Town Center Microgrid
Trenton, NJ
Microgrid Feasibility Study
Rev 1

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0. ABBREVIATIONS GLOSSARY

ASCE- American Society of Civil Engineering
"Black Sky"- Grid Outage Event
"Blue Sky"/ "Normal"- Non-outage Operation
BPL- Body Politic Lighting
BPU- New Jersey Bureau of Public Utilities
CHP- Combined Heat and Power
CIG- Cogeneration Interruptible Service
CPI- Current Rate of Inflation
DER- Distributed Energy Resources
DG- Distribution Generation
EDC- Electrical Distribution Companies
ELRP- Emergency Load Response Program
EMP Update- Energy Master Plan Update
ERB- Energy Resiliency Bank
FGR- Flue Gas Recirculation
GPL- General Power and Lighting
GSG- General Service
H&A- Health and Agriculture
H/P- Heat-to-Power Ratio
HHV- High Heating Value
HTS- High Tension Service
IBC- International Building Code
IRS- Internal Revenue Service
Justice- Richard Hughes Justice Complex
L&I- Labor and Industrial
LDC- Local Distribution Companies
LHV- Lower Heating Value
LPL- Large Power and Light
MACRS- Modified Accelerated Cost-Recovery System
MCIA- Mercer County Improvement Authority
MOUs- Memorandums of Understanding
NJIT- New Jersey Institute of Technology
PCC- Point of Common Coupling
PSE&G- Public Service Enterprise Group
QF- Qualifying Facility
ROW- Right of Way
RPS- Renewable Portfolio Standard
TC DER- Town Center Distributed Energy Resource
TDEC- Trenton District Energy Center
TIAC- Turbine Inlet Air Cooling
Treasury- Department of Treasury
Veolia- Veolia North America

1. Executive Summary

In response to the TC DER Microgrid Feasibility Incentive Program, the State of New Jersey under the Treasury, in partnership with Veolia TDEC, the City of Trenton, the County of Mercer, Rutgers University, and PSE&G have completed the feasibility review of a Downtown Trenton Microgrid. This report outlines the results, particularly as it pertains to the technical and regulatory feasibility of establishing a microgrid in the state of New Jersey.

Downtown Trenton houses a cluster of critical facilities for the state, city, and county that are vulnerable to grid outages during emergencies. During an emergency, these facilities can provide essential services, house critical data and records integral to the state's operations, and be utilized as shelter and assembly locations. Loss of utilities to these facilities could be disastrous during an extreme weather event. These facilities are currently tied into Veolia's Thermal Energy District Network in Downtown Trenton. This network provides chilled water, hot water, and steam under one contract with the Department of Treasury. The existing commercial utility agreements and integrated district energy infrastructure between the Treasury and Veolia form the basis on which this microgrid is being developed.

The primary goal of this study is to meet the objectives of the New Jersey BPU by providing these critical and municipal facilities with standby power during a "black sky" event utilizing existing tariffs under "blue sky" operation or proposing additional tariffs. The Trenton Microgrid requires upgrades to the existing generating capacity, control and distribution networks, and development of the appropriate tariff arrangements. Additionally, this feasibility review considers what facilities are critical to a municipality in an emergency as well as what regulatory and technical hurdles may prevent such a microgrid from being implemented.

This study reviewed twenty three (23) facilities in Downtown Trenton and identified fourteen (14) that could be feasibly connected into a microgrid. These facilities were selected based off of geographical, grid infrastructure, and regulatory examinations. The buildings are a mix of critical, municipal, and senior/affordable housing.

In order to simulate a realistic Downtown Trenton Microgrid, two phases were developed for the implementation. Phase 1 provides primary and standby power to four (4) buildings, utilizing existing Veolia TDEC electrical feeders that are connected to Justice, the L&I, and the H&A municipal buildings independently of the PSE&G Network. Phase 2 utilizes the existing Veolia TDEC interconnection to export electricity to a 27 kV PSE&G feeders, which could "backfeed" ten (10) additional buildings that are fed from PSE&G's Downtown Trenton East and West Network in an outage. The H&A Building is scheduled to be retired and/or demolished and the Tax Building will be relocated to the site. For the purpose of this study, the H&A building is continually reference but the loads and sizing can account for the new Tax Building when it's constructed.

Phase 1 provides for the installation of a new, efficient, 5.7 MW CHP Gas Turbine, with dual-fuel capability in the Veolia TDEC, with a duct-fired boiler. This installation can generate electricity as well as high temperature hot water through waste heat recovery which could be used to supply the year round hot water load. Existing electrical infrastructure could distribute and provide electrical upgrades within the L&I, H&A/Tax, and Justice Complex buildings to connect to the main switchgear with new microgrid controls.

An additional option to this phase, called Phase 1A, would add a dedicate feeder to supply the New Jersey State Capitol Building. This, along with Option 1B, would consider an additional prime mover installed at the Statehouse complex, to provide additional reliability. The prime mover here would consist of two (2) gas powered reciprocating engines capable of islanding the Statehouse campus from the remaining PSE&G grid. This could also be used, in parallel with the prime mover at the Veolia TDEC, to provide a nameplate capacity of 8.1 MW in downtown Trenton.

Phase 2 includes the installation of an additional 5 MW of high response, duel fuel reciprocating engines, along with 2MW of solar and 2 MWh of battery storage to supply and export load to the entire microgrid of 14 buildings during blue and black-sky events. Additionally, new SCADA, and microgrid controllers would be installed to allow for selected buildings in the Downtown Trenton grid to be supplied electricity, generated from the Veolia TDEC and distributed via the local PSE&G Trenton network in the event of a grid wide outage.

Table 1: Microgrid Table

Description	Phase 1	Phase 1 – Option A	Phase 1 Option B	Phase 2	Total
Opinion of Capital Costs	**$19,700,000**	**$6,600,000**	**$10,000,000**	**$23,900,000**	**$60,200,000**
Renewable Capacity (MW)	**0 MW**	**0 MW**	**0 MW**	**2 MW**	**2 MW**
Annual GHG Savings (Metric Tons)[1]	**6,100**	**2,500**	**2,500**	**2,600**	**11,200**
Total Standby Capacity	**5.7 MW**	**5.7 MW**	**8.1 MW**	**13.1 MW**	**13.1 MW**
Total Energy Efficiency DER Capacity	**5.7 MW**	**5.7 MW**	**8.1 MW**	**15.1 MW**	**15.1 MW**
Sq. Ft. of Municipal and Critical Buildings with Standby Power	**1,100,000**	**1,500,000**	**1,500,000**	**3,200,000**	**4,700,00**
Number Municipal and Critical Buildings Supported	**4**	**1 (Statehouse Campus)**	**1 (Statehouse Campus)**	**9**	**14**

1 – GHG Reductions between these phases do not aggregate

Microgrid Regulatory and Tariff Review

These two (2) microgrid arrangements can only be partially supported under current New Jersey regulations. As a District Energy Supplier, New Jersey has regulations allowing the facility to sell electricity under certain provisions. This would enable the commercial viability of self-sustaining microgrid for Phase 1. This is achieved by using existing or grandfathered infrastructure that is no more than one ROW from the electrical generator – a condition met by the existing connections to Justice, H&A/Tax, and L&I. This provision would allow Veolia to expand their existing thermal contract with Treasury and sell electricity at comparable retail rates to finance the infrastructure upgrades required. The microgrid would be located "behind" an existing PSE&G-Veolia interconnection which would serve as the PCC. This would allow Veolia to utilize a blue sky arrangement interconnection, during blue sky operation as well as an islanded, black sky condition. Phase 1A could also be supported within existing configuration by connecting the Statehouse Complex with feeders from L&I, which are only one ROW apart.

Phase 2, which utilizes the PSE&G 27 kV downtown network, could not be fully supported under the existing New Jersey tariffs. While technically feasible to export electricity from the Veolia TDEC onto the PSE&G 27 kV Network (through Monument Breaker Station and to the East and West Trenton Networks) there is no existing tariff structure to utilize this smaller network without incurring higher costs to the customer. The site could export to the PSE&G grid but at rates ($.03-.05/kWh average) too low to finance the required infrastructure upgrades.

Proposed Tariff

To support the complete implementation of Phase 2, a virtual, net metering tariff could be established for those buildings included in the Downtown Trenton Microgrid. Instead of exporting to the wholesale PJM markets, the Trenton Microgrid could be exported at retail LPL-S/L rates, blended ($0.09-0.10/kWh). This would incur no additional cost to the state of New Jersey and could cover the costs of the PSE&G and Veolia upgrades when amortized over a reasonable payback period. The alternative to a virtual net metering arrangement is a standby rate that could be paid on a monthly, per kW basis for standby services ($10-25/kW). This could be funded from the state or from PSE&G under the Societal Benefit Charge.

Recommendations

Consistent with the Societal Benefit Charge, this feasibility study recommends proceeding with the preliminary planning and design of Phase 1 to connect the four (4) critical buildings. This phase would be funded from the same program and would advance the current Project Team to a 30% design phase. Concurrently, this study recommends the development of an additional tariff specifically for microgrids. This could be a net metered tariff based on the export from distributed generating assets vs the net import of the loads within the microgrid. The boundaries of the microgrid would consist of the critical assets being served and the generating assets within.

An additional recommendation, that requires further coordination with PSE&G, would be to incorporate a PSE&G feeder into the Microgrid. Currently, this is the feeder that supplies electricity to the Veolia TDEC and a secondary feed to the Justice Complex from the Statehouse. As currently configured, this arrangement almost serves as its own Microgrid.

2. Project Approach

2.1. Project Intent

The Project Team assembled has created this report to examine the feasibility of installing a microgrid in Downtown Trenton. The intent of the microgrid is to make Downtown Trenton more resilient to outage events, provide new energy efficient system solutions, and enable critical municipal operations to function in an emergency. A microgrid would allow certain critical assets and buildings to be islanded from the existing PSE&G grid during a "black sky" event and would potentially provide energy to services parallel to the grid during "normal" operations. This operation requires that distributed electrical generating equipment be located in the Downtown Trenton region and that infrastructure be in place to supply critical assets with electricity during a black sky event.

This study determines which assets in the Downtown Trenton area are critical to emergency operations, as well as the technical, economical, and regulatory feasibility of connecting these assets to a single microgrid. In some cases, critical assets in Downtown Trenton may be critical to operations but geographically sparse, making them infeasible for microgrid inclusion. This study examines the critical building operations in Downtown Trenton, the existing infrastructure present to facilitate a microgrid, the regulatory constraints, and proposes a solution that meets the BPU's objectives.

2.2. BPU Microgrid Development Background

The development of the TC DER Microgrid Program was a response to both resiliency as well as other broader energy initiatives that the state of New Jersey has developed as part of the Energy Master Plan.

In recent history, New Jersey's electric distribution system has been impacted by weather-related events that have caused extended electrical outages. These outages led several critical facilities such as wastewater treatment plants, hospitals, nursing homes, care centers, communication centers, county evacuation centers, and numerous critical facilities to be left without power. These events left many facilities either operating on or requesting emergency generators while there was a shortage (New Jersey Board of Public Utilities Microgrid Report).

2.2.1. *Master Utility Plan*

To address these major weather events the 2015 EMP Update for New Jersey established a new section, "Improve Energy Infrastructure Resiliency & Emergency Preparedness and Response," based on New Jersey's Plan for Action in the aftermath of Superstorm Sandy. As summarized in the NJ BPU Microgrid Report, 2016) This section includes:

- Protecting the state's critical energy infrastructure
- Improving the EDC emergency preparedness and response
- Increasing the use of microgrid technologies and applications for DER
- Creating long-term financing for local energy resiliency measures through the ERB and other financing mechanisms
- Increasing in-state electricity generation to maintain the progress on controlling energy costs. Newer, more efficient forms of DG such as combined heat and power, fuel cells, and solar must also be included.

- The state will encourage using new forms of DG and will continue to focus on expanding the use of CHP by reducing the financial, regulatory, and technical barriers and identifying opportunities for new entries. The BPU should initiate a stakeholder process to determine how to reduce these barriers and increase the development of DG with a focus on CHP, fuel cells within a microgrid. This should include evaluating revisions to the CHP and fuel cell incentives to promote local energy resiliency.
- The state should continue working with the USDOE, utilities, local and state governments, and other strategic partners. This will help identify, design, and implement TCDER microgrids to power critical facilities and services across the state.

The EMP also had an additional 31 policy initiatives grouped into four (4) categories shown below:

- Expand In-State Electricity Resources
- Cost Effective Renewable Resources
- Promote Cost Effective Conservation and Energy Efficiency
- Support the Development of Innovative Energy Technologies

The improvements to the Energy Infrastructure Resiliency & Emergency Preparedness and Response, coupled with the additional 31 policy initiatives, are all addressed with the microgrid initiative.

2.2.2. *Microgrid Incentive Feasibility Study*

To begin implementing the new policy goals, the BPU moved forward and targeted locations to develop site specific microgrids. The BPU worked with NJIT to map the potential TC DER Microgrids. The resulting report mapped 24 potential TC DER Microgrids across the 17 municipalities in the 9 Sandy-designated counties. Mercer County was one of the 9 designated counties. Trenton, a major municipality, was specifically identified within Mercer County and examined for microgrid feasibility.

The BPU initiated the Town Center – District Energy Resources Microgrid Feasibility Program to examine the feasibility of the site-specific applications. It is only eligible to state or local government entities that own or manage critical facilities. These entities may partner with private institutions, other local government, and the LDC.

2.3. Project Team

2.3.1. *Primary Applicant*

The primary applicant for the Downtown Trenton feasibility is the Treasury Department but includes other local municipalities, private utilities and the local EDC. The Department of Treasury oversees the financial and business matters pertaining to the state of New Jersey. Within the department, the Division of Property Management & Construction oversees the operation and maintenance of state-owned facilities in the Capitol Complex in Downtown Trenton, among other responsibilities. This division manages all the energy initiatives for all municipal buildings in the state government.

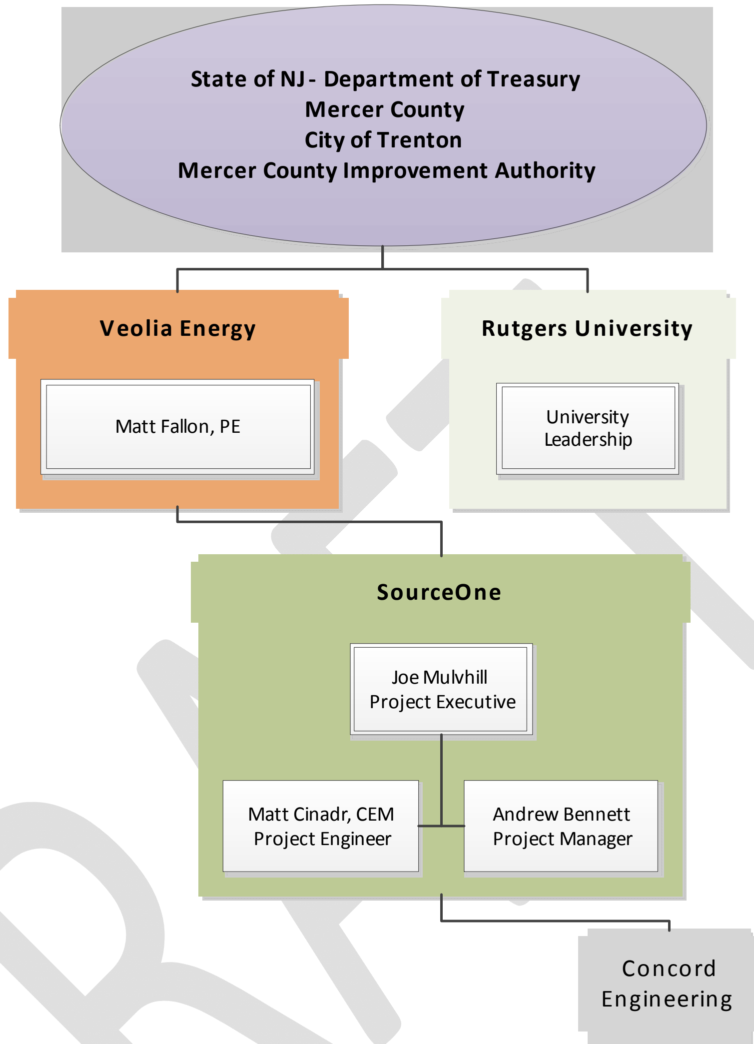
2.3.2. *Private Partnership*

The applicant requested a partnership through MOUs to various stakeholders in Downtown Trenton, including Veolia. Veolia serves numerous state-owned facilities in Downtown Trenton through a district energy system. The district energy system consists of underground chilled and hot water piping which serves approximately forty (40) buildings in the Downtown Trenton area, both public and private. The main plant is located at 320 S. Warren St, Trenton, NJ, and has a previously utilized 27 kV interconnection with PSE&G. It was designed to export electricity to PSE&G as a QF under the previous PURPA laws (See Section 4 for additional discussion). Given the existing arrangement of the plant operating a "thermal microgrid," its interconnection to PSE&G, and previous export status, the main Veolia plant would be the main hub of the Trenton Microgrid.

2.3.3. *Project Team*

The applicant asked Veolia as well as a team of experienced and talented industry experts of both public and private entities, herein referred to as the Project Team, to evaluate the feasibility of the Downtown Trenton Microgrid. The team has a wealth of experience in energy master planning, design, and construction in the utility space, as well as experience owning and operating energy generation and distribution assets. The Project Team assembled is resourced to perform the feasibility study as well as continued project development from concept to commercial operation.

Figure 1: Project Team Organization Chart



Mercer County

Mercer County contains the City of Trenton and operates buildings within the Downtown Trenton district that would be included in the microgrid. Mercer County was not one of the counties included in the NJIT report, but this application still meets the intent of the TC DER Microgrid Report.

City of Trenton

The City of Trenton holds the seat of government for the state and has additional municipal buildings within the Downtown Trenton District. These buildings also are served from Veolia and provide crucial municipal services.

Mercer County Improvement Authority

MCIA was created under the County Improvement Authorities Law to undertake certain projects for the benefit of the residents of Mercer County. The mission of the MCIA is to serve the needs of Mercer County improving the quality of life for the residents by providing programs and services for the county, municipalities, school and fire districts, and not-for-profits in the areas of financing, project management, redevelopment, solid waste and recycling. Grid resiliency and energy initiatives pertaining to the county are of concern for MCIA.

Rutgers University

Rutgers, the state university of New Jersey, is a leading national research university and the state of New Jersey's preeminent, comprehensive public institution of higher education. Established in 1766, the university is the eighth oldest higher education institution in the United States. Nearly 69,000 students and 22,000 full- and part-time faculty and staff learn, work, and serve the public at Rutgers locations across New Jersey and around the world. The university has developed an advanced modeling tool that utilizes data on existing electrical grid networks to analyze and evaluate various microgrid scenarios.

Veolia

Veolia is a global leader in district energy systems and central utility plants. This corporation owns/operators the largest portfolio of district energy systems in the United States. Veolia has focused on creating integrated energy, infrastructure, and environmental solutions for more than 160 years. Nowadays, Veolia ranks as the only global company to offer the entire range of environmental services in water, waste, and energy management sectors.

SourceOne

Veolia's subsidiary company, SourceOne, is a nationally recognized energy consulting firm. This firm provides a wide spectrum of energy related services to ensure requisite tools for monitoring and managing the customer's energy needs efficiently. SourceOne provides engineering support throughout the lifecycle of energy projects that range from initial feasibility studies to construction support through retro/re-commissioning. SourceOne crafts integrated solutions for energy management, improved power quality, reliability, and sustainability initiatives by using a vendor and technology-neutral approach.

Concord Engineering

Concord Engineering is a full-service engineering, energy consulting, construction management and commissioning firm that is headquartered in Voorhees, NJ. Concord was established in 1989 by Michael Fischette and other investors. This company delivers turnkey services while maintaining the personal attention required by savvy clients. Other offices are located in Philadelphia, Atlantic City, New York City, and Wilmington. Overall, Concord employs over 100 trained engineers and designers.

2.3.4. *Team Coordination*

During the project, the team will hold biweekly meetings to share knowledge, discuss scheduling, and perform the necessary due diligence to examine the practicality of a microgrid. The proposed solution and draft of this feasibility study was submitted and provided for review.

2.4. Critical Assessment Review

To ensure that the goals of the feasibility study are met, a review of the critical operations and buildings were performed as essential due diligence. An initial step when applying for the application was to propose a cluster of buildings with which to form the microgrid. This list was re-examined under the definitions of Critical Facilities and Risk Categories defined by the FEMA Mitigation Team Assessment Report for Hurricane Sandy in New Jersey and New York. Critical Facilities include both Category III and Category IV facilities. These categories are assembled from the 2012 IBC and the ASCE 7-10.

According to the definitions, *"Risk Category IV, the highest risk category, includes buildings and structures that, if severely damaged, would reduce the availability of essential community services necessary to cope with an emergency. Risk Category IV buildings and structures include hospitals, police stations, fire stations, emergency communication centers, and similar emergency facilities...."* Section 1.2 goes on to read *"The 2012 IBC also includes other public utility facilities required for emergency back-up…such facilities include power generating stations…. Local jurisdictions can also designate other facilities as Risk Category IV on the basis of their critical function in the community.*"

Additionally, "*Risk Category III includes such structures as theaters, lecture halls, and elementary schools, prisons, and small healthcare facilities.*"

The report goes on to mention that Risk III and Risk IV categories may both be considered critical facilities when dealing with a dense urban environment.

2.5. Geographical and Infrastructure Review

Once the critical facilities were identified, an assessment was performed on the existing geography and infrastructure to assess the feasibility of inclusion into one microgrid. Downtown Trenton, the host location of the seat of the state of New Jersey, the county of Mercer, and the city of Trenton, has numerous critical facilities. Depending on geographical considerations, existing PSE&G infrastructure, and FEMA flood plains, some facilities critical to operations may be better served by an alternate form of generation.

2.5.1.1. Downtown Trenton – Area

The Downtown Trenton area was reviewed based on available topographical drawings that the Trenton plant in Veolia had and maps publically available on the internet. Distances were approximated from the scales provided from the respective sources. A more detailed survey will have to be provided in the detailed engineering phase. Additionally, the FEMA Flood Plain was reviewed in order to determine the potential impact of a storm event.

2.5.1.2. Veolia Infrastructure

The existing Veolia infrastructure was reviewed based on available site drawings, field visits, available maintenance records, and meetings with site personnel. The site provided equipment lists, description of dispatch operations, and informal knowledge of plant and state building operations. The plant's 8760 data for electrical load, hot water send out, chilled water send out, and gas consumption were also provided and used in the study. These data exchanges occurred over bi-weekly conference calls, site meetings and visits that occurred from September 2017 to when the report was issued.

2.5.1.3. PSE&G Infrastructure

The existing PSE&G infrastructure was reviewed via conference calls, in person meetings, and follow up emails with PSE&G. The goal of the review was to understand how the existing PSE&G infrastructure could be integrated into the Trenton Microgrid. The review focused on capacity and technical limitations, existing network boundaries, and providing a general understand of how existing electricity is delivered to Trenton.

2.5.1.4. State Building Infrastructure Review

Once the critical buildings have been identified, the state building electrical infrastructure in critical facilities will be reviewed to understand how the buildings are connected electrically.

2.6. Regulatory Review

A critical component of this review is understanding the regulatory landscape in New Jersey that does or does not allow microgrids. Rules pertaining to microgrids are evolving and the goal of this feasibility study will be to aid the BPU in proposing new regulation around microgrids. This feasibility study examined both the existing regulations surrounding microgrids, how this proposed solution holds up to current regulation, and additional tariff solutions going forward.

2.7. Energy Use Analysis & Microgrid Options

Based on the results of the infrastructure and regulatory reviews, the energy use of those buildings which can feasibly be joined into a microgrid were analyzed and aggregated to determine how to best serve the load in “blue sky” and “black sky” conditions. These buildings will be aggregated in a variety of microgrid scenarios to be evaluated for costs and benefits.

For the Veolia plant, the loads were taken from 2017 calendar year. The loads from the other eligible buildings in the microgrid were taken from a mix of 2016 and 2017. The government building electrical loads do not vary consistently with the seasons; the hot water and chilled water loads are met by the district energy plant. The load data was aggregated to capture coincidental loads. This was critical as these buildings are mostly government office buildings and coincidental load needs to be properly assessed.

The 8760 data was provided by PSE&G and the state of New Jersey’s energy bills were also provided. The bills were analyzed to understand consumption, demand, and applicable tariffs.

2.8. Cost Benefit and Economic Evaluation

Once the feasible microgrids were identified, a cost-benefit analysis was performed by both SourceOne and Rutgers. SourceOne used proprietary modeling tools to determine the optimal payback, source energy savings, and greenhouse gas emissions reductions. Rutgers used RU-LESS, a proprietary software tool.

3. Critical Assessment Review

3.1. Review Functionality, Critical Considerations

To develop the list of critical facilities in Downtown Trenton, the team discussed with stakeholders the buildings that may be considered critical or may in fact function as a critical building in the event of an emergency. This is not a complete list of every building but a collection of mostly municipal buildings discussed among the stakeholders. The only private facility included in the review was the Kingsbury Housing Corporation.

3.2. FEMA Classifications

The cluster of state buildings in Downtown Trenton include numerous critical facilities that are essential to the conducting normal operation of the New Jersey State government. The below lists describe the basic function and purpose of many of the buildings to be included in the microgrid, along with a FEMA classification as defined in Section 2.4.

Table 2: Critical and Municipal Facility Review

Item	Facility Name/ Building Name	Building/Structure Category	FEMA Classification	Description/Purpose
V	Veolia Thermal District Energy Center	Utility	4	Provides heating and cooling to forty (40) buildings in the downtown area. During a storm event, it's critical that this plant be operational so that those buildings on the district with power have conditioned air.
1	NJ St Prison	Prison	3	State men's prison operated by the New Jersey Department of Corrections, the only one of which is a completely maximum security prison. Loss of utilities to this facility during an emergency would only hamper state's efforts to manage a potential crisis.
2	Justice	Critical Municipal	3	The Richard J. Hughes Justice Complex has been home to the Department since it was completed in 1982. The building is shared with the New Jersey Judiciary, Office of the Public Defender, and the Attorney General's office, including some agencies in the Department of Law and Public Safety. The State Trooper's office operates a command center in this building.
3	State House	Critical Municipal	4	This complex houses the seat of government for leaders, assemblymen, and elected officials that manage the business of the state. This building is critical to providing essential services during an emergency. The complex also houses a library, museum, and an auditorium which could serve as emergency assembly locations and shelters.
4	Taxation Building	Municipal	3	Taxation houses the Department of the Treasury – Division of Taxation. This facility houses personnel for the processing for administrating of the state's taxation responsibilities.
5	Labor	Municipal		Consists of agencies and departments for all divisions pertaining to labor and industry in the State of New Jersey.

6	Health Building	Municipal		Houses the Department of Health. The current offices of the Department of Health may be relocated to the current Taxation Building.
7	Ashby Building GOB	Municipal		Houses the Department of Community Affairs
8	Capitol Place One	Municipal		Houses the Department of Human Services
9	DEP HQ	Municipal		Administrative Headquarters for the New Jersey Department of Environmental Protection
10	Mercer County Criminal Courthouse	Municipal		No defendants are held overnight. Holding cells only for defendants to be tried that day. Courts would not be in session during extended outage. Sheriff Department Operations in the courthouse pertains only to operations in the courthouse themselves. No critical communications occurs to manage outside operations.
11	MVC 225 E State	Municipal		Local Motor Vehicle Commission Office.
12	NJ Network	Municipal		Houses the public television network/
13	Old Barracks	Lecture/Assembly Area	3	Old Barracks Museum could serve as an emergency refuge area in the event of an emergency
14	Thomas Edison College	Lecture Hall - Assembly	3	The campus as numerous classroom, lecture halls, and assembly areas that could be utilized during an emergency.
15	War Memorial	Theater/Assembly	3	Consists of ballrooms, event spaces, and an auditorium which seats 1,807. This space is designed to serve large numbers of people under normal operation.
16	CURE ARENA	Theater/Assembly	3	The Arena has accommodations for up to 10,000 guests. The Arena was used a staging area for disaster relief equipment during 9/11. The Arena would be considered an assembly area.
17	Wastewater Treatment Plant		4	Provides a critical utility for residents that if down during a storm event.
18	Trenton Fire Department	Fire Department – Emergency Services	4	The emergency management operations are based out of the Fire Department, which is currently not included on the thermal grid or the Trenton East Network. Fire Department has a mobile emergency management operations center which handles the majority of the emergencies.
19	Trenton Police Department	Police Department– Emergency Services	4	Trenton Police department is considered a critical emergency asset

20	Mercer County Administration Building (640 Broad St.)	Municipal		Administration building for the County of Mercer.
21	Monument and Chauncey Breaker Station	Utility	4	Provides the main switching gear for the East and West Downtown Trenton Networks. They distribute power to approximately
22	City Administration Building	Municipal		City Hall does not currently run any emergency management operations. The director of Emergency Management with the Fire Department has an office in the building but does not operate any management operations from the building.
23	Kingsbury Twin Towers	Senior/Affordable Housing		The Twin Towers is an affordable housing community that encompasses 364 high-rise apartment units.

For those areas that may be considered assembly areas, approximately 50 % of the square footage could be considered used for emergency shelter. Areas with back-up generators can generally provide critical life safety load for up to 8 hours. This is load that allows for people to safely exit the building if need be. Durations longer than this require a steady fuel supply which none of these buildings have.

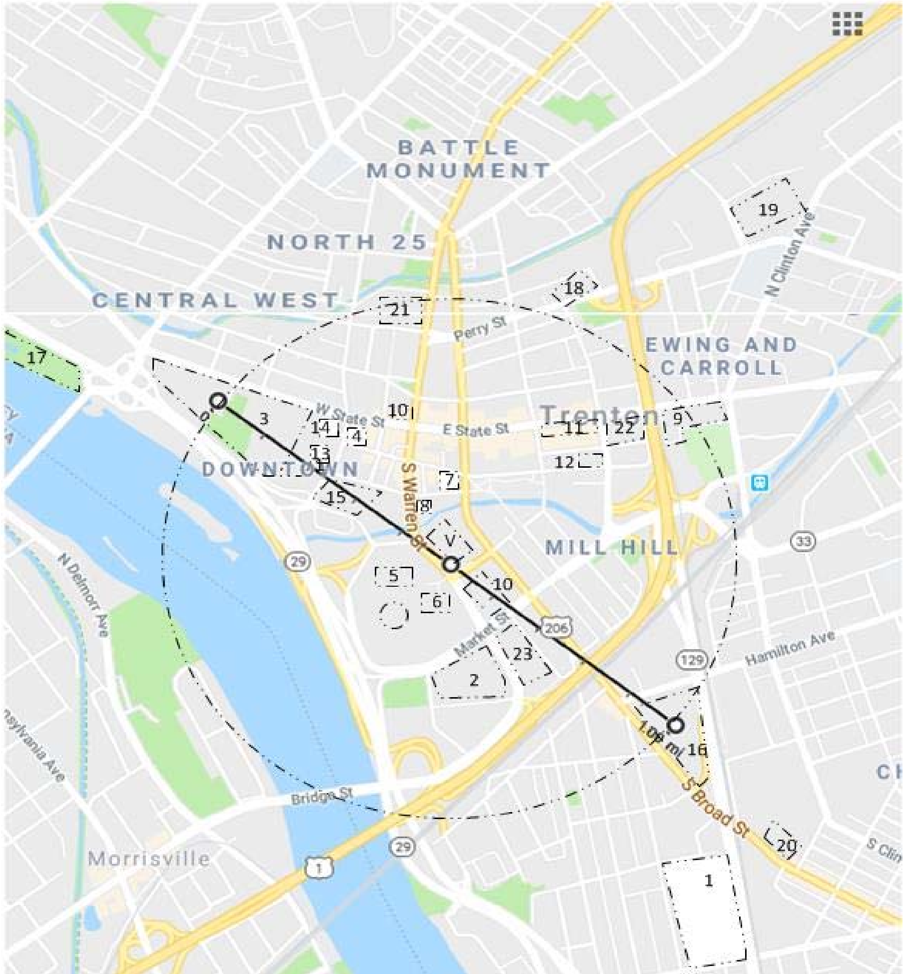
3.3. Geographical and Infrastructure Review

3.3.1. *Downtown Trenton Geographical Area*

Due to the volume of potentially critical buildings in Downtown Trenton, a geographic review was performed to determine which buildings were within a mile of each other. The purpose of this initial review was to broadly understand how feasible it would be to link these buildings to together in a microgrid. A 1 mile guideline was suggested in the Application for Town Center Distributed Energy Resource Microgrid Feasibility Study Incentive Program. The buildings are shown on the map below with the approximate 0.5 mile radius shown from the Veolia District Energy Center.

Figure 2: Critical Infrastructure, Downtown Trenton

V. Veolia Plant
1. State Prison
2. Justice Complex
3. Statehouse
4. Tax
5. L&I
6. H&A
7. Ashby
8. Capital One Place
9. DEP
10. Mercer County Criminal Court House
11. MVC Building
12. New Jersey Network Building
13. Old Barracks
14. Thomas Edison College
15. War Memorial
16. Arena
17. Wastewater Treatment Plant
18. Fire Department
19. Police Department
20. 640 Broad St. (Mercer County)
21. Monument Breaker Station
22. City Administration Building.
23. Kingsbury Housing Corporation



The map indicates that the Wastewater Treatment Plant, Fire Department, Police Department, Mercer County Administration Building, and the State Prison are not within a mile cluster of the majority of critical infrastructure.

3.3.2. *Veolia Infrastructure*

The existing plant was designed as two (2) Combined Heat and Power lineups sized for 6 MW each with the ability to export to the 27 kV grid. The exhaust from two reciprocating engines is used to generate hot water for the high temperature hot water loop. The high temp hot water loop also heats, in a cascading effect, the medium temperature and low temperature loops.

Later additions included two chiller plant additions to feed the chilled water loop. The first plant, constructed around 2001, contains hot water absorption chillers and centrifugal chillers for a total approximate capacity of 3,000 tons. The second chiller plant was constructed in 2016 and contains two (2) centrifugal chillers for a capacity of 6,000 tons.

3.3.2.1. Existing Mechanical Infrastructure

3.3.2.1.1. Existing Reciprocating Engines

The existing plant was originally designed to export to the PSE&G network as a Qualifying Facility. It was powered by two (2) 6 MW reciprocating engine CHP generators. Engine 1 is retired and no longer in use. Engine 2 is near the end of its useable life and fires on dual fuel.

Manufacturer:	Cooper Bessemer
Model:	LSVB-20-GDT
Capacity	8386 bhp
Qty	2

3.3.2.1.2. Existing Hot Water Heaters

Firing from the exhaust of the reciprocating engine is two (2) high temperature Hot Water Heaters. Hot Water Heater #1 has undergone continuous repairs.

Manufacturer:	NBN's 16111 & 16112
Model:	LSVB-20-GDT
Capacity	80 MMBTU/hr
Qty	2

3.3.2.1.3. Absorption Chillers (2 Stage)

In 2001, a chiller plant was constructed with both absorption chiller and centrifugal chillers. The absorption chillers are fueled from the high temperature hot water generated on site.

Manufacturer:	Trane
Model:	ABTF950
Capacity	950 Tons
Qty	2

3.3.2.1.4. Centrifugal Chiller

The below centrifugal chiller was also added.

Manufacturer:	York
Model:	YKQ4Q4K2-DBGS
Capacity	1370 Tons
Qty	1

3.3.2.1.5. New Chilled Water Plant (2016)

Manufacturer:	Trane
Model:	ABTF950
Capacity	950 Tons
Qty	2

3.3.2.1.6. Absorption Chillers (Plant)

Manufacturer:	Trane
Model:	CDHF-3000
Capacity	2850,3150 Tons respectively

3.3.2.1.7. Distributed Chillers

Harnessing the hot water distribution system, the Veolia owned and operated chillers that also fed the chilled water loop or local chilled water loop.

Item	Location	Tag	Manufacturer:	Capacity (Tons)	Model	Serial
001	Justice	JR-4	Frick	1500	RWB-II-676	10241B42422986Z
002	Justice	ACC-1	Trane	103	CGAM110F2	U12L32324
003	Justice	ACC-2	Trane	103	CGAM110F2	U12L32923
004	Kingsbury	KR-1	Carrier	500	23XRV5556ERVR450	1316Q25114
005	Kingsbury	KR-2	York	500	Y1A-HW-10E2	UGCMA-00307

3.3.2.2. Existing District Loop

The plant serves four (4) separate underground district energy piping systems with the below approximate operating conditions.

Table 3: District Operating Conditions

Loop	Supply (Temp./Pressure)	Return (Temp./Pressure)
High-Temperature	390F/375psig	345F/290psig
Medium-Temperature	320F/290psig	240F/220psig
Low-Temperature	240F/280psig	200F/220psig
Chilled Water	40F	54F

The following is the list of buildings and the networks by which they are served.

Table 4: Building List with Energy Services

Item	Building	High Temp	Medium Temperature	Low Temp	Chilled Water
V	Veolia Thermal District Energy Center	X	X	X	X
1	NJ St Prison	X			
2	Justice	X			X
3	State House	X			X
4	Taxation Building		X		X
5	Labor		X		X

6	Health Building		X		X
7	Ashby Building GOB		X		X
8	Capitol Place One		X		X
9	DEP HQ		X		
10	Mercer County Criminal Courthouse				X
11	MVC 225 E State		X		X
12	NJ Network		X		X
13	Old Barracks		X		X
14	Thomas Edison College		X		X
15	War Memorial		X		
16	CURE ARENA	X			
17	Wastewater Treatment Plant	N/A	N/A	N/A	N/A
18	Trenton Fire Department	N/A	N/A	N/A	N/A
19	Trenton Police Department	N/A	N/A	N/A	N/A
20	Mercer County Administration Building (640 Broad St.)	N/A	N/A	N/A	N/A
21	Monument and Chauncey Breaker Station	N/A	N/A	N/A	N/A
22	City Administration Building		X		
23	Kingsbury Housing Corporation	X			X

The district energy systems are principally radial networks but there are loops in the system in some locations for added redundancy.

3.3.2.2.1. Chilled Water Loop

The chilled water piping is buried within a duct bank which also contains conduit for control wiring as well as spares.

3.3.2.2.1.1. Spare Conduits

There are spare conduits located in the existing chilled water duct banks that would be suitable for control wiring. A survey was conducted in 2009 and the conduit was deemed not suitable for 27kV wiring. It could be used to run new control wires.

3.3.2.2.2. Thermal Loops

3.3.2.2.2.1. Direct-Buried Pipe

The thermal loop is in direct-buried, insulated carbon steel pipe that traverses beneath the streets of Downtown Trenton. The pipes are between 12" and 6" in size.

3.3.2.2.2.2. Ongoing Capital Improvement Repairs

As part of the continuing effort to upgrade the infrastructure, Veolia has fixed leaks, damage pipes, and other repairs to the district energy system. In 2016, Veolia sent a "pig" through the pipes to take thickness readings and is aggressively working to replace pipe where significant issues in the pipe wall were found. The majority of leaks were found in the Medium Temperature Pipe.

3.3.2.3. Existing Electrical Infrastructure

The Veolia plant currently has operates on 5 kV within in the plant. The generators are connected via a main-tie-main arrangement to a main 5 kV bus in the switchgear.

<u>Outside of the plant:</u>

To provide power to existing chillers and other infrastructure, the following existing feeders radiate out from the plant.

Table 5: Feeder Schedule

Station	**Feeder**	**Voltage**
H&A &L&I	4" Conduit – (3) 500MCM 5kV & (1) #1 GD	4.16 kV
Justice	4" Conduit – (3)#1/0 35 kV and (1)#1G	27 kV
Chilled Water Storage Plant	(4) 4" Conduit, (3) 500 Kcmil & #4/0 GND (one spare set)	480 V

3.3.2.1. Ongoing ECM, EE, and Capital Upgrade Projects

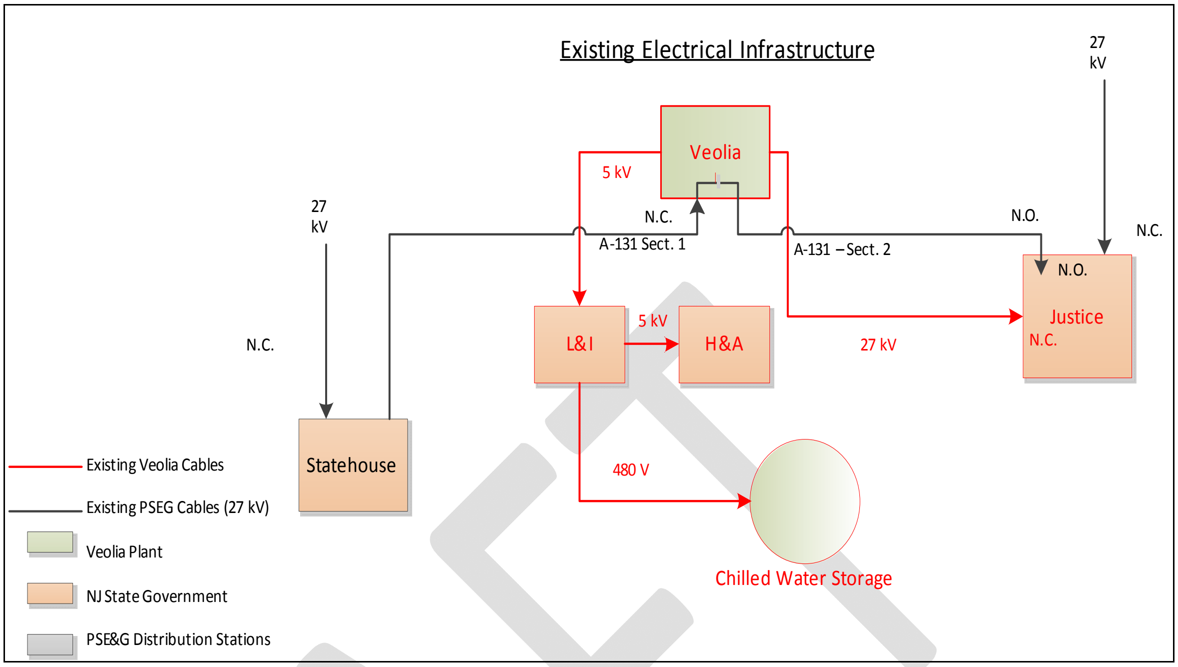
Currently, no large scale energy efficiency (EE) or (ECM) projects are being undertaken at these buildings. The notable upgrades related to buildings are the following:

1. Veolia Plant - Chiller Plant Extension - Veolia recently built a new 6,000 ton Chiller plant with high efficiency centrifugal chillers.

2. Justice Complex – New UPS Upgrades to provide additional resiliency to critical infrastructure

3. Statehouse Complex – Renovation of the Executive Statehouse would likely results in minor efficiency gains.

Figure 3: Existing PSE&G/Veolia Infrastructure



3.3.2.2. Existing Controls Network

The plant uses a Honeywell network that is connected to the following buildings (Veolia, H&A, L&I, Justice, and Tax Building. This controls system was used to manage the chillers that Veolia owned and operate. The controls circuitry still remains.

3.3.2.3. Existing Electrical Interconnection – 27 kV and Breaker description

The plant currently has an existing interconnection with the PSE&G 27 kV Network. The interconnect appears to be capable of up to 15.8 MW of bi-directional feed limited by a single 600 amp, 26.4 kV line switch to two 26.4 kV feeders. The original arrangement supported up a PUPRA agreement where the plant was capable of exporting up to 12 MW. This agreement would have to be reexamined and reanalyzed

3.3.3. *PSE&G Infrastructure*

3.3.3.1. Downtown Trenton Network

3.3.3.1.1. Trenton Switching Station

The bulk of the power that enters in the area is via a 27 KV Trenton Switching Station. The Trenton Switching Station then feeds Monument Breaker Station and Chauncey Street Substation. The Monument Breaker Station feeds the Trenton East and West Networks, as well as additional high tension feeders A-131. These networks are below grade and rated at 27 KV networks. The Trenton East and West Network are 3 and 2 circuit spot networks which feed individual buildings via network protectors and transformers.

Based on this arrangement it appears technically feasible to feed the buildings in the Trenton East and West Network from the Veolia station, via feeder A-131 and the Monument Breaker Station.

3.3.3.2. Lamberton & Kuzkow Network

There are assets on the eastern region of buildings examined in the microgrid that are not located within the Downtown Trenton East and West Network. The New Jersey State Prison and the Arena are located on above ground, 13.2 kV Networks which have no ability for backfeed or to be connected to each other. They are not fed from the Trenton Switching Station.

3.3.3.3. Additional Assets Beyond Microgrid

The Wastewater Treatment Plant, Police Department, Fire Department, and 640 Broad St are also fed from Networks outside of the Trenton East and West Network

Table 6: PSE&G Infrastructure Review

Veolia Feeders	**PSE&G 27 KV (A-131 Feeder)**	**PSE&G 27 KV East and Wes t Network Feeder)**	**Additional Assets Outside of Trenton East and West Network**
Veolia TDEC	Statehouse	Kingsbury Tower	Wastewater Treatment Plant
Justice Complex	Monument Breaker Station	Thomas Edison College	Fire Department
H&A		War Memorial	Police Department
Labor & Industrial		Old Barracks	640 Broad St
		MVC Building	State Prison
		NJN Building	Arena
		Ashby	
		Capital One Place	
		DEP	

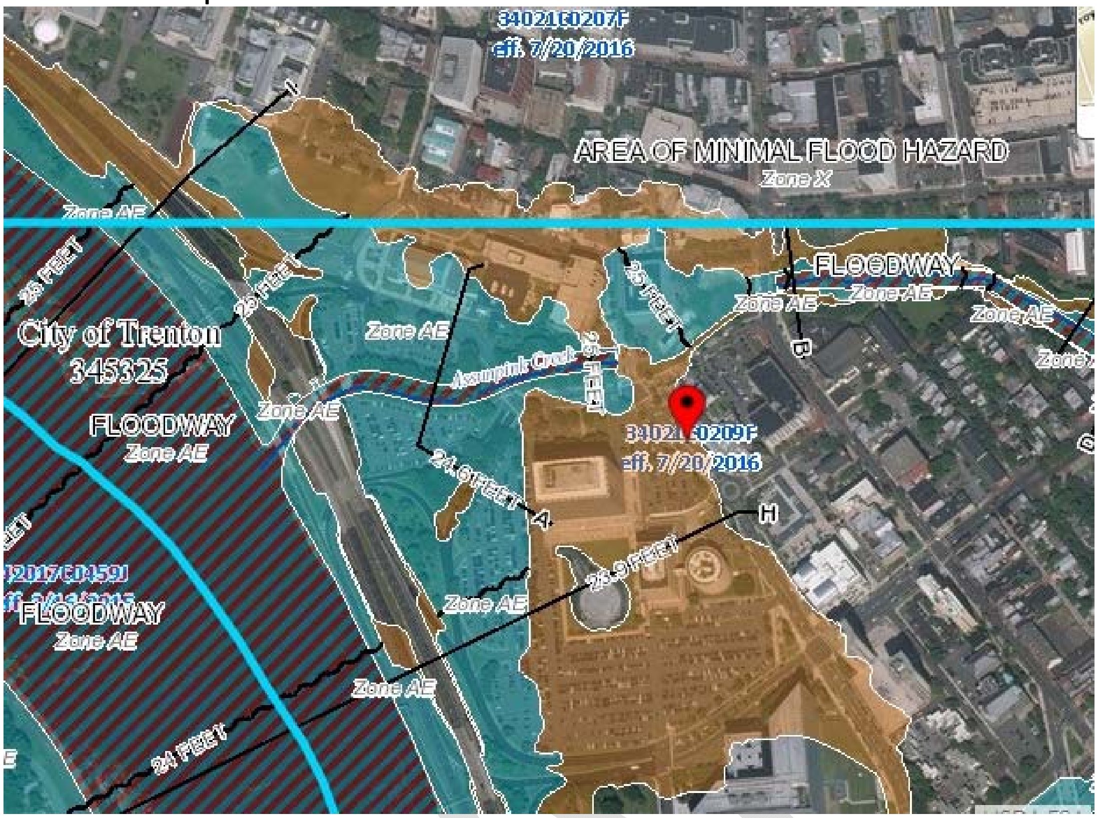
3.3.4. *PSE&G Natural Gas Connection*

PSE&G currently operates a 12” 60 psig design distribution main on which TDEC’s service is currently connected.

3.3.5. *FEMA Flood Review*

In order to understand the potential impact of a flood event on the critical infrastructure, the FEMA flood maps were consulted to understand the risk associated with the region.

Table 7: FEMA Flood Map



The red marker shows the location of the Veolia TDEC plant. It is located above the flood plain due to the elevated terrain where it lies.

3.3.6. *Microgrid Review*

Based on a review of the existing arrangements, it appears the Veolia TDEC plant could create a microgrid with consideration for the following items.

1. A district energy plant can serve electricity to existing users that are on the microgrid.
    a. Critical assets considered in this microgrid are currently being served by Veolia TDEC Plant.
2. A district energy plant can serve electricity to users that are no more than one ROW away from the generating source.
    a. The following critical assets – H&A/Tax, L&I, and Justice are one ROW away from the plant.
    b. The Statehouse, if connected from L&I, can also be considered on ROW away from the plant.
3. Existing infrastructure that has been grandfathered into new microgrids
    a. Existing feeders to H&A, L&I, and Justice were built to supply electricity for utility purposes.

The following section provides additional summary and interpretation of the regulations pertaining to the Microgrid.

3.3.6.1. Current Regulatory Landscape

As currently set forth in N.J.S.A. 48:3-51 and 48:3-77.1, a district thermal energy facility that expands to supply electric service, or an advanced microgrid, can only serve the on-site electric end-use customer that is geographically contiguous and only cross one ROW.

- To connect multiple electric commercial customers that cross multiple ROW, the expanded district thermal energy facility, or advanced microgrid, must use the existing electric distribution system. (Basis: economic efficiency)
  - **Municipalities may be exempt**
    - First, municipalities may construct and operate municipal microgrids as general improvements pursuant to N.J.S.A. 40:56-1. Second, municipalities have retained the right to construct general public improvements, like microgrids, in their municipal ROW. Third, because municipalities have a superior nonpossessory interest in their ROW, such a microgrid is outside of N.J.S.A. 48:3-77.1. Fourth, a utility's franchise rights are not violated if a municipality constructs a microgrid to only connect municipal buildings, and does not sell energy to current utility customers.
  - **Campus Microgrids Grandfathered in**: Several level 2 campus wide microgrids, which were developed prior to the amendments in N.J.S.A 48:3-77.1, cross multiple public ROWs that transect their campus.[1]

3.3.6.2. Options for Developing Advanced Microgrids in NJ Currently

- The owner/operator of the advanced microgrid, at their cost, would construct the advanced microgrid and all the pipes and wires/lines connecting the multiple critical customers over multiple ROW. The wires/lines connecting multiple microgrid customers across several ROWs would be constructed to the EDC's established specifications. This would include all interconnection devices and any other related distribution grid required equipment. Once the advanced microgrid system and the wires/lines were constructed the owner/operator of the advanced microgrid would "turn over" the microgrid wires/lines connecting multiple critical customers over multiple ROW to the EDC. The advance microgrid wires/lines would become part of the EDC's system including the One Call system. There would be a Town Center DER microgrid tariff established that pays for the ongoing maintenance of the wires/lines. The Town Center DER microgrid tariff would be a cost based tariff and include the overall costs and benefits to the advance microgrid customers and to the overall EDC system and its customers.

[1] http://www.nj.gov/bpu/pdf/reports/20161130_microgrid_report.pdf

3.3.6.3. Standards and Codes

An advanced microgrid must meet all building code requirements. The New Jersey Department of Community Affairs – Division of Construction Code Enforcement regulates the fire and life safety aspects of emergency energy systems and will review any plan related to the systems that connect multiple DER technologies to multiple critical customers across multiple ROWs.

IEEE 1547 series of standards addresses the interconnection of DER to the distribution grid. IEEE 1547.4 addresses the standard related to islanding of DER microgrids.

Updates to 48:3-77.1 Utilization of locally franchised public utility electric distribution infrastructure.

In order to avoid duplication of existing public utility electric distribution infrastructure, and to maximize economic efficiency and electrical safety, delivery of electric power from an on-site generation facility to an off-site end use thermal energy services customer as defined in section 3 of P.L.1999, c.23 (C.48:3-51), shall utilize the existing locally franchised public utility electric distribution infrastructure. The New Jersey electric public utility having franchise rights to provide electric delivery services within the municipality shall provide electric delivery services at the standard prevailing tariff rate that is normally applicable to the individual off-site end use thermal energy services customer.

It is noteworthy that based on the PSE&G tariff resale of electricity under the all the PSE&G rates examined is prohibited. However according to section 9.2.2 of the PSE&G tariff, sub-metering is permitted when the basic characteristic if use is industrial or commercial i.e. not residential except if condominiums or government owned.

4. Facility Rate Overview

Analysis of the external market allows the microgrid to proactively plan its energy future in a manner that leverages a combination of available service offerings and revenue opportunities. Specifically, this review includes an analysis of potential energy rates (costs) and revenue streams to the microgrid. The microgrid economic model is based on a 20 year time horizon from 2018 to 2037. Through the discussion of rates, an appropriate combination of available rates can be leveraged that will result in a viable economic model and maximize stakeholder benefit.

4.1. Rates and Tariffs Analysis

Identification and accurate modeling of utility rate & tariffs is pertinent when evaluating the financial feasibility of the microgrid. The table below provides a summary of the applicable energy services and rates that have been used to evaluate the microgrid configurations in Section 5 and 6 of this report. The rates are presented in categories depending on the energy type (such as electricity or natural gas), provider or utility, and specific service with the applicable rate.

Table 8: Energy Services and Rate Summary

Provider/Utility	Energy Type	Service Classification	Rate Number
PSE&G	Electricity (delivery only)	Body Politic Lighting Service	BPL
		General Lighting & Power Service	GLP
		Large Power & Lighting Service	LPL-S
			LPL-P
		High Tension Service Subtransmission	HTS-S
	Natural Gas	General Service	GSG
		Cogeneration Interruptible Service	CIG
Veolia	Thermal Energy	Hot Water Service	-
		Chilled Water Service	-

As part of the feasibility study, SourceOne compiled one year of utility bills (2016) for a selection of critical and non-critical buildings in Downtown Trenton. The table below provides a summary of applicable utility rates for each building evaluated as part of this study.

Table 9: Energy Service & Rate per Building

Building/ Rate	Electricity					Natural Gas		Thermal Energy	
	BPL	GLP	LPL-S	LPL-P	HTS-S	GSG	CIG	Hot Water	Chilled Water
Veolia Plant					X		X		X
State Prison	X	X		X		X		X	X
Justice		X			X			X	X
State House					X			X	X
Taxation		X	X					X	X
Labor		x	X					X	X
Health			X					X	X
Ashby			X					X	X
Cap Place One		X	X					X	X
DEP HQ	X	X		X					X
M Roebling			X					X	X
MVC 225 E State (DMV)		X	X					X	X
NJ Network		X	X					X	X
Old Barracks		X						X	X
Thomas Edison College	Invoices not received							X	X
War Memorial		X	X			X			X
MCIA Arena	Invoices not received								X
Kingsbury Tower	Invoices not received								X
640 Broad Street	Invoices not received								

Four different energy services are currently provided to the identified buildings; namely, electricity and natural gas by PSE&G as well as hot and chilled water by Veolia.

5. TARIFF AND RATE REVIEW

The rate model of this evaluation is comprised of six components: electricity delivery, electricity supply, natural gas delivery, natural gas supply, hot water and chilled water. Below we describe how we modeled each component from 2018 through 2037. Twenty year forecast seemed appropriate give the expected life of the new equipment, existing overall life of the plant (35-40) years, and the permanence of the capital buildings located in Trenton.

5.1.1. *Electrical Service Rates*

Electricity Delivery

PSE&G Body Politic Lighting Service

PSE&G's BPL electric rate is applicable to use for luminaires used for street and area lighting. The PSE&G tariff provides standard rates for different types of luminaires as well as for metered service. BPL rate charges to buildings only represent a small fraction of electric charges.

PSE&G General Power & Lighting Service

PSE&G's GLP electric rate is applicable to customers at secondary distribution voltages. The rate was modeled off of the PSE&G tariff. It is comprised of multiple charges:

- Service Charge ($/month)
- Annual Demand Charge ($/kW)
- Summer Demand Charge ($/kW)
- Distribution Charge ($/kWh)
- Societal Benefit Charge ($/kWh)
- Non-Utility Generation Charge ($/kWh)
- Securitization Transition Charges ($/kWh)
- System Control Charge ($/kWh)
- Solar Pilot Recovery Charge ($/kWh)
- Green Programs Recovery Charge ($/kWh)
- Capital Adjustment Charge ($/kWh)
- Commercial and Industrial Energy Pricing Standby Fee ($/kWh)

PSE&G Large Power & Light Service

PSE&G's LPL electric rate is applicable to customers at primary and secondary distribution voltages where the monthly peak demand exceeds 150 kW. Different rate charges are applicable based on the applicable distribution voltage. The rate was modeled off of the PSE&G tariff. It is comprised of multiple charges:

- Service Charge ($/month)
- Annual Demand Charge ($/kW)
- Summer Demand Charge ($/kW)
- Societal Benefit Charge ($/kWh)
- Non-Utility Generation Charge ($/kWh)
- Securitization Transition Charges ($/kWh)
- System Control Charge ($/kWh)
- Solar Pilot Recovery Charge ($/kWh)
- Green Programs Recovery Charge ($/kWh)
- Capital Adjustment Charge ($/kWh)
- Commercial and Industrial Energy Pricing Standby Fee ($/kWh)

PSE&G High Tension Service

PSE&G's HTS-S electric rate is applicable to customers at sub-transmission voltages. The rate was modeled off of the PSE&G tariff. It is comprised of multiple charges:

- Service Charge ($/month)
- Annual Demand Charge ($/kW)
- Summer Demand Charge ($/kW)
- Societal Benefit Charge ($/kWh)
- Non-Utility Generation Charge ($/kWh)
- Securitization Transition Charges ($/kWh)
- System Control Charge ($/kWh)
- Solar Pilot Recovery Charge ($/kWh)
- Green Programs Recovery Charge ($/kWh)
- Capital Adjustment Charge ($/kWh)
- Commercial and Industrial Energy Pricing Standby Fee ($/kWh)

Electricity Delivery Charge Forecast

For 2018, each charge was modeled according to the tariff. PSE&G recently requested an electricity rate increase that is pending review by the New Jersey Board of Public Utilities. For 2019 and 2020, the existing 2018 charges were escalated in the model according to the requested rate increase (approximately 1% per year). For 2021 and beyond, the charges were escalated using the current rate of inflation.

Electricity Supply

In unregulated markets such as PJM, buildings can typically choose to procure power from a third party supplier or the utility.

Third Party Supply

When procuring a third party supply contract, the timing, and specific building load as well as duration of the contract is critical in securing favorable pricing. The reason behind this is that third party suppliers are able to offer fixed price supply contracts through procuring long term power purchase agreements and through hedging against market volatility. The utility bills reviewed by SourceOne, revealed that all buildings procure electricity supply through a third party supplier except for the Veolia plant that procures power through PSE&G's Basic Generation Service. SourceOne did not have access to the terms of third party supply agreements for each of the buildings. A cursory comparison between billed historical supply costs and PSE&G supply charges found third party supplied power to be competitive.

PSE&G Basic Generation Service for Commercial and Industrial

Electricity supply for the Veolia plant was modeled off of the PSE&G tariff for basic generation service for commercial and industrial customers. The supply cost is comprised of multiple components:

- Commodity (electricity only)
- Ancillary Services and Reconciliation Charges
- Capacity
- Transmission

The *commodity price* was obtained through hourly pricing for the PSE&G LMU for 2017 through a third party vendor. Note that high prices in December are due to extreme cold observed at the end of 2017.

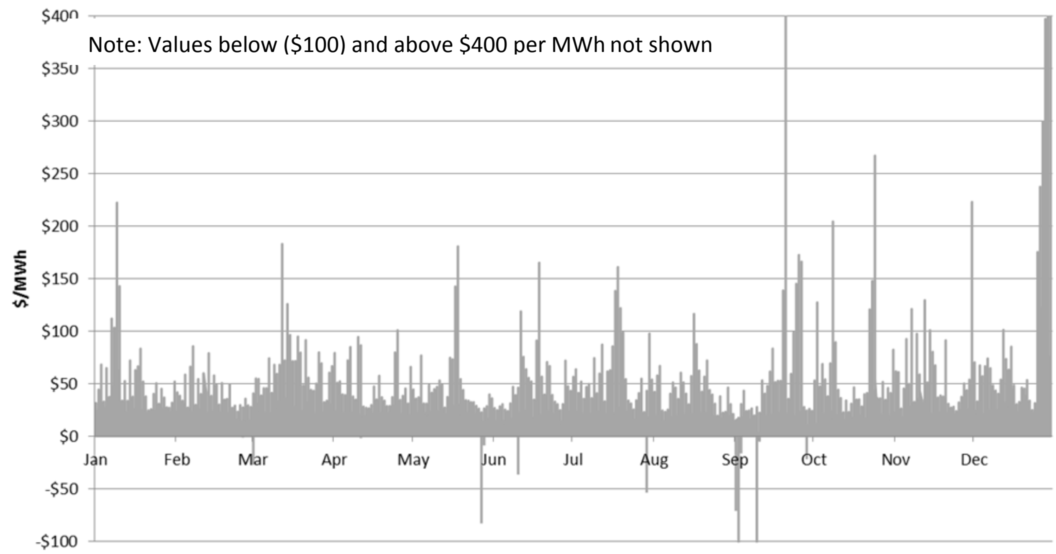


Figure 4: 2017 PSE&G Hourly Real Time LMP

The commodity price was then forecasted using forward monthly strip prices for the PSE&G zone within the PJM region, adjusted for transmission losses associated with sub-transmission and transmission service. After 2017, it was assumed that energy payments will increase by 1.2% per annum.

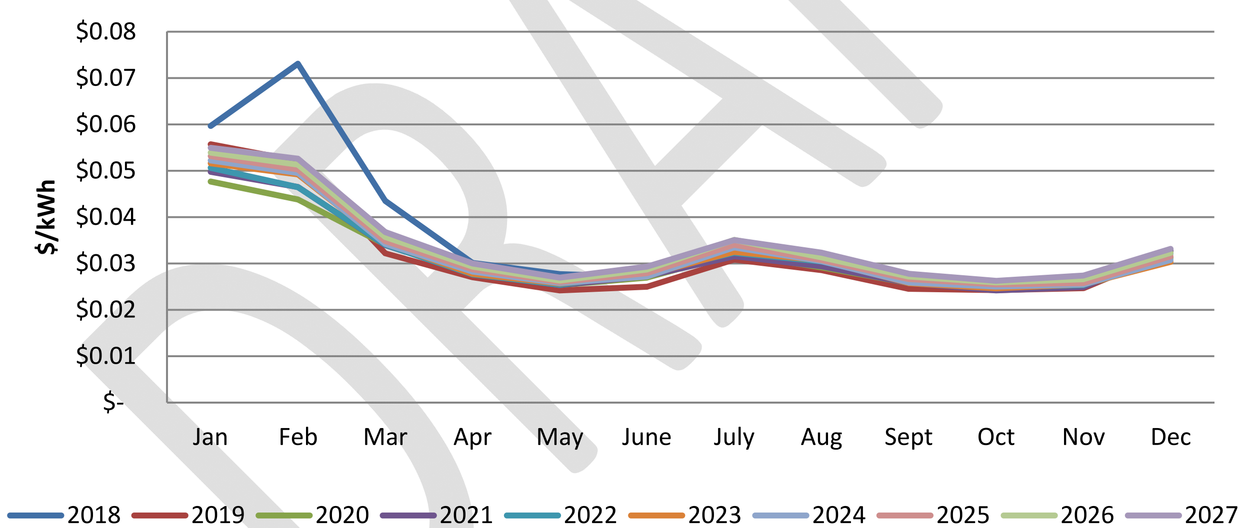


Figure 5: PJM PSE&G- Monthly Forward Loss-Adjusted Electricity Prices

Ancillary services and reconciliation charges for 2018 were taken from the PSE&G tariff. For 2019 through 2037 these charges were scaled based on the EIA 2017 Annual Energy Outlook's year-over-year projection of end-use prices for commercial customers.

Capacity charges reflect the cost of having sufficient generating capacity on the grid. PJM runs regular auctions to procure sufficient generating capacity to meet the region's projected peak demand plus a reserve margin. In these auctions, generators commit their capacity in exchange for payment on a $/kW basis. Utilities and suppliers pass these charges along to end users as a capacity charge on a $/kW basis. Thus, the auction's clearing price in a given year is the primary determinant of your capacity charge that year. Auctions are held 3 years in advance. Future capacity charges through 2021 were modeled to reflect the clearing prices for completed auctions that were already held. In 2022, capacity charges were based on an average of the preceding 7-years. In 2023 and beyond, capacity prices were modeled using CPI as an escalator.

Transmission charges are analogous to capacity charges in that they reflect the cost of having sufficient transmission and distribution infrastructure to deliver electricity throughout the grid. These charges are tied to investment in grid infrastructure. As a result, there is no way that is both simple and accurate to model future transmission charges. The best approximation is to track upcoming infrastructure investments and estimate their likely impact on transmission charges. New Jersey is in the midst of substantial upgrades to its grid infrastructure. Increases to transmission charges are expected over the next few years. Beyond that, the rates are difficult to predict. We modeled the future transmission charges accordingly. In 2019 PSE&G anticipates a 9% growth in infrastructure investment and 7% in 2020 and 2021. Our model uses those growth rates. In 2022 and beyond, transmission charges were modeled using CPI as an escalator.

For Capacity and Transmission charge calculations, one needs to calculate a facility's annual capacity tag (BGS transmission and generation obligation). Given that the capacity tag is based on facility load at the PJM RTO and PSE&G system 5 highest coincident peaks[2], SourceOne assumed that the annual capacity tag is 44% of the peak summer load[3].

5.1.2. *Natural Gas*

This section outlines the electric service rates as well as documents SourceOne's rate forecasting methodology.

Natural Gas Delivery

PSE&G General Service

PSE&G's GSG service is procured for general purposes to customer with usage not exceeding 3,000 therms in any month. Only the JN State Prison and War Memorial were found to take service through GSG. The reason is that the buildings receive thermal energy through the Veolia district energy system. This rate is comprised of multiple charges:

- Service Charge ($/month)
- Distribution Charge ($/Dth)
- Balancing Charge ($/Dth)
- Societal Benefits Charge ($/Dth)
- Weather Normalization Charge ($/Dth)
- Margin Adjustment Charge ($/Dth)
- Green Programs Recovery Charge ($/Dth)
- Capital Adjustment Charges ($/Dth)

PSE&G Cogeneration Interruptible Service

Gas delivery at the Veolia Plant was modeled off of the PSE&G tariff for CIG. This rate is limited to customers continuously taking service under this rate schedule since January 2002 and involve cogeneration facilities of no more than 20 MW (except if receiving service prior to 1993). This rate is comprised of multiple charges including:

- Service Charge ($/month)
- Distribution Charge ($/Dth)
- Societal Benefits Charge ($/Dth)

[2] https://www.pjm.com/-/media/planning/res-adeq/load-forecast/summer-2017-pjm-5cps-and-w-n-zonal-peaks.ashx?la=en
[3] Derived through the Veolia plant utilities model.

- Green Programs Recovery Charge ($/Dth)
- Capital Adjustment Charges ($/Dth)

Natural Gas Delivery Charge Forecast

For 2018, each charge was modeled according to the tariff. PSE&G recently requested a gas rate increase that is pending review by the New Jersey Board of Public Utilities. For 2019 and 2020, the existing 2018 charges were escalated in the model according to the requested rate increase (approximately 1% per year). For 2021 and beyond, the charges were escalated using the current rate of inflation.

Natural Gas Supply

PSE&G General Service

Similar to electricity supply, customer can choose whether to receive natural gas supply directly from PSE&G or a third party supplier.

PSE&G Cogeneration Interruptible Service

Natural gas supply under PSE&G' CIG service is procured through PSE&G (based on BGSS- CIG Commodity Charges specified in the Tariff). Supply charges are based on several components including the estimated average commodity cost for each month (NYMEX), the variable cost of commodity and fuel, pipeline demand costs and loss factor. To model natural gas supply, SourceOne utilized the Veolia plant's utilities model.

To forecast the CIG supply cost, monthly gas forwards for the NYMEX were utilized for the period of 2018-2027. After 2027, it was assumed that supply prices will increase with the current CPI. This section outlines the electric service rates as well as documents SourceOne's rate forecasting methodology.

For all natural gas calculations, to convert Higher Heating Value to Lower Heating Value natural gas volumes a factor of 1.1027 was used.

5.1.3. *Thermal Energy*

The Veolia plant provides hot and chilled water services to an array of customers in Downtown Trenton. For modeling purposes, Veolia plant hot water and chilled water sales volumes and rates were assumed to remain fixed.

5.2. Revenues

In addition to the various energy services and rates the microgrid can utilize, there are several potential applicable revenue streams. These include revenue from energy as well as incentives, grants and rebates. Critical provisions are highlighted with each service and incentive or grant when applicable.

5.2.1. *Electricity Export to PJM*

If the microgrid is to generate more power than what is needed to satisfy its load, it can potentially export power to PJM. As discussed in Section 3 the Veolia plant is currently interconnected to PSE&G at a 27 kV and is both capable to import power from PSE&G as well as export power to PJM.

Energy Payments

PJM market energy payments were modeled through hourly pricing for the PSE&G LMU for 2017 through a third party vendor. Note that high prices in December are due to extreme cold observed at the end of 2017.

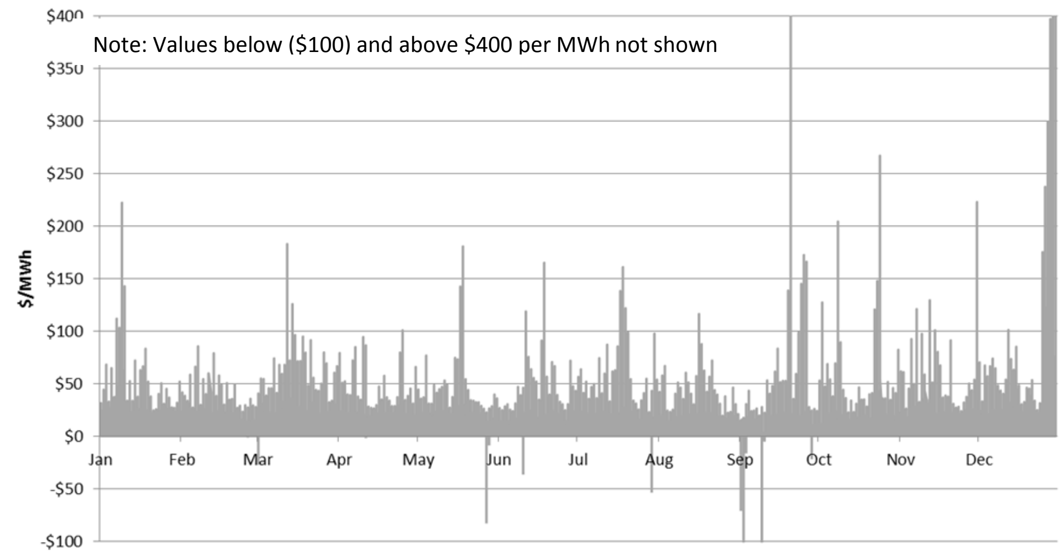


Figure 6: 2017 PSE&G Hourly Real Time LMP

For forecasting we used forward monthly strip prices for the PSE&G zone within the PJM region from a third party vendor available until 2027. Thereafter, it was assumed that energy payments will increase by 1.2% per annum.

Capacity Payments

No capacity payments were factored in the analysis.

5.2.2. *Demand Response*

Demand response programs incentivize utility customers to provide load relief and can act as a source of revenue that the microgrid can access through generation assets as well as potential load shedding schemes and/or energy storage.

Examples of utility load relief include the Veolia district energy system chilled water storage tanks, as well as the plant's reciprocating engines. Additional dispatchable generation such as battery storage and new reciprocating engine(s) can potentially supplement current demand response capabilities. If a gas turbine is employed as part of the microgrid, by investing in excess power generation technologies such as the TIAC, the cogeneration plant can provide excess power during times of load relief events and capture a significant revenue stream from demand response programs. It can also add operational flexibility to the system and allow excess electrical and thermal production when needed.

SourceOne identified several demand response programs available to the microgrid. The most applicable of those programs is likely to be the Emergency Load Response Program. The ELRP program helps maintain grid stability by calling emergency events which require customers to adjust their power consumption. Typical emergency events happen on hot summer days and last around 4 hours. The ELRP program features three tiers, each of which has call period durations. ELRP demand response program participation can be archived via load aggregation across microgrid buildings through a Curtailment Service Provider or through a single location with at least 100 kW in demand response curtailment. For compensation, customers receive a capacity and energy payment based on the applicable capacity value for their load zone and performance. For the 2018/2019 in PSE&G's territory capacity payments[4] are in the range of $82,000 per MW dropping to $43,800 for 2019/2020 and increasing to $68,500 for 2020/2021.

Finally, if electricity is curtailed through an agreement with PSE&G, for a minimum of 100 kW of load curtailment a credit of $6.11 per kW (excl. sales tax) will be received for actual average curtailed demand.

5.2.3. *Electricity and Thermal Energy Exported to Microgrid Buildings*

Blue Sky Conditions

Under blue sky conditions, the following rates are assumed to hold for energy exports from the Veolia plant to microgrid buildings:

Electricity: Table 9 reveals that each building examined as part of this microgrid feasibility study features a unique combination of electricity service and rates. Based on utility bills analyzed by SourceOne from January through December 2016, the average blended rate for microgrid buildings (excluding the Veolia plant) was approximately $0.100- $0.105 per kWh. For electricity exported from the Veolia plant to microgrid buildings, a fixed rate of $0.105 per kWh is assumed for 2018 and inflated thereafter with the current CPI. Since, each of the scenarios evaluated in this study involves different buildings; this assumption was made as a means to simplify the analysis. A sensitivity analysis on microgrid electricity exported to microgrid buildings was performed with each configuration evaluated.

When applicable, a microgrid standby fee is also included as revenue in the analysis. This fee is aimed to recover microgrid related expenses from generating equipment that is sized to operate during a utility outage, for demand response program participation or limited hours of the year.

Natural Gas: Due to advantageous Veolia plant CIG natural gas rate it is assumed that all natural gas electricity generation will be procured exclusively for the Veolia plant.

Thermal Energy: Current Veolia hot water and chilled water billing methodology, without any changes.

Black Sky Conditions

For the purposes of this evaluation it is assumed that under black sky conditions, the same rates as blue sky conditions will hold.

5.2.4. *Incentives, Grants, & Rebates*

The assessment of revenue potential also includes federal, state and local applicable incentives and grants. The most applicable incentives/programs are summarized below:

New Jersey Clean Energy Program: CHP Incentive

This program offers incentives for CHP installations that can achieve at least 65% LHV annual system efficiency and run for at least 5,000 hours per year. It is applicable to commercial and industrial entities that pay into the Societal Benefits Fund. Incentives are tiered and are capped at 30% of the project cost (40% if absorption cooling is utilized) or $2-$3 million depending on the nameplate electrical capacity and type of system prime

[4] https://cpowerenergymanagement.com/help/pjm-dr-changes/

mover. It is noteworthy that as of the end of 2017, the program has approximately $10.8 million in funding available through June 30, 2018. The table below provides an overview of incentives

Table 10: CHP Incentive Overview

Eligible Technologies	Size (Installed Rated Capacity)	Incentive ($/kW)	% of Total Cost Cap per Project	$ Cap per Project
Powered by non-renewable or renewable fuel source	≤500 kW	$2,000	30-40%	$2 million
Gas Internal Combustion Engine	>500 kW -1 MW	$1,000		
Gas Combustion Turbine	> 1 MW - 3 MW	$550	30%	$3 million
Microturbines and Fuel Cells with Heat Recovery	>3 MW	$350		

Solar Renewable Energy Credits

New Jersey's Renewable Portfolio Standard includes a carve-out for solar, requiring utilities to procure a fraction of the electricity used to serve customers through in-state solar installations. Solar facilities have a 15-year "qualification life", meaning that they are eligible to generate SRECs for 15 years. The solar curve out is set to expire in 2028. For modeling solar PV, SourceOne assumed that SREC's will be valued at $210 per MWh until 2028.

Metering

Net metering allows utility customers to offset utility procured electricity with exported electricity generated through renewable sources. Specifically, net metering is available to utility customers that generate electricity using renewable sources such as solar, wind, landfill gas, biomass and fuel cells. The system size of eligible for net metering is only limited to that needed to meet annual on-site electric demand.

Solar Energy Sales Tax Exemption

The state of New Jersey (through the New Jersey Division of Taxation) offers a full exemption from the State sales tax (6.625%) for solar energy equipment (PV and solar thermal).

Property Tax Exemption for Renewable Energy Systems

The state of New Jersey (through the New Jersey Division of Taxation) offers an exemption of renewable energy systems used to meet on-site electricity and thermal needs from local property taxes. Some noteworthy technologies include in exception are solar, wind, fuel cells and biomass.

PSE&G Energy Saver Program

The Energy Saver Program is applicable to government, non-profit and some small business facilities. It featured a free on-sit energy audit and pays for up to 70 percent of recommended energy conservation measures.

U.S. Department of Energy: Loan Guarantee Program

This program can help obtain project financing through the federal government.

Modified Accelerated Cost-Recovery System

The Internal Revenue Service offers a depreciation of the costs of eligible power technologies to corporations. Depreciation allows for recovering the cost of investments through deductions. The MACRS establishes a set of class lives for various types of property. Renewable energy technologies are typically classified for five year MACRS. Bonus depreciation on top of the published rates is also available.

Business Energy Investment Tax Credit

This financial incentive provides corporations that invest in eligible energy technologies a federal tax credit. The incentive is 30% for solar, wind and fuel cells and 10% for geothermal and CHP (Full credit available up to 15MW of electrical capacity and efficiency of 60% and a partial credit if more than 15 MW but less than 50 MW).

6. Energy Use and Load Analysis

Based on the review of the previous scenarios, a variety of load scenarios were analyzed to understand the potential distributed generation that may be required for the microgrid. The load scenarios were based on grouping the critical assets on their load requirements and geography, expanding the load scenarios to encompass more building assets. The load scenarios are shown in the table below:

Table 11: Load Summary

Scenario	Description	Approx. Sq. Footage	Annual kWh	kWh/Sq.ft
1	Veolia + H&A/Tax, L&I, Justice	1,098,258	26,916,041	24.51
1a	Veolia + H&A/Tax, L&I, Justice, State	1,487,982	40,634,674	27.31
2	Microgrid (14 buildings)	4,666,904	67,773,790	14.52

6.1. Load Case– Baseline Veolia Plant

The Veolia Trenton Thermal Plant supplies district heat and chilled water to various buildings in Downtown Trenton. The active chiller plant on site consists of two (2) Trane CDHF-3000 electric centrifugal chillers operating in series for a total capacity of 6000 tons refrigeration. There is also a secondary 1900 ton absorption chiller plant with two (2) Trane ABTF950 chillers that is utilized at peak demand times. Two (2) 72MMBtu/hr hot water generators supply both the hot water system and absorption chillers. Plant load data, thermal sendout, and CHW sendout is shown below. All plant data is from the 2016 calendar year.

Table 12: Plant Load Duration Curve

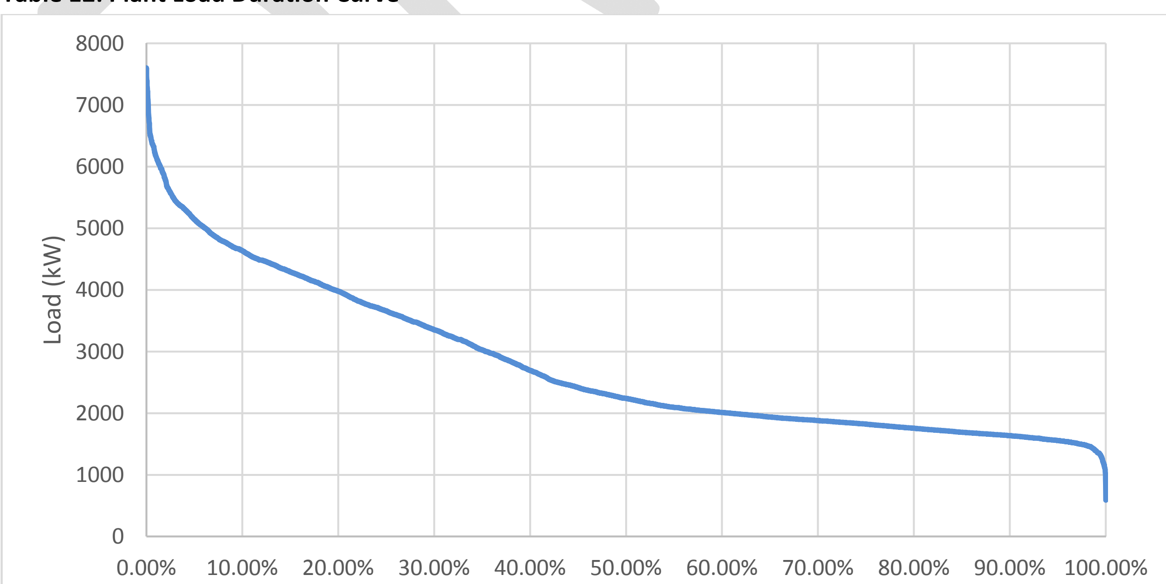


Table 13: Plant Chilled Water Sendout

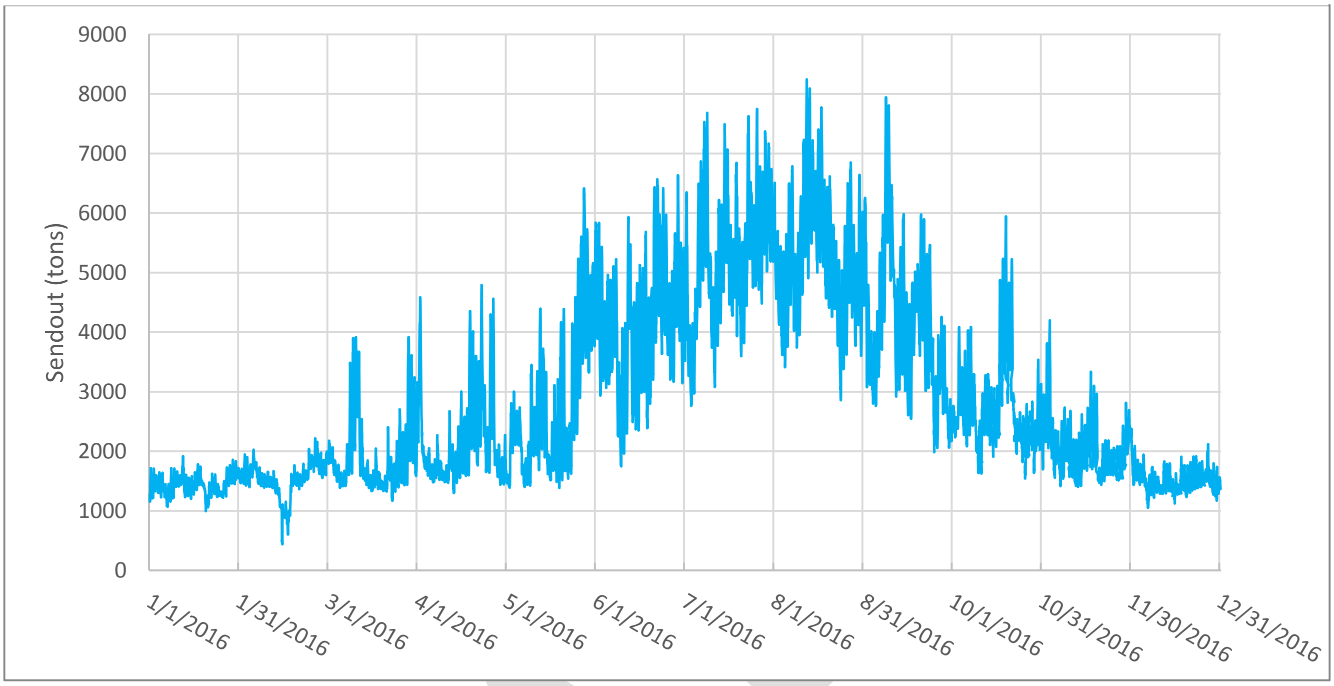
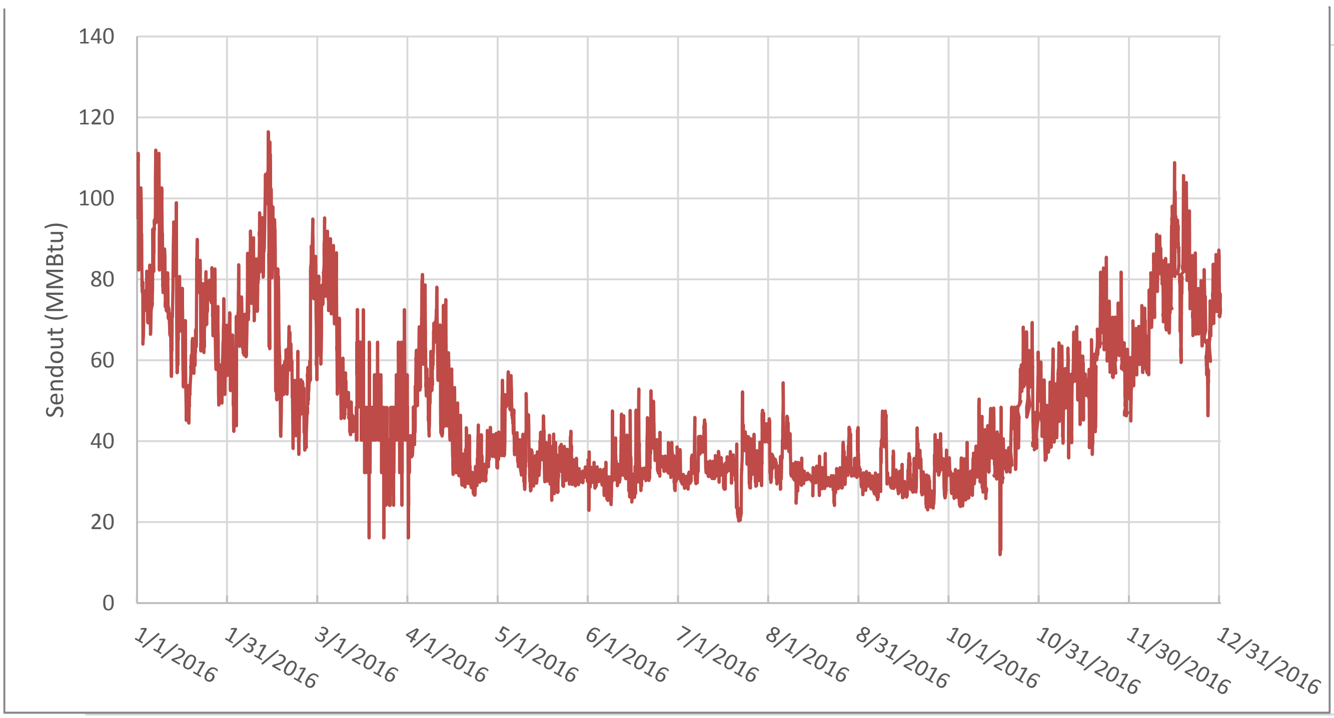


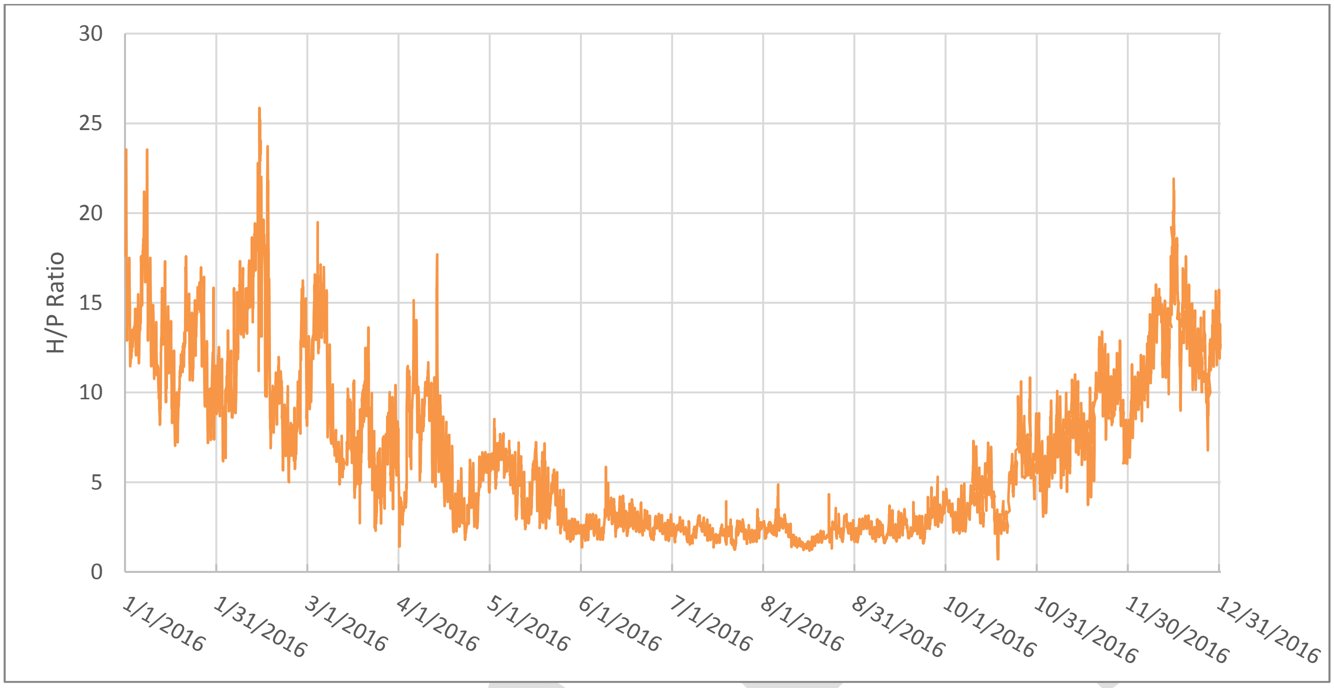
Table 14: Plant Thermal Sendout



In the summer months, peak loads reach 7500 kW electrical and 7500 tons cooling. The electrical baseload year-round is approximately 1700 kW, with 1500 tons of cooling. Hot Water sendout reaches a peak demand in the winter of 115 MMBtu/hr, and has a baseload of 40 MMBtu/hr.

The following chart shows plant heat-to-power ratio consumed at the plant as it varies throughout the year. As shown, H/P varies from 1.5 in the summer to 25 in the winter, with an annual average of 6.61.

Table 16: Plant Heat to Power Ratio



The plant supplies hot water to Downtown Trenton buildings through three (3) separate HW loops: high temperature, medium temperature, and low temperature. Site hot water generators supply heat to the high temperature loop directly, and a portion of the high temperature water is used to heat the medium temperature loop. Low temperature HW is then heated in the same way from the medium temperature loop. This "cascading" system operates at the following temperatures and pressures:

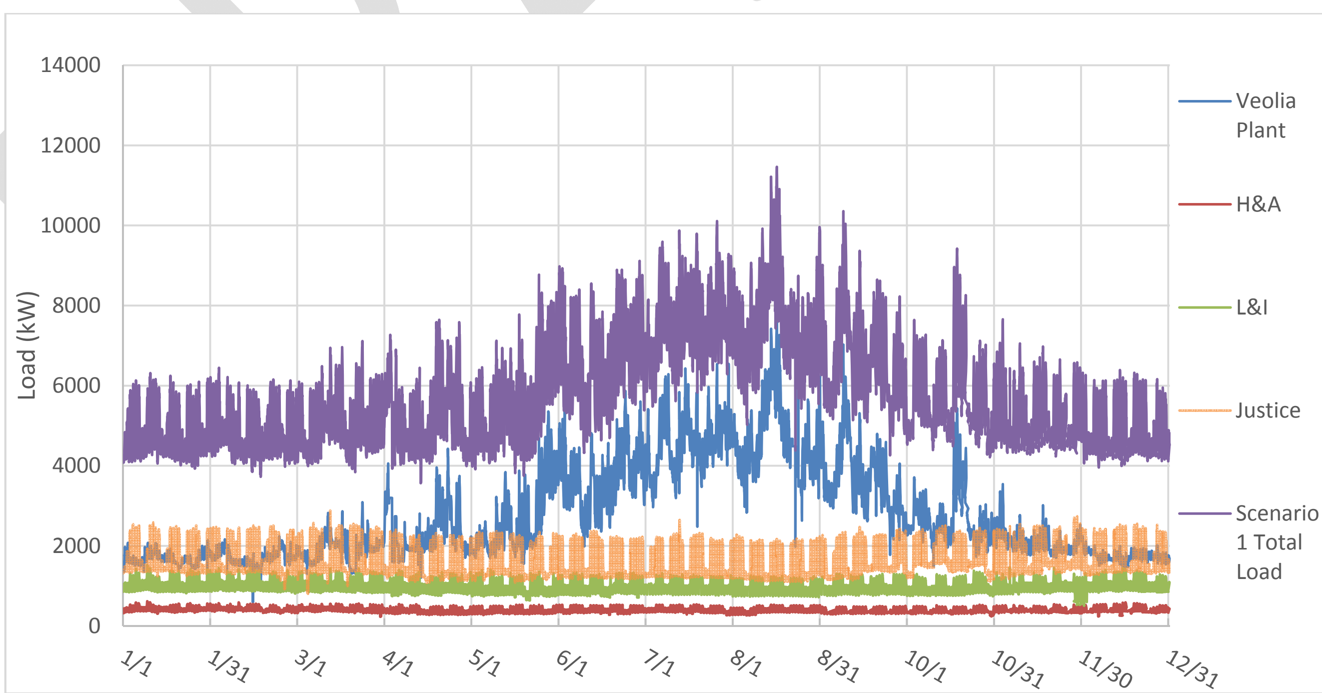
Chilled water is distributed to building loads via a single piping network. CHW is supplied at 40F and returns at 54F. There is a 2.67 million gallon CHW storage tank located in the L&I Building parking lot, which is located just across S Warren St from the Plant. The storage tank is not currently used.

6.2. Load Case (Phase) 1

In Load case 1, electrical load includes the TDEC plant, H&A, L&I, and Justice and the Justice Complex. Justice experiences a similar load profile to H&A and L&I. Load is consistent throughout the year, peaking during business hours on weekdays and returning to baseload at all other times. The table to the right summarizes building characteristics for all government buildings included in load case 1.

Building Name		Labor	Health Building	Justice
Electric Consumption	kWh	8,824,498	3,592,989	14,498,554
Blended Electric Rate	$/kWh	$ 0.106	$ 0.104	$ 0.092
Thermal Consumption	MMBTU	12,207	9,563	37,820
Peak Thermal Demand	MMBTU/hr	12.00	15.55	19.80
Thermal Rate	$/MMBTU	25.26	31.53	20.76
Cooling Consumption	ton-hr	1,688,005	459,926	3,165,266
Peak Cooling Demand	ton	879	700	1,723
Cooling Rate	$/ton-hr	0.56	0.71	0.50
Square Footage	ft^2	439,750	163,108	1,098,258
Total Electric + Thermal	MMBTU	47,593	23,779	100,468
Total Energy/ft^2 (MMBTU/ft^2/Year)	MMBTU/ft^2/Year	0.108	0.146	0.091
Electric Network		West	West	27 kV
Bldg on CHW Loop?		YES	YES	YES
Service by which Thermal Loop(s)?		LTW, HTW	LTW, HTW	HTW

Table 17: Load Case (Phase) 1a



6.3. Load Case (Phase 1A)

The combination of all Load Case 1 loads and the State House electric load make up phase 1a. Yet again, the State House is a government office building operating during normal business hours, and exhibits a similar load profile to the other government buildings. The following is a summary for each building:

Table 18: Scenario Energy Summary

Building Name		Labor	Health Building	Justice	State
Electric Consumption	kWh	8,824,498	3,592,989	14,498,554	13,718,633
Blended Electric Rate	$/kWh	$ 0.106	$ 0.104	$ 0.092	$ 0.091
Thermal Consumption	MMBTU	12,207	9,563	37,820	20,577
Peak Thermal Demand	MMBTU/hr	12.00	15.55	19.80	13.06
Thermal Rate	$/MMBTU	25.26	31.53	20.76	21.85
Cooling Consumption	ton-hr	1,688,005	459,926	3,165,266	1,844,261
Peak Cooling Demand	ton	879	700	1,723	693
Cooling Rate	$/ton-hr	0.56	0.71	0.50	0.43
Square Footage	ft^2	439,750	163,108	1,098,258	389,724
Total Electric + Thermal	MMBTU	47,593	23,779	100,468	72,061
Total Energy/ft^2 (MMBTU/ft^2/Year)	MMBTU/ft^2/Year	0.108	0.146	0.091	0.185
Electric Network		West	West	27 kV	27 kV
Bldg on CHW Loop?		YES	YES	YES	YES
Service by which Thermal Loop(s)?		LTW, HTW	LTW, HTW	HTW	MTW

Table 19: Load Case 1a Electrical Profile

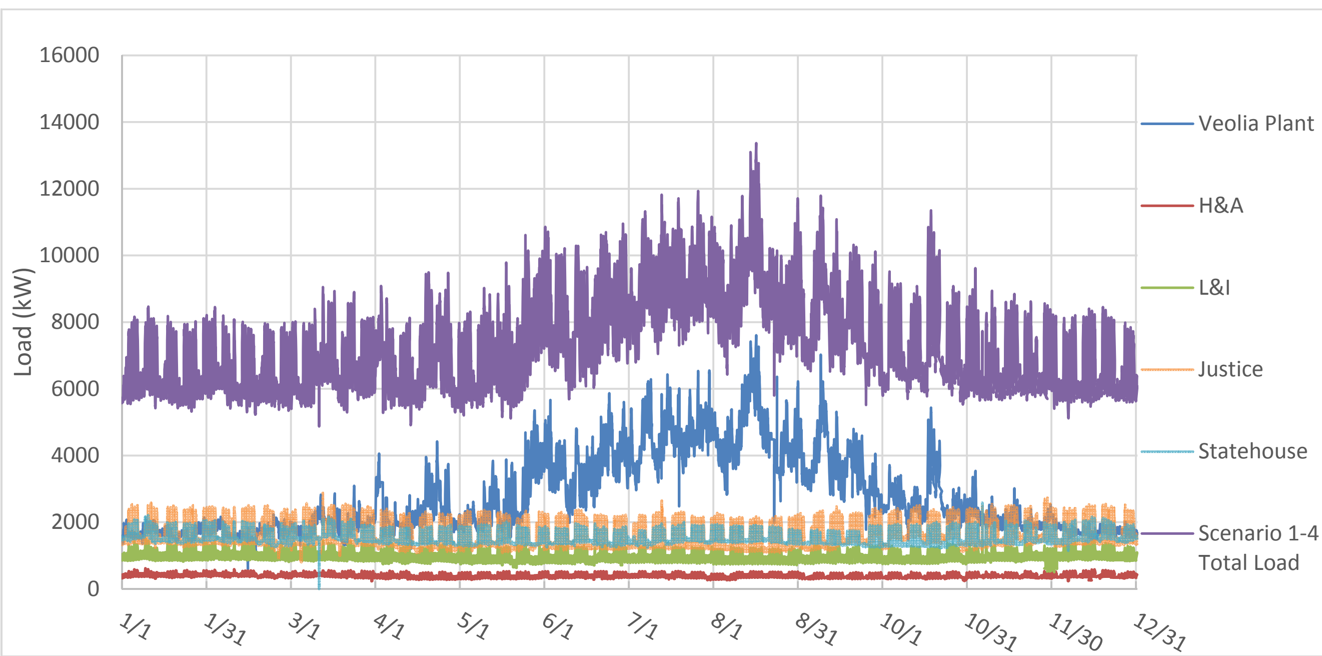
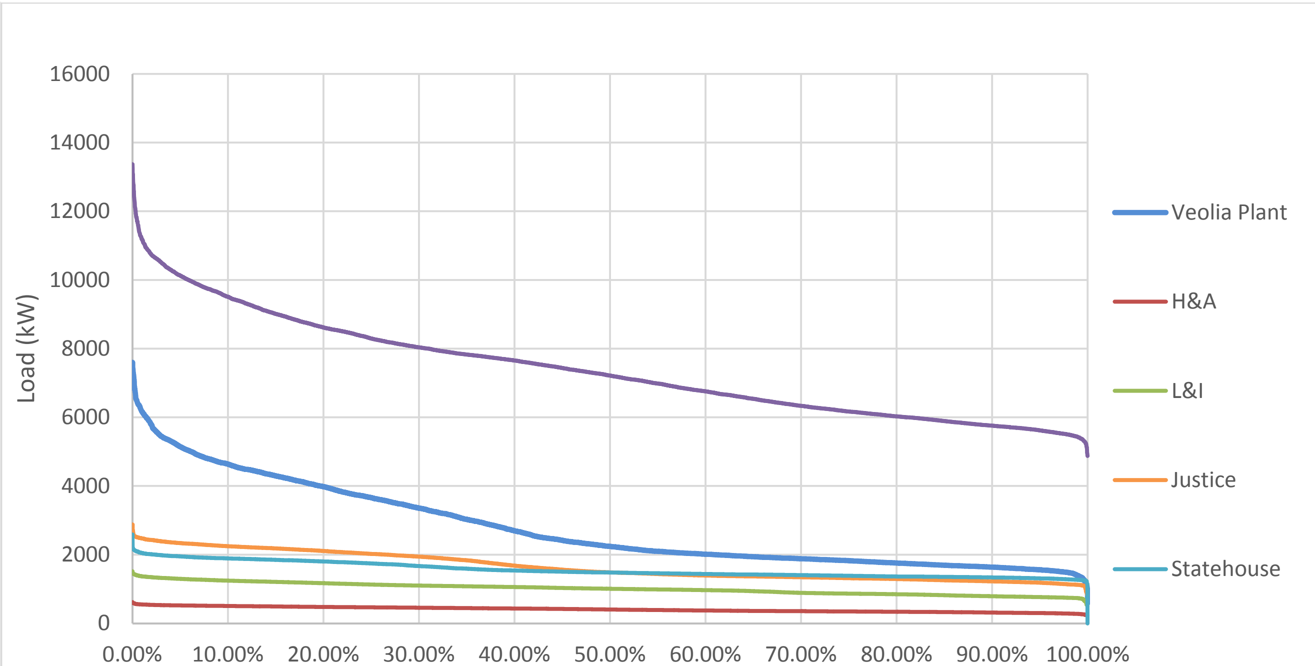


Table 20: Scenario 1a Duration Curves



6.4. Load Case (Phase) 2

Load Case 2 is the virtual microgrid scenario in which electricity is produced at the Veolia plant to offset the load of 14 government buildings in Downtown Trenton. Each building has a similar load profile, but with various peak and baseloads. The buildings are listed and summarized below:

Table 21: Load Case 2 - Microgrid Loads

Building Name	Electric Consumption	Blended Electric Rate		Thermal Consumption	Peak Thermal Demand	Thermal Rate	Cooling Consumption	Peak Cooling Demand	Cooling Rate	Square Footage	Total Electric + Thermal	Total Energy/ft^2	Electric Network	Bldg on CHW Loop?	Service by which Thermal Loop(s)?
	kWh	$/kWh		MMBTU	hr	$/MMBTU	ton-hr	ton	$/ton-hr	ft^2	MMBTU	MMBTU/ft^2/Year			
Justice	14,498,554	$	0.092	37,820	19.80	20.76	3,165,266	1,723	0.50	1,098,258	100,468	0.091	27 kV	YES	HTW
State House	13,718,633	$	0.091	20,577	13.06	21.85	1,844,261	693	0.43	389,724	72,061	0.185	27 kV	YES	MTW
Taxation Building	3,667,834	$	0.110	25,256	3.69	17.06	1,201,068	570	0.45	223,370	40,451	0.181	West	YES	MTW
Labor	8,824,498	$	0.106	12,207	12.00	25.26	1,688,005	879	0.56	439,750	47,593	0.108	West	YES	HTW
Health Building	3,592,989	$	0.104	9,563	15.55	31.53	459,926	700	0.71	163,108	23,779	0.146	West	YES	HTW
Ashby Building GOB	2,472,253	$	0.114	23,953	2.53	16.66	726,187	466	0.56	185,000	34,609	0.187	West	YES	LTW
Cap Place One	2,860,471	$	0.119	5,963	4.65	23.32	986,034	555	0.48	146,708	17,484	0.119	West	YES	MTW
DEP HQ	5,786,029	$	0.113	18,959	5.02	18.26	N/A	N/A	N/A	385,000	43,320	0.113	East	NO	MTW
M Roebling Building	2,672,142	$	0.107							300,000			West	YES	MTW
MVC 225 E State (DMV)	5,018,423	$	0.104							382,000			East	YES	MTW
NJ Network	2,579,304	$	0.113	25,321	7.82	18.74	540,121	430	0.49	105,000	35,382	0.337	East	YES	MTW
College	946,243	$	0.117	4,923	3.50	22.66	506,548	170	0.43	35,635	8,580	0.241	West	YES	MTW
War Memorial	1,136,417	$	0.120	16,165	3.64	17.87	895,394	300	0.44	72,000	20,906	0.290	West	NO	MTW
OVERALL	67,773,790	$	0.109			21.27			0.51	3,925,553					

Table 22: Microgrid Energy Profile

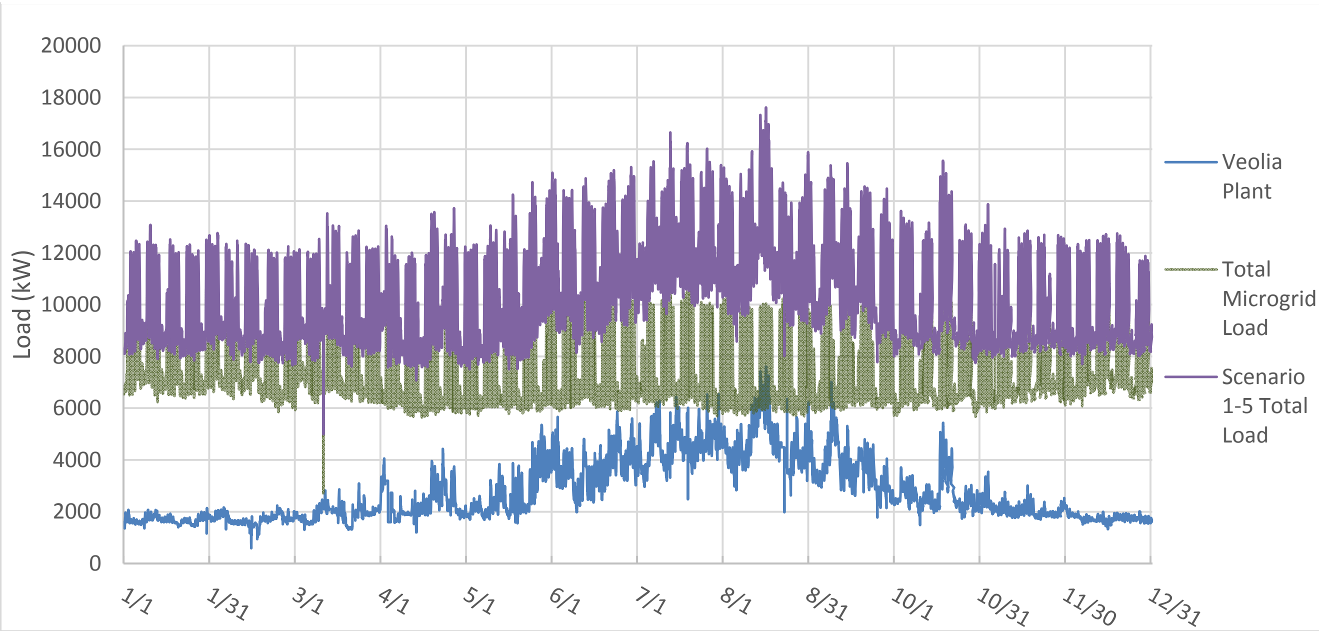


Table 23: Duration Curve

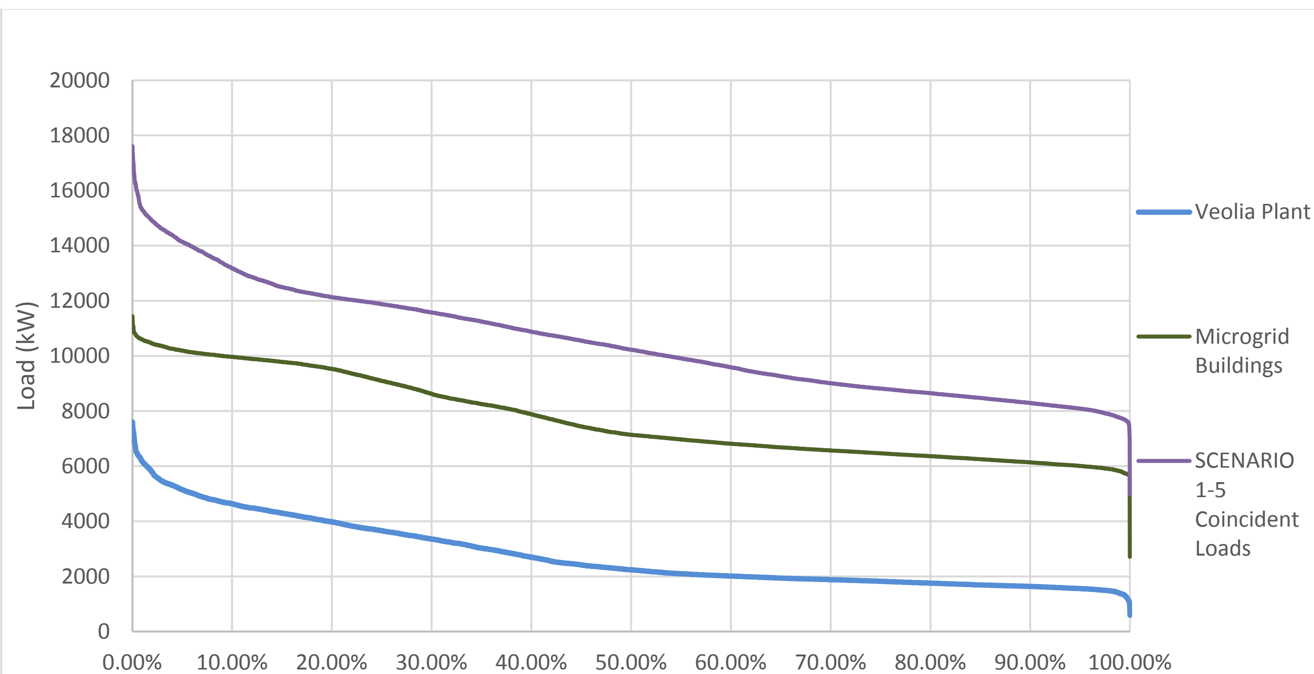


Table 24: Annual Electricity Spend

	Electricity						
Source:	8760 meter data & 2018 PSE&G Rates						
Utility:	PSE&G						
Component:	*Peak kW*	*kWh*		*$*		*$/kWh*	
State	2,212	13,683,465	$	1,226,790	$	0.090	
Justice	2,880	14,494,746	$	1,310,815	$	0.090	
L&I	1,515	8,889,812	$	919,496	$	0.103	
H&A	618	3,574,796	$	372,621	$	0.104	

7. GENERATING OPTIONS EVALUATION

The load profiles in the previous section show the effects of aggregated office loads in buildings on a thermal energy grid; no seasonal energy consumption variation and significant increase in loads corresponding with occupancy hours. For scenarios 1 and 1a, there's approximately 2MW difference between the peak and base loads. Additional financial analysis concludes that due to the sharp swings, and low wholesale prices for export, it is not financially optimal to export onto the wholesale market. Therefore, a baseloaded prime mover was explored.

7.1. Distributed Generating Scenarios Load 1 and 1a and 1b

In order to evaluate the various prime mover arrangements, a financial analysis was performed using modeling techniques defined in Section 4 to determine the optimal payback as well as the highest greenhouse gas reduction. Based on the electrical loads as well as the plant's thermal sendout to the district, the high heat output from the combustion turbine (as opposed to reciprocating engines) complements the output at the plant. Additionally, gas turbines perform better at high electrical output (>4 MW) are generally a better fit to meet high load application.

For this preliminary analysis, the financial analysis was based on known utility tariffs.

Table 25: Financial IRR - Scenario 1 and 1a

Scenario	Add baseloaded gas turbine ONLY (no duct firing)							
	Export	Prime Mover/Peak O	DF		CapEx	NPV	IRR	GHG %
H&A L&I	No**	Taurus 60: 5.7 MW	N		$ 15,625,194	($1,720,200)	7%	14%
			Y					
	No	Mercury: 5.0 MW	N		$ 13,014,578	($100,000)	8%	12%
			Y					
	Yes	Taurus 60: 6.4 MW	N		$ 17,547,534	($4,129,200)	5%	7%
			Y					
	Yes	Mercury: 5.0 MW	N		$ 13,845,355	($1,101,600)	7%	9%
			Y					
H&A L&I Justice	No	Taurus 60: 6.2MW	N		$ 19,623,669	$ 1,817,900	9%	16%
	No	Taurus 60: 6.2MW	Y		$ 19,730,000	$ 1,680,000	9%	18%
	No	Mercury: 5.0 MW	N		$ 16,373,880	$ 3,334,500	10%	13%
	No	Mercury: 5.0 MW	Y		$ 16,755,000	$ 2,884,400	10%	15%
	No**	Taurus 70: 8 MW	N		$ 23,351,078	($1,827,300)	7%	17%
	No**	Taurus 70: 8 MW	Y					
	Yes	Taurus 70: 9 MW	N		$ 26,652,042	($5,953,100)	5%	8%
	Yes	Taurus 70: 8 MW	Y		$ 26,030,000	($5,349,800)	5%	9%
Direct & State	No	Taurus 60: 6.4 MW	N		$ 24,967,952	$ 2,635,500	9%	16%
			Y					
	No	Mercury: 5.0 MW	N		$ 21,395,355	$ 3,663,200	10%	12%
			Y					
	No	Taurus 70: 8 MW	N		$ 30,127,069	($1,389,400)	7%	18%
			Y					
	Yes	Taurus 70: 8 MW	N		$ 31,602,042	($3,167,000)	7%	15%
			Y					
Microgrid (PSE&G Wires)	No	Taurus 60: 6.4 MW	N		$ 18,932,534	$ 18,107,200	18%	13%
			Y					
	No	Mercury: 5.0 MW	N		$ 15,230,355	$ 19,176,100	21%	9%
			Y					
	No	Taurus 70: 8 MW	N		$ 25,379,328	$ 14,420,900	14%	17%
			Y					
	No	2 Mercury's: 9.9 MW	N		$ 27,561,378	$ 13,055,500	13%	18%
			Y					
	No	2 Taurus 60's	N		$ 34,177,091	$ 5,392,400	10%	15%

The highlighted regions of the table highlight the best returns of Scenario 1 (H&A, L&I, and Justice) and Scenario 1a (Scenario 1 + Feeder to the Statehouse Complex) and Scenario 1B (Scenario 1 + Statehouse Island Option).

Once the high level unit pricing analysis was complete, a more granular financial analysis was performed with the following results. The below analysis does not reflect any confirmed pricing from Veolia TDEC but represents an analysis strictly from Tariffs.

Table 26: Financial Summary - Utility Analysis

Description	Phase 1	Phase 1a	Phase 1b
Net Capital ($ Million)*	$16,770,000	$6,660,000	$8,000,000
Return ($ Million)	$2,043,500	$437,700	$900,000
Simple Payback (Years)	8.2	15.0	11.1
CHP Capacity (MW)	5.7	5.7	8.1

Phase 1 includes CHP incentives.

7.1.1. *Connection to Existing Utilities – Phase 1*

7.1.1.1. PSE&G Electrical Connection

The existing 15.6MW bi-directional interconnection should be adequate to provide the entire load of Phase 1 and Phase 1A is needed. In this "behind the meter" application, the electrical infrastructure in the plant would have to supply the electrical load to the entire load of 4 buildings or 5, depending on the arrangement. Phase 1 peak is less than 12MW and Option 1A is less than 14 MW. PSE&G infrastructure, Feeder A-131, can accept approximately 20 MW, more than adequate for the load.

7.1.1.2. PSE&G Gas Connection

Based on a demand of 312 dekatherms/hour (about 2 times higher than needed), network analysis indicates that the pressure at the service inlet to TDEC could be expected to be in the range between 20 psi and 55 psi. The pressures vary depending on total system demand and temperature conditions. PSE&G can only guarantee 5 psi of delivery pressure at the service inlet and the customer should design accordingly. PSE&G's evaluation did not consider temperature conditions under which gas could be curtailed.

A Taurus 60 with duct-firing will have less demand than this. PSE&G's evaluation indicates that will only guarantee gas pressure at 5 psi. The Taurus 60 will require gas pressure around 230 psig. A 450 hp gas compressor skid will have to be installed to boost this.

7.1.1.3. Connection to the Hot Water Loop

The waste heat from the Taurus 60 would be recovered and connected to the existing high water loop. Within the Veolia plant, an existing heat exchanger connected to Hot Water Heater #1 would have to be replaced in order to connect to Veolia High Temp Hot Water. Replacing the existing Hot Water Heater #1, which is need of repair, the plant could install duct-firing on the back end.

7.1.1.4. Existing Plant Utilities

The system would utilize existing air, exhaust, lube oil, cooling systems at the facility.

7.1.2. *Blackstart, Islanding, and "Blue Sky" Operation*

7.1.2.1. "Blue-Sky" Operation

7.1.2.1.1. Power Import

A normal operation, the facility would operate as "behind the meter" installation with the existing interconnection being the "Point of Common Coupling" or PCC. When the Microgrid needs electricity from the PSE&G, power will flow through the existing 27 KV switchgear onsite, through the 27 and 5 KV infrastructure on the Veolia TDEC property to the four (4) end-users (Veolia TDEC, Justice, H&A/Tax, and L&I). This would also be the power flow while generation on site is in a planned outage for preventative maintenance.

7.1.2.1.2. Generating

The new prime mover would sync with the existing grid at the PCC mentioned above. The generator output would electrically load follow the aggregate loads of all end-users.

Generator controls would be installed to modulate the generator output and slight variations (over or under protection) would be buffered by the grid. For example, if the generator produces more electricity at the end of the day (when office workers go home) then is needed, the electrical grid could handle these slight variations.

7.1.2.2. Outage Conditions

7.1.2.2.1. Loss of Generator

In the event the prime movers at the plant were down for maintenance, the electricity from the PSE&G grid would continue to supply the Microgrid with electricity. There may be a flicker of lights but all critical loads should be protected. The Justice Complex is protected with UPS and back-up generators.

7.1.2.2.2. Loss of Fuel

If the natural gas supply to the plant is curtailed for any reason, the compressor and prime mover would shutdown. The plant has four (4) 25,000 gallon tanks of #2 fuel oil which would be used to maintain heat to the district hot water loop. Electricity would be provided by PSE&G grid. It's infeasible to store liquefy natural gas or rely on other fuel that requires trucks to ship them in. In the event of an emergency, there's no guarantee of availability from offsite sources.

7.1.2.2.3. Veolia Electrical Infrastructure Failure

If there is a failure with cabling, switchgear, or other infrastructure on any electrical distribution to the end-users, the Justice Building, L&I, H&A/Tax would all have Manual Transfer Switches back to PSE&G grid. In this "behind the meter" application, these buildings primary feed would be existing TDEC electrical infrastructure. Personnel, in coordination with PSE&G, would manual transfer power back to PSE&G service. The Justice Complex already has this infrastructure built in. L&I and H&A/Tax would have this equipment included as part of the work

7.1.2.2.4. Grid Outage

7.1.2.2.4.1. Less than 8 hours

If the event lasts under 8 hours, it is unlikely that any major restart of the system would occur in that time. The Microgrid may wait for power to be restored before restarting.

7.1.2.2.4.2. Greater than 8 hours

If the event lasts more than 8 hours, and PSE&G communicated with the Microgrid that an extended outage is expected, the microgrid would begin in islanded mode operation. The existing switchgear would be open at this point, either from Veolia TDEC or PSE&G.

1. The dual-fuel Cooper Bessemer Engine #2 would be started and provide the initial power to the plant needed to start the Taurus 60. Taurus 60 requires approximately 750 kW to start. Cooper Bessemer can reliably provide this amount for start-up.

2. Load Shedding would be coordinated via SCADA and BMS system, as well as personnel.

3. Taurus 60 would be brought online.

4. Gradually, per pre-determined priority loading, select loads be turned on gradually so as not to fluctuate the Turbine wildly. Pre-determined step loading, less than 10% at a time, would be detailed in a procedure and utilized via BMS/SCADA system.

5. Continue to operate in this manner, carefully monitoring loads and keeping all critical and emergency areas powered during the duration.

6. Once PSE&G confirms the grid is restored, the Microgrid and PSE&G will load shed again, only base load the prime mover, and reclose the breaker to sync with the PSE&G grid.

7. When the prime mover is synced with the grid, all loads will be brought back into service gradually as to not overload the generator.

7.1.3. *Connection to Existing Utilities – Phase 1B*

7.1.3.1. PSE&G Electrical Connection

The new CHP installation would effectively serve as a "behind the meter" application at the Statehouse itself. The CHP would have to be connected to the existing PSE&G switchgear on site. PSE&G has a 27KV connection that is fed from more than one location. Relay protections would be provided in most cases from backfeeding the PSE&G grid.

7.1.3.2. PSE&G Gas Connection

The PSE&G gas availability remains to be determined at this point. Using natural gas powered reciprocating engines at the statehouse will not require significant gas boosting. It seems likely that the natural gas is available.

7.1.3.3. Connection to the Hot Water Loop

The waste heat from the reciprocating engine would be used internally on the Statehouse campus to the extent that demand is there. Any excess heat generated from the engine would be rejected and/or reused in the district system.

7.1.3.4. Existing Plant Utilities

There is no existing heat rejection (cooling towers) or exhaust stacks at the Statehouse Campus that could be utilized. These new facilities would have to be constructed for this project.

7.1.4. *Blackstart, Islanding, and "Blue Sky" Operation*

7.1.4.1. "Blue-Sky" Operation

7.1.4.1.1. Power Import

A normal operation, the statehouse Microgrid would operate as a "behind the meter" installation with the existing OSE&G switchgear serving as the "Point of Common Coupling" or PCC. When the Microgrid needs electricity from the PSE&G, power will flow through the existing 27 KV switchgear onsite as it does now.

7.1.4.1.2. Generating

The new prime movers would sync with the existing grid at the PCC mentioned above. The generator output would electrically load follow the aggregate loads of all end-users. Generator controls would be installed to modulate the generator output to avoid any backfeeding to the system

7.1.4.2. Outage Conditions

7.1.4.2.1. Loss of Generator

In the event the prime movers at the Statehouse were down for maintenance, the electricity from the PSE&G grid would supply the complex.

7.1.4.2.2. Loss of Fuel

If the natural gas supply to the plant is curtailed for any reason, the compressor and prime mover would shutdown. It is not feasible to store significant fuels onsite as the complex is primarily a place of government business. Limiting the environmental risks is critical.

7.1.4.2.3. Grid Outage

7.1.4.2.3.1. Less than 8 hours

If the event lasts under 8 hours, it is unlikely that any major restart of the system would occur in that time. The statehouse back-up generators would come on and provide priority loads. The Microgrid may wait for power to be restored before restarting.

7.1.4.2.3.2. Greater than 8 hours

If the event lasts more than 8 hours, and PSE&G communicated with the Statehouse that an extended outage is expected, the Statehouse would begin islanded mode operation. The statehouse would be islanded from PSE&G.

1. The existing back-up generators would be used to provide parasitic loading for the CHP.
2. Load Shedding would be coordinated via SCADA and BMS system, as well as personnel.
3. The gas reciprocating engines would be brought online.

4. Gradually, per pre-determined priority loading, select loads be turned on gradually so as not to fluctuate the Turbine wildly. Pre-determined step loading, less than 10% at a time, would be detailed in a procedure and utilized via BMS/SCADA system.

5. Continue to operate in this manner, carefully monitoring loads and keeping all critical and emergency areas powered during the duration.

6. Once PSE&G confirms the grid is restored, the Statehouse and PSE&G will load shed again, only base load the prime mover, and reclose the breaker to sync with the PSE&G grid.

7. When the prime mover is synced with the grid, all loads will be brought back into service gradually as to not overload the generator.

7.2. Distributed Generating Scenarios Load (Phase) 2

To serve the broader microgrid (14 buildings) additional generating capacity would be added to meet the standby loads (approximately 50% of the microgrid loads), comply with additional objectives of this feasibility study, and provide a unique blend of solar storage dynamic response standby generators.

There is enough physical space for approximately 2MW of canopy solar to be installed in the parking lot of the H&A, L&I complex. To mitigate effects of shading and maximize the ability to integrate the solar with natural gas generation, approximately 2 MWh of solar with 1MW power converter would be provided. Additionally, 5 MW (2 x 2.5MW) of dynamic start, gas generators that can respond to varying loads during both blue sky and black sky events would be installed to boost the total generation capacity.

To estimate the costs and benefits, there is no existing tariff that can be used to estimate payback. The non-financial benefits are listed in the recommendations section. The connections to the existing facilities and the island mode operation would be similar to the method described above

7.3. Clarifications/Assumptions

In modeling the system, the following items were considered:

1. With single PCC, Veolia and state Loads are "behind the meter" of Veolia interconnect. State buildings are isolated from PSE&G via existing disconnects.
2. Electricity sold to state buildings at 10.5 cents per kWh (approx. market rate)
3. CHP electricity supplies directly state "behind the meter" microgrid loads first and excess load is exported at PJM rates. No Capacity rates included.
4. Thermal Grid remains integral to electric microgrid solution. CHP loses value if it can't fully cogenerate.

8. Capital Upgrades Systems and Siting

Phase 1 Upgrades within the plant:

8.1. Gas Turbine

The Gas Turbine preliminarily specified for this project is the Solar Taurus 60, Generator set package with dual fuel capability. The Solar Taurus 60 is a widely used, utility grade turbine with a favorable heat rate. See attached equipment specifications.

8.2. Gas Compressor

The Gas Turbine will be supplied with high pressure, natural gas from PSE&G. The plant has an existing, low pressure gas supply used for the existing combined heat and power engines. To provide the high pressure needed for the Gas Turbine, a new gas compression skid will be installed outside of the plant. The gas compression skid will be a 450 HP, Frick screw compressor with the necessary filtration skids. Please see attached equipment specification sheet.

8.3. Hot Water Heat Recovery

8.3.1. *Hot Water Heat Recovery*

To recover heat off the exhaust of the combustion turbine, a waste heat recovery system with duct-firing will be utilized.- Hot water forced recirculation water tube generators specifically designed for high temperature water generation and for full utilization of maximum outlet and return water temperature differentials will be specified for this installation.

The design will incorporate a counter flow of water and combustion gases to provide maximum efficiency and fuel cost savings. Factory packaging greatly reduces field labor costs and assures proper coordination of the generator and fuel-burning equipment. Tangent tube furnace-wall construction limits the use of potentially troublesome refractory in the furnace area. Double casing construction, with inner casing seal-welded gas-tight, prevents furnace gases from penetrating to the insulation and outer casing.

8.3.1.1. Hot Water Heat Recovery Specs

The following shall be included in scope:

CT Waste Heat
Interconnecting piping
Walkway and ladder system
Trim
Expansion Joint at Lamont inlet, outlet and economizer outlet
Duct Burner with fuel train, BMS, Scanner Blower Fans / Motor, Distribution Grid
Flue Gas Ducting from waste heat recovery to Economizer and Economizer to existing plant stack
Economizer with support steel
Combustion controls and field instruments

8.3.1.2. Diverter Valve

This diverter damper system will include the following scope of supply:

Diverter damper at Lamont inlet

Inlet and outlet expansion joints
Lamont inlet isolation guillotine damper
Economizer inlet isolation guillotine damper
Flue gas ducting

8.3.1.3. Fresh Air Firing

This fresh air firing system will include the following scope of supply:

Fresh air fan and motor
Fresh air dampers
Fresh air expansion joints
Fresh air ducting and mixing bussel

8.4. MEP SCOPE

8.4.1. *Demo/Removals*

Remove the existing 6 MW reciprocating engine as well as hot water heater #1.

8.4.2. *Install*

New Combustion Turbine will be installed in tandem with duct fired heat recovery boilers.

8.4.3. *New High Temp Hot Water Heater*

New Combustion Turbine will be installed with duct burning capabilities. New high temperature hot water heat recovery pumps to provide 125 MMBTU of recovered heat for the high temp loop. High temperature loop is between 400F Supply and 320 Return.

8.4.4. *Electrical Upgrades*

To connect each of the loads into the building, modifications will occur in each of the following building, Justice, H&A/Tax, L&I.
Additionally, new switchgear in the Veolia yard will receive power from the CHP and send to those building.

8.4.5. *Exhaust*

Combustion Turbine will be provided with duct fired, hot water heat recovery coils, duct burners, and SCR/NoX emissions before connecting to the existing plant stack. Exhaust will be connected to the existing stack. Exhaust duct will be provided with a bypass damper and will have fresh-air firing capabilities on the duct-burners.

8.4.6. *Combustion and Vent Air*

New combustion air fans and openings will be provided for the new prime movers.
New duct-fans will provide flow to fresh air fans.

8.4.7. *Natural Gas*

The existing natural gas service entering the plant on the southeast corner of the building will be upgraded to accommodate new gas compression skid located in the paved area to the northeast side of the plant.

8.4.8. *Dual Fuel*

New prime mover shall have duel fuel capabilities. Design shall require new distribution capabilities from existing fuel oil tanks to the new prime mover.

8.4.9. *BMS*

The new prime mover shall load follow the combined load served to Justice, H&A/Tax, L&I, and the Veolia plant.

8.4.10. *Chilled Water*

The new CT will have chilled water coils included per spec to increase efficiency during summer months. This chilled water coil will be supplied from the existing chilled water loop at the plant

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8.5. Civil and Structural

8.5.1. *Demo*

1. Existing 6MW reciprocating engine #1 to be removed as well as hot water heater.
2. Supporting Steel shall also be removed.

8.5.2. *CT and Hot Water Heater Support*

1. Platforms and structural support for the new combustion turbine.
2. Platforms around the new Hot Water Recovery and Duct Firing to provide operational access.

8.5.3. *Gas Compression*

1. Provide all modifications to the existing parking lot in order to support the gas compression skid.
2. Gas Compression skid to be located in the western corner of the parking lot.

8.5.4. *Fan Support*

1. New combustion air fans and openings to be provided for the new prime movers and to be supported from roof.

8.5.5. *Plant Auxiliaries*

1. New pumps and heat exchangers shall be included and will require new concrete housekeeping pads.

8.5.6. *Electrical*

2. New switchgear to be located outside will require new concrete pad in the yard. New underground cables/conduits within the yard shall be provided. These underground cable/conduits shall span underneath the driveway.

8.6. Exhaust System

A critical component of the installation of new prime movers is determining how the air is going to be handled.

8.6.1. *Existing System*

The existing plant has one main plant stack which serves the entire plant. The stack is 164 ft. in height, 6'6" ID, and gunnite lined at exit. The Stack has 1 10 ft. OD at the base. The breaching inlet is 8ft high by 6 ft. wide. The stack receives three (3) exhausts inputs. Two (2) of the exhaust inputs are from each of the reciprocating engines. The third input is a start-up exhaust that bypasses the hot water heaters downstream of the engine that was designed for use only to start the engine. Per plant history, the burner 1 had to be on for Engine 1 to start. Engine 1 is abandoned. Burner 2 did not have to be on however currently, burner 2 does need to be on for engine 2 to operate. There is also a Flue Gas Recirculation system on each exhaust line.

8.6.2. *Exhaust Comparisons*

To determine if a gas turbine can be tied into the existing stack, existing engine outputs were compared with a variety of prime movers. The below table shows the comparison of the engine exhausts.

Table 27: Prime Mover Comparison

Description	Taurus 60	Existing Engine 1	Existing Engine 2	Existing Plant Totals
Output Power Kw	5,670	6000	6000	12000
Full Load Amps @ .8PF	983	1041	1041	2082
Horse Power	7,700	8,384	8,384	16768
C\A Inlet Flow CFM	18,735	28,000	28,000	56,000
Heat Rate (Btu\Kw) LHV	10,830	9,235	9,235	9,235
Exhaust Flow (lbs.\hr.)	172,810	90,000	90,000	180,000

Exhaust Temp. Deg. F	950	950	950	

8.6.3. *New Stack Requirements*

It appears that the existing stack is most likely capable of supporting either two (2) reciprocating engines of comparable size or one (1) new gas turbine. Per go by drawings submitted by vendors, they have provided stacks with ID of 6'-6". For the plant to operate either two (2) gas turbines or one (1) gas turbine and one (1) reciprocating engine, a new stack would have to be constructed.

The new stack would have to be sized per Good Engineering Practice (GEP) stack analysis as determined by the EPA's stack height regulations as specified by the 40 Code of Federal Regulation (CFR) 51 of the EPA by could potentially be as tall as the existing stack or greater. Because the overall plant's combines thermal input would be greater than 65 MMBTU and ineligible for a general permit. Currently the plant has a Title V permit which would have to be modified to include the new stack. GEP stack analysis typically requires that the stack be at least 212 feet high.

8.6.4. *Operability*

For any gas turbine arrangement, the operational flexibility to provide diverter valves and fresh air firing would have to be considered as well. The diverter valve would allow the gas turbine to fire without the downstream heat recovery in the event that repairs to those systems needed to occur. Fresh air firing would bring in additional outside air on a separate train from the combustion turbine to allow for duct-firing to occur when the gas turbine is isolated from exhaust ducting due to repair.

9. FINANCIAL SUMMARY

9.1. Total Capital – Opinion of Cost

The phases previously outline can be summarized in the following table. A more detailed breakdown is included below.

Phase	Phase 1
Phase 1	**$19,700,000**
Option 1A	**$6,600,000**
Option 1B	**$10,000,000**
Phase 2	**$23,900,000**
Total	**$60,200,000**

In this preliminary feasibility stage, these opinions of cost are not official estimates based on a complete construction set. Estimates may vary between 20-50% based on the final design.

9.1.1. *Total Capital – Phase 1*

Based on the scope of work listed above, the following opinions of costs were compiled for Phase 1 of the project.

Table 28: Opinion of Capital Costs Phase 1

Item	Category	Description	Qty	Unit	Cost	Total
001	Equipment	Taurus 60	1	Ea	$3,969,600	$3,969,600
002	Equipment	Gas Compressor Skid	1	Ea	$850,000	$850,000
003	Equipment	Gas Compressor Skid Enclosure	324	sq.ft	$400	$129,600
004	Equipment	HTHWR -	1	Ea	$500,000	$500,000
005	Equipment	HTHWR - w/ SCR	1	Ea	$600,000	$600,000
006	Equipment	HTHWR - W/ Duct Firing	1	Ea	$500,000	$500,000
007	Plumbing	Plumbing - Veolia	1	Ea	$500,000	$500,000
008	Mechanical	Mechanical - Veolia	1	Ea	$900,000	$900,000
009	Electrical	Electrical - Veolia	1	EA	$500,000	$500,000
010	Electrical	Justice (Penthouse modifications)	1	EA	$900,000	$900,000
011	Electrical	Electrical - Justice (P-1 Level modifications)	1	EA	$1,400,000	$1,400,000
012	Electrical	L&I Modifications to connect	1	EA	$600,000	$600,000
013	Electrical	H&A Modifications to connect	1	EA	$100,000	$100,000
014	Controls/ SCADA	Meter and Load Shedding Panel at each building	4	Ea	$ 100,000	$ 400,000

015	Controls/ Programming	Programming Load Shedding Priority and blackstart dispatch	1	EA	$ 200,000	$ 200,000
016	Controls/ Programming	Programming Load Shedding Priority and blackstart dispatch	1	EA	$ 200,000	$ 200,000
017	Demo	Veolia Removals of existing equipment	1	EA	$ 300,000	$ 300,000
018	Rigging	Rigging	1	EA	$ 240,000	$ 240,000
019	Structural/Civil	Structural/Civil	1	EA	$1,400,000	$1,400,000
Subtotal						**$14,189,200**
020		Engineering	12	%	$1,702,704	$1,702,704
021		Project Management + GC	10	%	$1,418,920	$1,418,920
022		Commissioning	2	%	$283,784	$283,784
023		Permit	0.2	%	$28,378	$28,378
024		Contingency	15	%	$2,128,380	$2,128,380
Total						**$19,751,366**
Price/KW		Installed MW	5.7			$3,465.15

9.1.2. *Total Capital – Phase 1a*

Table 29: Opinion of Capital Costs - Phase 1A

Items	**Category**	**Description**	Qty	Unit	Cost	Total
001	Electrical	Statehouse Internal Modifications	1	Ea	$1,400,000	$1,400,000
002	Electrical	Excavating and Underground routing of to power Statehouse	2000	LF	$1,500	$3,000,000
003	Controls/ SCADA	Pulling Fiber Optic through Statehouse	500	LF	$100	$50,000
004	Controls/ SCADA	Meter and Load Shedding Panel at each building	1	Ea	$100,000	$100,000
005	Controls/ Programming	Programming Load Shedding Priority and blackstart dispatch	1	EA	$200,000	$150,000
Subtotal						**$4,700,000**
010		Engineering	12	%	$564,000	$564,000
011		Project Management + GC	10	%	$470,000	$470,000
012		Commissioning	2	%	$94,000	$94,000
013		Permit	0.2	%	$9,400	$9,400
014		Contingency	15	%	$705,000	$705,000
Total						**$6,542,400**

9.1.3. *Total Capital – Phase 2*

Table 30: Opinion of Capital Costs - Phase 2

Items	**Category**	**Description**	Qty	Unit	Cost	Total

007	Equipment	CAT-(2.5MW)	2	EA	$ 1,500,000	$ 3,000,000
010	Equipment	Solar Panels (installed in Parking Lot by L&I)	2	MW	3,300,000	$ 6,600,000
011	Equipment	Battery Storage (assume Inverter rated for 2 hour discharge)	2	MWh	1,200,000	$ 2,400,000
012	Equipment	Battery Equipment Enclosure	2,000	Sq. Ft.	400	$ 800,000
013	Plumbing	Plumbing - Veolia	1	Ea	$200,000	$ 200,000
014	Mechanical	Mechanical - Veolia	1	Ea	$500,000	$ 500,000
015	Electrical	Electrical - Veolia	1	EA	$200,000	$ 200,000
023	Controls/ SCADA	Pulling Fiber Optic through existing chilled water	8300	LF	$100	$ 830,000
024	Controls/ SCADA	Meter and Load Shedding Panel at each building	11	Ea	$ 100,000	$1,100,000
025	Controls/Programming	Programming Load Shedding Priority and blackstart dispatch	1	EA	$200,000	$200,000
027		Veolia Removals of existing equipment	1	EA	$300,000	$300,000
028		Rigging	1	EA	$50,000	$50,000
029		Structural	1	EA	$800,000	$800,000
Subtotal						**$ 16,980,000**
011		Engineering	12	%	$ 2,037,600	$ 2,037,600
012		Project Management + GC	10	%	$1,698,000	$ 1,698,000
013		Commissioning	2	%	$339,600	$ 339,600
014		Permit	0.2	%	$ 33,960	$33,960
015		Contingency	15	%	$ 2,547,000	$2 ,547,000
Total						**$23,636,160**

9.2. Detailed Cashflow Schedule

The cashflow for the above scenarios is based on approximately 3 year schedule, with preliminary engineering and design work beginning in Q1 of 2019. The below cashflow represents Phase 1. Phase 1A and Phase 2 cashflows would require additional discussion with utilities and the State of New Jersey before they can be accurately depicted.

9.2.1. *Cashflow – Phase 1*

VEOLIA

Trenton Microgrid

Task	Year	Estimate 2018	2019	2020	2021	2022	Comment	Deliverable
		$ 175,000	$ 5,150,000	$ 6,950,000	$ 5,565,000	$ 1,784,000		
1	2018	$ 175,000					Estimate for 2018 spending as part of the NJ BPU Grant	Initiated the study and report to the NJBPU
2	2019		$ 300,000				Estimate for 2019 new spending. Accomplished by May 1, 2019	Follows up on package as part of the 2018 study commissioned by NJ BPU. Deliverable will codify the base case estimate, specify early release packages (demo, power island, HRB, compressor, SG. As well as IFP documents for client review.
3	2019		$ 450,000				Estimate for 2019 new spending. Accomplished by December 31, 2019	Follows up on task 1, and progresses the design to 30%, sufficient for the decision to go EPC or plan / spec. Tasks include preliminary permitting and integration of early packages into final design.
4	2020			$ 1,450,000			Estimate for 2020 new spending. Accomplished by December 31, 2020	Follows up on task 1 and 2, and progresses the design to IFC assuming a plan and spec path is taken. This will include the bulk of final design, early package integration, permitting and Construction Administration (CA) activities. Estimate project completed in the mid Q3 / Q4 2020 time frame.
5	2019		$ 820,000				Estimate 10% for Equipment Purchase (One CTG & HRSB) @$8.5MM	Payment necessary for shop drawings and to get us in the fabrication queue.
6	2019		$ 2,460,000				Estimate 30% for Equipment Purchase ((One CTG & HRSB) @$8.5MM Progress payments	Payment necessary for progress payments in 2019.
7	2020			$ 4,100,000			Estimate 50% for Equipment Purchase ((One CTG & HRSB) @$8.5MM Progress payments in 2020	Payment necessary for progress payments in 2020.
8	2021				$ 820,000		Estimate 10% for Equipment Purchase ((One CTG & HRSB) @$8.5MM Progress payments in 2021	Payment necessary for final payments in 2021

Trenton Microgrid

Task	Year	Estimate 2018	2019	2020	2021	2022	Comment	Deliverable
		$ 175,000	$ 5,150,000	$ 6,950,000	$ 5,565,000	$ 1,784,000		
9	2019		$ 130,000				Estimate 10% for Equipment Purchase (Compressor) @ 1.3MM	Payment necessary for shop drawings and to get us in the fabrication queue.
10	2019		$ 390,000				Estimate 30% for Equipment Purchase (Compressor) @$1.3MM Progress payments	Payment necessary for progress payments in 2019
11	2020			$ 650,000			Remaining 50% for Equipment Purchase (Compressor) @$1.3MM Progress payments in 2020	Payment necessary for progress payments in 2020
12	2021				$ 130,000		Remaining 10% for Equipment Purchase (Compressor) @$1.3MM Progress payments in 2021	Payment necessary for progress payments in 2021
13	2019		$ 150,000				Estimate 10% for Equipment Purchase (Switchgear and long lead time electrical) @$1.5MM	Payment necessary for shop drawings and to get us in the fabrication queue
14	2019		$ 450,000				Estimate 30% for Equipment Progress Payments (Switchgear and long lead time electrical) @$1.5MM	Payment necessary for progress payments in 2019.
15	2020			$ 750,000			Estimate 50% for Equipment Progress Payments (Switchgear and long lead time electrical) @$1.5MM	Payment necessary for progress payments in 2020.
16	2021				$ 150,000		Remaining 10% for Equipment Purchase (Switchgear and long lead time electrical) @$1.5MM	Payment necessary for final payments in 2021.
17	2021				$ 4,465,000		Balance of Plant Project at $20MM	Includes BOP Equipment, Contractors, commissioning.
18	2022					$ 1,784,000	10% Retainage for Closeout and Commissioning	Includes BOP Equipment, Contractors, commissioning.

9.3. Financing Options

There are a variety of ways the state could fund this project, each method has its cost and benefits, and depend largely on available capital funds.

9.3.1. *Microgrid as Service/PPA*

In order to limit capital exposure and outsource significant operational risk, a traditional Microgrid as service and/or PPA arrangement would be provided. A 3rd party provider would arrange to finance and operate the Microgrid under a long term service agreement. The state would have to be willing to enter an agreement, anywhere from 10-20 years, that outlines cost, availability and other service conditions. Given the relatively low cost of electricity that the state pays now, it may not be feasible for the state to pay no capital and receive market or below market rates for commodities.

9.3.2. *State Issued Bonds with and Operations & Maintenance Agreement*

A traditional method for raising capital, the state could raise the capital via debt on the market. Bonds would be backed by the energy savings, capital equipment itself, or larger general obligation guarantees. The state could then operate the plant itself or contract with a 3rd party to operate and maintain the plant.

9.3.3. *Capital Costs out of State Budget*

Depending on the state budgets for that year, the state could opt to finance the capital with cash. The state could also opt to operate and maintain the equipment itself.

9.3.4. *Incentives*

Numerous government incentives could be offered to help finance the project. Refer to section 5.2 for a list of potential eligibility.

10. PSE&G

10.1. Ongoing Smart Grid Programs

As part of the ongoing Smart Grid program, PSE&G is installing SCADA to open and close network protectors on the East and West Trenton Network. The majority of the buildings (40-50 per PSE&G meeting notes) on the network have had this upgrade installed; however it may not be fully functional or commissioned, depending on the building. This allows PSE&G to remotely bring users on and off the system remotely and could facilitate implementation of Microgrid 2. PSE&G estimates $100,000 to complete additional buildings.

10.2. SCADA and Communications Description

Currently, there is no existing SCADA implemented between Veolia and PSE&G at the Point of Common Coupling. To properly restore generating ability to Veolia, PSE&G would require remote transfer trip capabilities at the main switchgear. Currently, the Veolia TDEC has the ability to trip the switchgear, and this would have to be integrated with PSE&G smart grid communications that are installed. To implement Phase 2, remote transfer trip capabilities would have to be installed at the Monument Breaker Station as well. Currently the transfer is manual. This would be integrated with the PSE&G smart grid that is being installed.

For any future communications, Veolia TDEC has a spare conduit in its chilled water loop that can be used to route communications/fiber cable. Currently, the Veolia plant has a Honeywell control system that is integrated at Justice Complex, H&A, L&I, and the Tax Building. The conduit is available to route more fiber to truly integrate a SCADA system or interface with PSE&G smart gird.

At the Justice Complex, the existing PSE&G switchgear is capable of having motorized switches that could be integrated into a Controls System. The switchgear has two redundant switchgear and the building/load side of it can be retrofitted to allow for remote switching of the switchgear.

As part of this project, remote transfer between Veolia network and PSE&G network at each building would be installed to ensure reliability.

10.3. Remaining Items – Ongoing Discussions

10.3.1. *Electrical/Microgrid*

1. Additional discussions with PSE&G will occur to discuss a Microgrid tariff or standby fee.
2. For Option 1A – providing an independent feed from L&I to the Statehouse. Need further clarification on PSE&G stance.
3. Use of feeder A-131 for the Microgrid. Can we isolate this section of the grid?
4. Respond to the following inquiries below (sent out on March 19, 2018)
    a. Please confirm that Veolia imports on the HTS tariff.

b. There doesn't currently appear to be a net metering tariff for High Tension Service but is that something that PSE&G would and/or is considering. This would be considered under an actual or virtual arrangement for the government buildings included in the downtown list. Net meter would be import of electricity to the government buildings vs export from Veolia plant onto the electrical grid.

c. For buildings to be powered from Monument breaker on the spot network in downtown Trenton, how would PSE&G typically account for these upgrade costs (amortization overall rate payers, etc.)? Are there any capital projects occurring on the spot network, 27KV A-131 feeders, Monument breaker station, or other nearby infrastructure that would coincide with this work?

d. Are the recurring costs that are avoided for PSE&G/rate payers by having a localized generation on the 27KV network feeding the local network under normal operation? For instance, directly powering Justice, Veolia, and Statehouse on A-131 would potentially reduce the kW flowing through wires. Does PSE&G factor O&M costs or depreciating assets based on usage? Would a proposed microgrid offset additional capital/operations costs by having less current flow through Monument breaker station?

e. If the existing CHP facility chooses to export incidental power will it be eligible for compensation under the existing PSE&G PEP Tariff? Will this require an application or system analysis. (FYI under PEP the CHP is compensated at average LMP for export)?

f. Can the existing CHP be qualified as a PJM Interconnection and what would be the process and cost? (there are many advantages among which is that exported power is compensated at actual LMP making it cost effective to export into the grid when LMP is high enough to exceed spark spread plus value of thermal. This could justify behind the meter CHP upgrades with significant hours of operation.

10.3.2. *Gas*

1. Need to confirm gas availability for Statehouse CHP.

11. SCHEDULE AND PERMITTING

11.1. PERMITS & Agreements

11.1.1. Environmental Permitting

Update existing Title V agreements with the State of New Jersey DEP. This process can up to 12 months or longer. The existing site has a Title V permit which is consistently being attended to so there may be some improvement on this time.

Additionally, a preliminary review of the sites Title V reveals some treatment of exhaust will be required. This would be through Selective Catalytic Reduction (SCR) with ammonia. The site currently does not have that installed so this may take some time for approval.

11.1.2. PSE&G Gas –

To turn on the gas, official approval of the load and final signoff is required. Initial approval will be 3-6 months. Final Signoff will occur once construction is complete and equipment is ready to be turned on.

11.1.3. PSE&G Electrical

The existing PURPA agreement is most likely no longer applicable for this microgrid. A new, interconnection agreement would have to be established between PSE&G and the Microgrid. The interconnection agreement would have to clarify the terms, capacity, cost, availability, among other terms between the Microgrid and the utility. Finalizing the interconnection agreement can take up 12-18 months.

11.2. Schedule

Anticipated Timeframe of the Total Project

Item	Description	Duration	Year
1	30 % Design and Preliminary Agreements with major stakeholders	6-12 months	0
2	Complete Design, ready for construction. Obtain all permits and necessary approvals for construction	6 months	1
3	Complete the buyout of equipment and contractors	6 months	1
4	Perform construction.	12 months	2
5	Commissioning, Testing, and Closeout	3-6 months	3
Total		33-42 months	~3 years

11.3. Codes

11.3.1. *General Site Codes*

- ASME American Society of Mechanical Engineers
- AGA American Gas Association
- AISC American Institute of Steel Construction
- AISI American Iron and Steel Institute
- ASTM American Society of Testing and Materials
- ANSI American National Standards Institute
- AWS American Welding Society
- FM Factory Mutual Recommendations
- IEEE Institute of Electrical and Electronics Engineers
- ISA Instrumentation, Systems and Automation Society
- NEC National Electric Code
- NEMA National Electrical Manufacturers Association
- NFPA National Fire Protection Association
- OSHA Occupational Safety and Health Administration
- UL Underwriters Laboratory
- 2018 International Building Code (International Code Council)
- 2018 International Mechanical Code (International Code Council)

12. RECOMMENDATIONS

12.1. General

The results of this feasibility study show that a creation of the microgrid should be pursued to meet the objectives of the NJ BPU, the Department of Treasury for the State of New Jersey, and Veolia. There is existing electrical distribution infrastructure from both PSE&G and Veolia to create a Downtown Trenton Microgrid. There are existing regulations which make Phase 1 possible to create and further discussions and tariff discussions and/or incentives would have to be developed to implement Phase 2.

The benefits of such a microgrid for each stakeholder are listed below:

BPU

Objective: Improve Energy Infrastructure Resiliency & Emergency Preparedness and Response
Trenton Microgrid would provide 10.7 MW of Standby Power in the event of grid wide outage for 14 buildings

Objective: Expand In-State Electricity Resources
Trenton Microgrid would provide addition 12.7MW of generating capacity

Objective: Promote Cost Effective Conservation and Energy Efficiency
Trenton Microgrid reduces in greenhouse gas emissions by 11,200 Metric Tons annually

Objective: Support the Development of Innovative Energy Technologies
Trenton Microgrid provides a combination of battery storage, solar technology, and reciprocating engines.

New Jersey State Treasury

Objective: Improve Reliability for Thermal Production and Delivery
Trenton Microgrid would replace aging hot water heaters with new, duct-fired burners and waste heat recovery.

Objective: Efficient Sources of Energy
Trenton Microgrid would provide new, high efficiency equipment as well renewable energy assets.

Veolia

Objective: Increase Asset Utilization
Trenton Microgrid would replace and/or utilize existing infrastructure that currently supports retired or existing assets.

Objective: Expand additional Energy Services

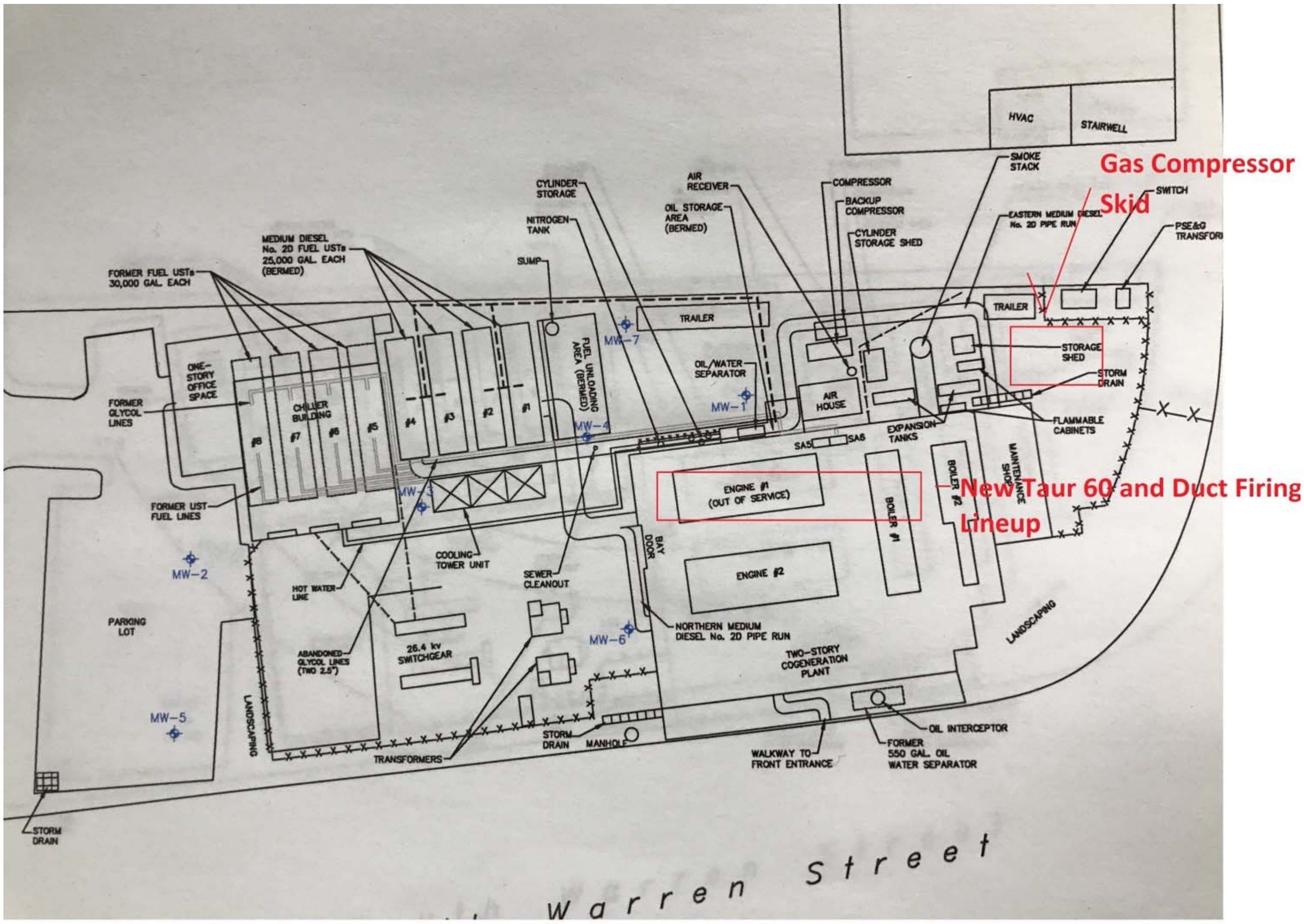
Trenton Microgrid would allow Veolia to expand its existing utility services.

12.2. Societal Benefits Charge

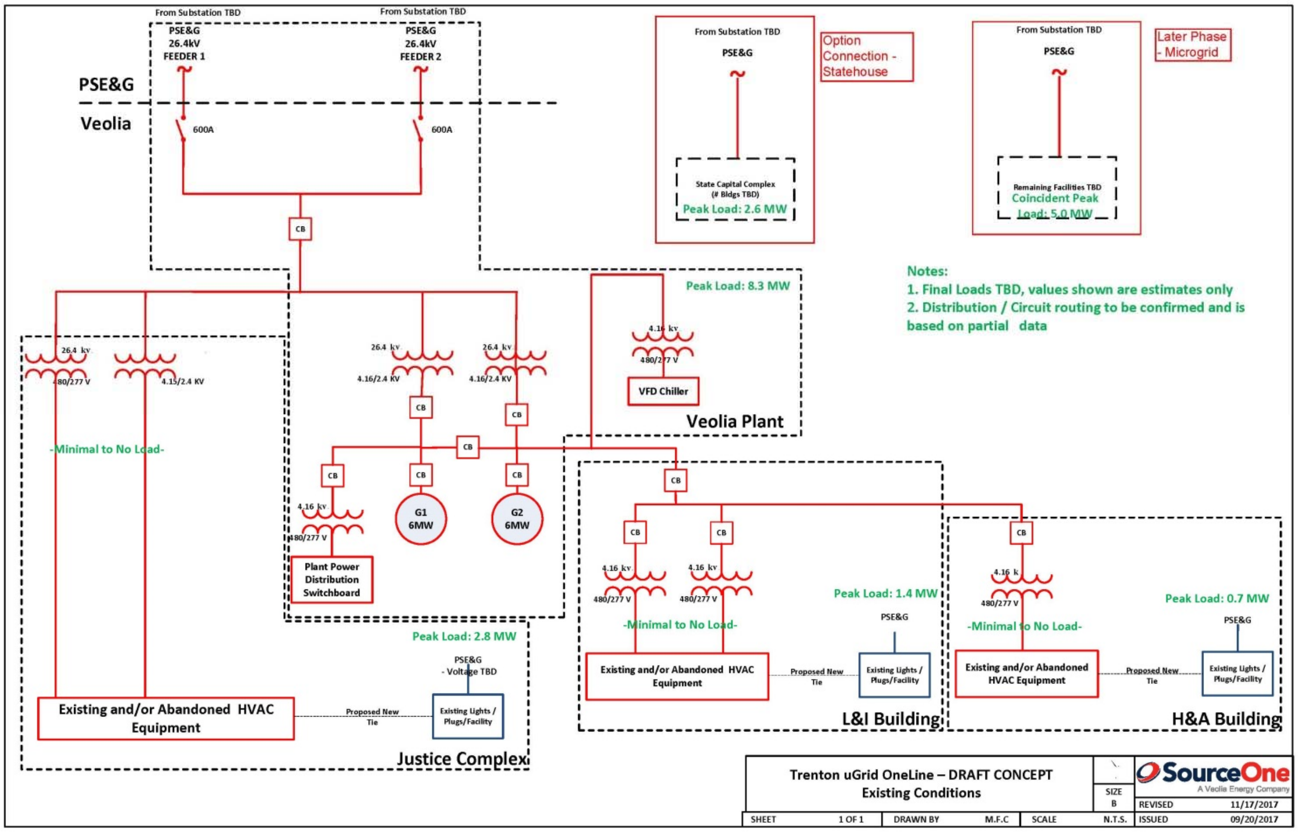
Under guidelines set forth by the N.J.S.A. 48:3-60(a)(3), this microgrid project is consistent with the use of the Societal Benefits Charge. The social benefits charge supports investment in energy efficiency and “Class 1” renewable energy, which is consistent with the additional DER and energy efficiency initiatives included the microgrid feasibility study. Class 1 assets include the solar photovoltaics panels as well as the energy efficient generation installed at the plant. Energy efficiency measures at the Veolia plant will include the installation of new, energy efficient CHP infrastructure.

13. Attachments

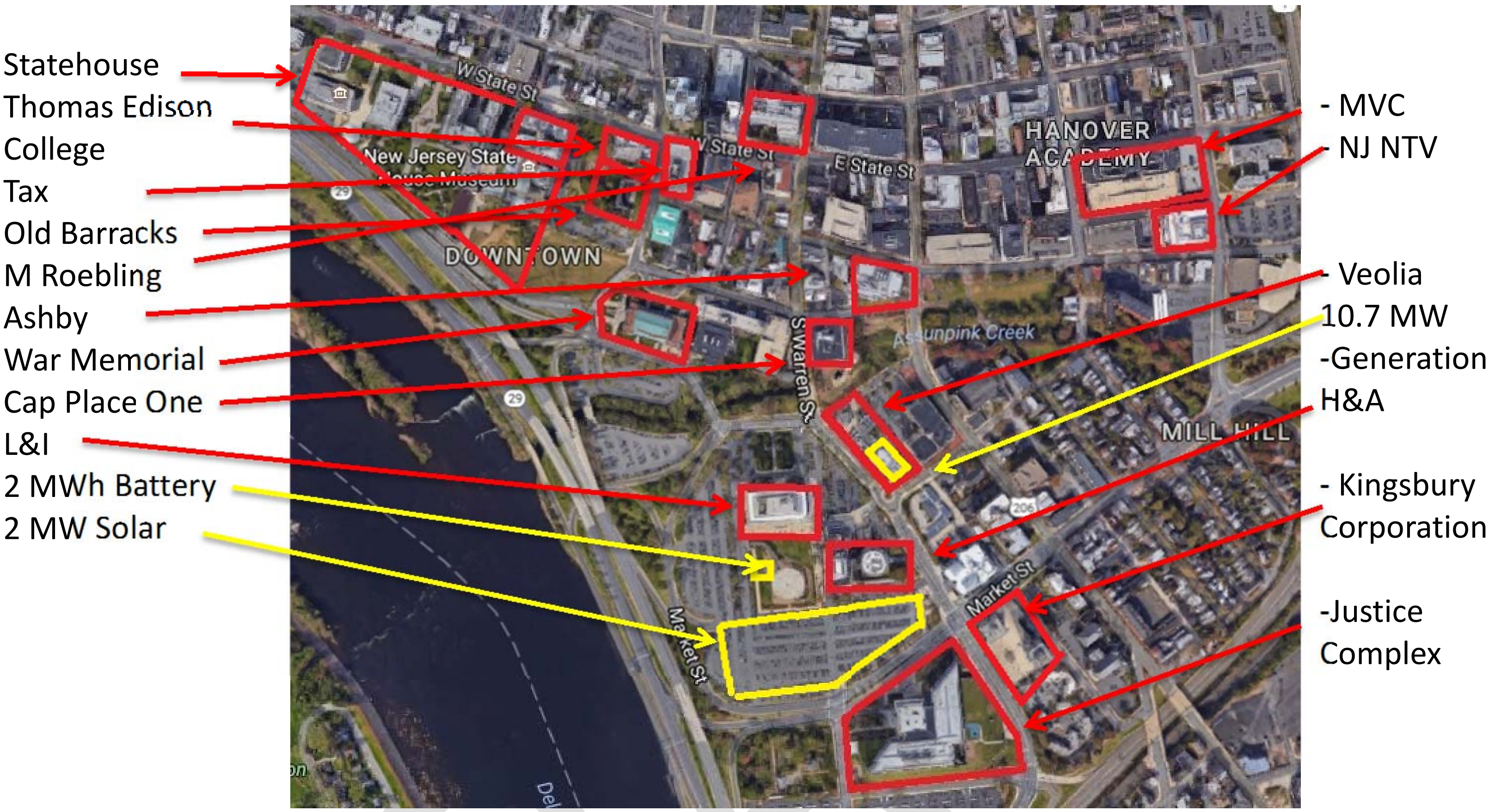
13.1. Site Plan



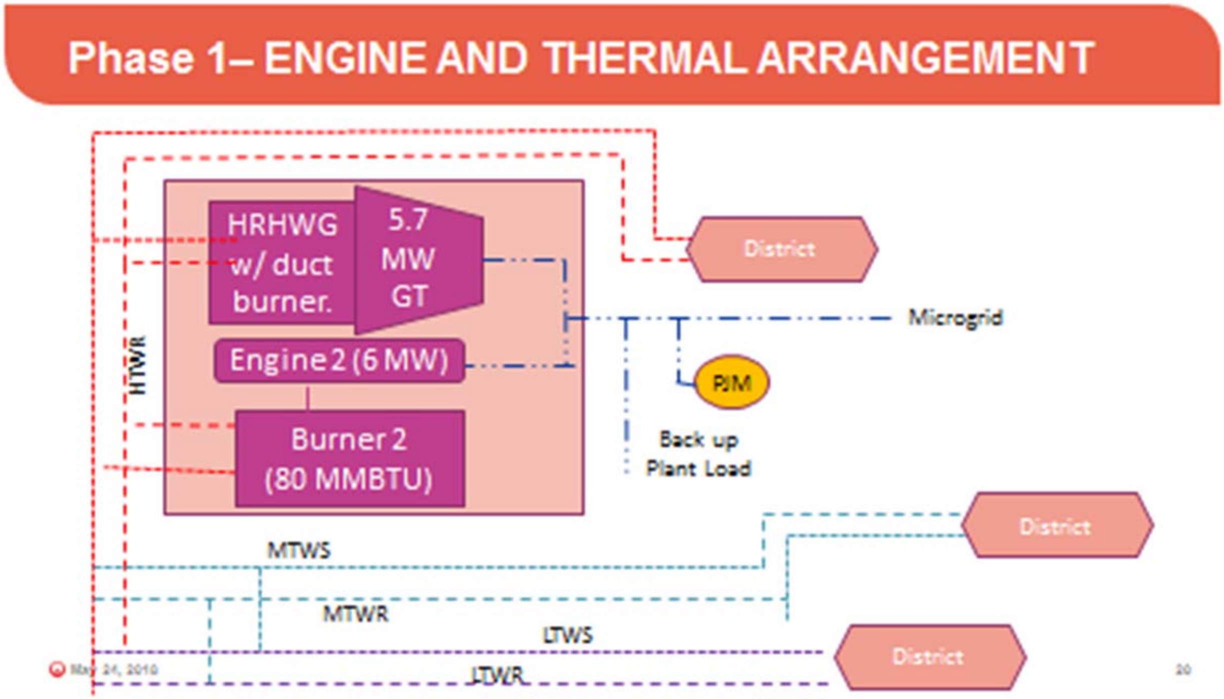
13.2. Electrical Interconnection Concepts



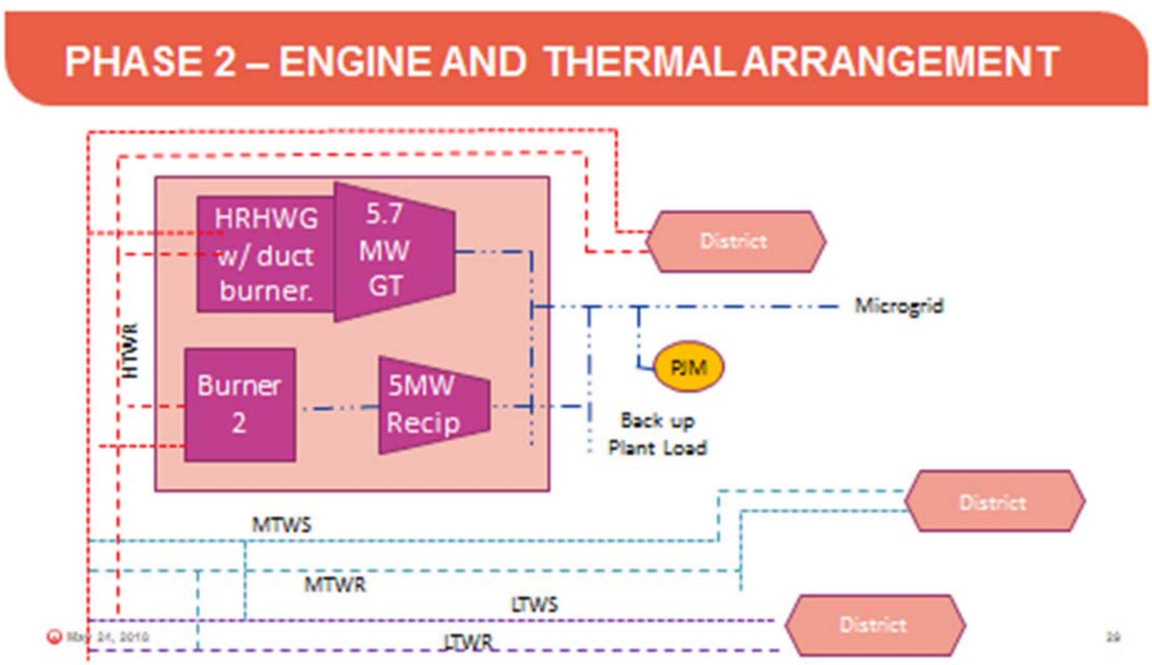
13.3. Microgrid Map



13.4. Phase 1 and 1A-TDEC Internal Configuration



13.5. Phase 2-Veolia Internal Configuration



13.6. Equipment Cut Sheets

1. Gas Turbine
2. Reciprocating Engine
3. Gas Compressor Skid
4. Hot Water Heat Recovery Unit – Waste Heat Only

Taurus 60-7901S Generator Set Package Features

Gas Turbine:

One shaft turbine, designed for industrial use
Axial compressor design
Annular type combustor employing dry, low NOx technology (15 ppm NOx @15%O2)

Basic Options:

Fully enclosed, generator set package requiring 460V, 3-phase, 60 Hz AC power
Rated Class I, Div II, Groups C,D per NEC
120V, 1-phase, 50/60 Hz internal lighting and heater power
Gas turbine engine in upward oriented air inlet and axially oriented exhaust outlet
1800 rpm; 60 Hz
Continuous Duty, Open Drip Proof Medium voltage generator featuring Class F insulation, B rise

Included Package Features:

Direct AC start motor system
Duplex lube oil filter system
Allen-Bradley based Turbotronics control system including:

- Ethernet network interface
- Touch Screen display with Engine Performance map
- Software for heat recovery interface (without diverter valve control)
- Software for CO2 system "lock out" (maintenance access to enclosure)
- Backup Safety Shutdown System
- kW Control
- kVAR/Power Factor Control

Included Factory Testing/Customer Witness/Quality Control Documentation:

Standard package static testing
Factory vibration testing
Factory emissions testing per Solar's ES 9-97
Observation on "Non-Interference" basis
Quality Control documentation (Level 1)

Field-installed Ancillary Equipment (excludes ducting):

Updraft air inlet filter
Engine air inlet silencer
Exhaust bellows (interface to waste heat recovery equipment)
Elbow type enclosure inlet/exhaust ventilation system with silencer

Included "Off-Skid" Components/Systems:

Remote desktop PC/monitor and Printer/Logger
Gas fuel flow meter (for Gas-only and Dual Fuel configurations)
AC motor-driven Liquid Fuel boost pump skid (for Liquid Fuel configurations)
3-micron duplex filter/coalescer with auto drain (for Liquid Fuel configurations)
CO2 system cabinet
Air/Oil lube oil cooler
VRLA Batteries with 120V DC charging system (back-up post lube)
Portable engine cleaning cart

Miscellaneous

Short-term preservation for shipment
Four (4) paper copies of Solar's Instruction, Operation and Maintenance manuals
Four (4) CD-ROM copies of Solar's Instruction, Operation and Maintenance manuals
UV Light and Gas Sensor test kit
Internal equipment handling system

Cogeneration Plant Estimated Performance Summary

Customer Name

Solar Turbines Incorporated

January 19, 2018

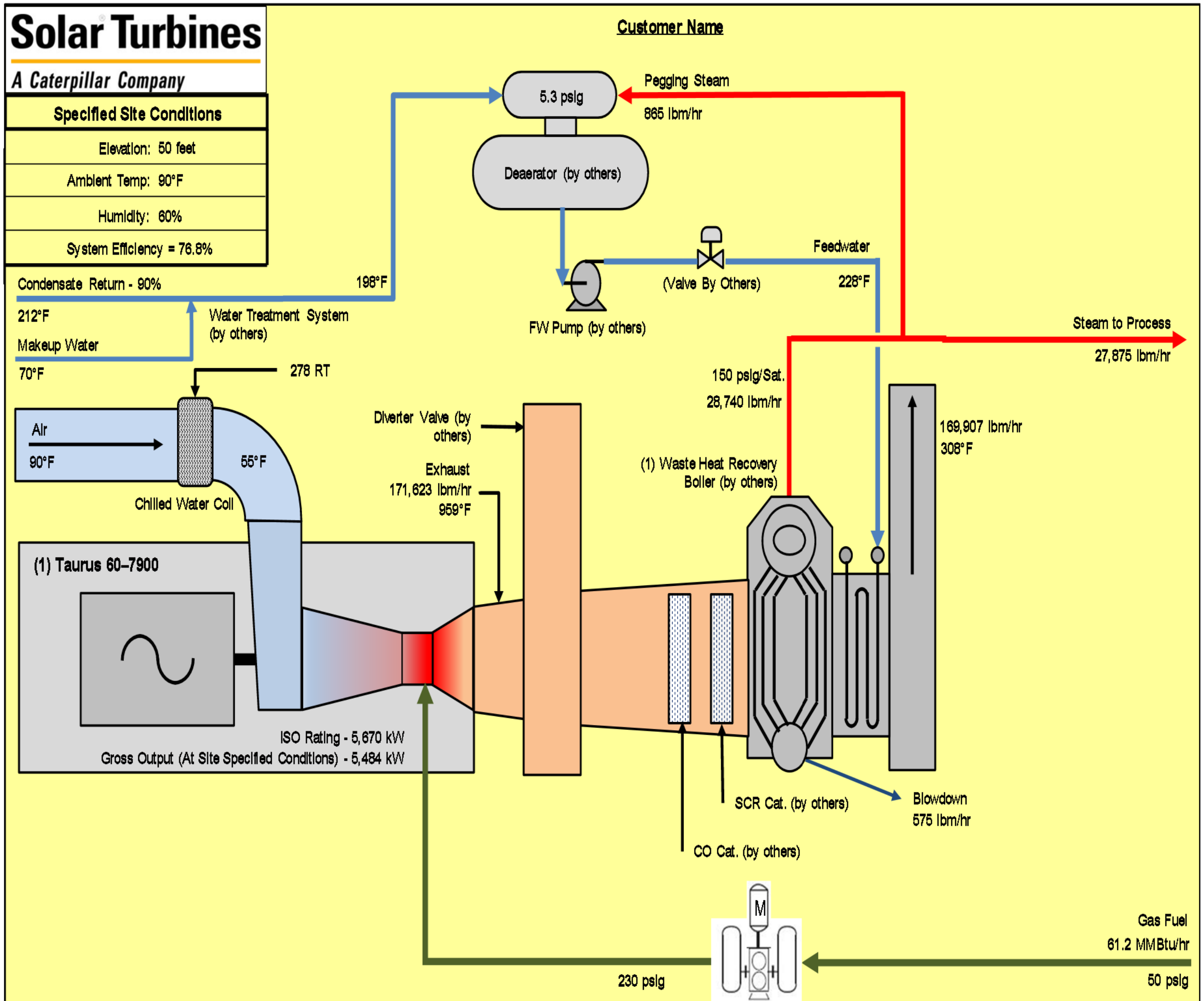
Performance listed below is estimated, not guaranteed.

Gas Turbine:		
KW Gross Output @ ISO Conditions:	5,670	kW
Site Ambient Temperature for Performance Analysis:	90	°F
Site Elevation for Performance Analysis:	50	feet
Site Ambient Relative Humidity for Performance Analysis:	60	%
Turbine Inlet Pressure Loss:	5.0	"H2O
Turbine Outlet Pressure Loss:	12.0	"H2O
Turbine Fuel Consumption @ specified site conditions (LHV):	61.2	MMBtu/hr
KW Gross Output @ specified site conditions:	5,484	kW
Gas Compressor Power:	122	kW
Turbine Auxiliary Power:	10	kW
Condensate Pump Power:	1.0	kW
Boiler Feed Pump Power:	8.6	kW
Total Auxiliary Power Consumption:	142	kW
Net Gas Turbine Power Production:	5,342	kW
Black Start kW Requirement (Turbine Generator Set Only):	350	kW

Boiler:		
Condensate Return:	90	%
Condensate Temperature:	212	°F
Makeup Water Temperature:	70	°F
Process Steam Pressure:	150.0	psig
Process Steam Temperature:	366	°F
Deaerator Steam Consumption:	865	lbm/hr
Boiler Steam Flow (HRSG design uses 27.0°F pinch, 18.0°F approach):	28,740	lbm/hr
Steam Flow to Process:	27,875	lbm/hr

Cycle Performance (lower heating value basis):		
Net Turbine Electrical Heat Rate:	11,450	Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,450	Btu/kWHR
Overall Cycle Efficiency (LHV):	76.7	%

CEP Version 10.5



Fuel Flow(s) based on Lower Heating Value

Note: For Estimating Purposes only. For Guaranteed Performance, see your Solar Turbines Representative.

January 19, 2018

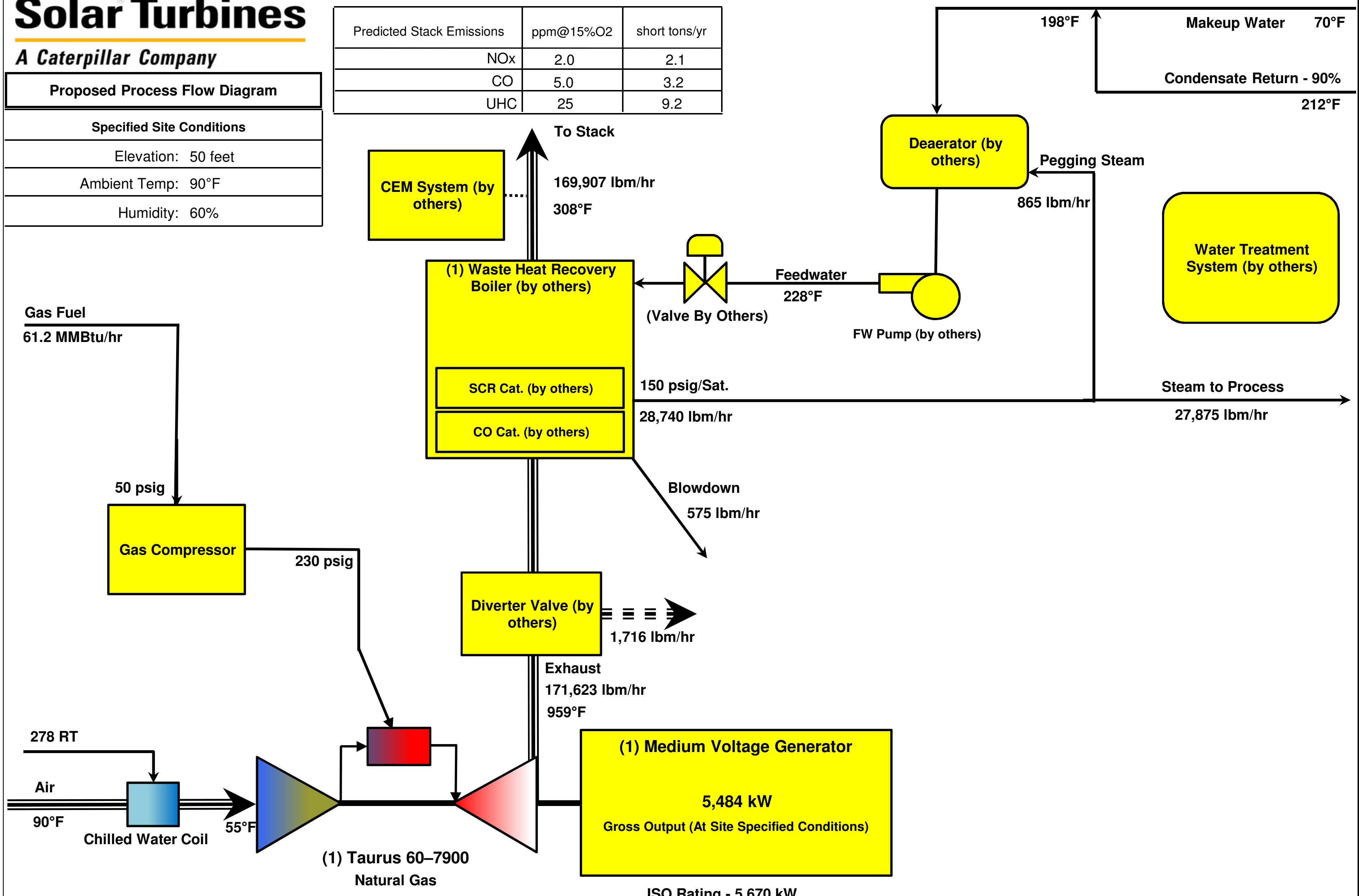
CEP Version 10.5

Solar Turbines
A Caterpillar Company

Proposed Process Flow Diagram

Specified Site Conditions	
Elevation:	50 feet
Ambient Temp:	90°F
Humidity:	60%

Predicted Stack Emissions	ppm@15%O2	short tons/yr
NOx	2.0	2.1
CO	5.0	3.2
UHC	25	9.2



CEP Version 10.5

System Efficiency = 76.7%

Fuel Flow(s) based on Lower Heating Value

Note: For Estimating Purposes only. For Guaranteed Performance, see your Solar Turbines Representative.

Customer Name		
Ref. #	Inquiry Number	January 19, 2018
Designed by	Bernie Pfeifer	

Off Design Performance Worksheet

Customer Name

January 19, 2018

Prepared by Bernie Pfeifer

Taurus 60-7901S

Natural Gas

(Inlet Cooling in use in this column)

	As-Designed Values							
Site Elevation	50	feet			Process Steam Demand		lbm/hr
Barometric Pressure	29.87	"Hg			Unfired Steam Flow	27,138	lbm/hr
Inlet Duct Loss	5.0	"H2O			Max Steam Flow	27,138	lbm/hr
Exhaust Duct Loss	12.0	"H2O			Firing Temperature	Off	°F
					Duct Burner Fuel Flow	Off	MMBtu/hr

	As-Designed Values						
# of Turbines in Service	1	1	1	1	1	1	
Ambient Temperature (T1)	90.0	0.0	30.0	50.0	70.0	90.0	°F
Relative Humidity	60.0	60.0	60.0	60.0	60.0	60.0	%
Part Power (kW), % Load, or 0 for Max	0	0.00	0.00	0.00	0.00	0.00	kW
Inlet Chilling On/Off	On	Off	Off	Off	Off	Off	
Inlet Chiller Load	278	0	0	0	0	0	RT
Engine Inlet Air Temperature (T1)	55.0	0.0	30.0	50.0	70.0	90.0	°F
Nominal Output Power @ Terminals	5,484	6,456	5,929	5,573	5,172	4,721	kW
Fuel Flow (LHV)	61.2	69.5	64.9	61.9	58.7	55.5	MMBtu/hr
Inlet Air Flow	168,655	182,559	175,468	170,130	163,159	155,494	lbm/hr
Exhaust Gas Temperature (T7)	959	933	946	956	970	989	°F
Exhaust Gas Mass Flow	171,623	185,930	178,618	173,135	166,007	158,187	lbm/hr
Exhaust Gas Volumetric Flow	38,925	42,444	40,741	39,473	37,836	36,046	SCFM
Nominal Electrical Efficiency @ Terminals	30.6	31.7	31.2	30.7	30.1	29.0	%
Nominal Electrical Heat Rate @ Terminals	11,154	10,758	10,946	11,109	11,349	11,758	Btu/kWHR
Exhaust Heat Captured	29.0	30.4	29.8	29.4	28.8	28.2	MMBtu/hr
% Argon, wet	0.9	0.9	0.9	0.9	0.9	0.9	
% CO2, wet	3.0	3.1	3.0	3.0	3.0	2.9	
% H2O, wet	6.7	7.8	7.6	7.5	7.5	7.4	
% N2, wet	75.1	74.3	74.4	74.4	74.5	74.5	
% Oxygen, wet	14.3	13.9	14.0	14.1	14.2	14.3	
					Net CHP System Efficiency =	78.8	%

Fuel Flow(s) based on Lower Heating Value

(1) Taurus 60-7901S with HRSG		Plant Total
Exhaust Emissions At Stack		
NOx (assumes 87% reduction SCR)	ppm@15%O2	2.0
	lbm/MMBtu*	0.00715
	lbm/hr	0.485
	short tons/yr	2.12
CO (assumes 80% reduction CO catalyst)	ppm@15%O2	5.0
	lbm/MMBtu*	0.0109
	lbm/hr	0.738
	short tons/yr	3.23
UHC	ppm@15%O2	25.0
	lbm/MMBtu*	0.0311
	lbm/hr	2.11
	short tons/yr	9.24
VOC	ppm@15%O2	5.0
	lbm/MMBtu*	0.00622
	lbm/hr	0.422
	short tons/yr	1.85
$PM_{10}/PM_{2.5}$	lbm/hr	0.671
	lbm/MMBtu*	0.01
	short tons/yr	2.94
SO_2	lbm/hr	0.228
	lbm/MMBtu*	0.0034
	short tons/yr	1
SCR Ammonia Slip	ppm@15%O2	5
SCR Reduction Efficiency	%	87%
CO Catalyst Reduction Efficiency	%	80%
VOC Catalyst Reduction Efficiency	%	0%
CO_2	lbm/MMBtu*	119
	lbm/hr	8,040
	short tons/yr	35,200.0
	tonne/year	31,900

*HHV

Emissions Notes:

1. This document is for initial emissions estimates only. For air permit applications, Solar can provide appropriate site-specific turbine emissions documentation.

2. Fuels must comply with Solar specification ES 9-98. Actual emissions may vary due to site fuel characteristics. Zero fuel bound nitrogen is assumed for gaseous fuels, and less than 0.02% for liquid fuels.

3. Turbine "ppm" values are applicable for operation at ambient temperatures between 0 and 120°F.

4. The table below gives the load ranges to which the turbine ppm emissions listed above apply. Mass based estimates are valid at ambient temperature and operating load noted.

Pollutant	Load Range
NOx	50 to 100%
CO	50 to 100%
UHC	50 to 100%

5. SO2 emissions depend upon the fuel's sulfur content. The SO2 estimate is based upon EPA's AP-42 document (Tables 3.1-2a. and 3.1-2b. April 2000).

6. Annual estimates shown above assume 8760 hours/year operation.

Contact: Bernie Pfeifer, 203-644-8264, berniepfeifer@solarturbines.com
Caterpillar Confidential: Do not disclose without Solar’s approval

G3520H

GAS ENGINE TECHNICAL DATA

CATERPILLAR®

ENGINE SPEED (rpm):	1500
COMPRESSION RATIO:	12.1:1
AFTERCOOLER TYPE:	SCAC
AFTERCOOLER - STAGE 2 INLET (°F):	118
AFTERCOOLER - STAGE 1 INLET (°F):	192
JACKET WATER OUTLET (°F):	210
ASPIRATION:	TA
COOLING SYSTEM:	JW+OC+1AC, 2AC+GB
CONTROL SYSTEM:	ADEM4 W/ IM
EXHAUST MANIFOLD:	DRY
COMBUSTION:	LOW EMISSION
NOx EMISSION LEVEL (g/bhp-hr NOx):	1.0

RATING STRATEGY:	HIGH RESPONSE
APPLICATION:	GENSET
RATING LEVEL:	CONTINUOUS
FUEL:	NAT GAS
FUEL SYSTEM:	CAT LOW PRESSURE WITH AIR FUEL RATIO CONTROL
FUEL PRESSURE RANGE(psig):	2.0-5.0
FUEL METHANE NUMBER:	85
FUEL LHV (Btu/scf):	905
ALTITUDE CAPABILITY AT 77°F INLET AIR TEMP. (ft):	4921
POWER FACTOR:	0.8
VOLTAGE(V):	4160-13800

RATING		NOTES	LOAD	100%	75%	50%
GENSET POWER	(WITH GEARBOX, WITHOUT FAN)	(1)(2)	ekW	2483	1862	1242
GENSET POWER	(WITH GEARBOX, WITHOUT FAN)	(1)(2)	kVA	3104	2328	1552
ENGINE POWER	(WITHOUT GEARBOX, WITHOUT FAN)	(2)	bhp	3467	2606	1752
GENERATOR EFFICIENCY		(1)	%	96.8	96.6	95.8
GENSET EFFICIENCY(@ 1.0 Power Factor)	(ISO 3046/1)	(3)(4)	%	44.7	43.6	41.5
THERMAL EFFICIENCY		(3)(5)	%	41.1	42.6	45.6
TOTAL EFFICIENCY (@ 1.0 Power Factor)		(3)(6)	%	85.8	86.2	87.1
ENGINE DATA						
GENSET FUEL CONSUMPTION	(ISO 3046/1)	(7)	Btu/ekW-hr	7674	7851	8255
GENSET FUEL CONSUMPTION	(NOMINAL)	(7)	Btu/ekW-hr	7939	8122	8540
ENGINE FUEL CONSUMPTION	(NOMINAL)	(7)	Btu/bhp-hr	5686	5805	6053
AIR FLOW (77°F, 14.7 psia)	(WET)	(8)	ft3/min	6321	4685	3128
AIR FLOW	(WET)	(8)	lb/hr	28027	20776	13871
FUEL FLOW (60ºF, 14.7 psia)			scfm	363	279	195
COMPRESSOR OUT PRESSURE			in Hg(abs)	141.3	107.2	74.4
COMPRESSOR OUT TEMPERATURE			°F	457	386	292
AFTERCOOLER AIR OUT TEMPERATURE			°F	128	121	120
INLET MAN. PRESSURE		(9)	in Hg(abs)	135.0	100.9	68.5
INLET MAN. TEMPERATURE	(MEASURED IN PLENUM)	(10)	°F	128	123	121
TIMING		(11)	°BTDC	22	20	16
EXHAUST TEMPERATURE - ENGINE OUTLET		(12)	°F	735	798	901
EXHAUST GAS FLOW (@engine outlet temp, 14.5 psia)	(WET)	(13)	ft3/min	15134	11832	8571
EXHAUST GAS MASS FLOW	(WET)	(13)	lb/hr	29021	21539	14406
MAX INLET RESTRICTION		(14)	in H2O	14.45	10.06	7.28
MAX EXHAUST RESTRICTION		(14)	in H2O	20.07	11.29	5.34
EMISSIONS DATA - ENGINE OUT						
NOx (as NO2)		(15)(16)	g/bhp-hr	1.00	1.00	1.00
CO		(15)(17)	g/bhp-hr	1.52	1.46	1.41
THC (mol. wt. of 15.84)		(15)(17)	g/bhp-hr	2.26	2.35	2.27
NMHC (mol. wt. of 15.84)		(15)(17)	g/bhp-hr	0.32	0.33	0.32
NMNEHC (VOCs) (mol. wt. of 15.84)		(15)(17)(18)	g/bhp-hr	0.25	0.26	0.25
HCHO (Formaldehyde)		(15)(17)	g/bhp-hr	0.21	0.21	0.22
CO2		(15)(17)	g/bhp-hr	397	403	411
EXHAUST OXYGEN		(15)(19)	% DRY	9.7	9.4	8.9
LAMBDA		(15)(19)		1.77	1.71	1.63
ENERGY BALANCE DATA						
LHV INPUT		(20)	Btu/min	328538	252091	176708
HEAT REJECTION TO JACKET WATER (JW)		(21)(29)	Btu/min	33909	29109	23892
HEAT REJECTION TO ATMOSPHERE		(22)	Btu/min	4321	3605	2896
HEAT REJECTION TO LUBE OIL (OC)		(23)(29)	Btu/min	12741	11431	9822
HEAT REJECTION TO EXHAUST (LHV TO 77°F)		(24)(25)	Btu/min	88102	71483	54625
HEAT REJECTION TO EXHAUST (LHV TO 248°F)		(24)	Btu/min	62627	52373	41908
HEAT REJECTION TO A/C - STAGE 1 (1AC)		(26)(29)	Btu/min	25725	14306	4894
HEAT REJECTION TO A/C - STAGE 2 (2AC)		(27)(30)	Btu/min	16714	11658	6298
HEAT REJECTION FROM GEARBOX (GB)		(28)(30)	Btu/min	1162	873	587

CONDITIONS AND DEFINITIONS

Engine rating obtained and presented in accordance with ISO 3046/1. (Standard reference conditions of 77°F, 29.60 in Hg barometric pressure.) No overload permitted at rating shown. Consult the altitude deration factor chart for applications that exceed the rated altitude or temperature.

Emission levels are at engine exhaust flange prior to any after treatment. Values are based on engine operating at steady state conditions, adjusted to the specified NOx level at 100% load. Tolerances specified are dependent upon fuel quality. Fuel methane number cannot vary more than ± 3.

For notes information consult page three.

FUEL USAGE GUIDE

CAT METHANE NUMBER	<50	50	60	70	75	85	100
SET POINT TIMING	-	16	16	16	16	22	22
DERATION FACTOR	0	0.65	0.80	0.90	1	1	1

ALTITUDE DERATION FACTORS AT RATED SPEED

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating
120	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating
110	0.97	0.91	0.85	0.79	0.72	0.60	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating
100	1	1	0.98	0.93	0.88	0.84	0.79	0.74	0.70	0.66	0.62	0.58	0.54
90	1	1	1	1	0.95	0.90	0.86	0.81	0.76	0.71	0.66	0.61	0.56
80	1	1	1	1	1	0.98	0.93	0.89	0.84	0.80	0.76	0.68	0.59
70	1	1	1	1	1	1	0.95	0.91	0.87	0.82	0.78	0.72	0.61
60	1	1	1	1	1	1	0.95	0.91	0.87	0.82	0.78	0.72	0.61
50	1	1	1	1	1	1	0.95	0.91	0.87	0.82	0.78	0.72	0.61

ALTITUDE (FEET ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS (ACHRF)

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating
120	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating
110	1.15	1.19	1.23	1.26	1.30	1.34	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating	No Rating
100	1.10	1.14	1.17	1.21	1.25	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
90	1.05	1.08	1.12	1.16	1.19	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
80	1	1.03	1.07	1.10	1.14	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
70	1	1	1.01	1.05	1.08	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
60	1	1	1	1	1.03	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
50	1	1	1	1	1	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01

ALTITUDE (FEET ABOVE SEA LEVEL)

FUEL USAGE GUIDE:

This table shows the derate factor and full load set point timing required for a given fuel. Note that deration and set point timing reduction may be required as the methane number decreases. Methane number is a scale to measure detonation characteristics of various fuels. The methane number of a fuel is determined by using the Caterpillar methane number calculation program.

ALTITUDE DERATION FACTORS:

This table shows the deration required for various air inlet temperatures and altitudes. Use this information along with the fuel usage guide chart to help determine actual engine power for your site.

ACTUAL ENGINE RATING:

To determine the actual rating of the engine at site conditions, one must consider separately, limitations due to fuel characteristics and air system limitations. The Fuel Usage Guide deration establishes fuel limitations. The Altitude/Temperature deration factors and RPC (reference the Caterpillar Methane Program) establish air system limitations. RPC comes into play when the Altitude/Temperature deration is less than 1.0 (100%). Under this condition, add the two factors together. When the site conditions do not require an Altitude/ Temperature derate (factor is 1.0), it is assumed the turbocharger has sufficient capability to overcome the low fuel relative power, and RPC is ignored. To determine the actual power available, take the lowest rating between 1) and 2).

1) Fuel Usage Guide Deration
2) 1-((1-Altitude/Temperature Deration) + (1-RPC))

AFTERCOOLER HEAT REJECTION FACTORS(ACHRF):

To maintain a constant air inlet manifold temperature, as the inlet air temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor (ACHRF) to adjust for inlet air temp and altitude conditions. See notes 29 and 30 for application of this factor in calculating the heat exchanger sizing criteria. Failure to properly account for these factors could result in detonation and cause the engine to shutdown or fail.

INLET AND EXHAUST RESTRICTIONS FOR ALTITUDE CAPABILITY:

The altitude derate chart is based on the maximum inlet and exhaust restrictions provided on page 1. Contact factory for restrictions over the specified values. Heavy Derates for higher restrictions will apply.

NOTES:

1. Generator efficiencies, power factor, and voltage are based on standard generator. [Genset Power (ekW) is calculated as: (Engine Power (bkW) - Gearbox Power (bkW)) x Generator Efficiency], [Genset Power (kVA) is calculated as: (Engine Power (bkW) - Gearbox Power (bkW)) x Generator Efficiency / Power Factor]
2. Rating is without engine driven water pumps. Tolerance is (+)3, (-)0% of full load.
3. Efficiency represents a Closed Crankcase Ventilation (CCV) system installed on the engine.
4. ISO 3046/1 Genset efficiency tolerance is (+)0, (-)5% of full load % efficiency value based on a 1.0 power factor.
5. Thermal Efficiency is calculated based on energy recovery from the jacket water, lube oil, 1st stage aftercooler, and exhaust to 248ºF with engine operation at ISO 3046/1 Genset Efficiency, and assumes unburned fuel is converted in an oxidation catalyst.
6. Total efficiency is calculated as: Genset Efficiency + Thermal Efficiency. Tolerance is ±10% of full load data.
7. ISO 3046/1 Genset fuel consumption tolerance is (+)5, (-)0% of full load data. Nominal genset and engine fuel consumption tolerance is ± 1.5% of full load data.
8. Air flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 5 %.
9. Inlet manifold pressure is a nominal value with a tolerance of ± 5 %.
10. Inlet manifold temperature is a nominal value with a tolerance of ± 9°F.
11. Timing indicated is for use with the minimum fuel methane number specified. Consult the appropriate fuel usage guide for timing at other methane numbers.
12. Exhaust temperature is a nominal value with a tolerance of (+)63°F, (-)54°F.
13. Exhaust flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 6 %.
14. Inlet and Exhaust Restrictions are maximum allowed values at the corresponding loads. Increasing restrictions beyond what is specified will result in a significant engine derate.
15. Emissions data is at engine exhaust flange prior to any after treatment.
16. NOx tolerances are ± 18% of specified value.
17. CO, CO2, THC, NMHC, NMNEHC, and HCHO values are "Not to Exceed" levels. THC, NMHC, and NMNEHC do not include aldehydes. An oxidation catalyst may be required to meet Federal, State or local CO or HC requirements.
18. VOCs - Volatile organic compounds as defined in US EPA 40 CFR 60, subpart JJJJ
19. Exhaust Oxygen tolerance is ± 0.5; Lambda tolerance is ± 0.05. Lambda and Exhaust Oxygen level are the result of adjusting the engine to operate at the specified NOx level.
20. LHV rate tolerance is ± 1.5%.
21. Heat rejection to jacket water value displayed includes heat to jacket water alone. Value is based on treated water. Tolerance is ± 10% of full load data.
22. Heat rejection to atmosphere based on treated water. Tolerance is ± 50% of full load data.
23. Lube oil heat rate based on treated water. Tolerance is ± 20% of full load data.
24. Exhaust heat rate based on treated water. Tolerance is ± 10% of full load data.
25. Heat rejection to exhaust (LHV to 77°F) value shown includes unburned fuel and is not intended to be used for sizing or recovery calculations.
26. Heat rejection to A/C - Stage 1 based on treated water. Tolerance is ±5% of full load data.
27. Heat rejection to A/C - Stage 2 based on treated water. Tolerance is ±5% of full load data.
28. Heat rejection to Gearbox based on treated water. Tolerance is ±5% of full load data.
29. Total Jacket Water Circuit heat rejection is calculated as: (JW x 1.1) + (OC x 1.2) + (1AC x 1.05) + [0.753 x (1AC + 2AC) x (ACHRF - 1) x 1.05]. Heat exchanger sizing criterion is maximum circuit heat rejection at site conditions, with applied tolerances. A cooling system safety factor may be multiplied by the total circuit heat rejection to provide additional margin.
30. Total Second Stage Aftercooler Circuit heat rejection is calculated as: (2AC x 1.05) + [(1AC + 2AC) x 0.247 x (ACHRF - 1) x 1.05] + (GB x 1.05). Heat exchanger sizing criterion is maximum circuit heat rejection at site conditions, with applied tolerances. A cooling system safety factor may be multiplied by the total circuit heat rejection to provide additional margin.

FREE FIELD MECHANICAL & EXHAUST NOISE

MECHANICAL: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	Overall	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
2483	100	3467	121.9	84.9	96.4	96.1	98.4	100.7	106.8	105.2	105.9	106.3	107.5
1862	75	2606	119.1	84.1	94.8	94.7	96.3	97.6	105.0	103.1	104.2	104.3	106.1
1242	50	1752	116.7	81.2	91.7	92.2	94.3	96.6	103.2	100.9	102.6	103.4	107.0

MECHANICAL: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
2483	100	3467	105.3	107.8	108.0	106.6	106.9	105.9	105.4	112.9	117.9	111.7	105.6
1862	75	2606	103.7	106.5	106.9	105.2	105.8	105.9	106.5	114.5	104.7	107.7	100.9
1242	50	1752	102.6	105.5	106.3	104.3	105.0	105.1	108.7	104.4	101.6	103.9	94.4

EXHAUST: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	Overall	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
2483	100	3467	129.3	92.5	104.2	113.3	114.1	108.4	111.3	117.7	115.4	118.0	116.3
1862	75	2606	126.2	90.2	108.0	113.5	113.1	103.4	105.5	110.3	110.1	110.4	109.0
1242	50	1752	123.3	87.8	105.5	114.5	112.6	99.1	101.4	104.5	102.7	101.7	102.9

EXHAUST: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
2483	100	3467	116.6	116.7	116.6	117.2	118.2	118.8	116.9	117.2	119.2	116.5	113.5
1862	75	2606	109.7	110.1	113.7	115.6	116.3	116.4	116.2	116.1	116.2	112.8	111.9
1242	50	1752	103.5	104.4	109.9	112.4	114.1	113.7	112.8	112.3	111.5	110.6	109.6

SOUND PARAMETER DEFINITION:

Sound Power Level Data - DM8702-02

Sound power is defined as the total sound energy emanating from a source irrespective of direction or distance. Sound power level data is presented under two index headings:
Sound power level -- Mechanical
Sound power level -- Exhaust

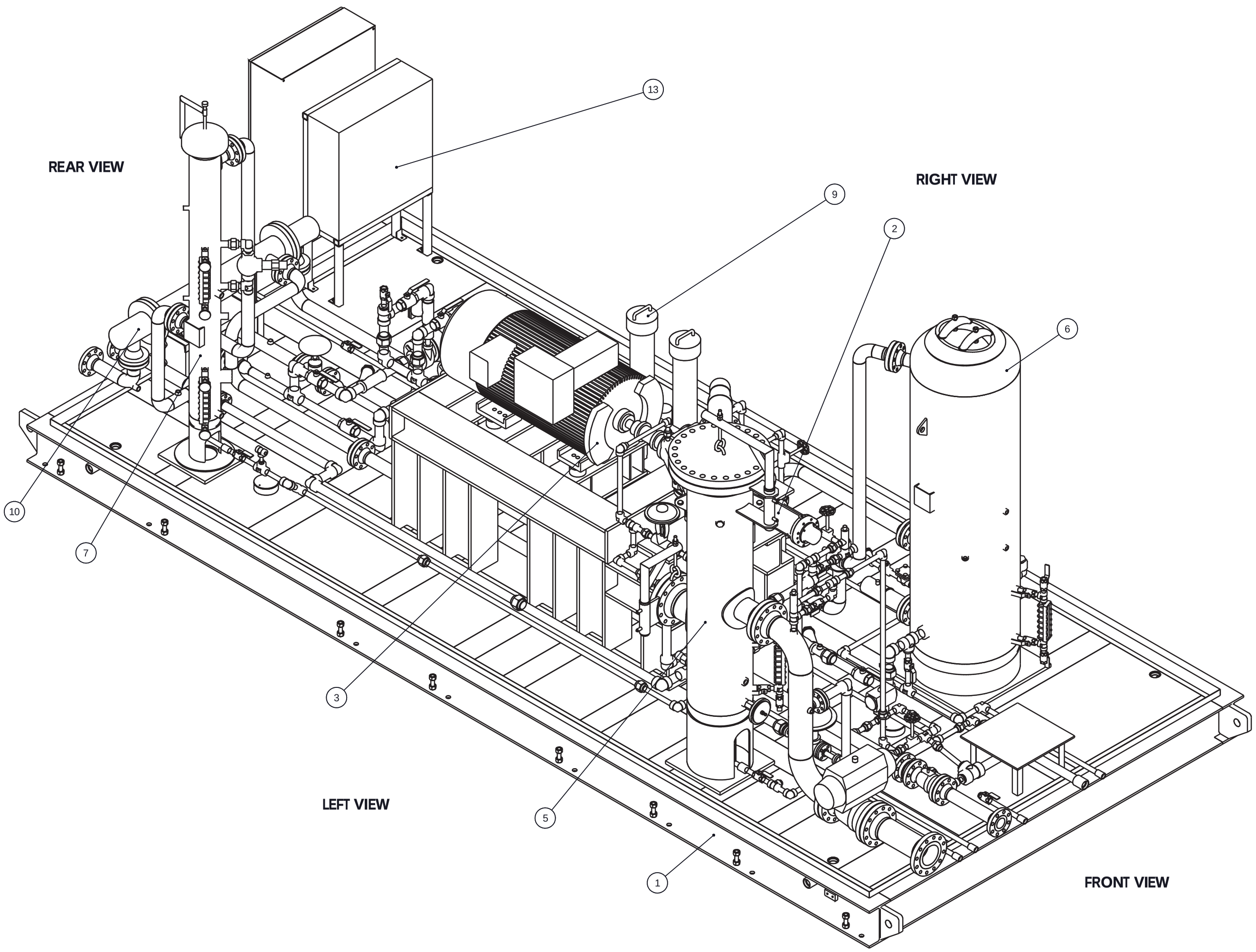
Mechanical: Sound power level data is calculated in accordance with ISO 6798. The data is recorded with the exhaust sound source isolated.

Exhaust: Sound power level data is calculated in accordance with ISO 6798 Annex A. Exhaust data is post-catalyst on gas engine ratings labeled as "Integrated Catalyst".

Measurements made in accordance with ISO 6798 for engine and exhaust sound level only. No cooling system noise is included unless specifically indicated. Sound level data is indicative of noise levels recorded on one engine sample in a survey grade 3 environment.

How an engine is packaged, installed and the site acoustical environment will affect the site specific sound levels. For site specific sound level guarantees, sound data collection needs to be done on-site or under similar conditions.

REV.	DESCRIPTION	REVISED BY	DATE APPROVED	APPROVED BY
A	ISSUED FOR REVIEW	CR	05/10/16	RTS
B	SWITCHED LOCATION OF POWER AND CONTROL PANELS, UPDATED ENCLOUSURE	CR	06/30/16	RTS
C	UPDATED POSITION OF CONTROL PANEL ISSUED FOR FABRICATION	CR	08/03/16	RTS



GENERAL NOTES:

1. ESTIMATED UNIT WEIGHT 46,000#.
   ESTIMATED SHIPPING WEIGHT 46,000#.
2. ALL CUSTOMERS PIPING THAT IS ATTACHED TO SKID CONNECTIONS SHALL BE SELF SUPPORTING.
3. EXACT LOCATION OF NOTED ITEMS ARE TO BE DETERMINED AT FINAL ASSEMBLY.
4. NOTED CONNECTIONS MUST BE VENTED TO A SAFE LOCATION.
5. PIPING CONNECTIONS TO THIS PACKAGE SHALL NOT BE COMPLETED WITH PRE-FABRICATED PIPING SPOOLS. THE MANUFACTURING TOLERANCES OF THE COMPONENTS INVLOLVED ARE NOT SUFFICIENT TO ALLOW PRE-FABRICATED PIPE SPOOLS WITHOUT UNACCEPTABLE PIPING STRAINS. UE COMPRESSION WILL NOT BE HELD LIABLE FOR RE-WORK TO PRE-FABRICATED COMPONENTS ATTACHING TO THIS PACKAGE.
6. CENTERLINE HEIGHT OF CUSTOMER AUXILIARY CONNECTIONS IS BASED OFF OF BOTTOM OF PIPE LOCATION, UNLESS OTHERWISE NOTED.
7. SEE UE COMPRESSION DRAWING 31424 (AB DRAWING) FOR ANCHOR BOLT LOCATIONS, LIFTING PROVISIONS, LIFTING LUG SIZE AND LOCATION, AND FOUNDATION REQUIRMENTS.
8. USE LIFTING LUGS ON MAIN SKID ONLY. DO NOT USE LUGS ON VESSELS OR OTHER COMPONENTS FOR LIFTING UNITS.
9. GUARDS ARE NOT SHOWN FOR CLARITY, GUARDS WILL BE PROVIDED BY UE COMPRESSION INC. ON ALL ROTATING SHAFTS, COUPLINGS, SHEAVES AND BELTS.
10. THE COMPLETE PACKAGE SHALL BE PAINTED PER UEC STANDARD SDF008. TYPE 4 PAINT SYSTEM. THE FINAL COLOR SHALL BE SOLAR GRAY RAL 7032.
11. NOTED ITEMS ARE TO SHIP LOOSE AND BE INSTALLED IN THE FIELD BY CUSTOMER.
    - COOLER
    - EXPANSION TANK

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION	WEIGHT	TOTAL WEIGHT
-	-	-	TOTAL WEIGHT OF MAJOR COMPONENTS	-	32353
13	1	NEMA TYPE 4X	POWER DISTRIBUTION PANEL	300	300
12	1	NEMA TYPE 4X	CONTROL PANEL	300	300
11	2	SUMMIT PUMP 1X2X6	GLYCOL PUMP	200	400
10	1	6" X 48" BEM	GAS TO GAS RE-HEATER	490	490
9	1	52530-5230	DUPLEX OIL FILTER	360	360
8	1	GBS 700M-X-70 (X1,X4) ASME	OIL COOLER	150	150
7	1	ACF-3-8-500	DISCHARGE FILTER	800	800
6	1	902049	GAS/OIL SEPARATOR	2140	2140
5	1	902048	SUCTION SCRUBBER	1815	1815
4	1	XTSR71 1088	REXNORD COUPLING	28	28
3	1	BALDOR G5010S	BALDOR ELECTRIC MOTOR	4850	4850
2	1	TDSH193S	FRICK SCREW COMPRESSOR	1720	1720
1	1	31423	SKID 12' x 27' x W12X50 BEAM	19000	19000

- BILL OF MATERIALS -

DRAWING CONTENTS

SHEET #	SHEET DESCRIPTION	SHEET CONTENTS
1	ISOMETRIC - LEFT	LEFT ISO VIEW, GENERAL NOTES, BOM, PAGE DESCRIPTION INDEX, ITEM CALLOUTS
2	ISOMETRIC - RIGHT	RIGHT ISO VIEW, ITEM CALLOUTS
3	PLAN	PLAN VIEW, CUSTOMER CONNECTIONS TABLE & CALLOUTS
4	ELEVATION - LEFT	LEFT ELEVATION VIEW, CUSTOMER CONNECTION CALLOUTS
5	ELEVATION - RIGHT	RIGHT ELEVATION VIEW, CUSTOMER CONNECTION CALLOUTS
6	ELEVATION - FRONT/REAR	ELEVATION VIEWS OF PIPING CONNECTION CALLOUTS
7	ISOMETRIC WITH ENCLOSURE	ISOMETRIC VIEW OF ASSEMBLY WITH ENCLOSURE BUILDING
8	ELEVATION WITH ENCLOSURE	ELEVATION VIEW OF ASSEMBLY WITH ENCLOSURE BUILDING
9	ENCLOSURE LAYOUT	ENCLOSURE BUILDING DETAILS

CUSTOMER CONNECTIONS TOLERANCE	STANDARD TOLERANCE	UECS WORK ORDER NUMBER:	
UNLESS OTHERWISE SPECIFIED	UNLESS OTHERWISE SPECIFIED	P40210-1-1 1 UNIT(S)	
FRACTIONAL: FRACTION ± 1" DECIMAL: 1 PLACE ± .1, 2 PLACE ± .06, 3 PLACE ± .031 BREAK SHARP EDGES	FRACTIONAL: FRACTION ± 3/8" DECIMAL: 1 PLACE ± .1, 2 PLACE ± .06, 3 PLACE ± .031 BREAK SHARP EDGES	– / 74512-13 – / 71078 902049 / 71077 902048 / 40668 74547 / 31423-26 74514-15 / 10693 RELATED DWGS	

UE Compression
Gas Compression and Power Generation
Parts and Service
DENVER, COLORADO

FUEL GAS BOOSTER (PO # 1715210-10-02)
FRICK TDSH193S / BALDOR G5010S 450HP

DRAWN BY:	DATE DRAWN:	SCALE:	DRAWING DESCRIPTION:
C. RAWLS	05/04/16	1:16	GENERAL ARRANGEMENT
CHECKED BY: R. SPRAGUE	DATE CHECKED: 05/10/16	DRAWING SIZE: D	DRAWING NUMBER: 10693 — REV. C

ALL DIMENSIONS IN INCHES

SHEET 1 OF 9

D 10693 C

INDECK®
KEYSTONE ENERGY, LLC.

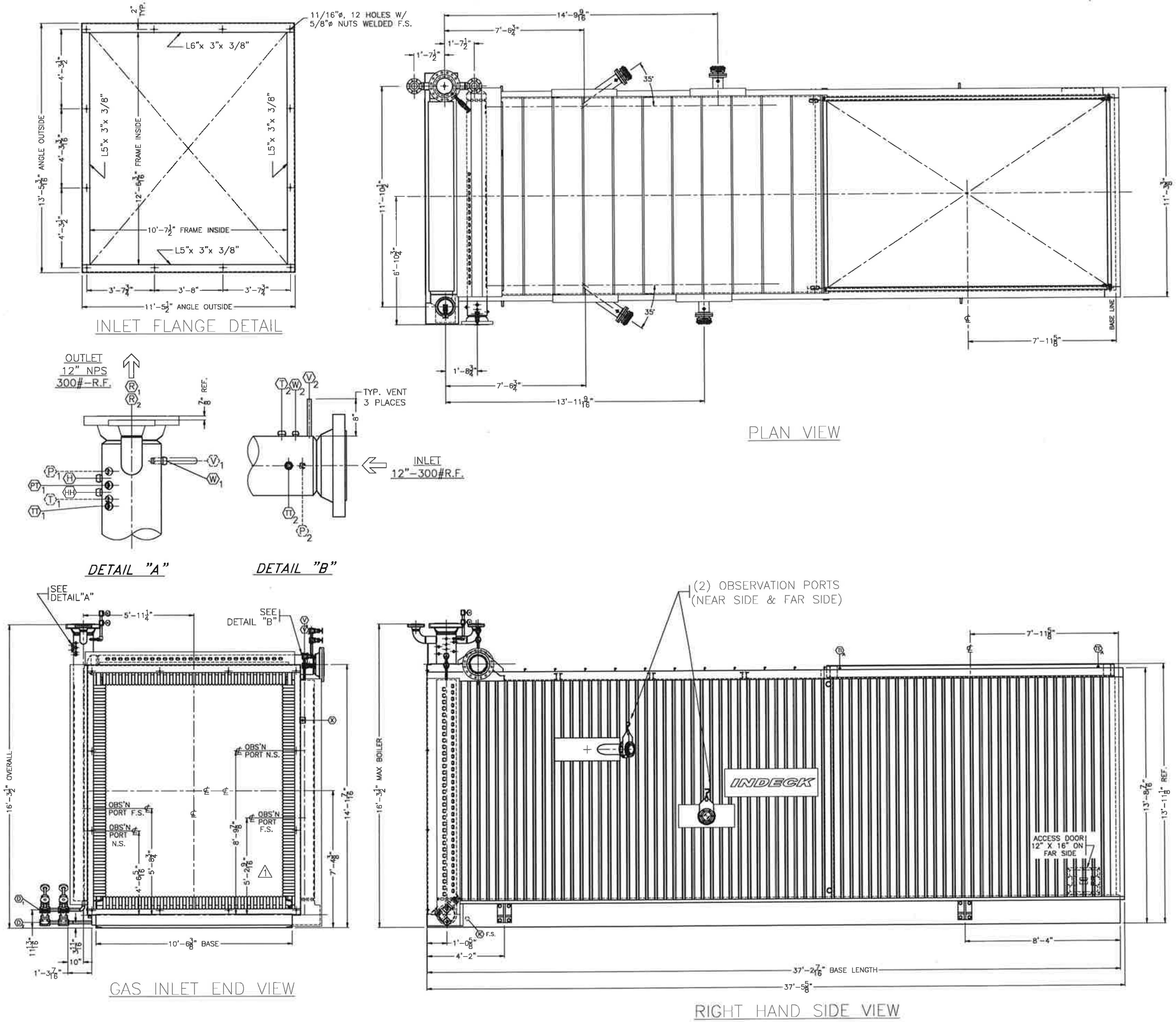
Inquiry Number	QU-24470	Engineer	tpaw
Customer	Source One Energy	Date	02/28/18
Project	WH-Hot Water Boiler	Rev.	0

Turbine Description	Taurus 70	
Burner Operation	Fired	
Ambient Air Temp	59 F	
Exhaust Gas Flow	212,300 lb/hr	
Exhaust Gas Temp	914 F	
	Exhaust Gas Analysis	
	% by Vol	% by Wt.
H2O	6.74	4.26
CO2	2.99	4.62
O2	14.32	16.08
SO2	0.00	0.00
Ar	0.90	1.26
N2	75.05	73.78
Total	100.00	100.00

Duct Burner Fuel	Nat.Gas
Duct Burner Heat Input	95.563 MMBtu/hr

Gas Temperatures	
Duct Burner Inlet	914 F
Duct Burner Outlet	2444 F
Economizer Outlet	325

Water Conditions	
Water Flow Rate	833,851 lb/hr
Inlet Water Flow	1,800 gpm
Outlet Water Flow	1,985 gpm
Inlet Water Temp	286 deg.F
Outlet Water Temp	430 deg.F
Total Heat Output	127.20 MMBtu/hr



CONNECTIONS

D 1,2	DRAIN	– 1 1/2" SW
H	OPER. WATER TEMP. AUTO RESET	– 3/4" NPT
HH	EXCESS WATER TEMP. AUTO RESET	– 3/4" NPT
K	CASING DRAIN	– 1 1/2" NPT (PLUGGED)
P 1,2	PRESSURE GAUGE	– 1/2" NPT
PT 1	OUTLET PRESSURE TRANSMITTER	– 3/4" NPT (PLUGGED)
R 1	SAFETY RELIEF VALVE	– 4"–300# R.F. FLG.
R 2	SAFETY RELIEF VALVE	– 4"–300# R.F. FLG.
T 1,2	THERMOMETER	– 3/4" NPT
TE A	SPARE	– 3/4" NPT (PLUGGED)
TI A	THERMOMETER	– 3/4" NPT
TT 1	OPERATING TEMP. CONTROL	– 3/4" NPT
TT 2	INLET TEMPERATURE TRANSMITTER	– 3/4" NPT (PLUGGED)
V 1,2,3	VENT	– 1" SW
W 1,2	TEST WELL	– 3/4" NPT
X	FURNACE PRESSURE	– 1" NPT

* ALL FLANGE BOLT HOLES STRADDLE CENTERLINES

NOTES:

1. WORK THIS DRAWING WITH GENERAL ARRANGEMENT SHEETS 2 & 3, DWGS. G101 & G102.
2. SEE DRAWING G200 FOR FOUNDATION LOADS.
3. UNIT DESIGNED PER ASME SECTION I.
4. REFER TO INDECK KEYSTONE ENERGY DESIGN SUMMARY REPORT FOR ANTICIPATED PERFORMANCE.
5. LAMONT IS COMPLETELY FIELD ERECTED.

Rev.	Date	Revision Description
A	DRK 07/14/10	DRAWING STATUS CHANGED TO ISSUED FOR CONSTRUCTION
1	DRK 06/04/10	UPDATED DRAWING – ADDED OBSERVATION PORTS, INLET FLANGE DETAIL, REVISED CONN'S WHERE INDICATED

INDECK KEYSTONE ENERGY, LLC
ERIE, PA U.S.A. PHONE 1-800-322-5995

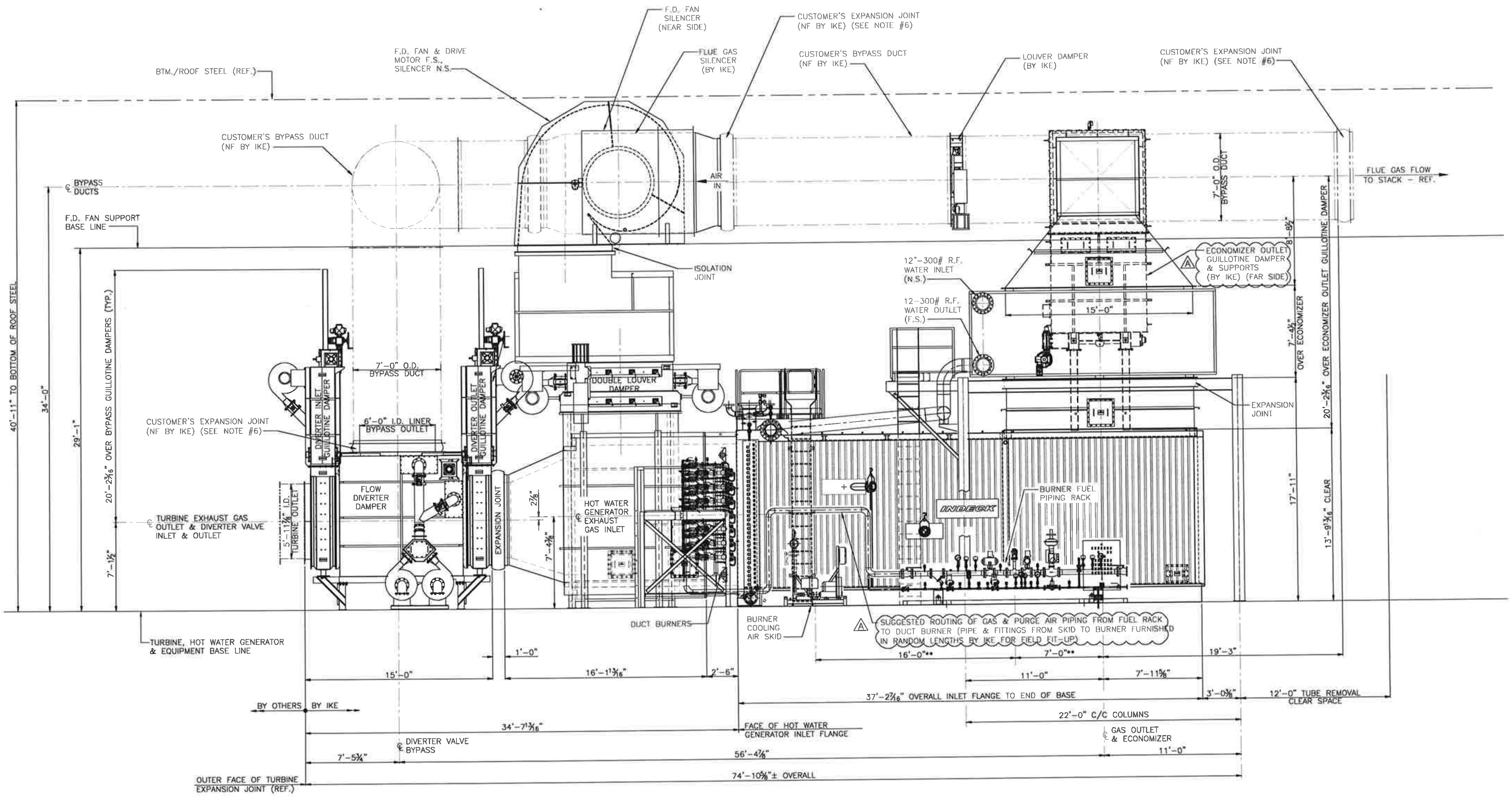
CONFIDENTIAL

ISSUED FOR CONSTRUCTION

Created by	Checked by	Approved by
DRK	DRK	MR

Title: GENERAL ARRANGEMENT SHT. 1 of 4

Drawing: –G100 Revision: A



RIGHT HAND SIDE VIEW OF EQUIPMENT FACING SOUTH

NOTES:

1. WORK THIS DRAWING WITH GENERAL ARRANGEMENT SHEETS 1,3 & 4, DWGS. G100, G102 & G103.
2. SEE DRAWING G200 FOR FOUNDATION LOADS.
3. ALL GAS & AIR DUCT FLANGES FURNISHED WITH FIT-UP HOLES FOR FIELD SEAL WELDING.
4. DESIGN & SUPPLY OF SUPPORTS FOR THE FOLLOWING BY OTHERS: F.D. FAN/MOTOR/SILENCER, BYPASS DUCTING (INCL. SILENCER, EXPANSION JOINTS & LOUVER DAMPER).
5. DIMENSIONS MARKED ** ARE THEORETICAL AND ARE TO BE SUBJECT TO CHANGE DUE TO CONDITIONS IN THE FIELD.
6. EXPANSION JOINT FLANGE F/F DIM. IN CUSTOMER'S SUPPLIED BYPASS DUCTS IS ASSUMED TO BE 1'-0".

CONFIDENTIAL

INDECK KEYSTONE ENERGY, LLC

ERIE, PA. U.S.A. PHONE 1-800-322-5995

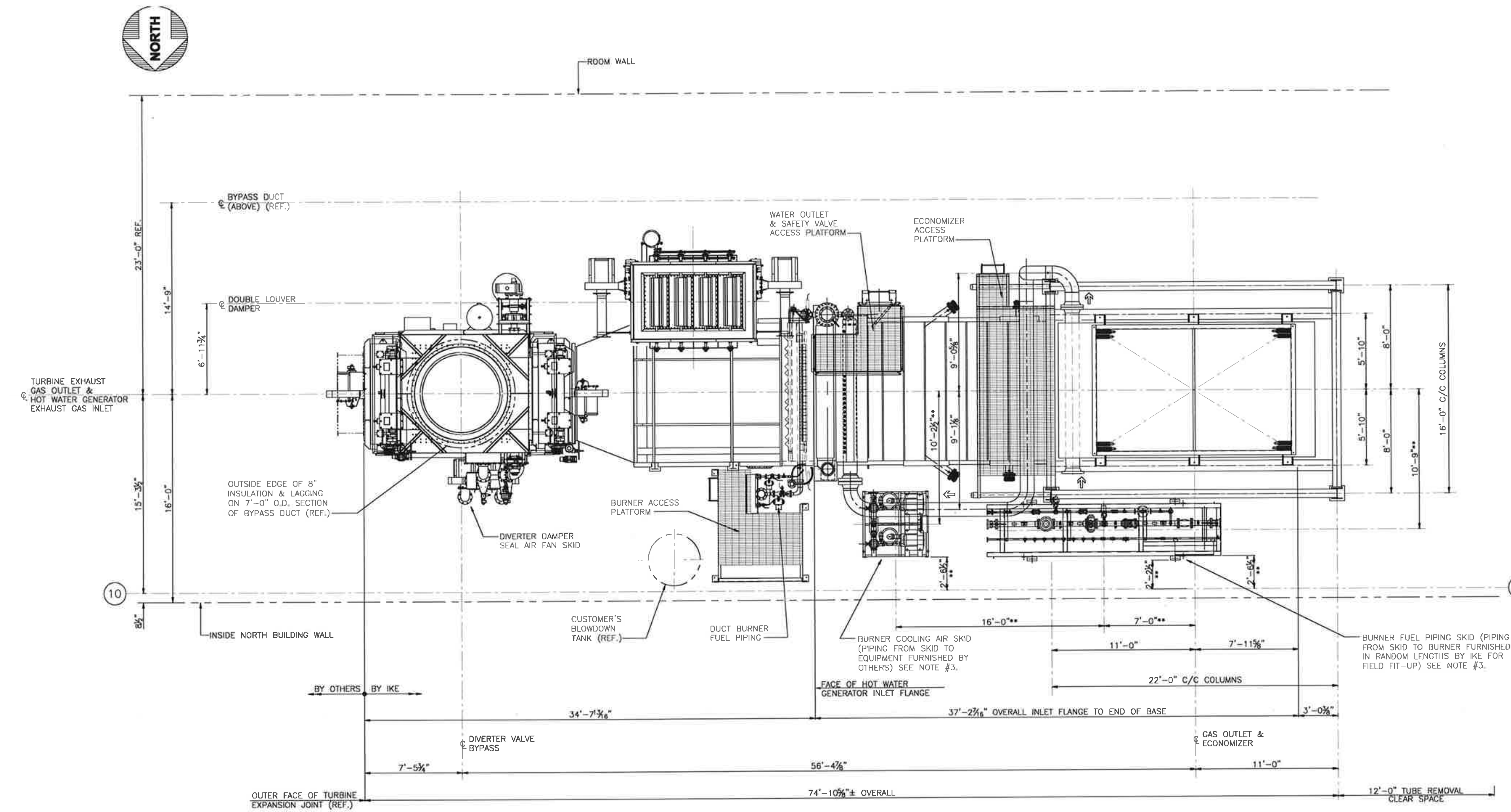
Rev.	Date	Revision Description
⚠	07/14/10	ADDED FUEL PPG. FROM FUEL PPG. RACK TO DUCT BURNER, NOTED SUPPORTS FOR ECON. OUTL. DAMPER BY IKE, DRAWING STATUS CHANGED TO ISSUED FOR CONSTRUCTION
⚠	06/29/10	UPDATED DRAWING – REVISED BYPASS DUCTS & UPDATED PLATFORMS, REV. DWG. TITLE & NOTE #4 FOR ADDITION OF 4TH SHT. OF GA DWG. G103, ADDED NOTE #6
⚠	06/09/10	UPDATED DWG. – REM. REFERENCE TO POSS. INTERFERENCE WITH BLDG. BEAM @ ECON. OUTLET DUCT, ADDED VENDOR EQUIP. (DAMPERS, FAN, ETC.) TO DWG., REV. DIMS. @ ⚠

ISSUED FOR CONSTRUCTION

Created by	Checked by	Approved by
DRK	DRK	MR

Title: GENERAL ARRANGEMENT SHT. 2 of 4

Drawing: G101 Revision: A



PLAN VIEW OF EQUIPMENT AT OPERATING FLOOR LEVEL

NOTES:

1. WORK THIS DRAWING WITH GENERAL ARRANGEMENT SHEETS 1, 2 & 4, DWGS. G100, G101 & G103.
2. SEE DRAWING G200 FOR FOUNDATION LOADS.
3. DIMENSIONS MARKED ** ARE THEORETICAL AND ARE TO BE SUBJECT TO CHANGE DUE TO CONDITIONS IN THE FIELD.

Rev.	By / Date	Revision Description
A	DRK 07/14/10	UPDATED FUEL PIPING RACK, DRAWING STATUS CHANGED TO ISSUED FOR CONSTRUCTION
2	DRK 06/28/10	UPDATED DWG. – REV. DIM. TO C/L BYPASS DUCTS (WAS 14'-8"), UPDATED PLTFMS., ADDED CUST. B.D. TANK, REV. DWG. TITLE & NOTE #4 FOR ADD. OF 4TH SHT. OF GA DWG.
1	DRK 06/28/10	UPDATED DWG. – REM. REFERENCE TO POSS. INTERFERENCE WITH BLDG. BEAM @ ECON. OUTLET DUCT, ADDED VENDOR EQUIP. (DAMPERS, FAN, ETC.) TO DWG., REV. DIMS. @ 1

ISSUED FOR CONSTRUCTION

C O N F I D E N T I A L

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KEYSTONE ENERGY, LLC
ERIE, PA. U.S.A. PHONE 1-800-322-5995

Client: / Project:	Created by	Checked by	Approved by
	DRK	DRK	MR

Title: GENERAL ARRANGEMENT SHT. 3 of 4

Drawing No.: G102 | Revision: A

VEOLIA

Resourcing the world

Trenton, NJ - Microgrid Development

Conceptual Development & Presentation to the State of New Jersey

February 8, 2019

Agenda

1. Pros and Cons of a plant located at the State House vs Service from South Warren Plant only

    a. Alternate: Extending cable connection from Veolia South Warren plant to State House for use only when back-up power is needed

2. BPU-PSEG meeting report

3. Microgrid tariff options

4. Is OSB the best location or would other locations work better

5. Buildings to be served from a State House Plant
    - Entire State House Complex
    - Culture Complex
    - Department of State Building (225 West State)
    - Thomas Edison State College
    - War Memorial?
    - Any Veolia non-State customers within one street crossing from State House?

6. Veolia “go” or “no go” on developing microgrid to serve State House

7. Review Schedule

8. Responsibilities matrix-division of design work between State House Team and Veolia team

9. Next Steps

VEOLIA

Resourcing the world

Microgrid Qualitative Description

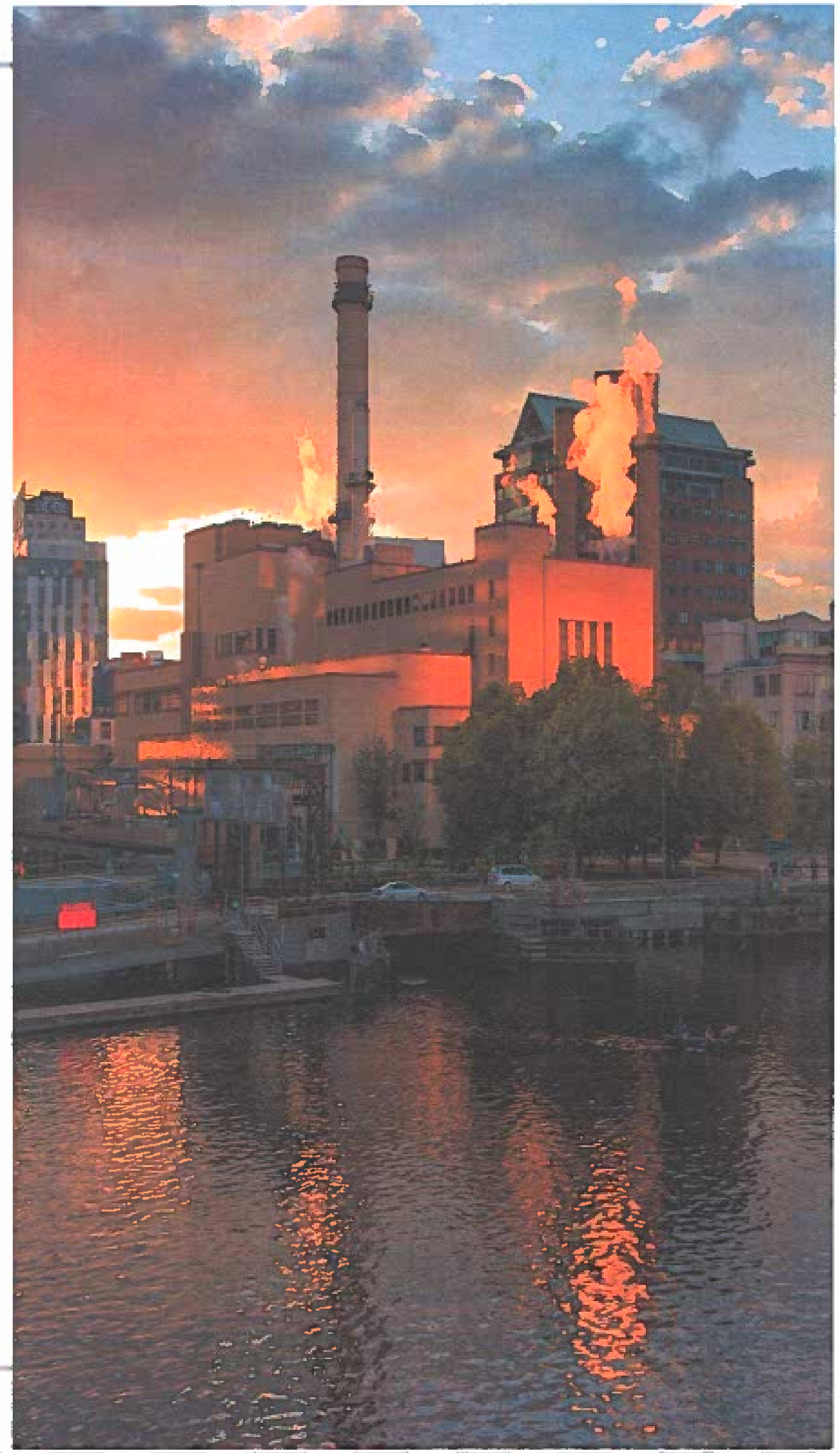
Plant Configuration

Option A - Veolia Warren Plant Only

- Central power station to feed L&I, Tax, Justice, and State House campus
- 5-7 MW Capacity
- New/ refurbished electrical feed to customers
- Re-use of existing thermal infrastructure with added capital investment

Option B - Veolia Warren Plant + State House sited plant

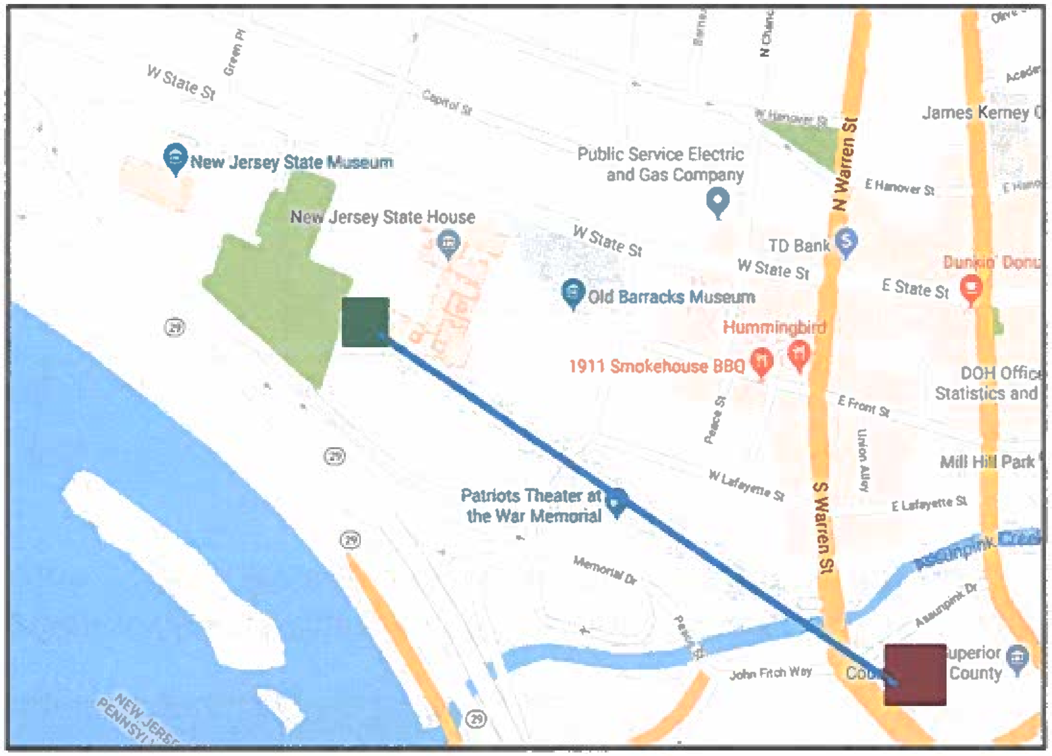
- Two plant option
  - 5-6 MW located at Warren Plant
  - 1-2 MW located on State House campus
- Interconnected Electrically (See next 3 slides)
- Modify thermal infrastructure at State House campus to accept thermal input



Electrical Interconnection

2 Options

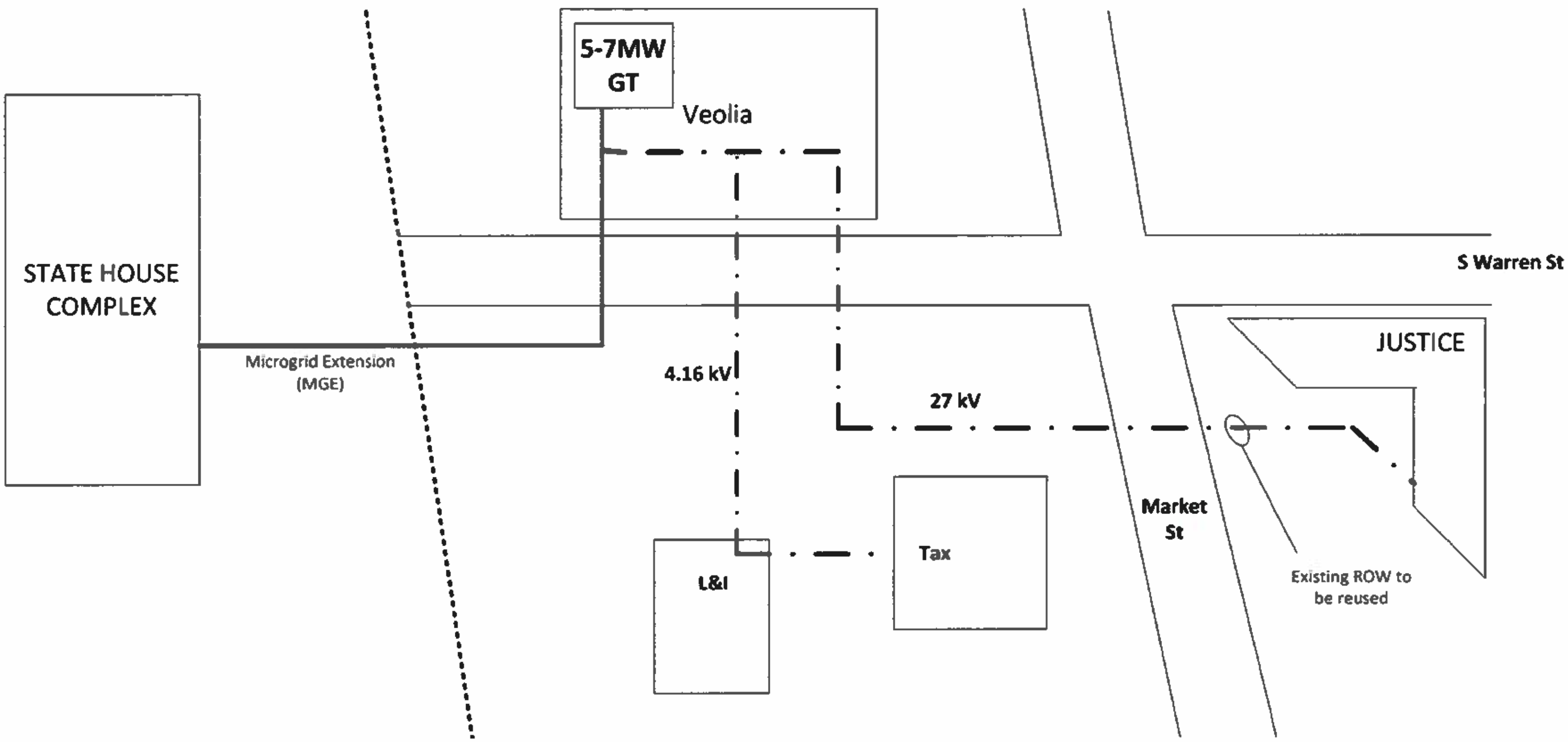
Interconnection between Warren Plant and State House Campus. This will require detailed design and coordination with State, PSEG and other AHJs



Electrical Interconnection

Option #1

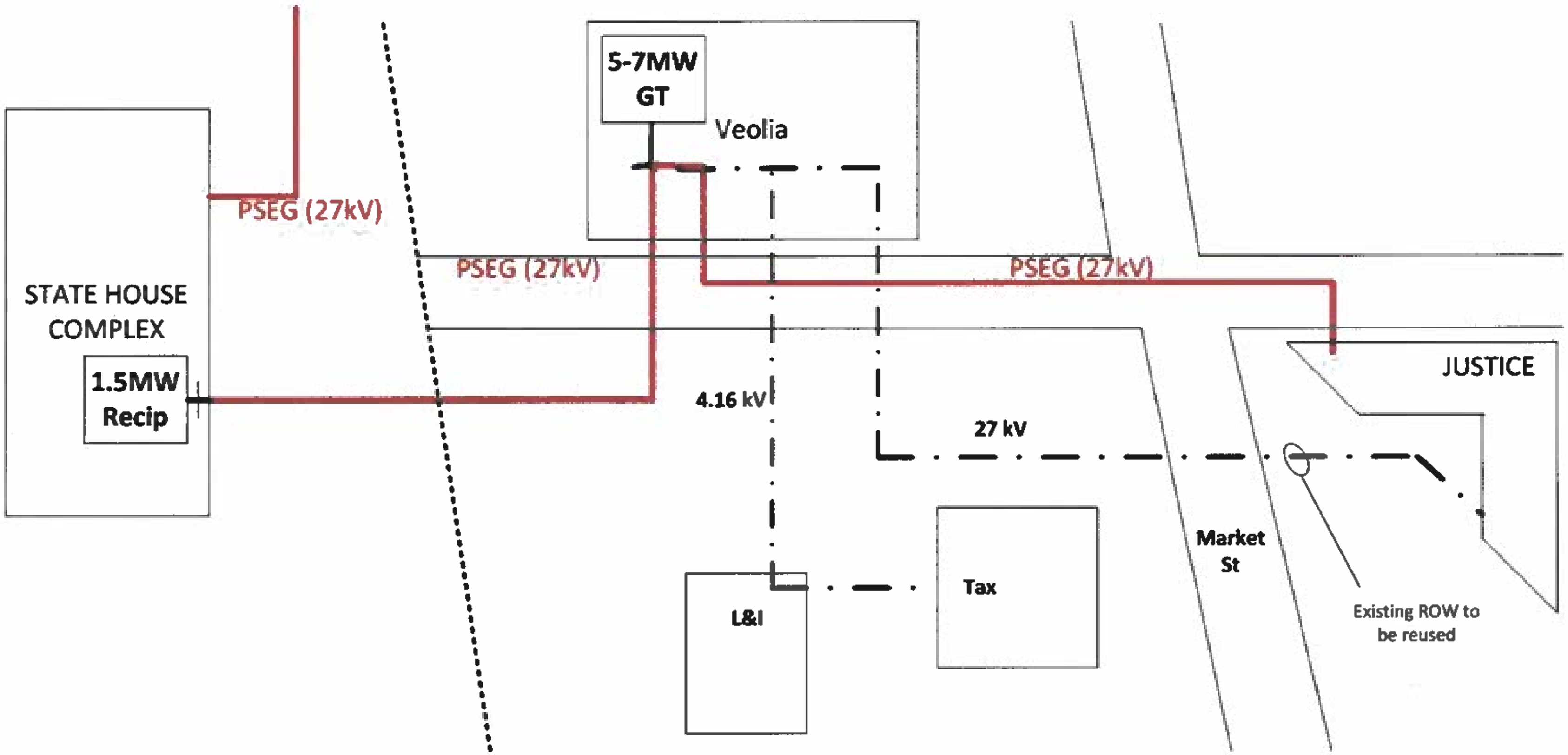
New Interconnection between Warren Plant and State House Campus. This will require further coordination with State and PSEG. Potential investment requirement of PSEG. Potential new tariff structure.



Electrical Interconnection

Option #2

Utilize existing PSEG Interconnection between Warren Plant and State House Campus. This will require further coordination with State and PSEG. Potential investment requirement of PSEG. Potential new tariff structure.



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Microgrid Quantitative Evaluation

Option A - Capital Cost

Option A - Veolia Warren Plant Only

Description	Capital
Veolia Warren Plant Upgrade	$16.2 M
Electrical Infrastructure within L&I, Tax	$1.0 M
*Electrical Infrastructure within Justice	$2.5 M
*Electrical Interconnect with Statehouse	$6.5 M
Total	$26.2 M

***Potential Savings from utilizing PSEG infrastructure between Justice and Statehouse (Total Project Cost is $17.2M)**

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Option B - Capital Cost

Option B - Veolia Warren Plant + State House sited plant

Description	Capital
Veolia Warren Plant Upgrade	$16.2 M
Statehouse CHP Plant (1-2MW)	$7.0 M
Electrical Interconnect w/ L&I, Tax,	$1.0 M
*Electrical Interconnect w/ Justice	$2.5 M
*Electrical Interconnect Statehouse	$6.5 M
Total	$33.2 M

***Potential Savings from utilizing PSEG infrastructure between Justice and Statehouse (Total Project Cost is $24.2M)**

Pro's vs. Con's - Option A

<u>Option A - Veolia Warren Plant Only</u>

Pro's

- Simplicity of development - Lower cost option
- Less disruption to State House campus during construction and over long term
- No architectural impact or stack issues at State House
- Less complex operation and maintenance
- Better prime mover options (efficiency, size, various supplier)
- Full heat capture
- Possible - simpler electrical interconnect
- Simpler thermal interconnection

Con's

- Limited plant diversity
- No Island-ability/ isolation of State House Campus
    - Lower resilience than a 2 Plant option
- Less potential for economic dispatch

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Microgrid Options Comparison

Pro's vs. Con's - Option B

Option B - Veolia Warren Plant + State House sited plant

Pro's

- Higher resilience than single plant option
  - Isolatable/ Islandable configuration for State House Campus
- Potential for economic dispatch to meet a variety of seasonal/ market conditions
- Improved resilience of overall thermal system - With some reconfiguration

Con's

- Higher project cost & more complex development
- Potential architectural impact
- Additional operations and maintenance costs
- Limited equipment configurations
  - State house limited to Recip based plants.
- Higher waste heat rejection - Lower system efficiency
- Complexity of electrical interconnection
- Additional Assets to be maintained.

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BPU - PSEG Meeting Report

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Microgrid Tariff Options

Microgrid Tariff Options

Existing Thermal Agreement - The current agreement will need to be renewed and potentially reconfigured to accommodate the preferred option by the State.

- Long Term renewal - [20+ years]
- Tariff structure may need some modification to accommodate cogeneration and sales of potential hot water and electric to the State. Thermal base cost should be expected to remain stable with historic rates, and electric costs may be set based upon additional cost associated with operations, and capital recovery. The goal will be to get rates at parity with the utility or lower.

Electricity Tariff - This will need to be further developed with the State based upon the desired configuration and what is feasible in relation to PSEG

Tarriffs may include availability payments, contract demand provisions, resiliency charges, etc. We would work through the development of the system to fairly structure a mutually beneficial tariff structure.

VEOLIA

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Development Considerations

Development Considerations

Open Discussion

- If Option B is a feasible and desirable option, is the Old Substation Building (OSB) the best location or would other locations work better?
- Buildings to be served from a State House Plant
    - Entire State House Complex
    - Culture Complex
    - Department of State Building (225 West State)
    - Thomas Edison State College
    - War Memorial?

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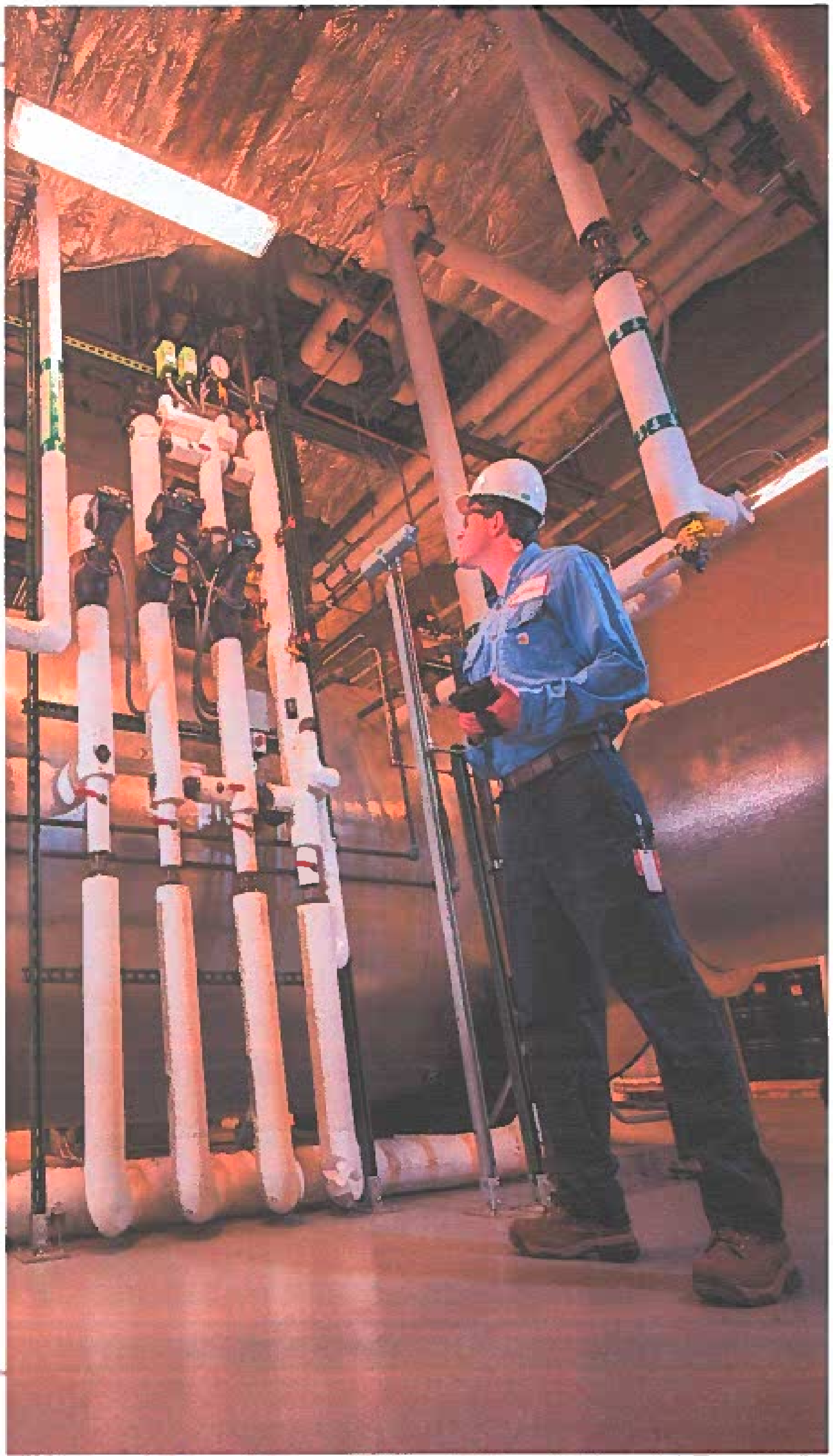
Next Steps

Veolia Decision

Veolia is committed to further development of this project in collaboration with the State. This will be subject to further development and agreement on design configuration, tariff structure and appropriate approvals by the various stakeholders who may influence this transaction

Legal Disclaimer: This presentation is an expression of our current interest in a possible transaction with the State of New Jersey on the indicative terms and conditions summarized herein. Nothing in this proposal shall be interpreted as (i) being a binding offer to perform due diligence, negotiate, or consummate the transaction, or (ii) requiring either party to enter into any agreement or arrangement with the other party with respect to a transaction, or (iii) requiring Veolia North America or any of its affiliates to enter into any form of collaboration with you. This proposal is not intended to, and does not, contain all matters upon which agreement would have to be reached with respect to a transaction in order for us to make a binding agreement or commitment. Any future binding agreement or commitment with respect to a transaction will be subject to the completion of our due diligence investigation, the negotiation and execution of a definitive agreement containing mutually acceptable terms and conditions, and the receipt of all necessary Veolia group internal authorizations, which we may decline to provide in our sole and absolute discretion.



Development Schedule

- Review Meeting - February 8, 2019
- Active discussion and clarification on development process and preferred option - Estimate the balance of February. Deliverables:
  - Decision on preferred path Option A or B
  - Clarification with PSEG on feasibility of interconnection
  - Detailed project schedule by phase with decision milestones
  - Draft of a Letter of Intent/ Memorandum of understanding
    - Mutually layout the expectations of all parties and roles & responsibilities
- March - May 2019: Complete conceptual design and budget estimates, draft initial proposal on tariff structure, development and execution of project development agreement.
- June - December 2019: Design development
- January - February 2020: Bid & Review
- March - April 2020: Negotiation & execution of construction contracts
- May 2020 - Ground breaking
- 12 - 18 month construction timeframe
- Late 2021 - Commercial operation of Trenton Microgrid

Permitting (June 2019 – April 2020)

Development Matrix

Open Discussion & Collaboration

- Division of design work between State House Team and Veolia team
- Decision making process by State
- Key milestones and output goals by State

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Thank you for your time.

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Trenton Microgrid Agenda for 2/8

1. Pros and Cons of a plant located at the State House vs Service from South Warren Plant only
    a. Alternate: Extending cable connection from Veolia South Warren plant to State House for use only when back-up power is needed

2. BPU-PSEG meeting report

3. Microgrid tariff options

4. Is OSB the best location or would other locations work better

5. Buildings to be served from a State House Plant
    - € Entire State House Complex
    - € Culture Complex
    - € Department of State Building (225 West State)
    - € Thomas Edison State College
    - € War Memorial?
    - € Any Veolia non-State customers within one street crossing from State House?

6. Veolia "go" or "no go" on developing microgrid to serve State House

7. Review Schedule

8. Responsibilities matrix-division of design work between State House Team and Veolia team

9. Next Steps

STATE HOUSE MICROGRID 2/8/2019

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State House Microgrid Responsibility Assignment Matrix

Page 1

	R=Responsible A=Accountable C=Consult I=Inform	Bldg. Auth.	DPMC	Loring	Veolia S1	BPU	PSEG	DPP				
1	Confirm state house electrical loads											
2	Confirm state house cooling loads											
3	Confirm state house heating loads											
4	Confirm state house emergency electrical loads											
5	Provide prime mover options											
6	Approve prime mover solution (state house equipment)											
7	Approve prime mover solution (Warren Street Equipment)											
8												
9												
10	Prepare utility interconnection agreement											
11												
12	Offer microgrid tariff											
13	Approve microgrid tariff											
14	Approve phase-2 microgrid design tariff											
15												
16												
17												
18	Provide Cap-Ex for Veolia cooling connection											
19	Provide Cap-Ex for Veolia thermal connection											
20	Provide Cap-Ex for Veolia electric generation equipment and connection											
21	Negotiate Power Purchase Agreement											
22	Submit gas load letter to PSEG											
23	Approve gas service											
24	Provide Cap-Ex of gas service to State House											
25	Hire microgrid design firm											
26												
27												
28	Emission permit submission											
29	Permit drawing review											
30	Bid construction of the COGEN plant (state house)											
31	Bid construction of the COGEN plant (Warren Street)											
32												