Woodbridge Town Center Advanced Microgrid
Feasibility Study Report
Woodbridge Township, NJ

November 7, 2018

design/construction solutions

WOODBRIDGE TOWNSHIP, NJ

MICROGRID FEASIBILITY STUDY REPORT

Prepared for:

Woodbridge Township
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Woodbridge, NJ 07095

Prepared by:

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CHA Project Reference No:

33632

Date:

November 7, 2018

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1.0 EXECUTIVE SUMMARY

The Township of Woodbridge has taken new steps on its road to becoming a more resilient community with its inclusion as one of the 13 New Jersey Board of Public Utilities (BPU) Town Center Distributed Energy Resource Microgrid Feasibility Study Incentive Program. The Township has been working with the team of CHA, Greener by Design, and GI Energy to build on the initial study conducted under the Gardinier Environmental Fund grant through Sustainable Jersey's Small Grants program to further develop a microgrid design that will make the community more resilient, while incorporating energy conservation, efficiency, and renewable energy. The study envisions development of a Town Center Microgrid in two phases with the first including the following facilities:

1.1 Phase I Facilities

Facility Name	FEMA Risk Category
Town Hall/Police	IV
Fire Department	IV
Stern Towers Senior Living (will be demolished and replaced with Brook Street Lofts)	III
Ross Street Elementary School	III
The Medicine Shoppe Pharmacy	II
Gas Station (placeholder)	II
Main Street Development	II
Reo Diner Restaurant	II
Mawbey Street Elementary School	III
Woodbridge Middle School	III
Adams Tower Senior Living	III
Finn Towers Senior Living	III
Pump Station (201 Woodbridge Avenue)	III
North James St. Redevelopment	Unk.

The team also examined the potential to include additional facilities along Woodbridge's Main Street Corridor, which are listed as Phase II facilities and include the following:

1.2 Phase II Facilities

Quick Chek (Convenience Store)	Woodbridge Veterinary Group
Medical Offices	Walgreens
Amici's Sandwich Shop	Krauzer's Food Store
European Deli	Woodbridge Animal Group
Apartments at 75 Main	Chamber Building

CVS/Main Street Farmers Market	MAX Challenge
San Remo Pizza	Woodbridge United Methodist Church
Apartments at 75 Main	St. James Roman Catholic Church

The Phase I facility cluster includes two FEMA Category IV buildings (Town Hall and Woodbridge Fire Department), seven Category III (Senior Living and Schools), and four Category II buildings to support the surrounding population and emergency services, totaling in thirteen buildings. For reasons described in Section 6.2, only 5 of the 16 potential Phase II facilities were included in the DER-CAM model.

The combined existing and proposed WAM assets are estimated to be able to generate up to 6,436,000 kWh of electricity annually which represents approximately 67% of the total annual electricity consumption (9,633,000 kWh) of the Phase I microgrid customers. The total thermal load for all Phase I facilities are estimated to be 1,141,000.

Phase I of the project will also to serve loads from new developments (Brook Street Lofts, Rahway Ave. Redevelopment, Main Street Development and the North James Street Redevelopment) planned within the downtown core. These facilities have respective electric and thermal loads (derived by interpolating similar facility data analyzed for Phase I &II facilities) of 4,407,000 kWh and 500,000 therms of gas respectively.

The area of the Woodbridge Town Center Advanced Microgrid (WAM) spans approximately 1.25 miles from the farthest points, Mawbey Street Elementary School and the Pump Station, with at least nine of the sites within a ½ mile radius via roadway, the cluster covers a distance of approximately 1.5 miles end to end. A detailed satellite image of the Woodbridge Advanced Microgrid boundary denoting the Phase I & II facilities under study is provided in Appendix A - WAM Microgrid Boundary.

The WAM facility (thermal and electrical) load profiles were represented in DERCAM™ (Distributed Energy Resources Customer Adoption Model) to allow for the selection, optimization and placement of a variety of distributed energy resources (DERs) considered for this project. The DERCAM software (developed by the Berkeley Lab) can be used to find the optimal portfolio, sizing, placement, and dispatch of a wide range of DERs, while co-optimizing aspects of load shifting, peak shaving, power exporting via participation in ancillary service markets. In the process of finding optimal DER solutions for the WAM, several attributes must be satisfied, including:

- What is the optimal portfolio of DER that meet the specific needs of the WAM?
- What is the ideal installed capacity of these technologies to minimize costs?
- How should the installed capacity be operated so as to minimize the total customer energy bill?
- What is the optimal DER solution that minimizes costs while ensuring resiliency targets?

In satisfying these key considerations of the WAM, the selection of DERs respective of facility was contingent upon the selected DER's technology spatial requirements, heat-to-power ratio to be displaced by the host facility(s) and the attributes of the DER's generative capacity on the respective PSE&G circuit serving the facility. The optimal selection and configuration of DER's for the WAM are best described in the block-chain diagram "DER-CAM Microgrid Topology" found in Appendix B. This diagram, in conjunction with the DER's recommended for further implementation and their prescribed mode(s) of operation are depicted in section 8 herein.

The result of the DER-CAM model and subsequent analysis for the facilities studied finds that the Woodbridge Township Microgrid is technically feasible and financeable. The recommendation of this study is for the Township of Woodbridge engage an independent developer(s) to solicit a contracting model to implement the suggested DERs (cited below) and subsequent facility modifications to support implementation of the WAM.

Facility Name	Recommended DER Technology to be Installed	Capacity (kW)
Woodbridge Town Hall	Gas Engine Generator (CHP)	500
Mawbey Street Elementary School	Photovoltaic	54
Reo Diner Restaurant	Photovoltaic	177
Woodbridge Middle School	Photovoltaic	40
Fire Department	Photovoltaic	70
Ross Street Elementary School	Photovoltaic	344
Stern Towers (Brook St. Lofts Redevelopment)	Photovoltaic	262
Woodbridge Town Hall	Photovoltaic	340
Main Street Redevelopment	Photovoltaic	449
Rahway Avenue Redevelopment	Photovoltaic	200
North James Street Redevelopment	Photovoltaic	200

2.0 PROJECT NAME

Woodbridge Town Center Advanced Microgrid (WAM).

3.0 PROJECT APPLICANT

The Township of Woodbridge.

4.0 PROJECT PARTNERS

In developing this report, Woodbridge Township has worked with several partners and anticipates additional partners as the project continues. Woodbridge has signed documents with the Board of Public Utilities and the local utilities PSE&G and Elizabethtown Gas. Both local utilities have been forthcoming, and their cooperation is outlined in section 15. Additionally, the team engaged other thought leaders to add deeper information for the study. Siemens provided information on technology and controls based on the information provided through generation and location of feeders. Navigant/Compass provided insight on financial analysis and ownership structures. BRS, Inc. assisted the team with tariff analysis.

Woodbridge anticipates entering into MOU/LOIs with existing enrolled entities to secure their involvement once the microgrid project enters into the next stage. Such project partners are the private businesses and school district buildings identified in this study. Additional businesses, as outlined in phase 2 along Woodbridge’s Main Street corridor and future mixed development projects, will have the option of enrolling into the microgrid infrastructure once complete. Woodbridge is considering the adoption of a local ordinance that would compel these developments to connect to the microgrid. Woodbridge and the project team engaged the developers in discussion that would require their connection to the current microgrid project. The larger user base provided by these loads will enhance the economics of microgrid. Future development projects will be required by the township to connect to the microgrid when feasible and specific language will be incorporated into their developer’s agreement with the township.

4.1 Consulting Team

CHA Consulting, Inc.

CHA is a full-service engineering consulting firm, is ranked among Engineering News-Record's Top 100 firms in the nation. A staff of 1000 highly qualified and skilled professionals provides a wide range of engineering and support services. We are extremely active in the energy audit market as well as energy conservation and renewable energy design. Our energy audits have saved our clients over $50 million dollars in energy costs. CHA has many years of experience and has successfully completed tens of thousands of projects in the engineering of building systems (structural, mechanical, electrical and plumbing) and the design and installation of roof mounted telecommunications equipment. CHA is currently working on renewable projects throughout the U.S. Most recently, we are completing a wind/solar roof mounted system at the Rochester International Airport and are in the implementation partner selection stage of a campus wide microgrid for Gallaudet University in Washington DC.

CHA has served the energy industry nationwide from 40 offices throughout the United States. Our project management expertise, efficient production methods, and fast-track project scheduling enables us to quickly and effectively plan, design, permit, and construct energy systems of all sizes and scopes. Expertise gained from our long successful history of designing building systems can be applied to a wide variety of renewable energy solutions include structural analysis and design, utility coordination and design, zoning, permitting, preparation of construction documents, permitting, grounding design and photo simulations.

Greener by Design

Greener by Design, an Energy Investment and Environmental Asset Management TM firm, and its multidisciplinary staff of energy, engineering and environmental financial, project management and grant writing professionals, is pleased to present this Town Center Distributed Energy Resource Microgrid Feasibility Study proposal to the Township of Woodbridge. Greener by Design's regular service offerings and experience are extremely well suited to the requirements of this study. In fact, accomplishing assignments such as this is a major focus of our firm. Greener by Design brings a comprehensive understanding of the economic and policy underpinnings of a rapidly changing energy and environmental landscape as well as a fresh perspective on how technology, innovation and legislation will influence the market in years to come.

Greener by Design presently provides or has provided Energy Investment and Environmental Asset Management planning and grants services to a number of private and public clients. Of these, NJ municipalities include Hoboken, Seaside Heights, Mantoloking, Woodbridge, Paterson, Linden, Rahway, Dover, Jersey City, Newark, Greenwich, Harding Township, Parsippany-Troy Hills, Warren and Monmouth Counties, CCMUA (Camden County Municipal Utilities Authority and grant writing and management/compliance services for Hudson County Improvement Authority (2011 through 2017). Additionally, under contract to the non-profit New Jersey Clean Cities Coalition, Greener by Design managed a $15 million DOE grant to offset the cost of the conversion of 305 garbage trucks and shuttle buses to Compressed Natural Gas (CNG), and the installation of six CNG fueling stations. The major public/private participants in the NJCCC project include the City of Newark, Atlantic County Utilities Authority (ACUA), Waste Management, Central Jersey Waste, Atlantic City Jitney Association, and Clean Energy.

Greener by Design specializes in facilitating several programs offered by the New Jersey Clean Energy Program. Our detailed project management and familiarity with the programs has allowed our team to successfully secure incentive monies from Direct Install, Pay for Performance, Local Government Energy Audit, Combined Heat and Power and Fuel Cells, Prescriptive and Custom Upgrades for Indoor Lighting, and procured SRECs for several solar projects.

Greener by Design's staff has recently worked on a variety of post-Sandy planning projects for energy master planning. Under a sub-contract with NJIT, Greener by Design is working with Neptune, Galloway, and Newark to create a toolkit and academic program for resiliency planning and the preliminary feasibility of back-up power or microgrids. GbD also obtained a Gardinier Environmental Fund Grant through Sustainable Jersey Small Grants program in December 2015 to examine the potential development of a microgrid in the Township of Woodbridge. The study identified public and private stakeholders that would need the ability to operate critical functions and provide necessary support for the town and the surrounding area.

GI Energy

GI Energy is an innovative integrator of distributed energy and sustainability resources for large commercial buildings, campuses, municipalities and large real estate developers. As a technology agnostic provider, our team focuses on delivering bespoke solutions for our clients, leveraging the latest in commercial technologies including geo-exchange HVAC, energy storage, renewable electricity generation, fuel cells and combined heat and power. We seek opportunities where multiple technological solutions can be brought to bear on a complex set of economic and environmental problems.

GI Energy specializes in providing consulting, development, underwriting, engineering, management, construction and advisory services to building owners and property developers with a specific focus on distributed energy resources (DERs). GI Energy operates with offices in California, Illinois and New York and includes seasoned energy and financial analysts, engineers, project development professionals and operations and maintenance technicians.

GI Energy's development group possesses unique commercial and technical expertise in developing sustainable and efficient distributed energy resources.

5.0 PROJECT LOCATION

The area for the Woodbridge Town Center Advanced Microgrid (WAM) stretches approximately 1.25 miles from the farthest points, Mawbey Street Elementary School and the Pump Station, with at least nine of the sites are within a ½ mile radius via roadway, the cluster covers a distance of approximately 1.5 miles end to end. A detailed satellite image of the Woodbridge Advanced Microgrid boundary denoting the Phase I & II facilities under study is provided in Appendix A - WAM Microgrid Boundary.

6.0 PROJECT DESCRIPTION

6.1 Introduction

Woodbridge, New Jersey is located in the heart of the transportation network that helps to make our state one of the most vital economic engines in the US. The home to over 100,000 people that swells to multiples of that during the day as people come to work, shop and go to school here in town.

These assets, combined with a large population, a large business community and the fact that Woodbridge is a vulnerable Coastal Community all point to the critical need for a distributed generation system that is robust and capable of being able to help operate during times of critical need.

Woodbridge has been the leader in the state when it comes to its efforts on sustainability and energy conservation. Woodbridge was the Sustainable Jersey Town of the Year for 7 of the last 8 years. Woodbridge has engaged in the auditing of all of its facilities, has implemented Energy Efficiency and conservation and control measures and has worked with its school board and others to install solar and other energy production and efficiency measures.

While the listed facilities in Section 7.2 (and the selected DER's highlighted in Section 7.4 & 7.5) meet the requirements of a Town Center Microgrid (i.e. present financial benefits, price stability, power quality, efficiency, sustainability and resiliency to customers) there are numerous other facilities within the downtown core that would prove valuable to the community should they ultimately be served by WAM. These businesses include convenience stores, pharmacies, gas stations, etc. As part of the ongoing effort to implement the microgrid, we would seek to add as much adjacent commercial load as possible to enhance the community value vector and economic sustainability.

Phase I locations for DER technologies can be identified in Appendix A and were selected through an analysis of the overall load breakdown between electric and thermal consumption. Furthermore, the proximity to nearby circuits that serve additional Phase I facilities, and available space for potential PV applications was also considered when determining Phase I facilities. With the exception of the Gas Station(s) and Pump Station (201 Woodbridge Avenue), new and existing DER technologies for the critical facilities were included in DER-CAM to develop an initial concept for an optimized microgrid system. The gas station(s) were excluded from the WAM analysis due to the minimal electrical and thermal profiles that could be displaced by subject DERs and their physical proximity to the black-sky circuit dedicated to serve the WAM. The Pump Station facility was excluded from the WAM analysis due to the economic trade-offs considered in formulating the conceptual design for the WAM's black-sky mode of operation where described in section nos. 8.2 and 8.3. It is recommended that the Pump Station facility implement a "behind the meter" natural gas fired reciprocating engine-generator operating in simple-cycle that is capable of displacing the facilities entire electrical load while operated in "island" mode (isolated from the utility when power supply or quality becomes an issue). It is further recommended that this engine-generator be located is an area at this facility to ensure its operation and resilience in time of need, i.e. on the building's roof-top or elevated on piers such that the equipment/system is accessible from the main facilities electrical/mechanical room.

6.2 Approach to Analysis

Analysis of each facility was based on utility data for monthly electric and thermal consumption during 2015 – 2017 where available for the listed Phase I facilities in Section 7.2. Since each facility is either a residential/commercial/government type of building, detailed interval data highlighting variations in daily, weekend, seasonal loads was not available. A profile of the overall peak, minimum, and average loads was able to be estimated for Phase I facilities from their respective utility bills; however, this breakdown of thermal and electrical loads for Phase II potential additional facilities was not available.

Annual electrical and thermal consumption was estimated for the Phase II potential additional facilities by utilizing the operating hours, and square footage of the facility to develop an adjustment factor. This factor was applied to the total annual load derived from a Phase I facility of similar type. A 24-hour load profile was estimated from this data, which was then implemented into DER-CAM for further analysis of potential distributed energy resource (DER) technologies. Of the potential facilities in the Phase II cluster, only the below five (5) were considered in the WAM model as the remaining facilities examined have minimal displaceable electrical and thermal loads. Although the remaining Phase II facilities were not modeled, because they provide what may be determined to be critical community services, they remain as potential Phase II facilities. The Phase II facilities that were included in the model were determined based on their proximity to the electrical feeders that are planned to be utilized in Phase I, and quantity of the facility's respective load profile that could be displaced. These facilities are:

- European Deli
- Apartments 75 Main Street
- Amici's Sandwich Shop

- Walgreens
- Quick Check (Convenience Store)

None of the potential Phase II facilities included in the DER-CAM model were assumed to have any DER assets. Section 6.3 and 6.4 below discuss the total monthly utility production and consumption for the entire microgrid shown in Appendix C, and each Phase I facility is shown in Appendix D. Appendix B includes a DER-CAM microgrid topology that highlights the respective DER technologies, and heating/cooling loads for the critical facilities and potential additional facilities included in the model.

6.3 Monthly Analysis

6.3.1 Electrical

Electrical production and consumption for each facility studied are denoted in Appendix B. The categories indicated are: PV production, CHP production, utility purchase, and original electric load. DER-CAM develops a typical 24-hour load profile based on load information that was input to the model. This 24-hour load profile is extrapolated over the course of a year to generate the annual profile, broken down by each month. There exists no discrete differentiation between week and weekend loads due to the restrictions from the available data sets collected.

Section 7.4 outlines the CHP and mode of operation while Section 7.5 outlines the PV DER technologies and mode of operation for the Phase I facilities. PV production includes all renewable solar generated electricity from the combined solar arrays from each of the highlighted Phase I facilities with new and existing PV installations. Both categories are a lumped value that also includes the amount of electricity that is exported for sale to the grid during blue-sky operation. In the event of black-sky operation, the PV production will supplement the loads of the other facilities connected in the microgrid.

6.3.2 Heating & Cooling

Heating dispatch was analyzed in a similar method as the electrical generation in DER-CAM, under the premise that a 500 kW reciprocating combustion engine would be implemented at the Woodbridge Town Hall with waste heat recovery. Appendix B shows the monthly profile for heat generated from CHP and heat generated through the purchase of fuel. The heat load summary in Appendix B shows the representation of heat consumption for all facilities modeled in DER-CAM, not just those connected on the thermal loop. Only the facilities included on the thermal loop have the potential to subsidize their heating load through excess heat that is exported by DER technologies into the loop itself. For example, the heat from the CHP unit is used to displace the heating loads of all the buildings in the thermal loop. There is no excess heat from the CHP that isn’t utilized by the buildings in the thermal loop, as the original heat load matches the sum of heat generated from the CHP, and from fuels.

During the summer months when heating is not required, two situations can occur. The first relies on expansion of the thermal loop to potentially include new modular absorption chillers that will serve the Main Street redevelopment, Rahway Ave. Redevelopment, Walgreens, and Quick Check cooling loads. Refrigeration load at the Town Hall would not be displaced by these chillers as this facility has already installed relatively new (efficient) chillers. If the economics of this possibility do not prove worthwhile, the second option is shutting down the CHP unit entirely.

6.4 Phase I Facility Analysis

Appendix D shows the monthly profiles for electrical and thermal consumption for each facility identified in the DER-CAM model. This includes all of the Phase I facilities, and the Phase II potential additional facilities listed in Section 6.2.

As the Phase II potential additional facilities do not possess any DER technologies of their own, their loads act as a “sink” for when excess loads are exported from the Phase I facilities that do utilize DER technologies. As an inherent limitation to DER-CAM, the electric utility purchase for each facility is only considered at the user specified sub-stations. All the outstanding electricity that is not generated within facilities connected in the model is “purchased” at the substation, and then exported to each subsequent facility in the system. As a result, the representation of “power import” includes facility generated power, as well as purchased power from the grid. DER-CAM does not possess the ability to break out the amount of electricity purchased by each individual facility. Categories of “PV production” and “CHP production” include the total production from each respective generation source, including power utilized for self-consumption and exportation to the grid.

6.4.1 Mawbey Elementary School

The Mawbey Elementary School has an existing 100 kW PV system on the roof of the school. An additional 54 kW system is proposed for the school’s premises, as shown in Figure 1 below. The combined PV system would be capable of supplying the school with sufficient electrical load during the day, with the ability to export a portion of this electrical production to the grid during blue-sky operation. Periods in which the PV system is not active would require the facility to purchase electricity from the grid. As shown in the monthly profile for the facility, PV production satisfies at a minimum 50% of the electrical load during the winter months, and >70% during the summer months. Throughout all months there is a significant portion of PV production that can be exported to the grid.

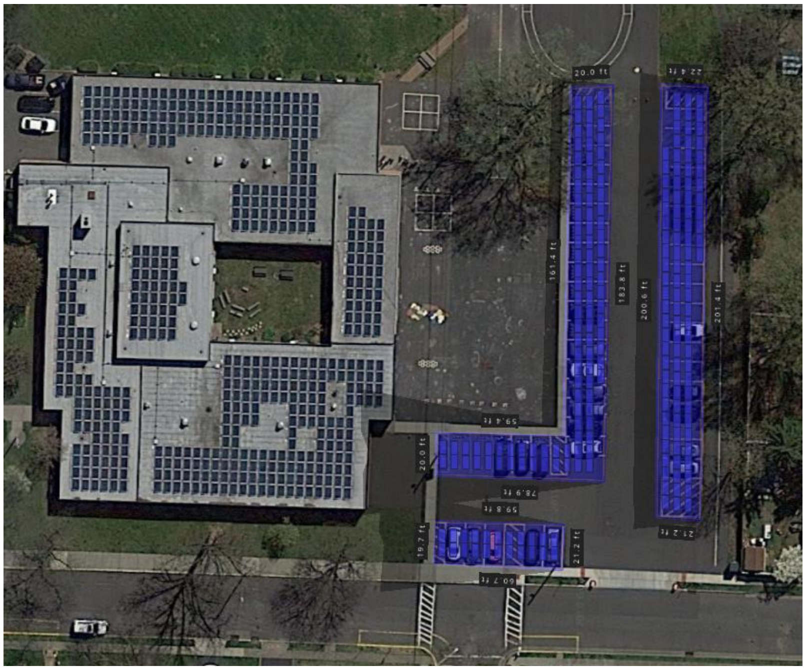


Figure 1. Mawbey Elementary School Helioscope Solar PV Mock-up.

As there exists no heating DER technologies at the Mawbey Elementary School, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

6.4.2 Reo Diner Restaurant

The Reo Diner Restaurant has no existing generation technology on-site. A new 177 kW PV system is proposed for the diner's premises. This PV system is proposed to be ground-mounted in the parking lot of the diner and is intended to displace the majority of the diner's electrical load. Figure 2 below is a visual representation of the proposed solar PV canopies for the Reo Diner. As seen in Appendix B the monthly summary for electrical consumption, the PV system acts to displace between 30% – 50% of the electrical load during the year. There exists minimal opportunity to export power to the grid at this location, with a range of 2,000 – 10,000 kW exported through the year depending on the month.

Figure 2. Reo Diner Helioscope Solar PV Mock-up

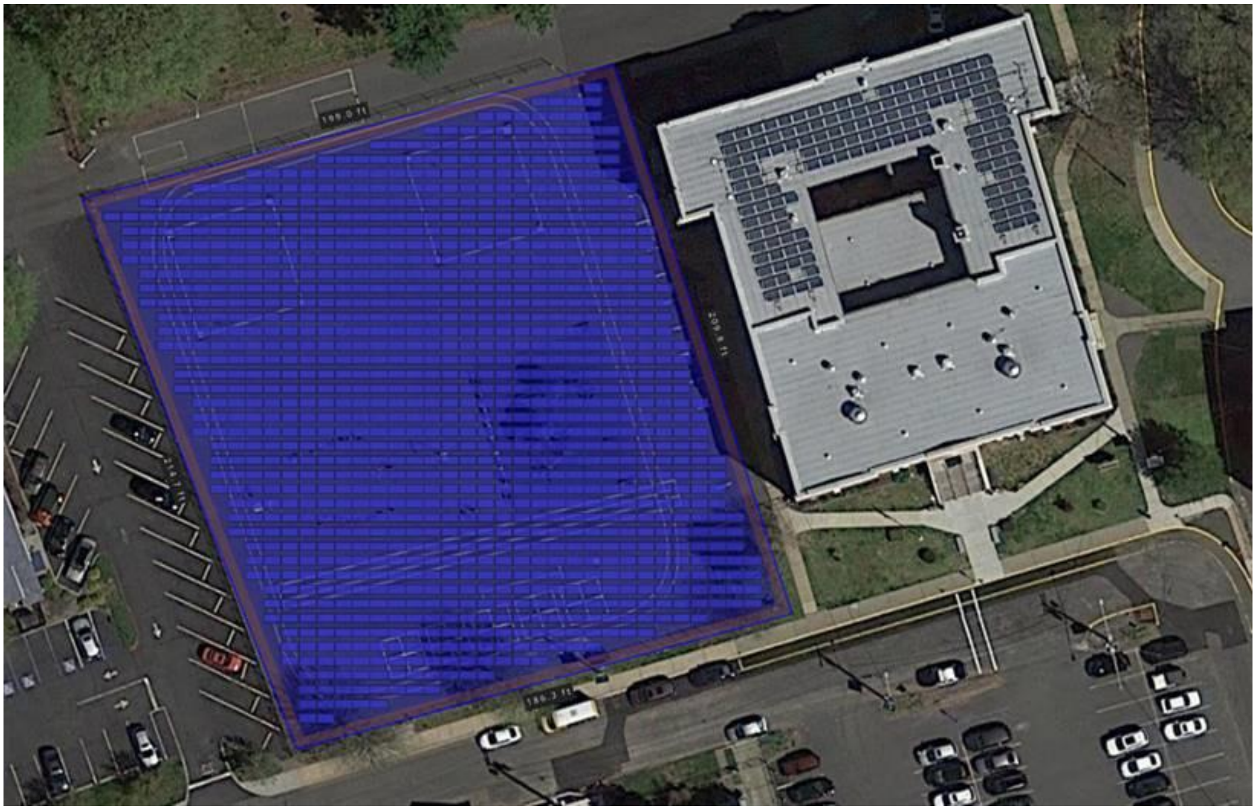
As there exists no heating DER technologies at the Reo Diner Restaurant, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

6.4.3 Ross Street Elementary School

The Ross Street Elementary School has an existing 30 kW PV system on the roof of the school. An additional 344 kW system is proposed for the school's premises. The combined PV system would be capable of supplying the school with sufficient electrical load during the day, with the ability to export a portion of this electrical production to the grid during blue-sky operation. Periods in which the PV system is not active would require the facility to purchase electricity from the grid. As shown in the monthly profile for the facility, PV production satisfies approximately 50% of the electrical load during the winter months, and between 55% – 80% during the summer months. Opportunities for exporting power to the grid exist from February – November.

As there exists no heating DER technologies at the Ross Street Elementary School, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

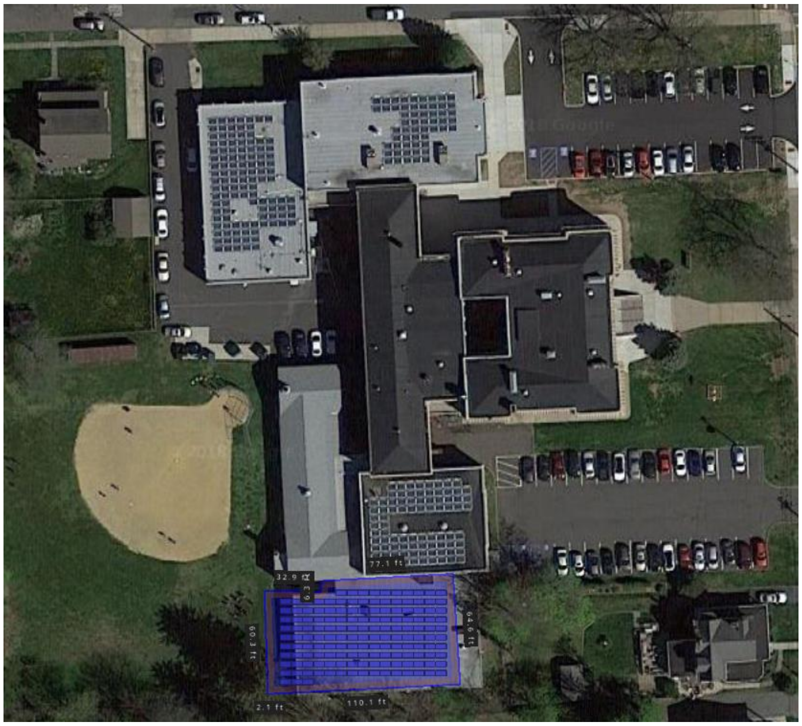
Figure 3. Ross Street Elementary School Helioscope Solar PV Mock-up



6.4.4 Woodbridge Middle School

The Woodbridge Middle School has an existing 50 kW PV system on the roof of the school. An additional 40 kW system is proposed for the school's premises. Figure 4 below is a visual representation of the solar PV array proposed for Woodbridge Middle School. This PV system is restricted to a roof space that can accommodate new PV. Parking canopies may be considered but were not included at this time due to aesthetics concerns. Periods in which the PV system is not active would require the facility to purchase electricity from the grid. As shown in the monthly profile for the facility, PV production satisfies a 20% - 50% of the electrical load profile throughout the year. In addition, a 50 kW BESS (Battery Energy Storage System) is contemplated at this facility to help reserve some of this PV production due to its remote location from other critical facilities. Opportunities for exporting power to the grid are minimal, with only August and September showing potential.

Figure 4. Woodbridge Middle School Helioscope Solar PV Mock-up



As there exists no heating DER technologies at the Woodbridge Middle School, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

6.4.5 Woodbridge Fire Department

The Woodbridge Fire Department has an existing 20 kW PV system on the roof of the facility. There is the potential to add an additional 70 kW of PV; however, due to the construction of the roof, and the minimal space in the parking lot, this opportunity may be limited. As such no new solar PV was included in the DER-CAM model. Currently, the on-site PV system in place can supply upwards of 50% of the total original electric load, while possessing the ability to export further power each month of the year. Periods in which the PV system is not active would require the facility to purchase electricity from the grid.

As there exists no heating DER technologies at the Woodbridge Fire Department, and it is too far displaced to be a part of the thermal loop, the heating consumption at the facility is 100% the result of purchased fuel.

6.4.6 Stern Towers / Brook Street Lofts Redevelopment

Stern Towers has no existing generation technology on-site. As this facility will be demolished and re-developed as the Brook Street Lofts redevelopment. A new 262 kW PV system for the roof and parking lot is contemplated for the new facility. Based on the assumption that this new development will possess a similar thermal and electrical load to Stern Towers, the new PV system will provide 20% - 40% of the original electrical load. There exists the opportunity to export power to the grid throughout the year except for July and August; however, as this is a residential building, this is heavily dependent on load and time-of-day, resulting in greater or fewer opportunities throughout the year.

As there exists no heating DER technologies at Stern Towers, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

6.4.7 Adams Towers

Adams Towers has no existing generation technology on-site. New generation technologies were not included for this site due to their proximity to the other critical facilities and insufficient roof space for solar PV.

As there exists no heating DER technologies at Adams Towers, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

6.4.8 Finn Towers

Finn Towers has no existing generation technology on-site. New generation technologies were not included for this site due to their proximity to the other critical facilities and insufficient roof space for solar PV.

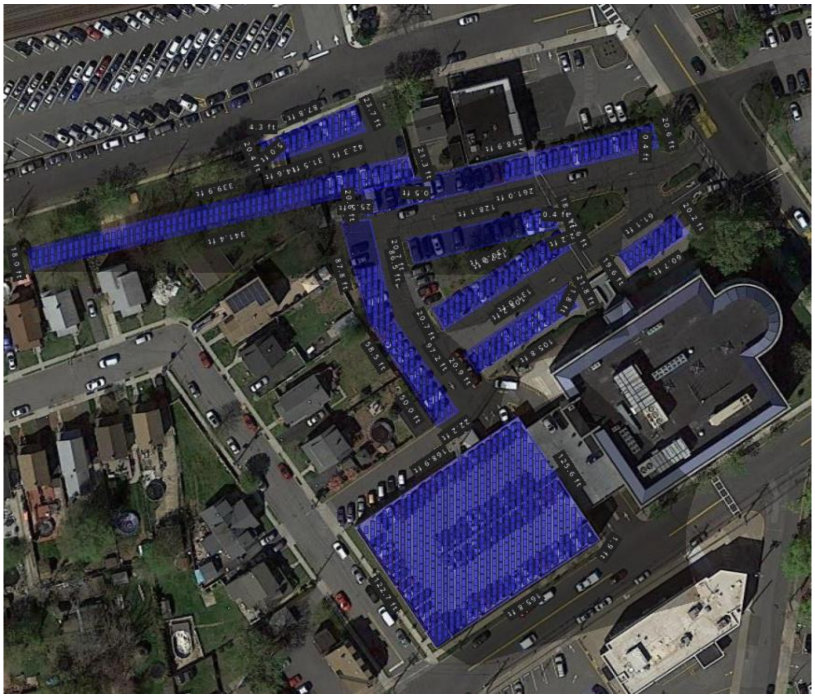
As there exists no heating DER technologies at Finn Towers, and it is too far displaced to be a part of the thermal loop, the heating consumption at the school is 100% the result of purchased fuel.

6.4.9 Woodbridge Town Hall

A 500 kW engine generator, and 340 kW PV system is proposed as new DER technology for the Woodbridge Town Hall for power production and heat recovery. Figure 5 below is a visual representation of the solar PV proposed for the Town Hall. As seen in the Appendix B, there is a significant portion of electrical consumption that is displaced by the PV array. The engine generator was specified to operate at a minimum load of 400 kW; however, during black-sky operation this engine would need to be designed to load follow to ensure the overall microgrid load can be matched during this operation. Furthermore, since there is more electrical production from the generator than consumption for specific months, the engine would need to load follow during blue-sky operation, pending further investigation into the sale of generator produced electricity back to the grid. Section 7.4 describes CHP mode of operation during blue-sky and black-sky operation in more detail.

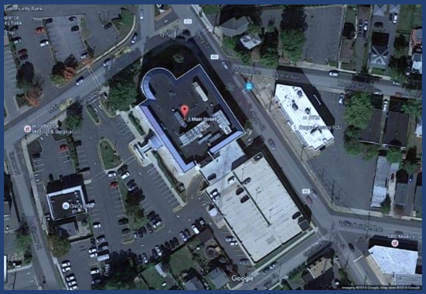
The 340 kW PV system supplements the original electrical load during periods in which the engine generator cannot supply enough power to meet the demand of the facility. Opportunities exist in all months of the year to export solar power to the grid.

Figure 5. Town Hall Helioscope Solar PV Mock-up



The Woodbridge Town Hall is the only location specified in the microgrid that will generate heat for the thermal loop. All heat generated beyond the original heating load is "exported" from the facility and used to supplement the heating load for connected facilities in the thermal loop. It is estimated that the engine generator will be able to provide the entire heat load for the Woodbridge Town Hall throughout the year, as well as provide additional supplemental heat to the thermal loop where denoted in Appendix F.

TOWN HALL/POLICE



1 MAIN STREET WOODBRIDGE TOWNSHIP, NJ 07095

FACILITY TYPE:	**MUNICIPAL BUILDING**
FEMA CATEGORY:	**RISK CATEGORY IV**

Contact Information:
Brian Burke
Brian.Burke@twp.woodbridge.nj.us
732.675.4619 ext. 2042

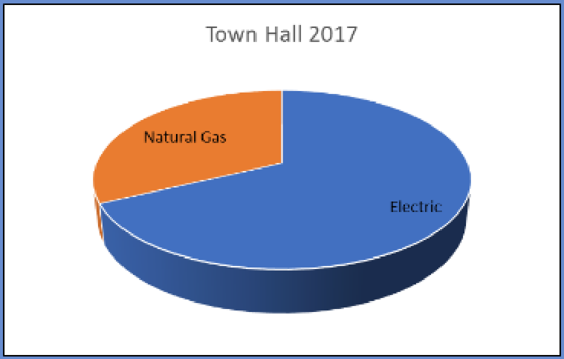
DESCRIPTIONS/SIGNIFICANCE

The Woodbridge Townhall is the anchor and emergency center of the city. Along with the fire station, this facility is one of the highest assets to guard during emergency times. The building to host to the critical government decision making for the township as well as the police headquarters. The township's communications center and relays are also hosted on site.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**YES**

ENERGY USAGE FACT SHEET

Hours of Operation:	**24/7**
Annual Electric Load:	**2,857,784 kWh**
Monthly Load:	**238,149 kWh**
Annual Cost:	**$341,991**
Total Sq Footage:	**93,700**
Annual Gas Load:	**46,001 Therms**
Monthly Load:	**3,833 Therms**
Annual Cost:	**$37,995**
ECM Installed:	**YES**
Demand Response:	**NO**

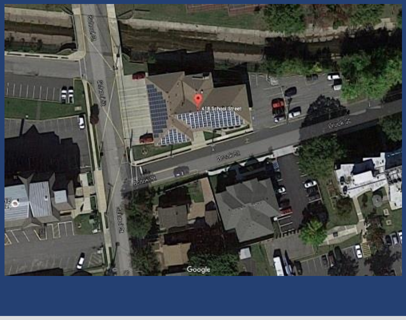


FIRE DEPARTMENT

418 School St, Woodbridge, NJ 07095

FACILITY TYPE:	**FIRE EMERGENCY**
FEMA CATEGORY:	**RISK CATEGORY IV**

Contact Information:
Chief Patrick Kenney
Patrick.kenny@twp.woodbridge.nj.us
732-602-7361



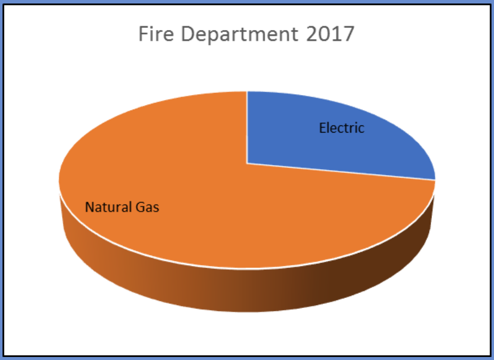
DESCRIPTIONS/SIGNIFICANCE

The Woodbridge Fire Department is one of several firehouses that serves greater Woodbridge. Woodbridge Fire Department serves the residents of Woodbridge Proper and Sewaren, a population of about 22,000 over approximately 5 square miles. The critical building is located on School Street and is a few blocks away from Main Street and the Town Hall.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**YES**

ENERGY USAGE FACT SHEET

Hours of Operation:	**24/7**
Annual Electric Load:	**83,712 kWh**
Monthly Load:	**6,976 kWh**
Annual Cost:	**$9,433**
Total Sq Footage:	**1,600**
Annual Gas Load:	**7,335 Therms**
Monthly Load:	**611 Therms**
Annual Gas Cost:	**$4,948**
ECM Installed:	**NO**
Demand Response:	**NO**



STERN TOWER

55 Brook Street, Woodbridge, NJ 07095
FACILITY TYPE: **Senior Living**
FEMA CATEGORY: **RISK CATEGORY III**

Contact Information:
Lawrence Stecker
ls@woodbridgehousingauthority.org
732-726-1006

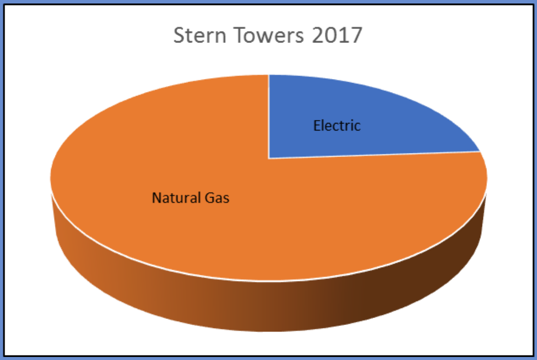
DESCRIPTIONS/SIGNIFICANCE

One of several residential towers in Woodbridge, Stern Towers house is located across the street from Woodbridge Train Station and is one block over from Main Street. The building houses 60 units over 5 floors. The tower is under the management of the Woodbridge Housing Authority and houses seniors who will shelter in place during emergency times.

Shelter Capability: **YES** State or Federal Critical Facility: **NO**

ENERGY USAGE FACT SHEET

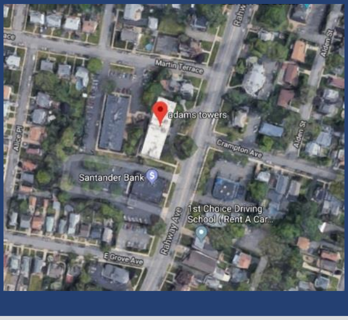
- Hours of Operation: **24/7**
- Annual Electric Load: **321,600 kWh**
- Monthly Load: **26,800 kWh**
- Annual Cost: **$40,338**
- Total Sq Footage: **43,725**
- Annual Gas Load: **36,188 Therms**
- Monthly Gas Load: **3,016 Therms**
- Annual Gas Cost: **$32,610**
- ECM Installed: **NO**
- Demand Response: **NO**



ADAMS TOWER

555 Rahway Ave, Woodbridge, NJ 07095
FACILITY TYPE: **Senior Living**
FEMA CATEGORY: **RISK CATEGORY III**

Contact Information:
Lawrence Stecker
ls@woodbridgehousingauthority.org
732-726-1006



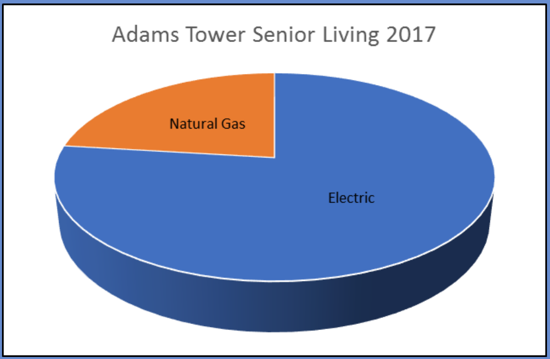
DESCRIPTIONS/SIGNIFICANCE

Adams Towers is located at 555 Rahway Avenue in Woodbridge and is attached to Finn Towers via a breezeway and has close proximity to Main Street and the train station. The building has 5 floors with 65 units. The tower is under the management of the Woodbridge Housing Authority and houses seniors who will shelter in place during emergency times.

Shelter Capability: **YES** State or Federal Critical Facility: **NO**

ENERGY USAGE FACT SHEET

- Hours of Operation: **24/7**
- Annual Electric Load: **323,266 kWh**
- Monthly Load: **26,939 kWh**
- Annual Cost: **$34,302**
- Total Sq Footage: **52,110**
- Annual Gas Load: **2,760 Therms**
- Monthly Gas Load: **230 Therms**
- Annual Gas Cost: **$3,020**
- ECM Installed: **NO**
- Demand Response: **NO**

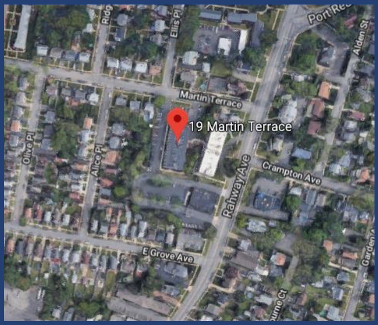


FINN TOWER

19 Martin Terrace, Woodbridge, NJ 07095

FACILITY TYPE:	**Senior Living**
FEMA CATEGORY:	**RISK CATEGORY III**

Contact Information:
Lawrence Stecker
ls@woodbridgehousingauthority.org
732-726-1006



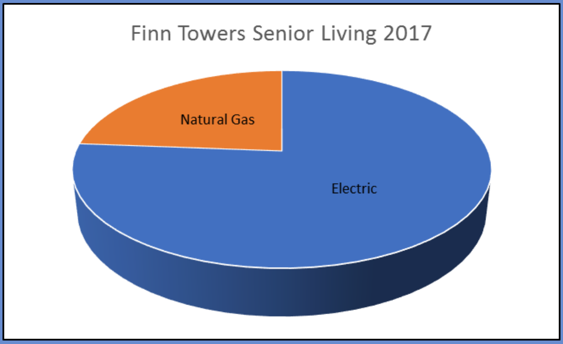
DESCRIPTIONS/SIGNIFICANCE

Finn Towers is located at 19 Martin Terrace and is attached to Adams Towers. The building has 6 floors with 70 units and with Adams Towns houses seniors who will shelter in place during emergency times. Both buildings are within close proximity to the Main Street corridor.

Shelter Capability:	**YES**	State or Federal Critical Facility:	**NO**

ENERGY USAGE FACT SHEET

Hours of Operation:	**24/7**
Annual Electric Load:	**359,000 kWh**
Monthly Load:	**29,917 kWh**
Annual Cost:	**$40,446**
Total Sq Footage:	**35,000**
Annual Gas Load:	**3,438 Therms**
Monthly Gas Load:	**286 Therms**
Annual Gas Cost:	**$3,599**
ECM Installed:	**NO**
Demand Response:	**NO**



PUMP STATION

201 Woodbridge Ave, Sewaren, NJ 07077

FACILITY TYPE:	**Pump Station**
FEMA CATEGORY:	**RISK CATEGORY III**

Contact Information:
Brian Burke
Brian.Burke@twp.woodbridge.nj.us

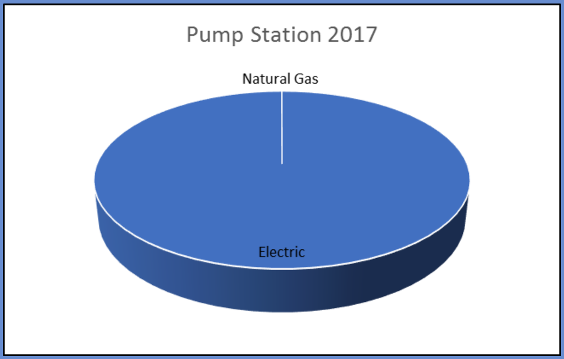
DESCRIPTIONS/SIGNIFICANCE

Woodbridge Pump Station is a vital asset for Woodbridge Township as it pumps sewer water from the community. The facility uses several sewage pumps that demand a high but constant energy usage throughout the year without which, the community could face flooding and backed sewer issues.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**YES**

ENERGY USAGE FACT SHEET

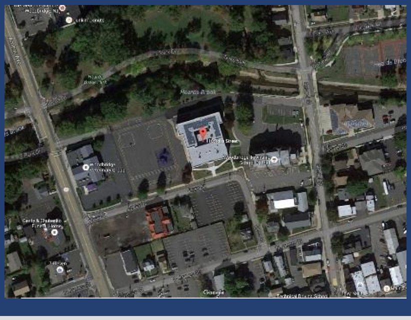
Hours of Operation:	**24/7**
Annual Electric Load:	**3,503,645 kWh**
Monthly Load:	**291,970 kWh**
Annual Cost:	**$418,331**
Total Sq Footage:	**2,270**
Annual Gas Load:	**42 Therms**
Monthly Gas Load:	**4 Therms**
Annual Gas Cost:	**$311**
ECM Installed:	**YES**
Demand Response:	**NO**



ROSS STREET ELEMENTARY

110 Ross Street, Woodbridge, NJ 07095
FACILITY TYPE: **Shelter/School**
FEMA CATEGORY: **RISK CATEGORY III**

Contact Information:
Brian Burke
Brian.Burke@twp.woodbridge.nj.us



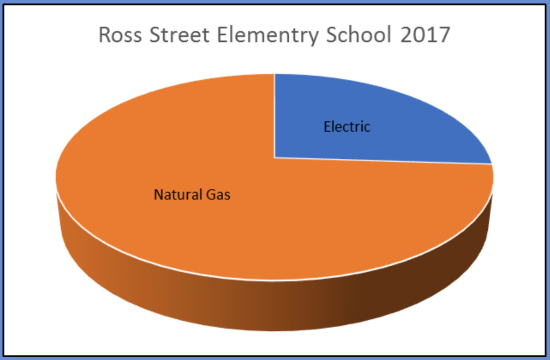
DESCRIPTIONS/SIGNIFICANCE

Ross Street Elementary School is one of several schools in the area and is closed to the Main Street corridor. The school is currently under reconstruction, but is planned to have a similar footprint to the previous school. This school along with the two others listed will act as shelter for emergency situations.

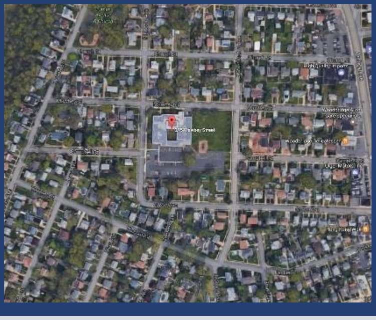
Shelter Capability: **YES** State or Federal Critical Facility: **NO**

ENERGY USAGE FACT SHEET

- Hours of Operation: **8AM–4:30PM**
  Closed Weekend
- Annual Electric Load: **168,743 kWh**
- Monthly Load: **14,062 kWh**
- Annual Cost: **$13,221**
- Total Sq Footage: **47,511**
- Annual Gas Load: **15,600 Therms**
- Monthly Gas Load: **1,300 Therms**
- Annual Gas Cost: **$7,709**
- ECM Installed: **YES**
- Demand Response: **NO**



MAWBEY STREET ELEMENTARY



275 Mawbey Street, Woodbridge, NJ 07095

FACILITY TYPE:	**Shelter/School**
FEMA CATEGORY:	**RISK CATEGORY III**

Contact Information:
Brian Burke
Brian.Burke@twp.woodbridge.nj.us

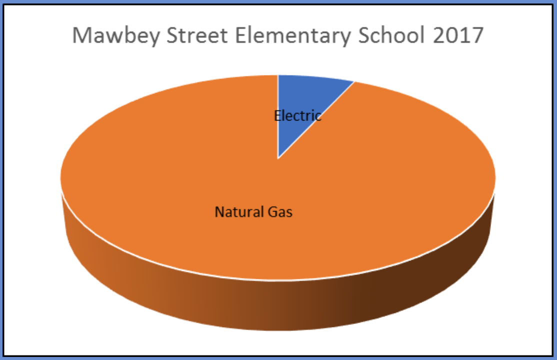
DESCRIPTIONS/SIGNIFICANCE

Mawbey Street is the second elementary school and one of three schools within the microgrid that will act as shelter in emergency situations. Built in 1962, the school houses nearly 400 students and 20 teachers along with additional staff. Like the other schools listed, they already have solar roofs install.

Shelter Capability:	**YES**	State or Federal Critical Facility:	**NO**

ENERGY USAGE FACT SHEET

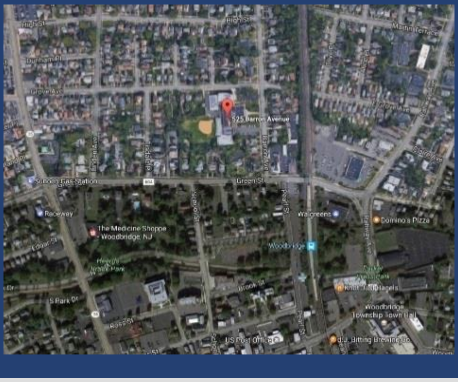
Hours of Operation:	**8AM–4:30PM** **Closed Weekend**
Annual Electric Load:	**28,125 kWh**
Monthly Load:	**2,344 kWh**
Annual Cost:	**$331**
Total Sq Footage:	**27,967**
Annual Gas Load:	**12,973 Therms**
Monthly Gas Load:	**1,081 Therms**
Annual Gas Cost:	**$5,578**
ECM Installed:	**YES**
Demand Response:	**NO**



WOODBRIDGE MIDDLE

525 Barron Ave, Woodbridge, NJ 07095
FACILITY TYPE: **Shelter/School**
FEMA CATEGORY: **RISK CATEGORY III**

Contact Information:
Brian Burke
Brian.Burke@twp.woodbridge.nj.us



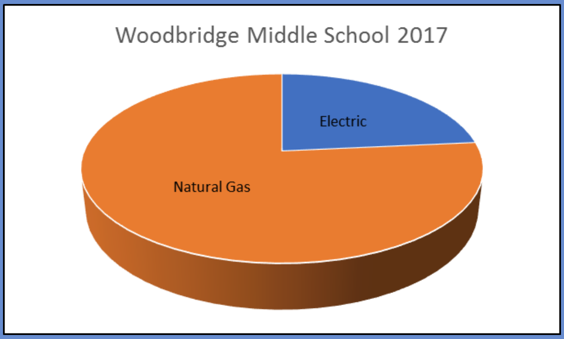
DESCRIPTIONS/SIGNIFICANCE

Woodbridge Middle School is the third school listed within the microgrid along with the two elementary school. The school was built in 1910 and currently serves over 500 students and another 100 in faculty and staff.

Shelter Capability: **YES** State or Federal Critical Facility: **NO**

ENERGY USAGE FACT SHEET

Hours of Operation:	**8AM–4:30PM** **Closed Weekend**
Annual Electric Load:	**353,698 kWh**
Monthly Load:	**29,475 kWh**
Annual Cost:	**$52,274**
Total Sq Footage:	**82,988**
Annual Gas Load:	**37,111 Therms**
Monthly Gas Load:	**3,093 Therms**
Annual Gas Cost:	**$18,040**
ECM Installed:	**YES**
Demand Response:	**NO**

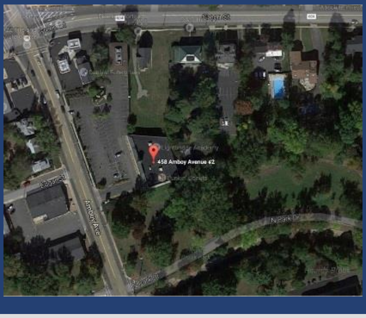


THE MEDICINE SHOPPE

458 Amboy Ave #2, Woodbridge, NJ 07095

FACILITY TYPE:	**Pharmacy**
FEMA CATEGORY:	**RISK CATEGORY II**

Contact Information:
Amy Joswick
732-636-0011



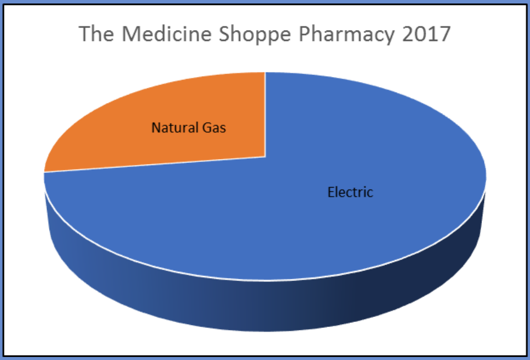
DESCRIPTIONS/SIGNIFICANCE

The Medicine Shoppe is a local pharmacy that has served the community since 1975 for vital prescriptions and medications. The pharmacy located in Mocci Park Center which is owned and managed by Mocci Properties. This is one of several pharmacies in the microgrid area, but was the only active participating pharmacy stakeholder.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**NO**

ENERGY USAGE FACT SHEET

Hours of Operation:	**9AM-6PM** **Closed Sunday**
Annual Electric Load:	**20,125 kWh**
Monthly Load:	**1,677 kWh**
Annual Cost:	**$2,864**
Total Sq Footage:	**1,000**
Annual Gas Load:	**276 Therms**
Monthly Gas Load:	**23 Therms**
Annual Gas Cost:	**$432**
ECM Installed:	**NO**
Demand Response:	**NO**

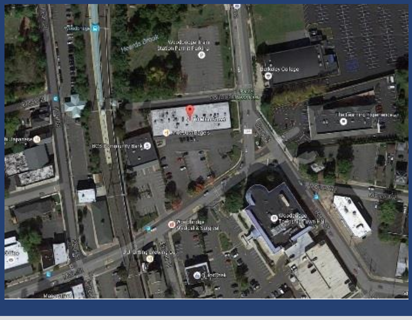


KNOT JUST BAGELS

10 Main St J, Woodbridge, NJ 07095

FACILITY TYPE:	**Food Service**
FEMA CATEGORY:	**RISK CATEGORY II**

Contact Information:
Sharon McAuliffe
732-750-1999



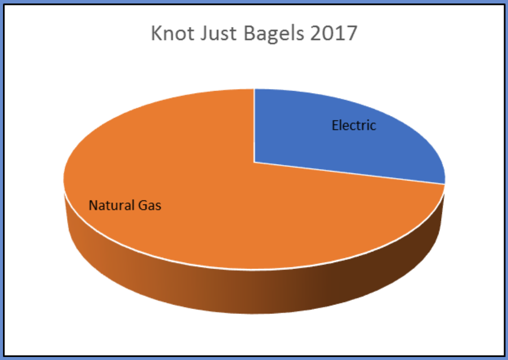
DESCRIPTIONS/SIGNIFICANCE

Knots Just Bagels is located in the plaza across from Town Hall. The shop not only services municipal employees and local residents, but served as a crucial food facility to emergency workers during Hurricane Sandy. The plaza is under plans for possible future develop, which is also examined in the microgrid study, in that case the shop will relocate to Main Street with a similar footprint.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**NO**

ENERGY USAGE FACT SHEET

Hours of Operation:	**5AM-3PM**
Annual Electric Load:	**77,578 kWh**
Monthly Load:	**6,465 kWh**
Annual Cost:	**$8,742**
Total Sq Footage:	**1,500**
Annual Gas Load:	**6,609 Therms**
Monthly Gas Load:	**551 Therms**
Annual Gas Cost:	**$4,327**
ECM Installed:	**NO**
Demand Response:	**NO**

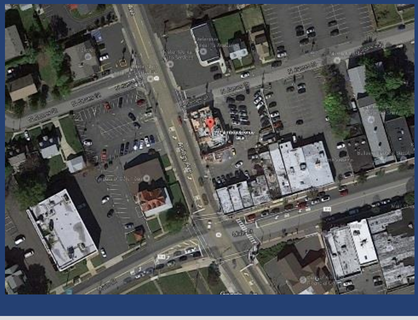


REO DINER

392 Amboy Ave, Woodbridge, NJ 07095

FACILITY TYPE:	**Food Service**
FEMA CATEGORY:	**RISK CATEGORY II**

Contact Information:
Irene Kokodis
732-634-9200



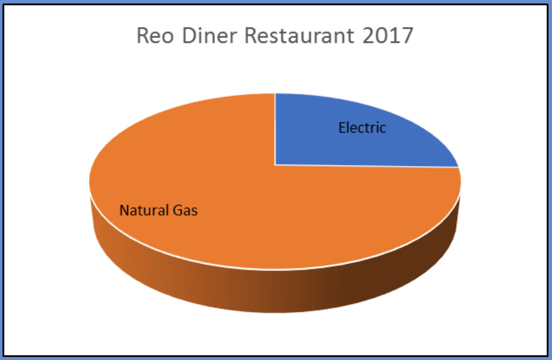
DESCRIPTIONS/SIGNIFICANCE

Reo Diner is the largest food provider and restaurant along Main Street and is located near the corner of Amboy Avenue. During emergency times, the diner will be active in servicing the community and emergency workers.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**NO**

ENERGY USAGE FACT SHEET

Hours of Operation:	**24/7**
Annual Electric Load:	**405,855 kWh**
Monthly Load:	**33,821 kWh**
Annual Cost:	**$45,736**
Total Sq Footage:	**6,500**
Annual Gas Load:	**40,742 Therms**
Monthly Gas Load:	**3,395 Therms**
Annual Gas Cost:	**$33,500**
ECM Installed:	**NO**
Demand Response:	**NO**



GAS STATION

Green St and Amboy Ave, Woodbridge, NJ 07095

FACILITY TYPE:	**Gas Station**
FEMA CATEGORY:	**RISK CATEGORY II**

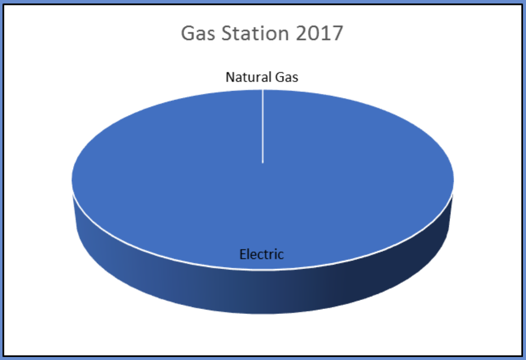
DESCRIPTIONS/SIGNIFICANCE

There are three gas stations located on the corner of Amboy Avenue and Green Street. While none were active participants in the study, data from similar gas stations were used to calculate the energy footprint. Gas stations were crucial during Hurricane Sandy as they provided fuel for residents, emergency workers, and temporary generators, however, many in New Jersey were out of service due to power issues.

Shelter Capability:	**NO**	State or Federal Critical Facility:	**NO**

ENERGY USAGE FACT SHEET

Annual Electric Load:	**100,560 kWh**
Monthly Load:	**8,380 kWh**
Annual Cost:	**$11,332**
Total Sq Footage:	**1,000**
ECM Installed:	**NO**
Demand Response:	**NO**



6.5 Permits/Applications and Right of Way Crossings

To serve the connected thermal loads at each facility prescribed in the WAM, it is envisioned that an underground supply/return network of pre-insulated, direct buried piping would connect the Woodbridge Town Hall (heating supply) to an energy transfer station (ETS) residing within each facility's respective mechanical room. The governing concept is that thermal energy (available as a bi-product of generating electricity in a gas-engine generator) would be pumped though this underground network wherein each facility's respective heating demand would be independently satisfied by drawing the proportionate amount of energy from the thermal loop's heating media ("hot water" aka - 50% propylene glycol-water based solution). The energy contained in the "hot water" would be transferred to the respective facility's heating system through a bank of dedicated heat exchangers (ETS) essentially displacing the quantity of energy that would otherwise be produced by the facility's on-site boiler system(s) firing natural gas.

Installation and operation of this underground thermal network would require that the systems owner engage the respective land owners, public utilities and any other authorities having jurisdiction within this domain to obtain express consent and/or easement of the subject properties.

A Thermal Distribution Network Diagram serving the prescribed facilities in area A is presented in Appendix E.

Listing of Potential Permits

A list of potential permits to implement the WAM are described below; these include:

- Interconnection Approval
- Soil Erosion and Sediment Control Permit
- PSE&G Connection Impact Assessment and System Impact Analysis
- Air Permit(s) for each facility hosting a natural gas fired engine-generator
- Building Permit (respective of each facility modification)

7.0 OWNERSHIP & BUSINESS MODEL

7.1 Overview

State energy policy, incentive programs, current regulatory landscape, and local utility delivery tariff structures affect, in part, how and where behind-the-meter (BTM) distributed energy resources (DERs) are deployed across New Jersey. DERs are the cornerstone assets of a microgrid, thus the microgrid business model is formed, by factors that shape BTM DERs business models. Microgrids touch multiple buildings, link unaffiliated customers, and cross public rights of way, which introduces many new challenges around energy procurement transactions, satisfying regulatory requirements, and the role of the utility. These challenges and proposed solutions are discussed here in the context of the Woodbridge microgrid.

The goal of the WAM is to ensure resiliency and uninterrupted service to critical loads during black-sky events. Black-sky events may be result from failure of grid components, cyberattacks, or natural disasters. The duration and probability of major gird failure, while historically low, is expected be more frequent.[1] Even infrequent grid failures

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[1] State of New Jersey, Department of Environmental Protection: Adapting to a Changing Environment. Retrieved from: https://www.state.nj.us/dep/aqes/adapting.html

have proven to be highly destructive and costly to impacted communities. In addition to providing resiliency during black-sky events, the microgrid should also be able to operate cost effectively during blue-sky conditions. Blue-sky operations are necessary to generate revenues to repay the capital investment.

Several business models for microgrid development have evolved under the current paradigm of interconnection standards, tariff structures, incentives and utility regulations. Three generic business structures assume specific roles for each major stakeholder - the local utility company, the microgrid owner, and the customers. There are also a handful of existing or developing microgrids throughout the world which provide nuance to these roles, and overall microgrid business model approaches. Broadly, the general business models that exist today are described in Table 1:

Table 1. Microgrid Business Models.

Business Model	Description
Entirely Private	The Entirely Private model involves financing, owning and operating the microgrid by a non-utility, third-party or municipal entity. The role of the utility is minimal. Existing and/or new generation and distribution assets are installed, owned and operated by the non-utility entity. DERs in this model may be sited at various locations among the microgrid with the owner determining the economic dispatch. Revenues are generated through energy services, demand reduction and/or microgrid resilience premiums. Customers would purchase most or all their energy from the microgrid.
Entirely Utility	The Entirely Utility model assumes ownership and control of all infrastructure and generation assets lies with the utility. The utility and microgrid customers enter into an agreement regarding fees for resiliency services. The customers continue their interaction with the utility as they would without the microgrid, i.e. paying regular utility bills. However, they may pay a premium for microgrid services over and above their existing rates. In general, complete utility-owned microgrids are not feasible in deregulated states, such as New Jersey where there are restrictions on utilities owning distributed, dispatchable generation assets.
Hybrid (Private & Utility)	The Hybrid model sits somewhere between the Entirely Private and Entirely Utility models. This model assumes a non-utility entity owns the generating assets and controls their dispatch during normal blue-sky conditions. Typically, DERs would be sited BTM at one or more customer sites. Power would then be wheeled during blue-sky and/or black-sky conditions to other microgrid customers through utility-owned distribution assets. Close coordination is required between the utility and microgrid owner to sequence the islanding and paralleling modes of the microgrid. Revenues to the microgrid owner would come from energy sales to customers, services sold into wholesale energy markets, and services rendered to the local distribution utility (ex: demand reduction). The microgrid customers might pay for services through the utility billing mechanism or may receive separate bills from both the utility and the microgrid owner. This model allows the utility to play a role in microgrid distribution asset ownership and operations, even within deregulated states where utility ownership of generation may be prohibited.

7.2 Phase I and Phase II Facility Descriptions

The proposed Town Center microgrid for Woodbridge includes the following sites.

Table 2.

Phase I Facilities	Address
Woodbridge Town Hall	1 Main St, Woodbridge NJ 07095
Fire Department	418 School St, Woodbridge NJ 07095
Stern Towers/Brook Street Lofts	55 Brook Street, Woodbridge NJ 07095
Adams Towers	555 Rahway Ave, Woodbridge NJ 07095
Finn Towers	19 Martin Terrace, Woodbridge NJ 07095
Ross Street Elementary School	110 Ross St, Woodbridge NJ 07095
Mawbey Street Elementary School	275 Mawbey St, Woodbridge NJ 07095
Woodbridge Middle School	525 Barron Ave, Woodbridge NJ 07095
The Medicine Shoppe Pharmacy	458 Amboy Ave #2, Woodbridge NJ 07095
Main Street Development	10 Main St J, Woodbridge NJ 07095
Reo Diner Restaurant	392 Amboy Ave, Woodbridge NJ 07095
Rahway Ave. Redevelopment	10 Main St, Woodbridge, NJ 07095, USA
North James Street	James and Ross Street, Woodbridge NJ 07095, USA

Annual energy costs for these facilities are summarized below. A more detailed monthly breakdown is included in Appendix D.

Phase I Facilities	Annual Elec (kWh)	Annual Elec Cost (USD)	Annual Gas (therms)	Annual Gas Cost
Woodbridge Town Hall	2,851,919	$341,375	46,001	$37,997
Fire Department	83,712	$10,020	7,335	$6,059
Stern Towers/Brook Street Lofts	736,531	$88,163	84,351	$69,674
Adams Tower	302,829	$36,249	2,760	$2,280
Finn Tower	312,613	$37,420	3,438	$2,840
Ross Elementary School	164,195	$19,654	15,600	$12,886
Mawbey Elementary School	27,996	$3,351	12,973	$10,716
Woodbridge Middle School	332,904	$39,849	37,111	$30,654
Medicine Shoppe	20,125	$2,409	276	$228
Main Street Development	1,456,081	$174,532	6,609	$5,459
Reo Diner Restaurant	407,745	$48,807	40,742	$33,653
Rahway Ave. Redevelopment	1,499,846	$179,532	169,122	$139,695
North James Street	714,720	$85,552	714,720	$590,359
Phase II Facilities (5 that were modeled)	722,125	$86,438	26,121	$21,576

In total, the annual electrical and natural gas consumption of these sites is approximately 9,633,000 kWh and 1,167,000 terms of gas. Together, these facilities pay an average all-in electric rate of $0.12/kWh and an average all-in gas rate of $ 0.83/therm respectively.

In addition to the aforementioned sites, the following additional sites have been identified as potential additions to the overall microgrid in the future.

Table 3.

Phase II Additional Facilities of Consideration	Address
Medical Offices	100 Main St, Woodbridge, NJ 07095, USA
Amici's Sandwich Shop	96 Main St, Woodbridge, NJ 07095, USA
European Deli	90 Main St, Woodbridge, NJ 07095, USA
Apartments	54 Main St, Woodbridge, NJ 07095, USA
CVS (Pharmacy) / Main Street Farmers Market	107 Main St, Woodbridge, NJ 07095, USA
San Remo Pizza	87 Main St, Woodbridge, NJ 07095, USA
Apartments	75 Main St, Woodbridge, NJ 07095, USA
Woodbridge United Methodist Church	69 Main St, Woodbridge, NJ 07095, USA
QuickChek (Convenience Store)	5 Main St, Woodbridge, NJ 07095, USA
St. James Roman Catholic Church	369 Amboy Ave, Woodbridge, NJ 07095, USA
Woodbridge Veterinary Group	424 Amboy Ave, Woodbridge, NJ 07095, USA
Walgreens	17 Green St, Woodbridge, NJ 07095, USA
Krauzer's Food Store	535 Amboy Ave, Woodbridge, NJ 07095, USA
Woodbridge Animal Group	195 Woodbridge Ave, Sewaren, NJ 07077, USA
Chamber Building	52 Main St, Woodbridge, NJ 07095, USA
Max Challenge	83 Main St, Woodbridge, NJ 07095, USA

7.3 Microgrid Business Model

The most cost-effective business model to support the Woodbridge Microgrid will be a Hybrid model (described above). Because New Jersey is a de-regulated market, utility ownership of dispatchable generation assets is not permitted, which rules out the Entirely Utility model from a regulatory perspective. In addition to regulatory challenges of its own, the Entirely Private model is ultimately not cost effective because it would require the Microgrid project to carry costs for installing redundant electric distribution infrastructure to electrically connect the Microgrid customers. The Hybrid model attempts to solve both the regulatory and cost barriers of the other models by combining the best characteristics of both.

Under the Hybrid model, a non-utility third-party developer-owner would be responsible for designing, building, owning, operating, and maintaining (DBOOM) the microgrid generation assets. All electricity (and thermal energy in the case of the CHP system) would be sold to microgrid customers at the owner's Levelized Cost of Electricity (LCOE)[2]. Energy sales from the microgrid to customers during blue-sky conditions would be on par with prevailing rates for energy. Under blue-sky conditions, electricity and thermal energy from the CHP system would be sold to the Town Hall building through an Energy Services Agreement (ESA). Electricity from additional solar PV installations would be sold to their host buildings under a Power Purchase Agreement (PPA).

The utility would continue to own the distribution assets serving the microgrid customers under blue-sky conditions and would continue to bill customers for distribution services and any energy purchased from the grid. The business model for the CHP system and the solar PV systems during blue-sky conditions rely on industry standard ESA / PPA agreements and behind-the-meter (BTM) interconnections. Therefore, during blue-sky conditions, the role of the EDC (Electric Distribution Company) and GDC (Gas Distribution Company) are the same as for other BTM DER systems.

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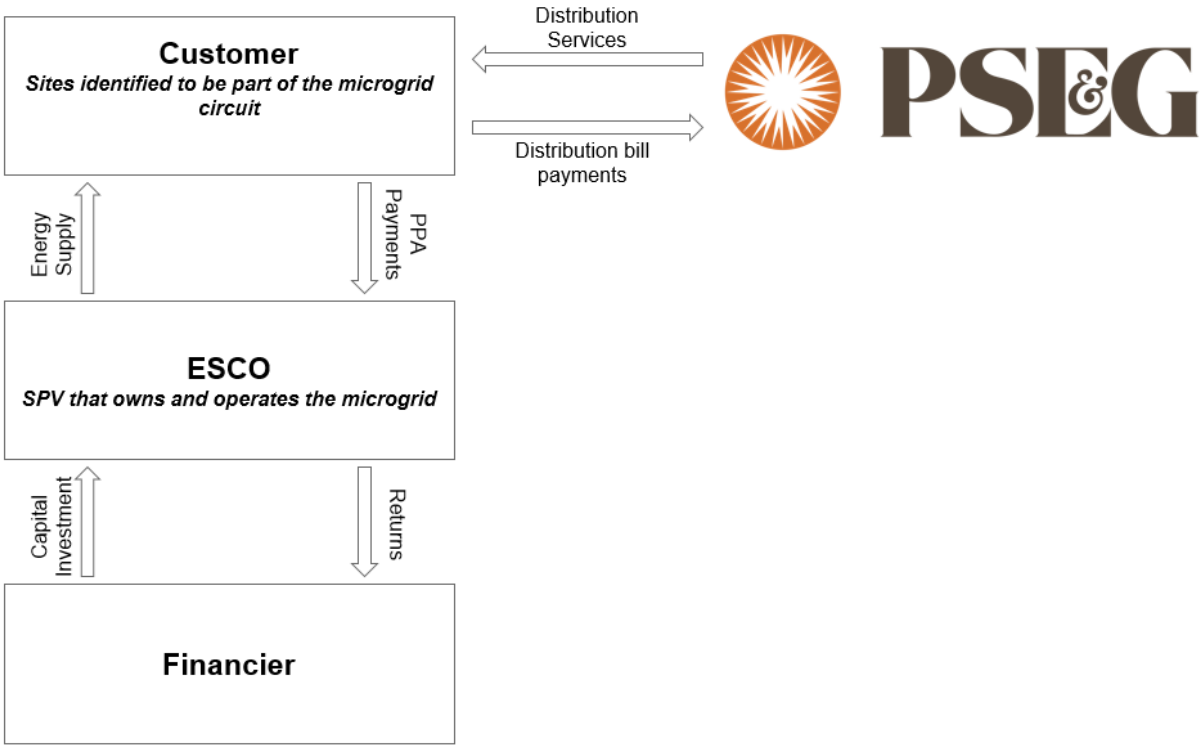
[2] The $/kWh rate that allows the microgrid owner to earn their required rate of return

The microgrid assets are estimated to be able to generate up to 6,436,000 kWh of electricity annually which represents approximately 72% of the total annual electricity consumption of the microgrid customers. To keep the LCOE (and thus, the all-in electric rates charged to customers) as low as possible, it is imperative to suppress soft costs, maximize incentives, and ensure that all revenues streams are being monetized. This can be achieved by structuring the microgrid owner and off-taker relationship depicted in the diagram below:



The energy to support the Microgrid during both blue-sky and black-sky conditions comes from the CHP sited at the Town Hall and rooftop PV arrays across various sites. The specific business model for each microgrid asset derives from the general structure depicted in the illustration.

7.4 CHP Business Model

The 500 kW CHP system to be sited at the Town Hall building will be able to generate nearly all of the electricity used in the building annually. However, the Town Hall will continue to remain connected to PSE&G for supplemental electricity supply during maintenance and other unscheduled downtimes. Under black-sky conditions, the CHP can be run at full load to power the Town Hall building and other loads connected to the microgrid.

The CHP system will also generate enough thermal energy during blue sky operations in the form of hot water to supply the heating and domestic hot water needs of the Town Hall building. At times, the CHP system produces excess thermal energy that cannot be used within the Town Hall. This energy, in the form of hot water, may be sent to other buildings through a hot water loop that will be installed as part of the project.

As listed in Section 6.3.2, excess heat during the summer months can be utilized by absorption chillers to service the cooling loads of the Main Street redevelopment, Rahway Ave. redevelopment, Walgreens, and Quick Check; however, this is predicated on the economics of expanding the thermal loop to include a chilled water loop. If this is not feasible, the CHP unit should be shut down during the summer months. The CHP system would be owned and operated by a third party under the DBOOM model. Revenues from blue sky conditions would include:

- Electricity sales to the Town Hall
- Thermal (hot water) sales to the Town Hall
- Thermal (hot water) sales to other customers connected to the thermal loop (optional)

The transaction would occur under a long-term Energy Sales Agreement (ESA) between the CHP owner and the Town Hall. In addition, ESAs would also need to be executed between the CHP owner and the thermal customers purchasing hot water from the hot water loop.

The thermal and electric energy will be sold at rates comparable to what the sites currently pay for their energy. The ESA contract will typically last the length of a CHP systems accepted useful life, i.e. 20 years.

7.5 Solar PV Business Model

The proposed 2,521 kW of solar arrays will be spread across several sites, as depicted in the table below:

Table 4.

Phase I Facility	Annual Electricity Use (kWh)	Proposed Solar Installation (kW)	Est. Annual Solar PV Production (kWh)
Mawbey Elementary School	27,996	54	95,580
Reo Diner Restaurant	407,745	177	313,290
Ross Street School	164,195	344	608,880
Woodbridge Middle School	332,904	40	70,800
Woodbridge Fire Department	83,712	70	123,900
Stern Towers (Brook St. Lofts Redevelopment)	736,531	262	463,740
Adams Towers	302,829	0	
Finn Towers	312,613	0	
Town Hall	2,851,919	340	601,800
Main Street / Redevelopment	1,456,081	449	794,730
Rahway Ave. Redevelopment	1,499,846	200	354,000
North James Street Redevelopment	714,720	200	354,000
Total	**8,891,091**	**2,136**	**3,780,720**

Under Blue Sky operations, each of the host buildings would enter into a Power Purchase Agreement (PPA) with the DBOOM entity. Electricity produced by the solar PV systems would be sold to the host building at rates at or below what they pay for electricity today. A number of town facilities already operate under a PPA contract for existing solar PV systems. This contractual arrangement is well known, and the Town likely has experience executing them. The PPA contract is likely to mirror the CHP ESA and last approximately 20 years.

Despite these offtake agreements, the solar PV systems are likely to generate excess electricity at Mawbey and the Fire Department. Recently, Governor Murphy signed into law the Act Concerning Clean Energy, which has a special provision for establishing community and remote net metering programs in the state by December 19th, 2019. The DBOOM entity expects to use these net metering programs to monetize the excess PV production during Blue-Sky conditions. During Black-Sky events, the solar PV systems would still generate electricity and would be connected to support the microgrid.

8.0 TECHNOLOGY, BUSINESS & OPERATIONAL PROTOCOL

8.1 Summary of the Proposed DER technologies.

DERs selected for each critical facility within the microgrid boundary are as follows:

Facility Name	DER Technology	Existing Capacity (kW)	New Capacity (kW)	Total Capacity (kW)
Woodbridge Town Hall	Gas Engine Generator (CHP)		500	500
Mawbey Street Elementary School	Photovoltaic	100	54	154
Reo Diner Restaurant	Photovoltaic	0	177	177
Woodbridge Middle School	Photovoltaic	50	40	90
Fire Department	Photovoltaic	20	70	90
Ross Street Elementary School	Photovoltaic	30	344	374
Stern Towers (Brook St. Lofts Redevelopment)	Photovoltaic	0	262	262
Adams Towers	Photovoltaic	0	0	0
Finn Towers	Photovoltaic	0	0	0
Woodbridge Town Hall	Photovoltaic	0	340	340
Main Street / Redevelopment	Photovoltaic	0	449	449
Rahway Ave. Redevelopment	Photovoltaic	0	200	200
North James Street Redevelopment	Photovoltaic	0	200	200

DER technologies selected for the microgrid include a combination of Photovoltaic (PV) arrays and a mechanical/electrical gas engine reciprocator engine generator coupled in a proposed district energy heating loop serving the thermal demands of the connected facilities.

Natural gas engines for power generation offer low first cost, fast start-up, proven reliability when properly maintained, excellent load-following characteristics, and significant heat recovery potential. As a combustion by-product, gas engine generators produce “waste-heat” in the forms of hot water (used to cool the engine) and hot exhaust gas. This waste heat can be transferred to usable thermal energy in the form of hot water, steam or chilled water. Thermal loads most amenable to engine-driven CHP systems in commercial/institutional buildings are generally matched with space heating and hot water requirements for the host facility or connected facilities via a thermal heating loop; aka – District Energy Heating System. The primary applications for this technology in the commercial/institutional and residential sectors are those building types with relatively high and coincident electric and hot water demand such as institutional facilities, multifamily residential buildings, and lodging.

Photovoltaic (PV) devices convert light energy to electricity. When semiconducting materials are exposed to light, they absorb some of the sun's energy in the form of photons and emit electrons in the form of electricity. PV systems are made up of multiple components that collect the sun's radiated energy, convert it to electricity and transmit the electricity in a usable form. The performance of the PV array is affected on-site by geographic, meteorological, and seasonal conditions, as electricity production is dependent on the amount of solar irradiance the array is able to receive any one location, cloud cover, and other environmental factors such as smog and dust. Electricity produced by individual panels is direct current (DC) which is brought together in a combiner box and fed as a single DC flow to an inverter which converts the electricity to alternating current (AC), a form that can distributed, transmitted or exported by the electrical grid.

District energy is a long-term investment to improve the physical infrastructure of the community it serves. It consists of a network of underground pipes carrying hot water, steam, or chilled water from a central plant to the buildings using the service. District energy networks offer a complementary infrastructure to gas and electricity networks. When coupled with appropriate DERs they can exploit a variety of fuel sources, both fossil and renewable, such as natural gas, geothermal, and solar/photovoltaic. The proposed district energy network will be able to capture and distribute surplus heat from the array of DER assets within the microgrid and satisfy the aggregate the thermal demand of multiple buildings to a scale that enables the use of technologies with higher efficiencies, or ones that may otherwise not prove to be economical to deploy at the individual building level.

8.2 Proposed Connections

8.2.1 Description of the Proposed Connections of the Critical Facilities and the DER technologies.

The electrical connectivity scheme for each DER respective of each critical facility are as follows:

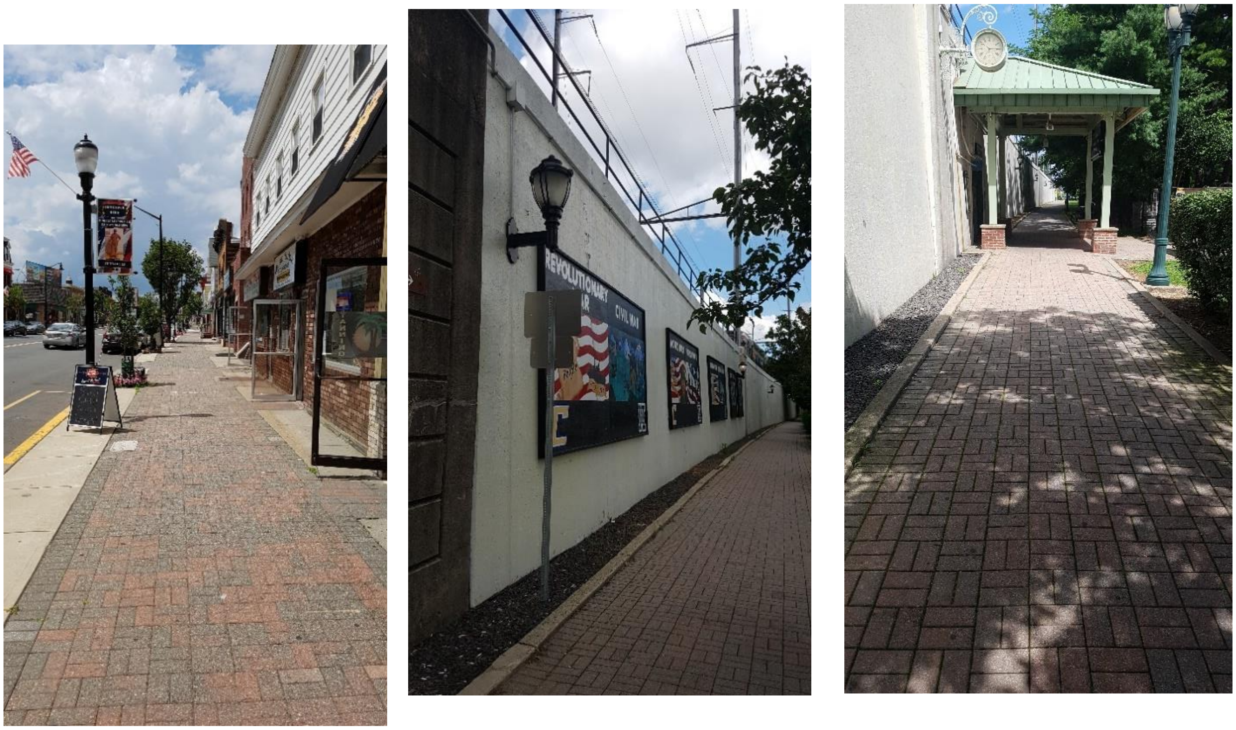
Critical Facility	Proposed DER Electrical Connection (Blue-sky Mode of Operation)	Proposed DER Electrical Connection (Black-sky Mode of Operation)
Woodbridge Town Hall (Gas Engine-Generator)	Facility is connected to WOR8018 via underground to 1500kVA SWGR internal to facility	DER will alternate to PSE&G circuit AVE4009 via new ATS, switchgear and protection/control scheme.
Mawbey Street Elementary School	DER will remain connected to AVE4003. Additional capacity to be served under NJ Legislated Community Solar Program.	None

Reo Diner Restaurant	DER will connect to AVE4003. Installed capacity to be served under NJ Legislated Community Solar Program.	None
Woodbridge Middle School	DER will remain connected to AVE4009. Additional capacity to be served under NJ Legislated Community Solar Program.	DER will serve the segregated network of AVE 4009
Fire Department	Additional capacity added will serve community solar connected to AVE 4009.	DER will serve the segregated network of AVE 4009
Ross Street Elementary School	DER will remain connected to AVE4009. Additional capacity to be served under NJ Legislated Community Solar Program	DER will serve the segregated network of AVE 4009
Stern Towers (Redevelopment)	DER will remain connected to AVE4009. Additional capacity to be served under NJ Legislated Community Solar Program.	DER will serve the segregated network of AVE 4009
Adams Towers	DER will connect to WOR8018. Installed capacity to will be serve existing loads under a net metering scheme.	None
Finn Towers	DER will connect to WOR8018. Installed capacity to will be serve existing loads under a net metering scheme.	None
Woodbridge Town Hall (PV Array Addition)	DER will connect to WOR8018. Additional capacity to be served under NJ Legislated Community Solar Program.	DER will alternate to PE&G circuit AVE4009 via new ATS, switchgear and protection/control scheme.

The only affected natural gas utility connection to accommodate the microgrid DERs resides at Woodbridge Town Hall. The natural gas riser serving this facility currently provides the energy source for the on-site boilers and heaters to serve the building heating and domestic hot water needs (load). With the installation and continuous operation of a 500kW gas reciprocating engine generator these building thermal loads will be met using the thermal energy generated by the engine's waste heat in the form of hot water. The size of the existing natural gas connection does meet the requirements for the incremental volume of natural gas required for the 500kW gas engine generator. However, the incremental volume (new demand of natural gas) may warrant the need for commercial discussions between Woodbridge Township and Elizabethtown Gas to leverage a separate rate class to optimize this utility cost.

The conceptual design of the underground thermal (district energy) network serving the downtown core of Woodbridge is simplistic and expandable. In fact, the infrastructure from recent development projects within the downtown core lends to the ease of installing these underground works as the routing for the heating loop is proposed to reside beneath existing walking paths and side-walks consisting of removable interlocking stone (Figure 6 below.)

Figure 6 – Indicative Grade Along Routing for Underground District Energy Network.



The location and subject rights of way defining the routing of the proposed underground district energy network are shown in Appendix F. An electrical connection diagram for the DER's operating under black-sky mode of operation is denoted in Appendix E.

8.3 Communication and Connection of the Proposed Town Center Microgrid DER technologies to PSE&G's Grid.

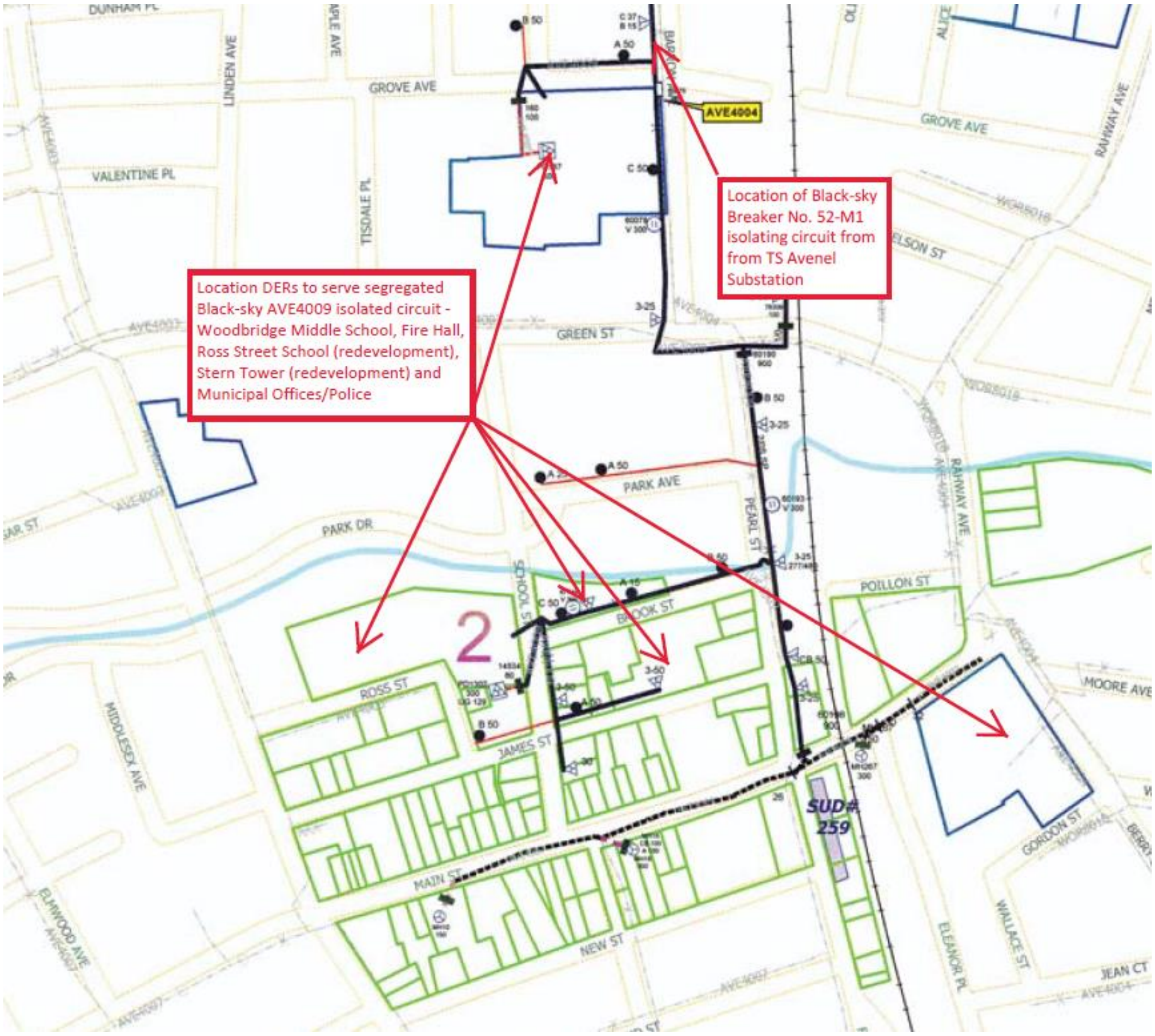
Communication between the microgrid DERs and the utility will occur through remote terminal units utilizing intertie network protection for the generation assets under blue-sky mode of operation. Under this mode of operation all DERs will operate in parallel with the utility under a displacement, net-metering or community solar generation scheme.

When power from the utility is lost, all DERs within the microgrid will be tripped. If power from the utility is not restored within a prescribed period (~10s) the direct transfer trip looking out on the utility will be commanded by PSE&G to open breaker no. 52-M1, isolating circuit no AVE 4009 north of Grove Ave from the utility (Avenel Substation) where denoted on CHA SLD 33654-ESK001 (Appendix E). Once breaker no. 52-M1 has proven its position as "open", a relay will provide the command to enable an auto-transfer switch (ATS) to shift the new DERs at the Woodbridge Town Hall from feeder WOR 8018 to AVE 4009. Thereafter, all DERs allocated to AVE 4009 will need to be closed in and reloaded in a priority sequence such as not to over/underload the any given DER (to be defined at the detail design stages of this project). The microgrid will base load the proposed generating equipment to satisfy the electrical demands of the host facility, while utilizing the resulting thermal by product for winter space heating, (with the potential to augment the heat supply to a connected absorption chiller (future)), and year-round production of domestic hot water.

Recent super storms, such as "Sandy" emphasize the need for distributed generation of electrical power and thermal energy at critical facilities such as hospitals, municipal centers etc. In case of a loss of grid incident, whether on account of a weather event or otherwise, a microgrid can be "islanded" (i.e. isolated from the utility) and the connected facilities can continue operating as usual. In the absence of a distributed energy generation microgrid, the facilities would have had to significantly reduce their power consumption by switching over to respective back-up generators, which present limitations that impede status-quo operations.

This proposed scheme will enable the Township to maintain power to the "down-town" core utilizing PV and Gas-Engine DER assets from Woodbridge Town Hall, Woodbridge Middle School, Stern Towers (Redevelopment), Fire Department and any DER allocated to "Phase 2" land parcels on Main Street provided that the utilities network controller was replaced or reconfigured at the respective underground point of common coupling (connection to the utility). A schematic depicting this conceptual area to be served for black-sky mode of operation is provided in Figure 7 below.

Fig. 7 – Woodbridge Township Area Served Under "Black-sky" Mode of Operation.



Location of Black-sky Breaker No. 52-M1 isolating circuit from from TS Avenel Substation

Location DERs to serve segregated Black-sky AVE4009 isolated circuit - Woodbridge Middle School, Fire Hall, Ross Street School (redevelopment), Stern Tower (redevelopment) and Municipal Offices/Police

8.4 Information Technology (IT)/Telecommunications Infrastructure Characterization

Load management for powering the microgrid will be accomplished using a variant on the smart grid technology, in that the microgrid isolation and islanding, and dispatch of the generation will be controlled by PSE&G's distribution SCADA, coordinated with control of the building loads by building automation systems. The two will be firewall isolated, yet will provide coordinated load management, such that the ability to maximize the generating assets will be accomplished, i.e., if a significant solar PV component becomes feasible, its variability need to be accommodated by control of conventional generation assets and building load management. Additionally, the energization of large loads will be managed to effectively accommodate the block loading capability of the generating assets.

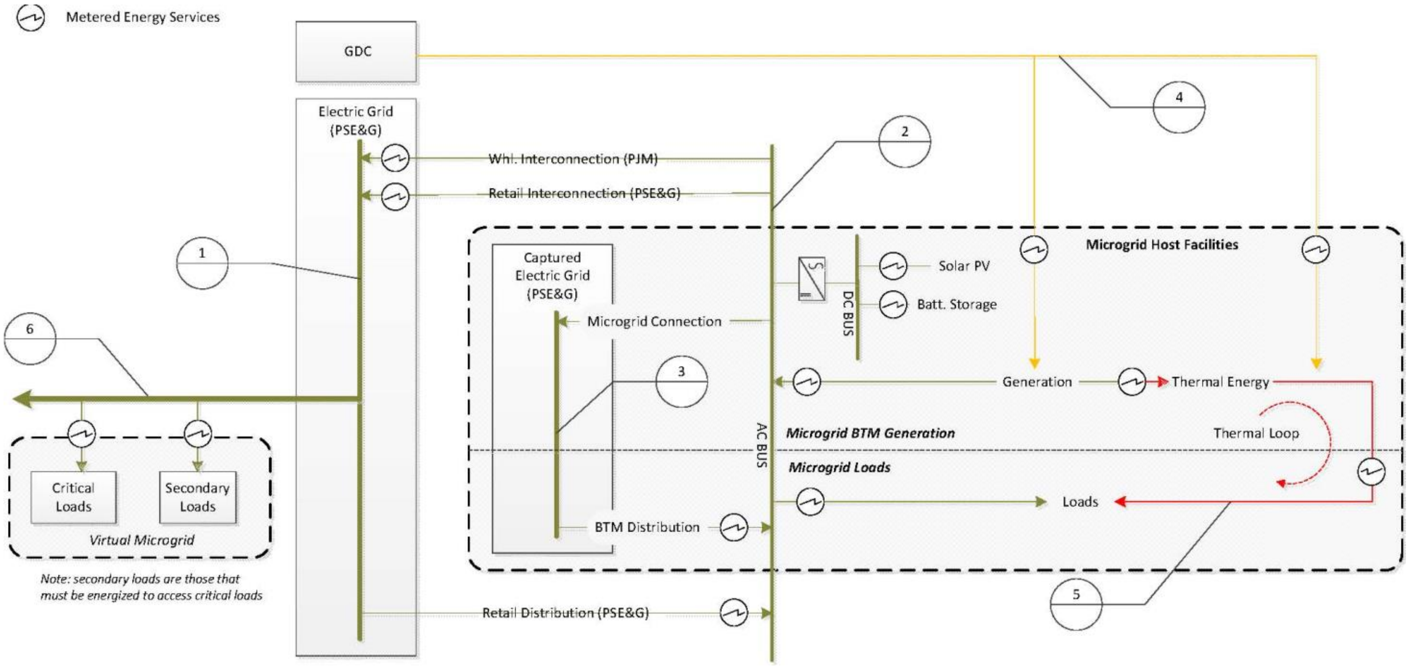
It is proposed that the Microgrid control system shall employ SCADA technology, contained entirely within the microgrid. This will utilize fiberoptic communication and is intended to exclude internet connection to any of the control system.

8.5 Introduction to Tariffs

To properly assess the feasibility of the WAM we need to provide a detailed description of the governing tariff requirements and issues, tariff controls on distributed generation interconnection requirements, and the potential impacts on tariffs by planned scenarios for smart grid distribution automation improvements. This section also includes discussion of proposed changes to the various tariffs that would address factors that have inhibited the implementation of advanced microgrids and potentially improve project financial performance. These changes generally include removing barriers to interconnection and establishing standard terms for the value of services exchanged between the microgrid operator and the utility.

The development of an advanced (multi-user) microgrid challenges the existing tariff structure in multiple ways that were not anticipated in the historic development of the centralized transmission grid, nor in the subsequent decades of deregulation of the energy industry. To address these varied and overlapping issues and identify current applicable tariff requirements in a systematic way, a techno/economic model of the WAM is provided in Figure 8 to identify the six (6) principal metered energy flows that comprise the proposed system. Each of these six energy flows are then described in detail. These six energy flows include: 1) the local utility (PSE&G) distribution grid, including feeders and distribution equipment installed onto the feeders; 2) the localized microgrid generation meshed network modelled as an AC bus; 3) a captured portion of the PSE&G distribution grid re-purposed for use of microgrid power distribution between host facilities and with the larger grid; 4) natural gas distribution; 5) the microgrid thermal energy loop; and 6) a virtual microgrid residing outside of the microgrid boundaries, but connected to microgrid generation resources.

Fig. 8 – Woodbridge Town Center Advanced Microgrid Unbundled Utility Tariff Structure.



The WAM Tariff Structure

1. Distribution Grid (PSE&G/PJM)
2. Microgrid Generation Bus (Non-Tariff)
3. Captured PSE&G Distribution Grid (Non-Tariff)
4. Natural Gas Distribution
5. Microgrid Thermal Energy Loop (Non-Tariff)
6. Virtual Microgrid (PSE&G)

Energy Flows

Electricity
Natural Gas

8.5.1 Regulatory Framework

In the United States, jurisdiction over energy industry operating standards and commodity prices are generally divided between the federal government and the states. The Federal Energy Regulatory Commission (FERC) of the U.S. Department of Energy (DOE) regulates the interstate transmission of electricity, natural gas, and oil, while the states govern intra-state retail markets. In the 13-state area that includes all of New Jersey, FERC delegates administrative authority over the power transmission grid on a regional basis to the PJM Interconnection (PJM) Regional Transmission Organization subject to the Open Access Transmission Tariff (OATT). FERC sets natural gas and oil wholesale transportation rates directly through approved tariffs for interstate pipeline services.

In New Jersey the Board of Public Utilities (BPU) authorizes Electric Distribution Companies (EDC) and Gas Distribution Companies (GDC) to act as public utilities offering basic delivery and retail services. Woodbridge Township and WAM are within the operational regions of Public Service Electric and Gas (PSE&G) and Elizabethtown Gas. Due to New Jersey's energy industry deregulation, the supply and distribution in the governing tariffs are separate to open competition for supply from Third Party Suppliers (TPS) who are licensed and regulated by BPU. The EDC and GDC continue to deliver energy as a monopoly through their wires and pipes and maintain ownership and responsibility for the maintenance and repair of the delivery infrastructure.

It should be noted that several of the energy flows in the microgrid are non-tariff, in that they are flows between generating resources and co-located loads on the same premises or inside the microgrid boundary, which for purposes of this discussion are assumed to operate free of the EDC franchise on the distribution of electric power.

8.5.2 Tariff Structure

Tariffs are complex. They do double duty of setting industry prices and terms & conditions for service and are necessarily detailed and multi-layered. Retail electricity tariffs generally offer single or "flat" rates (non-time-dependent), time-of-use rates (dependent on time of day to capture peak demand), and rates for controlled loads. Tariffs typically identify various service categories dependent on the customer type (i.e., residential, commercial, industrial, institutional, etc.) and selected rate type. Tariffs also provide for rate riders for additional (sometimes temporary) charges or refunds separate from the basic monthly rates. These can include rate riders for generation services such as energy, transmission and capacity charges which are a pass-through from the wholesale provider of electric power; societal benefits charges; and (of course) sales and use taxes. The final monthly bill will therefore be an aggregate of the many applicable charges, fees and possible refunds broken down into the basic separable categories of: generation, transmission, distribution, and retail services. The single bill is delivered by the local utility, who serves as an agent for others, such as PJM and third-party suppliers, who receive portions of the customer payment for their particular contribution to the metered energy flow.

Natural gas tariffs typically only provide a single non-time varying rate type but will offer price discrimination based on the quantity of gas delivered within a certain time block (i.e. daily, monthly or quarterly delivery). Natural gas prices also vary with the season with increases expected in winter months due to increased demand for space heating. Basic natural gas rates, like electricity rates, include separable charges for customer use (per meter), demand, and delivery charges. Service categories include use for commercial natural gas customers using distributed generation technologies such as microturbines and fuel cells, and also for large consumers of natural gas (greater than 10,000 therms daily) for the sole purpose of generating electricity.

8.5.3 Distributed Generation Interconnection Requirements

One tariff jurisdictional issue of particular importance to microgrid projects is the threshold question for a small generator project of whether the project falls under the PJM or the PSE&G interconnection process. PSE&G (governed by BPU) manages retail applications. PJM Interconnection (governed by FERC) is responsible for managing all wholesale interconnections to member EDC systems.

Three basic factors determine the jurisdiction of the small generator project: 1) the type of facility to which the project proposes to interconnect; 2) whether the output of the generator would only serve local load, and 3) whether all or some of the output of the generator may be available for wholesale sales under the OATT (the FERC-approved tariff). As the WAM project anticipates connection only to the PSE&G retail distribution network (a non-FERC network) and the WAM generation will not be selling into the wholesale market under a FERC tariff (but will only be consuming the power locally), no PJM interaction is anticipated. However, as potential export markets, including to the PJM wholesale markets for energy, capacity and ancillary services are attractive sources of future income for the project, this potential pathway is included in the detailed tariff structure analysis.

Retail interconnection to the PSE&G system is defined in the operating tariff and requires a detailed application process to avoid violations of the tariff's Single Source of Energy Supply requirements. Interconnection fees and costs for distributed generation, standby service and demand charges are also applicable. The interconnection process consists of 3 levels based on the type and capacity of the generator. Levels 1 & 2 applies to inverter-based facilities limited to 2 MW and apply principally in the case of the WAM to solar photovoltaic systems installed at the host facilities. Level 3 applies to facilities which do not qualify for either the Level 1 or Level 2 and applies to the larger fuel-fired existing and planned generation at the WAM facilities. Distributed generation systems that want to sell or provide their excess energy and capacity to the PJM wholesale market must be interconnected per PJM requirements through a separate application process. The PJM interconnection requirements are provided in Manual 14A (Generation and Interconnection Process) and follow the small generator interconnection procedures included in the OATT.

Customers that wish to sell power to PSE&G are restricted by the terms and conditions of Rider QFS of the PSE&G tariff for Cogeneration and Small Power Production Service. For generators larger than 1 MW, specific contract arrangements must be negotiated as part of the interconnection process to determine the price of delivered energy and capacity, which are controlled by the utility's ability to receive compensation for resale of the energy and capacity at PJM wholesale market prices. PSE&G may also put significant restrictions on delivery of energy based on local circuit conditions and may refuse to allow such an interconnection should it not be technically feasible for feed-in to the meshed network. All such contracts are subject to BPU approval.

Net metering is a type of feed-in tariff that can generate revenue for owners of Class 1 renewable behind-the-meter generation assets in the microgrid. In the case of the WAM, net metering will apply to Level 1 & 2 interconnections (inverter-based facilities limited to 2 MW), which, as indicated, will be principally solar photovoltaic systems installed at the host facilities. Net metering provides for the billing or crediting, as applicable, of energy usage by measuring the difference between the amount of electricity delivered by PSE&G to a customer-generator. The amount of credit however is restricted to the amount of electricity supplied by PSE&G over an annualized period – therefore this cannot act as a positive revenue stream but only a potential offset against PSE&G charges.

8.5.4 Smart Grid Distribution Automation

In response to demand to improve reliability and efficiency of the power system, smart grid communication and control enhancements, paired with increased automation is being implemented on distribution systems. Microgrids through their use of interconnected distributed energy resources, and automated interfaces with end-users can provide opportunities for the development of new automation scenarios that build off primary distribution smart grid and automation functions implemented by the EDC at the substation and feeder distribution equipment. These functions currently include monitoring and control of distributed equipment to perform system protection actions when necessary, such as in the case of undetected faults or unplanned islanding of the microgrid. Improved automation and smart grid enhancements by the local utility could provide enhanced demand response and load management to the microgrid, and assist in contingency planning and analysis, monitoring of non-operational data (e.g. reference and historical data for making short and mid-term load predictions) and market operations of the distributed equipment, and assisting with predicative maintenance.

Smart grid distribution automation functions can provide both benefits and costs. The potential benefits include: 1) financial benefits such as lower costs (to customers), avoided costs (to utilities), and price stability; 2) power reliability and quality improvements; 3) increased visibility for utilities and field personnel into unsafe situations providing increased safety performance; 4) energy efficiency improvements, reduced energy usage and reduced peak demand; and 5) environmental and conservation benefits. Benefits that directly reduce costs for utilities, should result in lower tariffs or avoiding increased tariffs, although the connection may not be direct. Societal benefits are often harder to quantify but can be equally critical in assessing the overall benefits of a particular function.

8.6 Part 2: The WAM Tariff Structure

Figure 8 in the attachment identifies six (6) principal metered energy flows that comprise the proposed system. Each is described in detail within this section.

8.6.1 Distribution Grid (PSE&G/PJM)

This system includes local feeders servicing the microgrid and distribution equipment installed onto the feeders. These feeders are not dedicated solely to the microgrid and are energized through one or more local substations. Metered flows include the following:

1) Retail Distribution: Retail sale of electricity by PSE&G to the microgrid through an aggregated Point of Common Connection (PCC). One or more meters is anticipated with aggregated monthly billing paid by either by the Special Purpose Entity (SPE) that will own and operate the microgrid assets, or by the host microgrid facilities directly responsible for their own consumption of grid-supplied power.

2) Retail Interconnection: Levels 1, 2 or 3 Interconnection to the PSE&G distribution grid for resale by the utility at rates pegged to PJM wholesale rates. Also includes any net metering from Class 1 renewables at the microgrid (principally solar PV). As indicated, many technical factors currently inhibit the full functioning of this interconnection to reach its maximum economic value (see Footnote 2).

3) Wholesale Interconnection: Small generator interconnection allowing access to the PJM wholesale market. In this interconnection, PSE&G wheels the energy through its system to PJM. The owner of the microgrid assets deals with PJM directly for sales of services on the wholesale markets.

8.6.2 Microgrid Generation Bus (Non-Tariff)

This energy flow resides on a localized microgrid generation meshed network modelled as an AC bus. Metered flows for use inside the microgrid, which are not subject to any tariff, include solar photovoltaics, battery storage, conventional (fuel-fired) generation, and service to co-located loads. As per the Ownership & Business Model of the Feasibility Study Report, a host site would first take energy from the coincident production of the microgrid. In other words, each facility will use resources on its property to provide baseload, and then consume imported power to make up its residual load. Inherent in the structure of the microgrid, is the ability to use non-tariff metering between various local distributed energy resources and across microgrid connected buildings. This cost offset, from building-to-building and from customer-to-customer, is a major contributor to the overall value proposition of the microgrid.

Any excess energy from the distributed resources that is fed back into the grid through the captured PSE&G infrastructure (see below) will be sold to other microgrid customers sites, proportionate to their overall energy consumption. Since the microgrid assets will utilize existing utility distribution infrastructure, the host sites will continue to pay PSE&G via the delivery charge on the monthly bill. Host sites would amend their existing bi-lateral supply agreements to account for the fact that a portion of their supply would now come from the microgrid. Each microgrid generating asset will be paired with a dedicated meter (as shown on the diagram) that will measure the output for internal accounting.

8.6.3 Captured PSE&G Distribution Grid (Non-Tariff)

Portions of the feeders and attached distribution equipment of the PSE&G distribution grid will be repurposed for use of microgrid power distribution between host facilities and with the larger grid. Excess power exported from the host facilities will be distributed and sold to other microgrid customers sites, proportionate to their overall energy consumption. Individual host facilities importing energy from this internal network will have a meter to capture in-flows for internal accounting.

8.6.4 Natural Gas Distribution (Elizabethtown Gas)

Natural gas will be provided by the local GDC (Elizabethtown Gas) and used directly at the host facilities to power conventional generation such as the combined heat and power unit envisioned at Town Hall, and for elements of the thermal loop including absorption chillers and boilers. Each type of service (i.e. electrical generation and thermal production) is shown with a separate meter.

8.6.5 Microgrid Thermal Energy Loop (Non-Tariff)

The thermal energy loop includes the use of co-located thermal energy resources at the host facilities, and the circulation of thermal energy from adsorption chillers, boilers, etc. Exhaust from the CHP units will also be used in the thermal loop and is therefore metered to compensate the owner of the CHP asset. Like the flow energy on the Microgrid Generation Bus and the Captured PSE&G Distribution Grid, the energy flows in the thermal loop to microgrid facilities is not subject to tariff.

8.6.6 Virtual Microgrid (PSE&G)

The virtual microgrid refers to loads residing outside of the microgrid boundaries but connected by feeders to microgrid generation resources. Using the PSE&G Level 3 interconnection these microgrid DERs should, in theory, be able to energize the feeder and brings these loads back on line in the case of contingencies lasting anywhere from a few minutes to several days or weeks (depending on the flow of natural gas and state of the PSE&G infrastructure). It should be noted that there are multiple technical challenges involved with making this potential revenue stream a reality, including access to the meshed network in a way that is safe and reliable. Primary critical loads are those that provide critical services and are the priority targets for service restoration in contingencies. Secondary loads are those loads on the feeder between the critical loads and the microgrid that will be energized incidentally as primary critical loads are brought back on line. These loads will continue to pay for their service under normal tariffs to the distribution company (PSE&G) however, a tariff rider that compensates the microgrid distributed resource asset owners for the reliability and resiliency services should be developed.

8.7 Part 3. Conclusions & Recommendations

8.7.1 Microgrid Tariff

The interconnection standards in the PSE&G/BPU tariff is based, in part, on the IEEE 1547 series that addresses the interconnection of distributed resources to the distribution grid. As the use of distributed generation clusters, embedded networks and microgrids (especially advanced microgrids) have grown, there has been additional work done on advanced topics, such as IEEE 1547.4, which addresses the standard related to islanding of microgrids. As such, special microgrid tariffs have been proposed in certain jurisdictions to address the unique nature of the emerging business models. These tariffs would address factors that have inhibited the implementation of advanced microgrids and potentially improve project financial performance. These changes generally include removing technical barriers to interconnection and establishing standard terms for the value of services exchanged between the microgrid operator and the utility.

The new tariffs should recognize the value imparted by the microgrid to the distribution grid, including avoided costs for maintenance and capacity expansion as well as increased reliability and resilience. This could be accomplished through approval of special microgrid rates for imported power and by eliminating (or mitigating) standby and demand charges. The new microgrid tariffs should also allow utilities to cede some of their franchise rights to a municipal authority and/or owner and operator of the advanced microgrid to allow for non-tariff distribution of microgrid generated energy.

Improved Interconnection Procedures

With improved interconnection procedures that address the technical challenges of adding fully functional distributed resources to the grid, microgrids could provide a host of generation services to support a substation during contingencies that would provide an alternative to distribution-system capacity improvements. These generation services, when combined with load reduction could provide utilities a very valuable resource to minimize customer loss of service and power quality problems during contingencies. Studies produced by the Pacific Northwest National Laboratory have evaluated the potential for use of microgrids as a resiliency resource to local grids in the event of a severe weather events and has found that, given the right conditions, microgrids can supply critical loads outside of the microgrid during contingencies where the utility power is unavailable for days or even weeks.

In return for these services microgrids could receive payments for deliberate islanding to manage load, payments for exporting power, and payments for maintaining critical loads during a larger system outage. A contract between the microgrid and the local utility for resiliency and reliability resources could call for immediate response in local contingencies, not just to reduce peak system demand. Short-term markets for local service would include local voltage and VAR support, short-term substation relief, and emergency services. Microgrids could make on-call energy exports to the grid or assume pre-determined load shapes or provide circuit-by-circuit grid restoration services to ensure local reliability. These potential markets should be studied by BPU and included into future tariffs. However, to achieve this variety of services to the grid, the interconnection process must become more robust allowing full integration of distributed resources into the larger grid.

9.0 OVERALL COST

9.1 Approach to Cost Analysis

The eventual success of the project will be determined by the difference between the computed Levelized Cost of Electricity (LCOE) of the microgrid and the energy rates paid by host sites under the status quo. The LCOE in turn, is governed by the following factors:

- The feasibility of assumptions around operating parameters of each microgrid asset, which include:
    - Average % capacity at which the CHP can operate across the year taking into consideration available loads and regulations that govern back-feeding of excess CHP production onto the grid
    - Off-take of thermal energy generated by operating the CHP system
    - Available loads to off-take PV production and regulations that govern back-feeding of excess PV production onto the grid
- Availability of incentives and rules governing the layering of different incentive schemes in a mixed-technology project such as the proposed Town Center microgrid at Woodbridge
- The total capital expenditure required to install all the proposed assets for the microgrid

It follows that a simple and robust business model that avoids complexity and inflated soft costs is critical. GI Energy computed the LCOE taking into consideration the following factors:

9.2 Revenues

- All energy (kWh) produced by the microgrid assets (CHP and Solar PV) are sold at a fixed price, either to the identified sites in the form of a supply contract
- All thermal energy is sold at the prevailing average gas rate
    - Thermal energy is a useful byproduct of CHP generation and is an added bonus revenue stream
    - In order to qualify for prevailing incentives, it is necessary to use the thermal energy productively so that the efficiency required to qualify for the incentive is met

An important note here is that the batteries are assumed to behave as a sink of any excess production. There may be opportunities to capture additional revenues if the batteries are deployed for services such as Demand Charge Reduction and Energy Arbitrage.

9.3 Costs

- Annual natural gas expenditure to run the CHP plant
- Annual O&M expenditure for the Solar PV, CHP and batteries

9.4 Description of the Overall Cost

The Woodbridge microgrid is composed of four main systems listed below. These individual systems work together to achieve the objectives of the microgrid, both technically and from a business model perspective.

- Solar PV at various facilities
- CHP at Town Hall
- Hot water thermal loop
- Switchgear

We estimated the costs and operations for each of these systems individually, and then grouped the systems together into an overall budget and pro forma cash flow model for the entire microgrid. Capital costs for the major components are listed below. An Excel model that details the cash flow is also included.

Microgrid Component	Cost
Solar PV across all facilities	$5,767,200
Battery at Woodbridge Middle School	$100,000
CHP at Town Hall	$1,750,000
How water thermal loop	$1,080,000
SCADA and Switchgear (Transfer-Trip Switch, ATS, Switchgear, transformer at Town Hall)	$325,000
Soft Costs (Development Fees, Project Management, Engineering Support, Permitting, Interconnection Applications)	$1,724,660
Total Project Cost Estimate	**$10,746,860**

10.0 CASH FLOW EVALUATION

This analysis assumes that a non-utility, third party will develop the microgrid through a DBOOM model. Revenues will come from electricity sales from the solar PV systems and electricity and hot water sales from the CHP system during blue-sky conditions. By themselves, the solar PV PPA and CHP ESA are financeable investments for a third-party owner. However, these revenues will also need to cover the costs for the hot water loop, SCADA control system, and switchgear that normally would not be included in a standalone, BTM CHP project.

Energy	Annual Production	Unit Price	Year 1 Energy Sales
Solar PV	3,780,720 kWh	$0.12 / kWh	$453,686
CHP Electricity to Town Hall	2,655,747 kWh	$0.12 / kWh	$318,690
CHP Hot Water to Town Hall	36,801 therms	$0.826 / therm	$30,398
CHP Hot Water to Thermal Loop	74,741 therms	$0.826 / therm	$61,736
Total Revenue from Energy Sales			**$864,510**

Operations and maintenance costs are estimated for all systems. These costs are covered by the PPA and ESA payments and are paid for by the microgrid system owner. Maintenance assumptions are listed below.

Microgrid Component	Assumption	Year 1 Cost
Solar PV across all facilities	$12.00 / kW	$25,632
Battery Warranty Costs	$ 1,000 per year	$1,000
Battery Parasitic Energy Cost	Constant draw at 2.5% of inverter size (50 kW)	$1,314
CHP Natural Gas Cost	$0.826 / therm	$230,333
CHP Maintenance	$0.030 / kWh	$79,672

11.0 POTENTIAL FINANCING

11.1 Project Financing Summary

This analysis includes a 20-year financial model to estimate the overall operational and financial performance of the Woodbridge microgrid. The model includes the initial project costs, operating assumptions, fuel costs, maintenance costs, and all applicable incentives. Revenues and expenses for the systems are incorporated into a cash flow model which calculates the overall return on investment to the microgrid owner under a DBOOM scenario. The ownership model considered here is not the only ownership option. Options remain for the utility to play a role in the ownership of the transfer trip switch on circuit AVE 4003 and / or the thermal loop. Alternatively, the municipality could decide to invest and own in portions of the microgrid.

The following assumptions were included in the model.

- CHP electricity sales to the Town Hall at $ 0.12/kWh which is at par with the Town Hall's current all-in electric rate
- CHP hot water sales at $ 0.826/therm which is at par with the Town Hall's current all-in gas rate
    - It is assumed that all thermal energy is sold to the Town Hall and thermal loop customers
- Solar assets are eligible to be enrolled in the proposed New Jersey Community Solar Program
- Solar PPA rate of $ 0.12/kWh which is the average all-in rate paid by the identified sites for the Woodbridge microgrid
- SREC revenues at $210/MWh for the first 10 years of the project
    - It is assumed that there is sufficient demand in the NJ market to offtake all of the generated SRECs for compliance or voluntary use
- The project is financed through 80% equity and 20% debt at 5%

One of the drivers of success for the proposed microgrid project is the available incentives. This includes the following:

- New Jersey Clean Energy Program CHP incentive ($525,000)
    - To qualify, it is necessary to use the thermal energy productively so that the minimum fuel conversion efficiency is at least 60%
- 30% Federal Investment Tax Credit (ITC) for Solar PV and battery ($1,760,160)
    - Assumes that the battery is charged exclusively by the solar PV system
- MACRS with 30% bonus depreciation for the Solar PV and battery system
- 100% accelerated depreciation[3] for the CHP and thermal infrastructure
- SREC sales at $210/MWh

11.2 Analysis of Financial Model

The objective of the microgrid is to deliver a system that can provide critical power during a loss of utility grid power while operating and selling energy during blue-sky conditions at competitive rates to microgrid customers. These objectives introduce limitations on the financial model within which the microgrid must demonstrate financial feasibility. The scenario detailed below assumes that the microgrid owner finances, owns, and operates all aspects of the microgrid and all tax and other state incentives are fully monetized.

Scenario	Energy Sale Price	IRR
CHP and Solar PV systems operate continuously during blue-sky conditions and all energy produced is sold	$0.120 /kWh Solar PPA $0.120 /kWh for CHP electricity $0.826 /therm for Hot Water	10.6%

This analysis suggests that the microgrid is marginally financeable while keeping energy costs at today's rates and assuming no additional financial support from the state or Woodbridge Township. However, it should be noted that the returns are sensitive to the availability and certainty of securing all the incentives listed above. As an example, eliminating the SREC revenues results in a significant reduction in the IRR to the point where it is not financeable by a third party**.** Furthermore, the model also assumes that all the available tax incentives can be easily monetized; in

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[3] http://programs.dsireusa.org/system/program/detail/676

practice, this may require a partnership with a tax equity investor if the project owner does not have sufficient tax liability.

Private investors and microgrid owners may seek higher rates of return for projects of this type with long time horizons, multiple off-takers, and potential risk from changes to future loads. In addition, a the microgrid relies, in part, on sales of thermal energy (hot water) to buildings and tenants that have yet to be built.

These risks can be mitigated through support from the State Board of Public Utilities and / or Woodbridge Township. Due to the uncertainty of loads and future customers, the Township could support the microgrid by guaranteeing a minimum revenue to the microgrid owner. This would not necessarily increase the overall project IRR but would de-risk the project and attract investors with a different risk profile. Additionally, the microgrid financier may be able to secure low interest loans through support from the New Jersey Economic Development Authority (discussed below).

The State of New Jersey, through the BPU, could support the project via an initial grant to assist in paying for the necessary infrastructure costs that do not, by themselves, generate revenues. These include the hot water thermal loop, SCADA system, and the switchgear necessary to connect electric customers and create the microgrid.

11.3 Recommendations

This analysis finds that the Woodbridge Township microgrid is technically feasible and financeable. The large portion of renewable solar PV generation provides environmental benefits and operate during blue-sky conditions. The CHP system at the Town Hall will serve as the cornerstone of the microgrid during black-sky events and will deliver efficient thermal and electric energy to the Town Hall during blue-sky conditions. This configuration is highly expandable for future phases. Additional generation assets can be added to the facilities connected electrically via AVE 4003 or connected thermally via the hot water loop. During black-sky conditions, the resilient generating assets will be able to support critical operations and support the community.

The analysis reveals several opportunities for policy and/or regulations solutions that may improve the business model from the perspective of the microgrid owner, customers, and EDC. We recommend that the New Jersey Board of Public Utilities explore the following options:

- Create provisions that prevent CHP host sites from moving to stand-by charges if the generating asset is a part of a microgrid. The argument here is that the CHP asset is installed for the benefit of the larger community and not only for the host site exclusively. In this case, the CHP host site is the Woodbridge Town Hall.
- Provide grant funding and access to cheaper forms of capital (e.g. Green Bonds created specifically to finance the proposed microgrid) which will enhance the overall financial opportunity and more easily attract investors
    - Creating a dedicated bond to finance part of this microgrid is likely to have a halo effect; it will inspire more confidence in the project and attract equity partners with lower hurdle rates, as well as allow the community to invest in the asset and feel a sense of pride in contributing to the well-being of Woodbridge Township. Furthermore, the earnings will be channeled back to the bond holders.

There is increasing evidence from other parts of the country that suggest that New Jersey can benefit from expanding the sources of funding and possibly establish a stand-alone Green Bank as well as expand the scope of the NJ Environmental Infrastructure Trust, which is currently set up to support water infrastructure projects. New Jersey does have an established *Energy Resilience Bank*, which was set up after Hurricane Sandy to drive greater investment into resilient energy supply systems at critical facilities like hospitals, water and wastewater treatment facilities. This was originally meant to operate similar to a Green Bank; however, it has stopped receiving applications for funding.

The Energy Resilience Bank sits under the larger umbrella of the New Jersey Economic Development Authority (NJEDA). The New Jersey Economic Development Authority is an independent State agency that finances small and mid-sized businesses, administers tax incentives to retain and grow jobs, revitalizes communities through redevelopment initiatives, and supports entrepreneurial development by providing access to training and mentoring programs. In particular, NJEDA provides bond financing options for Large Business and Development. Under this scheme, $500,000 to $10 million in tax-exempt bonds are available for for-profit companies, up to 20 years for real estate and 10 years for equipment. Eligible projects include facilities that furnish electric power. This suggests that the microgrid owner may be able to collaborate with the NJEDA to create unique financing opportunities using cheaper capital.

12.0 PROJECT BENEFITS

The primary benefits of a microgrid are energy reliability, redundancy, fuel flexibility, energy efficiency, a reduction in associated emissions, capacity relief on the electric grid, and reductions of electricity transmission losses. With a population over 100,000, Woodbridge Township serves several communities in the area that may benefit from the proposed microgrid. Additionally, the Woodbridge microgrid would be able to provide economic benefits. By incorporating renewable technology and by continuing to contribute to the Societal Benefit Charge through electricity and gas delivery bills, the proposed project is consistent with the use of the SBC as set forth in N.J.S.A. 48:3-60(a)(3) and furthers objectives of the Department of Environmental Protection and Board of Public Utilities.

The potential benefits of this microgrid include:

Financial benefits: Traditionally, the resiliency benefits arising from microgrids have been synonymous with increased charges, or a “resiliency” premium. However, the proposed business model for the Woodbridge microgrid aims to maintain consistent energy costs from the microgrid as compared to what they pay today (both on the electric as well as thermal side). Thus, the community will receive the financial benefit of avoiding a costly resiliency premium while receiving all the peripheral benefits of a resilient microgrid, which includes access to critical facilities, food and shelter during emergency events.

The microgrid provides advantages to the utility as well, in the following ways:

- **Utility grid support:** Potential grid constraint relief for the utility can be achieved from solar PV self-consumption at microgrid facilities and from behind-the-meter self-generation of the CHP system at the Town Hall. This is achieved when microgrid facilities are demanding less electricity during times feeder-level peak demand times (i.e. during peak summer cooling months).
- **Distribution System Cost Deferral:** The addition of the microgrid generating assets may delay or avoid electric distribution system upgrades that would otherwise be necessary to support future load grown in the downtown core.

Power reliability and quality improvements: The proposed microgrid project approach is different from traditional DER development in that the assets will continue to generate electricity when the local utility grid is down. Currently, many DERs, and especially solar PV systems, are interconnected such that they are unable to generate electricity during outages, which inhibits their use as a resiliency asset. The microgrid circumvents this obstacle by incorporating distribution switching and interconnections which allow for the system to island itself when the distribution grid is down while continuing to provide power to the interconnected critical facilities. This, in turn, allows for seamless transition from utility to microgrid energy supply, and keeps the lights on in spite of outages in other areas of the grid.

Power quality and load-balancing during black-sky operations will be managed by a central microgrid controller. In addition, the energy storage asset will assist to balance the loads and generation assets during black-sky events.

Safety of operations: Through the use of existing distribution lines, the utility is able to monitor islanded feeders at all times. This increases reliability to customers without creating additional safety hazards for utility field personnel. By using utility infrastructure, the microgrid is held to high safety performance standards, protecting utility personnel and customers. Furthermore, the microgrid infrastructure includes state of the art switching and safety equipment that provides further assurance of safe and reliable operations.

Reduction in energy use: Many customer sites are proposed to install solar PV panels on rooftops and over parking spaces. Solar PV installation shields rooftop from solar gain, ultimately reducing cooling needs for the building under it. As a result, some buildings may see energy use reductions during summer month.

Environmental protection and conservation: Deployment of the microgrid is likely to be accompanied by positive externalities, primarily in the form of reduced carbon emissions. The 2 MW of solar PV installed through this project will inject renewable energy into the local distribution grid on a daily basis, decreasing reliance on fossil-fueled electricity generators which suffer transmission losses sending electricity to customers. The solar PV is a completely renewable form of electricity generation, emitting no pollution. CHP technology increases the efficiency of natural gas generation. While the CHP plant requires fossil fuels, it does replace traditional boiler systems which would combust natural gas without the added benefit of local electricity generation.

Community Benefits By enrolling the microgrid facilities in community solar, the project will maximize the solar PV installation across all sites. Instead of right-sizing for the load of a given building, the project is right-sizing for the solar PV that the building can host by utilizing all viable roof or canopy space. Through New Jersey’s proposed community solar program, the microgrid enables excess renewable energy to be used by neighbors. In addition, all of Woodbridge benefits from using a microgrid to keep public services such as the fire department, and access to food and shelter, available during emergency events.

The microgrid model, which pairs community solar programs with CHP and battery storage, seeks to maximize the above benefits through its sizing and configuration. The base load capability of the CHP generator can replace solar PV production at night or when solar PV production is insufficient. Although it would not be physically or financially viable to install all of the DERs needed for reliability at one customer site, different DERs located at different customer sites are leveraged throughout the microgrid to achieve this purpose.

13.0 COMMUNICATION SYSTEM BETWEEN THE MICROGRID DER AND UTILITY

Load management for powering the microgrid will be accomplished using a variant on the smart grid technology, in that the microgrid islanding and dispatch of the generation will be controlled by PSE&G’s distribution SCADA, coordinated with control of the building loads by each respective facility building automation system. The respective SCADA (Supervisory Control and Data Acquisition) supervisory software will need to prioritize the loading of connected facilities under black-sky modes of operation as deemed feasible to match the capacity of the available DER. i.e., if a significant solar PV component becomes available, its variability needs to be accommodated for by the control of conventional generation assets and building load management systems. Additionally, the energization of any large loads under this mode of operation will be managed to effectively to accommodate the block loading capability of the DER assets.

It is proposed that the Microgrid control system shall employ SCADA technology, contained entirely within the load controller/network controller of the Woodbridge Township connected facilities. This will utilize fiberoptic communication and is intended to exclude internet connection to any of the control systems.

14.0 ESTIMATED TIMEFRAME & CONSTRUCTION SCHEDULE

The Township should allow 12 to 14 months overall for the construction of the microgrid. This schedule is based on the time required to engineer, procure, and construct the CHP system at the Woodbridge Municipal Town Hall. The other systems (including the rooftop solar PV, energy storage, and thermal hot water loop) may be constructed in parallel with the CHP construction schedule or as development synergies or opportunities exist with adjacent utility or public works projects.

In reference to the Gantt Chart Project Schedule (Appendix G) initial schematic design for the Townhall CHP and Microgrid DERs (PV system addition/expansion) respective of facility will take initially upwards of 60 days. The schematic design will provide for a more granular look at the facilities energy demand profile and validate the results of the MICROGRID WAM feasibility study. Early in this phase of the project interconnection applications must be developed further for each DER developed during the feasibility study. Upon completion of this phase, major equipment specifications will be generated and issued for competitive bid. During the bid/evaluation period for major equipment and systems detail design efforts should commence for the next 140 days; completed by the availability of “shop-drawings” or respective design details published by the equipment suppliers and manufacturers (OEMs) specific to the respective facility requirement(s). Further definition of the civil requirements for the town center’s thermal district energy network at the on-set of the detail design phase will provide for the opportunity to advance the earthworks for the underground piping distribution network, structural and electrical modifications to accommodate new (or added) PV arrays throughout the microgrid and early-works for mechanical, electrical and plumbing modifications that will be required to install the engine-generator (CHP) system at the Woodbridge Town Hall. However, completion of the CHP system will be predicated on the lead-time for the engine-generator equipment (and subsequent interconnection and testing thereof). The project will conclude with a commissioning phase for all DER systems and acceptance of the testing protocols and procedures of these systems by the respective equipment Owner(s) and PSE&G.

15.0 ONGOING WORK WITH THE EDC AND GDC

The local utilities serving Woodbridge have fully cooperated with the microgrid study and provided full information upon requests. Woodbridge is served by PSE&G and Elizabethtown Gas as their Electric Distribution Company and Gas Distribution Company respectively. PSE&G is represented by Frank Lucchesi, the Regional representative. The consultant team has worked with Mike Henry Elizabethtown Gas is represented by Susan Buck of South Jersey Industries, the parent company. The gas utilities involved has been limited but will likely be the main gas supplier to the CHP technology. PSE&G has provided utility usage and line diagrams serving the microgrid area. The latter served as the basis for microgrid layout and technology placement, but the line diagrams have not been included due to security reasons. Although PSE&G’s role as a user and/or possible ownership role has not been solidified, the utilities along with PSE&G remain active stakeholders in the project.

WOODBRIDGE ADVANCED MICROGRID PROJECT

Woodbridge, NJ

APPENDIX A

WAM Microgrid Boundary

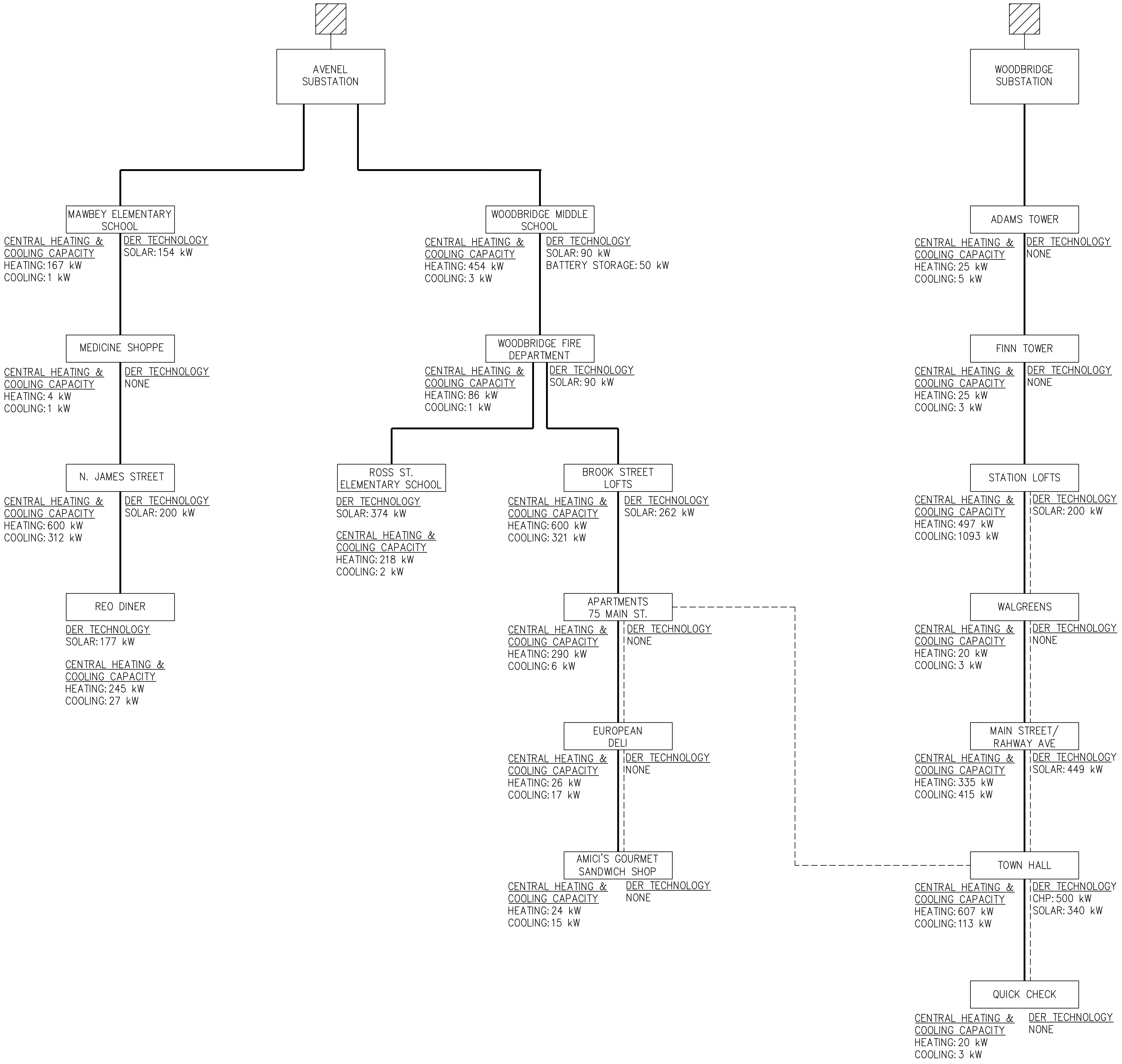
Prepared March 20, 2018 by Sean Burns
Township of Woodbridge - Division of Engineering

WOODBRIDGE ADVANCED MICROGRID PROJECT

Woodbridge, NJ

APPENDIX B

DERCAM Topology



LEGEND

- - - - - - - THERMAL
——— ELECTRICAL

NOTES
1. Data is based on outputs from DER-CAM.

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WOODBRIDGE
TOWN CENTER
Woodbridge, NJ

ADVANCED
MICROGRID (WAM)
PROJECT

No.	Submittal / Revision	App'd.	By	Date
PA	ISSUED FOR REVIEW	JJ	CC	10/19/18

DERCAM
MICROGRID
TOPOLOGY

Designed By:	Drawn By:	Checked By:
CC	CC	JJ
Date:	Project No:	Scale:
OCT. 2018	33654	NONE

Drawing No.:

MSK-001

File: V:\PROJECTS\ANY\K4\33654\CADD_ACAD\WORKING\33654-MSK-001.DWG
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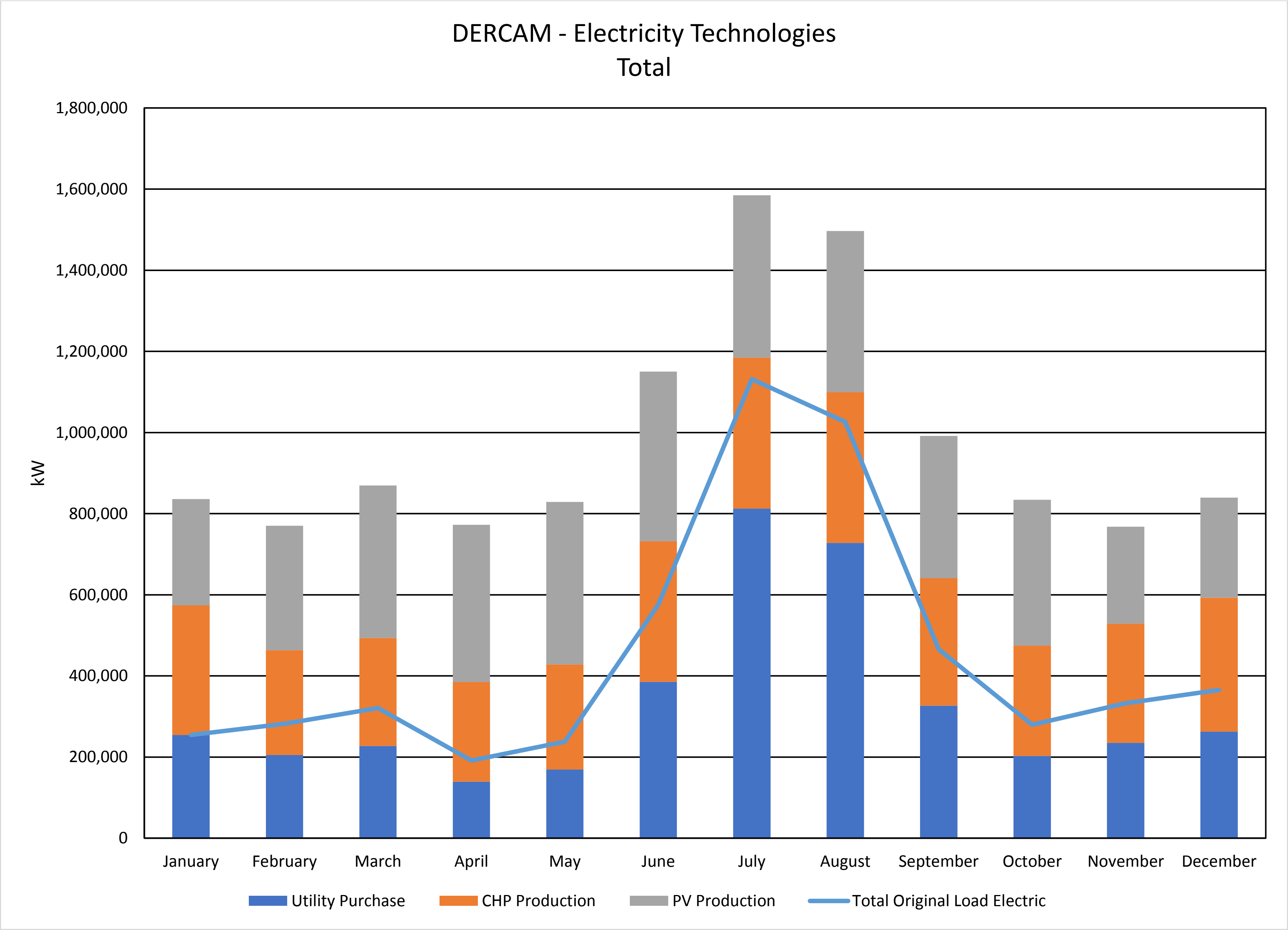
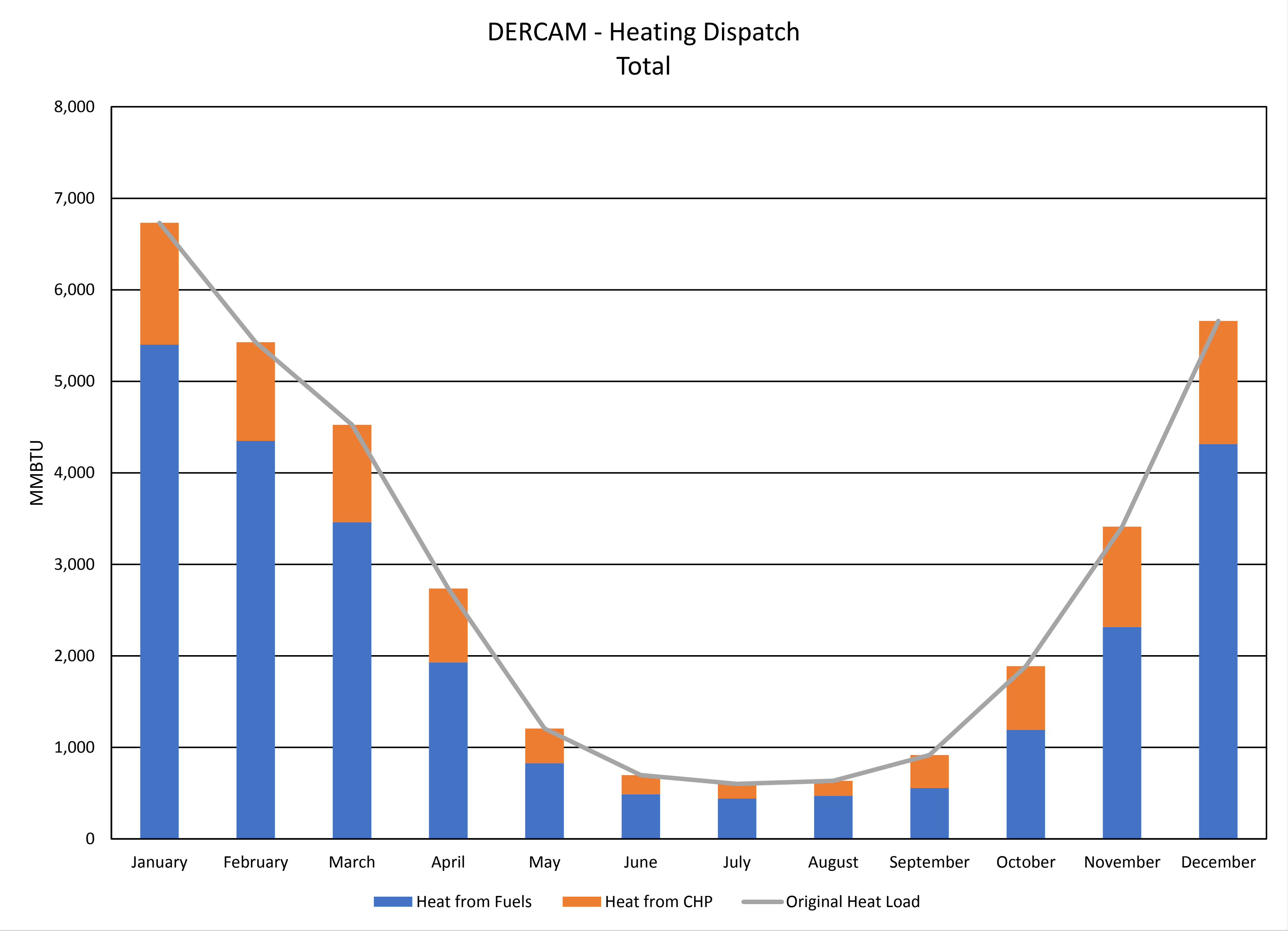
WOODBRIDGE ADVANCED MICROGRID PROJECT

Woodbridge, NJ

APPENDIX C

Monthly Thermal and Electrical Profiles – Total Microgrid


DERCAM - Electricity Technologies
Total
kW
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Utility Purchase
CHP Production
PV Production
Total Original Load Electric

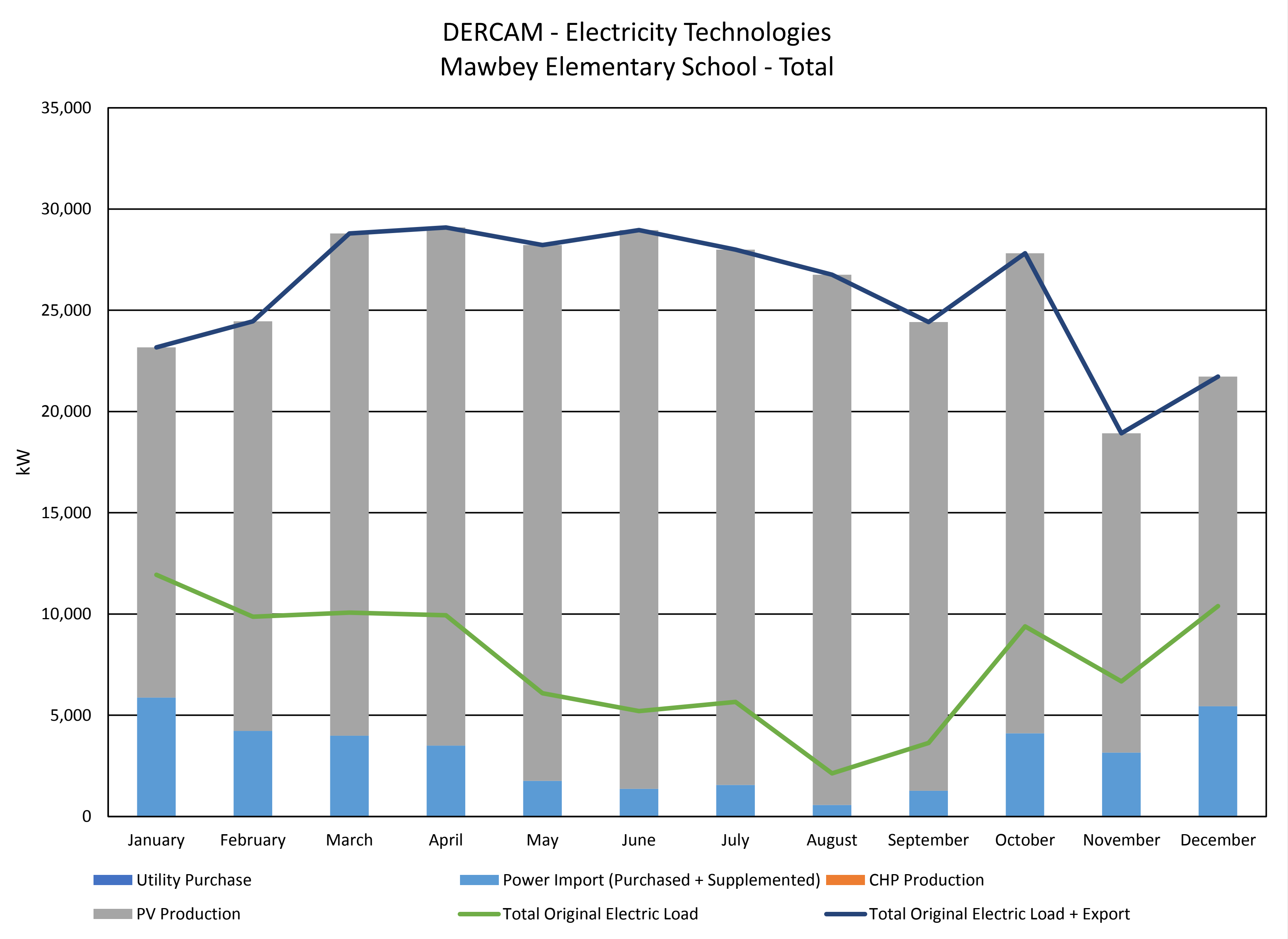

DERCAM - Heating Dispatch
Total
MMBTU
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat from CHP
Original Heat Load

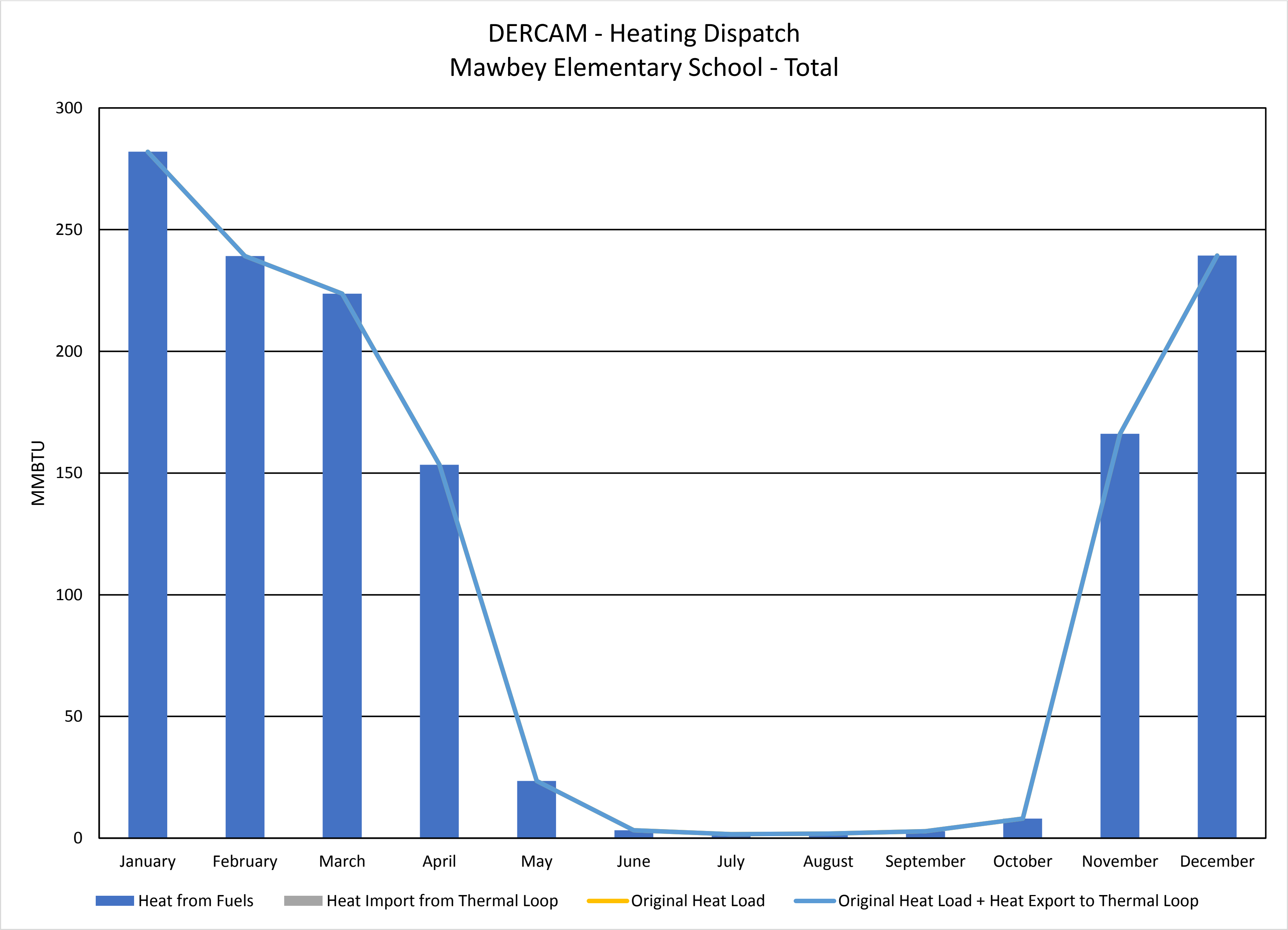
WOODBRIDGE ADVANCED MICROGRID PROJECT

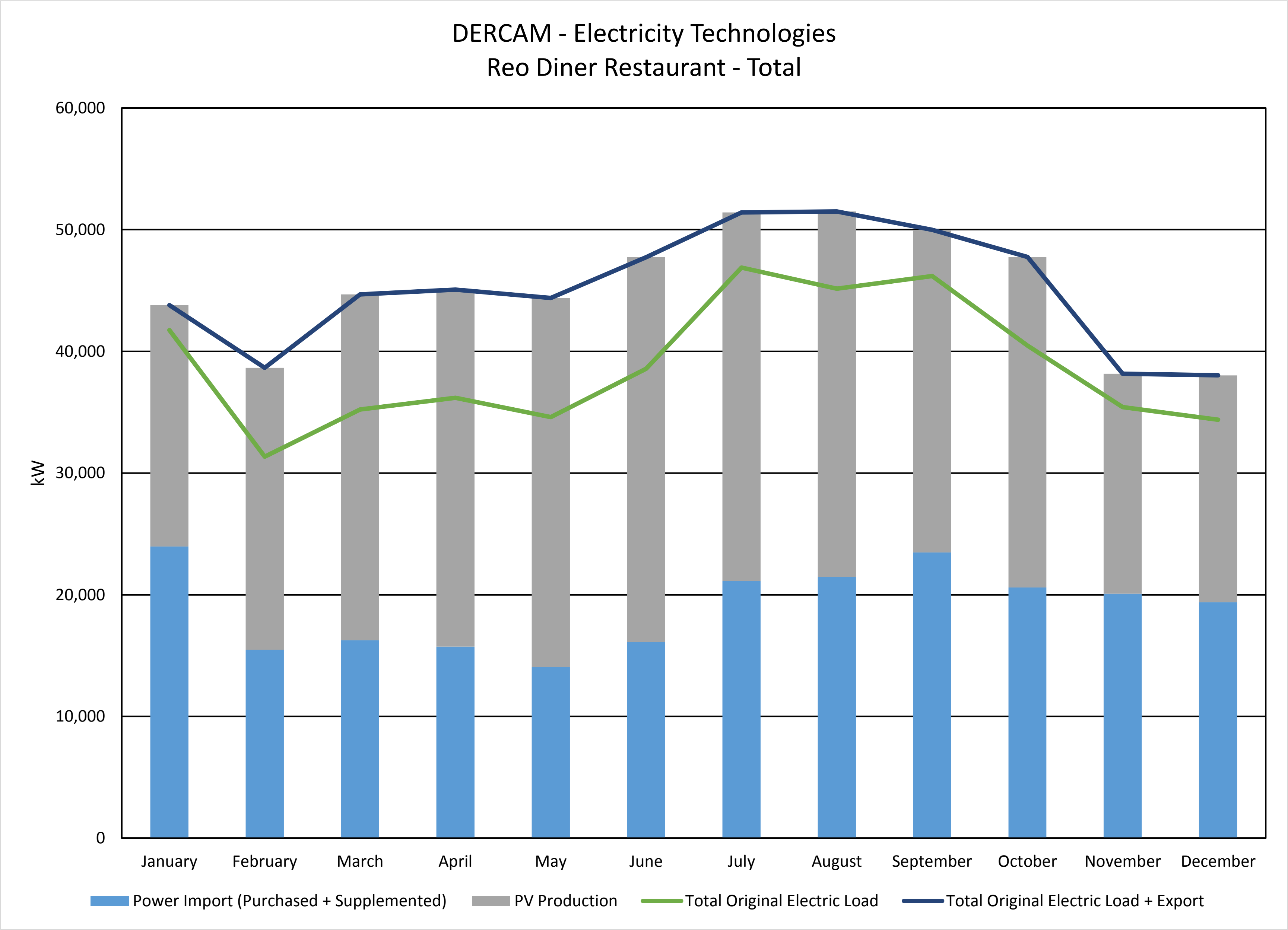
Woodbridge, NJ

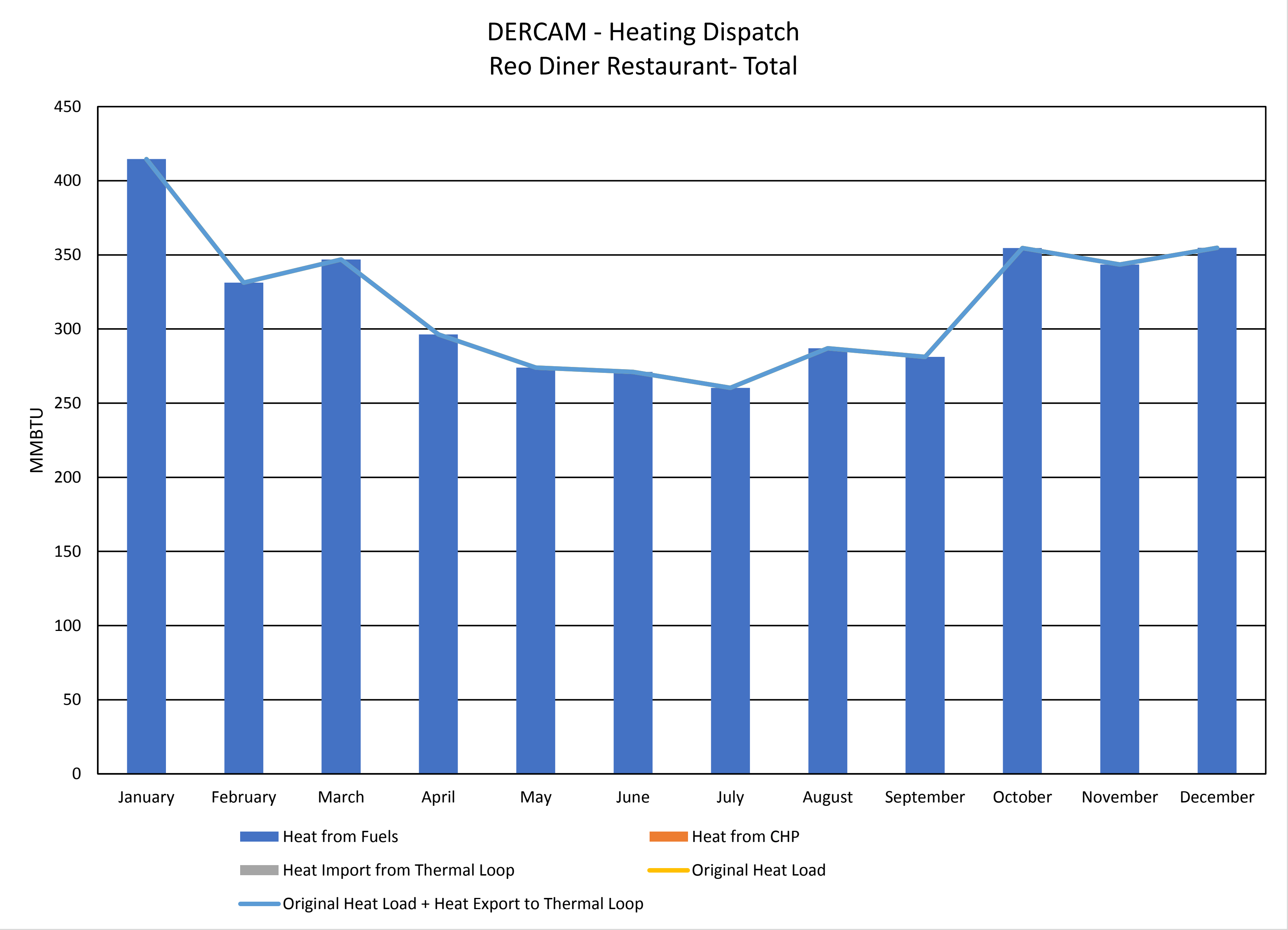
APPENDIX D

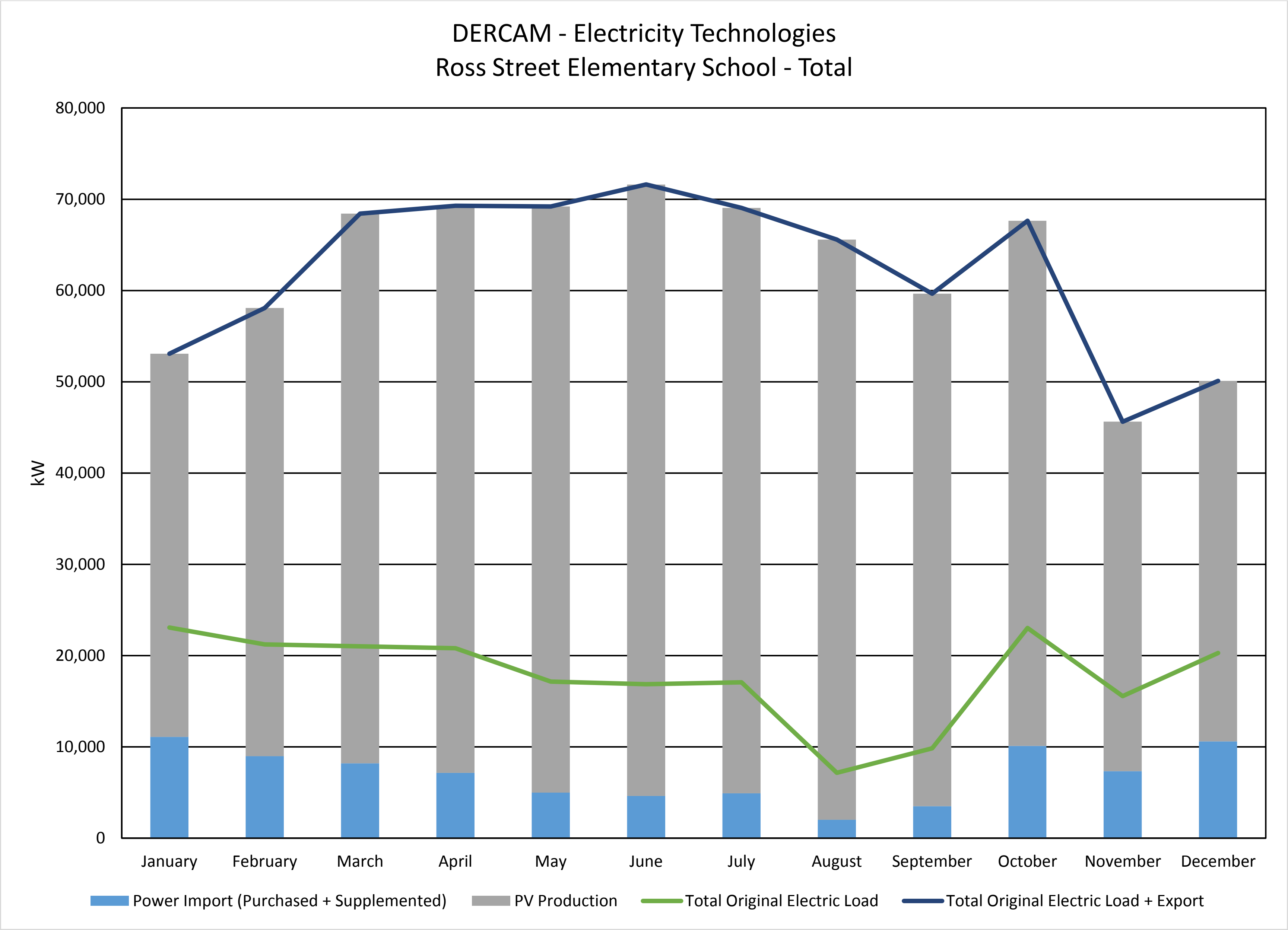
Monthly Thermal and Electrical Profiles – Phase I Facilities

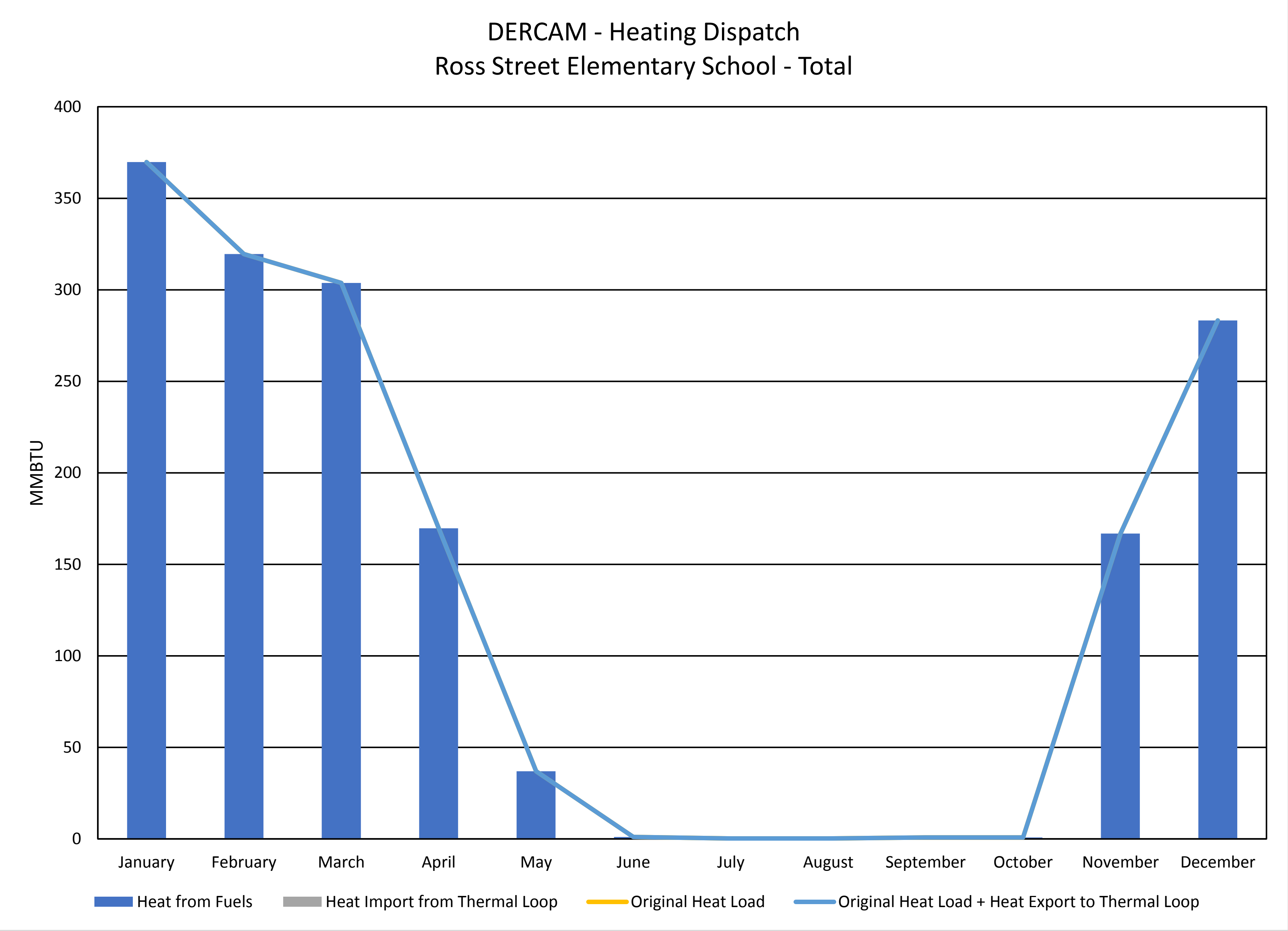

DERCAM - Electricity Technologies
Mawbey Elementary School - Total
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
kW
January
February
March
April
May
June
July
August
September
October
November
December
Utility Purchase
Power Import (Purchased + Supplemented)
CHP Production
PV Production
Total Original Electric Load
Total Original Electric Load + Export

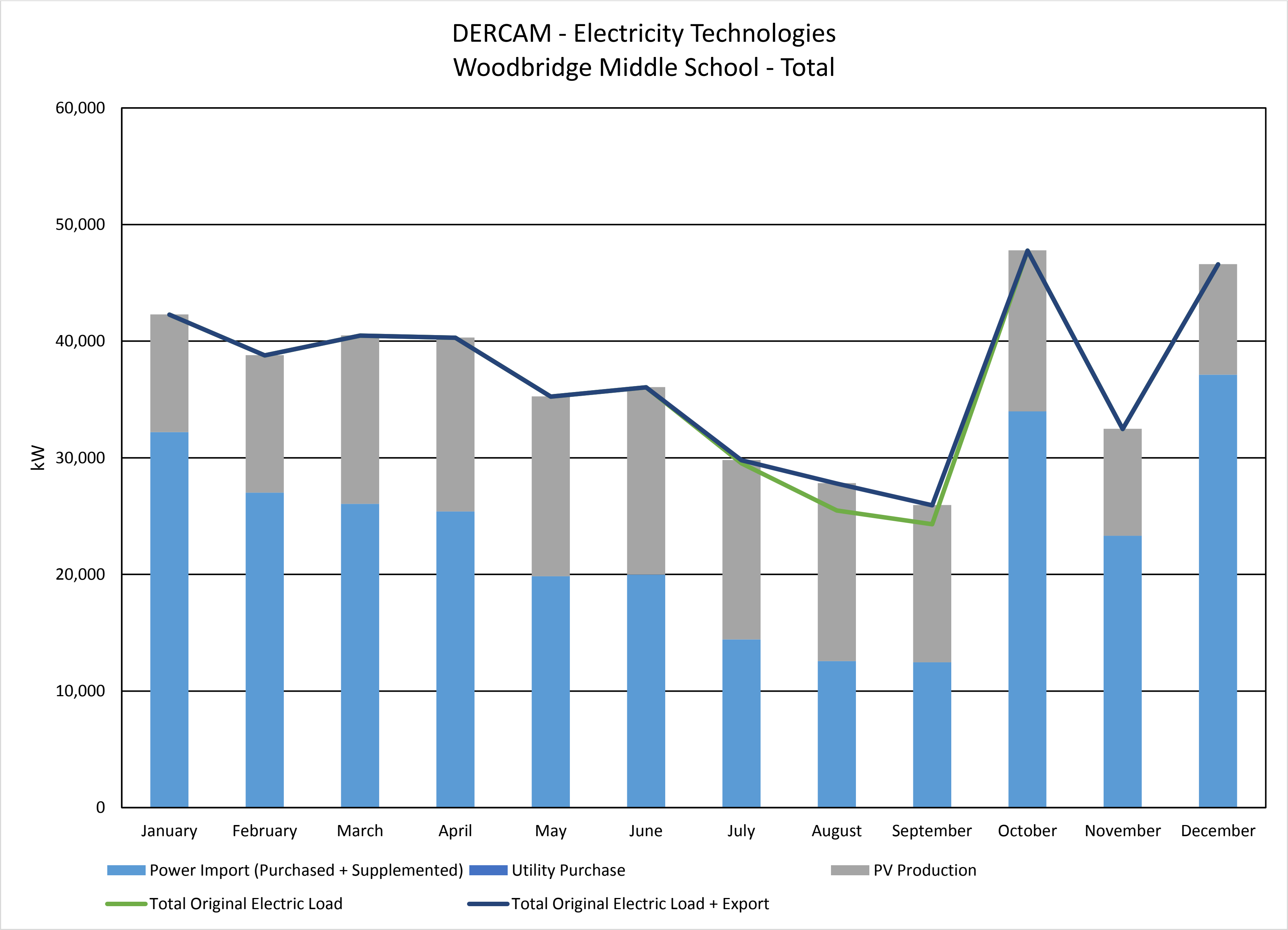

DERCAM - Heating Dispatch
Mawbey Elementary School - Total
MMBTU
300
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

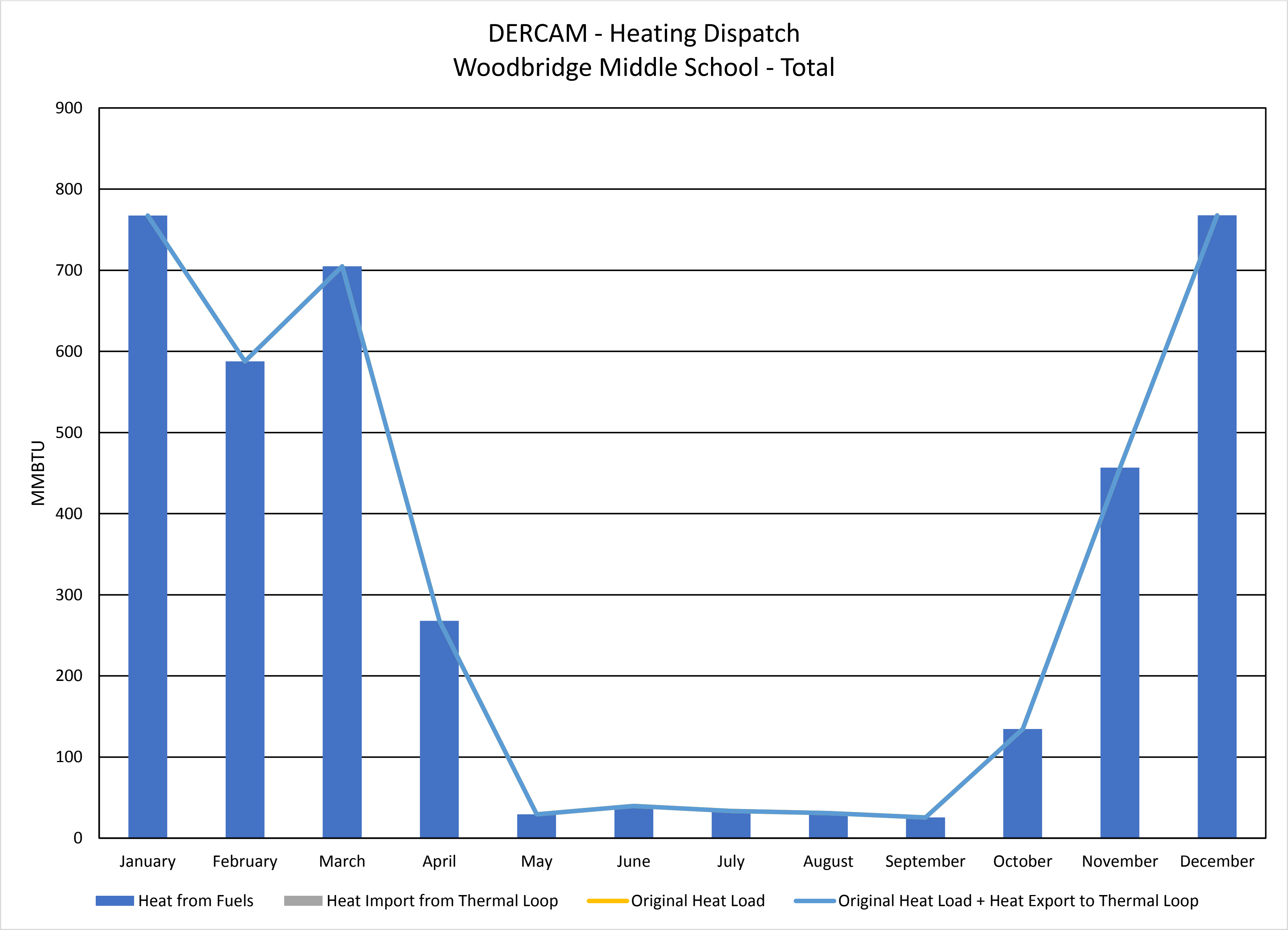

DERCAM - Electricity Technologies
Reo Diner Restaurant - Total
kW
60,000
50,000
40,000
30,000
20,000
10,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
PV Production
Total Original Electric Load
Total Original Electric Load + Export

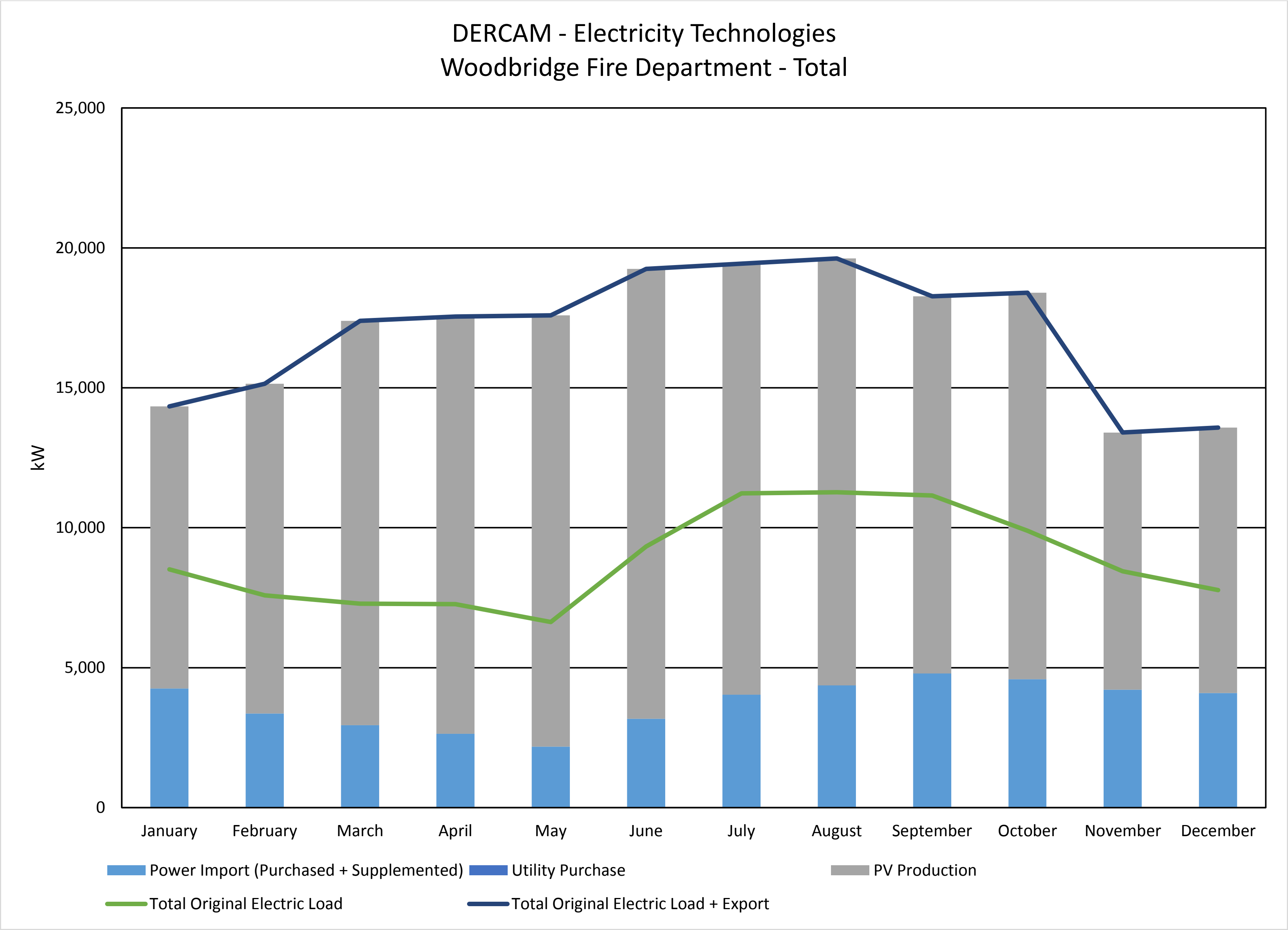

DERCAM - Heating Dispatch
Reo Diner Restaurant- Total
MMBTU
450
400
350
300
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat from CHP
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop


DERCAM - Electricity Technologies
Ross Street Elementary School - Total
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
kW
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
PV Production
Total Original Electric Load
Total Original Electric Load + Export

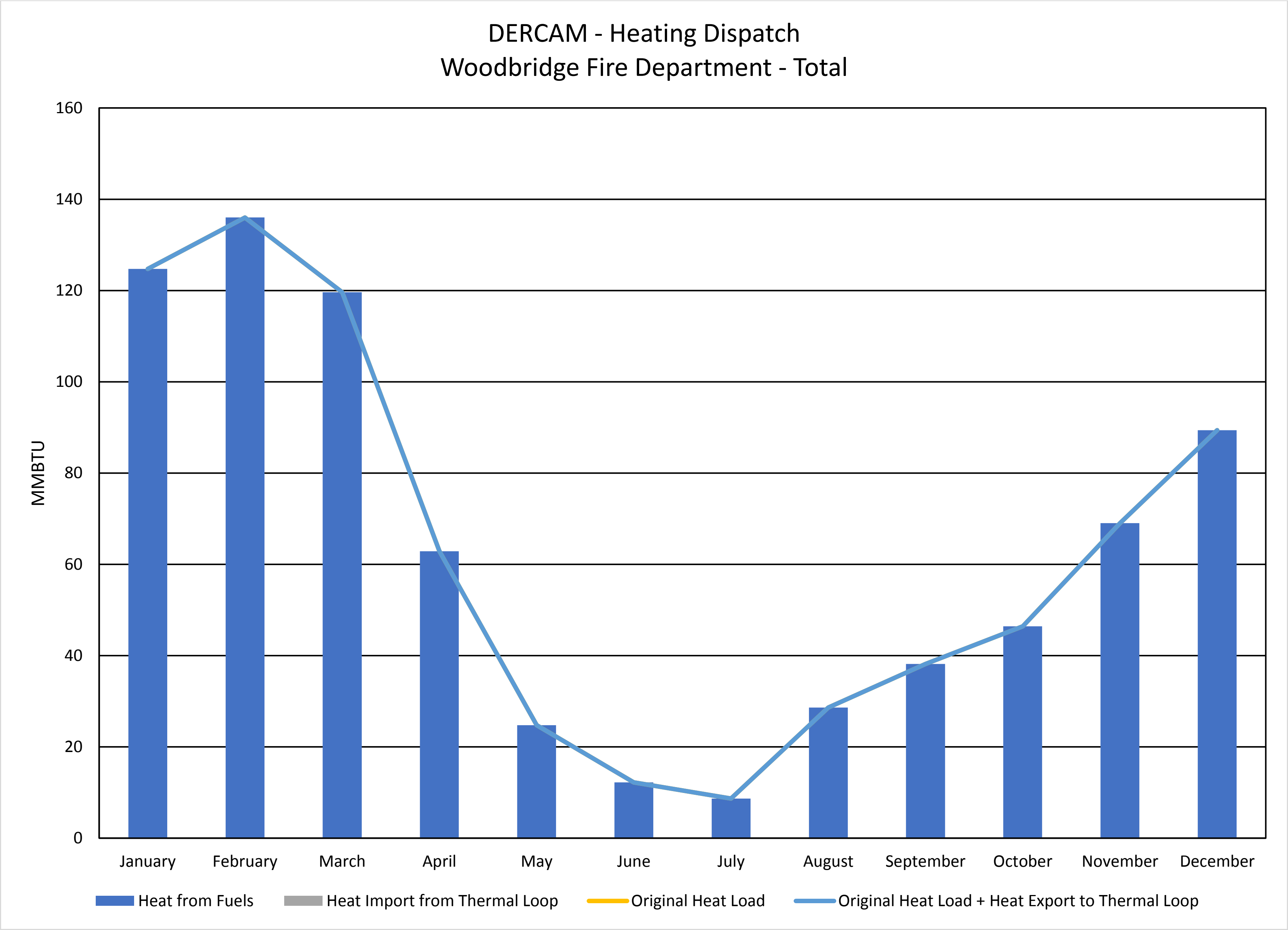

DERCAM - Heating Dispatch
Ross Street Elementary School - Total
MMBTU
400
350
300
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

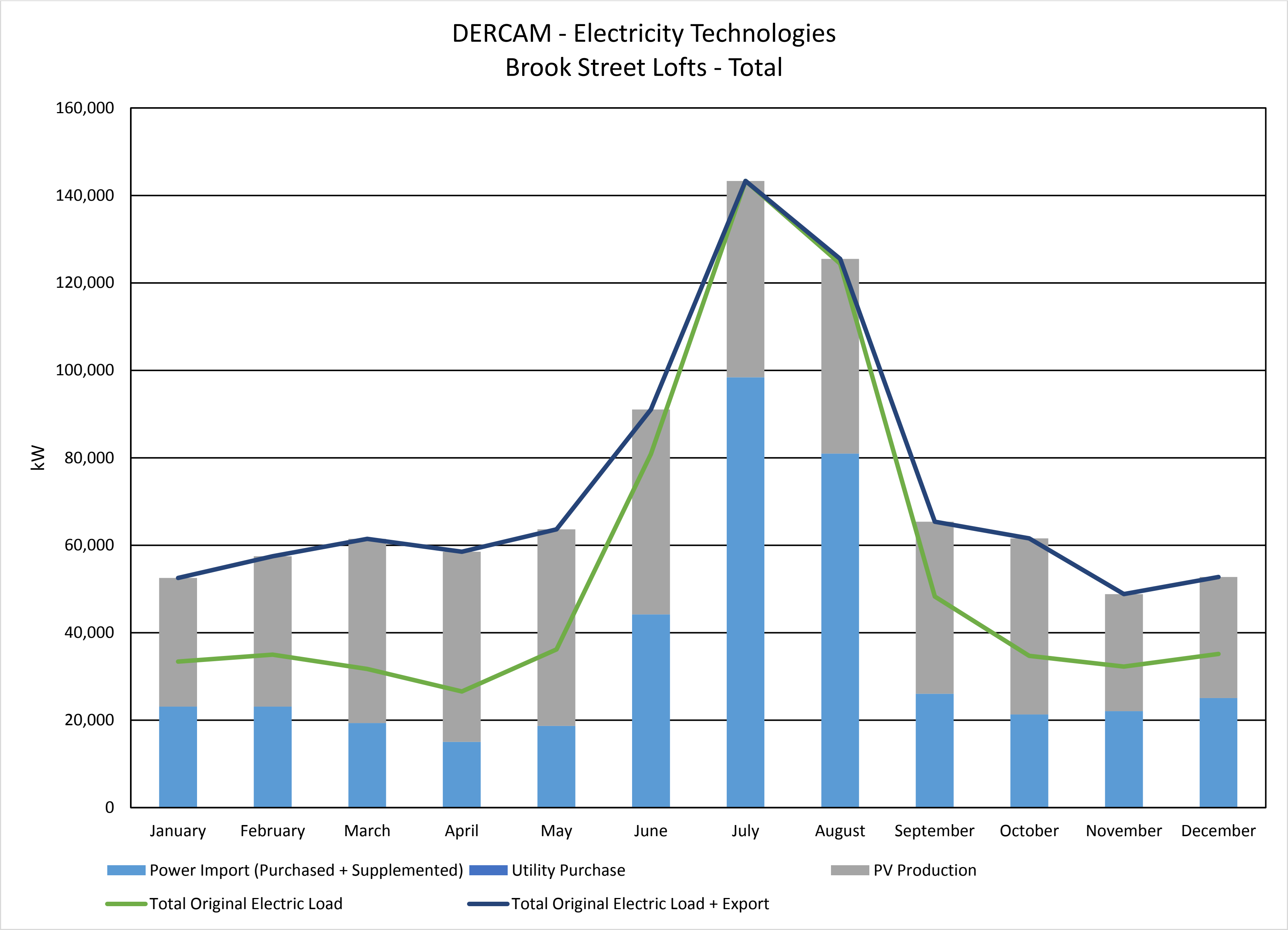

DERCAM - Electricity Technologies
Woodbridge Middle School - Total
kW
60,000
50,000
40,000
30,000
20,000
10,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
Utility Purchase
PV Production
Total Original Electric Load
Total Original Electric Load + Export

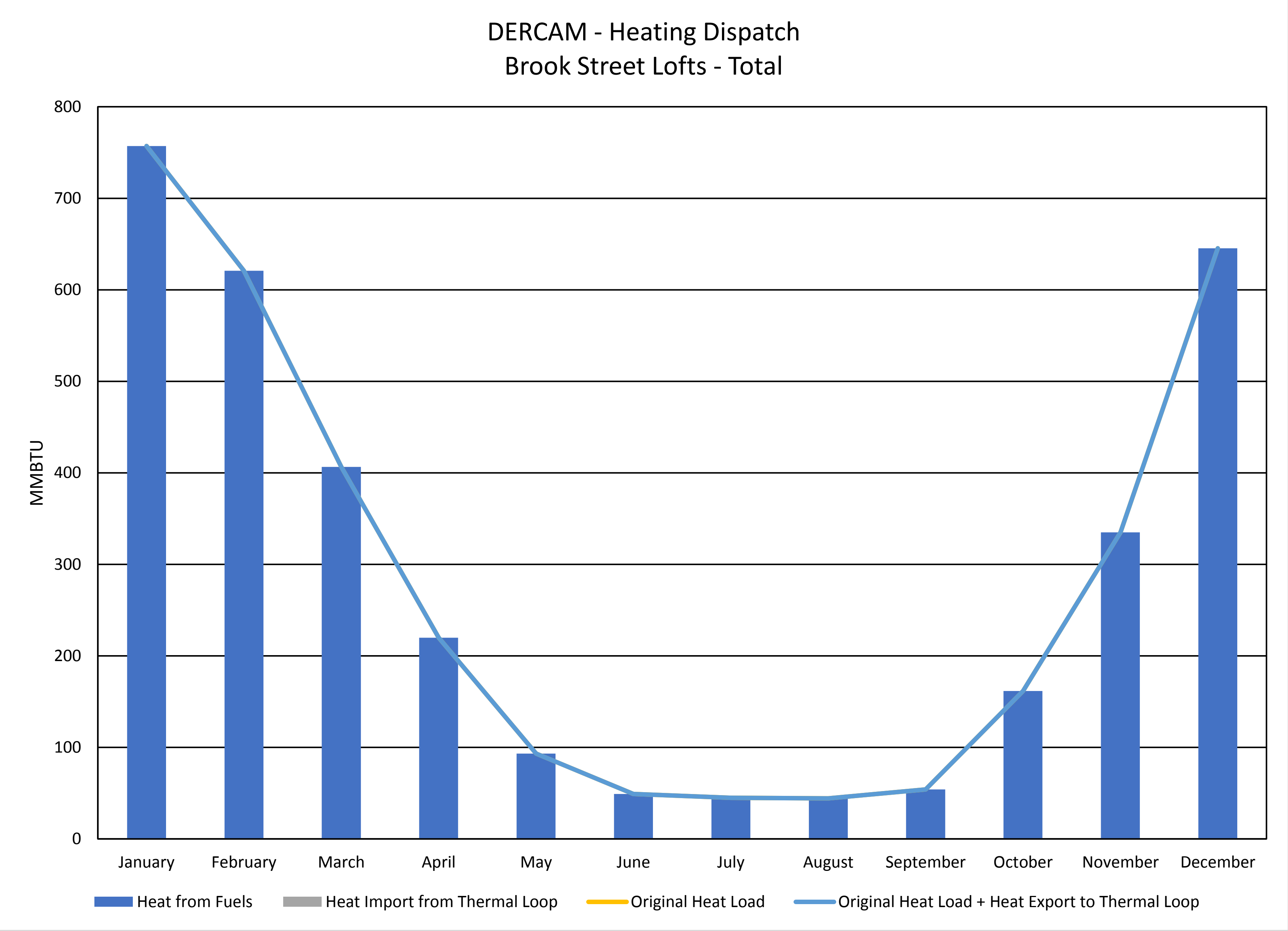
DERCAM - Heating Dispatch
Woodbridge Middle School - Total
MMBTU
900
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop



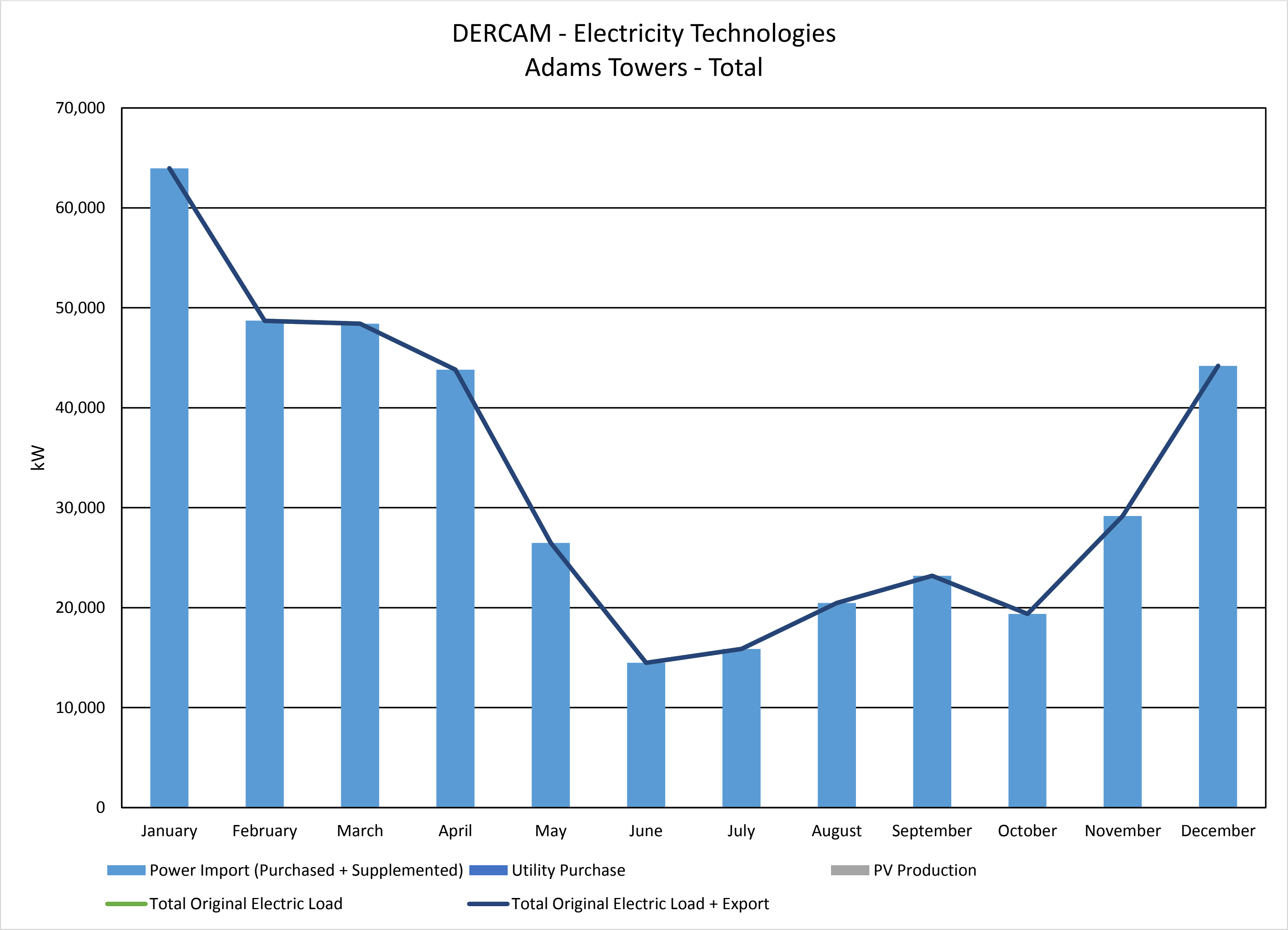
DERCAM - Electricity Technologies
Woodbridge Fire Department - Total

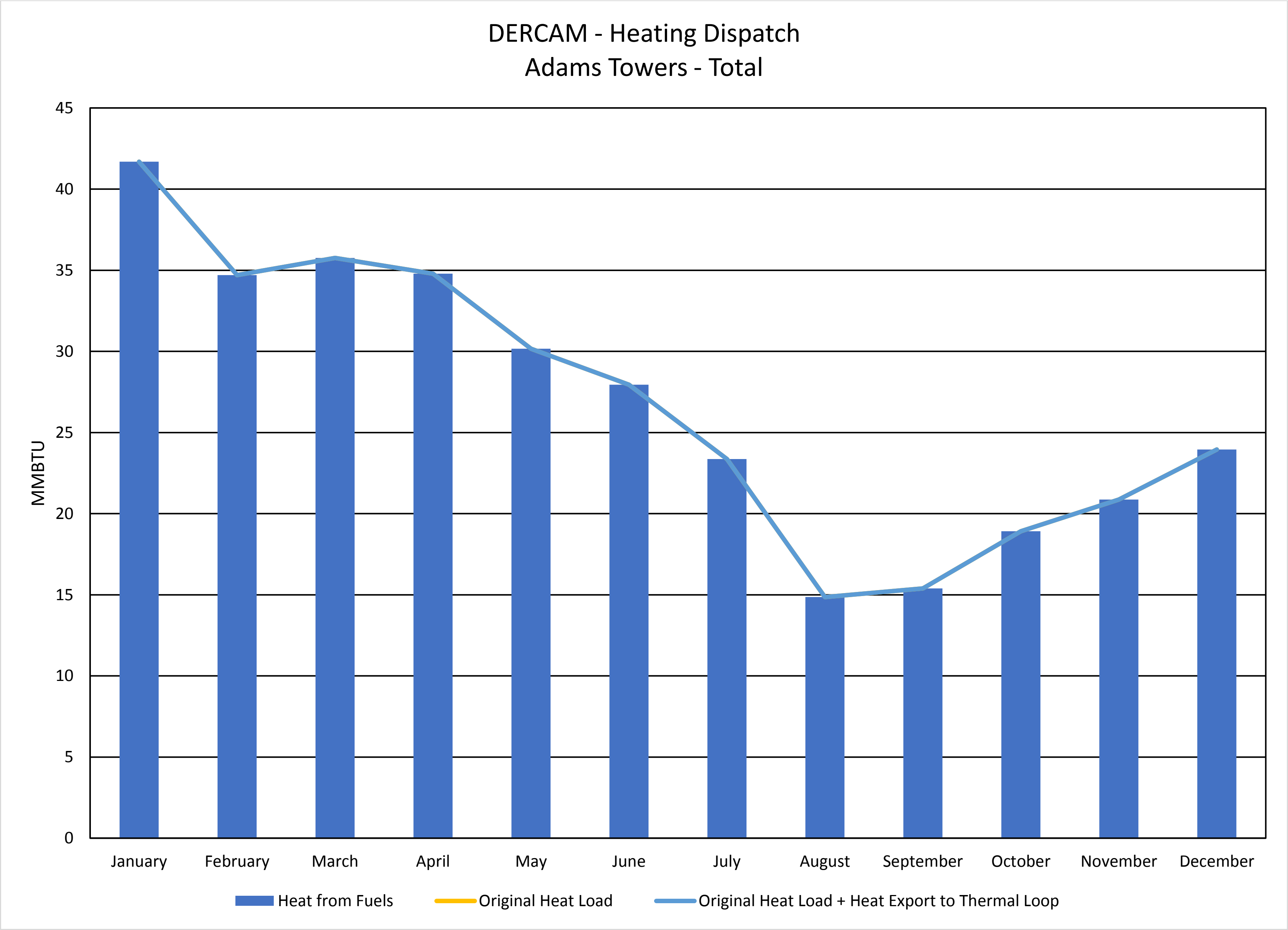
DERCAM - Heating Dispatch
Woodbridge Fire Department - Total
MMBTU
160
140
120
100
80
60
40
20
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

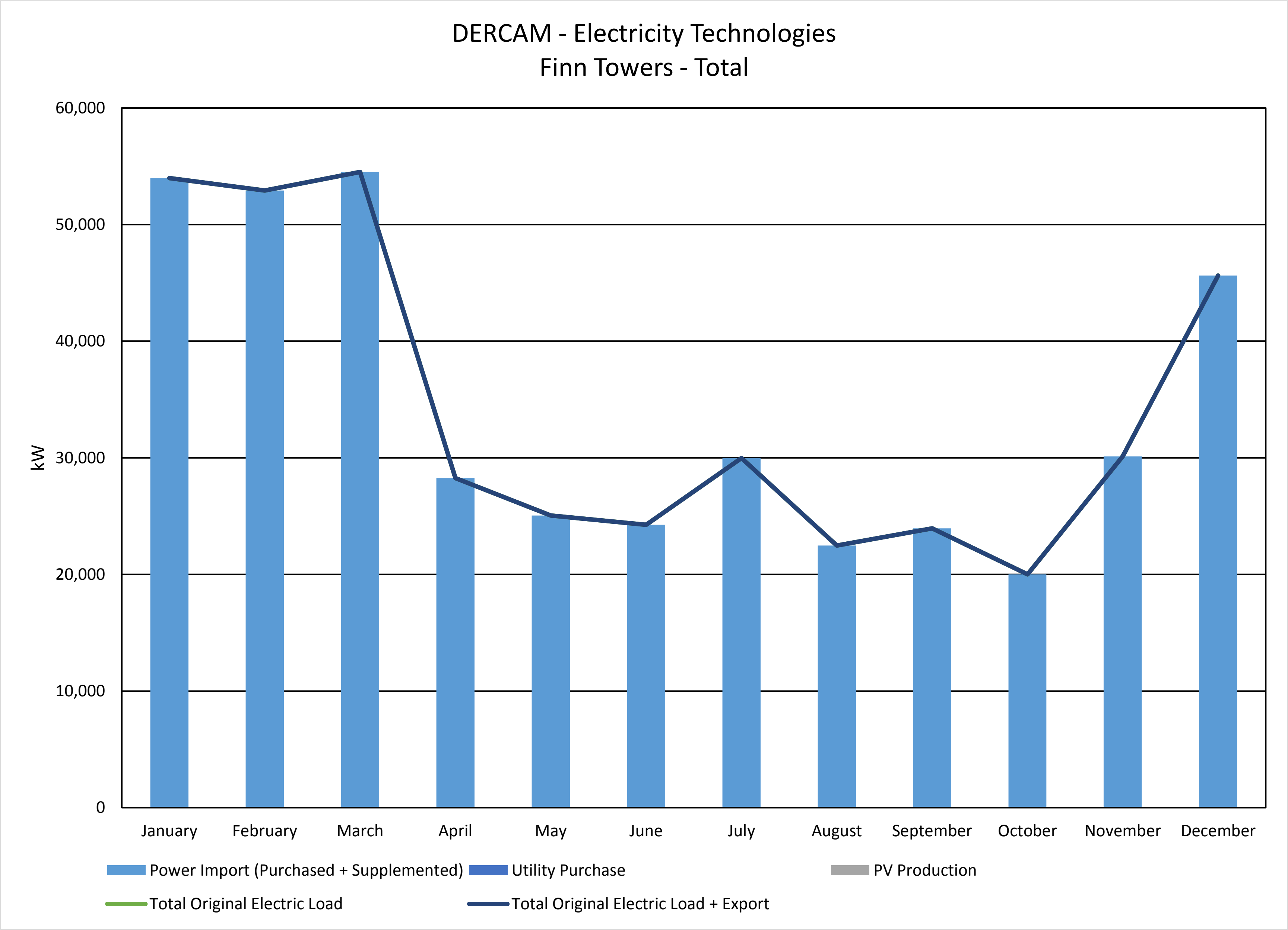
DERCAM - Electricity Technologies
Brook Street Lofts - Total
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
kW
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
Utility Purchase
PV Production
Total Original Electric Load
Total Original Electric Load + Export

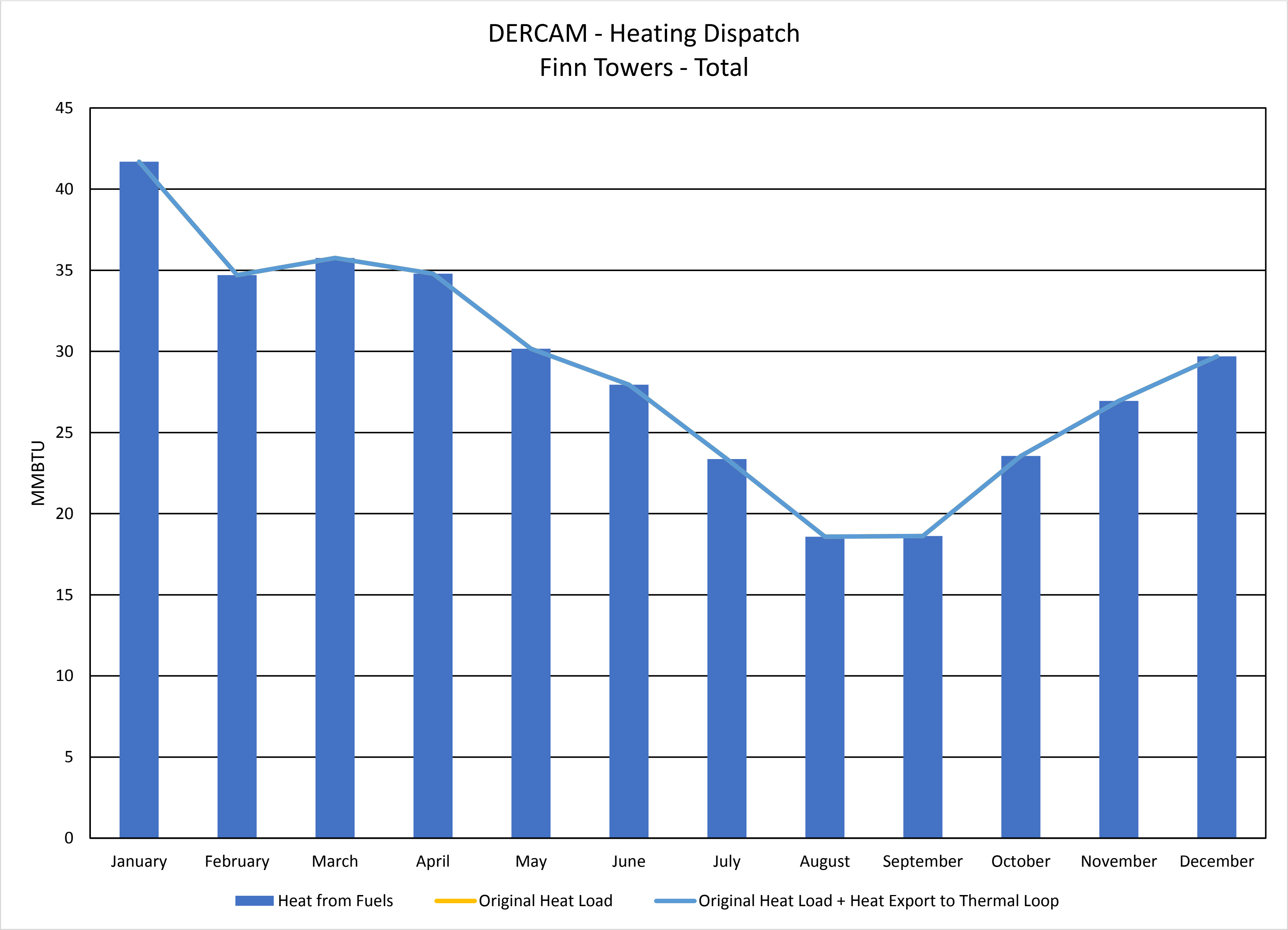


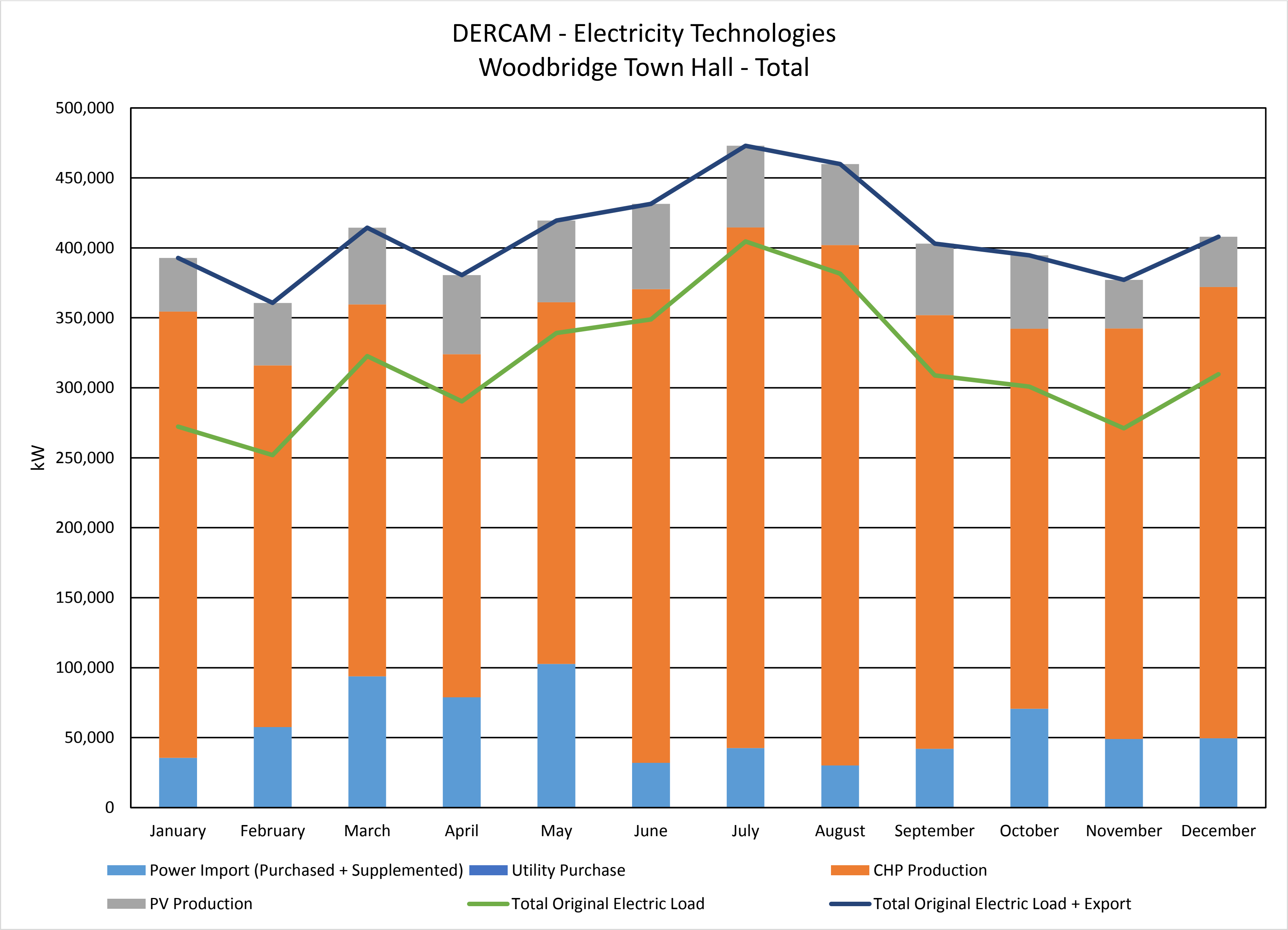
DERCAM - Heating Dispatch
Brook Street Lofts - Total
MMBTU
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

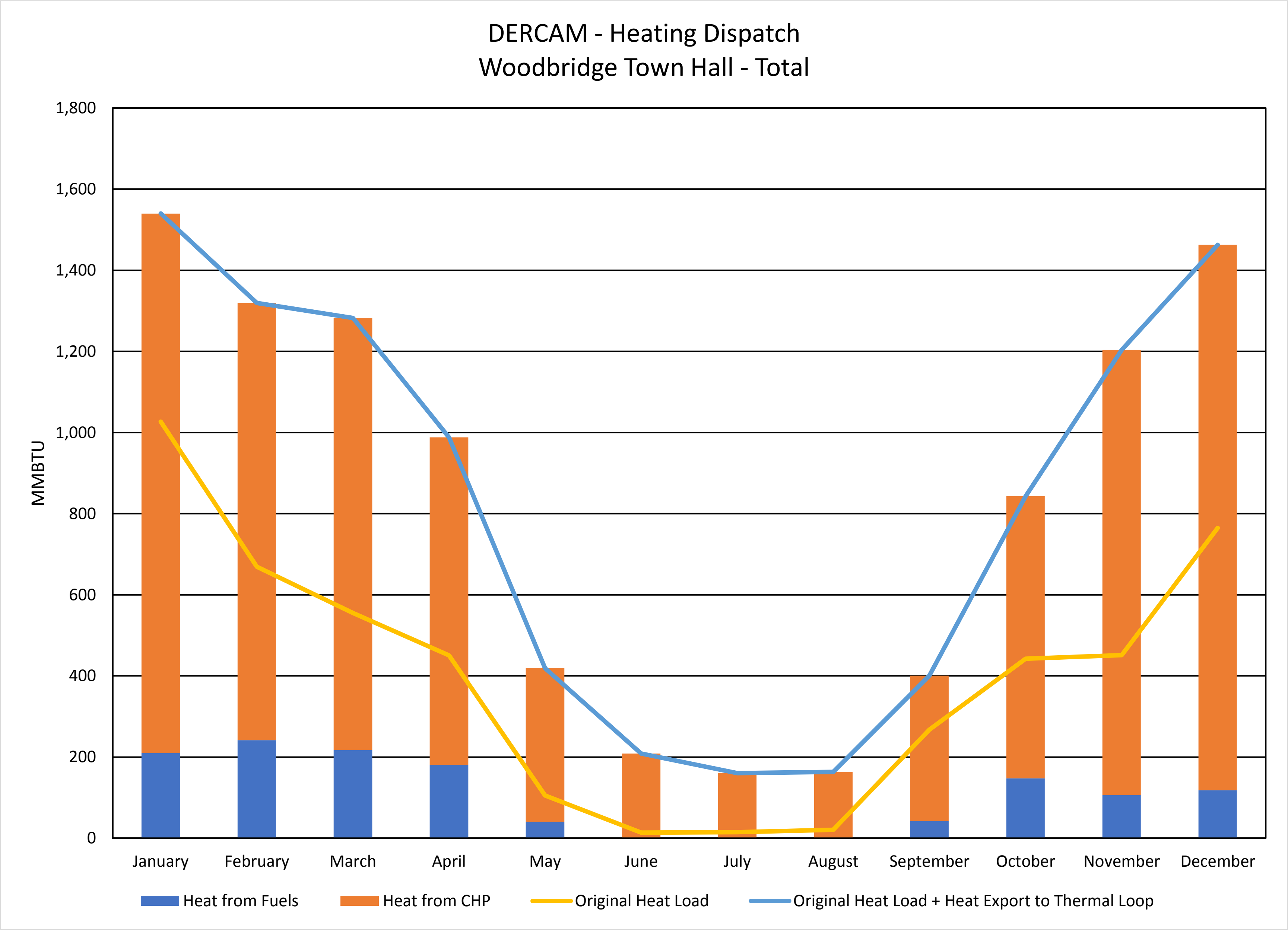

DERCAM - Electricity Technologies
Adams Towers - Total
kW
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
Utility Purchase
PV Production
Total Original Electric Load
Total Original Electric Load + Export

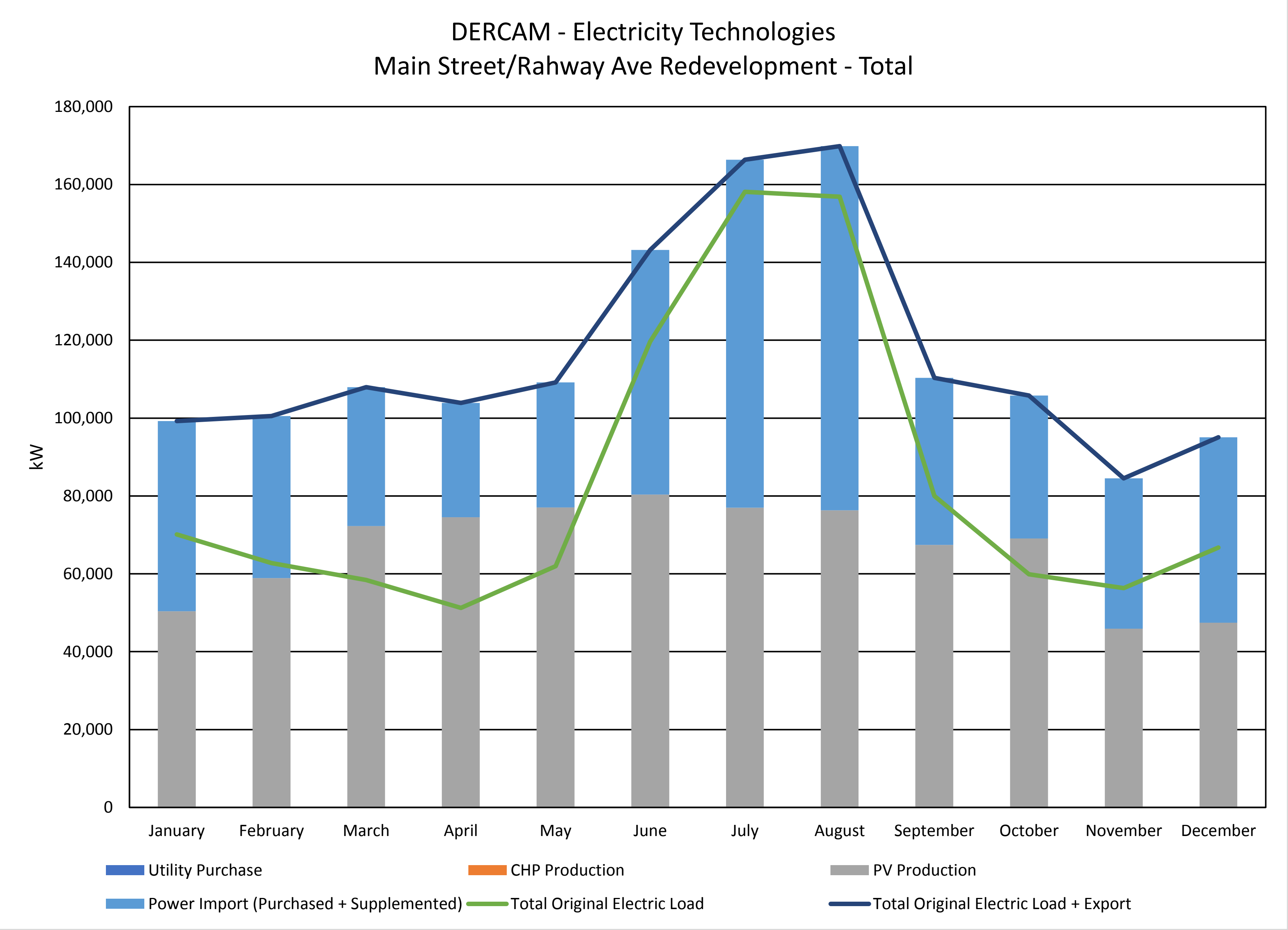

DERCAM - Heating Dispatch
Adams Towers - Total
MMBTU
45
40
35
30
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

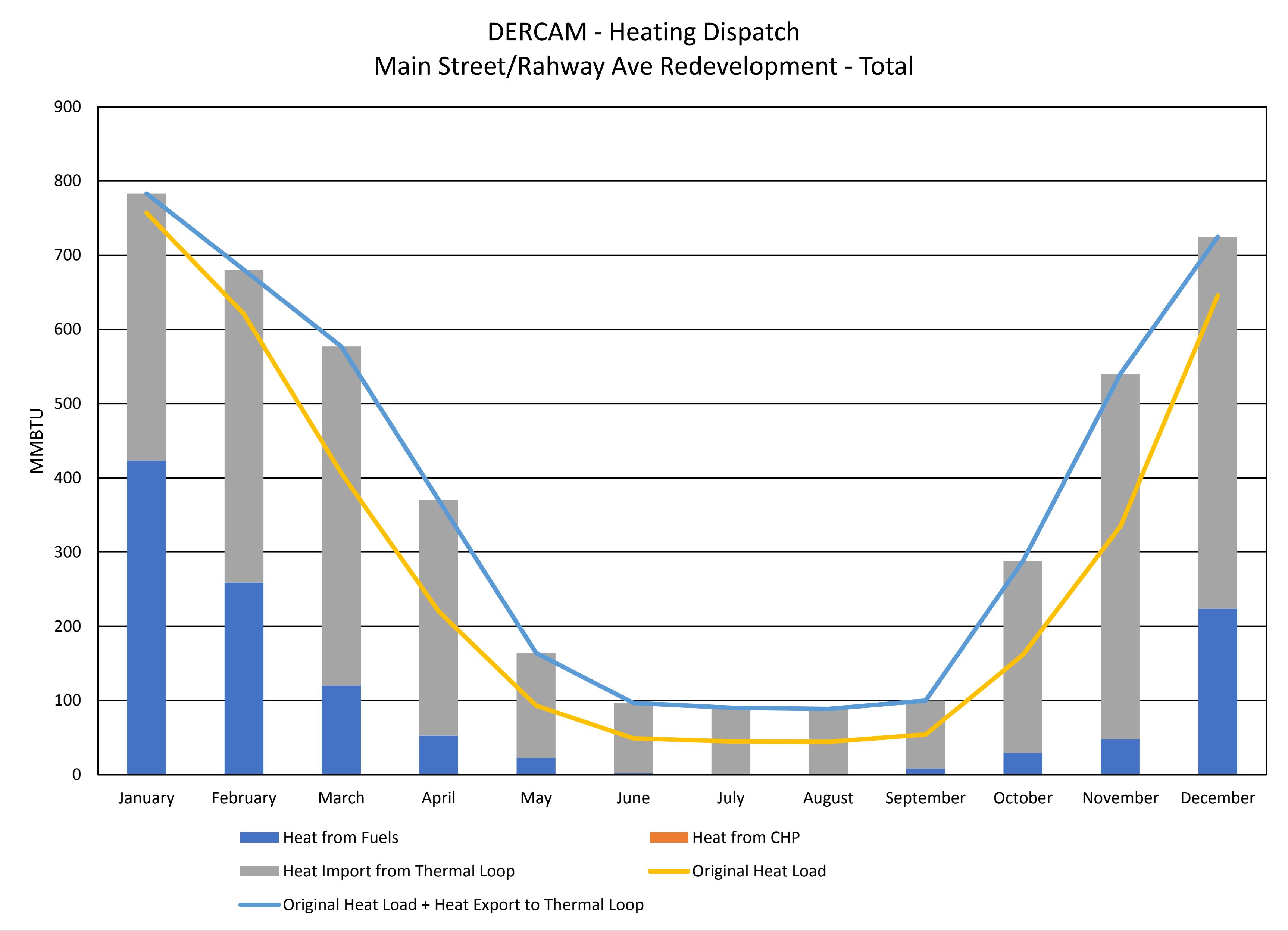

DERCAM - Electricity Technologies
Finn Towers - Total
60,000
50,000
40,000
30,000
20,000
10,000
0
kW
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
Utility Purchase
PV Production
Total Original Electric Load
Total Original Electric Load + Export

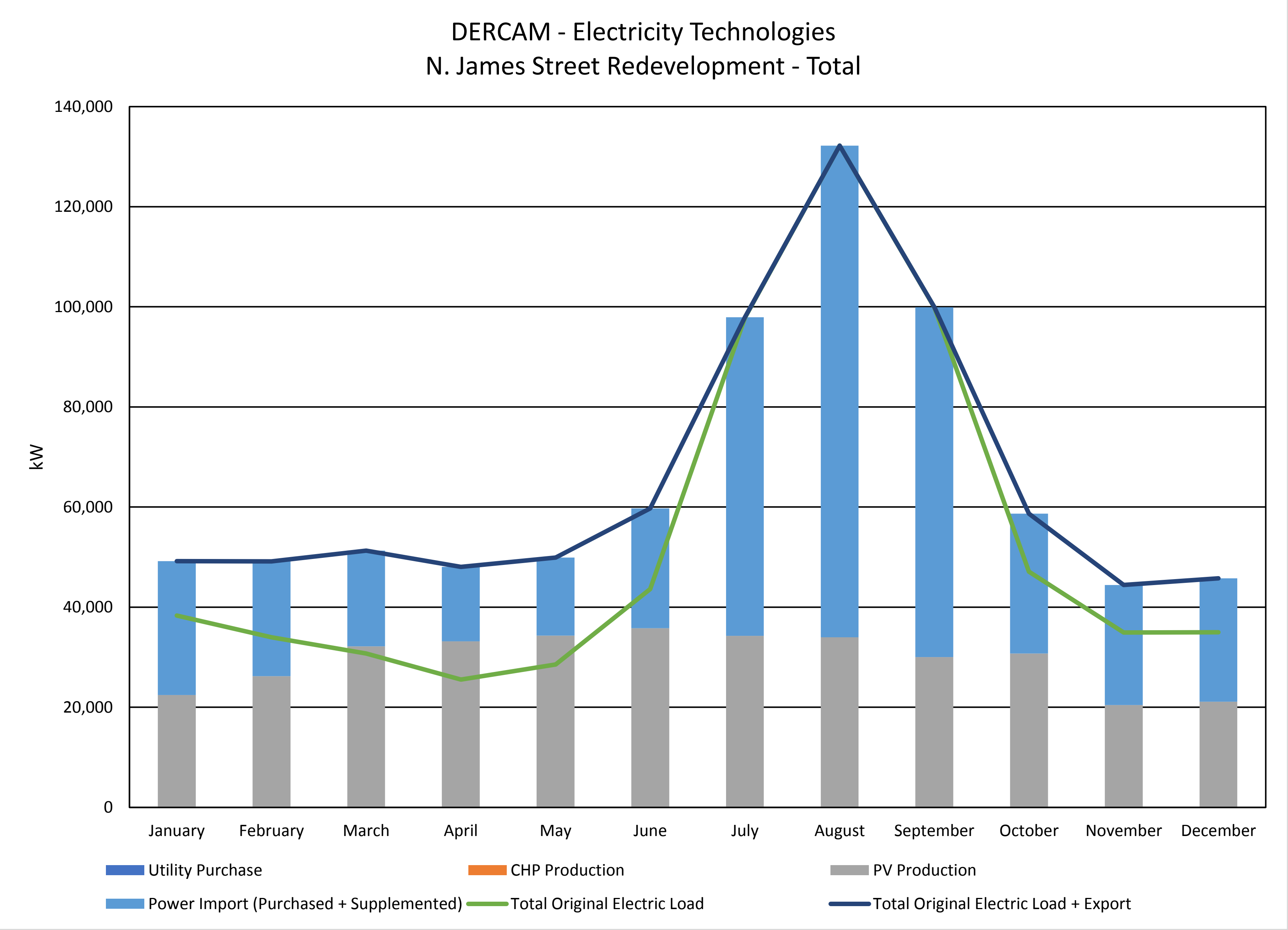

DERCAM - Heating Dispatch
Finn Towers - Total
MMBTU
45
40
35
30
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

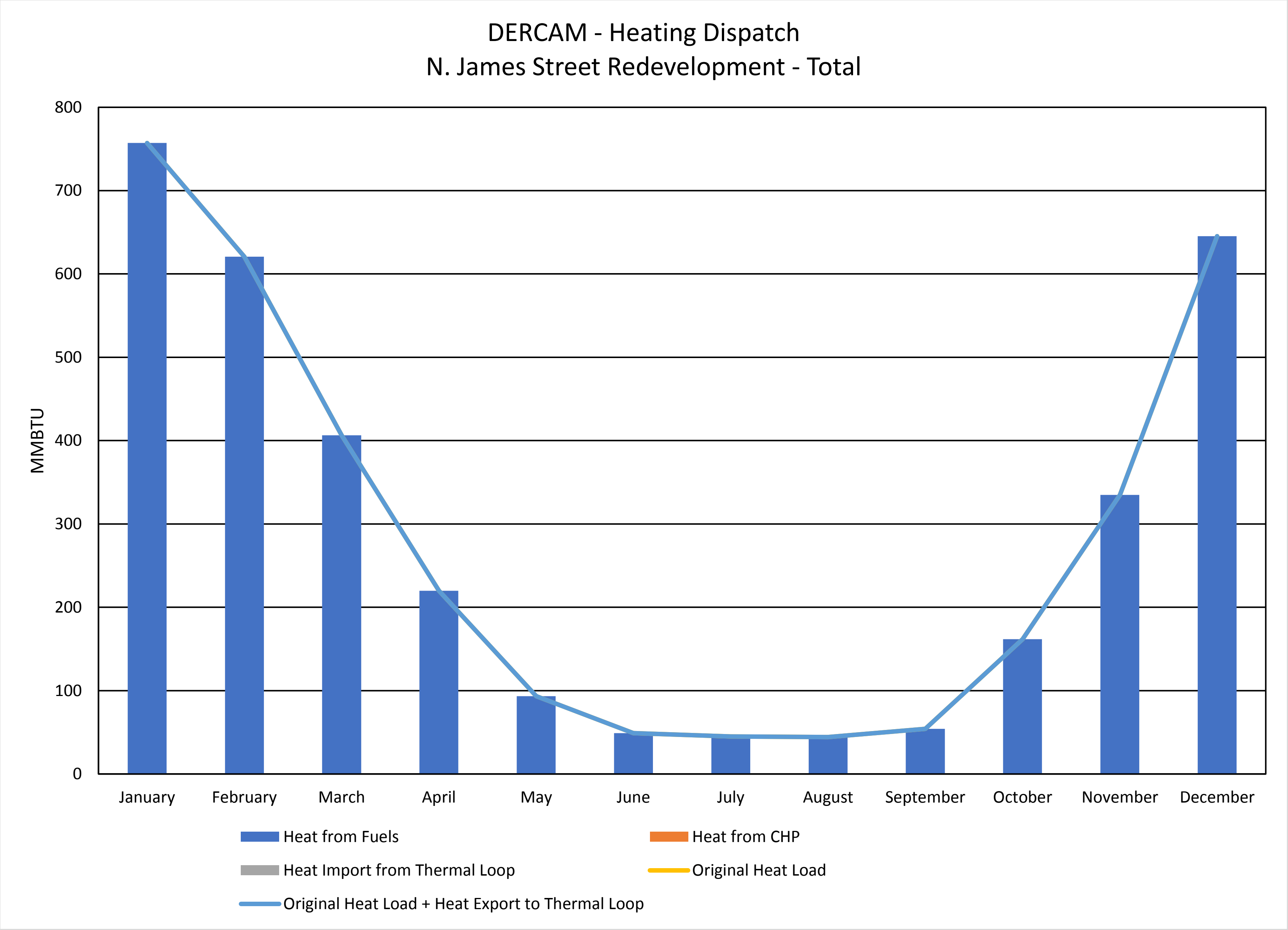

DERCAM - Electricity Technologies
Woodbridge Town Hall - Total
kW
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
Utility Purchase
CHP Production
PV Production
Total Original Electric Load
Total Original Electric Load + Export

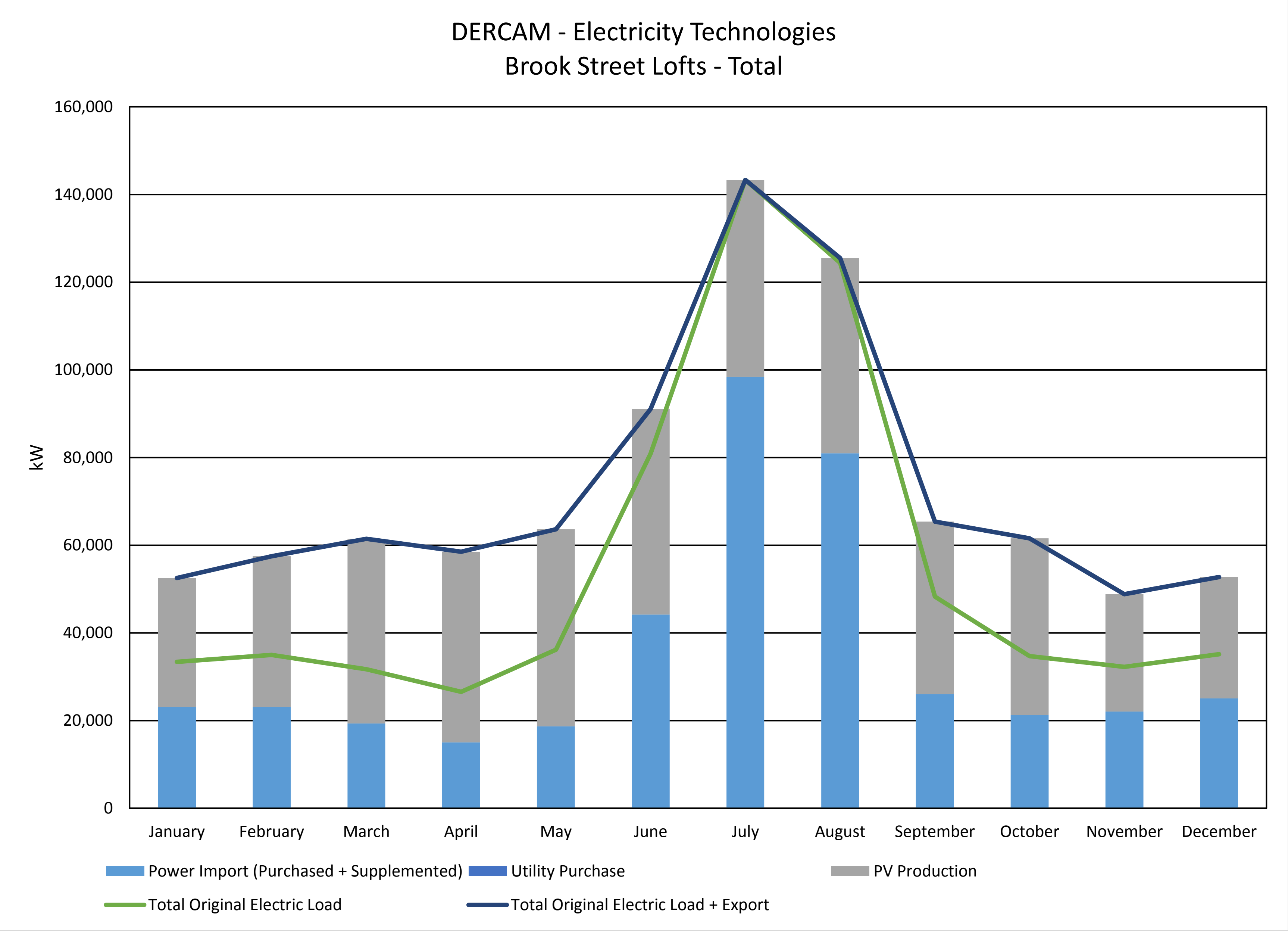

DERCAM - Heating Dispatch
Woodbridge Town Hall - Total
MMBTU
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat from CHP
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

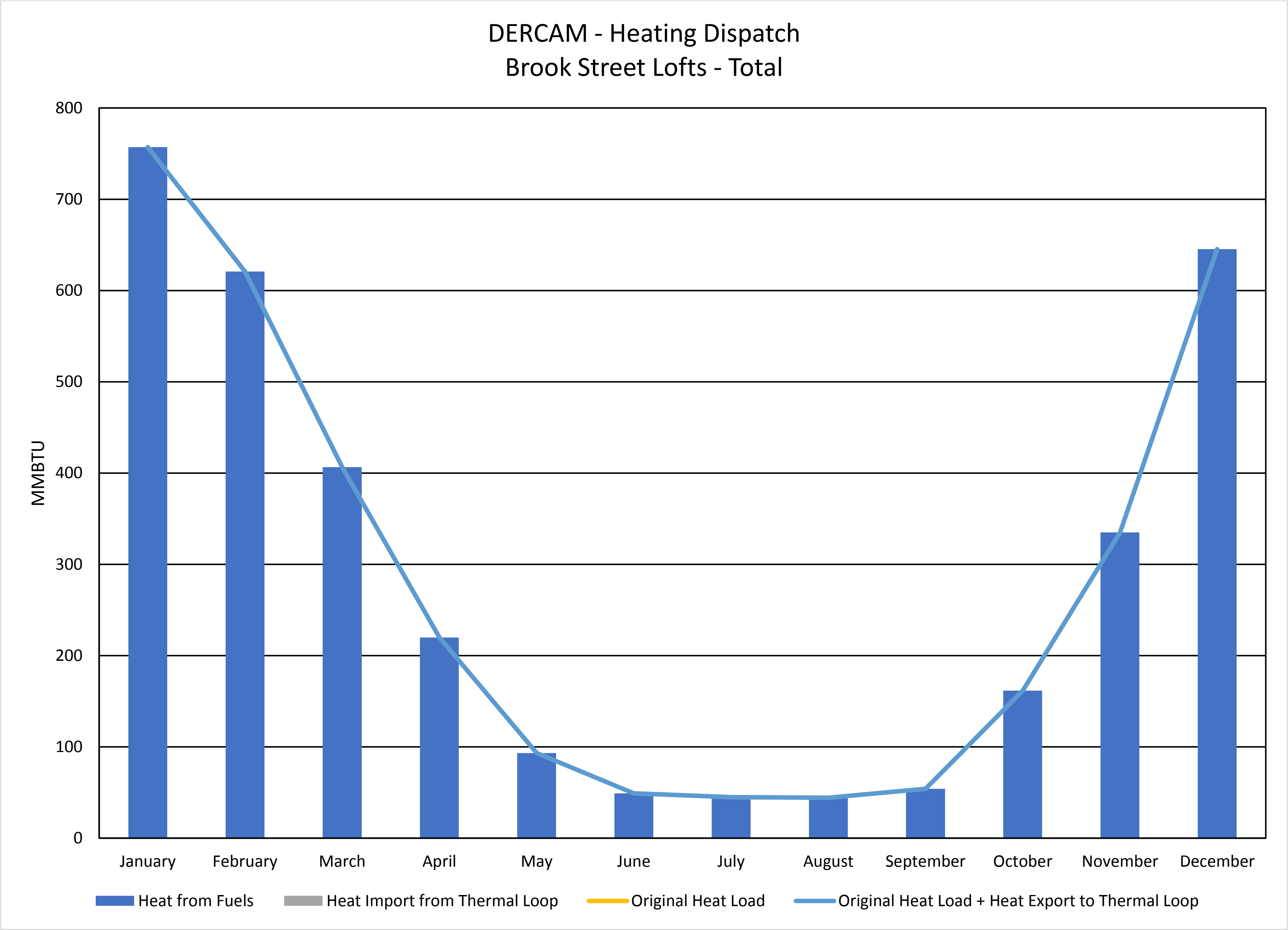

DERCAM - Electricity Technologies
Main Street/Rahway Ave Redevelopment - Total
kW
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Utility Purchase
CHP Production
PV Production
Power Import (Purchased + Supplemented)
Total Original Electric Load
Total Original Electric Load + Export


DERCAM - Heating Dispatch
Main Street/Rahway Ave Redevelopment - Total
MMBTU
0
100
200
300
400
500
600
700
800
900
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat from CHP
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop


DERCAM - Electricity Technologies
N. James Street Redevelopment - Total
kW
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Utility Purchase
CHP Production
PV Production
Power Import (Purchased + Supplemented)
Total Original Electric Load
Total Original Electric Load + Export


DERCAM - Heating Dispatch
N. James Street Redevelopment - Total
MMBTU
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat from CHP
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

DERCAM - Electricity Technologies
Brook Street Lofts - Total
kW
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
January
February
March
April
May
June
July
August
September
October
November
December
Power Import (Purchased + Supplemented)
Utility Purchase
PV Production
Total Original Electric Load
Total Original Electric Load + Export


DERCAM - Heating Dispatch
Brook Street Lofts - Total
MMBTU
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December
Heat from Fuels
Heat Import from Thermal Loop
Original Heat Load
Original Heat Load + Heat Export to Thermal Loop

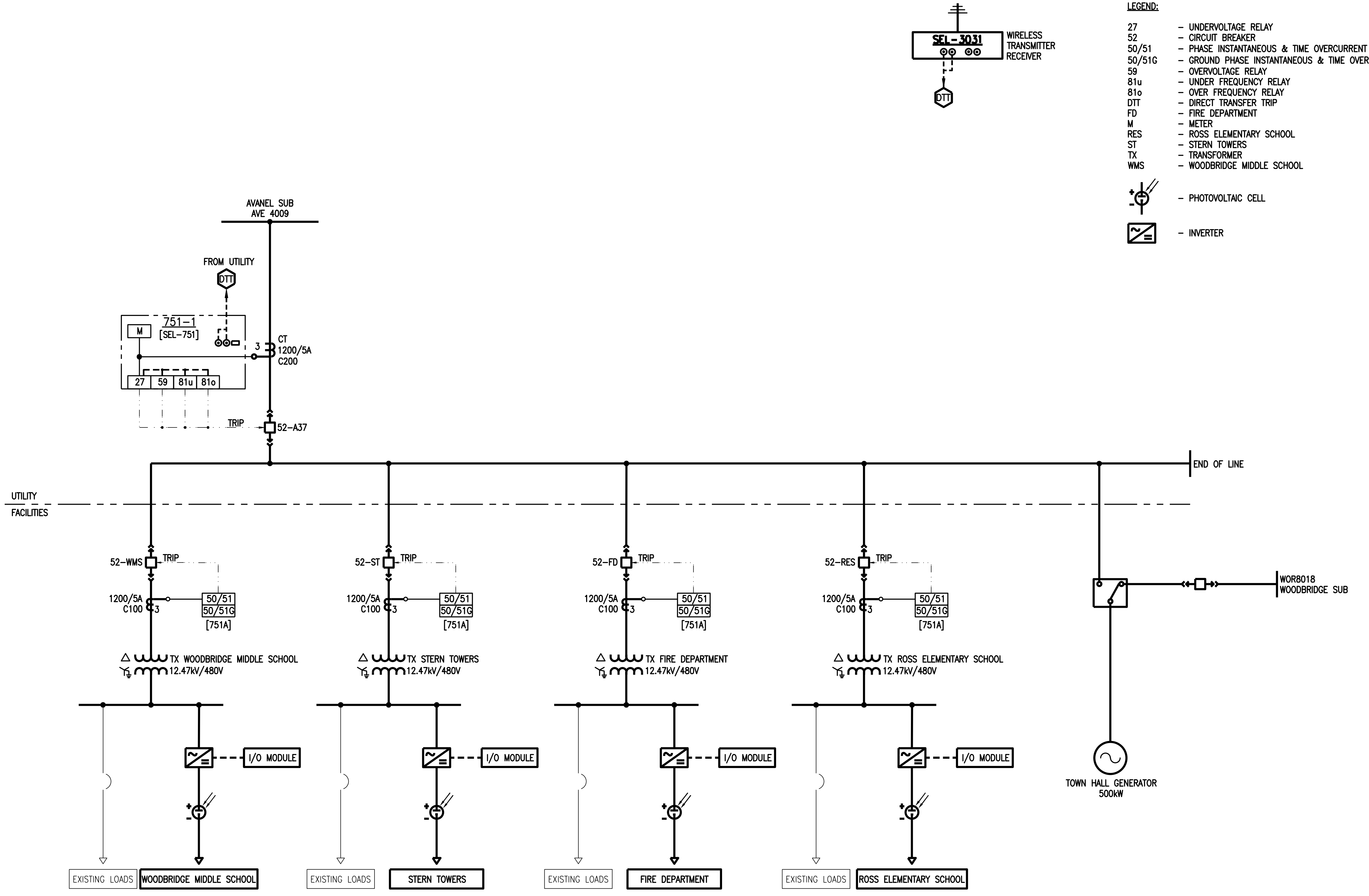
WOODBRIDGE ADVANCED MICROGRID PROJECT

Woodbridge, NJ

APPENDIX E

Single Line Diagram – Black-sky Mode of Operation

NOTES:



LEGEND:

27	– UNDERVOLTAGE RELAY
52	– CIRCUIT BREAKER
50/51	– PHASE INSTANTANEOUS & TIME OVERCURRENT RELAY
50/51G	– GROUND PHASE INSTANTANEOUS & TIME OVERCURRENT RELAY
59	– OVERVOLTAGE RELAY
81u	– UNDER FREQUENCY RELAY
81o	– OVER FREQUENCY RELAY
DTT	– DIRECT TRANSFER TRIP
FD	– FIRE DEPARTMENT
M	– METER
RES	– ROSS ELEMENTARY SCHOOL
ST	– STERN TOWERS
TX	– TRANSFORMER
WMS	– WOODBRIDGE MIDDLE SCHOOL
⊕	– PHOTOVOLTAIC CELL
⧄	– INVERTER

NOT FOR CONSTRUCTION

File: \\CHA-LLP.COM\PROJ\PROJECTS\ANY\K4\33654\CADD_ACAD\EL\33654-ESK001.DWG
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CHA
Powers Building, 16 West Main Street, Suite 830
Rochester, NY 14614-1607
Main: (585) 262-2640 • www.chacompanies.com

WOODBRIDGE TOWN CENTER ADVANCED MICROGRID (WAM) PROJECT
BLACK-SKY MODE OF OPERATION

No.	Submittal / Revision	Apprd	By	Date
PA	Issued for	SK	MS	MM/DD/18

OVERALL SINGLE LINE DIAGRAM

Designed By: SK	Drawn By: MS	Checked By: SK
Issue Date: MM/DD/2018	Project No: 33654	Scale: NONE

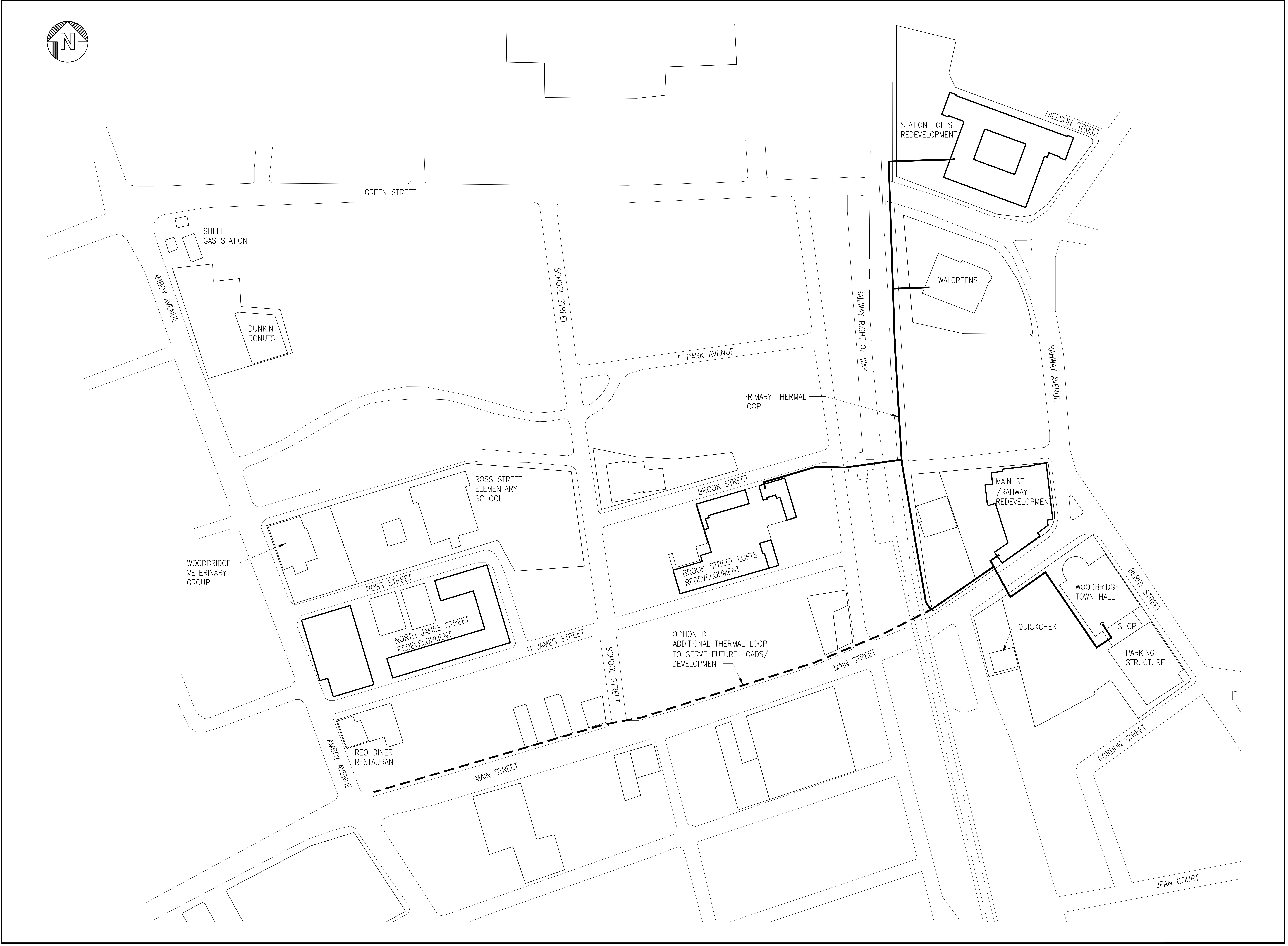
Drawing No:
ESK001

WOODBRIDGE ADVANCED MICROGRID PROJECT

Woodbridge, NJ

APPENDIX F

District Energy Underground Thermal Loop



CHA
III Winners Circle. PO Box 5269 • Albany, NY 12205-0269
Main: (518) 453-4500 • www.chacompanies.com

WOODBRIDGE TOWN CENTER
ADVANCED MICROGRID
(WAM) PROJECT

No.	Submittal / Revision	App'd.	By	Date
PB	ISSUED FOR REVIEW	JJ	BG	09/19/18
PA	ISSUED FOR REVIEW	CC	DM	07/08/18

DISTRICT ENERGY
- UNDERGROUND
THERMAL LOOP

Designed By:	Drawn By:	Checked By:
CC	DM	CC
Issue Date:	Project No:	Scale:
07/09/2018	33654	NTS

Drawing No.:

MSK-001

File: V:\PROJECTS\ANY\K4\33654\CADD_ACAD\MT\MSK-001.DWG
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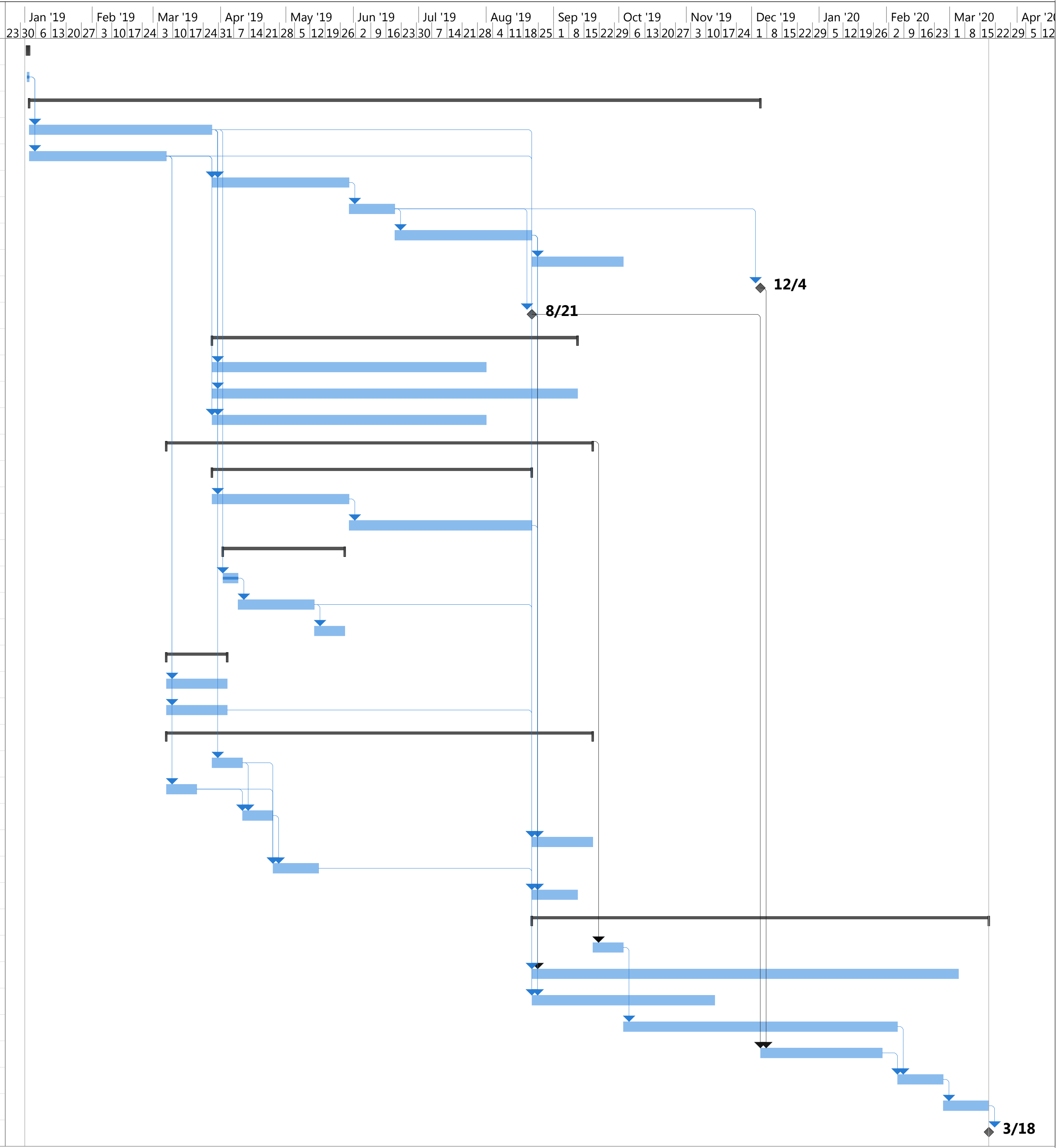
Woodbridge TC Microgrid
Project Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Notice to Proceed**	**1 day**	**Wed 1/2/19**	**Wed 1/2/19**	
2	Kick-off and Alignment Meeting with EPC Contractor	1 day	Wed 1/2/19	Wed 1/2/19	
3	**Schematic Design and Major Equipment Procurement Phase**	**240 days**	**Thu 1/3/19**	**Wed 12/4/19**	
4	Schematic Engineering and Procurement - CHP System (Townhall)	60 days	Thu 1/3/19	Wed 3/27/19	2
5	Schematic Engineering and Procurement - PV Systems (Various Locations)	45 days	Thu 1/3/19	Wed 3/6/19	2
6	Bid/Evaluation/Clarifications and Recommendation(s)	45 days	Thu 3/28/19	Wed 5/29/19	5,4
7	Equipment Contract Award	15 days	Thu 5/30/19	Wed 6/19/19	6
8	Major Equipment Detail Drawings and Schematics (Electrical/Control/O&M)	45 days	Thu 6/20/19	Wed 8/21/19	7
9	Major Equipment Detail Drawings and Schematics (Mech/Structural)	30 days	Thu 8/22/19	Wed 10/2/19	8
10	Major Equipment Delivery - CHP (Engine Generator)	0 days	Wed 12/4/19	Wed 12/4/19	7FS+120 days
11	Major Equipment Delivery - PV Arrays and Inverter Hardware	0 days	Wed 8/21/19	Wed 8/21/19	7FS+45 days
12	**Permitting Phase**	**120 days**	**Thu 3/28/19**	**Wed 9/11/19**	
13	PSE&G Utility Connection (Gas)	90 days	Thu 3/28/19	Wed 7/31/19	4
14	NJEP Air Permitting	120 days	Thu 3/28/19	Wed 9/11/19	4
15	Site Plan Amendments	90 days	Thu 3/28/19	Wed 7/31/19	4,5
16	**Detail Design Phase**	**140 days**	**Thu 3/7/19**	**Wed 9/18/19**	
17	**Mechanical/Piping**	**105 days**	**Thu 3/28/19**	**Wed 8/21/19**	
18	Piping Model - Thermal Underground Network	45 days	Thu 3/28/19	Wed 5/29/19	4
19	Piping Arrangements/Details/Supports/ETS Stations by Facility	60 days	Thu 5/30/19	Wed 8/21/19	18
20	**Site Civil Works**	**40 days**	**Tue 4/2/19**	**Mon 5/27/19**	
21	Geotechnical Findings Review	5 days	Tue 4/2/19	Mon 4/8/19	4FS-40 days
22	Site Preparation Design - Thermal Loop	25 days	Tue 4/9/19	Mon 5/13/19	21
23	Concrete - Engine Generator Module Foundations	10 days	Tue 5/14/19	Mon 5/27/19	22
24	**Structural**	**20 days**	**Thu 3/7/19**	**Wed 4/3/19**	
25	PV Dead/Live Load Analysis - CHP System	20 days	Thu 3/7/19	Wed 4/3/19	5
26	Roof and Parking Canopy Structures Interface Arrangement/Details - PV Array	20 days	Thu 3/7/19	Wed 4/3/19	5
27	**Electrical**	**140 days**	**Thu 3/7/19**	**Wed 9/18/19**	
28	General Arrangement Drawings - Engine Generator Module	10 days	Thu 3/28/19	Wed 4/10/19	4
29	General Arrangement Drawings - PV Array	10 days	Thu 3/7/19	Wed 3/20/19	5
30	General Arrangement Drawings - Site Services	10 days	Thu 4/11/19	Wed 4/24/19	28,29
31	Protection Philosophy/Intertie/Metering Designs	20 days	Thu 8/22/19	Wed 9/18/19	4,8,5
32	Electrical Site Plan and Equipment Arrangement Drawings	15 days	Thu 4/25/19	Wed 5/15/19	28,29,30
33	Switchgear and Transformer Arrangement Drawings and Details	15 days	Thu 8/22/19	Wed 9/11/19	8,32
34	**Construction Phase**	**150 days**	**Thu 8/22/19**	**Wed 3/18/20**	
35	Mobilization	10 days	Thu 9/19/19	Wed 10/2/19	16
36	Staging of Facility PV Arrays - Structures/Electrical Infrastructure for all TC DER's	140 days	Thu 8/22/19	Wed 3/4/20	26,11
37	Trenching and Integration of Thermal Loop - Area A	60 days	Thu 8/22/19	Wed 11/13/19	22,19
38	Ancillary Mechanical/Electrical & Plumbing Works - Town Hall	90 days	Thu 10/3/19	Wed 2/5/20	35
39	Equipment Placement and Assembly - CHP System	40 days	Thu 12/5/19	Wed 1/29/20	11,10
40	Commissioning - CHP System	15 days	Thu 2/6/20	Wed 2/26/20	39,38
41	Testing and Validation	15 days	Thu 2/27/20	Wed 3/18/20	40
42	**Project Complete**	**0 days**	**Wed 3/18/20**	**Wed 3/18/20**	**41**



Project: Section 14 Schedule_09
Date: Wed 10/10/18
Revison 2.

Task	▬	Summary	┌─┐	Inactive Milestone	◇	Duration-only	▬	Start-only	[	External Milestone	◆	Manual Progress	─
Split	┈	Project Summary	┌─┐	Inactive Summary	┌─┐	Manual Summary Rollup	─	Finish-only	]	Deadline	⬇		
Milestone	◆	Inactive Task	▭	Manual Task	▬	Manual Summary	┌─┐	External Tasks		Progress	─		

Project: Woodbridge Advanced Microgrid - Base Case

Contact Information:

Utility Information:
PSE&G
PSE&G

Number of Buses: 20

Bus Information:

Bus 1 Details:

Building/Bus Name: Avenel Substation
Building/Bus address: 2 Julius St, Woodbridge, NJ 07095, USA
Slack Bus: Yes

This Bus does not contain demand
Slack bus voltage (kV): 12

Bus 2 Details:

Building/Bus Name: Mawbey Elementary School
Building/Bus address: 275 Mawbey St, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 100
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 2
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 3 Details:

Building/Bus Name: Medicine Shopp
Building/Bus address: 458 Amboy Ave #2, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 3
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 4 Details:

Building/Bus Name: N. James Street Redevelopment
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 4
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 5 Details:

Building/Bus Name: Reo Diner
Building/Bus address: 392 Amboy Ave, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 5
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 6 Details:

Building/Bus Name: Woodbridge Middle School
Building/Bus address: 525 Barron Ave, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand

Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 50
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 6
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 7 Details:

Building/Bus Name: Woodbridge Fire Department
Building/Bus address: 418 School St
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 20
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 7
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6

Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 8 Details:

Building/Bus Name: Ross St. Elementary School
Building/Bus address: 110 Ross St, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 30
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 8
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 9 Details:

Building/Bus Name: Brook St. Lofts
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available

Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 9
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 10 Details:

Building/Bus Name: Apartments
Building/Bus address: 75 Main Street
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 10
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 11 Details:

Building/Bus Name: European Deli
Building/Bus address: 90 Main St
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 11
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 12 Details:

Building/Bus Name: Amici's Gourmet Sandwich Shop
Building/Bus address: 96 Main St
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 12
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 13 Details:

Building/Bus Name: Woodbridge Substation
Building/Bus address:
Slack Bus: Yes

This Bus does not contain demand
Slack bus voltage (kV): 12

Bus 14 Details:

Building/Bus Name: Adams Tower
Building/Bus address: 555 Rahway Ave, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 14
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 15 Details:

Building/Bus Name: Finn Towers
Building/Bus address: 19 Martin Terrace, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 15
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 16 Details:

Building/Bus Name: Station Lofts Redevelopment
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 16
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 17 Details:

Building/Bus Name: Walgreens
Building/Bus address: 17 Green St, Woodbridge, NJ 07095, USA
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 17
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 18 Details:

Building/Bus Name: Main Street / Rahway Redevelopment
Building/Bus address:
Slack Bus: No

This Bus contains demand

Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 18
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 19 Details:

Building/Bus Name: Woodbridge Town Hall
Building/Bus address: 1 Main St, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 19
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 20 Details:

Building/Bus Name: Quick Check
Building/Bus address: 5 Main St, Woodbridge, NJ 07095, USA
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 20
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Power Network Connection

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	1	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	1	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	1	-*-	1	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-

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Distance

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	825.1	-*-	-*-	-*-	1273	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	825.1	-*-	615.2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	615.2	-*-	296.2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	296.2	-*-	279.7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Node 5	-*-	-*-	-*-	279.7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	1273	-*-	-*-	-*-	-*-	-*-	1273	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	1273	-*-	144.8	301.2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	144.8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	301.2	-*-	-*-	90.7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	90.7	-*-	98.3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	98.3	-*-	98.3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	98.3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1726.6	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1726.6	-*-	41.2	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	41.2	-*-	719.2	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	719.2	-*-	356.5	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	356.5	-*-	881.2	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	881.2	-*-	716.7	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	716.7	-*-	90.7
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	90.7	-*-

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Resistance

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	1E-05	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	1E-05	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-

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Inductance

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

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Ampacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	2.9099	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	2.9099	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-

Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-

Power Capacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	2.9099	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	2.9099	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-	2.0985
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.0985	-*-

Hot Water Network Connection

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-

Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-

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Hot Water Temperature Capacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-

---

Hot Water Network Thermal Loss

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-

Chilled Water Network Connection

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Chilled Water Temperature Capacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Chilled Water Network Thermal Loss

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Inputs based on DER-CAM.

Project: Woodbridge Advanced Microgrid - With New DER Technologies

Contact Information:

Utility Information:
PSE&G
PSE&G

Number of Buses: 20

Bus Information:

Bus 1 Details:

Building/Bus Name: Avenel Substation
Building/Bus address: 2 Julius St, Woodbridge, NJ 07095, USA
Slack Bus: Yes

This Bus does not contain demand
Slack bus voltage (kV): 12

Bus 2 Details:

Building/Bus Name: Mawbey Elementary School
Building/Bus address: 275 Mawbey St, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 100
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Power Generation Technologies (Solar Generation 2):
Number of cells:
Power rating (kW): 54
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 2
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 3 Details:

Building/Bus Name: Medicine Shoppe
Building/Bus address: 458 Amboy Ave #2, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 3
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 4 Details:

Building/Bus Name: N. James Street Redevelopment
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 200
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 4
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 5 Details:

Building/Bus Name: Reo Diner
Building/Bus address: 392 Amboy Ave, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 177
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 5
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 6 Details:

Building/Bus Name: Woodbridge Middle School
Building/Bus address: 525 Barron Ave, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 50
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Power Generation Technologies (Solar Generation 2):
Number of cells:
Power rating (kW): 40
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):

Max power current (Amp):

Voltage constraints Bus 6
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 7 Details:

Building/Bus Name: Woodbridge Fire Department
Building/Bus address: 418 School St
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 20
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Power Generation Technologies (Solar Generation 2):
Number of cells:
Power rating (kW): 70
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 7
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 8 Details:

Building/Bus Name: Ross St. Elementary School
Building/Bus address: 110 Ross St, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 30
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Power Generation Technologies (Solar Generation 2):
Number of cells:
Power rating (kW): 344
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 8
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 9 Details:

Building/Bus Name: Brook St. Lofts
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 262
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 9
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 10 Details:

Building/Bus Name: Apartments
Building/Bus address: 75 Main Street
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 10
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 11 Details:

Building/Bus Name: European Deli
Building/Bus address: 90 Main Street
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 11
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 12 Details:

Building/Bus Name: Amici's Gourmet Sandwich Shop
Building/Bus address: 96 Main St
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 12
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 13 Details:

Building/Bus Name: Woodbridge Substation
Building/Bus address:
Slack Bus: Yes

This Bus does not contain demand
Slack bus voltage (kV): 12

Bus 14 Details:

Building/Bus Name: Adams Tower
Building/Bus address: 555 Rahway Ave, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 14
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 15 Details:

Building/Bus Name: Finn Towers
Building/Bus address: 19 Martin Terrace, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 15
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 16 Details:

Building/Bus Name: Station Lofts Redevelopment
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 200
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 16
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 17 Details:

Building/Bus Name: Walgreens
Building/Bus address: 17 Green St, Woodbridge, NJ 07095, USA
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 17
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 18 Details:

Building/Bus Name: Main Street / Rahway Redevelopment
Building/Bus address:
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 449
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 18
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 19 Details:

Building/Bus Name: Woodbridge Town Hall
Building/Bus address: 1 Main St, Woodbridge NJ 07095
Slack Bus: No

This Bus contains demand
Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Power Generation Technologies (CHP 1):
Prime mover: Reciprocating engine
Power rating (kW): 500
Number of units: 1
Electric efficiency (kW/kW): 0.33
Power to heat ratio: 1.104

Power Generation Technologies (Solar Generation 1):
Number of cells:
Power rating (kW): 340
Panel area (m2):
Solar panel efficiency (%): 14.969
Open circuit voltage (V):
Max power voltage (V):
Max power current (Amp):

Voltage constraints Bus 19
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Bus 20 Details:

Building/Bus Name: Quick Check
Building/Bus address: 5 Main St, Woodbridge, NJ 07095, USA
Slack Bus: No

This Bus contains demand

Demand data is available
Elec. Rate Schedule:
Gas Rate Schedule:

Voltage constraints Bus 20
Maximun acceptable voltage (kV): 13.8
Minimum acceptable voltage (kV): 9.6
Maximun acceptable voltage angle (rad): 0.09
Minimum acceptable voltage angle (rad): -0.18

Power Network Connection

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	1	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	1	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	1	-*-	1	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-

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Distance

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	825.1	-*-	-*-	-*-	1273	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Node 2	825.1	-*-	615.2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	615.2	-*-	296.2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	296.2	-*-	279.7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	279.7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	1273	-*-	-*-	-*-	-*-	-*-	1273	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	1273	-*-	144.8	301.2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	144.8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	301.2	-*-	-*-	90.7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	90.7	-*-	98.3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	98.3	-*-	98.3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	98.3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1726.6	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1726.6	-*-	41.2	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	41.2	-*-	719.2	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	719.2	-*-	356.5	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	356.5	-*-	881.2	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	881.2	-*-	716.7	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	716.7	-*-	90.7
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	90.7	-*-

Resistance

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	1E-05	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	1E-05	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	0.0001	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	0.0001	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	0.0001	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	0.0001	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	0.0001	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-	0.0001
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	0.0001	-*-

Inductance

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

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Ampacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	2.9099	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	2.9099	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-

Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-

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Power Capacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	2.9099	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	2.9099	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-	2.9099
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	2.9099	-*-

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Hot Water Network Connection

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-	1
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1	-*-

Hot Water Temperature Capacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-	17.062
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	17.062	-*-

Hot Water Network Thermal Loss

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20

Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-	1E-05
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	1E-05	-*-

Chilled Water Network Connection

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Chilled Water Temperature Capacity

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Chilled Water Network Thermal Loss

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20
Node 1	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 2	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 3	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 4	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 5	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 6	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 7	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 8	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 9	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 10	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 11	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 12	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 13	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

Node 14	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 15	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 16	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 17	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 18	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 19	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-
Node 20	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-	-*-

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Inputs based on DERCAM.