Local Government Energy Audit:
UMDNJ CHP Interconnection Investigation

Regional Medical Examiners Office

State of New Jersey Division of Law and Public Safety (NJ-LPS)

325 Norfolk Street
Newark, NJ 07103

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Final Report by:
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Disclaimer

The intent of this investigation report is to identify opportunities associated with interconnecting the northern Medical Examiners office with the combined heat and power plant located at the University of Medicine and Dentistry of New Jersey (UMDNJ). Approximate savings and costs are included in this report to help make decisions about improving the efficiency of the facilities, reducing their carbon footprint, and lowering operating costs. This report, however, is not intended to serve as a detailed engineering design document. Note that detailed design efforts are required in order to implement the interconnections evaluated as part of this analysis.

The estimates of energy consumption and available utilities from UMDNJ contained in this report have been reviewed for technical accuracy. However, all estimates contained herein are not guaranteed, because energy consumption and available UMDNJ utilities ultimately depend on behavioral factors, the weather, and many other uncontrollable variables. Historical availability of UMDNJ utilities was requested, but insufficient information was provided to facilitate the development of an informed estimate. TRC Energy Services (TRC) and New Jersey Board of Public Utilities (NJBPU) shall in no event be liable should the actual energy consumption or UMDNJ utility availability vary from the estimates shown herein.

Estimated installation costs are based on a variety of sources, including our own experience at similar facilities, our own pricing research using local contractors and vendors, and cost estimating handbooks such as those provided by RS Means. The cost estimates represent our best judgment for the proposed action. The owner is encouraged to independently confirm these cost estimates and to obtain multiple estimates when considering measure installation. Since actual installed costs can vary widely for a particular installation, and for conditions that cannot be known prior to in-depth investigation and design, the energy assessor does not guarantee installed cost estimates and shall in no event be liable should actual installed costs vary from the estimated costs herein.

New Jersey's Clean Energy Program (NJCEP) incentive values provided in this report are estimates and are based on information available at the time this report is written.

The NJBPU reserves the right to extend, modify, or terminate programs without prior or further notice, including incentive levels and eligibility requirements. The owner should review available program incentives and requirements prior to selecting and/or installing any recommended measures.

Executive Summary

The New Jersey Board of Public Utilities (NJBPU) has sponsored this Local Government Energy Audit (LGEA) report for State of New Jersey Division of Law and Public Safety's (NJ-LPS) Regional Medical Examiners office.

The goal of this LGEA study is to provide you with information on the feasibility of interconnecting the Northern Region Medical Examiners Office (ME) to the combined heat and power plant located next door at Rutgers University of Medicine and Dentistry of New Jersey. TRC Energy Services (TRC) conducted this study as part of a comprehensive effort to assist New Jersey local and state governments in controlling energy costs, protecting our environment, and cutting greenhouse gas emissions by offering a full spectrum of building level energy management options.

As part of the study, TRC reviewed historical building operations and interviewed combined heat and power (CHP) plant operators. Unfortunately, only historical trend data on the CHP plant electrical generation was available. We used information gathered from interviews, drawings, and best practices to estimate heating and cooling energy generated by the CHP plant.

Based on the information provided, it appears the Rutgers campus is currently using all of the electricity and thermal energy produced by the combustion turbine generators. Interconnecting the ME to the UMDNJ CHP plant will not increase plant efficiency or reduce the carbon foot print of either facility.

Interconnecting the facilities may, however, provide a monetary and sustainability benefit if the UMDNJ CHP plant can purchase electricity and natural gas for less than the ME. This analysis assumes that the ME can purchase electricity for 10% less and hot and chilled water for 20% less respectively, than they can be produced on site. This has the potential to save the ME over $19,500 annually. We estimate the cost of interconnecting the sites is over $300,000.

Northern Region Medical Examiners Office

In New Jersey, whenever a death occurs under circumstances that raises the public's interest, the State's Medical Examiners Office investigates the death to determine and explain the cause and manner. Medicolegal death investigators at the scene attempt to identify the recently deceased, examine their medical records, and photograph both the scene and the deceased. If it is determined a case will be brought in for an external examination or complete autopsy, in the counties of Essex, Hudson, Passaic, and Somerset, the deceased is brought to the Northern Regional Medical Examiners Office (NRMEO) located in Newark.

The Northern Medical Examiners Office is a 33,000 square foot facility comprised of various space types. The first floor is a mix of office space, public space, and a morgue. The autopsy and forensic analysis area operates similar to a hospital with some

process equipment. A robust refrigeration system is required for storage. The second floor consists of office and lab space with a large mechanical room. There are ventilation hoods and process equipment used in the labs.

Mechanical Systems

Primary electric consumers

The ME office contains three main categories of energy using systems comprised of lighting (primarily T12 Linear Fluorescent); heating, ventilation, and air conditioning (HVAC); and process loads associated with forensics labs and refrigerated storage. The Regional Medical Examiners office has a significant number of fans and motors associated with ventilation for both air quality and process fume hoods. Most of the air handling units (AHU) condition supply air using 2-pipe coils fed by the chillers and boilers. There are also three large walk-in refrigeration units at the ME office that use dedicated direct expansion (DX) refrigeration compressors and condensers. The operation of the morgue accounts for the largest portion of energy use since it requires lighting, significant HVAC, and DX refrigeration.

Chilled and Hot Water Distribution

In a 2-pipe system, the chilled water and hot water system use the same piping to distribute water throughout the facility. To prevent mixing chilled and hot water, the system toggles between heating and cooling modes. Redundant distribution pumps, each driven by a 5 hp motor, circulate the water serving the AHU 2-pipe coils. AHU-2 and AHU-3 are on a glycol distribution loop, which is heated or cooled through a heat exchanger with the 2-pipe system.

Chiller

The facility has a single water-cooled ClimaCool modular chiller, which is comprised of three 32-ton compressors. The chiller is designed to deliver 45°F chilled water through the 2-pipe coils. A 100-ton cooling tower provides condenser water to the chiller. Chilled water is primarily only used between May and September when the 2-pipe system is in cooling mode. The chiller plant is in good operating condition. A new chiller was installed in the summer of 2016.

Boilers

The facility has two H.B. Smith non-condensing boilers, each rated at 2,100 MBh output capacity. The boilers are designed to deliver 200°F heating hot water through the 2-pipe coils and variable air volume terminal unit reheat coils. Heating hot water is primarily only used between November and March when the 2-pipe system is in heating mode. The boiler plant is old and at the end of its listed useful life; however, well-maintained boilers can function with little degradation well beyond their listed useful life.

Utilities

PSE&G provides electricity and natural gas. The average electric cost (combined for commodity, transmission, and distribution) for the past 12 months is $0.091/kWh, which is the blended PSE&G rate used throughout the analyses. The average gas cost for the past 12 months is $0.842/therm, which is the blended PSE&G rate used throughout the analyses.

Figure 1 - Electric and Natural Gas Usage & Demand

Period Ending	Days in Period	Electric Usage (kWh)	Demand (kW)	Demand Cost	Total Electric Cost	Natural Gas Usage (Therms)	Natural Gas Cost
2/1/15	31	69,885	136	$2,735	$6,411	11,554	$9,510
3/1/15	28	76,833	266	$2,910	$7,049	12,914	$10,459
4/1/15	31	75,883	141	$2,914	$6,962	6,911	$4,415
5/1/15	30	77,523	181	$3,102	$7,112	1,835	$1,256
6/1/15	31	117,828	264	$6,720	$10,810	251	$262
7/1/15	30	141,839	271	$7,340	$12,837	95	$163
8/1/15	31	144,752	279	$7,375	$13,100	90	$162
9/1/15	31	159,095	276	$7,247	$14,398	102	$183
10/1/15	30	119,148	275	$3,980	$10,783	235	$254
11/1/15	31	86,978	191	$2,891	$7,882	1,460	$2,654
12/1/15	30	89,402	203	$2,833	$8,091	3,774	$4,234
1/1/16	31	79,068	159	$1,857	$6,783	9,698	$7,661
Totals	**365**	**1,238,234**	**278.6**	**$51,906**	**$112,217**	**48,918**	**$41,213**

The charts below represent the monthly consumption and peak demand graphically. The charts generally demonstrate a seasonal load profile with electric cooling in the summer and natural gas heating in the winter. The high electric baseload (energy and demand) reflect the 24-hour nature of the facility and the continuous DX refrigeration load. In February of 2015, the 266kW demand spike appears to be due to an out-of-season chiller start-up.

Figure 2 - Electric Usage & Demand

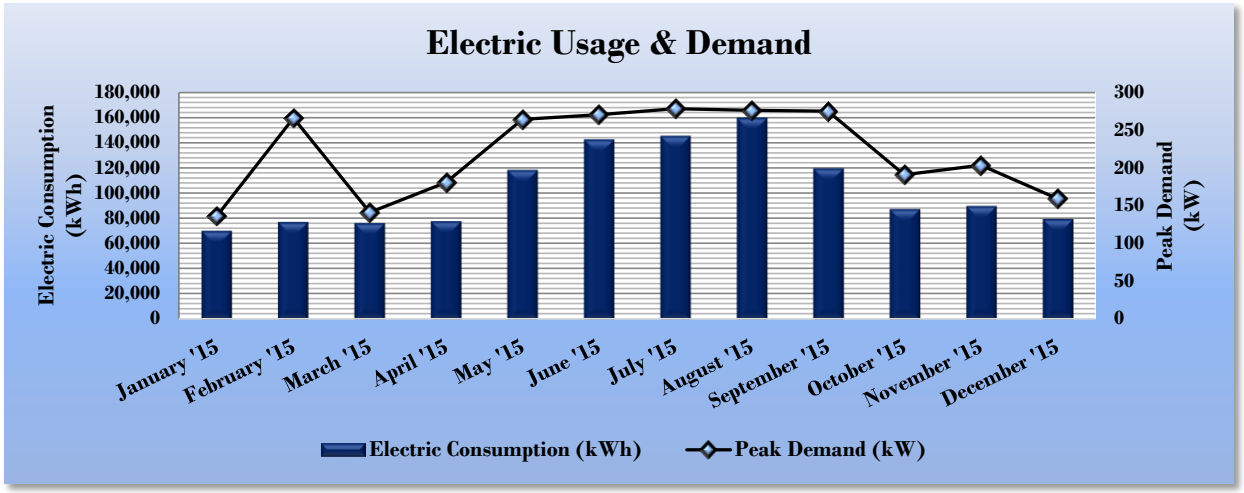
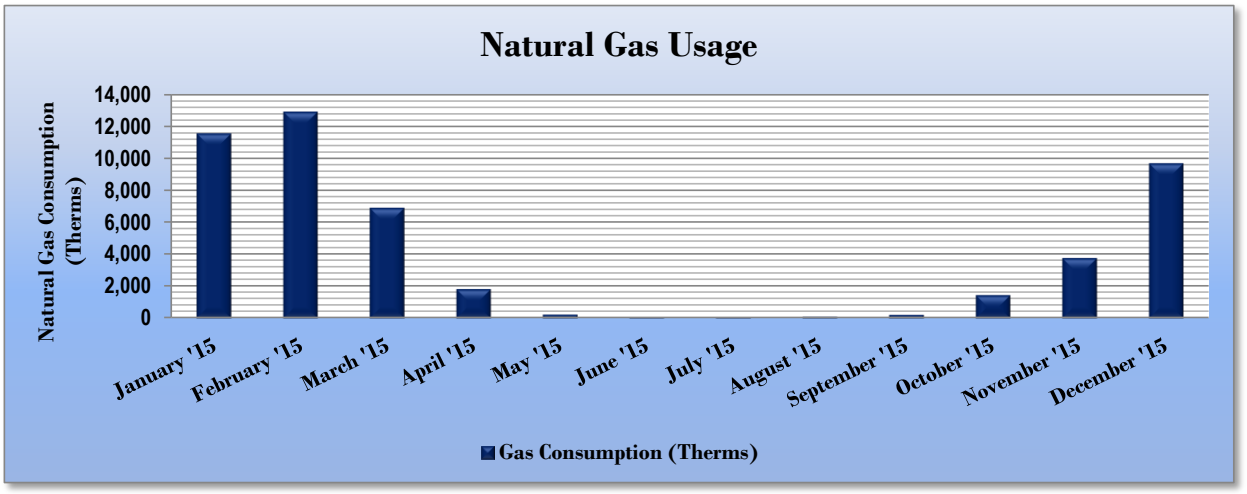


Figure 3 - Natural Gas Usage



Rutgers University of Medicine and Dentistry of New Jersey

The University of Medicine and Dentistry of New Jersey (UMDNJ) was a state-run health science institution was founded in 1954. By the 1980s, it was both a major school of health sciences and a major research university. On July 1, 2013, it was dissolved, with most of its schools merging with Rutgers University to form a new Rutgers School of Biomedical and Health Sciences.

The facilities associated with the UMDNJ are adjacent to the NRMEO facility in Newark. These Rutgers owned facilities include the University Hospital, School of Dental Medicine, University housing, and a combined heat and power plant.

Combined Heat and Power Plant

The CHP plant came online in 1989 and is comprised of three Solar Centaur 50 combustion turbine generators (CTG), each with a capacity of 3.5 MW, for a total plant electrical capacity of 10.5 MW. The campus has a peak electric demand around 40MW and a base load that is typically over the capacity of the CHP plant. The CTGs run at 100% load nearly all of the time.

The CTGs are at the end of their useful life and have become unstable; they regularly trip offline if their loading is varied. The campus anticipates repowering the plant within the next two years – replacing the turbine-generator sets with new models that will operate more efficiently, and produce more, power.

Each CTG is paired with a heat-recovery steam generator (HRSG) and duct burner. Each HRSG can produce 20,000 lb/hr of steam and each duct burner can increase steam production by 21,000 lb/hr of steam. The total steam generation capacity of the plant is 123,000 lb/hr. The plant primarily uses steam to create high-temperature hot water (HTHW) or create chilled water with steam-turbine driven chillers. The plant sends a small fraction of the steam directly to the University Hospital. During the peak winter demand, the full capacity of the HRSGs are used to generate HTHW. During the summer, the plant uses only about 23,000 lb/hr of steam to generate HTHW, the rest of the steam generates chilled water.

A series of cascading tanks generate 365°F HTHW, which the campus uses primarily for heating. Heat exchangers within the buildings are used to generate lower temperature heating hot water. The plant has two 96,000 lb/hr steam boilers, which provide backup to the CTGs and HRSGs. The steam boilers are set to provide 205 psi steam. During the winter, one boiler is typically on hot standby. Reportedly, a single boiler can carry the campus heating load most of the winter.

The plant has four steam turbine driven chillers and two electric chillers, all of which are set to produce 42°F chilled water.

Chiller #1	Steam	1,900 tons	36,000 lb/hr
Chiller #2	Steam	2,700 tons	24,000 lb/hr
Chiller #3	Steam	3,800 tons	56,000 lb/hr
Chiller #4	Steam	3,800 tons	56,000 lb/hr
Chiller #5	Electric	2,550 tons	n/a
Chiller #6	Electric	6,000 tons	n/a

During peak summer, steam driven chillers and the small electric chiller typically cools the campus load. Reportedly, Chiller #6 can carry the whole campus most of the summer, and there is no demand for chilled water during the winter.

A dispatch program managed by Icetech has the ability to determine the most cost-effective plant lineup, but since the CTG cannot reliably modulate, the plant runs fully loaded at all times.

Interconnection Analysis

Evaluating the interconnection a facility to an existing CHP plant requires analyzing the facility load, the load already served by the CHP plant, and the capacity of the CHP plant. Since electric, heating, and cooling loads vary throughout the day and the year, ideally our analysis is based on a year of 15-minute trend data. With detailed trend data, we can develop load profiles that allow us to determine the electric, heating, and cooling coincident loads and compare them against CHP plant capacity. When detailed trend data is unavailable, we manufacture load profiles based on interviews with facility operators and monthly utility data.

Detailed trend data for the UMDNJ CHP plant was requested, with the goal of evaluating the electric, heating, and cooling production and comparing it to plant capacity. With plant trend data we would have an accurate projection of the amount of spare CHP plant capacity and what the ME would need to supplement from the utility and on-site mechanical systems. This data is available from most CHP plants. Unfortunately, the UMDNJ CHP plant was only able to provide us CHP plant electric generation and campus utility import for eight months (January 2, 2017, through August 19, 2017). After multiple attempts, we received no information regarding the thermal operation of the plant.

The provided trend data substantiates that the CHP electric generation is used entirely by the campus nearly all of the time. Occasionally during winter nights, there are times where the CHP plant can supply the entire campus load. In our analysis, we assume that the campus uses all of the HRSG steam for heating and cooling all of the time.

To electrically and thermally interconnected the ME to the UMDNJ CHP plant, we assume:

- The ME would purchase all its electricity from the UMDNJ CHP plant, who in turn would purchase power on the open market and pass it through at a rate 10% less than historical PSE&G electric rates.
- The UMDNJ CHP plant electrical interconnection will be through a transfer switch and a transformer. The ME would keep its existing PSE&G electrical connection, and safeties would need to be put in place to prevent multiple points of interconnection with the grid.
- The ME would purchase all its hot water from the UMDNJ CHP plant via its HTHW distribution system. The UMDNJ CHP plant will need to use a natural gas boiler to generate enough heat to serve the ME. The UMDNJ CHP plant will sell HTHW at a 20% discount, as compared to the ME historical hot water generation costs.
- The ME would purchase all its chilled water from the UMDNJ CHP plant via its chilled water distribution system. The UMDNJ CHP plant will need to use an electric chiller to generate enough chilled water to serve the ME. The UMDNJ CHP plant will sell chilled water at a 20% discount as compared to the ME historical chilled water generation costs.
- The UMDNJ CHP plant thermal interconnections will be through heat exchangers.

Calculation Methodology

Based on the site the inspection, our review of mechanical drawings, and the LGEA analysis previously submitted, we calculated the annual cooling and heating requirement of the ME office, the energy required to generate chilled and hot water, and the associated historical costs.

Electricity for CHW	161,529 kWh/yr	$14,639	cost from PSE&G
ME CHW Demand	179,341 ton-hr/yr	$0.082	per ton-hr of CHW
Therms for HHW	44,800 therms/yr	$37,744	cost from PSE&G
ME HHW Demand	3,360 MMBtu/yr	$11.233	per MMBtu of HHW

The ME cooling electricity and heating therms were subtracted from the historic utility bills to determine the quantities that would need to be purchased from the UMDNJ CHP plant. The rate discounts were applied to UMDNJ CHP purchased electricity, chilled water, and heating hot water. The difference between historical utility costs and the UMDNJ CHP utility costs is the savings associated with interconnection.

A cost estimate was developed based on the data and assumptions listed above. Cost line items were obtained from RS Means 2016 or based on our experience.

The results of our analysis is presented in the tables below.

Historical						
Provider	**Utility**	**Qty.**	**Unit**	**Rate**	**Unit**	**Annual Cost**
PSE&G	Electricity	1,238,234	kWh/yr	$0.091	per kWh	$112,217
PSE&G	Therms	48,918	therms/yr	$0.842	per therm	$41,213
					Total	$153,430

Proposed						
Provider	**Utility**	**Qty.**	**Unit**	**Rate**	**Unit**	**Annual Cost**
UMDNJ	Electricity	1,076,705	kWh/yr	$0.082	per kWh	$88,290
UMDNJ	CHW	179,341	ton-hr/yr	$0.066	per ton-hr	$11,836
UMDNJ	HHW	3,360	MMBtu/yr	$8.986	per MMBtu	$30,193
PSE&G	Therms	4,118	therms/yr	$0.842	per therm	$3,469
					Total	$133,788

Annual Savings	**$19,642**
Cost	**$308,191**
Simple Payback	**15.7 years**

See Attachment A for the complete analysis and cost estimate.

Incentives

Based on the information provided, this project does not increase cogeneration capacity or improve cogeneration efficiency, so no incentives are available for this work.

Summary and Next Steps

Based on the information provided, it appears the Rutgers campus is currently using all of the electricity and thermal energy produced by the CTG. Interconnecting the ME to the UMDNJ CHP plant will not increase plant efficiency or reduce the carbon foot print of either facility.

Interconnecting the facilities may, however, provide a monetary and sustainability benefit if the UMDNJ CHP plant can purchase electricity and natural gas for less than the ME. This analysis assumes that the ME can purchase utilities for less than the campus can produce them on-site. The price at which the ME would purchase these utilities is a critical assumption and should be validated as the likely next step.

Rutgers will need to determine the rules and regulations associated with interconnection. This is beyond the scope of this investigation, and Rutgers should investigate before proceeding.

Attachment A (Excel – NRMEO CHP Interconnection Analysis R1)