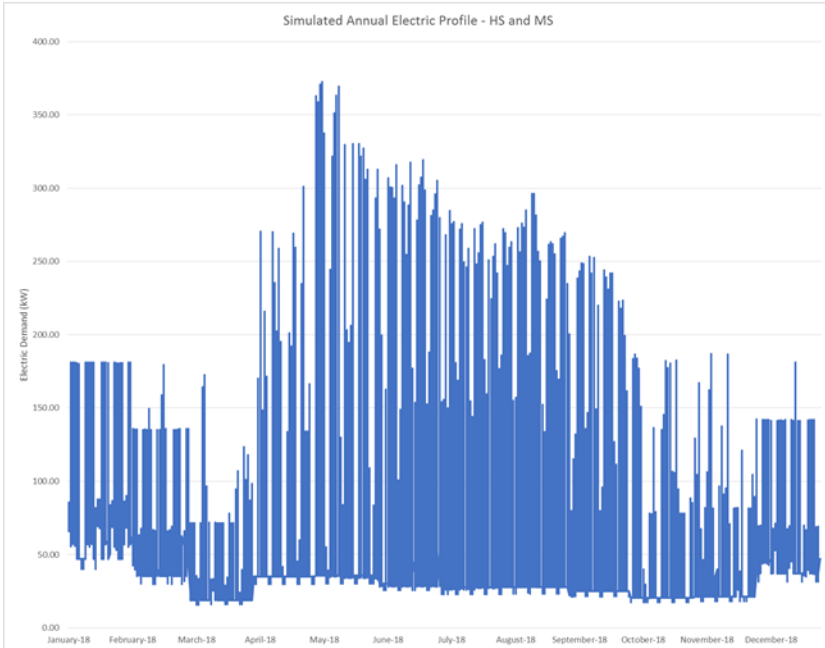

Simulated Annual Electric Profile - Police Department
Electric Demand (kW)
70
60
50
40
30
20
10
0
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

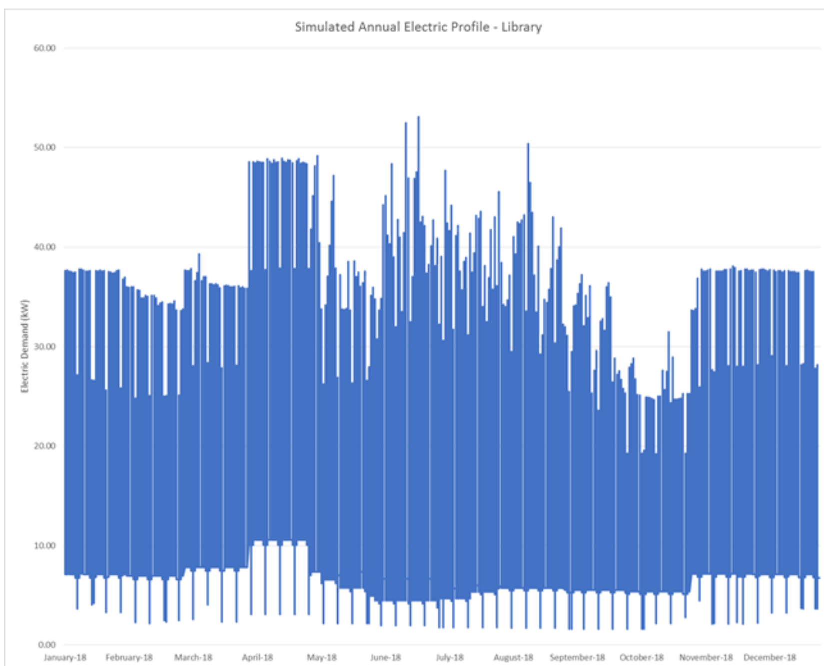

Simulated Annual Electric Profile - Bartle Elementary
Electric Demand (kW)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

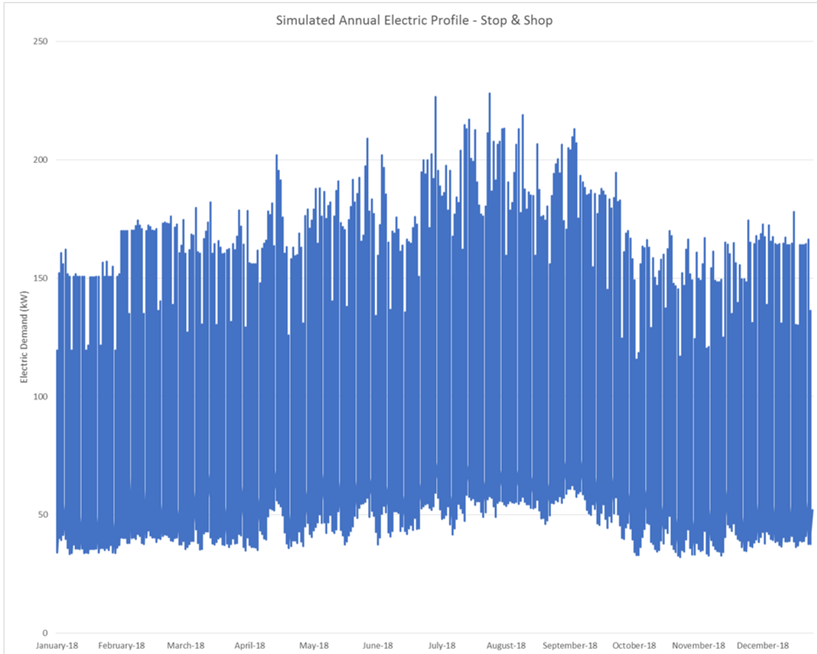

Simulated Annual Electric Profile - Senior Center
Electric Demand (kW)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

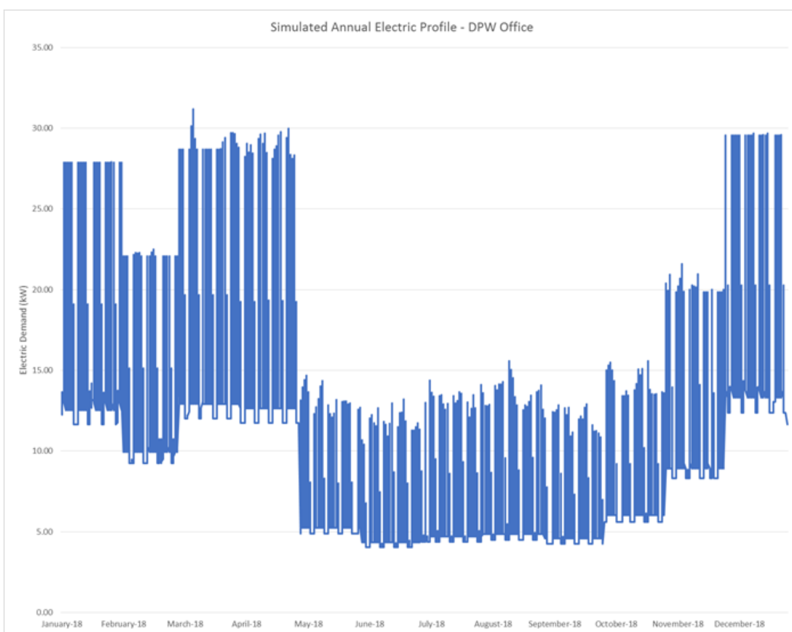

Simulated Annual Electric Profile - Samuel Kronman Apartments
Electric Demand (kW)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

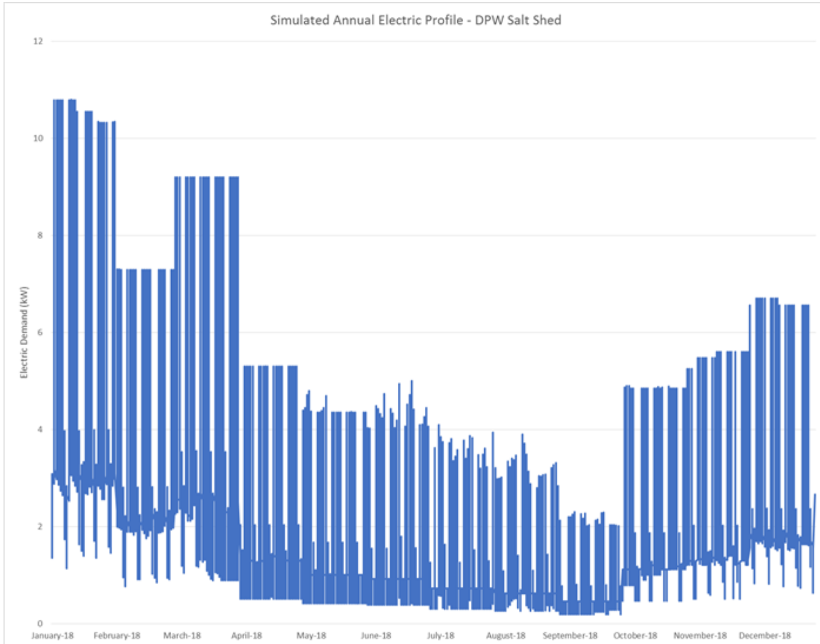

Simulated Annual Electric Profile - AHEPA Housing
Electric Demand (kW)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18


Simulated Annual Electric Profile - HS and MS
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Electric Demand (kW)
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

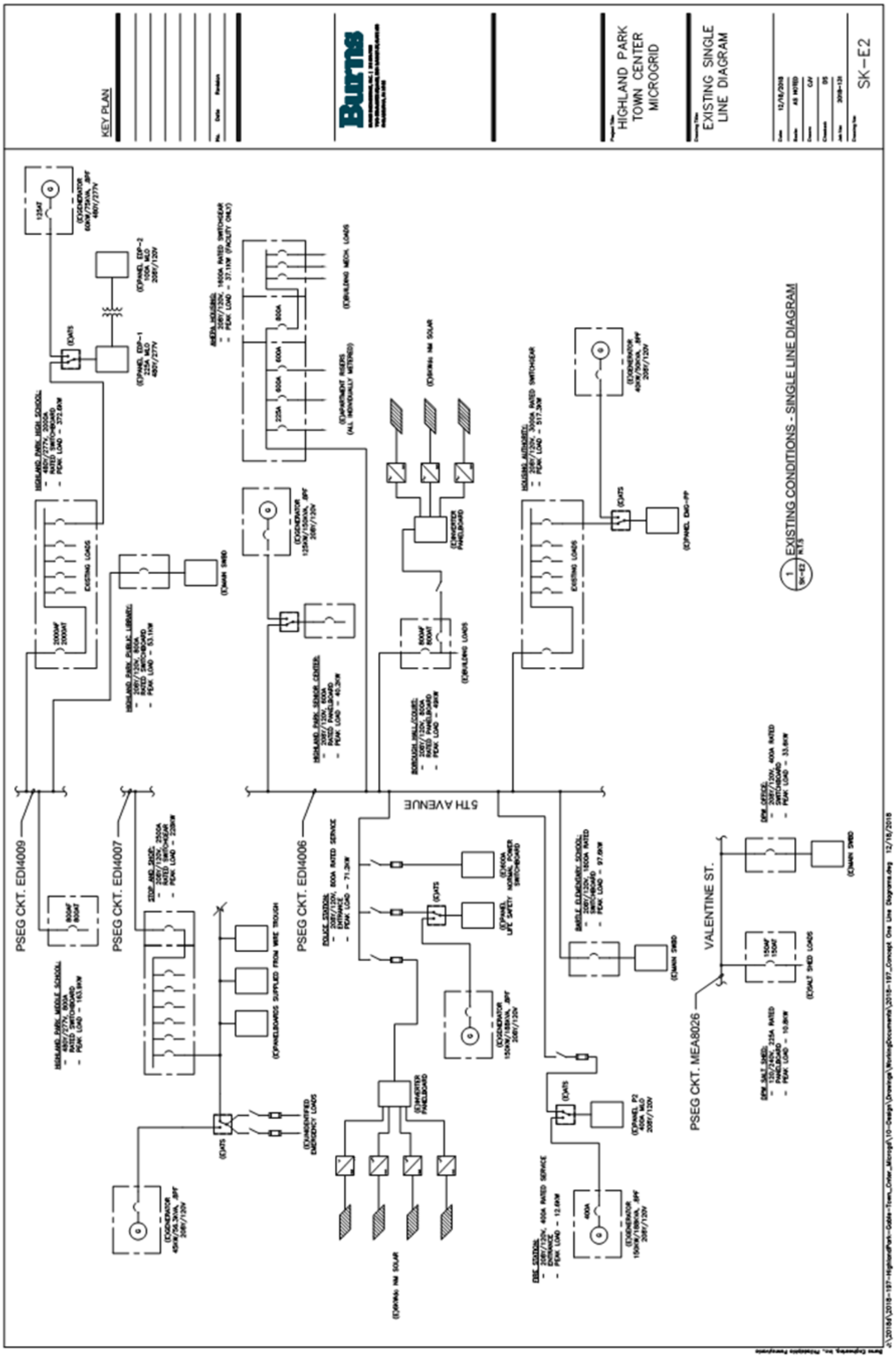

Simulated Annual Electric Profile - Library
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Electric Demand (kW)
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18


Simulated Annual Electric Profile - Stop & Shop
Electric Demand (kW)
250
200
150
100
50
0
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

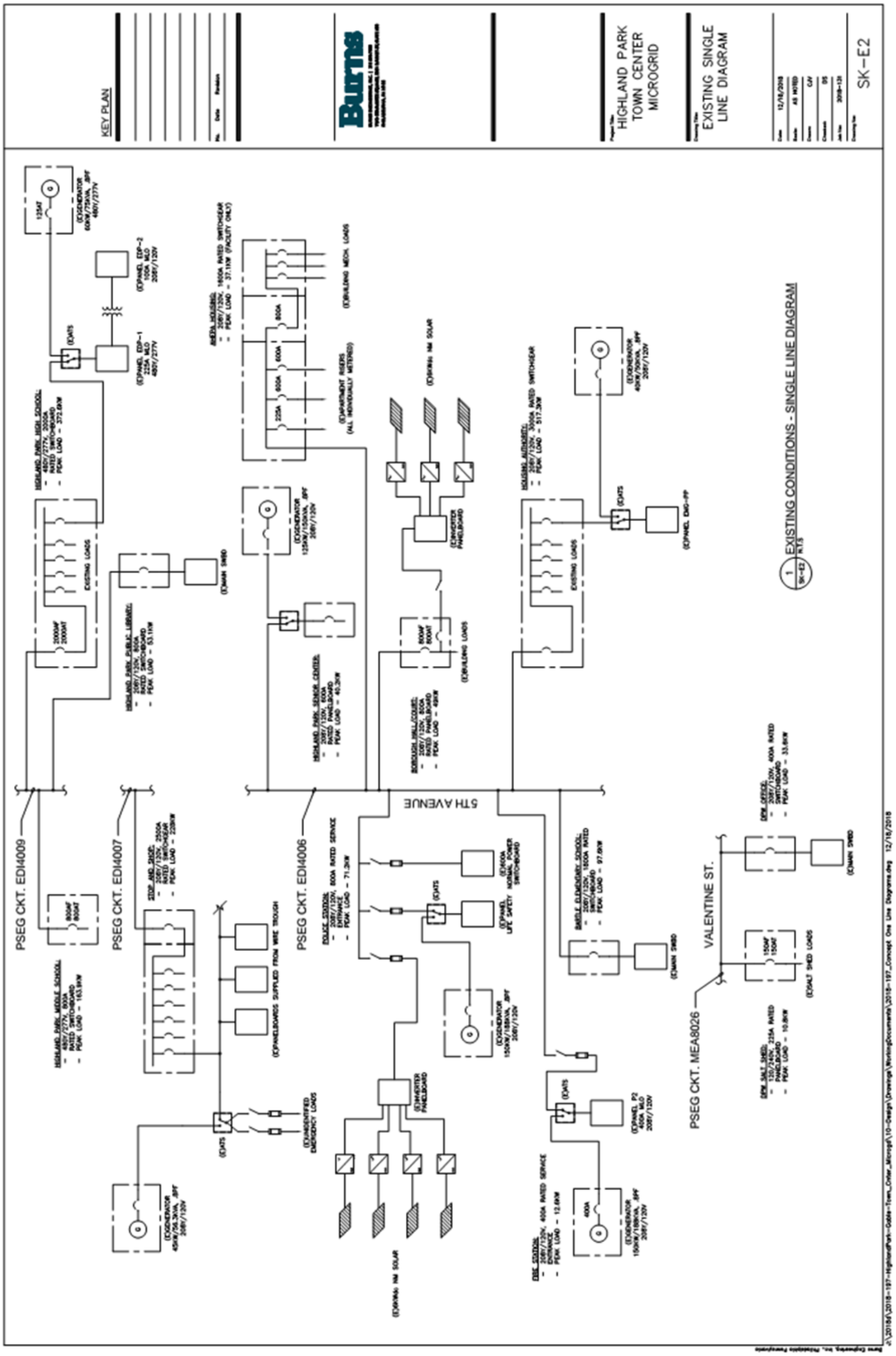

Simulated Annual Electric Profile - DPW Office
Electric Demand (kW)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

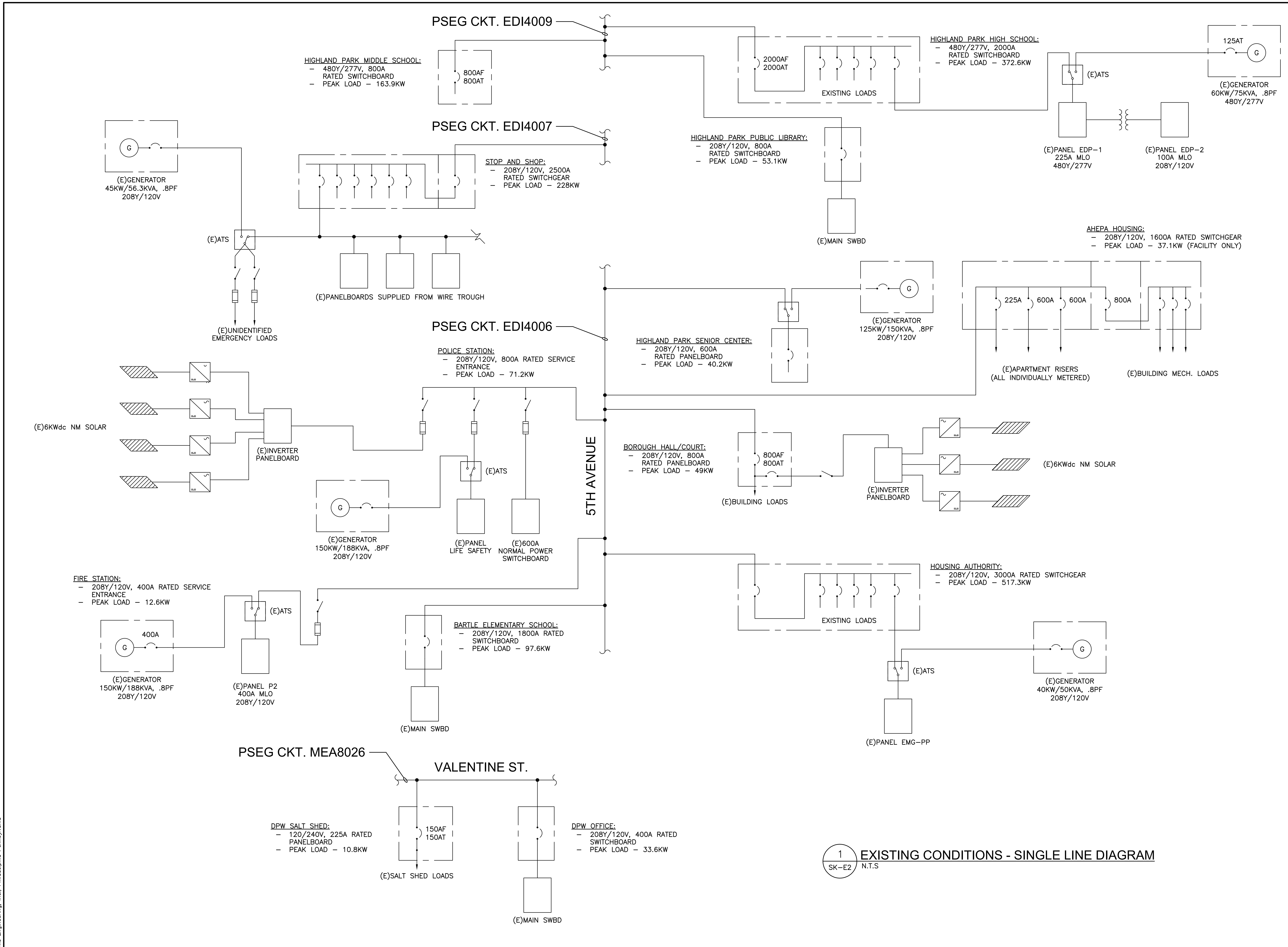

Simulated Annual Electric Profile - DPW Salt Shed
Electric Demand (kW)
12
10
8
6
4
2
0
January-18
February-18
March-18
April-18
May-18
June-18
July-18
August-18
September-18
October-18
November-18
December-18

18 Appendix C: One Line Diagram – Existing System



19 Appendix D: One Line Diagram – Nominal Microgrid Solution





EXISTING CONDITIONS - SINGLE LINE DIAGRAM
N.T.S

KEY PLAN

No.	Date	Revision

Burns

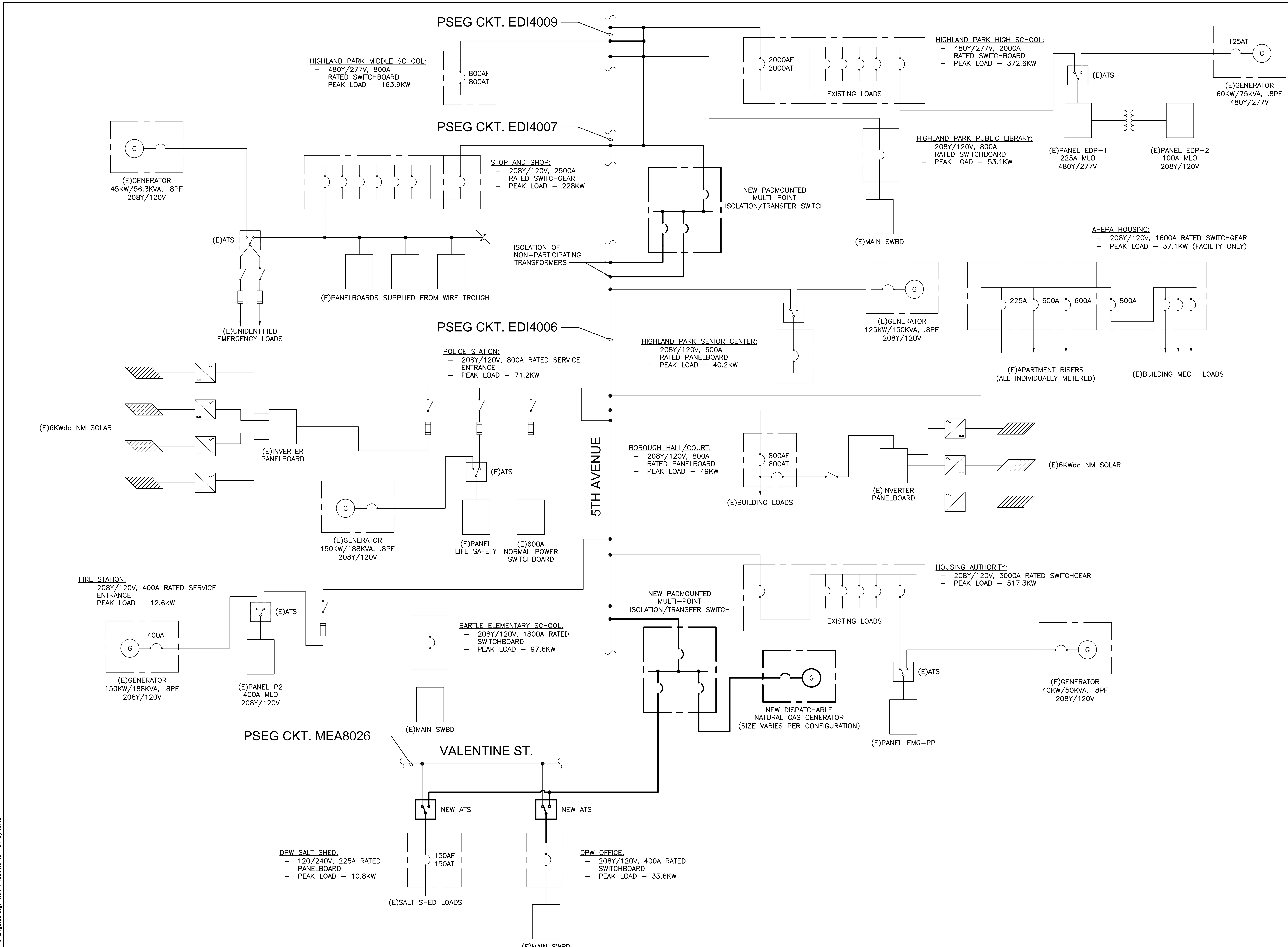
BURNS ENGINEERING, INC. | 215 979-7700
TWO COMMERCE SQUARE, 2001 MARKET ST, SUITE 600
PHILADELPHIA, PA 19103

Project Title:
HIGHLAND PARK TOWN CENTER MICROGRID

Drawing Title:
EXISTING SINGLE LINE DIAGRAM

Date:	12/18/2018
Scale:	AS NOTED
Drawn:	CJV
Checked:	DS
Job No:	2018–131

Drawing No:
SK–E2



KEY PLAN

No. Date Revision

BURNS ENGINEERING, INC. | 215 979-7700
TWO COMMERCE SQUARE, 2001 MARKET ST, SUITE 600
PHILADELPHIA, PA 19103

Project Title:
HIGHLAND PARK TOWN CENTER MICROGRID

Drawing Title:
PROPOSED SINGLE LINE DIAGRAM

Date:	12/18/2018
Scale:	AS NOTED
Drawn:	CJV
Checked:	DS
Job No:	2018–131
Drawing No:	SK–E3